Schlumberger

JET Manual 31

Coiled Tubing Units

Version 1.0

JET Manual 31 Coiled Tubing Units

InTouch Content ID# 4221769
Version: 1.0
Release Date: February 22, 2007
Owner: Well Services Training & Development, IPC

Schlumberger private

Document Control

Revision History

Rev	Effective Date	Description	Prepared by

Table of Contents

This page left intentionally blank

1.0 Introduction

Schlumberger Coiled Tubing Services operates more than 200 coiled tubing units (CTUs) in various parts of the world.

Irrespective of its function and/or working environment, a CTU will include the following main components:

- CTU prime mover, or power pack
- control console or control cabin
- CT reel
- injector head
- pressure control equipment.

This job execution training (JET) manual offers a brief overview of the functions of these components.

1.1 Learning objectives

Upon completing this training, you should be able to do the following:

- identify the main components of a CT
- demonstrate knowledge of the function of the prime mover
- demonstrate knowledge of the function of the control cabin
- demonstrate knowledge of the function and purpose of the CT reel
- demonstrate knowledge of the function of the tubing injector head and its components
- demonstrate knowledge of the function of the pressure-control equipment, including conventional and high-pressure configurations
- understand how to perform a standard technical equipment maintenance (STEM) 1 check on the main pieces of equipment.

This page left intentionally blank

All of the relevant parts of Well Services (WS) Safety Standard 5, Pressure Pumping and Location Safety, InTouch Content ID# 3313681, and WS Safety Standard 22, Coiled Tubing Operations, InTouch Content ID# 4221755, must be applied when rigging up and performing CT operations.

Standards 5 and 22 can be found in the Schlumberger Well Services Safety Standards and the Well Services Field Safety Handbook. They can also be viewed online through InTouch.

> **Warning:**
> Proper supervision is required during hands-on training. Request assistance from your supervisor if you are unfamiliar or uncomfortable with an operation. To prevent hazardous situations during operations, anyone engaged in the service or repair of equipment must ensure personnel safety.

> **Caution:**
> Remember that personal injury can occur when maintaining equipment in the yard just as it can on the wellsite.

Potential sources of injury for operators working with CT equipment are

- getting body part or clothes stuck in rotating machinery
- being struck by a loose CT string
- exposure of the eyes and skin to acid and other chemicals
- falling from a height
- falling objects.

> **Warning:**
> Death and injury can occur while working with CT equipment.

When working with a CTU, check the following:

- An approved permit to work (PTW) is in place.
- During the prejob meeting, all personnel are made aware of the sequence of the operation and their own role in it.
- Only necessary personnel are in the area.
- Work areas are barriered off.
- Full personal protective equipment (PPE) is worn by all personnel.
- All equipment is current on STEM checks.
- Suitable fall arrestors and harnesses are being used when working above 6 ft.

> **Note:**
> If you are unsure of any aspect of an operation, or feel that it may be an unsafe situation, STOP THE JOB!

This page left intentionally blank

3.0 Types of CTU

CTUs are used for a wide range of applications in many different types of environments. For some land operations, CTUs are driven to location on standard paved roads, while in other locations they may be driven through harsh conditions, such as the Arctic or the desert.

Offshore, conditions range from platforms to jack-up rigs to deepwater drilling rigs and swamp barges. Different CTU designs have evolved to cater for different environments.

Furthermore, some CTUs have been adapted to meet the needs of specific CT applications, such as CT drilling.

CTUs are often described as either three-piece or four-piece units, depending on their configuration.

A three-piece unit is made up of

- integrated power pack and control cabin
- CT reel
- injector head.

A four-piece unit is made up of

- power pack
- control cabin
- reel
- injector head.

3.1 Land operations

Schlumberger uses the following CTUs specifically designed for land use.

- paved road trucks (Fig. 3-1): These trucks can legally operate on roads in the operating area. Typically, in paved road trucks, a crane supports the injector head.
- mobile mast units (Fig. 3-2): These units are equipped with a mast rather than a crane to support the injector head. The mast allows lifting and stabilizing tools, and running pressure-control and other equipment. One type of mast is the specially developed CTX* CT Express unit (Fig. 3-2), which allows highly efficient rig-up times.
- off-road trucks (Fig. 3-3): These trucks are smaller and have all-wheel drive. They can work in remote areas such as deserts.

Figure 3-1. Paved Road Trailer-Based CTU

Figure 3-2. Mobile Mast CTU

Figure 3-3. Off-Road Bobtail CTU

3.2 Offshore operations

Schlumberger uses CTUs designed with offshore use in mind (see Figs. 3-4). The primary restriction for offshore operations is the ability to get the equipment on and off the rig or platform. The equipment weight must fall within the safe working limit of available cranes. Consequently, lightweight units are typically required. Various versions of the land CTUs include the following:

- skid-mounted units: A skid is a steel frame. In skid-mounted units, equipment such as the reel or control cabin are mounted on a steel frame to facilitate handling with cranes or trucks.
- barge-mounted and lift boat units: Barge-mounted and lift boat units are typically configured for a complete package of CT and associated equipment, including chemicals and materials for mixing and pumping, to be shipped on board. The CT equipment is typically skid mounted for flexibility and ease of positioning. Barges are used in shallow waters. Lift boats are different from barges in that they can be lifted off the water to reach elevated platforms. Lift boats also have more stability because they are not susceptible to water tides.

Figure 3-4. Skid-Mounted CTU

4.0 Power Pack

The CTU power pack, also called the *prime mover*, is usually a diesel engine (see Fig. 4-1). The power pack provides hydraulic power through a system of pumps, valves, and lines, to operate the CTU functions and controls. The system comprises multiple hydraulic circuits.

Figure 4-1. CTU Power Pack

The power pack drives several hydraulic pumps, which supply each circuit with the pressure and flow rate required to power a CTU component or part of a component. For example, individual hydraulic circuits power the injector head motors, reel motor, and levelwind assembly. Current power packs operate independently of exterior power or air supplies once they are started, to provide energy satisfactorily under varied conditions and for the duration of any CT operation.

In addition to the hydraulic power supplied when running, the power pack incorporates an accumulator facility to allow limited operation of pressure-control equipment following engine shutdown.

Power packs are classified according to the type of hydraulic circuit powering the injector head. There are three types of injector head hydraulic circuits:

- standard open loop
- high-pressure open loop
- high-pressure closed loop.

You will learn more about these circuits later in Section 4.3.1.

4.1 Hydraulic control system

Regardless of its design or configuration, the power pack hydraulic control system usually includes the major components described in the following sections.

4.1.1 Engine

The engine powers the hydraulic pumps that force hydraulic fluid through the system to power CTU components.

Depending on the age of the unit, the engine may be a General Motors Detroit series or a Caterpillar engine.

4.1.2 Hydraulic fluid

The CTU uses hydraulic fluid, which is oil, to power the CTU components. The hydraulic pumps draw the hydraulic fluid from the storage reservoir. The pumps force the fluid through the system.

Hydraulic fluid performs several functions:

- power transmission: To transmit power to the CTU, hydraulic flow must flow easily through the system. The fluid should flow with as little friction as possible, since friction results in a loss of power. Also, the fluid must be incompressible so that it will transmit power immediately on startup.
- lubrication: Hydraulic fluid lubricates the components in the system. The fluid contains additives to ensure antiwear properties and thus long component life.
- sealing: Hydraulic fluid and close mechanical fit provide the only seal against leakage for most components in the hydraulic system.
- cooling: Hydraulic fluid dissipates the heat generated by the components in the system.

4.1.3 Hydraulic fluid reservoir

The hydraulic fluid reservoir (Fig. 4-2) performs several functions:

- stores the hydraulic fluid
- allows the fluid to cool
- allows settlement of dirt and metal particles
- allows entrained air to be released.

The reservoir is generally mounted high in the power pack to provide a positive head of pressure at the hydraulic pump suction port.

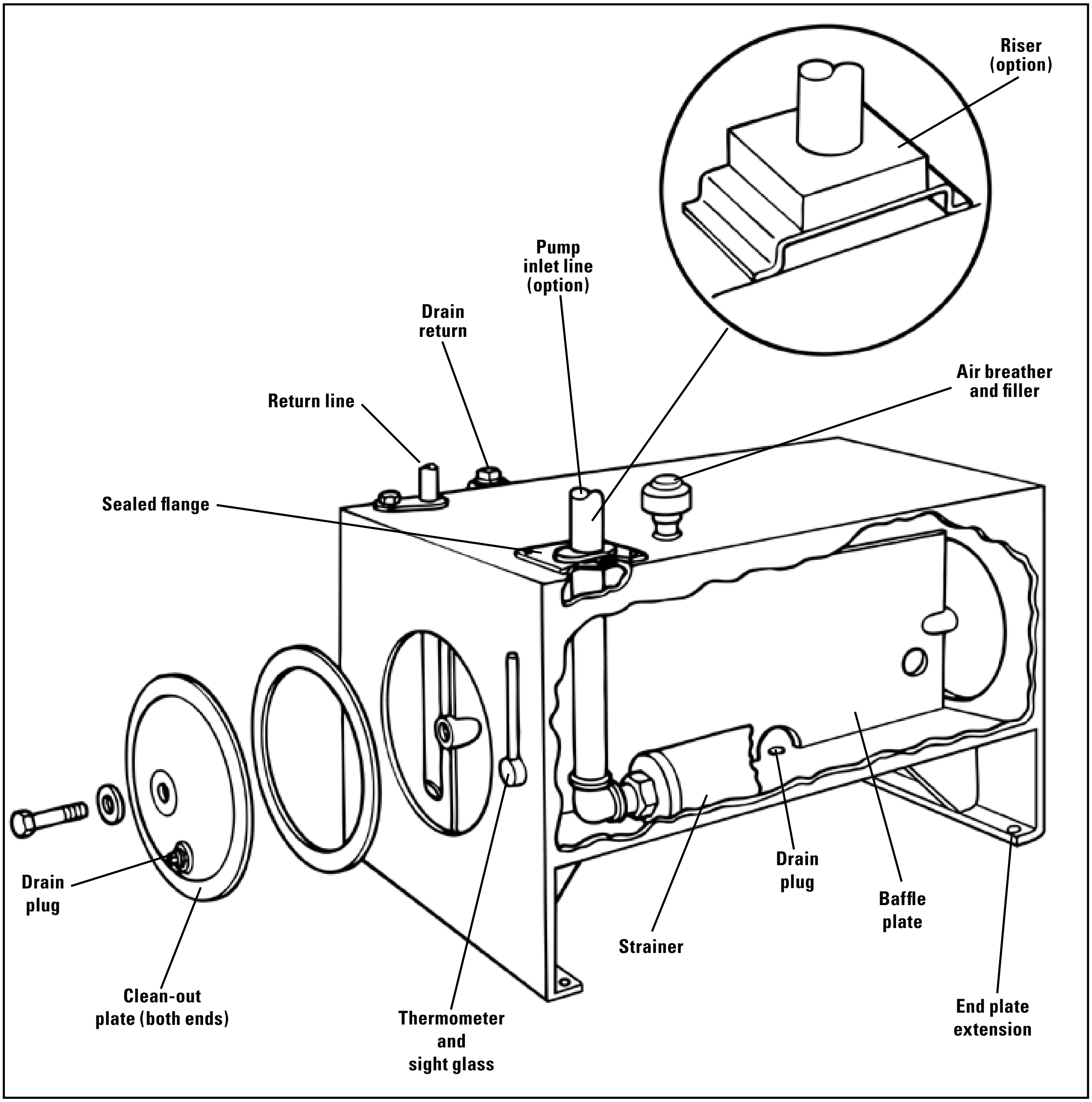

Figure 4-2. Hydraulic Fluid Reservoir

4.1.4 Filters and strainers

The hydraulic system uses filters and strainers to clean the hydraulic fluid as it flows through the circuits.

- filter: A filter removes small particles from the hydraulic fluid (see Fig. 4-3). There is a filter on the return line to the reservoir. Also, some circuits have inline filters, particularly where flow is limited. For example, a filter is typically installed on the supply line to the injector head main control valve.
- strainer: A strainer is a coarse filter that removes larger size particles. Typically, the strainer is fitted to a suction line inside the reservoir.

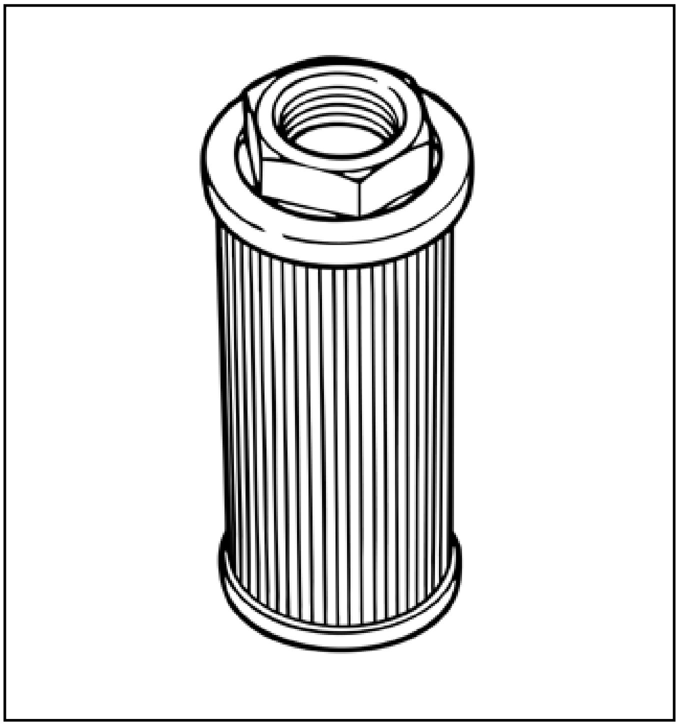

Figure 4-3. Filter for Hydraulic Fluid

Many filter assemblies incorporate a filter condition indicator. This device simply indicates the differential pressure between the two sides of the filter. A filter that is partially plugged will create a larger differential, which is commonly indicated by the colored indicator. A green display during operation is normal; a red display indicates the filter requires changing.

4.1.5 Heat exchanger

The heat exchanger is located on a main return line to the reservoir. It cools the hydraulic fluid on its return to the reservoir to assist with the dissipation of heat generated by hydraulic system components. Heat exchangers can use air or water to cool the fluid.

4.1.6 Accumulator

An accumulator is a storage bottle used to store energy. CTUs typically use a hydropneumatic accumulator. These accumulators have a gas and a hydraulic compartment. Bladder-type accumulators, charged with nitrogen gas, are the most commonly used type of accumulator on CTUs.

The accumulator has two functions:

- energy storage: The accumulator allows limited operation of the well control equipment following engine shutdown.
- shock absorption: The accumulator cushions the pulsation effect in the system.

4.1.7 Hydraulic pumps

The engine drives the hydraulic pumps, which draw oil from the reservoir and force it to flow to the various components of the CTU. Pumps in power packs can differ because of various customer requirements, upgrades, and improvements.

The positive displacement hydraulic pumps used in a CTU power pack may be vane pumps or piston pumps.

4.1.7.1 Vane pumps

Vane pumps (Fig. 4-4) can be found on older versions of CTU power packs. An example of a double-vane pump is the Denison T6 series pump.

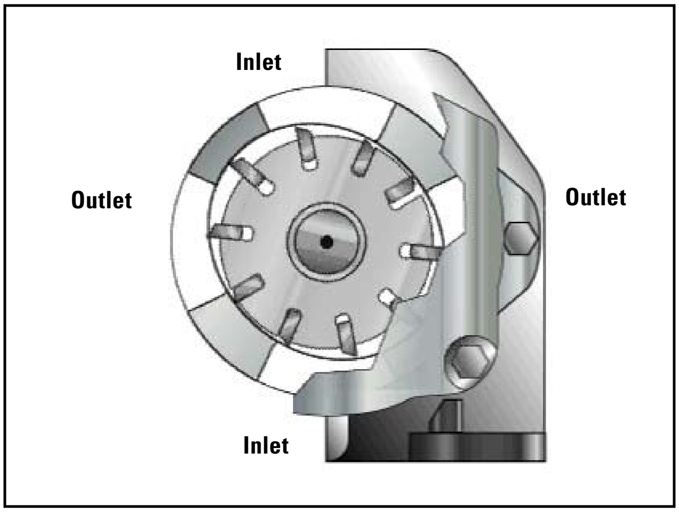

Figure 4-4. Vane Pump

Vane pumps are cheaper than piston pumps and very dependable. They are less sensitive to hydraulic oil contamination and run at a lower temperature.

4.1.7.2 Piston pump

Piston pumps (Fig. 4-5) are found on newer models of power pack, and are more efficient than vane pumps, allowing them to generate higher pulling forces. A Denison P16 is an example of a piston pump used in CTU power packs.

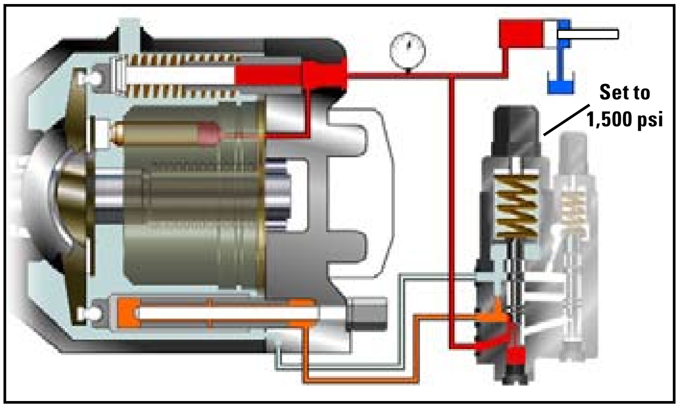

Figure 4-5. Piston Pump

Piston pumps are, however, more sensitive to hydraulic oil contamination and more expensive than vane pumps.

4.1.8 Pressure-control valves

A hydraulic system generates considerable pressure, and this pressure must be controlled (see Fig. 4-6). Every circuit has pressure limits. Pressure-control valves control the maximum pressure within each hydraulic circuit. The valves protect the system from excessive pressure. If circuit pressure increases beyond these limits, the control valve will direct flow back to the hydraulic reservoir to reduce pressure.

Three types of pressure-control valves are used in a CT hydraulic system:

- preset relief valves: These valves are manually set to the maximum desired pressure within a circuit. Once this pressure is reached, the valve lifts, allowing excess flow to return to the hydraulic reservoir.

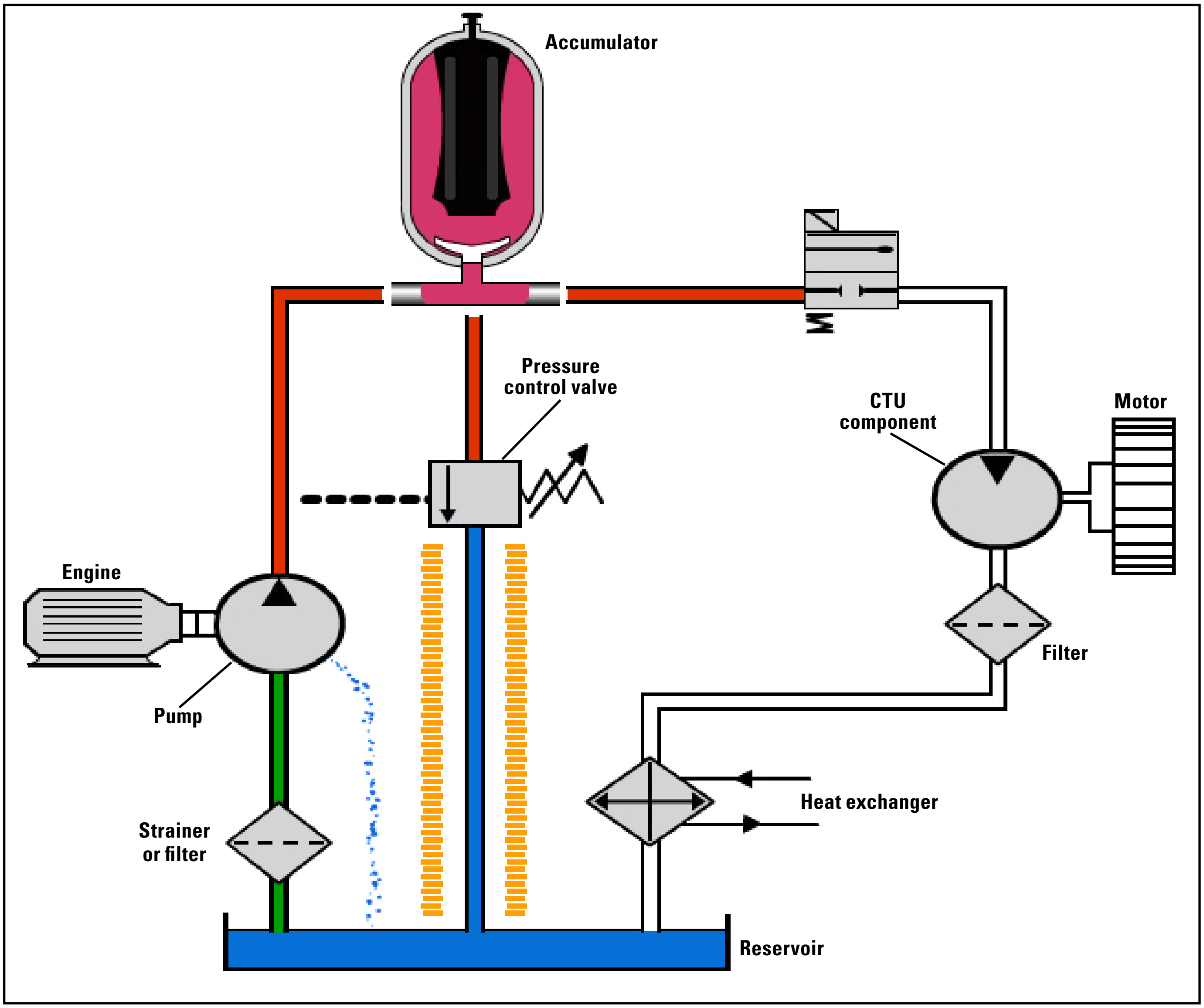

Figure 4-6. Hydraulic System Pressure Control in a Simplified Hydraulic Circuit

- pilot-operated relief valves: These valves function like preset relief valves with the addition of a pilot control valve and pilot control line connected to the relief valve. The setting of the pilot control valve can be remotely varied up to the maximum preset value of the relief valve.
- unloader valves: These valves are similar to relief valves except that when the preset maximum pressure is reached, the valve actuates to isolate the circuit and direct flow back to the reservoir. When circuit pressure is reduced, the valve actuates to recharge the circuit.

4.2 Hydraulic circuits

CTUs depend on hydraulic circuits to operate.

4.2.1 Classification

All power packs have similar basic characteristics. The main difference between them is the injector head drive circuits. Section 4.2.6 discusses these in detail.

4.2.2 Standard CTU hydraulic circuits

A standard HydraRig CTU has seven main hydraulic circuits.

4.2.2.1 Priority circuit

The priority circuit supplies the following CTU functions:

- levelwind raise/lower
- injector head two-speed selector
- injector head directional control (Monsun Tison valve)
- reel brake
- control cabin raise/lower
- inside chain tension
- outside chain tension.

Priority circuit pressure will vary between 1,800 and 2,000 psi during normal operation.

The accumulator, precharged with nitrogen at 1,000 psi, reduces the shocks within the system as functions are activated and stores hydraulic power.

4.2.2.2 BOP supply circuit

The BOP supply is a dedicated supply for controlling the BOP functions only.

The circuit pressure will vary between 2,700 and 3,000 psi during normal operation.

The accumulator is precharged with nitrogen to 1,400 psi. This accumulator stores hydraulic power, allowing limited operation of the BOP following shutdown of the power pack.

4.2.2.3 Auxiliary circuit

The auxiliary circuit supplies the following CTU functions:

- injector head hose reel spooling motor located on power pack
- BOP and injector head hose reels located on control cab
- an auxiliary supply facility allowing hydraulically operated equipment, such as jacking frames, to be connected to the CTU power pack.

This circuit operates at 2,500 psi.

4.2.2.4 Injector head drive circuit

The injector head drive circuit controls the movement of the injector head as well as the automatic injector brake.

There are three types of injector head drive circuits:

- standard open loop circuit: The maximum operating pressure of a standard open loop circuit is 3,000 psi, and the main relief valve is set at this pressure. In this type of circuit, the oil returns through a filter and heat exchanger back to the tank, after passing through the injector motors. Generally, a double vane hydraulic pump is used in this type of circuit, such as a Denison T6 series pump.
- High-pressure open loop circuit: The maximum operating pressure of a high-pressure open loop circuit is 5,000 psi, although the main relief valve is set at 4,600 psi. In this type of circuit, the oil exiting the injector motors returns to the pump inlet (not the tank) after passing through a filter and heat exchanger. A pressure relief valve in the return line ensures that oil not required by the pump is routed back to the tank. This type of circuit utilizes a variable displacement piston pump such as a Denison P16 pump.

  The advantage of this circuit over the closed loop circuit is that it generates less heat than a closed loop circuit, and can be used to power jacking substructures or cylinders.
- closed loop circuit: The maximum operating pressure of a high-pressure open loop circuit is 5,000 psi and the main relief valve is set at 4,600 psi. In this type of circuit, oil returns through a filter and goes directly back to the pump inlet (not the tank). The closed loop circuit uses a flush circuit to replenish internal leaks and add cool oil into the low side of the loop to stabilize the oil temperature.

  The closed loop injector drive circuit uses a bidirectional, variable displacement piston pump, such as a Denison P11 or P14 pump. The pump actually comprises three pumps: main pump, charge pump (charges the main pump), and servo pump (shifts the swash plate).

Section 4.3.1 provides more information about these types of circuit.

4.2.2.5 Stripper circuit

The stripper hydraulic circuit compresses the stripper element to form a seal around the CT string.

The circuit is driven by a Haskell air-over hydraulic pump, controlled from inside the control cabin. It has an operating pressure of 5,000 psi, although generally much lower pressures are required.

Because of the importance of the stripper function, the Haskell air-over-hydraulic pump has two backup systems in case of failure. The Haskell pump may be operated manually, or a separate manual Rucker pump may be used.

The Haskell and Rucker pumps can also be used to provide backup hydraulic power to control the BOP and injector head traction skates.

4.2.2.6 Levelwind override circuit

The levelwind override circuit allows the operator to manually override the automatic side-to-side movement of the levelwind, to make minor adjustments while spooling the CT. The same circuit is used to raise and lower the levelwind arm. The circuit operates at 2,500 psi.

4.2.2.7 Reel drive circuit

The reel drive hydraulic circuit drives the reel motors, which control the rotation of the CT reel. The circuit operates at 2,500 psi.

4.3 Engine control panel

Typically, the engine has controls and instrumentation mounted on the side of the power pack (see Fig. 4-7).

The following describe the components shown in Fig. 4-7.

- The check engine light indicates a abnormal operating condition for the engine.
- The engine rpm gauge monitors engine speed.
- The engine start switch sends an air signal to the starter.
- The engine stop/run switch is a switch in the battery circuit. On stop, it acts as an electrical disconnect. On run, it connects the battery circuit to the CTU components that require electrical power.

  It also deactivates/activates the cylinder that closes the fuel rack for normal engine stop. The fuel rack is a valve, which shuts off the flow of fuel to the engine when it is closed.
- The emergency stop button sends air to a miniature cylinder that trips a latch and shuts off the air intake to the engine. This button should only be used in emergencies.
- The engine throttle knob sends regulated air pressure to the throttle actuator controlling the fuel rack, which controls engine speed.
- The hour meter displays engine run time in hours. It is used to schedule the unit for STEM 2 and 3 checks.
- The oil pressure gauge monitors engine oil pressure, which will vary greatly from one engine to another depending on its age and how well it has been maintained.
- The voltmeter monitors the battery condition.
- The water temperature gauge monitors engine temperature.

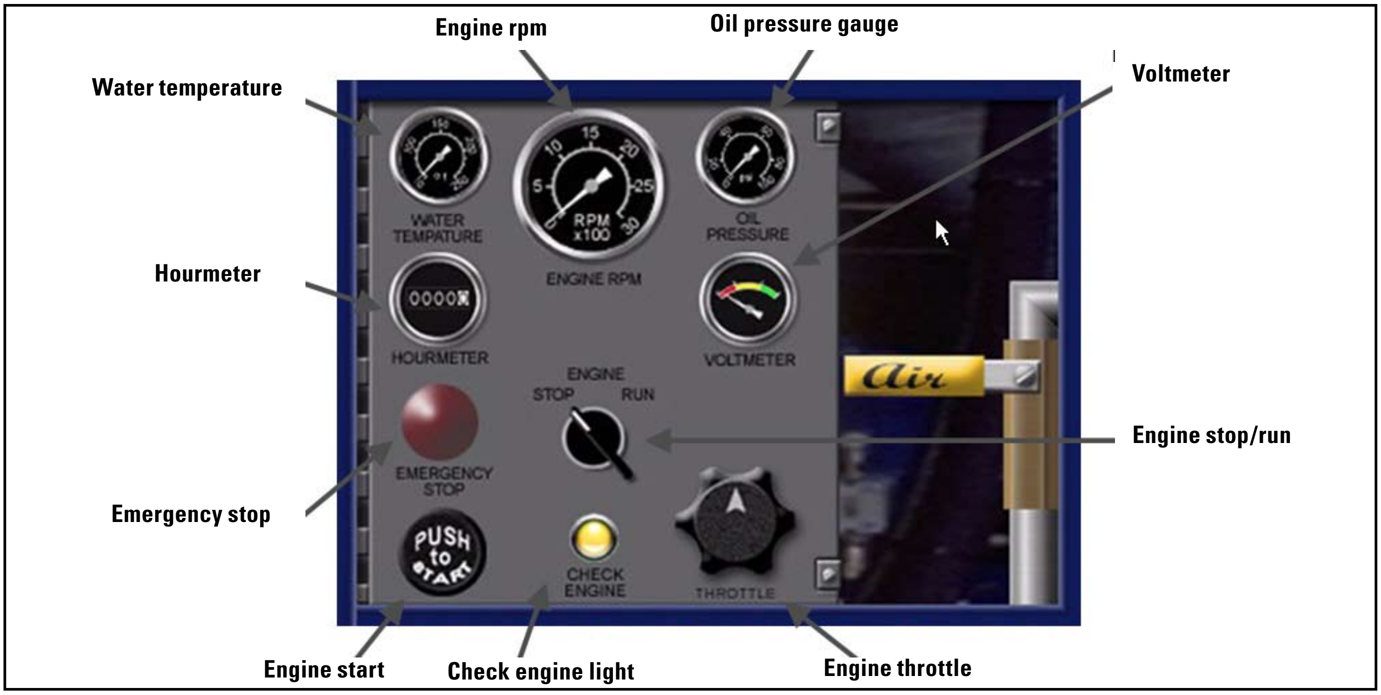

Figure 4-7. Engine Control Panel

4.4 Hydraulic control panel

All standard engines have hydraulic controls and instrumentation mounted on the side of the power pack; see Fig. 4-8.

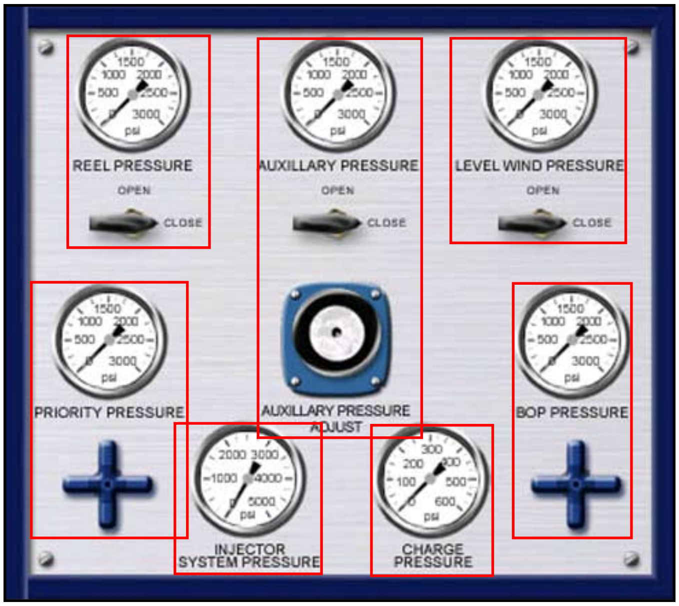

Figure 4-8. Hydraulic Control Panel

The following describe the components of the control panel.

- The auxiliary two-way valve, auxiliary pressure adjust, and pressure gauge control and monitor the auxiliary circuit that powers the crane, hose reel, and auxiliary equipment.

  The auxiliary two-way valve opens and closes the auxiliary circuit. When open, the valve allows hydraulic pressure from the auxiliary pump into the circuit.

  The auxiliary pressure adjust valve controls the pressure on the auxiliary circuit. The pressure can be monitored on the auxiliary pressure gauge.

- The BOP needle valve and pressure gauge control and monitor the BOP circuit, which powers the BOP rams.

  When actuated, the BOP needle valve opens or closes the BOP circuit. For example, turning it clockwise allows hydraulic pressure from the pump into the BOP circuit. Turning it counterclockwise routes the pressure back to the hydraulic reservoir.

- The charge pressure gauge monitors the setting of the preset relief valve used to maintain 80-psi back pressure on the pump inlet, on units with high-pressure open loop circuits.

  On units with closed loop circuits, this gauge monitors the pressure on the flush circuit.

- The injector system pressure gauge monitors the pressure from the injector pump into the injector circuit, which powers the injector motor and brake.

- The levelwind two-way valve and pressure gauge control and monitor the levelwind circuit, which powers the levelwind assembly on the reel.

  The two-way valve opens and closes the levelwind circuit. When open, the valve allows hydraulic pressure from the levelwind pump into the circuit.

- The priority needle valve and pressure gauge control and monitor the priority circuit, which is one of the most important in the hydraulic system. It powers several components including the following:

  ○ injector head traction cylinders

  ○ injector head outside tension cylinders

  ○ injector motor direction

  ○ injector high-low velocity

  ○ reel brake

  When actuated, the priority pressure needle valve opens or closes the priority hydraulic circuit. Turning it clockwise allows hydraulic pressure from the pump into the priority circuit. Turning it counterclockwise routes the pressure back to the hydraulic reservoir.

- The reel two-way valve and pressure gauge control and monitor the reel circuit. When open, the valve allows hydraulic pressure from the reel pump into the circuit.

> **Note:**
> The pressure on the reel circuit is controlled by the reel pressure adjust valve, which is not on the power pack hydraulic control panel. The reel pressure adjust valve is on the control console, described in Section 5.0.

4.5 Pneumatic system

For safety and reliability, current power pack design requires an air supply for certain functions such as engine start, engine kill, throttle, and fuel combustion.

To perform these functions satisfactorily, the power pack has its own air system (pneumatic system; see Fig. 4-9). This system allows the power pack to operate independently of other CTU air systems after the engine is started.

The following describes the components of the control panel.

- The air compressor compresses air from an initial intake pressure to a higher discharge pressure.
- The air filter cleans the air supply.
- The storage tanks store the discharged airflow. Discharged air flows through a heat-resistant line to a check valve and into the tank.

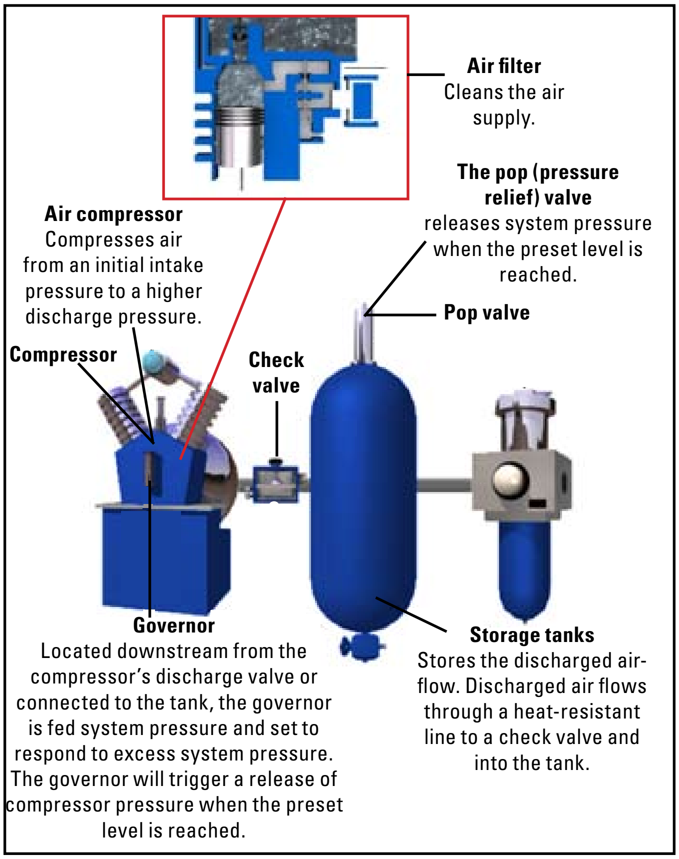

Figure 4-9. Pneumatic System

- The governor, located downstream from the compressor's discharge valve or connected to the tank, is fed system pressure and set to respond to excess system pressure. The governor will trigger a release of compressor pressure when the preset level is reached.
- The pop (pressure relief) valve releases system pressure when the preset level is reached.

4.6 STEM 1 check on CTU power pack

The guidelines for performing a STEM 1 check on the CTU power pack are discussed in the following sections. This procedure should be carried out before and after every CT job, or at regular intervals during longer operations.

On completion of the STEM 1 check, the STEM 1 report should be signed. The information must be placed in the Fleet Assistant system, which tracks the maintenance of the equipment fleet at each location.

4.6.1 Hydraulic hoses and connections

The hydraulic hoses and connections require careful inspection and maintenance.

> **Caution:**
> The fluid inside the hydraulic hoses is under great pressure. If a leak develops or a line bursts, personnel can be injured or equipment damaged.

- Inspect hydraulic hoses and hose bundles for evidence of wear, damage, or leaks.
- Ensure hose bundle ties and securing chains or straps are in good order and appropriately adjusted.
- Check hydraulic hose connection seals and the O-rings securing/latching mechanism.
- Check connection protectors.
  - Ensure connections are clean before making up a connection and that dust caps are fitted after breaking out a connection.
  - Ensure the hose identification tag (or similar connection coding system) is clean and clearly visible.

4.6.2 Power train components oil and lubrication

The power train components need to be well lubricated to operate correctly.

- Check for oil leaks. Check around engine and gearbox area for evidence of wear, damage or leaks.
- Check engine oil level.
- Check level and observe general condition of engine oil.
- Check level and observe general condition of gearbox oil.

4.6.3 Air and fuel systems

Maintain the air and fuel systems as follows.

- Check air filter.
- Check the condition of the engine intake air filter(s) and observe general condition of air ducting and fittings.
- Where fitted, check the condition of exhaust system flame traps.
- Check and drain water/moisture from fuel reservoir drain cock.

4.6.4 Cooling system

Maintain the cooling system as follows:

- Check the level and general condition of engine coolant.
- Observe the condition of key cooling system components and check for evidence of wear, damage, or leaks.

4.6.5 Hydraulic system

Maintain the hydraulic system as follows:

- Check hydraulic fluid level.
    - Check the level and general condition of the hydraulic fluid.
    - Drain any water from the hydraulic fluid reservoir.
- Check hydraulic system relief valves. Visually check that the hydraulic system relief valve lock nuts are secure.

4.6.6 Pneumatic system

Drain water or emulsion from air receiver and secure the receiver drain valve.

4.7 STEM 2 check of CTU power pack

A STEM 2 check should be carried out every 750 hours of power pack operations. Guidelines for STEM 2 checks can be found in the CT Surface Equipment Maintenance program (InTouch Content ID# 4196880).

This page left intentionally blank

5.0 Control Console

This section introduces you to the control console and how it is used to control the operation of the CTU (Fig. 5-1). The major components of the CTU are driven by several hydraulic control systems located in the power pack. The hydraulic systems use fluid pressure to drive the CTU components.

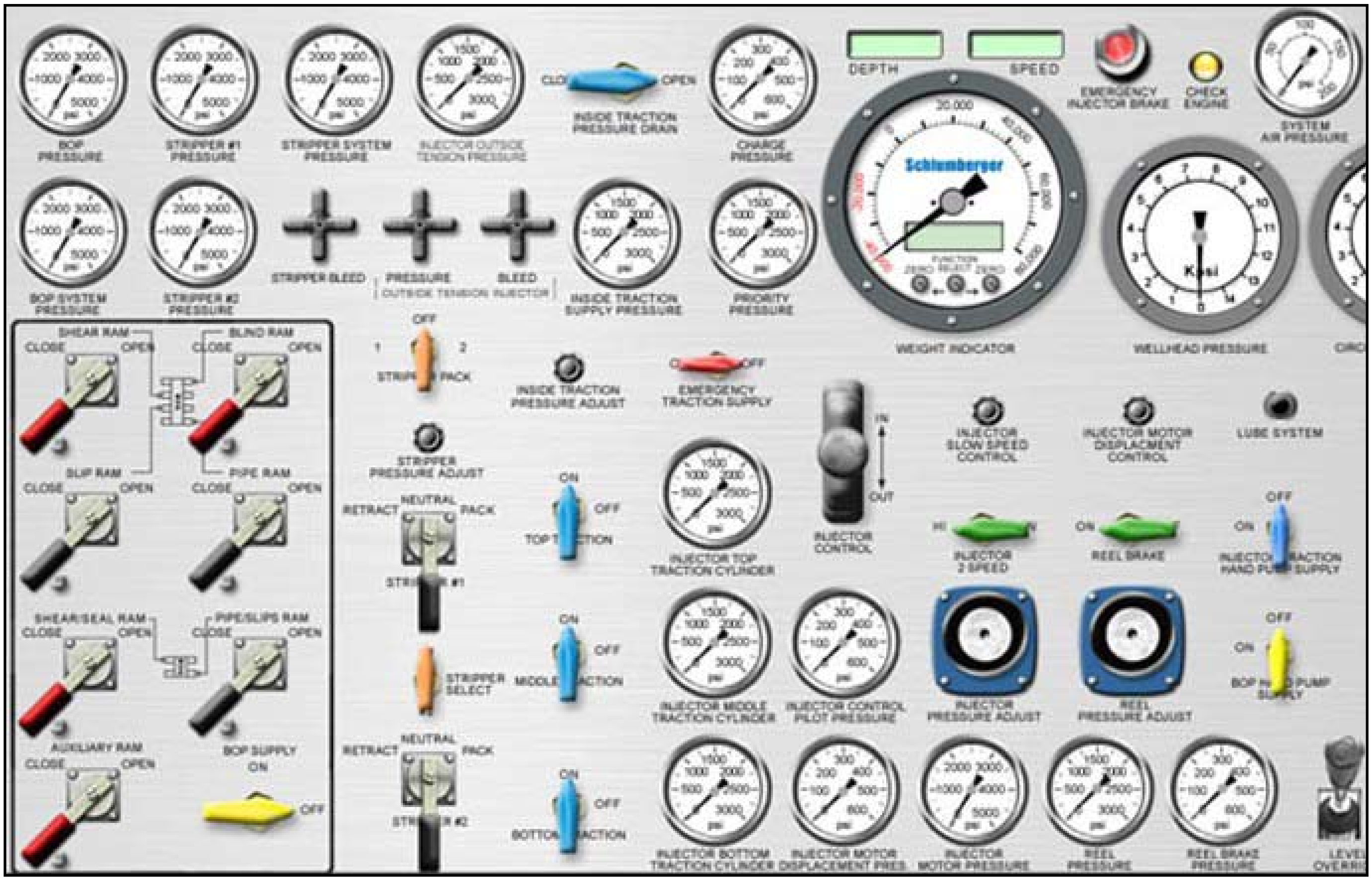

Figure 5-1. Control Console

The CT operator controls the power pack hydraulic systems from the control console. Control console design varies by manufacturer, but normally all controls are positioned on one console. The console includes all the controls and gauges required by the CT operator to control and monitor operation of all CTU components (see Fig. 5-2).

Figure 5-2. Controls and Gauges to Operate CTU Components

5.1 Control console components

The control console provides the CT operator with the controls to perform the following:

- perform reel and injector head operating functions required to move and hold the CT string
- control pressure control equipment (stripper, BOP).

The console also provides gauges for monitoring and recording the principal operating parameters (Fig. 5-3), including

- wellhead pressure monitored at the wellhead
- circulating pressure monitored at the reel
- tubing weight at the injector head
- tubing depth.

Figure 5-3. Control Console Gauges for Principal Operating Parameters

5.2 Control console functional areas

The control console comes in a variety of configurations depending on the manufacturer's specifications and CTU design or model. Figure 5-1 shows the layout of a typical control panel.

Regardless of its configuration, every console is designed to achieve the following basic functions:

- well control
- drive chain traction and tension
- injector motion and direction
- reel motion and direction
- engine remote control
- system monitoring.

5.2.1 Well control

The control console contains the controls for the BOP and stripper (see Fig. 5-4).

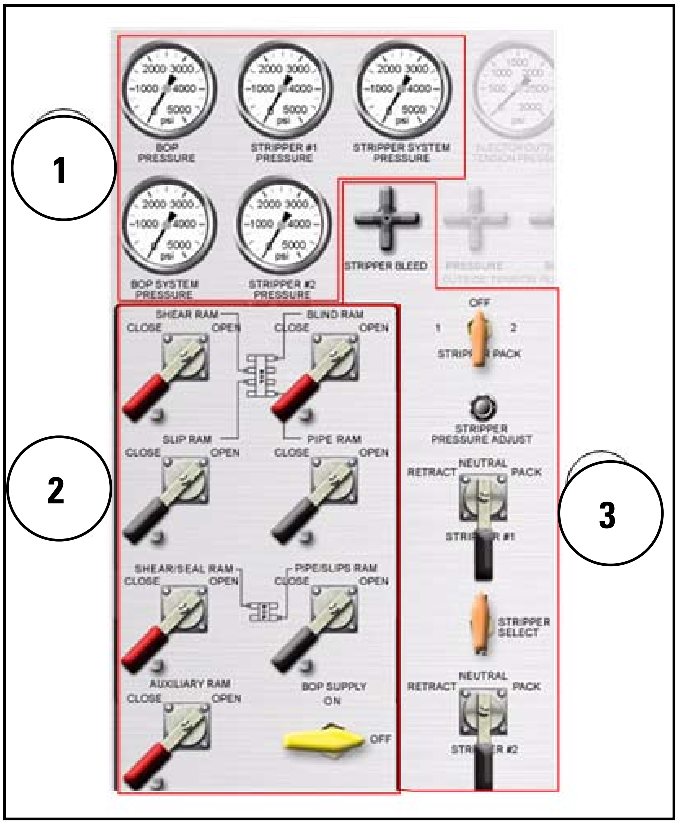

Figure 5-4. BOP and Stripper Controls

The CT operator can do the following from the control console:

- 1-monitor the BOP and stripper hydraulic pressure
- 2-open and close the BOP rams
- 3-select and control the hydraulic pressure to the stripper.

You will learn more about the operation and control of the BOP and stripper in Section 7 of this module. More detailed information on well control equipment can be found in JET 13, CT Pressure Control Equipment, InTouch Content ID# 4221744.

5.2.2 Drive train traction and tension

The injector traction system uses traction cylinders to apply force to the gripper blocks on the injector drive chains. The force holds the CT string during operations. This is often referred to as *inside traction*.

The tension system uses tension cylinders to take slack from the injector drive chains. This is often referred to as *outside tension*.

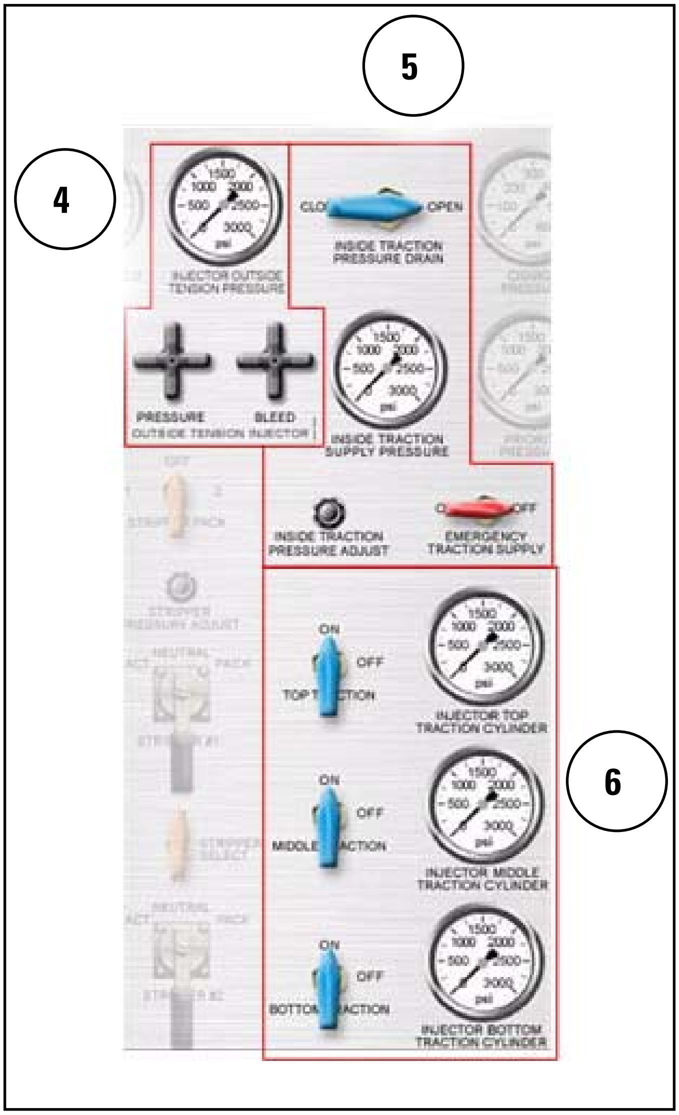

Figure 5-5. Tension Controls

The CT operator can do the following from the control console (see Fig. 5-5):

- 4-control and monitor the hydraulic pressure to the tension cylinders
- 5-independently control and monitor the hydraulic pressure to the traction cylinders. In an emergency, these allow the full system pressure to the cylinders, bypassing the traction adjust.
- 6-isolate and monitor the traction cylinders.

You will learn more about the operation and control of the drive chain traction and tension systems in Section 6.4.

5.2.3 Injector motion and direction

The injector motors control the movement of the tubing. To ensure correct CT motion and direction, the CT operator must properly set the injector motors' controls. Figure 5-6 shows the controls for the injector motors.

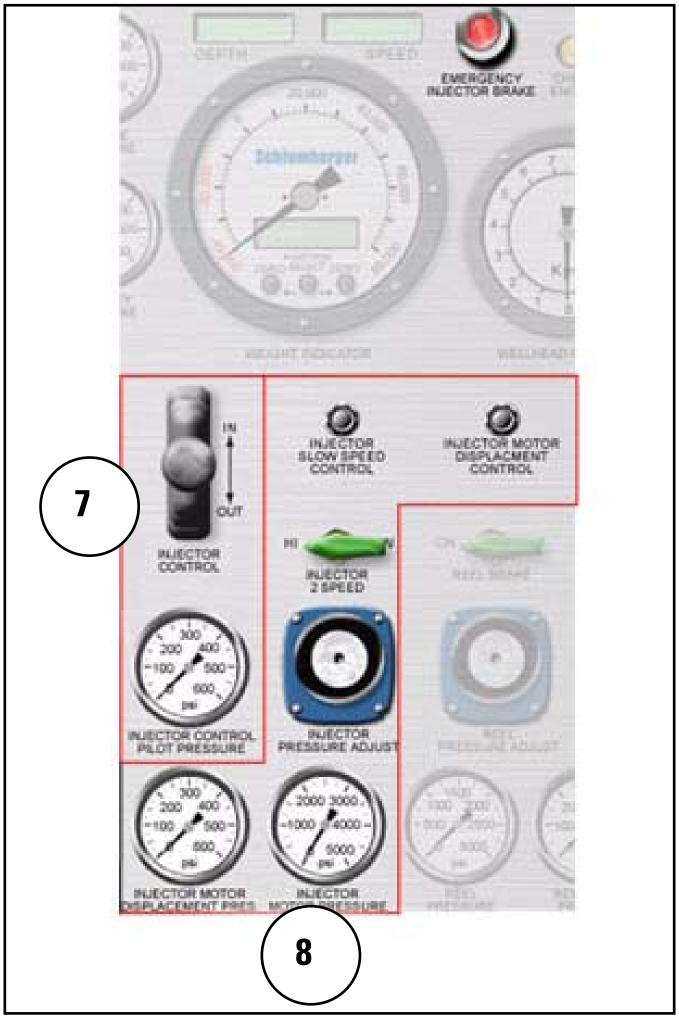

Figure 5-6. Injector Motor Controls

The CT operator can do the following with these controls:

- 7-control and monitor the hydraulic pressure to the direction control valve for the injector motors
- 8-control the speed of and pressure at the injector motors.

You will learn more about the operation and control of the injector head motors in Section 6.

5.2.4 Reel motion and direction

The controls for the reel are usually on the lower right portion of the panel; see Fig. 5-7.

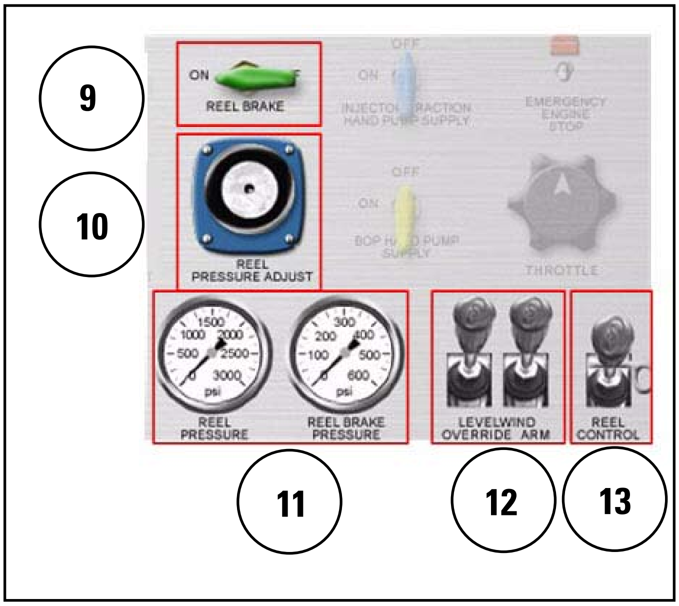

Figure 5-7. Reel Controls

The CT operator can do the following with these controls:

- 9-turn the reel brake on and off
- 10-adjust the hydraulic pressure at the reel motor
- 11-monitor reel pressure and reel brake pressure
- 12-control the movement and direction of the levelwind
- 13-control the direction of the reel motor.

You will learn more about the operation and control of the reel in Section 6.5.

5.2.5 Power pack engine remote control

The CT operator can remotely control the power pack engine from the control console (Fig. 5-8).

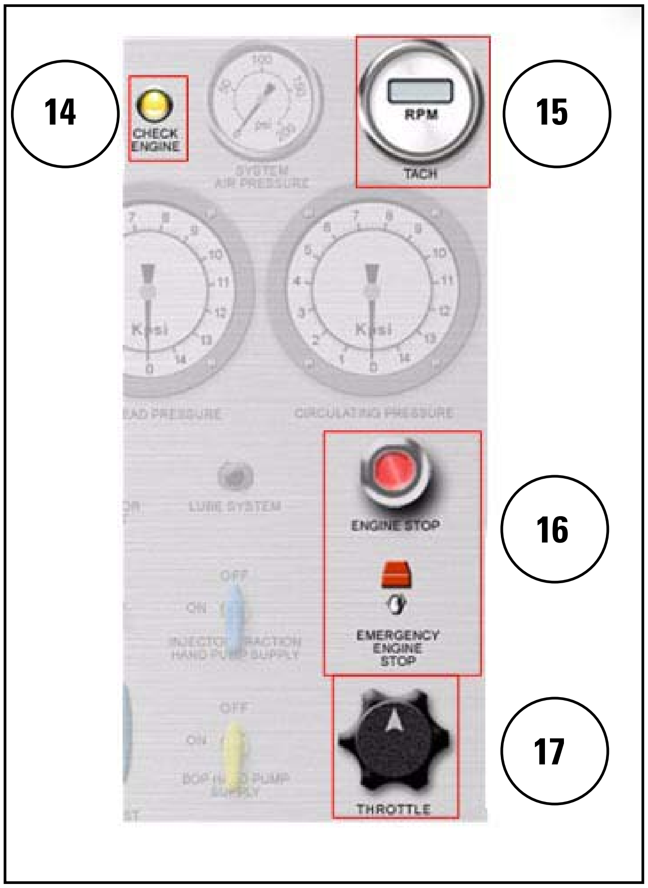

Figure 5-8. Power Pack Controls

The CT operator can do the following with these controls:

- 14-monitor engine status
- 15-monitor engine rpm. The gauge also appears on the engine control panel
- 16-stop the engine
- 17-adjust the throttle to control engine speed. This control also appears on the engine control panel.

5.2.6 System monitoring

There are several gauges and indicators that the operator can use to monitor the CTU system (Fig. 5-9).

The CT operator can monitor the following with these gauges.

- 18-the weight of the CT string as measured by a load cell installed at the injector head
- 19-the wellhead pressure (WHP) measured by a sensor installed on the BOP
- 20-the circulating pressure measured by a sensor installed at the reel manifold
- 21-the depth of the tubing
- 22-the movement of the CT string
- 23-the pressure in the priority hydraulic circuit, which is one of the most important circuits of the CTU (the same gauge is on the engine control panel)
- 24-the pressure at the charge pump (the same gauge is on the engine control panel).

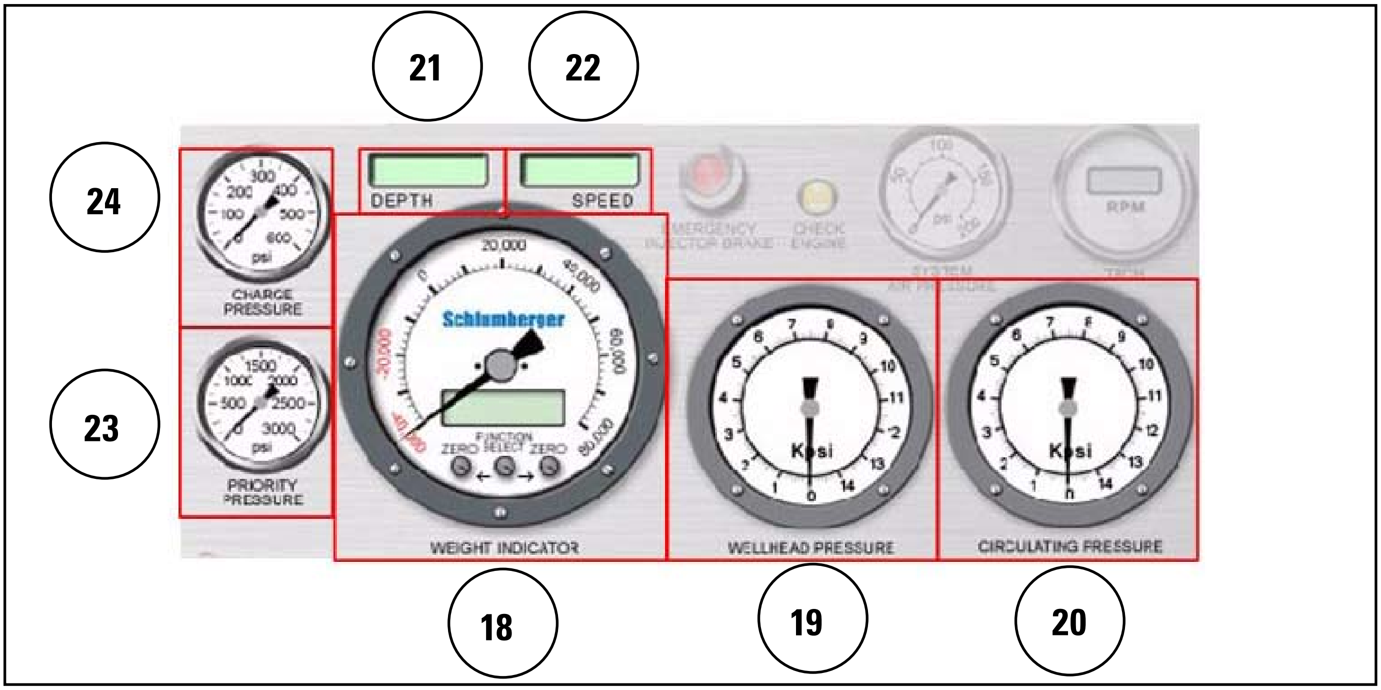

Figure 5-9. System Monitoring Gauges and Indicators

5.2.7 Haskell and Rucker pumps

The Haskell and the Rucker pumps are primarily used to supply pressure to the stripper. The Haskell is an air-driven pump that is controlled by the stripper pressure adjust valve.

The Rucker is a manual pump that is normally used as a backup in case of an emergency in which the system air pressure is lost.

The Haskell and Rucker pumps perform a very important secondary function in an emergency. The CT operator can energize the BOP, stripper, and drive chain traction system circuits by activating the injector traction and BOP hand pump supply valves (Fig. 5-10). This allows pressure control to be maintained if a major equipment component fails.

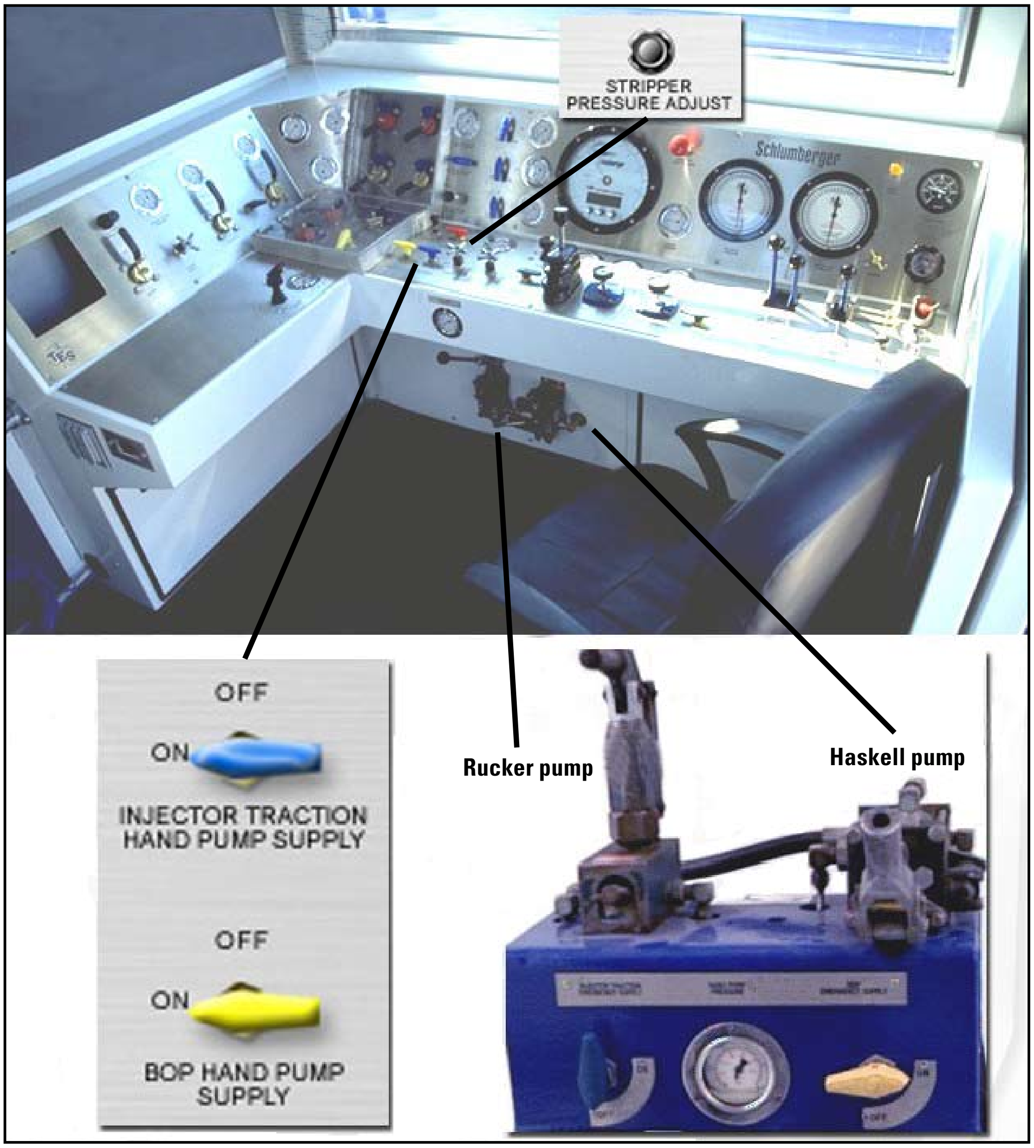

Figure 5-10. Emergency Pump Controls

5.3 Instrument scanning

To detect unusual circumstances as soon as possible, the operator must constantly scan the CTU instrument array during a CT operation.

All personnel who will operate a CT unit should become comfortable with running a simulated CT unit using the CoilSIM simulator. This can be downloaded at InTouch Content # 4067660.

5.3.1 Priority level 1

The following instruments, gauges, and locations are priority level 1 because they can change quickly during an operation. The operator should scan these at all times, except when checking the priority levels 2 and 3 instruments and gauges.

- weight indicator display
- wellhead pressure gauge
- circulating pressure gauge.
- injector head/wellhead
- CT reel.

5.3.2 Priority level 2

The following instruments and gauges are less likely to change rapidly and are assigned a priority level 2. Priority level 2 items should be checked every 2 to 3 minutes.

- depth measurement system
- stripper pack pressure
- inside chain tensioner system.

In addition, the flow and auxiliary equipment location is assigned a priority level 2.

5.3.3 Priority level 3

The following instruments and gauges are generally static throughout the operation. They do not normally require adjustment and are assigned a priority level 3. All of the systems and locations in this priority level should be checked every 4 to 5 minutes.

- power pack engine gauges
  - oil pressure
  - coolant temperature
  - air supply
- pressure gauges for
  - priority circuit
  - BOP circuit
  - stripper system supply
  - injector motor and direction
  - outside chain tension
  - inside chain tension supply
  - reel back tension.

5.4 STEM 1 check for control cabin

A STEM 1 check should be carried out before and after every CT job, or at regular intervals during longer operations.

On completion of the STEM 1 check, the STEM 1 report form should be signed. The information must be placed in the Fleet Assistant system, which tracks the maintenance of the equipment fleet at each location.

For the most up-to-date STEM guidelines, refer to the CT Surface Equipment Maintenance program (InTouch Content ID# 4196880).

5.4.1 Power pack controls and instrumentation

Perform the following checks.

- Check remote engine controls.
  - Check operation of engine remote control systems.
  - Check operation and response of engine gauges and instrumentation.

- Check hydraulic system controls.
  - Check operation of hydraulic system controls.
  - Check operation and response of primary hydraulic system gauges and instrumentation.

5.4.2 CTU controls and instrumentation

Perform the following checks.

- Check injector head controls.
  - Check operation of chain tension control systems.
  - Check operation and response of injector head control system.
  - Check operation and response of gauges and instrumentation.
- Check reel controls.
  - Check operation of reel drive and control systems.
  - Check operation and response of reel control system.
  - Check operation and response of gauges and instrumentation.
- Check stripper controls.
- Check operation of stripper control systems.
- Function test standby and emergency stripper control equipment.
- Check operation and response of stripper system gauges and instrumentation, including standby and emergency systems.
- Check BOP controls.
  - Check operation of BOP control systems.
  - Function test stand-by and emergency stripper control equipment.
  - Check operation and response of BOP system gauges, including standby and emergency systems.
- Check general controls, instrumentation and equipment such as lights, window wipers, horn, and heater.

5.5 STEM 2 check for control cabin

A STEM 2 inspection should be carried out every 750 hours of CTU operations. Guidelines for STEM 2 checks can be found in the CT Surface Equipment Maintenance program.

6.0 CT Reel

This section explains the function and major parts of the reel and its hydraulic system (Fig. 6-1). It also explains how to control the reel from the control console.

Figure 6-1. CT Reel

The primary function of the reel assembly is to store and protect the CT string. The reel system uses the reel drum and crash frame to perform this function.

The reel also performs several other functions including the following:

- maintains proper tension between the reel and the injector head
- efficiently spools the CT string onto the reel drum
- circulates fluids through the CT string with the reel drum rotating
- allows the introduction of balls or darts into the CT string
- provides a mounting for the tubing lubrication, monitoring, and measuring equipment.

The reel equipment is grouped into the following systems or assemblies:

- reel drum
- reel drive and brake system
- levelwind assembly
- depth counter
- lubrication system
- reel swivel and manifold.

6.1 Reel drum

The reel drum assembly generally consists of the following:

- drum axle
- flanged connection on the axle to allow the swivel to be connected
- chain sprocket on the axle by which the drum is driven
- second chain sprocket on the axle by which the levelwind lead screw is driven.

The reel axle bearings are mounted and secured on support posts, which form part of the reel chassis.

> **Warning:**
> The reel must not be transported with only the hydraulic brake to secure it against rotation. The reel must also be secured against rotation in both directions with chains and binders between the rim of the drum and a point on the reel chassis. Figure 6-2 shows a reel chained to the frame on both sides.

Figure 6-2. Reel Chained on Both Sides

Reels that have installed wireline require a modified axle to allow an electrical collector to be fitted to the axle.

6.1.1 Calculating reel capacity

The theoretical tubing capacity of any drum can be calculated using the following equation, illustrated by Fig. 6-3. This method assumes perfect spooling across the width of the drum. However, in practice this is difficult to achieve, therefore an allowance must be made for a capacity slightly less than calculated.

$$L = (A+C)\,(A)\,(B)\,(K)$$

where

- L (ft) = tubing capacity
- A (in) = flange rim to core distance–freeboard
- B (in) = width between flanges
- C (in) = reel drum core diameter
- K = K-value for different tubing sizes.

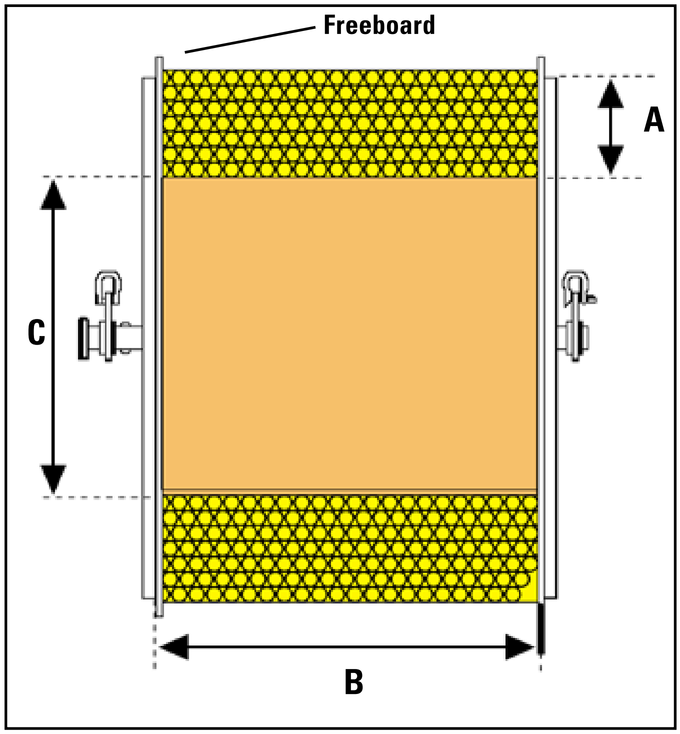

Figure 6-3. Calculating Tubing Capacity of Drum

The freeboard is the amount of space between the top of the external wrap of CT string and the OD of the reel drum.

The minimum recommended freeboards for different sizes of CT string are given in Table 6-1.

Table 6-1. Freeboard for CT String

Size of CT String (in)	Minimum Recommended Freeboard (in)
1	1.5
1 1/4	1.5
1 1/2	2.0
1 3/4	2.0
2	3.0
2 3/8	3.0
2 7/8	3.5

Each different size of CT string has a K-value given by Table 6-2:

Table 6-2. K-Values of CT String

Size of CT String (in)	K-Value
1	0.262
1 1/4	0.168
1 1/2	0.116
1 3/4	0.086
2	0.066
2 3/8	0.0464
2 7/8	0.0317

6.1.2 Drop-in drum reels

A special type of CT reel has been developed to allow easier management of CT strings, especially the larger and heavier strings. Drop-in drum (DID) reels allow the reel drum to be easily separated from and reattached to the power stand. Figures 6-4 through 6-6 show the DID.

Figure 6-4. DID Reel Drum

Figure 6-5. DID Reel Power Stand

Figure 6-6. DID Assembled

When separated, the CT reel can be transported as two separate and lighter lifts, and reassembled on site. This capability is particularly important in an offshore environment, where a platform or rig crane may not be able to handle the weight of the entire CT reel.

This system also allows increased flexibility in changing CT strings. On a standard reel, changing CT string is quite a lot of work; one string has to be spooled off onto another reel or transport drum, and the second string is then spooled onto the empty workreel.

Using the DID system, the first reel is lifted out of the power stand, and the new reel of tubing is simply dropped in to the stand to replace it.

You will learn more about CT spooling in JET 12, Coiled Tubing Handling and Spooling Equipment, InTouch Content ID# 4221738.

6.2 Reel drive and brake systems

The following sections describe the reel drive and brake systems.

6.2.1 Reel drive system

Though reel design and control may vary among manufacturers and reel models, all reel drive and brake systems are currently controlled hydraulically. Most reels can be powered in both the inhole and out-of-hole directions. However, during normal CT operations, only the out-of-hole option should be selected. This means that the reel motor is always trying to turn the reel drum in the pull-out-of-hole (POOH) direction, even when the CT string is been fed to the injector head. This keeps the CT string in tension.

The back pressure within the hydraulic drive system controls the torque output of the motor. This control allows the tension on the CT string between the injector head guide arch (commonly called the *gooseneck*) and reel to be varied. Generally, only sufficient tension to keep the tubing straight between the reel and injector head should be applied.

Currently, the reel drive motor is either mounted on the base of the reel chassis or directly to the reel axle. If mounted to the chassis, the reel drive motor is connected by a chain and sprockets to the reel axle. The brake is incorporated with the motor assembly (Fig. 6-7).

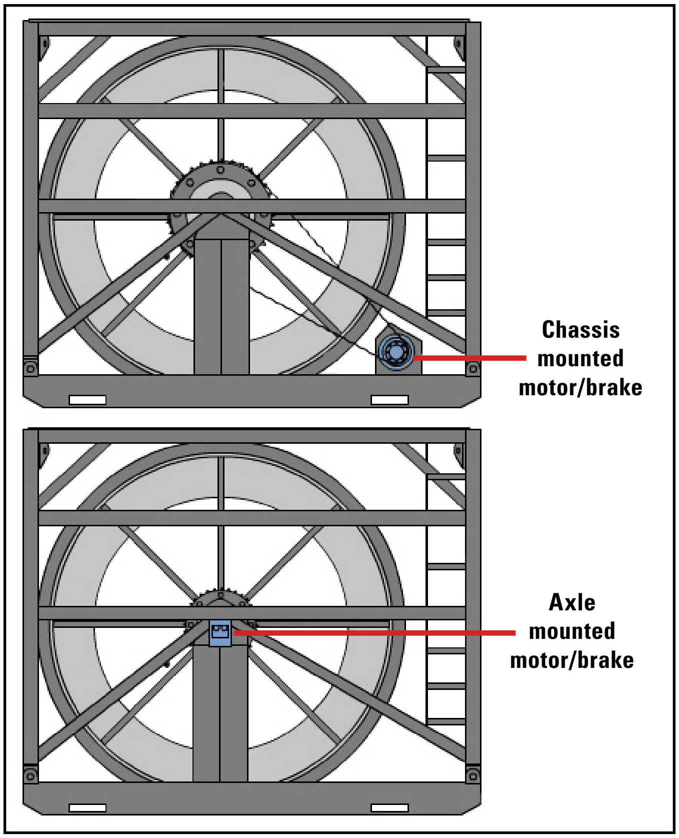

Figure 6-7. Examples of Reel Motor Brakes

The CT operator applies and monitors reel drive and brake system hydraulic pressure using the following controls and instrumentation.

6.2.1.1 Reel pressure adjust

The CT operator controls the reel to maintain proper tension on the tubing during CT operation using the controls shown in Fig. 6-8.

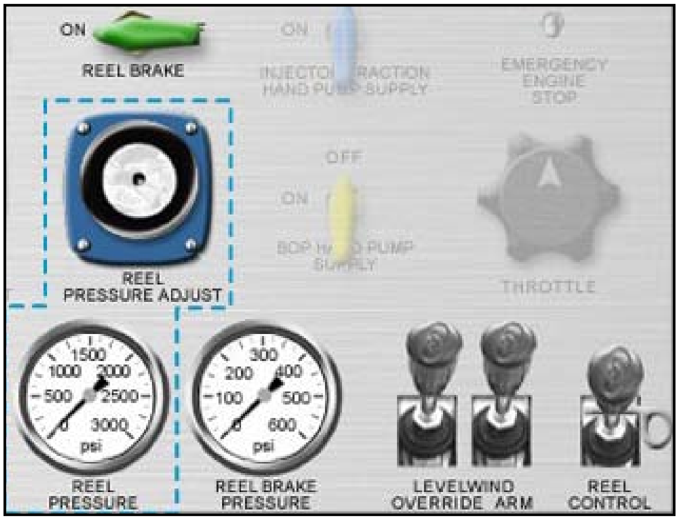

Figure 6-8. Reel Controls

- reel pressure adjust: the reel circuit hydraulically powers the reel motor and the CT operator uses the reel pressure gauge to monitor the hydraulic pressure at the motor.
- reel pressure: by varying the pressure to the motor, the operator controls the motors torque output, which controls the tension on the tubing between the reel and the injector head. Increasing the pressure increases the torque and vice versa.

The amount of hydraulic pressure required to achieve satisfactory tension will depend on the amount of tubing contained on the reel and the distance from the guide arch. Another factor that affects the required drive pressure is the weight of the tubing. This factor is noticeable when starting from a static position or when the reel contains fluids or electric line.

Tension on the tubing should be reduced while injecting tubing into the well. This reduction will allow the injector to smoothly pull the tubing off the reel.

Tension on the tubing should be increased when tubing is removed from the well so that a tight wrap is maintained on the reel while the injector is pulling at a high rate of speed.

Applying excessive tension may result in premature failure of the hydraulic and drive components or damage to the guide arch, CT string, or wellhead. Overtension combined with incorrect spooling will almost certainly result in some tubing damage. Figures 6-9 through 6-11 illustrate the effects of various levels of tension on the CT string.

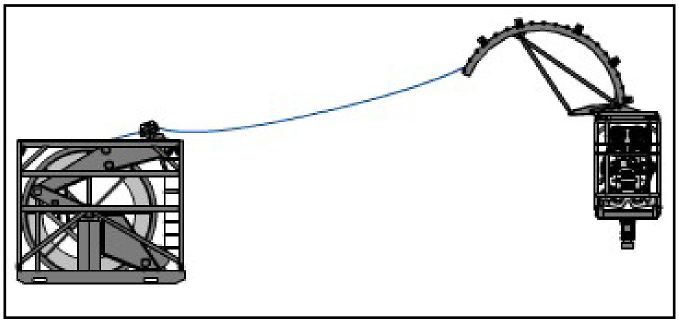

Figure 6-9. Insufficient Tension on CT String

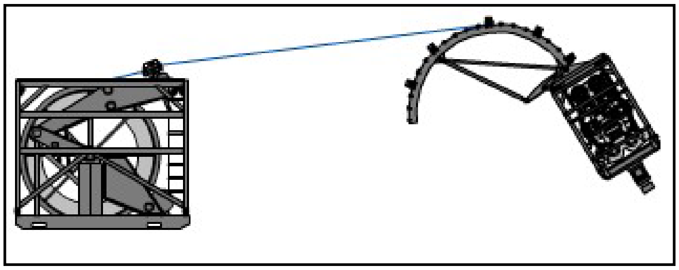

Figure 6-10. Excessive Tension on CT String

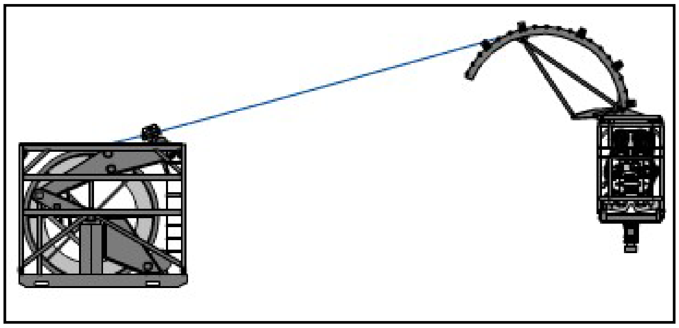

Figure 6-11. Correct Tension on CT String

For running in hole, a hydraulic pressure in the region of 400 to 600 psi is required, while a pressure in the region of 800 to 1,200 psi will be necessary for pulling out of hole.

Note:
Be advised that the reel tension affects the weight indicator readings.

6.2.2 Reel brake

The reel brake is self-actuating by an internal spring and requires 300-psi hydraulic pressure to operate the brake release. This setup ensures that the reel brake will be applied if hydraulic pressure is lost, thus immediately stopping the reel.

Warning:
Never disconnect or otherwise disable the internal spring that self-actuates the reel brake.

The CT operator sets and releases the hydraulic brake using the reel brake valve on the control console; see Fig. 6-12.

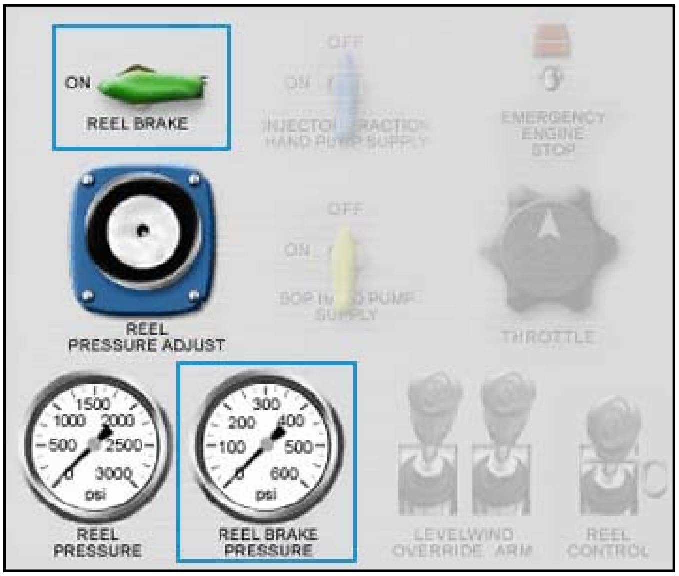

Figure 6-12. Reel Brake Controls and Gauges

The priority circuit hydraulically powers the reel brake, which means that the reel brake functions independently of the reel circuit. The operator uses the reel brake pressure gauge to monitor the pressure at the brake and ensure that the pressure is actually applied.

The brake is designed to slip if the CT string is pulled by the injector head or a runaway occurs.

> **Note:**
> Chains and binders must be used along with the reel brake to stop the reel from rotating while being transported.

6.2.3 Reel control

The CT operator uses the reel control to change the direction of the reel motor (Fig. 6-13). The reel can be powered in the inhole and out-of-hole direction.

Figure 6-13. Reel Control

During normal operations, the reel should be in the out-hole direction, even while running the CT string in hole. The action of the motor in this direction provides the necessary back tension on the CT string while running it in and out of hole.

6.3 Levelwind assembly

The levelwind assembly (Fig. 6-14) ensures close, even, and efficient spooling of the CT string back onto the reel drum. The tubing must be properly spooled so that the reel drum is used to its maximum capacity.

Poorly spooled tubing can cause mechanical damage to the string itself, as well as allowing the rate of corrosion to increase because water can penetrate more easily into the inner wraps of the spooled pipe.

The automatic movement of the traveling head needs to occur at different speeds according to the size of CT string being used, because a large OD CT fills the reel faster than a small OD CT. The different speeds are achieved by using a different sprocket for each size of CT. This sprocket turns the lead screw at a different speed for each size of pipe (the larger the CT OD, the faster it turns), which varies the speed of the traveling head.

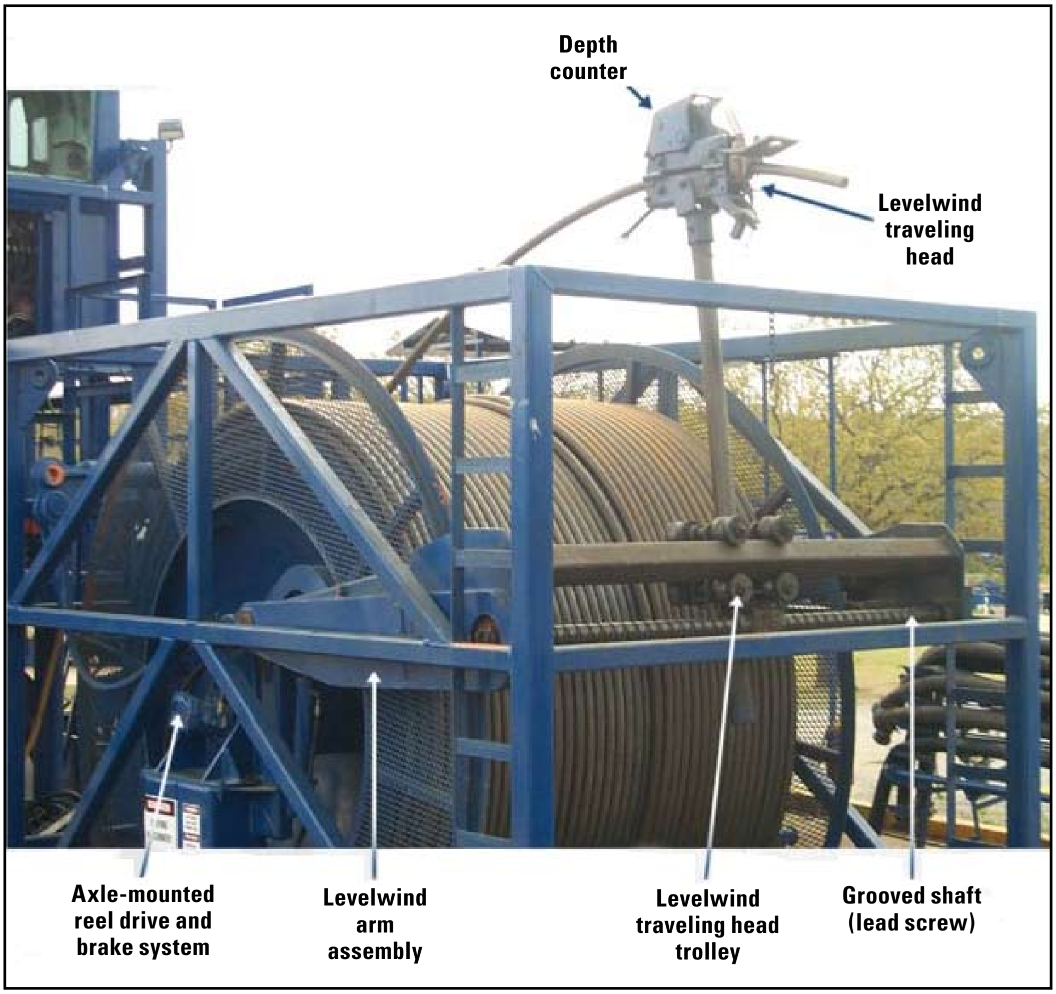

Figure 6-14. Levelwind Assembly

The operator will sometimes need to correct the traveling head position during the actual spooling of the pipe, to ensure efficient spooling on the reel drum. Two clutch plates are mounted at each side of the sprocket to allow the operator to override the automatic turning of the lead screw. This override allows the levelwind override motor to move the lead screw faster in either direction, using the levelwind override controls (Fig 6-15).

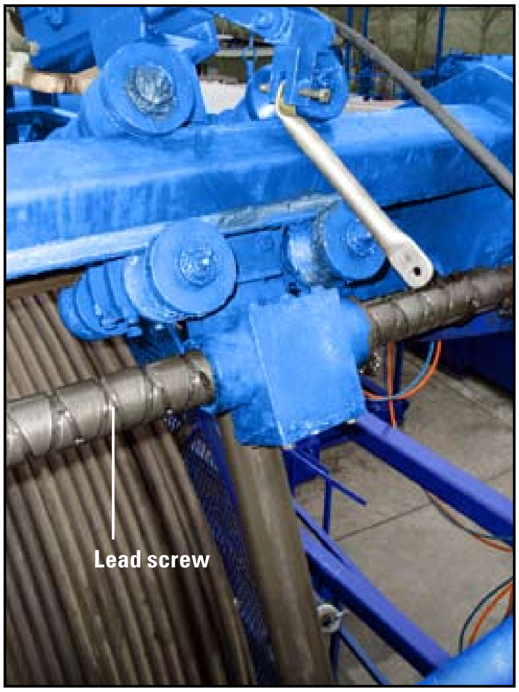

Figure 6-15. Reel Traveling Head

The operator may make adjustments to the position of the traveling head using the levelwind override (Fig. 6-16).

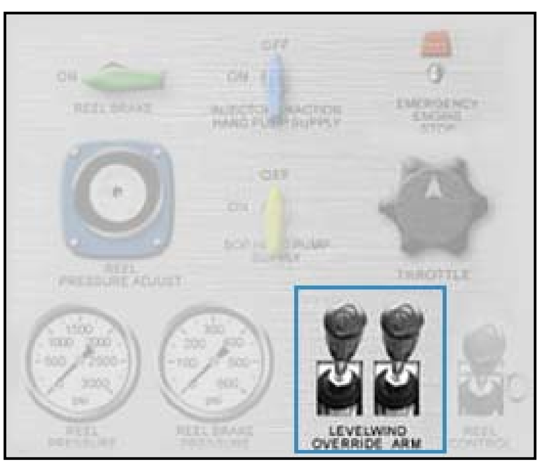

Figure 6-16. Levelwind Override Arm Control

The levelwind arm controls a piston cylinder that raises or lowers the traveling head. The level of the levelwind arm will depend on the position of the injector head relative to the reel, and will generally not change during an operation.

Counterbalance valves are mounted on the reel skid to hold the induced load (weight of the levelwind and tubing) in case of a hydraulic power loss. These valves also prevent the levelwind arm cylinders from creeping down.

6.4 Depth counter

A mechanical depth counter (Fig. 6-17) can be mounted on the levelwind traveling head or the injector head. The counter comprises a friction wheel and a mechanical counter. It reads the length of tubing reeled on and off the reel drum.

An encoder can be added to the counter. If it is added, the system becomes a depth sensor. Depth encoders are devices that convert mechanical depth signals to electrical signals to calculate a depth measurement. This depth measurement is also used to calculate the running speed of the tubing.

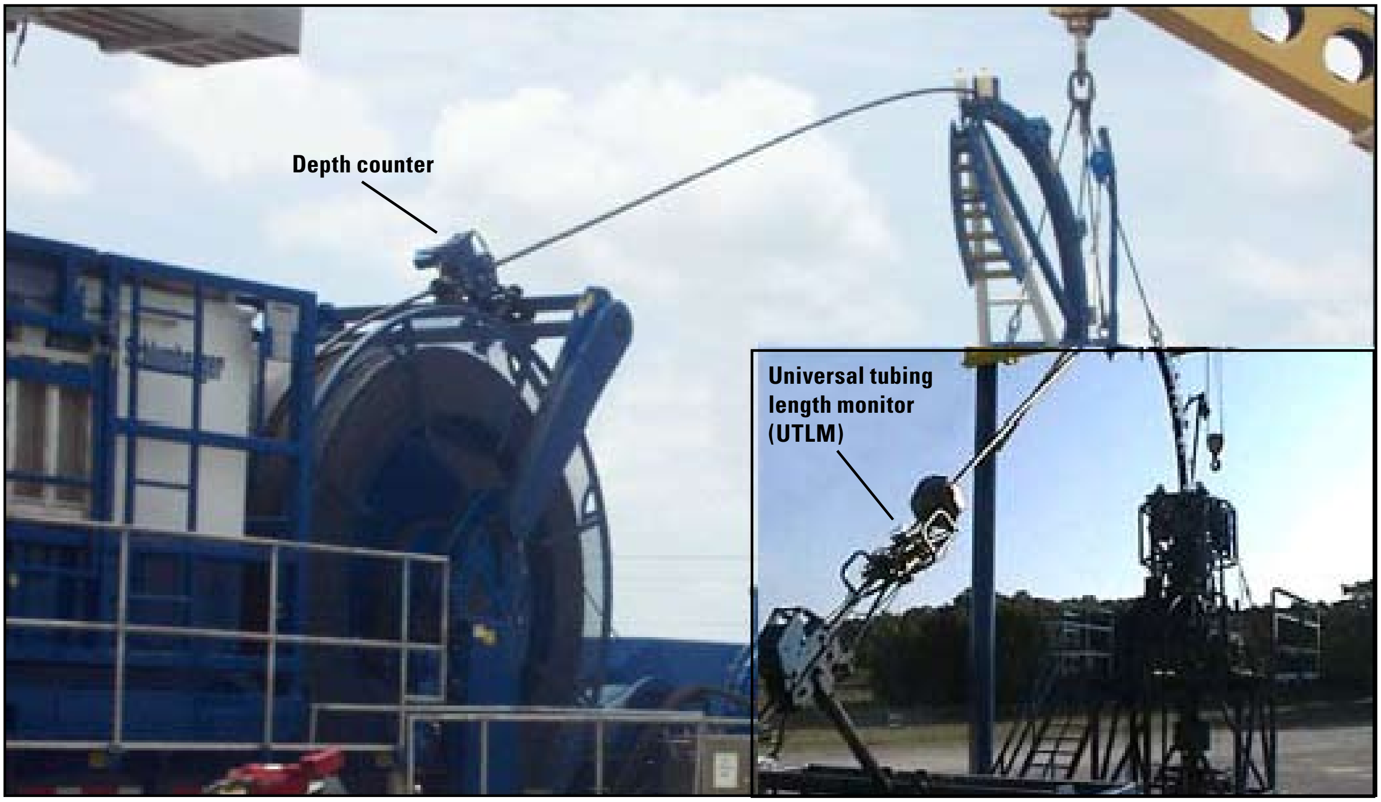

Figure 6-17. Reel Depth Counter and UTLM

Normally, the signal from the depth sensor is displayed digitally on a depth and speed indicator panel. An example of a depth sensor is the universal tubing length monitor (UTLM) show in Figs. 6-17 and 6-18.

Figure 6-18. UTLM

The CT operator can monitor tubing depth from the indicator on the control console and from the mechanical counter that is visible on the traveling head.

The levelwind mechanical depth counter also serves as a backup to the electronic sensor, in case of an emergency.

6.5 Lubrication system

The lubrication system applies an inhibitor or protective coating to the string. The system is mounted on the reel chassis; see Fig. 6-19.

Figure 6-19. Reel Lubrication System

Note:
It is important to maintain a coat of oil on the tubing to prevent corrosion. Coating the tubing also minimizes friction as the pipe goes through the stripper. However, too much oil can cause unnecessary dripping of oil. It can also cause the pipe to slip in the injector chains.

The CT operator controls the lubrication system from the control console or from the lubricating valve mounted on the lubrication tank.

6.6 Reel swivel and manifold

The swivel and manifold provide a flow path through the CT while the reel drum is rotating (Fig. 6-20). The flow path can be used to pump fluids as well as solids or to make a connection to a wireline cable installed inside the CT string.

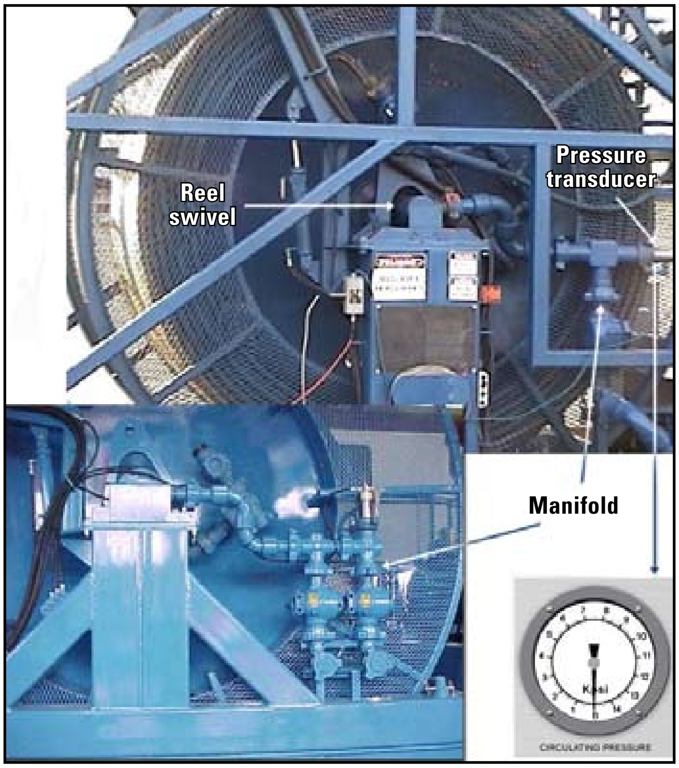

Figure 6-20. Reel Swivel and Manifold

The design and configuration of the reel swivel and manifold will vary among manufacturers. However, it will have the basic elements described in the following sections to perform its functions.

6.6.1 Swivel

The swivel (Fig. 6-21) is also called a *rotating joint*. It provides the ability to pump into the CT as the reel rotates.

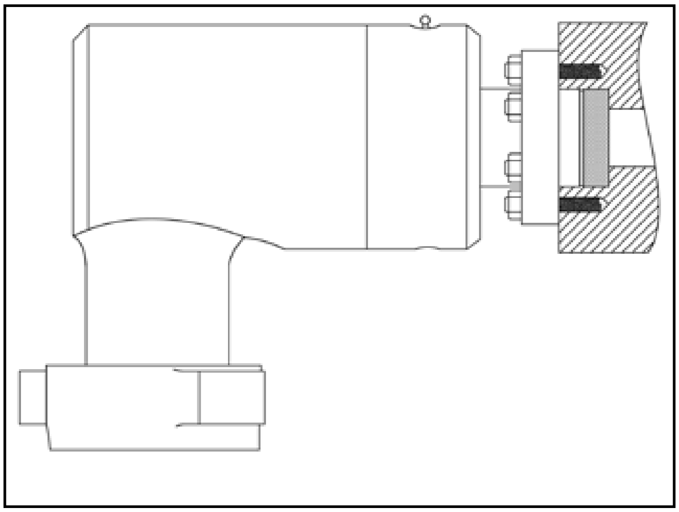

Figure 6-21. Reel Swivel

Standard reels generally come with a 1 1/4-in or 1 1/2-in ID swivel, rated to a working pressure of 10,000 psi.

> **Note:**
> High-pressure swivels, rated to a 15,000-psi working pressure, are mandatory on high-pressure operations.

> **Note:**
> Special CoilFRAC* stimulation through coiled tubing swivels are mandatory for CoilFRAC operations because of the high rates of abrasive material pumped through the swivel in these applications.

> **Note:**
> On all CT operations, it is important to have spare face seals and packings for the reel swivel in case of a leak.

The makeup of the swivel to the reel is critical. When mounting a swivel, always ensure that

- the correct type, length, and quantity of studs and nuts are used
- proper tightening sequence and torque is used when mounting or rechecking the swivels (see Fig. 6-22 for an example of what can happen if the wrong torque is applied).

Figure 6-22. Damage Caused by Incorrect Torque on Swivel

Check the manufacturer documentation to get the correct specifications for each type of reel.

6.6.2 Manifold

The treating iron and valves come in two manifolds.

- The internal manifold (Fig. 6-23) connects the swivel to the tubing on the reel drum. It includes a 2x2 Hamer valve that can isolate the CT string if required. It should be configured with a tee to allow a ball or dart to be inserted and pumped through the CT string if necessary to activate a downhole tool.

The internal manifold will be configured with a tee to install a pressure bulkhead if an electric cable is inside the CT string.

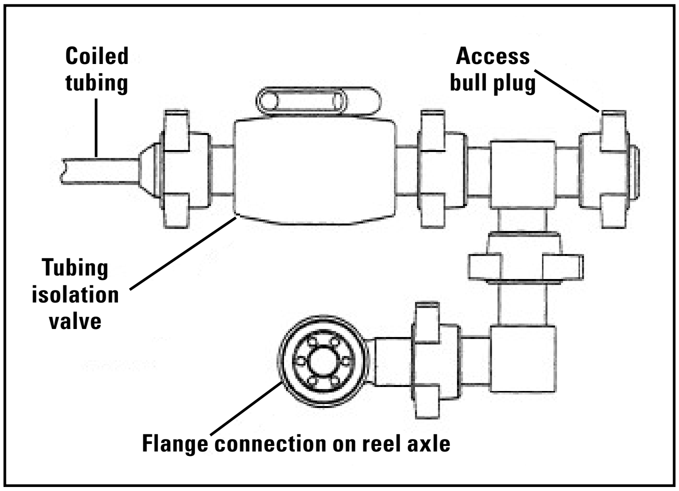

Figure 6-23. Internal Manifold

- The external manifold (see Fig. 6-24) connects the swivel to external pumps through a 2x2 Hamer valve. It also includes a 4:1 pressure debooster for the hydraulic circulation.

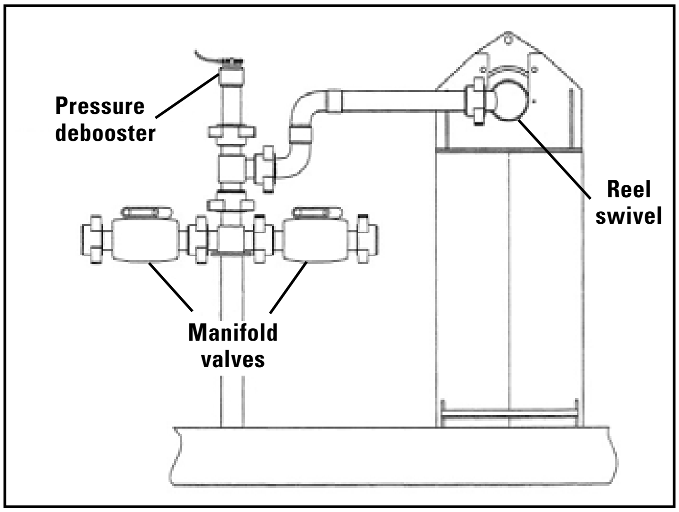

Figure 6-24. External Manifold

6.6.3 Pressure transducer

The pressure transducer monitors the circulation pressure through the CT string. The operator monitors circulating pressure at the circulating pressure gauge on the control console.

6.7 Crash protection frame

The crash protection frame for the DID reel protects the CT string from mechanical damage during transport (Fig. 6-25). The lifting pad eyes are generally integral to the crash frame.

Figure 6-25. Crash Protection Frame for DID

6.8 Changing the size of the CT

When the size of the CT string on a reel is changed, the reel levelwind sprockets that enable automatic spooling of the tubing must also be changed.

6.9 STEM 1 check for CT reel

A STEM 1 check of the CT reel should be carried out before and after every CT job, or at regular intervals during longer operations.

On completion of the STEM 1 checking process, the STEM 1 report should be signed. The information must be placed in the Fleet Assistant system, which tracks the maintenance of the equipment fleet at each location.

For the most up-to-date STEM guidelines, refer to the CT Surface Equipment Maintenance program (InTouch Content ID# 4196880).

6.9.1 Hydraulic hoses and connections

Check the hydraulic hoses and connections as follows.

- Check hydraulic hoses.
  - Inspect hydraulic hoses and hose bundles for evidence of wear, damage or leaks.
  - Ensure hose bundle ties and securing chains or straps are in good order and appropriately adjusted.
- Inspect hose connection seals, O-rings, and securing/latching mechanisms.
- Check connection protectors.
  - Ensure connections are clean before making up a connection and that dust caps are fitted after breaking out a connection.
  - Ensure the hose identification tag (or similar connection coding system) is clean and clearly visible.

6.9.2 General lubrication

Check the lubrication of the unit as follows.

- Check inhibitor/lubrication reservoir.
  - Check chain lubrication fluid level to ensure enough is available for the duration of the intended operation.
  - Ensure that reservoir caps are securely made up before operating the system.
  - Operate the chain lubrication system and visually confirm controlled application of lubricant.
  - Check/drain drip pans or containment devices are operating effectively. Ensure drip pans are drained before transportation.
- Using an appropriate grease (or lubricant where appropriate), lubricate all STEM I lubrication points.

6.9.3 Reel drive and brake systems

Perform the following checks.

- Check drive system main components.
  - Visually inspect the reel drive components for evidence of wear, damage or distortion.
  - Inspect drive system fixtures, welds and brackets for damage or wear and ensure they are secure.
  - Inspect gearbox/angle-drive housing for cracks or damage.
- Observe unusual noise or heat from the reel main bearings while reel drum is rotating.

6.9.4 Swivel and fluid manifold

> **Warning:**
> Before entering the reel drum core or conducting work on the reel drum, ensure that the reel brake is applied, and that the reel is chained and secure.

- Inspect swivel and adjacent fittings for evidence of wear, damage or leaks.
- Check the reel fluid manifold components for obvious wear or damage.

6.9.5 Levelwind assembly

Perform the following checks of the levelwind assembly.

- Check operation of reel levelwind override clutch and spooling systems.
- Check levelwind drive system.
    - Visually check condition and operation of reel levelwind drive chains and lead screw.
    - Lubricate chains and components as required by operating environment.

6.9.6 Skid/chassis/crash frame

Perform the following checks of the skid, chassis, or crash frame:

- Check reel drum flanges for splay or distortion.
- Check condition of CT string measuring equipment mounting points or fixtures.

6.10 STEM 2 check for CT reel

A STEM 2 check should be carried out every 750 hours of CTU operations or 3 months, whichever comes first. Guidelines for STEM 2 checks can be found in the CT Surface Equipment Maintenance program.

This page left intentionally blank

7.0 Injector Head

This section explains the function and major parts of the injector head and its hydraulic system. It also explains how to control the injector head from the control console.

The injector head (see Fig. 7-1) pulls, pushes, holds, and guides the CT string.

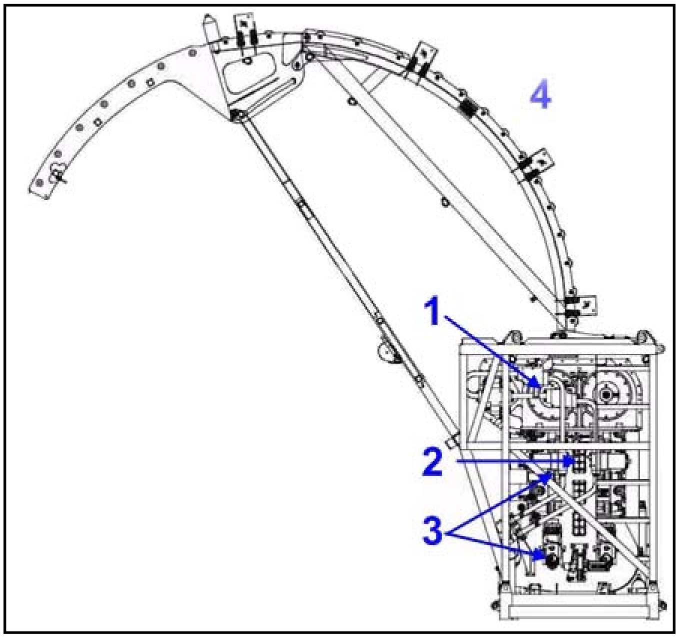

Figure 7-1. Injector Head

The equipment that performs these operations is grouped into the following systems:

- 1-drive and brake system
- 2-chain assembly
- 3-traction and tension system
- 4-guide arch system.

From the control console, the CT operator can remotely operate the components mounted on the injector head using specific hydraulic circuits. The hydraulic circuits allow the operator to exercise a high degree of control over any movement of the CT string.

7.1 Drive and brake system

The drive and brake system (Fig. 7-2) drives the chain system so that it can push, pull, and hold the CT string.

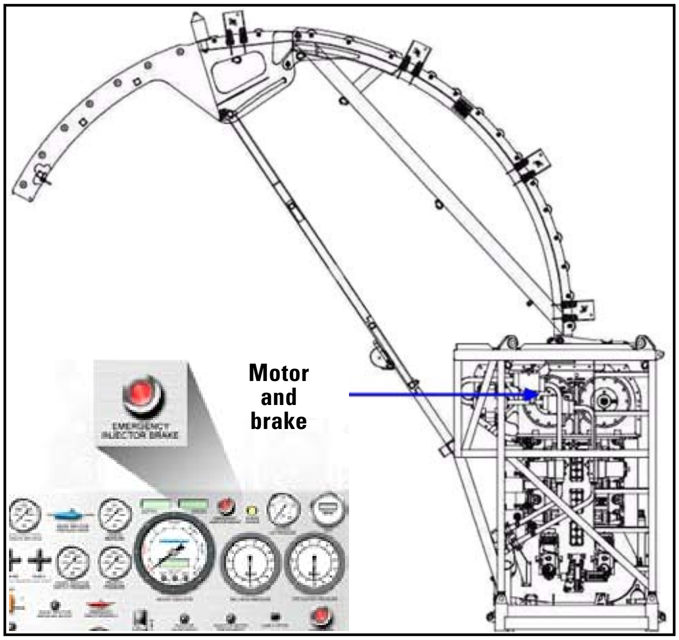

Figure 7-2. Injector Head Drive and Brake System and Controls

Hydraulic motors located at the top of the injector head convert hydraulic pressure into mechanical energy to drive the shafts connected to the chain system.

Pressure levels in the drive system control the brake, which is an integral part of the motor assembly.

The brake is automatically applied when drive pressure falls below a preset value. The braking mechanism is an internal spring that exerts pressure against the brake pistons, preventing the drive shafts from rotating.

The brake is released when drive system pressure rises above a preset value.

In emergency situations, the operator can activate the brake using the emergency injector brake button on the control console (see Fig. 7-2). This button drains the flow of hydraulic fluid to the motor, causing the pressure to fall below the brake's preset pressure and triggering it to self-actuate.

7.2 Drive system

The injector drive circuit and the priority circuit supply hydraulic pressure to operate the drive system. At all times, the resultant pressure must be sufficient to overcome all the force that arises when snubbing (pushing) or retrieving the CT during a well operation. Figure 7-3 shows the controls for these circuits.

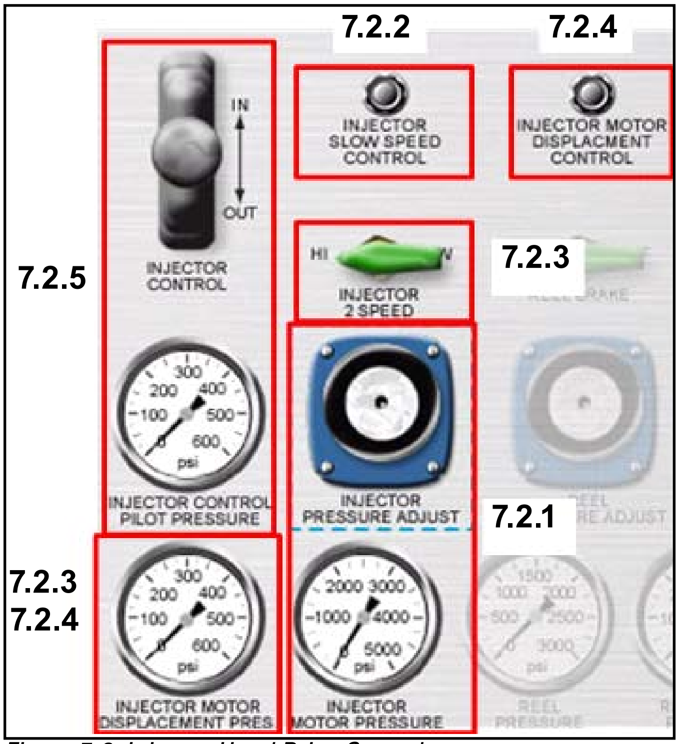

Figure 7-3. Injector Head Drive Controls

The operator applies and monitors drive system hydraulic pressure and injector motor direction using the controls discussed in the following sections.

7.2.1 Injector pressure adjust

The injector pressure adjust is a remote pressure control valve. The CT operator controls the actual pressure applied to the injector motors by adjusting this valve.

The injector motor pressure gauge indicates the hydraulic pressure at the injector motors.

7.2.2 Injector slow speed control

The injector slow speed control is a flow-regulating valve that controls the low speed of the injector motors. It allows the operator to finely tune the flow of hydraulic pressure to the motors.

7.2.3 Injector two-speed

Fixed displacement motors only operate in two displacement positions: high or low gear. The CT operator selects the gear using the injector two-speed valve.

When the operator selects low gear, also called *low-speed mode*, the motors provide maximum torque or pulling force.

> **Note:**
> Low gear is typically used when a heavy load must be overcome or where low torque is required, such as when going through the wellhead or a restriction. Using low gear will help minimize damage to the CT downhole component if it hits an obstruction. Examples of when low gear would be used are when pulling a high CT weight during retrieval, or when snubbing against a high wellhead pressure.
>
> When the operator selects high gear, or high-speed mode, the motors provide low torque and high running speed. High gear is usually used when you want speed or you want the injector motor to stall, such as when going across the wellhead or restrictions.

The injector motor displacement pressure gauge indicates the motor displacement change. Use this gauge to confirm that you have the correct amount of pressure required to ensure that the motors are operating in the selected mode.

7.2.4 Injector motor displacement control

Variable displacement motors operate in various positions within the range of allowable applied pressure.

The CT operator uses the injector motor displacement control to control the range of applied pressures. The displacement control provides the motors with an internal gear option capable of varying speed versus load rating (pull and snubbing load). The injector motor displacement pressure gauge indicates the motor displacement change.

7.2.5 Injector control (Monsun Tison valve)

The CT operator uses the Monsun Tison valve to control the direction of the injector motors. The operator can also use the valve as a method of varying the injector motor speed.

To select the inhole direction, the CT operator pushes the handle forward.

To select the out-of-hole direction, the CT operator pulls the handle backward.

The priority circuit supplies hydraulic pressure to the injector control valve. The injector control pilot pressure gauge indicates the amount of hydraulic pressure applied to the injector control valve.

At engine startup, the operator must have the injector control valve in neutral.

7.2.6 Injector displacement control

Currently, injector motors come in two models: fixed or variable motor displacement.

The CT operator uses the injector displacement control valve (see Fig. 7-4) to select the displacement mode for the particular model of injector motor that is installed. The valve is usually found below the control console, although the position may vary depending on the design of the control console.

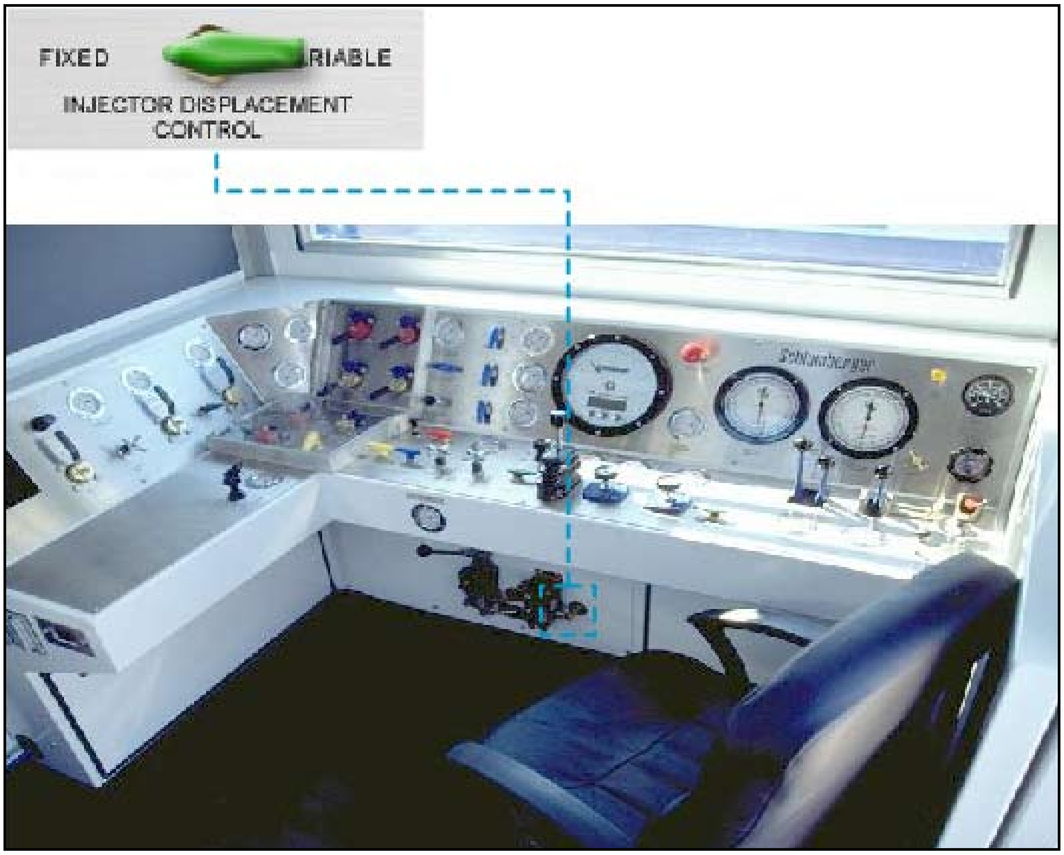

Figure 7-4. Injector Displacement Control Valve

7.2.7 Chain assembly

The injector head is fitted with two sets of opposing endless chains. The injector motors drive the chains through the sprockets. Gripper blocks mounted on the chains hold the tubing (see Fig. 7-5).

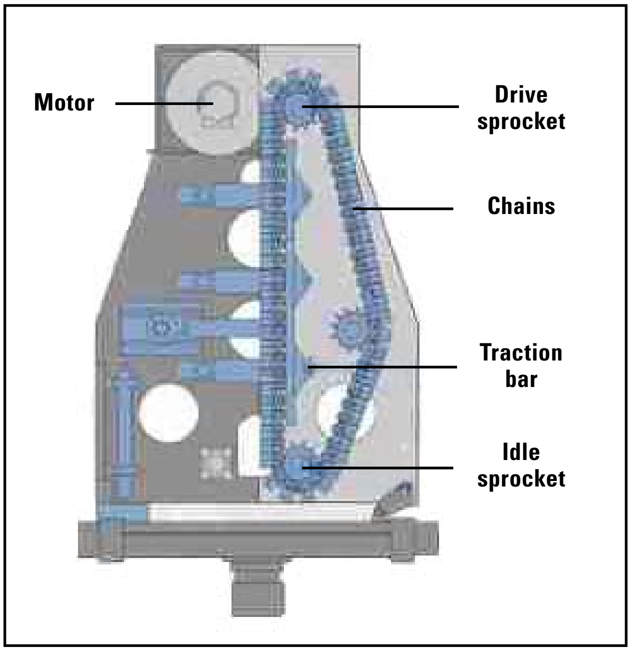

Figure 7-5. Chain Assembly on Injector Head

The two configurations currently available for the injector head chain assembly are the R- and S-type chains (see Fig. 7-6). On the R-type chains, the roller and cam is installed on the skate or traction bar; therefore, the gripper block of the chains has a flat back. On the S-type chains, the roller or cams are installed on the back of the gripper blocks of the chains; therefore, the traction bars (sometimes called *skates*) have a flat surface.

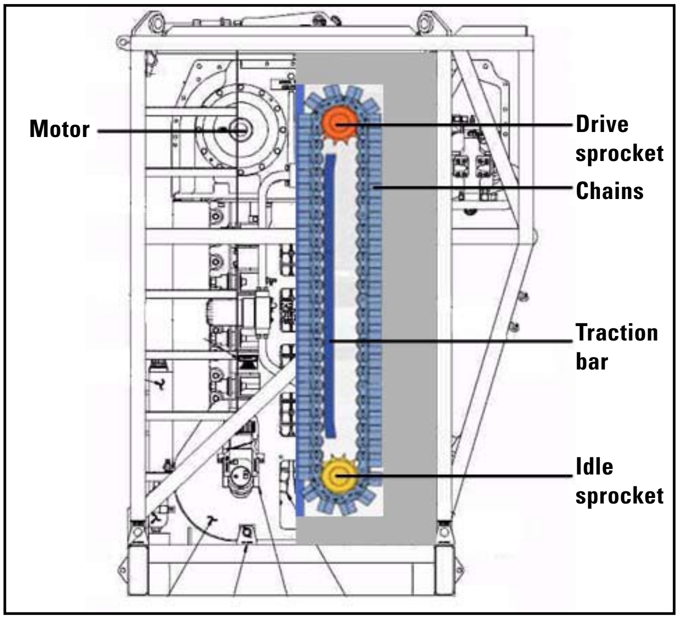

Figure 7-6. Chain Assemblies

7.3 Traction and tension system

The traction system controls the gripping force on the CT string, and the tension system controls the tension in the chains.

7.3.1 Traction

The traction system, also called the *inside chain traction system*, provides the force necessary for the chains to grip the tubing.

Three pairs of traction plates are in the traction system. Each pair of traction plates is linked to a hydraulic piston. The pistons, when energized, provide and transmit to the injector chains the force needed to grip the CT string.

7.3.2 Tension

The outside chain tensioner system takes the slack from the injector chains. This function provides smooth chain movement and prevents damage to the tubing. Hydraulically activated pistons, connected to the tensioner sprockets, maintain the proper tension in the chains. The positioning of the tensioner pistons varies depending on injector head design.

7.3.3 Accumulator

To reduce vibrations to the traction and tensioner pistons, shock-absorbing accumulators are mounted on the injector head. The number of accumulators mounted on the injector head varies depending on the injector head model.

Figure 7-7 shows the action of the tension and traction system on the HydraRig 400 and 500 Series injector heads. The traction system is shown in blue, and the yellow arrow shows how the tension is applied.

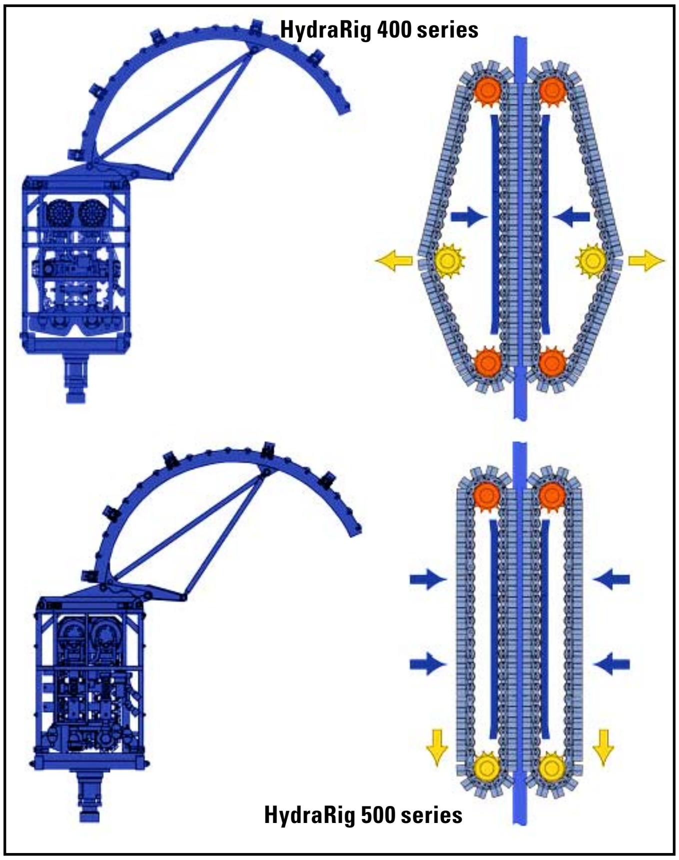

Figure 7-7. Action of Tension and Traction System

7.4 Traction and tension system hydraulic circuit

The priority circuit provides the hydraulic pressure to power the inside traction and outside tensioner pistons.

The operator applies and monitors hydraulic pressure on the traction and tension systems using the controls shown in Figure 7-8.

- 6-outside tension pressure and bleed.

Several configurations of the traction system controls on the console are possible.

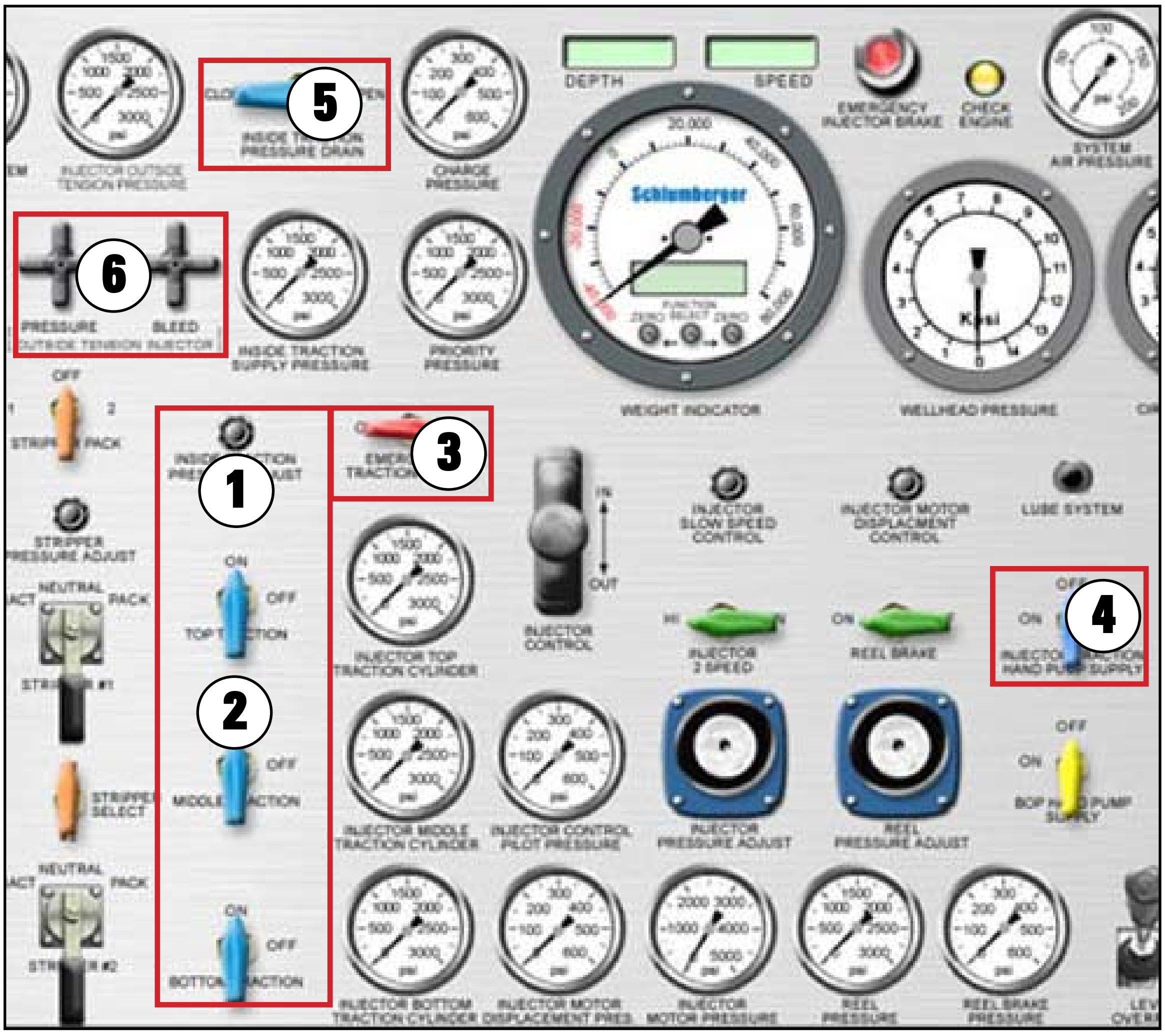

Figure 7-8. Controls for Traction and Tension Systems

- 1-inside traction pressure adjust
- 2-top, middle, and bottom traction
- 3-emergency traction supply
- 4-injector traction hand pump supply
- 5-inside traction pressure drain

7.4.1 Inside traction pressure adjust

In this control console configuration, the CT operator uses the Inside Traction Pressure Adjust control to adjust the actual pressure applied to the traction pistons (see Fig. 7-9). The pistons apply pressure to the gripper blocks via the three pairs of traction bars.

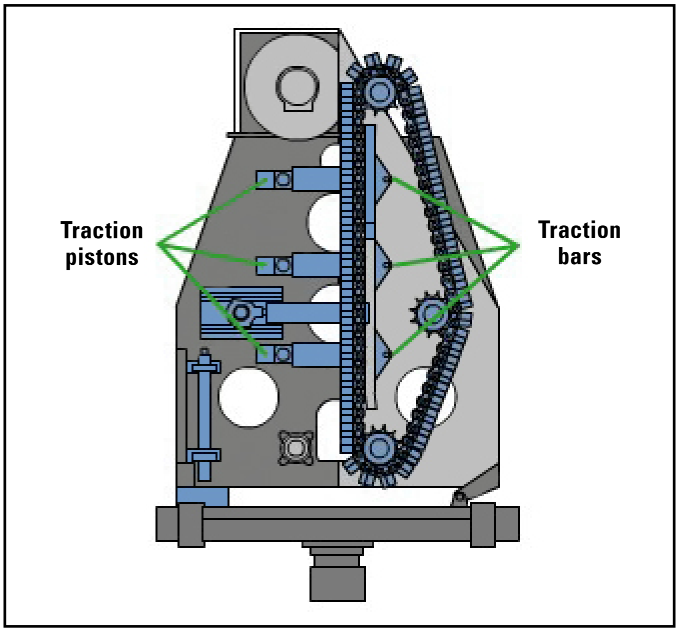

Figure 7-9. Injector Head Traction Pistons and Bars

The CT operator uses the inside traction supply pressure gauge to monitor the pressure applied to the traction system.

7.4.2 Top, middle, and bottom traction valves

In this control console configuration, the CT operator uses the top, middle, and bottom traction on/off valves to direct hydraulic pressure, which is controlled by the Inside traction adjust valve, to the traction pistons. The pistons apply pressure to the gripper blocks via the three pairs of traction plates.

The operator can trap the pressure in the pistons using the on/off valve.

In case of emergency or hydraulic leak, the operator can isolate each piston by closing it until the problem has been solved.

The CT operator uses the top, middle, and bottom traction cylinder gauges to monitor the pressure to the hydraulic pistons.

7.4.3 Emergency traction supply

In case of emergency (for example, hydraulic leak, runaway tubing, etc.) the CT operator can direct up to the maximum of the priority circuit hydraulic pressure directly to the traction pistons using the emergency traction supply on/off valve.

The emergency traction supply line bypasses the inside traction pressure adjust line that is used during normal operation.

The CT operator uses the top, middle, and bottom traction cylinder gauges to monitor the pressure to the hydraulic pistons.

7.4.4 Inside traction pressure drain

The CT operator can bleed the hydraulic pressure from the traction pistons using the inside traction pressure drain valve.

The valve must remain closed at all times during CT operation. If this valve is open, you cannot apply any pressure to the traction system.

> **Note:**
> On some injector head designs, a second drain valve may be located on the injector head itself.

7.4.5 Outside tension pressure and bleed

The pressure supply to the outside tensioner system comes from the priority circuit.

The CT operator controls or adjusts the pressure in the outside tensioner hydraulic pistons (Fig. 7-10) using the outside tension pressure and bleed needle valves.

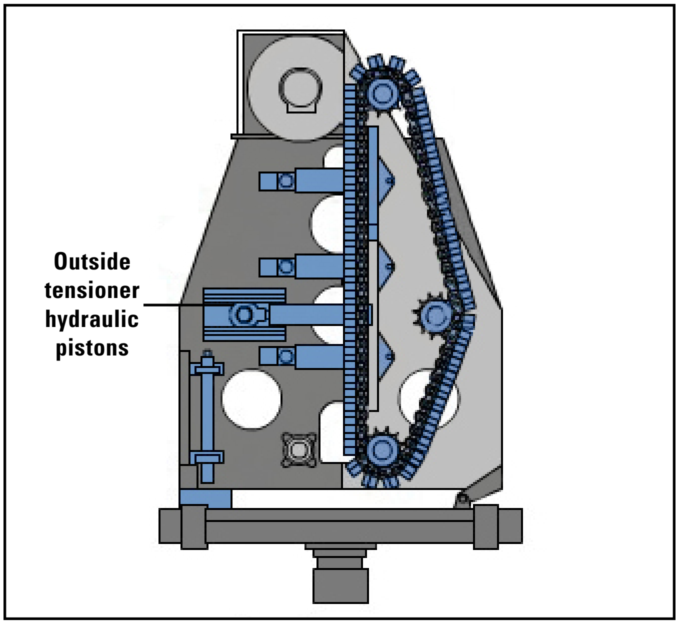

Figure 7-10. Outside Tensioner Hydraulic Pistons

7.4.5.1 Pressure valve

The CT operator applies pressure to the tensioner pistons by opening the pressure needle valve. Once the desired pressure is attained, the CT operator closes the valve, which holds the applied pressure.

7.4.5.2 Bleed valve

To reduce the pressure to the outside tensioner pistons, the CT operator opens the bleed needle valve. This bleeds the pressure from the pistons.

The CTU operator monitors the pressure in the outside tension system by monitoring the injector outside tension pressure gauge.

7.4.6 Injector traction hand pump supply

During an emergency (e.g., power pack failure), the CT operator uses the injector traction hand pump supply on/off valve (Fig. 7-11) to direct hydraulic pressure from the stripper circuit to the traction system.

Figure 7-11. Injector Traction Hand Pump Supply Valve

The supply from the hand pump line ties directly to the emergency traction line. A pressure control valve in the system ensures that the pressure will not exceed the priority system pressure.

During normal operation, the hand pump supply on/off valve is always off.

7.5 Guide arch

The guide arch guides the CT string into the injector head (see Fig. 7-12). It guides the tubing through the angle as the tubing leaves the reel. Then, it guides the tubing to the vertical position as the tubing enters the top of the injector head chains.

Rollers support the tubing as it travels over the arc of the guide arch.

The guide arch can have a radius of between 48 in and 120 in, depending on the size of CT string being used.

Using a larger guide arch size reduces the fatigue of the CT string. The industry best practice recommends a 40:1 ratio for the guide to CT OD for pipe fatigue management.

The chart in Fig. 7-13 shows the most commonly used guide arch sizes for various sizes of CT string.

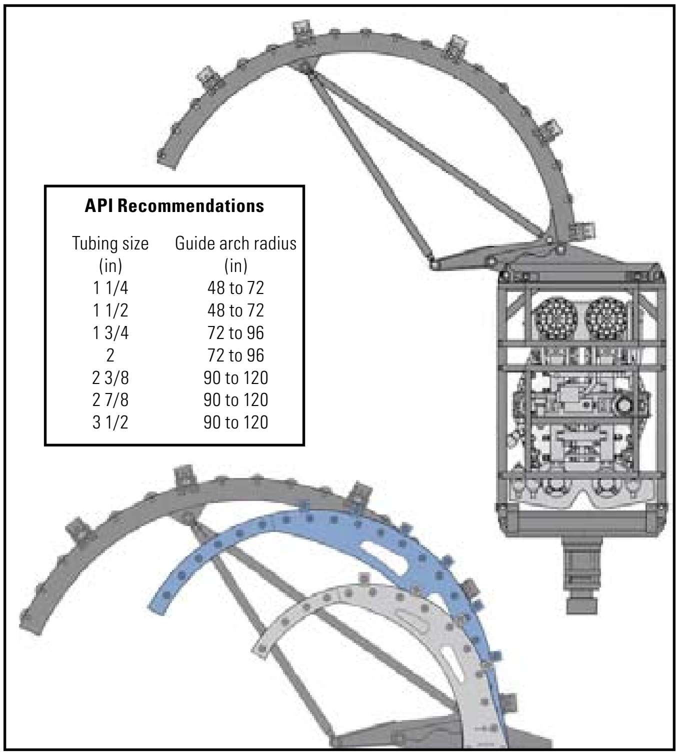

Figure 7-12. Guide Arch and Recommended Radii

7.6 Changing the size of the CT

When the size of the CT is changed, the gripper blocks in the injector head chain assembly also must be changed. The guide arch must also be within the recommended OD radius range for the new size of CT.

7.7 STEM 1 check for injector head

This check should be carried out before and after every CT job, or at regular intervals during longer operations.

On completion of the STEM 1 check, the STEM 1 report should be signed. The information must be placed in the Fleet Assistant system, which tracks the maintenance of the equipment fleet at each location.

For the most up-to-date STEM guidelines, refer to the CT Surface Equipment Maintenance program (InTouch Content ID# 4196880)

7.7.1 Fall protection equipment

Check fall protection equipment as follows:

- Visually inspect equipment fittings, webbing, and stitch patterns for evidence of abrasions, cuts, holes, or burns.
- Visually inspect the lanyard for any frayed areas.
- Ensure that a secure anchor point above the user is used and that any slack in the lanyard is kept to a minimum.
- Ensure that fall protection appropriate to the conditions is used. For example, clearance below the operator should be a minimum of 5.75 m for a 2.00-m energy-absorbing lanyard. This clearance is required to enable safe expansion of the device while continuing to support the user.
- Check the general condition of mechanical fall arrestors. Test the breaking mechanism to ensure smooth operation.
- Ensure that all safety equipment has been checked by an appropriate third-party inspection service at least once every 12 months.
- Ensure that equipment is stored in a dry environment.

7.7.2 Hydraulic hoses and connections

Perform the following checks on the hydraulic hoses:

- Visually inspect hoses and hose bundles for evidence of wear, damage or leaks.
- Ensure hose bundle ties and securing chains or straps are in good order and appropriately adjusted.
- Visually inspect hose connection seals and securing mechanism (thread or ball latch).
- Check connector protectors and identification.
    - Ensure connections are clean before making up a connection and that dust caps are fitted after breaking out a connection.
    - Ensure the hose identification tag (or similar connection coding system) is clean and clearly visible.

7.7.3 General lubrication

Perform the following checks on the lubrication system:

- Check chain lubrication reservoir.
    - Check chain lubrication fluid level and ensure sufficient is available for the duration of the intended operation (clean 40 weight oil).
    - Ensure that reservoir caps are securely made-up before operating the system.
    - Operate the chain lubrication system and visually confirm controlled application of chain lubricant.
    - Check/drain oil drip pans and ensure that drain plugs are fitted. Ensure drip pans are drained before transportation.
- Using an appropriate grease (or lubricant where appropriate), lubricate all STEM I lubrication points.

7.7.4 Injector head drive and brake systems

Perform the following checks on the injector head drive and brake systems:

- Check the injector head hubometer (see Fig. 7-13):
- Visually check general condition of hubometer.
- Record hubometer reading on STEM I report.

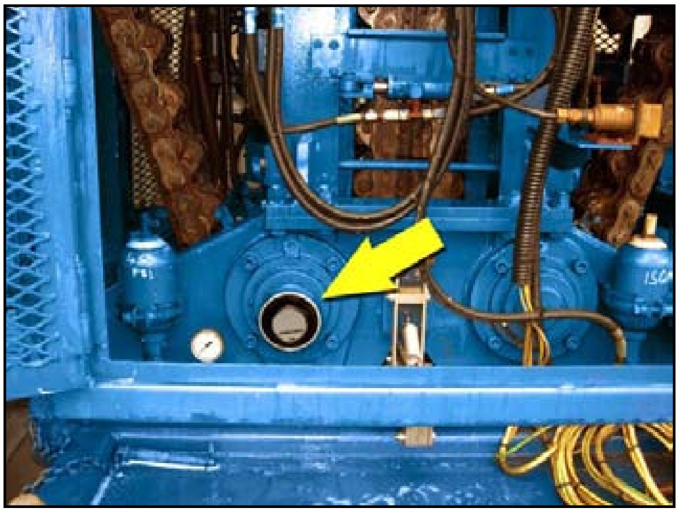

Figure 7-13. Location of Injector Head Hubometer

- Check the visual indicator for the condition of the injector head drive system inline filter.

7.7.5 Injector head chains

Visually inspect the injector head chains.

- Visually inspect the chain bearings and gripper blocks for evidence of excessive wear or damage.
- Before the CT string is stabbed, run the injector head chains slowly and check for unusual noise or vibration from the chains.

> **Warning:**
> Do not place hands or hand tools on the chains or inside the injector head while the CTU power pack is running.

7.7.6 Chain tensioner systems

Check the chain tensioner system components:

- Check the chain tensioner system hydraulic cylinders, hoses, and fittings for evidence of damage or leaks.
- Check hydraulic system gauges (on injector head) for normal operation and condition.
- Visually inspect the chain tensioner mechanical components for evidence of wear or damage. Include skate bars, linkages, general sprocket alignment, and adjustment gaps.
- Visually inspect load/force bearing components, e.g., injector head side plates and tie rods.

7.7.7 Guide arch

Perform the following checks on the guide arch:

- Ensure that folding linkages and securing mechanisms on the guide arch are operating efficiently and are properly secured before stabbing the CT string.
- Check guide arch alignment.
  - Ensure that the guide arch alignment is adjusted to enable smooth insertion of the CT.
  - Check that the CT string is properly inserted in the injector head chains.
  - Check condition and operation of guide arch securing pins/mechanism.
- Check guide arch rollers.

Check guide arch roller bearings for smooth operation.

Check the guide arch roller profiles for wear or damage and ensure guide arch and rollers are compatible with CT size for the intended operation.

7.7.8 Weight indicator system

Check the weight indicator system for the following:

- Check condition, adjustment and operation of weight indicator jacking and locking system.
- Check general condition of weight indicator load cell.
- Inspect cables and connectors for evidence of wear or damage.
- Where applicable, ensure that weight indicator system travel bolts are in place before transportation.

7.7.9 Skid/chassis/crash frame

Perform the following checks.

- Check slings and lifting equipment:
  - Ensure that all slings and shackles are secure and that applicable inspection test dates or periods are valid.
  - Where applicable, ensure that tare weight, payload, and gross weights are posted and clearly visible.
- Ensure that all cables, mounting fixtures, and components of the electronic equipment are secure.
- Check loadbearing components:
  - Check general condition of injector head frame and skid for evidence of wear or damage, including distortion or cracks at key load-bearing locations.
  - Where applicable, ensure that the crash frame roof is fitted and secured before transportation.
  - Ensure that crash frame locking pins are secured and retained (by split pins, or similar).
  - Where applicable, check access ladders, handrails and walkways for damage. Ensure handrails and such moveable items are securely stowed for transportation.
- Check that all guards, shields and protection devices are secure. Ensure all guards are replaced following any inspection or repair processes.
- Ensure that fixed asset number (or similar unit identification) is posted and clearly visible on each component.

7.8 STEM 2 check for injector head

A STEM 2 check should be carried out every 600,000 running feet (182,870 running meters). Guidelines for STEM 2 checks can be found in the CT Surface Equipment Maintenance program.

This page left intentionally blank

8.0 Pressure Control Equipment

Most well intervention operations, including CT, are required to use multiple barriers, or potential barriers, to control wellbore pressures and fluids (see Fig. 8-1).

Figure 8-1. Pressure Control Equipment for a CT Operation

Generally, these barriers are classified according to the following three categories (see also Fig. 8-2):

- primary barrier: The primary barrier is the one in use during normal operations. In CT operations, the stripper (including dual or tandem strippers) is the primary barrier.
- secondary barrier: The secondary barrier is brought into operation if the primary barrier is compromised. It is not applied during normal operations. In CT operations, the secondary barrier is the blowout preventer (BOP).
- tertiary barrier: The tertiary barrier is operated on a contingency or emergency basis, being brought into operation as a last resort. The use of a tertiary barrier usually depends on several factors, including wellbore conditions. Typically in CT operations, this barrier is a shear/seal BOP fitted directly on the wellhead.

This section will briefly cover the basics of pressure control equipment.

Pressure control equipment is covered in greater detail in JET 13, CT Pressure Control Equipment, InTouch Content ID# 4221744.

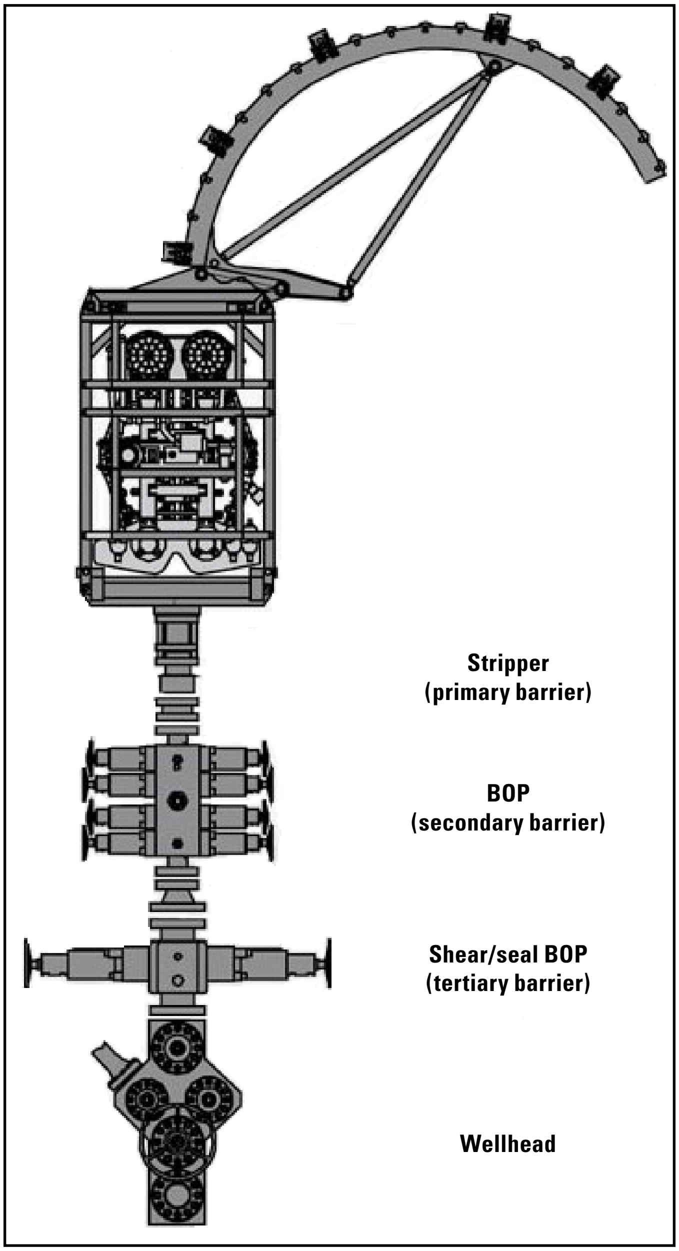

Figure 8-2. Three Barriers to Control Pressure

8.1 Stripper

The stripper provides a dynamic seal around the tubing (Fig. 8-3). The seal is achieved by applying hydraulic pressure that compresses a set of elastomeric elements, causing them to push against the CT.

> **Note:**
> Elastomers are elastic materials resembling rubber. They are typically used as to manufacture sealing devices.

The stripper ensures that the tubing can be safely inserted in and extracted from the wellbore while containing well pressure.

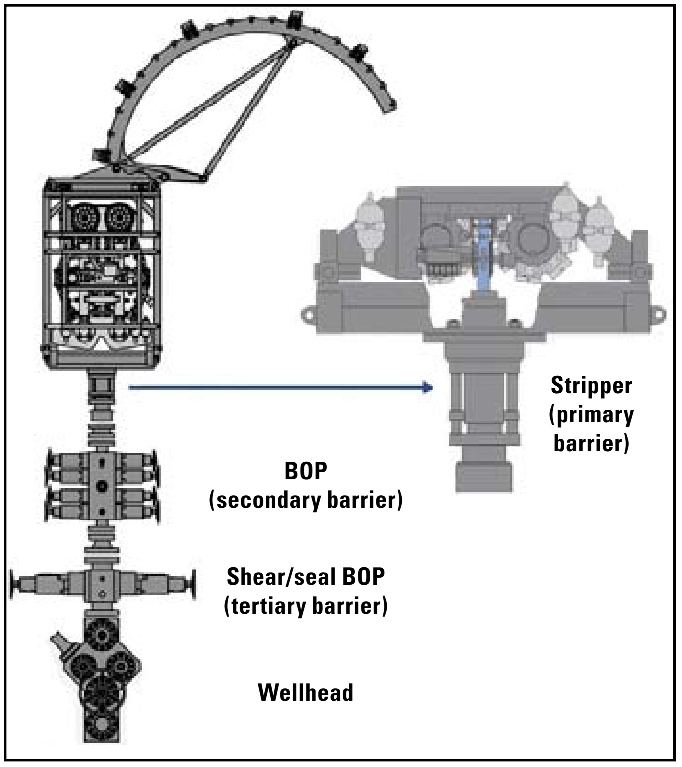

Figure 8-3. Stripper

8.1.1 Types of strippers

Strippers come in the configurations described in the following sections.

8.1.1.1 Conventional stripper

Conventional strippers are the oldest type of stripper. Hydraulic pressure is applied axially (along the axis) from below. These strippers are serviced from the top.

8.1.1.2 Side-door stripper

The side-door stripper was introduced to enable easier and safer replacement of components while the equipment is rigged up. Direct access is achieved through the side doors. Depending on the model or design, the stripper element can be energized axially from the top or from the bottom.

8.1.1.3 Tandem stripper

Tandem strippers are used as backup or contingency strippers in conjunction with a side-door or conventional stripper. When mounted in tandem, only one stripper is energized at any one time. In general, the top stripper is used first. Before the lower stripper is put into operation, the upper one should be deenergized and the pressure between the strippers bled off through a special port.

8.1.1.4 Sidewinder stripper

The sidewinder stripper (Fig. 8-4) is energized from the side, and the elements and bushings can be completely retracted from the main bore. This feature allows easy deployment of large OD components.

Figure 8-4. Sidewinder Stripper Assembly

8.1.1.5 Over/under stripper

An over/under stripper serves as two individual strippers in one stripper body. It can be used as a replacement for a two-stripper configuration, fulfilling the requirements for a primary and a tandem stripper packer in higher WHP applications. It gives a reduction in stack height of 1.2 m [4 ft] over the two-stripper configuration.

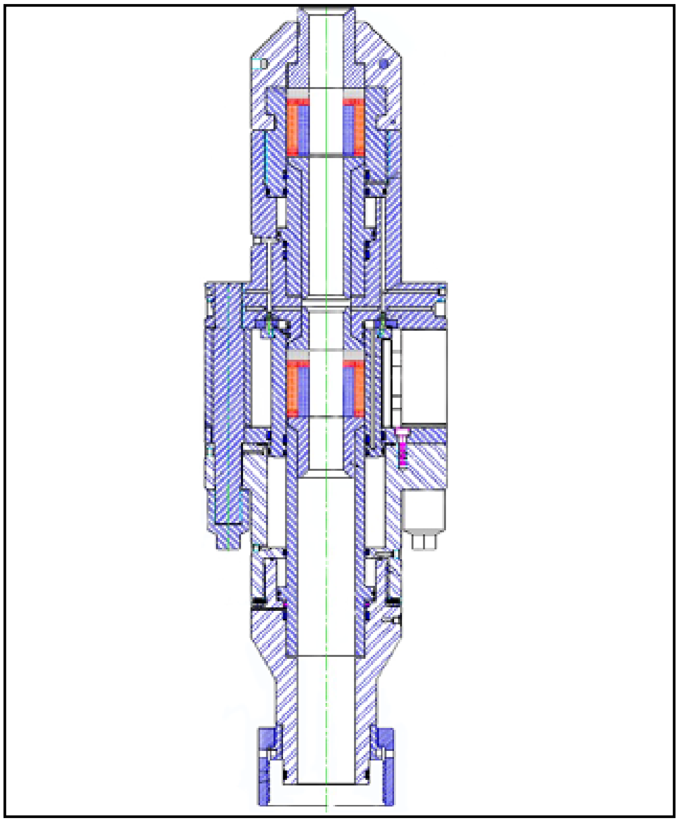

Figure 8-5. Over/Under Stripper

8.1.2 Stripper components

The components of a conventional stripper are listed in the following sections (see Fig. 8-5).

> **Note:**
> Different CT sizes can be run through the same stripper by changing the size of the packing inserts, the upper and lower brass bushings, and the nonextrusion ring.

8.1.2.1 Bushings

Wear bushings are mounted above and below the packing insert. The bushings help keep the CT centralized as it passes through the packing. Both upper and lower bushings are manufactured of brass to minimize abrasion of the CT and to decrease the chance of generating sparks. The upper bushing is split, allowing it to be removed when the CT string is through the assembly, The lower bushing is not split.

8.1.2.2 Energizer

Generally, the energizer is a urethane sleeve formed around a steel spring. It is a one-piece part and cannot be replaced with the CT in place. Some models of energizer are available without the internal metal spring and as a two-piece construction.

8.1.2.3 Packing inserts

Packing inserts are split sleeves made of elastomeric materials. The materials used depends on the well conditions, for example, high temperature or presence of H_2S or CO_2 gas. The inserts are assembled inside the energizer. The split construction allows the inserts to be removed and replaced with the CT string in place.

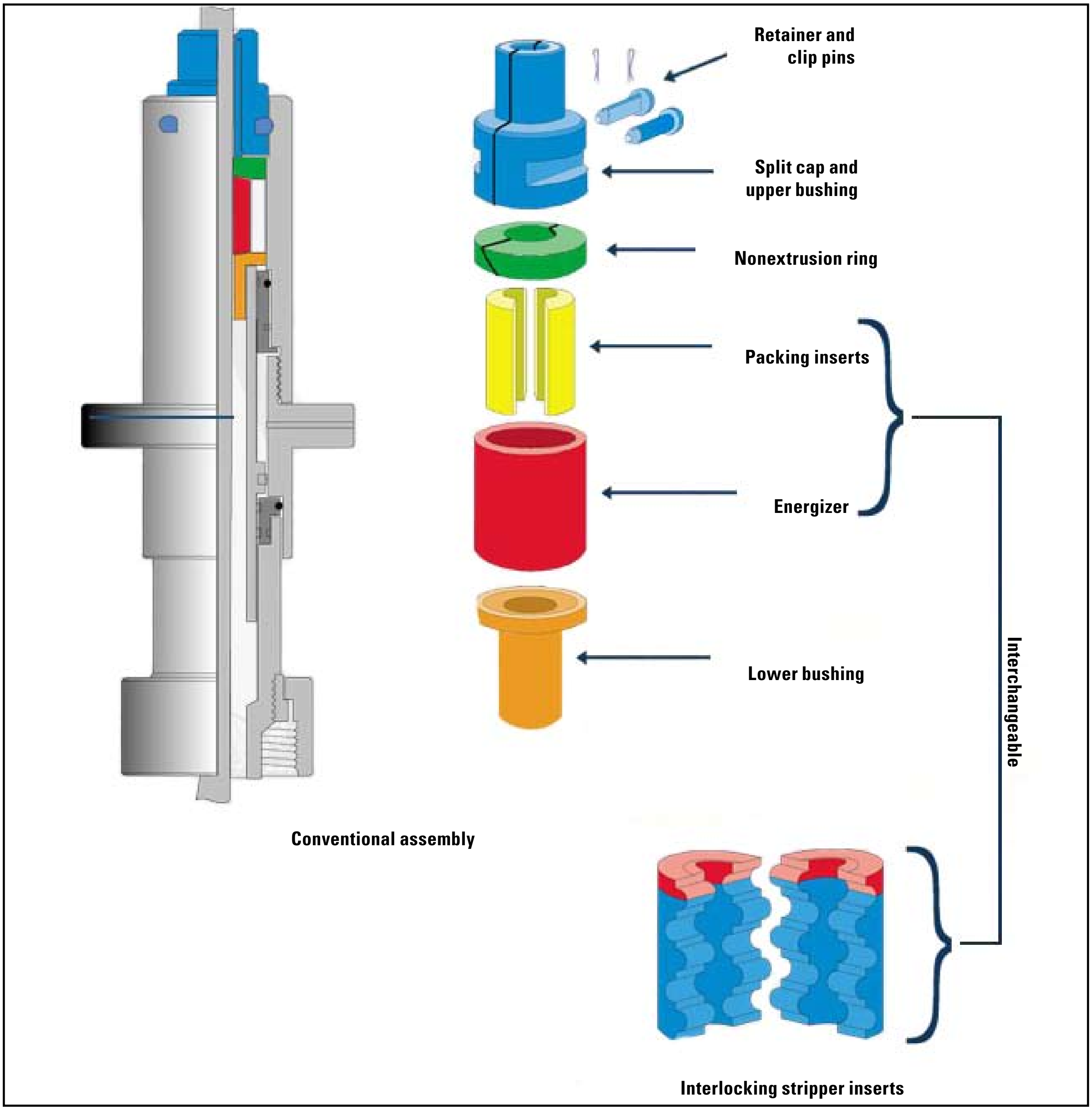

Figure 8-6. Components of Conventional Stripper

8.1.2.4 Nonextrusion ring

The nonextrusion ring is placed between the energizer/inserts and the upper wear bushing. The ring prevents the stripper elastomers from extruding from compression when the CT is run in and out of the well. It can be removed with the CT string in place. Radial and side-door strippers have a lower antiextrusion ring as well.

8.1.2.5 Interlocking stripper inserts

Interlocking stripper inserts are made of split elastomeric material with interlocking features. The split allows the inserts to be changed with the CT in place.

8.1.3 Stripper operation

All strippers, regardless of their type, operate basically the same way, with some differences that are beyond the scope of this manual. Depending on the stripper design and packing arrangement (Fig. 8-7), hydraulic pressure is applied to the top, bottom, or side bushing via a stripper actuator piston. The piston compresses the energizer, which in turn forces the packing insert against the tubing.

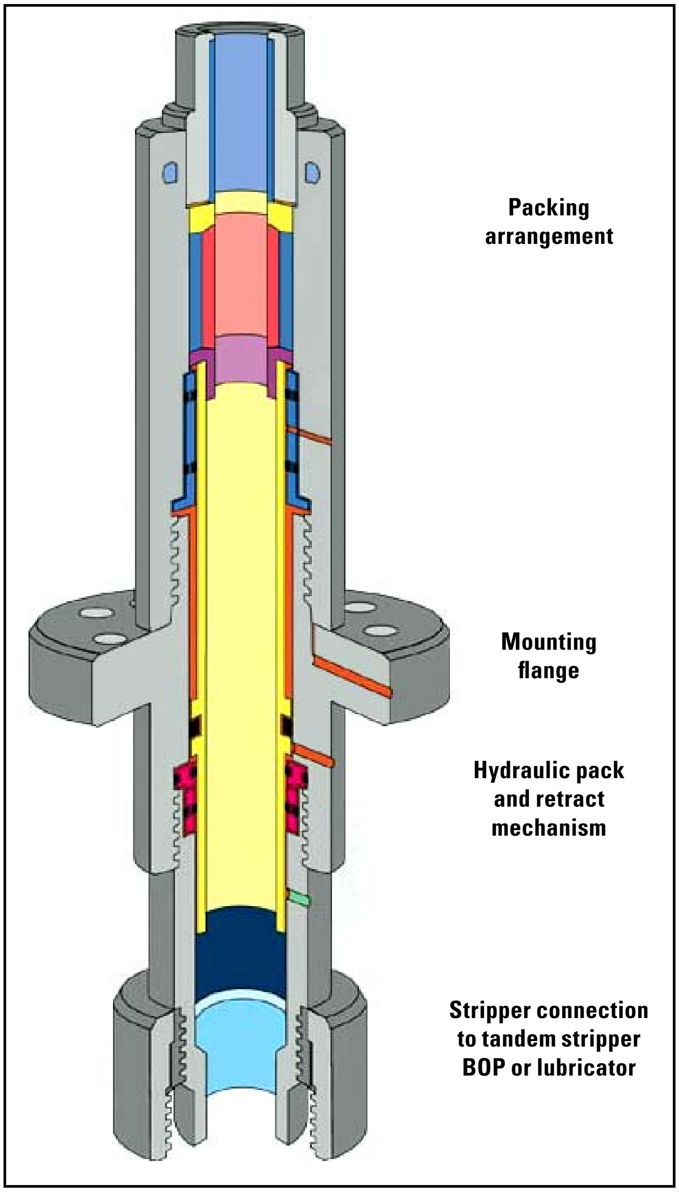

Figure 8-7. Stripper Operation

Most actuator pistons are dual acting, which means they hydraulically pack and retract the stripper. Packing causes the piston to actuate the energizer and packing inserts. Retracting causes the piston to deactuate the energizer and packing inserts.

8.1.4 Controlling the stripper

The CT operator controls and monitors the stripper's hydraulic system using the controls and instrumentation shown in Fig. 8-8.

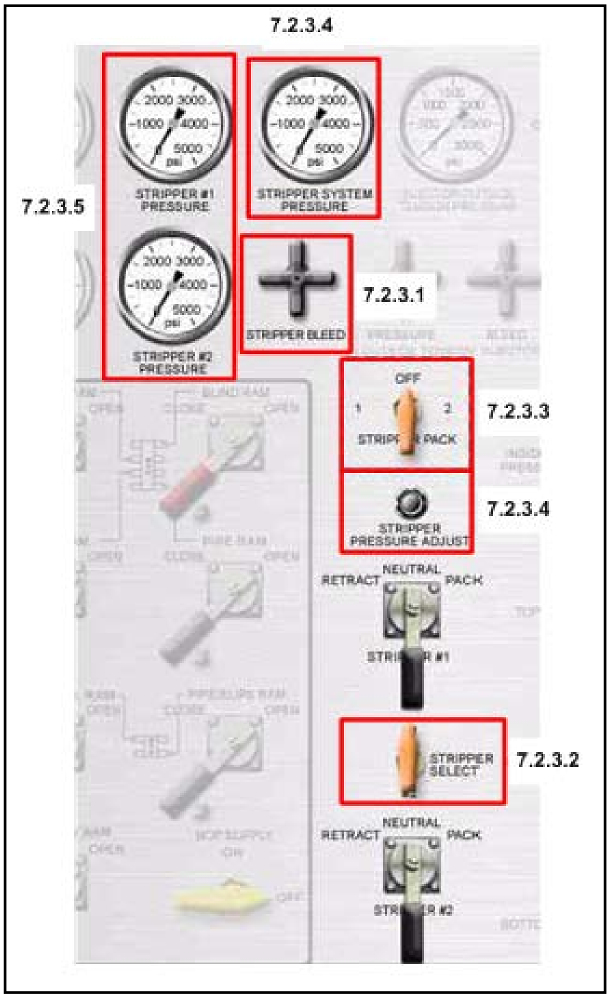

Figure 8-8. Stripper Controls

8.1.4.1 Stripper bleed

The operator uses this needle valve to bleed the pressure from the stripper circuit.

8.1.4.2 Stripper select

Most CTUs have two pairs of hydraulic lines for operating the strippers. Both strippers #1 and #2 have a pack and retract line. The operator uses the stripper select valve to direct hydraulic flow to either of these pairs of lines.

When strippers are run in tandem, the operator uses this valve to select one of two tandem strippers for use during an operation.

8.1.4.3 Stripper pack

When this three-way valve is available, the operator uses it to direct priority circuit hydraulic pressure to the selected stripper. The valve is used in situations where volume is required to quickly actuate a stripper.

8.1.4.4 Stripper pressure adjust

The operator uses this air regulator valve to control the operation of the Haskell supply pump. The pump is located on or near the control console. The pump supplies pressure to the stripper and other circuits. Pressure cannot be decreased using this valve.

The operator uses the stripper system pressure gauge to monitor the discharge pressure of the Haskell or Rucker supply pump.

8.1.4.5 Retract/neutral/pack stripper #1 and #2 switches

The CT operator sets these switches to pack or retract the actuator piston.

When the switch is set to pack, the stripper seals around the CT string. When the switch is set to retract, the stripper loosens around the CT string. The stripper packing inserts can only be changed in the deenergized position.

When set to neutral, the flow of hydraulic pressure from the Haskell valve is not directed to either of the stripper pack or retract ports. Any pressure already applied to the stripper will be trapped, so effectively it can still be in packed position and operate correctly.

The operator monitors the pressure to each stripper packing insert using the Stripper #1 and #2 pressure gauges.

8.1.5 Changing the size of the CT

If the size of the CT string is changed, the stripper inserts, stripper bushings, and nonextrusion rings also need to be changed.

8.2 BOP

The BOP (Fig. 8-9) is the secondary line of defense in a CT well intervention operation. In some cases, the BOP also provides the tertiary line of defense. Some of the main functions of the BOP include the following:

- provides a secondary barrier against wellbore pressure and fluids (pipe rams and blind rams)
- secures and supports the CT string against the operating weight or snubbing forces (slip rams)
- provides wellbore access for fluid (kill port) and pressure measurement (pressure port)
- supports the weight of and forces applied to the CT equipment under the rated wellbore pressure.

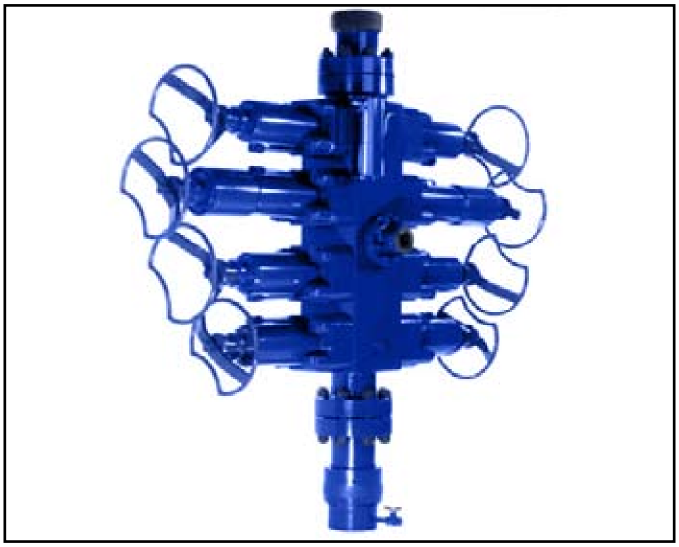

Figure 8-9. BOP

8.2.1 BOP rams

The BOP consists of a stack of one or more rams. In Fig. 8-10, the four basic types of rams are combined into one stack called a quad BOP.

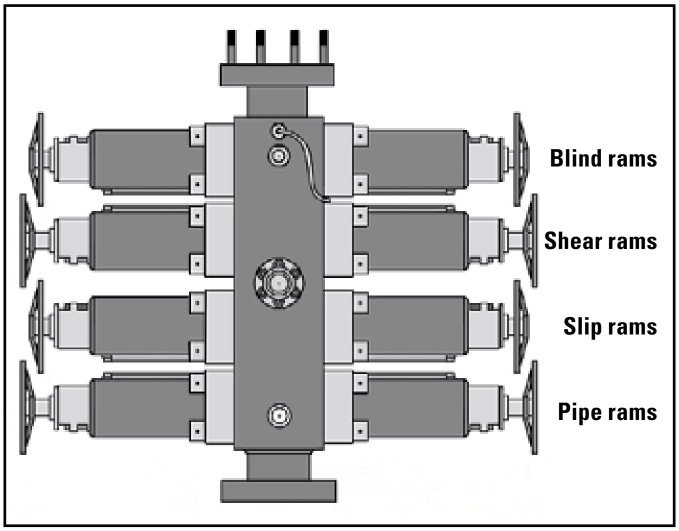

Figure 8-10. Quad BOP

Four types of rams can be combined into a stack:

- Blind rams are flat at the mating surfaces. The mating surfaces are coated with elastomeric material enabling the rams to seal over an open wellbore. They are designed to close and seal the entire wellbore when no tubing or toolstring is in the BOP body.

> **Note:**
> Blind rams hold differential pressure from below only; they cannot hold differential pressure from above.

- Shear rams are fitted with a tool steel-cutting surface. They close on and completely shear through the tubing and any installed cables.

- Slip rams close on and mechanically hold the CT string preventing upward and downward movement. Under normal operation, the slip rams cause only minimal damage to the tubing surface.
- Pipe rams close on and seal around the tubing.

> **Note:**
> Like blind rams, pipe rams hold differential pressure from below only; they cannot hold differential pressure from above.

Other combinations of these ram types can be found in other types of BOPs such as those discussed in Section 8.2.3, Types of BOP.

8.2.2 BOP components

Figure 8-11 illustrates the components of a quad BOP. A more detailed description of BOPs can be found in JET 13, CT Pressure Control Equipment.

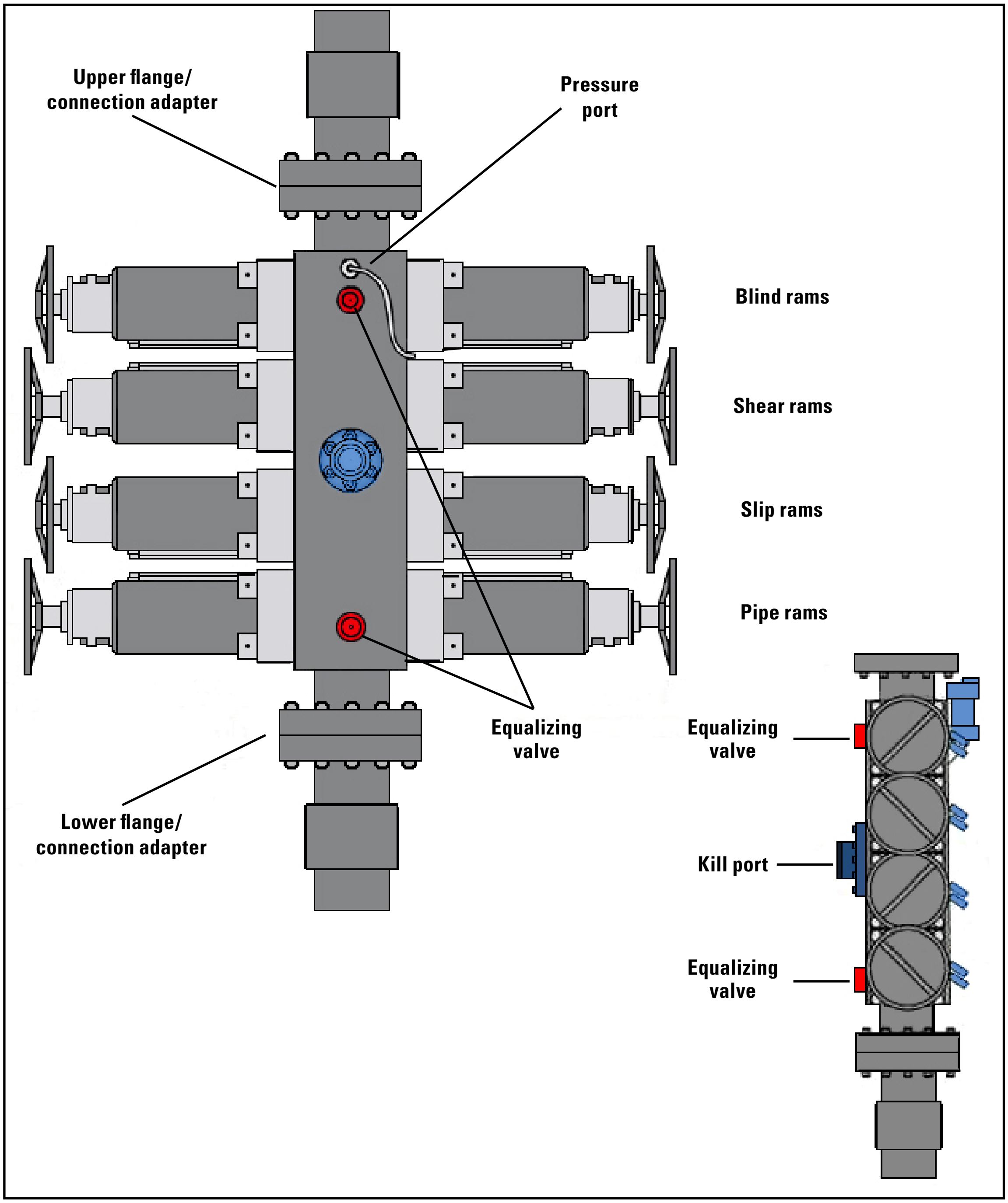

Figure 8-11. Quad BOP Components

The components are as follows:

- equalizing valve: When the blind or pipe rams are used to hold pressure from below, it is important to equalize (balance) the pressure above and below the rams before reopening the rams. This equalization is accomplished with the aid of an equalizing valve.

> **Note:**
> Opening a ram without equalizing the pressures will cause damage to the face of the sealing ram.

  Opening the equalizing valve opens a small pathway between the bore of the BOP above and below the closed rams. This opening allows the pressure to slowly build up above the closed blind or pipe ram. When the pressures above and below the rams are equal the valve can be closed again and the rams can be opened safely.

- pressure port/debooster: A pressure port is located on the BOP body above the blind rams. This port allows wellhead pressure to be monitored only when the blind rams are open.

  The pressure port is connected by a small-bore steel tube to a pressure debooster fitted on the BOP body. The pressure debooster hydraulically reduces the WHP by a factor of 4:1, thus reducing the pressure within the hydraulic gauge hose running to the control cabin.

- side port: The side port, often called the *kill port,* is a flanged connection on the front of the BOP body that can be used to pump fluids into the CT/tubing annulus, or through the cut CT string if the BOP shear rams have been activated in an emergency. The name *kill port* arises because you can pump through this port to kill a well.
  On 3.06-in and 4.06-in, 10,000-psi, BOP models, the kill port is a 2 1/16-in, 10k flange, which is generally provided with an adaptor to a 2-in 1502 Weco connector for easy rigup of a pumping line.

  In operations up to 7,000 psi wellhead pressure, the kill port is isolated with two plug valves during operation. The electronic pressure sensor for wellhead pressure is generally rigged up between these valves.

8.2.3 Types of BOP

Several variations of BOP are used in CT operations. The most common are listed in the following sections.

8.2.3.1 Quad BOP

The quad BOP (Fig. 8-12) is primarily used as the secondary well control barrier during well intervention. *Quad* refers to the four sets of actuators in the stack.

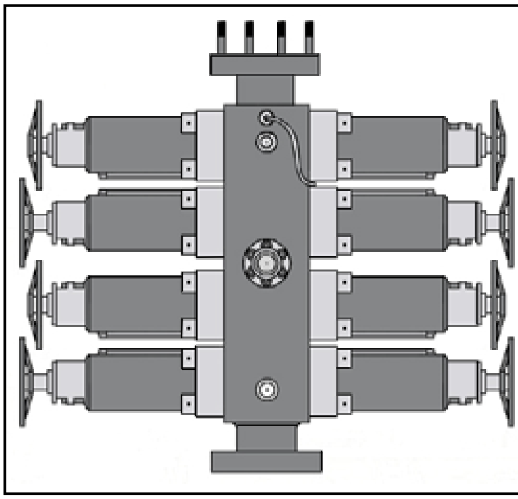

Figure 8-12. Quad BOP

8.2.3.2 Combi BOP

The *combi BOP* is used as a secondary or tertiary barrier. The combi BOP is so named because it has two sets of actuators in the stack. Each pair of rams (blind/shear and pipe/slip) is dressed to perform a dual function.

The most common configuration for a combi BOP is shown in Fig. 8-13.

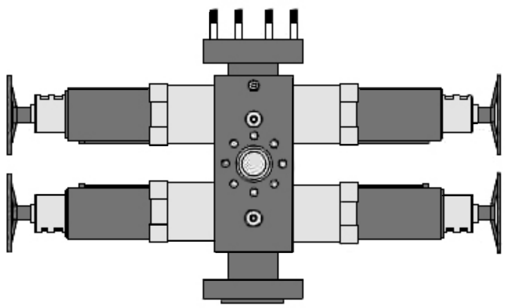

Figure 8-13. Combi BOP

8.2.3.3 Triple BOP

The *triple BOP* is so named because of the three sets of actuators in the stack.

The most common configuration for a triple BOP is shown in Fig. 8-14.

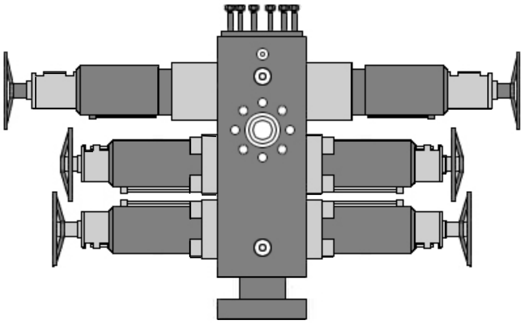

Figure 8-14. Triple BOP

> **Note:**
> Note that the top ram is dressed to perform the combined functions of the blind and shear rams.

8.2.3.4 Shear/seal BOP

The shear/seal BOP is primarily used as a tertiary barrier (see Fig. 8-15). The most common configuration of the single set of actuators is dressed to perform the blind and shear functions.

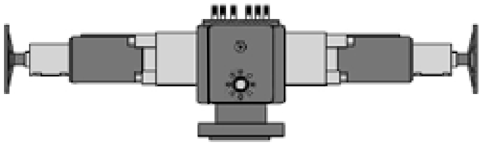

Figure 8-15. Shear/Seal BOP

8.2.4 BOP operation

BOP rams are hydraulically actuated. The rams may also be actuated and locked manually under certain conditions. The tubing must be stationary before activating the rams.

The BOP actuator pistons are dual acting, which means they hydraulically pack and retract the BOP rams. The rams are attached to an actuator rod and the actuator is in turn connected to the piston actuator. When hydraulic pressure is directed to the pack port, the piston actuators move towards each other. When hydraulic pressure is directed to the retract port, the piston actuators move away from each other.

The CT operator controls and monitors the BOP hydraulic system using the controls and instrumentation shown in Fig. 8-16 and described in the following sections.

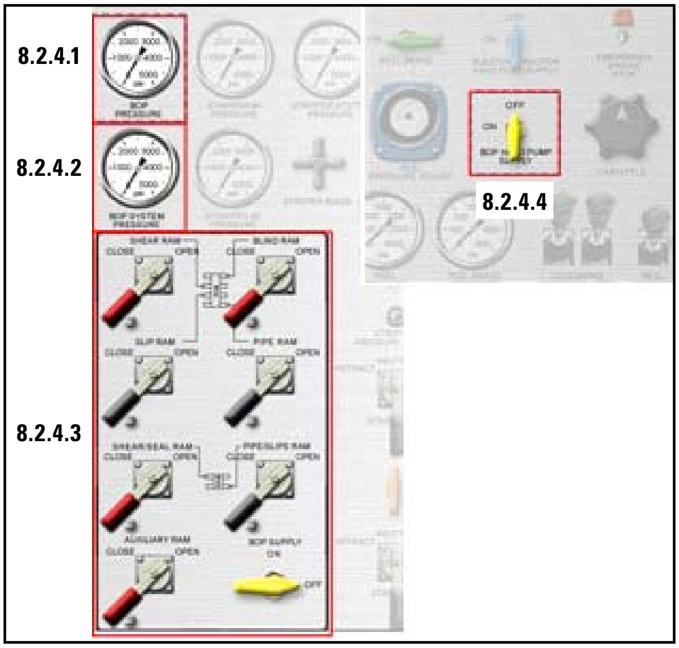

Figure 8-16. BOP Controls

8.2.4.1 BOP pressure gauge

The CT operator uses this gauge to monitor BOP circuit pressure.

8.2.4.2 BOP supply

The CT operator uses this valve to allow or shut off hydraulic pressure from the BOP main hydraulic pump (system pressure) to the various ram valves. The ram valves direct this pressure to the appropriate set of rams.

The BOP system pressure gauge monitors the pressure in the BOP hydraulic cylinders.

8.2.4.3 Ram valves

The CT operator opens and closes each set of rams using the ram valves by directing hydraulic pressure from the BOP circuit to the pack or retract ports.

8.2.4.4 BOP hand pump supply

The CT operator uses this on/off valve to direct hydraulic pressure from the stripper circuit to the BOP system during an emergency, such as a power pack failure.

The supply from the hand pump line ties directly to the BOP main circuit line. The pressure control valve in the system ensures that the pressure will not exceed BOP system pressure.

During normal operation, the on/off valve is always set to the OFF position.

8.2.5 Changing the size of the CT

When the size of the CT string is changed, the BOP ram inserts, except for the blind rams, must also be changed. Blind rams are never used when the CT string is in the BOP, so they are independent of the CT size.

8.3 STEM for pressure-control equipment

For the most up-to-date STEM guidelines, refer to the CT Surface Equipment Maintenance program (InTouch Content ID# 4196880)

This page left intentionally blank

9.0 CTU Electronics

CoilCAT* coiled tubing computer-aided treatment is a PC-based system that is used to monitor, record, and report CT jobs (see Fig. 9-1). This acquisition and monitoring system provides real-time computer-aided design, execution, and evaluation for CT applications.

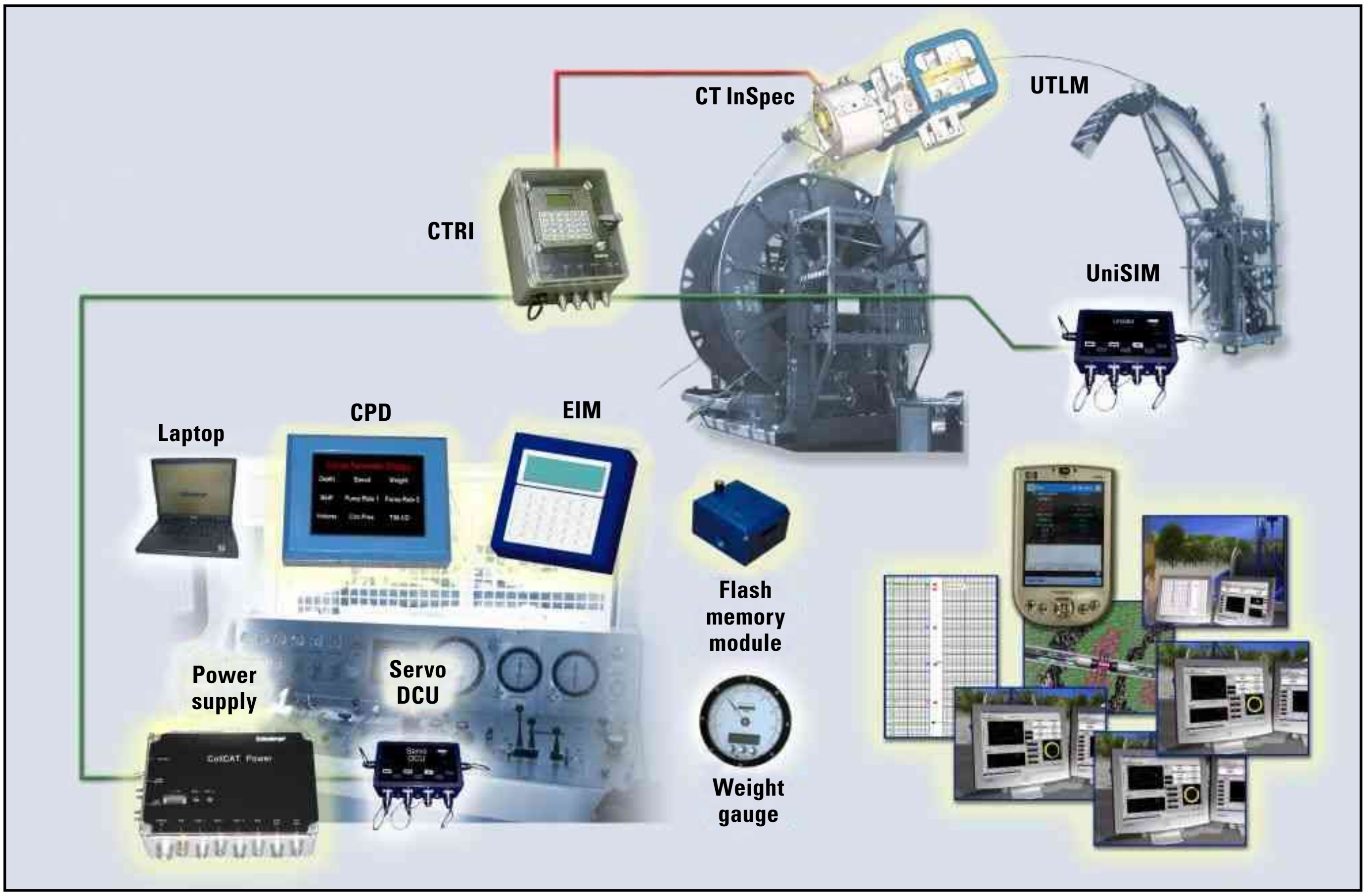

Figure 9-1. CoilCAT System in a CTU

The latest version of CoilCAT software runs on a Schlumberger standard computer (a laptop in the field), using the equipment interface module (EIM) as the front-end data acquisitions system. The CT operator needs to know the basic physical configuration of the system, as well as how it is used for acquisition and some basic troubleshooting.

Depending on the version of CoilCAT that is being run in a specific location, slightly different equipment configurations may be used, which may not include all of the components explained in this section. The electronic technician at your location can explain in detail the exact setup in a location-specific CTU.

9.1 Sensors

Sensors are devices designed to measure a certain parameter, such as

- fluid pressure/coiled tubing weight
- pump rate
- CT depth.

Sensors measure a parameter and output an electronic signal. This signal travels through a SIM (sensor interface module), which converts the signal into a digital value, according to the sensor calibration information that is stored in the SIM. Figure 9-2 shows some of the sensors that might be found in a CTU.

Sensors are powered from the power supply in the control cabin.

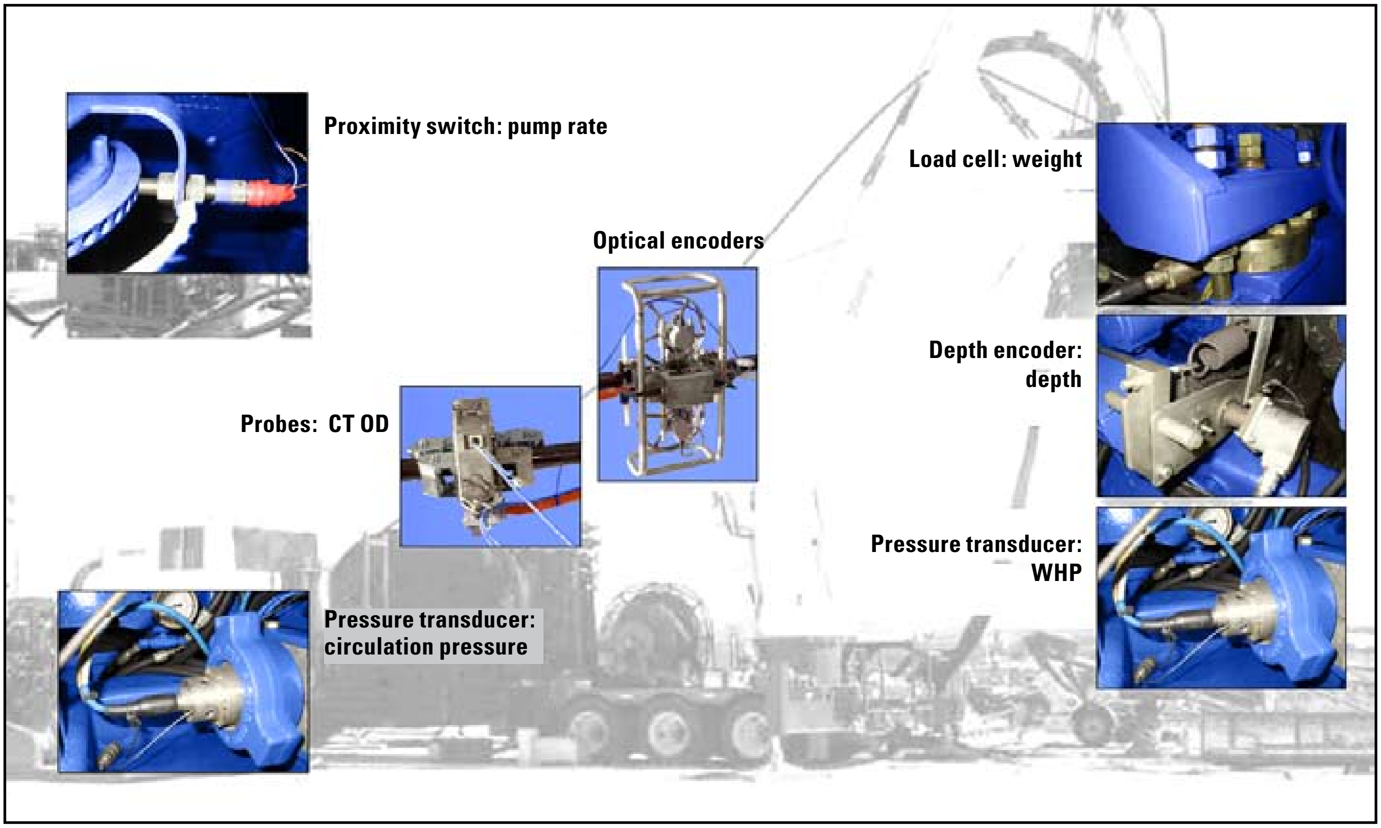

Figure 9-2. Sensors in a CTU

9.1.1 CT weight

The weight of the CT string in the hole is measured by the load cell (Fig. 9-3). This sensor is mounted on a pivot point at the bottom edge of the injector head chassis, and it senses the change in load applied to the injector chains.

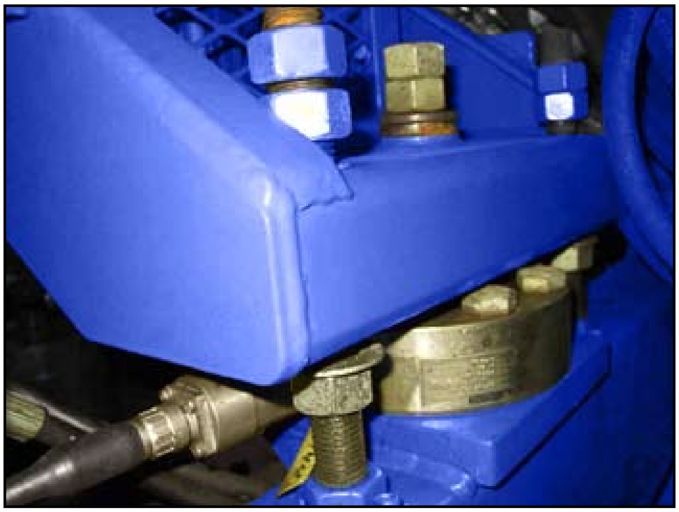

Figure 9-3. Load Cell

The load cell is a dual-acting sensor, which means that it can sense both tension and compression. To accomplish its dual-acting, weight-sensing task, the load cell is bolted to both the inner and outer frame. When transporting the CTU, the inner frame must be lifted and secured with bolts so that the vibration and weight do not damage the load cell.

The load cell is generally one of the sensors connected to the injector SIM. The unit's calibration parameters depend on the type of injector head being used.

In an emergency situation where the electronic signal is lost because of a SIM failure, the load cell can be connected directly to the power supply with a cable. If the load cell, EIM, or power supply fails, then the weight checker kit can be used to reestablish the weight measurement to safely pull the coiled tubing out of the well.

9.1.2 CT depth encoder

The simplest device to measure the depth and movement of the CT string is a depth encoder (Fig. 9-4). This encoder is typically driven by a friction wheel held against the CT string by a spring force. As the CT string moves, the wheel rotates. The speed and direction of the rotation is read by the depth encoder and translated into CT direction and depth. This information can also be translated into a reading for CT speed.

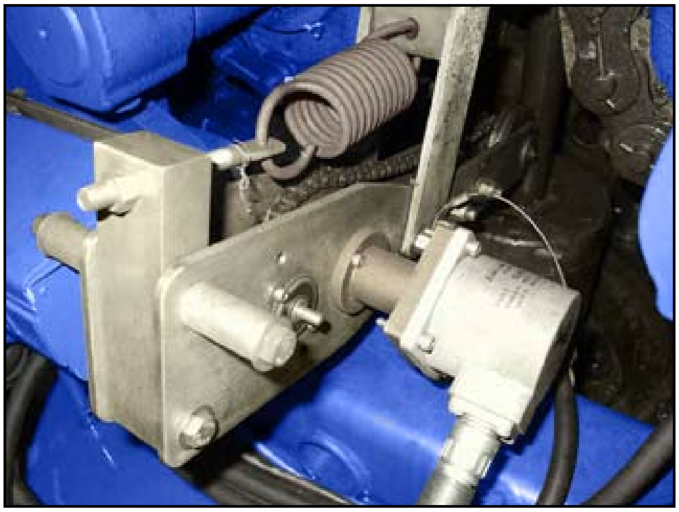

Figure 9-4. Depth Encoder

Typically, depth encoders are mounted on a friction wheel in one of three positions:

- on the front of the injector head, just below the chains
- on the mechanical counter, on the levelwind assembly
- on the drive shaft of the injector motor or chain sprocket.

The output signal of a depth encoder is a series of square pulses called *quadrature* (see Fig. 9-5). This type of signal can only be read by an injector SIM, UniSIM™, or ISDCU.

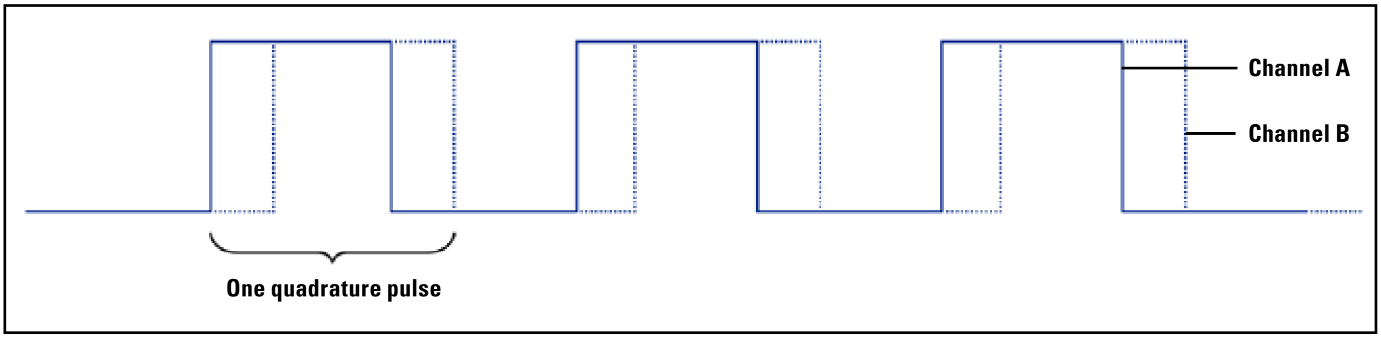

Figure 9-5. Depth Encoder Output

9.1.2.1 Universal tubing length monitor

The universal tubing length monitor (UTLM) is Schlumberger's most accurate surface depth measurement system for CT (see Fig. 9-6).

Figure 9-6. UTLM

It is a dual-wheel assembly that is generally mounted above the reel levelwind. On some occasions, it may be mounted just below the guide arch if there is movement between the reel and injector head, such as on semi submersible rigs or drill ships.

The UTLM has an accuracy of ± 10 ft in 10,000 ft. It has minimal errors due to slippage of the wheel on the CT string because the software can recognize if one wheel slips and will read the signal from the other wheel.

Like the depth encoder, the output signal of a depth encoder is a quadrature. The UTLM will be connected to either the injector SIM or UniSIM for a CT sensor interface (CTSI) data acquisition system or to the CT real interface (CTRI) for a CoilCAT 7 or higher version data acquisition system.

9.1.3 Pressures

Viatran™ pressure sensors (Fig. 9-7) measure the wellhead and circulating pressures on the system.

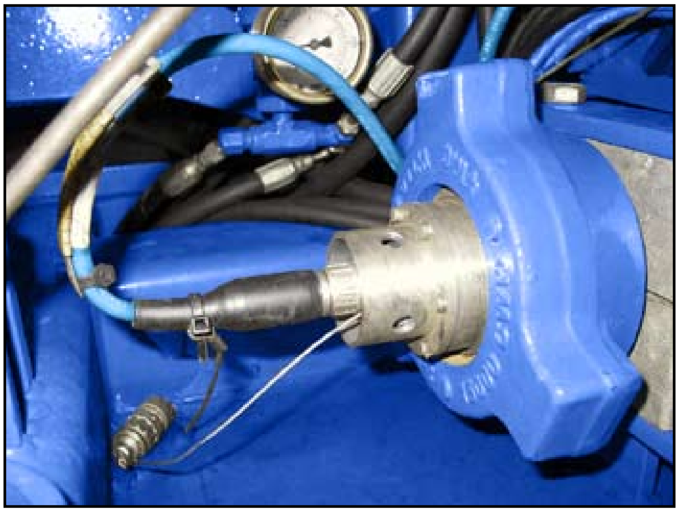

Figure 9-7. Viatran Pressure Sensor

The circulating pressure is normally measured on the external manifold of the CT reel. The wellhead pressure is normally measured at the side port of the BOP. These sensors are generally rated up to 15,000 psi and give an output of 4 to 20 mA, depending on the pressure.

Pressure gauges can be connected to any type of SIM.

9.1.4 Pump rates and fluid volume

Proximity switches are used to measure volume and pump rate (Fig. 9-8). They are generally installed on the shaft of a triplex pump.

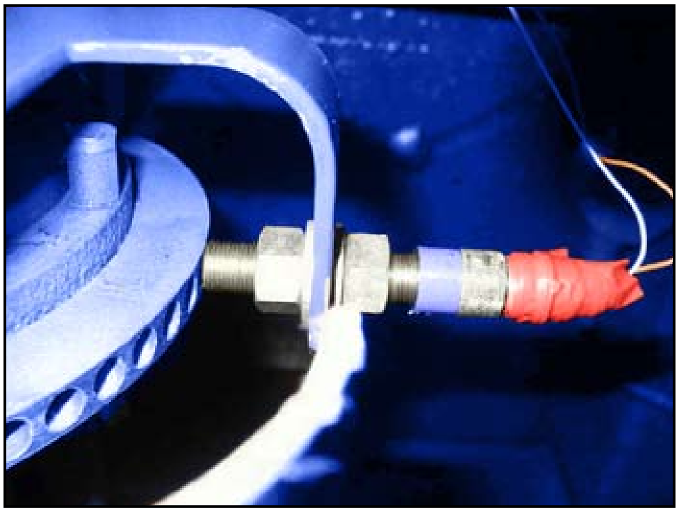

Figure 9-8. Proximity Switch

The proximity switch is mounted on a bracket near the pump drive shaft. Specially fabricated bolts with extended heads are used to replace the existing bolts previously used on the drive shaft flange. When the pump is in operation, the drive shaft spins. The proximity switch senses the proximity of these bolts as they rotate past it, and it sends a pulse each time.

The frequency of the signal is proportional to the rotation of the drive shaft, which is proportional to the volume pumped. A calibration factor, the K-factor, is programmed into the CoilCAT system to convert the raw frequency signal into a pump rate of barrels per minute or liters per minute.

The K-factor depends on the type of triplex pump (diameter of the plunger and stroke length). K-factors are available from the pump manual or InTouch for all triplex pump arrangements.

9.1.5 CT OD and wall thickness

The CT InSpec* coiled tubing real-time wall thickness measurement device uses ultrasonic sensors to measure CT wall thickness and the OD.

The CT InSpec is mounted around the CT string above the reel levelwind. It is connected to the CTRI, which sends signals back to the EIM.

9.2 SIMs

SIMs are used to digitize the input from the standard CT sensors and communicate their value to the EIM.

SIMs have very important functions in the CoilCAT acquisition system. They give the system versatility and simplicity in the rig up, monitoring, and recording of CT jobs.

The main functions of SIMs are to

- convert the analog signal from the sensor into a digital signal
- store calibration data for sensors: this information is stored in a flash memory chip and can be changed via CCAT.

SIMs can be connected in any order, to any of the BUS connections on the power supply in the control cabin. New versions of SIMs have a built-in LED to aid with troubleshooting. If a red LED lights, either the power supply or the communication devices have failed.

According to the application (where on the unit they are placed), different SIMs are available:

- standard SIM
- injector SIM
- uniSIM
- CTRI
- DCU.

9.2.1 Standard SIM

Standard SIMs are the most basic SIM available. They are designed to connect one sensor only, and can accept a current, voltage or frequency output from the sensor.

9.2.2 Injector SIM

The injector SIM can handle four sensor inputs. Its architecture and functionality is very similar to the standard SIM, but it has a larger circuit board with additional inputs. It can handle current, volts, frequency, and quadrature output signals from the sensor.

9.2.3 UniSIM

The UniSIM (Fig. 9-9) can handle multiple sensors simultaneously.

Figure 9-9. UniSIM

The UniSIM has several advantages over the injector SIM; the main advantages are listed below:

- higher reliability
- more water resistant
- more robust wire connection terminals
- delivered prewired—ready to program and use
- LED indicators to assist in troubleshooting. Thirteen LED indicators are visible through the clear lid that indicate the communication, programming, and encoder signal status of the UniSIM.

9.2.4 CTRI

The CTRI replaces the ReelSIM* on CoilCAT versions 6.0 and lower.

Figure 9-10. CTRI

The CTRI is used to interface to the CT InSpec, and the UTLM to the EIM. It also contains a depth connection for a wireline truck, which can be used in CT logging or perforation operations.

The CTRI also stores the string database for a string on a particular reel. The string database is a record of the CT string history and fatigue life. It is discussed in more detail in JET 12, CT Handling and Spooling.

9.2.5 DCU

The DCU is a multipurpose acquisition and control device. In acquisition mode, it acts like a SIM to send sensor data to CoilCAT. In new-generation CTUs, the DCU can also be used to control pump units, valves, and the CT reel.

9.4 Control cabin components

The remaining components of the CTU electronic system can be found inside the CTU control cabin.

9.4.1 EIM

The EIM is a programmable device (Fig. 9-11), which provides an interface between the SIMs and the laptop. The EIM displays the depth, speed, and weight parameters. It can be used to enter K-factors for depth and pump rates, and to zero all pertinent parameters (pressures, depth, and weight). It also records data to a solid state flash memory card.

Figure 9-11. EIM

The EIM is located in the CTU control cabin and replaces the CTSI main unit used in earlier versions of CoilCAT hardware.

9.4.2 Power supply

The power supply located in the CTU control cabin provides power to the sensors in the system. The cables from the SIMs are wired into the power supply. A single cable then connects the power supply to the EIM.

The power supply also has connection points for emergency depth and emergency weight cables. These connections are invaluable if a SIM failure occurs because they allow a cable to be connected from the power supply directly to the depth counter and load cell without passing through a SIM. This connection gives the operator depth and weight readings, allowing the CT string to be safely retrieved in an emergency.

Figure 9-12. Sensor Power Supply

9.4.3 Critical parameter display

The critical parameter display (CPD) is a display panel that shows 12 parameters in real time (Fig. 9-13). The operator can select which parameters are displayed through the CoilCAT software. Typically, the CPD is configured to display the most important parameters to the operator (depth, weight, speed, and pressures).

Figure 9-13. CPD

9.5 STEM 1 check for electronic components

Perform the following STEM 1 checks before and after every job. For the most up-to-date STEM guidelines, refer to the CT Surface Equipment Maintenance program (InTouch Content ID# 4196880).

9.5.1 Sensor cables

Perform the following checks of the sensor cables.

- connections
  - Clean the connections with an electronic contact cleaner.
  - Fit protective caps to all the connections to keep free of dirt or debris.
- cable
  - Spool cable and store in a dry environment.
  - Check the cable for any kinks or wear.

9.5.2 UTLM

Check operation and security of UTLM wheels, roller, and scrapers. Check the electrical fittings for evidence of wear or damage.

9.5.3 CT InSpec

Check packers and tubing guides. Replace if wear is evident. Packers will have to be changed every 1 to 2 jobs, whereas the tubing guides should last for approximately 100,000 running feet.

Check condition of oil tubes. Ensure tubes are clean and clear of any obstruction.

Check electrical connections and fittings for evidence of wear or damage.

9.5.4 Weight indicator load cell

Check that the load cell(s) are secure and that the injector head mechanical pivots are free to operate properly with the load cell.

Check electrical connections and fittings for evidence of wear or damage.

10.0 Troubleshooting

Often when a problem arises with a component or system, there is no immediately clear cause. However, most problems can be identified using a logical approach and a good knowledge of the systems involved.

In many cases, following the STEM 1 guidelines will identify the problem before it becomes severe enough to interfere with the operation of the CTU.

> **Caution:**
> When checking the operation of the components and systems, it is occasionally necessary to remove guards or protection devices. If this occurs, extreme caution must be exercised when the equipment is operated. Systems or equipment must not be operated while personnel or tools are in contact with moving machinery or located closer than would be normally allowed with any fitted guard.

Because all main parts of the CTU are hydraulically driven, the same things need to be checked regardless of which component has the problem.

- Attempt to operate the hydraulic system or circuit to ensure that the problem exists.
- Check that all controls and valves are positioned correctly and that the corresponding pressure gauges display the anticipated system pressures.
- Check that all hoses are correctly connected and that no gross leaks are evident. Incorrectly fitted hoses and malfunctioning connector check valves are a common source of problems.
- Check components for evidence of leaks, binding, or obvious damage.
- Check the hydraulic oil reservoir to ensure that there is sufficient hydraulic oil.
- Check whether the filters are clogged.
- Follow the troubleshooting guidelines contained in the appropriate technical manual for the specific piece of equipment.

Problems associated with the loss or lack of hydraulic pressure or flow that cannot be identified following the above checks will require a close inspection of the power pack and external circuitry.

Further checks can be done on the specific parts of the CTU according to the following sections.

10.1 Power pack

The following sections discuss troubleshooting the power pack components.

10.1.1 Hydraulic system

The main three factors that control and transmit power in a hydraulic system are

- flow
- pressure
- direction of flow.

It is important to check these factors as part of the troubleshooting of any hydraulic problem.

Other important aspects that can be easily checked are

- temperature
- noise
- contamination level
- leaks or bypass flow.

These factors are used as an aid in both locating the failed component and determining the reason for failure.

Components such as relief or unloader valves are particularly sensitive to dirt or particles in the hydraulic system. Often, adjusting such components resolves the problem by allowing the particles to pass through. However, care must be taken to ensure that the discharge pressure of such valves is not allowed to exceed the normal preset system pressure.

If one of the unit hydraulic systems fails to operate and checking the factors listed above fails to resolve the problem, the following guidelines should be followed to isolate the problem.

- Attempt to operate the system to establish if a fault really exists.
- Ensure that the system is activated by the needle or plug valve located by the system relief valve.
- Observe the pressure on the system gauge. If pressure exists on the system gauge, check that the system control/ pilot lines and valves are connected and operating as intended.
- If no pressure is shown on the system gauge, check the pump, pump suction valves, and reservoir conditions. If normal, disconnect the system hoses from the power pack.

> **Note:**
> Do not disconnect the case drain hoses unless a flow check is to be made. Failure to replace the case drain hoses may result in serious damage to motor components.

- With the engine at idle, attempt to activate the system by closing the plug valve located by the system relief valve.
    - If the system pressurizes, troubleshoot the controls and circuit components downstream of the power pack.
    - If the system does not pressurize, the pump or relief valve may need servicing. The priority and BOP circuits are fitted with accumulators that, if improperly charged, may be slow to build up pressure.

10.1.2 Engine

Diesel engines used to power the CTU are similar to those used in most of the powered equipment found within Well Services. However, an important feature of the CTU power pack is that the drive to the hydraulic pump array cannot, in most cases, be disconnected. Consequently, each time the power pack engine is started, consideration must be made to the effect on the hydraulic system.

A faulty hydraulic system may prevent the engine from starting by providing sufficient resistance to overload the starting system.

Any diesel engine requires three essential factors to start or run, and the availability of these factors should be investigated in this order:

1. air
2. fuel
3. compression (to provide ignition).

Availability of air and fuel may be investigated by the CTU operator; however, should the problem persist, further assistance should be sought from a mechanic.

10.2 Reel

Some specific problems that can occur with the CT reel are described below, along with some methods for investigating the source of the problem.

10.2.1 Reel drum not rotating

See Figure 10-1 to troubleshoot the reel drum rotation.

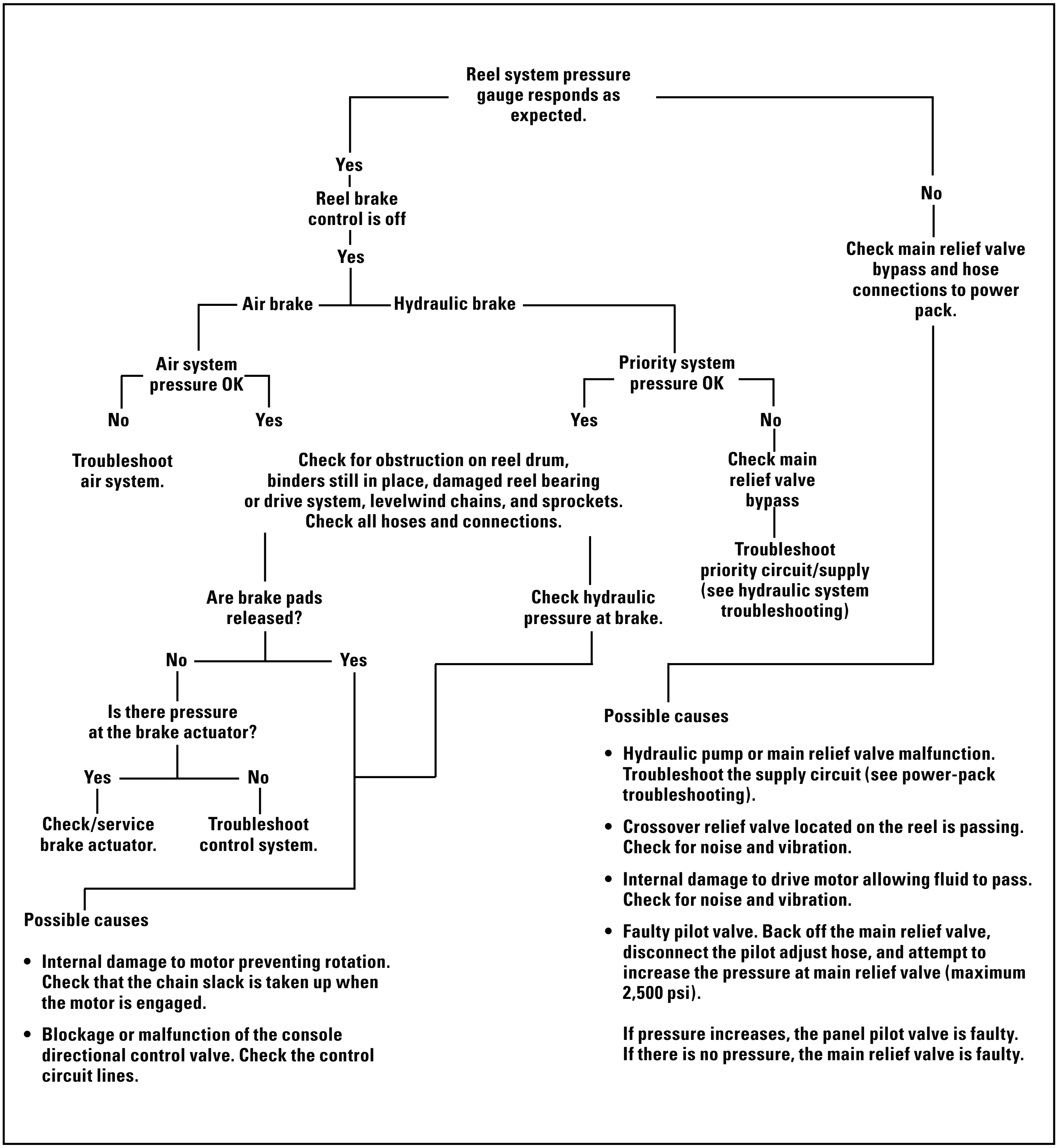

Figure 10-1. Troubleshooting Process for Reel Drum Not Rotating

10.2.2 Reel drum not rotating as fast as injector feeds tubing

Increasing system pressure will normally increase the starting and running speed of the reel drum. The pressure required to drive the reel will require to be increased as the weight of tubing on the reel increased, e.g., when POOH.

If an increase in system pressure does not increase the speed check for mechanical binding on the drum flanges, drive system, and levelwind system driven from the reel axle.

If the system pressure cannot be increased, check the pressure setting of all relief valves. In addition, it may be necessary to check the level of wear on the hydraulic pump and pressure controlling equipment.

10.2.3 Levelwind override motor not rotating

See Figure 10-2 to troubleshoot the levelwind override motor not rotating.

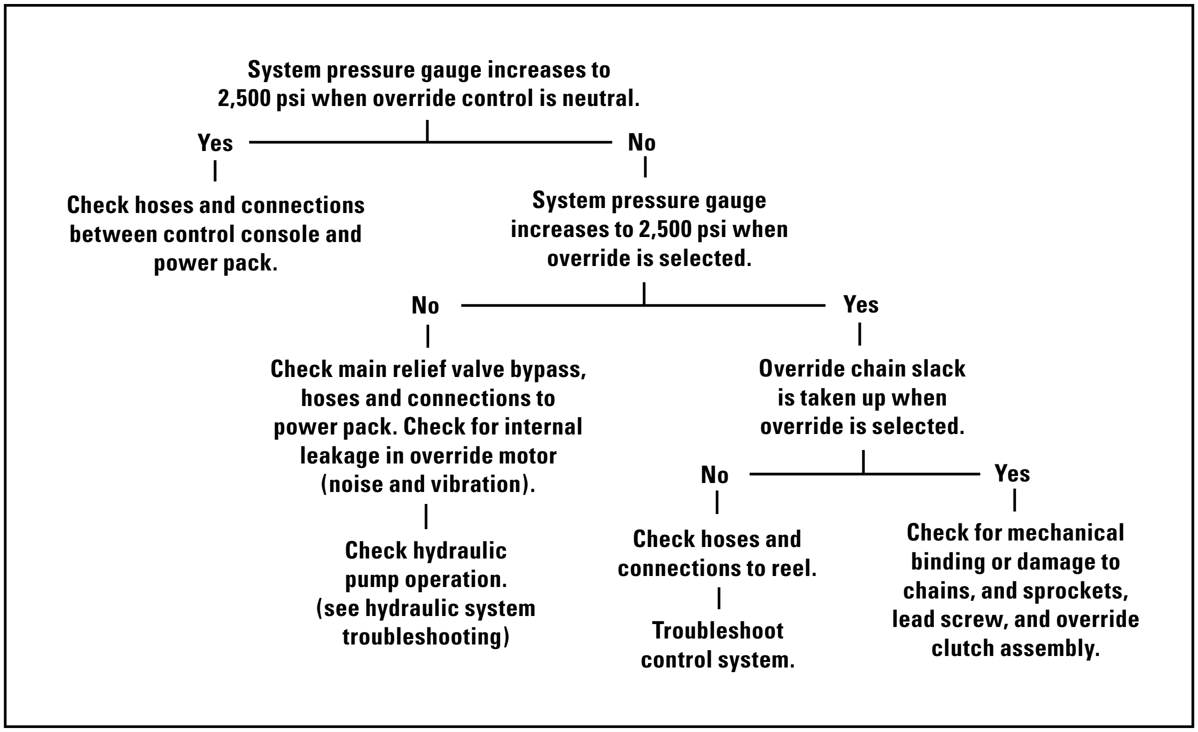

Figure 10-2. Troubleshooting Levelwind Override Motor Not Rotating

10.2.4 Lead screw not turning with reel drum

See Figure 10-3 to troubleshoot the lead screw not turning with the reel drum.

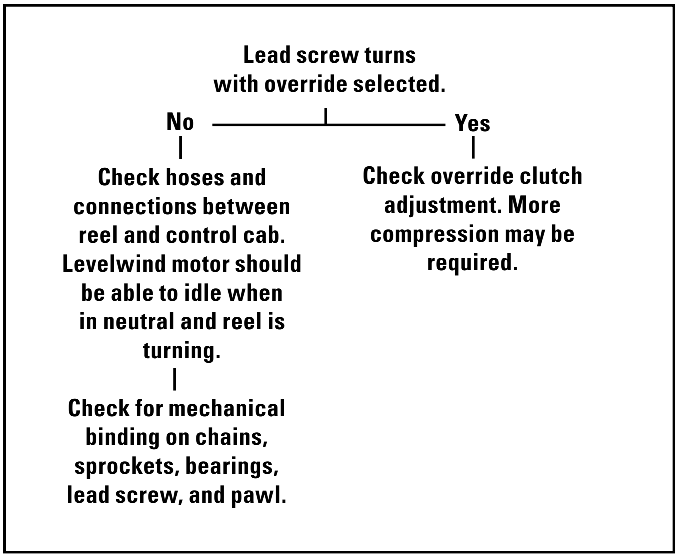

Figure 10-3. Troubleshooting Lead Screw Not Turning

10.3 Injector head issues

The following sections discuss various problems that may occur with the injector head.

10.3.1 Inside/outside chain tensioner system malfunctioning

If the inside/outside chain tensioner system is malfunctioning, it might have one of several different causes.

10.3.1.1 Inside chain tension circuit pressure not increasing to 2,000 psi

Perform these checks and remediate issues as necessary:

- Check that priority system pressure is 2,000 psi. If not, troubleshoot priority circuit.
- System drain valve may be improperly closed or leaking.
- Inside chain tension pressure adjust valve on control console may be faulty.

10.3.1.2 Inside chain tension circuit not holding pressure

Perform these checks and remediate issues as necessary.

- Check hoses and fitting for external leaks.
- Traction rams may be leaking internally. Remove the hose fitting from the nonactive end of the ram and check for continuous flow of fluid.
- Air may be trapped in the rod end (active end) of the cylinder. Bleed cylinders by loosening the fitting until air is expelled.
- The accumulator may be leaking internally. Check the accumulator precharge pressures with all hydraulic pressure bled off.

10.3.1.3 Outside chain tension circuit not increasing to 110 psi

Perform these checks and remediate issues as necessary.

- Check that priority system pressure is 2,000 psi. If not, troubleshoot priority circuit.
- System drain valve may be improperly closed or leaking.
- The outside chain tension system pressure-reducing valve, located beneath the operator’s console, may require servicing.

10.3.1.4 Outside chain tension circuit not holding pressure

Perform these checks and remediate issues as necessary.

- Traction rams may be leaking internally. Remove the hose fitting from the nonactive end of the ram and check for the continuous flow of fluid.
- Air may be trapped in the rod end (active end) of the cylinder. Bleed cylinders by loosening the fitting until air is expelled.
- The accumulator may be leaking internally. Check the accumulator precharge pressures with all hydraulic pressure bled off.

10.3.1.5 Injector head running noisily

Perform these checks and remediate issues as necessary.

- Outside chain tension may be insufficient. Check that the pressure is maintained.
- If inside or outside chain tensions pressure gauges are oscillating, the accumulators may require charging.

10.4 Injector drive/brake systems issues

The following sections discuss several causes of injector drive/brake system problems.

10.4.1 Injector head motors not turning

For the following symptoms, perform the indicated checks and remediate any problems as necessary.

- Hydraulic pressure appears abnormal. If CTU is equipped with a multiple pump option, check that at least one pump is selected.
- Observe pumps for high temperature or noisy operation. If operation appears abnormal, check that the supply line and strainers are clear.
- On multiple pump models, check that the relief valve located on the Husco valve is closed. This valve must be open for spooling.
- Check control pressures. With the Monsun Tison direction control valve fully shifted, the direction control valve pilot pressure must be at least 200 psi to operate the Husco valve.
  - If this pressure is low, check that the priority supply is turned on at the power pack.
  - A small amount of debris in the relief valve, located beneath the control console supplying the direction control valve, may interfere with the delivered pressure. Fully opening and closing the adjustment knob may resume operation of the valve.
  - Always reset to 600 psi.
  - If the problem is still not resolved, troubleshoot the priority system.
  - Also, check the condition of the I-line filter to the directional control valve.
- Remove the injector drive hoses from the power pack connections.
- Shift the direction control valve fully in one direction; the system pressure should increase to 3,000 psi as the pilot valve is adjusted.
- If the pressure does not increase, back out the knob on the drive system main relief valve. This is located between the pump check valves and the Husco valve on the power pack.
- Disconnect the hydraulic connector for the injector pilot pressure adjust, thereby isolating the pilot valve from the supply.

- Shift the directional control valve fully in one direction and attempt to adjust the system pressure using the main relief valve on the power pack. If the pressure increases, the panel-mounted pressure relief valve is faulty. Do not exceed 3,000 psi.
- Ensure that the injector head drive hose connections are fully made up.
- Hydraulic pressure appears normal.
- Check that the manual brake is released (where fitted).
- Check that 1 1/2-in hose couplings are fully assembled.
- Observe the weight indicator. If weight moves with attempts to move, the tubing may be stuck or held by BOP rams.
- Check pressure to automatic brake components. Ensure that the brake pilot line needle valve, located on the injector head, is open.
- Check counterbalance pilot needle valves are open. Normal setting is two full turns open from closed position.
- Check for mechanical locking or binding, generally indicated by severe noise.

10.4.2 Injector head motors not achieving full speed

The following problems may be present. Remediate any problems as necessary.

- Engine rpm may be too low.
- Hydraulic brakes may be dragging.
- System relief valves may be incorrectly set.
- Injector motors or pumps may be worn.
- Injector counterbalance valve is not fully open.
- The direction control valve is not fully shifting the Husco valve.
- The Husco valve may be faulty.

10.4.3 Injector head only achieving full speed in one direction

The following problems may be present. Remediate any problems as necessary.

- The Husco valve may be malfunctioning because of debris or wear.
- The hydraulic connections between the directional control valve and the Husco valve may be improperly assembled.

10.4.4 Operation of the injector head erratic

The following problems may be present. Remediate any problems as necessary.

- The needle valves on the counterbalance pilot lines may be improperly adjusted. Normal setting is two full turns open from closed position.
- Air is in one or both of the counterbalance valve pilot lines.
- One or both of the injector head motors may be damaged, causing intermittent loss of hydraulic flow and pressure.
- One of the bearings in the injector drive train has failed.

10.4.5 Injector head not stopping when directional control valve centered

The following problems may be present. Remediate any problems as necessary.

- The directional control valve may require servicing. Fit a gauge to both Husco pilot control lines and check that pressure is zero when the valve is centered. Also, check that the centering springs on the directional control valve are effective.

- The counterbalance valves may be worn or affected by debris, allowing the motors to creep.
- The injector motors may be worn or damaged internally and the hydraulic brake may also be worn or damaged.

10.4.6 Hydraulic system running hot

The following problems may be present. Remediate any problems as necessary.

- The fluid level may be low or pump suction is restricted.
- The heat exchanger and thermostatic valve operation may be faulty.
- A hydraulic system may be dumping continuously over a relief valve. This result may be caused by improper connection of hoses or poor operating technique.

10.4.7 Injector running but not engaging in high gear

The following problems may be present. Remediate any problems as necessary.

- Priority system pressure may be abnormal.
- The levelwind raise/lower valve may not be centered. Both valves have a common supply; improper operation of one may affect the other.
- The pressure may be incorrect. The pressure gauge under operators console, located downstream of the pressure-reducing valve, should indicate a maximum of 600 psi.
    - If pressure exists, install a pressure gauge at the motor end of the high/low shift control hose. With the high gear selected on the high/low shift valve, if the pressure is above 145 psi, the internal shift mechanism may be suspect. If the pressure is below 145 psi, check hoses and fitting between the injector head and the console.
    - If no pressure exists, the pressure reducing valve may require servicing.

10.4.8 Injector running but will not engage in low gear

Install a pressure gauge at the motor end of the high/low shift control hose. With the low gear selected on the high/low shift valve, if the pressure is zero, the internal shift mechanism may be suspect.

If the pressure is above 145 psi,

- the system hose connections may be defective
- the control valve on the operator’s console may require servicing
- the free-flow check valve around the pressure-reducing valve may be blocked or defective.

10.4.9 Injector head brake not releasing

The following problems may be present. Remediate any problems as necessary.

- The needle valve, located on the injector head brake release line, may not be open.
- The gauge should display 600 psi when the brake release is activated. If it does not, the priority valve (Marco valve) may require servicing.

10.4.10 Injector head brake not engaging

The following problems may be present. Remediate any problems as necessary.

- The needle valve, located on the injector head brake release line, may not be open.

- The internal check valve in the pressure-reducing valve may not be allowing reverse flow.
- The priority valve spool spring centering mechanism may not be effective.
- With the pressure at the motor brake port at or near to zero, close the brake-line needle valve. Shift the direction control valve fully in either direction and slowly increase the drive system hydraulic pressure. Monitor the hydraulic system pressure on the gauges mounted on the injector head counterbalance valves. The injector head brakes should not slip at less that 2,375-psi differential pressure. If the pressure is less, it is likely that the friction discs in the hydraulic brake assembly require replacement.

10.5 Stripper

To simplify the stripper troubleshooting procedure, two flowcharts are shown. Figure 10-4 outlines the recommended procedures to locate and rectify a leak on the stripper assembly. Figure 10-5 outlines the procedure that will assist in identifying problems in the stripper hydraulic system.

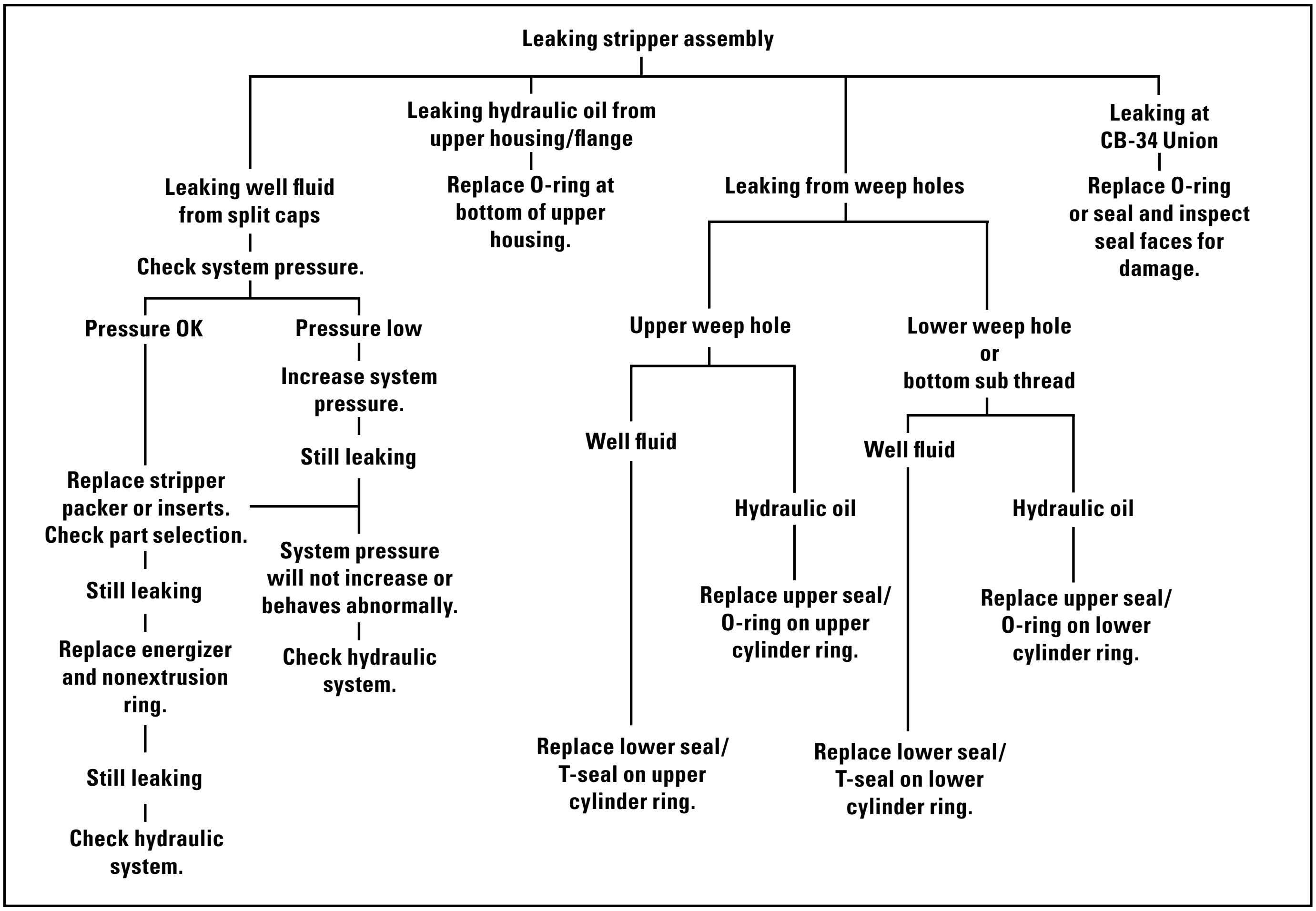

Figure 10-4. Locating and Rectifying Leak on Stripper Assembly

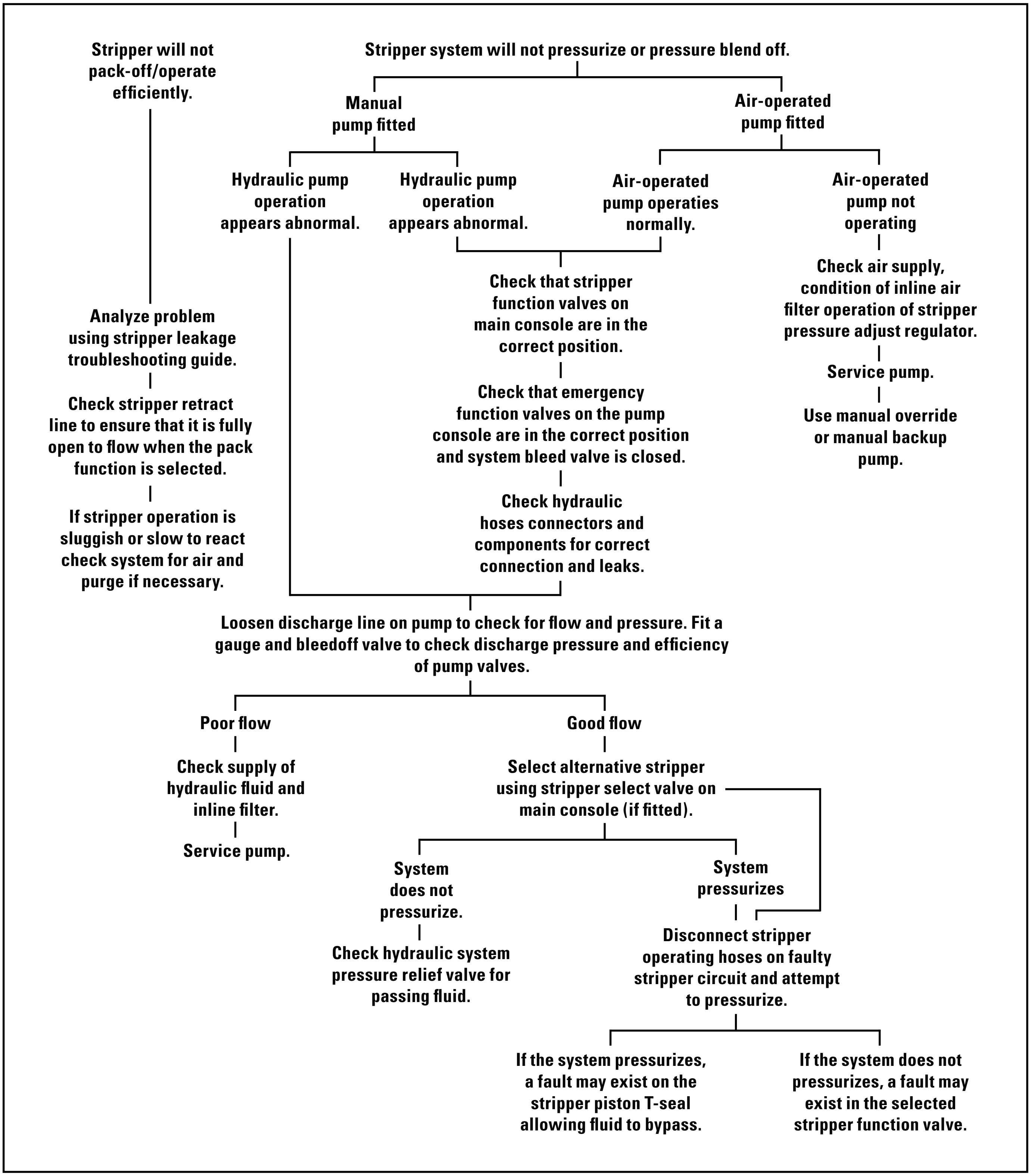

Figure 10-5. Identifying Problems in Stripper Hydraulic System

Some additional points that may contribute to a fault or condition are listed below.

- Tubing that has been damaged or is oval may not allow the stripper to seal properly. Check surface condition and shape of tubing when sealing problems occur.
- Poor stripper/injector head alignment can lead to sealing difficulties. Always inspect bushings for abnormal wear when servicing the stripper assembly.
- Whenever seals or O-rings are changed, the corresponding seal face area must be checked for damage or excessive wear.
- The number of interchangeable packing arrangements available from various manufacturers and suppliers, together with the similarity in sizes, allows sizing errors to be made easily if care and attention are not exercised in their selection. Double-check packer insert sizes to ensure they are suitable for use with the energizer in place. This is especially applicable to the spare inserts which are carried with the unit.
- Internal O-rings and seals in the stripper assembly should, if possible and practical, be changed as a set.
- Never attempt to strip through the pipe rams if a stripper fails. The pipe rams exert a considerable force to the tubing wall, which will almost certainly result in the distortion of the rams or tubing. The pipe rams are an important well control barrier and should only be used for the purpose for which they are intended.
- In common with all hydraulic systems, the operation of the stripper will be impaired if air is allowed to enter the control system. Every effort should be made to prevent excessive loss of oil and corresponding influx of air while rigging up, operating, or maintaining the stripper system.
- Dry rusted or scaled tubing is the most common cause of premature stripper packer failure. Appropriate treatment to prevent tubing rust, together with tubing lubrication while running in the hole, will minimize the risk of excessive wear.

10.5.1 BOP blind or pipe rams do not hold well or test pressure is low

See Figure 10-6 for troubleshooting procedures.

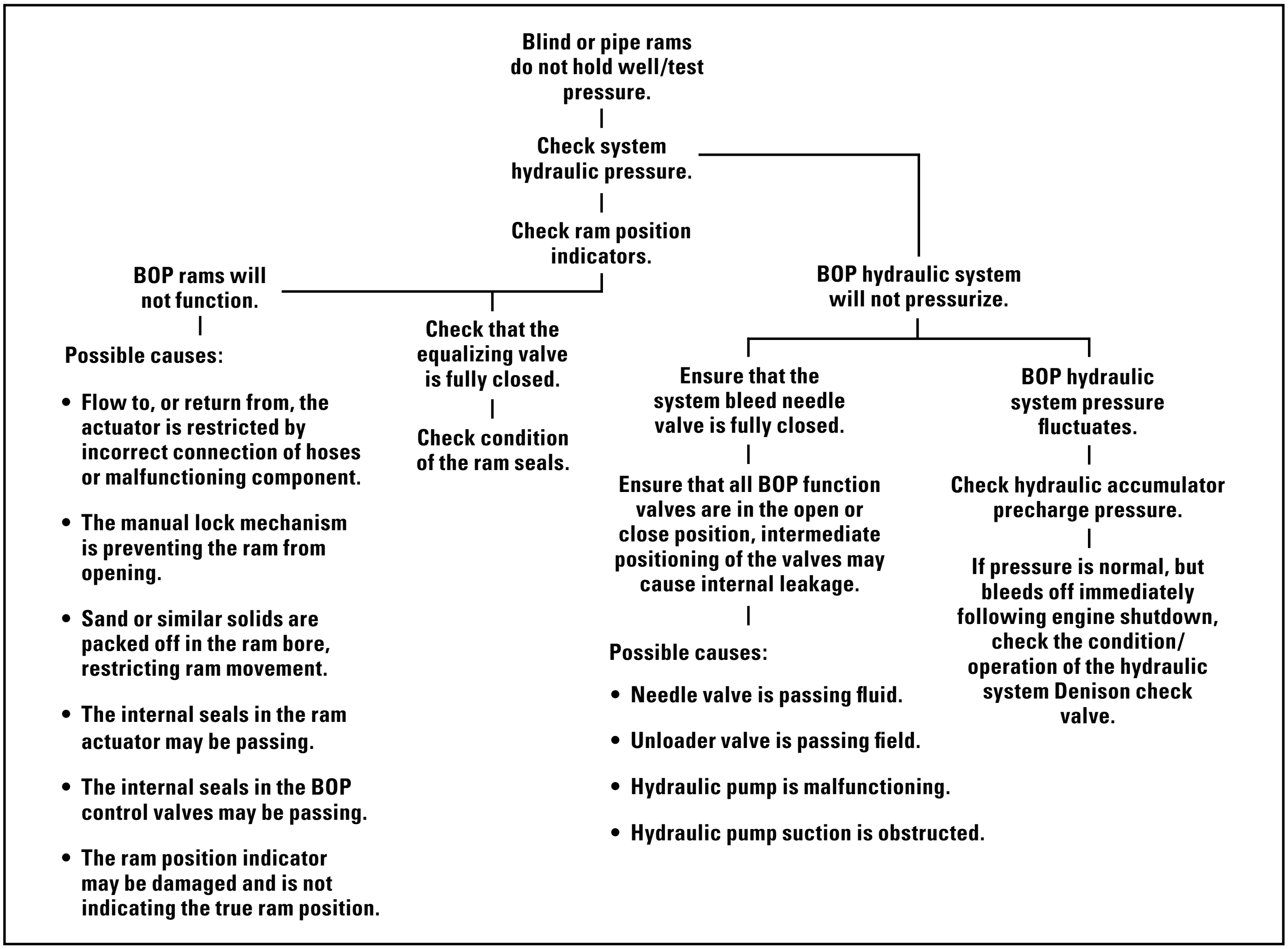

Figure 10-6. Troubleshooting Blind or Pipe Rams Not Holding Pressure

> **Note:**
> Further training on hydraulic systems is available from the ITZ (Industrial Training Zone) online Basic Hydraulics 4.2 course, at http://training.itz.net. A user name and password can be obtained from the training centers.

This page left intentionally blank

11.0 Glossary

BHA	bottomhole assembly
BOP	blowout preventer
CT	coiled tubing
CTRI	CT real interface
CTSI	CT sensor interface
CTU	coiled tubing unit
DCU	distributed control unit
EIM	equipment interface module
H_2S	hydrogen sulfide
POOH	pull out of hole
RIH	run in hole
SIM	sensory interface monitor
UTIM	universal tubing integrity monitor
UTLM	universal tubing length

This page left intentionally blank

12.0 References

Refer to the following references for more information.

- Well Services Safety Standard 5: Pressure Pumping and Location Safety, InTouch Content ID# 3313681
- Well Services Safety Standard 22, Coiled Tubing Operations, InTouch Content ID# 4221755
- CT Surface Equipment Maintenance program, InTouch Content ID# 4196880
- JET 12, Coiled Tubing Handling and Spooling Equipment, InTouch Content ID# 4221738
- JET 13, CT Pressure Control Equipment, InTouch Content ID# 4221744

This page left intentionally blank

13.0 Check Your Understanding

1. Which two components of a CTU are integrated in a three-piece CTU?
   A. power pack
   B. control cabin
   C. reel
   D. injector head

2. The CTU power pack usually runs on __________ .
   A. gasoline
   B. electricity
   C. diesel
   D. methane

3. Power packs are generally classified according to the type of hydraulic circuit powering the injector head. What are the three types of injector head hydraulic circuits?
   A. standard open loop
   B. standard closed loop
   C. high-pressure open loop
   D. high-pressure closed loop

4. Which of the following functions does hydraulic fluid perform?
   A. transmits power to the CTU components
   B. lubrication of system components
   C. sealing
   D. cooling
   E. all of the above

5. Which of the following functions is not performed by the hydraulic fluid reservoir?
   A. allows entrained air to be released
   B. allows settlement of dirt and metal particles
   C. stores the hydraulic fluid
   D. allows the fluid to be warmed

6. In a CTU, accumulators are used for which two reasons?
   A. cooling the hydraulic fluid
   B. shock absorption
   C. energy storage
   D. clean debris from the hydraulic fluid

7. Which type of hydraulic pump allows higher pulling forces, but is more sensitive to hydraulic fluid contamination?
   A. centrifugal pump
   B. vane pump
   C. piston pump
   D. triplex pump

8. In which type of injector head circuit does the hydraulic oil return to the reservoir after passing through the injector head motors?
   A. standard open loop
   B. high-pressure open loop
   C. high-pressure closed loop

9. Which type of injector head circuit is a flush circuit used to replenish internal leaks and add cool oil into the circuit?
   A. standard open loop
   B. high-pressure open loop
   C. high-pressure closed loop

10. Which two CTU circuits contain accumulators?
    A. priority and BOP
    B. injector head and auxiliary
    C. high-pressure and stripper
    D. BOP and stripper

11. How often should a STEM 1 check be carried out on a power pack?
    A. every 750 working hours
    B. every 750 working hours or 3 months, whichever comes first
    C. before and after every CT job, or at regular intervals during longer operations

12. Which two of the following sentences is true?
    A. The tension system applies force to the gripper blocks to grip the CT string.
    B. The traction system applies force to the gripper blocks to grip the CT string.
    C. The traction system applies force to take slack from the injector drive chains.
    D. The tension system applies force to take slack from the injector drive chains.

13. When scanning the instruments and gauges on the control console, which group is the most important to keep under constant observation?
    A. depth measurement, stripper pack pressure, inside chain tension
    B. weight indicator, wellhead pressure, circulating pressure
    C. power pack engine gauges, hydraulic gauges

14. How should a reel be secured from rotation during transportation?
    A. chains and binders securing in each direction
    B. the hydraulic brake is applied
    C. all of the above

15. Which of the following sentences is correct about the reel drive system?
    A. The reel drive should be set in the out-of-hole direction during POOH, and in the inhole direction during RIH.
    B. The reel drive should be set in the out-of-hole direction during POOH and RIH.
    C. The reel drive should be set in the inhole direction during POOH and RIH.

16. The reel pressure should be __________ .
    A. higher during RIH than during POOH
    B. kept at approximately the same value during RIH and POOH
    C. higher during POOH than during RIH

17. Which two of the following sentences is true about the reel brake?
    A. 300-psi pressure required to release the reel brake
    B. 300-psi pressure required to activate the reel brake
    C. the reel brake powered by the priority circuit
    D. the reel brake powered by the reel drive circuit

18. The levelwind system allows accurate and efficient spooling of the CT string onto the reel drum. Which of the following are disadvantages of a poorly spooled CT string?
    A. increased chance of mechanical damage to the CT string
    B. increased corrosion
    C. CT string may not fit on reel drum
    D. all of the above

19. Which component of the reel makes it possible to pump through the CT string even during rotation for the reel drum?
    A. external manifold
    B. swivel
    C. Chiksan
    D. axle

20. Which hydraulic system on the injector head uses three hydraulic pistons?
    A. inside chain traction
    B. outside chain tension
    C. accumulator

21. What is the purpose of the accumulators fitted to the injector head?
    A. store energy to allow the activation of the traction cylinders in case of a hydraulic failure
    B. reduce vibrations to the traction and tensioner pistons
    C. no accumulators on the injector head

22. Guide arches are manufactured with a radius between 48 in and 120 in. How is the size chosen for a particular CT string size?
    A. The radius should be a minimum of 40 times the OD of the CT string to minimize CT fatigue.
    B. The radius should be a maximum of 25 times the OD of the CT string to minimize CT fatigue.
    C. The radius should be the same as the radius of the reel drum.
    D. CT string size is not important; the right radius of the guide arch depends on the type of injector head.

23. What is the primary hydraulic supply for the stripper?
    A. Haskell air-over-hydraulic
    B. Rucker manual pump
    C. priority circuit
    D. Haskell manual pump

24. Slip rams prevent movement in which direction?
    A. upward
    B. downward
    C. upward and downward

25. When changing the size of CT, which BOP rams do not need to be changed in a quad BOP?
    A. blind rams
    B. shear rams
    C. slip rams
    D. pipe rams
    E. no rams

26. In the CTU acquisition system, what is a SIM?
    A. sensor integrity monitor
    B. sensor interface module
    C. system interface module
    D. setup interface manual

27. What does the CT InSpec monitor?
    A. CT depth and speed
    B. CT weight
    C. CT wall thickness and OD measurements
    D. pump rate

28. Proximity switched are used to measure what type of signal?
    A. CT weight
    B. pressure
    C. volume and pump rate
    D. depth

29. What is the common name for the calibration factor for a sensor on a pump?
    A. C-factor
    B. K-factor
    C. G-factor

30. The UTLM should be connected to a standard SIM.
    A. true
    B. false