This manual will help users operate and maintain the drill rig correctly. The manual supplied with the drill rig is primarily intended for use by operator. It is particularly important that the drill rig operator should read these instructions carefully not only prior to using the drill rig for the first time (in order to become acquainted with its operation and special features), but also so as to take full advantage of its capabilities during use, or for lubricating and servicing operations. Otherwise accidents or damage may occur.

The manual should be regarded as the permanent part of drill rig and kept in the cab for consultation at any time. And the manual should be attached when the drill rig is transferred or sold.

The drill rig is designed according to the metric system, all the data presented are metric and only metric parts and apparatus can be used.

Position definition: RIGHT and LEFT always mean the left and right of an operator seated correctly in the drill rig. The drive sprockets of undercarriage are located at the rear.

For best drill rig performance, all instructions given in this manual should be complied with strictly. Possible warranty claims may be considered only provided that all operations are made by qualified operator and scheduled inspections are made at the specified times by qualified technician. Warranty claims will not be considered provided the drill rig is abused, overloaded, or if there are changes to the original functions of drill rig.

Regarding SAFETY in particular, we recommend carefully reading the SAFETY RULES in this manual and complying with all the safety rules.

The equipment covered by this manual meets the applicable technical specifications effective as of its date of issue. The manufacturer SUNWARD reserves the right to make from time to time and without prior notice any modification or amendment of any nature, deemed useful or necessary, to any drill rig component, without any obligation to amend the content of this manual accordingly. Pictures and data contained in this manual are not binding. Consequently, no claim raised in this respect will be considered.

American Piledring Equipment, Inc.
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§ 1 Safety Rules

§ 1.1 Safety Mark

The figure to the right is a safety reminder. When you see this mark on the drill rig or in the manual, it indicates that you may be in danger of injury.

§ 1.2 Safety Label

There are various labels at various places on the drill rig indicating various risks, such as Danger, Warning, Attention, etc (right figure), they have the following meaning:

Danger---Direct danger. It will cause death or grievous bodily harm (GBH) if accident occurs.
Warning---Potential danger. It may cause death or GBH if accident occurs.
Attention---Potential danger. It may cause flesh or moderate wound.

Danger, Warning safety labels are placed at given locations of the drill rig in the possible dangerous area. General attentions are listed on the “Attention” safety label. In this manual, “Attention” is also used to remind of safety instruction.

§ 1.3 General Safety Instruction

- Read the manual carefully and follow the safety instructions on the labels and manual before operating the drill rig.
- Always keep the safety labels clean. Change any lost or damaged labels with new ones. If the labels or manual are lost, you can contact the dealer and indicate the model of drill rig to purchase.
- Only trained and qualified operators are permitted to operate this drill rig. Keep the drill rig in good condition as per this
Do not modify the drill rig without prior authorization, otherwise it will affect the performance and service life of the drill rig, or may cause injuries to human body.

ATTENTION: The safety instructions in this manual include only the general safety rules of the drill rig. Not all possible danger is covered. Should any problems occur, please report to your superior before operating and maintaining the drill rig.

§ 1.4 Preparation For Emergency

All personnel related to operating the drill rig should pay attention to prevent accidents from happening. Always keep a first-aid kit and fire extinguisher nearby. Have phone numbers of a doctor, ambulance, hospital, and fire department with you in case of emergency.

§ 1.5 Wear Safety Protective Gear

Before operation, always wear protective gear as the work requires, this includes:

- Tight work clothes
- Hard hat
- Safety gloves
- Safety glasses, goggles, or shield
- Dust mask or respirator
- Earplug
§ 1.6 Check Drill rig Before Start-up

Before each day or shift, check the drill rig according to the “Check drill rig before start-up” section.

§ 1.7 Adjust Operator Seat

You may adjust seat to suit yourself, Lean your back on the back of seat and let your feet reach the pedals.

§ 1.8 Enter or Leave Drill rig

Always face the drill rig when you use the steps and hand-holds to enter or leave drill rig. Never use any control lever as a handhold. Never enter or leave drill rig when the drill rig is traveling, swinging, or drilling.

§ 1.9 Start Engine

The operator must sit on cab seat to start engine. Standing on the crawler to start engine is not permitted. Hot wire start-up (including terminal start-up) is not permitted.

§ 1.10 No Passenger Allowed In The Cabin

When the drill rig is in operation or traveling, no passenger is allowed to stay on or in the drill rig except the operator.

§ 1.11 Keep Drill rig Away From Power Line

Any part or load of the drill rig touching power line will cause human death or GBH. Prohibit drill rig or its load from operating in close proximity to any power line. Keep the drill rig 3 meters (10feet) away from any power line(50,000KV or less) and follow OSHA rules.
§ 1.12 Move Drill rig Safely

- Before the drill rig travels and swings, know the position of other people, and keep the drill mast backward $15^\circ$ to avoid the drill rig tilting.
- Before the drill rig travels or swings, warn other people by tapping the horn.
- Hand signal should be used when operation or swinging is in confined area, and agree upon the hand signals before drill rig start-up.
- Know that the pedal/control levers are corresponding to the traveling direction before operate the drill rig.
- Raise drill mast and tool before moving drill rig. Stop the engine and take any necessary measures should the kelly bar fall.

§ 1.13 Prevent Accident While Backing Up or Swinging

Swinging

In order to prevent accidents while backing up or swinging, the operator must:
- Look around and confirm nobody is there before backing up or swinging.
- Ensure that other people are out of the working range. Warn other people by tapping the horn or using other signals before the drill rig moves,
- Keep a signal man within his/her vision range if the operator’s vision is obscured.
- Understand the meaning of flags, marks and signals before the drill rig moves or swings.
- Keep windows, mirrors, and lights clean.
- Use lights when visibility is obscured by dust, rain, fog, etc.
- Read carefully and understand the contents of this manual.

§ 1.14 Operate Safely

- All non-work related people should be kept away from the drill rig’s working range.
- The jobsite MUST be hard enough to
support the drill rig, or use 2 steel plates to support the crawlers in order to prevent the drill rig from tipping over.

- When the drill rig works close to a hole, the tension wheel end should be towards the hole, the crawlers should be placed in a position such that the drill rig can move away easily in case of hole collapse.

- Hole location should be in the center line of the two crawlers. Leave enough space for the drill rig to swing or dump soil.

§ 1.15 Avoid Accident when The Drill Rig Out Of Control

GBH or death may occur when attempting to climb onto a moving drill rig or trying to stop an out-of-control drill rig.

In order to prevent that from happening, pay attention to the following:

- Stop the drill rig on a flat ground and try to avoid stopping on slope. Shut down the engine according to the following procedures:
  - Run engine at low RPM for 3 minutes to cool down the drill rig.
  - Stop engine, take out key from key switch.
  - Switch off hydraulic control switch by lifting the Left Console.
  - Use chocks to block crawlers, and boom down the drill mast if the drill rig has to stay on slope.
  - Secure the drill rig to prevent accidental movement.
  - Keep the drill rig away from other machinery.
  - Pin superstructure with undercarriage during transport.

§ 1.16 Park drill rig safely

Stop drill rig according to the following steps:

- Place drill rig on flat ground.
- Boom down the drill mast to horizontal position.
- Run engine at low RPM for 3 minutes to cool drill rig down.
- Slide the fuel handle to stop position; turn the ignition key to “OFF” position.
- Switch off pilot control by lifting the Left Console.
- Close window, sky window, and cabin.

§ 1.17 Safe Maintenance

- Maintenance Steps:
  Keep the working area clean and dry.
  Don’t lubricate or maintain a moving drill rig.
  Keep body and clothing from touching any moving parts.
- Preparation for maintenance:
  Place the drill rig on flat ground.
  Lower the mast foot on the ground or boom the mast down on the horizontal support bracket.
  Run engine at low revs for 5 minutes.
  Push fuel handle forward, stop engine, and take out key from the ignition.
  Hang the “Drill rig out of Duty” plate at control lever.
  Switch off pilot control.

- Safety in maintenance
  One person should remain inside the cabin if the maintenance must take place while the engine is running.
  Check some parts at regular intervals. Repair or replace, if necessary. (Refer to the “maintenance” chapter of this manual)
  Make sure all parts are in good condition and fit correctly. Replace worn or damaged parts. Clean any excess lubricant.

When adjusting electric system or welding on the rig, disconnect both positive and negative poles of battery and all the connections on PLC and Rexroth controls(see
§ 1.18 Support Drill rig Correctly

Prohibit repairing or maintaining drill rig before the drill rig is well supported. Before maintenance, lower the drilling tools to the ground or lower the drilling mast on the bracket. Don’t support the drill rig on any slag, hollow brick, or fragile objects.

§ 1.19 Clean Trash From The Rig

Keep the engine, radiator, battery, hydraulic line, fuel tank, and cabin clean.

After stopping engine, the engine temperature may rise immediately. Open engine compartment doors to cool engine as soon as possible and clean engine apartment. Clean drill rig at regular intervals, eliminate excess lubricant and other trash. Do not spray water or vapor into cabin.

§ 1.20 Prevent Battery Explosion

Prohibit fire or flame close to the battery top, battery gas may cause explosion.

Check the electric charge with a voltage meter or gravimeter. Do not place metal bestriding connection rod to check electricity deposit.

Never charge a frozen battery, otherwise it will explode. The battery should be warmed up to 16° C (60° F).

§ 1.21 Grinding Safely

Minimize grinding dust and debris by appropriate means. Wear goggles. Keep people away from work area to avoid accidents.

§ 1.22 Prevent Parts From Flying

Off
The grease in the crawler tension unit is under high pressure. To avoid injury, do not discharge grease cup or valve. Also keep your body and face away from any valves in case any unexpected parts fly off.

§ 1.23 Keep Away From Transmission

Parts

Touching transmission parts may cause GBH. When you work around the transmission parts, pay attention not to let your hand, foot, hair or clothes touch the drill rig.

§ 1.24 Prevent Inhaling Asbestos

Dust

Prevent inhaling possible asbestos dust. The asbestos fiber may cause lung cancer. Some seals contain asbestos fiber. In these components, normally, the asbestos is in the resin or kept closed. If the asbestos containing parts don’t cause dust, there isn’t any danger in normal disposal. In order to prevent dust, don’t clean with compressed air, and avoid brushing and grinding asbestos-contained materials. In maintenance work, wear regulated respirator, and use a special dust collector to clean asbestos. If dust collector is not available, use a little oil or water to damp the asbestos-contained material. Comply with working area rules and asbestos disposal rules. Keep other people from entering in working area.

§ 1.25 Beware Of Inhaling Smoke or Exhaust Gas

Inhaling exhaust gas may cause disease, or even death. If the drill rig is operated inside a building, open windows and doors to ensure sufficient ventilation, or use long exhaust pipe to discharge smoke.
§ 1.26 Beware of Scalding

During operation, engine oil, gear oil, hydraulic oil will become hot. Also engine, hose, exhaust pipes, and other parts will also become hot. Beware of scalding. Carry out inspection and maintenance after oil and parts have cooled to prevent scalding. The hydraulic oil tank and pipeline are high pressured. Before maintenance or replacement, the pressure should be released to avoid hot oil erupting.

§ 1.27 Be Careful Of Pressured Liquids

Liquids in high pressure can penetrate through skin, causing GBH. Release pressure before disconnecting any pipes to avoid this. Operate control lever many times to release pressure. Before pressurizing, tighten all the connections. Inspect leakage with cardboard. Pay attention to protect your hand and body. If accident occurs, see a doctor at once. Any liquid penetrating the skin must be cleaned within a few hours, otherwise it will cause tissue decay.

§ 1.28 Avoid Heating Near A Pressured Oil Pipe

To prevent severe burns, do not weld or flame cut near pressured oil pipe or other flammable materials.

A temporary fireproof protection cover should be provided when welding, flame cutting or gas welding takes place.

§ 1.29 Avoid Heating Flammable Liquid Pipe
Pipes with flammable liquid are not permitted to be welded. Pipes or hoses must be cleaned completely with incombustible solvent should any welding be required on those pipes.

§ 1.30 Remove Paint Before Welding or Heating

Prevent potential poisonous gas and dust. When paint is heated up by welding or other methods, it will produce poisonous gas. Remove paint by the following methods before welding or heating:

- Wear a regulated mask to prevent inhaling dust when removing paint with abrasive paper or sand wheel.

- Remove paint with solvent or paint remover. Clean paint remover with soap and water and wait for about 15 minutes for solvent to evaporate before welding.

Paint removal work should be conducted outdoors or in a well ventilated area.

§ 1.31 Liquid Disposal

All fuels, most lubricants, and some coolants are flammable. These flammable liquids should be stored away from fire. Do not burn or punch any liquid containers. Dispose of fuel carefully; stop engine before adding fuel; prohibit smoking while adding fuel. Add fuel outdoors. Do not put oil-containing rags on the drill rig to ensure the drill rig stays clean.

§ 1.32 Chemical Disposal

Touching harmful chemicals directly will cause serious injury to the human body. The chemicals used in this drill rig, such as lubricant, coolant, paint, and adhesive may be harmful. Before using harmful chemicals, check and understand its danger; know how to use them safely.
§ 1.33  Fire Prevention

Following these steps to prevent fire:

Prevent fire caused by leakages of fuel, hydraulic oil and lubricant.

Inspect clamps and ensure they are intact, check hoses and pipes to see they are in the right position; check hydraulic oil cooler, connections; check leakage using a piece of cardboard; never check leakage by hand.

Tighten, repair, or replace any clamps, pipes, hose, oil cooler, and flange bolts of oil cooler.

Do not twist or punch any high-pressured pipe.

Do not use any twisted or damaged pipe or hose.

• Inspect short circuits. Short circuiting of the electric system can cause fire.
  Check cables and wires before every shift or after 8 hours operation.
  Check connectors before every shift or after 8 hours operation.
  Tighten, repair, or replace any loosened or damaged cables, wires and connectors before operation. Do not operate the drill rig if the cables and wires are not in good condition.

• Repair switch
  Check key switch and engine emergency stop switch before everyday operation. Repair immediately if they are not functioning.
  Fire might be even worse or GBH might happen if engine can not be stopped in case of fire.

Clean out flammable materials

Spilled fuel, excessive coal dust, and other flammable materials may cause fire. Keep the drill rig clean every day to prevent fire.
§ 2 DESCRIPTION

SA-20/70 rotary drill rig is designed for cast-in-drilled-hole construction and widely used in foundation construction of roads, bridges, wharves and high-rise buildings with many features like high torque, high mobility and high efficiency. Equipped with long or short auger, drilling bucket, core barrel or hydraulic hammer, it can be used in drilling clay, sand, gravel or medium weathered rock layers.

§ 2.1 Model Definition

<table>
<thead>
<tr>
<th>SA</th>
<th>20</th>
<th>70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of Drill rig: 70 metric tonnes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. Rotary Torque: 20t/m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group Code: SUNWARD--APE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

§ 2.2 Applicable Range

Use short auger for clayed soil, silty soil, backfilling, medium density sand and weathered rock layers above water table.

Use drilling bucket with slurry for clayed soil, silty soil, sand, backfill, gravel and weathered rock layers below water table.

Use rock auger for gravel, medium hard rock and weathered rock layers.

Use core barrel for weathered rock layer and cracked rock layer.

§ 2.3 Operation Condition

Ambient temperature should be -15°~+45°C(60°~113°F) and ground gradient should be less than 5°. Stop working and boom down drill mast when rainstorm occurs or wind speed is more than 15m/s(34mph).

§ 2.4 Features

1. Special designed undercarriage, big roller winch, excellent stability, long wire rope service life.

SA-20/70 hydraulic drill rig utilizes hydraulic retractable undercarriage. The main and auxiliary winches are installed on the swing platform for stability of the drill rig. Large
diameter roller winch reduces wire rope layers and increase wire rope service life.

2. **Patented parallelogram system, high torque, high mobility**
   Computerized design, simple hinge connection, high torque and parallelogram system for excellent stability. Drilling mast can be rigged or boomed down no matter where the rotary head and Kelly bar are located for easy transportation.

3. **Easy load and unload**
   Drilling mast can be boomed down and extended by its own parallelogram system without additional equipment. Safety is ensured and rigging/unrigging becomes easy at site.

4. **Multifunctional Mast Foot**
   A hydraulic mast foot is built at the bottom of drilling mast for easy casing installation, crawlers retract/extend and maintenance.

5. **Rotary head**
   The rotary head uses two hydraulic motors, two speed transmission reduction with circulating lubrication system to enhance lubrication and cooling effect. Anti-shear structure and optimized consumable parts make the rotary head more reliable. Both interlocking and friction kelly bars are used for the rotary head. Crowd cylinder pushing force reaches to 40,786 lbs, lifting force reaches to 46,297 lbs. The cylinder stroke is 197 inches.

6. **Patented electronic control system with features and various functions for reliable and easy maintenance**
   Intelligent control technology, CAN BUS technology and virtual monitor technology, embedded controller, true color LCD screen and SUNWARD DESARSR electronic control system are employed in the system. The system is precise, fast, stable with available Chinese (or English) computer interface that can ensure simple and reliable operation.
Automatic mast verticality adjustment and manual control of booming up; manual or automatic return after spinning off; automatic real-time drilling depth monitor; operation malfunction automatic recording; hole depth recording; signal input/output adjustment and inspection; mast L/R titling angle limitation; parallelogram system safety control; cooling system auto-start; main & auxiliary winch misoperation protection; moving and working operation interlocking and platform swing lock when drilling a hole.
§ 3 Technical Data

§ 3.1 Drill rig component and dimension

The structure of equipment, components and installation dimensions are shown in Figure 1 and Figure 2. The transportation dimension is shown in Figure 3.

Figure 1
Figure 2
### §3.2 Main technical data

<table>
<thead>
<tr>
<th>Item</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. drilling diameter</td>
<td>inch $\varnothing 80$ (mast to center of kelly bar)</td>
</tr>
<tr>
<td>Max. drilling depth</td>
<td>ft</td>
</tr>
<tr>
<td>Measurement</td>
<td>Working condition ft</td>
</tr>
<tr>
<td></td>
<td>Transportation condition ft</td>
</tr>
<tr>
<td>Total weight (working condition)</td>
<td>lbs</td>
</tr>
<tr>
<td>Engine</td>
<td>Model</td>
</tr>
<tr>
<td></td>
<td>Rated power hp/rpm</td>
</tr>
<tr>
<td></td>
<td>Max. torque ft-lb/rpm</td>
</tr>
<tr>
<td>Hydraulic system</td>
<td>Max. Working pressure psi</td>
</tr>
<tr>
<td></td>
<td>Main pump</td>
</tr>
<tr>
<td></td>
<td>Auxiliary pump</td>
</tr>
<tr>
<td></td>
<td>Max. oil flow rate gal/min</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotary Head</td>
<td>Max. torque ft-lb</td>
</tr>
<tr>
<td></td>
<td>Rev rpm</td>
</tr>
<tr>
<td></td>
<td>Max. Spin-off rate rpm</td>
</tr>
<tr>
<td>Crowd cylinder</td>
<td>Max. crowd force push lbs</td>
</tr>
<tr>
<td></td>
<td>Max. crowd force pull lbs</td>
</tr>
<tr>
<td></td>
<td>Max. stroke ft</td>
</tr>
<tr>
<td>Main winch</td>
<td>Max. line pull lbs</td>
</tr>
<tr>
<td></td>
<td>Max. line speed ft/min</td>
</tr>
<tr>
<td></td>
<td>Wire rope diameter inch</td>
</tr>
<tr>
<td></td>
<td>Max. line pull lbs</td>
</tr>
<tr>
<td>Component</td>
<td>Specification</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td><strong>Auxiliary winch</strong></td>
<td>Max. line speed</td>
</tr>
<tr>
<td></td>
<td>Wire rope diameter</td>
</tr>
<tr>
<td><strong>Mast tilt</strong></td>
<td>Left and Right Tilt</td>
</tr>
<tr>
<td></td>
<td>Forward Tilt</td>
</tr>
<tr>
<td></td>
<td>Backward Tilt</td>
</tr>
<tr>
<td><strong>Turntable</strong></td>
<td>Swing angle</td>
</tr>
<tr>
<td></td>
<td>Swing speed</td>
</tr>
<tr>
<td><strong>Undercarriage</strong></td>
<td>Max. travel speed</td>
</tr>
<tr>
<td></td>
<td>Max. travel slope</td>
</tr>
<tr>
<td></td>
<td>Min. ground clearance</td>
</tr>
<tr>
<td></td>
<td>Width of track shoes</td>
</tr>
<tr>
<td></td>
<td>Overall width of crawler</td>
</tr>
<tr>
<td></td>
<td>(retract/extend)</td>
</tr>
<tr>
<td></td>
<td>Overall length of crawler</td>
</tr>
</tbody>
</table>
§4  Main Structural Features and Working Theory

§4.1 Drilled Shaft Installation Procedure

§4.2 Structure and Basic Theory

Basic Function and Theory:

See Fig. 1 for drill rig structure. The house and undercarriage of the drill rig are interlocked. When in traveling mode, the hydraulic motors drive the traveling planetary and the crawlers move forward/backward, left/right and stop. Crawlers extend and retract, mast booms up/down. Crowd force is controlled by hydraulic cylinder. Kelly bar rotation, main/auxiliary winches and turntable utilizes planetary. The rotary head is equipped with hydraulic motors and planetary and the driving sleeve drives the kelly bar. The crowd cylinder is connected with the rotary head and the cylinder can generate the necessary compressive vertical force on the rotary head. Rotate to proper location to raise drilling tool for dumping. Total drilling depth and depth of each pass are displayed in the virtual digital display and drilling procedure is stopped when designed tip elevation is reached.

Casing can be installed by mast foot or casing twister.

For transportation, the mast can be boomed down with kelly bar and kelly bar bracket detached. With the cathead and lower mast folded and crawlers retracted, the drill rig can move onto lowboy and the counterweight can be removed if road condition does not permit.

Main Structure

§4.2.1 Undercarriage

Undercarriage includes frame and traveling components. Frame is box structure and two main beams are controlled by hydraulic cylinder. Crawlers traveling mechanism (Fig. 5) includes planetary, sprocket, track roller, carrier roller, guide wheel, crawler assembly, tension unit (Fig. 6).
Crawler traveling mechanism (Fig. 5) is driven by sprocket, speed reducer and hydraulic pumps. Planetary (Model GFT80T3) is made by Rexroth equipped with constant-close, multi-plate brake system when it runs at high speed. The brake system works under tension spring when the drill rig is stopped, and the brake is released when traveling is engaged.

**Fig. 5 Crawler**

1. planetary 2. sprocket 3. track roller 4. carrier roller 5. tension unit 6. guide wheel 7. tracks assembly

Crawler tension unit (Fig. 6) is composed of tension cylinder, tension spring, guide wheel, oil cup. The function of tension unit is to keep enough tension on the crawlers during drilling or traveling. If the crawlers are too loose, use grease gun to fill grease through grease zerks and the guide wheel will shift outward and the crawlers will tighten.

**Fig. 6 Tension Unit**

1. guide wheel 2. tension spring 3. tension cylinder 4. grease zerk
§4.2.2 Turntable

Turntable is composed of rotating planetary, slewing bearing, rotating frame and mast support. Rotation is achieved by a slewing bearing driven by a planetary gear. Planetary (Model Rexroth GFB36T3) is three-speed, planetary gear box with constant-close, multi-plate brake. Slewing bearing is a single-row four point contact ball slewing ring.

§4.2.3 Drill Mast and Parallelogram System

The box type drill mast is composed of three sections. The upper cathead section and the lower drill mast section can be automatically folded or attached/detached (Fig. 7). Rotate the drill mast 90 degree and raise one side of the crawlers by pushing the lower drill mast down to extend or retract the crawlers (Fig. 8).

Fig. 7 Lower mast off from main mast

Fig. 8 Crawlers extend and retract

The parallelogram system is composed of arms, triangle frames and parallelogram cylinders (Fig. 9). The parallelogram cylinders control the angle of arms, the mast hydraulic cylinders control the main mast verticality. The main mast can tilt 5 degree left/right; 5 degree forward and 15 degree backward. Kelly bar must be vertical during drilling to prevent A-frame and kelly bar damage. **DRILLING WITH MAST MORE THAN 2% OUT OF PLUMB Voids ANY WARRANTY.**
**§4.2.4 Main/Aux. winches**

The main/aux. winches are located on the turntable. The main winch is used for kelly bar and the aux. winch is used for assistance to drilling. The aux. winch is not to be used as a crane or to replace service crane. Winch planetary is made by Roxroth and the main winch has dual-speed control and free-fall control (Free-fall is not permitted if the drill rig is not in drilling status).

**§4.2.5 Rotary Head**

Rotary head is composed of bracket and driving components. The bracket supports the driving components and takes vertical force from the crowd cylinder. The driving components consist of two hydraulic motors, planetary, driving gear, gear box and driving sleeve. The working theory is that the driving sleeve drives the kelly bar to rotate after speed is reduced by driving gear and speed reducer.
The first stage lubrication of the gear box adopts circulation lubrication and the second stage lubrication adopts oil-bath lubrication. Planetary runs in high speed by a small transmission ratio when spinning-off is required. The driving sleeve has rectangle teeth and rotates with the kelly bar when they are engaged. The control system is a variable pump, variable motor system and it can automatically adjust its speed and torque(power load sensing) according to different soil condition.

Fig. 12 Drilling tool
§4.2.6 Kelly Bar, Drilling Tool

The outer kelly bar engages with rotary head and the top kelly is connected with kelly bracket which slides up/down on the mast guide. When the teeth disengage, each section of the kelly can freely extend and retract. The top inner kelly bar is connected to the wire rope by a swivel and the bottom square connects to the drilling tool. The kelly bar can be retracted (interlocking bar disengage) by main winch wire rope.

Common drilling tools (Fig. 12) and specification (Chart 2, 3, 4 & 5)

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Name</th>
<th>Hole Dia(mm)</th>
<th>Tool Dia(mm)</th>
<th>Pitch(mm)</th>
<th>High(mm)</th>
<th>Note</th>
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<tbody>
<tr>
<td>Rock auger</td>
<td>Φ500</td>
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<tr>
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<td>Φ1200</td>
<td>Φ1170</td>
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<th>Pitch(mm)</th>
<th>High(mm)</th>
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</thead>
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<tr>
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<td>350</td>
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<td>Φ600</td>
<td>Φ580</td>
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</table>
### Table 5

<table>
<thead>
<tr>
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<th>Hole Dia (mm)</th>
<th>Tool Dia (mm)</th>
<th>High (mm)</th>
<th>Note</th>
</tr>
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<tbody>
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<td>Φ600</td>
<td>Φ580</td>
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</tr>
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</tr>
<tr>
<td>Φ1500</td>
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</tr>
</tbody>
</table>

### §4.2.7 Engine

**CUMMINS M11-C330, 246kw/2100rpm** (See engine manual)

### §4.2.8 Hydraulic System

SA-20 main components—traveling, rotating, parallelogram, mast tilting, main/aux winch, rotary head are driven by hydraulic motors and cylinders (See hydraulic diagram Fig. 13).

The hydraulic system has two major parts—the turntable/undercarriage hydraulic system and upper hydraulic system.

Open hydraulic micro switch by lowering down the Left Console before operation and let pilot pressure oil flow into pilot control valves and solenoid valves.

(1) **Undercarriage Hydraulic System**

Traveling system and crawlers extend and retract:

1) Traveling system: working through an M8 Valve and L/R dual pedal pilot valve, two main pumps pump oil for two traveling motors which drive the drill rig
forward/backward and left/right.

2) Crawlers extend and retract: Switch on SA1 and solenoid valve Y34 works. Directional valve changes the pilot oil direction. Push Left Pedal forward/backward to extend/retract the right/left crawler while the right/left crawler is off the ground and the main drill mast is 90 degree relative to the right/left crawler.

(2) Uppercarriage Hydraulic System

Uppercarriage hydraulic system controls parallelogram, mast angle, crowd force down/up, main/aux. winches, upper structure swing, rotary head rotation (See Fig 14, 15 for joysticks, switches layout. Operation diagram see Table 6).

1) Parallelogram: Through M8 Valve, the main pump pumps oil to the parallelogram cylinders. Control pilot right joystick by pushing forward/pulling backward. The mast can horizontally move forward/backward.

2) Mast angle adjustment: Mast angle can be changed by controlling Electric Handle(with button SB7 pushed) (Attention: Left/Right tilting angle is less than 5 degree).

3) Crowd force down/up operation: Switch on SA10 and push right joystick forward or pull backward and the piston rod of hydraulic cylinder extends/retracts. If SA15 is switched on at the same time, the piston rod can quickly push downward/upward.

4) Rotary head: Switch on SA10, push right joystick left/right, the rotary head rotates counterclockwise/clockwise. If SB4 (or SB5) is switched on at the same time, high counterclockwise/clockwise spinning off speed is achieved.
Fig. 13  SA-20 Drill Rig Hydraulic Diagram
5) Superstructure swing: Push Left joystick left/right and the superstructure swings 360° counterclockwise/clockwise.

6) Main winch: Push Left joystick forward/backward to lower/lift load by the main winch. If SB1 (or SB2) is switched on, the main winch rope can quickly fall/lift.

7) Main winch free-fall: Switch SA11 on for main winch free-fall.

   **Attention**: No kelly bar free-fall is permitted if the rig is not drilling.

8) Mast foot extension: Push SB5, push Right joystick left/right, the foot cylinder retracts/extends.

9) Aux. winch: Push right joystick left/right to lower/lift load.

10) Cooling System: Superstructure hydraulic system provides cooling for the whole drill
rig. Open SA8 to start the cooling pump (Fig. 13)

The hydraulic system has balance valves to prevent stall, buffering valve is for rotation buffering, pilot operated check valve locks the piston location of the hydraulic cylinder.

(3) Pilot Control System

The drill rig hydraulic system uses hydraulic pilot control. The micro switch under the left console controls the pilot oil passage.

(4) Filters

The alarm will beep if oil filter is too dirty and filters need to be replaced. A high pressure oil filter is installed at the exit port of the pilot hydraulic pump to keep hydraulic oil clean.

Disabling this alarm voids any warranty.

(5) Hydraulic Oil

The drill rig uses YB-N68 hydraulic oil and hydraulic oil needs to be REPLACED every 1000 hours. When adding or replacing hydraulic oil, use the following grade:

ISO 4606 17/14-18/15 or NAS 1638 Grade 8—9
§5 Electric System

Attention: !!! All the control units should be unplugged should any welding occur on the drill rig !!!

§5.1 Description

Electric system includes engine, controllers, control panels, sensors and display instruments. Equipped with advanced intelligent modules of CAN BUS programmable logic controller (PLC), graph guide display controller and engine maximum power-output-adjustment controller, the electric system becomes an intelligent control system with many functions of data collection, programmable control, virtual instruments display, BUS transmission and problem diagnosis. When pushbuttons are switched on, sensors check working parameters and limit parameters. PLC magnifies and calculates commanding signals, sensor signals to interlock or drive (motors, solenoid valves) so that operator can finish operations like monitoring engine, traveling, drilling, automatic leveling, automatic verticality of main mast, problem diagnosis and data saving. Hole depth display, drill rig working condition animation display, virtual instruments display are real-time shown on the monitor through CAN BUS transmission (Fig. 15).

§5.2 DESARS Intelligent Control System

DESARS Intelligent control system is a new generation of control system developed by Sunward Intelligent Machinery CO., Ltd. (Patent Registration Number: 2005SR05206). The system has functions of BUS transmission, automatic leveling, automatic swing, drill monitoring, system adjustment and setup, real-time monitor, data dynamic display, problem real-time diagnosis and operation and malfunction recording.
Fig. 15  SA-20 Electric System Layout
§5.2.1 Main Control Panel

Push ‘MOVE’ button (Button 1): Boom up mast, leveling and swing (see 5.2.2 Fig. 17).

Push ‘WORK’ button (Button 2): Monitor drilling process (see 5.2.3 Fig. 18).

Push ‘CCD’ button (Button 3): Video monitor.

Push ‘ADJUST’ button (Button 4): Hydraulic cylinders adjustment (see 5.2.4 Fig. 19).

Push ‘MONITOR’ button (Button 5): Instruments and sensors monitor (see 5.2.5 Fig. 20).

Push ‘SETTING’ button (Button 6): Setup new parameters (see 5.2.6 Fig. 26).

Push ‘RECORDER’ button (Button 7): Drilling record (see 5.2.7 Fig. 27).

The blue bar on top of monitor displays the software version and the company name and the bottom green bar displays at which working condition the drill rig is. The sign △ flashes when malfunction occurs. Push “MONITOR” button 5 to see where the problem is. Check engine if engine hydraulic oil pressure sensor beeps.

§5.2.2 Adjusting Control Panel

Push ‘MOVE’ button (Button 1) to enter control panel (Fig. 17).
Current display is MANUAL mode. Push button 2 AUTO mode for auto leveling. Auto leveling fails if X and Y axles show 5° more and the display goes back to MANUAL mode again and LEVEL DISPLAY shows “UNEVEN”. If X and Y angles are less than 5°, auto leveling keeps the mast straight and LEVEL DISPLAY shows “EVEN”.

Push Button 1 for MANUAL mode if needed.

Adjust X+, X-, Y+, Y- for kelly bar verticality.

Push “X +” (Button 5) to increase angle on X-direction (tilting right increase);
Push “X -” (Button 6) to decrease angle on X-direction (tilting left increase);
Push “Y +” (Button 7) to increase angle on Y-direction (tilting backward decrease);
Push “Y -” (Button 8) to decrease angle on Y-direction (tilting backward increase).

Push Button 4 to EXIT.

Sign △ flashes if malfunction occurs. Push “MONITOR (Button 5) for further details. LEVEL DISPLAY shows “EVEN” when X and Y are within 0.2° range otherwise the LEVEL DISPLAY shows “UNEVEN” (Fig. 17).
§5.2.3 Work Panel

Push “WORK” (Button 2) from (Fig 16) Main Control Panel and the Main Control Panel becomes Fig. 18-Driling Panel which shows current kelly bar right tilting angle (X) and front tilting angle (Y), rotation angle, previous hole depth, current hole depth, water temperature, engine speed, rotary head pressure, crowd force, main winch pressure.

Push “ROTATE ORIGIN” (Button 1) and ROTATION ANGLE becomes zero. This function enables the drill rig to return to its original location after spinning off. The rotation angle is controlled within a range of 0.1 degree.

Push “CLEAR DEPTH” (Button 2) and set current hole depth to zero after drill tool is set on ground.

“FREE FALL” appears on the right corner when kelly bar depth reaches to previous drill depth.

Sign ⚠️ flashes when malfunction occurs. Push “MONITOR” (button 5) to check further details. Push “EXIT” (button 4) to go back to Main Control Panel.
§5.2.4 Adjust Panel

Push “Adjust” (Fig. 16 Main Control Panel) (Button 4) to enter Fig. 19 Adjust Panel and the real-time display shows rotary head pressure, crowd force pressure, main winch hoist pressure and engine speed. The main function of this mode is to manually adjust the verticality of the mast.

Push “Button 5” to extend left cylinder of the drill mast;
Push “Button 6” to retract the left cylinder of the drill mast;
Push “Button 7” to extend right cylinder of the drill mast;
Push “Button 8” to retract the right cylinder of the drill mast.
Push “SPACE SET” (Button 3) for space setting up.
Push “EXIT” (Button 4) to exit to main control panel.

Sign ⚠️ flashes when malfunction occurs. Push “MONITOR” (button 5) to check further details. If during drilling procedure hole becomes more than 2 degree out of plumb and operator tries to correct by manually changing mast or proceeds beyond 2 degree verticality in hole it may result in kelly bar damage.
§5.2.5 Monitor Panel

§5.2.5.1 Instrument Monitor Panel

Push “Button 5” on the Main Control Panel (Fig. 16) to enter to Monitor Panel-1 (Fig. 20).

Alarm icon Fig. 21:

1: Engine fault alarm;
2: Coolant temperature alarm;
3: Hydraulic oil temperature alarm;
4: Fuel level alarm;
5: Charge battery alarm (Low battery alarm);
6: Main winch limitation alarm;
7: Hydraulic enable signal;
8: Hydraulic oil filter plugged alarm.

Icon flashes and changes to red color if safe parameter is out of range.

Hydraulic Pilot Handle (Safety Handle): When the left console is lowered and the micro switch is on, the Icon 7 should be red alerting the operator that the rig is in operation mode.

Virtual instrument displays water temperature, hydraulic oil temperature, fuel level, and...
engine rpm. Green zone is safe zone and red zone is critical zone. Wait and slow down until water temperature reaches to safe zone before normal drilling if water temperature indicator is in the yellow zone.

Push “>>>” (Button 8) to enter next page (Fig. 22 Monitor Panel-2);
Push “SENSOR” (Button 2) to enter SENSOR diagnosis panel (Fig. 25);
Push “PORT” (Button 3) to enter port check panel;
Push “EXIT” (Button 4) to go back to Main Control Panel.
Push “<<” (Button 4 Fig. 23) to go back Monitor Panel-2 (Fig. 22).

Alarm icon turns red, flashes and beeps when parameter is out of range (Fig. 24).

§5.2.5.2 Sensor Malfunction Panel

Push “SENSOR: (Button 2 Fig. 20) to enter Fig. 25 Malfunction Sensor Panel. When icon turns to 😞, it indicates malfunction on the sensors and these sensors need to be replaced.

Push “EXIT” (Button 4) to exit and return to Fig. 20 Monitor Panel-1
§5.2.6 Setup Panel

Push “SETUP” (Button 6) in Main Control Panel (Fig. 16) and input password (Fig. 26).

Special Note: Changing “SETUP” will change system parameter and system setup. Any inappropriate setup would affect the performance of the drill rig or may cause operation out of control thus lead to accident. Therefore, SETUP should be carried out under the supervision of our technician otherwise we are not responsible for any consequences caused.

§5.2.7 Recording Panel

Push “RECORDER” (Button 7 Fig. 16) to enter to RECORDING PANEL (Fig. 27).
It records the total drill depth (unit: meter) and total working hours. When the total drill depth exceeds 32,766 meters, the display will use 32,767 + Xm to show the accumulative drill depth.

Push “EXIT” (Button 4) to go back to Main Control Panel.

§5.3 Control, operation of Engine and Auxiliary Appliances

§5.3.1 Main Power Open and Auxiliary Appliances Control

The main power is controlled by SA Key switch. When the key is turned to the first slot, the main power is on and the followings can be completed:

1) Push “SA1” for crawler extend/retract;
2) Push “SA2” for fast travel;
3) Push “SA3” for horn;
4) Push “SA4” for headlights;
5) Push “SA5” for cabin light;
6) Push “SA6” for crowd force limit;
7) Push “SA7” for wiper;

8) Push “SA8” for hydraulic cooling system (when hyd. oil is at 150°F)

9) Push “SA9” for WARNING light;

10) Push “SA10” for MOVE/WORK;

11) Push “SA11” for main winch free fall;

12) Push “SA12” for aux. winch free fall;

13) Push “SA13” to set engine speed (engine default speed is at 1600rpm);

14) Push “SA14” for idle speed. When joysticks are at neutral position and the rig is not working, four seconds after the button pushed, engine speed automatically drops to 1200rpm;

15) Push “SA15” for crowd force push fast;

16) Push “SA16” for rotary head torque limit;

17) “SA17” for Engine Fault (for idle speed adjust: push top, idle speed is increased by 30r; push bottom, idle speed is decreased by 30r. This switch is also used as page turnover for engine malfunction when engine is shut down and SA17 is switched on)

18) “SA18” for engine diagnose.

In case the Orange Light on the Right Console is on, the engine malfunction can be diagnosed by pushing open SA18 . Simply by counting how many times the Red Light flashes after SA18 is on, engine error code can be found. Follow the steps below to diagnose engine error:

(1) Push down SA18 when the Orange Light is on;
(2), Write down how many times the Red Light flashes, if the light flashes 1 time, write down 1;

(3), There should be one second pause between the first and the second time flash;

(4), Count how many times it flashes, if the light flashes 5 times, write down 5;

(5), Then there will be another one second pause;

(6), Count how many times it flashes, if the light flashes 3 times, write down 3;

So the error code of the engine is 153. Check the error code chart on §5.5 to find the engine problem.

§5.3.2 Engine Start-up

Check oil, coolant before engine start-up; insert ignition key and turn the key to the first slot position; then change the display to Monitor Panel-1 to check virtual gauges and warning lights; continue turn the key to the second slot position to start the engine (Do not engage starter for more than 10 seconds).

§5.3.3 Engine Shut-down

Switch off the micro switch by lifting the left console before engine shut-down. Let the engine run for a short period of time to eliminate excessive heat and turn the key to ‘OFF’ position to shut down the engine.

§5.4 Control During Drilling Process

In order to have a friendly working interface and safe working interlock, the drill rig has adopted two processes—drilling and moving. All the hydraulic system is enabled and hydraulic
pilot lines are pressurized only after hydraulic micro switch is pushed on.

§5.4.1 Drill Rig Move Mode

Move mode includes: drill rig traveling; drill mast lower foot extend and retract; crawlers extend and retract; main/aux winches; parallelogram; upper carriage manual/auto rotating and mast automatic boom up.

After engine start-up, push down the Left Console, the right Emergency Stop Button off; Set SA10 Button(MOVE/WORK) to MOVE (Fig. 28) and the drill rig is ready to move.

§5.4.2 Drill Rig WORK Mode

WORK Mode includes: main/auxiliary winches operation; rotary head operation; upper carriage rotation and crowd force.

After engine start-up, push down the Left Console; the right Emergency Stop Button off; set SA9 Button(MOVE/WORK) to WORK (Fig. 28) and the drill rig is ready to drill.

See Table 6 for drill rig MOVE/WORK joystick/pedal operation:
<table>
<thead>
<tr>
<th>SA9 ON MOVE</th>
<th>Left Joystick (SB1 SB2 SB3)</th>
<th>Right Joystick (SB4 SB5 SB6)</th>
<th>Pedal</th>
<th>Electric Handle (push SB7)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>![Main winch down]</td>
<td>![+SB4 Parallelogram down]</td>
<td>![Drill rig moves forward]</td>
<td>![Mast boom up/ mast forward tilting]</td>
</tr>
<tr>
<td></td>
<td>![Main winch up]</td>
<td>![Parallelogram up]</td>
<td>![Drill rig moves backward]</td>
<td>![Mast boom down/ mast backward tilting]</td>
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<tr>
<td></td>
<td>![Upper-carriage left swing]</td>
<td>![Aux. winch down]</td>
<td>![Drill rig turn right]</td>
<td>![Mast left tilting]</td>
</tr>
<tr>
<td></td>
<td>![Upper-carriage right swing]</td>
<td>![+SB5 Mast foot retract]</td>
<td>![Drill rig turn left]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>![Push SB3 Auto swing to original position]</td>
<td>![+SB5 Mast foot extend]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Joystick (B1 SB2 SB3)</td>
<td>Main winch down</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>----------------------------</td>
<td>-----------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+SB1</td>
<td>Main winch down, merge (mid-speed) (+Push SB1 first)</td>
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<tr>
<td>+SB2</td>
<td>Main winch variable + main winch down + merge (hi-speed) (+Push SB2 first)</td>
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<table>
<thead>
<tr>
<th>Main winch up</th>
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<tr>
<td>+SB1</td>
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<tr>
<td>+SB2</td>
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<table>
<thead>
<tr>
<th>Upper-carriage Left swing</th>
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<tr>
<td>Upper-carriage Right swing</td>
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<table>
<thead>
<tr>
<th>Auto swing to original position</th>
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<tbody>
<tr>
<td>Crowd force push/ Hyd. Cyl. extend</td>
</tr>
<tr>
<td>Crowd force lift/Hyd. Cyl. retract</td>
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<table>
<thead>
<tr>
<th>Rotary head clockwise rotation</th>
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<tbody>
<tr>
<td>+SB4</td>
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<tr>
<td>+SB6</td>
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<table>
<thead>
<tr>
<th>Rotary head anticlockwise rotation</th>
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<tbody>
<tr>
<td>+SB4</td>
</tr>
<tr>
<td>+SB5</td>
</tr>
</tbody>
</table>
§5.4.3 Other Operation Control

1) When hydraulic oil reaches to 65°C, open SA8 to keep oil temperature not exceeding 85°C.

2) During drilling process, open SA11 for kelly bar free fall; open SA12 for auxiliary winch free fall.

3) When soil condition is complicated, slows down drilling speed, open torque limitation switch SA16 and crowd force limitation switch SA6 to protect rotary head and kelly bar.

4) In case of emergency and people or equipment are in danger, push down Emergency Stop Button to stop all hydraulics.

§5.4.4 Interlocking and Safe Protection

For the safety of people and drill rig, the following interlocking and safe protection steps have been taken:

a) Main winch pull-up limitation: in order to protect cathead from being hit by kelly bar when main winch pulls up, a limit switch is activated when kelly bar reaches to the top and the main winch can only descend and not ascend. Following those steps to bypass limit switch:

Switch MOVE/WORK to MOVE, pull Left Joystick back, with both SB1 and SB2 buttons pushed, now the main winch can pull the kelly bar over the limit switch.

USE THIS OPERATION WITH CAUTION.

b) Swing Limitation: when drill rig is in drilling operation and drilling depth reading is greater than zero, the system considers that the kelly bar is inside hole and accidents
may occur if upper-carriage swings and the program restricts this operation.

Upper-carriage can swing only drilling depth reading is less than -20cm(-0.8 inch). If the
drilling depth proximity switch is damaged and the drilling depth reading is less than
zero, switch the SA10 to MOVE for upper carriage Left/Right swing.

c) Tilting limitation: Leveling drill rig before booming up mast and set MOVE/WORK
( SA10 ) to MOVE. When left and right of mast deflection is over 5 degree, use
Electric Handle for mast tilting; when mast’s X and Y axles are within the range of ±5
degree, use Auto Leveling.

d) Spin-off limitation: when drill rig is in drilling operation and drilling depth reading is
greater than zero, the system considers that the kelly bar is inside hole and spin-off is
restricted. Spin-off works only the drilling depth reading is less than -20cm(-0.8 inch).

e) In case of emergency and people or equipment are in danger, push down Emergency Stop
Button to stop all hydraulics.
### §5.5 Engine Malfunction Indication and Error Code Chart

Table 2 (Y=yellow  R=red  W=white)

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Light</th>
<th>SPN</th>
<th>FMI</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>111/Y</td>
<td>629/12</td>
<td></td>
<td></td>
<td>Engine control module internal error</td>
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<tr>
<td>115/Y</td>
<td>190/2</td>
<td></td>
<td></td>
<td>Engine speed/location sensors signals lost</td>
</tr>
<tr>
<td>122/Y</td>
<td>102/3</td>
<td></td>
<td></td>
<td>Air intake pipe pressure sensor circuit---hi-voltage short circuit</td>
</tr>
<tr>
<td>123/Y</td>
<td>102/4</td>
<td></td>
<td></td>
<td>Air intake pipe pressure sensor circuit---low-voltage short circuit</td>
</tr>
<tr>
<td>131/Y</td>
<td>091/3</td>
<td></td>
<td></td>
<td>Throttle pedal sensor circuit---hi-voltage short circuit</td>
</tr>
<tr>
<td>132/Y</td>
<td>091/4</td>
<td></td>
<td></td>
<td>Throttle pedal sensor circuit---hi-voltage short circuit</td>
</tr>
<tr>
<td>133/Y</td>
<td>029/3</td>
<td></td>
<td></td>
<td>Remote throttle pedal sensor circuit---hi-voltage short circuit</td>
</tr>
<tr>
<td>134/Y</td>
<td>029/4</td>
<td></td>
<td></td>
<td>Remote throttle pedal sensor circuit---hi-voltage short circuit</td>
</tr>
<tr>
<td>135/Y</td>
<td>100/3</td>
<td></td>
<td></td>
<td>Engine oil pressure sensor---hi-voltage short circuit</td>
</tr>
<tr>
<td>141/Y</td>
<td>100/4</td>
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<td>Engine oil pressure sensor---low-voltage short circuit</td>
</tr>
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<td>143/Y</td>
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<td>144/Y</td>
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<td>Engine coolant temp.sensor---hi-voltage short circuit</td>
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<td>Engine coolant temp.sensor---hi-voltage short circuit</td>
</tr>
<tr>
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<td>110/0</td>
<td></td>
<td></td>
<td>Engine coolant temperature low</td>
</tr>
<tr>
<td>151/R</td>
<td>110/0</td>
<td></td>
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<td>Engine coolant temperature high</td>
</tr>
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<td>153/Y</td>
<td>105/3</td>
<td></td>
<td></td>
<td>Air intake pipe temp. sensor circuit---hi-voltage short circuit</td>
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<td>154/Y</td>
<td>105/4</td>
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<td>Air intake pipe temp. sensor circuit---low-voltage short circuit</td>
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<td>155/R</td>
<td>105/0</td>
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<td>Air intake pipe temperature high</td>
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<td>191</td>
<td>876/11</td>
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<td>A/C clutch short circuit</td>
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<td>235/W</td>
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<td>Speed sensor signal lost</td>
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<td>084/10</td>
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<td>Error in speed sensor signal</td>
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<td>513/4</td>
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<td>Error in brake delay signal---42</td>
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<td></td>
<td>Error in fan clutch delay signal---31</td>
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<td>261/Y</td>
<td>174/0</td>
<td></td>
<td></td>
<td>Fuel temperature too high</td>
</tr>
<tr>
<td>Code</td>
<td>Value</td>
<td>Description</td>
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<td>-------</td>
<td>-------------</td>
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<tr>
<td>264/Y</td>
<td>174/2</td>
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<tr>
<td>278/Y</td>
<td>1075/11</td>
<td>Error in pump signal ---11</td>
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<tr>
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<td>636/4</td>
<td>Engine speed sensor circuit---hi-voltage short circuit</td>
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<td>297/Y</td>
<td>1084/3</td>
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<td>298/Y</td>
<td>1084/4</td>
<td>Aux. pressure sensor signal input circuit---hi-voltage short circuit</td>
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<tr>
<td>319/W</td>
<td>251/2</td>
<td>Actual clock signal broken</td>
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<td>349/Y</td>
<td>191/0</td>
<td>Gear box speed output too high</td>
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<td>352/Y</td>
<td>620/4</td>
<td>Wire 10 voltage too low</td>
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<tr>
<td>361/R</td>
<td>1076/3</td>
<td>Fuel pump current too high</td>
<td></td>
<td></td>
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<tr>
<td>362/Y</td>
<td>1076/4</td>
<td>Fuel pump voltage too low</td>
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<tr>
<td>363/Y</td>
<td>1076/7</td>
<td>No fuel in fuel tank</td>
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<tr>
<td>364/Y</td>
<td>1077/9</td>
<td>No connection between ECMand fuel pump</td>
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<td>365/Y</td>
<td>1077/4</td>
<td>Fuel pump control circuit---low voltage short circuit</td>
<td></td>
<td></td>
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<tr>
<td>366/Y</td>
<td>1077/2</td>
<td>Fuel pump power supply 6-24VDC</td>
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<td>367/R</td>
<td>1078/11</td>
<td>Fuel pump location sensor signal lost</td>
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<td>368/Y</td>
<td>1078/8</td>
<td>Fuel pump in delay receiving signal</td>
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<td>372/Y</td>
<td>1077/11</td>
<td>Fuel pump detects continuous signal from idle speed switch</td>
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<tr>
<td>373/R</td>
<td>1077/3</td>
<td>Fuel pump control circuit—hi voltage short circuit</td>
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<td>1077/12</td>
<td>Fuel pump error</td>
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<td>375/Y</td>
<td>629/2</td>
<td>Fuel pump actuator-drill rig plugged</td>
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<td>376/R</td>
<td>1077/13</td>
<td>Fuel pump module not adjusted</td>
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<tr>
<td>377/Y</td>
<td>1077/7</td>
<td>Fuel pump module not connected</td>
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<td></td>
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<tr>
<td>381/Y</td>
<td>626/11</td>
<td>Error signal in preheat relay---wire 41</td>
<td></td>
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<tr>
<td>382/Y</td>
<td>626/11</td>
<td>Error signal in preheat relay---wire 31</td>
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<td></td>
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<tr>
<td>385/Y</td>
<td>620/3</td>
<td>Remote throttle sensor+5VDC too high</td>
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</tr>
<tr>
<td>386/Y</td>
<td>620/3</td>
<td>Engine speed sensor+5VDC too high</td>
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<tr>
<td>387/Y</td>
<td>091/3</td>
<td>Throttle location sensor+5VDC too high</td>
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<td>391/Y</td>
<td>632/11</td>
<td>Fuel pump wire43 signal error</td>
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</tr>
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<td>415/R</td>
<td>100/1</td>
<td>Engine oil pressure too low</td>
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<td></td>
</tr>
<tr>
<td>418</td>
<td>097/0</td>
<td>H2O in fuel</td>
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<td></td>
</tr>
</tbody>
</table>
Fig. 29  Control Diagram for Engine and Aux. Electrical Components
§§6 Operation

§6.1 Preparation and Check-up Before Operation

(1) Choose different drilling tool based on different soil condition.

(2) Check hydraulic oil, no oil leakage.

(3) Check Fuel.

(4) Check wire rope.

(5) Check tools.

(6) Check bolts and nuts.

(7) Check joysticks, levers and gauges.

(8) Check engine coolant (see engine operation manual).

§6.2 Operation and Gauges

See Fig. 14 to 15 for names and codes of operational instrument in the cabin; see Fig. 16 to 28 for LCD display of working modes and switches.

Pressure gauges

You can also monitor the system maximum pressures by checking on the three gauges:

Gauge 1                 Gauge 2             Gauge 3

Gauge 1:
  Parallelogram up/down = 300 bars
  Main winch = 300 bars
  Left travel = 280 bars
Gauge 2:
Crowd force pull = 280 bars
Crowd force push = 120 bars
Mast up/down = 280 bars
Mast foot retract = 280 bars
Swing = 240 bars

Gauge 3:
Rotary head = 300 bars
Aux. winch = 240 bars
Right Travel = 280 bars

§6.3 Operation

(1) Open Main Power SA switch and start engine (see engine manual)
(2) Move fuel control lever to “Mid” position.
(3) Run engine at low rpm for 5 minutes after engine start-up.
(4) Stop engine if engine oil icon becomes red. Check engine and begin operation after everything is normal.

§6.3.1 Drill Rig Positioning

Open Main Power SA switch; open hydraulic switch by lowering down the Left Console; step on pedals. Step on both pedals for drill rig forward/backward. Step on left pedal, drill rig turns right, step on right pedal, drill rig turns left (see Table 6 for details).

Attention for operator when drill rig is travelling:
1. Pin down undercarriage and turntable(pin is under driver’s right foot) and pull pin out when drill rig is in drilling process;
2. Mast must be boomed down;
3. Lock crawler extend/retract cylinder.

§6.3.2 Rig up

1. Mast self rigging/derigging
1) Reconnect coupling if crowd cylinder is disconnected or not loaded

2) Use rope to pull top folded top mast straight and bolt together with main mast; use crane or use rope to connect crowd cylinder (extend) to pull cathead.

3) Pull right joystick backward and the arm cylinder will extend; push Electric Handle (with SB7 pushed) forward and the parallelogram cylinders extend; use joystick and Electric Handle alternatively until mast is completely boomed up. Do not let mast touch ground during booming up. Feeding out main/aux. winch cables as mast and parallelogram go up. Stop electric handle operation when the lower mast and main mast are fully connected (otherwise components may be damaged). Take off the link rod between the triangle frame and lower mast.

4) Open switch SA9 to WORK, push right joystick forward and the crowd cylinder extends (push SA14 for quick cylinder action); continue pushing until cylinder is completed extended and ready for rotary head connection.

5) Take off the stopper plate under the sliding frame of the rotary head and move it to the bottom of the mast; push crowd cylinder to push rotary head downward; connect lower mast with main mast.

Mast derigging process is vice versa to the process above.

Special Attention:

1) A helper is required during mast rigging/derigging.

2) Use proper length of wire rope during the mast rigging/derigging process. No wire rope overlapping is permitted to happen in the main/aux winches.

2. Crawler Extend/Retract

Attention: For the safety and stability of the drill rig, the crawlers must be fully extended before drilling operation.

Crawler extend: Choose a firm, flat ground; push Left Joystick left (or right) to swing uppercarriage left (or right) 90 degree; push Right Joystick forward and the parallelogram bows down until drill mast is in contact with the ground; put a piece of wood or steel plate
under the drill mast if the ground is not firm enough.

Push Right Joystick right (with SB5 pushed) to extend mast foot cylinder until left (right) crawler is raised; take off crawler pin; Push Left pedal forward until crawler(s) is fully extended.

Crawler retract is vice versa to the process above.

3. Counterweight Mount

Follow Step 1, Step 2 and Step 3 to mount counterweight.

4. Kelly Bar Mount

Crowd cylinder is fully extended and rotary head is at low position; mast tilts forward; push Left Joystick forward to lower down main winch rope; connect to swivel; pull Left joystick backward and main winch winds up until kelly bar reaches the top mast; keep mast vertical, lower kelly bar through rotary head to complete kelly bar mounting.
5. Check mast tilting degree through LCD display; adjust mast verticality.

6. Hook up drilling tool and start drilling.

§6.3.3 Hole Opening and Casing Installation

Use reamer to open a hole after drill rig is positioned. The hole diameter should be equal to casing diameter. Use auxiliary winch to pull casing to hole location and use mast foot or drilling tool to push casing down. Casing embedded depth and casing length are based on soil condition and water table level.

§6.3.4 Drilling

1. Short auger drilling:

   Switch on SA10; push Right Joystick left and the rotary head rotates clockwise; switch on SA10 for main winch free fall; push Right Joystick left-forward for crowd force down.

   Special attention: No free fall is permitted if drill rig is not in drilling process.

Drilling depth of each pass will be displayed on the LCD monitor.

1) Push Right Joystick right and the rotary head turns anticlockwise; the kelly bar and rotary head sleeve disengage.

2) Use Left Joystick for main winch up to raise kelly bar and at the same time use Right Joystick to retract crowd cylinder so that rotary head can come up.

3) Use Left Joystick to swing uppercarriage; and use Right Joystick with push button SB4 engaged for high speed spinning off.

4) Return to original position after spinning off. Use Left Joystick to lower kelly bar (Attention: Do not use Free Fall to lower kelly bar).

5) Repeat the above procedures.

6) Clean hole after design tip is reached.

Pay attention during drilling process:

● Drill slow at the beginning, speed up after auger goes inside soil; slow down when drilling soft-hard soil junction layer.
● Handle with care should an abnormality like high ground water level, hole collapse or hole shrinking happen.
● Do not push to drill when clean hole; do not rotate drilling tool when pulling drilling tool up.

2. Digging bucket

1) Install casing. Casing imbedded length is based on soil condition and water table level.
2) Use stabilizer to keep hole from collapsing.
3) Using drilling bucket with the same procedure as augers except that the drilling bucket has an opening mechanism and the door is open when the opening mechanism hits a keeper plate on the rotary head.

3. Core Barrel

1) Drilling procedure is same as auger.
2) Pay attention to drilling speed and pressure; keep kelly bar from jumping up and down.
3) Slow down drilling with low pressure before core barrel enters rock; increase speed and pressure when core barrel enters rock layer.
4) Slow speed with low pressure to prevent core barrel from sliding when inclined rock face is encountered. Crooked hole may break kelly bar.

§6.3.5 Drill Rig Move

Check ground condition; ground slope should be less than 5 degree. Repeat the above procedures for a new hole.

§6.3.6 LCD Monitor, Warning Icons

Check LCD Monitor and alarm warning icons. Take necessary measures when alarm beeps

Attention:
● When Alarm icons in Fig. 21, 23 and 24 turn red or flash, please check the drill rig.
1) When #1 icon turns red, it means the engine oil pressure is low. Do not start engine before the problem is eliminated.

2) When #2 icon turns red, it means the coolant temperature is too high. Slow down until the coolant temperature drops down.

3) When #3 icon turns red, it means the hydraulic oil temperature is too high. Slow down until hydraulic oil temperature drops down to normal temperature.

4) When #4 icon turns red, it means the fuel is not sufficient.

5) When #5 icon turns red, it means battery charger problem (or low battery). Engine can work but battery discharges quickly.

6) When #6 icon turns red, it means the main winch hoist has reached the limit. Stop main winch.

7) When #7 icon turns red, it means the hydraulic enabling switch is OFF.

8) When #8 icon turns red, it means hydraulic filter needs to be replaced.

§6.3.7 Shut down

1) Lower drilling tool and kelly bar down for short time engine shut down; Boom the mast down as in Fig. 3 for long time engine shut down.

Attention: Switch off main hydraulic by pushing the Left Console up before exit the driver’s cabin.

2) Run engine at low speed for 5 minutes to cool engine down.

3) Switch the ignition key to “OFF” position, pull ignition key out to switch off the main power.

4) Lock the cabin.

Attention:

● Stop drill rig on a flat ground;

● Clean drill rig, clean crawlers, rollers, carriers.

● Drain off any coolant which is easily to be frozen in winter.
§6.3.8 Steps to exit from drilling mode to transportation mode

1 ) Stop drill rig on a flat ground, lower rotary head to the bottom of drill mast by pushing down crowd cylinder;
2 ) Pull kelly bar up until kelly bar bracket is off the mast guide;
3 ) Let mast tilt forward until kelly bar away from mast and rotary head;
4 ) Lower main winch until kelly bar is on ground;
5 ) Use main winch and traveling mechanism to lay down kelly bar, disconnect wire rope from kelly bar;
6 ) Mast boom up vertically, swing uppercarriage left(right) 90 degree, lower mast foot down to push left(right) crawler up so that left(right) crawler can be retracted;
7 ) Swing mast back (facing front), connect triangle frame with lower drill mast;
8 ) Follow procedure in “Mast self rigging/derigging” to derig;
9 ) Use crane to fold cathead and pin cathead with mast;
10 ) Pin uppercarriage and undercarriage together;
11 ) Pin crawler cylinders;
12 ) Retract crowd cylinder or dissemble crowd cylinder;
13 ) Derigging is complete.

Special Attention:

1 ) A helper is required during mast rigging/derigging.
2 ) Use proper length of wire rope during the mast rigging/derigging process. No wire rope overlapping is permitted in the main/aux winches.
§7 Maintenance and Service

Periodic and proper maintenance is very important to the performance and service life of the drill rig.

§7.1 Bolt Torque

1 ) Torque

Table 7

<table>
<thead>
<tr>
<th>PARTS</th>
<th>SPECIFICATION</th>
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<th>GRADE</th>
<th>TORQUE</th>
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<tr>
<td>Crawler Track</td>
<td>GB10677-89</td>
<td>LS20×1.5</td>
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<td>Mount</td>
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2) Standard fitting torque (grade 8.8)

Table 8

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<th>M16</th>
<th>M18</th>
<th>M20</th>
<th>M24</th>
<th>M30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torque (N.m)</td>
<td>10</td>
<td>24</td>
<td>44</td>
<td>78</td>
<td>190</td>
<td>260</td>
<td>370</td>
<td>640</td>
<td>1300</td>
</tr>
</tbody>
</table>

§7.2 Fuel

Fuel tank capacity is 400L. See Engine Manual for Fuel brand and usage.

§7.3 Hydraulic Oil

Hydraulic oil tank capacity is 750L and use FUCH, TOTAL or China #46 hydraulic oil.

§7.4 Lubrication Oil (Fat)

<table>
<thead>
<tr>
<th>COMPONENTS</th>
<th>LUBRICATION OIL (FAT)</th>
<th>QTY</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roller</td>
<td>HC-8HC-11 (Winter) HC-14 (Summer)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrier</td>
<td>#10 (Winter), #15 (Summer)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Idler</td>
<td>HC-8HC-11 (Winter) HC-14 (Summer)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traveling Speed Reducer</td>
<td>CLP220LS2</td>
<td>Full</td>
<td></td>
</tr>
<tr>
<td>Crawler</td>
<td>Calcium Based Lubricant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tension Unit</td>
<td>Calcium Based Lubricant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gear</td>
<td>N150E (Winter) ; H200EP (Summer)</td>
<td>Full</td>
<td>Overflow</td>
</tr>
<tr>
<td>2ND Stage Reducer</td>
<td>VG150EP (Summer) VG100EP (Winter)</td>
<td>Full</td>
<td></td>
</tr>
<tr>
<td>Bearing</td>
<td>(Lithium Based) LGMT3 LGEP2</td>
<td>4Kg</td>
<td>2/3</td>
</tr>
<tr>
<td>Reducer</td>
<td>CLP220LS2</td>
<td>Full</td>
<td></td>
</tr>
<tr>
<td>Wire rope</td>
<td>Calcium based grease</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### §7.5 Coolant

See engine manual.

### §7.6 Maintenance

1. Daily/ every 10 hours maintenance
   ① General check
       a) Check any leakage on fuel/oil tanks, cylinders, hoses, couplings and grease zerks;
       b) Check cooling system, leakage, hose damage and spoil built-up;
       c) Check wind shield, wiper;
       d) Check ladder, hand railing, passage;
       e) Check light.
   ② Check wire rope; grease on swivel; slewng bearing; kelly bar bearing.
   ③ Check hydraulic oil;
   ④ Check fuel;
   ⑤ Check coolant; engine oil level;
⑥ Check operating levers, gauges;

⑦ Check drilling tool.

2 Weekly/every 50 working hours maintenance

① Check rotary head
   a) gear box lubricant;
   b) bolts and nuts;
   c) speed reducer lubricant;

② Slewing bearing bolts and nuts;

③ Swing speed reducer lubricant, bolts and nuts;

④ Grease on pin, bearing, guide;

⑤ Kelly bar bearing, A-frame bolts.

3 Three Months/every 500 working hours maintenance

① Crawlers traveling fittings
   a) check crawler tension unit, adjustment(after 50hours);
   Use a long ruler placed on top of two carries to measure how much the crawler drops down.
   Normal sagging should be 40 to 50 mm. Fill grease to increase crawler tension;
   b) check for wear and tear, strange sounds, loose bolts and nuts of traveling components;

② Hydraulic system check(1st check after 50hours)
   a) change main hydraulic oil and pilot hydraulic oil filter cartridge;
   b) change hydraulic oil tank air filter;

③ check guide, bolts of rotary head;

④ check rotary sleeve;

⑤ Main hydraulic oil needs to be filtered( cleaned);

4 Six month/ every 1000 working hours Maintenance

① change rotary head gear box lubricant;

② change traveling speed reducer lubricant;
③ change winch speed reducer lubricant;
④ change rotary head speed reducer lubricant;
⑤ change swing speed reducer lubricant;
⑥ check battery;

5 Yearly/every 2000 working hours Maintenance

① change hydraulic oil (1st oil change after 500 working hours)

6 See Engine Maintenance Manual

7 Maintenance and service after stopping for long time

① clean drill rig, keep traveling components clean;
② Grease hinges, guide;
③ drain coolant, take battery off;
④ Put drill rig in a dry place and cover with tarp;
⑤ Run drill rig on a monthly basis;

8 Maintenance Chart(Fig.30)
<table>
<thead>
<tr>
<th>CODE</th>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>MAINTENANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wire Rope</td>
<td>Check Wear &amp; Tear</td>
<td>10h/Daily</td>
</tr>
<tr>
<td>2</td>
<td>Fuel</td>
<td>Check Full Level</td>
<td>10h/Daily</td>
</tr>
<tr>
<td>3</td>
<td>Hydraulic System</td>
<td>Check HYD. Level</td>
<td>10h/Daily</td>
</tr>
<tr>
<td>4</td>
<td>Coolant</td>
<td>Check Level</td>
<td>10h/Daily</td>
</tr>
<tr>
<td>5</td>
<td>Control Lever/Gauges</td>
<td>Check Lever/Gauge</td>
<td>10h/Daily</td>
</tr>
<tr>
<td>6</td>
<td>Drill Tool</td>
<td>Mount/Wear</td>
<td>10h/Daily</td>
</tr>
<tr>
<td>7</td>
<td>Shaft, Bearing, Slide Frame</td>
<td>Lubrication</td>
<td>50h/Weekly</td>
</tr>
<tr>
<td></td>
<td>Cathead/Pulley/Bearing</td>
<td>Lubrication</td>
<td>2000h/Yearly</td>
</tr>
<tr>
<td>8</td>
<td>Swing Speed Reducer</td>
<td>Lubricant/Bolt/Nut</td>
<td>50h/Weekly</td>
</tr>
<tr>
<td>9</td>
<td>Slewing Bearing</td>
<td>Bolts</td>
<td>50h/Weekly</td>
</tr>
<tr>
<td>10</td>
<td>Rotary Head Guide</td>
<td>Bolts</td>
<td>50h/Weekly</td>
</tr>
<tr>
<td>11</td>
<td>Rotary Head Transmission</td>
<td>Lubricant/Bolts</td>
<td>50h/Weekly</td>
</tr>
<tr>
<td>12</td>
<td>Rotary Head Speed Reducer</td>
<td>Lubricant</td>
<td>50h/Weekly</td>
</tr>
<tr>
<td>13</td>
<td>Swivel</td>
<td>Lubricant/nuts</td>
<td>50h/Weekly</td>
</tr>
<tr>
<td>14</td>
<td>Air Filter</td>
<td>Filter Core/Replace</td>
<td>250h/Monthly</td>
</tr>
<tr>
<td>15</td>
<td>Hydraulic System</td>
<td>Initial Check/Replace</td>
<td>50h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oil Filter/Air Filter</td>
<td>250h/Monthly</td>
</tr>
<tr>
<td>16</td>
<td>Slewing Ring</td>
<td>Lubricant</td>
<td>2000h/Yearly</td>
</tr>
<tr>
<td>17</td>
<td>Crawler Track</td>
<td>Initial Tension Check</td>
<td>50h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adjust Tension</td>
<td>250h/Monthly</td>
</tr>
<tr>
<td>18</td>
<td>Rotary Guide</td>
<td>Bolts</td>
<td>250h/Monthly</td>
</tr>
<tr>
<td>19</td>
<td>Rotary Head Sleeve</td>
<td>Wear &amp; Tear</td>
<td>250h/Monthly</td>
</tr>
<tr>
<td>20</td>
<td>Kelly Bar Guide</td>
<td>Bolts</td>
<td>250h/Monthly</td>
</tr>
<tr>
<td>21</td>
<td>Traveling Speed Reducer</td>
<td>Change Oil</td>
<td>1000h/Six Months</td>
</tr>
<tr>
<td>22</td>
<td>Swing Speed Reducer</td>
<td>Periodic Change Oil</td>
<td>1000h/Six Months</td>
</tr>
<tr>
<td>23</td>
<td>Rotary Head Gear Box</td>
<td>Change Oil</td>
<td>1000h/Six Months</td>
</tr>
<tr>
<td>24</td>
<td>Rotary Head Speed Reducer</td>
<td>Change Oil</td>
<td>1000h/Six Months</td>
</tr>
<tr>
<td>25</td>
<td>Hydraulic System</td>
<td>Change Oil</td>
<td>500h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Change Oil</td>
<td>2000h/One Year</td>
</tr>
<tr>
<td>26</td>
<td>Air Filter</td>
<td>Change</td>
<td>2000h/One Year</td>
</tr>
<tr>
<td>27</td>
<td>Roller</td>
<td>Change Oil</td>
<td>2000h/One Year</td>
</tr>
<tr>
<td>28</td>
<td>Carrier</td>
<td>Change Oil</td>
<td>2000h/One Year</td>
</tr>
</tbody>
</table>
§8 Transportation

§8.1 Trailer Transportation

1. See Fig. 4 for drill rig outer dimension. Dismantle drilling tool, kelly bar and crowd cylinder. Fold upper and lower drill masts up.

2. Choose right trailer.

3. Load drill rig

   3.1 Choose a flat ground;

   3.2 Block the trailer wheels;

   3.3 Trailer ramp should be within 15 degree;

   3.4 Driving wheel should be at back of drill rig, i.e. back drill rig on the trailer;

   3.5 Keep drill rig balance when passing through the joint between the ramp and trailer;

       keep rotary head above ground by pushing up hydraulic cylinders;

4. Tie drill rig

   4.1 Lift hydraulic control (Left Console) to “LOCK: position;

   4.2 Turn ignition key to “OFF” position and pull key out from engine;

   4.3 Pin uppercarriage with undercarriage;

   4.4 Lock doors;

   4.5 Put wedges under crawlers, tie drill rig with cables.

§8.2 Break-down Transportation

Drill rig can be broken down for small trailer transportation, disassemble Kelly bar, drill tool, rotary head, mast and counter weight. Drill mast can be broken down into three sections.
## §9 Trouble-Shooting

### §9.1 Common Malfunction and Check-ups

<table>
<thead>
<tr>
<th>MALFUNCTION</th>
<th>CAUSES</th>
<th>CHECK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine does not start or difficult to start</td>
<td>Battery bad or low battery</td>
<td>Change /charge battery</td>
</tr>
<tr>
<td></td>
<td>Starter damaged</td>
<td>Replace</td>
</tr>
<tr>
<td></td>
<td>Poor Connection/short circuit</td>
<td>Repair</td>
</tr>
<tr>
<td></td>
<td>See engine manual for other malfunction</td>
<td></td>
</tr>
<tr>
<td>Joysticks loose/slow action</td>
<td>Air in hydraulic system</td>
<td>Check any leakage</td>
</tr>
<tr>
<td></td>
<td>Hyd. Oil temperature too low, too sticky</td>
<td>Pre-heat engine</td>
</tr>
<tr>
<td></td>
<td>Hyd. Oil bad</td>
<td>Replace oil</td>
</tr>
<tr>
<td></td>
<td>Hyd. Pressure low</td>
<td>Check Hyd. System</td>
</tr>
<tr>
<td>Cylinders not working/slow</td>
<td>Pilot Valve</td>
<td>Repair</td>
</tr>
<tr>
<td></td>
<td>Cyl. seals</td>
<td>Replace</td>
</tr>
<tr>
<td></td>
<td>Overflow valve damage</td>
<td>Repair</td>
</tr>
<tr>
<td>Abnormal sound in rotary head</td>
<td>Bad Lubricant</td>
<td>Replace</td>
</tr>
<tr>
<td></td>
<td>Low Lubricant</td>
<td>Re-fill</td>
</tr>
<tr>
<td></td>
<td>Gear damage, worn out</td>
<td>Replace</td>
</tr>
<tr>
<td></td>
<td>Bearing worn out</td>
<td>Replace</td>
</tr>
<tr>
<td>No Signal from Gauges</td>
<td>Gauges damaged</td>
<td>Repair/Replace</td>
</tr>
<tr>
<td></td>
<td>Fuse Burnt</td>
<td>Replace</td>
</tr>
<tr>
<td></td>
<td>Poor connection/short circuit</td>
<td>Repair</td>
</tr>
<tr>
<td>Issue Description</td>
<td>Possible Issues</td>
<td>Solution</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------</td>
<td>---------</td>
</tr>
<tr>
<td>No swing/Slow swing</td>
<td>Pilot Valve</td>
<td>Repair</td>
</tr>
<tr>
<td></td>
<td>Directional Valve/Break Valve</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Motor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Swing Speed Reducer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slewing Ring</td>
<td></td>
</tr>
<tr>
<td>Engine Stops/Hyd. Arm not working/slow</td>
<td>No pressure/low pressure on bladder accumulator/check valve leaking</td>
<td>Add Nitrogen</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check check valve port</td>
</tr>
<tr>
<td>One side of crawlers not moving/slow moving</td>
<td>Pilot Valve</td>
<td>Repair</td>
</tr>
<tr>
<td></td>
<td>Directional/break valve</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Central Coupling Seals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Motor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Traveling Speed Reducer</td>
<td></td>
</tr>
<tr>
<td>High Hyd. Oil Temperature</td>
<td>Radiator too dirty</td>
<td>1.Clean</td>
</tr>
<tr>
<td></td>
<td>Hyd. Components worn out, low efficiency/ overflow valve on/off too often</td>
<td>2.Check W/Sale Dept.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.Slow down drilling speed</td>
</tr>
</tbody>
</table>