TDS-11 TOP DRIVE 30-HOUR MAINTENANCE COURSE

Provided by Rig Angel LLC

TDS-11 TOP DRIVE
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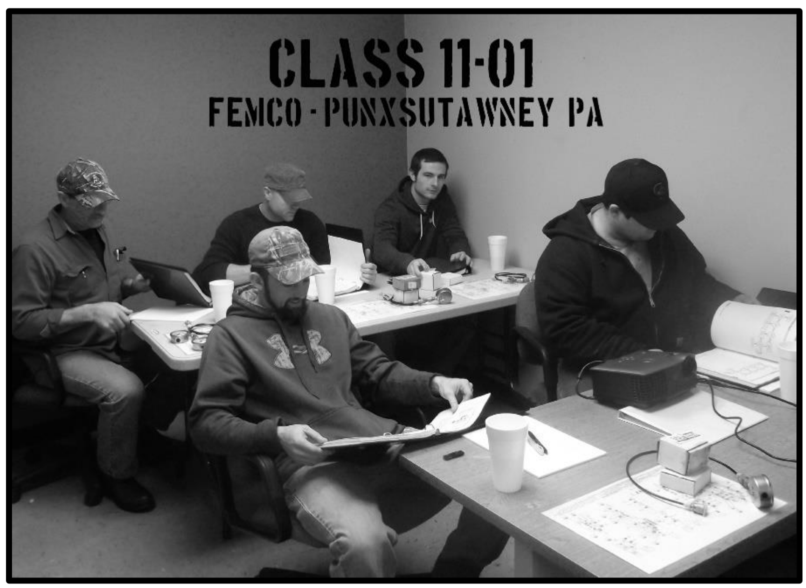
NOTE REGARDING TRAINING FLOW: *This curriculum is written for working adults. It's a wordy document, so it is recommended that the course be driven via the accompanying PowerPoint slide presentation (which is more concise), and that excerpts of the written document be selectively read during the classroom portion in order to keep within schedule.*

IMPORTANT NOTE REGARDING SAFETY: *Safety is Continuous. This document has been produced solely for technical training purposes, and while specific safe procedures and practices may be annotated in some cases, it excludes WARNINGS, CAUTIONS, and NOTES that relate to general safe working procedures. Facilitators and students are expected to exercise safe practices in class, shop, and field practical application—using common sense, basic industrial safety guidelines as outlined in 29 CFR 1910 (OSHA), oil & gas industry standards, and the rules and regulations of all companies applicable to class personnel (i.e. drilling contractor & operator safety rules). Keep your heads on a swivel; remember that all hands are active safety observers, practice Stop Work Authority—if you see something, say something.*

NOTE FROM THE AUTHOR: *Learning should be fun… it should be real. Keep in mind that this was not written for a corporation; it's yours, it's mine, it's free. So I wrote this the way I would teach it, and you may find some whacky analogies, a few sidebars on personal experience, or even some colorful language. This is not intended to offend, rather to emphasize in field terms. Chew up the meat and spit out the bones.*

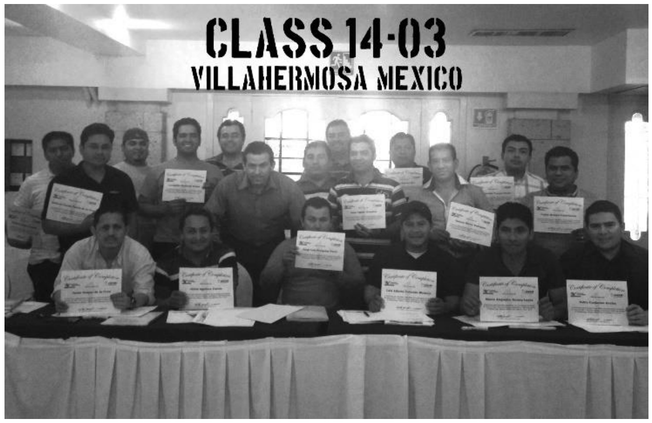
INTRODUCTION:
History of this Course

Hi! My name's Matty Speights and I'm the owner of Rig Angel LLC, a field-based rig maintenance & repair company that started in West Texas in 2014. Thanks for attending this course! I hope that you will find its information useful to your day-to-day operations, whether you're an experienced oil & gas maintenance professional or a new-to-industry Floorhand. It is an intense 30-hour course designed for Roughnecks and intended to equip students to handle most of the maintenance & repair issues common to this equipment.



I developed this course for Patterson-UTI Drilling in 2010, as part of a series of maintenance classes designed for the same audience to meet the same purpose. At that time, it was a five-day period of instruction which culminated in a 40-hour certification. The course was attended by personnel of all ranks and

professional backgrounds from divisions across the country, and it was lauded as a success by the company. In 2014, the curriculum was redeveloped as a 30-hour course for use by GDS International, a Houston-based Top Drive manufacturer. Three other courses stemmed from this one, covering Canrig 500, Tesco, and GDM Top Drives. Augmented by a team of top technicians and translators, GDS proceeded to train international customers in a formal setting. The customer feedback was very positive, and the training was internalized to teach our own Top Drive techs.



In 2020, I was contacted by a Superintendent at Precision Drilling who sought TDS-11 training materials for his hands. To meet this need, the course was revised and largely rewritten under Rig Angel colors and uploaded to rigangel.com for download as a shareable training resource. Since its initial rollout in 2010, more than 300 individuals have received this training—likely including Top Drive technicians who have been called to work on your company's rigs. Also, several past students used this course as a launch point to transition from professional drilling roles into oilfield technical trades.

The information you'll be receiving has been screened and vetted by industry professionals, and has even been hailed as "better" than the $6,500 OEM course at NOV's Technical College. Best of all, it's free, it's streamlined, and it's built for YOU. If you have questions, please reach out day or night. Now get ready to learn, and best wishes in your future endeavors!

v/r

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CHAPTER 1

MACHINE BASICS

HYDRAULIC PRIMER

ELECTRICAL PRIMER

CHAPTER 1:
Machine Basics, Hydraulic Primer, Electrical Primer

In this section, we will learn the following:

1. Definition and purpose of a machine
2. Some basic mechanical concepts
3. Definition and purpose of a ‘force multiplier’
4. A few principles of physics
5. Basic hydraulic theory
6. Basic electrical concepts
7. How a system ties everything together

1.1 What is a Machine?

A machine is **something designed to make work easier**. The idea behind a machine’s purpose is to **provide greater physical output with less physical input**. Machines have been used since the dawn of humankind.

Simple machines were developed using basic geometric objects and principles. Applications using spheres, blocks, cylinders, pyramids, or cubes… could all be used in some way to transfer, amplify, or change direction of input energy to achieve a desired result.

One of the earliest discoveries in machine development—though it was not completely realized at the time—is that force or pressure can be traded for distance. The simplest illustration of this is in the example of a lever and fulcrum. When the fulcrum is placed at the center of the lever, the amount of force required to lift an object on the opposite end is equal to the object being lifted. If the fulcrum is moved closer to the object, however, the force required to lift the object is less than the weight of the object itself. So force is traded for distance, and work is made easier. The same concept can be applied to block and tackle systems (think traveling blocks in the derrick), wherein the addition of each pulley reduces the amount of force required to lift an object (force is traded for longer cable across multiple pulleys).

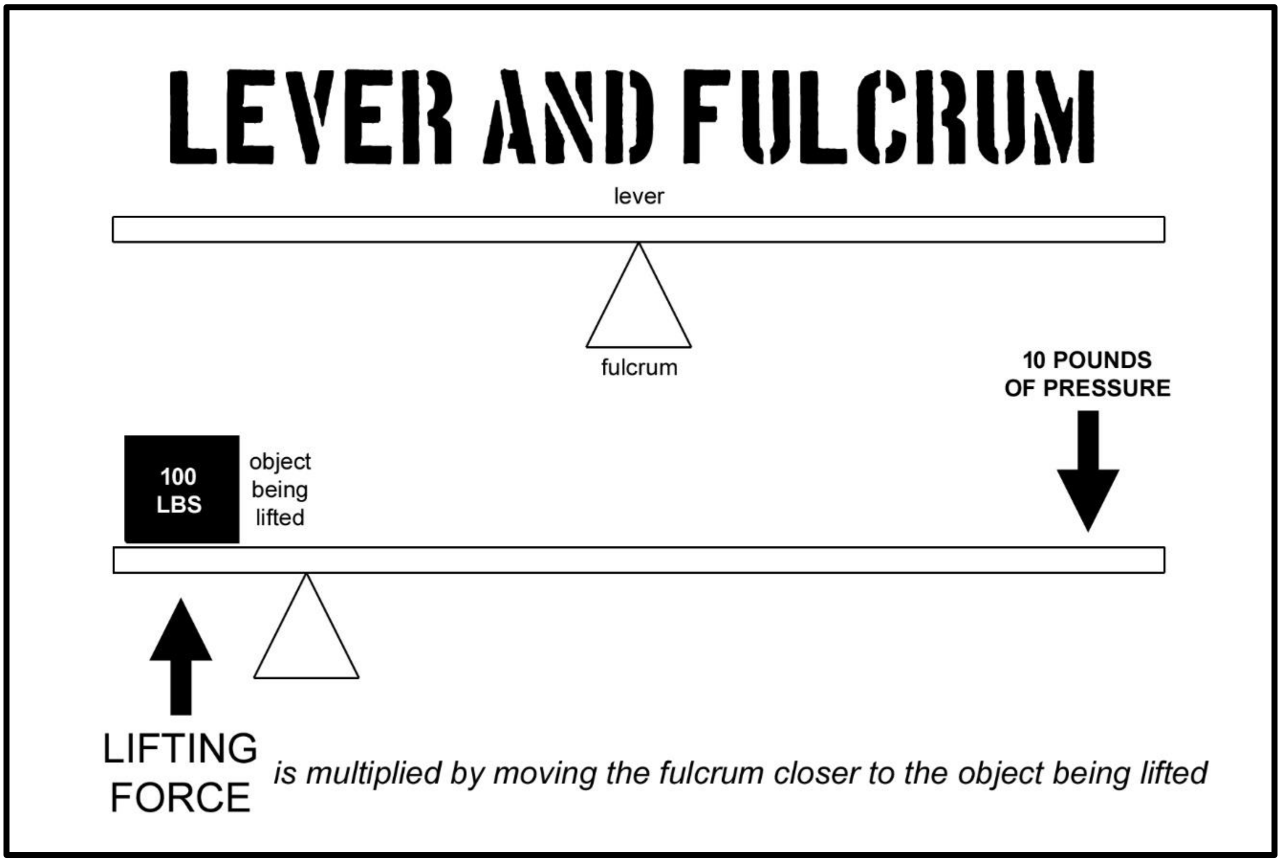


Figure 1.1

1.2 Force Multipliers: Advancing the Fleet

What is a *force multiplier*? A force multiplier **is an object or factor that increases the effectiveness of a force**. In essence, anything that gives someone an advantage could be considered a force multiplier, such as healthy living habits, motivation & morale, favorable weather, tools & technology, quality training, and experience. Colin Powell, former *Secretary of State*, has founded his leadership on Thirteen Rules. His thirteenth rule is this: "Perpetual optimism is a force multiplier." Forbes Magazine is riddled with articles about CEO's who push the force multiplier concept in the business world.

Mechanically speaking—as outlined above—the proper use of fulcrums, levers, and pulleys can be used to multiply the load-lifting capacity of the human body. Nutcrackers, Vise-Grips, wheelbarrows, and crowbars are other simple mechanical examples. Hydraulic equipment is another powerful force multiplier when measured against our own biophysics. For example, a single backhoe and operator can out-dig 15 men. Similarly, in electricity, a capacitor collects and stores energy and then releases it in greater quantities. In radio communications, relays and repeaters are used to multiply the distance that a signal can be carried. These are all examples of force multipliers.

With this same concept in mind, your company is investing in quality maintenance training for its employees. Your Primary Objective in this TDS-11 Top Drive Maintenance Course is to retain as much information as possible, go back to your workplace, and show what you have learned. You will then act as a force multiplier to advance the knowledge of your team. As on the battlefield, our leaders have a specific intent: to minimize downtime and maximize bottom-line operational efficiency through a safe, professional, informed, and maintenance-savvy fleet.

1.3 Basic Hydraulic Theory

Before diving into hydraulic or electrical theory, there are a few basic concepts of physics that you'll need to know. The first is this: the **First Law of Thermodynamics** states essentially that **energy cannot be created nor destroyed, only transformed (or transferred) into one form or another**. Machines and machine systems of all sorts follow this principle.

When you start up a rig, the sequence of energy transfer begins with the firing of a motor. Chemical energy stored in a battery is transformed into electrical energy to fire a starter, where the electrical energy is transformed into mechanical energy to engage the Bendix to physically turn a flywheel (or, in the case of an air starter, pneumatic energy is transformed into mechanical energy at the starter). The mechanical energy of a rotating shaft is transformed into electrical energy through an engine-driven generator, which powers a light plant, SCR or VFD house, and so on.

In hydraulics, there are three examples that will be mentioned in greater detail later in this course. A **hydraulic pump** essentially converts mechanical energy into hydraulic energy. A **hydraulic motor** does the opposite, as it converts hydraulic energy into mechanical energy. A **hydraulic piston** or **cylinder**, like a hydraulic motor, converts hydraulic energy into mechanical energy.

"Hydraulics" is another name for *fluid science*. One of the most important physical concepts in hydraulics is derived from **Pascal's Law**, which states that, when acted upon, fluid (or gas) exerts force equally and in all directions against the walls of its container. The measure of this force is expressed in pounds per square inch, or PSI.

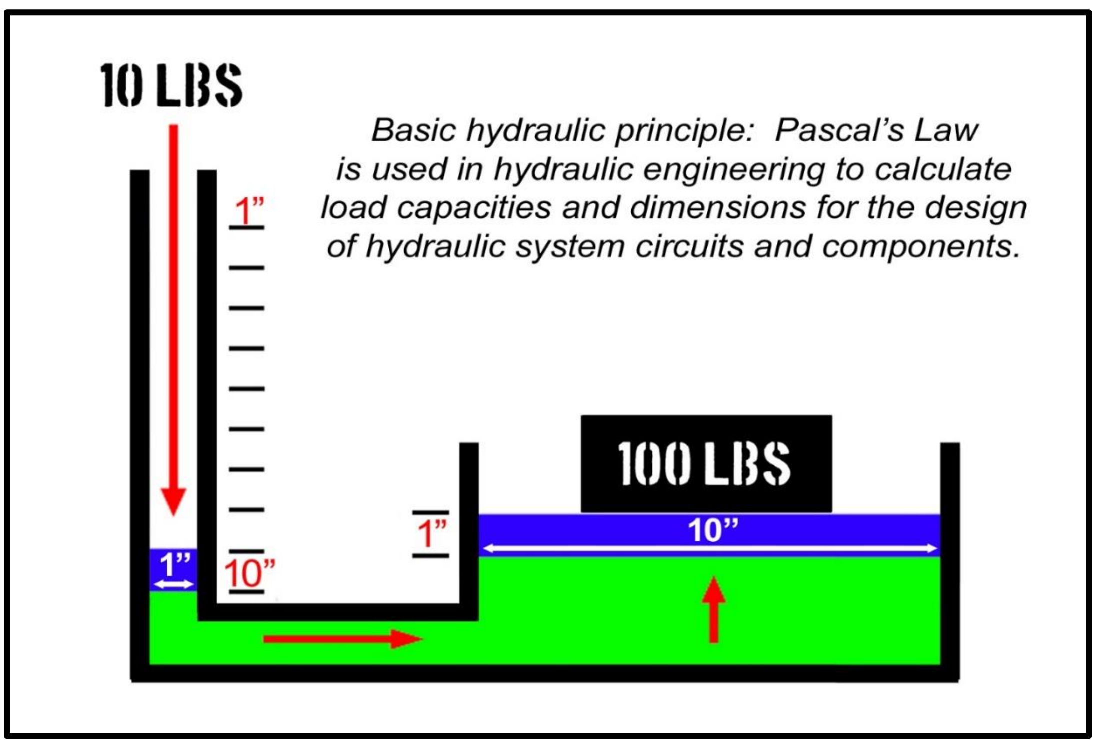


Figure 1.2

Modern hydraulics have a fascinating history. Simple machines that used levers and elaborate linkages were replaced by machines with pneumatic systems, applying Pascal's law with the use of compressed air through tubes and flexible hoses… it made machine actuation simpler and less expensive. The problem with pneumatics is that air circuits are subject to moisture contamination, and components often fail due to corrosion brought about by moist air (the reason that lubricating oil and air dryers were introduced into pneumatic systems). Another problem with pneumatics is that air is compressible, which makes the actuation of pneumatic components less reliable (especially when controls are distant from the components). Hydraulic systems eventually replaced pneumatic systems because, while the theory of both is similar, fluids are less compressible than air. With time, hydraulic fluids were engineered at the molecular level to become nearly incompressible, so that actuation of a hydraulically-driven component is nearly instantaneous, regardless of the length of the circuit between operator controls and the end actuating device

1.4 Hydraulic Systems

As applies to industry, **a 'system' is the collective term for a machine and its auxiliary components, controls, connective elements, and incorporated protective devices**. Hydraulic systems are classified in several types, but most often as either "open loop" or "closed loop." This course will not cover all scenarios that comprise these systems; here are the key discriminators:

An open loop system:

(1) Fresh fluid is constantly supplied to the pump from the reservoir
(2) The reservoir is usually sealed; actuator fluid returns to reservoir
(3) Provides flow without significant pressure or heat generation
(4) Examples include turbines, compressors, and the TDS-11 Top Drive

A closed loop system:

(1) Recirculates fluid from the actuator to the pump
(2) Provides flow and on-demand pressure for precise response time
(3) Is used for high-pressure applications and generates significant heat
(4) Examples include internal combustion engines, refrigerating systems, and hydraulic Top Drives (the drive portion, not the auxiliaries)

The image below illustrates some components that are common to all pressure hydraulic systems (open loop illustration):

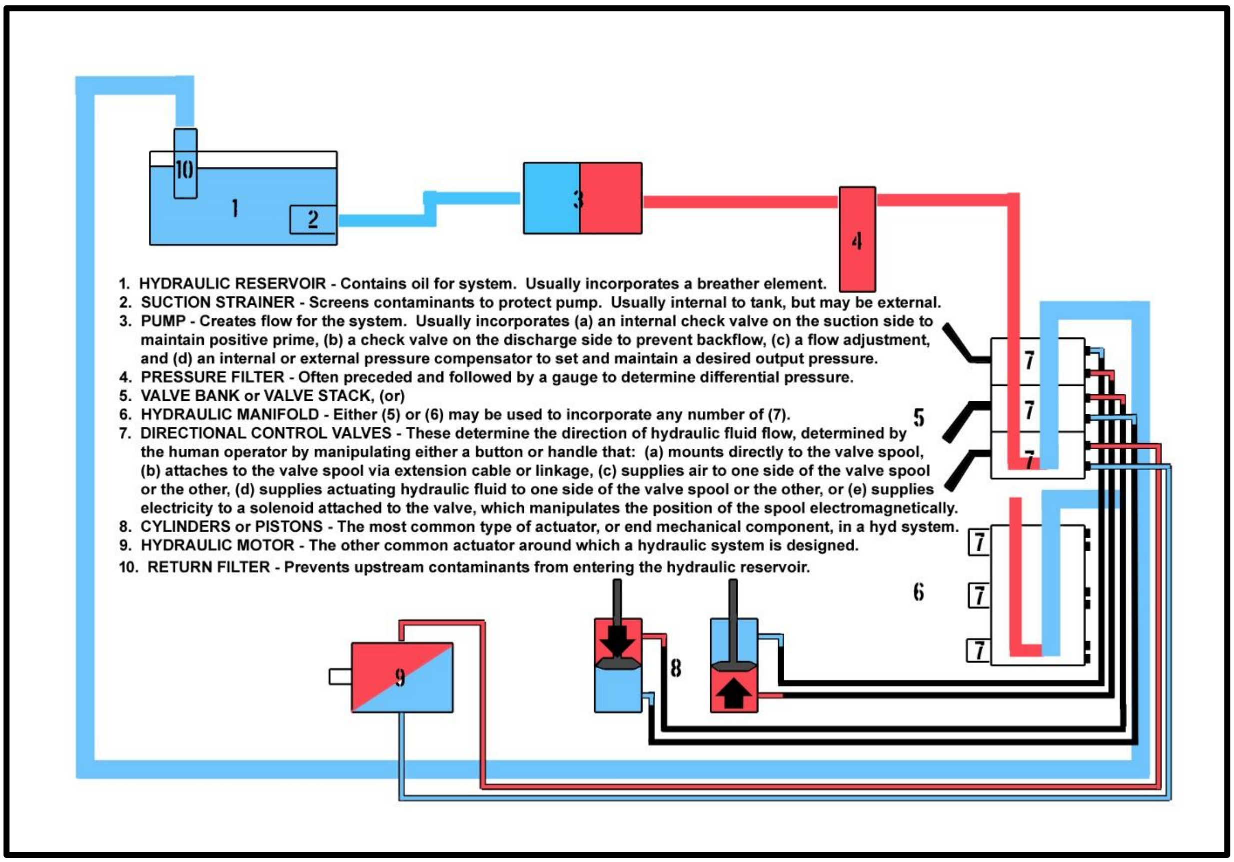


Figure 1.3

(1) Hydraulic Reservoir – aka tank or sump, this holds the fluid for use in a hydraulic system. May incorporate a breather, fill port, drain,

internal or external suction strainer(s) near the bottom before / after the outlet, high-mounted internal or external return filter(s), an internal heater element for cold weather applications, a sight glass or level indicator, and low-level and / or high temperature shutoff safety devices. The reservoir should be installed inside of a secondary containment area that is capable of capturing the full contents of the reservoir.

(2) Suction Strainer – first line of filtration defense in the system, protects the pump from contaminants that may have settled to the bottom of the reservoir.

(2b) Shutoff Valve (optional) – One should be installed upstream from each pump to isolate reservoir fluid during pump changes. Usually a quarter-turn ball valve, this device can be a cause of pump cavitation and failure, especially if the pump is energized while the valve is still closed.

(3) Pump – **Creates flow** for the hydraulic system. There are several types used for different applications. The pump is driven mechanically by a motor shaft, usually incorporating some type of coupling made of softer material (aluminum / rubber / composite) to prevent secondary component failure (in theory, if the motor seizes while running, the coupling disintegrates and spares the pump; if the pump seizes while running, the coupling disintegrates to spare the motor). Examples of motor / pump couplings are Dodge, Magnaloy, and Lovejoy type.

(3b) Check Valves – These one-way flow control valves are often installed just downstream of the pump. Some types of pumps have incorporated these valves internally.

(3c) Pressure Compensators and Regulators – Used to set, adjust, and maintain a desired downstream pressure. May be located internal or external to the pump, or at any place in a hydraulic system. Similarly, a flow adjustment may be located on the pump itself.

(4) Pressure Filter – Downstream of the pump, this is the primary filter in the hydraulic system. May incorporate more than one filter in an assembly.

(5) Valve or Valve Bank / Stack – One or more directional control valves that are each used to control an **actuator**, such as a piston or a hydraulic motor. A stack of six individual valves may be referred to as a "six-valve bank," a "six-station valve stack," or any variation thereof.

(6) Hydraulic Manifold – A hydraulic manifold is simply a block of metal with holes drilled through it, some which intersect. The holes serve as channels to direct fluid through orifices and fixed or adjustable cartridge valves which may be installed into the manifold for various purposes. Small manifolds are often referred to as valve blocks or valve bodies. On the TDS-11 Top Drive, the large Main Manifold also take the place of a seven-station valve bank, as its design allows for the external mounting of seven solenoid-operated directional valves. **Hydraulic manifolds can be compared to traffic intersections** for ease of understanding.

(7) Directional Control Valves – These types of valves are used to control the directions of double-acting cylinders and bi-directional hydraulic motors. Refer to the illustration above to see how changing the position of a directional valve's handle position will determine which side of a cylinder receives fluid under pressure. As the cylinder's piston rod moves, the low-pressure side of the cylinder is vented back into the return circuit through the directional valve. Of course, this doesn't just happen magically. On the outside of the valve, we see a handle. But that handle is mechanically connected to a valve spool—basically a shiny rod with cutouts for porting fluid, usually returning to a neutral center position by way of spring tension—and inside the valve, the spool is manipulated directionally to allow pressure to exit the valve through either "A Port" to one side of a cylinder, or through "B Port" to the other side of a cylinder. Simultaneously, the cutouts in the valve

spool allow fluid to return from the actuator (in this example, a cylinder).

(8) Cylinders / Pistons – The most common type of actuators in a hydraulic system. Most hydraulic systems are designed to either push or pull something; to do that, the end component in the system is usually a cylinder. The cylinders we will cover in this course are the most common type: single-stage (one continuous piston rod), dual-acting (or double-acting, meaning the cylinder works both ways, in and out).

(9) Hydraulic Motors – The second most common type of actuators in a hydraulic system. All motors are used to create motion, whether they are electric, hydraulic, or combustion-engine type. Hydraulic motors are always torsional (twisting or rotating, like most motors), and are generally used for low speed, high torque applications.

(10) Hydraulic Return Filter – The last stage of filtration in a hydraulic system, installed to protect the hydraulic reservoir from upstream components that are beginning to fail, for example.

(11) Everything Else

(A) Hydraulic Accumulators – There are several different types of accumulators, but they all serve the same essential purposes: (1) to store pressurized hydraulic fluid for rapid disbursal, especially in heavy load applications, and (2) to absorb fluid shocks & imbalance. The TDS-11 uses the most common type of accumulators—bottle-style with nitrogen-filled bladders inside. The maintained pressure of the fluid is determined by the size of the bottle, the size of the bladder, and the amount of nitrogen pre-charge pressure applied to the bladder.

(B) Fittings – There are four common types of fittings used in pressure hydraulic applications: (1) NPT (National Pipe Thread, aka pipe fittings—ONLY USE Schedule 160 or XXH thick-walled, NOT standard iron pipe); (2) JIC, aka 37° flare fittings, which are the most common used on the TDS-11 Top Drive; (3) ORB, aka O-Ring Boss or 'Boss-O' fittings—these are used to install into recessed machine surfaces such as hydraulic manifolds, pump and filter housings; and (4) ORFS (O-Ring Face Seal, aka 'flat face' O-ring fittings)—in the US drilling industry, these are used on Canrig Top Drives, Schramm carrier-mounted workover rigs, and in a few other applications.

(C) Hoses, Tubes, and Connections – Rigid tubing is typically stainless or carbon steel type, and hoses are wire braid reinforced (2-wire minimum). Hydraulic connections are either standard XXH QD, Stucchi, or Parker FET-style. All hoses, tubes, and connectors in a high-pressure hydraulic circuit should be rated over the max rated pressure of the hydraulic system + 33%. This is the minimum standard. For a TDS-11, all hydraulic components should be minimally rated to 3,000 PSI, though 5,000 PSI is preferred.

(D) Other Types of Valves – In pressure hydraulics, there are many types of valves used. Regulating valves maintain a desired working pressure. Relief valves ensure a safe system pressure. Counterbalance and load-holding valves work to protect cylinders while holding heavy loads. In most cases, these are cartridge-type valves, which are threaded for insertion into valve bodies and manifolds. The TDS-11 uses valves from the most common cartridge valve manufacturer, SUN Hydraulics Corporation.

That about sums up your basic hydraulic primer. For further study, you are encouraged to research the roles of oil purifiers / dehydrators and monitoring devices (flowmeters, pressure gauges, particle counters, Coriolis or 'mass flow' meters) as used in hydraulics. For further study in fluid dynamics, brush up on Newton's Second Law of Motion and

Bernoulli's Principle. We're now going to talk about circuits, as a segue into our segment on basic electricity.

1.5 Circuit Fundamentals

The word "circuit" is used to describe a path in both electricity and hydraulics.   Because many functions of the TDS-11 Top Drive are electrically actuated and hydraulically operated, each function has both types of circuits. Why is this important to know? Because, when dealing with devices that are electric over hydraulic, it helps to know whether they are energized open or closed, or de-energized open or closed. This is especially crucial to the understanding of schematics / technical diagrams. Don't worry, we'll cover this info quickly.

Hydraulic circuits are opened or closed by way of valves. When a valve is open, fluid is free to flow from the pump to the device being operated. When closed, fluid is stopped at the valve. Too simple, right? Well with electricity, you need to flip that way of thinking 180 degrees. Instead of valves, we're dealing with switch contacts, and a CLOSED switch contact is what allows the flow of current through an electrical circuit. An OPEN contact will de-energize (or stop the flow of current through) an electrical circuit. A normally open electrical contact means that you need to turn a knob, flip a lever, or push a button to close the contact and allow current to flow (turn the device *on*). Electricians often refer to this as "making" the contact. When you turn a light switch on in your bedroom, you are actually closing the electrical contact between the hot wire and the switch leg (the wire that goes to the light), in turn *closing the circuit* or 'making the switch.' Refer to the image below for better understanding.

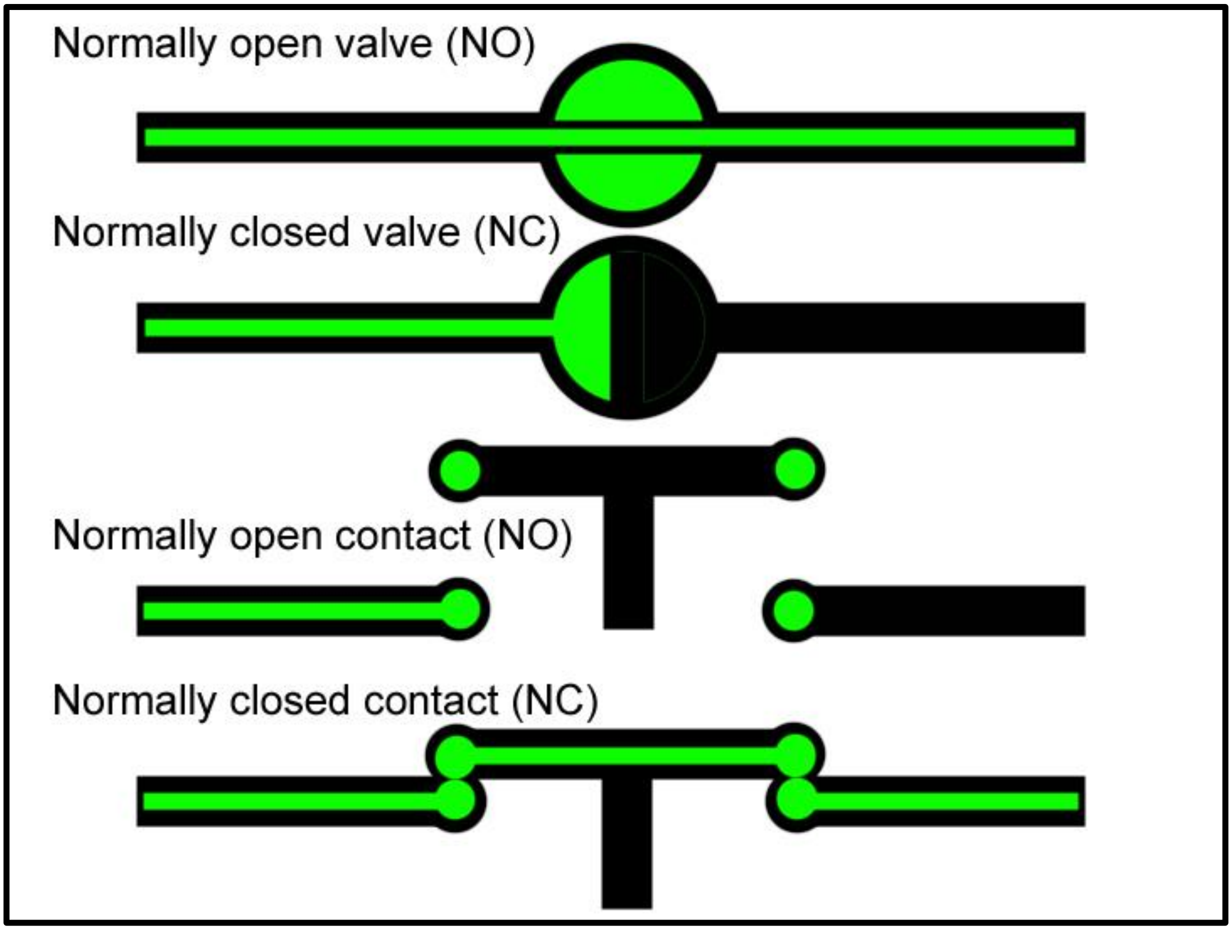


Figure 1.4

Now, perhaps you're wondering why the words 'open' and 'closed' are preceded by the word 'normally' in the image above. It's because all technical drawings, diagrams, prints or schematics you'll ever read—will depict components in the way that they are when at a *resting* state, or de-energized. Something needs to happen in order to take them out of their normal state, meaning that the component must be acted upon by some outside force mechanically, electrically, hydraulically, or pneumatically to cause it to change position.

You will typically only see the abbreviations 'NO' or 'NC' on electrical devices, especially switches, to indicate that the internal contacts are either normally open or normally closed. The abbreviations may be labeled, stamped, engraved or embossed. NO is also sometimes referred to as "de-energized open," or "energized closed." Conversely, NC = de-energized closed, or energized open.

If there are no abbreviations, then the colors red and green are alternately used on the parts themselves. For electrical switch contacts, Green = NO and Red or Orange = NC (IEC breakers also use green and red to indicate open and closed, respectively). Similarly, for anyone who has engaged in replacing a standard 120V electrical outlet / house plug, you'll probably remember that the gold screws are where you connect (black) power wires, silver screws are where you connect (white) common wires, and the green screw is where you connect the (bare copper) ground wire. This is not the only place where colors are used as differentiators in electrical application. Industrial cord grips are color-coded according to wire diameter. Multiconductor cables such as those used on Top Drives, while usually numbered, are often colored in a specific pattern. Canadian drilling rigs and US drilling rigs often differ in their standard 3-phase plug terminations. Colors are important in electrical application, just keep that in your back pocket.

1.6 Basic Electrical Theory

Talk about going around the asshole to get to the elbow. Now let's cover some electrical basics. I'm going to admit, that though I'm perfectly comfortable working with 480V and 600V electricity, I've always had a hard time truly understanding the basics of electricity when they were taught to me. Hopefully, my explanation is less confusing to you.

Atoms are the smallest elements of matter. All solids, liquids, gases and plasma are comprised of atoms. Every atom is orbited by electrons, which are subatomic particles with a negative ~~charge.~~ Strike that. For ease of explanation, we'll just say that electrons are negative particles that are everywhere, and they always remain negative. They are attracted to positive particles (specifically protons, which are part of every atom). Electrons are constantly moving, and when they're affected by an outside source—light, heat, sound, friction—they literally jump their orbit (briefly becoming free electrons) before being attracted to the positively-charged proton of another atom (or ion, which is an imbalanced atom), where they resume orbit. These transfers happen rapidly.

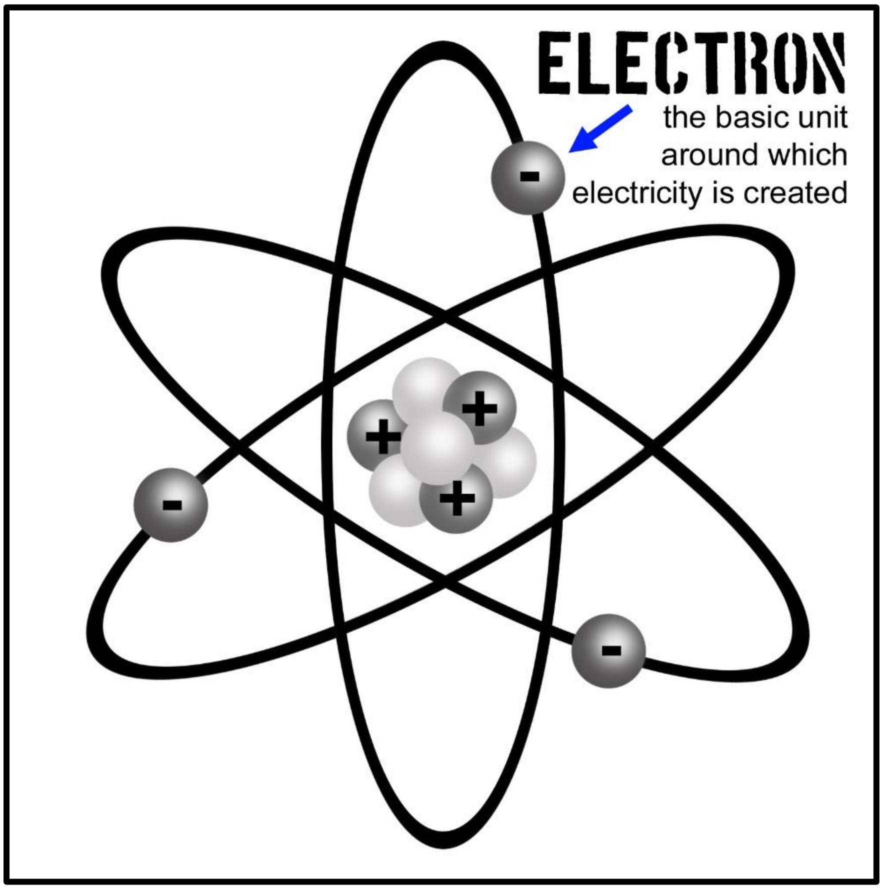


Figure 1.5

Electric charge is produced by either an excess or deficiency of electrons. A surplus of electrons on a substance creates a negative charge, and a deficiency of electrons creates a positive charge. Electricity is the migration of electric charge from negative to positive or from positive to negative.

Static Electricity – Some materials tend to be positive in nature because they give up accumulated electrons when they contact other materials.

Conversely, other materials tend to be negative in nature because they attract and retain electrons. When you walk across a carpet, depending on what your shoes or clothes are made of, and especially when your skin is dry, your body becomes rapidly loaded with electrons that you've kicked up—making you negatively charged. But since dry skin tends to be a 'positive' material, readily willing to give up excess electrons, when you make contact with a door handle made of nickel, copper, or brass (all of which tend to be negative materials, attracting and retaining electrons), the difference of potential results in static shock, as the surplus of electrons on your body race to the negative material which happens to have a more positive charge than yourself at the moment.

Does that make sense? It's all about yin-yang style balance and harmony. Think of a clear tube-style water level—when water is added to one side of the tube, the other side of the level rises until the height of water is equal horizontally. When you shake the level, there will be brief moments of inequality, but the water on both sides of the tube constantly strives for perfect balance. Similar in concept is the balance of positive and negative charge, constantly seeking a state of neutral balance. The movement of electrons to find that balance results in what we call electricity. The same way we create turbulence by shaking a water level, we 'create' electricity by causing electron imbalance.

Current Electricity—Electrons can essentially move freely through or across certain types of material, particularly metals such as copper, gold, aluminum, and silver. That's because the atoms of these materials have electrons that are loosely bound. Such materials are referred to as conductors. Other materials oppose the free movement of electrons, such as rubber, plastic, wood, glass, and air. These materials are called insulators. When we direct the transfer of electrons across a solid copper wire conductor, we are creating current electricity or electrical current. Current is measured by the number of electrons traveling across the cross-section of a conductor per second, and it is expressed in amperes, amps, or 'A'. Voltage is electromotive force, measured in volts or 'V'. One volt equals the amount of force required to move one amp across a resistance of one Ohm. Ohms are the measurement units of resistance, expressed by the Greek Omega symbol (Ω). Resistance, which occurs naturally in any substance, is the characteristic of an object that impedes the flow of electrons. Resistance is increased proportionately with the increase of a conductor's distance, or with a decrease in a conductor's diameter.

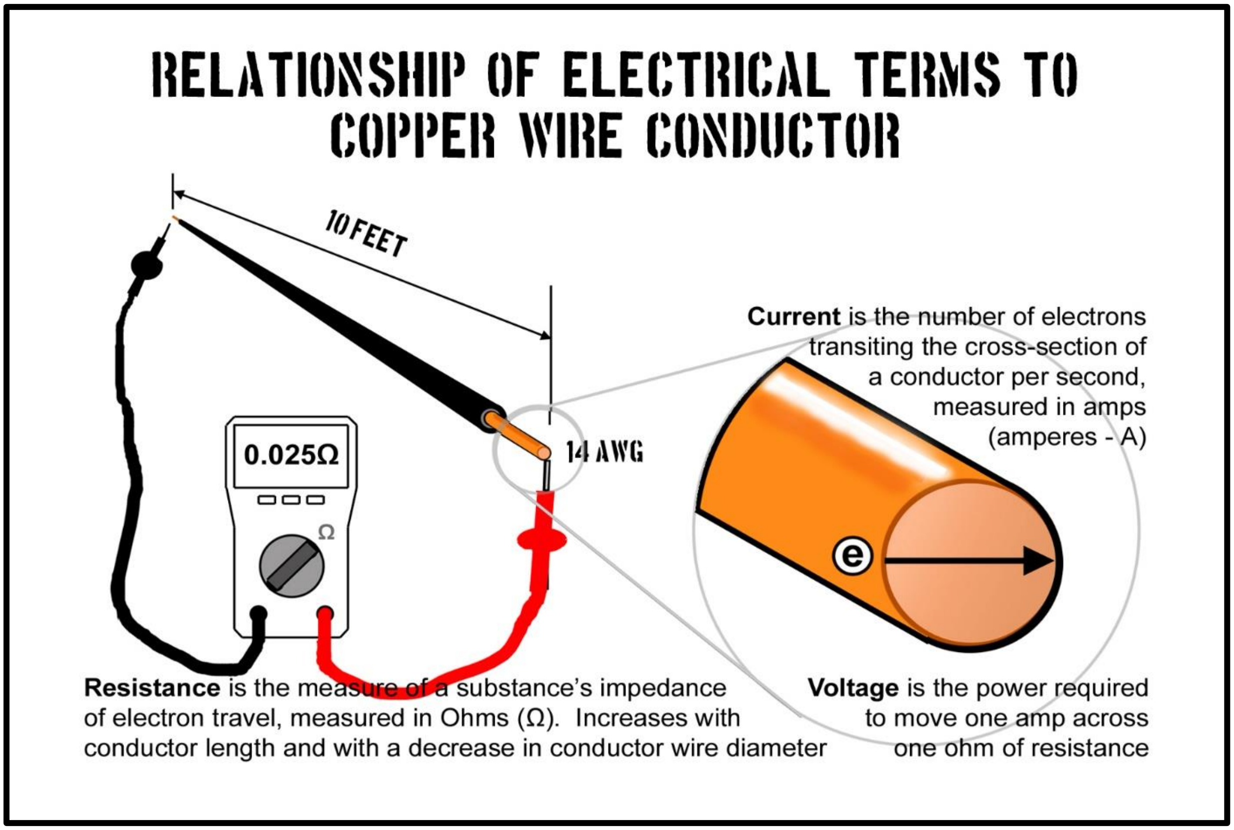


Figure 1.6

Confusing Science—Before electrons were discovered, it was accepted and firmly established by the scientific community that electrical current travels from positive to negative. It has since been discovered that electrons travel from negative to positive. Because this discovery would discredit some brilliant scientists (Benjamin Franklin in particular), the scientific fraternity has decided that electrons travel one direction while current travels the other. Since irrefutable, globally-accepted proof does not exist on either theory, this contradicting information stands as gospel. For now. Sounds goofy, but don't take my word for it… do the research.

If you have a grasp of the info above relating to electrons, then it's easier to understand exactly how electricity works. There are, as you know, two types of electricity, AC and DC. With Direct Current, electrons flow in a single direction from an area of negative polarity—or concentration—to an area of positive polarity. Most often, DC power is associated with battery power, especially when explained in theory. We're going to do the same, and then touch on AC power and some basic terminology before moving to the next chapter of the course. Drilling rig and Top Drive-specific electrical information will be covered later.

1.7 DC Power

DC power is expressed in volts, V, volts DC, VDC, or by the symbol "⎓". It is produced most commonly by a battery, and all batteries produce only DC voltage. In high voltage applications, DC power is produced by a **rectifier, a device which converts AC power into DC power**. In low-voltage applications of 24VDC or less, it is converted from AC using a Power Supply, which essentially is a miniature version of a rectifier.

Let's break down a battery. A battery is an engineered source of DC power consisting of a negative plate or electrode—called an anode, a positive plate or electrode—called a cathode, and an electrolyte medium between the two, usually acid. Batteries may exist in one of three states: static (not connected), charge, and discharge. When the two terminals of a battery are connected to an electrical device, electrons travel from the anode through the electrical device to the cathode until the amount of electrons at the cathode are roughly equal to the amount of electrons at the anode. That's when the difference of potential has been equaled or neutralized, the battery reads zero volts because electrons stopped moving between the two points, and we pitch the battery.

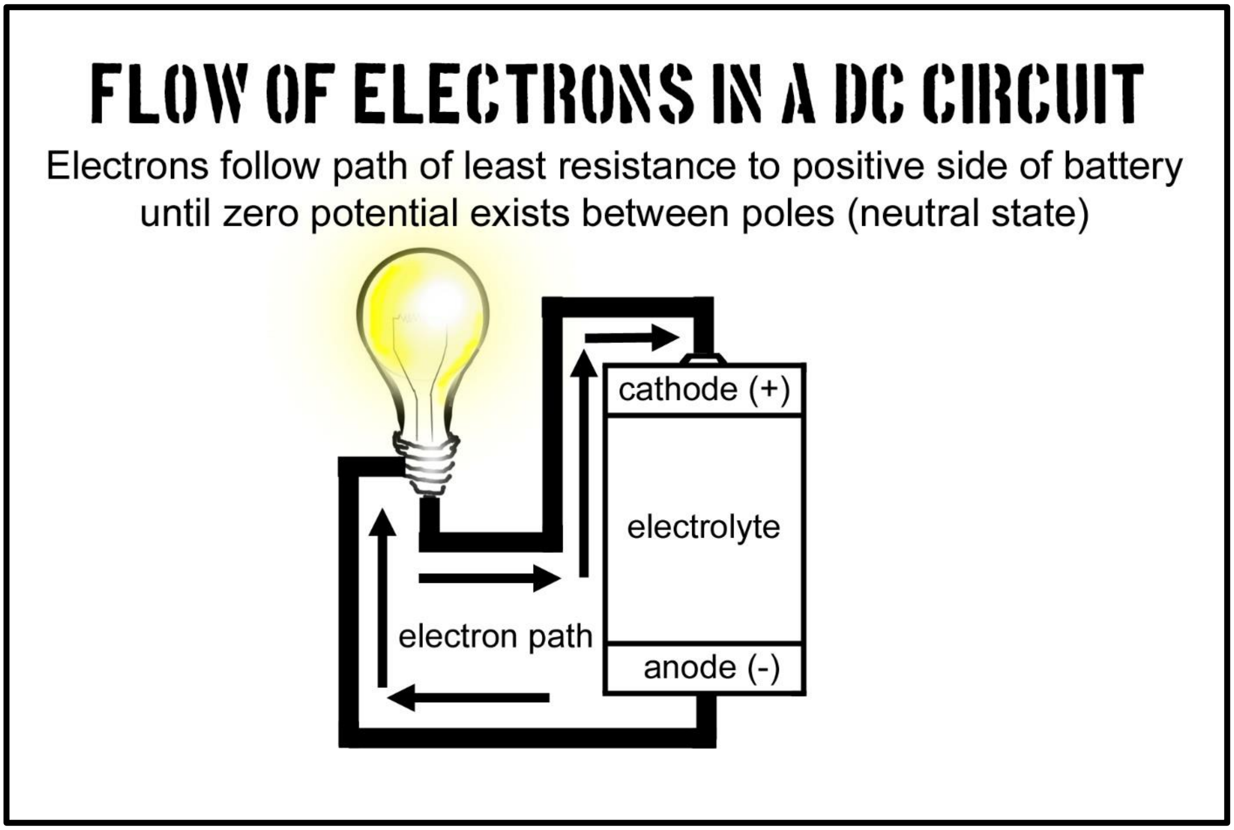


Figure 1.7

Not all batteries are (re) chargeable… it depends on their chemical design. In the example of a NiCad battery, the positive cathode is made of nickel hydroxide, and the negative anode is made of Cadmium. When a higher voltage of DC electricity is applied to the battery, a chemical reaction occurs within the battery's electrolyte, reacting with the electrodes in a way which causes electrons to leave the cathode and recollect at the electrode. Voila, battery charged. The same is true of car batteries. An car's alternator is a device that uses the technology of both a generator, which converts the mechanical energy of a belt-driven rotor across static windings into AC voltage, and a rectifier, which converts the AC back to DC for recharging the battery and powering the vehicle's DC-rated components.

1.8 AC Power

In the previous section, the word potential was used on a few occasions. Once upon a time, voltage = potential difference = electromotive force. It’s become more confusing because all are now each their own separate entity, scientifically speaking, though they are all expressed in volts. The difference in energy (or difference in the number of electrons) between two points is called Potential Difference, or PD. The principle behind measuring PD is derived from Ohm’s Law, which states that the current through a conductor between two points is directly proportional to the voltage (and inversely proportional to the resistance) between those two points. In other words, $V = IR$, where V is voltage, I is current and R is resistance. The greater the difference in potential between two points, the higher the voltage.

In Alternating Current, electricity is produced using generator or turbine technology. A motor is used to rotate a shaft, attached to which is a coil. The coil rotates inside an electromagnetic field… literally, between magnets of opposite poles. External DC power is applied to the generator through a continually-charged battery, supplying electron charge to the generator. Charge is created and moved by the coil rotating between the magnets, then forced away from the generator through diodes—the one-way check valves of electrical devices. Voltage passes in one direction initially, then in both directions alternately as the conductor’s potential changes with each rotation of the generator coil. The opposite electromotive force (EMF), comparable to voltage, is directed back into the generator through opposing diodes. The concept is the same for three-phase generators, which incorporate more coils (three or six). An AC motor works almost exactly the same as an AC generator, except instead of using shaft rotation to generate electricity, the motor at the end of the circuit uses electricity to turn a shaft.

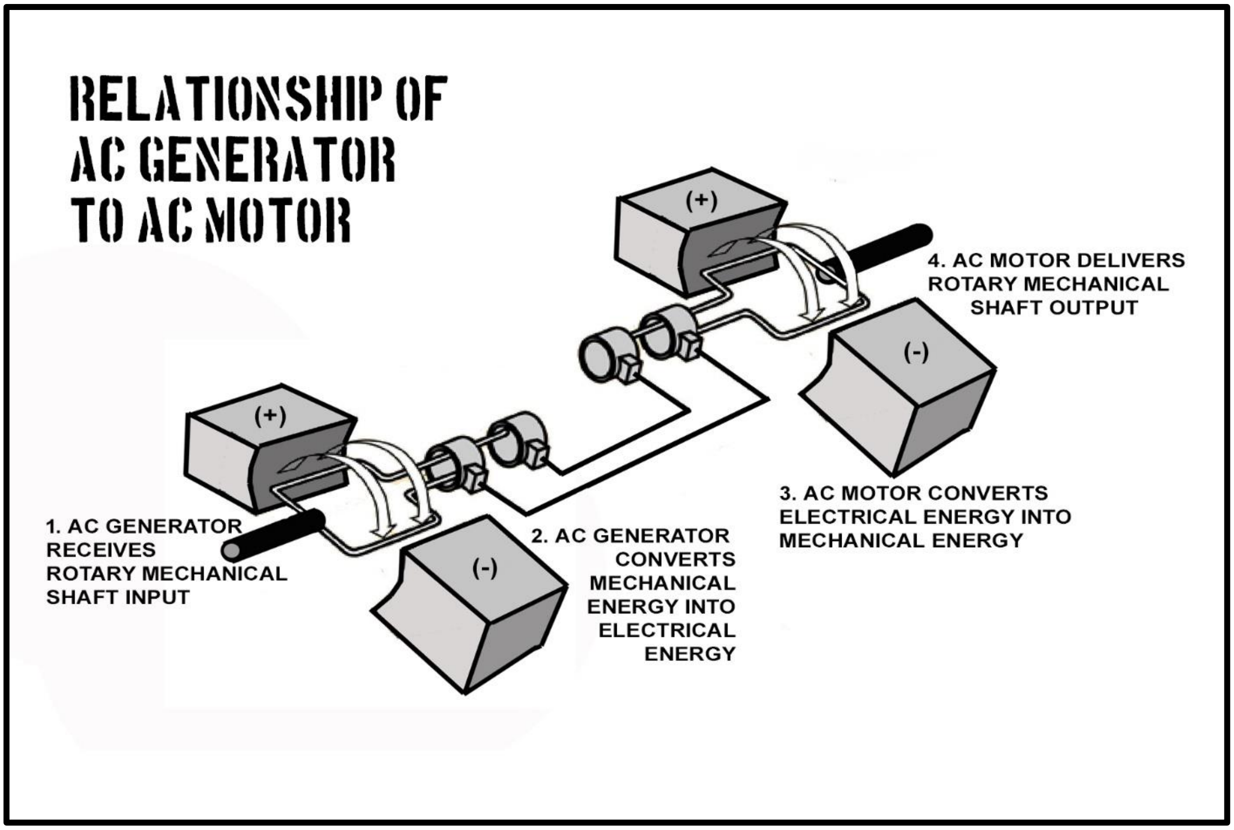


Figure 1.8

1.9 Grounding and Bonding

The reason we ground a device or piece of equipment, is to disperse the charge or accumulation of electrons across its surface area that occurs when it is energized, or when an adjunct device is energized. As the device's charge increases, the potential discharge becomes greater… and could injure or kill the first person to touch it. The concept behind grounding is to provide a path for electrons to attach to a much larger object (called 'bonding'), or directly into the earth (grounding). Devices with a high potential charge often require a "dedicated" ground (such as a VFD), meaning an isolated ground wire and grounding rod that shares with no other equipment. See the image below for a simple illustration.

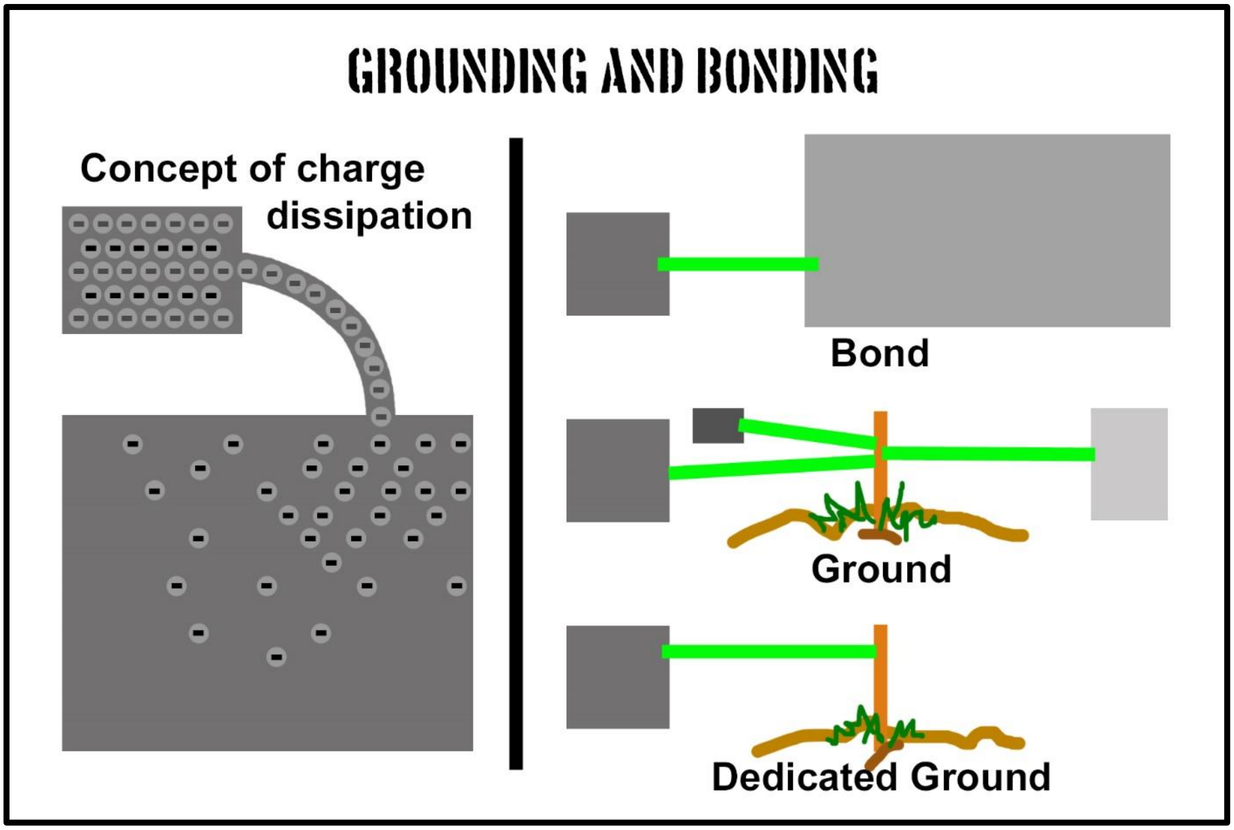

GROUNDING AND BONDING
Concept of charge dissipation
Bond
Ground
Dedicated Ground

Figure 1.9

1.9 Common Electrical Terms

Electron	A subatomic particle with a negative charge
Current	The movement of electrons through a conductor, aka electricity
Conductor	A substance w/ properties that permit free motion of many electrons
Insulator	A substance that contains few free electrons
Semiconductor	A substance that is neither a good conductor nor insulator (silicon)
Amperage	The measured rate of current flow
Resistance	The opposition to current flow, measured in ohms
Resistor	A component manufactured to possess a specific value of resistance
Volt	A unit of electric force or potential, conceptually similar to water pressure
Potential	Refers to the performance or composition of an electrical charge
Potential Difference	Measurement between two objects / bodies w/ different electrical charges
Ground Potential	Zero potential with respect to ground – essentially zero or neutral charge
DC	Direct Current electricity, in which electrons flow in one direction only
AC	Alternating Current electricity, which reverses direction at intervals
Frequency	Rate of AC current directional change, expressed in Hertz (cycles p/ sec)
VFD	Variable Frequency Drive – A system for controlling an AC motor
Inverter	A device that converts DC power into single- or multi-phase AC power
Single Phase	AC power, one electrical output provided for each complete source cycle
3-Phase	AC electrical circuit made up of three conductors, synched 120 deg. apart
Diode	A 2-terminal semiconductor that only allows current flow in one direction
Rectifier	A device that converts AC power into DC power through diodes
SCR	Silicon-Controlled Rectifier, used for high-voltage applications
Voltage Source	A device capable of supplying and maintaining voltage under load
Transformer	A device used to step the voltage in a system circuit up or down
Power Supply	Converts AC to controlled DC power in low-voltage applications
Capacitor	A device used to store an electrical charge
Relay	A device to open / close circuits manually or at predetermined parameters
Solenoid	A mechanical device that actuates when current is applied to its coil
Short	A damaged circuit malfunction wherein current is directed to ground
Open	Refers to a break in the flow of electrical current
Closed	Refers to completion of an electrical circuit which allows current travel
Keyer	A component that opens and closes contacts using heat-sensing elements
Shunt	A resistor used to supply voltage in relation to current flow through it
Series Circuit	An electrical circuit wherein all current flows through one path to ground
Parallel Circuit	A circuit where current flows through separate paths to a common ground
PLC	Programmable Logic Controller; computer to control multi-tool sequences
SBC	Single Board Computer; implements single-system tool control sequences
Braking Chopper	Aka Dynamic or Resisting Brake, dissipates excess voltage as heat
Encoder	Device which relays motor speed conditions to a drive system
HMI	Human-Machine Interface; a touchscreen operator panel
HOC Battery	Provides external DC power to engine-driven generators
MCC	Motor Control Cabinets or Cubicles; the 480V wall of a rig's Drive House
Composite Cable	A multiconductor cable containing multiple individually-insulated wires

CHAPTER 2

FUNDAMENTALS OF WORLD-CLASS MAINTENANCE

CHAPTER 2:
Fundamentals of World-Class Maintenance

In this section, we will learn the following:

1. Types of maintenance programs
2. Common factors in maintenance excellence
3. Definition of machine failure
4. Consequence management theory
5. Maintenance management, monitoring, & reporting
6. Maintenance roulette

2.1 Maintenance Programs – These days, maintenance personnel love to tout the concept of being proactive vs. being reactive. They build inspections procedures that will supposedly change the world, swearing that if you follow their system, everything will be sunshine and rainbows and downtime will be a forgotten word. They use fancy terms like 'predictive' maintenance and RCM—Reliability-Centered Maintenance.

Well, the concept of proactivity with regard to machine care is as old as machines itself. The term 'PM' or Preventive Maintenance, has been around since at least the 1930's, courtesy of the US Army. I'm sure that as far back as the year 1200, a rider wouldn't wait until his horse was crippled before he had him re-shoed. Inspections are always being redeveloped, new maintenance systems and programs are introduced every time the reign of a company's equipment program changes hands, and it does not dismiss the very true fact that the value of *prevention* is not quantifiable. In any field.

So let's break down the different types of maintenance programs today. For starters, there's <u>Preventive or 'Preventative' Maintenance</u>. Using standardized quality inspections, servicing procedures, recordkeeping and communication / handover, this type of program works. It's also the most commonly-used type of maintenance program used around the world, all industries considered. The reason that it doesn't work in some situations is discipline. Just like diets, there are many different methods of starting a preventive maintenance program—almost any method will work, if you and your team is committed to being disciplined.

Predictive Maintenance is the next-gen type of program which incorporates 'conditions monitoring' equipment and smart technologies to predetermine the failure point of machines and their components. For more than two decades, the leader in industrial predictive maintenance systems and supplies to aid a company in achieving this is Emerson Global, with a catalog of process equipment that could choke a donkey. If there's a sensor for monitoring gases, fluids, vibrations, alignment, atmospheric sensitivity, electromagnetic interference or whatever you could dream up, they have it. Today, hundreds of other companies have copied or modeled components after theirs. Of course, there's more to predictive maintenance than just the monitoring equipment. A lot of metrics are developed to support the process—all well-intended but time consuming. Going predictive, in my humble opinion, sounds good on paper but is not quite the answer for the drilling industry… yet. First, it's damn expensive to pay for an offsite SCADA team on a monthly subscription basis. Second, rig moves are an inherent part of every drilling operation, and no amount of monitoring or predicting will keep components from prematurely failing when they bounce down Permian pothole roads on non-air-ride trailers every other month.

RCM is a popular maintenance program that gained traction in the 90's. It is concentric to corporate asset management. Most companies, including most drilling companies, have integrated some form of asset management into their broader maintenance and reliability practices. Implementation of RCM created a few more jobs and brought follower companies into standards compliance of ISO (and in our industry, API). The key tenets of RCM include (1) structure—or discipline—and scope to preserve equipment assets; (2) detailed analysis to determine how specific equipment fails, and how to prevent those failures; (3) the triage of failures in order of importance (time, $, and personnel resources); and

(4) the creation of maintenance tasks and the appointment of proper candidates to perform the tasks.

2.2 Maintenance Excellence – There exist some fundamentals of equipment care that withstand the test of time. Consider the aviation industry. They use motors, pumps, hydraulic and electrical and pneumatic systems just like ours. Many of the components they use are no different than the ones we use on our drilling rigs. Yet over the past several decades, when a 747's motor has failed, the whole world heard about it. It's a highly uncommon occurrence. Even the small HPU pumps and hydraulic boost packages that support flap, rudder, and aileron control are incredibly resistant to failure. How, or why is that?

Discipline. Think about it, they use the same parts we do. From the same manufacturers we do. Wires, hoses, linkages and actuators… maintained by human beings just like you and me. And the average aviation maintainer makes less than a Derrickhand! BUT… tool accountability is paramount. In aviation maintenance, every nut, bolt, rivet and wrench is accounted for at the end of a job, or all operations will ultimately be halted and heads will roll. Torque values, OEM service manuals, and standardized company checklists are stringently adhered to. Personnel training is well-funded, structured, and deliberate. Gaskets and seals are not made on location, they're ordered to proper specs. Welder modification and 'field engineering' of equipment is as much a terminable policy as smoking pot while pulling slips. Every piece of attaching hardware is safety wired, and properly so. On-hand warehouse inventory is optimal, and well-secured. PM schedules are religiously followed. Personnel health and rest are mandatory pillars, not just a concept. Finally, everything—EVERYTHING—is documented, and then reviewed again before going to work.

Maintenance excellence is achievable in any industry; but it requires considerable investment of ownership by all hands from top to bottom. The reward? In our case, rigs free of incidents and non-profitable time due to R&M (repair & maintenance).

2.3 Machine Failure – All machines fail. Beginning the moment they enter service, subject to the laws of physics, they begin to fail. For the sake of this course, **equipment failure** is defined as: **Any equipment deviation outside of normal operating parameters, per manufacturer specifications, that is detected through observation, inspection, or condition monitoring**. What this means is that a pump doesn't fail only when it stops working completely, failure begins when the pump starts operating outside of manufacturer specs. If a failure is discovered early, then it can likely be fixed so that it does not become a total failure… and it can be fixed on our (scheduled) time, and not on *down* time. Early discovery of a failure cannot occur unless (1) we know and understand the heartbeat of our equipment, and (2) we inspect our equipment frequently. By doing this, we control the equipment instead of letting the equipment control us.

Consequence Management Theory – There is an important side to equipment maintenance and reliability that is often overlooked. The term 'consequence management' is a child of human factors engineering. People make mistakes, sometimes without realizing it. Consequence management prompts the important question, "What's the *wrong* right decision?" In 2005, Amtrak learned a valuable lesson in the recertification of train engines, when the same major failure was occurring on several engines within months after each had been overhauled. The failure involved a complex drive system which was removed, rebuilt, tested and reinstalled during each 3-year overhaul. The end finding was that the company, in an attempt to be proactive and score investor relations points with their new *Acela* models, forced the rebuild of a complex system that incorporated newer technology, without first investing in the training of organic and external personnel who were performing the physical work. A re-evaluation of their maintenance program found that the system did not need to be rebuilt for 12 years, and that the 'proactive' overhauls caused human-driven failures on more than twenty engines, costing tens of millions in lost potential revenue. The moral is, before we go maintenance crazy, evaluate the consequences… even of being proactive.

Back to failed equipment within our own industry. When a failure has been identified on a particular piece of equipment, the Rig Manager must be well informed about the issue, to include all related factors that may be associated with the failure. Following is a checklist of items that a mechanic, electrician, or technician will need to know:

1. Does the failure create an actual or potential safety hazard? If so, what is the actual or potential severity?
2. What is the specific equipment that failed? Photos help.
3. What is the severity of the failure?
4. If intermittent, at what specific time / place does failure occur?
5. Can the condition be replicated or exaggerated without causing a hazardous condition? Let's talk about it first.
6. When was the last time the equipment was running properly?
7. What is the current state of rig operations?
8. What events took place immediately preceding the failure?
9. Who was operating the equipment when it failed?
10. Any other equipment issues that may be related to the failure?
11. What is the equipment history? Is there a history of this type of failure of this or similar equipment on other rigs?
12. Who was the last person to work on or around this equipment?
13. What are the current atmospheric conditions (weather, e.g.)?
14. Has this equipment been moved?
15. If electrical, is it plugged in?
16. If hydraulic, is the pump running?
17. If the component is supposed to move, does it move at all?
18. Do you have a spare? If not, does a co-located rig have one?
19. Without this equipment, is there a safe, approved alternative to continue operations? If so, for how long?
20. Are there any special tools required, or weighing circumstances a maintenance person should know before heading to the rig?
21. Are the published rig directions / coordinates accurate?

Upon discovery of an equipment failure that requires technical-level assistance, the Rig Manager must inform his Drilling Superintendent immediately. The Superintendent will then decide upon how to handle the situation, using personnel or equipment assets at his disposal. Often this necessitates other calls to operations & maintenance leadership, who will verify the specific information with the Rig Manager and then decide upon a course of action. The flow chart below illustrates a sample reporting chain.

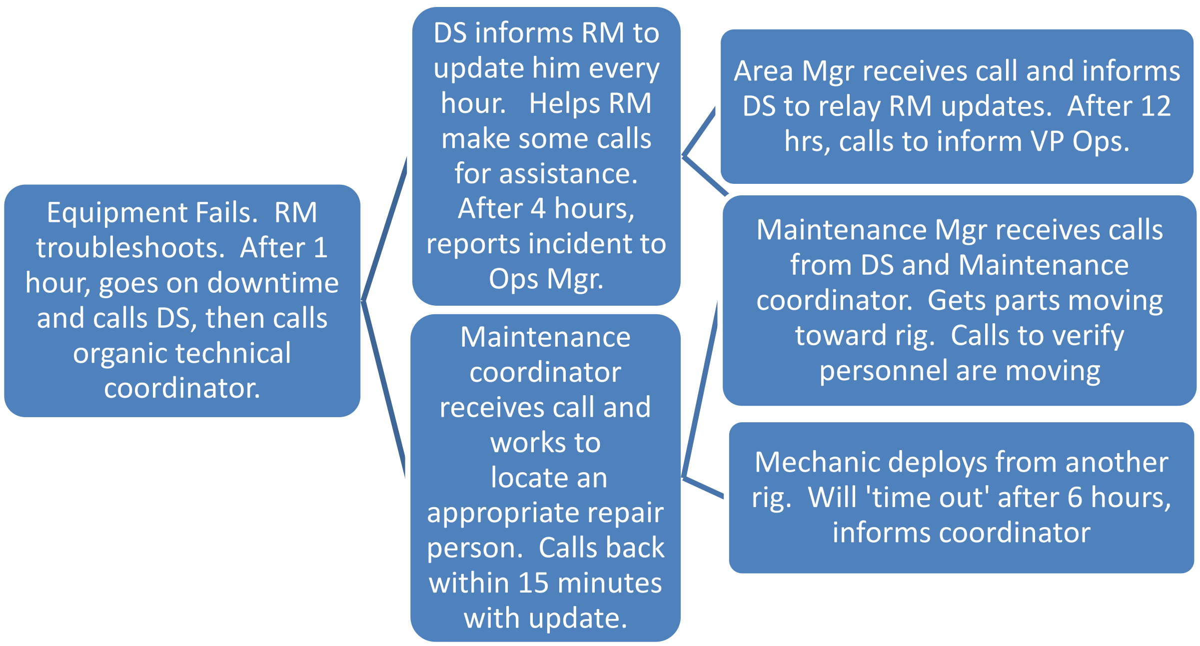
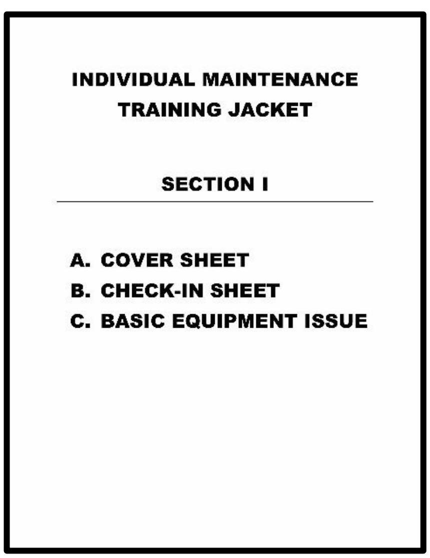


Figure 2.1

2.4 Maintenance Management – this is a big one. When it comes to skilled trade jobs, not all roads lead to management. Just because someone is really great at fixing brakes at *Midas*, doesn't mean that he or she needs to be the service manager based on seniority. When mechanics, electricians, and technicians move up, we lose their valuable skills in the field, and often their irreplaceable asset value to the company. That is why it's important to keep top performers well-compensated or otherwise incentivized, and to provide favorable working conditions. One of the biggest plagues to our industry in terms of equipment maintenance lies in turnover and retention of skilled trades personnel. Solid teams are built and maintained by solid maintenance leaders; as it is said, people don't follow companies, they follow people. Conversely, they don't quit companies, rather people.

Modern maintenance programs almost always incorporate some form of CMMS, or Computerized Maintenance Management System. The system is used for accurate and precise recordkeeping, PM scheduling, and document control. The CMMS should contain a library of technical publications and data excerpts that can be viewed and shared by all within a controlled setting. Other elements common to maintenance program efficiency include warehousing, shop efficiency, field coordination, tool control, vendor management or coordination, and most importantly, continuous personnel training & development. The service tradesman is the nucleus of an efficient and effective maintenance program, and therefore maintenance personnel management is a #1 priority.

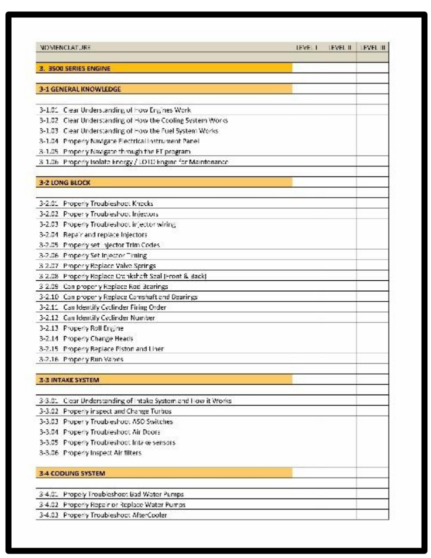
IMTJ, Personnel Evaluation, Training & Efficiency Monitoring – The *Individual Maintenance Training Jacket* is a strong tool for the management of maintenance personnel. This multi-section folder, modeled after the military, tracks all training, qualifications, and evaluations for an individual in a maintenance program. The jacket is the property of the company until the individual leaves the company, at which point it belongs to the individual, for use as a working resume of sorts.



INDIVIDUAL MAINTENANCE TRAINING JACKET

SECTION I

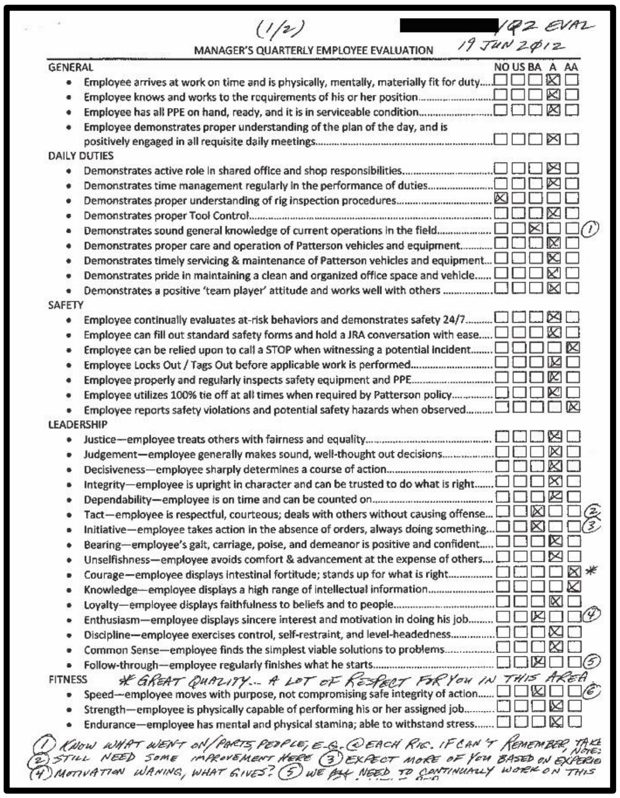
A. COVER SHEET
B. CHECK-IN SHEET
C. BASIC EQUIPMENT ISSUE



NOMENCLATURE	LEVEL I	LEVEL II	LEVEL III
3. 3500 SERIES ENGINE			
3-1 GENERAL KNOWLEDGE			
3-1.01 Clear Understanding of How Engines Work			
3-1.02 Clear Understanding of How the Cooling System Works			
3-1.03 Clear Understanding of How the Fuel System Works			
3-1.04 Properly Navigate Electrical Instrument Panel			
3-1.05 Properly Navigate through the ET program			
3-1.06 Properly Isolate Energy / LOTO Engine for Maintenance			
3-2 LONG BLOCK			
3-2.01 Properly Troubleshoot Knocks			
3-2.02 Properly Troubleshoot Injectors			
3-2.03 Properly Troubleshoot injector wiring			
3-2.04 Repair and replace Injectors			
3-2.05 Properly set Injector Trim Codes			
3-2.06 Properly Set Injector Timing			
3-2.07 Properly Replace Valve Springs			
3-2.08 Properly Replace Crankshaft Seal (Front & Back)			
3-2.09 Can properly Replace Rod Bearings			
3-2.10 Can properly Replace Camshaft and Bearings			
3-2.11 Can Identify Cylinder Firing Order			
3-2.12 Can Identify Cylinder Number			
3-2.13 Properly Roll Engine			
3-2.14 Properly Change Heads			
3-2.15 Properly Replace Piston and Liner			
3-2.16 Properly Run Valves			
3-3 INTAKE SYSTEM			
3-3.01 Clear Understanding of Intake System and How it Works			
3-3.02 Properly inspect and Change Turbos			
3-3.03 Properly Troubleshoot ASO Switches			
3-3.04 Properly Troubleshoot Air Doors			
3-3.05 Properly Troubleshoot Intake sensors			
3-3.06 Properly Inspect Air filters			
3-4 COOLING SYSTEM			
3-4.01 Properly Troubleshoot Bad Water Pumps			
3-4.02 Properly Repair or Replace Water Pumps			
3-4.03 Properly Troubleshoot AfterCooler			

Figures 2.2 – *IMTJ Excerpts*

Personnel evaluation in a formal setting, using a standard evaluation format and occurring at regular intervals for all personnel (i.e., quarterly or biannually), is an excellent motivator. A few elements are key to good personnel evaluations: (1) managers must also be evaluated; (2) each reporting period must be a clean slate for every individual; (3) there should always be a standard of "average," and a scoring system should be applied; and (4) the reporting grade should be used to build a track record for retention & promotability, pay increases, and other incentives. While training should be a regular part of every maintenance management program, *advanced* training makes an excellent incentive for top performers.

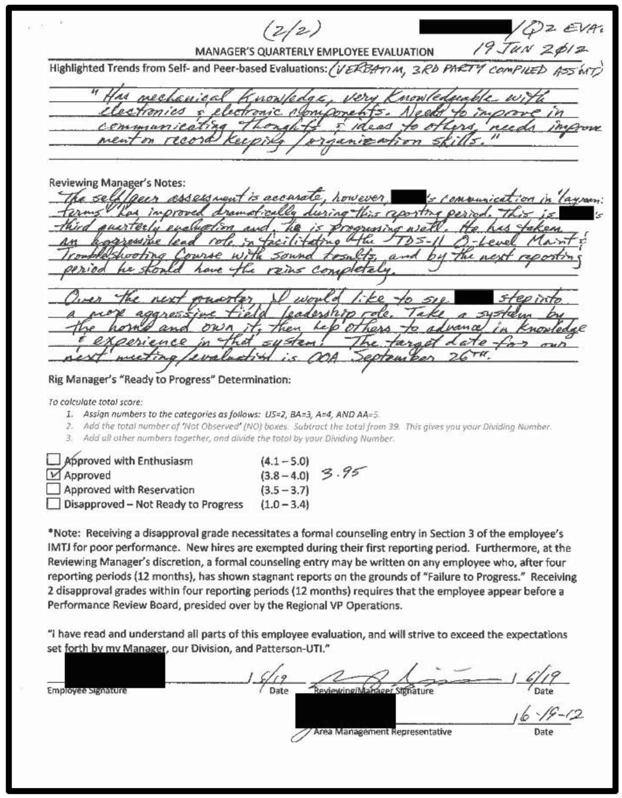


(1/2) [redacted] / Q2 EVAL

MANAGER'S QUARTERLY EMPLOYEE EVALUATION 19 JUN 2Ø12

	NO	US	BA	A	AA	
GENERAL						
• Employee arrives at work on time and is physically, mentally, materially fit for duty				X		
• Employee knows and works to the requirements of his or her position				X		
• Employee has all PPE on hand, ready, and it is in serviceable condition				X		
• Employee demonstrates proper understanding of the plan of the day, and is positively engaged in all requisite daily meetings				X		
DAILY DUTIES						
• Demonstrates active role in shared office and shop responsibilities				X		
• Demonstrates time management regularly in the performance of duties				X		
• Demonstrates proper understanding of rig inspection procedures	X					
• Demonstrates proper Tool Control				X		
• Demonstrates sound general knowledge of current operations in the field			X			(1)
• Demonstrates proper care and operation of Patterson vehicles and equipment				X		
• Demonstrates timely servicing & maintenance of Patterson vehicles and equipment				X		
• Demonstrates pride in maintaining a clean and organized office space and vehicle				X		
• Demonstrates a positive 'team player' attitude and works well with others				X		
SAFETY						
• Employee continually evaluates at-risk behaviors and demonstrates safety 24/7				X		
• Employee can fill out standard safety forms and hold a JRA conversation with ease				X		
• Employee can be relied upon to call a STOP when witnessing a potential incident					X	
• Employee Locks Out / Tags Out before applicable work is performed				X		
• Employee properly and regularly inspects safety equipment and PPE				X		
• Employee utilizes 100% tie off at all times when required by Patterson policy				X		
• Employee reports safety violations and potential safety hazards when observed					X	
LEADERSHIP						
• Justice—employee treats others with fairness and equality				X		
• Judgement—employee generally makes sound, well-thought out decisions				X		
• Decisiveness—employee sharply determines a course of action				X		
• Integrity—employee is upright in character and can be trusted to do what is right				X		
• Dependability—employee is on time and can be counted on				X		
• Tact—employee is respectful, courteous; deals with others without causing offense			X			(2)
• Initiative—employee takes action in the absence of orders, always doing something			X			(3)
• Bearing—employee's gait, carriage, poise, and demeanor is positive and confident				X		
• Unselfishness—employee avoids comfort & advancement at the expense of others				X		
• Courage—employee displays intestinal fortitude; stands up for what is right					X	*
• Knowledge—employee displays a high range of intellectual information					X	
• Loyalty—employee displays faithfulness to beliefs and to people				X		
• Enthusiasm—employee displays sincere interest and motivation in doing his job			X			(4)
• Discipline—employee exercises control, self-restraint, and level-headedness				X		
• Common Sense—employee finds the simplest viable solutions to problems				X		
• Follow-through—employee regularly finishes what he starts			X			(5)
FITNESS * GREAT QUALITY... A LOT OF RESPECT FOR YOU IN THIS AREA						
• Speed—employee moves with purpose, not compromising safe integrity of action			X			(6)
• Strength—employee is physically capable of performing his or her assigned job				X		
• Endurance—employee has mental and physical stamina; able to withstand stress				X		

(1) KNOW WHAT WENT ON/PARTS, PEOPLE, E.G. @ EACH RIG. IF CAN'T REMEMBER, TAKE NOTE: (2) STILL NEED SOME IMPROVEMENT HERE (3) EXPECT MORE OF YOU BASED ON EXPERIENCE (4) MOTIVATION WANING, WHAT GIVES? (5) WE ALL NEED TO CONTINUALLY WORK ON THIS



(2/2) [redacted] / Q2 EVAL

MANAGER'S QUARTERLY EMPLOYEE EVALUATION 19 JUN 2Ø12

Highlighted Trends from Self- and Peer-based Evaluations: (VERBATIM, 3RD PARTY COMPILED ASS'MT)

"Has mechanical knowledge, very knowledgeable with electronics & electronic components. Needs to improve in communicating thoughts & ideas to others, needs improvement on record keeping / organization skills."

Reviewing Manager's Notes:

The self/peer assessment is accurate, however, [redacted]'s communication in 'layman terms' has improved dramatically during this reporting period. This is [redacted]'s third quarterly evaluation and he is progressing well. He has taken an aggressive lead role in facilitating the TDS-11 O-Level Maint & Troubleshooting Course with sound results, and by the next reporting period he should have the reins completely.

Over the next quarter, I would like to see [redacted] step into a more aggressive field leadership role. Take a system by the horns and own it, then help others to advance in knowledge & experience in that system! The target date for our next meeting/evaluation is OOA September 26TH.

Rig Manager's "Ready to Progress" Determination:

To calculate total score:

1. *Assign numbers to the categories as follows: US=2, BA=3, A=4, AND AA=5.*
2. *Add the total number of 'Not Observed' (NO) boxes. Subtract the total from 39. This gives you your Dividing Number.*
3. *Add all other numbers together, and divide the total by your Dividing Number.*

- [ ] Approved with Enthusiasm (4.1 – 5.0)
- [x] Approved (3.8 – 4.0) 3.95
- [ ] Approved with Reservation (3.5 – 3.7)
- [ ] Disapproved – Not Ready to Progress (1.0 – 3.4)

*Note: Receiving a disapproval grade necessitates a formal counseling entry in Section 3 of the employee's IMTJ for poor performance. New hires are exempted during their first reporting period. Furthermore, at the Reviewing Manager's discretion, a formal counseling entry may be written on any employee who, after four reporting periods (12 months), has shown stagnant reports on the grounds of "Failure to Progress." Receiving 2 disapproval grades within four reporting periods (12 months) requires that the employee appear before a Performance Review Board, presided over by the Regional VP Operations.

"I have read and understand all parts of this employee evaluation, and will strive to exceed the expectations set forth by my Manager, our Division, and Patterson-UTI."

[redacted] / 6/19 — Employee Signature / Date

Reviewing/Manager Signature / 6/19 — Date

[redacted] / 6-19-12 — Area Management Representative / Date

Figures 2.3 – Maintenance Personnel Evaluation

Lastly, a monthly efficiency tracker can be designed to break down the total number of hours worked by each employee, into the type of equipment they worked on, driving hours, general / non-technical hours, and job numbers to which assigned. Divided into the total number of available working hours (days of the month at X working hours a day, less scheduled days off, approved sick days, and training days), you can calculate efficiency of each employee as a percentage, while also gleaning the data to track proficiency. Both of these can be used during personnel evaluations; while generally a positive tool, the data is also sometimes necessary to justify employment termination, particularly when work is performed somewhere not deemed a "right to work" state.

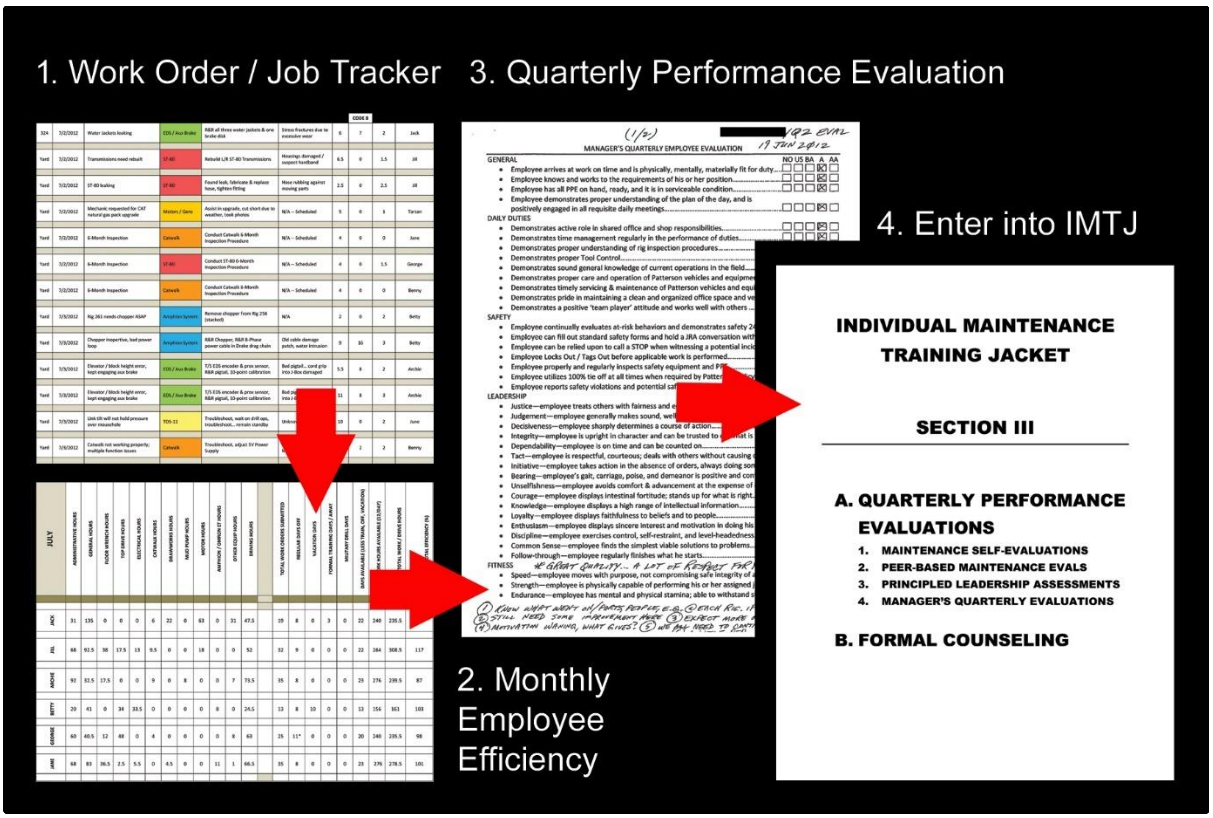


Figure 2.4 – Personnel Management Data Flow

2.5 Maintenance Roulette – In the drilling industry, no matter how hard we try to avoid it, our maintenance and repair activity is largely reactive. While you'll agree that a reactive system is not the optimal solution, it's okay to be reactive… so long as crisis reactivity is structured in a way that reduces wasted time and money. To illustrate this, allow me to introduce the concept of 'maintenance roulette'.

What is the only way to win a game of Russian roulette? **By keeping all the revolver's chambers empty**. In *maintenance* roulette, we keep each chamber round-free by filling it with something else:

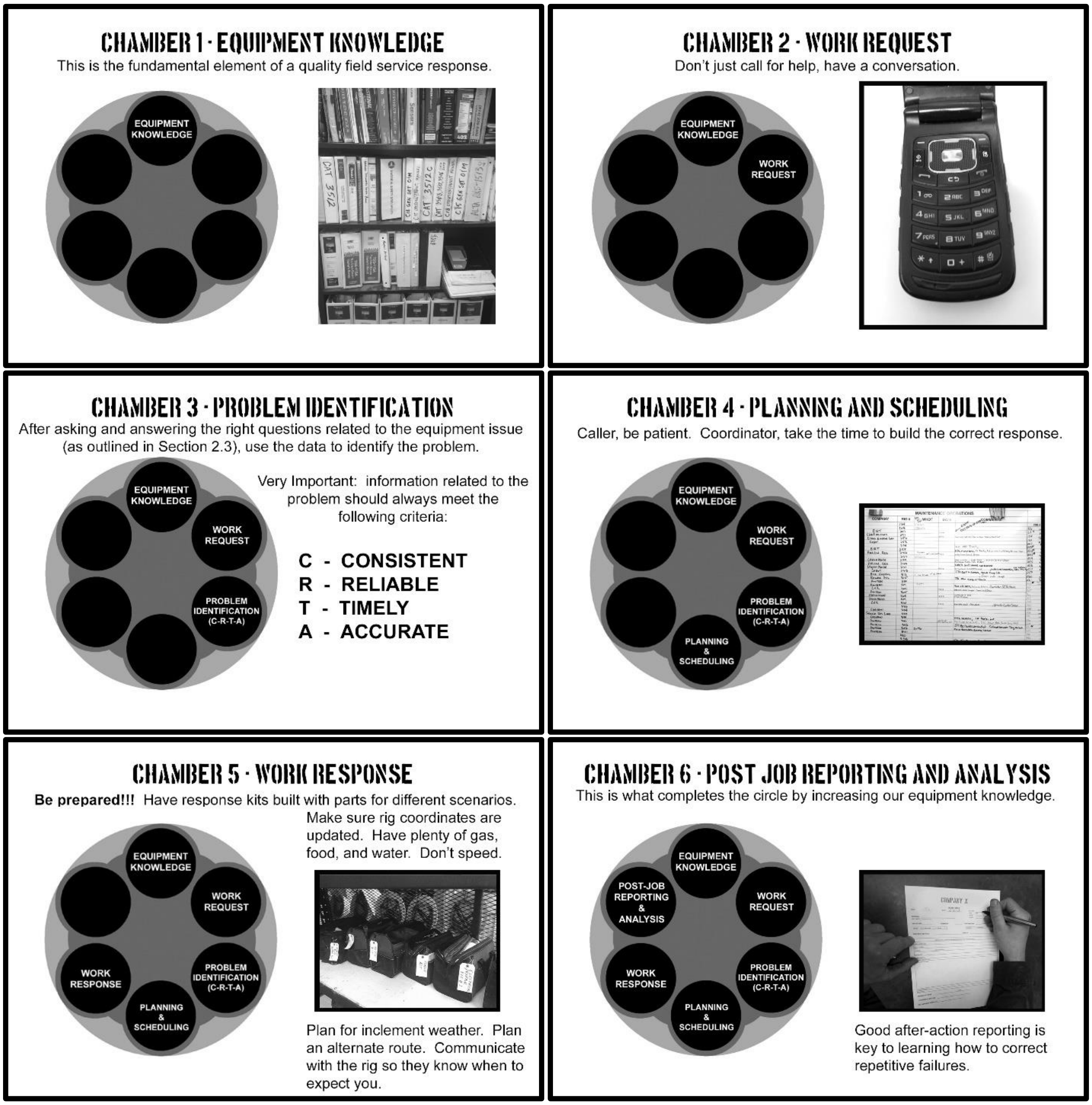


Figure 2.5 – The Six Empty Chambers of Maintenance Roulette

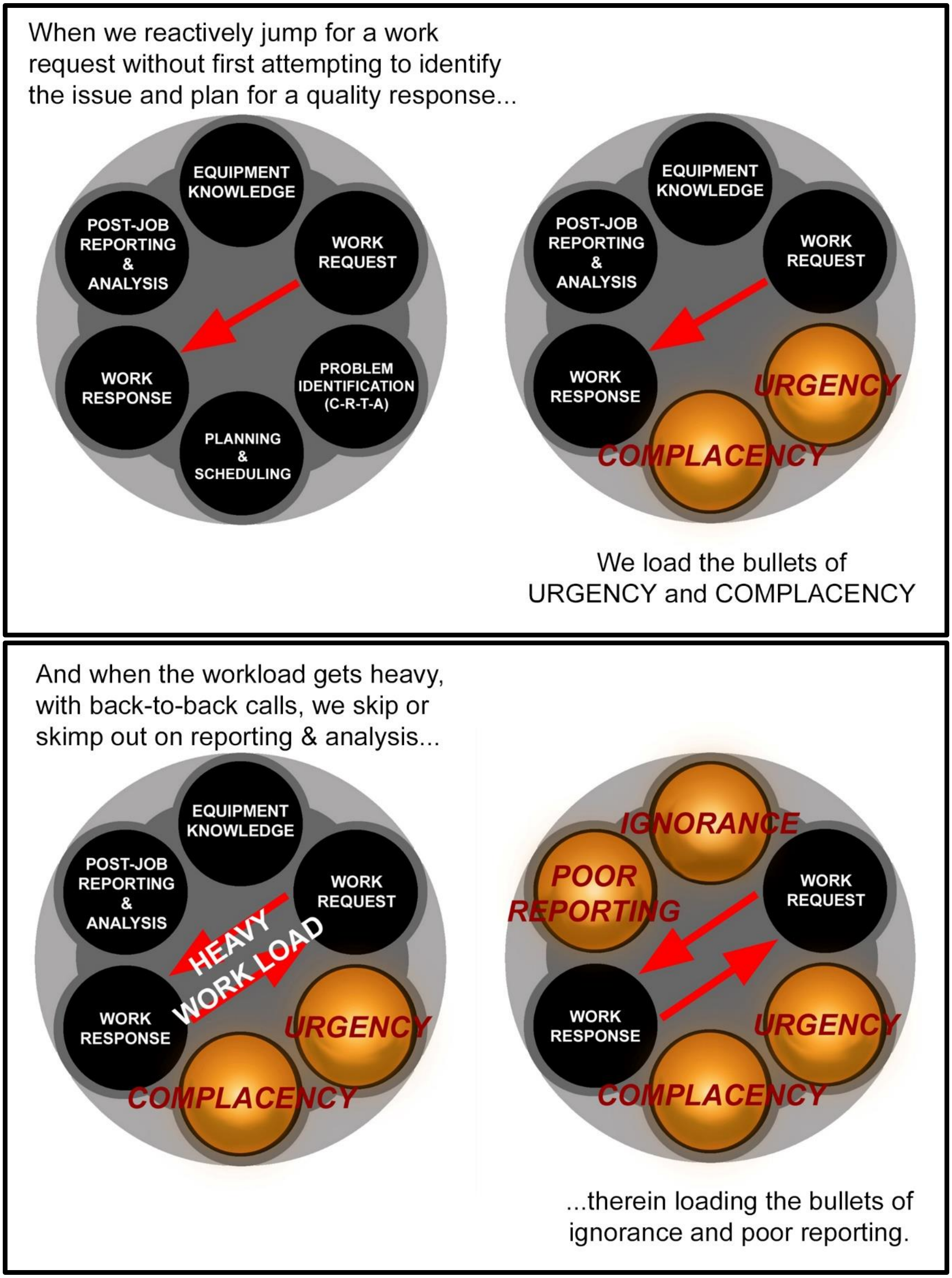


Figure 2.6 – Loading the Chambers

Figure 2.7 – Avoidable Risks

Reactive maintenance activity is often* a corner-cutting, unstructured and haphazard approach to mitigating downtime. Perpetuating this cycle does nothing to reduce like failure incidents in the future, and often ends in injury or death. In the oilfield as in general industry, our rules, regulations and policies are often written in blood—something we can all agree is unnecessary. Don't let someone die before you change your approach as a company. **Note: a measure of reactive maintenance is required in the oilfield. Reactivity can be planned and structured, however, so that is not driven by a perpetual state of 'emergency'.*

In Cecil B. DeMille's 1956 classic *The Ten Commandments*, Moses (Charlie Heston) and Ramses (Yul Brenner) are adoptive brothers competitively vying for the throne of Egypt. Both have been tasked with important projects; Moses was told to build a huge city and Ramses was told to find the Hebrew slaves' prophesied "deliverer." One day, their dad—the Pharaoh—calls for a meeting and Moses doesn't show. His spiteful brother says, "Yeah dad, Moses said he's busy." So the Pharaoh is pissed. Together with Ramses and an entourage of important Egyptians, Pharaoh takes a trip to Moses' planning pavilion in the city he's building. Moses is there, stressed, overseeing the critical lift of a 300' obelisk not unlike the Washington Monument in D.C.

Pharaoh then begins to relay some recent accusations against Moses. Walking over to a measuring scale, Pharaoh picks up a weight and asks Moses, “You raided the temple granaries?” Moses replies, “Yes.” Pharaoh drops the weight on the scale and picks up a second one off the table. “You’re gave that grain to all the slaves?” Again, Moses replies “Yes” and his pops drops the other weight on the scale. He picks up a third. “And… you’re giving the slaves a day off every week?” “Yes.” Pharaoh drops the third weight and tips the scale, then asks him in front of everybody, “What do you have to say about these accusations??”

Moses looks around the room and locates a brick. He walks quickly to the scale and holds the brick up in the air. This is what he says: “Your city is made of brick, Pharaoh. The strong make many, the starving make few.” Then he slams the brick down on the scale’s other balancing plate, burying it into the table while sending his point home… “The dead make none.”

The number one cause of death in the drilling industry today is vehicle accidents, which occur driving to and from the rig. It happens because we’re all rushed to get to a job, or rushing to get home. It happens because we’re tired, or because of poor decision-making due to improper nourishment. As leaders, we have a responsibility to take care of our people. It is **all of our** responsibility to weigh the cost of downtime against the loss of life, and to make responsible decisions thereto. Stop Work Authority applies in these cases also. Dead Roughnecks can’t trip pipe, and in terms of maintenance, dead Top Drive techs can’t turn wrenches.

Figures 2.8 (upper left) and 2.9 (lower right) – “The Dead Make None”

CHAPTER 3

LEVELS OF MAINTENANCE / ROLES & RESPONSIBILITIES

CHAPTER 3:

Levels of Maintenance / Roles & Responsibilities

In this section, we will learn the following:

1. The importance of establishing maintenance levels
2. Examples of maintenance levels
3. Operational roles and responsibilities

3.1 Maintenance levels within an organization are important for two reasons: (1) They allow promotability within the technical trade fields, for example: instead of progression from mechanic to foreman to supervisor—which requires allocations to backfill and retrain more mechanics every time someone progresses—it instead provides a growth path for tradesmen, i.e. Mechanic I, Mechanic II, Mechanic III; and (2) the development of maintenance levels segregates the type of work into classifications based upon the skill level required to do the job.

There are three recognized technical trade categories used as an industrial standard in the United States: apprentice, journeyman, and master. A company's maintenance program should, as a minimum standard, be divided into levels that correlate. *Note: These levels are to be part of a company's internal maintenance program, and in the oilfield are not to be confused with API's inspection categories for equipment.*

3.2 Examples of maintenance levels:

LEVEL I is basic maintenance, also sometimes referred to as Organizational-, Operational-, or O-Level maintenance. This category of maintenance includes end user or operator servicing, preventive maintenance, basic troubleshooting, and removal and replacement of simple parts of any machine or system. This type of work is generally categorized as that which can be performed by one or two individuals of relative competence, using regular hand tools, within a short period of time. Of course, ‘short’ is subjective, so we’ll assume a 4-hour timeframe for instructional purposes. On a drilling rig, the rig crew performs LEVEL I maintenance (a shit-hot Motorman should exemplify it and display Level II qualities).

LEVEL II is intermediate or technical level maintenance. This facet of maintenance—as the name implies—includes troubleshooting of a complex nature, removal and replacement of complex components, and the competent disassembly / repair / replacement of machine systems with limited assistance or supervision. Level II maintenance incorporates specialty tools (electrician’s multimeters, hydraulic pressure-testing equipment, dial indicators and micrometers). In the oilfield, most organic and 3rd-party field service hands provide Level II support.

LEVEL III is depot or expert level maintenance. This level applies advanced troubleshooting and testing to equipment by personnel who have the aggregate expertise of experience (usually > 5 years) and certified training from a recognizable authority. Depot-level work is often performed in a controlled shop environment. Level III may also incorporate precision machining, pressing, fabrication to engineered specifications, large-scale rework and overhaul. In addition to the use of advanced tools, this expert level of maintenance also uses advanced heat & cooling methods, blasting, and exposure to dangerous chemicals (paints, thinners, dipping acids, liquid nitrogen, liquid oxygen, etc.)

LEVEL IV is precision commissioning and maintenance. This level includes certified new-build / repair and recertification work to OEM and industry standards, and includes Professional Engineering [PE] design, certified master inspections, and the full spectrum of Non-Destructive Inspection & Testing (NDI/T) & quality control in a *Standard Day* (theoretically perfect vacuum) testing environment. In an oilfield example, a certified API 8C facility provides Level IV maintenance service on Top Drives.

3.3 Operational roles and responsibilities – the oilfield is a unique community. Though each person has a specific title or position, many roles are overlapping. For example, we know that each of us is a deputized safety hand. Regardless of title or position, we have the **responsibility** and **authority** to stop any potentially unsafe act or condition that we observe. We are also good stewards of oilfield property and reputation… sometimes that means picking up another's trash or policing our own in public. Likewise, on a drilling rig, every person is responsible for maintaining equipment to keep our rigs in serviceable condition. So where do specific roles come into play?

As mentioned in the last section, rig hands are responsible for all Level I, or *Organizational Level* maintenance. This is further broken down in the following maintenance guidelines, which should be adhered to in addition to (or in conjunction with) each position's regularly assigned duties:

Important Note: Rig Angel does not presume to negate, in any way, the operational structural or system of any company. Following are general recommendations—like all concepts within this document, these are not intended to interfere with a company's policies, procedures, or guidelines. Where conflicts of interest are discovered, follow your own company's lawful directives.

Floor Hands:

(1) Practice preventive maintenance by keeping equipment clean. Know how to clean, where to clean, and where NOT to clean. As a rule of thumb, don't pressure wash within close proximity of electrical or electronic equipment.

(2) Learn the types and uses of specific lubricants. Not every grease zerk is made to accept standard red NGLI grease. Don't use red grease on any electric motor bearings. Don't grease sealed circuits that are intentionally plugged off on the opposite side. If you don't know or understand,

ask! Do not mix oils. Use only immaculately clean buckets and pumps to service hydraulic equipment.

(3) Learn the basic operation of all major pieces of equipment… if you don't know what the proper operation looks and sounds like, then you will not know how to identify malfunctions, misuse, or signs of failure!

(4) Learn and apply the basic techniques and procedures for extending the service life of each piece of equipment on the rig (specifically, the **location, type, amount,** and **frequency** of lubrication for all moving parts and mating surfaces).

(5) Learn the locations of ALL filters for every system. Often, there are filters on rigs that are continually overlooked. Do not blindly trust the red / green pop-up indicators on filter housings, or the visual sight glasses or sight tubes that indicate oil levels.

(6) When rigging up / down, pay close attention to plug and connector labels and color codes. If something is confusing (two red-painted hydraulic male connections, either one could be connected to the opposing two red-painted female connections), STOP. Address it with your Driller. Replace labels as required.

(7) MOST IMPORTANT: Know the approved Emergency Shutdown Procedures for all equipment on your rig.

Motor Hands: (1) Know, understand, and work to the seven responsibilities of Floorhands (above). Mentor Floorhands in the basic startup, shutdown, and maintenance procedures that relate to your own job. This assures continuity so you can move up.

(2) Maintain an inventory of clean, properly-labeled filters, lubricants, bulk fluids, and critical spare parts for each piece of equipment.

(3) Continue to learn and hone the proper operational techniques and procedures for each piece of equipment; familiarize yourself with / study the applicable service manuals, operations & maintenance manuals, and drawings.

(4) Know your company's maintenance policies, procedures, and safety procedures, front to back. Reiterating from the Floorhand duties, know the Emergency Shutdown Procedures for each piece of equipment.

Derrick Hands: (1) Starting with the equipment on your pits, keep a log, recording pertinent data including (but not limited to) serial number, manufacturer, known defects, fixes applied, and servicing performed. Then grow your log to incorporate all major equipment on your rig.

(2) Take an active role in training your crew members in proper servicing and preventive maintenance techniques and procedures. Oversee your Motor Hand's training and mentoring of Floor Hands, to ensure that no steps are being skipped and that the procedures are correct.

(3) During tripping operations, you have a distinct vantage point of the Top Drive, and of derrick components, that others do not see as frequently. Learn everything about the Top Drive, that way, when something looks or sounds out-of-place, you'll be the first to catch it.

(4) Know all rig equipment Emergency Shutdown

Procedures well enough to teach your hands.

Assistant Drillers:

(1) Follow the Derrick's guidelines above.
(2) While your position is one of training, it is awarded because of your experience and maturity. Use these tools to set the example on every rig you may be fortunate to train on. Attitude is contagious; leave a lasting impression.

Drillers:

(1) Keep a log with all pertinent equipment info, as outlined for Derricks (above).
(2) Lead your crew, intentionally creating opportunities to train your men, and allow them in turn to train others on your team when opportunity is available. Remember, a well-trained and knowledgeable team makes your rig run right—and it also reflects well upon yourself.
(3) Know where to find answers to maintenance questions that your hands might have. Keep equipment maintenance manuals & drawings readily accessible; these tools are every bit as valuable as the ones in your doghouse tool box.
(4) Know who to call for maintenance-related questions or concerns. Have those numbers available. Build your phone list for qualified technicians, mechanics, welders, etc., so that you are prepared—from an R&M perspective, to assume a Rig Manager's position when one becomes available, should you choose to do so.

Rig Managers:

(1) When reporting a maintenance issue, ensure that All information relayed about the problem is **Consistent, Reliable, Timely, and Accurate**.

Strive for perfection in this area, and you will spare your rig from the costly downtime that results from misinformation.

(2) Practice proper downtime coding. This is crucial to the prevention of recurring failures. Don't blame everything on the Top Drive.

(3) Foster a maintenance-centric work environment, rewarding good practices with recognition and encouragement. As you know, there is no greater hindrance to operational efficiency than a leader who does not challenge, motivate, and reward his or her team… and "what's important to my boss fascinates the hell out of me." Make equipment maintenance important.

Superintendents:(1) Provide your rigs with keys to maintenance success. Encourage your RM's to share details of failures and fixes for the betterment of your total team. Give them training tools, like this course, to cover with their hands during ten-minute 'tailgate training' segments every day. Incorporate brief maintenance training discussions into tourly safety meetings. Reward top performers.

(2) Set maintenance expectations for your Rig Managers. Inspect what you expect. A comprehensive rig inspection is a strong motivator to get things turning the right direction.

(3) Have a good working knowledge of the personnel assets in your region that will help with R&M situations, both internal and external to your company. You should have the biggest rolodex.

(4) Assist in your company's maintenance metrics development by monitoring the key performance indicators of your rigs. The five standard KPI's

of maintenance are:

(A) Unscheduled work activity / lost time
(B) Reactive R&M hours (besides Code 8)
(C) R&M cost (vs. rig cost, vs. day rate)
(D) Mean Time Between Failure (MTBF)
(E) Work Order Cycle Time

Ops Managers:

(1) Stress the importance of proper downtime coding. If you have high RM turnover, this needs to be stressed continually. If not being done adequately at the corporate level, take charge and have someone develop the metrics for an accurate look at where your region's downtime is. Triage your R&M budget allocation to reflect the percentage of downtime by each piece of equipment respectively. Compare to other regions.

(2) Regularly review your company's maintenance & repair program to determine what's working and what isn't. If adjustments are needed in your area of responsibility, propose changes. If you need ideas but are unsure of their quantitative long-term cost / benefit impact, don't worry—you don't have to re-invent the wheel. A quick Google search of Fortune 50 companies will start you down a rabbit trail… pick a few companies that regularly make the list, study how they stay on top of their R&M, adopt some ideological tenets and make your pitch.

(3) Promote the sharing of maintenance knowledge. The greatest impacts to your company, both positive and negative, are determined by what you make important to your people.

(4) 10,000' View – You're responsible for a geographic area… but remember that the best

maintenance-related opportunities for your region may come from outside your region.

(5) Champion your company's MOC policy as applies to R&M. Disallow even the smallest of job site (equipment) modifications unless they are properly vetted and approved through a company matrix considering factors of cost, design, safety, human / training impact and long-term benefit.

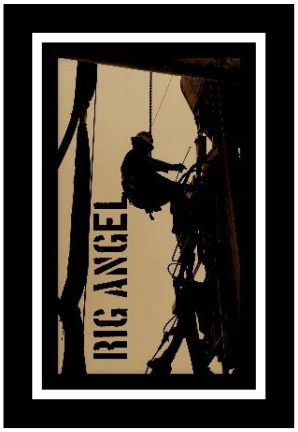
(6) Start a monthly vendor meeting. Invite non-vendors also, to stay abreast of new ideas and potential partnerships ("you're either green and growing or you're ripe and rotten"). Cater a cheap lunch and use this time to pass new company policies or changes that apply to vendors. Let your vendors get to know each other. Automate your consumables / common parts restocking process. Develop a plan for having your third-party groups work together to support your operation; it will spare your Superintendents and maintenance personnel a lot of unnecessary drive and call time.

VP's:

(1) Compare your current R&M cost not only with its currently allocated budget, but with last FY's costs and budget projections for alignment of future forecasting. Invest deliberately in structured, formal equipment training and compare its impact on NPT and R&M beginning for three years after rollout.

(2) Standardize your equipment. Do the SWOT analysis and you'll find that the greatest drilling industry opportunity for equipment standardization rests flatly in Drawworks. Like the Top Drive, which is generally responsible for the most downtime, it's the one other piece of

equipment on each rig that doesn’t have a backup or accepted way around it should it fail. When you adjust CAPEX to ensure >50% of your fleet’s like-rigs have the same make and model of DW, you’re going to see hard improvement in this equipment’s historical R&M / nonprofitable time segment.



CHAPTER 4

INTRODUCTION TO THE NOV TDS-11 TOP DRIVE

CHAPTER 4:
Introduction to the TDS-11 Top Drive

In this section, we will learn the following:

1. Top Drive description and importance
2. History and development
3. TDS-11 specifications

4.1 What is a Top Drive? Description and Industry Importance

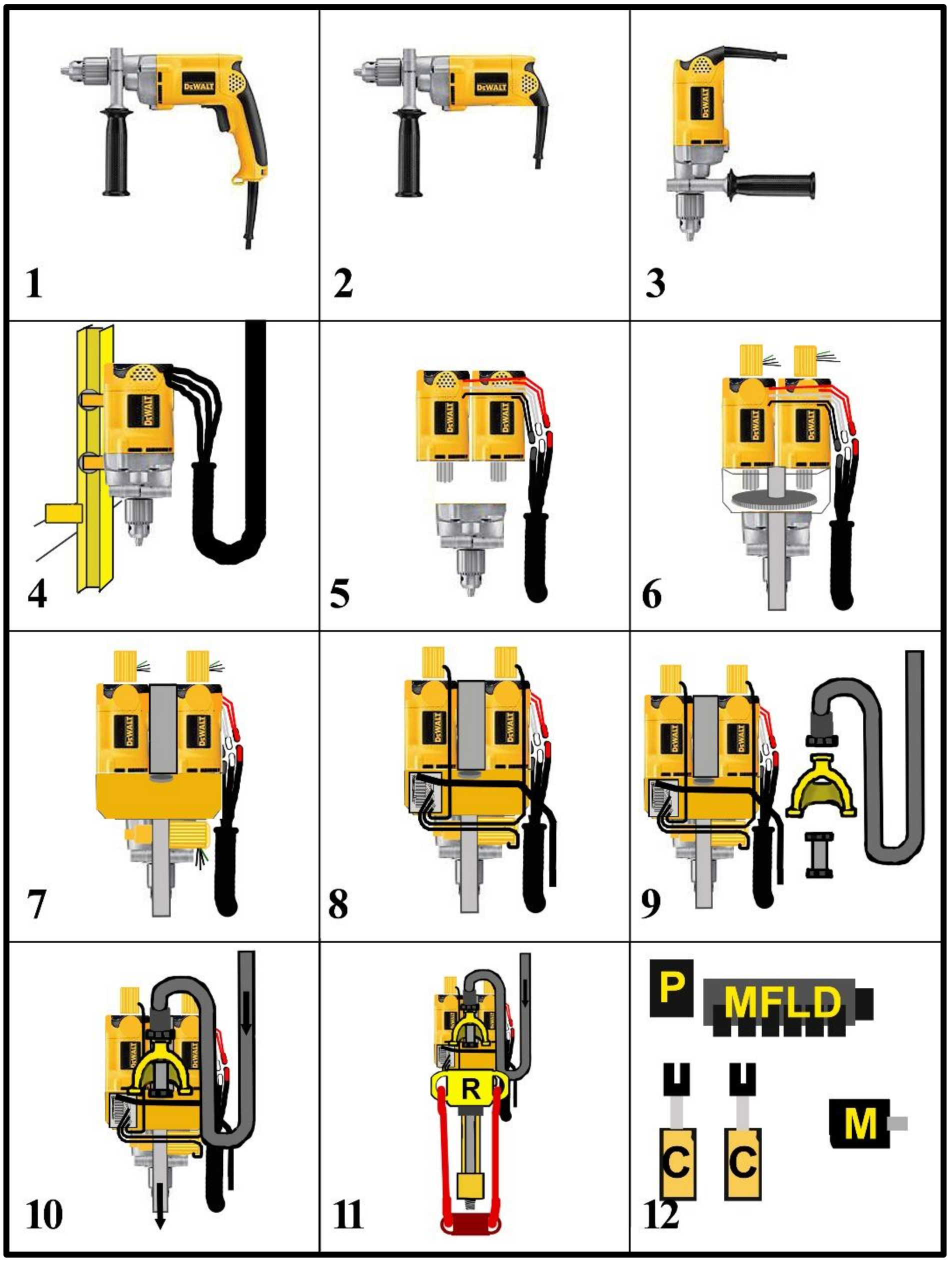
This segment is included for new-to-industry students. In basic terms, a Top Drive is a giant corded DeWalt drill. It is mounted inside a frame that travels up and down a track in the derrick of a drilling rig. The track is secured near the bottom of the derrick so that the Top Drive can drill without torqueing up and spinning around in circles uncontrolled.

So with this big yellow drill, there are a few differences. We call its cord a service loop, because it is made up of several independent wires and it's about 300' long. Also, since this drills really deep holes, we don't mount the drill bit directly to the unit. We keep the bit on bottom and we just keep adding extensions between the drill and the bit. The extensions are hollow, and we pump a thick fluid through a channel in the center of the Top Drive, all the way down to the bit. This is done for several reasons, but we'll stick with the simplest one for instructional purposes: the drill mud removes cuttings as we drill, through the powers of force, hydrostatic pressure, fluid viscosity and fluid surface tension.

Since this is a big machine and it drills deep, it has two parallel motors that connect at a gearbox, to turn the Top Drive's shaft at a 10.5:1 speed reduction. In other words, if the shaft and connected drill pipe are turning at 100 RPM, then both motors are spinning at 1,050 RPM each.

Lastly, this particular drill can change its own drill pipe without minimal hands-on assistance from a human. It can twist 360-degrees infinitely in either direction and then lock into any position. It can pick up or release each section of drill pipe, screw into or out of the next piece. The rig's Driller controls the machine like it's a remote-controlled robot. The robotics are provided by a hydraulic system (tank, pumps… cylinders providing mechanical movement) that's built onto the Top Drive, controlled by the Driller electrically from the rig floor. The only real "hands on" occurs when latching to, or unlatching from, a piece of pipe. While the technology exists to automate this, in land drilling applications it is still usually done manually.

The invention of the Top Drive revolutionized the drilling industry because it is a huge time saver. While this machine is drilling, we can now *make up* (connect) three *joints* (pieces) of interconnecting drill pipe into triple sections, using a hoist and a floor wrench. These triples, collectively called *stands* of drill pipe, can then be stacked in a 'standard triple' derrick (172' mast, +/- ~ 6'), and when the Top Drive is drilled down to the rig floor, the crew sets slips (an interconnected band of pipe wedges) around the top pipe in the interconnected stack (called a drill string in its entirety), just under its flange. The Driller lowers the Top Drive until his weight indicator shows that the slips have wedged against the pipe (and the weight of the drill string is now supported / suspended by the Rotary Table). With the weight off the Top Drive, the Driller breaks out (unscrews the shaft assembly of the Top Drive from the drill string, essentially), then he raises the Top Drive to the top of the derrick, where he then reaches out for another stand of pipe (a triple). The Derrickman feeds the pipe into the Top Drive's elevators with enough force that they automatically latch around the pipe, then the Driller sets the stand on the stump, makes up the top and bottom ends of the stand to a specified torque value, and then picks up on the drill string to assume the load, which loosens the grip created by the pipe slips. The crewmembers on the drill floor quickly remove the slips, the Driller lowers the string back to the bottom of the hole and continues drilling.



DRILL TO TD CONVERSION:

1. Okay, we have a drill.
2. Don't need the handle.
3. Let's invert it since we're drilling into the ground. The broomstick's nice, keeps from twisting your wrist off, but we can adapt something better.
4. So we remove the broomstick grip and we attach the unit to an I-beam with brackets and wheels that travel recessed in both sides of the beam, up and down. Then we'll secure the upright beam to a crossbeam or girt that travels horizontally between the derrick's A-legs. You'll notice that we got rid of that puny single-phase power cord. Hell, we made the motor bigger. It's a three-phase motor, rated for 600V AC. Its power wires are protected inside a big hose that comes from the VFD House.
5. You know what, let's replace that big motor with twin motors, 400 HP each. We'll use the same power service loop (power cord), we'll just split the three phases between each motor.
6. Ok, those motors now spin the same direction, but they're kinda fast. Oh, and they need to turn a singular shaft. So we'll mount a big bull gear to the main shaft, and set it inside a gearbox. The pinion gears of the motors will each turn an intermediate gear, which in turn will turn the bull gear in the same direction of the motors. The bigger (more teeth) the bull gear, the greater the speed reduction. We're shooting for 10.5 to 1. Also, we added a blower assembly to the top of each motor, to keep them cool. Each blower fan is driven by a 5 HP motor, also 3 phases and 600 VAC, but at lower amperage (much smaller wires).
7. Now that I think about it, we're going to add some robotics later. So let's install the first parts of a hydraulic system. We'll squeeze a 25-gallon hydraulic reservoir between the motors and install an HPU under the gearbox, consisting of a 10HP motor (3-phase 600VAC) which turns a primary hydraulic piston pump. We'll also add a 'piggyback' vane pump for the gearbox lube system later. It's mechanically splined to the main.
8. Let's add a power cord to the Top Drive. This one will be a 19-Pin, having 18 to 20 individually insulated wires inside of it, depending on the cable manufacturer. We'll run this 'Auxiliary Service Loop' (because it powers the three auxiliary motors we just added—blower, blower, HPU motor) from the VFD House to the Top Drive, and we'll add a junction box where the cable terminates. Then we'll run a pigtail wire from each aux motor to the J-box.
9. We're gonna need a way to pump drilling fluid down through our hollow drill shaft and hollow drill pipe. This fluid cools and lubricates the bit, helps build up a wall cake inside the uncased hole to keep it from collapsing, and it removes the cuttings and brings them back to the surface. The problem is, we can't just connect our mud hose, or Kelly hose, to a rotating shaft… it'll twist right off. So we're gonna add an intermediate hollow piece that swivels inside of a bonnet. This will allow the mud to stay sealed inside its path, and on the top of the bonnet we'll have a stationary connection for our Kelly hose.
10. Here we see it all together. The swivel pack reverse threads into the main drill shaft below (aka stem or quill), and reverse threads to the bonnet above.
11. Now we're going to add some components below to manipulate the drill pipe. First we need a way to rotate the bottom of the Top Drive 360 degrees, since the top is fixed (connected to a stationary track). Thankfully, the technology already exists, with something called a rotary manifold (depicted in the image by the letter 'R'). A rotary manifold allows us to transfer stationary hydraulic circuits to another part of a machine that moves and has its own own lines. We'll put ears on the manifold so we can hang some arms or links, and connect a latching clamp (pipe elevators) to the bottom of those links for controlling the pipe. Our rotary manifold with ears… we'll call it a Rotating Link Adapter (RLA). To secure this heavy sonofagun, we'll install a Load Collar on the drill shaft just underneath it. Also, we're gonna hang a torque tube off the bottom of the RLA, and at the bottom we'll install a grabber assembly with a piston for gripping the pipe when we want to make up or break out (screw / unscrew).
12. Let's complete the hydraulic system. We'll now install a manifold (MFLD) downstream from the main pump (P). Here' we'll dial the incoming pressure down to 2,200 PSI, and install electrically-actuated directional valves that the Driller can control functions with buttons and switches. We'll connect the hoses for our robotic elements to the manifold (cylinders (C), hydraulic motors (M)… so can move those links back and forth, grip the pipe, rotate the manifold, etc.). The electric-over-hydraulic valves, called solenoid-operated valves, will need another power cord. We'll use a big one, a 42-conductor, and connect it to the J-box as well. We'll use all those extra wires to power little sensors like an encoder, pressure switches, and drill motor RTD's also. Done.

To summarize, during drilling operations with a Top Drive, the operational tempo must only be paused once for every three joints of drill pipe to make a connection. In the past, every joint of drill pipe had to be connected, and it took at least three times longer to drill a well than it does today.

4.2 History and Development

Conventional kelly drilling uses the rig floor's Rotary Table to turn the through-passing drill string. The first top-down drive system was called the "hydraulic drive power sub unit," invented by a company called Baash Ross and used offshore on the drillship *Nola I* in the early 1950's. In the 1960's, after several other offshore companies were using hydraulic power sub technology, the hydraulic power swivel made its debut on the dynamically positioned coring vessel *EUREKA*. It wasn't until the 1970's that Brown Oil Tools, Inc. partnered with S.R. Bowen of Bowen Tools, Inc., to produce the first fully-electric power swivel, which was patented by Brown as an "electric power drive assembly" in 1975. In 1976, the company ARCO—which is not affiliated with Varco—improved this design to produce a high-speed electric power swivel.

In 1981, a man named Duke Zinkgraf was working at SEDCO, now known as TransOcean. He conceptualized a means of drilling top-down while incorporating handling tools to manipulate pipe. His vision, which came at a time when US drilling was just about to enter one of its harshest downturns, would transform offshore and land-based drilling the world over. He took his idea to the Varco manufacturing plant in Orange, California. Varco embraced the concept, assigned a team of R&D engineers to the project, and early in 1982 put the first "Top Drive System" prototypes to work on the SEDCO jackups *Sedneth 201* and *202*, drilling for Abu Dhabi Marine Operating Company in the Middle East. **In 1982, Varco upgraded the prototypes to produce the world's first commercially available Top Drive**, the TDS-3. An improved model, the TDS-4, was awarded the P.E.I Engineering

Innovation Award at OTC in Houston the following year. **Duke Zinkgraf is recognized as the father of the Top Drive drilling system**.

With the TDS-6 model, Varco partnered with GE to marry the GE 752 high torque DC locomotive motor into the Top Drive, a move that was adopted by other prominent Top Drive companies for decades to follow. Varco also worked with GE to develop the GEB-20 AC motor for drilling. Canrig and GDS / GDM Top Drives still use these GE motors today, which have over the years been adapted specifically for drilling use. Other developments by Varco and NOV include the first 2-speed Top Drive, released in 1988; and the first dual-motor unit, the 700HP TDS-9S.

Many companies in the 80's and 90's contributed to Top Drive development. Maritime Hydraulics, now grafted into Aker Solutions, introduced the link-tilt technology that is widely used. Tesco is credited with introducing and widely marketing portable Top Drives for land drilling application. Through continued advancements in technological research and development, NOV released the TDS-11 500-Ton, 800 HP Top Drive. **It is to date the most popular Top Drive system in history, with more than 2,000 units sold**… that's an average of over 100 units per year for the past two decades.

A sidebar on non-profitable time – what's interesting, is that Top Drives—all Top Drives including the TDS-11—<u>are responsible for more down time on drilling rigs today than any other piece of equipment</u>. Part of the reason is that they do not have backup alternatives: during much of a rig's drilling activity per well, a mud pump or engine-driven generator can go down and the rig can still cripple along on its spare equipment until repairs are made. Secondly, Top Drives are expensive. At ~$1.6M, you can buy six brand new 1600 Triplex Mud Pumps for the price of a TDS-11… so when times are good and drilling activity is at its peak, drilling contractors are less likely to have an operational spare just laying around in the yard to swap out.

The up-front cost of downtime or NPT for a standard double or triple drilling rig, in terms of crew pay, fuel consumption, and all quantitative factors is ~$800 +/- $100. The total cost of downtime, weighing intangible and after-incident factors, can be up to three times that number. For example, the longer a rig remains on downtime, the more personnel become involved… even if only over the phone. Time spent by company personnel on the phone supporting a downtime incident = time lost on whatever project they would otherwise be working on. In another example, the longer a rig is on downtime, the more sleep is lost, which directly or indirectly affects the operational tempo (and efficiency) immediately following a downtime incident. Whenever regular time is affected, the additional costs of downtime become clear.

Having worked as a 3rd-party hand for thirty-two different drilling contractors, I've experienced rigs who rarely accrue even the five-to-ten hours their operator might afford per month. Conversely, I've worked on rigs that regularly see >50 hours of equipment-related downtime per month. While older equipment, smaller company budgets, and poor weather or well conditions are always factors, the number one discriminator between these two types of companies… is people. Attitude and aptitude of company leaders and workers in the drilling industry will most often determine which type of rigs they have, comparable to the examples above. *This training is intended to improve aptitude relating to the most common model of the most common equipment responsible for downtime on a rig.*

4.3 TDS-11 General Specifications

Top Drive	Weight	27,000 lbs. (+/- 2,000 config.-based)
	Stack-up Height	17.8’
	Power Requirements	700 KVA @ 575-600 VAC, 50/60 Hz
	Horsepower	800 HP (400 per motor)
	Output Torque (Cont)	37,500 ft. lb. (800 HP)
	Tool Torque (Intermit)	55,000 ft. lb.
	Maximum Speed	228 rpm (w/ 4.38:1 reduction option)
	Hoisting Capacity	500 ton (API 8C, PSL-1, SR-1)
	Drilling Capacity	500 ton (API)
	Static Locking Brake	39,000 ft. lb.
	Load Path	Single
	Gooseneck Entry	3" 1002 Female Union
	S-Pipe Hose Connection	4" API Pipe or 4" 1002 Female Union
	Rotating Head (RLA)	Infinitely positionable
	Water Course	5,000 psi CWP (3.0” wash pipe)
Drilling Motors	Type	Reliance AC-575 VAC (2 x 400 HP)
	Rated Speed	1,200 RPM
	Maximum Speed	2,400 RPM
	Max Continuous Torque	1,800 ft. lbs. (each)
	Max Intermittent Tq.	2,600 ft. lbs. (each)
Pipe Handler	Type	PH-75 (75,000 ft. lb. Backup Torque)
	Upper IBOP (Remote)	6-5/8” API Regular, RH, Box on Box
	Lower IBOP (Manual)	6-5/8” API Regular, RH, Pin on Box
	IBOP Pressure Rating	15,000 psi CWP
	Saver Sub Min Shoulder	8”
	Elevator Links	350 ton or 500 ton API
Drill Pipe	Sizes	3.5” to 6-5/8” (4” to 8-1/2” OD Joint)
VFD	Types	ABB ACS800, 575-600 VAC
		IDM Yaskawa Drive (800 HP, 575 VAC)
		Siemens (800 HP, 600 VAC)
Motor Braking	Type	Hydraulic Caliper Disc Brakes

Motor Cooling	Type	Local Intake Pressure Blower
	Power	(2) 5 HP AC Motors
	Speed	3,600 rpm
	Output	1,100 cfm
Transmission	Type	Single Spd, Double Reduction Helical
	Reduction	10.5:1 (4.38:1 optional)
	Gears	(1) 102T Bull gear, (2) 34T motor pinion gears, (2) 63T/18T compound
Gear Lubrication	Type	Pressure feed, filtered
	Reservoir Capacity	15 gal
	Flow Rate	10 gpm
	Oil Pressure	33 psi optimal
	Low Pressure Indication	20 – 18 PSI Descending
Hydraulic System	Power	10 HP, 600V AC Motor
	Flow Rate	8.0 gpm/3.5 gpm (Hi/Lo)
	Reservoir Capacity	25 gal
	System Capacity	25 gal

Performance Curve

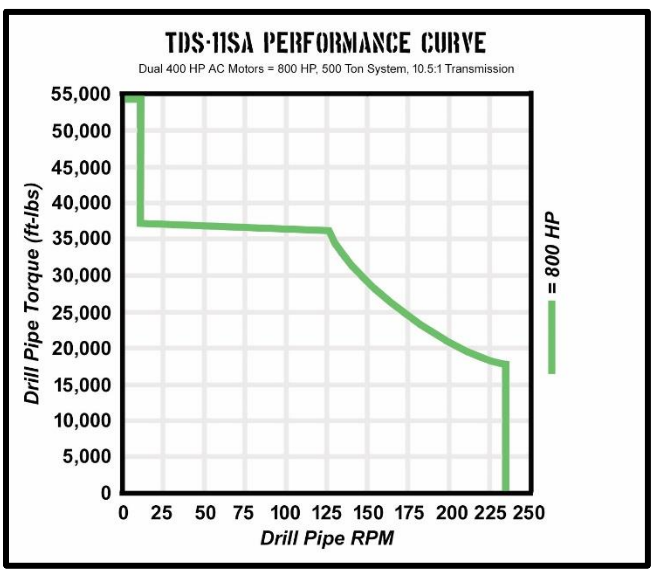
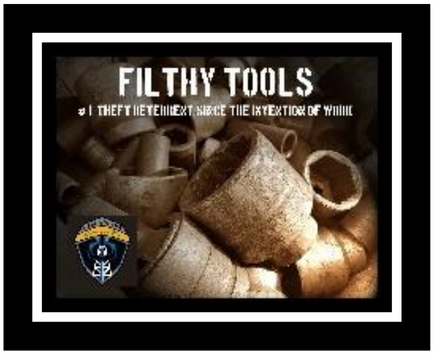


Figure 4.1

Current-to-Torque Chart

TORQUE (FTLB)	CURRENT (A)	TORQUE (%)	VALUE #
0	200	0	1
1680	214	4	2
3360	226	9	3
5040	240	13	4
6720	256	17	5
8400	270	21	6
10080	290	26	7
11760	314	30	8
13440	334	34	9
15120	355	38	10
16800	376	43	11
18480	400	47	12
20160	424	51	13
21840	446	55	14
23520	470	60	15
25200	500	64	16
26880	525	68	17
28560	550	72	18
30240	580	77	19
31920	606	81	20
33600	632	85	21
35280	664	89	22
36960	693	94	23
38640	725	99	24
39480	732	100	25
40320	755	103	26
42000	785	106	27
43680	804	111	28
45360	845	115	29
47040	874	119	30
48720	908	123	31
50400	940	128	32
52080	970	132	33
53760	1004	136	34
55440	1034	140	35
57120	1070	145	36
59220	1110	150	37



CHAPTER 5

TOOLS OF THE TRADE

CHAPTER 5:
Tools of the Trade

This section names the tools required to work on the TDS-11 Top Drive, in checklist form.

ITEM/TOOL/EQUIPMENT:	QUANTITY:	CHECK:
I. PPE AND GENERAL RESPONSE ITEMS		
SERVICE TRUCK	1	________
SERVICEABLE SPARE TIRE	1	________
FIRST AID KIT	1	________
CELL PHONE	1	________
CELL BOOSTER	1	________
BLUETOOTH HANDS-FREE DEVICE	1	________
RIG DIRECTIONS / GPS (CELL) AND PHYSICAL MAP	1	________
VEHICLE A/C INVERTER	1	________
FILLED WATER COOLER (OR 2 CASES WATER)	1	________
FOOD FOR TWO DAYS	A/R	________
LAPTOP	1	________
ETHERNET CABLE	1	________
EXTERNAL DRIVE W/ PRINTS & MANUALS	1	________
FLAME-RESISTANT COVERALLS	2	________
HARD HAT	1	________
PAIR STEEL-TOED WORK BOOTS	1	________
H2S MONITOR	1	________
SAFETY HARNESS	1	________
LOCKING STUBAI-85 STEEL CARABINERS	2	________
OVERHEAD TOOL BAG	3	________
TOOL LANYARD WITH SELF-LOCKING D-RINGS	4	________
PAIR THIN WORK GLOVES	3	________
RUBBER GLOVES (BOX)	1	________
PAIR IMPACT GLOVES	1	________
PAIR CLEAR OR TINTED SAFETY GLASSES	1	________
PAIR SAFETY SUNGLASSES	1	________
FACE SHIELD	1	________
II. TOOLS AND TOOL KITS		
ASSORTED HYDRAULIC FITTING KIT	1	________
HYDRAULIC HARD LINE REPAIR KIT (FLARE OR FERRULE)	1	________

ASSORTED NUT, BOLT, & WASHER KIT	1	________
ASSORTED SWITCH, FUSE, AND BULB KIT	1	________
ASSORTED BATTERY KIT – 2 SPARE SETS FOR EACH TOOL	1	________
MULTIMETER	1	________
AMP CLAMP	1	________
MEGGER	1	________
18V BATTERY-OPERATED DRILL & CARBIDE INDEX SET	1	________
18V ½" IMPACT AND SOCKET SETS (DEEP & SHALLOW)	1	________
18V BATTERY CHARGER	1	________
18V BATTERIES	4	________
UNIBIT	2	________
SET HEX NUT DRIVER BITS	1	________
SET ALLEN HEAD BITS	1	________
HYDRAULIC TEST KIT (STAUFF OR SIMILAR)	1	________
NITROGEN ACCUMULATOR TEST KIT	1	________
DIAL INDICATOR	1	________
VERNIER CALIPERS	1	________
25'+ RETRACTABLE TAPE MEASURE	1	________
5' BAR	1	________
LARGE CROW BAR	1	________
FLAT PRY BAR	1	________
CAT'S CLAW / NAIL PULLER	1	________
10 LB. SHOP HAMMER	1	________
RUBBER MALLET	1	________
BRASS HAMMER	1	________
LARGE STEEL WIRE BRUSH	1	________
SMALL BRASS WIRE BRUSH	1	________
COLD CHISEL & PUNCH SET	1	________
SCRAPER / PUTTY KNIFE	1	________
TAP & DIE SET	1	________
BOLT & SCREW EXTRACTOR SET	1	________
STANDARD O-RING KIT	1	________
VITON O-RING MAKING KIT	1	________
BUNA O-RING MAKING KIT	1	________
GASKET MAKING KIT	1	________
TURBO TORCH	1	________
TORCH FUEL	2	________
ELECTRIC GRINDER	1	________
GRINDER METAL GRINDING WHEELS	2	________
GRINDER SOFT WHEELS	2	________
GRINDER METAL CUTTING DISKS	4	________
GRINDER WIRE WHEEL, SIDE BRUSH	1	________
GRINDER WIRE WHEEL, FRONT BRUSH	1	________
DIE GRINDER W/ ACCESSORY KIT	1	________

DIE GRINDER ASSORTED FLAPPER WHEELS (BOX)	1	________
DIE GRINDER ASSORTED DISKS (BOX)	1	________
DIE GRINDER METAL CUTTING DISKS	5	________
SOLDERING GUN W/ ACCESSORIES	1	________
1/2” RATCHET AND SOCKET SET (STANDARD)	1	________
3/8” RATCHET AND SOCKET SET (STANDARD)	1	________
1/4” RATCHET AND SOCKET SET (STANDARD)	1	________
SET OF SOCKET EXTENSIONS	1	________
1/2” X 150 LB. TORQUE WRENCH	1	________
3/4” X 600 LB. TORQUE WRENCH	1	________
TORQUE MULTIPLIER	1	________
1/2” UNIVERSAL / SWIVEL HEAD ADAPTERS	3	________
3/8” UNIVERSAL / SWIVEL HEAD ADAPTERS	3	________
SET OF STANDARD END WRENCHES, 1/4” – 1-1/2”	1	________
1-1/2” SPECIALTY WRENCH*	1	________
SET OF STANDARD STUB WRENCHES, 1/4" – 1”	1	________
SET OF STANDARD CROW’S FEET, 1/4” – 1”	1	________
3” HAMMER WRENCH	1	________
SMALL SET OF STANDARD ALLEN WRENCHES	1	________
SMALL SET OF METRIC ALLEN WRENCHES	1	________
SET OF T-HANDLE STANDARD ALLEN WRENCHES	1	________
SET OF T-HANDLE METRIC ALLEN WRENCHES	1	________
SET OF STANDARD HEX NUT DRIVERS	1	________
SET OF STANDARD SCREWDRIVERS	1	________
SET OF PHILLIPS SCREWDRIVERS	1	________
SET OF SMALL ELECTRICAL SCREWDRIVERS	2	________
SIDE-CUTTING DIKES	2	________
FRONT-CUTTING DIKES	1	________
SAFETY WIRE PLIERS**	1	________
.032 SAFETY WIRE**	2	________
.041 SAFETY WIRE**	2	________
.051 SAFETY WIRE**	2	________
ID SNAP RING PLIERS	1	________
OD SNAP RING PLIERS	1	________
STANDARD PLIERS	1	________
VARIOUS NEEDLE-NOSE PLIERS	4	________
ADJUSTABLE / CRESCENT WRENCHES (6,” 8,” 10,” 12”)	4	________
VISE-GRIPS	1	________
VARIOUS CHANNEL LOCKS (SM / MED / LG)	3	________
DRAG MAGNET OR TELESCOPING MAGNET	1	________
MAGNETIC BOLT TRAY	1	________
FLEXIBLE CLAW FISHING TOOL	1	________
ELECTRICAL PLIERS	2	________
PIN CRIMPER AND PUSH TOOL SET	1	________

FERRULE KIT W/CRIMPERS	1	________
CABLE LUG CRIMPERS W/ DIES FOR 646 / 777	1	________
WIRE STRIPPERS	1	________
RACHETING CABLE CUTTERS	1	________
BUCHANAN CRIMPS	1	________
BUTTER CUTTERS	1	________
RETRACTABLE UTILITY KNIFE FOR SHEATHING CABLE	1	________
PAIR ELECTRICAL GLOVES	1	________
SET ASSORTED COLOR ELECTRICAL TAPE	1	________
SET ASSORTED COLOR ZIP-TIES	1	________
BOX OF ASSORTED WIRE NUTS	1	________
BAGS OF BUCHANAN COPPER BUTT-SPLICES W/ CAPS	2	________
PACKAGES OF SM - LONG HEAVY-DUTY ZIP TIES	4	________
ROLLS ELECTRICAL TAPE	6	________
ROLLS TEFLON TAPE	2	________
ROLL DUCT TAPE	1	________
BOX RAGS	1	________
BOX SHOP TOWELS	1	________
CONTAINER OF HAND CLEANER	1	________
CAN WD-40	1	________
CONTAINER DRY GRAPHITE LUBRICANT	1	________
CAN PB BLAST	1	________
GREASE GUN	1	________
TUBES RED NGLI GREASE	4	________
TUBES CHEVRON EP2 BLACK PEARL GREASE	2	________
CONTAINER OF LIQUID TEFLON	1	________
TUBE ANTI-SIEZE COMPOUND	1	________
TUBE LOCTITE / THREADLOCK	1	________
TUBE SUPERGLUE	1	________
ROLL SHEET RUBBER	1	________
HIGH-VOLTAGE SPLICE KIT	1	________
SMALL HEAT SHRINK TUBING KIT	1	________
MEDIUM HEAT SHRINK TUBING KIT	1	________
LARGE HEAT SHRINK TUBING KIT	1	________
ASSORTED SIZE ZIPPER SHRINK KITS	3	________
2-PART POTTING EPOXY KIT	1	________
PENS, MARKERS, PAINT MARKERS, NOTEBOOKS EACH	2	________

** Note 1: Traditional TDS-11 configurations often require a specialty wrench for removal of the two upper rear bolts for each drill motor. A drawing is provided on following page.*
*** Note 2: All fasteners on overhead traveling equipment in the oilfield must be outfitted for secondary retention. For this purpose, we use pre-drilled bolts with thru-cable and crimped ferrules, or traditional safety wire. Guidance is per OEM, and per API Spec 8C Sec. 4.9.3. Safety wiring instructions are found in Chapter 1 of the TDS-11 Service Manual.*

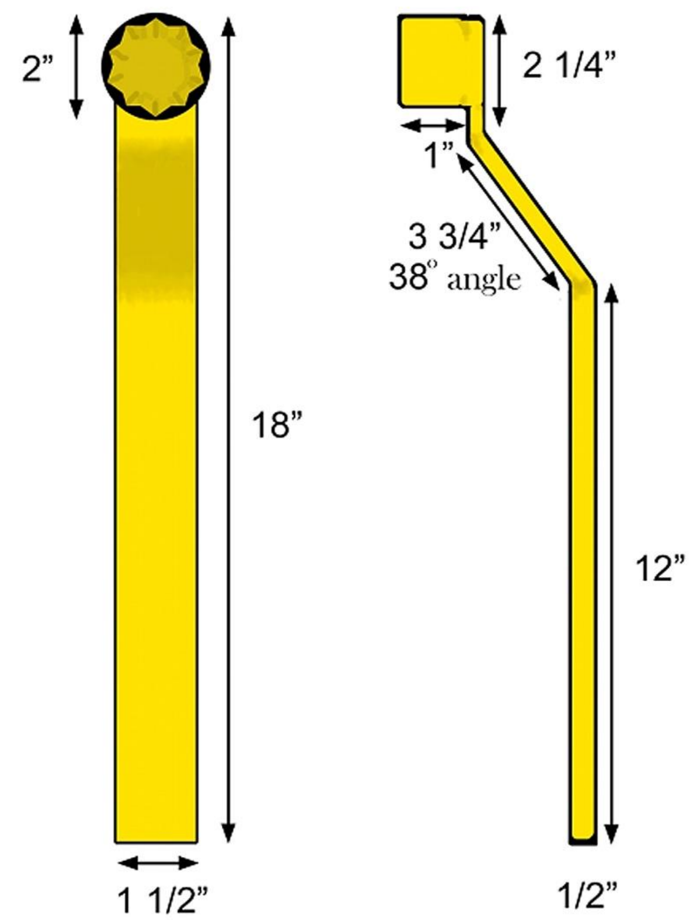


Figure 1. 1-1/2" Specialty Wrench

RIG ANGEL

	INITIAL	CURRENT
DRAWN		
CHECKED		
APPROVED		
DATE		

TITLE: **SPECIALTY WRENCH FOR TDS-11 BACK MOTOR MOUNT BOLTS**

SIZE	DRAWING NO.	REV.
A	RATD003	0

SCALE	WT. LBS.	PAGE
NTS		1 of 1

Figure 5.1

CHAPTER 6

TDS-11 MAIN ASSEMBLIES & SUBCOMPONENTS

CHAPTER 6:
TDS-11 Main Assemblies & Subcomponents

In this section, we will learn the following:

1. The seven major sections / systems of a TDS-11 Top Drive
2. The names and locations of some key TD subcomponents
3. A rudimentary illustration of how the hydraulic and electrical systems interact

Notes: In this and subsequent chapters, you will notice a recap of some principles or basic components covered in Chapter 1, applying them now to the TDS-11. This repetition is intentional to aid in memory retention.

2.1 Main Assemblies

There are seven major sections / systems on the TDS-11 Top Drive (controls will be covered in another chapter):

(1) Power Section

(2) Drive Train

(3) Mud Circulation

(4) On-board Hydraulic System

(5) Electrical System

(6) PH-75 Pipe Handler

(7) Carriage & Hoisting

1. Power Section

There are two 400-HP Baldor Reliance AC traction motors on the TDS-11 Top Drive. Each motor is rated at 600VAC, 50/60 Hz. Attached to each motor is a top-mounted 5HP blower motor, blower fan, and hydraulic brake assembly. The **left side** (DS) motor's blower shroud houses a heat exchanger. The **right side** (ODS) motor's blower shroud houses a pulse encoder, which reads the actual rotation speed of the motor, converts the mechanical input into an electrical signal, and sends the signal to the ABB drive for measurement, adjustments, and drive fault indications.

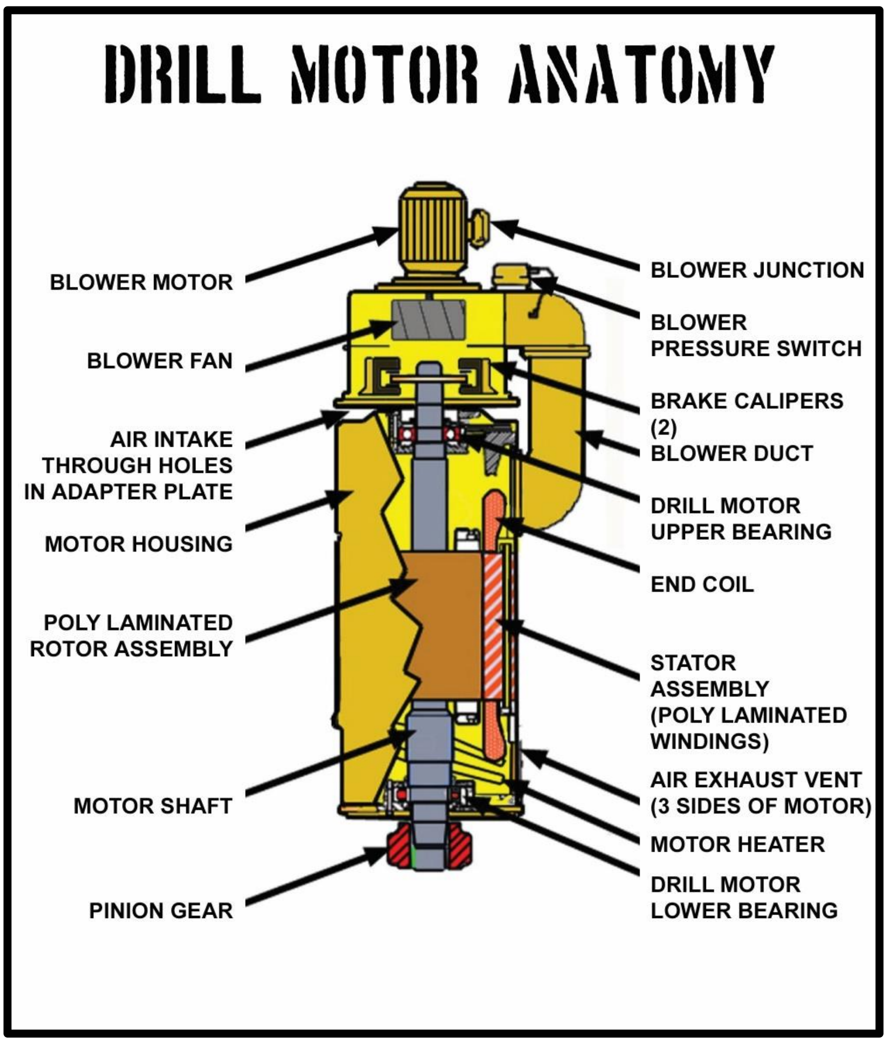


Figure 6.1

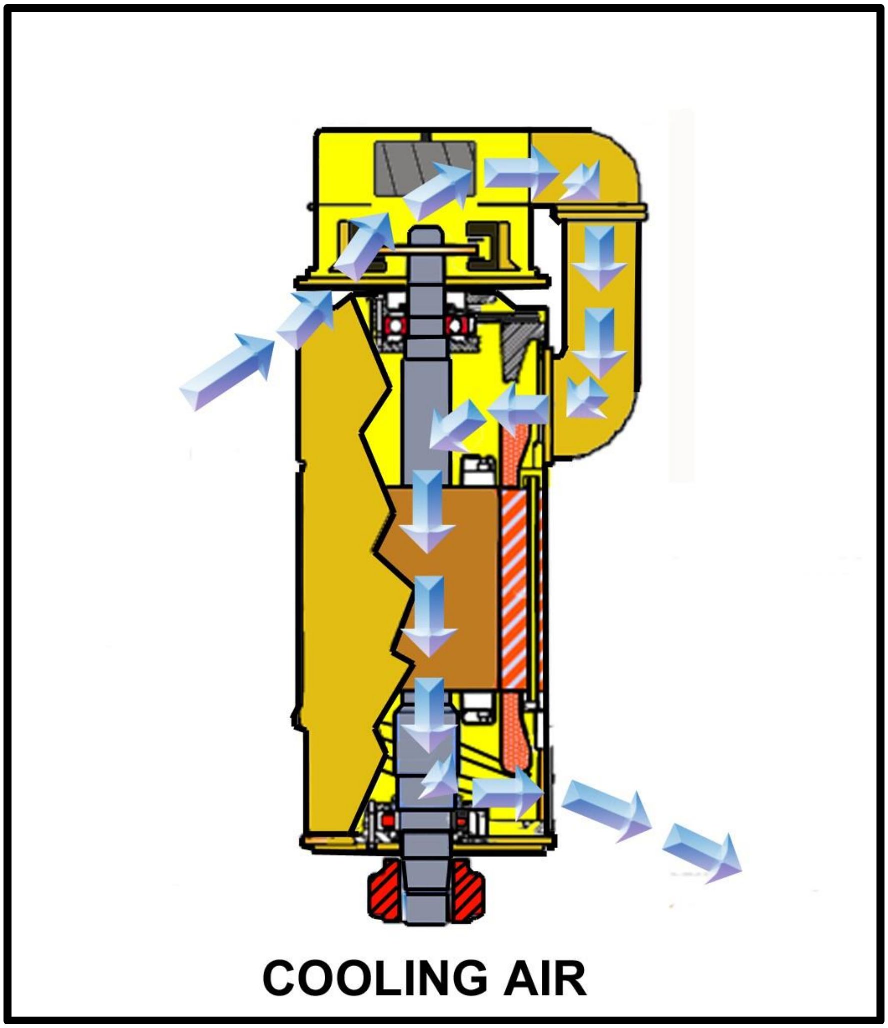
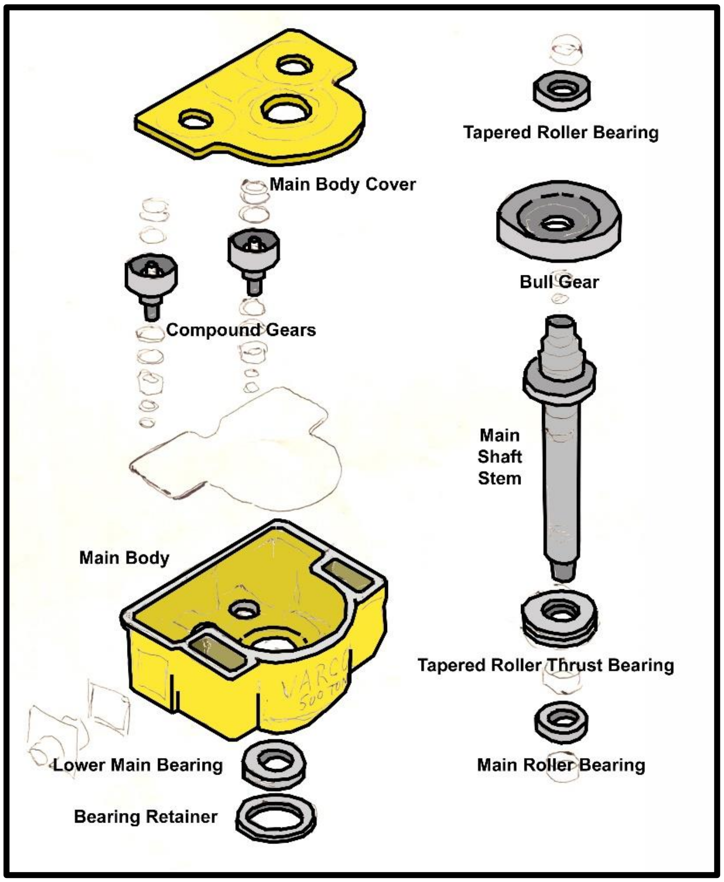


Figure 6.2

2. Drive Train

A large reduction gear assembly is located inside the transmission housing, directly below the motors. The transmission is also known as the gearcase, the case, the gearbox, the reduction gearbox, or the RGB. It provides a **10.5 to 1** reduction.

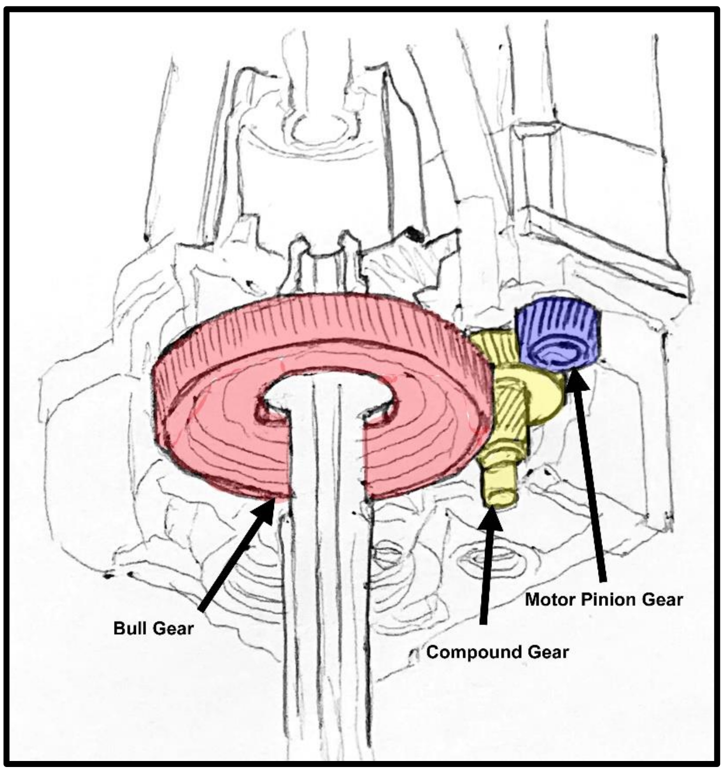
Inside the transmission, each of the two motor pinion gears turns a respective compound gear. A compound gear is a single component with two different diameters and tooth counts. You'll see an illustration on the next page. The compound gears transmit the motor torque to turn



a large, centralized bull gear, which is bolted to the hollow drive stem (aka main shaft or quill) of the Top Drive. The drive stem passes downward from the gearbox through the RLA, below which is a Load Collar upon which the RLA rests when hydraulic system pressure is relieved. Attached to the bottom of the drive stem, in descending order, are the upper IBOP, the lower IBOP, and Saver Sub. Attached above the drive stem is a swivel pack (encased by a protective bonnet), which is attached to—and rotates with—the drive stem below while maintaining a seal with the fixed-position Goose neck, S-Pipe, and kelly hose above.

Figure 6.3 (Above)

Figure 6.4 (Below)



Gearbox lubrication is provided by a continuous positive pressure fed pump that is mounted in the gearbox. The pump is turned by an external hydraulic motor, which is driven by the HPU vane pump whenever the hydraulic system is energized. Optimal case pressure in the gearbox is 33 PSI; a gear lube pressure switch is plumbed into the case, and it makes the "Oil Pressure Loss" lamp on the Driller's Console illuminate when pressure drops between 20 to 18 PSI descending. Extended operation of the Top Drive with less than 12 PSI gear case pressure will cause a catastrophic failure of the gearbox.

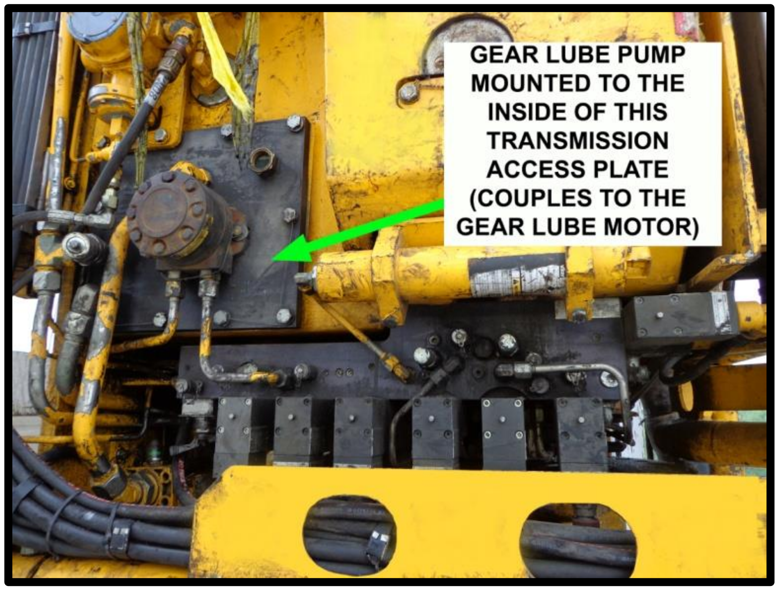
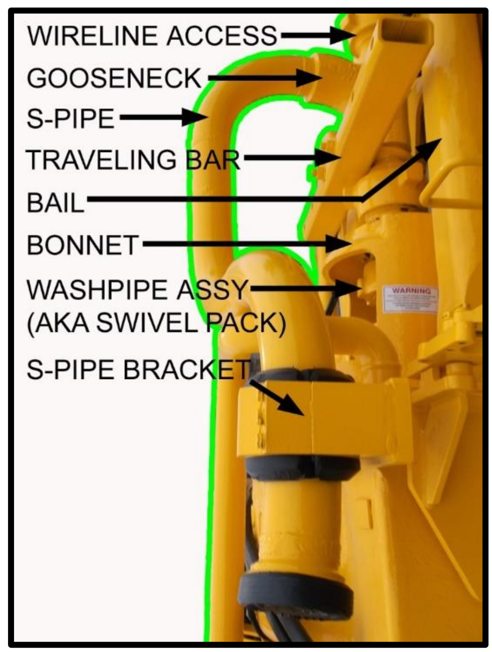


Figure 6.5

Figure 6.6

3. Mud Circulation

Top Drive systems are an integral part of the rig's drilling fluid circulation system, and have proven instrumental in the development of horizontal drilling technology. Standpipe fluid under pressure is channeled through rigid HP pipe up the side of the derrick to just below board height, at or about 73 feet, where it enters a 10K PSI rated kelly hose approximately 75 feet long. The kelly hose should dip down to around six feet above the floor when connected to the Top Drive at its lowest conventional position in the derrick (~ -4').



The hose connects to the S-Pipe at the TD, which is of rigid HP construction and fixed to the TD with a rubber-lined robust clamp (S-Pipe can be configured for either side of the TD). The S-Pipe then transfers fluid to the goose neck, which directs fluid downward into the bonnet through the swivel pack while also providing for well intervention with a wireline cap. Because the IBOP valves are rated at 10K PSI, the only restrictive element that comes standard on a TDS-11 is its 3" 5K PSI wash pipe at the core of the packing. With the sweep of land triples upgrading to 7,500 PSI MP fluid ends over the past decade, the TDS-11 and similarly-rated Top Drives upgraded to 4" 7,500 PSI washpipes. The future of land drilling begs a complete 10K PSI circulation system, but it will likely require the redesign of entire drill strings among other equipment, and probably a revisit of API RP 53.

Figure 6.7 (a) and 6.8 (b)

4. On-board Hydraulics

This <u>25-gallon</u> system includes the reservoir, suction strainers, hydraulic pressure filter, main manifold, accessory manifolds, RLA, pre-charged accumulators, actuators (pistons / cylinders and hydraulic motors), steel lines and hoses. The TDS-11 is the first commercial Top Drive to boast a completely "on board" hydraulic system; nearly all other Top Drives draw their hydraulic fluid through a set of hydraulic hoses attached to the service loop, from a reservoir and pump assembly located remotely on the drill floor or on a ground-mounted skid.

Main hydraulic system fluid is driven by the 3.5 – 8 GPM **HPU piston pump**. Gearbox lubrication is provided by a *hydraulic motor* that is driven by the **HPU vane pump**. The HPU electric motor is powered through the 19-pin auxiliary service loop. All hydraulic functions are electrically actuated via VFD House-supplied 24VDC power through the 42-pin composite service loop. When a robotic function is selected by the Driller, 24V passes through a closed switch contact at the Driller controls, down to the VFD house, where it is re-routed through the 42-pin to the Top Drive Junction Box (hereafter, J-Box). The actuating voltage then powers one of seven solenoid-operated (directional) valves, or SOV's. The solenoid essentially acts as an electromagnet, forcing the spool against spring pressure to allow pressurized hydraulic fluid to flow to the desired side of its respective actuator. The hydraulic system is fully detailed in Chapter 9.

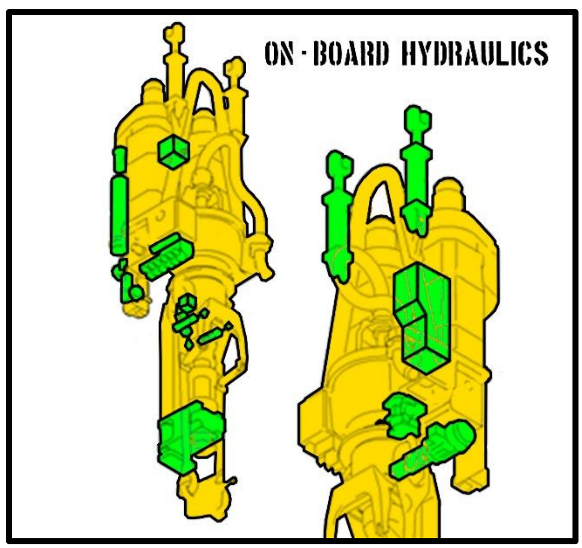


Figure 6.9

5. Electrical Section

The TDS-11 receives power via three separate service loops that begin at the Variable Frequency Drive (VFD) house, run up the outside of the derrick, and hang from a rainbow shaped termination near the monkeyboard to create a traveling loop on the inside of the derrick before they connect to the Top Drive. Some rig models incorporate a drag chain to protect the service loop bundle, but most simply allow the loops to hang freely to the side of the Top Drive, usually wrapped in a heavy-duty nylon 'sock' or coiled with large-diameter plastic hose wrap. The service loop bundle comprises three individual service loops:

(1) A 600V 3-phase ***power service loop*** with grounds, contained in a durable 4" hose and flange-mounted to a weldment plate on the side of the TD. The three large armored cables in this loop have colored plugs—black, white, and red—which correspond to like-colored bulkhead connections the Top Drive plug panel. The grounds are mounted at a common brass block near the hose flange weldment. The power service loop supplies power to the two 400HP drill motors (for rotation, speed and torque), the loop supplies power to nothing else. For VFD fault indications, suspect the VFD House (inverters, rectifiers, chopper / DB module, associated fuses) OR a drill motor, OR one or more phases of this service loop (LOTO and look for physical cable / plug deficiency).

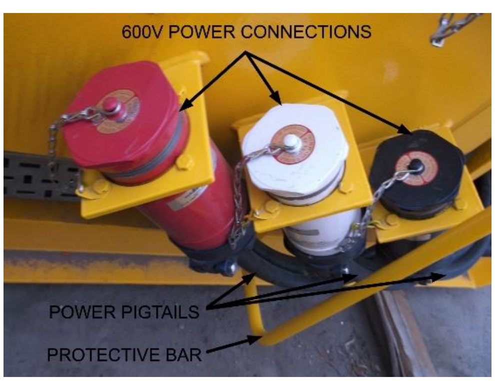


Figure 6.10

(2) The ***19-pin auxiliary service loop*** supplies 3-phase, 600V power and ground wires to the three auxiliary motors from their respective motor starters in the VFD House:

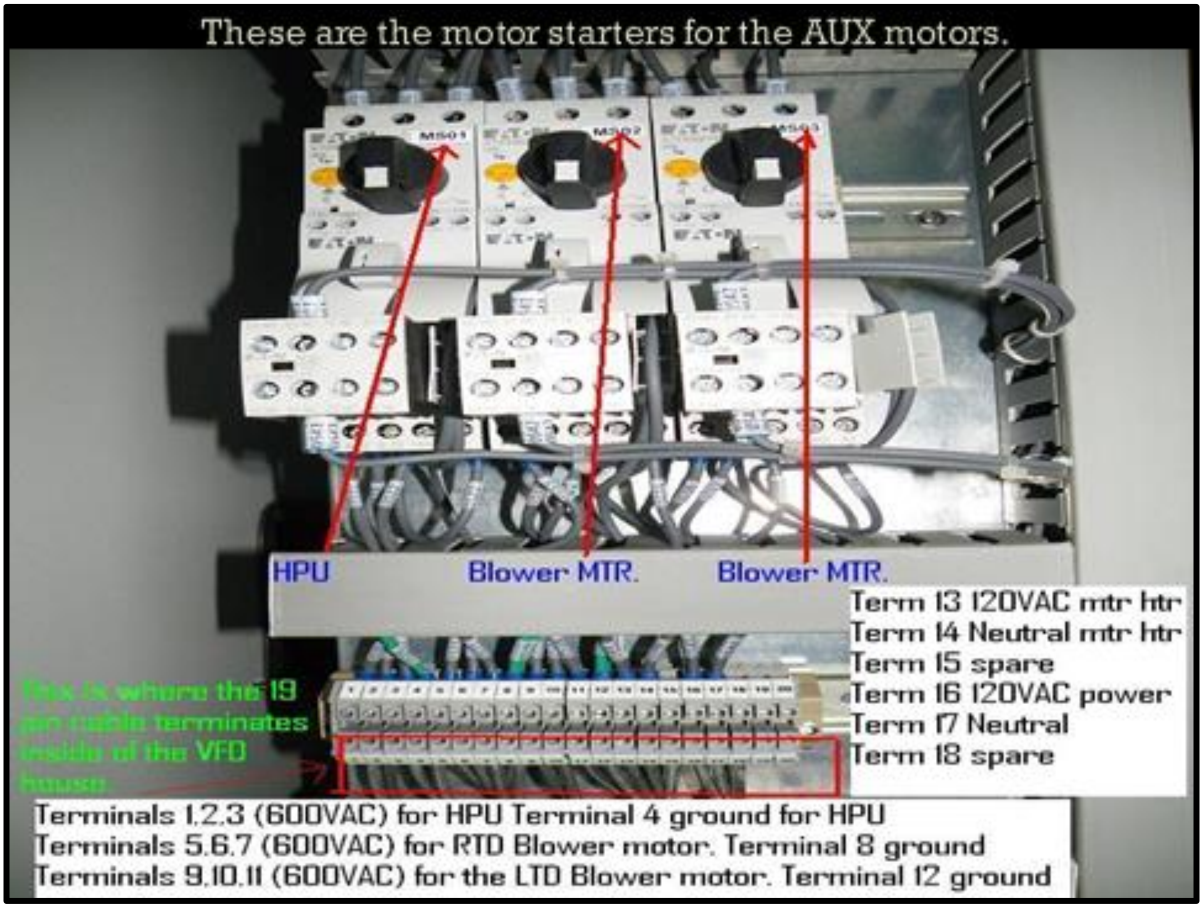


Figure 6.11

The 19-pin also provides 120 VAC power to the drill motor heaters for cold-weather applications. So the aux motors and the drill motor heaters, and nothing else. If you're experiencing a problem with one of these items, suspect the 19-pin auxiliary service loop and its connected circuit components, and nothing else. Similarly, if there is a problem with anything else on the Top Drive besides blower / HPU operation or drill motor heaters, do not suspect the 19-pin (it would be highly irregular, unless it is shorting to something else). Sounds simple, but this is a common reason that 3rd-party gets called out, to determine which service loop a customer needs to get coming. That's why I'm reiterating.

3. The *42-pin composite service loop* supplies power from the VFD House to the TD J-Box for robotics (SOV's) and sensing devices (pressure switches, motor RTD's [overtemp warning devices], and the encoder. If the Driller is getting a blower loss light or indication, and the blower is still blowing, suspect a blower pressure switch or some segment of the 42-pin. If the blower is not blowing, suspect the blower motor, motor starter breaker, or some segment of the 19-pin. Get it? Good.

In traditional rig layouts, the 42-pin and 19-pin service loops are continuous, while the three power wires and grounds connect together at a termination point (saddle) near the board (splitting the inner power loop from the outer power loop).

6. Pipe Handler

The PH-75 Pipe Handler (rated at up to 75,000 ft. lbs of torque) mounts underneath the RLA and is comprised of four major components: the torque arrestor, the clamp cylinder or *grabber* assembly, the IBOP actuator yoke & piston, and the link-tilt assembly consisting of two cylinders and the link-tilt crank. As described, the Pipe Handler uses electrically-actuated, hydraulically-operated piston and cylinders to handle pipe.

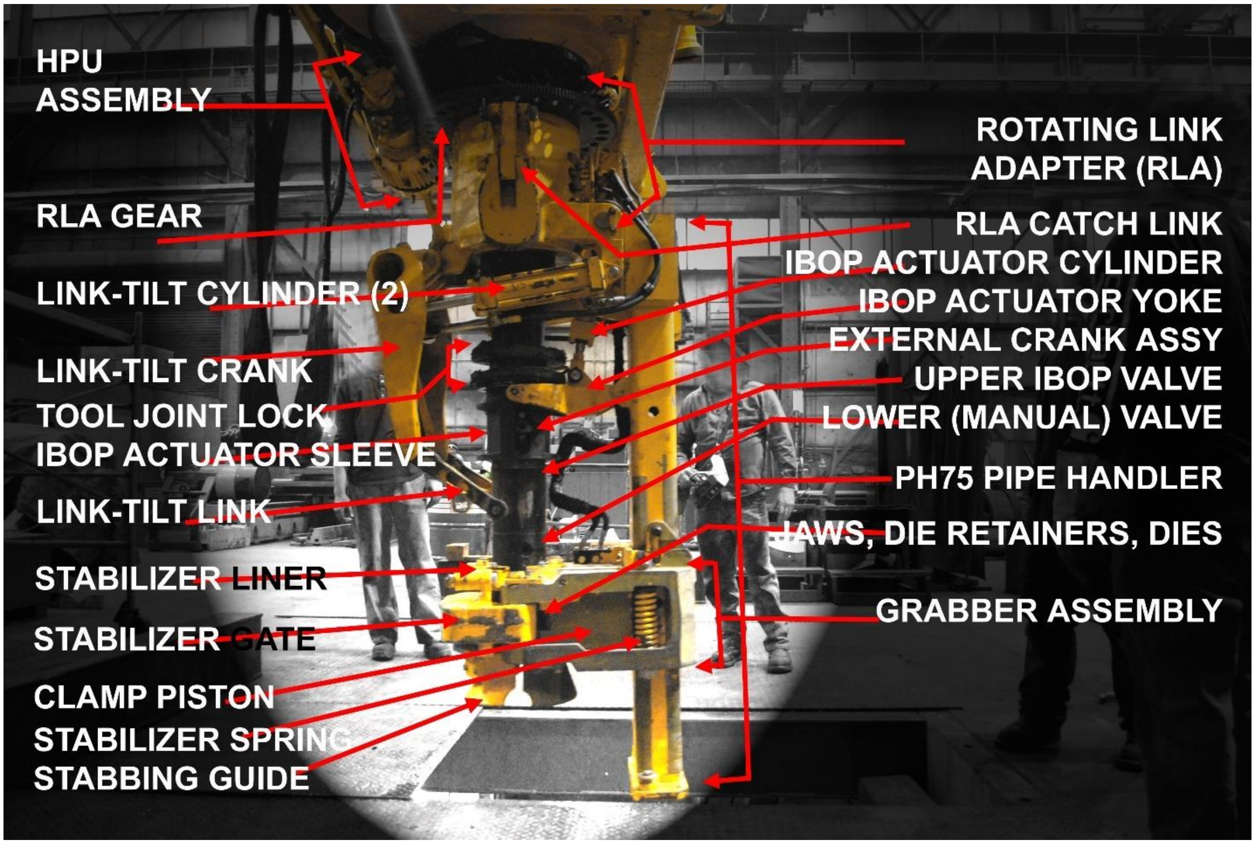


Figure 6.12

Figure 6.13

Figure 6.14

7. Carriage and Hoisting

The Top Drive is hoisted up and down in the derrick by a 500-ton McKissick hook & block combo [or other variable combination of block and hook], controlled by the Drawworks. The hook connects to the Top Drive bail. In this conventional setup, the TDS-11 Top Drive has four (4) bogey roller assemblies attached to a carriage that's bolted to the TD, which ride up and down a modular track at the back of the unit. In the case of dolly-mounted TDS-11's that have guide runners which ride along the sides of the derrick (where the traditional track and carriage is not used), the blocks may not have a hook, rather an attachment which accepts pins for the TD arms (used in lieu of a bail). This configuration of Top Drive, fyi, was originally called the TDS-11HP, named after the first customer to incorporate the design change.

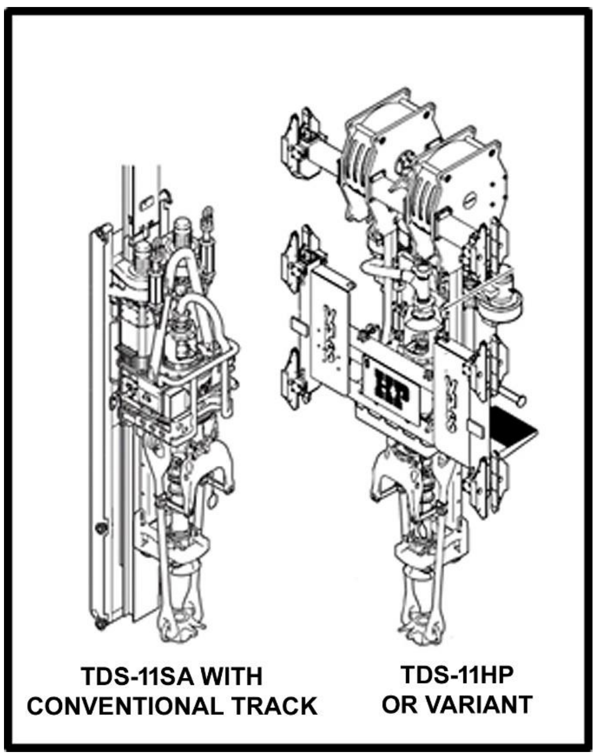


Figure 6.15

The following page provides a simple illustration of how the TDS-11's hydraulic and electrical components / circuits interact.

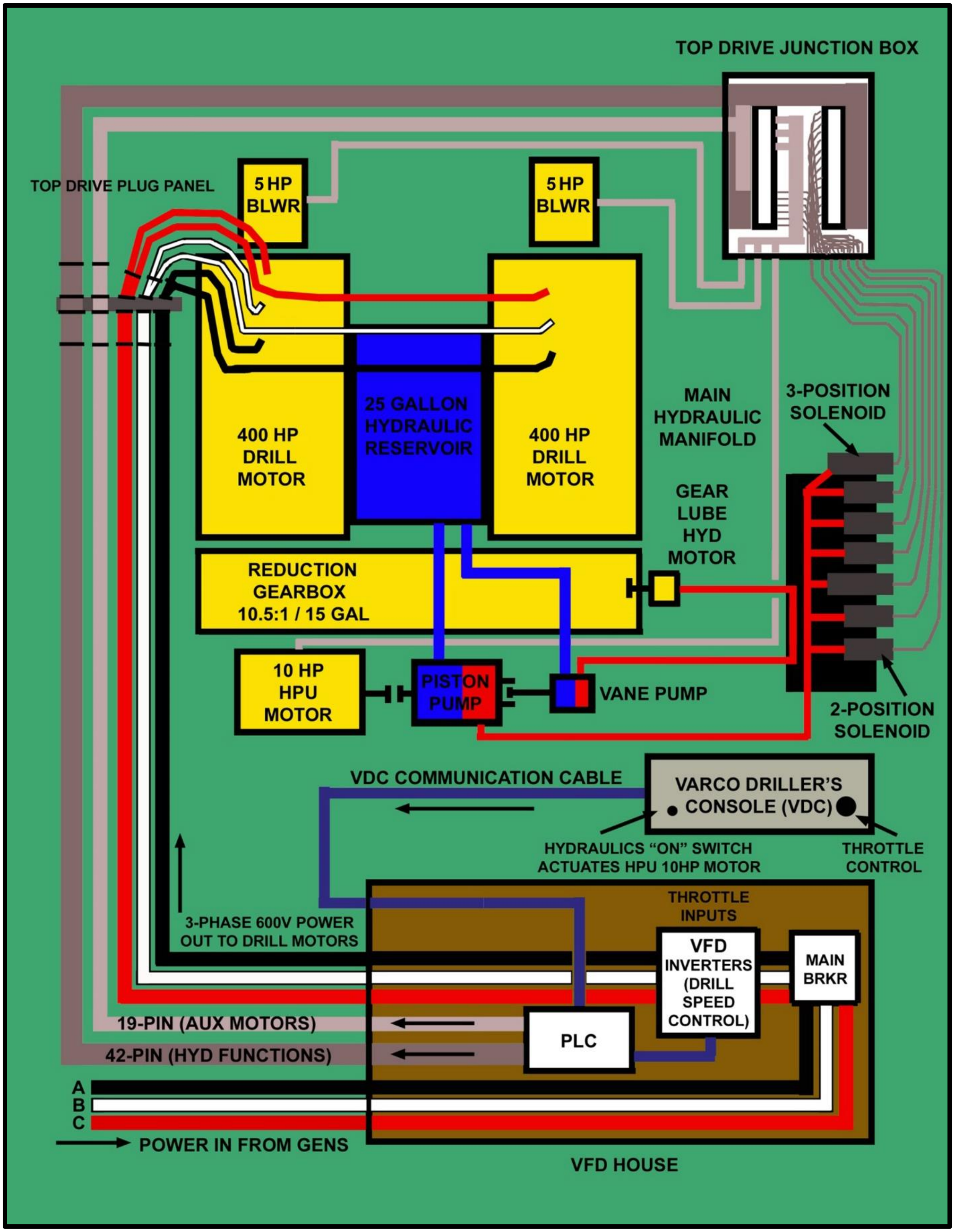

TOP DRIVE JUNCTION BOX
TOP DRIVE PLUG PANEL
5 HP BLWR
5 HP BLWR
400 HP DRILL MOTOR
25 GALLON HYDRAULIC RESERVOIR
400 HP DRILL MOTOR
MAIN HYDRAULIC MANIFOLD
3-POSITION SOLENOID
GEAR LUBE HYD MOTOR
REDUCTION GEARBOX 10.5:1 / 15 GAL
10 HP HPU MOTOR
PISTON PUMP
VANE PUMP
2-POSITION SOLENOID
VDC COMMUNICATION CABLE
VARCO DRILLER'S CONSOLE (VDC)
HYDRAULICS "ON" SWITCH ACTUATES HPU 10HP MOTOR
THROTTLE CONTROL
THROTTLE INPUTS
3-PHASE 600V POWER OUT TO DRILL MOTORS
VFD INVERTERS (DRILL SPEED CONTROL)
MAIN BRKR
19-PIN (AUX MOTORS)
42-PIN (HYD FUNCTIONS)
PLC
A
B
C
POWER IN FROM GENS
VFD HOUSE

Figure 6.16

CHAPTER 7

TDS-11 TOP DRIVE OPERATION & CONTROLS

CHAPTER 7:
Top Drive Operation and Controls

In this section, we will learn the following:

1. The definition and explanation of controls
2. Common control configurations that are available today
3. Where to find your configuration on the Student Thumb Drive
3. How to operate the TDS-11 Top Drive

*So when I was developing this training—as in right now, as I'm writing this—I'd like to avoid writing a manual within this chapter. So here's what we'll do. We'll talk about controls, then we're going to discuss the different **drive control systems** for the TDS-11, which basically means **machine** controls… and then we'll talk about the different **operator interfaces**, or **human** controls for the TDS-11. We'll cover the basic gist of all of them, and I'll teach you how to fish (which manuals to look for in your student thumb drives to find answers, based on the system you're using). Then we'll use the classic Varco Driller's Console of a brake handle rig—the simplest method—to explain the basic operation of the Top Drive. Sound good? Let's git after it.*

7.1 What are Controls? A control is any device we use to start, use, or stop a machine. When we say "controls" in plural, it usually refers to a control system… which is an interconnected network of physical devices, circuits, or electronic programs that we use to command or regulate a machine. Controls can be manual or mechanical, pneumatic, hydraulic, electric, electronic, or fiberoptic… and a control system uses a few different types of controls that work together to make a machine do what we want.

To illustrate, we're going to use power wrenches as our example, or 'floor wrenches' in the oilfield. If you've ever used a Blohm & Voss Floorhand, you'll note that when you push or pull a handle, you are physically moving a valve spool that is attached to that handle, because the handles are mounted on the valve bank. An NOV ST-80 works in similar fashion but adds a level of complexity. While you are still moving handles to mechanically operate the machine, those handles are connected to cables, and the cables are routed to the valve bank to move the hydraulic valve spools. These are examples of manual controls.

On a workover rig or a super single, the floor wrenches are also hydraulic but the actuators are not mechanical handles or cables. They're typically air actuated (USA Oil Tools wrenches, for example). So when you lift a handle, air under 120 PSI pressure is ported through a 3/8" air hose to a pneumatic actuator on the hydraulic valve bank, to move the spool and direct fluid. Even some doubles and triples still use air-actuated floor wrenches. Anybody remember the Hawkjaw Sr.? It's an overbuilt set of pipe spinners with articulating jaws… and it floats off the A-leg like manual tongs do. Pneumatic over hydraulic controls. Uses Lincoln tubes instead of hoses.

Hydraulic controls: Schramm's T-Series rigs use hydraulically-actuated, hydraulically operated tools. Their valve banks have hydraulic actuators, and the Driller's control panels have handles and knobs that direct pressurized fluid when moved, actuating a hydraulic valve spools by pushing against them hydraulically. That concept is called 'pilot pressure' when hydraulics are used to actuate other hydraulic devices.

Then we've got the IR-3080 and TM-80 or 120. Electric over hydraulic. The *coup de grace* is found on state-of-the-are offshore rigs, where everything is automated and usually begins electronically… by pushing a button on a touchscreen. Ultimately, a hydraulic valve spool still gets moved to do the action, but as you can see, power wrenches offer the full spectrum of controls options.

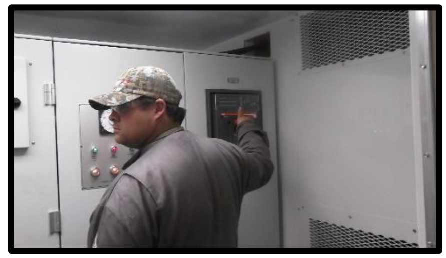
7.2 TDS-11 Drive Control Systems. The first drive control system for this unit was a Siemens Drive House, the Atari of VFD Houses. The house itself came in three sizes: tiny, super tiny, and micro (not much bigger than a port-a-shitter). You'll know you're in this house if, when you open the door to enter, there's a red digital screen with two or three digits that look like letter-numbers (is that an 'F' or a '7'?). The house was made by Siemens and uses Siemens drives, aka inverters, aka VFD's or Variable Frequency Drives. IF YOU EVER FIND YOURSELF in one of these houses because your TDS-9, 10, or 11 is having issues, you need to know two things: First, the most common way to fix speed or torque issues—after you've shut down the unit, LOTO and checked out all the power cables (same cables, slightly smaller black/white/red 646 with smaller plugs), is to run the drive's "Auto Parameterization" function. You have to do it several times for it to work, usually. How do you do this? Read the instructions. That brings us to # 2: the *Siemens Simovert Compendium*. This is the Bible for that entire drive house. And just like with the real Bible, if you read it enough, you'll start to understand it. Promise. It's on your student thumb drive. Cool about this house: encoder bypass is just a switch.

Next up, the IDM Yaskawa Drive House. Same frame and setup as the Siemens House mentioned above, only with different inverters. Though Yaskawa drives are still used for the TDS-11 in Omron applications, and in Canrig and GDM Top Drive VFD Houses, the IDM Yaskawa Drive House for TDS-11's is believed to be completely phased out on land rigs today.

Ok, this next one is still pretty popular with customers in West Texas, anyway. For anyone who has a DC rig (SCR rig) and a TDS-11 Top Drive, they probably have one of the three classic variations of *ABB Stand-Alone Drive House*. All three have two (2) ABB ACS-800 drives that control speed and torque for the TD, and a standard ABB keypad mounted on the wall, looks like the photo at left below. Now, you see the photo at right? If you have one of these drive houses, but that main breaker is underneath the ABB keypad at knee-level with a clear plastic case around it, then you have the rarer of these three versions of VFD house, the *ABB Finnish Drive House* (made in Finland).

Figure 7.1

Figure 7.2



So, the Finnish ABB house is configured differently, but the other two are identical except for the guts. The original of them incorporated Siemens PLC technology, the discontinued parts for which are all but extinct today, and stupid expensive if you can find some. The other house uses SBC technology (NOV Amphion), and the Driller's Console is different. You have the prints for all styles of ABB VFD House on your student thumb drive: PLC, SBC, and Finnish houses.

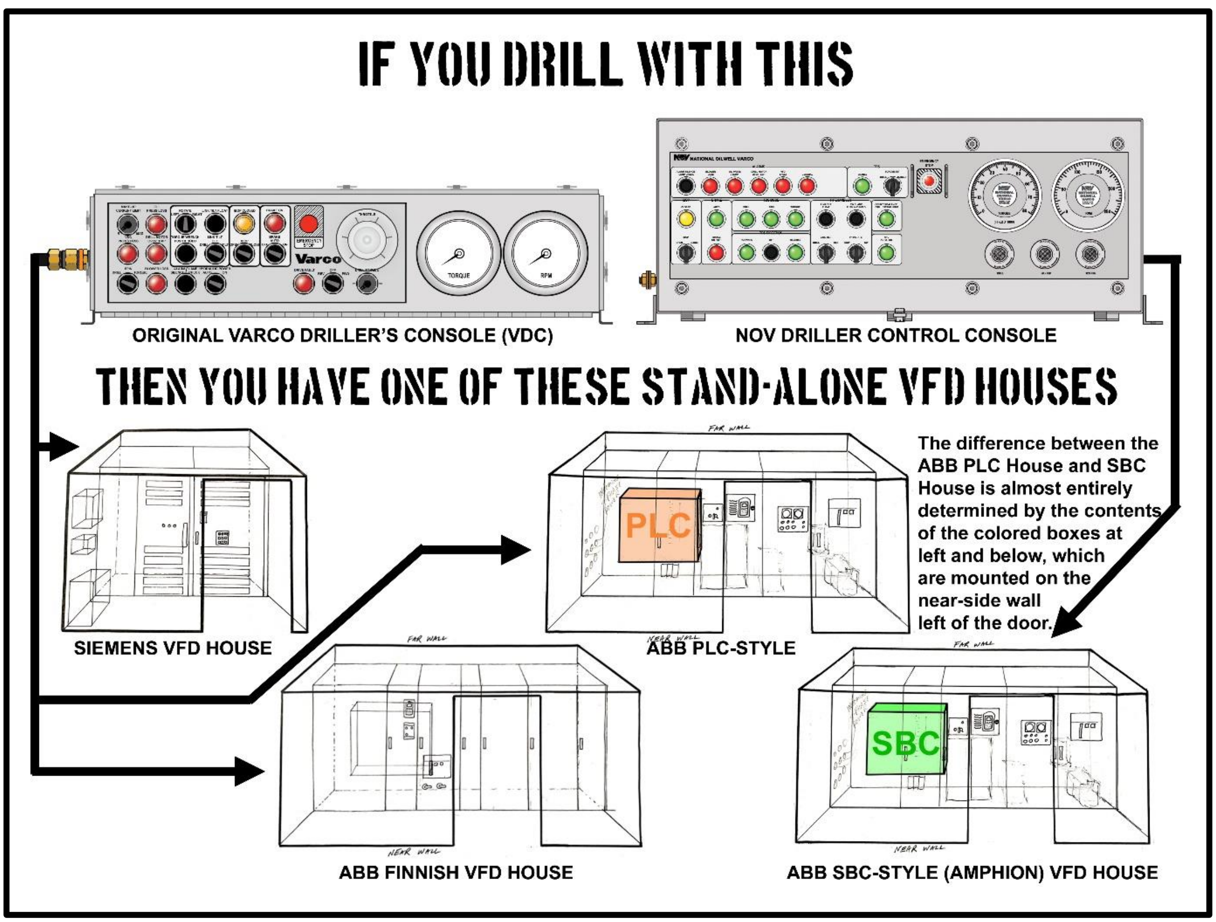


Figure 7.3

Moving on to AC rigs. AC rigs don't need "stand-alone" Top Drive VFD houses, because the Top Drive, Drawworks, and Mud Pumps all use AC drives (inverters) in what's called an *Integrated Drive House*. If you have an NOV rig, you'll either see those same ABB keypads for each piece of equipment, or you might see Siemens Sinamics or Simatics controllers… could be button-style or touchpad. If you have one of these rigs with ABB drives, you have a set of prints on your Student Hard Drive. If they're Siemens drives, you'll need to obtain a copy of the prints. I have several that are similar but none for the TDS-11. Keep in mind there are a lot of variations and the technology changes too fast to keep up. The good news is, for all NOV TDS-11 drive houses, if you're an end user (work for a drilling contractor), you can usually get a copy emailed to you if you sweet talk the tech support folks at NOV. What you'll need is the 4-digit Job Number that's on the data plate of your VFD house… usually mounted just outside the door. If your house is so old that it doesn't have a data plate, good news! You have the info now to determine what kind of VFD house you're dealing with. If it's not an NOV design of drive system, you'll need to see who your company used when they built the rig. IEC, IDC, IPS, Unico… there are all kinds of customer-unique VFD designs, albeit relatively rare. Hope this info helps you understand the different configurations a little better than you did already.

7.3 Operator Interfaces.

Now comes the fun part. In a brake handle scenario, the operator (Driller) of a TDS-11 typically uses either a traditional Varco Driller's Console (VDC), an Amphion VDC, or in conjunction with an EDS system. In a Driller's Cabin / cyberbase setting, the Driller will likely use an Amphion or Omron program's HMI screen… (Human-Machine Interface, aka touchscreen). Of course, there are some outliers that use other custom-designed programs & systems. All of the ones I just mentioned are pretty easy to use once you get the hang of them, and the instructions for each are—*you guessed it*—on your thumb drive.

Here are the basic operator interfaces.

For brake handle drilling:

Figure 7.4 – Varco Driller's Console

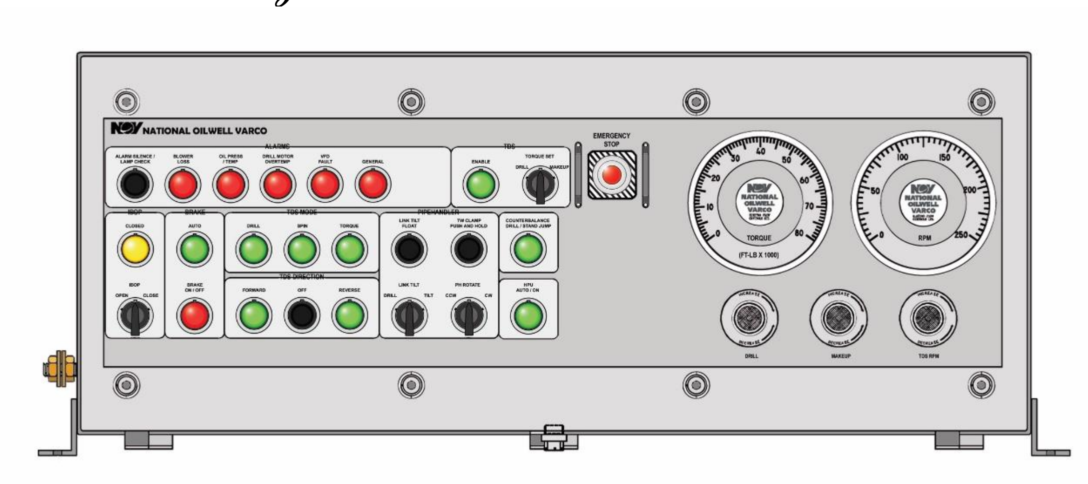
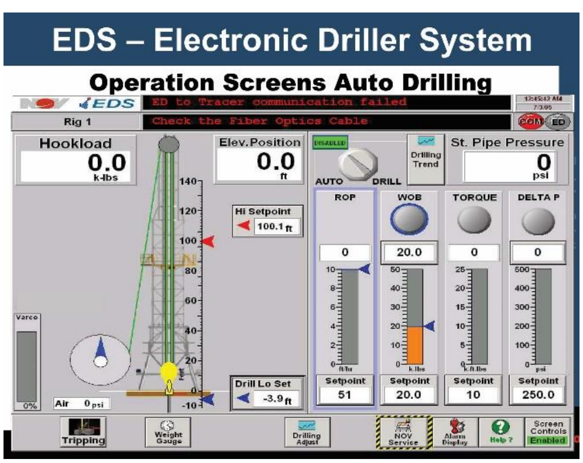


Figure 7.5 – NOV Driller Control Console



Used in conjunction with one of the consoles above: EDS or AutoDriller system (Pason, Totco, WildCat, e.g.)

Figure 7.5 – NOV Electronic Drilling System (EDS)

For cyber-based drilling (Driller's Cabin / cyberchair):

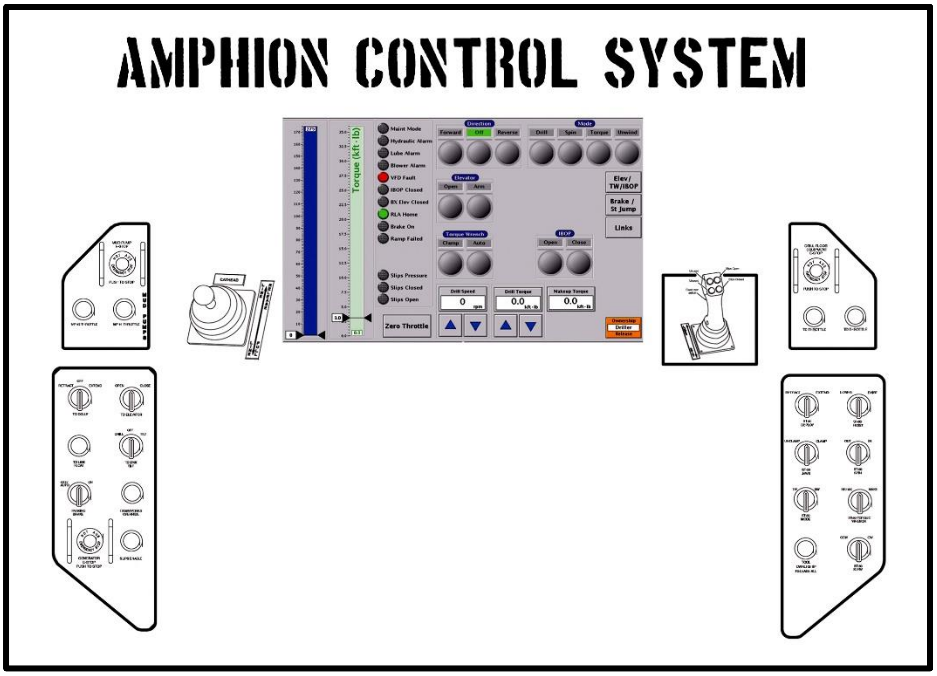
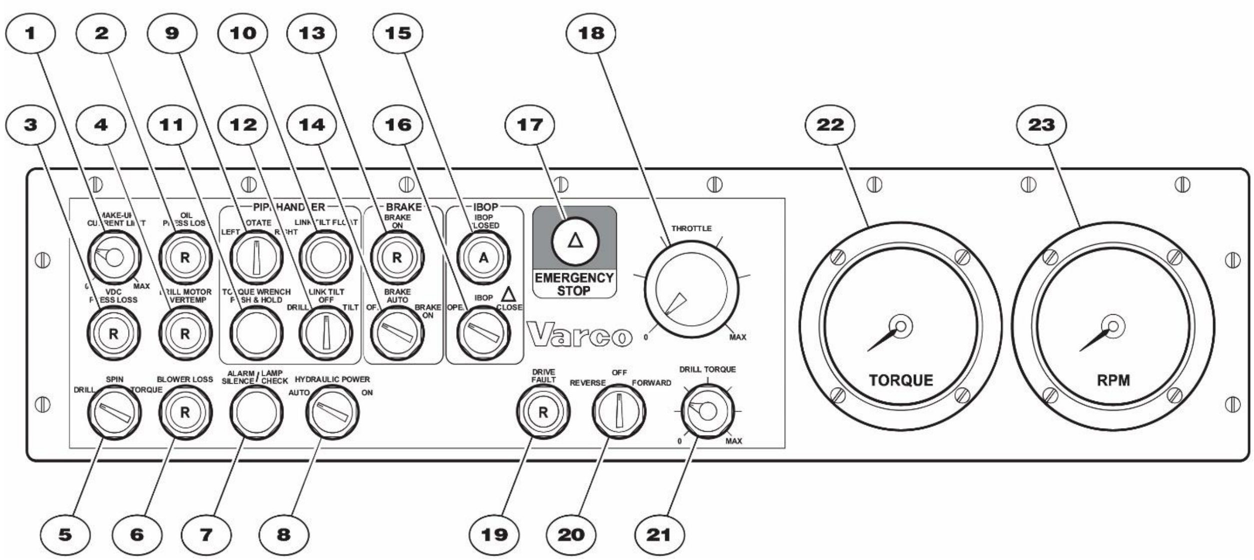


Figure 7.6

Figure 7.7

7.4 Operation of the Top Drive. The TDS-11's operations will be explained herein through the functional description of the Varco Driller's Console, in the pages that follow. For drilling and tripping instructions, please refer to the TDS-11 Operation Manual in your Student Thumb Drive.



1. MAKE UP CURRENT LIMIT

The term 'Make Up' means to connect & tighten drill pipe. This potentiometer adjusts the operator's torque limit when operating in TORQUE mode, by regulating electrical current output in the VFD House.

2. OIL PRESS LOSS

Short for "**Gear** Oil Pressure Loss." This red lamp flashes when the gear case oil pressure drops below 20-18 PSI descending. The normal pressure of the gear case is 33 PSI +/- 3. There is no oil pressure loss indication for hydraulic fluid on the TDS-11.

3. VDC PRESS LOSS

This red lamp flashes normally unless the driller's console is equipped with air pressurization. It indicates that there is a loss of air pressure in the Driller's console. VDC = Varco Driller's Console. Note: Class I Div I explosion-proofing applies here and should be adhered to (pressurization required, like in a Driller's Cabin). Ironically, I've never seen a TDS-11 Console in the field that is pressurized.

4. DRILL MOTOR OVERTEMP

This red lamp flashes when one or both of the drilling motors are overheating, or when there's an open Motor RTD circuit (broken wire in 42-pin plug, pin not making contact, etc.) Always treat this alarm seriously in case of an actual overheat condition (ensure blower airflow from the bottom vents of each motor / compare temps with a temp gun).

5. DRILL / SPIN / TORQUE

This three-position mode selection switch can remain in the fixed position "DRILL" (drill—normal during drilling operations) or "SPIN" (spin—rotates at a fixed or preset speed). Switch must be held in the "TORQUE" position to make or break a connection (spring-loaded to return from TORQUE to SPIN).

6. BLOWER LOSS

This red lamp flashes if there is a loss of cooling air from one or both blowers, or in the event of a faulty or maladjusted blower pressure switch.

7. ALARM SILENCE / LAMP CHECK

This pushbutton should be held in before operating the Top Drive, to test all warning lamps for operation. Holding the button for five seconds should also test the RPM and TORQUE gauges (the needle of each gauge will move from zero through maximum value, then return back to zero). This button may also be pushed to acknowledge an alarm. If fault is not reset, alarm will return in five minutes. Pressing this button will not clear any critical alarm.

8. HYDRAULIC POWER AUTO / ON

This two-position switch can remain in "AUTO" to allow the hydraulic pump to be turned on automatically when either drill mode is selected (forward / reverse) and throttle actuated, or it can be switched into the "ON" position to energize the pump when desired.

9. ROTATE LEFT / RIGHT

This three-position switch is spring-loaded to return to the center position (Off). Holding the switch in the "LEFT" position will rotate the Pipe Handler in the counter-clockwise position. Holding the switch in the "RIGHT" position will rotate the Pipe Handler in the clockwise position. Note: the Pipe Handler will not rotate unless the Elevators are in the "FLOAT" position.

10. LINK TILT FLOAT

Depressing this pushbutton will fully relax the Link-Tilt Cylinders, allowing the Elevators to be in the neutral position and enabling the Driller to rotate the Pipe Handler or operate the torque wrench.

11. TORQUE WRENCH PUSH & HOLD

Holding this pushbutton in will allow the Pipe Handler to rotate enough to be locked into place by the Shot Pin, and will then engage the Pipe Clamp. Note: The clamp will not engage if the brakes are engaged, the links are extended, or the throttle is open.

12. LINK TILT DRILL / OFF / TILT

This switch has three fixed positions: "DRILL" will move the Elevators to the maximum extended position to allow the operator to drill down. "TILT" will extend the Elevators in the opposite direction. In the "OFF" position, the Elevators will remain in their last position until commanded otherwise.

13. BRAKE ON

This red lamp illuminates when the Brake Solenoid Valve is energized.

14. BRAKE OFF / AUTO / ON

This switch has three fixed positions. When "ON," the Brake Solenoid is energized. When placed in the "AUTO" position, the brake is released when the throttle is advanced and the brake is set when the throttle is off. In the "OFF" position, the brake is released. If a Drive Fault is indicated in the VFD, the brake will engage regardless of switch position.

15. IBOP CLOSED

This amber-colored lamp illuminates when hydraulic pressure is applied to the cylinder that closes the IBOP valve. It receives that pressure indication from the IBOP Pressure Switch.

16. IBOP OPEN / CLOSE

This switch has two positions. In the "OPEN" position, the IBOP actuator cylinder extends to open the IBOP Valve. In the "CLOSED" position, the IBOP actuator cylinder retracts to close the IBOP Valve.

17. EMERGENCY STOP

This red mushroom-style pushbutton, when depressed, will automatically slow the drilling speed to approximately 25 RPM (regardless of throttle position) and set the brake. All auxiliary functions (hydraulics / robotics) will remain enabled.

18. THROTTLE: 0 – MAX

This knob controls the speed of the drill motors when in operating in DRILL mode, by sending a reference signal to the VFD House. The resulting speed is indicated on the Tachometer.

19. DRIVE FAULT

This red lamp flashes when a VFD fault has been detected. It can also indicate an air conditioner overpressure fault. If configured, the Top Drive will slow to approximately 25 RPM, then the brake will set.

20. REVERSE / OFF / FORWARD

This switch has three fixed positions: "FORWARD," "OFF," and "REVERSE." FORWARD and REVERSE are used to select drill rotation, and to make or break a connection. This switch also assigns commands to the auxiliary motors when the Hydraulic Selector Switch is in the AUTO position. The "OFF" position deselects the VFD.

21. DRILL TORQUE: 0 – MAX Continuous

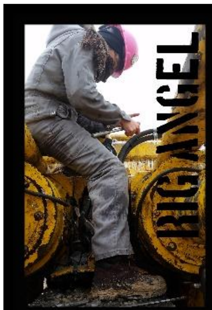
This potentiometer sets the current limit in the VFD during drilling operations. It is used to set the maximum allowable drill pipe torque. It is adjusted by setting the brake and adjusting the knob to increase or decrease the torque. This adjustment is indicated on the Torquemeter.

22. TORQUE METER

This gauge displays drill pipe torque in foot-pounds. In DRILL mode, torque is set by the DRILL TORQUE potentiometer. In TORQUE mode, torque is set by the MAKE-UP CURRENT LIMIT potentiometer.

23. TACHOMETER

Displays drill pipe rotational speed in RPM. Rotational speed is controlled by the throttle control knob.



CHAPTER 8

SERVICING AND PERIODIC MAINTENANCE

CHAPTER 8:
Servicing and Periodic Maintenance

The following pages detail the scheduled PM's of a TDS-11 Top Drive. They are broken down into the following periods, derived from the *TDS-11 Service Manual* using the same language as the manufacturer (for example, '3 Month' as opposed to 90 Day or X operating hours [hours are included for suggestion only]):

(1)	Daily	(3)	Monthly	(5)	6 Month
(2)	Weekly	(4)	3 Month	(6)	Annual

Additional inspections of a more detailed nature include the TDS-11 Commissioning Inspection (NOV proprietary), the 5-Year Recertification per API 8C, and special inspections. The Student Thumb Drive contains the *TDS-11 Service Manual*, a 5-Year checklist and a Post-Jarring inspection procedure.

Some of the inspection items have been reassigned to a different schedule of periodic maintenance, based on industry standards derived from conditions monitoring data. For example, the reliability of shot pin seals allows for replacement at six months, not one month as originally directed by OEM. Conversely, the quill end play should be checked at least every six months, to monitor deficiencies that could lead to catastrophic failure of drive components.

IMPORTANT SAFETY NOTE: ALL INSPECTION AND SERVICING PROCEDURES ARE TO BE PERFORMED ON A UNIT THAT IS DE-ENERGIZED AND LOCKED OUT, UNLESS OTHERWISE SPECIFIED!!! FOR PROCEDURES THAT REQUIRE THE VISUAL OBSERVATION OF MOVING COMPONENTS, ENSURE THAT THEY DO NOT CONFLICT WITH YOUR DRILLING COMPANY'S OR OPERATING COMPANY'S POLICIES.

TDS-11 TOP DRIVE -- DAILY SCHEDULE

To Be Completed During Rig Service

RIG #____________ RIG MANAGER: ______________________________

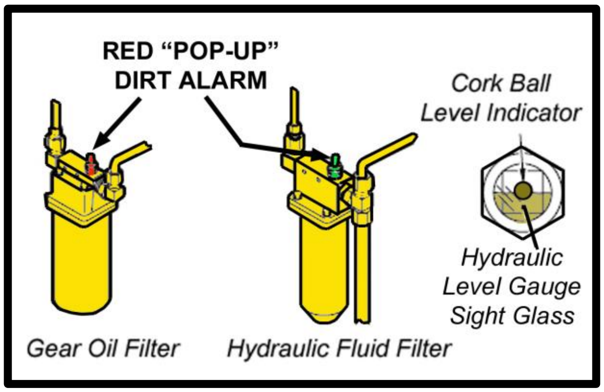
DATE: ______________________ INSPECTOR: ______________________________

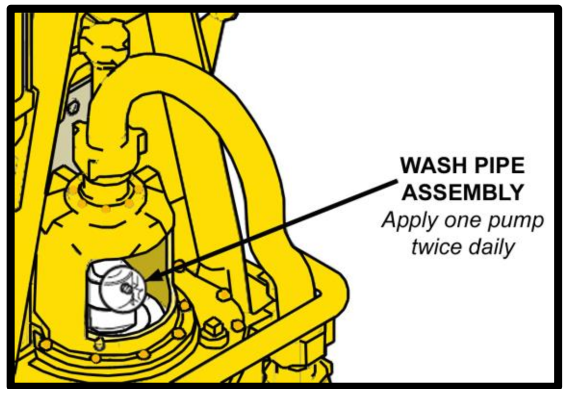
EQUIPMENT S/N: ______________________ ASSET #: ________________

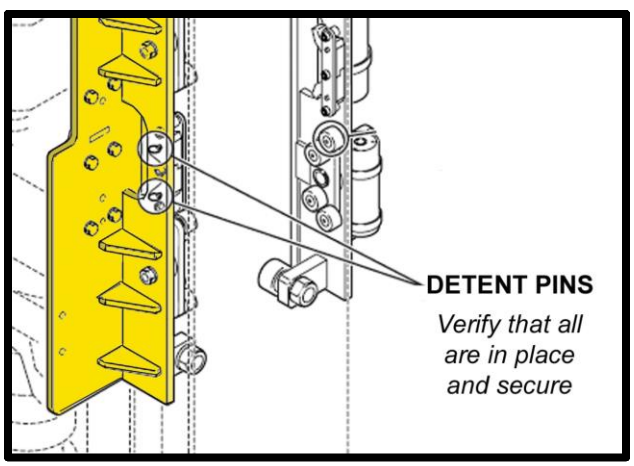
Component	**Lubrication Points**	**Type**	**Initial**
Wash Pipe Assembly	1	Grease	________
IBOP Actuator Cranks	2	Grease	________
IBOP Yoke & Cylinder Pins	5	Grease	________
Stabilizer Bushing	4	Grease	________
Clamp Cylinder Gate	2	Grease	________
Gear Oil	Check / Add	Amt.______	________
Hydraulic Oil	Check / Add	Amt.______	________
Shot Pin Assembly	Check	Proper Operation	________

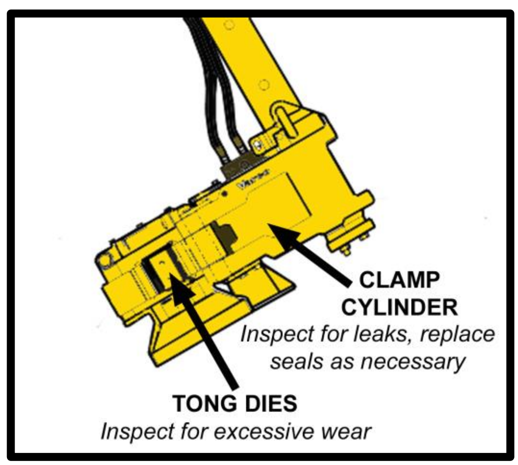
Visual Inspection	**Check For:**	**Initial**
TDS Motor Assembly	Loose bolts, fittings, safety wire, cotter pins, ensure both blowers are working	________
Pipe Handler	Loose bolts, fittings, safety wire, cotter pins, tong dies	________
Upper / Lower IBOP Valves	Proper Operation	________
Top Drive Assembly	Leaking hoses, connectors, Wash Pipe, alignment over well center	________

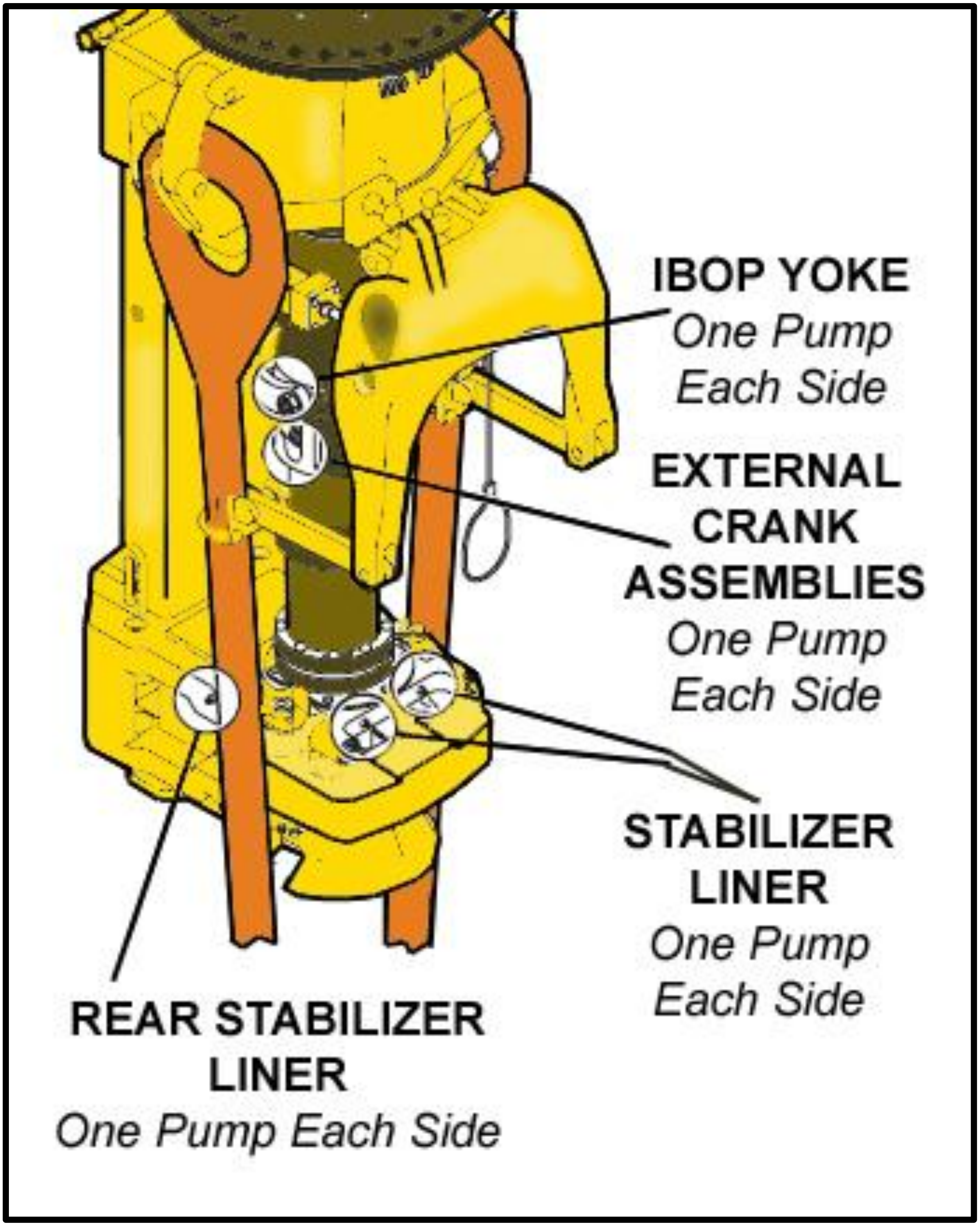
Carriage & Guide Beams	Missing / loose / damaged retainer pins, lynch pins, track pins, rollers, fasteners	_______
TDS Controls	Verify Operation	_______
Hydraulic & Gear Oil Filters	Indicator Pop-up	_______
RLA / Link Tilt	Lift operation, pins, clevises, leaks, Hoses, link tilt bolts	_______










IBOP YOKE
One Pump
Each Side
EXTERNAL
CRANK
ASSEMBLIES
One Pump
Each Side
STABILIZER
LINER
One Pump
Each Side
REAR STABILIZER
LINER
One Pump Each Side

TDS-11 TOP DRIVE -- WEEKLY SCHEDULE

To Be Completed After 160 Drilling Hours, in conjunction with Daily Service

RIG #____________ RIG MANAGER:______________________________

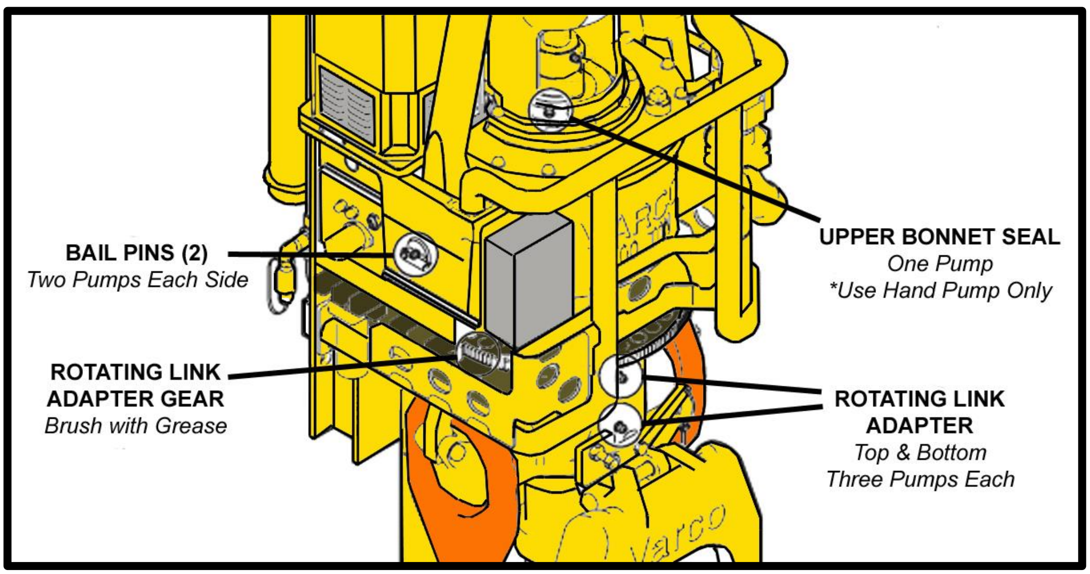
DATE:______________________ INSPECTOR:__________________________

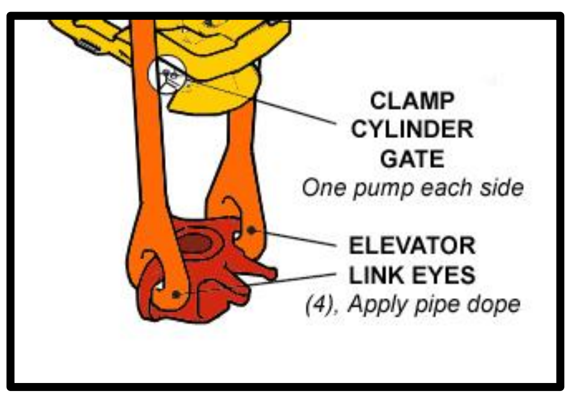
EQUIPMENT S/N:_______________________ ASSET #:________________

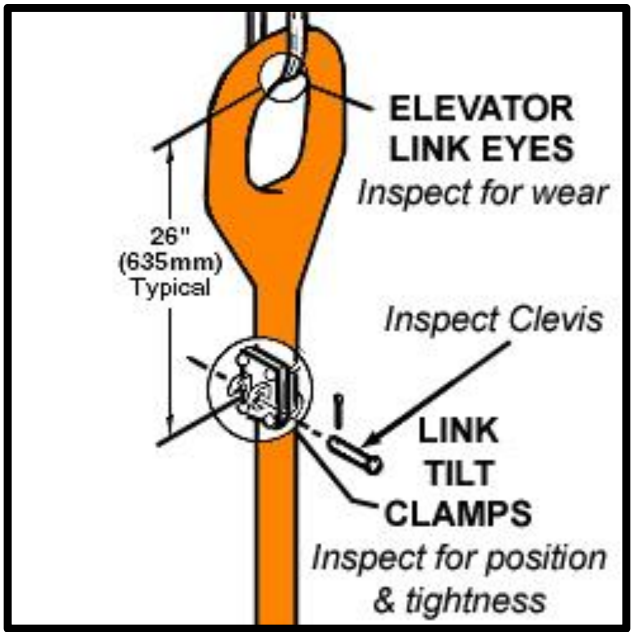
Component	Lubrication Points	Type	Initial
Upper Bonnet Seal	1	Grease	________
Bail Pins	2	Grease	________
Rotating Link Adapter Gear	Teeth	Grease	________
Rotating Link Adapter	2	Grease	________
Upper IBOP Valve	1	Grease	________
Carriage Assembly	20	Grease	________
Wireline Adapter	2	Grease	________
External Link Eyes	4	Pipe Dope	________
Clamp Cylinder Torque Arrestor	4	Grease	________

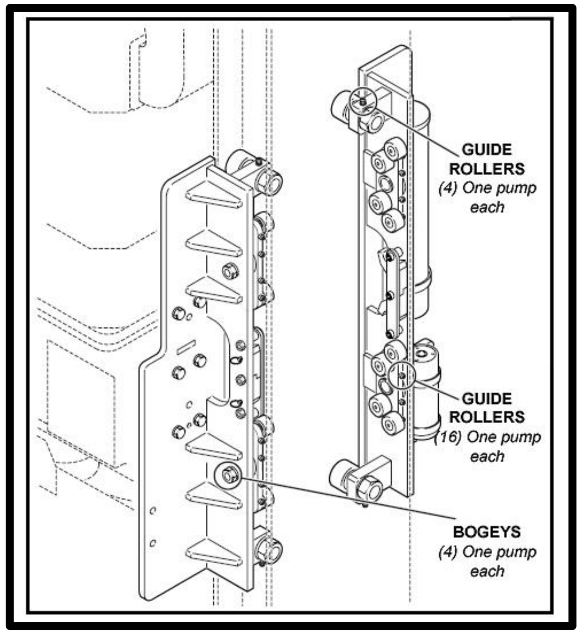
Visual Inspection	Check For:	Initial
Top Drive Assembly	All bolts tightened and wire tied	________
Service Loops & All Wiring	Damage, abrasions, and snag points	________
Link Tilt	Pins, yokes, position & tightness	________
Stabbing Guide & Flippers	Damage and wear	________
Stabilizers	Wear	________

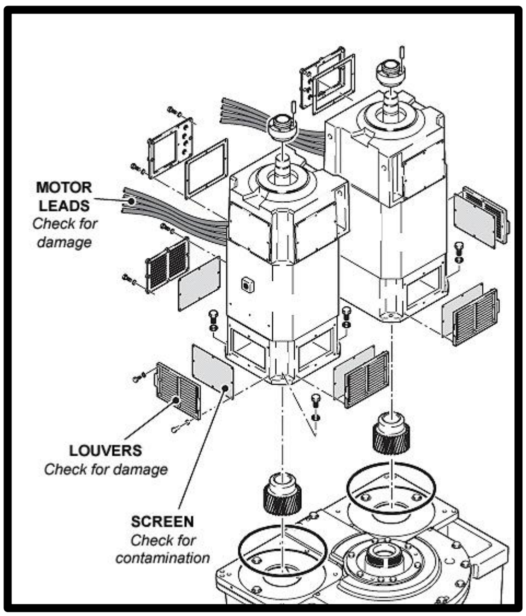
IBOP Actuator Cylinder	Leaks and tight fittings	_______
IBOP Actuator Rollers	Wear, flat spots, excessive play	_______
Tool Joint Locks (Fetters)	Loose bolts	_______
Upper & Lower IBOP's	Damage	_______
Crown Padeye	Weld cracks or other damage	_______
Guide Beam Joints	Weld cracks or other damage	_______
Carriage, Gd Bms, Tiebacks	Missing, loose, damaged hardware / welds	_______
Carriage Rollers	Damage, wear, excessive play	_______

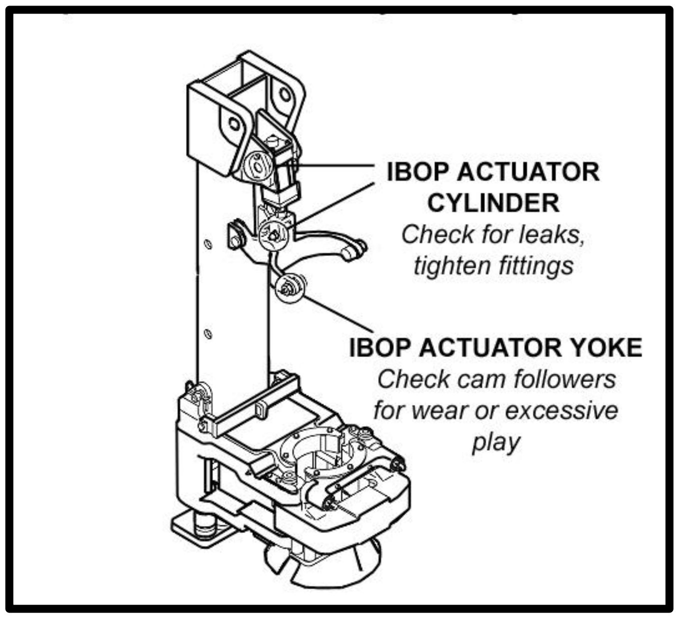


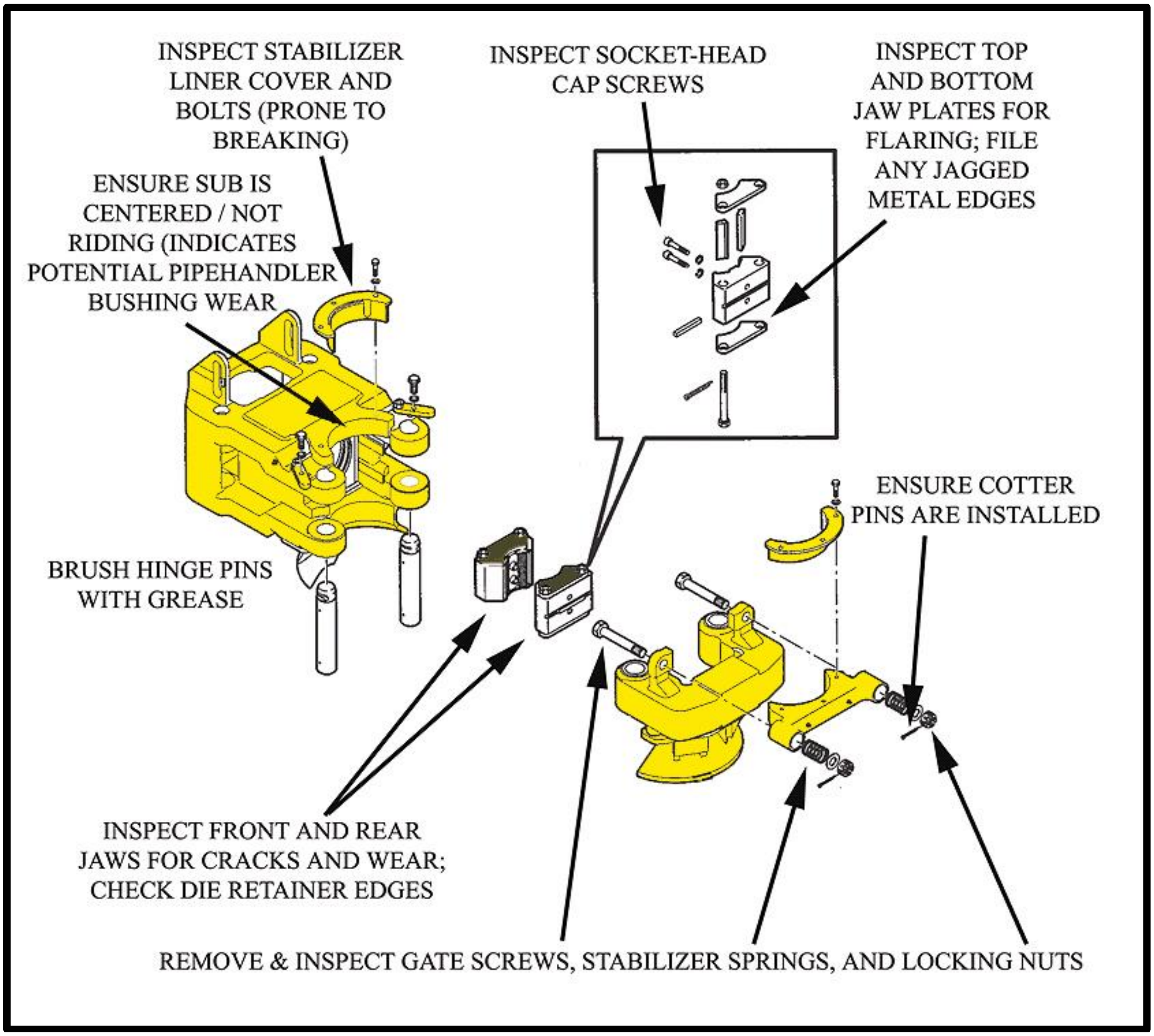



ELEVATOR
LINK EYES
Inspect for wear
26"
(635mm)
Typical
Inspect Clevis
LINK
TILT
CLAMPS
Inspect for position
& tightness


GUIDE
ROLLERS
(4) One pump
each
GUIDE
ROLLERS
(16) One pump
each
BOGEYS
(4) One pump
each


MOTOR
LEADS
Check for
damage
LOUVERS
Check for damage
SCREEN
Check for
contamination


IBOP ACTUATOR
CYLINDER
Check for leaks,
tighten fittings
IBOP ACTUATOR YOKE
Check cam followers
for wear or excessive
play


INSPECT STABILIZER LINER COVER AND BOLTS (PRONE TO BREAKING)
INSPECT SOCKET-HEAD CAP SCREWS
INSPECT TOP AND BOTTOM JAW PLATES FOR FLARING; FILE ANY JAGGED METAL EDGES
ENSURE SUB IS CENTERED / NOT RIDING (INDICATES POTENTIAL PIPEHANDLER BUSHING WEAR
ENSURE COTTER PINS ARE INSTALLED
BRUSH HINGE PINS WITH GREASE
INSPECT FRONT AND REAR JAWS FOR CRACKS AND WEAR; CHECK DIE RETAINER EDGES
REMOVE & INSPECT GATE SCREWS, STABILIZER SPRINGS, AND LOCKING NUTS

TDS-11 TOP DRIVE -- MONTHLY INSPECTION

To Be Completed After 600 Drilling Hours, along with Daily & Weekly Service

RIG #____________ RIG MANAGER: ______________________________

DATE: ______________________ INSPECTOR: ______________________________

EQUIPMENT S/N: ______________________ ASSET #: ____________

Visual Inspection	**Check For:**	**Initial**
Gearbox Oil & Filter	Take oil sample, replace filter as req'd	________
Hydraulic Oil & Filter	Take oil sample, replace filter as req'd	________
Main Body	Oil flow with lube pump running	________
Upper Main Shaft Liner	Erosion caused by leaking Wash Pipe	________
Upper Bearing Retainer	O-Ring, oil seal, isolator bearing wear	________
Blower Motor Assemblies	Loose or missing bolts	________
Brake Pads	Wear	________
Elevator Link Eyes	Wear	________
Link Tilt Bushings	Wear	________
L/T Cylinder Clevis Pins	Wear	________
IBOP Actuator Yoke	Excessive play or wear	________

Shot Pin Assembly Wear or damage ________

Hang-off Link, Bolt, Shackle Missing pins, worn bores, other damage ________

DETAILED DESCRIPTION OF DISCREPANCIES & ACTIONS TAKEN:

Inspector Signature / Date: ______________________________ / __________

Rig Manager Sign / Date: ______________________________ / __________

TDS-11 TOP DRIVE – 3-MONTH INSPECTION

To Be Completed After 1800 Drilling Hours, along with Daily, Weekly, and Monthly Schedules. Inspect during rig move beginning on old location.

RIG #____________ RIG MANAGER:____________________________

DATE:____________________ INSPECTOR:____________________________

EQUIPMENT S/N:________________________ ASSET #:________________

Gearbox Oil & Filter: If no recorded change in past three months, remove & replace filter. Replace oil if required.

____

Hydraulic Oil & Filter: If no recorded change in past three months, remove & replace filter. Replace oil if required.

____

Carriage Assembly: (If equipped) – Inspect bolts and roll pins to ensure they are secure and undamaged. Inspect bogey assemblies for wear.

____

Tie-Back Assembly: Inspect for evidence of movement / TD wellbore alignment. Adjust A/R. Inspect clamps and pins for damage.

____

Encoder & Cable: Visually inspect encoder and complete cable for signs of damage or stress. Check belt tension physically by feeling under encoder sled. Verify TD is operating in encoder mode (not in bypass).

____

Hydraulic Heat Exchanger: Inspect tubing for cracks or leaks; look for missing or smashed fins. Replace A/R.

____

Brake Rotors: Check for grooving, pitting, heat damage, and wear. ________

Motor Shafts: Using a dial indicator, measure shaft end play and record findings: If either finding is >0.050," have RM notify DS of an impending motor failure.

____

DS: ______________________

ODS: ______________________

Reservoir Bladder: Remove breather and inspect bladder with a bright flashlight. If fluid is noticed, remove reservoir lid and replace bladder and lid gasket.

____

Top Drive Track: With track hung, inspect transition areas to ensure there are no snag points, including damaged metal and damaged track bushings near the pin ends. Ensure that the TD Dog locks pins are secured with keepers and secondary retention lanyards / cables.

____

Dolly Assembly: Inspect stops, pins, and glide pads for damage or excessive wear. Apply grease to guide shoe alignment pins as required (until grease is visibly protruding). Glide pads should have a nominal thickness of 5/8." Replace as required.

____

Hydraulic Cylinders: Inspect all hydraulic cylinders for proper function, leaks at rod / fittings/ hoses, and other damage. Annotate findings on each below:

____

DS Link-Tilt: ____

ODS Link-Tilt: ____

DS Stand Jump: ____

ODS Stand Jump: ____

IBOP: ______________________________

Clamp Piston: ______________________________

Brake Calipers: ______________________________

Hydraulic Accumulators: Test each accumulator for proper nitrogen pre-charge. Service as required. Annotate the final pressure for each below:

____

Main (800 PSI): ________________

CB / Stand Jump (900 PSI): ________________

IBOP Time Delay (800 PSI): ________________

Load Collar: Carefully inspect for evidence of galling or heat damage near the top of the collar. Verify safety wire is installed. Notify RM immediately of any deficiencies.

____

IBOP Actuator: While having Driller work the controls, from a safe distance—using a flashlight—carefully inspect the movement of the IBOP yoke, sleeve, external crank assemblies and cam followers while rotating.

____

Auxiliary Electric Motors: Check the three auxiliary motors (HPU and blowers) to see whether each has grease fittings (or plugs that can be removed for the momentary installation of grease fittings), or whether they have sealed bearings, requiring no service. Circle the type of each for future inspection purposes:

DS Blower _Has Grease Fittings / Sealed Bearings _________

ODS Blower _Has Grease Fittings / Sealed Bearings _________

HPU _Has Grease Fittings / Sealed Bearings _________

For any motor that has grease ports that are plugged, temporarily install a grease fitting. Apply 3 pumps to each bearing on each motor. USE ONLY dielectric grease, such as the Black Pearl EP2 used on drilling motors.

Disconnect the 19-Pin from the TD. Using a megger, test 1, 2, and 3 to each other, and then to pin # 4 (HPU three phases / pin #4 is ground), Repeat with pins 5-8 (with 8 being ground) for one blower, then repeat with pins 9-12 (with 12 being the ground) for the other blower. *Note: Few electricians follow protocol per NOV prints when wiring auxiliaries; for this reason it's impossible to say which blower's wires power which blower, for any given rig.* Record your megger readings; values in parentheses are the standard:

HPU Phase-to-Phase:	Phase-to-Ground
(0Ω) ____________________	(> 1 MΩ) ____________________
(0Ω) ____________________	(> 1 MΩ) ____________________
(0Ω) ____________________	(> 1 MΩ) ____________________

Blower 1 Phase-to-Phase:	Phase-to-Ground
(0Ω) ____________________	(> 1 MΩ) ____________________
(0Ω) ____________________	(> 1 MΩ) ____________________
(0Ω) ____________________	(> 1 MΩ) ____________________

Blower 2 Phase-to-Phase:	Phase-to-Ground
(0Ω) ____________________	(> 1 MΩ) ____________________
(0Ω) ____________________	(> 1 MΩ) ____________________
(0Ω) ____________________	(> 1 MΩ) ____________________

Drill Motors: Remove at least one motor access panel and one vent from each motor to conduct a thorough visual inspection. Ensure rotor is not rubbing against pigtail leads. If visible, ensure RTD / heater wire bundle is properly terminated and not stretched or pinched. Look for evidence of oil seal blowout (grease everywhere) and make a note of findings.

____

For each drill motor, locate the top and bottom grease fittings or tamper-proof plugs, then locate the relief ports for each. For the lower bearing, the grease zerk and relief plug should be near each other. For the upper bearing, the servicing point should be facing outboard and the relief port should be on the inboard side, facing its sister motor. Remember that these are sealed grease circuits… if you pump grease into them without removing each grease fitting's corresponding relief, then you'll only be placing undue pressure against the motor bearing seals. Remove each relief cap and pump ONLY Chevron EP2 grease into each circuit until the grease begins to free-flow out of the relief port. Cap it all back off and teach hands not to touch electric motors on rig service.

____

Take a megger reading of each drill motor's phases. Per OEM, readings to ground should be better than 1 MΩ.. Readings between Phases should produce 0.0Ω on the meter.

Power Plug Phase-to-Phase:	Phase-to-Ground
(0Ω) ____________________	(> 1 MΩ) __________________
(0Ω) ____________________	(> 1 MΩ) __________________
(0Ω) ____________________	(> 1 MΩ) __________________

Service Loops: Disconnect both ends of the 19-Pin, 42-Pin, and Power Service Loops from the Top Drive and VFD House. Use a multimeter to test resistance (check ohms) from pin-to-pin on both ends of the multiconductor cables. Visually inspect all plugs to include barrel threads & locking nuts, making note of pin damage or misalignment, heat damage, or evidence of moisture. Lubricate power pins (red / white / black power service loop connections) with approved electrical lubricant such as 2-26 before re-installation. Do not use electrical lubricant on multi-pin plugs such as the 19- and 42-pin.

____

Pipe Handler: Conduct a detailed inspection of the PH75, checking pin connections, front and rear stabilizers, proper operation of clamp cylinder, and hose / fitting integrity. Ensure that no hardware is missing or improper for application, and that all hardware is safety wired. Remove one of the two grabber assembly gate hinge pins and check its diameter using Vernier calipers. OEM OD is 2.25." Acceptable wear is 0.020." Measure pin boss to ensure it is not worn beyond 2.30." Apply standard NGLI grease to pin boss. Make note of whether or not the grabber assembly is outfitted with a secondary gate pin retainer plate underneath. If so, ensure it is properly attached and secured with safety wire. With the jaw open, measure the thickness of the stabilizer liner. OEM OD is 1.0." Acceptable wear is 1.25." Check the dies and die holder blocks; re-torque die block bolts to between 80 and 85 ft-lbs. Re-install or replace components as required, then remove and check opposite gate hinge pin.

____

Upper Main Shaft: Remove the swivel pack (reverse threaded top and bottom). Using a large flat-blade screwdriver, remove the rubber bearing shield to expose the upper main shaft. Clean and inspect bearing shield. Coordinate with the Driller to have him screw into a test joint and set the slips, but do not have him lower the blocks to release weight. Using a dial indicator, check the quill end play / upper bearing tolerance as 25,000 ft-lbs is set on the slips according to the weight indicator. Record the change, if any. Acceptable end play is 0.001" – 0.002." If outside of tolerance, remove the bearing retainer and adjust the number of shims so that the end value is within acceptable tolerance.

____

Swivel Pack: Inspect seals, re-pack as required. ________

DETAILED DESCRIPTION OF DISCREPANCIES & ACTIONS TAKEN:

Inspector Signature / Date: ______________________________ / __________

Rig Manager Sign / Date: ______________________________ / __________

TDS-11 TOP DRIVE – 6-MONTH INSPECTION

To Be Completed After 3600 Drilling Hours, in conjunction with all prior Schedules. Inspect during rig move beginning on old location.

RIG #____________ RIG MANAGER:______________________________

DATE:____________________ INSPECTOR:______________________________

EQUIPMENT S/N:__________________________ ASSET #:__________________

Gearbox Oil & Filter: If no recorded change in past three months, remove & replace oil and filter.

____

Hydraulic Oil & Filter: If no recorded change in past three months, remove & replace oil and filter.

____

Upper Main Shaft: Remove upper stem liner and replace polypack seal.

____

S-Pipe: Remove S-Pipe and conduct a detailed visual inspection. Scrape paint on any areas that display potential corrosion, erosion, or pitting. Surface damage must not exceed 0.125.” Use a flashlight to thoroughly inspect visible areas of the bore. If evidence of internal pitting or corrosion exceeds 0.125,” order an ultrasonic inspection and pressure test.

____

Shot Pin Assembly: Remove and disassemble the Shot Pin Assembly. Visually inspect the pin and pin bore. Replace all seals, reassemble and reinstall unit.

____

Hang-off and Track Assembly:

Prior to inspecting the track and its components, be sure that all rigging and hoisting components are serviceable, and that personnel involved in rigging up / down the Top Drive are trained and competent. Rigging components may include, but are not limited to: crane, pole truck, forklift, slings, cables, shackles, pick-up and tag lines, Drawworks, Blocks, drill line, winches & hoists, and controls.

For the following items, inspect the welds, bushings, pins and pin bores, keepers, and hooks for general integrity. Ensure all track components are clean and free from debris. 2" pins have a maximum allowable OD wear of 0.005." Pin bushings and bores have a maximum allowable ID of 2.045." For each section, MPI lifting lugs / hooks and all welds within a 3'distance from each end of the track. Inspect track for roller wear and use a grinding disk and / or soft flapper wheel to smooth over surface grooves and sharp edges. Perform dye penetrant test of all pin welds. Additional inspection items for each component, if any, are annotated. Refer to the TDS-11 Service Manual and to the track bushing prints in the Service & Inspection section of your Student Drive.

Hang-off Link	Inspect the plate holes for elongation, stress, mushrooming or other fatigue / deficiency. Ensure the link straight, and of proper length for track standoff from drill floor. MPI link ends.	________
Lifting Carriage	Inspect weldment, wire rope sling, eyelets, clevises and connection points.	________
Hang-off Track Section		________
Short Track Section		________
Intermediate Sections		________
TD Connection Section		________
Top Drive Skid		________

DETAILED DESCRIPTION OF DISCREPANCIES & ACTIONS TAKEN:

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Inspector Signature / Date: ______________________ / ________

Rig Manager Sign / Date: ______________________ / ________

TDS-11 TOP DRIVE – ANNUAL INSPECTION

To Be Completed After 7200 Drilling Hours, in conjunction with all prior Schedules. Inspect in a controlled (shop) environment. *Note: the OEM does not give a specified 'Annual Inspection' procedure, only a number of items which much be addressed annually (some of these are covered in earlier inspection schedules, based on general industry standards). The annual inspection procedure varies according to drilling contractor; some requiring a complete teardown and others requiring something more like a 6-month Rig Angel inspection procedure.*

ENSURE THAT VALVES / SUBS ARE BROKEN WHILE TD IS RIGGED UP, PRIOR TO SENDING TO SHOP

RIG #____________ RIG MANAGER:_____________________________

DATE:____________________ INSPECTOR:__________________________

EQUIPMENT S/N:____________________ ASSET #:________________

Top Drive: Teardown all except Transmission Gearbox; HPU / manifolds & associated plumbing; Carriage; Grabber Assembly; and J-Box, cables & wiring. MPI the following:

Quill / Main Shaft (exposed end… also inspect threads)
Load Collar
Bogey Roller Assembly Pins
Bail (3' of curved section and 2' from each end)
Bail Pins
RLA Link Ears and Retaining Brackets
RLA Torque Tube
Dolly Assembly (all welds)
Pear Links
Link-Tilt Crank Assembly (pin bosses)
Transmission Gearbox

As Top Drive is reassembled, replace all O-Rings, seals, and bushings

Encoder Belt: Remove and replace ________

Hydraulic System: R&R reservoir bladder, O-Ring and breather ________

Upper Main Shaft: R&R stem liner, wear sleeve, and isolator bearing ________

400 HP Drill Motors: Recondition (clean, dip & bake) ________

Brakes: Replace pads; inspect and turn rotors / rebuild calipers A/R ________

Rotating Link Adapter (RLA): Re-seal and pressure test @ 500 PSI ________

S-Pipe: R&R Seal ________

Swivel Pack: R&R Washpipe and re-pack ________

Bogey Roller Assemblies: Inspect rollers; if dimensional integrity and functionality are within OEM specs, re-pack with grease and re-use; otherwise replace. ________

DETAILED DESCRIPTION OF DISCREPANCIES & ACTIONS TAKEN:

Inspector Signature / Date: ______________________ / __________

Rig Manager Sign / Date: ______________________ / __________

CHAPTER 9

TDS-11

HYDRAULIC

SYSTEM

CHAPTER 9:
TDS-11 Hydraulic System

In this section, we will learn the following:

1. The number, location, & types of pumps on the TDS-11
2. The number, location, & types of hydraulic motors on the TD
3. The number, location, & types of cylinders / pistons on the TD
4. The number, location, & types of manifolds on the TD
5. The importance & components of the Main Hydraulic Manifold
6. How the Rotating Link Adapter works
7. The number, location & types of accumulators on the TD
8. Basic circuits, pressure settings and adjustments
9. Leak detection and Classes of Leaks

9.1 Introduction – As covered briefly in Chapter 6, the TDS-11 Top Drive has a self-contained, onboard hydraulic system. A 10-hp, 1800 rpm AC motor drives two hydraulic pumps that provide flow through the system. There is a third pump located on the Top Drive, which is a gear sump-type located in the Transmission Gearbox. Though it is not considered to be part of the hydraulic system, by machine classification it is a hydraulic pump, so we will cover it in this section.

9.2 Pumps – A **hydraulic pump** is used to <u>create flow</u>. Nearly all 'fluid power' hydraulic pumps are mechanically actuated and operated. A hydraulic pump may be reversible (bi-directional) or uni-directional. On the Top Drive, all three pumps are uni-directional and turn clockwise when viewed from their respective motors. A hydraulic pump may also be fixed displacement or variable displacement, meaning that the volume and pressure of fluid may (variable) or may not (fixed) be controlled. The TDS-11 has three pumps:

(1) A variable-displacement piston pump at the center of the HPU That supplies main hydraulic pressure to the Top Drive. This pump is located closest to the HPU electric motor, to which it

is coupled by way of an interconnecting safety device called a Lovejoy coupling. If the motor bearings seize while the pump is running, the Lovejoy is designed to disintegrate in order to save the pump. Similarly, if the pump catastrophically fails during operation, the Lovejoy coupling may save the motor and its electrical circuits from a surge due to load spike.

This is our main pump, responsible for all hydraulic functions (static motor brakes, powered rotating head, remote actuated IBOP, pipe backup clamp cylinder, link tilt, and counterbalance system). We use it to pressurize the Main Hydraulic Manifold, so that fluid power is available on-demand for use where the Driller commands it, as long as the HPU is energized. The power to energize the hydraulic pump, which is delivered through the 19-Pin Auxiliary Service Loop, is completely independent of the power supplied to rotate the Top Drive quill.

(2) A fixed-displacement vane pump on the end of the HPU, driven mechanically by rotational thru-transfer of electric motor torque (the vane pump's pinion shaft couples with the piston pump's shaft… for this reason, like any pump that is mechanically splined to another, it is often called a 'piggyback' pump). This cube-shaped pump's sole responsibility is to supply hydraulic pressure to the lube pump motor.

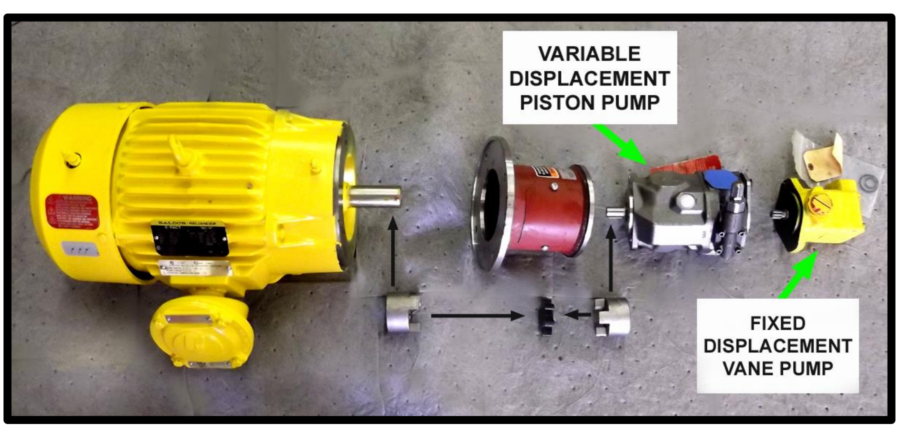


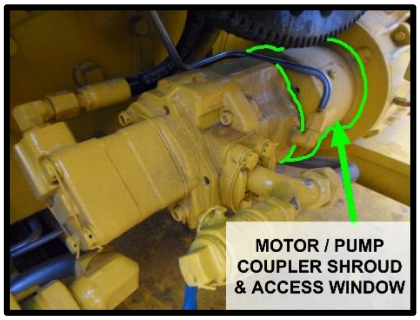
Figure 9.1

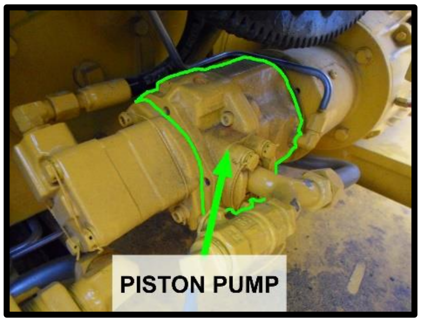
(3) A Gearbox-internal lube pump that circulates oil in the transmission to cool and lubricate the gears and bearings. It is not driven by an electric motor, rather a hydraulic motor, which is powered by the HPU vane pump. Note: the concept has drawn puzzled looks, even from engineers. Varco uses a motor to drive a pump that drives a motor which drives a pump. The images below were depicted in Chapter 6, but are provided again for reference.

Figure 9.2

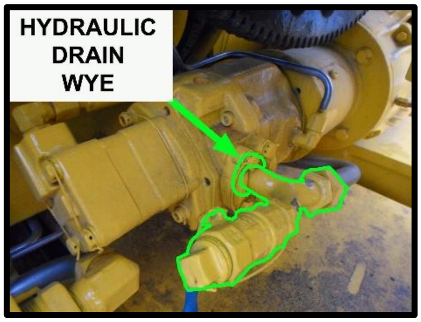
Figure 9.3

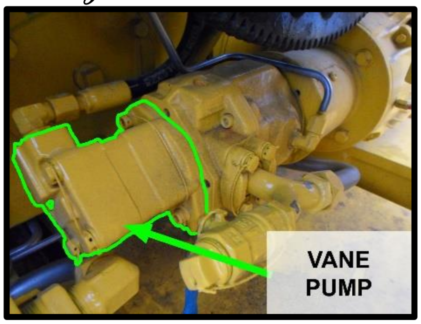
Here's another look at the HPU, as it is mounted on the Top Drive:





Clockwise from Top Left: Figures 9.4 – 9.7





9.3 Hydraulic Motors – On the previous page, Figure 9.2 depicts the gear lube hydraulic motor. You'll remember that a **hydraulic motor** converts hydraulic energy into mechanical energy. There are two hydraulic motors on the TDS-11—the other is mounted on the Shot Pin Assembly, and is used to turn the RLA by way of the RLA Gear.

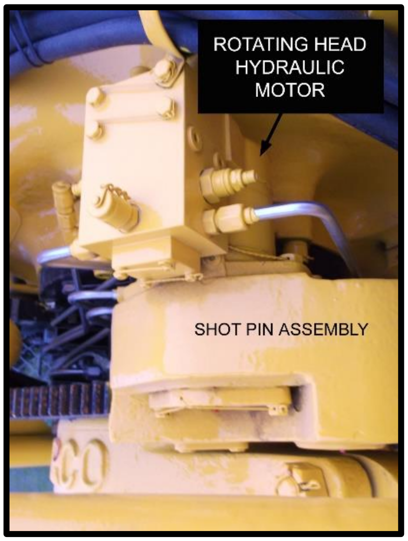


Figure 9.8

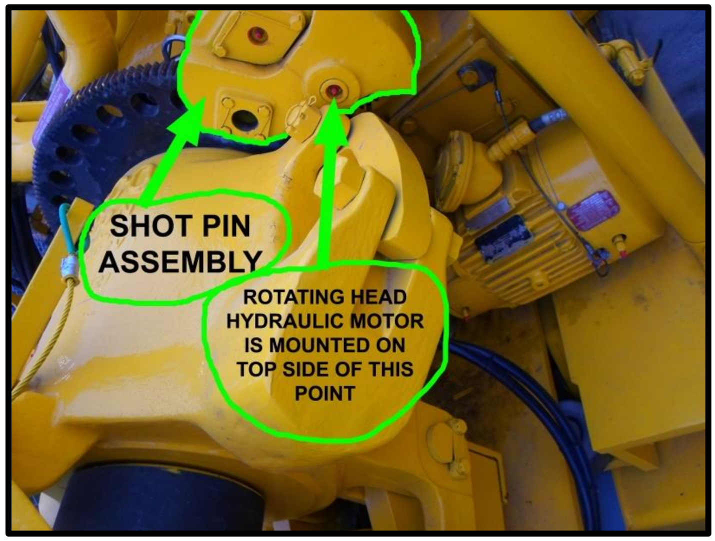


Figure 9.9

9.4 Cylinders and Pistons – A **hydraulic cylinder** or **piston** is a linear mechanical actuator which also converts hydraulic energy into mechanical energy. Technically, the word 'cylinder' describes the cylindrical housing or bore in which a piston moves, such as in the block of a gas combustion engine. However, in terms of part descriptions, an isolated piston / cylinder assembly used in hydraulics is called a hydraulic cylinder, and in the oilfield—outside of engine mechanic's circles—is usually referred to as simply a cylinder.

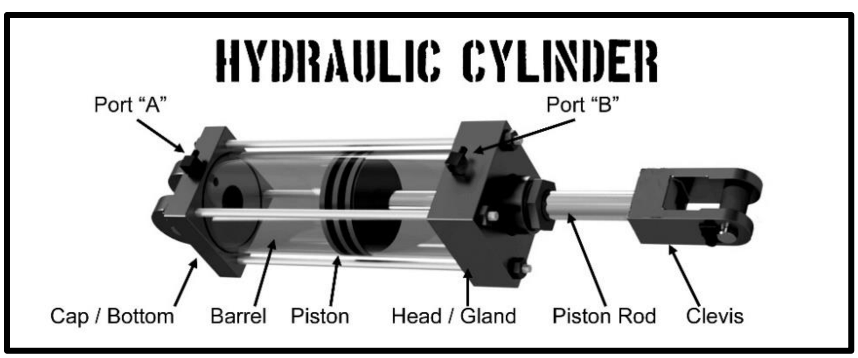
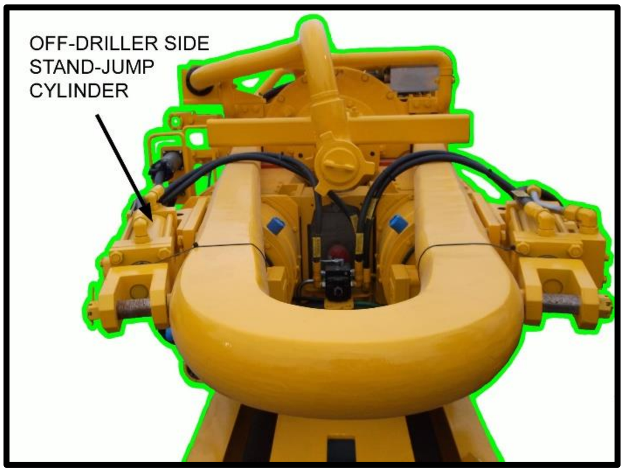
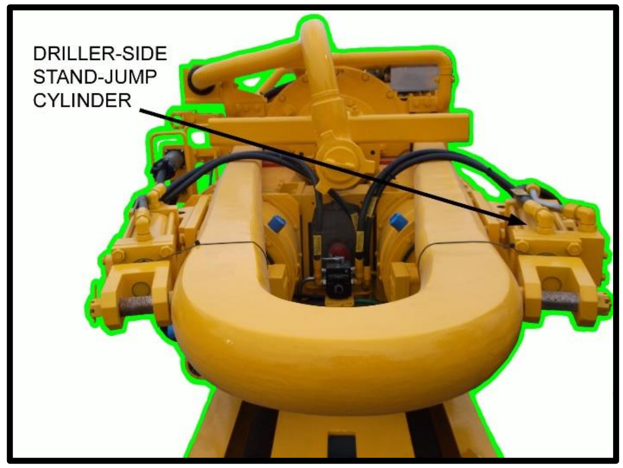


Figure 9.10 – Parts of a Hydraulic Cylinder

There are six different types of cylinders or pistons on the TDS-11:





Clockwise from Bottom Left – Figures 9.11 – 9.13

The two **Stand Jump Cylinders** work together to lift the weight of the Top Drive. Attached to either side of the TD Bail, they perform a literal pull-up when actuated by the Driller, to save the drill pipe and saver sub threads during connections. This action alleviates the problem posed by a combination of Top Drive weight and Drawworks control, by offering 'finesse' to block travel.

An **IBOP Actuator Cylinder** is mounted to the PipeHandler Assembly to allow opening and closing action of the upper IBOP safety valve.

Two **Link-Tilt Cylinders** control the fore / aft directional movement of the elevator links.

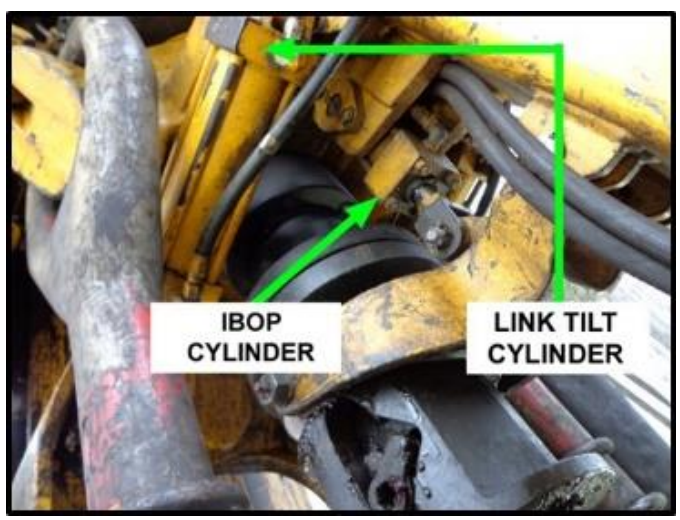
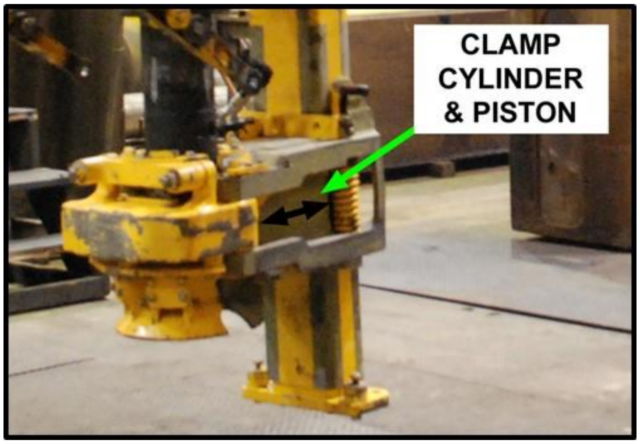
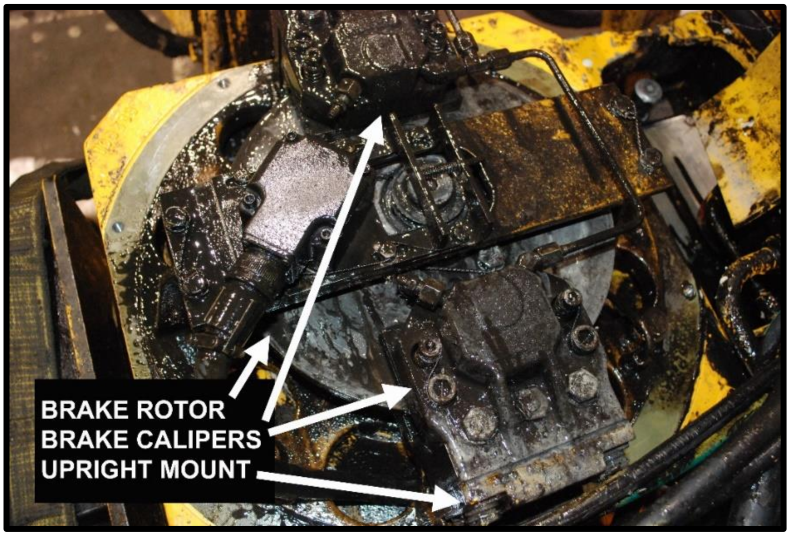


Figure 9.14



A large **Clamp Piston** is mounted inside the Grabber Assembly, allowing the Driller to grip pipe when making / breaking connections.

Another type of piston on the TDS-11 is found in the four static **brake calipers** (two per motor). Each caliper contains four hydraulic pistons that push the upper and lower brake pads against the brake rotor like a friction sandwich. For lack of a better image at the time this course was written, the picture below depicts the TDS-11 brakes and also serves as an example of how



Top Left – Figure 9.15 *Bottom Right – Figure 9.16*

messy the inside of a blower shroud can get when a brake caliper is leaking. The motor brakes on a TDS-11 (one set of brakes for each motor) are considered static or stationary brakes. Primary braking is provided by electrical current—the VFD receives the Driller's throttle inputs and reverses the phase sequence of the motors, sending the load current back to a braking chopper. The mechanical brakes depicted are essentially a parking brake, primarily used to hold a tool face position during directional drilling. When brake loads slip, the most common cause is the buildup of oily residue on the rotor and brake pads—usually resolved with a can of brake cleaner.

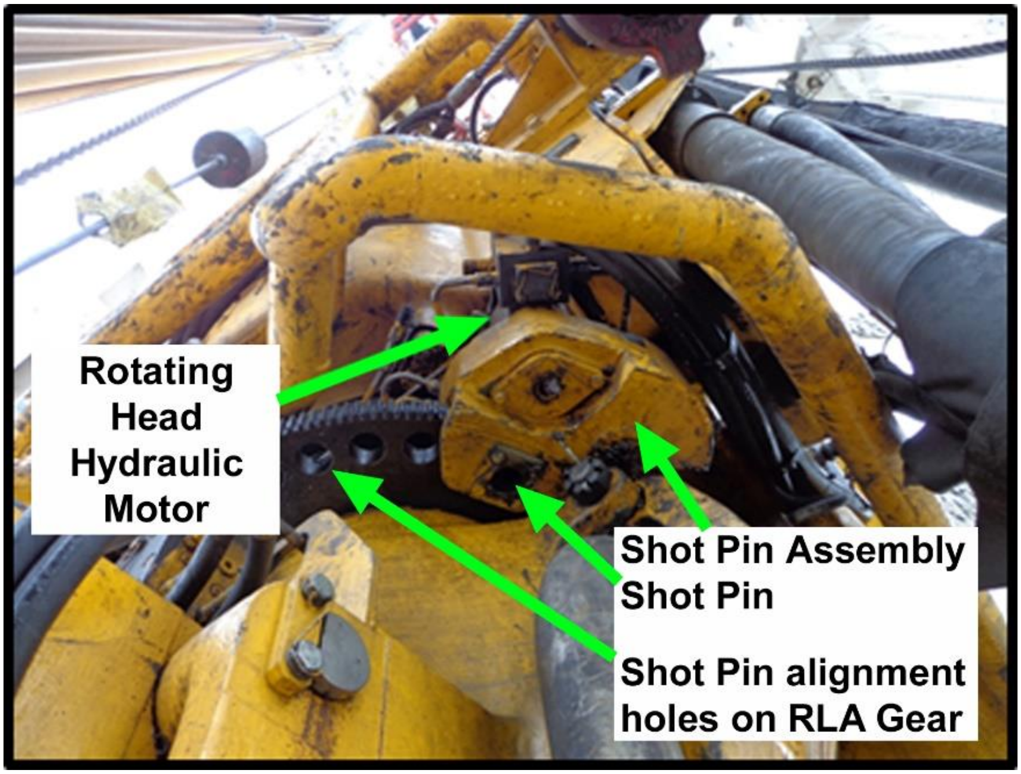


Figure 9.17

The final type of piston found on a TDS-11 is the **Shot Pin**. The Rotating Head Hydraulic Motor that is mounted on the Shot Pin Assembly allows for bi-directional rotation of the RLA Gear. That same gear is manufactured with outer perforations through which the Shot Pin may pass, to lock the Pipe Handler in a desired position.

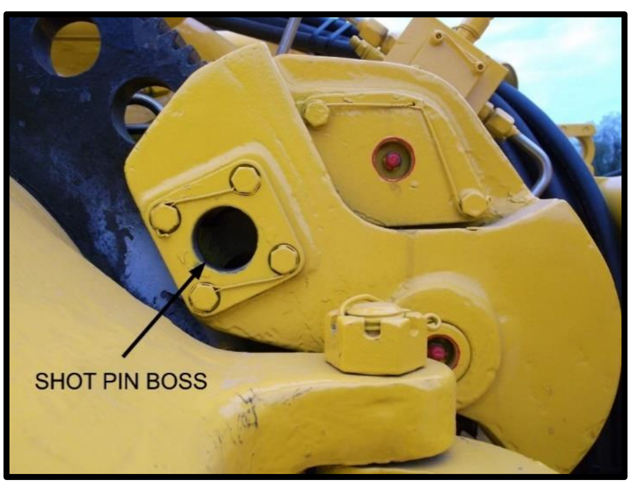
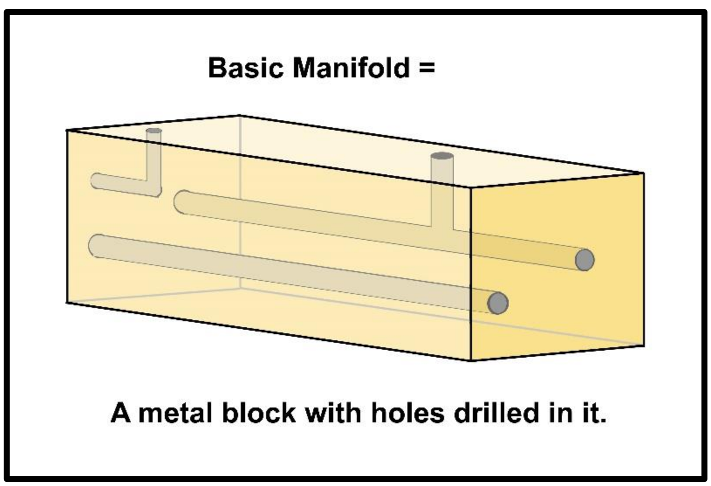


Figure 9.18

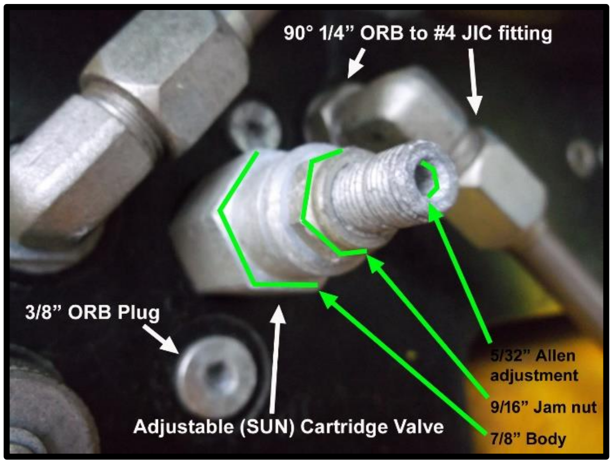
Hydraulically, the Shot Pin is located midstream in the Grabber Clamp hydraulic circuit. When the Driller selects *Torque Wrench* to engage the grabber for making or breaking pipe connections, fluid flows from the Torque Wrench Clamp SOV at the Main Manifold to the Shot Pin Manifold, which is mounted to the Shot Pin assembly. Fluid is then directed over the top

of the piston pin (400 PSI to actuate), forcing the pin to travel 2.84" through the RLA Gear. The pin is then held down by system pressure (2,200 PSI by the book… ~2,100 PSI actual) as the pressurized fluid continues to through the RLA to the Clamp Piston at the grabber assembly. If the Shot Pin does not 'find'—or align with—a hole on the RLA Gear, the Torque Wrench clamp piston will not engage. The most common cause of this failure is fluid debris that finds the smallest restrictions in the circuit—the A5 and B5 orifices on the Main Manifold.
9.5 Manifolds – A manifold performs the same function for the hydraulic system that a traffic intersection does for a street system. Hydraulic fluid is restricted, blocked, or diverted into different directions, through valves and orifices that are internally or externally attached to the manifold. This is used to control flow and pressure to meet the requirements of downstream components. There is nothing magical about a manifold. From a machinist's standpoint, it's just a block of metal—can be steel or aluminum—that is bored out in multiple places to an engineered design.

Figure 9.19



After boring and surface treating, design engineers use the manifold as a platform for adding devices to each hydraulic circuit in the system, customed to support the downstream component requirements:



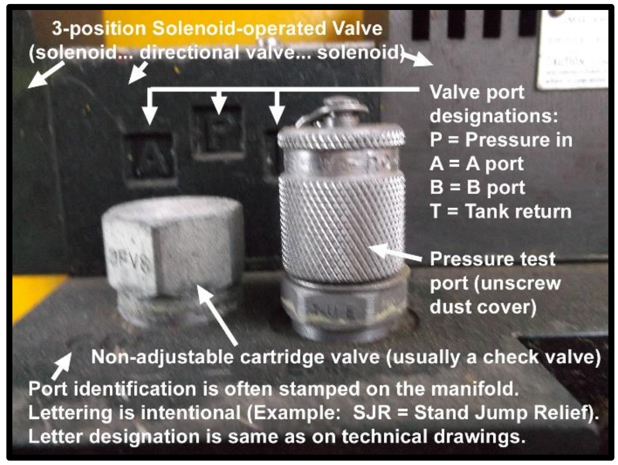


Figure 9.20 *Figure 9.21*

There are five prominent manifolds on the TDS-11 Top Drive. By prominent, that is to say they support more than a single valve, in which case they are commonly referred to as valve blocks or valve bodies. They are the Counterbalance or Prefill Valve Manifold, the Link-Tilt Manifold, the Shot Pin Manifold, and the RLA—which is classified as a rotary manifold. The final and most important is the **Main Hydraulic Manifold**—the central intersection of all hydraulic "traffic" on the Top Drive. Mounted here are the seven Solenoid-Operated Valves (aka SOV's, SV's, electrovalves, solenoid valves, solenoids, or directional valves) which make our machine's robotics possible.

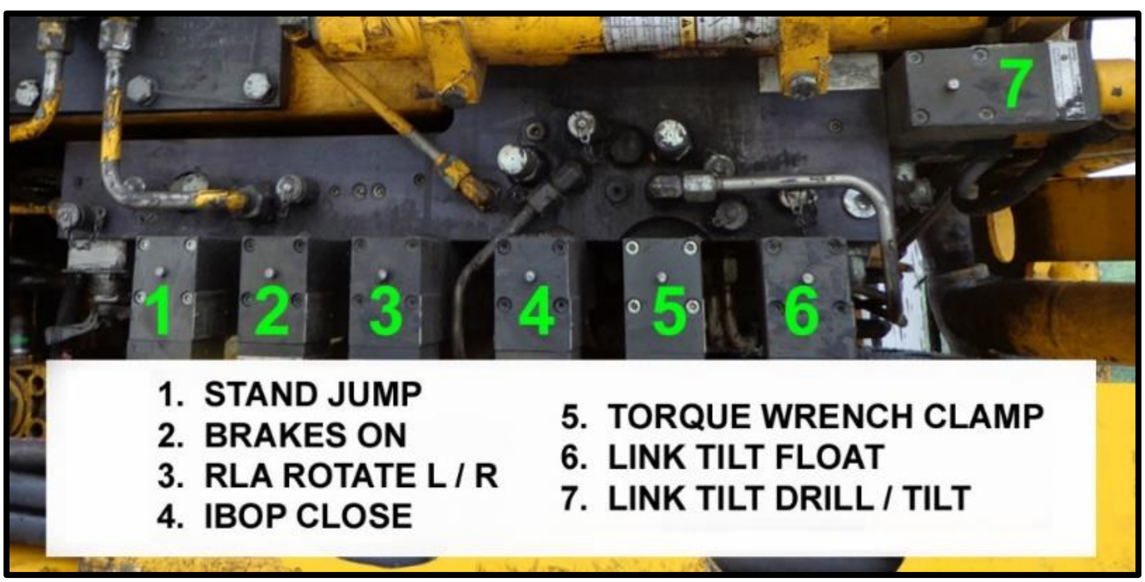


Figure 9.22 – Main Hydraulic Manifold with SOV's Attached

The role of these SOV's on the TDS-11 cannot be overemphasized. For the robotic circuits—which account for roughly 50% of Top Drive downtime—**each of these valves is the starting point for troubleshooting to determine whether a problem is electrically or hydraulically related.** A **solenoid** is a controlling device used to convert electrical energy into linear mechanical energy. It consists of a three-dimensional coil that produces a magnetic field when current passes through it. The resulting field forces an actuating plunger away from the field. When the solenoid is connected to a directional valve, the actuated plunger forces a spool from its neutral position against spring tension. When the spool moves, it allows fluid paths—which are blocked in neutral—to align, directing pressurized hydraulic fluid through one circuit or another. De-energizing the solenoid allows the spring to return the valve spool to the neutral (closed) position. The design of the spool will determine how the fluid is ported, and thus, the designation of the valve. Valve designations are usually indicated by an identification plate, often with a simple drawing or schematic to illustrate the fluid paths. This is the case of the ATOS brand of solenoid-operated directional valves that are used on a TDS-11.

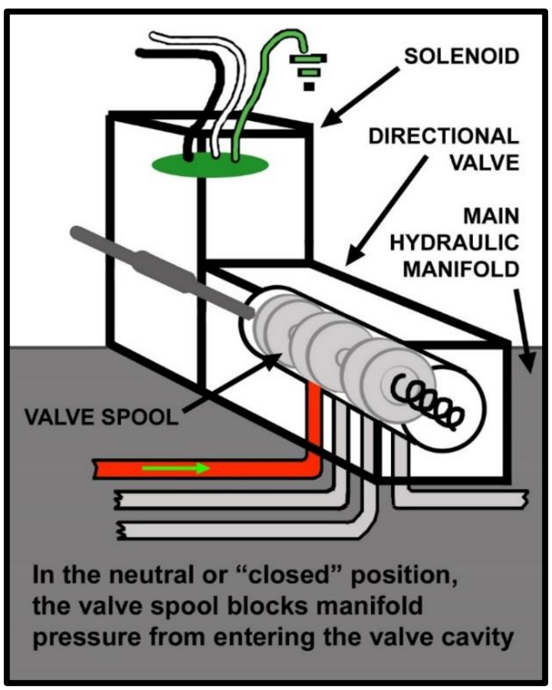


Figure 9.23

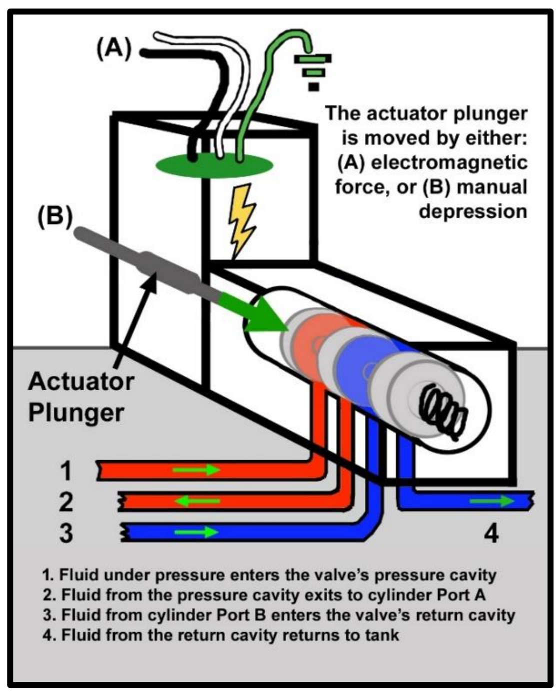
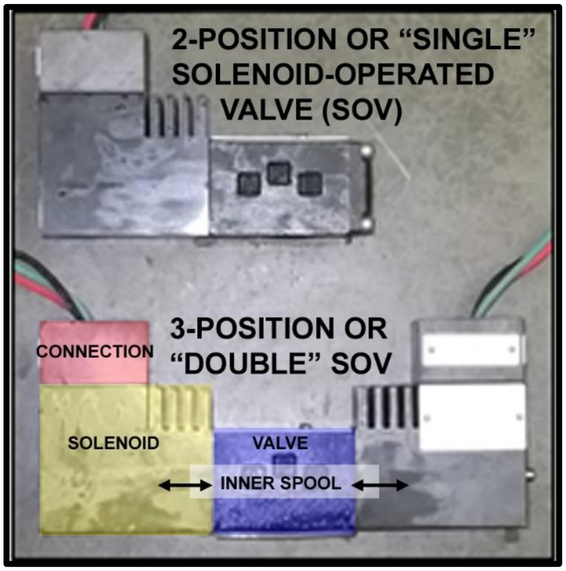


Figure 9.24

As illustrated above, the ATOS SOV's allow for mechanical (manual) actuation as well as electrical. We operate them manually as a troubleshooting tool, or sometimes to assist a stuck valve spool. The TDS-11 has seven (7) SOV's. These are either 2-position or 3-position, all energized closed. Starting from the 3-position Counterbalance Valve Switch ('Rig Up' Switch), they are in order as follows:
(1) Stand Jump SOV. This is a 2-position valve (open / closed).
(2) Brakes On SOV. This is a 2-position valve (open / closed).
(3) RLA Rotate SOV. This is a 3-position valve (left / right / closed).
(4) IBOP Close Solenoid. This is a 2-position valve (open / closed).
(5) TW Clamp Solenoid. This is a 2-position valve (open / closed).
(6) Link Tilt Float Solenoid. This is a 2-position valve (open / closed).
(7) Link Tilt Solenoid. This is a 3-position valve (left / right / closed).

Note: some models of TDS-11 come standard with additional SV's mounted to their own self-supporting manifolds. The three most common add-ons are for the TD functions "BX Elevator Open / Close," "Dolly Extend / Retract," and "Brakes Off / Open." The first two are not typical functions of a land-based TD as of 2020 (only one drilling contractor uses the dolly function, to my knowledge; same of the hydraulic elevators. The third is used by some rigs, with a change in brake actuators to eliminate spring release of brakes. Also important to note is that the dolly mentioned above is not a traveling dolly as mentioned earlier in this course (TDS-11HP & AC Ideal variants). Instead, this dolly refers to the apparatus that extends the Top Drive away from the track—a standard function on other makes of TD.



The 3-position valves are bi-directional, meaning that pressurized fluid can be directed either to "A" Port or "B" Port. This is accomplished by the design of the valve, which has a solenoid mounted on both sides to manipulate the valve spool either direction from the neutral position against spring tension.

Figure 9.25

The SOV's covered over the previous pages are mounted on the Main Hydraulic Manifold. There's one other manifold we'll cover for understanding, and that's the rotary manifold of this Top Drive, or RLA.

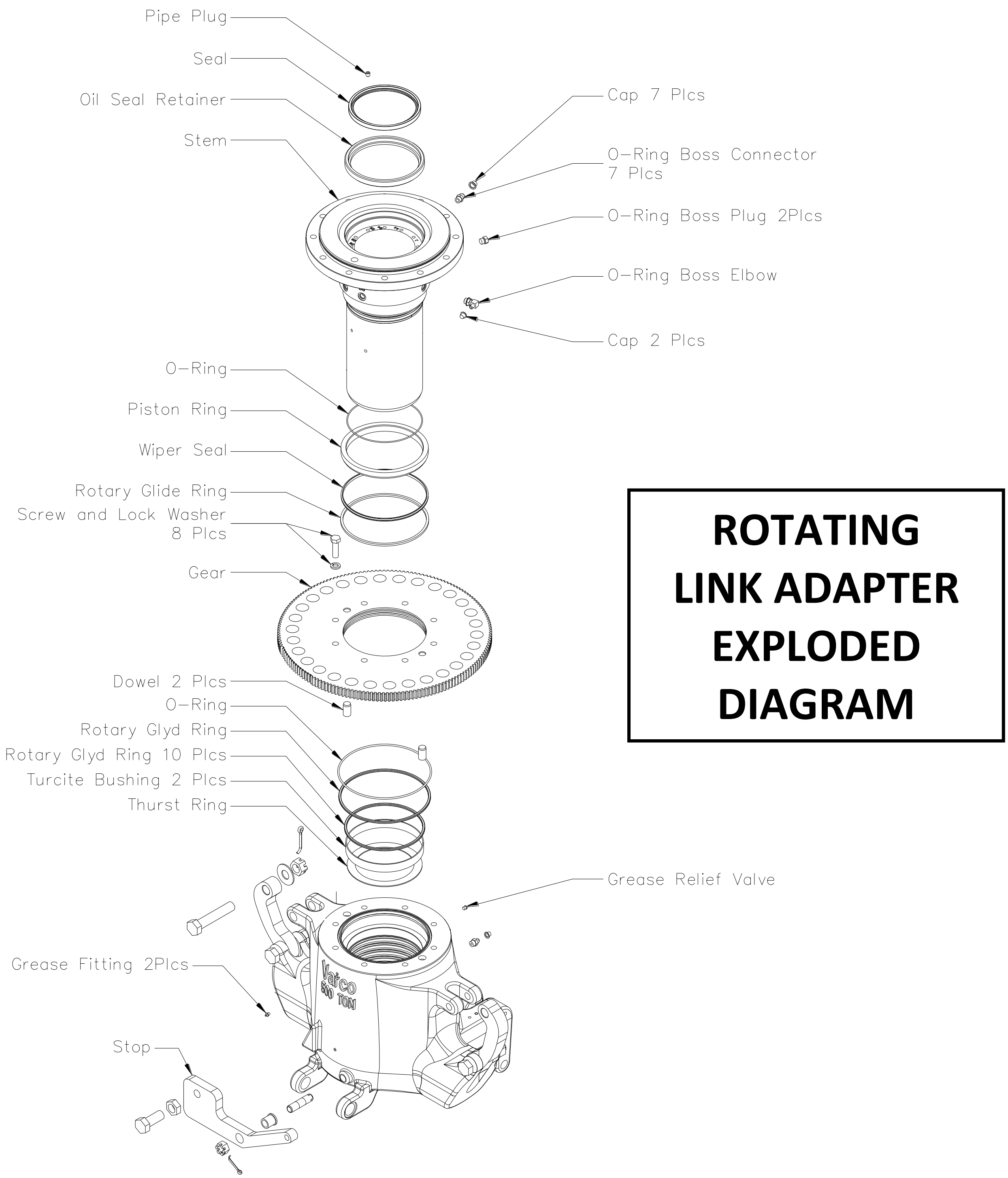


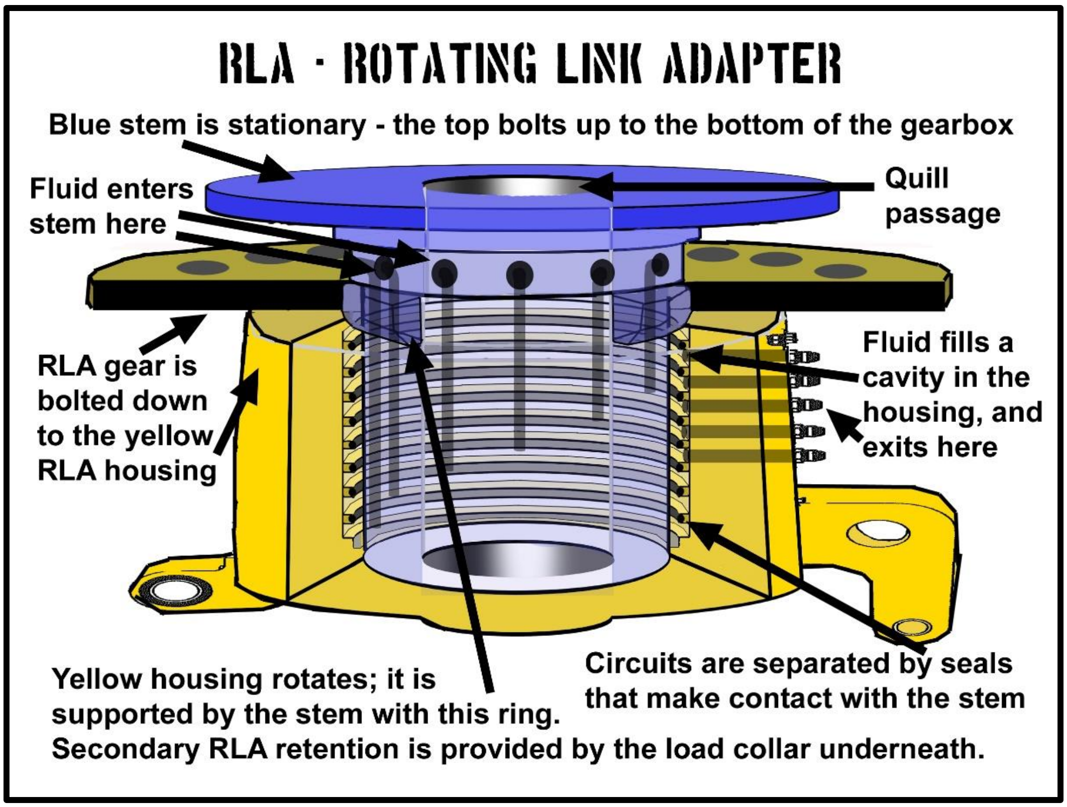
Figure 9.26

The purpose and operation of the RLA is best illustrated by the following images:

In the design of this and other Top Drives, one of the biggest challenges was this: we need to be able to provide hydraulics to the unit's lower cylinders (IBOP, L/T) and clamp piston, BUT we also need the ability to rotate the PipeHandler / torque wrench. If we ran hoses from the Main Hydraulic Manifold directly to those actuators (as depicted in the image at left), they would twist off when the handler is rotated.

A rotary manifold solves this problem. NOV calls theirs the ***RLA***.

The RLA works like this: there's a *stationary inner member* called the Stem, which bolts to the main body (transmission gearbox) of the Top Drive. Like any manifold, it is bored out to create channels for each PipeHandler actuating component's (cylinder's) circuit. Then, there's a *rotating housing* that glides on a ring that's super-heated and cooled high on the Stem, and retained by a robust retaining ring, like a super snap ring. The housing has grooved concentric cavities that are separated by seals which contact the Stem. Each cavity allows fluid to exit through a drilled port to the outside of the housing, where steel lines and hoses are connected that run to the lower actuating cylinders and piston.



Figures 9.27 (top) and 9.28 (bottom)

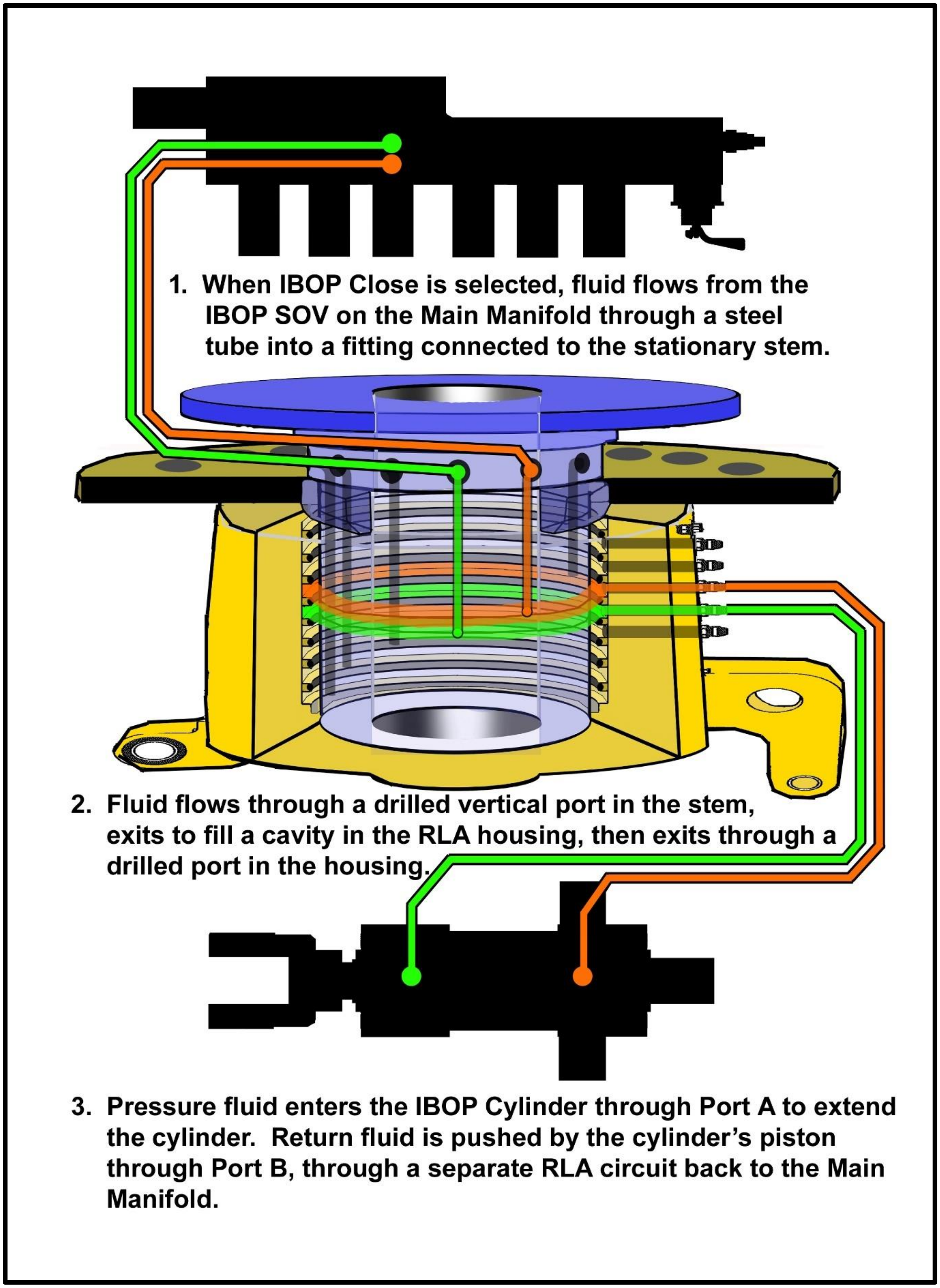

1. When IBOP Close is selected, fluid flows from the IBOP SOV on the Main Manifold through a steel tube into a fitting connected to the stationary stem.
2. Fluid flows through a drilled vertical port in the stem, exits to fill a cavity in the RLA housing, then exits through a drilled port in the housing.
3. Pressure fluid enters the IBOP Cylinder through Port A to extend the cylinder. Return fluid is pushed by the cylinder's piston through Port B, through a separate RLA circuit back to the Main Manifold.

Figure 9.29

9.6 Accumulators – An accumulator is a hydro-pneumatic device which utilizes pressurized hydraulic fluid to compress a pre-charged quantity of air. Nitrogen is typically used because it is an inert gas, non-reactive to heat or compression—perfect for maintaining a precise pressure. Pressure accumulators are of three types: bladder accumulators, piston accumulators, and diaphragm accumulators—which essentially combine a piston and a bladder. There is a fourth type of accumulator which is foam filled or ‘bladderless,’ such as the style of some Mud Pump pulsation dampeners. This type is for reciprocating pump systems and is not used in *pressure* or *control* hydraulic systems (high-pressure precision hydraulic fluid systems).

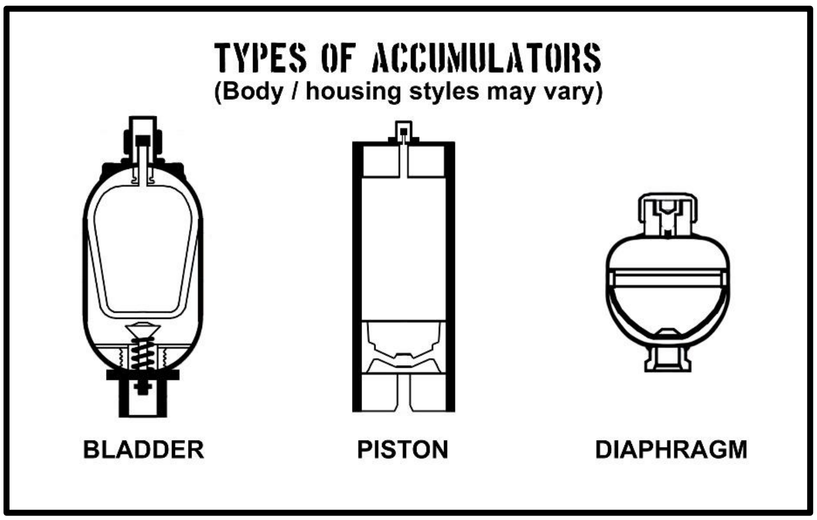


Figure 9.30

Three bladder-type accumulators are located on the main body of the TDS-11. From smallest to largest, they are the IBOP Time Delay Accumulator (800psi nitrogen precharge), the Main Hydraulic Accumulator (800psi nitrogen precharge, and the Counterbalance Accumulator (900psi nitrogen precharge). The location and description of each is outlined in the image on the next page. For further clarification of the Main System Accumulator’s purpose, it (1) helps the system to maintain constant pressure when cycling between functions; (2) provides hydraulic assistance in lifting the RLA off the load collar during startup, which aligns the RLA housing’s circuit cavities with the drilled ports of the RLA stem; and (3) acts comparable to a pulsation dampener to reduce surges and stalls which can cause vibration of lines and premature failure of pumps, valves, and other critical components in the system.

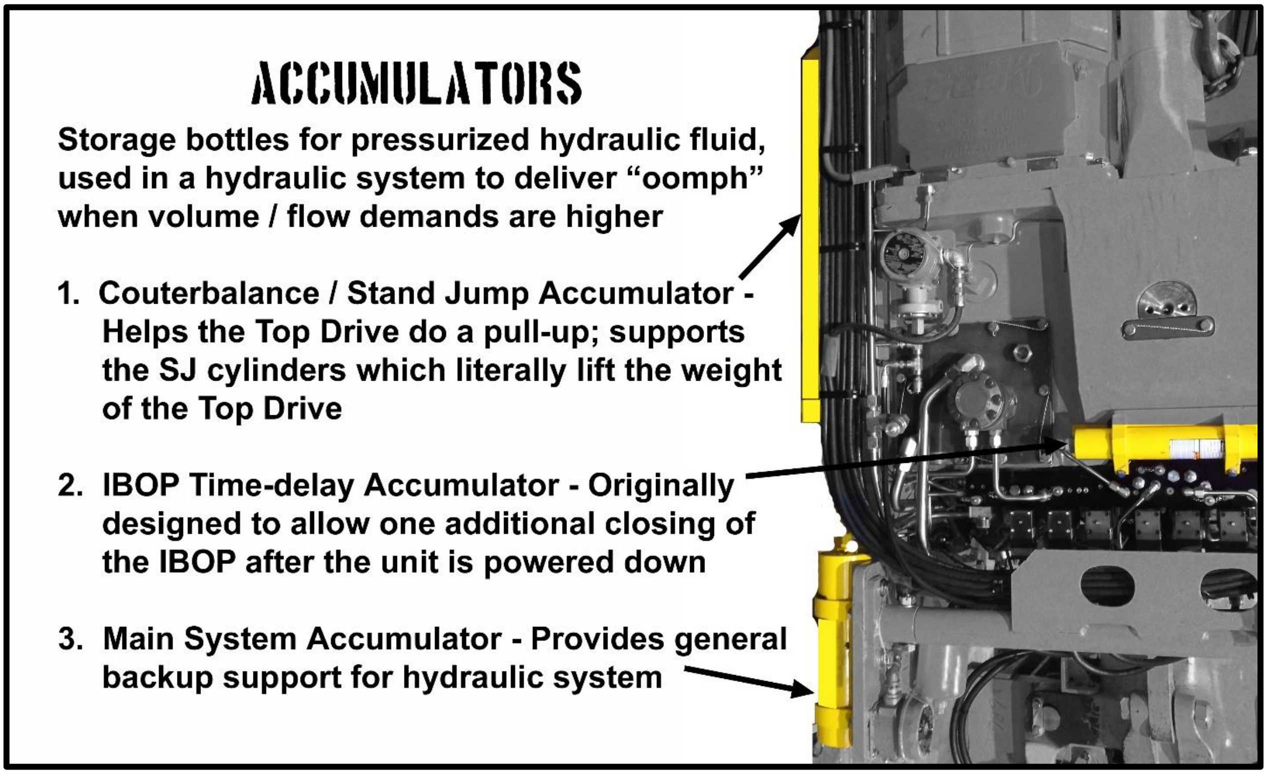


Figure 9.31

9.7 Reservoir and Servicing – A **25-gallon**, sealed stainless steel reservoir supplies strained hydraulic fluid to the two pumps on the HPU. The entire system is also about 25 gallons when running, with the tank filled about 30%. The reservoir is mounted between the AC drilling motors and is equipped with a bladder, which allows breathing for expansion / contraction of fluid while blocking outside contaminants that could foul the system. A sight glass on the front of the reservoir allows for visual inspection of fluid level. It should be checked when the HPU is de-energized and the 3-position Counterbalance Valve Switch is in "Shutdown" mode. A pop-off valve on top of the reservoir opens at 4psi to relieve system pressure during refilling. A canister breather is also located on top.

Some inconsistencies exist in how a rig crew is taught to service the hydraulic fluid on a TDS-11. Part of the reason is that NOV's documentation has never been updated to include the step of placing the TD hydraulics into Shutdown mode. Using a new container of AW-32 or -46 (AW stands for Anti-wear, also called HM which is the ISO designation), and using only a clean, hydraulic-oil-only dedicated pump and fill hoses, hook up to the QD fill fitting on the Top Drive. LOTO the TD and place the hydraulic system in "Shutdown" mode. Listen for the distinct sound of air hissing as the accumulators release pressure and the hydraulic system is relaxed. The RLA should rest down atop the load collar. The system is now ready to be serviced (also, repeat these steps before ever working on the hydraulic system, i.e., removing a hose or changing the pressure filter). With a crewmember watching the cork ball level indicator, fill the TD until the cork ball is in the center of the glass. Stop pumping, disconnect the fill-up hose and place the TD 3-Position CB Valve Switch back into "Run" mode (parallel with the long axis of the Main Manifold, handle pointing toward the V-Door). Failure to follow the above procedures—bleeding the system back to tank prior to servicing—causes overfill, which will be noticed within about 30 seconds of energizing the HPU. Excess oil will overpressure the reservoir, and cause the manual breather to pop at 4 PSI. The excess fluid will flow over the sides of the tank, collect near the base of the motors under

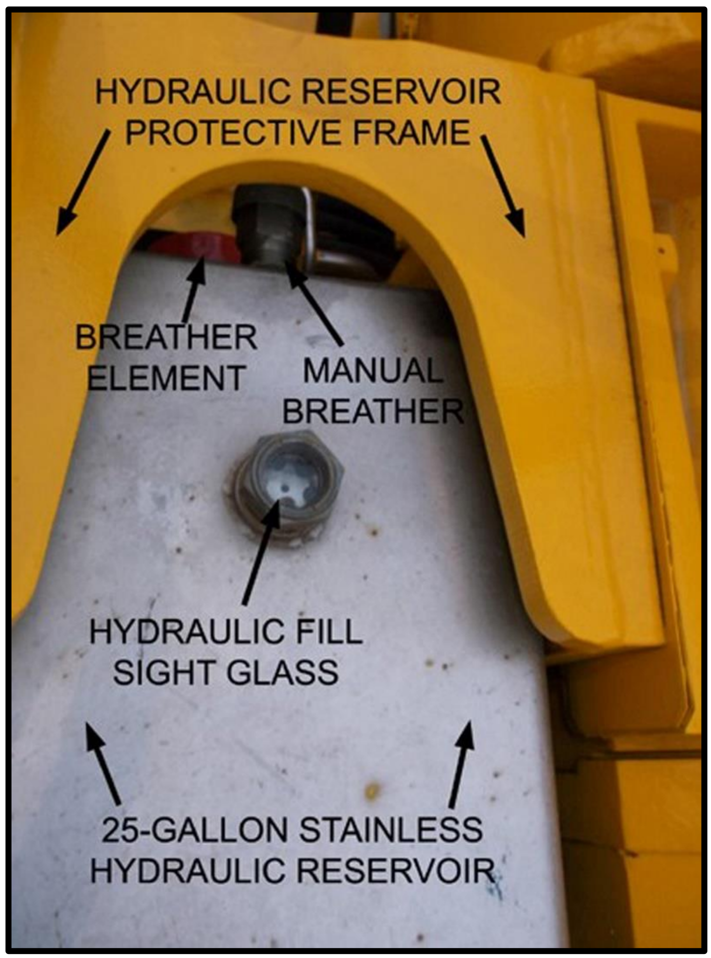


Figure 9.32

the tank, and run down the back of the TD to pool on the RLA Gear. Often, this prompts the Rig Manager to mistakenly call for maintenance, citing a 'source-unknown' leak from one of the steel lines above the RLA.

9.8 Leak Detection – Leaks are our prime indicator of a failed component or a potentially failed component. It is important to remember a few things about leaks. First and foremost, a pressurized hydraulic leak can be dangerous, potentially slicing or severing the skin and injecting harmful fluid into the body. Use extreme caution once a leak has been detected.

Leaks often provide information about what is going on with a particular system, and can aid in troubleshooting. Some leaks only occur, or occur more severely, when certain conditions are applied. These conditions may be human controlled, such as actuating a particular function. They may also be the result of atmospheric conditions (cold / hot ambient temp, elevation, etc.).

There are four classes of leaks:

> Class I leaks are characterized by discoloration or wetness of the surrounding area.
>
> Class II leaks are called 'standing' leaks. These are leaks that form drips that do not fall to the ground.
>
> Class III leaks are characterized by leaks that drip. These should be promptly reported and addressed.
>
> Class IV leaks are called 'running' leaks, where fluid is escaping in sufficient quantity that it does not drip, rather runs out in a stream. If a Class IV leak is detected, the associated equipment should be shut down. If it is not possible to shut down immediately in a safe manner, then escaping fluid should be captured and the reservoir

should be monitored until the equipment can be shut down properly for repair.

9.9 Hydraulic System Summary – First I'd like to lead in with a sidebar… In 1999, I underwent a career progression move that took me from the back of a KC-130 refueling plane where I'd worked for years as an in-flight mechanic, to the center seat between the pilots as a flight engineer. After months of classroom and simulator training, students entered the flight phase for a final 3 months of qualification training and testing before a culminating 'check ride'. The flight training was rigorous, requiring me to pass a series of tests on different systems in a stringent timeline… hydraulic, electric, gear lube, fuel, pneumatic, A/C, controls, etc. One of the infamous confidence-busting methods of testing that was used by flight engineer instructors, was to tell a student during flight, "You're a drop of (JP-5 jet fuel, MIL-H-83282 hydraulic fluid, or MIL-L-23699 lubricant), and you've just been added at the aircraft's servicing point. You're going to exit the aircraft as a leak from such-and-such component." Students like myself would quite literally have to memorize each and every component of every system, know every technical detail about the components, be able to sketch them from memory, know where they are located and what to do if they fail in flight. In similar fashion, to sum up this chapter, the following tree will describe the flow path of a drop of oil as it leaves a 55-gallon drum of AW-32 hydraulic oil and enters the TDS-11, until it is drained into a waste oil drum. The Marines believe that you can learn anything through ample illustration and having an associated mental picture. I believe this works for anyone. Pay close attention to the last pages in this chapter, as the method of example will help you know how to troubleshoot the hydraulic system better than most TD techs.

"Poof. You're a drop of hydraulic oil that just got pumped into a TDS-11. Now go make shit work."

1. A drop of oil departs from its 55-gallon drum and travels through a hose to the inlet side of a peanut pump or hand pump. It departs the discharge side of the pump and enters the vertical ¾" steel tube called the **hydraulic fill line** at the quick-disconnect fitting on the Driller's Side* of the TDS-11 *(in standard track configurations).

2. The oil in the fill line has three directions it could potentially travel. One direction is a dead end, it leads to the "restricted entry" side of the one-way Tank Return Check Valve (CTR) where fluid exits the Main Manifold. In another direction is the heat exchanger / oil cooler, beyond which is the fixed-displacement vane pump on the HPU. Since the vane pump is unidirectional, it is also a dead end. So the drop of oil follows the path of least resistance in the third direction, flowing directly to the hydraulic pressure filter housing.

3. The 6-micron hydraulic pressure filter element was changed three months ago, but it is clogged because of oil from a filthy container during a previous service. The head of the filter assembly contains a 50 PSID bypassable check valve and corresponding red pop-up indicator. When enough of its buddies join the drop of oil coming from the peanut pump, so that their side of the check valve has 50 pounds greater pressure than the oil on the opposite side of the check valve, they force a spring-loaded gate open and the drop of oil flows with its hombres through the valve to the Prefill Valve Manifold.

4. The oil flows through the Prefill Valve Manifold to the Hydraulic Reservoir. There it waits until the HPU is energized.

5. Once the HPU is energized, the oil takes one of two random paths:

   A. It exits one of two suction strainers at the bottom of the reservoir, which leads to the HPU Primary Pump inlet.

1. Oil exits the discharge side of the Primary Pump (full description is a Parker- or Rexroth-brand, variable displacement, pressure-compensated piston pump) at ~2,500 PSI and flows into the Main Manifold. It immediately crosses the adjustable valve cartridge RV1 (Relief Valve 1), which reduces the system pressure to 2,200 PSI. There, the 2,200 PSI pressurized oil flows one direction (see [a.] below), while the bled-off fluid flows another direction (see [b.] below):

    a. Oil under pressure exits RV1, providing and maintaining balanced pressure with the (main) System Accumulator (SA), which is simultaneously interconnected to the (P) Pressure inlet of all solenoid valves. *Note: at some solenoid valves, the pressure fluid's path is blocked until actuation, as illustrated on Page 127*, *Figure 9.22*. *At other SV's, the neutral position allows flow through the solenoid until actuation changes the fluid path. For this reason, in one example, system pressure can be checked at Rig Floor level, on the small manifold mounted on the Grabber Assembly*. If no functions are being used, oil continuously flows through the manifold, exiting through Port 'TR' (Tank Return) through CTR, the Tank Return Check Valve. It enters the hydraulic fill line and circulates back to tank in the way that was already explained during servicing / adding oil.

    b. The excess pressure that is bypassed at cartridge RV1 travels a short distance through the Main Manifold to UV1 (Unloading Valve… there's only one in the system), which directs the fluid through CV1 and CV2 (Check Valves), the PCC Valve

(Counterbalance Positioning Control valve), CV3, and then to a 'T', where it maintains the pressure of the CB / Stand Jump Accumulator on one side, and on the other side is directed to the Prefill Valve Manifold. Our drop of oil passes through the manifold and returns to tank (reservoir).

B. The drop of oil travels from the reservoir through the other suction strainer, which feeds the inlet side of the fixed-displacement Secondary (vane / piggyback) Pump.

1. Oil exits the discharge side of the vane pump and flows into the Main Manifold. It immediately crosses the adjustable valve cartridge RV2 (Relief Valve 2), where pressure is adjusted to between 330 – 360 PSI while running (400 PSI deadhead).

2. Oil leaves the RV2 cartridge and flows into the Gear Lube Hydraulic Motor. The drop of oil, along with its posse under 330-360 PSI pressure, pushes a vane around in circles. The vane is connected to a shaft that couples with the Gear Lube Pump (dry-spline… hydraulic fluid is sealed inside the motor to turn an outside or 'dry' shaft) that inserts into the DS gear access plate. After the drop of oil gets tired of spinning in circles once or twice, it exits the Gear Lube Hyd Motor.

3. Oil is pushed upward in a separate line that parallels the fill line in the direction of the pressure filter. This line's path is plumbed directly into the back of the DS Brake Adapter Plate. It flows through a horizontally-drilled hole in the plate (as do the brake circuits, through separate bores), then into the steel

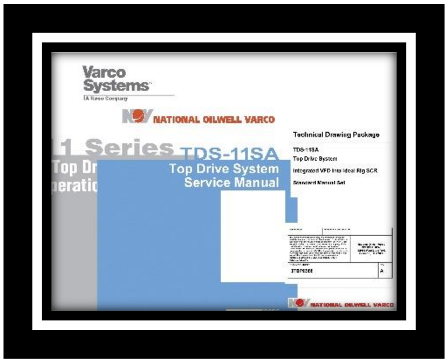
tube inlet of the hydraulic oil heat exchanger / oil cooler, where heat is displaced through the cooler's fins as air is sucked through them by the drill motor blower.

4. The drop of oil leaves the exit side of the oil cooler, travels out of the brake adapter plate and joins its traveling compadres in the Fill Line, following the path to tank by way of the pressure filter and prefill valve manifold as previously explained.

6. Our drop of oil will continue to circulate through one of these paths while the HPU is energized. When the HPU is de-energized, the drop of oil will hold in place wherever it was when the pumps stopped running.

7. When a rig crewmember physically selects "Shutdown" mode on the 3-position Counterbalance Valve Switch of the Main Hydraulic Manifold, oil is ejected from the accumulators by nitrogen pressure, and the drop of oil is pushed along the path of least resistance back to tank. About 90% of the oil drops make it back to tank. The others hang out in the tubing and components of the hydraulic system until the HPU is placed back into "Run" mode and then re-energized.

8. When the oil is changed, the hydraulic system is LOTO and Shutdown is selected. Oil is returned to tank. Then a hose is connected to the Hydraulic Drain Wye (Y) and placed inside an empty waste oil container of > 25 gallon capacity, the quarter-turn ball valve is opened, and oil flows from the suction / inlet side of the Primary Pump which is gravity-fed from the tank. The drop of oil is discharged from the TDS-11 hydraulic system and into the waste container for proper disposal.



CHAPTER 10

NOV TECHNICAL PUBLICATIONS

CHAPTER 10:
NOV Technical Publications

In this section, we will learn the following:

1. The different types of NOV tech pubs
2. How to find specific information

10.1 Types of NOV Technical Publications

As with any company, NOV has undergone a lot of developmental changes over the years since the TDS-11 has been in operation. The info they once shared has been changed repeatedly through various official revisions—sometimes omitted, sometimes corrected or simply updated. Document names change, and many documents have been created solely for a specific customer. I have found that some of the older documentation actually contains more technical info, presumably because the nature of companies over the past couple decades has been increasingly protective of intellectual property. The document examples listed herein have been added to the Student Thumb Drive.

There are several types of technical documents related to the TDS-11 that are available from the manufacturer today. The document numbers—which NOV considers part numbers—are included; if you are a TDS-11 end user / owner, these numbers can be used to order hardcopy publications. They're also all in the Student thumb drive. The types of technical documentation are as follows:

(1) *Technical Drawing Packages* (TDP's) – These are what NOV calls the collection of their technical prints, schematics, diagrams, parts manuals or illustrated parts breakdowns for a particular piece of equipment. The individual drawing numbers within a TDP are usually identical to the part numbers they represent. There are too many TDP variations to list, so here's just an example: *P/N 3TDP0146*. NOV TDP's will be

covered in Chapter 12.

(2) *The TDS-11 Pocket Guide*, also published under the title *Pocket Reference Guide*, P/N 30153911. It's a good reference to keep handy on the Rig Floor, covers basic info and servicing procedures.

(3) Posters – also good to keep in the Top Doghouse. The first of these two is relatively common:

TDS-11 Lubrication & Maintenance
P/N 125770

Varco Wash Pipe Assembly Guide
P/N 128844

(4) Operations Manuals – Sometimes integrated with TDP's and Service Manuals for customers, and renamed "Owner," "Operator," or "User" manuals. The most reliable NOV documents for actually operating the TDS-11 are titled:

TDS-11 Series Top Drive Operations Manual
P/N 3OPS01981;

TDS-11 VFD Operation Manual
P/N D25TDS11-MAN-001;

NOV Blak-JAK Installation, Care, and Operations Manual, [No Part Number]

(5) Service Manuals – These manuals provide basic servicing instructions and provide the basis for all periodic maintenance per OEM standard. They also provide helpful information for technical-level work on the hydraulic system, such as setting up the circuits, adjusting pressures, and minor troubleshooting.

TDS-11SA Top Drive System Service Manual
P/N SM00856B

TDS-11HP Top Drive System Service Manual
P/N SM00947B

TDS-11 Control System Service Manual
P/N SM00003

NOV Washpipe Assembly Service Manual
P/N SM01053

IBOP Safety Valves Service Manual
P/N SM00611

(6) Troubleshooting Guides – These manuals are relatively small in content and are often included as addenda to the Service Manuals. The troubleshooting steps provided for any given fault or failure are rather basic; nearly all paths end in "Call Field Service." There have been several versions of the TDS-11 Troubleshooting Guide, each having only minor changes. It is for this reason that a more detailed troubleshooting section has been included in this curriculum.

TDS-9SA / 11SA Troubleshooting Guide
127425B

(7) Technical Bulletins – There are only two that I have ever come across. Both are essentially an introduction to the TDS-11 Top Drive—almost a lengthy sales brochure—introduced when these units were new on the market. Revision A contains more data.

TDS-11SA Top Drive Drilling System Technical Bulletin – April 1998 Rev. A (No part number)

(8) Product Information Bulletins (PIB's) – There are numerous PIB's that cover updates to the Top Drive and its procedures. There exists a library of PIB's online, but NOV has moved the digital location. Login is required. To view samples, look for these documents on the Student Thumb Drive:

10682546-PIB Rev. 1 / PH75 Pipe Handler

D611005397-PIB-001 Rev. 1 / Stabbing Guides

TDS-93-1 Rev. B / Post-Jarring Checklist Update

(9) Checklists – There are a few different checklists that are employed by NOV, but to the best of my knowledge, only one is for external customers:

Post-Jarring Checklist, Version 1.1 / 12 Mar 03

(10) Vendor Documentation Packages (VDP's) – These publications are the NOV re-write of 3rd-Party component / system technical information. Examples include:

TDS-9SA / 11SA Top Drive Drilling System - Siemens
VDP0011-TOC

TDS-9SA / 11SA Top Drive Drilling System – IDM
VDP0012-TOC Rev. B

(11) Vendor Supplied Documents (VDR's) – These are 3rd-Party OEM publications for various components and systems, packaged and delivered under NOV header. Examples include manuals for ABB drive hardware (3VDR00173) and Reliance drill motors (VDR00029 / VDR00030).

(12) Bills of Material (BOM's) – These NOV documents are like

customer receipts or bills of lading, excluding dollar figures and listing part numbers. They can actually be helpful in ordering sets of data or parts—such as to build a kit or to support a system—to keep from looking up individual part numbers in the future.

Nearly everything you need to know about the TDS-11 Top Drive can be found in a (unit-appropriate) TDP, Operations Manual, and Service Manual. Part numbers for ordering about 95% of all parts are found in the TDP. If at any time you need further help, contact NOV's Tech Support Hotline (formerly 'Houston Service Department') at (+1) 281-569-3050. The phone representative will need to know your name, the company you work for, the specific type of equipment (TDS-11), and whether you need parts, field service, or phone support. It helps to have the Top Drive serial number and VFD House Job Number. The TD S/N is located on a plate mounted to the main body of the Top Drive. The VFD Job Number is typically a 4-digit number located on a plate mounted just outside the door of the VFD House.

CHAPTER 11

TDS-11

ELECTRICAL

SYSTEM

CHAPTER 11:
TDS-11 Electrical System

In this section, we will learn the following:

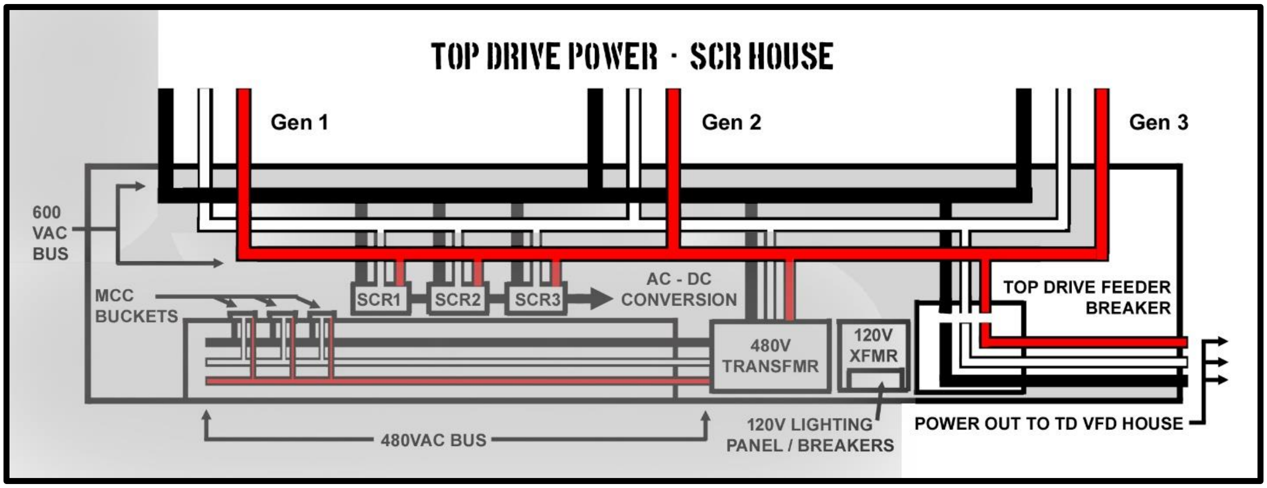
1. The basic electrical circuits of the NOV Top Drive System
2. The basic electrical circuits of the TDS-11 unit
3. Key component locations & descriptions

11.1 System Power from SCR to VFD. The best way to understand how a system works is to know how it is powered. Following is a brief description of the electrical energy path from the gen skids to the TDS-11, in basic terms. First we will cover the SCR house-configured rig, and then it will be easier to explain the setup on an AC rig. We will use the colors black, white, and red to describe the three phases of 600V electricity used by the TD. Two images are also provided to illustrate the explanation.

1. Regulated power (3-phase, 600VAC, 60Hz) is produced by each engine-driven generator.

2. Inside the rig's SCR house, each set of the generator's phases ties to the other (black wires together powering one conductive bar, white wires together powering a separate bar, red wires together powering a separate bar. The three separate bars are connected to the back wall of the SCR house by insulated hardware. This 3-bar section is collectively known as the 600VAC bus.

3. The 600V bus bars provide power to rectifiers (SCR's) which convert the AC power into DC for use by the DC motors on the rig (DW, MPs, RT). The 600VAC bus also supplies power to the Top Drive Feeder breaker. When closed, this breaker sends the 3-phase 600V power from the bus to the stand-alone Top Drive VFD house.



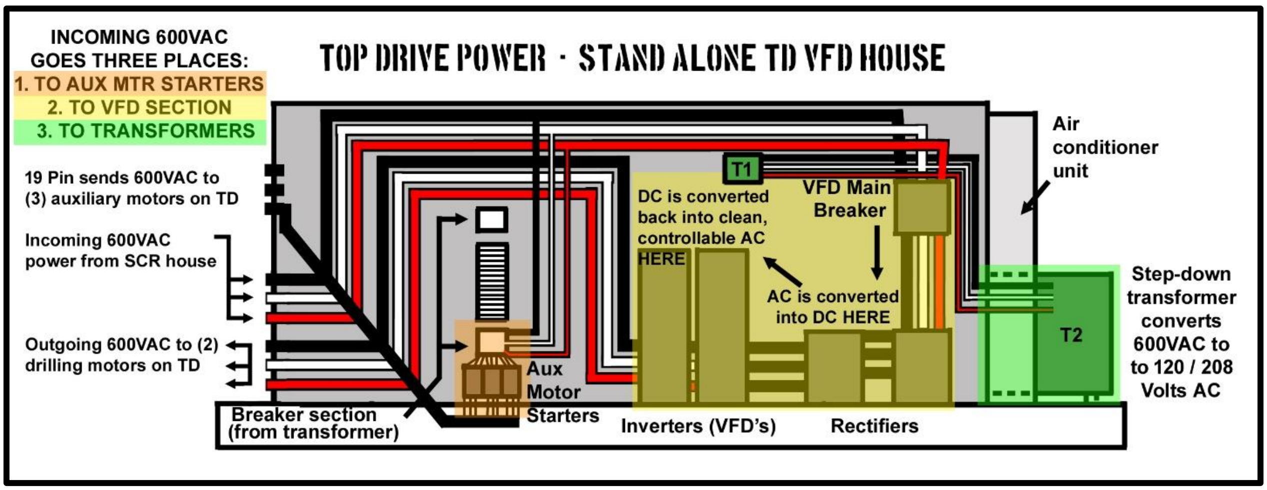


Figure 11.1 (top) *Figure 11.2 (bottom)*

4. Upon entering the TD VFD house, the incoming 600V is distributed to three different places simultaneously:

   A. The **Auxiliary Field Switch** (SW02), which supplies power to the three Auxiliary Motor Starters (they also each have their own integral circuit breaker). From left to right: 9.6A HPU, 3.8A DS Blower, 3.8A ODS Blower. If the SCR's TD Feeder Breaker is closed / energized and SW02 is also, then 600V power is available to the blowers and the HPU electric motor upon command, via the 19-Pin Auxiliary Service Loop.

B. **The Transformer Field Switch** (SW01). This supplies 3-phase 600V power to:

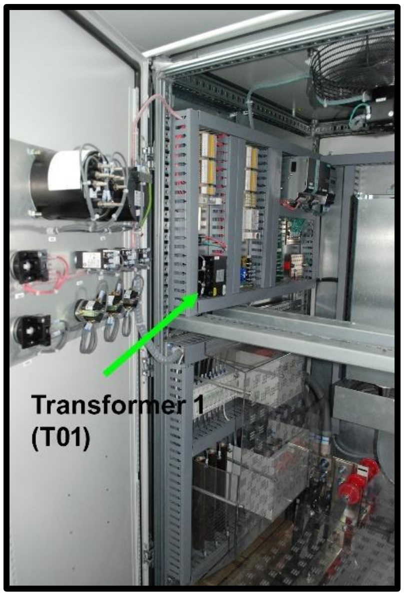
1. CB10, which powers Transformer 2 (T02) with 3-phase 600V. T2 is a large transformer on the VFD house skid located just outside the house itself (house *porch*, per drawings),. This transformer supplies 208VAC to the two house air conditioning units, and 120VAC to the distribution panel (see left) for use by lights, TD drill motor heaters, and house control power circuits.

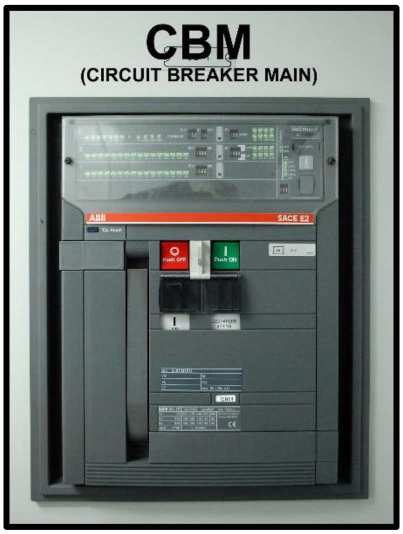
2. The Control Systems AC Switch / Fuses, which power Transformer 1 (T01) with single phase 600V. T01 is dedicated to powering two 24V DC Power Supplies for low-voltage control power (Driller's Console, PLC or SBC Rack, communications equipment); T01 also powers the rectifier, inverter, and chopper fans.

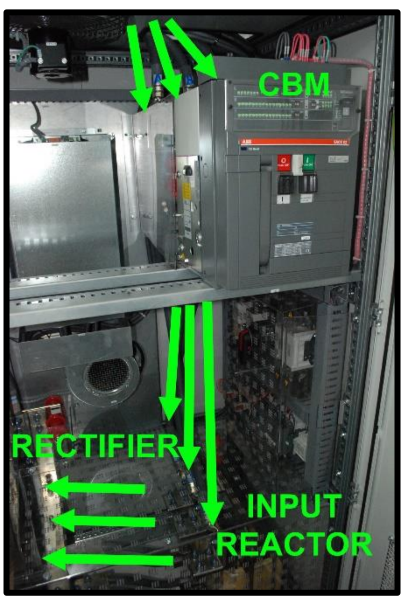
C. It feeds the VFD **Main Circuit Breaker** (aka CBM…charging handle, red and green buttons), which when closed sends power to through the following path:

1. Input Reactor – To keep the generator-supplied current steady, each of the three phases travel through an input reactor. This surge protection device is a 3-coil assembly

Figure 11.13 … (next page) Figures 11.14-11.16







which limits incoming current by temporarily delaying or impeding the flow of current through 3 windings, essentially absorbing voltage spikes / surges and stalls. This secondary protection measure guards against damage to equipment downstream.

2. The Incomer Rectifier(s)

From there, two rectifier/filters convert incoming AC power to filtered 740 to 810 VDC for use by the inverters.

3. The AC Inverters (aka Drives / VFD's)

The inverters require DC power input. They convert the DC into a clean, controllable (or 'simulated') AC power for use by the drill motors on the Top Drive, using Pulse Width Modulation (PWM) and field vector control measures. Each inverter works in parallel with the other, allowing both Top Drive traction motors to operate on just one inverter in the event that the other fails. At the inverter section, two things happen:

(a) Power leaves the inverter and exits the VFD House en route to the Top Drive.

(b) The inverter receives input signals from the PLC CPU or SBC to control the frequency of inverter output to the Top Drive (this signal begins when the Driller operates the throttle on the

VDC in Drill or Torque mode).

5. Power Service Loop

Figure 11.17

3-phase power exits the VFD House through the Power Service Loop, which is made of two sections: an outer service loop and an inner service loop. The outer (power) service loop is typically around 210' long and it remains stationary. The inner service loop is around 86' long and it travels up and down with the Top Drive in the derrick. The two sections are connected at the derrick termination—aka saddle or waterfall—which is mounted just below board height on the inside of the derrick. The majority of each service loop is contained in / protected by a robust, steel-reinforced hose. *Note: If hydraulics work and one or both blowers come on, but there is no movement of the quill when "Drill" and FW or REV are selected, the first thing to check is whether or not the VFD Main Circuit Breaker (CBM) is closed.*

6. The inner service loop connects at the Top Drive's power junction or plug panel, where the line (incoming) power is passed through the black, white, and red power pigtails to each of the two drill motors. The pigtails enter each motor through the rear motor access plate, passing through individual Hawke fittings (special pass-through glands used for armored cable) and connecting inside the motor housing at the motor terminal blocks. Electrical power is transferred through the terminal blocks into the motor windings, where phasing is synchronized

and finally discharged through stator poles. Electrical energy is then transferred into mechanical energy through a magnetized rotor attached to the torque shaft, causing (each) motor shaft to turn.

11.2 Integrated Drive House – AC Rigs don't need stand-alone VFD Houses for their Top Drives. Instead of an SCR house, which exists solely to provide DC power to DC traction motors, the AC rigs have Integrated VFD or AC Drive houses. The incoming 600VAC from the generators is simply harnessed and dispersed much in the same way it is in a stand-alone house, then replicated for the Drawworks, Pumps, and Rotary Table.

The TDS-11 still has the same electrical demands / requirements. It needs controllable 600VAC (575+) for its drill motors, and 600VAC for its auxiliary motors (in rare cases, the auxiliary motors have been changed to 480V, with power distributed from the MCC Cabinet). So, all of the stand-alone components exist, only in different places. The control cubicle of a stand-alone house is thus transformed into a larger Control Cabinet, and the drives themselves still require rectified DC power input. The three aux motor starters still exist, finding their way into a separate bucket along the small section of 600V power components.

11.3 Top Drive Electrical – At the unit itself, it's really pretty simple. There are three separate service loops supplying power to the TD, that connect at the TD Plug Panel: Power (red, white, and black plugs), 19-Pin Auxiliary, and 42-Pin Composite. Five plugs in all. Each of these circuits continues to its respective components through 'pigtails', which are short extensions of each loop that stay connected to the Top Drive. On the receiving end—as previously explained—the red, white, and black pigtails are each split into two cables coming out of their bulkhead plugs. The three phases are split between the two drill motors, which makes them turn in parallel when energized (both motors receive power at the exact same time, not one before the other). They both turn the same direction. *IF one or both motors have just been changed, and upon function test, the torque gauge spikes with zero RPM physically noted or gauge-indicated, it is probable that the motors are oppositely phased, turning opposite directions of—or 'fighting'—each other. Cycle the brakes first, to make sure that they are not causing the torque condition.*

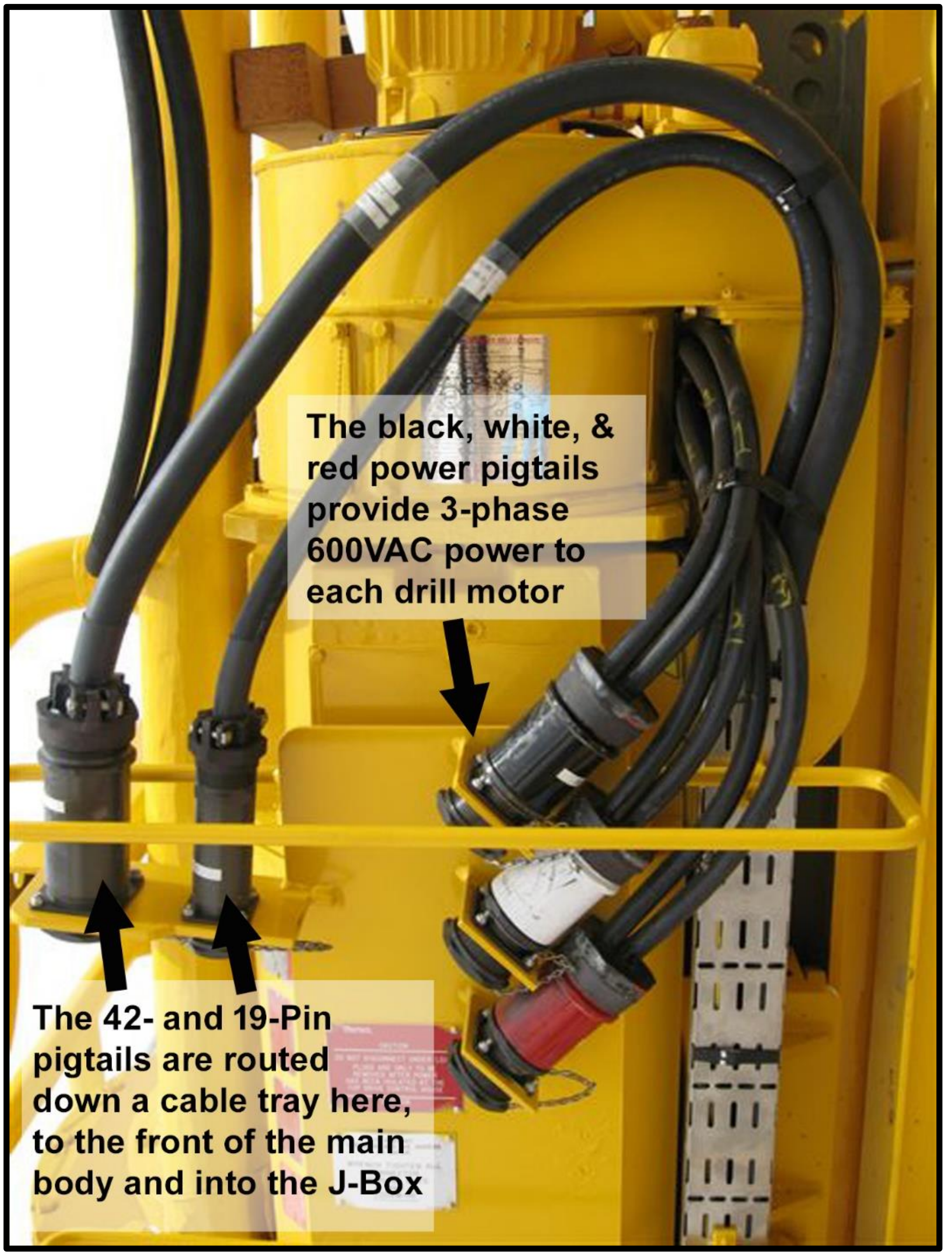


Figure 11.18

The other two pigtails—the 19- and the 42-Pin—are routed from the plug panel into the J-Box on the Top Drive. From there, each of their wires continues its circuit to a downstream component through the individual component pigtails.

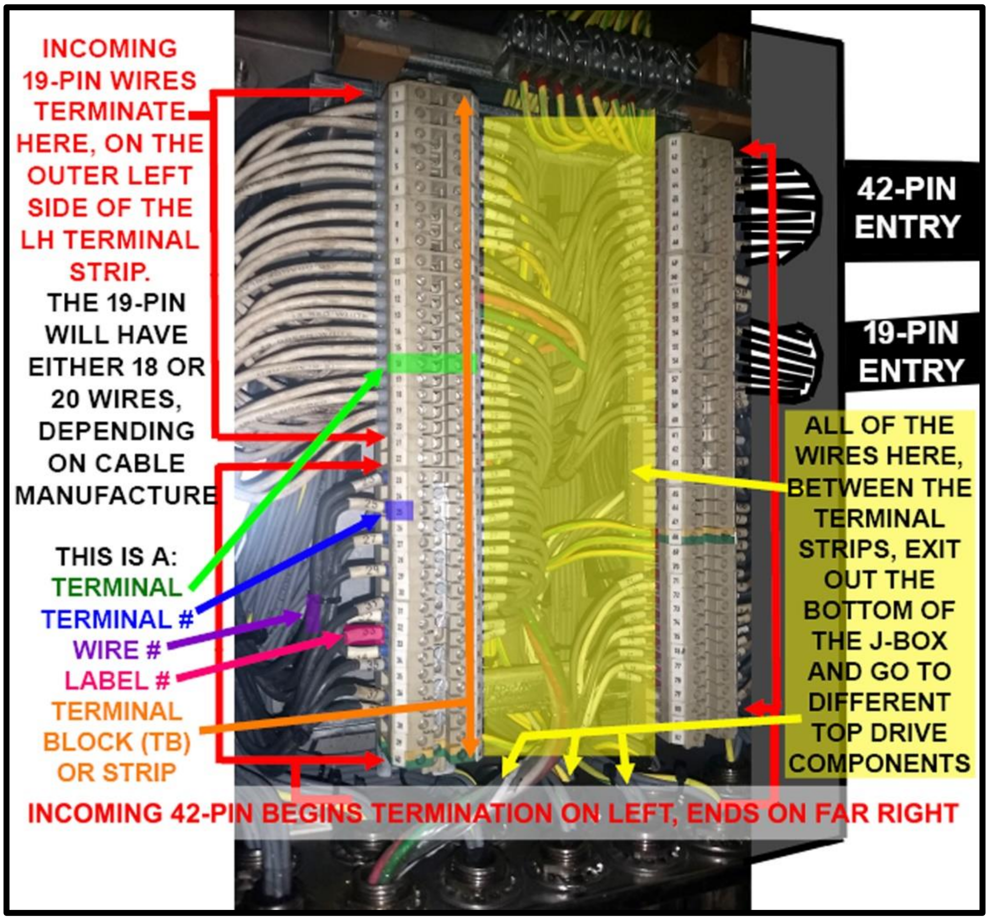


Figure 11.19

The images on the following two pages are included for study and reference; they are also practical for posting inside the TD J-Box and Amphion SBC Cabinet, respectively.

19-PIN 01	1	HPU 600V	BRAKES ON SOL	42	42-PIN 20, WIRE 11
19-PIN 02	2	HPU 600V	RLA ROT RT SOL	43	42-PIN 19, WIRE 12
19-PIN 03	3	HPU 600V	RLA ROT RT SOL	44	
19-PIN 04	4	HPU GND	RLA ROT LT SOL	45	42-PIN 18, WIRE 13
19-PIN 05	5	ODS BLWR	RLA ROT LT SOL	46	
19-PIN 06	6	ODS BLWR	IBOP COLSE SOL	47	42-PIN 17, WIRE 14
19-PIN 07	7	ODS BLWR	IBOP CLOSE SOL	48	
19-PIN 08	8	ODS BL GND	TQ WRENCH SOL	49	42-PIN 16, WIRE 15
19-PIN 09	9	DS BLWR	TQ WRENCH SOL	50	42-PIN 15, WIRE 16
19-PIN 10	10	DS BLWR	LT EXTEND SOL	51	42-PIN 14, WIRE 17
19-PIN 11	11	DS BLWR	LT EXTEND SOL	52	
19-PIN 12	12	DS BL GND	LT DRILL SOL	53	42-PIN 13, WIRE 18
19-PIN 13	13	ODS M-HTR 120	LT DRILL SOL	54	
19-PIN 14	14	ODS M-HTR N	LT FLOAT SOL	55	42-PIN 12, WIRE 19
19-PIN 15	15	SPARE	LT FLOAT SOL	56	
	16	RTD SPARE	COMMON	57	42-PIN 11, WIRE 20
	17	RTD SPARE	SOL COMMON	58	42-PIN 10, WIRE 21
19-PIN 16	18	DS M-HTR 120	SJ SOL	59	42-PIN 09, WIRE 22
19-PIN 17	19	DS M-HTR N	SJ SOL	60	
19-PIN 18	20	SPARE	ELEV OPEN (OPT)	61	42-PIN 08, WIRE 23
	21	RTD SPARE	ELEV OPEN (OPT)	62	
	22	RTD SPARE	EL CLSE (OPT)	63	42-PIN 07, WIRE 24
42-PIN 30, WIRE 01	23	ODS OVERTMP	EL CLSE (OPT)	64	
	24	ODS OVERTMP	SPARE	65	42-PIN 06, WIRE 25
42-PIN 29, WIRE 02	25	DS OVERTMP	SPARE	66	42-PIN 05, WIRE 26
	26	DS OVERTMP	SPARE	67	42-PIN 04, WIRE 27
42-PIN 28, WIRE 03	27	ODS BLWR PS	GROUND	68	42-PIN 03, WIRE 28
	28	ODS BLWR PS	GROUND	69	42-PIN 02, WIRE 29
42-PIN 27, WIRE 04	29	DS BLWR PS	GROUND	70	42-PIN 01, WIRE 30
	30	DS BLWR PS	15VDC ENCODER	71	42-PIN 42, WIRE 01 BLACK
42-PIN 26, WIRE 05	31	IBOP PS	0 VDC ENCODER	72	42-PIN 41, WIRE 01 WHITE
	32	IBOP PS	ENCODER SHIELD	73	42-PIN 40, WIRE 01 SHIELD
42-PIN 25, WIRE 06	33	LUBE PS	A ENCODER SIGNL	74	42-PIN 39, WIRE 02 BLACK
	34	LUBE PS	A- ENCODER SIGNL	75	42-PIN 38, WIRE 02 WHITE
42-PIN 24, WIRE 07	35	SPARE	ENCODER SHIELD	76	42-PIN 37, WIRE 02 SHIELD
	36	SPARE	B ENCODER SIGNL	77	42-PIN 36, WIRE 03 BLACK
42-PIN 23, WIRE 08	37	SPARE	B- ENCODER SIGNL	78	42-PIN 35, WIRE 03 WHITE
	38	SPARE	ENCODER SHIELD	79	42-PIN 34, WIRE 03 SHIELD
42-PIN 22, WIRE 09	39	SPARE	SPARE	80	42-PIN 33, WIRE 04 BLACK
	40	M-SW COMN (T68)	SPARE	81	42-PIN 32, WIRE 04 WHITE
42-PIN 21, WIRE 10	41	BRAKES ON SOL	SPARE	82	42-PIN 31, WIRE 04 SHIELD

RIG ANGEL

TITLE

STANDARD CONFIGURATION
TDS-11 J-BOX TERMINATION

	INITIAL	CURRENT
DRAWN		
CHECKED		
APPROVED		
DATE	12/15/2010	06/22/2020

SIZE	DRAWING NO.	REV.
A	RATD011	0

SCALE	WT. LBS.	PAGE
NTS		1 of 1

Figure 11.20

TOP DRIVE FUNCTION	J-BOX TERMINAL	CONDUCTOR	PIN #	TBN-1 BOTTOM WIRE TAG	TBN-1 TERMINAL	TBN-1 TOP WIRE TAG	WAGO POSITION	WAGO TERMINAL
DRILL MOTOR OVERTEMP 1	23	1	30	TS-01+	1	TD-TS-01+	3	1 / DI 1
DRILL MOTOR OVERTEMP 2	25	2	29	TS-04+	2	TD-TS-04+	3	5 / DI 2
RH BLOWER PRESSURE SWITCH	27	3	28	PS-01+	3	TD-PS-01+	3	4 / DI 3
LH BLOWER PRESSURE SWITCH	29	4	27	PS-02+	4	TD-PS-02+	3	8 / DI 4
IBOP PRESSURE SWITCH	31	5	26	PS-03+	5	TD-PS-03+	4	1 / DI 1
GEAR LUBE PRESSURE SWITCH	33	6	25	PS-04+	6	TD-PS-04+	4	5 / DI 2
BX ELEV PRESS SW (NOT USED)	35	7	24	PS-05+	7	TD-PS-05+	4	4 / DI 3
DOLLY PRESS SW (NOT USED)	37	8	23	ZS-01+	8	TD-ZS-01+	4	8 / DI 4
POSITIVE 24 VOLTS DC	38	9	22	+24 VDC	9	+24 VDC	5	2 / 24V
BRAKES ON SOLENOID	41	10	21	SOV-01+	10	TD-SOV-01+	7	1 / DO 1
24 VOLT RETURN	42	11	20	24V RTN	11	24V RTN	7	3 / 0V
RLA ROTATE RIGHT SOLENOID	43	12	19	SOV-02+	12	TD-SOV-02+	7	5 / DO 2
RLA ROTATE LEFT SOLENOID	45	13	18	SOV-03+	13	TD-SOV-03+	8	1 / DO 1
IBOP CLOSE SOLENOID	47	14	17	SOV-04+	14	TD-SOV-04+	8	5 / DO 2
GRABBER / TW SOLENOID	49	15	16	SOV-05+	15	TD-SOV-05+	9	1 / DO 1
24 VOLT RETURN	50	16	15	24V RTN	16	24V RTN	9	3 / 0V
LINK TILT EXTEND SOLENOID	51	17	14	SOV-06+	17	TD-SOV-06+	9	5 / DO 2
LINK TILT DRILL SOLENOID	53	18	13	SOV-07+	18	TD-SOV-07+	11	1 / DO 1
LINK TILT FLOAT SOLENOID	55	19	12	SOV-08+	19	TD-SOV-08+	11	5 / DO 2
STAND JUMP SOLENOID	57	20	11	SOV-09+	20	TD-SOV-09+	12	1 / DO 1
24 VOLT RETURN	58	21	10	24V RTN	21	24V RTN	12	3 / 0V
BX ELEVATOR OPEN (NOT USED)	59	22	9	SOV-10+	22	TD-SOV-10+	12	5 / DO 2
BX ELEV CLOSE (NOT USED)	61	23	8	SOV-11+	23	TD-SOV-11+	13	1 / DO 1
DOLLY EXTEND (NOT USED)	63	24	7	SOV-12+	24	TD-SOV-12+	13	5 / DO 2
DOLLY RETRACT (NOT USED)	65	25	6	SOV-13+	25	TD-SOV-13+	15	1 / DO 1
24 VOLT RETURN	66	26	5	24V RTN	26	24V RTN	15	3 / 0V
24 VOLT RETURN	67	27	4	24V RTN	27	24V RTN	15	7 / 0V
INTRINSICALLY SAFE GROUND	68	28	3	PE	28	PE		
SPARE	69	29	2	SPARE	29	(EMPTY)		
SPARE	70	30	1	SPARE	30	(EMPTY)		
INTRINSICALLY SAFE GROUND	82	31	31	Z SHIELD	42	PE		
SPARE	81	32	32	ENC SPARE	41	ENCDR SPARE		
SPARE	80	33	33	ENC SPARE	40	ENCDR SPARE		
ENCODER	79	34	34	B SHIELD	39	PE		
ENCODER	78	35	35	B- (WHT)	38	TD-B/	SPLITTER	4/B/INPUT
ENCODER	77	36	36	B (BLK)	37	TD-B	SPLITTER	3/B/INPUT
ENCODER	76	37	37	A SHIELD	36	PE		
ENCODER	75	38	38	A- (WHT)	35	TD-A/	SPLITTER	2/A/INPUT
ENCODER	74	39	39	A (BLK)	34	TD-A	SPLITTER	1/A/INPUT
ENCODER	73	40	40	15 V SHLD	33	PE		
ENCODER	72	41	41	15V (WHT)	32	15 VDC	SPLITTER	8/+V INPUT
ENCODER	71	42	42	COM (BLK)	31	COM	SPLITTER	7/COM INPUT

*GROUNDING BARS ON TDS J-BOX TERMINALS: 24-32, 34-38, 42-48, 50-56, AND 58-64

RIG ANGEL

TITLE

AMPHION GEN I
TDS-11 42-PIN CIRCUIT

	INITIAL	CURRENT
DRAWN	Matty Spiger	Matty Spiger
CHECKED		
APPROVED		
DATE	12/15/2010	06/22/2020

SIZE	DRAWING NO.	REV.
A	RATD012	0

SCALE	WT. LBS.	PAGE
NTS		1 of 1

Figure 11.21

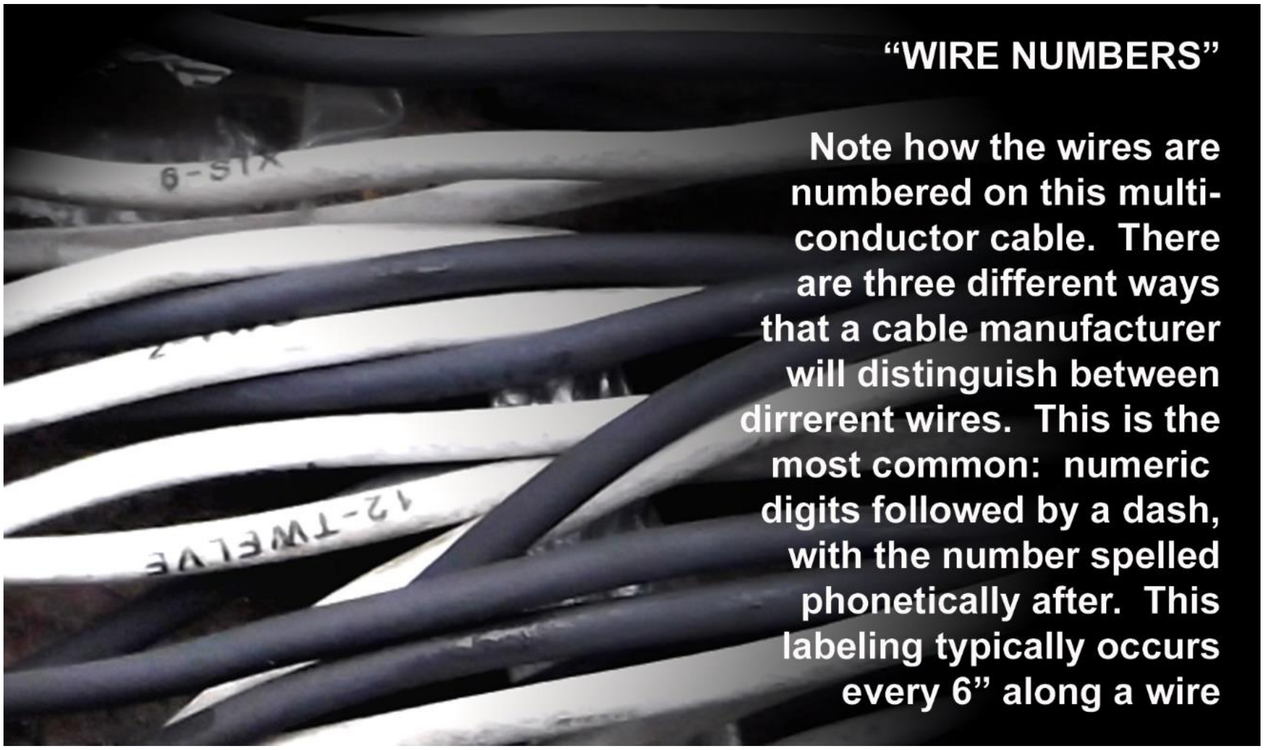


Figure 11.22

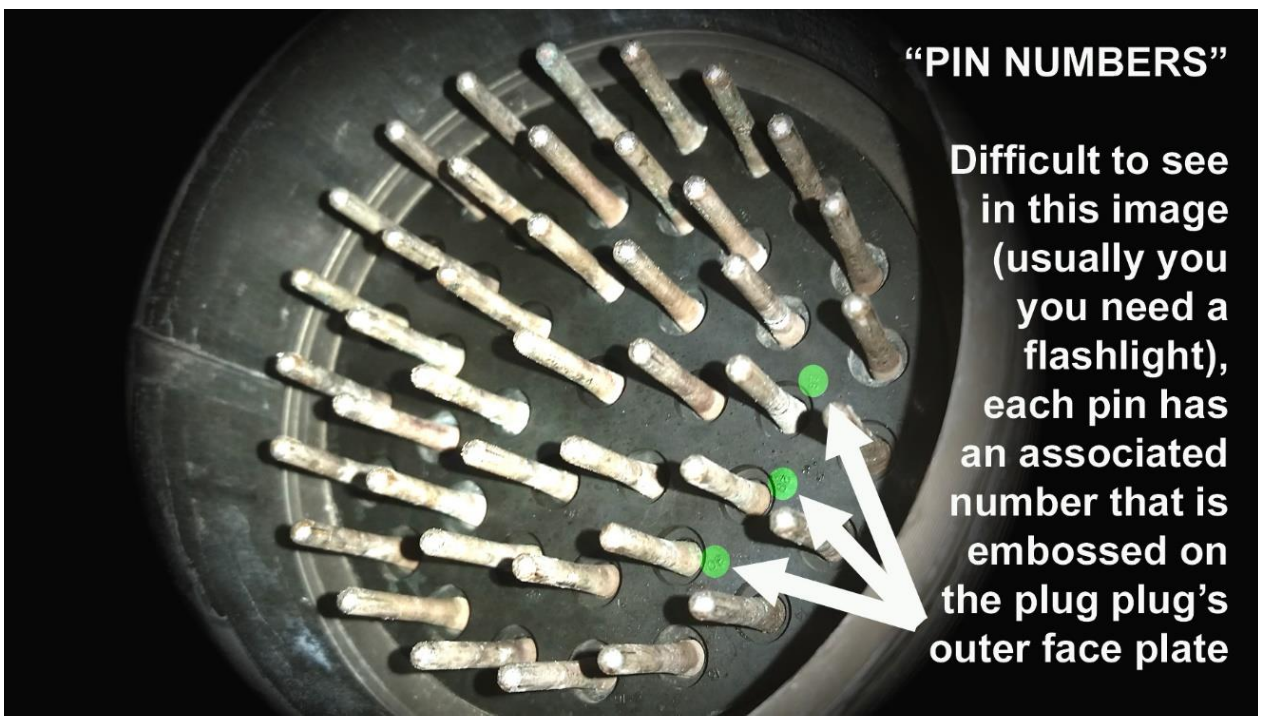


Figure 11.23

The charts and illustrations provided in this student manual are valuable in helping to troubleshoot the TDS-11 Top Drive whenever failures occur. In the images on the previous page, it's important to note that wire numbers and pin numbers are not always the same in a circuit. USUALLY they are the same for the 19-Pin… wire #1 lands on pin #1, etc. 19-pin service loops sometimes have an extra (spare) pin in the middle, because there are usually only 18 wires in the cable. To verify this, count the number of 19-pin wires coming into the J-Box. Note also, that if the auxiliary motors are on, then 600V is passing through nine of the first twelve terminals on the LH terminal strip in the J-Box.

Pin numbers begin on the outer ring of pins, starting with pin #1 which is aligned with either an outside detent or inside recessed groove on the plug housing. When looking at the plug face, numbers increase clockwise on a male pin face and counterclockwise on a female pin face.

Wires are distinguished apart from each other by one of three methods of marking. Examples of each are as follows:

1. (Printed Text) "13 – Thirteen"
2. (Printed Text) "13 – Red White"
3. (Colored, No Text) Red White (insulated red wire with a white stripe)

For colored wire bundles with no printed numbers or text, the manufacturer is following NEMA & ICEA Method 1 / K-2; a chart is provided on the next page. It's important to note that the colors—in the case of this Top Drive—are not meaningful other than to distinguish one circuit from another. For example, according to electrical standards, green wires should denote ground. Black or red wires are alternately hot / power wires, white wires are common, and other colors are used for signal wires. Those standards are not adhered to on the TDS-11 when a colored multi-conductor cable is used.

WIRE #	COLOR
01	BLACK
02	WHITE
03	RED
04	GREEN
05	ORANGE
06	BLUE
07	WHITE BLACK
08	RED BLACK
09	GREEN BLACK
10	ORANGE BLACK
11	BLUE BLACK
12	BLACK WHITE
13	RED WHITE
14	GREEN WHITE
15	BLUE WHITE
16	BLACK RED
17	WHITE RED
18	ORANGE RED
19	BLUE RED
20	RED GREEN
21	ORANGE GREEN
22	BLACK WHITE RED
23	WHITE BLACK RED
24	RED BLACK WHITE
25	GREEN BLACK WHITE
26	ORANGE BLACK WHITE
27	BLUE BLACK WHITE
28	BLACK RED GREEN
29	WHITE RED GREEN
30	RED BLACK GREEN
31	GREEN BLACK ORANGE
32	ORANGE BLACK GREEN
33	BLUE WHITE ORANGE
34	BLACK WHITE ORANGE
35	WHITE RED ORANGE
36	ORANGE WHITE BLUE
37	WHITE RED BLUE
38	BLACK WHITE GREEN
39	WHITE BLACK GREEN
40	RED WHITE GREEN
41	GREEN WHITE BLUE
42	ORANGE RED GREEN

ILLUSTRATION

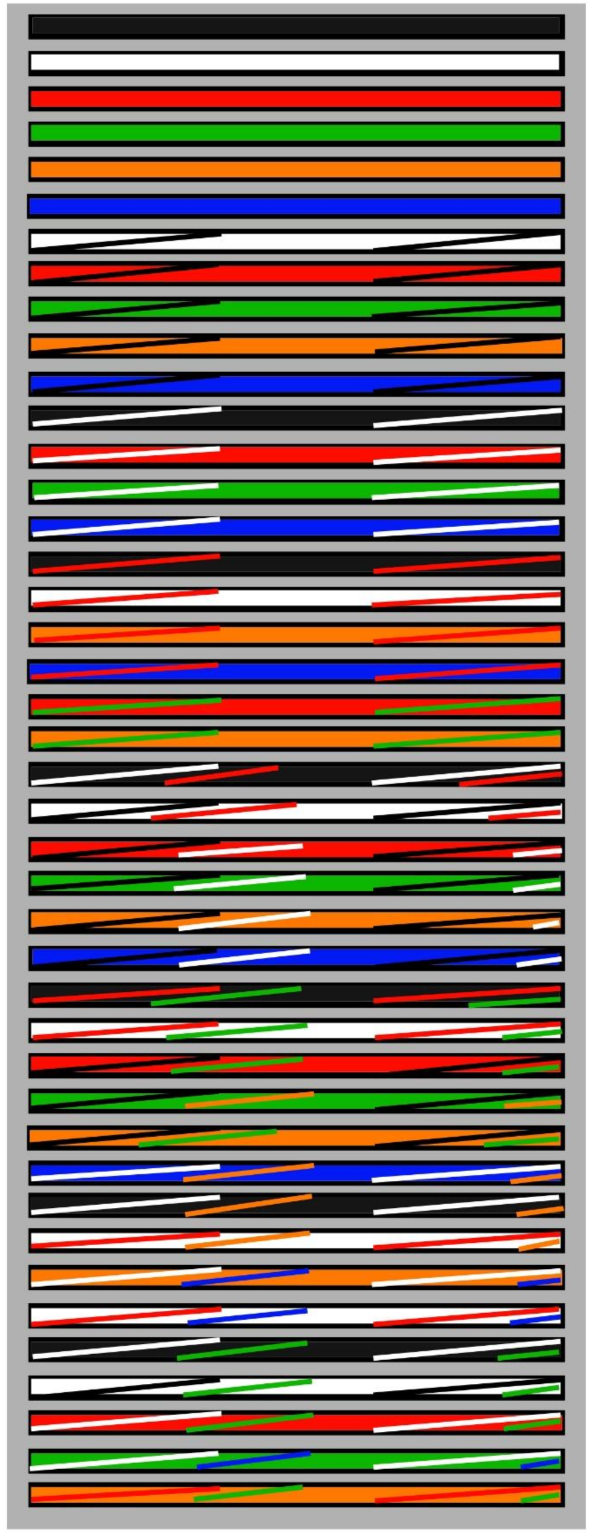
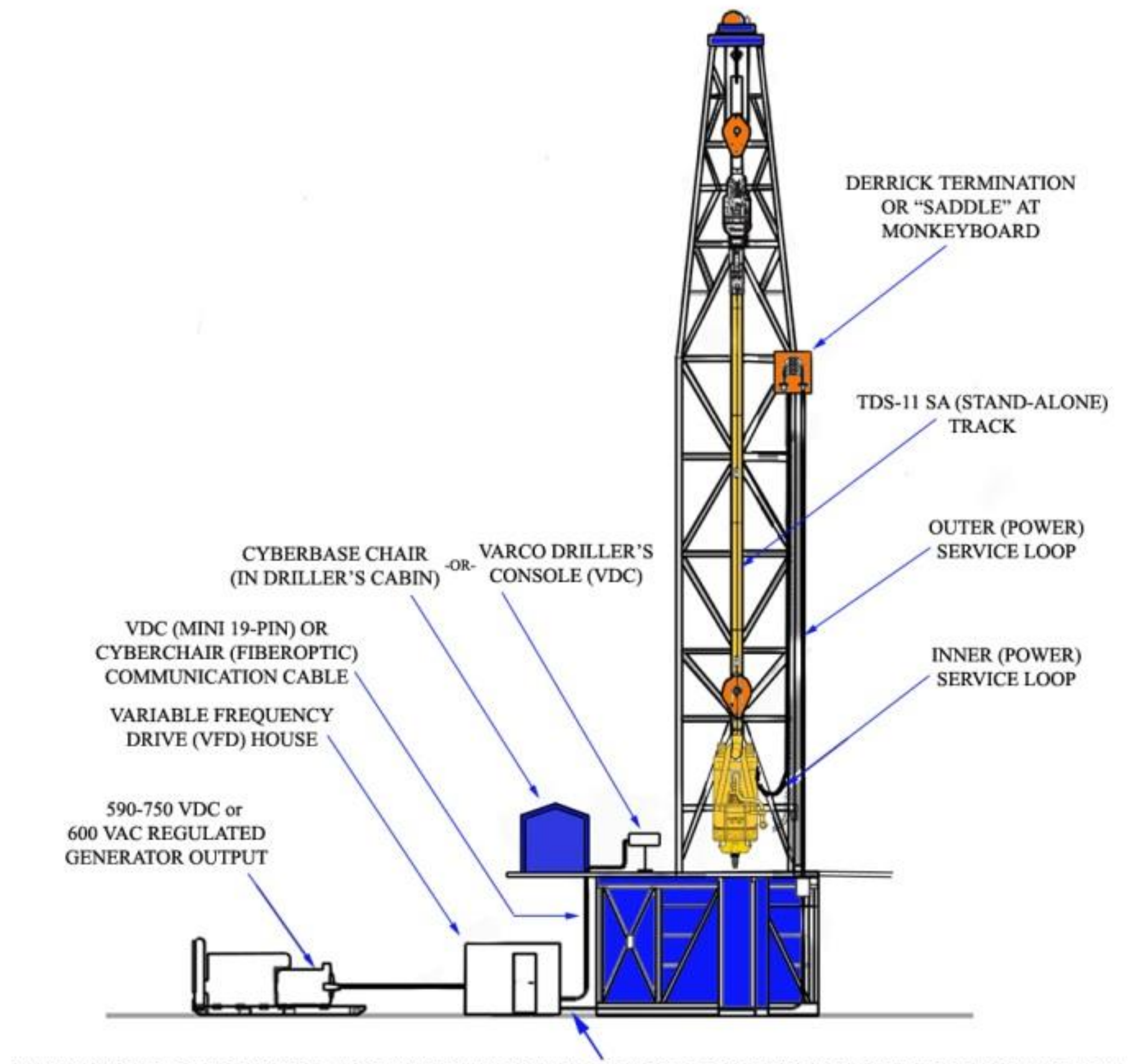


Figure 11.24



THE SERVICE LOOP CONSISTS OF A CONTINUOUS LENGTH ***19-PIN CONDUCTOR*** FOR TOP DRIVE BLOWERS, HPU, AND RTD [MOTOR OVERTEMP DEVICES]; A CONTINUOUS LENGTH ***42-PIN CONDUCTOR*** FOR INDIVIDUAL TOP DRIVE HYDRAULIC FUNCTIONS; AND THE ***TWO-PART (INNER / OUTER) POWER LOOP*** WHICH CONSISTS OF 3-PHASE, 600 VAC (RED, WHITE, BLACK) LINES AND A #4 COPPER GROUNDING CABLE.

Figure 11.25

11.4 Key Component Locations and Descriptions – There are six types of electrical components that are supported by the service loops, junction box, and pigtails on the TDS-11 Top Drive. They are:

(1) AC motors
(2) Encoder
(3) Pressure switches
(4) Solenoids
(5) Heaters
(6) RTD's

An **electric motor** is used to convert <u>electrical energy to mechanical energy</u>. It is electrically actuated, electrically operated. The TDS-11 Top Drive has five (AC) electric motors:

1. Two 400 HP traction motors that work together to turn the quill. When energized, they receive constant electricity at varying frequency until zero speed is commanded by the operator / Driller.

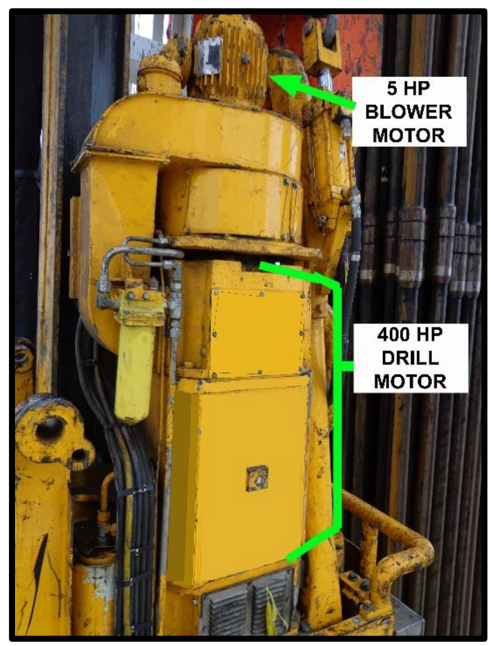


Figure 11.26

2. Two 5 HP blower motors that each turn a fan to cool the drill motors. When the hydraulics are energized, the LH (DS) blower comes on to cool the hydraulic fluid. The other blower energizes when Drill Forward / Reverse is selected. Some units are set up where both blowers come on when hydraulics are energized. In other configurations, the RH (ODS) blower does not come on until the throttle is increased out of zero speed position.

3. One 10 HP motor that powers the HPU Assembly.

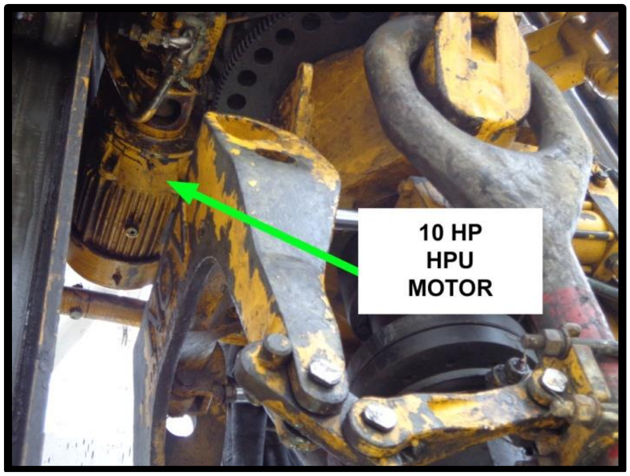


Figure 11.27

An **encoder** is a speed- and direction-sensitive device that provides feedback to a PLC or SBC for enhanced control of the machine. The TDS-11 Top Drive has one encoder, which is mounted on a 'sled' inside the RH blower shroud, just above the brake rotor. It is turned by a small belt which wraps around a drive wheel connected to the motor shaft above the brake rotor hub.

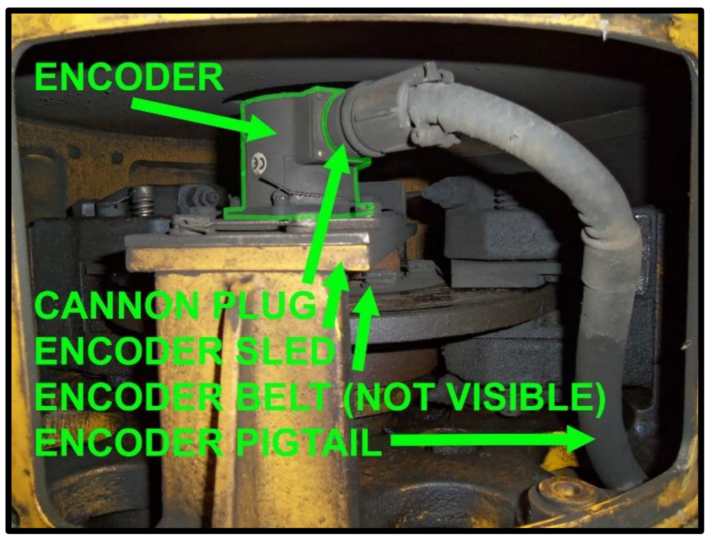
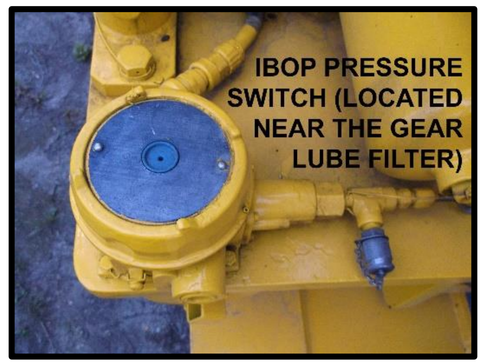


Figure 11.28

There are three common types of pressure sensors: pressure transducers, pressure transmitters, and pressure switches. Pressure transducers and transmitters are used to measure and translate pressure values. Pressure switches are much simpler, giving no reading, value or range—they only exist to trip or actuate a microswitch at a preset pressure. **The TDS-11 has a total of four pressure switches, which are of three different types: gear oil, hydraulic oil, and air.**

Two Blower Pressure Switches—one mounted atop each blower shroud—receive blower air through a ¼” tube. When the air pressure is above 100 mbar (approximately 1.5 PSI), the air pushes a plunger against spring tension to actuate a microswitch—this action extinguishes the Blower Loss lamp or alarm. When a blower failure occurs, the pressure in the inlet tube drops, the spring relaxes to the expanded position, moving the plunger and breaking the NO (Normally Open) switch contact. When the switch contacts open, the warning lamp illuminates / alarm shows on the HMI screen.



Figures 11.29 – 11.31

One Gear Lube Pressure Switch—actuates in the same way as the blower pressure switches, but instead of air, pressurized gear oil forces a plunger against spring tension to actuate a NO microswitch. When lube pressure rises above 20 PSI, the switch makes, closing the contacts and causing the Oil Pressure Loss lamp to extinguish. When the HPU is de-energized, or when the lube pump or lube pump motor fails in a way that cannot maintain the required pressure, the inlet tube pressure drops between 20 to 18 PSI descending, causing the switch contact to break and thus illuminating the lamp (or alarm indicates on the HMI screen).

One IBOP Closed Pressure Switch—actuates when hydraulic fluid pressure increases above 1,000 PSI. When this happens, it forces a plunger against spring tension to actuate the microswitch, causing the IBOP Closed lamp to illuminate / indication on the HMI.

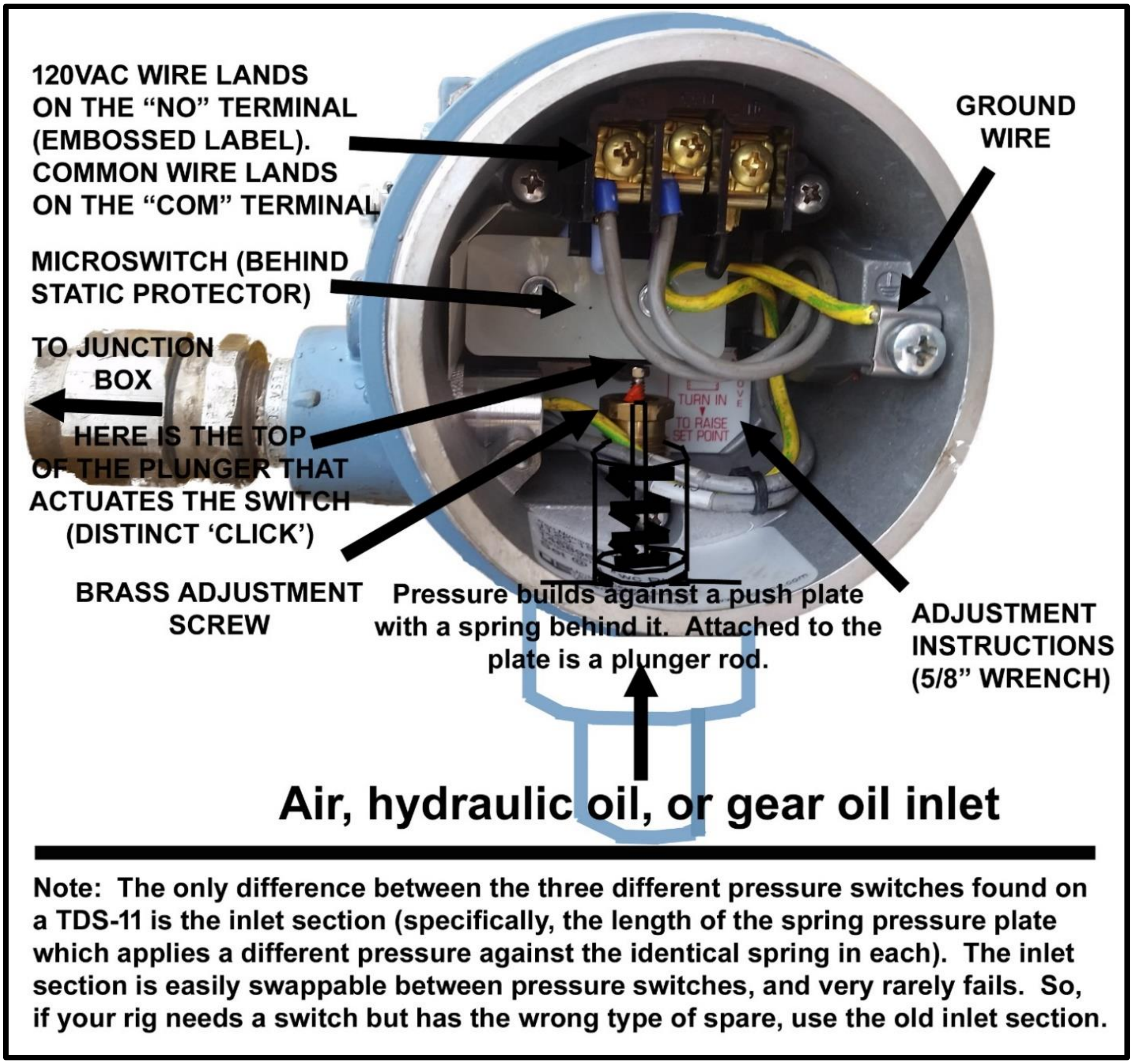


Figure 11.32

One last note on the TDS-11's pressure switches: none of them will CAUSE a failure for the protection circuit to which assigned. In other words, a failed IBOP pressure switch will not cause an IBOP failure; a failed gear lube pressure switch will not cause a gear lube pump failure; and a failed blower pressure switch will not be the cause of a failed blower. If a pressure switch fails, it will simply give an erroneous indication (or no indication). The only exception is general electrical failure or short, such as moisture that corrodes contacts and affects other circuits in the junction box.

Solenoids, heaters, and RTD's – Because Solenoid-Operated Valves (SOV's) were covered at great length in the hydraulic segment of this student manual, the electrical segment will be covered in the following statement and accompanying image:

> A solenoid is an electromagnet that converts electrical energy into mechanical energy. On our Top Drive, it is attached to a directional valve and used to push a spool against spring tension when energized.

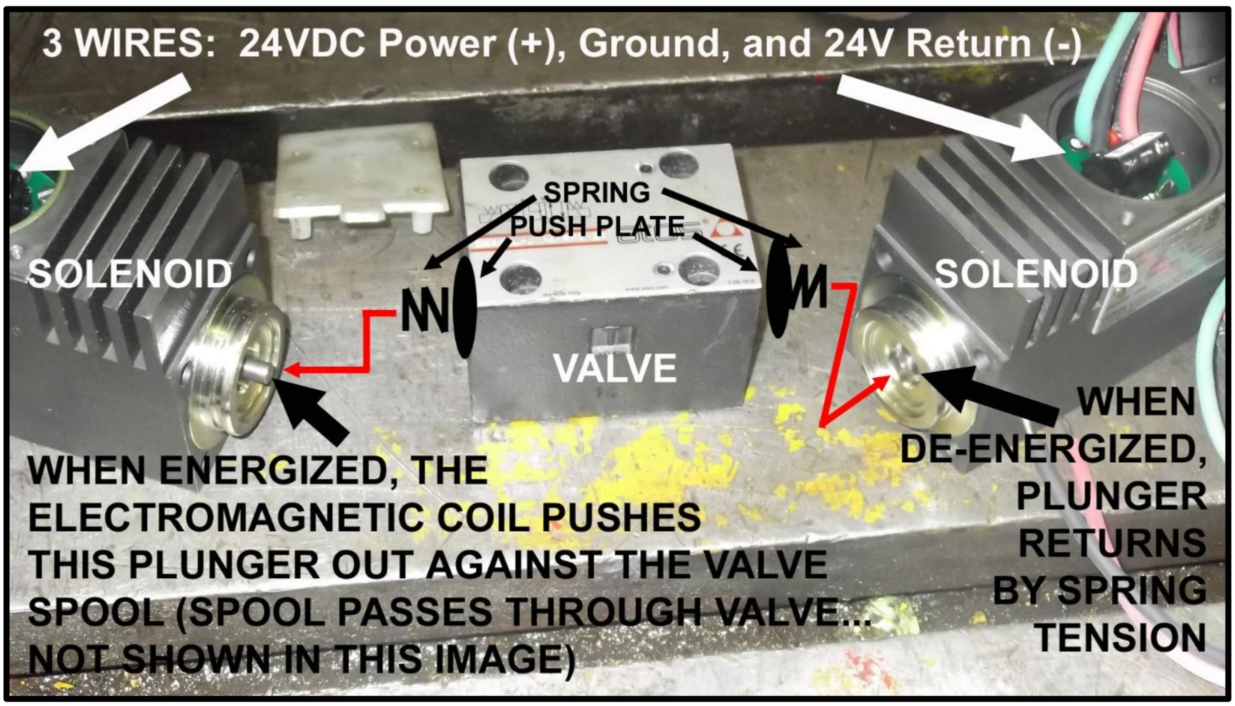


Figure 11.33 – Double Solenoid Valve

A heater element is located in the lower housing of each drill motor, used for pre-warming the heater windings in extreme cold weather environments. In warm-weather climes, the heaters often do more damage than good. Heaters receive 120V from Transformer 2 in the VFD House, transferred through the 19-Pin Auxiliary Service Loop to the TD J-Box, then passing through the back cable plate of each motor where the main power phases enter. The heaters may be coil- or tape-style, winding around the inside of the lower motor housing in three or four loops like a spring, or in older motor models may be dual heater elements each the size of a spark plug.

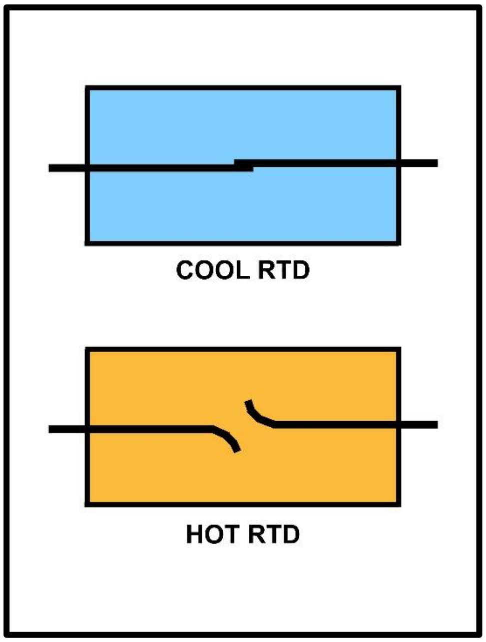
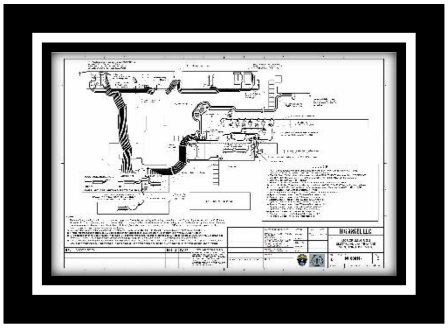


Figure 11.34

Lastly, each motor has three Resisting Temperature Devices, or RTD's, that are buried in the windings of each drill motor. The RTD's are wired to each other in series. If one of them gets hot—indicating a hot spot in the motor windings—its contacts coil up and break the electrical circuit, which in turn gives the Driller a *Drill Motor Overtemp* indication. When the windings cool down, the contacts uncoil and the circuit makes or closes again, and the alarm goes away.

Final chapter notes: (1) The use of multimeters for testing the TDS-11 will be covered in Chapter 17 – Troubleshooting Fundamentals. (2) Detailed VFD troubleshooting procedures will not be covered in this course, in order to discourage students from inadvertently damaging a program or shorting a major component. If the interest exists, this may be the basis for development of an advanced course in the future.



CHAPTER 12

PRINT READING & NOV TECHNICAL DRAWING PACKAGES

CHAPTER 12:
Print Reading & NOV Technical Drawing Packages

In this section, we will learn the following:

1. Print reading basics
2. Symbols common to all prints
3. How to read and interpret NOV Technical Drawings
4. How to navigate NOV Technical Drawing Packages

12.1 Print reading Basics – First and foremost, "prints" are a general term for many types of documents which use pictures, images, illustrations and symbols more than written words. Other terms used to describe prints are blueprints, schematics, schemes, drawings, illustrated parts breakdowns / IPB's, and exploded diagrams.

Prints are drawn and published professionally by engineers across a variety of industries, and may cover structures, mechanical parts, fabrication / machining, pneumatic / hydraulic / electrical / electronic systems, or a combination of any of these. Common to all professional prints are:

1. A drawing or diagram;

2. A legend which provides the reader with essential information about the drawing, such as size, scale, point-of-view, elevation, material type and application;

3. A title block with revisions, page numbers, approval dates and signatures, and notes; and

4. A proprietary statement which defines the document owner and user permissions.

Additionally, some prints may incorporate alphanumeric grid outlines (ABC / 123 along the vertical / horizontal edges)—such as NOV prints; grid or graph line overlays; cross-sectional views; materials or parts lists; hidden lines (3-dimensional objects that show the surfaces which are obstructed from view, usually expressed by dashed lines); dimension lines to show measurement over the span of an object; and continuation lines or markings to show where one part of a drawing ends and is continued, either on the same page / sheet or a separate page.

1. The Document Number is located on the 1st page of any technical drawing package. This is also the Part Number used to order a set of prints from National. Each new piece of NOV equipment is supposed to have a set of accompanying drawings issued to a rig, i.e. during commissioning. Many of these drawing packages have been lost, destroyed, or misplaced. It is important to keep a copy of each technical drawing package on your rig, preferably in the Rig Manager's house.

   The Document Number for the Standard (complete) TDS-11 Technical Drawing Package is 3TDP0366. When ordering, ask for the newest revision. Inside this package is a set of drawings for each subcomponent of the TDS-11. These drawings have their own Document Numbers as well.

2. **NOV drawings are read from bottom to top, right to left**. Each drawing has a grid reference side bar which reads A through D from bottom to top, and which reads 1 through 8 from right to left.

3. The hydraulic and electrical schematic sections of any NOV technical drawing package are preceded by a respective legend, which explains what each (electrical / hydraulic) symbol on the following drawings represents.

4. The bottom right corner of each drawing contains a block with a series of information boxes inside. These information boxes contain technical data about the drawing, such as the scale, the names of engineers who designed, checked, and reviewed the drawing and the draft date, the address and phone number to NOV Rig Solutions, and most important, the Title Box, Document Number, and Sheet # Reference.

5. As a rule of thumb, the P/N (Part Number) of any specific piece of equipment is located on the first page of its assigned Document Number. For example, if you are looking for a Rotating Link Adapter seal, you will see a graphic representation / cut-away drawing of the seal locations on Page 2 of Document 121341. In order to find the part number, you must match the number associated with the seal on this drawing to the number on Page 1 of Document 121341.

6. Note that a few drawings contain errors. If an error is noted, report it to NOV and request the most current revision of the document.

12.2 Technical Drawing Sample Packet – The following pages contain select drawings which will be reviewed as a class.

INSTRUCTOR / SELF-INSTRUCTION NOTE:

Ensuring that you are the owner / end user of a TDS-11 Top Drive and you are authorized to copy NOV materials per NOV's guidelines on authorized use & distribution, print the 11x17 sheets that are annotated on the following page, and insert them immediately after that page (Print files: Chapter 12 Training Prints [1] and [2]).

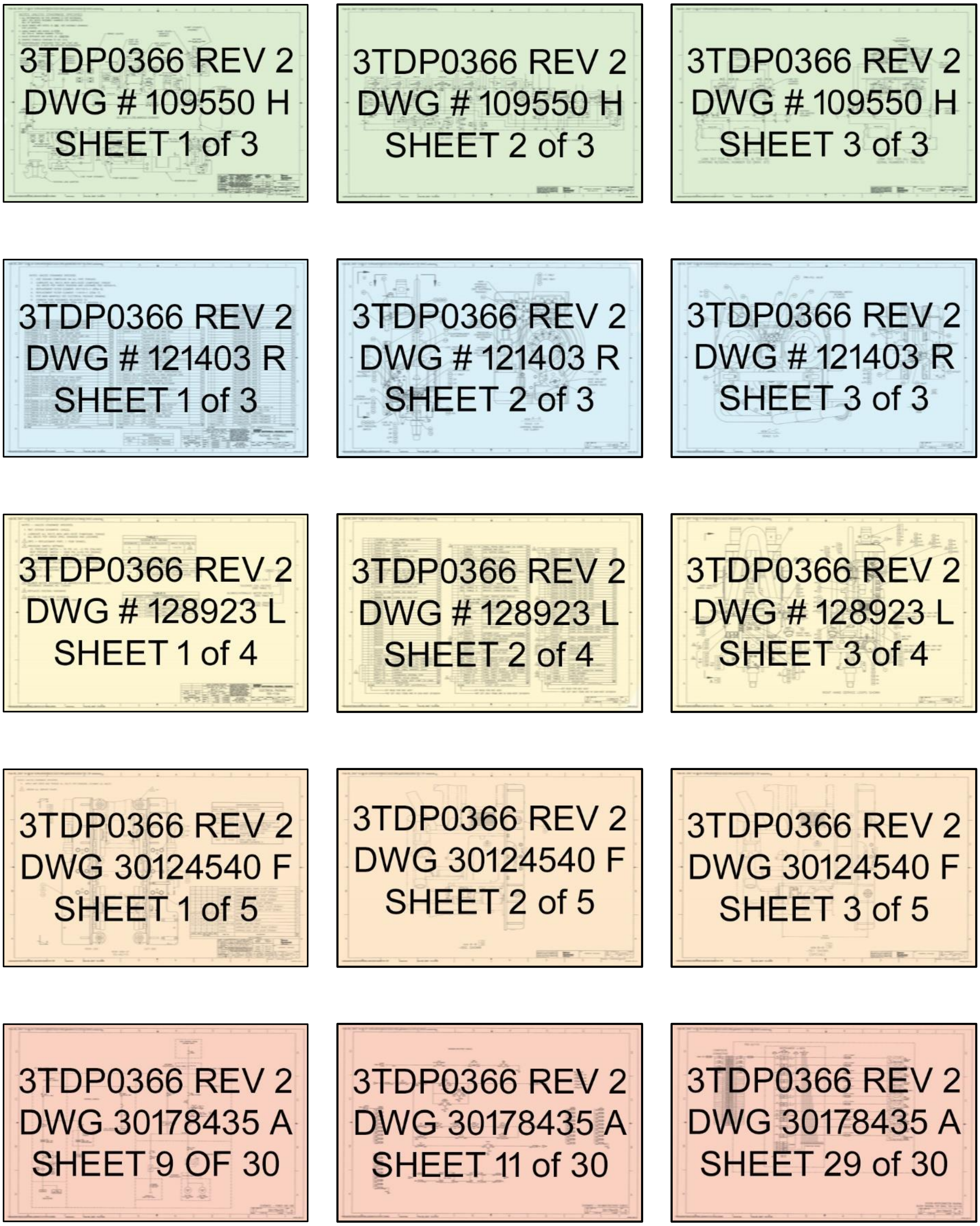


Figure 12.1 – ***TDP Excerpts for Training***

CHAPTER 13

VFD STARTUP / SHUTDOWN / BASIC TROUBLESHOOTING

CHAPTER 13:
VFD Startup / Shutdown / Basic Troubleshooting

In this section, we will learn the following:

1. How to reduce the incident of common start-up problems
2. How to properly energize the VFD
3. Normal VFD Shutdown Procedures
4. Emergency VFD Shutdown and Re-start
5. Basic VFD Troubleshooting

This chapter is designed to ensure successful startup and proper shutdown to enable smooth operations. Because there are many different types of VFD's, it is written to encompass them all in general terms.

1. Pre-Start Checks

The number one way to reduce startup failures is to conduct thorough pre-start checks. With repetition, these will become second nature, and you'll begin to notice deficiencies with ease. These procedures are meant to ensure both personnel and equipment safety. No meters, meggers, or special tools are required.

Once the VFD house has been set into place, ensure that it has been properly grounded. A 6' deep grounding rod, placed near the VFD house plug panel, should have a dedicated 4.00 (thick) ground cable securely fastened to it, that connects to the skid of the house—preferably to exposed metal, and not to a painted part. Also securely fastened. Next, if we're talking about a stand-alone VFD house, make sure that the VFD ground lug at the plug panel has a tightly-connected ground cable traveling to the SCR house ground.

Before plugging anything into the VFD house plug panel, physically check the service loops for any deficiencies. Check the power loops where they come out of the hose flanges on each end. Check the 19- and 42-pin service loops. Pay special attention to the plugs, ensuring that they are free of debris and moisture, and that there are no physical discrepancies with any pins. Check the VFD house plug panel, and the Top Drive plug panel as well. When satisfied with your inspection, connect all service loops to the Top Drive and VFD house, making sure that they are tightly connected (use a large pair of Channel Locks, if possible), and that they are not cross-threaded. Repeat this process for the Varco Driller's Console. When satisfied, plug in the console pigtail(s), as applicable, and connect them at the VFD house. At this point, the only cables NOT connected to the VFD house, are the incoming red, white, and black cables from the SCR house. Do not connect them yet.

Enter the VFD house and make sure that all primary breakers are off. In a Siemens house, there are two breakers on the outside of the reactor door at left. In an ABB standard house or ABB Finnish house, there will be a main circuit breaker for the drive, mounted to the outside door of the incomer / rectifier cubicle. Inside the tall, skinny control cubicle will be 3 to 5 breakers / disconnects, with at least one near the top having a standard disconnect handle (red and black, 90-degree turn—horizontal is open / off and vertical is closed / on), and several small (lighting panel) breakers, depending on the age and configuration of the house. After these are turned off, locate the auxiliary motor starter breakers and turn those off as well (horizontal).

Inspect the inside of each panel for any obvious visual deficiencies that may have occurred during rig move. If no deficiencies are noted, exit the VFD house go to the SCR. Ensure that the VFD power cables are disconnected and that the TD Feeder Breaker is off.

2. Proper Energization of the VFD

If any issues are detected while powering up the VFD house, refer to the TDS-11 troubleshooting scenarios in Chapter 16. Visually check the three cables between the SCR and VFD houses from end to end, especially at the plugs. If no deficiencies exist, plug the three phases into the VFD side, color for color. Then plug the opposite ends into the SCR house. Close the TD Feeder Breaker in the SCR (energize the circuit), and then enter the VFD house. Without energizing the VFD CBM (sometimes called CB1), close / energize the primary disconnects / breakers from the top down, one at a time, pausing between each one about five seconds to look, listen, and smell for deficiencies. Ensure that the lights come on, and that the air conditioner comes on, and that there is no smell of anything burning electrically.

Open the PLC or SBC cabinet and look for lights on the I/O. When verified, close the cabinet and turn on the auxiliary motor starter breakers, one at a time, with a five-second pause between each. If everything in the house is satisfactory at this point, go to the rig floor. Enable the HPU and blowers from the Driller's console. If the ODS blower doesn't come on, select drill forward. Some configurations may not let you proceed because the VFD CBM is not energized, in which case, don't sweat the ODS blower at the moment. Ensure positive airflow coming from the drill motor vents. Test hydraulic functions. Drill and spin will not operate, because CBM is not closed.

Return to the VFD house and pre-charge the DC bus by pressing the pre-charge button. Observe the DC voltmeter climb to ~850 VDC. Pump the spring-tensioned charging handle of the CBM until the spring is ready to discharge. This occurs with an audible 'click' and the inability to charge the handle further. Stepping away from CBM with your body, and facing away, press the green button to discharge the spring and close the breaker. Observe the three ground fault lamps to ensure they are all illuminated with equal brightness. The green MOV SSP lamp and green Chopper OK lamps should both be illuminated, as well as the red CB1 Closed lamp.

Return to the rig floor, go to the console and cycle the brakes. Leaving them in the off or auto position, select drill forward, increase drill torque and turn the quill at below 5 RPM for five minutes. Over the course of the next five minutes, incrementally increase the speed of the quill to 100 RPM (15… 30… 60… 100 RPM or similar fashion). The VFD has now been properly started and tested.

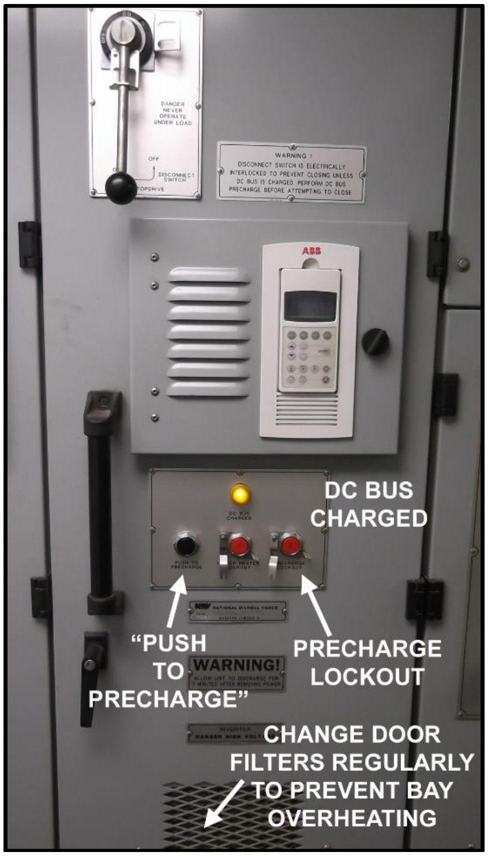


Figure 13.1

Figure 13.2

3. Normal Shutdown

At the Driller controls, with the TD rotation at zero speed, deselect drill mode. With some electronic configurations, the operator may now select TD VFD ‘Disable’ or TD Ownership ‘Release’. Go to the VFD house and open (de-energize) the CBM by pressing the red button. Then engage the mechanical locking hasp over the pre-charge disable button. In the control cubicle of any ABB drive house, open the primary circuits by turning the transformer disconnects from bottom to top. Finally, inside the SCR house (if applicable), open the TD Feeder breaker.

4. Emergency Shutdown (ESD) and Re-Start

In an emergency situation, the operator must shut down the TD VFD at the Driller controls by depressing the red mushroom-style ESD pushbutton. This may also be done by depressing the panel-mounted ESD button inside the VFD house, which is co-located with the DC bus and ground fault indicators.

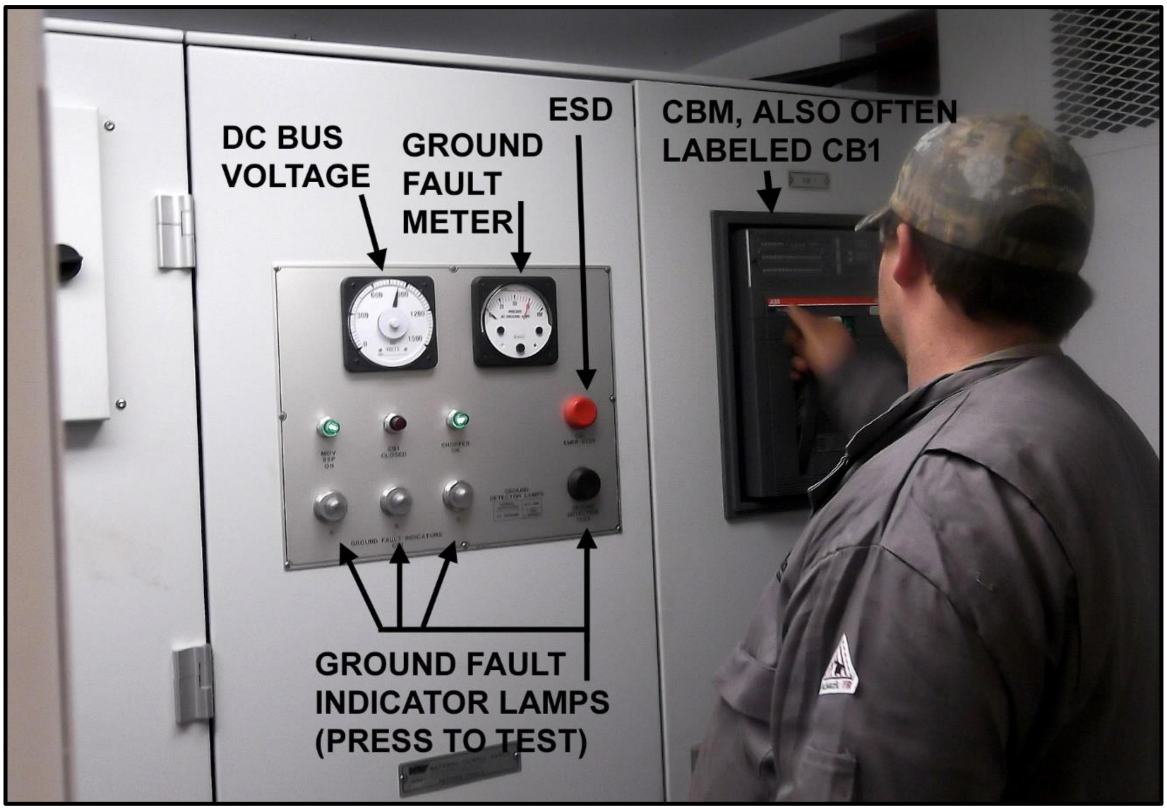
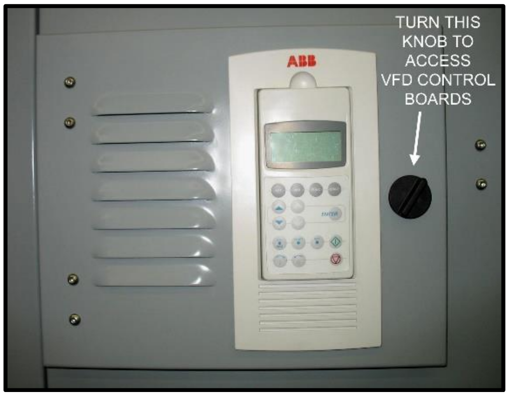


Figure 13.3

Performing an emergency shutdown, either from the operator controls or at the VFD house, opens a circuit that begins with a 24V DC power source and ends at the RDCU Drive Control Unit (in all ABB drive house configurations). The two images that follow will show the location of the RDCU of the VFD house. The way the ESD circuit works is as such: the continuous circuit described has multiple points at which the circuit can be opened, such as the two manual pushbuttons described above, the overtemperature switches of the chopper's resistor bank, the two fuse microswitches of each inverter, and several relays and breakers designed to protect the integrity of the drive system. When the circuit opens, the RDCU interrupts the inverters' firing pulse—note: pulse width modulation, or PWM, is how the inverters convert incoming DC into controlled AC, by literally turning 'on' and 'off' the flow of DC electrons at the Driller's throttle-commanded rate or speed. This interruption opens a relay which in turn opens the CBM.



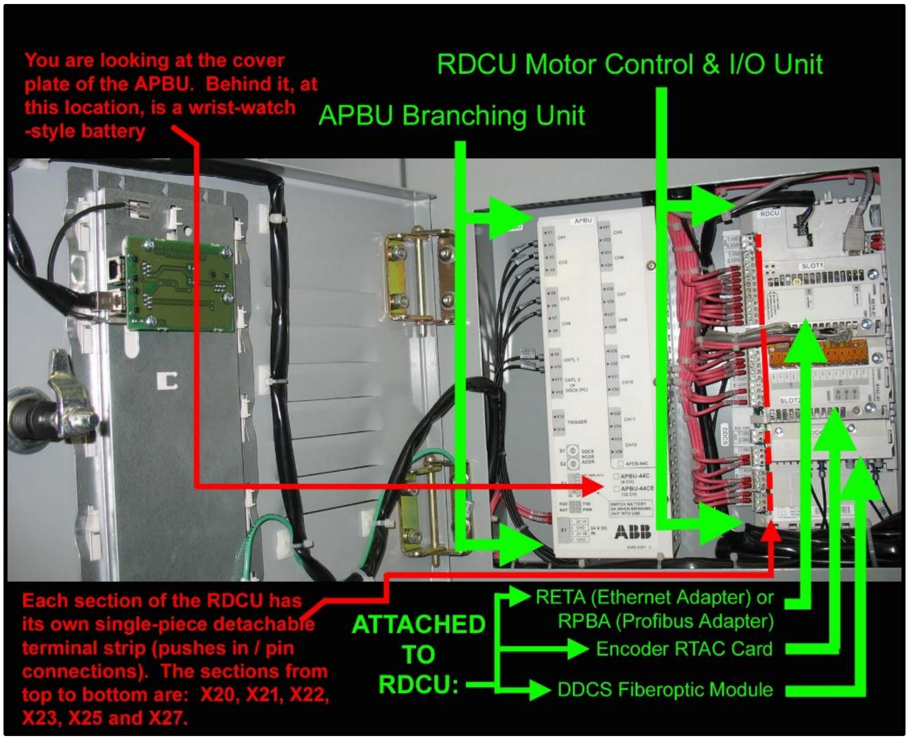


Figure 13.4 **(Above)** *Figure 13.5* **(Below)**

Restarting after emergency shutdown is usually just a matter of pre-charging the VFD, cranking the handle on the CBM and pressing the green button to send the spring home. In some configurations, it may be required to clear the ABB alarm code(s) at the keypad first, by pressing the ACT button and then the RESET button.

5. Basic VFD Troubleshooting

This information is derived from the Siemens SIMOVERT MasterDrives Compendium, and from the ABB ACS-800 Firmware Manual. Herein are listed some of the common faults and alarms, and the manufacturer's recommendations on what may have caused them (I have omitted the recommendations that are least common probable causes, and worded them for simplicity). In this section, you will see much repetition, as different symptoms & alarms during various stages of drive operation often share a common cause. For Yaskawa drives (Omron AC rigs), refer to the appropriate firmware manual for the type of inverters you're using (Modular and A-1000 are typical).

A. **Siemens** Drive Faults (drive shuts down)

CODE	DESCRIPTION	RECOMMENDATION
F002	PRE-CHARGING	Check the VFD's incoming power supply. Check components in the ESD circuit.
F011	OVERCURRENT	Follow the ground fault troubleshooting steps in Chapter 16, Scenarios 2(3) and 3A.
F015	MOTOR STALL	In the Driller's Console, check the wires and ground associated with the tachometer. On the ABB key pad, check the Encoder

		Module parameter group to ensure the pulse value is 1,024 counts.
F020	MOTOR TEMP	Follow the troubleshooting procedures in Chapter 16, Scenario 4.
F028	SUPPLY PHASE	Check the VFD's incoming power supply.
F035	EXT FAULT 1	Check communication wires. Most common in I/O components or comm wire connections between the Driller's Console and the VFD house.
F036	EXT FAULT 2	Same as previous (External Fault 1).
F051	SPEED ENCODER	Check Driller's Console tachometer and associated wires / grounding.
F103	GROUND FAULT	Follow the ground fault troubleshooting steps in Chapter 16, Scenarios 2(3) and 3A.

B. **Siemens** Drive Alarms (drive remains energized)

CODE	DESCRIPTION	RECOMMENDATION
A015	EXT ALARM 1	Check communication wires. Most common in I/O

		components or comm wire connections between the Driller's Console and the VFD house.
A016	EXT ALARM 2	Same as previous (External Alarm 1).
A020	OVERCURRENT	Check the chopper and its resistors for overheating, loose or damaged wiring, or water intrusion.
A021	OVERVOLTAGE	Check the VFD's incoming power supply.
A022	INVERTER TEMP	Check the inverter bay cooling fan to ensure it's working. Check the VFD house temperature and A/C unit.
A023	MOTOR TEMP	Follow the troubleshooting procedures in Chapter 16, Scenario 4.

C. **ABB** Drive Warnings (drive remains energized)

CODE	DESCRIPTION	RECOMMENDATION
7112	BR OVERHEAT	Check the chopper and its resistors for overheating, loose or damaged wiring, or water intrusion.
7510	COMM MODULE	Check communication wires and

		fibers. Most common in I/O components or comm wire connections between the Driller's Console and the VFD house PLC or SBC cabinet.
2330	CURRENT UNBAL	Check ground fault indicator lights and follow the troubleshooting steps in Chapter 16, Scenarios 2(3) and 3A. Call an electrician / AC drive specialist to test inverters.
2330	EARTH FAULT	Same as previous.
7301	ENCODER ERR	Refer to Chapter 16, Scenario 3C for encoder circuit troubleshooting.
7302	ENCODER A<>B	This usually occurs after a new encoder, encoder pigtail, 42-pin service loop or 42-pin pigtail has been changed. Noting original wire position, at the RTAC Card, swap the wires between A channel (A, A-) and B channel (B, B-). Clear the warning and try to rotate. If the warning appears again, swap them back to original position. Swap the A and A- wires, then the B and B- wires. Clear the warning and try to rotate. If the warning appears again, swap only A and A- wires to their original position. If that

		doesn't work, swap A and A- again, then swap B and B- to their original position.
4310	MOTOR TEMP	Follow the troubleshooting procedures in Chapter 16, Scenario 4.
N/A	START INTERLOCK	Check all components of the start interlock / ESD circuit, from Transformer 1 through RDCU terminal X22-11.

D. **ABB** Drive Faults (drive shuts down)

CODE	DESCRIPTION	RECOMMENDATION
4210	ACS800 TEMP	Check inverter fans' rotation, VFD house A/C unit, cabinet door outlet filters (if applicable) and heatsink fins for dust accumulation.
7510	COMM MODULE	Check all communication wires, connectors, and I/O components.
2330	CURR UNBAL	Check ground fault indicator lights and follow the troubleshooting steps in Chapter 16, Scenarios 2(3) and 3A. Call an electrician / AC drive specialist to test inverters.
3210	DC OVERVOLT	Check the chopper and its

		resistors for overheating, loose or damaged wiring, or water intrusion.
3220	DC UNDERVOLT	Check incoming VFD power to see if a phase dropped.
2330	EARTH FAULT	Check ground fault indicator lights and follow the troubleshooting steps in Chapter 16, Scenarios 2(3) and 3A.
7301	ENCODER ERR	Refer to Chapter 16, Scenario 3C for encoder circuit troubleshooting
7302	ENCODER A<>B	See 7302 in ABB Warnings section. Whether this manifests as a fault or a warning depends on the selected setting in parameter group 50: Encoder Module.
FF83	FAN OVERTEMP	Check inverter fans' rotation, VFD house A/C unit, cabinet door outlet filters (if applicable) and heatsink fins for dust accumulation.
4310	MOTOR TEMP	Follow the troubleshooting procedures in Chapter 16, Scenario 4.
2310	OVERCURRENT	Check ground fault indicator lights and follow the

		troubleshooting steps in Chapter 16, Scenarios 2(3) and 3A.
7123	OVERFREQ	Check minimum / maximum speed settings. Check braking chopper or dynamic brake module circuit.
3.08	RUN DISABLE	Check setting of parameter 16.01. Check all communications wiring and connections. Check drive control card wiring.

CHAPTER 14

RECOMMENDED SPARE PARTS

CHAPTER 14:
Recommended Spare Parts

Following is a list of 'recommended' spare parts for the TDS-11, compiled from a number of similar lists—ironically, though the TDS-11 has changed very little, NOV's recommendations have changed a lot—and still not based on triage / frequency of failure. These are not necessarily the spares you will want to keep on a rig; many should remain properly stored at your company's shop / yard.

MAIN BODY / GENERAL

(1)	30173521	BEARING ISOLATOR
(1)	30154362	SHIELD, BEARING
(1)	98290	LINER, UPPER STEM, STD. BORE
(1)	98291	SEAL, POLYPAK
(1)	91250-1	SEAL, OIL
(2)	77039	SEAL
(1)	141304	VALVE, RELIEF
(1)	30123290	ASSEMBLY, WASH PIPE
(1)	Z6001-CAN	LOCKWIRE, .051
(1)	Z6001.9	LOCKWIRE, .047
(1)	53003-16	PLUG, MAGNETIC
(10)	53219-2	FITTING, GREASE
(2)	51300-387-F	O-RING, MOTOR/COVER
(1)	51300-277-B	O-RING, COVER/BEARING RET.
(2)	51300-016-B	O-RING, OIL LUBE TUBE
(2)	51300-425-B	SEAL, HAMMER LUG UNION
(1)	109523	ADAPTER, S-PIPE
(1)	108216-12	BALL VALVE
(1)	118217-40R69E	DRILLING MOTOR ASSY, UNIVERSAL

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(1)	*10515072-001*	*ENCODER, HOLLOW SHAFT*
(1)	*10515072-003*	*ENCODER ANTI-ROTATION ARM*
(1)	*P611003989*	*ISOLATOR, CERAMIC SHAFT*
	OR	
(1)	*115299*	*ENCODER, DIGITAL, BEI*
(1)	*120117*	*BELT, TIMING, ENCODER*
(1)	*120357*	*DRIVE ASSEMBLY, RETROFIT, ENCODER BELT*

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(1)	122243	PIGTAIL ASSEMBLY, ENCODER
(1)	30122104	HEAT EXCHANGER, OIL
(1)	117603-1	PUMP ASSEMBLY, LUBE
(1)	121272-2	TUBE ASSEMBLY, BREATHER
(1)	121272-1	TUBE ASSEMBLY, BREATHER
(1)	30151875-504	SHOT PIN ASSEMBLY

RESERVOIR ASSY

(1)	30113165	VALVE, RELIEF-POPOFF
(1)	108119-16B	SIGHT GAGE
(1)	71613	RESERVOIR BREATHER
(1)	51300-038-B	O-RING

(1)	110132	GASKET
(1)	110191-501	BLADDER, RESERVOIR

WASH PIPE ASSEMBLY

(1)	30123289	PIPE, WASH, 3 INCH BORE
(5)	123292-2	PACKING SEAL KIT, STANDARD
(1)	30123562	RING, SNAP
(1)	53303-14	WRENCH, WASHPIPE

BRAKE ASSEMBLY

(2)	109555	ROTOR, BRAKE
(4)	109528	CALIPER, DISC BRAKE
(8)	109528-1	FRICTION PADS (2 PER CALIPER)
(2)	109528-2	SEAL KIT
(8)	109528-3	HEAVY DUTY SPRING
(8)	109528-4	SCREW, RETURN SPRING
(8)	109528-5	PIN, GUIDE
(4)	109528-6	BLEED SCREW ASSEMBLY

ROTATING LINK ADAPTER (RLA), 500 TON

(1)	51300-273-B	O-RING
(1)	51300-381-B	O-RING
(1)	30119319	GLYD RING ROTARY, 11.000 ROD
(1)	30119357	RING, THRUST
(1)	30119143	GLYD RING ROTARY, 11.500 ROD
(10)	118375	GLYD RING ROTARY, 10.000 ROD
(1)	119547	SEAL, WIPER
(1)	30117775	RETAINER RING
(2)	119358	BUSHING, TURCITE
(2)	115176	BUSHING
(2)	112754-130	BEARING, FLANGED
(2)	53250-5	RELIEF VALVE
(2)	77039	SEAL

PH-75 PIPE HANDLER PACKAGE / TORQUE ARRESTOR ASSY

(2)	118844-16-08	BEARING, SELF-LUBRICATING
(2)	118844-16-12	BEARING, SELF-LUBRICATING
(2)	118844-22-22	BEARING, SELF-LUBRICATING
(2)	120165	CLAMP, 500 TON
(2)	119139	U-BOLT, 500 TON
(2)	50412-C	LOCK NUT
(2)	50108-16	SCREW, CAP, HEX-HEAD
(2)	50108-20	SCREW, CAP, HEX-HEAD
(2)	30122112	BOLT
(2)	76444-2	BOLT
(2)	51108-C	WASHER, LOCK, HI-COLLAR
(1)	125051	JAW ASSEMBLY, 4.75 - 6.00 OD
(1)	125052	JAW ASSEMBLY, 6.25 - 7.50 OD
(1)	125053	JAW ASSEMBLY, 7.50 - 8.62 OD
(1)	125157	STABBING GUIDE ASSEMBLY, 4.75 - 6.00 OD
(1)	125158	STABBING GUIDE ASSEMBLY, 6.25 - 7.50 OD
(1)	125159	STABBING GUIDE ASSEMBLY, 7.50 - 8.63 OD
(6)	16781	TONG DIES

(6)	16401-2	TONG DIES
(2)	98898	CRANK ASSEMBLY, EXTERNAL, IBOP
(2)	71847	ROLLER / CAM FOLLOWER, IBOP
(1)	125098	TUBE ASSEMBLY
(1)	30125094	TUBE ASSEMBLY
(1)	30125097	TUBE ASSEMBLY
(1)	110042	SHELL, ACTUATOR, IBOP
(8)	107052	LOCK TAB
(1)	125594	CYLINDER ASSY, IBOP ACTUATOR
(2)	30119592	CYLINDER, LINK TILT

PH-75 CLAMP CYLINDER

(2)	72219	SEAL, PISTON
(2)	72220	SEAL, ROD
(2)	72221	RING, WIPER
(2)	30158690	RING, STABILIZER

HYDRAULIC PACKAGE

(2)	30173216-1	FILTER ELEMENT, HYDRAULIC
(1)	30111013	FILTER, 60 MICRON
(1)	110562-1CE	COUNTERBALANCE ACCUMULATOR
(1)	110563-1CE	SYSTEM ACCUMULATOR
(1)	110564-1SEP	IBOP TIME-DELAY ACCUMULATOR

PUMP MOTOR ASSEMBLY (HPU)

(1)	30179191-1	MOTOR ASSY (COUPLER HOUSING)
(1)	10721462-004	MOTOR, 7.5KW, 600VAC, 60HZ
(1)	P611004347	PUMP, HYD. PISTON, PRESS COMP.
(1)	107783-5C11R	PUMP, HYD. VANE, 1.0 CU IN./MIN
(1)	110023	FLEX COUPLING

ELECTRIC PACKAGE

(2)	30179069	MOTOR BLOWER, 3KW
(1)	83095	PRESSURE SWITCH, IBOP
(1)	87541-1	PRESSURE SWITCH
(2)	76841	PRESSURE SWITCH, AIR
(10)	53219-3	FITTING, GREASE
(1)	124459-01-20	19-PIN PIGTAIL ASSY
(1)	122718-01-20	42-PIN PIGTAIL ASSY
(1)	122443-9-H	VDC COMM CABLE PIGTAIL (SIEMENS PLC)
(1)	M614003124-BLK	POWER PIGTAIL, BLACK, 35' OAL 4/0 ARMORED
(1)	M614003124-WHT	POWER PIGTAIL, WHITE, 35' OAL 4/0 ARMORED
(1)	M614003124-RED	POWER PIGTAIL, RED, 35' OAL 4/0 ARMORED
(1)	128929-[135*]-25-4-B	SERVICE LOOP, OUTER POWER, 135' [*LENGTH PER P/N]
(1)	30175017-[86*]-4-3-B	SERVICE LOOP, INNER POWER, 86' [*LENGTH PER P/N]
(1)	30183959-[200*]-25-4-B	SERVICE LOOP, 19-PIN AUXILIARY, 200' [*LENGTH PER P/N]
(1)	122517-[200*]-25-3-B	SERVICE LOOP, 42-PIN COMPOSITE, 200' [*LENGTH PER P/N]

**ADDITIONAL NOTE ON SERVICE LOOPS: END NUMBERS INDICATE LENGTHS ON EITHER SIDE OF HOSE FLANGE, FOR EXAMPLE, -25-3 MEANS 25' LENGTH ON ONE END OF THE SERVICE LOOP HOSE FLANGE (FOR THE VFD-SIDE RUN) AND 3' LENGTH ON THE OTHER END BEYOND HOSE FLANGE (TD CONNECT).

HYDRAULIC PACKAGE

(2)	112554-D2	SOLENOID VALVE, 2-POSITION (SINGLE)	
(2)	112554-J2	SOLENOID VALVE, 3-POSITION (DOUBLE)	
(1)	30158011 / 114375 (OLDER)	MOTOR, HYDRAULIC, ROTATING HEAD	
(2)	94520-1AN	VALVE, RELIEF, ROTATING HEAD	RPEC-LAN
(1)	94522-1EN	VALVE, RELIEF, SHOT PIN	RDDA-LEN
(1)	111664-1EN	RELIEF VALVE, LOW FLOW, SJ RELIEF	RBAC-LEN
(3)	109858-1AN	REDUCING/RELIEVING VALVE (PC1)	PRBD-LAN
(1)	P614000063-1AN	RELIEF VALVE, VENTABLE	
(4)	107029-175N	PILOT-TO-OPEN CHECK VALVE	CVCV-XEN
(1)	107031-1AN	RELIEF VALVE (RV1)	RVCA-LAN
(1)	107028-1ANB	DIFFERENTIAL UNLOADING VALVE (UV1)	QCDB-LAN
(1)	93548-1S30N	CHECK VALVE (IBOP)	CXCD-XCN
(1)	99353-1AN	REDUCING / RELIEVING VALVE	PVDA-LAN
(1)	98402-800D	FLOW CONTROL VALVE	
(1)	94537-130N	PILOT-TO-CLOSE CHECK VALVE (CLAMP)	CODA-XAN
(1)	109302-130NC	CARTRIDGE, .047 FLOW CONTROL (CLAMP)	CNCC-XCN
(2)	94536-230N	CHECK VALVE (CTF)	CXFA-XCN
(3)	94536-14N	CHECK VALVE (CDR)	CXDA-XAN
(3)	94534-1CXN	LOGIC CARTRIDGE (LB6, LA6, LC5)	LODC-XDN
(1)	94520-1NN	RELIEF VALVE (RV2)	RPEC-LNN
(2)	94518-13HN	COUNTERBALANCE VALVE (LT CYLINDER)	CBCA-LHN
(2)	93547-1B30N	PILOT-TO-OPEN CHECK VALVE (LT CYLINDER)	CKCB-XCN
(1)	118463 / 117865 / 117846	MANIFOLD ASSY, LINK TILT	
(1)	93667-M13	CAVITY PLUG, T-13A SHORT	
(1)	93667-M11	CAVITY PLUG, T-11A SHORT	
(1)	30171921	MANUAL VALVE, 3-POS.	

CARRIAGE ASSEMBLY

(8)	109944	BUSHING, FLANGE
(2)	30155438	CAM FOLLOWERS 6”
(16)	30158767-04	CAM FOLLOWERS 4”
(16)	55324-C	NUT
(2)	51132-C	WASHERS
(16)	51024-C	WASHERS
(2)	80569	NUT
(2)	112875	BOGEY PIN
(2)	109944	BUSHING
(4)	30152845	RETAINING PINS
(4)	30157306	LYNCH PINS

COUNTERBALANCE KIT

(1)	110704	CYLINDER ASSY, COUNTERBALANCE / SJ
(1)	110703	CYLINDER ASSY, COUNTERBALANCE / SJ
(1)	108894-P40	SEAL, PISTON, SJ CYLINDER
(1)	94522-21N	RELIEF VALVE CARTRIDGE, SJ CYLINDER
(1)	108894-B40	BODY SEAL, SJ CYLINDER
(1)	108894-G20	ROD & GLAND SEAL, SJ CYLINDER
(1)	108894-Y4	ROD & GLAND WRENCH, SJ CYLINDER
(1)	108894-Z677	SPANNER WRENCH, SJ CYLINDER
(2)	94536-175N	CHECK VALVE, PRE-FILL VALVE ASSY
(1)	92654	CHECK VALVE, PRE-FILL VALVE ASSY
(1)	112825	CARTRIDGE, PRE-FILL VALVE ASSY

GUIDE BEAM

(2)	117496-1	LYNCH PIN
(2)	117783	RETAINER PIN
(2)	117782	JOINT PIN

AMPHION SBC STATELESS DRILLER'S CONSOLE

(1)	40943311-061 (10064178-086)	WAGO PROFIBUS INTERFACE MODULE
(1)	0000-9671-93 (10064178-040)	WAGO 4 POINT DIGITAL INPUT MODULE
(1)	0000-9671-92 (10064178-064)	WAGO 4 POINT DIGITAL OUTPUT MODULE
(1)	30171871-554 (10064178-024)	WAGO 2 POINT ANALOG OUTPUT MODULE
(1)	40943311-104 (10064178-034)	WAGO ENCODER MODULE, 32 BIT
(1)	40943311-105 (10064178-072)	WAGO FIELD SIDE POWER SUPPLY MODULE
(1)	40943311-080 (10064178-096)	WAGO POWER SUPPLY MODULE
(1)	938203-026 (10115078-001)	FUSE, 2A
(1)	10513206-001	HEATER, ELECTRIC, 140W w/ THERMOSTAT
(1)	938215-207 (10689547-001)	FUSE, 6A
(1)	30155573-12 (10546480-001)	METER, 0-250 RPM
(1)	30155573-27 (10546480-004)	METER, 0-80K FT-LBS
(1)	P250000-9900-28 (10066582-001)	PUSHBUTTON ACTUATOR, ILLUMINATED, GREEN
(1)	P250000-9900-29 (10066583-001)	PUSHBUTTON, ILLUMINATED, GREEN
(1)	P250000-9900-25 (10066579-001)	PUSHBUTTON ACTUATOR, ILLUMINATED, RED
(1)	P250000-9900-26 (10066580-001)	PUSHBUTTON, ILLUMINATED, RED
(1)	P250000-9699-08 (10066451-001)	LAMP, LED, YELLOW
(1)	P250000-9900-27 (10066581-001)	LAMP MODULE, YELLOW
(1)	P250002-0011-91 (10066997-001)	LAMP, LED, RED
(1)	0000-9652-70 (10044544-001)	LAMP MODULE, RED
(1)	932504-108:58P (10055017-001)	PUSHBUTTON, ACTUATOR - 1
(1)	123075-1001BN (10044540-001)	SWITCH, 3 POSITION - 1
(1)	0000-9652-59 (10044536-001)	SWITCH MODULE - 1
(1)	0000-9652-60 (10044537-001)	ESTOP, PUSHBUTTON - 1
(1)	10048305-004	ENCODER, INCREMENTAL - 1
(1)	0000-9604-54 (10043304-001)	HORN, I.S. - 1
(1)	951540-002 (10691095-001)	BARRIER, ISOLATION, 1-CH, ANALOG OUTPUT - 1
(1)	951540-119 (10121838-001)	BARRIER, ISOLATION, 1-CH DRIVER - 1
(1)	17796760-001	INPUT TRANSFORMER, 1000KVA, 690:600VAC, 50 Hz – 1

ABB DRIVE HOUSE - AMPHION SBC COMPONENTS

(2)	40943311-051 (10064178-058)	WAGO, 2 PT RELAY OUTPUT MODULE
(1)	40943311-050 (10064178-039)	WAGO, 8 PT INPUT MODULE, 24VDC
(1)	40943311-034 (10064178-051)	WAGO, 4 PT INPUT MODULE, 24VDC
(1)	30171871-554 (10064178-024)	WAGO, 2 PT ANALOG OUTPUT MODULE, 4-20ma
(1)	40943311-059 (10064178-032)	WAGO, ENCODER MODULE
(1)	40943311-052 (10064178-093)	WAGO, PWR SUPPLY, 0-23**0**V, AC/DC
(1)	40943311-061 (10064178-086)	WAGO, PROFIBUS DP INTERFACE MODULE
(1)	P250000-9688-27 (10066030-001)	BECKHOFF, INDUSTRIAL SBC CONTROLLER
(1)	P800000-9686-67 (10068309-001)	APPLICOM, CARD-DP1
(1)	P800000-9686-71 (10068310-001)	PWR SUPPLY FOR SBC
(1)	0302-0601-06 (10049527-001)	CB-1250AF/AT, 690VAC, 85KIC, LSI TRIP UNIT, FIXED, HORIZONTAL CONNECTIONS, 5NO/5NC CONTACTS, PADLOCK PROVISION (OPEN), IEC RATED

VARCO DRILLER'S CONSOLE – SIEMENS PLC

(1)	96920	PCB +5VDEC REGULATOR
(1)	116551	RHEOSTAT ASSY, IDM CONTROLS

(1)	117952	ENTRELEC SINGAL CONVERTER
(1)	30081736-2 OR 817362	POTENTIOMETER, 10K, 2W
(1)	30087708-02	SWITCH, PUSHBUTTON, FLUSH BLACK DC
(1)	30087708-26	SWITCH, 2 POS MAINTAINED
(1)	30087708-30	SWITCH, 3 POS RETURN TO CENTER
(1)	30087708-33	SWITCH, SPRING RETURN FROM RIGHT
(1)	30087708-36	SWITCH, 3 POS MAINTAINED
(1)	30087708-46	DC TORQUE POT OPERATOR
(1)	30087708-67	E-STOP OPERATOR
(1)	30087708-44	LAMP, MINI BAYONET BS 24V
(1)	30087708-38	LIGHT, INDICATING 24V DC RED
(1)	30087708-40	LIGHT, INDICATING 24V DC AMBER
(1)	91548-2 OR 30091548-2	INDICATING LIGHT, RED
(1)	88663	ALARM HORN
(1)	96219-11	TORQUE METER, 60K FT-LBS
(1)	PR1003A19	TACHOMETER, 250 RPM
(1)	122627-45	MODULE, REMOTE I/O, 4PT ANALOG
(1)	122627-46	MODULE, REMOTE I/O, DIGITAL, 24 IN, 8 OUT
(1)	122627-47	MODULE, REMOTE I/O, ANALOG
(4)	122627-54	FUSE, 2.5A, 250V (DIGITAL I/O MODULE)
(6)	122627-55	FUSE, 1.6A, 250V (ANALOG I/O MODULE)
(1)	122627-57	BASE, ANALOG SIEMENS / S7
(1)	122627-58	BASE, DIGITAL SIEMENS / S7

ABB DRIVE HOUSE – SIEMENS PLC COMPONENTS

(1)	P250002-0005-31	POWER SUPPLY, SOLA 24V 10-24-100C
(1)	0000-9609-83	PLC CPU, 315-2DP SIEMENS
(1)	122627-09	MODULE, INPUT, 16PT, 24VDC
(1)	122627-18	MODULE, OUTPUT, 8PT, 24VDC
(1)	122627-64	MODULE, OUTPUT, 16PT, 24VDC
(4)	122627-34	PROFIBUS CONNECTOR

ABB DRIVE HOUSE (SIEMENS PLC OR NOV AMPHION [BECKHOFF] SBC)

(1)	0000-9671-91 (10045286-001)	XFMR- 3KVA, 600/690:120/208/240 CVT, 1PH, ISOLATION & VR
(1)	0000-9671-60 (10045264-001)	XFMR- 30KVA, 600/690 PRI, 208Y/120 SEC, 50/60 HZ, ALUM
(1)	0000-9642-05 (10044171-001)	PC BOARD-ENCODER CARD FOR USE WITH ABB ACS800 DRIVE
(1)	0000-9649-07 (10044443-001)	PCB-DISTRIB CARD FOR PARALLEL OPERATION OF ABB 800 ACS INVERTER SECTIONS, PPCS BRANCHING AND DATALOGGER UNIT (64669982), CONSISTING OF: 1 - EN/MD MOD CDR MULTIDRIVE (6821268) 1 - ELECTRICAL PLANNING MANUAL (64783742) 1 - STANDARD SOFTWARE (64527592) 1 - FIRMWARE MANUAL (99999998) STD APPC 7.X
(1)	0000-9649-14 (10044446-001)	PC BOARD-MOTOR CONTROL UNIT KIT FOR ABB ACS80 INVERTERS, CONSISTING OF: 1 -X35/X34 CABLE (64672606) 1 - SOFTWARE (64565168) 1 -(10024943/KV)
(1)	0000-9651-08 (10044500-001)	PC BOARD-PROFIBUS MODULE, ABB PROFIBUS ADAPTER MODULE OPTION / SP KIT (64606859) FOR USE WITH ABB ACS800 CONTROL MODULES
(1)	0000-9652-42 (10044530-001)	MODULE-FIBER, DDCS ACS800

(1)	0000-9653-29 (10044563-001)	KIT-CONTROL PANEL MOUNTING PLATFORM KIT (WITH KED PAD)
(1)	P250000-9679-46 (10065574-001)	INVERTER-450KW, 690V, 486A, AIRCL ACS 800 AIR COOLED INVERTER, 486A, 450KW CONTINUOUS RATING, DV/DT OUTPUT FILTERS, SPEED CONTROLLED COOLING FANS, UNIT CAN BE PARALLELED X 12, 330LBS PER MODULE, CONSISTING OF: 1 - CURRENT FILTER (64315811) 1 - FAST POWER CONNECT (64698401) 1 - SOCKET BLOCK PIN (64674081) 1 - BRACKET (64789104) 1 - (ACS800-104-580-7+E2) INVERTER (64794086) ABB# ACS800-104-0580-7+E205+C126+Q950+V991
(1)	0305-0004-00 (10049598-001)	CB-UVR(YU), 24VDC, FOR E1 THRU E6 FRAME SIZE
(1)	0000-9641-88 (10044167-001)	DIODE-ASSY, DUAL, 1800V, AIR COOLED
(1)	0000-9653-26 (10044562-001)	CONTACTOR- 35A, 1000VDC, 3POLE IN SERIES, 1NO/1NC, 24VDC COIL, 50/60HZ
(1)	0000-9660-27 (10044812-001)	CONT-AUX CONTACT, 2NO, 2NC,TOP MOUNT FOR ABB CONTRACTORS
(1)	0000-9646-98 (10044370-001)	CHOPPER-BRAKING, 80AMPS
(1)	P250000-9679-45 (10065573-001)	FAN-ABB CHOPPER, 1PH, 115V, 50/60 HZ
(1)	0000-9642-66 (10044192-001)	FILTER-LINE (TVSS), 20A, 120VAC, DIN RAIL MTG
(1)	0000-9642-00 (10044170-001)	PWR SPLY- 24V/10A, INPUT VOLTAGE 115/230VAC, OUTPUT VOLTAGE 24V
(1)	1003-0095-00 (10050576-001)	XFMR- 50VA, 600: 26.5, CPT 1PH, 50HZ, ENCAPSULATED, CTR TAPPED
(3)	0000-6904-32 (10041444-010)	FUSE- 60A, 1000VAC, KIC, CLASS, STUD TYPE, W/ INDICATOR
(3)	0000-9607-67 (10043403-001)	FUSE BLOCK, 2 PIECE MODULAR STUD TYPE, 0.25" STUD DIA., 1.75 IN. MOUNTING HEIGHT
(3)	32 0001-0385-47 (10045961-001)	BUS-FUSE MTG, BUSSMANN AB03T
(3)	0000-6901-34 (10041937-028)	FUSE- 6A, 600V AC, 200KIC
(2)	0000-9641-46 (10044145-001)	FUSE- 2A, 250VAC, FASTBLOW, 5 X 20MM
(3)	0301-0010-00 (10056809-017)	FUSE- 2A, 500VAC, 10KIC, CLASS M
(3)	0301-0019-00 (10056813-029)	FUSE- 30A, 600VAC, 100KIC
(3)	0301-0009-00 (10056809-010)	FUSE- 0.6A, 500VAC, 10KIC, CLASS M
(1)	0000-6881-06 (10041157-001)	MOV- 750VRMS, 2600J, 70KA, 1880V@ 200A, 2KV@600A
(3)	0301-0043-00 (10056809-035)	FUSE- 15A, 500VAC, 10KIC, CLASS M
(2)	0000-6979-92 (10042488-001)	SW-MICRO,TWO ISOLATED FORM C CONTACTS, INSULATION RATING F/SW 1250VAC OR DC, NON INDUCTIVE - 30 VOLT 3A, 110 VOLT 3A, 250 VOLT 3A; INDUCTIVE CIRCUIT - 30 VOLT 2A, 110 VOLT 1A, 250 VOLT 1A
(1)	0000-9666-71 (10045048-001)	RELAY-LOGIC SOCKET
(1)	0000-9666-72 (10045049-001)	RELAY- 24VDC,8A, PLUG
(1)	0000-9666-73 (10045050-001)	RELAY-PROTECTION DIODE 6-230VDC
(1)	0000-9605-33 (10043315-001)	BRIDGE-RECTIFIER, 110A, 1800V, 3PH
(1)	0000-6817-69 (10040541-001)	RECT-3 PHASE BRIDGE, 30A, 1000V, 1PH
(1)	0000-6935-09 (10042050-001)	SUPPRESSOR-SURGE, 6-240VDC DIODE, PROTECT CONTROL CIRCUIT FROM VOLTAGE TRANSIENT, PLUG-IN
(1)	0000-6808-57 (10040429-001)	RELAY- 24VDC, 2A2B0C, 10A, IEC DEVICE
(1)	0509-3000-00 (10050025-001)	PCA-VOLTAGE FEEDBACK
(2)	0000-6896-31 (10041937-034)	FUSE- 10A, 600VAC, 200KIC, CLASS M
(1)	0000-9668-89 (10042382-001)	CB - 16AT, 1P, 230V, MISSLINE
(3)	0000-6970-86 (10042382-001)	FUSE - 60A, 600VAC, 200KIC, CLASS J, TIME DELAY, DUAL ELEMENT

(3)	0000-6968-98 (10042357-001)	FUSE - 100A, 600VAC, 200KIC, CLASS J, TIME DELAY, SEC VOLTAGE 500 VDC
(1)	P250000-9700-29 (10504335-001)	MS-COMBINATION, IEC, 10HP@575V, 9-12.5 FLA, INCLUDES MANUAL MOTOR PROTECTOR WITH OVERLOAD PROTECTION, STARTER, 120 VAC COIL
(1)	P250000-9700-28 (10066493-001)	MS-COMBINATION, IEC, 5HP@575V
(1)	1307-2018-03 (10051013-001)	CONT-BLK, 2A2B0C, IEC, TOP MOUNT
(20)	0000-6981-43 (10041937-036)	FUSE, 15A, 600VAC, 200KIC
(4)	0000-9642-27 (10044172-001)	FUSE - 1000A, 1100V
(2)	0000-9651-24 (10041285-027)	FUSE - 630A,1250V,100KIC HIGH SPEED SEMICONDUCTOR
(10)	0405-0016-00 (10049760-001)	LAMP BULB, 18V
(1)	0000-9611-72 (10043492-001)	PL-120V AC, 18MM W/O LENS, XFMR
(1)	0000-9650-24 (10044486-001)	PL-24VAC/DC,18MM, NO LENS
(1)	122627-26 (10602939-026)	BATTERY, CPU BACKUP, FUW S7-300
(1)	0000-6939-93 (10042131-001)	FUSE, 60A, 600V, 3P FUW J TYPE FUSES
(1)	0000-6854-44 (10040881-001)	SW-SEL, 2 POS, LEVER, OT OPR
(1)	0403-0008-00 (10049723-001)	SW-TEMP, 165 DEG
(1)	10504344-001	ASSY, 60hZ INVERTER
(1)	10065908-001	INV1 – INVERTER – 55KW, 690V, 57A, CONTINUOUS
(1)	10065926-001	F1, F2 – FUSE, 120VAC / 1000VDC
(1)	10065927-001	F1, F2 FUSE HOLDER FOR 1200V SEMI-CONTINUOUS
(1)	10045265-001	INV2 – INVERTER, 18.5KW, 690V, 22A
(1)	10041282-001	F3, F4 – FUSE, 35A, 1000V
(1)	10045371-001	F3, F4 HOLDER - FUSE BASE, 160A, 690V
(2)	10062871-001	TB1, 2, 3 – 4 PIN, 26-10 AWG, EX, UTTB4
(1)	10040429-001	RL1 – RELAY, 24VDC, 2A2B03, 10A, IEC
(1)	75 10045050-001	RL1 – SUPPRESSOR, SURGE, 6-24VDS

SIEMENS DRIVE HOUSE

(1)	116199-04	BOARD, INVERTER SNUBBER
(1)	116199-21	BOARD, CONTROL, INPUT CURRENT RECTIFIER
(1)	116199-22	BOARD, CONTROL, PER3
(6)	116199-25	FUSE, 2A
(3)	116199-26	FUSE, 800V, 800A
(10)	116199-27	FUSE, 250V, 7A
(1)	116199-34	INVERTER, TACH, DIGITAL
(1)	116199-42	CHOPPER, BYNAMIC BRAKING
(1)	30155505-17	CHOPPER, BONITRON DB (USED W/ YASKAWA DRIVES)
(3)	116199-46	FUSE, 600V, 30A
(10)	116199-48	FUSE, 250V, 1/2A
(10)	116199-49	FUSE, 250V, 2A
(1)	116199-75	PANEL, OPERATOR
(1)	116199-77	BOARD, CPB, AC INVERTER
(3)	116199-87	FUSE, 315A, DYNAMIC BRAKE

OMRON INTEGRATED DRIVE HOUSE

INVERTER SECTION

(1)	010.30.023	CONTROL UNIT, MODULAR
(1)	010.30.055	POWER SUPPLY, 600V
(1)	010.30.071	REACTOR, 600V, 400A
(1)	010.30.080	INVERTER, YASKAWA MODULAR
(1)	010.30.036	INVERTER, YASKAWA A-1000
(1)	010.30.085	TRANSFORMER, 600:215, 1.4KVA
(1)	010.35.155	PCB, PG-X2
(1)	010.35.190	PCB, SI-P1

(3)	070.20.140	CONTACTOR, AUX, NORMALLY OPEN
(1)	070.20.231	CTNR-3P, 24VDC, 3 NORMALLY OPEN
(2)	080.15.005	PUSH BUTTON, RED
(2)	080.15.045	CONTACT, NORMALLY CLOSED
(2)	090.21.313	CIRCUIT BREAKER, 2P, 3A
(2)	090.21.510	CIRCUIT BREAKER, 2P, 10A
(2)	090.21.558	CIRCUIT BREAKER, 1P, 6A
(2)	090.21.560	CIRCUIT BREAKER, 1P, 3A
(2)	090.21.568	CIRCUIT BREAKER, 2P, 4A
(2)	090.21.570	CIRCUIT BREAKER, 1P, 1A
(2)	090.21.575	CIRCUIT BREAKER, 1P, 10A
(3)	090.32.729	CONTACT, AUX, FORM C, 1 NO / 1 NC
(3)	100.20.014	FILTER, 20H X 8W X.75D
(1)	100.95.025	FAN, 1770 CFM, 230 VAC
(1)	130.20.052	TIMER, MULTI FUNCTION
(3)	130.25.033	RELAY, CONTROL, 4P, 24 VDC, 3A
(3)	130.25.505	RELAY BASE, 4P, 3A
(3)	130.25.852	RELAY, SAFETY
(2)	150.10.060	SENSOR, CURRENT, .25A SETPOINT
(1)	220.06.603	MODULE, DYN BRAKE, 600 APK, 425A CONT
(1)	220.16.015	CONTR, 1P, 1250A, 24 VDC COIL
(1)	230.95.416	OUTPUT, RELAY, 2CH, 230 VAC
(1)	230.95.419	MODULE, INPUT, RTD, 2 CH
(1)	230.95.428	MODULE, INPUT, DIGITAL, 8 CH, 24 VDC
(1)	230.95.430	INPUT, DIGITAL, 8 CH, 24 VDC
(1)	230.95.439	COUPLER, PROFIBUS, DP / VI, 12M BAUD
(1)	230.95.440	MODULE, SUPPLY, 24 VDC, 230 VAC
(1)	230.95.441	MODULE, INPUT, ANALOG, 2 CH, +/- 10V
(1)	230.95.443	MODULE, SUPPLY, PASSIVE
(1)	240.10.017	CAP, 8F, 400 VAC
(1)	240.95.013	SUPPRESSOR, ARC, 24 – 50V AC / DC

<u>RECTIFIER SECTION</u>

(1)	010.30.039	CONVERTER, IN / 380 / 690 VAC, 2295 AAC
(3)	080.10.303	LAMP, 120 VAC, RED
(2)	090.21.313	CIRCUIT BREAKER, 2P, 3A
(2)	090.21.560	CIRCUIT BREAKER, 1P, 3A
(2)	090.21.570	CIRCUIT BREAKER, 1P, 1A
(2)	090.21.575	CIRCUIT BREAKER, 1P, 10A
(3)	090.32.729	CONTACT, AUXILIARY, FORM C, 1 NO / 1 NC
(3)	100.20.013	FILTER, 20H X 17W X .75D
(1)	100.95.025	FAN, 1770 CFM, 230 VAC
(1)	150.05.201	TRANSFORMER, CPT, 50VA, 600:120V
(1)	150.10.060	SENSOR, CURRENT, .25A SETPOINT
(3)	160.55.030	FUSE, 250V, 8/10A
(3)	160.60.207	MICROSWITCH FOR MAIN FUSE
(3)	160.60.394	FUSE, 690 VAC, 3000A
(3)	160.60.801	FUSE, 1000 VDC, 1A
(3)	160.65.021	FUSE, 690 VAC, 1A
(5)	230.30.048	CONNECTOR, PROFIBUS
(1)	230.95.423	MODULE, RELAY OUTPUT, 2 CH, 230 VAC
(1)	230.95.428	MODULE, DIGITAL INPUT, 8 CH, 24 VDC
(1)	230.95.429	INPUT, ANALOG, 2 CH, 10 VDC
(1)	230.95.438	INPUT, DIGITAL, 2 CH, 120 VAC
(1)	230.95.439	COUPLER, PROFIBUS DP / VI, 12M BAUD
(1)	230.95.442	MODULE, THERMISTOR INPUT, 2 CH
(1)	230.95.615	MODULE, SUPPLY, 120 VAC
(1)	240.10.017	CAP, 8 UF, 400 VAC
(1)	240.45.007	CONVERTER, DC – DC, 24V / 5V, 30W
(1)	240.95.529	TRANSMITTER, 0 – 1000 VDC, 0 – 10V

PLC COMPONENTS

(1)	090.21.336	CIRCUIT BREAKER, MINI, 2P, 20A
(1)	160.60.730	FUSE, 250 VAC, 2A
(1)	240.45.016	PWS, 24 VDC
(1)	240.45.003	PWS, 12 VDC, 1.2A
(1)	240.45.013	PWS, 24 VDC, 1.3A
(1)	130.25.851	RELAY, SAFETY, 140 MA
(1)	220.95.410	INSULATOR, OPTICAL
(1)	230.05.495	CJ1W-PA205R
(1)	230.95.305	CJ2H-CPU66
(1)	230.05.481	CJ1W-PRM21
(1)	230.05.364	MODULE, ETHERNET
(2)	230.05.451	CJ1W-CORT21
(2)	230.05.371	DEVICE, NET
(1)	230.05.480	OUTPUT, RELAY
(1)	230.05.488	OUTPUT, DIGITAL
(1)	230.05.496	COUNTER, HIGH SPEED
(1)	230.95.099	ETHERNMAC102
(1)	230.95.072	TRANSCEIVER
(1)	230.95.311	ROUTER
(1)	230.95.313	TOUCH PAD, KEYBOARD, 17” LCD
(1)	230.95.445	RADIO, ETHERNET
(1)	020.20.013	CONVERTER, COPPER – FIBER
(1)	240.95.523	POWER SUPPLY, UNINTERRUPTED (UPS)
(3)	100.20.013	FILTER, AIR, 20L X 17W X .75D
(3)	100.20.014	FILTER, AIR, 20L X 8W X .75D
(2)	120.25.004	LATCH, LOCKING
(2)	120.25.016	LATCH, NON-LOCKING

DRILLER’S CHAIR

(1)	080.05.003	BUTTON, PUSH, MUSHROOM, RED
(1)	080.10.152	BUTTON, PUSH, ILLUMINATED, BLUE
(1)	080.10.159	BUTTON, PUSH, ILLUMINATED, AMBER
(1)	080.10.151	BUTTON, PUSH, ILLUMINATED, RED
(1)	080.10.160	BUTTON, PUSH, ILLUMINATED, WHITE
(1)	080.10.158	BUTTON, PUSH, ILLUMINATED, GREEN
(1)	080.10.246	SWITCH, 3-POSITION
(1)	080.10.430	SWITCH, LEVER, AMBER
(1)	080.10.427	SWITCH, PLSS
(1)	230.05.515	TOUCHSCREEN, 17”
(1)	221.03.293	JOYSTICK, 2-AXIS
(1)	221.03.317	JOYSTICK, 1-AXIS
(1)	230.95.319	ADAPTER, VGA
(1)	230.95.470	INPUT, ANALOG, 2 CH
(2)	220.01.948	CABLE, FIBER COMMUNICATIONS

VFD H216125

(3)	220.06.900	CONTACTOR, 24 VAC, 25A
(2)	220.06.901	CIRCUIT BREAKER, 13A
(3)	220.06.902	CIRCUIT BREAKER, 20A
(1)	220.06.903	TRANSFORMER, AC CONTROL
(1)	220.06.904	DRIVE, VARIABLE FREQUENCY, 3HP
(2)	220.06.905	POWER SUPPLY, DC, SOLA
(1)	220.06.906	PLC, LARGE, PC03
(1)	220.06.907	SENSOR, TEMP, WALL MOUNT
(1)	220.06.908	SENSOR, PRESSURE
(1)	220.06.909	SWITCH, HIGH PRESSURE, 375 PSI

(1)	220.06.920	COMPRESSOR
(1)	220.06.921	COIL, SOLENOID, COMPRESSOR UNLOADER
(1)	220.06.922	BLOWER ASSEMBLY, EVAPORATOR
(1)	220.06.923	FAN ASSEMBLY, CONDENSOR
(1)	220.06.924	VALVE, THERMOSTATIC EXPANSION
(1)	240.45.320	PWS, 6.5A
(1)	020.20.012	CONVERTER, COPPER – FIBER
(1)	221.03.301	PANEL, FIBER PATCH
(1)	230.95.466	INPUT, ANALOG
(1)	230.95.467	OUTPUT, ANALOG
(1)	230.95.465	MODULE, RTD INPUT
(1)	230.95.200	CONVERTER, PROFIBUS – FIBER
(2)	090.21.559	CIRCUIT BREAKER, MINI, 1P, 4A

GROUND FAULT PANEL

(1)	220.05.042	MONITOR, GROUND FAULT, BENDER
(1)	220.15.056	MONITOR, GROUND FAULT, ANALOG
(1)	150.05.100	TRANSFORMER, CPT, 460:120
(3)	160.25.495	FUSE, 600 VAC, .5A
(3)	160.55.030	FUSE, 250 VAC, .8A
(3)	160.25.486	FUSE, 600 VAC, 1A

The image on the following page shows a parts list which I use as a reference to order parts. It is broken down by section (Blower Shroud, Pipe Handler, etc.) and includes some pricing. It is not an all-inclusive list, but it is provided on the Student Thumb Drive as an editable Excel spreadsheet so you can continue to build your own price list. Also helpful for ST-80 Iron Roughneck and Forum Catwalk parts.

ITEM DESCRIPTION	COMPANY A	PART NUMBER	COST	LOCATION	NOTES
DRILLING RIG EQUIPMENT MASTER PRICE LIST					

Note: This list is not all-inclusive. Prices may vary according to time and location. Please help build the price list by adding new data under Section 17, preferably in red ink & all CAPS, and copy mspeights@rigangel.com. When entering data, be sure to include a detailed description of the component and the system it belongs to, if applicable, under Tab H on the right side of your screen (scroll to Section 17 for an example).

TABLE OF CONTENTS:

1. TDS-9/11 TOP DRIVE

ITEM DESCRIPTION	COMPANY A	PART NUMBER	COST	LOCATION	NOTES
VARCO DRILLER'S CONSOLE					
VDC THROTTLE ASSEMBLY	NOV	116551	$2,227.00	UNITED STATES	
ENTRELEC SIGNAL CONVERTER	NOV	912015-002	$886.32	UNITED STATES	
PUSHBUTTON, FLUSH BLACK DC	NOV	30087708-02	$43.20	UNITED STATES	
2-POSITION SELECTOR SWITCH	NOV	30087708-26	$87.12	UNITED STATES	
3-POSITION SELECT SWITCH, RTC	NOV	30087708-30	$156.60	UNITED STATES	
3-POS SELECT SWITCH, RTN FRM RT	NOV	30087708-33	$151.20	UNITED STATES	
3-POS SELECT SWITCH, FIXED	NOV	30087708-36	$98.10	UNITED STATES	
DC TORQUE POTENTIOMETER	NOV	30087708-46	$146.70	UNITED STATES	
POTENTIOMETER, 2W, 10K	NOV	817362	$24.42	UNITED STATES	
E-STOP RED MUSHROOM SWITCH	NOV	30087708-67	$220.50	UNITED STATES	
RED INDICATOR LIGHT	NOV	30091548-2	$75.78	UNITED STATES	
LAMP, MINI BAYONET BS 24V	NOV	30087708-44	$1.45	UNITED STATES	
LIGHT, INDICATING 24V DC RED	NOV	30087708-38	$83.25	UNITED STATES	
LIGHT, INDICATING 24V DC AMBER	NOV	30087708-40	$82.14	UNITED STATES	
TORQUE INDICATOR GAUGE, (TDS-9)	NOV	96219-7	$1,074.48	UNITED STATES	
TORQUE INDICATOR GAUGE, 60K F#	NOV	96219-11	$592.20	UNITED STATES	
TACHOMETER, 250 RPM, MDTOTCO	NOV	PR1003A19	$1,229.88	UNITED STATES	
HORN, J-BOX DC SCD	NOV	88663	$18.87	UNITED STATES	
HORN, ALARM, 24VDC	NOV	87124	$289.71	UNITED STATES	
FUSE, LARGE DIGITAL I/O BASE, 250V 2.5A	NOV	12262754	$8.68	UNITED STATES	
FUSE, SMALL ANALOG I/O BASE, 250V 1.6A	NOV	12262755	$7.69	UNITED STATES	
MODULE, 4-PT ANALOG REMOTE I/O	NOV	122627-45	$3,893.40	UNITED STATES	
MODULE, DIGITAL, REMOTE I/O 24 IN, 8 OUT	NOV	122627-46	$1,971.00	UNITED STATES	
MODULE, 4 ANALOG REMOTE I/O	NOV	122627-47	$3,704.40	UNITED STATES	
BASE, ANALOG SIEMENS / S7	NOV	122627-57	$413.10	UNITED STATES	NOV PRICE JUMPED TO $850; DISCONTINUED!
BASE, DIGITAL SIEMENS / S7	NOV	122627-58	$423.90	UNITED STATES	
FUSE, 250V, 2.5A [I/O MODULE]	NOV	122627-54	$9.90	UNITED STATES	
BLOWER SHROUD					
DRILLER SIDE, IN ORDER OF ASSEMBLY FROM THE BOTTOM UP					
ADAPTER PLATE, BRAKE	NOV	109553	$3,768.30	UNITED STATES	
HEX SCREW, ADAPTER PLATE MOUNTING	NOV	50010-10-C5D (QTY: 4)	$4.23	UNITED STATES	
LOCK WASHER, SPRING, 5/8"*	NOV	50910-C (QTY: 4)	$0.13	UNITED STATES	*SAME PART AS DIFF LINE ITEM (SEE COLOR)
.051 LOCKWIRE, 143'*	NOV	Z6001-CAN	$27.72	UNITED STATES	*SAME PART AS DIFF LINE ITEM (SEE COLOR)
HUB, BRAKE	NOV	109554	$2,016.90	UNITED STATES	
PIN, DOWEL (PRESSED INTO HUB)	NOV	51208-14 (QTY: 2)		UNITED STATES	
ROTOR, BRAKE	NOV	109555-30	$1,348.20	UNITED STATES	PRICE DROPPED TO $480
HEX SCREW, BRAKE ROTOR MOUNTING*	NOV	50008-10-C5D (QTY: 6)	$2.95	UNITED STATES	*SAME PART AS DIFF LINE ITEM (SEE COLOR)
LOCK WASHER, SPRING, 5/8"*	NOV	50910-C (QTY: 6)	$0.13	UNITED STATES	*SAME PART AS DIFF LINE ITEM (SEE COLOR)
.047 LOCKWIRE*	NOV	Z6001.9		UNITED STATES	*SAME PART AS DIFF LINE ITEM (SEE COLOR)
CALIPER, DISK BRAKE (INCLUDES PADS)	NOV	109528 (QTY: 2)	$1,721.70	UNITED STATES	PRICE DROPPED TO $1000
PAD, FRICTION BRAKE	NOV	109528-1 (QTY: 4)	$254.70	UNITED STATES	
SPRING, FRICTION BRAKE	NOV	109528-3	$43.11	UNITED STATES	
HEX SCREW, BRAKE CALIPER MOUNTING*	NOV	50008-10-C5D (QTY: 8)	$2.95	UNITED STATES	*SAME PART AS DIFF LINE ITEM (SEE COLOR)

Figure 14.1

CHAPTER 15

TROUBLESHOOTING FUNDAMENTALS

CHAPTER 15:
Troubleshooting Fundamentals

In this section, we will learn five flat-ass truths about troubleshooting.

1. Troubleshooting is the science of deduction. It arrives at conclusions based on a high percentage (~50%) of fact, a moderate percentage (~40%) of probability based on the facts, and a low percentage (~10%) of experience-based instinct. In rare occasions, it arrives at a fork, wherein the data inputs do not support a defined failure source, and 50/50 trial must be applied.

2. Regardless of title, position, experience, age or IQ… all troubleshooters are NOT created equal. 'Bout to get preachy. Troubleshooting is like a religion, applicable in all areas of life. However, not everyone is suited to this skill. Great troubleshooters are highly analytical and investigative in nature, naturally possessing a sleuth-like inquisitive mind. If you enjoy problem-solving, brain games, mystery novels, riddles, or puzzles, you are likely well-suited to troubleshooting and stand the best chance at becoming successful at it. On the other hand, if you tend to shy away from these things, or skip to the back of the book for answers, you're simply not going to be good at troubleshooting.

3. Synonymous with quality. Proper troubleshooting takes TIME. Time to read or study. Time to sketch or brainstorm. Time to isolate in segments. Time to observe and think. Time to explain the situation and findings—multiple times—in collaboration with others. It cannot be rushed. Often, under the pressure of downtime or adverse atmosphere, troubleshooting is a race to discovery: it stops at the first conclusion, or at the minimally-acceptable 'answer' to a given problem. This is a recipe for future failures and potential harm to people. That does not mean we can't opt for a quick fix at the behest of our customer. In those cases, we cover our reputation through quality reporting, wherein it is clearly stated that the root cause of failure was not yet determined… due

to time, state of rig's operation, and ultimately, a decision by competent authority within the customer's organization.

4. Proper troubleshooting considers all inputs in order to arrive at a responsible decision. Relative to machines and equipment, it considers original manufacturer's published data, industry standards, overall safety, energy path, alignment, load, lubrication, operation, atmosphere, personnel observations, probability, repetition and the laws of physics, just to name a few considerations. In theory, it should be highly collaborative, but often the conditions surrounding the problem will ultimately place the 'lead' troubleshooter in the lonely position of making a high-stakes decision or recommendation that others are not qualified to make, or that others aren't comfortable making. If you are the expert who finds yourself in these shoes, make sure that you are amply insured, whether literally or figuratively (depending on the situation), and prepared to warranty against the undesirable consequences of your decision.

5. Troubleshooting is unidirectional. Re-stated, it does not second-guess established hard facts. Determine the values of X and Y. If X + Y = Z, do not return later to question this. Write everything down. Long taught as a principle of urban tactical shooting in the Marines, once you have gained ground, do not give it up the space you occupy or cover with your weapon. In troubleshooting, we similarly keep moving forward, which makes it even more critical that our facts—the foundation of our end conclusions—are firmly based. When the troubleshooting scenario becomes long and drawn out, you will be increasingly pressured to second-guess your earlier troubleshooting steps based on another's opinion. If your methods are sound, make the unpopular choice to keep moving forward with your deductive process until the proper conclusion is reached.

CHAPTER 16

TROUBLESHOOTING / REPAIRING THE TOP 25 TDS-11 FAILURES

CHAPTER 16:
Troubleshooting / Repairing the Top 25 TDS-11 Failures

In this section, we will cover the top 25 failures of the TDS-11, and more importantly, how to troubleshoot and fix them in the order that makes the most sense, based on (1) most common historical causes of failure, (2) triage of components based on ease of removal and replacement. I believe that this is the most comprehensive troubleshooting guide to be published on the TDS-11. It is lengthy and some troubleshooting steps will be repetitive or mimicked for different symptoms, but hopefully you'll appreciate the detail when you're in a bind.

One very important aspect of troubleshooting involves WHO YOU CALL FOR HELP. When you get to a point where you know you should get someone coming, it's important to understand the following. In the oilfield, when you call for a rig mechanic, that usually means Mud Pump mechanic. If you want a Drawworks mechanic, you'll need to specify. If you call for an engine mechanic, that usually means Caterpillar mechanic. If you need a Cummins, Detroit, or Deutz mechanic, you should specify in advance. Similarly, with Top Drives, not all personnel are created equal. Technicians are usually either Varco, Canrig, or Tesco techs (also BenTec, Aker, FDS / Axxon, Warrior, Patriot, Victory, NorDrill, BPM, LeTorneau / Cameron, VentureTech…). So always specify the type of Top Drive when you call, and ask specifically for a Varco tech. Next, not all techs are electrically-versed. Some only work on the mechanical / hydraulic side. So specify. Lastly, when a Top Drive issue escalates within the VFD house, you need someone with experience. NOT JUST AN ELECTRICIAN. You may need an electronic technician, or ET. And in the case of this Top Drive, if you call NOV, you should first try to determine whether the problem is Top Drive-related, drive-related, or program-related. Because their people specialize in each of those facets and don't often overlap roles.

If you are not very specific about who you call for help, you will pay for more people and eat more downtime.

Before digging into troubleshooting steps, always ensure the following BASIC MEASURES are in place:

(1) All cables and fibers (if applicable) display good external integrity; connections are clean, dry,* and proper. Multi-pin plugs do not have pins missing, corroded, or pushed in.
**Single power pin plugs may have electrical lubricant applied… NOT multi-pin plugs.*

(2) The Top Drive has grounding wires attached tightly, and the VFD has a tightly-fastened, dedicated ground at the skid / house that is driven at least 6' into the ground. If this is a stand-alone VFD House, there is also a ground wire traveling from the plug panel to the SCR House main ground.

(3) The VFD House has been properly energized and no alarms exist on the drive keypad.

(4) All alarm lamp bulbs are working on the Driller's Console, if applicable. This is very important to keep from misdiagnosing the problem and to save a lot of time and headache. All active alarms / faults are cleared at the drive (Siemens / ABB / Yaskawa / IDM / IDE / IEC keypad, e.g.) and at the controls ("Alarm Silence" for consoles, or "Acknowledge / Clear" alarms for Amphion / Omron, e.g. In the event that a 'smart' drilling program is designed to interlock Top Drive functionality, make sure that block height and hookload tare weight are accurately depicted on screen—if not, re-calibrate (especially important with Amphion cyber system). For Omron controls, ensure that the "Slips Set" indication is not popping up on the drilling screen to prevent TD ownership from being taken. Saw that a few times.

(5) Ensure that fluid levels are proper (15 gallons of gear oil and 25 gallons of hydraulic fluid). On one rig—an old rig with an ancient Siemens drive house—someone had modified the TD and program so that it wouldn't operate at all if the gear oil level was low. Keep up with filter changes too, but for troubleshooting purposes, it's pretty uncommon for a filter to be the cause of a major failure on a TDS-11.

(6) Ensure that the operator understands how to operate the unit. Refer to the Operation Manual or the last person that operated the unit without issues.

DISCLAIMER:

Chances are, if you're digging into this troubleshooting section, it's not because you love to read. It's because you're experiencing an issue. It also means that you have a tech with you, working on the problem because your Superintendent told you to get someone out there who knows what they're doing. Well, no shit, in a rig-down situation everyone's a critic. So I don't know who is out there on location with you, but if they're shooting down the information that's in this troubleshooting segment, then they're more concerned about self-glorification than about your downtime. I'm not saying all the answers are in here… that's a ridiculous notion. We all learn new things every day. But beware the 'expert' who repels ideas. If your tech is not collaborative, and does things directly contrary to the steps in this segment, all I'm saying is that you should at least get a second opinion. Remember, I get nothing out of this… I'm not vested in your specific problem, but I am the one who spent a lot of time to give you this 100% free information, so that your organization can minimize dependency on 3rd-party.

TROUBLESHOOTING SCENARIOS:

Note: additional VFD troubleshooting is provided at the end of Chapter 13 in this book.

1. NOTHING WORKS

Okay, the first and most obvious questions are:

(1) Did you just rig up? If not, did it rain on location, or has something changed? Rig skid / walk? Tour or crew change?

(2) Has this happened before? If so, what was done to fix it last time? Is the E-Stop button engaged? If so, pull it out.

If you answered YES to any of the questions above, refer back to the BASIC MEASURES on the previous page. If you answered NO to all of the questions, proceed.

(3) If using an Amphion Driller's Control Console, can you enable the Top Drive? If NO, check cables, check cables, check cables. If using a cyber chair, can you take ownership of the Top Drive? If NO, check fibers, and try swiveling in your chair to see if it works in a different position. Lift chair and arm panel lids (if applicable) to make sure no cables are pinched or severed. Completely shut down and restart the VFD House. If YES to either of these scenarios, proceed.

(4) Have you attempted both turning to the right / drilling AND one or more hydraulic functions? Remember that drilling and handling are powered separately.

(5) POWER SUPPLY OR IMPROPER PHASING – If you have a stand-alone VFD House, are the lights on in the house? If not, is the Top Drive feeder breaker turned on in the SCR house? If

the lights are on, first check the power supplies in the SBC / PLC cabinet. A green light should be illuminated on each one. If using a meter, select AC power and check the incoming line power (place a meter lead on each of the two wires. If reading is -120V, swap your meter leads to read 120V. Now switch to DC power (dashed line over solid line symbol). Place your leads on the (+) and (-) posts where wires are terminated on the opposide side of the power supply. You should read 24V… this is your outgoing control power. Check each power supply… if you have one that reads 15V DC output, it's good—that means you have an older-style encoder circuit. If you're troubleshooting without a meter, just visually check for a green "power on" light on each power supply, or feel for warm air passing through a vent in the power supply's housing (some models have small fans inside). If the power supply or supplies don't appear to be powered, check the single 250A mini glass fuse in an ABB drive house's SBC / PLC cabinet, usually labeled F05 or F08, and also check all the breakers in the tall, skinny control cubicle. The standard 24V power supply used in most NOV configurations is a Sola 10-24-100C (replaces model P)(NOV P/N P250002-0005-31). If everything looks good here, let's check our phasing.

Start with the the air conditioner. Is it blowing cold air? If it blows ambient-temperature air, you may need to power down / LOTO and swap any two of the three incoming SCR power cables at the VFD plug panel. Another way to check this is to physically feel the TD HPU pump (or open the coupling window on the HPU assembly) to see if it's running but turning backwards, which would allow zero pressure for hydraulic functions. If you are standing under the electric motor looking up, then the shaft should rotate clockwise. Your blowers would also be rotating backwards if the incoming power to the VFD House was improperly phased. Unlike Canrig or GDS / GDM, NOV drive houses do not have phase monitors… so we have to troubleshoot improper phasing using the methods above.

(6) INPUTS & OUTPUTS (I/O) – If you are phased properly and everything looks good in the VFD House (no breakers tripped, drive can be pre-charged and energized, no alarms), then are there lights on your input / output components? I/O components will be located both in the VFD House at the computer (SBC or PLC) AND inside the Driller's Console.

WAGO – (Pronounced WAY-go or WAG-o depending on who you talk to) If you have an Amphion cyberbase, check the I/O (Wago cards) inside the TD SBC cabinet (usually in the Driller's Cabin). Amphion cyber systems incorporate fuses into their Wago rack—though this is not typical of Wago racks in Amphion SBC stand-alone drive houses. If all lights are off for a section of cards, look at the closest Wago Card on the left—which is the side closest to the power source—that has lights on. At the top, there may be an orange tab that pulls out to accept a 250A mini glass fuse. *Note: Rig Manager, if you're reading this, make a note to check your emergency fuse supply. Fuses, as you know, are cheap insurance. Order a bunch of every type of fuse on your rig, or just go online and order a big assortment. It is embarrassing and sometimes job-ending to accrue 8 hours of downtime over a 50-cent fuse... and you can't expect that every tech is willing to lie on his or her field service ticket to cover your ass.*

If you have a tech or ET on site, and s/he believes that a Wago card has failed, but can't figure out which one, here's the quick way to determine that. First, understand that 24V power comes from the controller on the left side of the Wago rack, and that the last card on the right completes the circuit. So if a card in the middle of the stack is suspected, remove all cards to the right of that suspect card EXCEPT the very last card. Move that far right card over to the left, and install it next to the suspected bad card. This method can be used to test each card on the Wago rack. To remove a card, pull out the thin orange plastic tab just centered and to the right of the card. Pull on that tab with one hand while wiggling the top and bottom of the card in a pulling motion with the other hand. Remember that some Wago cards are ‘doubles’, meaning they look like two separate cards but are one single unit.

SIEMENS MODULES – For original Varco Driller’s Consoles, the three dark gray boxes against the inside back wall are, from left to right, the (1) analog output module – sends drill and torque commands to the PLC; (2) analog input module – receives drill and torque data from the PLC to display on the console; and (3) the digital input / output module. Each of the Siemens I/O modules have a barely-visible switch that turns them on or off, located at the upper right corner of each module. When switched on, each module should display at least one red light on the left. There are also small, maroon-colored replaceable fuses on the base of each module. Call for info if you suspect this is an issue, such as in the case that all lights are extinguished on a ‘switched on’ module while the other two modules’ lights are illuminated.

If no lights exist inside your console, there is likely a cable issue. Check and re-check the plugs and cables going into your console, and down at the house. Always do this ONLY AFTER de-energizing / LOTO. Check the back of the plugs too, to see if wires have come disconnected from pins.

(7) DISCRETE INPUT LIGHTS – If you have lights on the I/O (Wago or Siemens modules) inside your console, try this: Check the discrete inputs by turning operator knobs and switches (link-tilt, IBOP, brakes, etc.), to see if a corresponding light illuminates on the I/O with each function. Turn the

throttle knob slightly to the right (just off of ‘zero speed’ and listen for a click and corresponding light on the I/O). If you’re not getting anything (which would be highly irregular), call an experienced Varco TD tech. If some of the input lights work and some don’t, you likely have a one or more bad I/O components, and they could be failed on both ends (VFD House and console). If all the functions have a corresponding light that illuminates, then try the following:

(8) SIEMENS AUTO-TUNE – If you have a Siemens drive house, run the auto-parameterization (or auto-tune) function. *Note: Siemens drive houses are pretty antiquated and not commonly found on rigs these days; ABB drive houses may still have Siemens parts. If you’re not sure which type of drive house you have, refer to Figure 7.3 in Chapter 7 of this student curriculum.* Refer to the Siemens MasterDrives Simovert Compendium in your Student Thumb Drive. The procedure is listed in the Table of Contents at the beginning of the manual. Do this only after verifying that there are no disconnected wires on the back of the pins at both ends of the Driller’s Console Serial Cable (Comm Cable – it’s a mini-19-pin between the console and the Drive House). Note: you may have to run the auto-parameterization (or ‘auto-tune’) several times for it to work properly.

RE-SETTING THE PLC MEMORY – If you have an ABB drive house with the old console, again, check the driller’s console serial cable first. 24V power and communications are on different wires in the same multiconductor cable. If the wires and pins are good, then walk into the drive house. When you walk in, open the cabinet hanging on the wall to your left. You should see a stack of dark gray boxes mounted left-to-right on a din rail, and each box says Siemens on it. To the far left is the CPU (Central Processing Unit, aka the brains of the I/O’s computer), and it will have an SD card inserted in it, usually mint green colored if it is an original Siemens card. DO NOT remove the card. You are going to conduct a memory reset of the card's program.

Everything needs to be powered up. Don't worry, it's fail-safe, so you won't fuck it up—anyone who tells you otherwise really doesn't understand the system…even if they're wearing an NOV jumpsuit. Just don't remove the card. See the switch near the card that says Run / Stop / MRES (Memory Reset)? Ok. There's a trick to this. Again, don't worry, you can try it multiple times until you get it right. First, flip the switch down out of RUN to the STOP position. You'll notice that RUN is a fixed position and STOP is also a fixed position, meaning that when you place the switch in either of those positions, the switch handle remains in that position. Well, MRES is not a fixed position. It is spring-loaded to return back to the STOP position. Most techs don't know this, but resetting the memory is actually pretty helpful in this stage of troubleshooting, and pushing the switch down once doesn't do anything to reset the memory.

So here's what you do. Remember, it will take more than a few tries and a little finesse and timing to get it right the first time. So, you've clicked the switch into STOP position. Now you're going to hold MRES down for barely a second, until you see an amber-colored light come on, at which point you immediately release the switch and instantly press it down again. Within less than a second, you'll see the amber light come on and you'll immediately release the switch and press it down again. Suddenly the amber light will start blinking quickly. That's what you want to see. Now place it back into run, and give the program a minute to unfuckerate itself. Go function your Top Drive. So the procedure looks like this, beginning at STOP position: down, light, updown, light, updown, light blinks rapidly. What I've found is that sometimes you need to not even wait for the first and second amber lights to appear, you almost need to anticipate the timing of when they will illuminate so you are moving the switch at the same time they blink on.

COMM WIRES, PROFIBUS CONNECTORS, AND TERMINATION RESISTORS – If you have an ABB Drive House with a new (Amphion) console, then you'll enter the drive house and open the same cabinet, but everything will look different than described above. You'll see a bunch of thin white Wago cards stacked left to right. To the left of that, a Beckoff controller with a bigger (CompactFlash) card inside of it. You're not gonna mess with any of that. If your console is working and you have discrete input lights, then you have a comm cable or connector problem. You see all those purple cables with the 7-pin Atari / Commodore looking plugs (go ask an older guy what I'm talking about)?

First, check the termination resistors. These are little red or black or gray switches on the connector plug bodies. If a plug has two purple comm wires going into it, the termination resistor switch needs to be in the OFF position (grab a flashlight and some reading glasses to read the position, lol). If a plug has only a single purple wire going into it, the termination resistor switch needs to be ON. This rule applies in the VFD House, at the console, and everywhere on your rig (except in the Woodward generator control circuits of a few ICD rigs—weird). For the Amphion-style console you have, instead of having I/O 24 VDC power and communications in the same mini 19-pin serial cable… you have two cables. One for power and one for back & forth communications between the two Wago racks. Your power cable is fine (you have lights on inside the console). Your current problem is either in the comm cable / comm connectors between the VFD and the Driller's Console (most common at this stage of troubleshooting), or in one of the smaller comm cables or plugs between the controller, Wago rack, or the top card behind the ABB keypad on the wall behind you (turn the black knob and open the small door to observe). Keep in mind, the words ‘comm connector’, ‘plug’, and ‘Profibus connector’ in this section all mean the same thing. At this point, call TD tech who has experience with this (who knows what you’re talking about), and have him or her head your way with enough comm cable to run between the VFD House and the Console. If the tech has access to parts, have him / her bring an ABB fieldbus / profibus adapter card (ABB P/N RPBA-01, as well as two Wago Fieldbus Couplers (Wago P/N 750-333 or NOV P/N 40943311-061), and two or more Profibus connectors, NOV P/N 6ES7 972-0BB41-0XA0.

FIBER OPTIC CABLES – Similarly, with an Amphion / Omron / hybrid (custom) cyber base, your problem will likely be communication cable / plug / I/O related, however… remember that we are operating under the assumption that nothing on the Top Drive works and there are no alarms, including COMM FAULT. Check those fiberoptic cables again. If you don’t have an approved cleaning tool / kit, use very clean hands and Q-Tips. Pull the cotton out to a fine point and twist gently so there are no loose fibers. Don’t bother using alcohol—which should be the ‘denatured’ type—and gently twirl to catch any specs of dirt or debris noticed on a fiber rod. If using a flashlight to test fiber channels, do not use a flashlight that is very bright, as it may give a false indication of clear channels. Carefully check fiber patch panel cables as well. And yes, you’ll need to check both the fiber plugs and receptacles… even if you have multiple walking suitcases and it takes four hours to clean them all.

2. EVERYTHING WORKS EXCEPT DRILL / SPIN FUNCTION

This covers the instance where ownership or enabling is achieved, but there is zero drill function and no movement of RPM or TORQUE gauges, NOT the instance where drill mode works for a second and then kicks out. Other drill mode issues will be covered in troubleshooting scenario # 3.

(1) CONSOLE CONSIDERATIONS – Increase drill torque. If later in troubleshooting, the drill torque potentiometer is suspected as a failure, power down, take photos of wire terminations on the back of the rheostat / potentiometer, and swap it out with the make-up torque potentiometer. If that works, order another DC torque pot (NOV P/N 30087708-46). On a classic Varco Driller's Console (VDC, for PLC applications), make sure the throttle shaft jamb nut is tightened so that the throttle's contactor moves along the pot.

(2) VFD HOUSE CONSIDERATIONS – Double check to ensure the drive was pre-charged and the main breaker closed in the VFD House (that's the handle that you pump to charge the spring and then press the green button to close). Closed means "on" or energized. Refer back to basic electrical orientation at the beginning of this book.

(3) DRIVE FAULT / ALARM – Check for alarms / faults. Rule of thumb, an 'alarm' / 'warning' either indicates a minor failure or impending major failure, whereas a 'fault' will actually shut down the drive and keep you from re-starting until the fault is cleared. If the fault will not clear, there are bigger issues at hand. Remember, we are troubleshooting a Top Drive that DOES NOT turn to the right, even for a fraction of a second. The worst case in this scenario could be a failure of both inverters, or—more than likely in the worst case of inverter issues—an inverter communication issue with the RMIO board / RDCU. If the Top Drive was able to drill, at least barely, then a Drive Fault or VDF Major Fault would change our

troubleshooting. We would go straight to the power service loop cables and plugs to look for ‘smoking gun’ damage, then to the drill motors, and then to the chopper or dynamic brake circuits. Remember also that the words ‘drive’, ‘VFD’, and ‘inverter’ are comingled in technical conversations, but that they all mean the same thing.

‘Start Interlock’ is one of the most common startup faults. If it doesn’t clear, call a tech. There are seven or eight physical VFD components in the Start Interlock circuit which may have failed. Usually, the fault occurs when startup procedures are incorrect or out-of-sequence, and the fault will clear and not persist. If it doesn’t clear, while waiting for a tech (or drive specialist), you can open the cabinet doors behind the main breaker and see if something smells burned. There’s a start interlock relay just along the left wall of an ABB stand-alone VFD House that could be burned up, but typically that failure wouldn’t allow you to close the breaker. Same with the UV coil which is attached to the breaker—could be burned up.

DIG THE BOOKS – For ABB Drives, look at the Alarm and Fault Code sections of the ABB ACS-800 Firmware Manual to determine the meaning and recommended troubleshooting steps of any alarm or fault which fails to clear. For Siemens stand-alone drive houses, consult the Simovert MasterDrive Compendium. For newer Siemens, Yaskawa or other drives that may be used in integrated VFD houses (uncommon on land rigs as of 09/2020), identify the make and model of the drive and consult the OEM documentation. Call me, I might have it. 910-381-0876.

(4) LOCAL vs. REMOTE – Ensure that the drive is not in LOCAL mode. On the ABB keypad, press the button that has the letter “L” on it. If you see an “L” disappear on the digital screen, great, you fixed the issue. I know we always assume that

nobody touches that keypad except to clear alarms, but it happens. If, when you press the L button, the letter L appears on the digital screen, then you were in remote mode already and that wasn't the problem. Press L again so that the L disappears from the digital screen. In a Siemens stand-alone drive house, switching between LOCAL and REMOTE is slightly more involved. There's a 99% certainty that one of the hands didn't do it, so the only time I would suspect this is if the VFD House just came from a shop, or if it's new to the rig and nothing is known about it. Consult the Simovert Compendium to switch out of LOCAL mode.

(5) 600V POWER DISCONNECTED – If the drive is energized (breaker closed), there are no alarms, and you're not in local mode, refer back to our BASIC MEASURES… are the "OUTGOING (to Top Drive)" red, white, and black power plugs disconnected from the VFD House? Or from the Top Drive? Or at the Saddle in the derrick, or any mid-mast or rig floor junctions? Believe it or not, I have even found two motors with all the leads hanging out when troubleshooting this scenario. Just came from the shop. Miraculously, the cables were not touching each other, the motor windings, or the metal housing! You see, though this is the most popular (by sales) Top Drive for land triples, it is also a 'dumb' To Drive. If any power plugs are disconnected, so long as they're not touching metal, the VFD will energize and when you turn the throttle, you'll send 600VAC into midair and get no alarms. Now wait!!! Before you yell at one of your hands to go check, let's power down the VFD House and LOTO. If everything's plugged in, remain powered down and call an NOV drive specialist. You may have to wait a day or two, in which case, call an electrician who is familiar with VFD's.

3. OTHER DRILL FUNCTION ISSUES

(1) SCENARIO 3A: GROUND FAULT / DRIVE FAULT – Top Drive quill turns to the right or left when commanded, but then shuts off. This is usually accompanied by a DRIVE FAULT or VFD FAULT or VFD MAJOR FAULT alarm, depending on the control system you're using. The fault is often—but not always—verified by an imbalance of brightness in the three ground fault lamp bulbs on the door of the incomer / rectifier cubicle of the VFD house. When testing, look for three dim bulbs; if one or two are brighter than another, it indicates a ground fault. Shut down the VFD house, kill the SCR's TD Feeder breaker and then disconnect the three outgoing plugs to the TD. Re-energize the house and test the ground fault lights again, this lets you know whether the fault is occurring in the house or in the service loop / TD. If the house is good, repeat the process, this time with the service loop connected at the house but disconnected from the TD. In an integrated drive house (AC rig), there will likely be a panel-mount ground fault meter or digital indicator, probably in addition to the three indicator lamps. If you're not getting that alarm on your console, check the bulb (hold LAMP TEST / ALARM SILENCE for five seconds to watch all lamps illuminate and gauges spike).

Check the control keypad's digital screen in your drive house, see what code popped up. Dig into the appropriate manual for your type of drive (see step 2 of the previous troubleshooting procedure), and see what the alarm means. If nothing else, doing this will help you better communicate with external help before you get them coming. I will tell you this: about 75% of the time, the root cause of this issue will be something you can identify. Water in one of the red, white, or black power plugs between the VFD and the Top Drive, or a burned / melted pin in one of those plugs, or an improper plug connection / cross threading. Could also be bare copper exposed on one of those cables, or even just the armor layer exposed, or one of those cables pinched or in a bind.

TROUBLESHOOTING WITH A MEGGER – IF you don't have a megger—an electric meter dedicated to testing insulation resistance in megaohms (MΩ), or an expensive-ass multimeter that also tests megaohms—then skip this step. You probably won't need one for this troubleshooting scenario anyway—usually you can physically find the "smoking gun" root cause of a ground fault unless it's inside a motor, inverter or chopper. If you DO have a megger and you know how to use it, set it at 1,000V. Place the black meter lead on the TD power service loop ground lug at the VFD house (or on any bare metal at the Top Drive) and test each phase. <u>If you read 0.0Ω</u>, you have a direct short-to-ground; that is, the bare conductor is touching ground. In the interest of mitigating lost time, immediately suspect one or both of the motors so you can get one coming if needed—open them both, isolate them by removing all three leads from each terminal block, and test the motors individually using the same method (red wire to each motor terminal, not to the pigtail leads). Then check the pigtail leads. Then check the service loop. Remember not to shoot voltage through the service loop until you've let all others know what you're doing so they keep clear of the power service loop. Also, if you're shooting from the TD down to the house, DISCONNECT from the house first. NEVER meg a circuit that is still connected to the VFD or any potential control source. If you read low megs AND low voltage (less than about 950V) you may just have a loose power plug connection, which could be external (the part where you make it up) or internal (the power pin could be loose inside the plug… also, if the plug had just been changed, make sure the power pin is sticking out roughly the same lengths as in the other two plugs, in case the electrician put the snap ring in the wrong place). Low megs and low voltage could also indicate a hard pinch. Low megs at full voltage (1,000V – 1,050V) usually just indicates the presence of moisture in the circuit, usually at a plug or in the motor windings themselves. Isolation will let you know where your problem is. In the case of the former finding, remove water with (non-explosive) electrical cleaner. In the case of the latter finding, run your blowers for a while to remove the moisture from the motors. Cold weather can cause low megs during an insulation test as well; if your motor heaters are not disabled, turn them on—and don't forget to turn them off when readings improve, or you'll potentially burn up a motor or two. Lastly, check phase-to-phase. You should read 0.0Ω phase-to-phase. Whether your phase-to-ground megger readings are good or not, if your phase-to-phase megger readings are not, I'll bet a kick in the dick that you've got a plug full of water somewhere. One final note: your company may have a minimum acceptable megaohm standard when performing an insulation (megger) test on a motor, and if the readings are below that, you are required to change the motor. Purely from a technical standpoint, if your company's stance differs from the original manufacturer's published stance—which has been set by their engineers and vetted by their quality policy—then someone at your company is a jackass who just wants to sound important. Baldor-Reliance drill motors that come standard on a TDS-11 have a 1.0 MΩ minimum value requirement before being run. At any value north of that, you can start and stop that Top Drive a thousand times without issues. Changing a TD drill motor just because it reads below 3M or 5M is a waste of time and money. Warm, dry air improves resistance value. Running the motor increases its resistance value. Basic science shit.

WHERE TO LOOK FOR DAMAGE THAT WOULD CAUSE A GROUND FAULT / DRIVE FAULT – Common areas of concern, if not at the plugs, will be at the back of the Top Drive where the power cables are potentially susceptible to rubbing against the track. Also, old wounds on a power cable / service loop that have been patched and water somehow intruded, now trapped inside by the patch job. Shut down the VFD, LOTO, and start checking the 3 power cables of the service loop, from where they plug in at the VFD House all the way into the Top Drive. Waiting five minutes after LOTO, take a ½" wrench to the Top Drive and remove the upper panels (above the vents) to inspect the termination blocks where the three fat wires connect to the motor windings. Just FYI, you can dissipate any stored energy in the motor by placing a long, plastic-handled screwdriver against any of the three metal lugs of the terminal block (or any exposed metal where the motor leads terminate into the windings, such as in the case of 'flying leads') and simultaneously touch the metal motor housing with the side of the screwdriver for a second or two. Then using gloves as a secondary precaution, tug on each of the motor leads to ensure tight connectivity to the terminal block. All connections should be tight-tight. There is a 25% chance that you have an inverter issue, or you lost one of those big ceramic IGBT fuses in the inverter bay, or that you have a chopper / dynamic brake module / resistor bank or grid issue. If your resistor grid is outside the VFD house, make sure the vent louvers are open and facing down. If facing up, when it rains, the grid gets wet and causes a ground fault. Big fans to create airflow, a heat source, and time are usually all that are needed to fix that issue. If you discover the source of the ground fault yourself (and chances are good that you will)—five or more wraps of electrical tape will do in a pinch. Just make sure to get the proper long-term fix coming. By the way, instead of using zipper shrink to patch an inner service loop (which moves and flexes)—presuming that your company even allows it—order some real splice kits from Global Mine Service in Pennsylvania. They have the 6-tape wrap system that keeps thousand-foot service loops in operations in the mines all day. Super robust and flexible. Expensive--$600 a kit—but worth it.

CONSEQUENCE MANAGEMENT – Earlier in this course, we touched briefly on 'consequence management', which was illustrated by the question, "What's the wrong 'right' decision?" In 2013, I was called out multiple times to work on one particular Precision Drilling rig in Pennsylvania. Their SOP for this rig was to use armor grounding on every three-phase cable. You see, underneath the first layer of rubber insulation on a standard 777 or 646 "armored" cable that is used to supply power to TD, DW, MP's, etc, is a 'non-conductive' braided wire layer called the cable's armor. Then there's another layer of rubber and a thin composite plastic layer before reaching the inner conductor wire. On this rig, a 3" section of outer insulation was removed about 3' from each plug end of every cable, where a 4.00 ground wire was then hose-clamped to the armor and then heat shrink was applied to overlap the exposed armor by at least six inches. At the end of the ground wire was a welder-style twist-lock ground connector. At first glance, it was impressive—certainly seemed like the 'right' decision to provide extra grounding to all these high-voltage cables. But then… those grounds were the only reason I was ever called to that rig. Hands kept reportedly getting shocked, and occasionally ground faults would occur. Always came down to those armor grounds. Years later, I was called to work on a Canrig for Latshaw, who was experiencing a TD ground fault in a thunderstorm. Canrig uses the same concept of armor grounding. In this case, a panel gland for one of these grounds had a loose jamb nut at the bottom of the lower J-box, and the arcing had melted a hole in the box. Because of the weather, no one had walked to the other side of the rig floor or they would have seen the arcing. Finally, a third instance—this time, an Orion rig in New Mexico. Their hybrid drilling program kept giving them a major VFD fault whenever they took ownership of the TD… a

TDS-11, I believe. Root cause? The zipper shrink had come off of the service loop's exposed armor where the ground wire was connected, and the hose clamp used to attach the wire was rubbing on a mesh strain relief that was holding up the DW cables on the subs, just under the ODS rig floor. Further investigation revealed that the roughnecks hated messing with their segregated ground panel—like a suitcase between the subs and VFD house, with nothing but armor ground connections—because the wires were always shocking the hell out of them. My whole point here, is that in our overzealous attempts to engineer-out ground faults, sometimes our rig designs are actually more ground fault prone.

A couple other notes on this scenario: in overcurrent and undervoltage conditions—which would be indicated in the fault codes generated by the drive, be sure to have an electrician check voltage and amperage coming from the SCR House on a DC Rig. Also, one thing to check while the electrician's coming… in the event of overcurrent, try drilling with the Top Drive while the Drawworks is de-energized. If the TD kicks off again, reset the fault and this time, stroke on only one pump. Try the TD again. If the TD kicks off while drilling again, swap pumps and stroke on another single pump. Once, we chased an issue for days… Top Drive overcurrent condition… and the root cause was a burned-up plug on a Mud Pump (kudos, Ruben). Just food for thought.

(2) SCENARIO 3B: TOP DRIVE QUILL TURNS IN REVERSE WHEN FORWARD IS COMMANDED (and vice versa) – Shut down the VFD House and SCR Top Drive Feeder. Swap any two outgoing power plugs (black, white, red) between the VFD House and the Top Drive. Long term fix: either swap the same phases in both drill motors, or change the plugs or receptacles so the colors match. Also, this can sometimes be an encoder issue. Determine if this is the case by following

your appropriate encoder bypass procedure in the step below.

(3) SCENARIO 3C: TOP DRIVE TORQUES UP – In drill mode, when the throttle knob is turned, the quill does not rotate but the torque gauge spikes. Reduce throttle position to zero speed. Cycle brakes on and off a few times, they might be stuck closed. Try to rotate. If issue persists, check another hydraulic function—such as link tilt—to make sure we still have hydraulics (otherwise we weren't doing crap when cycling the brakes, and that still might be the issue). If the link tilt function works, then we can assume that the brake function works, but just to verify, let's open those curved panels just beneath the blowers… one panel on each motor will do. What we're checking is to see whether the brake pads lift off of both the top and bottom of the brake rotor when brakes are turned 'Off' at the console, and whether they apply again when turned into 'Auto' or 'On'. There are two calipers for each motor, and each caliper has a top and bottom brake pad. Now, even if the brake controls are functioning properly, there's one thing we're hoping not to see, and that is the bottom pads buried into the rotor of either motor. This is a visual indicator of MOTOR SHAFT DROP, and the drill motor will need to be changed. To verify, get a tech coming with a dial indicator for 3rd-party verification, and in the meantime, place a 5-foot bar under the rotor or shaft hub and pry upward. If the shaft moves more than ¼," then you might as well get a motor coming too. When the shaft drops, its weight buries the brake rotor into the lower pads and you'll torque up every time, though usually you can still overcome the torque and turn the quill at about 15 20 RPM. If, however, we don't have shaft drop and the brakes are releasing when commanded, let's continue troubleshooting. Just for shniggles, though it's highly unlikely, check to ensure that the grabber isn't somehow engaged.

Next possibility, here's a question… since the last time this operated properly, has a drill motor been changed? If so, the motors are probably fighting each other. To test this theory, shut down, LOTO, and try to turn the quill using two men and large chain tongs / chain wrench. If it turns, there is nothing mechanically keeping us from turning to the right. If it doesn't, drain the gear oil and check the gearbox for anomalies. Highly uncommon. So if it turns by hand, go into the motor that was recently changed or worked on, and swap any two power leads / wires that are terminated. See SCENARIO 3A for instructions. Tape a lanyard to your wrench—you'll need either a 5/16" Allen, a 3/8" Allen, or one or two ¾" end wrenches, or possibly larger end wrenches, all depending on who made the motor and how your company prefers to have power leads terminated. If no motor was changed and the quill can be turned manually when de-energized (but not from the console when energized), this sounds like an encoder issue.

Before you troubleshoot further, check to see if the belt slipped off the encoder wheel. The encoder is located inside the ODS curved panel above the ODS drill motor (unless your TD is one of the dolly-mounted types where the swivel pack is on the DW-side of the TD and not the V-Door side, which means your TD is backwards compared to most… in which case the encoder is above the DS motor… also, in the case of ICD's [formerly SideWinder's] Cane Brake rigs, where the Driller's Cabin is on the opposite side of the rig floor, all DS and ODS references in this book must be reversed). LOTO the VFD house and ascend the TD, feel underneath the encoder for its wheel. The belt passes between the wheel of the encoder and a similar wheel atop the drill motor hub, through which the encoder wheel receives rotation. If you don't feel a belt, look around inside the blower shroud / brake area. If it slipped off and the belt is intact, you must remove the near side 1/4" steel line connection on the opposite end of the encoder sled (remove the opposite panel), loosen the far side connection of that steel line enough to angle the steel line upward, then disconnect the two bolts on each side of the encoder sled to remove the encoder assembly. Unscrew the pigtail connector from the encoder. To do all this, you'll need wire cutters, a small set of Channel Locks or Nipex, and a 9/16" wrench. Bring the sled-mounted encoder to the rig floor, re-position the encoder so that it is mounted closer to the edge of the sled (just a 1/4" or so, to remove slack from the belt when it is re-mounted), and re-ascend to install in reverse order. Don't forget to install the belt before moving the sled into position to bolt it back down. Note: this whole procedure also just taught you how to change your encoder, less the part where you remove four hex screws from the encoder base and remove the one or two set screws from the encoder wheel—making sure to note the wheel's distance on the shaft first. Wire tie your bolts. Back to our original troubleshooting… if the belt was intact and in place when you first checked, go to the next troubleshooting step.

You're now going to bypass the encoder. Doing this will let you know whether the encoder or its circuitry has any bearing on the issue you're experiencing.

BYPASSING THE ENCODER IN A SIEMENS DRIVE HOUSE – If you have a Siemens drive house, simply locate the encoder bypass switch by opening the LH incoming reactor door and looking above the wires in the bottom right corner nearest you. In some house models, the switch has been moved to the outside of the inverter door on the right, near the control panel. Switch from 'Encoder' to 'Bypass'. If it doesn't work, shut down and restart the VFD house. If it still doesn't work, auto-tune your drive (see Siemens Compendium – "auto-parameterization). If it still doesn't work, then your encoder has nothing to do with the problem. Get a tech coming.

BYPASSING THE ENCODER IN AN ABB PLC HOUSE – If you have an ABB PLC drive house, then go to the ABB control keypad. Press the PAR (parameter) button. Now, I want you to think of ABB parameters like the Bible. They are ordered in PARAMETER GROUPS and PARAMETERS, just like chapters and verses. Next, locate the four arrow / triangle buttons: double arrow up, double arrow down, single arrow up, single arrow down. The double arrows allow you to scroll through the parameter groups, or chapters. The single arrows allow you scroll through the parameters in each group (or verses in each chapter). Get it? Ok. So using the double arrows, scroll to PARAMETER GROUP 50. Then using the single arrows, scroll to 50.06. You should see the word "Encoder." If you see the word "Internal," then you are already in bypass and you've got some bigger issues. So presuming you see the word "Encoder," press the 'Enter' button. You should now see the word 'Encoder' encapsulated in brackets, like this: [Encoder]. When you see those brackets around any parameter entry, it is ready to be edited. So now, press either the up or down single arrow, and you'll see the only other option available for this parameter: "Internal." Press the enter button again and the brackets go away. You are now in bypass mode. Try to turn the Top Drive to the right.

BYPASSING THE ENCODER IN AN ABB SBC OR INTEGRATED DRIVE HOUSE – If you have an ABB SBC house or an integrated (AC rig) drive house with ABB drives, then read the paragraph above to familiarize yourself with the PAR and arrow buttons of an ABB control pad, and how they work. Here's what you're going to do: (1) Use the double arrows to scroll to PARAMETER GROUP 51 (COMMUNICATIONS MODULE). (2) Use the single arrows to scroll to Parameter 51:15. Its value should read 5006. If not, write the number down, take a picture of it with your phone, and tell the number to someone else as backup measures. Eventually it will get changed back to that number, after the encoder issue is fixed or if you determine that the encoder circuit has no bearing on the issue. (3) Press the 'Enter' button. The number value should now have brackets around it, like this: [5006]. (4) Use either of the 'down' arrow buttons to reduce that number to zero. The double arrows will get you there faster. (5) Press 'Enter'. The brackets should disappear from around the number. (6) Use the single arrows to scroll to Parameter 51.27. (7) Press Enter. Use either single arrow—up or down—to change the parameter value to "Par (Parameter) Refresh." Press enter again to make the brackets disappear. After a second, the value will change to "Done." (8) Use the double arrows to scroll to PARAMETER GROUP 50 (ENCODER MODULE). Then use the single arrows to scroll to Parameter 50.06. (8) Press Enter. Brackets appear around the word "Encoder." Press the single up or down arrow to change the value to "Internal." Press Enter again to remove the brackets. Bypass is completed. If in the rare occasion you cannot change any parameter values (ACCESS DENIED or similar alert pops up), or the word "Internal" keeps automatically changing back to the word "Encoder" within a second automatically, call me 24/7. There are several things that could be affecting this. If you feel comfortable navigating the parameters at this point, I can walk you through some steps. 910-381-0876.

BYPASS AND ENCODER CIRCUIT REPAIR CONSIDERATIONS – If bypassing the encoder fixes the problem and your company allows it, run in encoder bypass mode. It will not hurt anything on the TD. However, if your company does not allow it, or if you need to slide / drill directionally soon, then get a TD tech or electrician coming with the following: two encoders (very sensitive devices… ~one in ten is bad right out of the box!), an encoder belt, an encoder pigtail, an RTAC card, and an oscilloscope ("O-scope”). If the encoders are not BEI brand, or do not come from NOV, verify that they are “1,024-count” incremental encoders with the same body and shaft size. Other possibilities for parts needed (less common) may be (1) an encoder splitter card if using a PLC-style driller’s console; (2) Torque and RPM barrier cards if using an Amphion-style SBC console; (3) a 24V or 15V power supply—bring both if the tech has them handy; and if you have the Amphion SBC console or cyber chair, (4) two 750-631 Wago cards.

If bypassing the encoder does nothing to fix your problem, the only other things you can do to troubleshoot are (1) disconnect all third-party connections (Pason / Totco) from the driller’s console, and from the VFD house (Slider, Twister, Rockit, e.g… the VFD house connections may require an electrician); and (2) troubleshoot to determine if DW or MP power is affecting the Top Drive’s rotation from the console.

SIMPLE CHECKS THAT COULD IDENTIFY INDUCED ENCODER ISSUES – First, make sure your VFD house has a dedicated ground and is not just grounded to the SCR main ground and / or bonded to the substructure. De-energize the VFD House first / LOTO. Make sure grounds cables are securely and tightly connected to lugs and rods. Second, make sure that any slack in the 42-Pin and Power service loops are not coiled together. This creates electromagnetic interference that can disturb the highly sensitive encoder. Uncoil and separate the loops. If this didn’t affect the symptoms you’re experiencing, try the next troubleshooting step below.

RUNNING A 42-PIN SPARE – Your challenge will be to try to run spares before the tech arrives, to rule out the possibility of a 42-pin issue—which is also part of the encoder circuit. To run spares, grab a ‘tweaker’ (electrician’s small termination screwdriver) and refer to Figure 11-20, located on page 155 of this book. LOTO the Top Drive. Open the TD J-Box. Locate terminals 74, 75, and 76. You're going to be moving the wires on the left side of the terminal… these wires are coming from the encoder. Remove wire 'A' from the left side of terminal 74 and place it in the left side of (spare) terminal 80, which should not already have a wire in it (if it does, stop and wait for the electrician). Then remove wire 'A-' or 'A/' or A-Not' from terminal 75, and terminate it into the left side of terminal 81, which should also be empty. Finally, move the shield wire from the left side of terminal 76, to the left side of T82. Should be empty. The key to running spares, is that whatever you do at the TD junction box, you also need to do in the VFD House. In the VFD House, locate the 42 conductor. In an ABB stand-alone drive house, it is in the same cabinet hanging on the left side wall that contains your I/O… the cabinet is called an SBC or PLC cabinet, respectively. Underneath and to the left of the I/O are a bunch of left-to-right terminals. Physically look at the wires to see the wires stamped 01 through 42. That's your 42-pin circuit. Leave those wires in place—you'll be working on the opposite side of the terminals. Remove the wires (A, A-, and Shield) that connect to 74, 75, and 76. Re-terminate the wires into the empty terminal spaces across from 42-pin wires number 80, 81, and 82 just as you did at the Top Drive. Voila. Try to turn to the right. If the symptoms persist, place the wires in the VFD and Top Drive back into their original positions. Pull on each wire after you terminate it, to make sure each is securely fastened to its terminal block. So you just tested the 42-pin for encoder channel A. The encoder uses two channels, so now try moving B, B- and B-channel's shield from 77, 78, and 79, and swapping them over to 80, 81, and 82.

(4) SCENARIO 3D: TOP DRIVE QUILL JERKS OR OSCILLATES IN DRILL MODE – In drill mode, the quill oscillates back & forth, or moves in a jerky and erratic fashion. Sounds like an encoder issue, could also be a power issue—

although the latter should be accompanied by a Fault. Proceed by bypassing the encoder as outlined in SCENARIO 3C above. If bypassing the encoder does not fix the problem, then troubleshoot it using the logical order presented in SCENARIO 3A.

(5) SCENARIO 3E: TOP DRIVE RPM OR TORQUE GAUGE BOUNCES AROUND, OR HOLDS VALUE ABOVE OR BELOW COMMANDED VALUE – First, bypass the encoder. If this does nothing, get a tech coming with the same list of parts as outlined in SCENARIO 3C, in the section called "Bypass & Encoder Circuit Repair Considerations." You won't need the encoder or encoder pigtail. Add to that list the RPM gauge (NOV P/N PR1003A19) and / or Torque gauge (NOV P/N 96219-11), as applicable. Notes: swapping the encoder fixed this issue years ago on Patterson 480. However, one JDC rig operating in New Mexico had this problem for over a month—both the tach and torque gauges' needles kept bouncing around. Sometimes, the spikes were significant enough to show up on Pason. Finally, the operator had enough with it. In the end, everything was changed… the service loops, the console, every single cable and connector, every single Wago. Had NOV techs crawling through the VFD house. It wasn't until the VFD house was changed out that the issue went away. Truly believe that it was the result of a glitch in the SBC program. Sometimes you'll get a weird one like that.

(6) SCENARIO 3F: RPM NEEDLE RESPONDS PROPERLY WITH THROTTLE INPUT, AND YOU CAN HEAR THE TOP DRIVE RAMPING UP AND DOWN, BUT NO MOVEMENT OF THE QUILL – Very weird one, but it happened on Patterson 738 back in 2010. Drained the gear oil and removed the ODS gearbox access plate (the one where the oil drain is located). The TD had just come back from an

annual inspection, where the motors were sent in to be reconditioned. When inspecting the gearbox as the TD hung from the blocks, it was discovered that the motor pinion gears had simply fallen off, and were sitting in the bottom of the case. Turning the throttle was causing the motors to spin fine, just as commanded. They simply didn't have gears on their shafts to turn anything.

(7) SCENARIO 3G: SIZZLE, GROWL, SMOKE, FLAME, OR BACON – When Hoss went back to pushing, he called me one day. Horrible connection, I could barely hear him. Finally I pieced together what he was asking me. "Matty, does the Top Drive got bacon in it?" "No Hoss, why?" "Because it sounds like this! *Sizzle skeeeew POP pbpbpbpbpbth!!!*" So here's the deal: if your TDS-11 sounds like it has bacon in it, if it 'sizzles' or buzzes or hums loudly, or if smoke or fire shoot out of a drill motor… SHUT IT DOWN!!! You're likely experiencing a severe electrical problem, EVEN IF it sounds like it's growling mechanically. Even if you're dead sure it sounds mechanical, and you're positive you have a gearbox issue (the sound resonates in the gearbox like the grito of an Austrian yodeler)…9 out of 10 times, you either lost a drill motor or you have a power cable exposed and touching metal somewhere. De-energize the VFD house, LOTO, and follow the same steps as in SCENARIO 3A to locate the source of the problem.

(8) SCENARIO 3H: PROBLEMS IN SPIN & TORQUE WRENCH MODE (MAKE / BREAK) – If the problem relates to the speed of the quill or torqueing power, get a tech coming. The issue could be as simple as a bad switch or torque potentiometer, but could be as complex as a drive or program issue… roughly on a 50/50 basis. If the issue is pipe slippage during connections, did your drill string size just change? Conduct a thorough visual inspection of the grabber assembly

to ensure that dies are in good shape, and that the die holder block is appropriate for the size of pipe you're drilling with. For hydraulic issues, see the Grabber / Clamp scenario.

(9) SCENARIO 3I: DRILL SPEED ERRATIC OR 'JUMPY' – If, when commanded using the throttle on a driller's console, the physical reaction of the quill is jumpy or erratic, OR if the quill rotates slowly in forward or reverse without command, OR if response lags, then the issue could be encoder-related, although in my experience these issues often rest in the throttle rheostat / potentiometer. The standard Varco Driller's Console has a classic fixed-range rheostat, and it sounds like the contactor ring might just need to be cleaned with an eraser. Otherwise, replace the 10KΩ throttle pot (NOV P/N 817362). For Amphion SBC console applications—which have an 'infinite range' throttle knob, replace the Scancon throttle encoder (NOV P/N 0001-0870-32).

4. DRILL MOTOR OVERTEMPERATURE

(1) THEORY OF OPERATION – This lamp illuminates on the driller's console, or alarm appears on an HMI screen, when the heat-sensitive contacts of any of the three RTD's—or Resisting Temperature Devices—curl up due to overheating, and break contact. When they cool down, the contacts relax and make again, and the lamp extinguishes or alarm can be cleared. That being said, the indication of motor overtemp will occur whenever there is a break anywhere in the circuit, including the RTD terminal block inside the motor, the RTD pigtail, inside the J-box, in the 42-pin pigtail or connection, in the 42-pin service loop or connection, or in the VFD house. More oft than not, the problem is not actual—it is a faulty alarm incurred by a break in the 42-pin circuit.

(2) DETERMINING THE VALIDITY OF THE ALARM – For

starters, always treat this alarm seriously. If it is a true indication, then one of your motors has overheated and you need to get it cooled down before continuing operation. Only on some of the newest rigs will the TDS-11 go into automatic shutdown to protect itself, where safety features such as this have been built into the logic or program code. In all other cases, the TDS-11 will tell you that its motor(s) have overheated, but it will still let you operate until you catch them on fire. Also, only in a cyber base configuration will the control screen tell you which motor is affected. On any driller's console, you will get a light but still not know which motor has been affected. Most importantly, ensure that (1) your motor heaters are off (or disabled if you are not in a cold environment); and (2) that your blowers are running, and in the correct fan direction—which is determined by phase sequence. If the blowers are both running in Drill or Spin mode (outside of Drill or Spin modes, the ODS [Off-Driller's Side] blower is usually disabled because it is not necessary to cool a motor that is not energized and therefore not building heat [it becomes energized when the throttle turns, sending voltage to the motor to turn it]; the DS remains enabled regardless of mode, as long as hydraulics are on… that's because the hydraulic heat exchange-type oil cooler is located in the DS motor brake plenum / blower shroud), then use a heat gun or laser infrarometer to compare the temperatures of both motor housings, and of both motor windings if accessible through the vents. If both motor temperatures are comparable in temperature, and the outer housings read lower than ~180 degrees Fahrenheit after long continuous run time on a hot day, then there are likely no problems with the motors and your operation can proceed with caution, monitoring temperatures to make sure they do not increase. At earliest operational convenience, all 42-pin connections should be checked to ensure that no pins are pushed in / damaged, and that plugs are not cross-threaded, etc. The only exception to proceeding forward is in this circumstance: If the Drill Motor Overtemp indication was coupled with or preceded by a Blower Loss indication, and no other alarms are present, then you should take this very seriously. Verify positive blower displacement before moving forward. If the indication was accompanied by Blower Loss and also Oil Pressure Loss, then likely either (1) the VFD house incoming power is improperly phased—test your hydraulics to check… if the HPU is running but you can't function any hydraulics, then re-phase the VFD's incoming power (with power off, swap any two of the three power cable plugs coming from the SCR house at the VFD plug panel, see if that clears your alarms and makes the blowers' air displacement feel more forceful when you re-energize the VFD house), or (2) there is a 42-pin issue. For troubleshooting blower loss, see SCENARIO 8.

(3) AVOID SELF-INDUCED DAMAGE TO DRILL MOTOR – The most common way to create an actual motor overheating condition, is to drill without cooling blower air. The second most common way occurs after a new drill motor has been installed. One of the steps for installing a drill motor is to hook up the RTD and drill motor heater wires, which are fed into each motor through a common pigtail from the J-box. If for whatever reason, the incoming 120V heater wires were accidentally connected to the motor's RTD wires (due to mislabeling or improper prints, then when the heater is energized, it blows the middle of three series-connected RTD's, and literally makes a small explosion inside of the motor's windings. With time—about two months, to be exact—the heating and cooling of the motor's windings due to regular use of the TD will cause the damage to eat through the VPI epoxy of two separate motor phases, causing them to arc and the motor to fail. This was learned when Patterson ordered their first Omron Super Rigs in Pennsylvania. In just under a year, Rig 328 changed out six (6) DS drill motors. Finally, it

was discovered that Omron had issued erroneous prints, and their remote I/O junction box on the rig floor was wired in such a way that it was sending heater power to the RTD's. After each investigation, it was found that the middle RTD had caused a fire which burned a hole in the windings. So we purchased three platinum 100 RTD's at Rice Electric and wired them in series, then wired them to an extension cord and plugged them into a wall outlet. "Boom," middle thermistor popped. Provided that demonstration again for the Regional VP, and a third time to share the video & discovery with all operating regions. Rig 328 was following the standard practice of cold climates to warm the motors before operating the TD, and it was determined that the initial RTD damage did not typically present a motor failure until ~2 months had passed.

5. OIL PRESSURE LOSS

(1) THEORY OF OPERATION – When the 600 VAC HPU motor is energized on the TD, it turns a piston pump to pressurize the hydraulic system. Splined to the back of that piston pump is a 'piggyback' vane pump (NOV P/N 107783-5C11R), which—like the piston pump—accepts gravity-fed oil from the hydraulic reservoir, only its sole purpose is to turn the gear lube hydraulic motor (NOV P/N 30156326-36S [ask for new P/N]). After leaving the vane pump, oil is directed through the RV2 cartridge (SUN P/N RPEC-LNN or NOV P/N 94520-1NN) on the main manifold, where it is regulated to 330-360 PSI while running (400 PSI deadhead). That is the input pressure requirement for the hydraulic motor, in order to maintain proper speed of the internal gear lube pump (NOV P/N 109567). The gear lube motor, which we can see, transfers torsion through a dry spline in the DS gearbox access plate to the gear lube pump on the inside of the case. The internal pump directs fluid through drilled ports in the housing and lid, to the oiler jets over the gears. Tapping into one of these ports

from outside the lid is a 1/4" tube that directs pressurized lube oil to the gear lube pressure switch (NOV P/N 87541-1). Optimal case pressure is around 33 PSI with 15 gallons of 80-90W gear oil serviced in the gearbox. When the gear lube pressure drops between 20 – 18 PSI descending, the plunger needle in the pressure switch breaks physical contact with the microswitch, causing the OIL PRESS lamp to illuminate on the console (or the oil pressure loss alarm to appear on the HMI screen).

Note: the TDS-11 does not have an indicator for loss of *hydraulic* oil pressure.

(2) DETERMINING THE VALIDITY OF THE ALARM – This is another one to take very seriously. Again, not a 'smart' Top Drive, the TDS-11 will let you run your gearbox to failure. 16 PSI case pressure is 'danger close', and if you drill with a TDS-11 below 12# pressure—the nominal pressure required to siphon at least a few drops of oil onto the gears—a catastrophic gearbox failure is imminent. That means 5-10 days of downtime and at least $100K, unless you have another Top Drive to swap it out with. The only way to verify the accuracy of the alarm is to hook up a 60# or 100# gauge… and I would recommend installing one of those permanently, if your TD doesn't have gauges already. If the pressure is visibly greater than 20 PSIG, great! Just hammer the lid off the gear lube pressure switch and use a 5/8 end wrench to turn the brass insert CCW until the alarm lamp extinguishes. If you turn it more than two complete revolutions—about five or six wrench turns, then you have a bad pressure switch (the spacer / tensioner spring is likely worn inside the switch body's inlet) (NOV P/N 87541-1). If, however, your pressure is visibly below 20 PSIG, turn off the TD, check the gear oil sight glass, and add oil as required until the level is at least halfway in the glass. That should boost your pressure. If that doesn't do the

trick, install a Stauff line gauge to the test port under the main manifold that is located between the first two solenoid valves, counting from the 3-position valve switch. If your pressure while running is less than 350 PSIG, adjust RV2 clockwise until 360 PSIG is achieved. That will also boost your pressure. If pressure will not adjust, order a new RV2 cartridge (SUN P/N RPEC-LNN or NOV P/N 94520-1NN) and a vane pump (NOV P/N 107783-5C11R). If pressure is at 360 PSIG and gear oil level is proper, but pressure is below 16 PSI, order a gear lube pump rebuild kit from GDS / Premium along with a gear lube hydraulic motor (NOV P/N 117939). The rebuild kit will be significantly less expensive than the pump, which is some ridiculous price ($12K I think), and it's pretty cut-and-dry to take the pump apart and replace the handful of parts inside. If the motor isn't culprit (quick to change, 2-bolt mount, doesn't require draining gearbox so check that first), then you'll have to pull the pump anyway, and it only adds about 45 minutes for a novice to rebuild the pump. Use caution when removing the pump from the gear access plate, so as not to damage or lose the long, thin-diameter perimeter O-ring. I haven't heard of a gear oil filter affecting gear case pressure but it probably wouldn't hurt to change it while you're waiting on parts, if you have one on your rig. Order a replacement spare element (NOV P/N 30111013-1).

6. VDC PRESSURE LOSS

This is a bogus alarm, depending on how you look at it. VDC means Varco Driller's Console… so the alarm is telling you that your console is not pressurized. The console is outfitted with an air purge system, because it falls under the ASNI / NEC Class I, Div I rule of being within close proximity of flammable vapors (10' from the rig floor's wellbore access). So theoretically, the console should be pressurized, since all of its internal components are not explosion proof. However, I haven't worked on a single land rig that hooks an air line up to their driller's console; probably because the potential for moisture would render the electrical components useless over time, and nobody is going to dedicate an air dryer to a driller's console. So… it's a bogus alarm. Or a spare lamp bulb in case you need one elsewhere.

7. AUXILIARIES (BLOWERS, HYDRAULICS) DON'T WORK

(1) IT'S EITHER 19-PIN, MOTOR STARTERS, OR CONTROLS – First, verify that you are able to rotate the TD with the driller's console throttle, or by entering a speed value on the HMI screen from your cyber chair. If not, refer back to SCENARIO 1: NOTHING WORKS. Note: in some AC rig applications, the ability to drill will be disabled by the SBC program if the auxiliaries are not energized… in which case, continue with the troubleshooting steps below.

Locate the three side-by-side auxiliary motor starters, which are usually Eaton brand. Refer to Figure 11.13 in the electrical chapter of this book to know what you're looking for. In a Siemens drive house, they're behind the LH door (reactor cubicle) against the back wall. In an ABB drive house, they're behind the tall, skinny control cubicle door, mounted a foot above the floor. On an AC rig, the three may be together or separate, behind bucket doors on the MCC wall of the integrated drive house or behind similar doors in the Driller's cabin, or inside a common cabinet with other control components inside the Driller's cabin. In the AC rig locations, the cabinet will either be labeled TD Auxiliaries, or TD HPU and TD Blowers, or TD HPU, TD Blower 1 and TD Blower 2. For sake of explanation, we'll use the standard ABB drive house configuration. Locate the three, and note the switch knobs on each. If they are pointing up and down, the motor starter breakers are closed / energized, and your problem likely exists in the control program or I/O (Siemens PLC & modules or Beckhoff SBC and Wago racks, or other I/O—such as IDM

PLC / Siemens modules for H&P rigs, etc.). Get a controls specialist coming, but not before checking the basics… like is your 19-pin plugged in, pins in good shape, etc. Also, check your driller's console serial / comm cable(s) for damaged pins. Drill mode works but auxiliaries do not… different I/O. Unlikely, but still a possibility. LOTO first please.

(2) FOULED 19-PIN PLUG – If the three motor starters' breakers are in the off (horizontal position), turn them on (vertical position). If all three fail open (off) again, you have water in one of your 19-pin plugs, or some anomaly exists in the 19-pin circuit between the VFD house and the TD J-box. Think about it, it's not rocket science, right? A disconnected 19-pin alone will not cause the motor starter breakers to trip. Troubleshooting also incorporates probability, which in this case dictates that three separate, robust, explosion-proof motors did not all simultaneously fail. Well, the motors' individual power sources all travel together in the 19-pin between the VFD house and the TD J-box. A cross-threaded plug will not cause all three breakers to trip… impossible. That's 12 male and female pins, either making contact or not. So water in the plug. Or a Brillo pad stuffed into the end of the plug. Or, in rare cases, a plug insert has lost its clock position, and the male and female pins at the connection are mismatched—usually only possible with very old plugs, or with new plugs and very dumb electricians.

9:10 TIMES, IT'S THE PLUG! NOT THE WHOLE SERVICE LOOP – This part's important: unless there was a specific damage occurrence—and usually everyone knows when that happens, like when a service loop snags due to high winds and rips in half in the derrick—the problem with a 19- or 42-pin service loop is usually found at the plug connections. 9 times out of 10, the cable's fine. So you start looking and you discover water pouring out of the back of a plug. BACK of the plug. Don't just check the side you can always see. With the plug you discovered, though, it doesn't have a rubber grommet insert to keep water out. Instead, it's 'potted' or epoxied, but old and cracked or improperly mixed & set, and somehow water intruded and is shorting across the backs of the pins when 600V is applied. Get a plug coming. Take pics so that there's no confusion… you could have a male plug with female insert (female pins) or vice versa, so to alleviate confusion, just take a few snapshots and send them to your tech so he knows what to get. Meanwhile, let's get the rig off Code 8. You can do this.

SOFT-POTTED MULTICONDUCTOR PLUGS – So you're not an electrician. Got it. But let's be honest, the cable is disconnected, right? And the VFD house is LOTO. So really it's no different than rigging up, when you're handling cables and plugs all over the rig. Okay, let's continue: there are two types of potting material, designated 'soft' and 'hard'. A soft pot is messy but you can dig all that crap out of the plug with a screwdriver (gently when you get near the plug face, where the small wires are crimped into the pins). With the epoxy removed, shake all the water out, spray the hell out of the wires with Lektra-clean or contact cleaner (NOT 2-26 or 3-36 electrical lubricant!!!), blow it out with compressed air or five minutes of huffing and puffing, plug it in and go while you're waiting on a new plug (or really, just a rubber grommet). If it's raining outside, wrap that plug and cable with a fucking trash bag and tape the hell out of it so the rain stays out and you can stay off downtime. Now obviously, I'm not telling you how to run your operation, I'm just giving you your options. Don't take offense, just chew up the meat and spit out the bones.

HARD-POTTED MULTICONDUCTOR PLUGS – Okay, you found a plug with water dripping out the back side, but it's hard-epoxied and your screwdriver might as well be a dildo.

And you’re on downtime. If you have the right configuration of rig—and there’s no forecast of rain between now and the tech’s anticipated arrival—you might still be able to save the day before the tech arrives, with 45 minutes’ effort. First, only continue if you have a stand-alone drive house, or if you have an AC rig where all three aux motor starters are sandwiched together in one cabinet in the drill cabin. And don’t continue if you’re on an ICD rig, it won’t work without some other changes. Now, in NOV’s original design—which is still accurate for about half of the land rigs with TDS-11s, the 19- and 42-pin service loops are continuous from the VFD house to the Top Drive (only the power service loop and grounds have mid-mast connectors at the service loop hangoff [saddle]). If this describes your rig, perfect, continue. If however you have a sexy AC rig with service loop connection points / J-boxes up and down the derrick, then you are screwed and you’ll have to wait for the tech. Unless, that is, the plug you discovered with water in it is either the one that plugs into the VFD house or the one that plugs into the Top Drive—in which case, continue.

When the tech arrives, s/he will need to cut the bad plug off to install a new one. Well, you’re going to help the tech out by cutting the plug off for him or her. And you’re going to get your rig off downtime quickly. You’ll need some cutters, a knife, some big zip ties, and one of those little electrician’s termination screwdrivers, aka ‘tweaker’. If you can scrounge all that, let’s get started. Cut or chew the plug off. Strip back about 2 feet of outer insulation to expose the wires below. Here’s how you’ll do it carefully without cutting into the insulation of the individual wires: (1) measure back roughly 2’ from the gnawed-off end of the cable. Cut around the complete circumference of the cable, a little at a time. You’ll do this by bending the cable so it’s at a maximum bind where you’re cutting. That way, you barely have to apply pressure with your blade before the insulation starts to separate. Ever cut down a tree from its trunk? The back cut, where if the tree is leaning you barely have to touch it before she starts to go? Same concept. Cut all the way around, changing the position of the bend in the cable as you go, until the wires inside are just visible. (2) Now, carefully cut a line from the circumference cut you just made to the end of the cable. Don't cut deep until you're down to the last inch or two of cable. Go over the same line again with your blade, again not applying too much pressure until you're at the end. You should have a split at the end of the cable by now. (3) Separate that split until the insulation peels off. May take a few minutes and a little more slicing along your long cut—with finesse. (4) You should now be holding a bundle of undamaged wires that are about two feet long. Separate the ends. If you have any blue or yellow nylon-looking or plastic spacer threads in there, you can cut them off at the base of the cable's outer insulation. Careful not to skin any wires.

Check the end of each wire for slicing damage, cut the ends to make them neat and uniform in length, and strip between 3/8" and 1/2" of wire off the end of each wire. These wires are either numbered on their individual insulation, or they are all different colors. If the latter is true, refer to the wire color chart in Figure 11.24 of Chapter 11 this book (black = 1, white = 2, red = 3, green = 4, etc.). You'll either have 18 wires or 20.

(A) AT THE TOP DRIVE – Now, if you're at the Top Drive, open the J-box and locate the 19-pin pigtail. It's coming into the left side of the left terminal strip, beginning at the top with wire 1 in terminal one (wire 2 in terminal 2, etc.). Make a note of which wire goes where, in case someone else intentionally swapped some wires around in the past. It should be terminated exactly like the image in Figure 11.21 (Chapter 11 of this book). IF NOT, then write down the termination exactly as it appears in your J-box, or, go ahead and zip-tie the hell out of your field-stripped service loop to the guard frame of the TD, and start terminating wire-for-wire. Even if it looks like the previous electrician did a hack job with crisscrossed wires, you're going to do exactly what s/he did. Remove the existing WIRE # 1 from wherever it lands on the left side of the terminal. Should be terminal 1 but who knows. Now insert your WIRE # 1 in its place. Let the old one dangle… when you're finished, you'll touch those old ones all back to the left against the box. Don't worry, they're from the 19-pin pigtail, and nothing's plugged into it. As you tighten each screw to terminate your wire, give the wire a good tug to make sure it's properly terminated. And be careful not to let any straggler wire strands hang out where they can touch another wire. Twist the end of the wire before inserting in the terminal to avoid this. Lastly, don't let any wire or wires bear the weight of the cable. Make sure there's some slack for the thin wires, and zip tie, rope tie, and / or duct tape the hell out of the 19-pin cable to the rest of the service loop for at least ten feet or so. You should use at least 6 or 7 big zip ties. Remember, this will be traveling up and down in the derrick. You're done. Get down and go unlock the house, fire it up, and energize those three aux motor starter breakers. HA! They didn't trip. Good job. Get back to drilling.

(B) AT THE VFD HOUSE – The bad plug is at the VFD house plug panel. Do everything in step (A), except instead of terminating in the TD J-box, pull 15' of slack into the VFD house. Open the tall, skinny control cubicle door and get on your belly with a flashlight. Under those motor starters is a terminal strip, with terminal 1 on the far left and terminal 18 on the far right. Read the instructions in step (A); you're going to swap out one wire at a time, wire number for wire number, regardless of which terminal the wire lands on. In theory, here in the VFD house, wire 1 goes to terminal 1 and follows in logical sequence until wire 18 lands on terminal 18. Forget logic. Just place your field-stripped wire 10 wherever the existing wire 10 lands. With the old wires removed, push them all down to the floor and tuck them so they can't accidentally make contact with a live wire or terminal. Don't worry, even after you power up, they're dead wires that go to the plug panel of the VFD house. Nothing's plugged in there because you cut the plug off. And you're good. Unlock and re-energize the VFD House, turn on the aux motor starter breakers and get back to work. Zip-tie the service loop to the handrail outside the house so no one trips on the cable and yanks the wires out of the terminal block.

8. BLOWER LOSS

(1) LAMP ILLUMINATED… BUT ARE THE BLOWERS BLOWING? First, let's determine whether you have an actual issue, or just a faulty indication. Tie some caution tape onto the outside vents of your drill motors. Tie two or three flags on each vent, and tie them high enough that when the TD is de-energized, the tape segments lay across the whole face of each vent, from top to bottom as the TD hangs from the blocks. Now energize the TD and place it in drill mode… in some cases you need to move the throttle off of zero speed to energize the ODS blower. Either those flags are flying strong, or they're just drooping, maybe moving a little. This situation assumes that you can hear both blowers come to life, and they're not just silent. If one or both are silent, refer to step 4 below. If the flags are flying on both motors, then you know you've got good blower air, and your alarm is actually a false indication; likely the product of a faulty blower pressure switch—or maybe one of the blower pressure switches simply vibrated out of adjustment. First we gotta figure out which blower it is. Even if your HMI screen says Blower 1 / 2, LH / RH or DS / ODS, there's a 50/50 chance they're swapped in the VFD house or TD J-box. With the Driller watching the

console or alarm screen, send a hand up to the top of the TD with a tethered hammer, a small flathead screwdriver, and a 5/8” wrench. Located near the base of each blower motor is a blower pressure switch. Refer to Chapter 11 in this book for pressure switch identification. The hand will start on the DS switch and hammer the lid off gently. Ok, maybe not gently, but don’t treat it like a hammer union. Let him / her know in advance that the lid doesn’t need to be tightened on like that, either. Now yelling up at him, first ask whether there’s water or moisture inside the switch housing. Also tell him not to lick the two screws where the wires are connected, he’ll get shocked. If moisture is noted, shut down, LOTO, and wipe the inside dry after spraying some electrical or contact cleaner (NOT 2-26 or 3-36 electrical lubricant). Once dry, re-energize the unit, select drill mode and see if you still have the alarm.

If the inside of the housing is dry, have your roughneck locate the brass adjustment with a 5/8” hex body. Sticking up through it is a plunger, which actuates a little teat on the micro-switch. Using the screwdriver, have him press against that teat and hold it for ten seconds. He might have to move the plunger down away from the microswitch with his other hand. When he presses it with the screwdriver, he should hear a ‘click.’ As he’s holding it, Driller, reset your alarm or lamp. If the light extinguishes, have him keep holding it for another ten seconds or so to see if the alarm pops back up again. If not, have him release it and wait for 30 seconds. Does the alarm pop back up? It should. If not, disregard the anomaly for now, but you might have a bad pressure switch or something going on in your 42-pin circuit. If the alarm pops up again upon release, great—you found your issue. Using the 5/8” wrench, have him turn the 5/8” adjustment counterclockwise, one turn at a time, with a 10-second pause after each turn in case of delay. Driller, keep pressing ‘clear’ or ‘reset’ every five seconds during the process, until the alarm goes away (note: in most cases, you will not need to clear the alarm on the console, it will extinguish itself within five seconds or so after the microswitch is contacted). Now, let's back up. If he pressed on that microswitch with his screwdriver as described above, and nothing happened with the alarm, have him switch over to the other blower and repeat the steps on that other pressure switch. If the alarm still does not extinguish, get a tech coming at your convenience, and have him or her bring a blower pressure switch (NOV P/N 76841).

(2) BOTH BLOWERS ARE BLOWING BACKWARDS – If this happens, stop thinking about the blowers for a minute. Something else is probably going on, because it would be highly peculiar / improbable that two motors just started running backwards, unless there was an obvious change in the circuit. First, check your hydraulics (try to function something). If nothing functions but the hydraulic pump is running, see SCENARIO 1, part (5)—improper phasing of the VFD house incoming power. It the hydraulics do function, then something still had to change. Ah, I've got it. You changed out your 42-pin service loop, right? Or 42-pin pigtail, or VFD house, or Top Drive.

Ok, to get them running the right direction, you need to swap phases in each circuit. It's usually easier (or lazier / cleaner) to do in the VFD house, but since there are so many different types of rigs and corresponding possibilities of where the 42-conductor may end, we're just going to do it at the TD J-box. Shut down, LOTO, and taking a large flathead screwdriver and an electrician's small termination screwdriver (tweaker), ascend the Top Drive and open the J-box lid (note: don't unscrew the clamps on the right side of the lid, just loosen the left side and slide the right side of the lid up or down). Left side terminal strip, near the top. Terminals 5, 6, and 7 are the three phases for one blower, with T8 being the motor's ground wire. Terminals 9, 10, and 11 are the three phases for the other blower, with T12 being its ground wire. For each motor, we're going to swap two phase wires. We're not going to do it on the left side of the terminal blocks, leave those alone in this instance—that's our incoming 19-pin pigtail. We're going to swap wires on the right side of the terminal blocks—those are the wires going out to the motors, aka the motor pigtails. So go ahead and loosen the screws on terminals 5 and 6, and swap those wires. Making sure the wires are pushed all the way into their terminals (one at a time), tighten the screws and give a little tug on each wire to ensure proper termination. You just swapped the phases for one motor. Go ahead and do the same thing on T9 and T10. Now you swapped phases for the other motor. Button up the lid, descend the TD with both screwdrivers, and test the blowers. You're good.

(3) ONE BLOWER IS BLOWING BACKWARDS – The last step above describes how to swap phases on both motors. That's what you'll need to do in this step but with only one motor. First, though, you'll need to determine which wires in the J-box go to the motor you're trying to change. Using prints or the J-box diagram provided in this book is pretty much a worthless effort when it comes to blower termination, as I've found that 'Blower 1' and 'Blower 2' are subjective terms to the electricians that wire these boxes up, even in brand-new Top Drive wiring situations.

So LOTO the Top Drive, go to the J-box and look at the two vertical terminal strips. We're going to be working on the left side strip, inside wires (not the outside wires which are closest to the left edge of the J-box). Disconnect the wires from the right side of terminals 5, 6, 7, and 8. Terminal 8 is supposed to be a ground, but since I can't see it, we're not going to assume anything. Remember which wire goes to which terminal… the wires will hold their 'memory' so usually it's pretty selfexplanatory. Just pull them away enough that they won't find their way back to the terminals with a minute's vibration. With all four wires removed, descend from the TD, unlock and re-energize the TD. Select drill forward and bump the throttle barely off of zero. One of the blowers will not come on. If it's the one that was blowing backwards, great, just swap the wires between terminals 5 and 6, re-terminate all four wires, replace the lid and you're good. If the one you disconnected was the other motor (the one that was blowing properly), then re-ascend the TD, re-terminate the wires at terminals 5, 6, 7 and 8 in their original positions, and swap the wires between T9 and T10. Button up and function test. You're good.

(4) ONE OR BOTH BLOWERS ARE SILENT / NOT BLOWING—Test any hydraulic function. If it works, then your 19-pin is connected from top to bottom… rule that out. If it doesn't, refer back to SCENARIO 7. Another thing to rule out… if your ODS blower is not running, select drill mode + forward or reverse at the controls. Did the ODS blower come on? If not, bump the throttle to 1 RPM or greater. Did the blower come on that time? If it came on after drill forward, or after the throttle was manipulated, you're fine. That's how 90% of TDS-11's operate (originally designed that way). Just wanted clarify.

Okay, for instructional purposes, we will assume that only one blower is not working. Treat a two-blower issue the same as one. Locate the auxiliary motor starters as illustrated in Chapter 11. Look at the small part numbers on the top of each starter block. Typically, one of these part numbers is different than the other two (ICD rigs are one exception that comes to mind). The oddball is for the 10HP HPU electric motor (3-phase 600VAC), which has a higher amp rating. The other two are for your 5HP blower electric motors (3-phase 600VAC). Note: I have seen these in a 480V configuration, but it is very rare. If the three starter blocks are side-by-side, the HPU block is usually installed on the left. Are one of the blower starter breakers tripped (knob in the horizontal position)? If so, reset the breaker by twisting it to the right until it clicks into place, then place the TD in drill forward and see if it trips again. If everything works fine, make a note of the occurrence and continue operations while monitoring the blower. If it trips again, or continues tripping, don't keep re-setting the breaker, we need to get to the bottom of this.

FAULTY MOTOR STARTER BREAKER, AUX CONTACTOR RELAY, OR I/O COMPONENT – De-energize and LOTO the VFD house, disconnect the 19-pin plug from the house plug panel, have someone stand near the plug panel as a safety watch (to make sure no one plugs in the 19-pin), then unlock and re-energize the house. Watching the motor starter blocks, have the Driller take ownership of or enable the Top Drive. Let him / her know that some alarms will pop up because the 19-pin is disconnected (blower loss and oil pressure loss, namely—might also be a custom alarm on an HMI screen referring to auxiliaries, HPU or hydraulic pump). Reset the motor starter breaker that tripped. Does it remain energized, or did it trip again? If it did not trip, have the Driller disable and enable the Top Drive again—or turn off the blowers and turn them back on again, in the event that your TD auxiliaries are separately enabled with a H-O-A (hand / off / auto) switch on a cabinet door of the driller's cabin. Watch and listen to all three motor starters again—specifically at the small blocks connected to the lower front face of the starter blocks. These are the aux contacts. You're watching and listening to see if the contacts engage (or 'suck in') and remain engaged when selected by the Driller. If one of the blower aux contacts does not engage, or if it sucks in and then pops back out again, or if it sparks, then you need to get a blower auxiliary contactor relay coming (Eaton P/N XTCEXFAC22…

I get these from Grainger). If the motor starter breaker trips, get one of those coming as well (Eaton P/N XTPR6P3BC1). If neither the breaker trips nor the contact fails, then grab a multimeter if you have one, and select AC voltage (~). With the blowers engaged (contacts sucked in), test the three left-side termination screws (four or five screws total) at the bottom of the motor starter block—the ones that have wires terminated which go to the 19-pin terminal block below (18 or 20 terminal strip). Test the screws by placing a meter lead on the first and second screw, keeping as much distance between your terminal posts as possible. DO NOT touch your meter leads together while they are contacting the screws. Even getting them close together could potentially cause arc flash (very dangerous). You should read 600V, +/- 5V. Now place your meter leads on screws 1 and 3. 600V. Screws 2 and 3. 600V. If either of those three combinations displayed an oddball number like 150V, and the other two combinations were both reading in the vicinity of 600V, then you likely have a bad starter block. Test the voltage at the top of the starter block (incoming power) to verify that the dropped phase is not the result of a failed upstream breaker. If you have no issues with the motor starter breaker, or with the aux contact, or with the voltage… move to the next step. If you don't have a multimeter or a megger, move to the step after that entitled TROUBLESHOOTING BLOWER LOSS WITHOUT A MEGGER.

TESTING BLOWER LOSS WITH A MEGGER – De-energize and LOTO the VFD house. If you followed the previous troubleshooting step, your 19-pin plug should already be disconnected from the VFD house. With 1,000V selected (always select the next highest available value over the actual circuit rating, in this case 600V), test the 19-pin service loop going up to the TD. Be careful not to touch other pins or the plug body when testing. Test phases of one motor on pins 5, 6, and 7 to ground pin 8. Readings should be better than 1.0 MΩ. Test phase-to-phase (pins 5 to 6, 5 to 7, and 6 to 7). The readings should be 0.0Ω. These are our ACCEPTABLE NORMS for operation. Now test the other motor's phases on pins 9, 10, and 11 to ground pin 12. Readings should be better than 1.0 MΩ. Test phase-to-phase (pins 9 to 10, 9 to 11, and 10 to 11). The readings should be 0.0Ω. If all readings are good, then the only possible reason for blower loss is a failed I/O component or interconnecting comm wire, or you missed something in the previous troubleshooting steps. Re-read the blower loss troubleshooting in its entirety, or scroll down to the section entitled TESTING BLOWER LOSS WITHOUT A MEGGER. If any reading is deficient according to the norms above, ascend the Top Drive, disconnect the 19-pin service loop from the 19-pin pigtail at the plug panel, let the service loop dangle, and test both motors through the pigtail plug pins in the same fashion as described above for the service loop. Did readings improve to acceptable norms as posted above? If so, then there's a problem in your 19-pin service loop.

19-PIN SERVICE LOOP ISSUES – If phase-to-phase readings were greater than zero when you tested the service loop, and they read zero when testing the pigtail, then you likely have water intrusion at one or more service loop plugs. If phase-to-ground readings were below 1.0MΩ when testing the service loop, and the phase-to-ground pigtail readings improved at least 50% to greater than 1.0MΩ, then you could either have water intrusion, or a recessed or burned pin in the 19-pin service loop, or there was a cross-threaded or improper connection at the house or TD. Also possible on multi-pin plugs if someone sprayed electrical lubricant in the plug. *Electrical lubricant should be used as a corrosion inhibitor on single-pin connections only, like your red / white / black power plugs. And yes, WD-40 or standard red grease is fine too (di-lithium or industry-preferred Chevron EP2 Black Pearl is* *better), just wipe it clean so as to only leave a thin lubricating film. Just don't lubricate multi-pin plugs.* Once you find and correct the problem with the 19-pin service loop plug(s), re-connect the service loop and attempt to close the breaker on the motor starter that tripped. Should have fixed your issue.

19-PIN PIGTAIL ISSUES – If readings did not improve when testing the pigtail (the readings will not worsen, because your megger will give you the lowest or weakest reading across an entire circuit), then your service loop might be fine. If you're still at the Top Drive and the service loop is disconnected at both ends, test the motor phase pins of the service loop using the plug body as your ground. You should read significantly higher MΩ. Test the motor phase pins phase-to-phase. You should read zero. If both sets of readings are good, your 19-pin service loop is good. Now open the TD J-box and disconnect the motor phases from the right side of terminals (5, 6, 7 and 9, 10, 11).

Make note of which wire went into which terminal. You could disconnect the pigtail instead (left side of the same terminals), but when megging, it's easier this way and it gives solid grounding to the pigtail for testing. Assuming you followed my the former instruction and left the pigtail connected to the terminals, test T5, T6, and T7 each to T8 (physical motor ground). Then test phase-to-phase. Now do the same to each of the three wires you disconnected on the right side, leaving them disconnected while testing each to ground (T8), and then phase-to-phase. Between testing the 19-pin pigtail and the motor through its pigtail, you will have found the problem. The bad readings will exist on one or the other, and there is a slight possibility that both the 19-pin pigtail and the motor circuit are bad. Repeat this process for the other motor's circuit, removing the right-side wires from terminals 9, 10, and 11 and using 12 as motor ground. If the pigtail is bad, the problem will either be in the bulkhead plug at the plug panel (remove it from the panel, disconnect and inspect), or where the pigtail passes through the gland coming into the J-box. If the root cause is not discovered or is discovered and cannot be properly fixed, get a pigtail on the road.

BAD BLOWER MOTOR OR BLOWER MOTOR PIGTAIL– If the 19-pin pigtail readings are fine, and one of the blower motor circuit readings are not, follow these instructions: (1A) If the motor circuit's phase-to-ground reading is 0.0Ω, trace the pigtail cable from the J-box to its appropriate motor. If you found no deficiencies, open up the motor junction (aka 'pecker head') and visually inspect for bare metal exposure, such as from a wire that was pinched under the junction lid. Note any smell of burned electrical components. If bare metal is found, tape it up and test the motor circuit from the J-box again, you might have fixed the problem. Otherwise, get a motor coming (NOV P/N 30172028-1… *I'm pretty sure you don't need the "-1," as I believe it only indicates quantity*).

You can verify your finding by cutting the incoming three phase wires (leave the ground wire alone) and testing them to the ground screw. (1B) If you found a 'smoking gun' issue with the wire—such as exposed conductor rubbing on metal—open up the motor junction and cut the three phase wires that are coming in through the gland, but not the ground wire (ultimately terminates to the inside of the junction). Leave sufficient slack before you cut, for these to be reconnected again. Also, leave enough wire stub on each cut near the butt-splice to identify wire colors, to save yourself the step of finding the proper phase in case you re-connect to this same motor later. Test the phase of each motor through the cut stub to the ground screw. Then test phase-phase. If the motor is good, get a pigtail coming. 20' length will suffice for any wire or cable connected to the TD. To verify your finding, test the motor pigtail. (2A) If the phase-to-ground reading is not zero, but the phase-ground or phase-phase reading is out of tolerance, then trace the wires from the J-box to the appropriate blower motor, checking for deficiencies. Open up the motor junction. You will either discover water / moisture inside the junction, or a wire that was severely pinched under the junction lid but did not expose copper. Clean and dry the inside of the junction or tape the pinched wire as appropriate and re-test from the J-box, you might have fixed the problem. Otherwise, get a motor coming. You can test your finding by cutting the phase wires in the motor junction and testing the motor and pigtail using methods outlined in (1A) and (1B).

TESTING BLOWER LOSS WITHOUT A MEGGER – PART 1: ISOLATE THE VFD HOUSE FROM THE CIRCUIT – De-energize and LOTO VFD. Disconnect the 19-pin service loop from VFD house. Place safety person in the vicinity of plug panel, then unlock / energize the VFD house. Have the Driller energize the blowers. In most cases, that means select enable + drill forward. Let the Driller know in advance that some alarms will pop up. If the aux contacts suck in and the blower motor starter breakers do not trip (but one of them tripped when the service loop was plugged in), then you're good inside the VFD house. Shut it down and LOTO. *Note: if the Driller cannot take ownership of, or enable, the Top Drive with the 19-pin disconnected from the house—a rare condition on newer AC rigs—then you can't troubleshoot any more without a megger. Get a tech on the road with a replacement blower motor. Otherwise, continue.*

PART 2: ISOLATE THE VFD HOUSE AND 19-PIN SERVICE LOOP FROM THE TOP DRIVE – Go outside and plug the 19-pin back into the VFD house plug panel. Ascend the TD and disconnect the 19-pin from the TD plug panel. Let it dangle in the air. Ensure there is no way the pins of the hanging plug can make contact with metal. Descend the TD, unlock and energize the VFD house, and stand at the blower motor starters. Have the Driller energize the blowers. Alarms again. If the motor starter breaker trips this time, you have a problem in your 19-pin service loop. Follow the previous instruction step in this scenario entitled 19-PIN SERVICE LOOP ISSUES, and ignore the megger-specific information.

<u>PART 3: ISOLATE THE 19-PIN PIGTAIL</u> – If the motor starter doesn't trip, de-energize and LOTO the VFD House, ascend the TD w/ a large flathead and a tweaker, plug the 19-pin service loop back into the back into the TD plug panel, remove the J-box lid and disconnect the wires on the right side of terminals 5 through 12, after taking note or photos of which wire went where. Stow the wires so that they cannot find their way back to the terminals with vibration. When power is applied, it will end at the terminal strip; there will not be power in the wires you just pulled. Descend the TD, unlock and re-energize the VFD house, and stand at the blower motor starters. Have the Driller energize the blowers. Alarms again. If the breaker trips, you have a problem in your 19-pin pigtail. Refer to the previous instruction step in this scenario entitled 19-PIN PIGTAIL ISSUES, and ignore the megger-specific information.

<u>PART 4: DETERMINE WHICH MOTOR CIRCUIT HAS FAILED</u> – If the motor starter breaker does not trip, de-energize VFD / LOTO, ascend the TD and re-terminate the wires into terminals 5, 6, 7, and 8. Descend the TD, unlock and re-energize the VFD house, and stand at the blower motor starters. Have the Driller energize the blowers. Alarms again. If the breaker trips, go to the rig floor and listen to hear which blower motor is running. The blower motor that is not running will need to be replaced, unless you can find obvious damage on its pigtail (the wire between the blower and the J-box).

LOTO VFD and go physically check to verify it is the blower motor and not a blaringly obvious gash in the blower pigtail.

If the motor starter breaker does not trip, de-energize VFD / LOTO, ascend the TD and re-terminate the wires into terminals 9, 10, 11, and 12. Descend the TD, unlock and re-energize the VFD house, and stand at the blower motor starters. Have the Driller energize the blowers. Alarms again. The breaker will trip. Whichever blower is not currently running will need to be replaced, unless you can find obvious damage on its pigtail (the wire between the blower and the J-box). LOTO VFD and go physically check to verify it is the blower motor and not a damaged blower pigtail.

(4) HUMAN AND OTHER FACTORS – First, when feeling the drill motor vents to determine whether blower air is passing through the motor, it is often difficult for an inexperienced person to tell. If a blower is improperly phased, then the motor should be turning backwards and the fan impeller should be sucking air instead of blowing it, right? Well, it certainly doesn't always feel that way. Sometimes it feels like air is escaping from the vents, even if rather weakly. Logical reasoning dictates that one would compare each motor's air displacement against the other. But if both motors are improperly phased, someone might say they feel airflow and that the blowers are working fine. Just food for thought. When the blowers are blowing, you'll feel the positive airflow. Another consideration… is there a screen behind the metal vent? The fine-mesh screens are installed to prevent the gathering / nesting of swarming insects, to keep snow from accumulating in a rigged-down TD, and to mitigate the collection of water in the motor housing when rigged down, which may form ice in colder climes. If you in a cold-weather location or you are operating a newer TD, this is a conversation to have with your company's management. If you are in a

warm weather location and / or you're operating a shit-ass TD, poke a hole in the screen with a screwdriver while the blowers are running. If air starts blasting out through the hole, then woodpecker that sonofabitch with the screwdriver because she's packed off with oily residue inside the motor, and it's choking off your blower's ability to cool the motors. Damn the nesting insects. Remove the screens when your operational time allows; I recommend replacing them with a wider mesh screen (some motor manufacturers are already doing this).

Not everyone is honest. Or smart. If you have good blower air through both blowers, but you have an alarm, your tech might say that you have a bad pressure switch, just to make a sale. See that shit all the time. So trust, but verify. Send your hand up to check the pressure switches with a screwdriver. When the microswitch is engaged, the blower loss lamp should extinguish or HMI alarm should clear. Check both pressure switches (one next to each blower). Instructions are given near the beginning of this scenario (8. BLOWER LOSS (1)). Also, if a novice tech determines that you have good blower air pressure, and then s/he ascends to adjust both pressure switches, your spidey senses should be going off. A simultaneous failure or maladjustment of both pressure switches would be highly irregular. So double check your air pressure / get a second opinion.

(5) ONE WEIRD TIP – I really didn't want to write this, because it brings the naysayers and critics out of the woodworks. About 80% of oilfield electricians strongly disagree with me on this. Conventional electrical theory teaches us that for any three-phase motor, we change the direction of motor rotation by swapping phases. What I'm about to tell you defies that notion, but in my experience so far, this ONLY applies to the TDS-11 blower circuit—but not to ALL TDS-11's. Call me crazy. Here's where you'll apply my theory. (1) You have a

blower loss alarm. (2) It is the general consensus of all who placed their hands outside of the motor vents during operation, that there is good blower air flowing through both motors. Caution tape flags are flying. (3) The blower pressure switches on this TD are new and not suspected to have been damaged or adjusted.

Don't adjust either of the new pressure switches. Instead, find the motor's perfect wiring configuration… six different possibilities for each motor. For some TDS-11's the change isn't significant enough for either yourself or the pressure switch to notice. Perhaps there is no change in such cases (all the smart electricians may now pat themselves on the back for their masterful understanding of 3-phase theory). For other TDS-11's, it will become obvious to you that the phasing makes the difference between reverse, low speed, and high speed.

Don't do this if you're on downtime. As long as you have positive airflow coming out of the vents, you should not experience a motor overheat / overtemperature condition—which is the whole point of having blower air, along with hydraulic oil cooling. If the alarm is bothering the CM / DSM (or you don't want him / her to see the alarm), jump up on the TD with a hammer and a 5/8" wrench, hammer the lids off both of those brand-new pressure switches, and make 1/4-turn adjustments on each one with the wrench counterclockwise. Adjust the DS pressure switch, then the ODS pressure switch, then wait five seconds. Clear alarms. If the alarm continues, adjust DS, adjust ODS, wait five seconds, clear alarms. Repeat this cycle not more than ten 1/4-turn adjustments (2.5 full turns of the 5/8" hex brass adjusting ring). The microswitches should both be fully engaged and the blower loss alarm extinguished, otherwise there's another problem (I/O or program-related, or a break in the circuit [at the switch, or *pressure switch pigtail, 42-pin pigtail, 42-pin composite service loop, or VFD house]).*

Start in the J-box with Blower 1. Remember, these circuits are 600V, so you'll need to have the VFD locked out between tries (easier with 2 radios and someone else at the VFD house. So let's say that the Blower 1 circuit looks like this when you open the J-box, where 'T' is the terminal block and "U / V / W" are the labels on the three wires going to the blower motor:

T5 = U	Ok, cool. LOTO VFD. Now let's swap	T5 = U
T6 = V	the wires at terminals T6 & T7, like this…	T6 = W
T7 = W		T7 = V

Unlock & energize VFD, test blowers. You're listening for one to get louder and blow harder. Didn't work? LOTO VFD.

T5 = V	Try the configuration on the left. Unlock,	T5 = V
T6 = U	energize, and test blowers. Any change?	T6 = W
T7 = W	Ok, no problem. LOTO and try this one…	T7 = U

Unlock, energize, test. No joy? Ok, last Two configurations. LOTO and try the next one (bottom left).

T5 = W	Unlock, energize, test. If that one doesn't	T5 = W
T6 = V	produce some kickass air, LOTO and let's	T6 = U
T7 = U	try this last configuration on the right:	T7 = V

If one of these wiring configurations made an obvious difference in increasing airflow, and the alarm extinguished, great. If one of them made an obvious difference in increasing airflow, but the alarm did not extinguish, then repeat these steps for the other blower, replacing T5, T6, and T7 above with terminals T9, T10, and T11 for illustrative purposes. If none of these configurations made a noticeable change, then LOTO and place the wires in their original configuration.

(6) PIGGYBACKING BLOWERS – If you smoked a blower motor and you've got one on the way, but it's going to take several hours and you've got < 500' to TD, you might be able to continue drilling with precaution. First, check to see if you have newer-style blower shrouds (blower housings / plenums), the kind with an exit hole for debris. Sometimes these are plugged off, other times they just eject air while the blower is running. I always identified these at the Gulf Electroquip upgrades, though I'm not certain that's where they originated. Anyway, if one of your blower motors has failed, hook a hose up to connect the two outlets of both blowers. Now turn on your blowers and see whether you have airflow out of the drill motor vents on the failed blower motor side. If so, drilling may proceed with caution. I would first conduct a lamp test to confirm that your 'drill motor overtemp' light is working properly, and I'd watch it like a hawk. Now let's test the capacity of your cooling air. Set a timer, drill for one minute, cool down for two. If no alarms, drill for five minutes, cool down for ten. If no alarms, I still would continue at a 1:2 drilling-to-resting ratio, not exceeding 5:10. But that is a call for your company to make. Perhaps once, you could push the envelope, full WOB for a minute or two, to try to force the drill motor overtemp alarm so you know it's functioning properly. Follow such a test with a good cool-down period. Just giving some ideas. The goal here is not to burn up one or both $75K drill motors.

If piggybacking is disallowed or not possible, then help chisel the NPT (non-profitable time) by removing the blower while waiting on the new one. To do this, don't remove just the motor and don't remove the whole blower shroud. Instead remove the round plate on top of the fan shroud, the one that the blower motor shaft passes through. Kill auxiliary motor starter blocks, LOTO VFD, open the motor junction, and cut away the motor pigtail wires, leaving as much pigtail as possible for the new motor. To pull the wire through the gland on the side of the junction, loosen the outside nut first, then the middle nut. Once the cable is pulled out, remove the complete gland and reduction bushing (if applicable) from the bad motor, in case you need it on the new motor. You'll be removing the blower and fan together, and when it's on the rig floor, make note of the distance between the fan and the adapter plate. Disconnect the motor from the impeller by removing the (inside) impeller hub bolts, which are part of a self-tightening wedge lock that holds the impeller onto the shaft. Double-check to ensure there are no set screws keeping the impeller assembly connected to the motor shaft. Spray penetrating lubricant around the motor shaft / impeller and let soak in. Then attempt to pry the impeller off the shaft against the plate. If you gotta get stupid with it, don't damage the impeller. Save the screws, wedge plate, and motor key stock in the Doghouse knowledge box, or somewhere memorable OTHER than in the pocket of the Motor hand that's about to go off tour, or else your attempt to minimize downtime was for naught.

9. HYDRAULICS DON'T WORK

(1) DRILL MODE WORKS, BLOWERS WORK, HPU MOTOR RUNNING, NO HYDRAULIC FUNCTIONS—NOT EVEN A WINK – Either the main pump has uncoupled / failed or the HPU is out-of-phase. At a minimum, this failure should be accompanied by an oil pressure loss light or alarm (remember, that's GEAR oil pressure loss, but the gear lube pump's rotation begins with the rotation of the vane pump which piggybacks the HPU's main hydraulic piston pump). If your TDS-11 is outfitted / upgraded with hydraulic pressure and

gear lube pressure gauges, these should both be reading zero in this case. Turn off TD HPU / auxiliaries and remove the access cover of the HPU pump coupling. Is the coupling intact? If not, get a main pump (NOV P/N 109542) and Lovejoy coupling (NOV P/N 112640 for the pump / motor adapter pieces, NOV P/N 110023 for the Lovejoy) on the road. If the coupling is intact, have the Driller turn the HPU back on. The pump should be rotating in a clockwise direction, which means that if you stand under the 10HP HPU electric motor and place your arm straight out in front of you to represent the shaft, your arm should turn clockwise from your vantage point. If the motor / pump rotation is backwards, first check the blowers. If they are running but not blowing air forcefully, then you have multiple components phased backwards (in which case, you should also have a blower loss alarm). If you just changed your 19-pin service loop or pigtail, then LOTO, go into the TD J-Box, and swap either two wires on the right side of T1, T2, and T3 (HPU), as well as T5, T6, and T7 (Blower 1) and T9, T10, and T-11 (Blower 2). The detailed procedure for swapping these wires is found in the previous scenario, which covers blower troubleshooting. If no 19-pin components have been changed out since the last time this TD ran properly, then refer to SCENARIO 1(5).

(2) DRILL MODE WORKS, BLOWERS WORK, HPU MOTOR RUNNING, HYDRAULIC FUNCTIONS WORK, BUT BARELY – Several possibilities here. First, check the 3-position valve switch on the main hydraulic manifold (Rig Up / Run / Shutdown). It should be in ‘run’ mode (handle parallel to long axis of the main manifold). Also, check to make sure that there’s hydraulic oil in the TD. Second possibility, the HPU’s electric motor is single-phasing or experiencing a mechanical failure (bearings etc… not common but the motor’s NOV P/N is 109755-2). If the motor was experiencing any other electrical issue, the motor starter breaker would trip. If

often trips when single phasing, anyway. Third possibility, the supply power to the motor is improper. Check voltage at the bottom of the HPU motor starter block as described for blower motor starter blocks in the last troubleshooting scenario (HPU starter is typically the one with a different part number than the other two / a higher adjustable amp rating, or the block on the left, or the one with 19-pin circuit wires number 1, 2, and 3 coming out of the bottom). You can also check for incoming 600V at the TD J-box, by selecting AC volts (~) and placing your meter leads first on the terminal screws T1 and T2, then on T1 and T3, then on T2 and T3. To keep from holding your meter leads too close together (potential for dangerous arc flash), test the two terminals on opposite screws. For example, when testing T1 and T2, place your black lead on the left-side screw on terminal 1, and your red lead on the right-side screw of terminal 2. Also, for safety purposes I would only recommend checking auxiliary voltages either in the VFD house or inside the J-box, with wires connected at the terminals. Testing for 600V on loose / disconnected / dangling wires is potentially dangerous, as is checking a disconnected 19-pin plug that has voltage passing through it (because there is high potential for arcing against another pin or the plug body / housing). Fourth possibility, the HPU piston pump is failing internally (you would know this if your alarms are working properly, electrical testing reveals no deficiencies, 3-position valve is in 'run' and you have no alarms… or if you have pressure gauges on your TD and the system hydraulic pressure is low but the gear lube pressure is normal—because if the electrical circuit is good, then the pump shaft is turning at the proper speed all the way through the first pump to the vane pump). Fifth possibility—actually more common than possibility 4 and having the same symptoms—your RV1 cartridge is out-of-adjustment. Also not common, but I have seen it happen a few times. In this same family of root cause issues are the following possibilities: #6, the UV1 cartridge has failed and is fully unloading. #7, the three-position valve switch is stuck or has failed, and #8, either the main system accumulator of stand jump / counterbalance accumulator has lost its pre-charge pressure. Let's get a tech heading your way with a nitrogen bottle / test & fill kit, and with an RV1 cartridge (SUN P/N RVCA-LAN or NOV P/N 107031-1AN) and a UV1 cartridge (SUN P/N QCDB-LAN or NOV P/N 107028-1ANB), and a 3-position valve (Parker P/N 8453E6D2P or NOV P/N 30171921). The last possibility I can think of is outlined in #9. With the HPU de-energized / LOTO, take an oil sample from the 1/4-turn ball valve drain. Use an empty water bottle as your sampling container, and when it's at least half full, your sample amount is good. Swirl the oil in the bottle and hold it up to a light source for close visual inspection. It there are visible flakes and particles inside of it, drain the oil from the system. You're now going to order two hydraulic filter elements (NOV P/N 30173216)—one just to throw away—and you're going to use a whole drum of AW32 or 46 hydraulic oil, because you'll be dumping some oil and making two oil changes. And we're about to make a mess. Get a solid hydraulic tech to disconnect components, one at a time, followed by a quick-bump (on and off) actuation of the HPU or specific function. At a minimum, the ports behind RV1, RV2, UV1, PCC, A5, B5, and each direction of all piston circuits (brakes, grabber, stand jump, link tilt, IBOP) will need to be blown out with the first change of oil—add oil as required and attempt to capture expended oil in a waste container—do not re-use (clean the cartridges and orifices with compressed air or WD-40, then shake dry). When the tech is satisfied with the purging of contaminated oil, drain it off into an approved waste container, change the hydraulic filter again to install the second new filter, and refill the TD with ~25 gallons from the new oil drum. Have the tech reset the circuits and unload timing, test the hydraulic pressure, then perform a complete function test of all auxiliary robotics and continue working each function until functionality improves.

Note: if hydraulic fluid drains slowly, open the manual breather on the tank. Not the one with the external breather canister, the smaller 4PSID mechanical one on top of the reservoir that is closest to the goose neck. Be sure to close this after all oil is drained. DO NOT EVER blow compressed air into the drain wye to "loosen shit up." A rig in North Dakota did that, and they heard a pop—exploded one of their tank's suction strainers, and it literally disintegrated into a million little pieces over the course of a week while they continued operating. During that week, they changed out four hydraulic pumps, a lot of hydraulic components, and eventually the whole Top Drive.

10. LOUD TICKING SOUND OR LOUD HYDRAULIC PUMP

(1) If your HPU is really loud, or if you hear a fast ticking or clunking sound coming from the TD when the hydraulics are on even if you're not rotating, then you need to check your hydraulic fluid level and call someone out to check the nitrogen pre-charge of your accumulators. The TDS-11 has three accumulators. From largest to smallest, they are the (1) Stand Jump or Counterbalance Accumulator, (2) Main System Accumulator, and (3) IBOP Time Delay Accumulator. The nitrogen pre-charge for each, in the order listed above, is 900 PSI, 800 PSI, and 800 PSI. The first two are the ones of concern in this instance. Pay close attention when the technician is hooking up the test hose to the accumulator's Schrader valve (standard air fill valve like on a car or non-performance bicycle tire). This valve is located at the bottom the two vertical-mounted accumulators and is protected by a tamper-proof bracket. While the bladder is sometimes dry, in most cases it contains a little oil to extend the life of the bladder, so when hooking up or disconnecting, sometimes a bit

of frothy or foamy yellow oil can be seen collecting at, or dripping from, the test connection. If, however, when the centralized needle of the Schrader valve is depressed, pressurized dry or oily air does not escape, and only light or golden oil escapes under pressure, then the accumulator's bladder has been compromised. Shut down the HPU, place the 3-position valve in "Shutdown" mode for five minutes, and then have the technician check the pressure of the failed accumulator for verification. Disconnect and plug the steel line at the top of the accumulator, cap the fitting on the accumulator, and rig it down with a strap after removing the hex socket / Allen screws from the locking bands. Remove the fitting from the top of the accumulator and replace it with a rag, you might need it (presuming there's not a similar fitting in the parts house or Pusher's shack.

11. INTERMITTENT FUNCTIONS

(1) Any time you experience a fault or failure on the TDS-11 (or any piece of equipment), determine first whether the failure poses an immediate threat to personnel or equipment. If not, try to see if the failure can be replicated. On any Top Drive, the failure may only be experienced at a certain height in the derrick. The TDS-11 is notorious for displaying alarms or 42-pin service loop deficiencies in this manner, perhaps when the TD is 20' or 40' off the rig floor. It doesn't have to just be a 42-pin issue though. If you lose hydraulics or you can audibly detect a blower shutting off at a certain position in the derrick, then there's a 19-pin service loop issue.

(2) Usually, intermittent issues are electrical or ground-related. Could be a loose wire at a terminal inside the J-box, a cross-threaded or improperly-connected plug, a ground wire not tightly connected at the TD, or at the saddle in the derrick, or at the VFD house. Could also be a loose or recessed pin in the

42-pin or 19-pin circuits. If issue persists, shutdown, LOTO VFD, and investigate.

(3) Keep an open mind. If the failure cannot be replicated by derrick position, or by functioning a certain component, then is it operator-related? Does the Driller use a normal sequence, and the failure occurred when an AD or RM took control of the Top Drive and followed a different sequence? What about other equipment that may be affecting the failure, such as drill floor tools, or when energizing the Drawworks or one of the mud pumps? If the failure cannot be replicated and it is determined to pose no immediate threat, then have the operator / Driller remain keyed-in to the possibility of experiencing the failure again. That way, we can learn everything possible about the failure, so as to call it in and report it accurately.

12. ROBOTICS ARE BACKWARDS OR INCORRECT

(1) HYDRAULIC FUNCTIONS ARE WORKING BACKWARDS – If it's the IBOP, and open / close are functioning backwards, did you just rig up? If so, remove the external crank assemblies from each side of the IBOP sleeve and rotate it 180° on the automatic valve. If you didn't just rig up, has someone been working on the Top Drive? Because either the switch contacts in the console are wired backwards, or the hoses running between the RLA and IBOP cylinder need to be swapped.

If the link tilt 'drill' and 'tilt' functions are working backwards, then either the hoses at the RLA need to be swapped for each cylinder, or the contacts on the 3-position switch at the console need to be swapped.

If the stand jump is affected, it can be switch contacts as described above, or cylinder hoses at the prefill valve manifold, or a faulty 3-position valve on the main hydraulic manifold.

If the issue relates to brakes, the issue can only relate to switch contacts. Well wait, that's not true. The ultimate failure issue could be a damaged program in the PLC or SBC, but that would be the three-legged pink unicorn of failures.

(2) HYDRAULIC FUNCTIONS ARE INCORRECT – This section targets those issues wherein the control and the actuator are mismatched. In all of these cases, the failures were human induced. The biggest question is, what was touched before this point? Because you either have hoses swapped around, or wires swapped around, or a multi-conductor plug is clocked wrong. This section DOES NOT cover instances where multiple functions move when only one is actuated (you actuate the IBOP, it closes while simultaneously raising the elevator links… or the IBOP closes and two or three other things start to move also). Those issues are covered in the next topic.

So in this case, you actuate the IBOP and the RLA rotates instead, for example. That one sounds electrical. Let's isolate anyway, between electrical or hydraulic, just to verify. This is done using the SOV's, or solenoid-operated valves (SV's, solenoids, ATOS valves, directional valves… all mean the same thing). THE SOLENOID VALVE IS THE FIRST PLACE TO DETERMINE WHETHER A ROBOTIC ISSUE IS ELECTRICAL OR HYDRAULIC. The SOV's are located on the main manifold. Beginning near the 3-position valve switch, they are (1) Stand Jump, (2) Brakes On, (3) RLA Rotate L / R, (4) IBOP Close, (5) Torque Wrench Clamp / Grabber, (6) Link Tilt Float, and mounted high on the outside of the manifold, (7) Link Tilt Drill / Tilt. All of these SOV's have a manual button on the solenoid portion of the valve. That means that the RLA Rotate and Link Tilt has two buttons, one for each direction, because the valves each have two solenoids attached (one at either end of the valve). I wish I could tell you that the buttons are as responsive as the buttons of an arcade game or ATM machine, but they are not. I find them most effective when you push against them with a screwdriver. Sometimes they jam up and need to be tapped gently with a brass hammer—if you can find one of those in the oilfield. You get the gist. Tap very gently with a shop hammer on the side of the solenoid or on the button itself. Remember that the buttons can be held ‘sucked in’ both electrically and hydraulically. They will almost always return to their extended position by the assistance of an internal spring, when the HPU is powered down, electrical control signals have been removed, and the 3-position valve switch is placed in Shutdown mode. Don’t get wrapped so much around de-actuating them, as simply pushing them in fully to test them. Being mindful of moving parts (know which SOV is which), with the HPU running, let’s figure out why the RLA turns instead of the IBOP when the IBOP is actuated. So we locate the IBOP Close SOV, which is the fourth one over from the rig up / run / shutdown valve switch. We’re gonna push that silver button in. Be careful, the RLA might rotate again. *Push hard, so that the button is flush or slightly recessed inside the solenoid housing… use the lowest amount of force necessary to actuate the IBOP (or RLA if this thing is oddly plumbed). Okay, good. So you pushed the button and the IBOP closed, as it was supposed to. I figured this was an electrical issue, because otherwise someone replaced the form-fitted steel tubes above the RLA with hoses, and then accidentally swapped two between the rotating head hydraulic motor and the RLA inlet for the IBOP close circuit. Let’s open the J-box, grab a meter, select DC volts (dashed line over solid line), place your black lead on the ground bar above, and place your red lead on either of the termination screws of T47. If your J-box is rat-screwed, forget T47 and try whichever terminal has a wire labeled 14 in it. You're looking for 24V whenever the Driller closes his IBOP. If you don't have voltage, but the RLA moves again, then place your red lead on either T43 or T45 (depends on which direction the RLA is moving). Refer to the J-box termination diagram in Chapter 11 of this book. If you are getting voltage to the RLA but not to the IBOP, descend the TD and have a discussion in the Dog House. Did anything change? Did the 42-pin service loop or pigtail get changed before you guys started your hitch this morning? Have the Driller test other functions. Make a list of what's backwards. Referring to the J-box diagram (it's pretty cut & dry), re-wire accordingly. In this case, if you had 24V on T45, remove the inside (left) wire from that terminal and swap it with the inside (left) wire from T47.

13. MULTIPLE HYDRAULIC FUNCTIONS WORKING AT ONCE, WHEN ONLY ONE IS COMMANDED

(1) ELECTRICAL ISSUE – The first possibility in this instance stems from voltage that is crossing from one circuit to another, energizing two different solenoid valves. This could be happening in the J-box, or inside a 42-pin plug or the cable itself. To determine whether this is the case, try the desired function manually by pressing the button on the outside of its respective SOV (see SCENARIO 12 for further details). If, when the button is depressed, the desired actuator functions normally—meaning the previously-noticed (unintended) function fails to move—then the issue is electrical as described above. Check the corresponding terminals inside the junction box, check the 42-pin pigtail where it enters the J-box (wiggle wires around to see if it changes anything), check the grounding bar in the J-box to make sure it is firmly fixed, check the 42-pin service loops and plugs—could be water—make sure to check the back side of the plug. Also, when checking the 42-pin plugs, make sure that the barrel or body of

the plug is not loose, sometimes this happens and twists the wires inside tightly, leaving possibility for cross-wire contact (note, the head of the plug and the barrel are reverse-threaded to each other). Check the wires inside your console or in the Driller's cabin under the seat or under the control panel(s). Lastly, check your VFD house dedicated ground wire, to make sure it is firmly connected.

(2) HYDRAULIC ISSUE – If two robotic functions are working at the same time when only one is actuated, and they are both below the RLA, such as Link-tilt, Grabber / Clamp, or IBOP, then there is a possibility that one or more of the circuit-separating seals in the RLA have been compromised. This can be determined by manually functioning the SOV that was originally desired. If two functions move when one SOV button is pushed, the problem is hydraulic. If this occurs with any hydraulic actuator ABOVE the RLA (brakes, SJ, gear lube hydraulic motor, rotating head hydraulic motor—all very rare for shared hydraulic path occurrence), then you have a wash between two ports… possibly in the main hydraulic manifold. Below is a diagram of the hydraulic circuits below the RLA, where the crossing of hydraulic paths is most likely to occur. The left column is the port designator—an alphanumeric code that is stamped next to the physical ports on the face of the RLA (where the hoses come out) and also stamped next to the stationary ports above the RLA (where the stainless steel hardlines connect). The second column depicts the number of fittings assigned to that port (2 fittings for the 2 hoses that go to the back of the LT cylinders, for example, and one fitting that goes to the back of the IBOP cylinder). The third column describes the function. The fourth column describes the stroke position of the cylinder (if applicable). The dashed lines between each function represent the seals inside the RLA that separate the circuits. See Figure 9.27 in this book for a visual depiction / cutaway of the RLA.

PORT	# of FITTINGS	DESCRIPTION	STROKE
J	1	Spare	N/A
E6	2	LT Tilt / Mousehole	Extend
B8	2	LT Float	N/A
G6	2	LT Drill	Retract
G5	1	Unclamp (Grabber)	Retract
A4	1	IBOP Open	Extend
E5	1	Clamp (Grabber)	Extend
B4	1	IBOP Close	Retract
H	1	Spare	N/A

Okay, so the diagram above will help you troubleshoot this issue further, and it should also help you fix the problem. Let's say you reach up at the console and close your IBOP. The IBOP CLOSED light comes on and then you notice that the TD shifted position. Further investigation reveals that when you close your IBOP, the grabber clamp engages also. The diagram above explains why. The dashed line between those two functions represents the 10" seal that keeps those circuits segregated, and somehow that seal got damaged. So hydraulic fluid under pressure is coming from the IBOP Closed SOV when you actuate the function, and as it fills the circuit ring inside the RLA, it is also bleeding over to pressurize the clamp circuit. To fix this, you will need to change to a spare circuit. You can swap either the IBOP Close circuit or the Clamp circuit, doesn't matter. We'll swap the IBOP Close circuit. Start by finding the steel line that runs from the main hydraulic manifold to port B4 above the RLA. We're going to remove that line and replace it with a hose, because the hard line is form-fitted to land on B4. When you remove the line, put a permanent #8 JIC cap on the B4 fitting. You can get the cap from port H above the RLA, because that's where we'll terminate the new hose. Once that's done, go to the face / main body of the RLA where the hoses come out. Locate port B4. The ports are lined up exactly as depicted in the diagram above, so it will be second from the bottom. Remove the hose from B4. Remove the cap from port H and permanently cap port B4. Re-connect the hose to port H and function test the Top Drive. You have just successfully ran a spare in the RLA, and you have one spare circuit left (port J).

14. LINK TILT FUNCTION DOESN'T WORK

(1) LT FUNCTION DOESN'T WORK AT ALL, IN EITHER DIRECTION—Check your other hydraulic functions to see if they work. If not, refer back to SCENARIO 9. If other hydraulic functions work, then either you lost two separate solenoids, or a section of 42-pin cable or plug is damaged, affecting both circuits. Drill and Tilt are two separate circuits with two separate solenoids that share one valve. So the electrical paths of LT Drill and Tilt are just as different as LT Drill and Brakes On. Personally, I would suspect wire damage over the slightly less-probable instance of two failed solenoids, because the wires for each circuit are physically close together inside the cable. The same applies to the pins in the 42-pin plug connections, they are physically right next to each other. First, verify that the problem is electrical. Press the buttons at each end of the LT SOV, one at a time, and observe the movement of the elevator links in both directions. If they do not move, and they are in the floated position, then it is possible that float is being continuously energized (this also occurs when the LT 'double' solenoid valve is installed backwards, but you would have had a previous problem with

the link tilts that led you to such a conundrum). The only other possibility is possible but highly improbable: internal failure of both LT cylinders. So back to the (likely) electrical issue. If the valve works manually in both directions, start looking for damage to the 42-pin circuit as described above. If you have a multimeter, shut down the TD / VFD and LOTO. Ascend the TD and open the J-box. Select Ohms on your meter (Ω). Test each solenoid on the LT valve as such: first I want you to test the solenoid of something that you know was working, like the IBOP. The reason we're doing this, is that—despite everyone's expert opinion on the Ohm value you should be reading—I've found that the range can be about 65Ω +/- 10Ω, variable depending on ambient temperature I believe. But all the solenoids should have the same reading at any given time within a few Ohms. So by testing the solenoid of a known good function, you'll know what to expect when you're testing the LT solenoids. To test the IBOP solenoid, remove the incoming 42-pin wires on T47 and T48 (the wires on the right side of the terminal blocks). With the wires removed, place the red lead of your meter on left side termination screw of T47. Then place your black lead on the left side termination screw of T48. Whatever value you read (should be 65Ω +/- 10Ω), that's going to be our standard today. Now re-terminate those IBOP wires into their respective terminals, and remove the right-side wires from T51 and T52. With the wires removed, place the red lead of your meter on left side termination screw of T51. Then place your black lead on the left side termination screw of T52. The ohmatic value should be roughly the same as what you read on the IBOP solenoid. If the difference is greater than 10Ω, then the solenoid is bad (greater than 5Ω difference is suspect). Re-terminate the wires back into T51 and T52, and repeat this procedure with T53 and T54. Same go / no-go criteria applies. I suspect that in this case, the solenoids will be good, and that your issue stems from a physical break in the wires or pin connections somewhere (wires 17 & 18 in the 42-pin). I'm curious whether torque wrench / grabber clamp—wires 16 & 16—and / or LT float—wire 19—functionality have also been affected, due to their physical proximity inside the 42-pin composite cable and plug connections. To verify that a break in the circuit exists, power up the TD and select DC volts on your meter. With all wires re-terminated, place your black meter lead on the grounding bar above and place your red meter lead on T51. Have driller extend / tilt the links. If the circuit is not broken, you should read 24V. Now test the drill or drill-down function with your red lead on T53. If no voltage on either, go find your broken wires. Also check your I/O, you might have bad Wago card(s), or a burned resistor inside your Siemens digital I/O module (PLC-style driller's console), or Siemens slot card (PLC-style VFD house). FYI, the NOV P/N for a 3-position ("double") solenoid valve is 127908-J2. If you are not getting 24V to either or both directional functions of the Link Tilt when actuated at the controls, and you cannot find a 'smoking gun' wire or pin deficiency, try running 42-pin spare(s). The ideology and instruction behind running a spare is described in the last paragraph of SCENARIO 3C, in an encoder spare example. The encoder has different spares than the rest of the 42-pin. Always refer to the electrical schematics in the TDS-11 Technical Drawing Package, or to Figure 11.20 or Figure 11.21—as applies to your type of rig—when running a spare.

(2) LT ONLY WORKS IN ONE DIRECTION—It can be a pin or wire in the 42-pin, a bad I/O component, or bad solenoid. Leaning toward a bad solenoid in this case. See the previous instructions for testing.

(3) LT FUNCTION WORKS BOTH WAYS, BUT IT IS SLOW OR SLUGGISH—Make sure the 3-position valve on the main manifold is in the "Run" position (handle parallel to long axis of manifold). If that is not the case, check other robotic

functions. Check pressure at port P on the main manifold, should be cycling between about 1,500 and 2,000 (2,200 PSI setting + unloading relief). Check fluid level. Re-set circuits of UV1 & RV1 as such: (1) Turn off the HPU. (2) Locate RV1 on back of main manifold. You'll need to remove your hard hat and tuck yourself under the TD near the HPU to locate it. Break the adjusting screw's jamb nut with a 9/16" wrench. Then use a 5/32" Allen wrench to back the valve out fully counterclockwise. (3) Find the UV1 cartridge on the end of the main manifold. It's easier to locate by looking at the main manifold drawings in the TDS-11 Technical Drawing Package. Break the 9/16" jamb nut on UV1 and dial the adjusting screw in (clockwise) fully using a 5/32" Allen wrench. (4) Energize the HPU. With a 3,000 PSI pressure gauge tied in to port P, monitor the gauge while adjusting RV1 clockwise. Nothing will happen for the first few turns. Eventually, the pressure will rise from 100 PSI… you're going to adjust it to 2,200 PSI, then set the jamb nut. (5) At UV1, dial the adjustment screw out CCW until there is an obvious cycling of the hydraulics. It may be very loud with a rapid ticking at first, with steel line vibration that is unnerving to work around at high pressure. This is normal. Continue turning counterclockwise for approximately two turns, until the cycle time is about 20 seconds or greater. On some Top Drives, you will not get continuous cycle time better than 11 seconds. (6) Shut down the HPU. Bleed pressure back to tank by placing the 3-position valve into Shutdown mode for a few minutes, then fire up the HPU again and check cycle time. If it is off, you may need to dial UV1 all the way in again to reset it. Once desired cycle time is achieved, set the jamb nut on UV1, being careful not to turn the adjusting screw while tightening. Lastly, if this is not working, test the main accumulator and stand-jump / counterbalance accumulator pre-charge pressures.

(4) LT FUNCTIONS BUT WILL NOT HOLD LOAD / DROPS

OFF – Could be failed cylinder(s) or load holding valves. If the cylinders have both failed internally, you will not see an external leak. Instead, the piston seals have been compromised and fluid flows with relative ease from one side of the cylinder to the other. To test a cylinder, extend it all the way out. Then disconnect the hose that is closest to the exposed rod-end of the cylinder; plug the hose but leave the cylinder port open. Then try to actuate the 'extend' function of the cylinder again. If oil comes pouring or spraying out, then the piston has failed and the hydraulic cylinder must be replaced. Even if a seal kit is available, do not attempt to rebuild a cylinder in the field except in remote area emergencies. The more common reason that the LT function will not hold load, relates less to the simultaneous failure of both cylinders (one would have likely failed first, and the crew should have noticed a lagging or 'limp' elevator link before the other cylinder failed), than to the load-holding counterbalance valves in the LT manifold. The LT manifold is mounted to the RLA housing just above the Pipe Handler's torque tube. On top are two 'pilot-to-open check valve' cartridges (cartridge-style check valves look like bolt heads or hydraulic plugs, as they are non-adjustable)(SUN P/N CKCB-XCN or NOV P/N 93547-1B30N), and on the right side of the manifold—as viewed squarely when looking at the TD—are two adjustable counterbalance cartridge valves (SUN P/N CBCA-LHN or NOV P/N 94518-13HN). It's the latter two that are prone to failure, but get all four coming. You can first try to adjust the valves… whatever you do to one, do to the other as well. All hydraulic cylinder counterbalance valves work opposite to standard pressure relief or pressure-reducing valves. For counterbalance valves, dial the adjusting screw counterclockwise to increase load-holding capacity. So if you dial both cartridges all the way to the left and they still won't hold the load, then they're bad—UNLESS the LT Float circuit is being continuously energized (operator button or contact stuck, for example. Test this by checking to see if you have

24VDC on T55 in the J-box. If you do have voltage, float is energized, and the elevator links will not hold load). More common is the failure of CB cartridge valves. The cartridges, I believe, are usually plug & play, meaning that you don't need to adjust them if they're new. Remove with a 7/8" end wrench or deep-well socket. Do not use an impact wrench to remove or install cartridge valves. If installing new ones does nothing to improve your situation, turn both valves' adjusting screws fully clockwise, then CCW one-and-a-half turns. If the links still bleed down, adjust both valves CCW another half turn and extend elevators again. The bleed-off should have stopped or at least slowed. Adjust accordingly until both valves are equally adjusted to hold the load without gravity retraction of bails / links.

ONE ADDITIONAL NOTE: This one is an anomaly, but in ten years I have seen it happen on three different rigs with TDS-11's belonging to different companies. It baffles everyone. If, using the troubleshooting steps above, you've determined that the LT counterbalance valves are culprit, then when you remove them, clean the hex faces to identify the 7-letter SUN designator (P/N). They should read CBCA-LHN. IF THEY DO NOT, then you may need to special order the exact same valves that you removed, from whichever SUN hydraulics distributor in the world can produce them the fastest. Spare yourself the additional two or three days of downtime and trust me on this one. Here's what it looks like in reality: Your technician will tell you to order two CBCA-LHN's. You'll get them, replace them, and they do nothing. So then you'll replace the check valves. Still nothing. You'll call out another tech, and the two techs will start replacing shit—first the LT SOV, then the Float SOV, then the LT cylinders. Your Superintendent will be pissed, your Ops Manager will be pissed, and you'll eventually be on a conference call with the engineers at NOV who swear that

CBCA-LHN is correct. 3 NOV techs will deploy to your location and they'll change all the same shit that your original techs did. Then they'll say you have a wash—even though it will never be proven—either in your LT manifold or your main hydraulic manifold. Heaven forbid they talk you into replacing your main hydraulic manifold ($25K dressed, + 12 hours). *It is possible that replacing the smaller LT manifold will work*. The SUN engineering team, and anyone that can read, will be convinced that CBCA-LHN will work, because when comparing it to the original cartridges that you pulled out, they'll find that the cartridge is identical except that it is special-made and not readily available, and that CBCA-LHN simply has a broader pressure range and is therefore the correct replacement. You will avoid all this headache by simply finding new valves with the original part number, damn all the smarty-pants engineers and techs and people with big titles. I promise. Order extra valves and spread the knowledge so that this doesn't happen again.

(5) LT WILL NOT FLOAT – Try it manually at the SOV. If that works, then you either have a bad float solenoid, or a broken / disengaged wire or pin connection in the circuit (42-pin, TD J-box, Driller's console, VFD house). Faulty I/O is also possible, less probable. Check terminal 55 in the J-box for 24V when float is selected. If the voltage is there, replace the solenoid. You can verify that the solenoid is bad by checking Ohms on T55 and T56, following the steps outlined in SCENARIO 14(1). 2-position ("single") solenoid valve NOV P/N is 127908-D2.

(6) LT CYLINDER KEEPS FAILING—If you have one LT cylinder that has been changed two or more times in a short span of operation, then replace both cylinders. The reason for failure is likely related to the OPPOSITE cylinder, which has failed internally—at least enough that it is placing the bulk

elevator load on the cylinder that keeps displaying obvious damage. You see, when a cylinder fails, it is twice as likely to do so in a way that it is noticeable—that is, accompanied by a visible leak from the rod seal. So when you installed the replacement cylinder to replace an obvious failure, the new cylinder was holding the majority of load because the other (unsuspected) cylinder had the rarer form of internal failure. The new cylinder failed again, in the more common way, with an obvious discharge of oil from the front seal again. This one often baffles all and is very frustrating. Replace both cylinders, make sure your link brackets are equally spaced, and you'll be good.

15. IBOP DOESN'T WORK

(1) THE FUNCTION WORKS BACKWARDS—Remove the external crank assemblies (outside mechanical actuators that open / close the internal valve as the actuator sleeve is moved), and rotate the actuator sleeve 180°.

(2) IBOP FAILS TEST / FAILS TO FULLY CLOSE VALVE—Carefully inspect the IBOP cylinder, yoke, and external crank assemblies. If no obvious deficiencies, replace the IBOP & have the valve rebuilt. The busiest / most popular place to do this in the drilling industry (all subs) is Fishing Tool Crystin, Odessa TX.

(3) IBOP FAILS TO OPEN—Remove the hoses from the IBOP cylinder. With someone holding the hoses tightly over a bucket, bump test (quickly on-and-off) both IBOP Close and IBOP Open. Each line should have sprayed fluid when actuated. If so, replace IBOP cylinder. If not, locate CV4 and B4 on the main hydraulic manifold (use the TDS-11 Technical Drawing Package to locate). Remove, clean, and replace both. If no joy, order both parts and get them heading to the rig

(Directional Flow Control Valve: The Lee Company P/N FCFA2810800D or NOV P/N 98402-800D; CV4 Pilot-to-Open Check Valve: SUN P/N CODA-XCN or NOV P/N 94537-130N).

(4) IBOP FAILS TO CLOSE—Manually test the IBOP Close solenoid at its button. If this closes the IBOP, then you have pushed, burned, or disconnected male or female pin in one of the 42-pin plug connections (pin 17), or a broken, burned, or otherwise disconnected wire in the 42-pin service loop / pigtail (wire 14), or a burned terminal block in the J-box, or bad I/O card in the Driller's console or VFD house, or a bad solenoid valve (NOV P/N 127908-D2). You can verify that the solenoid is bad by checking Ohms on T47 and T48, following the steps outlined in SCENARIO 14(1) for the Link-tilt circuit (you must translate slightly, as the IBOP circuit uses only T47 and T48). If the solenoid tests fine, you can verify that one of the other electrical deficiencies exists by verifying no incoming voltage on T47. During normal operation with no problems, you should see 24VDC. If you do not see 24V when actuated from the controls, try running a 42-pin spare. The ideology and instruction behind running a spare is described in the last paragraph of SCENARIO 3C, in an encoder spare example. The encoder has different spares than the rest of the 42-pin. Always refer to the electrical schematics in the TDS-11 Technical Drawing Package, or to Figure 11.20 or Figure 11.21—as applies to your type of rig—when running a spare.

16. BRAKE ISSUES

(1) FAILED BRAKE CAPACITY TEST—If the brakes are applying but not holding at least 20K ft-lbs of torque, simply clean your braking components. Use at least one full can of brake cleaner or electrical cleaner on the brake pads and rotor (top and bottom) for each motor (curved access panels under

the blower… remove the two bolts on one side of a panel and just loosen the two bolts on the other side… the access panel / plate will usually just slide out). I would tell you to LOTO, but this is best accomplished by cleaning / rotating / cleaning / rotating / cleaning. Before the Driller rotates the quill each time—at the LOWEST RPM possible—ensure that you are far from the open access panel. Remember that the drill motor-to-quill speed ration is 10.5:1, so if the Driller is rotating at 5 RPM, the brake rotor is turning at just over 50 RPM. You don't want to get loose clothing, or a tool, or a lanyard, or long hair caught in that. Thoroughly cleaning the braking surfaces will usually improve your brake capacity test by 50 to 100%. Note: the best test I've seen on the TDS-11 was 41,000 ft-lbs of torque; most will start to slip at or below 32K, so I recommend only testing to 25K. If having issues at lower torque, swap the makeup & drill torque pots. If same issues follow, ensure pressure at port P1 on main manifold is 1,500 PSI when brakes are engaged. If not, adjust cartridge valve PC1 to 1,500 PSI with brakes on. If valve does not adjust (9/16" jamb nut and 5/36" Allen adjustment screw), remove the cartridge valve with a 7/8" deep-well socket, clean and re-install to attempt again. If still not adjusting, replace valve (SUN P/N PRDB-LAN or NOV P/N 109858-1AN).

(2) BRAKES REMAIN ENGAGED – One of the following has happened: (A) The contacts at the controls are sticking, (B) a brake pad has disconnected from its epoxied seat on its metal backer plate and become wedged under the opposite caliper's brake pad, (C) the 'brakes on' circuit has been energized through another circuit (see SCENARIO 13), or (D) one of the drill motors has dropped a shaft (See SCENARIO 3C).

(3) BRAKES ARE NOT ENGAGING – Ascend the TD and remove the outside curved panels above each drill motor. Observe the braking action as brakes are cycled on and off in

ten second increments. Look for brake line leaks, which will usually be discovered first as droplets escaping from the drill motor vents. If the brakes are moving, look at the thickness of the brake pads and compare them to the top / bottom / opposite caliper and opposite motor's brake pads. Sometimes the pads fall off over time and heavy use (directional drilling), which may be the case.

Sometimes the brake areas are filled with grease, due to over-greasing of the drill motor bearings (these grease channels are closed-circuit, meaning that both the entrance and exit ports are either plugged off, or the exit port is plugged off, or the exit has a popoff that is sealed shut. If grease fittings are exposed and one of the green hands performs TD service without being taught not to grease the motor bearings—except per service guidelines using Chevron EP2 Black Pearl grease only—then the bearings will be over-greased. With no escape path, the grease ejects the oil seals into the motor, and the braking surfaces will eventually be covered in grease, sometimes so badly that they provide very little braking action.

If the brakes are not moving when actuated, then have someone manually actuate the Brakes On solenoid while observing the brakes. If they move, then an electrical issue exists. Check terminal 41 in the J-box when brakes are actuated to see if 24V is making its way to the solenoid. If voltage is not arriving at the J-Box and no other functions are affected, then run a spare in the 42-pin. Remove the inside wires from terminals 41 and 42 in the J-box, and move them to any open terminal between T35 and T39 that has corresponding wires on the other side. Note the wire numbers of the new 42-pin wires you're using. Then in the VFD house, do the same thing. Remove the top side or I/O side wires from the terminals which hold 42-pin wires 10 and 11 on the opposite sides. Replace the I/O side wires in the empty terminals that are across from the new 42-

pin wires you're using in the J-box (as above, so below). If the solenoid is suspect, test it using the procedures outlined in SCENARIO 14(1), to test the brake solenoid at T41 and T42.

17. RLA FUNCTIONAL ISSUES

(1) DOESN'T WORK IN EITHER DIRECTION—Was this the result of an RLA backspin? If so, your rotating head hydraulic motor is shot. The hydraulic motor is mounted on the shot pin assembly, on the front ODS corner of the TDS-11. It is easiest to change with the shot pin assembly removed. Remove all steel hard lines going to the assembly. Choke a strap around the shot pin assembly to secure it, and attach a hoist that is run under the guard (the protective cage that surrounds the TD). Get the strap snugged up by the hoist. Remove the four bolts that secure the shot pin assembly to the bottom of the main body / gearbox. Slide the assembly out off the RLA gear and lower it to the rig floor. Remove the bolts that connect the rotating head hydraulic motor to the shot pin assembly. Install the new motor (note: there are two different types of motors… send photos of yours when ordering a new one—NOV P/N 114375 is most common). Installation is in reverse; be sure to run the hoist through the guard rail again when picking it up, or get it to where you can hold it in place and then have someone disconnect and re-route the hoist behind the guard to reconnect the strap.

Other possibilities for this scenario are the same for any electrically-actuated hydraulic / robotic function on the TD. Like the Link-Tilt SOV, this one is another 'double' solenoid. Two separate solenoids attached to a single valve, and therefore two completely separate electrical circuits. The same logical deduction and troubleshooting applies here as to the Link Tilt circuit in SCENARIO 14(1) and (2). The RLA Rotate SOV's are tested through terminals 43 and 44 for RLA *rotate right*, and 45 & 46 for RLA *rotate left*.

(2) ONLY WORKS IN ONE DIRECTION—See last paragraph. This issue will likely be electrical, but just to make sure, try to manually actuate both sides of the SOV. If it still doesn't rotate in one direction, LOTO and relieve the TD hydraulic pressure by placing the main manifold's 3-position valve in shutdown. Go to the rotating head hydraulic motor on the Shot Pin assembly at the front ODS corner of the TD. Mounted to the hydraulic motor is a valve block with two adjustable cartridge valves (both are NOV P/N 94520-1AN). Remove the valves with a 7/8" wrench and swap them. If the RLA now rotates only in the opposite direction, you found your problem. Shut down again, relieve pressure, and inspect the valves. Get one ordered and swap it with one. If same issue, swap it with the other (or trace the circuits to see which one is for which direction… or just replace both). Back to the more likely electrical issue. Refer back to the last troubleshooting step (last paragraph). Start looking to find the break or test the solenoid for the direction that isn't working. Note: all single SOV's on the TDS-11 have the same part number. Likewise, the double SOV's of the LT and RLA Rotate circuits both have the same NOV P/N: 127908-J2.

(3) ROTATES PARTIALLY, STOPS AT THE SAME POINT IN EITHER DIRECTION—There is a plate on the bottom of the shot pin assembly, which has a ~2" hole in the middle that aligns with the shot pin boss. The plate is held in place by four safety-wired 1/4" hex screws (7/16" heads). IF you experienced a board strike, a crown out, or dropped blocks that caused the elevators to slam into the floor, then there is a possibility that the RLA has become cockeyed, because either the stem has bent internally or the bail / link ears have become damaged. Twice, I've experienced this on drilling rigs from different companies where a post-catastrophic NDE or NDI/T

(MPI—Magnetic Particle Inspection) were performed on critical load-bearing parts. The load path items passed the test in both cases, and in both cases, the RLA would get hung up on those small plate bolts and come to a stop. In both cases, I shaved down the bolt heads ~1/16" to allow crossover, and I recommended sending in the TD for teardown and closer inspection. One of those rigs two weeks later had another catastrophic event, and half of the bolts above the RLA gear sheared. It went into the shop and everything below the gearbox was replaced due to misalignment. Case in point, an MPI will not reveal all of the damage incurred by your TD unit, nor the potential dangers that are impending. If your RLA is hanging up mechanically, then you need to investigate carefully into the prior occurrence of board strike or some other catastrophic incident. And I wouldn't keep running on the TD. On TDS-11 rigs, I've known of quills shearing and falling from the TD with 200K drill string attached, complete Pipe Handlers falling off, carriages & bogey roller assemblies falling off, and tracks dropping to the floor after snagging and twisting off the dog bone at the perforated eyes. Take RLA mechanical hang-up very seriously, you don't want that kind of liability 90' overhead.

(4) RLA TRIES TO ROTATE, BUT IN A BIND—Check to see if your shot pin is still engaged. It is likely not retracting back through an RLA gear hole. If you need to move it one time just to get out of a bind, LOTO the TD/ VFD, dump system pressure by placing the 3-position valve at the main manifold in Shutdown mode, disconnect the steel lines going into the shot pin assembly (not to the motor valve block on the shot pin assembly), then using a broomstick or 5-foot bar, push up on the pin and manually rotate the RLA. You'll need to push the pin up hole-by-hole to get to your desired position. To troubleshoot the issue, there are two possibilities. In rare cases where they are no leaks accompanying the failure, this will

likely be circuit-related. There are three relief valves on the Shot Pin assembly: two are on the rotating head hydraulic motor valve block, and one is on the shot pin housing. Turn this relief valve clockwise to see if it allows the shot pin to lift when RLA rotate is actuated. If not, then replace the cartridge valve (NOV P/N 94522-1EN). In most cases, this failure is accompanied by a leak. You will need to remove the Shot Pin assembly and replace the seals (NOV P/N's 51300-226-B, 110056, 110061, 53500-225, 30154362, 51300-277-B, and you may need to order a brass sleeve in case it is scratched up. I'm seeing two different part numbers—118563 and 30151951—ask NOV to explain the difference because I'm not sure; may just be an old number / new number disparity). It may take ten minutes to figure out how to remove the pin, but stay curious and you'll get it. Inspect the seals and you'll find your wash.

(5) KEEPS ROTATING DURING MAKE / BREAK FUNCTION; DOESN'T FIND HOLE—See SCENARIO 19: TORQUE WRENCH CLAMP ISSUES.

18. RLA SQUIRTING OR LEAKING

(1) RLA SQUIRTS FROM GREASE RELIEF / TATTLETALE—This symptom does not have a definitive answer. I haven't seen it in a while, but there were a few Patterson rigs, a Pioneer rig, and a PaceSetter rig that used to do this. The RLA has two pass-through grease ports, one high and one low. On the front side of the RLA, where the NOV or Varco embossed markings are, is where the grease fittings are located. On the opposite side, you can find the relief fitting(s). Older models don't have a lower exit / relief port, instead, the excess grease exits through the bottom of the RLA. Doesn't seem like it should do that but most of them do when over-greased, and it seems to have no bearing on the operation or failure of the RLA. The upper grease port is a different story. In theory, the relief

fittings allow you to pump each plenum full of grease without over-pressurizing and pushing against the hydraulic seals. What I've discovered though, is that the electro-galvanized coating of the inner stem often gets damaged and chips away from the hard edge where the ring is heated on to retain the RLA gear. Shop techs / mechanics don't heat the ring enough, and so they try to beat it over the lip and into its seat. The 'chrome'-looking electrogalvanized coating then chips along the edge of the lip. When the RLA is in use, the chipping continues, wearing away the edge and producing needles of chrome-like plating. For whatever reason, those needles like to gravitate toward the upper grease tattletale, packing it off. My theory is that then, when the RLA is greased again, it puts just enough pressure on the upper 10" hydraulic seal to unseat it partially, at which point hydraulic fluid is able to enter the grease plenum. It doesn't exit the grease zerk at the front of the RLA, because the ball at the tip of the fitting acts like a check valve. Instead, whenever the HPU is energized, the upper lift circuit picks up the RLA off the load collar and the RLA will squirt hydraulic oil from the relief port. The lift circuit is integral to the RLA and is not something we typically troubleshoot. It has an upper RLA entrance (port L) but none below. In the cases I've noted, the squirting is a slow countdown to RLA failure. Crews have, admittedly under my recommendation, cleaned the tattletale and continued to pack the plenum with grease, which provides up to a day's relief under drilling conditions and maybe three hours' relief while tripping—before it randomly squirts again when the hydraulic system's automatic unloading function cycles. This practice should discontinue if there is no grease coming out of the tattletale, or else the grease can be going nowhere but into the hydraulic system, contaminating the oil. Plugging off the tattletale will remove the symptoms and make the CM happy, but who knows what damage it is doing in the hydraulic system and the RLA. NOV has not been helpful in assessing this problem. If your RLA squirts oil, my recommendation is to try to make it through the well, and plan on having the RLA re-sealed during rig move. Make sure to tell whoever is rebuilding it, that you also want new grease zerks and tattletale(s).

(2) RLA LEAKS FROM THE BOTTOM—This one is tricky to get around, so pay attention. You've only got one shot at possibly fixing this without rigging down the RLA, which can be a pain in the dick depending on the availability of well-designed RLA stand, the availability of a sharp tech (or two) who really knows what they're doing, and of course the other suck factors depending on current state of operations, weather, and crew morale. Hopefully the stars will align for you. You are going to have to quickly study the simple RLA diagram in SCENARIO 13(2). Check to see if your RLA is currently plumbed in a way that either of the two spare ports are in use. If so, which function is using the spare port(s)? Start making notes of your observations. Ok, for instructional purposes, we're going to assume that your TD still has both spare ports (J a the top, H at the bottom). In that case, here's what we know (refer to the diagram as you read this… when I say 'seal' I'm talking about the dashed lines between the circuits). We know that the lowest hydraulic seal has failed. That's how we are seeing oil exit the RLA. We also know that the bottom two seals should contain no oil between them, because the bottom circuit is Spare Circuit H, which is capped off at both the upper (above the RLA gear) and lower (outside face of the RLA main body) ports. So this means that the seal between IBOP Close and Circuit H has also been compromised. What we're hoping, is that there are no other compromised circuit seals in the RLA except for these bottom two. If you haven't done so already, have someone start trying to locate an RLA and an RLA stand, and get them headed this way. Also order an RLA seal kit (NOV P/N 587915)—and make sure it comes with the lower

oil seal. The kit costs $4,500, but there's a good chance you can use it instead of buying the new RLA.

In the meantime, you're going to try to fix this. You'll need a 1/2" hose about 5' long, with #8 JIC females at each end. With the TD / VFD LOTO, release the hydraulic system pressure by placing the 3-position valve in Shutdown mode. Wait until you hear the 'hissing' sound stop… five minutes is safe. Now climb above the RLA gear and see if you can locate port BH. You see where all those steel lines connect to the stationary part of the RLA? It will be in that row somewhere. To the side of each fitting is a stamped circle with a letter designator at the center. You're looking for BH. Then you'll need to find port J and remove its cap. Remove the steel line from port BH and place the cap there. Tighten it. Remove the steel line from the main hydraulic manifold and replace it with the hose. Don't tighten it completely. Now attach the running end of that hose to the open port J and tighten it. Tighten the other end of the hose that you just attached to the main manifold. Make sure the steel line is completely removed or secured with zip ties for temporary operation (in the event you can't remove it without removing a bunch of other steel lines). Zip tie any excess slack in your hose so that it can't be contacted by the RLA gear when it rotates. Down on the face of the RLA, remove the hose from port BH. Remove the cap from port J and place it on port BH's fitting. Tighten it. Attach the hose to port J and tighten it. Place the 3-position valve handle back into the Run position on the main manifold. Unlock and energize the TD hydraulics. Is oil pouring from the bottom of the RLA? If not, then close the IBOP and see if oil starts pouring. Also see if there are any cross-functions that would indicate the failure of more seals. If there are none, congratulations, you fixed it! Keep the RLA and RLA stand on site, release your tech(s) and tell them to remain ready to respond if another seal fails (or retain them on location if you're close to TD). Get through the well and swap the RLA on your time, not on downtime. In all likelihood, you won't need a spare RLA, just a new seal kit… but I'd keep the RLA around anyway because I've seen some weird circumstances where the rings inside of the RLA were folded down from pressure, in which case, new seals won't help you.

If the attempt failed to fix the RLA leak, it's nothing you did wrong, just circumstantial. Bravo Zulu anyway for being Johnny-on-the-spot. Go ahead and hold a JSA / JRA / safety conversation about rigging down the Pipe Handler, which is the first step in removing the RLA and it doesn't require a lot of expert technical advice. Just mark your hoses with their fittings and save all pins and keepers and hardware in a clean bucket. Once it's off, clean the rig floor to clear a path for the RLA and the RLA stand. If your company would like a sharp RLA stand, with a few weeks' notice you can order one from Magic Industries or there's a place in northeast PA called FaberFab. I liked the FaberFab one because my team gave them the design we wanted and they built several for us to spec, made to set into the Rotary Table, telescoping from a wide base and having jack bolts at each corner. Many RLA stands are hokey and questionable from a safety standpoint, and there is no manufacturing standard that I'm aware of.

(3) RLA LEAKS FROM THE TOP, JUST UNDER THE BULL GEAR, BETWEEN THE GEAR AND THE MAIN BODY OF THE RLA—You have so got this. You'll need superglue (old-school superglue, the cheap kind that burns your nostrils and sticks skin together instantly), brake cleaner, some rags, and about four hours… probably less time than it takes to get a new RLA to your location. Get one coming anyway, or at least a seal kit—it's always cheaper to turn them around than to eat downtime. An O-ring making kit (not an O-ring kit) would be awesome but probably not required—EPDM, Viton or Buna-N

material—doesn't make a crap either way. LOTO the TD / VFD house, and bleed off the hydraulic pressure by placing the 3-position valve switch into Shutdown mode for five minutes. I like to move the valve handle back and forth between Rig-up and Shutdown to make sure audibly that all air has relaxed from the accumulators. Next, remove the TD guard… that's the metal cage of ~3" pipe that protects the Top Drive and gets in our way for this job. And have somebody scrounge up some wood blocks for cribbing (short 2x4 or and/or 4x4 pieces would be great).

Underneath the bull gear is the wide, flat, machined top surface of the RLA's main body. There's a groove cut in the top that goes all the way around, where a thick O-ring sits. What you need to do (and this is the most tedious part), is mark and remove all those steel lines above the RLA. Then, you'll need to make a note of the open fittings at the top of the RLA—the ones you disconnected the steel lines from—so you know whether they are straight fittings, or 45° fittings, or 90° fittings, and what angle they are pointing when tightened. Once that's done, remove them all. Next, you'll need to cut away all the safety wire from the big bolts on the RLA gear. DO NOT mess with the bolts above, the ones that mount the RLA to the bottom of the gearbox. We just want to remove the ones from the top of the gear. We can rotate the gear manually with a 5' bar propped through the one of the ears that the elevator links hang from, to make bolt removal easier. Once the bolts are removed, you'll need to locate the dowel pin(s) that are keeping the RLA gear attached to the top of the RLA. It's been so long since I've done this, I can't remember if there are one or two... I think it's just one. Anyway, locate the dowel(s) and see if there are any jack holes… I don't think there are. Hammer up on the gear in that vicinity to separate the gear from the RLA body. Resist the urge to pry, as we don't want to scar or otherwise damage the machined surface of the top of the RLA body. Once the gear is loose, we need to prop it up on each side, or at three points if possible, without getting in the way of that O-ring you're about to remove (and without leaving debris behind). That's where those blocks of wood might come in handy.

Now, use a short screwdriver to gently dig the O-ring out of its groove. Looky there, you found the problem. The O-ring was pinched or severed. If only pinched, then rotate the O-ring around to check for other damage points. If the pinched point is the worst of it, cut the O-ring about 2" away from the pinched section, as clean and perpendicular of a cut as possible. Use a razor blade, if available. Remove the O-ring. If already severed, great, just remove it. Spray out the groove and machined surface with brake cleaner, and then spray your fingers and the O-ring so that everything is clean. See if you can figure out how to fit the O-ring back together, but don't glue it just yet. *This next part only applies to an O-ring that was pinched, not severed. Do not glue a severed O-ring until it is back in the groove on the TD.*

If it was pinched, you're going to have to check in your parts house to see if you have any O-rings that are made of the same diameter material. Since you already cut 2" outside the the pinched section out of the O-ring with as much perpendicular precision as possible, do make another perfect-as-possible straight cut about 2" on the other side of the damage. Now take your small, cutout (pinched) section, and use your spare O-ring to cut a piece the exact same length, give or take 1/16." Clean it with brake cleaner. On a clean surface, lay the large O-ring down and set the small section inside of it, so that they follow the same curvature. Go ahead and dry-practice putting one end together only. If you feel confident that you can assemble the two without a seam, place a dab of superglue on one end and then firmly but gently put the two pieces together.

You should be pinching each side no more than an inch apart, holding them together carefully and with a little pressure, for about 30 seconds. If a drip develops after you put the two pieces together, gently wipe the seam against something solid to remove it, or have someone help remove it quickly with a clean rag while you're holding the pieces together. After 30 seconds, gently release one side and inspect all the way around the joint to ensure that there is no exposed seam, Using a razor or sharp knife, gently scrape away any excess glue or O-ring edge, so that this has the look and feel of a singular piece (as much as possible). DO NOT superglue the other side, we still need this big O-ring to be severed so we can install it the way we took it off, without having to remove the RLA. Once you are satisfied with your first glued segment, perform a dry run on attaching the last two ends together. If you are confident they'll go together without a seam, continue to the next paragraph… otherwise carefully slice an end so that they fit together better—saving as much rubber as possible.

Last step. Whether you removed a severed or pinched O-ring from the TD originally, you are now ready to re-install a clean, dry O-ring into a clean, dry groove on top of the RLA's main body. Wrap the O-ring around the RLA so that it rests in the groove. Then, holding the ends (ideally with needle-nose pliers), place a dab of superglue on one end and quickly but deliberately put the two ends together. Hold for 30 seconds and dab or wipe any forming drips against the edge of the groove while holding the O-ring ends together. After 30 seconds, slowly ease your grip and pull gently to test the set. Feel around the attachment point and clean up the joint to remove excess hardened glue or raised O-ring edge with a razor, gently. Finally, spray the area down one more time, remove the wedges with a second person's assistance (ensuring no debris was left behind), and set the RLA back onto its alignment dowels. Installation is in reverse of disassembly. If your work was clean and careful, be confident in the fact that you'll have no further leaks, and that this—believe it or not—will get you through a well with no problems. I've done this four or five times, and at least two were permanent fixes that never got changed until the next overhaul.

(4) UNKNOWN LEAK COMING FROM ABOVE THE RLA—This commonly reported issue often has nothing to do with the RLA. Sure, sometimes it's a loose fitting above the RLA. But often, it stems from one of three places: (A) loose brake lines, busted caliper diaphragms, or cracked hydraulic heat exchanger, all of which are found above the drill motors, behind the removable curved panels of the two blower shrouds. The blower sucks up the leaking oil, passes it through the drill motor, and spits it out through the vents at the bottom of the drill motor. Usually you'll notice a slick area under the vent(s), or oil droplets covering the rig floor. If the leak is significant enough, it will exit the motor vents (and also pool inside the bottom of the motor housing), run under the gearbox, and collect as a pool on top of the RLA gear. (B) When the TDS-11 is overfilled with hydraulic fluid, it dumps from the manual breather, funs down the sides of the reservoir following the path of least resistance, runs down the back of the TD, and under the gearbox where it collects as a pool on the RLA gear. When oil pools on the RLA gear, it may go unnoticed until the RLA is moved (usually when making / breaking connections). (C) The third place that this mystery leak can be coming from, is one of the connections at the back of the hydraulic reservoir. Sometimes this leak manifests as oil dripping off the hard lines that feed the pumps, and other times it runs down the body of the TD and collects on the RLA. If this is your scenario, sorry—you'll have to rig down the Top Drive to tighten those fittings. Don't let anyone talk you into splitting the track to fix this in the air; you can't reach those fittings that way. So live with the leak and keep topping off the oil, or rig it down,

unlatch dogs, slide the TD off its track section and rest the carriage assemblies on some stubby pipe racks.

19. GRABBER / TORQUE WRENCH CLAMP FUNCTION DOESN'T WORK

(1) ELECTRICAL ISSUE—Treat it like any other hydraulic function that doesn't work, by first manually actuating the Clamp SOV. The RLA will rotate in jerky / robotic fashion until it 'finds' a hole. The shot pin is engaged with 400 PSI of pressure. Once it is down, full system pressure passes over the back of the shot pin to hold it in the down / locked position, and passes through the RLA down to actuate the TW clamp piston. If this works manually, then an electrical issue exists. Check terminal 49 in the J-box when brakes are actuated to see if 24V is making its way to the solenoid. If voltage is not arriving at the J-Box and no other functions are affected, then run a spare in the 42-pin. Remove the inside (left side) wires from terminals 49 and 50 in the J-box, and move them to any open terminal between T35 and T39 that has corresponding wires on the other side. Note the wire numbers of the new 42-pin wires you're using. Then in the VFD house, do the same thing. Remove the top side or I/O side wires from the terminals which hold 42-pin wires 15 and 16 on the opposite sides. Replace the I/O side wires in the empty terminals that are across from the new 42-pin wires you're using in the J-box (as above, so below). If the solenoid is suspect, test it using the procedures outlined in SCENARIO 14(1), to test the brake solenoid at T49 and T50.

(2) HYDRAULIC ISSUE: CLAMP PISTON REMAINS ENGAGED—Down on the grabber assembly is a small manifold block with two cartridge valves. One of them is screwed into a recessed part of the block. We're going to look at the other one, which is the clamp piston's flow control valve

(SUN P/N CNCC-XCN-.047 or NOV P/N 109302-130NC). LOTO, bleed off TD system pressure at the 3-position valve on the main manifold by placing the handle in Shutdown position, and slowly remove the cartridge with a 7/8" wrench or socket. DO NOT STAND IN THE ENERGY PATH. What has happened, is that some piece of debris larger than the .047" orifice (that is indicated by the SUN Hydraulics part number) has blocked the pressure behind the piston from relieving. As you remove it, the cartridge will likely eject with a loud 'pop' and a stream of oil. Once removed, clean the valve with brake cleaner, beat the end of it on a solid surface, and re-insert it to see if that cleared up the issue. Don't forget to place the 3-position valve back in Run. If the issue persists, replace the valve.

(3) HYDRAULIC ISSUE: CLAMP PISTON TRIES TO ENGAGE, BUT BACKS OFF—Go to the grabber assembly's small clamp manifold and locate the clamp piston's pilot-to-close check valve (SUN P/N CODA-XCN or NOV P/N 94537-130N) that is screwed into the recessed part of the housing, next to the flow control valve described above. LOTO, bleed off TD system pressure at the 3-position valve on the main manifold by placing the handle in Shutdown position, and remove the cartridge with a 7/8" socket. Beat on the valve and clean it with brake cleaner, then re-install it, place the 3-position valve back into Run mode, energize the TD and see if the piston extends as it should. If not, replace the cartridge.

(4) HYDRAULIC ISSUE: RLA CONTINUES ROTATING DURING MAKEUP / BREAKOUT FUNCTION—The shot pin isn't 'finding' a hole. You have either one or two clogged orifices at the main manifold. Here's the fix. LOTO and relieve hyd pressure at the TD by placing the 3-position valve into Shutdown mode. Now, when looking at the outside of the main manifold with all of the manual SOV buttons facing you,

look at the right side of the manifold. There is one steel line coming from behind the manifold, that connects to a port marked 'A5'. Disconnect that steel line. This next part is important: the fitting that the steel line screwed into is not an ordinary fitting. It is a .031 flow control orifice. When you remove it, ASSUME THERE IS TRAPPED PRESSURE BEHIND IT, so stand to the side. Have someone else on the other side, if possible, playing catcher with a bucket. When the orifice is removed, take it into the doghouse and inspect it. Look for debris that is stuck in one side of the orifice, and dig it out with a paperclip, safety wire or needle. Spray the orifice out with brake cleaner and shake it dry. When working properly, you should be able to blow hard through one side of the fitting (yes, with your mouth), then blow hard through the other side of the fitting, and feel a small poppet shift against a spring. It should be slightly harder to blow through one side than the other, because there is an internal 5PSI bypass. When it is clogged, it will be impossible or near impossible to blow through the fitting. Replace the fitting in its place, re-connect the hard line, and then look for an identical orifice at port B5, located under the main manifold, closer to the RLA gear in the same cross-sectional vicinity of the manifold. You will need to remove two lines, I believe, to get to the orifice fitting. Repeat the cleaning process and re-install. It is possible for these to fail, so get a couple to keep in your spares (NOV P/N 1286936035). Be careful when purchasing from a 3rd-party source (besides NOV), because sometimes they will look the same, feel the same, and not work. Place the 3-postion valve back into Run mode, energize the TD, and attempt connections again.

20. STAND JUMP DOESN'T WORK

(1) YOURS AND EVERYBODY ELSE'S—Live with it. Just kidding.

(2) Short answer: manually test SJ solenoid, if it doesn't work, adjust cartridge valve PCC to 1,400 on main manifold while viewing gauge connected to test port PCC. Long answer: if this doesn't work, follow the long procedure outlined in the hydraulic chapter of the TDS-11 Service Manual.

(3) If manual test of solenoid does work, and the SJ function doesn't work only when actuated from the Driller's controls, then an electrical issue exists. Check terminal 59 in the J-box when SJ is actuated from the console / Driller's chair to see if 24V is making its way to the solenoid. If voltage is not arriving at the J-Box and no other functions are affected, then run a spare in the 42-pin. Remove the inside (LHS) wire from terminal 59 in the J-box, and move it to any open terminal between T35 and T39 that has a corresponding 42-pin wire on the other side of the terminal. Note the wire number of the new 42-pin wire you're using. Then in the VFD house, do the same thing. Remove the top side (or I/O side) wire from the terminal which holds 42-pin wire 22 on the opposite side. Replace the I/O side wire in the empty terminals that are across from the new 42-pin wire you're using in the J-box (as above, so below). If the solenoid is suspect, test it using the procedures outlined in SCENARIO 14(1), to test the SJ solenoid at T59 and T60.

21. DAMAGED HYDRAULIC LINES BEHIND TOP DRIVE

This is a crappy situation that happens sometimes, when your TD travels too close to the track (this, by the way, is usually a bogey roller bushing issue, or a roller issue). If the steel line(s) are smashed flat and leaking, you'll need to rig down and replace them. If a low section of tubing has rubbed a hole in the line, however, and the tubing above looks to be okay (use a bright flashlight to inspect), then do this:

(1) Have someone start calling your local hydraulic supply places to locate a high-pressure compression union for the size of line that's damaged, and a custom hose that makes up to one side of that union, with a JIC female fitting on the other end of that hose—tell them what length you need. Get two unions. Then get the order hot-shotted ASAP, and have the hotshot driver bring a battery-operated Dremel with a quick-disconnect head and some QD metal cutting discs (or an air-operated die grinder with thin cut discs, if you don't have one on the rig). If you want to try to improve track standoff, now is also the time to get two bogey roller assemblies and / or bogey bushings coming as well.

(2) Remove both pins and the swing gate (front stabilizer) of the grabber box.

(3) Remove the LT links / bails.

(4) Remove both Rotary Table bushings.

(5) Basket a strap through the front of the grabber assembly and pick up with the floor hoist whose chain / cable is centered on the TD until the grabber has slid up the PipeHandler torque tube, and the torque tube begins to kick out toward the mousehole.

(6) Energize the Drawworks. Using solid, clear communication, have the Driller slowly lower the blocks while carefully manipulating the floor hoist (lower as well), to get the TD as low as possible. WATCH THE LINK TILT MANIFOLD, as your lowering operation is limited to the point where either you're about to smash a line / fitting coming out of this manifold, or you're about to smash the manifold itself. You can kiss the manifold gently, but that's it (don't worry, the

manifolds are robust… I'm not gonna lie, I've seen the that manifold hold the weight of the TD with that torque tube jacked into it with no issues… but we don't operate like that. Let's exercise great caution). *Note: Performing steps 2 through 6 is also the best way to reduce downtime when waiting on a tech to come change a drill motor, as the tech will need to reach the back bottom motor mount bolts first.*

(7) At this point, you should have the steel line damage right in front of you. Do something to mitigate the leak until your compression union arrives (stuff an oversized O-ring in the hole and tape the hell out of it, or wrap the tube tightly with Teflon, etc.). Since the hole is already leaking, you don't need to relieve TD hydraulic pressure at the main manifold. If it's a pump supply line that's damaged, doing so would only increase the gravity pressure and amount of fluid in the tank that feeds that line.

(8) Now's the time to remove and replace those lower bogey roller assemblies, or remove the ones you've got and replace the bushings. Two 24" pipe wrenches or one and a 3" hammer wrench.

(9) Have someone stand next to you with the steel-line end of the union loosened or disassembled. Quickly and smartly cut the steel line, as clean and perpendicular as possible. You will get sprayed in the face with gravity-fed fluid. Immediately but deliberately install the fitting and tighten it—don't drop the pieces. Remove the lower half of the severed steel line and connect the union's hose in its place. May seem like a hokey fix, but it will work great. These unions are typically rated between 5,000 and 6,000 PSI. *Side note: JB Weld makes a 2-part epoxy that is rated at 5,000+ PSI. If you're stuck in the Congo and you need to patch a high-pressure hydraulic line for your airplane's rudder boost package, it works. Just*

sayin' … sometimes you have to trust the design engineer's ratings.

(10) Re-assemble the TD / RT and get back to work.

22. OIL CONTAMINATION

(1) HYDRAULIC SYSTEM – If sand, dirt, or mechanical debris is found in oil, you need to stop using the Top Drive. Get a hydraulic specialist on location who knows how to evacuate all lines, manifolds, and actuators. It will be messy and you'll be down for a day. Otherwise, the cost will be high. If rubber or plastic pieces are found across random samples, they may clog your cartridge valves and orifices, but you can possibly clear most of the debris through a number of oil and filter changes, recycling your oil into a clean barrel through a kidney loop filtration system. If water is present in your oil—which causes the oil to look milky and often yellowish, change the oil and filter at earliest convenience.

(2) GEARBOX LUBRICATION SYSTEM — Gear oil is more forgiving. Mild metallic contamination is not a game-ender, and is relatively common as you near the end of a five-year cycle between re-certifications. Look out for hard, shiny metallic flake, which is indicative of bearing failure. If you see a lot of this, with the gear oil drained, open the ODS access plate and feel around for larger pieces of metal. If discovered, get an expert headed to your rig for further inspection. If, when you drain gear oil, it looks like chocolate milk, be sure to note how much oil is removed. The gearbox is serviced with 15 gallons. So if, for example, you remove 30 gallons of water-contaminated oil, the water is being injected under the swivel pack. Remove the swivel pack and the rubber boot (mud / splash guard, bearing shield) beneath it (NOV P/N 30154362), then remove & replace the upper bearing isolator

(NOV P/N 30173521). Best done with a qualified technician. Similarly, if your oil quantity is excessively high, but it is not contaminated—only thinner than gear oil usually feels—then you have hydraulic oil intrusion. This happens when two related failures occur. First, the front seal of your TD's gear lube motor fails, pushing hydraulic oil under pressure into the dry-spline connection plenum of the gear lube pump plate; second, that hydraulic oil under pressure breaks the front seal of the gear lube pump, allowing hydraulic fluid to enter into the gearbox. You can live with the lube pump seal failure. Replace the gear lube hydraulic motor (NOV P/N 30156326-36S… I believe they have a different P/N for a cheaper replacement these days, ask NOV about it—or order Eaton P/N 101-1722-009).

23. TOP DRIVE ALIGNMENT ISSUES

(1) WELL CENTER MISALIGNMENT – The alignment disparity is growing wider. First, you can adjust the setback and side-side alignment of the intermediate tieback assembly (along the torque crossbeam). Second, is your rig level? Has it shifted? Double check. On rig up, you should have shot a laser from the center of the rig floor to the front edge of the crown. Now is the time to do it again. Same position?

(2) TRACK, CARRIAGE AND DOLLY ISSUES—Next question, have you found bearing material on the rig floor? If so, your track rollers are coming apart. If you don't have a track, did your dolly throw a guide pad, or are your guide pads excessively worn? Worn guide pads, or worn rollers and bogey assembly bushings are best indicated by a significant shift in TD stem-to-well center alignment when the IBOP is moved, the RLA rotates, and especially when the elevators are kicked out. The failure or wear of bogey rollers and bushings can also contribute to the incident of TD rubbing on the track,

which can cause damage in a number of ways, the least of which is the TD snagging on a flared section of track while traveling up or down in the derrick. Track inspections are paramount. For TDS-11's that have been modified to travel on a track with guide runners in lieu of rollers, the pre-rig-up track inspection is even more critical.

IMPORTANT NOTE: The TDS-11 Carriage is made up of two parts, DS and ODS. These carriage assemblies are what hold the bogey assemblies which contain your track rollers. If damage was sustained to the TD—such as crown-out, board strike or dropped blocks—the carriage assemblies will often shear bolts, until one or both assemblies are held in place by a single bolt each, or a roll pin, or Jesus. If your Top Drive is traveling in any way that appears abnormal, STOP, and inspect the carriage assemblies. These have fallen from the sky and they will absolutely kill your Floorhands. I still recommend aftermarket secondary retention of both carriages, after some of the scary field calls I've encountered relating to these components.

24. SWIVEL PACK ISSUES

(1) SWIVEL PACK LEAKING – Re-pack it. Inspect wash pipe for corrosion, pitting, or other damage.

(2) DRILL FLUID LEAKING OR SPRAYING FROM UNDER SWIVEL PACK – PolyPak seal failure. Call and order a new PolyPak seal (NOV P/N 98291). Remove swivel pack and rubber bearing shield. In the top of the quill is an insert with a cutout for prying on either side. Pry up with a big flathead screwdriver, small pry bar, small flat bar or crow's foot. Have the Driller rotate the quill slowly. Pry up on the other side. Continue this process, with the Driller rotating and stopping rotation as you pry up on the Upper Stem Liner. Once it's out,

make note of the slight bevel; the upper part of the seal has a slightly larger OD that the lower part. Remove & replace the seal, hammer the Upper Stem Liner back into place, then re-install bearing shield and swivel pack.

(3) SWIVEL PACK NUTS / UNIONS WON'T MAKE / BREAK – Both the top and bottom are reverse-threaded. Lefty-tighty, righty-loosey.

(4) SWIVEL PACK HAMMER UNIONS ARE BOTH LOOSE, BUT SWIVEL PACK CANNOT BE REMOVED – Remember that mud screen we lost a while back? … "Found it." Remove the well service / wireline cap from the top of the Gooseneck. Use a 5 foot bar and a sledge to pound the screen down out of it's bent position in the curvature of the Gooseneck. Make sure your IBOP's open.

25. TROUBLESHOOTING TIPS

(1) SAFETY FIRST – Every person on a drilling rig is a deputized safety observer with STOP WORK AUTHORITY AND RESPONSIBILITY. It is our #1 duty to keep ourselves and others safe, so maintain 360° dynamic safety awareness at all times. If you see something, say something. When troubleshooting, always consider not just the basic components of a JSA / JRA / safety conversation (PPE, pinch points, slips / trips / falls, fall protection, overhead hazards, entrapment, rotating equipment, tool control, hand placement, communication, alarm signals, H2S, permit work, first aid & emergency plan, contingencies, etc.), but also the types of energy, energy paths and their potential. As outlined in the disclaimer at the beginning of this book, this is a technical document, not a safety document. In every lesson, in every troubleshooting scenario, it is inferred that we all must adhere, AT A MINIMUM, to the HSE rules and guidelines set forth by

the drilling contractor, oil / gas operator, and third-party companies for which we work, in addition to OSHA, API, IADC / CAODC, and other organizations of oversight that are relevant to our job and / or working environment.

(2) USE ALL YOUR SENSES AND SOURCES – When troubleshooting, don't just rely on what you can see. Sound, smell, feel, and even taste are important to determining failures and fixes. And it is critical that we listen to what others have to offer, because keeping a rig running right is a team effort. Ask questions. Debate theories. Offer opinions. Compartmentalize stress, as all downtime situations become increasingly stressful with time. Stay sharp, stay calm.

(3) DEPOT-LEVEL FAILURES & CRITICAL VIOLATIONS – When a major failure is discovered, or when a major incident occurs which may reasonably have caused failure, be very thorough in your inspection processes; lives depend on it. If anyone decides to operate a TD or any piece of equipment—or use any tool—that has failed NDT or other inspection, that has exceeded its OEM design factor / mechanical limitations / Safe Working Load, or safety devices which have expired certification or display illegible data, that's your time to exercise Stop Work Authority, and to report violations of those who proceed.

(4) ON AUTHORIZATION AND PERMISSIONS – The troubleshooting scenarios contained herein are for instructional purposes only, and though this is designed as a certification course, it does not empower anyone to act outside of the accordance under which they are employed. This information is intended to enhance knowledge and encourage participation in troubleshooting and repair only to the extent that the reader's employer and all site supervisors allow. Knowledge and training are conversely proportional to risk, for the more we

know about something—in this case, the TDS-11 Top Drive—the less susceptible we are to being endangered by it.

CHAPTER 17

OVERVIEW OF MAJOR TDS-11 REPAIRS

CHAPTER 17:
Overview of Major TDS-11 Repairs

In this section, we will learn the following:

1. Best practices common to all major jobs
2. Drill motor removal and replacement overview
3. RLA removal and replacement overview
4. Load path component inspection
5. Shop vs. field considerations (throughout)

Note: quill removal and replacement (which encompasses gearbox component R&R) was omitted from this segment because it will only be performed at a depot-level facility, ideally one with a gearbox stand and a bored area where the quill can pass through the ground. If you are undertaking this project and need phone support, call 24/7. – Matty 910-381-0876.

1. Best Practices – In order to make any big job progress in the most efficient way possible, follow these steps. **They will make the job flow smoothly from start to finish, without pauses**:

   A. Dedicate 30 minutes to having a good pre-job meeting. In addition to basic JSA / JRA topics, identify essential personnel – those selected to perform the work or provide safety watch. Ensure that non-essential personnel keep clear of the work area. Establish a system of communication and identify who will be communicating. Stress the importance of tool control and dynamic (on-the-move) 360° risk assessment. Designate one person during the job who will have the singular responsibility of tool control, and discuss the tools that will be needed for the job as s/he takes notes. During the meeting, make a plan to have at least two more meetings (typically, I will hold three meetings for a job: one to cover the basics of the whole job and identify tasks during teardown / removal;

one before re-assembly; and one end-of-job / turnaround / handover meeting). This next part is important: during your meeting, talk about the human factor and the trends of a big job. ALMOST ALWAYS, there is a great team effort on the disassembly / teardown process. Then there is a long pause when disassembly is complete, and the re-assembly process is the slow effort of 50% of the workers. So address this up-front. During the transition period, that's when to break out the music, power snacks and coffee. Plan for a quick break, re-assembly meeting, and attack the second half of the job with as much vigor and enthusiasm as during the first half. If there are enough personnel, assign every working person a mirror who watches and supports, then have this two-person team swap roles during the second half. Before dismissing everyone from the meeting, designate a time-keeper, and require all hands (including non-essential personnel) to stick around and work for 30 minutes when the meeting concludes.

B. Immediately after conclusion of the pre-job meeting, have the time-keeper set his watch for 30 minutes. In the field, the Driller is a good designee. Then, all hands will begin cleaning the working area thoroughly for the given time.

C. When the cleaning is done, designate a space for tools and a space for parts. Have clean buckets available for small parts and hardware, and clean buckets available for fluid capture. Have the tool control hand obtain rags, soapy water, and brake cleaner / electrical cleaner, then have him / her set up the tool control area. Always have multiple common tools on hand, such as cutters and commonly-used wrenches. The tool control person will be busy handing and taking tools, cleaning them and placing them back in order for quick access. This person will also maintain a running overhead tool log.

D. If the Top Drive is not in position to get started with the work, now is the time to get it there, IAW (in accordance with) your pre-job plan. Once in place, get to work.

E. At the end of the first phase of work, have a brief meeting to check on everybody and explain the next steps of the job. Fuel up with some healthy high-energy snacks, make personnel changes as required, and plan for proper handover during tour changes if in the field (keep everyone from disappearing like roaches when the lights come on at 6). Immediately begin phase 2 of work.

F. At the end of the job, have multiple personnel look the equipment over from multiple angles, to ensure all parts are properly assembled, hardware is firmly secured and safety-wired, wires are properly terminated, and tools are turned in. Have the tool control person check the count on tools and visually verify ATAF ("A-taff" …All Tools Accounted For). Hold a post-assembly meeting and discuss what to look / listen for during runout.

G. Begin function test. Look / listen / smell for deficiencies. Complete function test. Begin 6- / 12- / 24- / 48-hour endurance test as required. In an endurance test, the equipment is run continuously to simulate different stages of operation (in the case of the Top Drive, drilling & tripping). If the unit fails in any way during the endurance test, the unit is LOTO, repaired, and the endurance test begins again at zero. In a 48-hour run test—as required during commissioning by major oil & gas operators—the Top Drive has run for 48 continuous hours, according to a schedule, without a fault or failure.

2. R&R Drill Motor Overview – This is one of the most common major repairs. The gist is to (1) remove everything attached to the motor, (2) unbolt it from the Top Drive, and (3) pull it upward out of the gearbox (or sideways, if the TD is laid over). We'll cover those three main steps

in a moment, but first, here are some important considerations, a few of which are listed in case you have time to prepare for such a job in advance.

A. The motors are not identical. The two are clocked differently, designated ‘Right’ and ‘Left’ as viewed when looking at the swivel pack. So when you need one, be sure to specify which.

B. Unless you have a newer track-mounted TDS-11, with man-passable space between the motors and the track (wide carriage assemblies), it will be very helpful to have a couple specialty wrenches built, for installation and removal of the upper track-side mounting bolts. A dimensional drawing is included at the end of Chapter 5 in this book (figure 5.1).

C. You can shave three hours off a field motor swap if you have a fully-assembled ‘quick change’ motor ready for each side. This entails taking a traction motor, adding a brake adapter plate, then assembling the brakes, encoder or heat exchanger, blower shroud and duct, blower impeller and blower motor to complete the unit. Otherwise, these will be removed from the old drill motor and installed on the new drill motor in the field.

D. Invest in a couple new lifting straps or slings to be used for motor swaps. 3” x 12’ (can be wider / longer), with an SWL of 10,000 pounds or better in basket configuration.

E. These days, there are several aftermarket manufacturers that supply new and upgraded motors. Within this competitive landscape are a variety of options related to hookup / wire termination and blower style. Make sure that the motor you order is compatible with your setup, or have an electrician handy with some lugs, crimpers, and a new set of (3) power pigtails to adapt accordingly in the field.

F. Motor re-conditioning decisions are important as well. You can save money by sending your motors up north, where a clean, dip and bake for a couple grand, or a complete re-wind (hand-wound, choice of wire, VPI [vacuum-pressure impregnation] epoxy, 3M low-heat rubber coating and upgraded bearings) will cost you $22K. Compare that to the West Texas standard of $10K for basic conditioning or $30K+ for a complete rewind. If you have two or three burned up motors, the savings here are self-evident. Of course, there are many options and preferences available today, such as triangle wire, form-wound armature stators, a variety of termination options, and add-in resistors.

Here are the main steps… an asterisk (*) is used preceding tips for challenging parts of the job.

A. First, stage the Top Drive for ease of access to the inside lower back bolt of the motor. There are three known ways to do this: (1) leave the TD in any position, and use a 4' long extension and heavy impact to reach and break the bolt free of its wire tie… easier shown than explained, and there are several drawbacks to doing this; (2) split the track sections to access the bolt between them… sounds good on paper but a pain in the ass; and (3) dropping the TD into the Rotary Table (my personal preference). For instructions on doing the latter, see Chapter 16, Scenario 21 (2) through (6).

B. Have two or three hands remove safety wire from upper access plates on the motor, and from each of the eight mounting bolts. When finished, they can start to remove the bottom mount bolts* using a 1-1/8" socket, and the side mount bolts** using an 1-1/2" wrench. *For the inside back bottom mounting bolt, see part 'A' above. For the front bottom mounting bolt, with one hand, place a 1-1/8" socket on the bolt head from inside the bonnet, behind the swivel pack. Then insert a long extension—or preferably two—with a universal swivel adapter into the socket from outside of the bonnet (the crack between the bonnet and the motor). **For the rear side mount bolts, which are higher on the motor and screw into the protective frame surrounding the hydraulic reservoir, use a 1-1/2" specialty wrench (figure 5.1 of this book). Disconnect the motor ground cable, usually found in the vicinity of one of the outside bottom mount bolts.

C. Remove the blower pigtail from the blower motor. A detailed description of how to do this is given in Chapter 16, Scenario 8(6), second paragraph.

D. Remove the 1/4" steel tube from the blower pressure switch. Then—keeping the wire connected—disconnect the blower pressure switch from the TD using a 7/16" wrench.

E. Remove the blower duct or 'downspout'. Leaving the wires in their glands, disconnect the back plate (where cables pass through) using a 1/2" wrench or ratchet / impact

F. Remove the four bottom-mount bolts* that secure the drill motor to the main body / gearbox lid.

G. Remove the brake line from the back of the brake adapter plate.

H. For a left drill motor, disconnect the steel line that connects under the prefill valve manifold, just above the reservoir (1-1/4" wrench). Disconnect the other end of that line, in the vicinity of the hydraulic pressure filter. Disconnect the inlet and outlet lines of the heat exchanger at the back of the brake adapter plate. On the adapter plate, turn 90° fittings face-down when removing the motor, face-up when installing (to prevent snagging).

I. For a right drill motor, disconnect the encoder and remove the encoder pigtail from the motor. Usually this is done by grinding the edge off both the motor and the brake adapter plate hole where the cable passes through, otherwise, disconnect the encoder pigtail at the J-box and pull it out from the plug end.

J. If the plug panel is installed on the motor you're removing, disconnect all five plugs. Choke a small strap against one corner of the safety bar on the plug panel, and use a hoist to pull slight tension. Then, using a 3/4" wrench or socket, remove the two upper and two lower bolts that attach the plug panel to the motor. Tie the panel back and away from the motor.

J. Disconnect the three leads from inside the motor. Disconnect the RTD / heater pigtail from the terminal block inside the side access plate of the motor. Leave the wires on the other side of the terminal block connected (the ones that go into the motor).

K. Pull the back motor plate toward the track, the one with the cables passing through it. Pull it away and tie it to the track (if applicable). Make sure all the cables are free from the drill motor and dangling outside of it.

L. Have someone retrieve a couple of railroad ties and 4x4's to place flatly / parallel on the rig floor. Optimally, we will stand the old motor and the new motor up on these tracks, side-by-side and in the same orientation. That way, we can remove fittings and blower / brake components from one and install them onto the other with ease. This can be done on the catwalk or on the ground as well, but it is less efficient.

M. Pass a long, serviceable 3" or 4" strap through the front and rear open access windows of the drill motor. Pass the rotor on the opposite side of the termination block. Attach a hoist to the basket-configured strap ends above the blower motor and raise the hoist until slack is removed. The strap should be centered on the motor access windows, and pushed up against the rotor on the inside of the motor. The hoist used should be the one which offers best vertical pull (DS hoist for DS motor, ODS hoist for ODS motor). Make sure the hoist is behind the traveling block.

N. Check the unit over for potential snag points. Ensure that all eight mounting bolts are removed, and all accessories are free and clear of the vertical path of the motor during removal / installation.

O. Have a brief meeting with everyone to discuss the next steps. During the pluck, one person should be standing on the gearbox, being especially mindful of the pinch point created by the motor and the bail. This person is to keep the motor from swinging out toward the V-door. Another should be on a ladder, slightly aside from the bottom of the motor, with a tagline ready. If the motor being pulled is the left motor, this person will pull out on the loose steel tube that is under the brake adapter plate, so that there is no danger of tube damage when the motor jumps up. Finally, a third person should be on top of the TD, standing aside near the opposite motor (or sitting on the opposite motor and pushing against the blower motor in a rocking fashion to break the seal as tension is pulled). The hoist operator must be in crystal clear understanding that once the seal pops, he stops (hands off the controls). The rest of the procedure will be an operation of finesse.

P. Pick up slowly on the motor until there is approximately a 4" gap between the bottom of the motor and the gearbox. The pinion gear will still be in the hole of the gearbox lid, keeping the motor from swinging away. At this point, the person on top should be holding the strap, the person on the gearbox should be steadying the motor with one arm, and the person on the ladder should now sling the latch end of the tagline around the pinion gear without placing a hand underneath the load. Use a screwdriver or Channel Locks if desired. Choke the tagline in the space above the pinion gear and hand it off. The lower person will now descend the ladder and move the ladder out of the way. Lower the motor to wherever you decided to work on it. There are long, thin spacing shims that may have fell off when the motor was removed, have someone locate and collect them, making certain that none dropped into the gearbox. Remove the large O-ring from the bottom of the motor before setting it in place, in case a replacement did not come with the new motor (even without an O-ring, a thin bead of silicone works… remember, only 33 pounds of pressure in the case at best, and oil does not collect near the motor except when the TD is laid over).

Q. Have one person clean up the area on the TD where the new motor will be stabbed. Place cardboard over the hole to prevent debris or rain intrusion into the gearbox. At the same time, have two or three people work on swapping over the blower and brake components to the new motor, along with adapter plate fittings if required.

R. When the new motor is prepped and ready to install, hold a brief safety meeting. Focus on re-energizing the crew for the next part of the job. Swap personnel to keep everyone fresh, if required. Of course, this entire job can be performed by one man… but it is the least efficient option; three more personnel make the difference between a five-hour job and a fourteen-hour job.

S. Installation is in reverse. Don't forget to install the O-ring underneath the motor—hold it in place with red grease. Also, when installing the motor, it will usually stab to the point that it is 1/8” from being fully inserted. The motor will need to be wiggled and twisted to drop until the mating surfaces are touching. When re-installing wires, refer to the electrical schematic if the wires are not labeled. Keep the power leads away from the rotor when they are terminated (use the installed loop to pass them through). Presumably, you’ll have an electrician on site. When the job is complete, conduct a Motor ID Run if you have an ABB Drive (see the ACS800 Firmware Manual for simple instructions), or conduct Auto-Parameterization if you have a Siemens Drive (see the SIMOVERT Compendium). If you are experiencing issues on runout, refer to Chapter 13 or Chapter 16 in this book.

Shop Considerations – In many ways, this is an easier process than in the field. There are two ways to do it: (1) remove the bail, or (2) prop the bail up with wood blocks on the opposite motor, and work around it. I usually just work around it, but the challenge is to install and remove straps as you are doing so. Removing the bail can be its own monster sometimes… if the bail pin(s) and or bushing(s) are seized, you’ll need a big rosebud and potentially a lot of heat, and the biggest port-a-power + pass-through jack that you can get your hands on. And patience, while you work the bail up and down. I’ve seen a shop refrigerator get demolished by a pin that flew twelve feet, and I’ve taken a Top Drive into Bridges Equipment to have the bail bushings reamed out on a humongous mill for 12 hours.

When it comes to strapping the motor while it’s laid over, you can try to work a strap around the lower body of the motor—a really tight fit—or (if the bail is removed) you can just remove the vent cover that’s facing up and the motor access panel where the leads connect, and choke straps around the upper and lower ends of the rotor for lifting. Drain the gearbox before removing the motor, at least a couple buckets’ worth.

3. R&R RLA Overview

Note: for field removal, this procedure will require an RLA stand. Call Magic Industries (Victoria or Midland, TX), FEMCO Machine (Punxsutawney, PA), Faber Fab (Lock Haven, PA), GDS International / Premium (Houston or Odessa, TX), or KAT Machine (OKC). Otherwise, borrow one from a friendly competitor.

A. Remove the elevator links. Remove tool joint clamps and break the quill out of the upper IBOP. Remove a front stabilizer hinge pin from the grabber box and swing the gate open. Remove the external crank assemblies from the IBOP actuator sleeve, pull back on the pipe handler and hammer down on the sleeve to remove it. Do not deform the sleeve. If it is not moving easily, grind down the die tooth marks on the quill to allow smooth travel; you'll need to do this either way before removing the RLA.

B. Regardless of whether the RLA will be removed in the shop or in the field, while still in the field, place the 3-position valve at the main hydraulic manifold into SHUTDOWN mode. Drain the hydraulic reservoir and the gearbox. If this is a re-seal job and not an RLA swap, soak the new seals in clean (new) hydraulic oil.

C. Remove the link tilt cylinders. Remove the LT crank or 'turtleback' that the link tilt cylinders attach to. Disconnect the hydraulic hoses going to the grabber's clamp manifold and to the IBOP cylinder. Finally, remove the pipe handler assembly from the RLA, being careful not to snag the hoses that pass through the top of the PH (feed / route them through).

D. Remove the shot pin assembly. See Chapter 16, Scenario 17(1).

E. Mark and remove all steel lines above the RLA (the ones which attach either to the RLA or to the shot pin assembly). Mark the tubes and associated fittings using colored zip ties, or using safety wire (one wire to one wire, two wires to two wires, etc.) When this is going back together, you'll want to re-install the lines in reverse order that you removed them, which generally means you'll start installing nearest to the HPU and working your way forward (or up, if the TD is laying over).

F. Remove the load collar assembly under the RLA. The assembly consists of two ribbed clamshells that fit into corresponding grooves on the quill. These are held in place by an outer cover, which is the first piece you'll remove.

G. If the TD is in the derrick, position the RLA stand under the TD and stab the quill through it. Lock the RLA into the stand with pins used for the pipe handler assembly. If so equipped, lock the stand into the RT or adjust the leveling jacks so that the stand matches the angle of the TD quill as closely as possible. Set 1,000 pounds on the stand per the weight indicator.

H. Using a paint marker, mark the edge of the RLA and main body of the TD (gearbox) where they meet. You'll need to transfer this marking to the new RLA if it's being swapped (and you're not just re-sealing the old one), so mark it in a conspicuous place. Some RLA's have a line etched at the center. Begin removing the tie wire and bolts that connect the RLA to the gearbox. Verify that the quill is buffed smooth, and apply a light coat of grease to the quill.

I. With all bolts removed, hold a brief meeting to explain the need for close safety observation on all sides. When the meeting concludes, have the Driller pick up slowly on the blocks. Have the Driller pause periodically to maneuver the RLA using the stand's leveling jacks, if applicable, so that the quill remains centralized as it raises out of the RLA. It's like playing the game of Operation. If the TD is laid over, the RLA is hoisted using straps that are firmly choked on the meaty portion of each RLA ear to maintain balance. A hand can use a 5' bar through one of the ears to maintain positioning control if doing this using a shop crane or forklift. Make sure the forklift is perfectly centered and parallel to the long axis of the quill.

J. With the RLA removed, place it on a level surface. If it is to be re-sealed, the stem and RLA gear will need to be removed from the main body. To do this, note the position of each fitting above the RLA gear. Remove the fittings, remove the safety wire and bolts, and using a 3-leg chain that is equally spaced on the RLA gear holes, pull up on the gear / stem until this subassembly is removed from the main body. You can now access the primary seals inside the main body. To replace stem seals, you must two-point the chain and roll the RLA over 180° onto soft matting or wooden blocks, so that the gear is on the bottom and the stem is sticking up. Remove the big snap ring and heat the retaining ring evenly to just over 240° Fahrenheit. The ring will remove with a few soft taps, and then the RLA gear can be removed. Remember, when referring to the TDP for correct positioning of new seals, that the stem is upside-down and your drawing is right side up.

K. Installation of the RLA / button up is in reverse order, steps J through A. The most important parts of re-assembly are: (1) do not crease the main 10" seals when installing them into the main body; (2) use extreme care when stabbing back onto the quill, so as not to damage the lower oil seal; and (3) maintain same positioning of RLA during reinstallation as during removal. Fill fluids to proper levels and make sure 3-position valve on main manifold is back in the RUN position. Function test and perform endurance test as required. Note: when possible after a re-seal job, pressure test each circuit to at least 1,000 PSI. This will spare the headache of discovering a leak after reinstallation.

4. Load Path Component Inspections – Post-incident inspections, per IADC, API and manufacturer guidelines, requires a non-destructive inspection of the following critical load path items on the TDS-11. Where distances and detailed areas of component inspection are not specified, industry SOP's are applied:

   A. Load Collar – 100% MPI of clamshells;

   B. Quill – MPI of quill that is visible under RLA + detailed thread inspection; if surface anomaly < 1/2" is detected, conduct UT inspection of visible section. If surface anomaly > 1/2" is detected, remove the quill and conduct 100% UT. If thread findings are outside of API profile, replace the quill.

   C. RLA – MPI 100% of elevator link ears and latches, and main body within two inches of ears;

   D. Elevator Links – MPI 3' from each end

   E. Bail Pins – 100% MPI; and

   F. Bail – MPI 2' from each end and 3' at the center.

Additionally, if TD is rigged down:

   G. Track Pins – 100% MPI; if any pin is nonconformant, replace all keeper pins;

   H. Track – MPI all welds and pins 3' from each end of each section (4' for Patterson-UTI rigs);

   I. Hang-off Link / Dog Bone – 100% MPI;

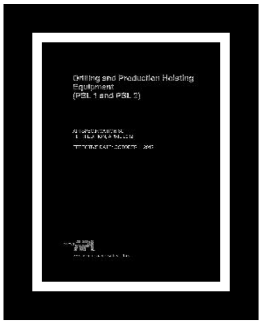
J. Wishbone – 100% MPI;

K. Crown Lug – 100% MPI and 4” circumference on crown; and

L. Hang-off Shackles – 100% MPI.

Note: The US standard for MPI process is ASTM E709, *Standard Guide for Magnetic Particle Examination*.

If any inspections are found to be nonconformant, the respective components must be replaced, or repaired & recertified at an API 8C facility.



CHAPTER 18

STANDARDS

CHAPTER 18:
STANDARDS

In this section, we will learn the following:

1. A brief history of standards in the oil & gas industry
2. API standards governing the TDS-11 Top Drive
3. API Categories of Inspection
4. Other standards applicable to the TDS-11

1. History – In 1919, the American Petroleum Institute was founded to set standards for the oil and gas industry. Today, the institute has a published standard for nearly every aspect of the industry, and is globally recognized as the leader in O&G subject matter expertise. Moreover, many companies within the industry have aligned themselves with API, relative to the policies which govern day-to-day work activities through a common quality program or quality management system (QMS). These companies are aligned through the institute's quality registrar, or APIQR. Most often, their QMS are registered under API Q1 and Q2, which are closely related to ISO 9001 and 14001 programs.

   In addition to APIQR accreditation, the institute offers the API Monogram program to oilfield equipment manufacturers who prove that they follow the published standards of API when manufacturing or re-certifying equipment. Successful standing within this program allows the manufacturer to apply the API Monogram to their products (basically, API's seal of approval).

2. API Standards Governing the TDS-11 Top Drive – API typically publishes two types of standards: Specifications, or 'Specs', and Recommended Practices, or RP's. The Specs are used to measure conformance by Monogram Program manufacturers. The standard which governs the manufacture and re-certification of Top Drives is API Spec 8C: *Drilling and Production Hoisting Equipment*. This

publication, in all actuality, is a collection of other pre-existing non-API industrial standards… all of which are referenced in the document.

The publication which offers guidelines for manufacturers and all others alike is API RP 8B: *Recommended Practice for Procedures for Inspections, Maintenance, Repair, and Remanufacture of Hoisting Equipment.* Ironically, to date there is no published standard specifically for Top Drives.

At the beginning of each API publication is a 'Special Notes' section, which offers an invitation for suggested revisions to the publication along with the institute's contact information. In this section, it is interesting to note that API does not assert their organization, or its publications and standards, as the 'end-all, be-all' of oilfield best practices, as illustrated by the following verbatim excerpts:

1. "API publications may be used by anyone desiring to do so."

2. "The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices."

3. "Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard."

4. "Users of this Specification should not rely exclusively on the information contained in this document. Sound business, scientific, engineering, and safety judgment should be used in employing the information contained herein."

3. API Inspection Categories – In each API publication that covers inspections, such as API RP 8B in the case of Top Drives, the institute sets the standard for the different types of inspections to be used within our industry. These categories are widely accepted as gospel. They are as follows:

Category I:	Observation of equipment during operation for indications of inadequate performance.
Category II:	Category I inspection, plus further inspection for corrosion; deformation; loose or missing components; deterioration; proper lubrication; visible external cracks; and adjustment.
Category III:	Category II inspection, plus further inspection, which should include NDE of exposed critical areas and may involve some disassembly to access specific components and identify wear that exceeds the manufacturer's allowable tolerances.
Category IV:	Category III inspection, plus further inspection where the equipment is disassembled to the extent necessary to conduct NDE of all primary load carrying components as defined by the manufacturer.

4. Other Standards Applicable to the TDS-11 – In addition to the previously covered NOV publications and the API references in this chapter, there are two common standards which may be applied to the utilization, care, manufacture and re-certification of the TDS-11, and Top Drives in general:

    A. The IADC Drilling Manual – In fairness, I have read Version 11, which was published in 2000, but only excerpts of the current Version 12, which was published in 2014. In V. 11, out of nearly 1,500 pages, only a handful relate specifically to Top Drives, and then only information specific to safety valves such as the IBOP, tubulars / subs / shafts and other shouldered thread connections, and load path items. V. 12 has a chapter on automation and some newer references that relate to Top Drives.

B. CAODC RP 2.0: *Inspection and Certification of Overhead Equipment* (*Drilling*… RP 4.0 covers overhead *production* equipment). Similar to the IADC Drilling Manual, this standard's scope with relation to Top Drives concerns load path equipment. Until recently, all of the 2016 CAODC RPs were publicly available for download through their web portal. The latest RP versions (2019 publications are now only accessible by members of the Association.

CAODC guidelines promote *Levels of Inspection* that are aligned closely with the four API *Categories of Inspection*, however it is important to note that the Association specifies the criteria of inspections and inspectors with a little more detail.

This concludes the 2020 TDS-11 30 Hour Maintenance Course. Thank you for your participation! I hope that you found the information contained herein to be advantageous and profitable not only to your personal / professional development, but to the sustainability of your company's operations. For further information, please refer to the materials included on your student thumb drive.

Corrections, suggestions, and general correspondence are encouraged. Positive feedback for the course would be most appreciated. Please contact me at mspeights@rigangel.com or mattyspeights@yahoo.com. For 24/7 service, support, or training assistance call 910-381-0876. Even if I am not working in the industry, I will offer phone support or try to point you in the right direction. Between now and then, stay safe, lead from the front, and keep turning to the right!

v/r