



# **BLUE ICE DRILL**

## **Operations and Maintenance Manual**

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April 28, 2021

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## **1.0 PURPOSE**

This document outlines proper set up and operation of the Blue Ice Drill in both the shallow and deep versions. The Shallow (Ropes) assembly uses a tripod, and the Deep version assembly uses a tower that can accommodate a tent.

## **2.0 SCOPE**

This document applies to all personnel working with the Blue Ice Drill.

## **3.0 REFERENCES**

- 1008-0014 SSEC Safety Plan
- 8431-0002 Mast Anchored, Suspended and Tensioned (MAST) Tent assembly manual

## **4.0 DEFINITIONS**

BID – Blue Ice Drill.

CRT – Core Retrieval Tool.

IDP – U.S. Ice Drilling Program, formerly IDDO.

QAS – Quality Assurance and Safety group.

SSEC – University of Wisconsin-Madison, Space Science & Engineering Center.

## **5.0 RESPONSIBILITIES**

IDP Engineering is responsible for the generation and maintenance of this document.

SSEC QAS is responsible for ensuring that this document is created, reviewed, approved, maintained and changed per applicable SSEC processes.

Project personnel are responsible for understanding this manual for safe set up and operation of the Blue Ice Drill.

## **6.0 RECORDS**

Seasonal and Weekly Preventive Maintenance Checklists.

## 7.0 SAFETY NOTICE



The Blue Ice Drill is an agile drill capable of drilling 9.5-inch diameter ice cores in solid ice and firn. All operators of the Blue Ice Drill should read and understand the following safety precautions of this device prior to using.

### Personal Protective Equipment (PPE)

- PPE – Workers shall wear gloves, eye, ear, arm or fall protection whenever there is the potential for injury.

### Mechanical Safety

- Cutters – The cutters on the drill can be extremely sharp. Operators shall use care whenever handling cutter assemblies or cutter blades and should wear protective gloves whenever possible.
- Pinch-points – There are several areas on the drill where a finger, hand, arm or clothing could be pinched. Workers should wear gloves whenever working around potential pinch-points.
- Suspended Loads – Users shall never stand under suspended loads. Injury may result from a moving, rotating, falling or unbalanced load.
- Eye Protection – Standard operations of the Blue Ice Drill do not require eye protection be worn by operators, however, eye protection shall be available onsite in the event of non-standard operations such as those using chemicals to free a stuck drill.
- Hardhats – Hardhats shall be worn whenever workers are exposed to a potential for head injury from falling or flying objects.
- Tower and Tent Assembly – While the tent is rated to withstand 50 knot winds when fully installed, it is recommended that the tower and tent be raised only with winds of no greater than 15 knots.

### Electrical Safety

- Voltage – Extreme care shall be taken when assembling, disassembling and servicing electrical equipment.
- Grounding – Because the drill sits upon a large thickness of ice, a common earth ground cannot be established. Workers shall ensure that all drilling equipment is bonded together to a common ground back to the drill operation's generator(s).
- Lockout Tagout procedure – Lockout/tagout procedures shall be followed whenever servicing electrical equipment.

### Chemical Safety

- Use care and observe all safety warnings when handling or using Ethanol or other chemicals.

### Fall Protection Safety

- Use care when walking on slippery surfaces (i.e. the ice surface) and when working near boreholes.

### Environmental Safety

- Cold – This drill will be deployed to extremely cold climates. Workers shall wear outerwear suitable to protect themselves from the cold, and monitor their own and fellow workers' activities for exposure to cold.

8.0 SYSTEM INTRODUCTION

The Blue Ice Drill (BID) is an electromechanical, coring drill developed by the U.S. Ice Drilling Program at the University of Wisconsin-Madison to take large-volume, near-surface, contamination-free ice samples. Ice cores of 241 mm diameter can be drilled to depths up to 200 meters. The BID design is typical of double-barrel ice coring drills, consisting of a cutter head, inner and outer barrel assembly, and motor/reducer section. Reaction torque can be applied via an anti-torque section of the drill or from the surface via a solid extension stem. An innovative core retrieval tool (CRT) can be used to break and recover samples. The subsurface equipment is supported by a single tower and steel drill cable for the Deep configuration and a tripod and rope for the Shallow configuration. Figure 1 details the major components of both Blue Ice Drill configurations.

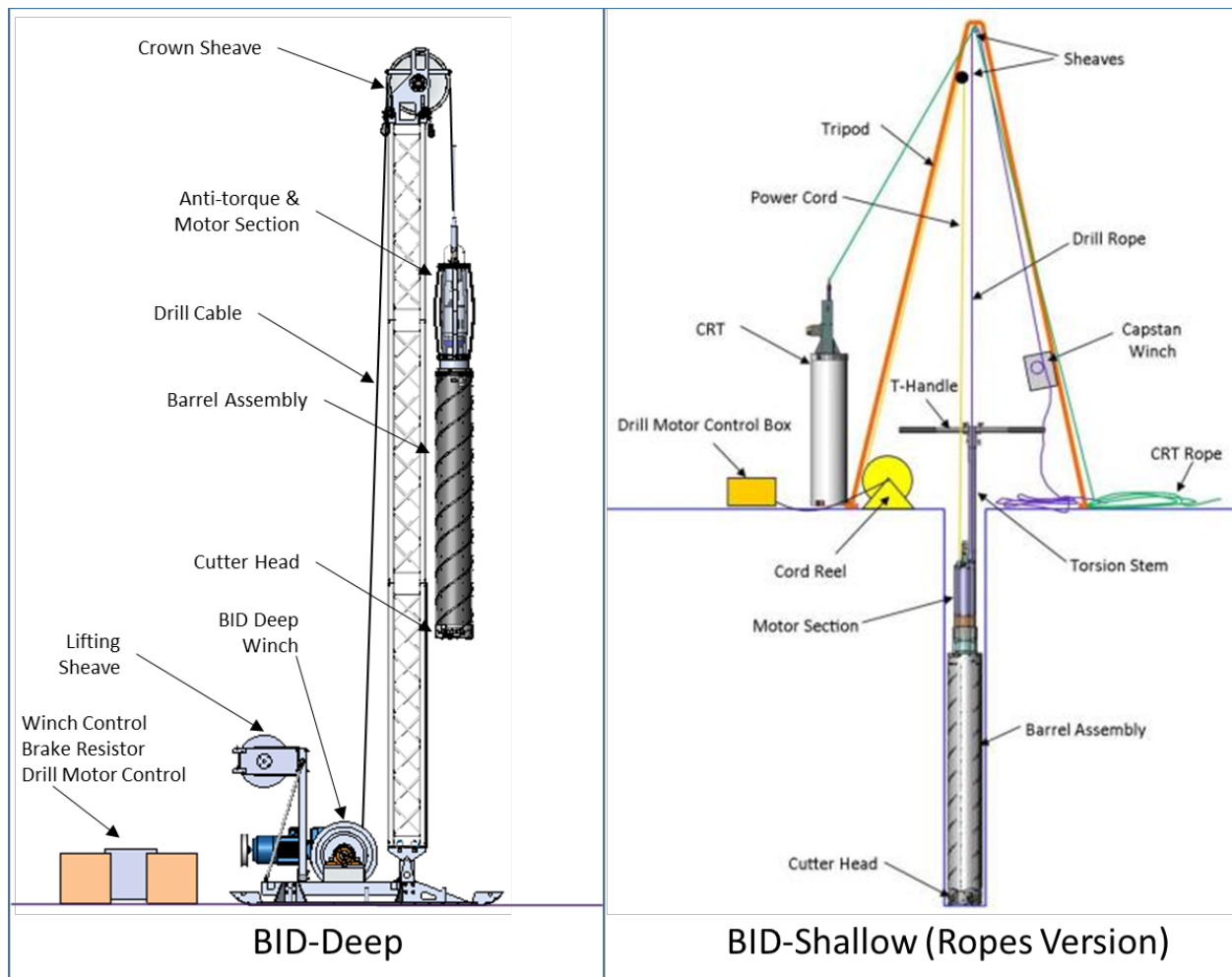


Figure 1: Main components of the Blue Ice Drill system.

## 9.0 Ropes Version Assembly

### 9.1 Assembly Steps

#### 9.1.1 Tripod Assembly

9.1.1.1 The BID Tripod assembly is detailed in IDP Drwg#86800190 (see appendix). It is composed of two adjustable legs made from 2.5-inch aluminum pipe (IDP Drwg#86800192) and one leg, made from 3.5-inch pipe, containing the capstan winch (IDP Drwg#86800191). The legs are connected at the tripod apex to a Top Frame Assembly (IDP Drwg#86800110) containing two sheaves.

9.1.1.2 Tripod assembly begins by removing the Leg Tube segments, Couplers (including Capstan Winch with Couplers), and Pivot Tab/Leg Cap assemblies from their shipping bags/cases. Refer to the Blue Ice Drill Packing Lists included with the system for the location of each component (an example Packing List is included in the Appendix). Insert each Coupler (including Capstan Winch) and Leg Cap into the corresponding Leg Tube segment, being careful not to get snow/ice into the joint. Each joint is held by a 0.5-inch quick-release Pin. Be sure to use the correct length Pin for each Leg Tube diameter. Secure the Leg Adjustment Tube on each 2.5-inch Leg Tube approximately in the middle location with a Pin. Attach each Foot Plate Assembly to the corresponding Pivot Tab and secure with the correct Modified Hex Bolt Pin with Snap Pin.

9.1.1.3 If the Anti-Torque Section will be used (see Anti-Torque Section below) the optional Tripod Leg Extensions should be installed to increase the Tripod height enough to ease separation of the Core Barrel from the Outer Barrel. Insert the Tripod Leg Extension between the upper most Leg Tube Segment and Pivot Tab/Leg Cap on each Leg Assembly, securing with 0.5-inch quick-release Pins.

9.1.1.4 Lay both 2.5-inch Leg Assemblies flat on the surface at approximately a 20-degree angle, and remove one Pin at the first Coupler/Leg Tube joint (not the Leg Adjustment Tube Pin). This allows the lowest Leg Tube segment to rotate. Position the Foot Plate Assembly of each leg flat on the surface. Attach each Leg Assembly to the Top Frame with a 5/8-inch Pin with Snap Pin. Position the assembled 3.5-inch Leg Assembly with Capstan Winch between the other legs and affix the top Pivot Tab to the Top Frame with the 7/8-inch Pin and Snap Pin. The end of the Capstan Winch spool should rest on the surface. Do not remove any Pins from the 3.5-inch Leg Assembly. See Figure 2.

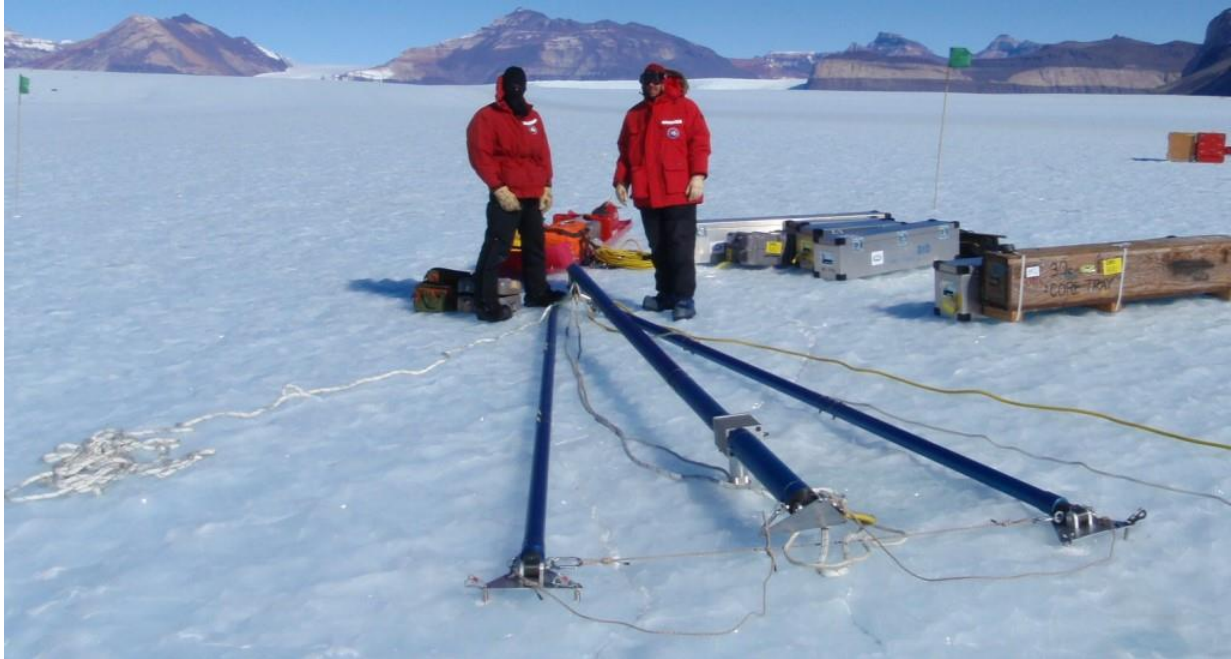


Figure 2: BID Tripod ready for standing. Note the position of the Footplates, ice screw anchors, and Safety Ropes between legs. Ropes and Electrical Cord have been installed and laid-out so as to not interfere with Tripod standing.

- 9.1.1.5 Before the Tripod is erected, all adjoining components higher than head-level should be attached. This includes the following:
- Drill Rope (5/8-inch, white with red fleck)
    - Insert in Top Frame by removing Sheave
  - CRT Rope (1/2-inch, orange)
    - Insert in Top Frame by removing Sheave
  - Electrical Power Cord Pulley Rope (general purpose cord)
    - Insert rope through Bolt Hanger anchor attached to 2.5-inch Leg Tube Cap at inside threaded hole with 3/8"-16 SHCS with washer.
- 9.1.1.6 Assemble Sled by aligning Sled Half Panels and securing with #10-24 FHSCS. Secure Sled End Panels with #10-24 FHSCS. Position assembled Sled under prone Tripod, aligning holes in Foot Plates of 2.5-inch Leg Assemblies with threaded inserts on Sled. Attach Foot Plates to Sled with a 1/2"-13 Hex Bolt through each Foot Plate. Note that this is not the final Foot Plate orientation. Secure Sled to ice surface with at least 3 Ice Screws. Connect Safety Ropes with carabiners to eye bolts threaded into bottom Leg Cap of each Tripod Leg. Route Safety Ropes so as not to impede with set-up of Tripod. Arrange all attached Ropes neatly to reduce trip hazard.

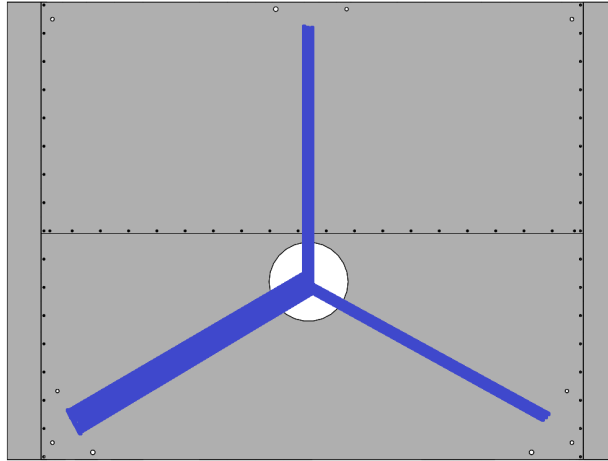


Figure 3: Orientation of the tripod to the sled platform in the ropes setup.

- 9.1.1.7 A safety anchor can be set-up by securing one end of the CRT rope to a Bolt Hanger anchor attached to the 3.5-inch Leg near the Capstan Winch. Run the other end of the CRT Rope to a Figure-8 Belay Device (an Ascender or Prussic can also be used) attached to an anchor. Construct the anchor in the ice surface by means of multiple V-Threads, Ice Screws, or Pickets connected with nylon Webbing and Carabiners.
- 9.1.1.8 Four people are ideal to stand the Tripod, one on each leg and one to belay the safety rope. The two people on the 2.5-inch Legs start by lifting the Top Frame Assembly and gradually walking-up the legs as the third person pulls on the 3.5-inch Leg and guides it into position. It is important to not pull on the 2.5-inch Legs, as one Pin has been removed from each to allow them to rotate as the Tripod is erected. The fourth person continually takes up slack in the Safety Rope as the Tripod is stood. Note that the Safety Rope will not hold the Tripod in position until it is approximately 30-degrees off the ground.
- Periodically adjust the alignment of the foot plates so that their hinges are properly aligned.



- 9.1.1.9 Once the Tripod is fully vertical, secure the Foot Plate of the 3.5-inch Leg Assembly to the Sled with two ½"-13 Hex Bolts. Rotate the lowest Leg Tube on each 2.5-inch Leg Assembly so that the holes in each Foot Plate align with the threaded inserts in the Sled. Attach with two ½"-13 Hex Bolts per Foot Plate. Refer to IDP Drwg#86800190 in the Appendix to ensure the orientation of the Foot Plates is correct. Re-insert the two quick-release Pins that were removed from each 2.5-inch Leg Assembly. Attach Sled to ice surface with three Ice Screws – one through each Foot Plate. The Tripod is leveled by means of the Leg Adjustment Tubes on each 2.5-inch Leg Assembly. Use the gold-painted Leveling Jack to support the weight of the Leg Adjustment Assembly, remove the Pin, and then crank the Leveling Jack up or down to align a different hole combination in the Leg Adjustment Tube. Adjust each Leg alternately until the Drill Rope (with a weight attached) hangs plumb above the center of the hole in the Sled. If the Drill Rope cannot be centered in the Sled opening within the adjustment range of the Leg Adjustment Assemblies it will be necessary to reorient the Tripod by rotating it to a new position around the desired hole location. It may be necessary to level the site by removing ice/snow from the area. Ensure that the surface is flat beneath the entire Sled area.
- 9.1.1.10 The three Safety Ropes attached to the Tripod Legs can now be removed. (Note that if the Tripod is to be used without the Sled, the three Safety Ropes must remain in place, and the Tripod affixed to the ice with three ice screws per Footplate.)

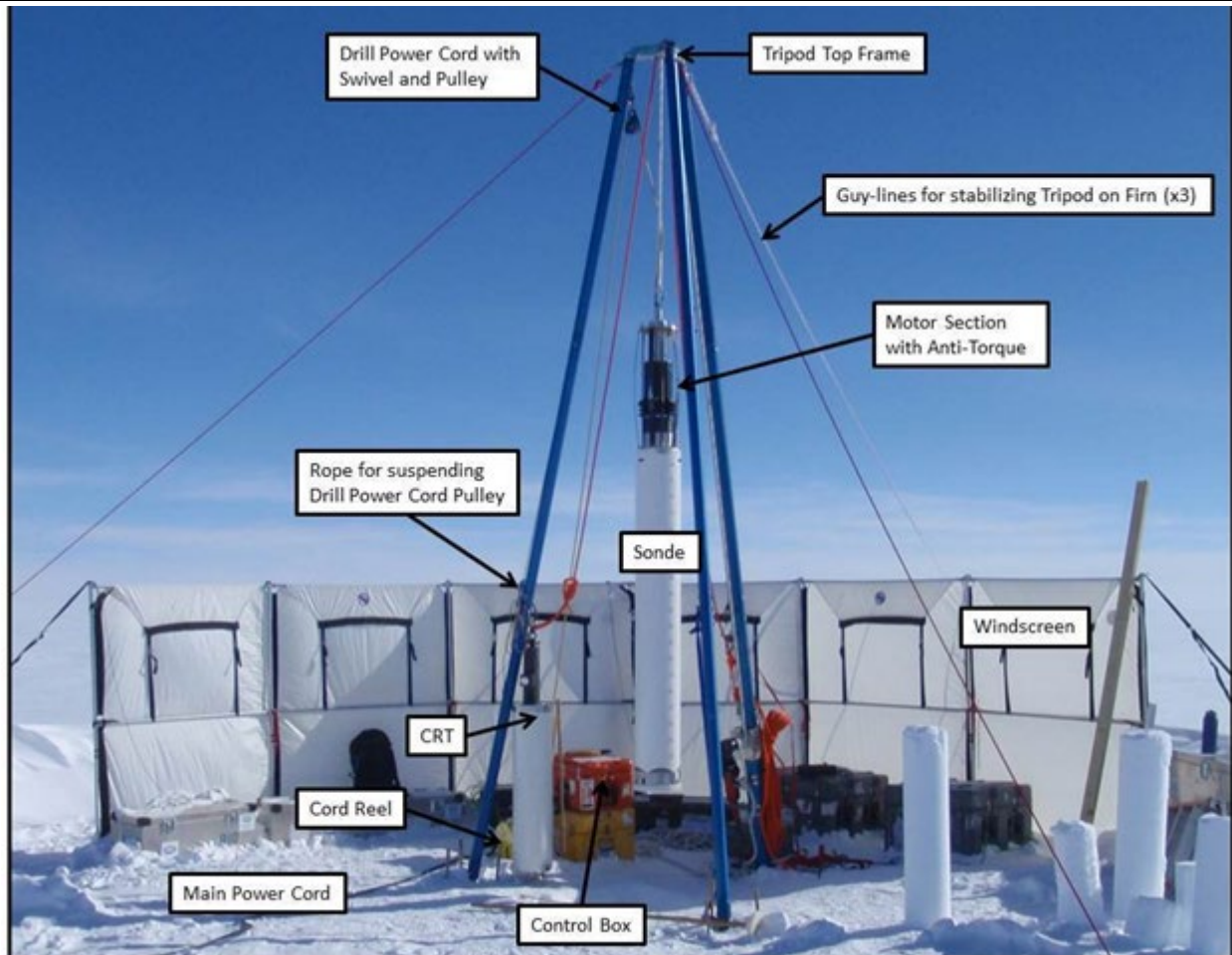


Figure 4: Full BID Drill System assembled near Summit Station, Greenland in 2013.

9.1.1.11 For use on firn/snow, the Tripod must be stabilized with a minimum of three guy lines running from near the apex to Pickets driven in the snow surface. The Safety Lines must be used between the Tripod Legs. Each footplate should be slightly inset into the snow surface and fixed in place with three Bamboo Stakes per Footplate.



**CAUTION:** The Tripod/Sled Assembly must be securely belayed during transport across sloping terrain by an Operator walking behind the sled. The Sled Assembly does not contain skags or a solid tow bar for control. It must be belayed and manually stabilized at all times.

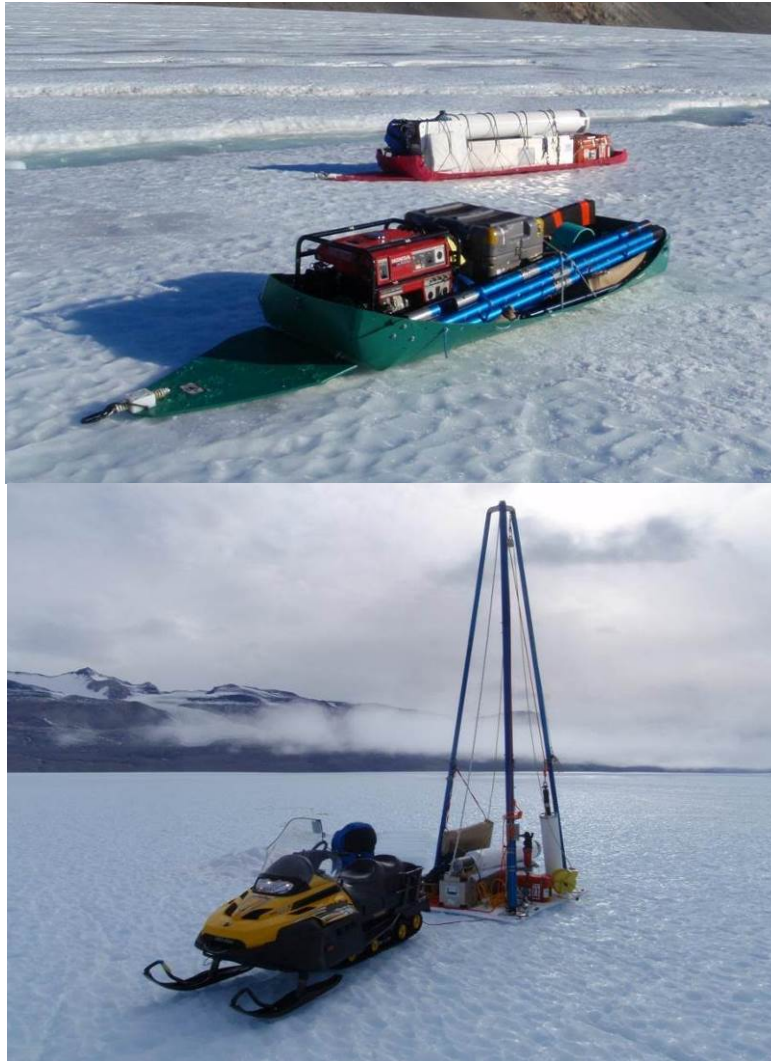


Figure 5: BID Drill System readied for transport on Taylor Glacier, Antarctica during the 2011-12 season. A bare-minimum system will fit on 2 Siglin sleds for long and/or rough trips (above). Short moves over gentle terrain can be accomplished with the Tripod standing (below). Stack drill cargo on the sled for stability.

### 9.1.2 Winch Assembly and Final Tripod Details

- 9.1.2.1 The Capstan Winch is driven by a right-angle Milwaukee Hole Hawg electric drill, controlled with a Footswitch. First, attach the Handle Mount to the lower Tripod Leg loosely with two hose clamps. Attach the chuck of the Winch Drill to the input shaft of the Capstan Winch using the chuck key, making sure to align the teeth of the chuck with the flats on the input shaft. A tight, well-aligned connection is critical to avoid damage to both parts. The handle of the Winch Drill should be between the arms of the Handle Mount. Secure the handle of the Winch Drill to the Handle Mount with the quick-release Pin and rotate the Switch Lock of the Handle Mount to engage the switch on the Winch Drill handle. Adjust the final position of the Handle Mount to ensure alignment with the Tripod Leg, Capstan Winch, and Winch Drill handle switch and tighten hose clamps. See Figure 6.
- 9.1.2.2 Plug the cord of the Winch Motor into the Foot Switch and the foot switch cord into a 120-volt outlet/extension cord. Route the cords so they will not be stepped on. This is especially important when wearing ice cleats, Stabilizers, or crampons.
- 9.1.2.3 Secure the Rope Cleat to the rear of the Capstan Winch with two 3/8"-16 FHSCS. Attach the Cam Cleat with Mount to the front of the Tripod Leg below the Capstan Winch with two hose clamps.
- 9.1.2.4 The Drill Rope is run through a Gibb's Device mechanical prussic as a safety against accidental falling of the Drill Sonde. The Gibb's Device is attached to a 1/2-inch Eye Bolt (in place of quick-release Pin) anchor above the Capstan Winch with a length of rope and locking-carabiners. A load-releasable knot, such as the one shown in the picture below) can optionally be used to simplify a winch malfunction situation. Do not use such knots unless you are familiar with their operation. Limit the downward travel of the Gibb's Device to approximately 8-inches with a piece of parachute cord, or similar, tied between the device and a higher anchor. See Figure 6.
- 9.1.2.5 The CRT Rope is not used with a mechanical prussic as the CRT is light and never lifted more than a few feet above the surface.
- 9.1.2.6 The Winch Motor has two gear ranges, Low and High. High is used for tripping at most depths. Low can be used for core breaks (when using Core Dogs or a Collet in the Coring Head) or for deeper depths with many Extension segments attached. Tripping speeds in Low range are very slow – switch to High whenever possible to increase overall efficiency. Do not switch gear ranges with the motor running.



9.1.2.7 The Electrical Power Cord is stored on a spring-energized Cord Reel to automatically pay-out and retract the Power Cord during drilling operations. Secure the Cord Reel Base Plate to the Drill Sled with ½"-13 Hex Bolts. If not using the Drill Sled, the Cord Reel Base Plate can be secured with Ice Screws or Bamboo Stakes. Insure the Guide-rollers on the Core Reel are aligned with the final PowerCord direction.

9.1.2.8 Install the Electrical Power Cord in the Pulley and attach the Pulley with a Swivel to the Electrical Power Cord Pulley Rope installed before the Tripod was erected. Pull the Pulley assembly up to the Bolt Hanger that suspends it, and tie-off the free end of the Rope to secure. See Figure 4.

### 9.1.3 Motor Section Assembly

The BID Motor Section consists of an AC induction-type electric Drill Motor connected to a 2-stage planetary Gear Reducer, mounted in one of several housings:

- Standard Motor Housing – with or without Anti-Torque Section
- Slide-Hammer Motor Housing – with or without Anti-Torque Section

#### 9.1.3.1 Standard and Slide-Hammer Motor Section without Anti-Torque Section

- IDP Drwg#86800214 details the assembly of the Standard Motor Section, while IDP Drwg#86800052 shows the Motor Section with Slide-Hammer. The motor section contains redundant seals to keep lubricants internal to the Motor Housing and is cleaned before packing. Take care to use clean gloves when handling.
- Remove Motor Section from case, using the Recovery Loop and Core Barrel Drive Plate as handholds, and set on the included Motor Section Cradle. Ensure all fasteners are installed and torqued to the values listed on the assembly drawing.
- Suspend the Motor Section from the Drill Rope by inserting the loop in the end of the rope into the Rope to Swivel Connector. Be sure to securely tighten all screws in the Rope to Swivel Connector and Swivel. The Capstan Winch can be used to lift the Motor Section from horizontal.

- The Drill Power Cord is secured to the Top Plate Motor Housing with a strain-relieved Cord Grip in a Mounting Plate. Install the Cord Grip/Mounting Plate assembly on the Power Cord (if not already installed). This will involve removing and then re-installing the 4-pin Amphenol Electrical Connector on the Drill Power Cord. Plug-in the Electrical Connector from the cord to the Drill Motor and carefully insert the connector into the hole in the Top Plate before securing the Mounting Plate to the Top Plate with FHSCS.
- For coring at depths less than approximately 30 meters, the Sonde can be anti-torqued from the surface by a second operator. The Anti-torque Handles are used with a Barrel Clamp for coring with the Barrel Assembly above the Surface, see IDP Drwg#86800082\_Barrel Clamp Assembly for details. The same Handles are attached to an adaptor for use with the Extension Tubes, which are added in 0.5 and 1-meter segments as drilling progresses. IDP Drwg#86800143c\_Extension Assy details the assembly.

#### 9.1.3.2 Anti-Torque Section

- IDP Drwg#86800233d\_Motor\_AT Section\_BID Deep and 86800234c\_Cable Bearing Assy\_BID Deep give details on the assembly of the Anti-Torque Section which can be used with either BID Motor Section. If the shorter, Standard Motor Section is used, the Spacer\_Motor Can must be used to extend the Motor Can and allow the Upper Hinge Plate assembly to interact with the Top Housing of the Anti-Torque Section.
- The Anti-Torque Section is shipped with the anti-torque blades unloaded. Pre-load the Anti-Torque Blades using the 3/8"-16 nuts. Nominal Anti-Torque Hinge Plate Spacing = 75.8 cm for ice and 75.6 cm for firm. This value is an average location and should be adjusted as conditions require.
- Ensure all fasteners are installed and torqued to the values given on Drwg#86800233d.
- The Drill Power Cord is run through the center bore of the Clevis Adaptor. The Electrical Connector must be connected before the Clevis Adaptor is screwed onto the Shaft\_Cable Bearing. Tighten this connection securely and check often during operation that it is still tight. Use a small amount of removable-strength thread lock, if desired. The Electrical Connector should be supported by securing it to the Clevis Adaptor with a hose clamp or the custom cable clamp. Protect the Drill Power Cord with electrical tape as needed.

- Suspend the assembled Motor Section with Anti-torque assembly using a steel, locking carabiner from the Drill Rope loop. Use the loop reinforced with a steel thimble.

#### 9.1.4 Barrel Assembly

9.1.4.1 The Core Barrel and Outer Barrel are packed as a set. Barrels are interchangeable, if necessary. Remove the barrels from the case and set on top of the case lid. Ensure that the Coring Head is attached securely with 9ct M6x16 lg FHSCS, as shown in IDP Drwg# 86800123d\_Core Barrel Assembly. Set up the Coring Head in the desired configuration described in 9.2.5 Coring Head Assembly.

9.1.4.2 Chip Separator Installation: Before the Outer Barrel is attached to the Motor Section, it may be necessary to make preparations for the Chip Separator, AKA “Little Man” or “Mango.” If the Core Recovery Tool will be used for core breaks, it is most efficient to use the Chip Separator in the “dumping mode”, allowing the chips to be removed from the upper Core Barrel without needing to remove the Core Barrel from the Outer Barrel. This saves a significant amount of time. Refer to IDP Drwg#86800222b\_Mango Assembly. The M4x14 lg FHSCS are not used in “dumping” mode. Include a Swivel between the suspending cord and the Line Hook on the bottom of the Outer Barrel Drive Plate to prevent the cord from twisting and binding during coring. The cord length should be adjusted so that the bottom plate of the Chip Separator can be accessed easily but the Chip Separator does not rest on the Coring Head. Use only a Locking Carabiner with a twist-lock bale (two are provided with the Drill System). Screw-type locking carabiners or non-locking carabiners are prone to dislodging during coring (this has happened multiple times and is difficult to recover from).

9.1.4.3 If cores are to be recovered with Core Dogs in the Core Barrel, the Chip Separator should be hung from one of the chip-fill windows on the Core Barrel using one of the supplied stainless-steel clips. Adjust the length of the suspending cord to keep the Chip Separator just above the height of core to be drilled in the Core Barrel. Use the M4x14 lg FHSCS's to retain the bottom plate to the housing of the Chip Separator. Chips will be removed by pulling the Chip Separator out the top of the Core Barrel after each coring run.



- 9.1.4.4 With the plastic Head Cover in-place, stand the Barrel assembly upright under the suspended Motor Section. Ensure that the Lock Pin Holes in the top of the Core Barrel are centered rotationally in the Windows in the Outer Barrel. Rotate the Core Barrel Drive Plate of the Motor Section until the Lock Pins are centered rotationally between the Barrel Stabilizer Pads on the Outer Barrel Drive Plate. This will ease alignment of the Core Barrel once the Outer Barrel is attached. Insert the Chip Separator suspending line and outer housing of the Chip Separator into the Core Barrel, if applicable.
- 9.1.4.5 Align the Depth Marks on the Outer Barrel with those on the Motor Section and carefully lower the Motor Section until the Outer Barrel Drive Plate just rests on the Outer Barrel. Tie-off the Drill Rope and install the 12ct M6x12 lg FHSCS, as shown in IDP Drwg#86800125e\_Blue Ice Drill Assembly. Tighten screws by opposing pairs to ensure concentricity of the mating parts. Using a M8 T-Handle Hex Tool, rotate each Lock Pin a partial-turn counterclockwise until the Pin extends through the Lock Pin Bushing in the Core Barrel. Each Pin will rotate a further partial-turn counterclockwise to lock, if installed correctly.

#### 9.1.5 Coring Head Assembly

- 9.1.5.1 IDP Drwg#86800071c\_Cutter Head Assembly shows details of the Core Dog version of the BID Coring Head. A Collet Head also can be used with a Fingered Collet for core recovery in loose firn. If core recovery is to be accomplished with the Core Recovery Tool (see Section 2.2.6), either Coring Head can be used without Core Dogs or Collet.
- 9.1.5.2 The BID has both Carbide-tipped and hardened Tool Steel Cutters. Carbide Cutters are used in ice with englacial debris; such as sand, cryoconites, and small rocks. Hardened steel cutters produce better core quality and are used for all coring in clean ice.
- 9.1.5.3 Three different Cutter widths can be used with either Coring Head:

Thin Kerf	Min. Core Clearance = 0.015-in Min. Hole Clearance = 0.063-in Kerf = 0.918-in
Wide Kerf	Min. Core Clearance = 0.045-in Min. Hole Clearance = 0.125-in Kerf = 1.015-in
Firn Kerf	Min. Core Clearance = 0.015-in Min. Hole Clearance = 0.125-in Kerf = 0.980

9.1.5.4 A variety of Penetration Shoe designs are included with the BID system. Flat Shoes (IDP Part# 8680B0226) have given the best performance in both firm and ice. All shoes can be adjusted to vary the Cutting Pitch (i.e. rate of penetration) using the supplied Shims of various thicknesses. Refer to the chart titled "Pitch, DoC, and Shim data for BID" in the Appendix for the relationship between Shims and Pitch. Insert Shims between the Shoe and Cutter and then tighten the M6x3- lg retaining FHSCS. Shoes and Cutters can be removed using a flat screwdriver in the pry-notch machined into each, being careful not to gouge the stainless steel parts.

9.1.5.5 Experience has shown that the following Coring Head set-up gives optimal results:

Ice	Cutter = Thin Kerf (IDP Part# 86800078) Penetration Shoe = Flat (IDP Part# 86800226) Pitch = 12-15mm/rev (4-5mm DOC per cutter)
Firn	Cutter = Firm (Part# 86800277) or Wide (Part# 86800074) Penetration Shoe = Flat (IDP Part# 86800226) Pitch = 21mm/rev (7mm Depth-of-Cut per cutter)

9.1.5.6 Core Dogs can be used in the Coring Head for core recovery in conjunction with the Slide-Hammer Motor Section.



**CAUTION:** Do Not use Core Dogs in the drill without a functioning Slide Hammer. The Capstan Winch does not have adequate torque to reliably break a core in ice or firm without the aid of the Slide-Hammer.

9.1.5.7 Three lengths of Core Dogs are supplied with the drill. Short Core Dogs work best for ice, while Medium and Long Core Dogs are suited for firm of various densities. Each of the 6 Core Dogs is held in the Coring Head with a Pull-Out Dowel Pin with retaining Set Screw. Core Dogs are removed with the aid of a Slide-Hammer Tool and #8-32 SHCS.



**CAUTION:** It is imperative to insert the Pull-Out Dowel Pin into the blind hole in the Coring Head with the tapped end of the Pull-Out Dowel Pin accessible for removal. The Pull-Out Dowel Pins are very difficult to remove if inserted backwards.

9.1.5.8 Various strengths of Torsion Springs are included with the drill system to pre-load the Core Dogs in the engaged position. Stiff springs are used for ice, and softer springs are used for firm. Experimentation with different strength springs, and the extent of pre-torqueing of each spring, is necessary to match specific firm/ice conditions.

### 9.1.6 CRT Assembly

9.1.6.1 Refer to IDP Drwg#86800122c\_Core Recovery Tool Assembly for assembly details. The Side-push Mechanism of the CRT is attached to the CRT Barrel with the same Lock Pins used to secure the Core Barrel to the Core Barrel Drive Plate. CRT Core Dogs are held in Mounts at the bottom of the CRT Barrel. Each Mount is secured with M6x16 lg FHSCS. Do not over-torque these FHSCS, as doing so will cause the CRT Core Dogs to bind in the Mount. Each Core Dog is held in place with a Dowel Pin, Retaining Set Screw, and Torsion Spring. Set-up is similar to that described above for the Coring Head Core Dogs, except that Dowel Pins are removed using a small punch inserted into the blind end of the Dowel Pin bore.

9.1.6.2 Suspend the CRT from the CRT Rope using the Clevis attached to the Shaft of the Side-Push Mechanism. Ensure the Clevis Pin has a locking pin to back-up the threaded nut and prevent accidental loss of the pin in the borehole.

### 9.1.7 Electrical Control

9.1.7.1 The BID System is run from a 240-amp, single-phase power source of 3.5 kW minimum capacity and controlled by a custom Control Box containing a Variable Frequency Drive (VFD). The VFD converts incoming 240-volt single-phase current to three-phase and manipulates the current to maintain Drill Motor torque over a wide range of rotational speeds. There are weather-tight plug connectors for the Main Power Cord, Drill Power Cord, and Anti-Torque Handle Interlocks. The Control Box also supplies 120-volt current to a standard receptacle for operation of the Capstan Winch Motor.

**NOTE:** The VFD may not operate correctly with GFCI enabled generators as the VFD will trip the GFCI as soon as rotational power is sent to the drill. If the drill system is being run on a generator with a GFCI, the GFCI may need to be bypassed by opening the front panel of the generator and rewiring as appropriate for that model of generator.

9.1.7.2 The Control Box Faceplate contains the following:

- Main Power: Energizes internal heaters, 120-volt receptacles, and E-Stop/VFD Power Switch.
- E-STOP/VFD: Energizes VFD (which supplies power to Sonde).
- Local/Remote: Switches between Control Box vs. Interlock Switch control of Drill Motor rotation.

- FWD/STOP/REV: Controls drill rotation direction. Contains a relay to prevent unexpected drill rotation when switching from Remote to Local (must switch to STOP before operation can continue in new mode).
- Potentiometer: Regulates Drill Motor rotational speed.
- Power Meter: Gives a general indication of relative Drill Motor effort.
- VFD Remote Panel: Allows setting and monitoring of VFD parameters from the faceplate.
- Heater LED: Indicates internal heater status (thermostatically controlled).



Figure 7: BID Control Box Faceplate.

- 9.1.7.3 100-ft of 4-10AWG cable with NEMA L14-30 twist-lock plugs is supplied for connecting the Control Box to the power source. A Plug Adaptor to convert to NEMA L14-20 is also supplied. Ensure the power source is energized (i.e. generator running normally) with breaker-off and Main Power and E-STOP/VFD switches OFF on the Control Box faceplate before connecting the Main Power Cord, Drill Power Cord, and Anti-Torque Handle Interlock Cord. Connect Caps of electrical plugs and sockets together to keep snow out for future use.
- 9.1.7.4 Open Faceplate by loosening 4ct captured SHCS (do not remove entirely) and inspect internal wiring to ensure all are connected correctly following shipping. Confirm Thermostat is set to approx. 3-deg C. Secure Faceplate screws and turn ON Power Source Breaker and Main Power Switch. Heater LED should turn on if the internal Control Box temperature is below the Thermostat set point. Allow Control Box to preheat until the Heater LED is no longer lit. The VFD has been cold-started during tests as low as -20-deg C without issue, but it is safer to allow it to warm to its rated temperature before use.
- 9.1.7.5 Once the Control Box has reached operating temperature, check that Rotation Direction is set to STOP and Potentiometer is set to 0. Check that the Core Barrel/Coring Head is clear and free to rotate. Pull up on E-STOP/VFD switch to energize the VFD. The VFD Remote Panel will activate after a few seconds. Refer to the VFD Manual to change the VFD Remote Panel Display to the desired output. While one operator anti-torques the drill, check operation of the Drill Motor by slowly ramping up the Drill Motor from 0 – 50 Hz in both directions with the Potentiometer. Next, with the Rotation Direction set to STOP, set the Potentiometer to 50, which corresponds to approximately 60 RPM at the Coring Head. The VFD is set to slowly accelerate up to the speed set by the Potentiometer. Confirm this by switching to FWD, and then to REV (after first coming to a full stop). Free rotation of the Core Barrel/Coring Head should be checked before each shift to ensure that the Core Barrel is not frozen within the Outer Barrel.
- 9.1.7.6 Rotation ON/OFF for the Drill Motor can be controlled by the Interlock Switches on the manual Anti-torque Handles (86800082c\_Barrel Clamp Assembly). This is the safest mode of operation if an operator is manually anti-torquing the sonde. Rotational Speed and Direction are still set at the Control Box Faceplate.

## 10.0 DEEP VERSION ASSEMBLY

The following section refers to assembly of the Deep Version Tower and Winch. All other components such as Barrel Assembly are the same as described in the Rope Version Assembly instructions.

### 10.1 Tower and Winch Assembly

10.1.1 The Winch Assembly (Figure 8) is comprised of the base, skis and lifting sheave.

- Assemble skis and lifting sheave to base if required per figure.

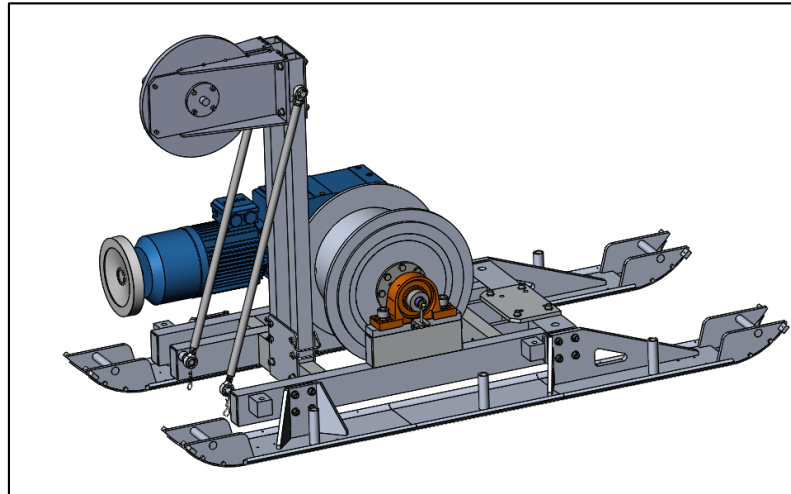


Figure 8: BID Winch Base with Lifting Sheave.

10.1.2 Stage tent around base (Figure 9).

- Remove pins from circular tubing to accommodate tower, drum and lifting sheave within the 4' opening.

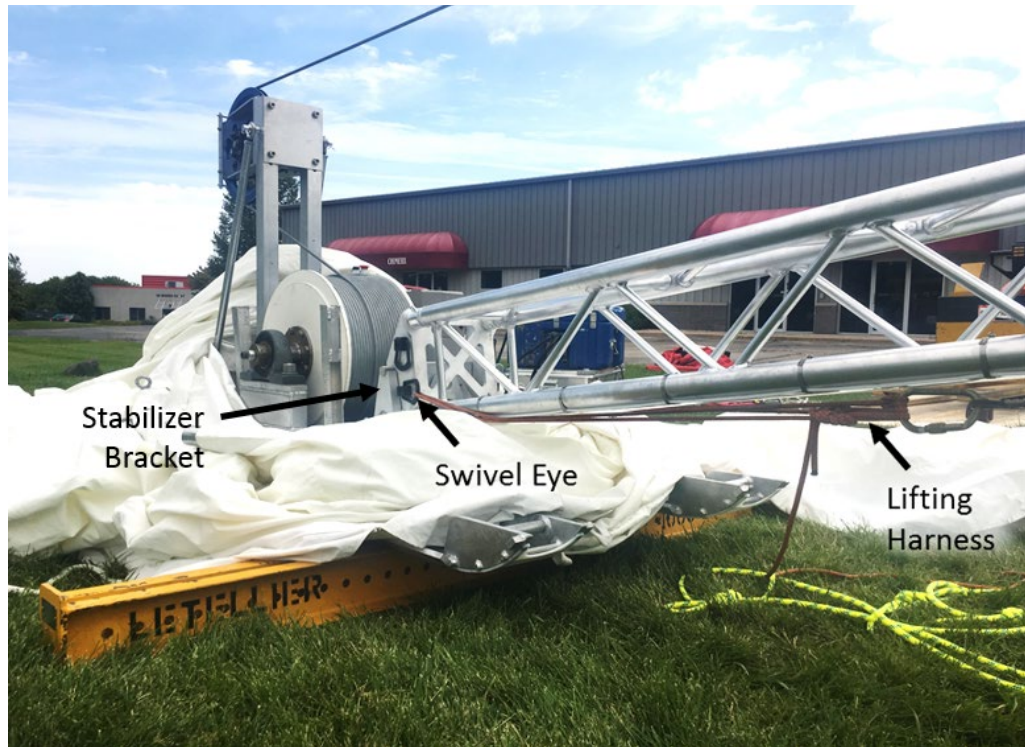


Figure 9: Tent Staging.

- 10.1.3 Connect two long tower sections to tower base using pins and cotter pins.
- 10.1.4 Attach the shorter top section of tower with crown sheave in a similar manner.
- 10.1.5 Install two temporary, triangular Stabilizer Brackets at tower base (Figure 9).
- 10.1.6 Route guy and tent lines to crown sheave.
- 10.1.7 Route drill cable through lifting sheave and crown sheave and use lifting harness and webbing to secure cable end to two front swivel eyes on tower base (Figure 10).

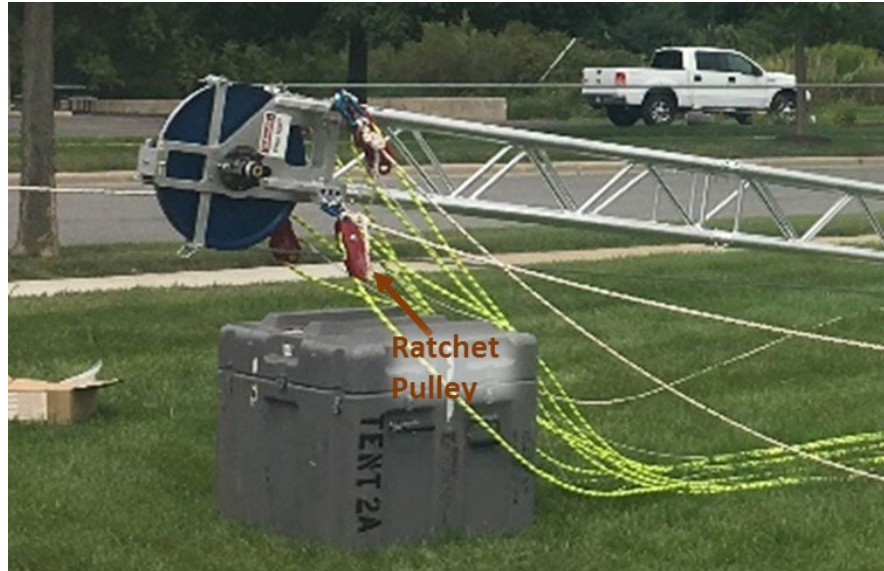


Figure 10: BID Crown Sheave with Rigging. Ratchet pulleys for tent on lower shackles and tower guy lines on upper shackles.

- 10.1.8 Cable winch control box to generator, brake resistor, pendant and winch motor (see details section 10.3).
- 10.1.9 Use front guy wires to stabilize tower as winch is used to raise the tower (Figure 11).



**CAUTION:** It is recommended that the tower and tent be raised only in winds less than 15 knots.



Figure 11: Tower Lifting. Two people stabilize tower with front guy lines.

- 10.1.10 Secure 4 guy lines at 20' from bore hole. Adjust and tighten guy lines to ~50 to 100lbs tension (Figure 12).





Figure 12: Secure 4 guy lines at 20' from bore hole with anchors appropriate for surface conditions.

10.1.11 Remove two Stabilizer Brackets and Lifting Sheave.

10.1.12 Reassemble circular tubing and lift tent with ratchet lines.

10.1.13 Assemble and secure tent (Figures 13 and 14) per the 8431-0002 MAST Tent assembly manual. The following points summarize the assembly procedure.

- First assemble tent tubing frame at color coded joints.
- Secure tent fabric to frame with zippers, ropes and straps provided.
- Secure frame base and fabric to ground with pickets, snow skirts.
- Tension lines through ratchet pulleys by hand (designed for tension to 180lbs).
- Install exterior guy lines and tension.
- Double check all joints, lines and fittings are installed and tensioned appropriately.



Figure 13: BID-Deep System with Tent.

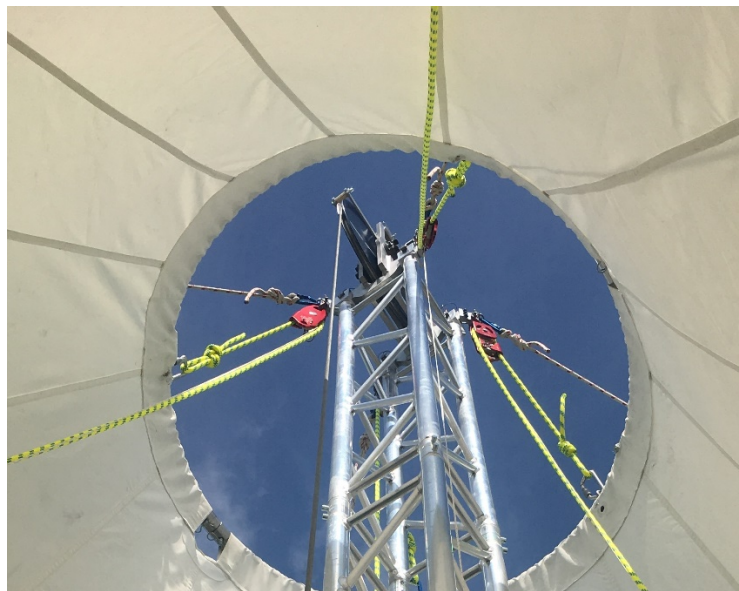


Figure 14: Erect BID Crown Sheave with Rigging.

## 10.2 Motor Section Assembly

Follow the instructions of section 9.1.3 with the following exceptions:

- 10.2.1 The anti-torque section must be used with the Deep Winch Version BID.
- 10.2.2 The winch cable is connected to the motor section via a pinned connection:
  - 10.2.2.1 Screw Cable End Pin Adapter 86800378 into the Evergrip termination on the end of the winch cable and secure by tightening the three set screws in the Evergrip housing.

- 10.2.2.2 The threaded collar of the female Amphenol connector must extend just beyond the bottom face of the adapter. Redo and adjust the position of the Evergrip termination if necessary.
- 10.2.2.3 Screw Sonde End Pin Adapter 86800379 onto the end of the drill sonde and secure by tightening the three set screws in its housing.
- 10.2.2.4 Pull out male Amphenol connector from inside of Sonde End Pin Adapter 86800379 with needle nose pliers. Connector should remove easily due to s-bend pigtail inside sonde bearing section.
- 10.2.2.5 Connect the Amphenol connectors between the winch cable and the drill sonde.
- 10.2.2.6 Slide the Cable End Pin Adapter over the Sonde End Pin Adapter. Connection should not require much force.
- 10.2.2.7 Install 2 Modified Dog Point Set Screws 86800418 into the threaded holes of the Cable End Pin Adapter.
- 10.2.2.8 Secure the Modified Dog Point Set Screws by connecting fasteners with safety wire passed through the holes in the fastener heads.

### 10.3 Electrical Control

Follow the instructions of section 9.1.7 with the following exceptions:

- 10.3.1 The BID Deep System is run from a power source of 5kW minimum capacity (remember to account for altitude loss [3.5% per 1000 ft]) and controlled by two different VFDs in two different control boxes.
- 10.3.2 One control box is the orange drill motor control box that is the same as described in 9.1.7.
- 10.3.3 The other is a blue Hardigg that is the winch control box.
- 10.3.4 There is also a third metal Zarges case that contains a brake resistor for bleeding excess current and heat from the winch brake.
- 10.3.5 General setup is as follows:
  - Connect the generator to the blue winch Hardigg via the 100-ft power cord.
  - Connect the blue winch Hardigg to the metal Zarges brake resistor box via the black netted cord stored inside the Zarges case.
  - Connect the winch pendant to the blue winch Hardigg.
  - Connect the winch to the blue winch Hardigg via the two cords that are hardwired to the winch.
  - Connect the orange drill control box to the blue winch Hardigg via the 50-ft power cord.
  - Connect the orange drill control box to the winch via the yellow cord.

- After the breakers are switched on inside the blue winch Hardigg, the three cases (orange drill Hardigg, blue winch Hardigg, and metal Zarges resistor case) can be stacked vertically with the orange drill Hardigg on top

## 11.0 ROPES VERSION OPERATION

The following operational instructions assume that the drill system has been assembled according to the preceding instructions in Section 9.0.

A minimum of two Operators are needed to run the drill. The first Operator operates the Capstan Winch and Control Box. If the Sonde will be anti-torqued from the surface, the second Operator provides the anti-torque force, adds and removes Extensions, and controls rotation with the Interlock Switches. If the Anti-Torque Section on the Motor Section is used, the second Operator can run the Control Box, allowing the Winch Operator to fully concentrate on belaying the Sonde during coring. Both Operators are necessary for Core Barrel Removal, Chip Cleaning, and Core Transport.

### 11.1 Winch Operation

- 11.1.1 The Rope running on the Capstan Winch must be “tailed” by the Winch Operator, i.e. tension must be applied by the Operator to the rope coming from the Winch Spool for the Winch to provide lift. If this tension is released, the Sonde will fall. It is imperative that the Gibb’s Device be used at all times to limit the fall of the Sonde to a few inches should the Drill Rope be unexpectedly slackened. A minimum of 2 wraps of Rope on the Winch Spool are necessary for lifting. Adding wraps decreases the tailing force required for lifting.
- 11.1.2 Lift the Sonde (or CRT) by first wrapping the Rope the desired number of times around the Winch Spool. Be sure that the Pawl on the Gibb’s Device (not used with the CRT Rope) is engaged against the Rope and that the Drill Rope runs behind the Belay Hook (see IDP Drwg#86800190d\_Tripod Assembly) at all times. Pull any slack out of the Rope on the Operator’s side of the Winch Spool, step on the Footswitch to energize the Winch Motor, and take up stack in the Drill Rope as it comes off the Winch Spool. Take foot off Footswitch to stop lifting, or slightly reduce the tailing tension applied so that the Rope slips on the rotating Winch Spool.



**CAUTION:** Be sure to stop lifting before the Sonde/CRT comes in contact with the Top Frame. It is especially important to stop winching before the braided overwrap (ie. thicker section) of the Drill Rope End Loop is pulled into the Top Frame. Damage can occur to the Tripod if full Winch power is applied to the Top Frame in this manner. Also, the Drill Rope can become tightly wedged in the Top Frame and be extremely difficult to remove.

- 11.1.3 Lower the Sonde (or CRT) by removing wraps of Rope from the Winch Spool, with the rope under constant tailing-tension, until 1-3 wraps remain. The Rope must pass behind the Belay Hook on the Winch Housing to prevent the rope from coming off the end of the Winch Spool when lowering. With one hand, depress the Pawl on the Gibb's Device, and let the Rope slip through the other hand to lower the Sonde. Always lower slowly and under control. Always plan ahead so that Rope on the surface is neatly arranged to feed easily, without tangling. Stop the lowering by applying tailing-tension. In an emergency, release the Pawl on the Gibb's Device to catch the Drill Rope.
  - 11.1.4 To secure the Drill Rope, with either the Sonde suspended or resting lightly on the Coring Head (with Head Cover on), wrap the Rope several times around the Winch Spool and then down and around the Cam Cleat Mount and up through the Cam Cleat. A final half-hitch around the Cam Cleat Mount will prevent the Rope from being accidentally knocked out of the Cam Cleat.
  - 11.1.5 When not in use, the CRT is held over to the Tripod Leg to the right of the Winch Operator with a carabiner. The CRT Rope is secured to the Rope Cleat attached to the back of the Capstan Winch. Keeping the CRT suspended slightly above the surface will help keep the CRT Core Dogs clean between runs.
  - 11.1.6 The Drill Sonde is strapped to the Tripod Leg opposite the Winch Operator when not in use, suspended a few inches above the sled surface. To switch from running the Drill Rope to the CRT rope on the Winch Spool, first strap the Drill Sonde to the Tripod Leg. Next, unwrap the Drill Rope from the Winch Spool and transfer the weight of the Sonde onto the Gibb's Device. Unwrap the CRT Rope from the Rope Cleat, wrap it onto the Winch Spool, and secure it in the Cam Cleat. Finally, back-up the Gibb's Device by securing the Drill Rope on the Rope Cleat behind the Winch. Reverse these steps to switch back to the Drill Sonde. Do not stand under the leaning Drill Sonde while the rope is being transferred from the Winch Spool to the Rope Cleat in case the Gibb's Device were to malfunction.
- 11.2 Starting a Borehole and Standard Coring Operations**
- 11.2.1 A new borehole is started with the aid of the Starting Bushing, a centering device that helps to keep the Coring Head from "walking" on the ice surface (not necessary to start a hole in firn).
    - Be sure to use Cutters appropriate for the drilling conditions. Carbide Cutters should be used where englacial debris is present. The upper meter or two of blue ice glaciers often contain cryoconites, or other debris. Core through these debris-containing zones with Carbide Cutter and then switch to Steel Cutters when clean ice is encountered.

- Thin Kerf Cutters generally work best in ice, while Wide or Firm Kerf Cutters should be used in firn for more borehole clearance.
- Secure the Starting Bushing to the ice surface with three Ice Screws. The Barrel Clamp and Anti-Torque Handles are required for starting a hole in ice, while the Outer Barrel can usually be anti-torqued by-hand in firn. Carefully lower the Sonde so that the Coring Head is below the top of the Starting Bushing. Set the Control Box to 0 speed, FWD rotation, and REMOTE operation. Depress the Interlock Switches on the Anti-Torque Handles (or set Control Box to FWD, if using LOCAL control) and slowly increase the Speed to approximately 20 on the Potentiometer. Slowly lower the Sonde until the Cutters begin to engage the ice. Lower the Sonde at a controlled, even rate. Do not lower faster than the Pitch Rate set by the Penetration Shoes. Once the Coring Head is fully below the ice surface, the Potentiometer can be increased to 50 and a full core drilled.

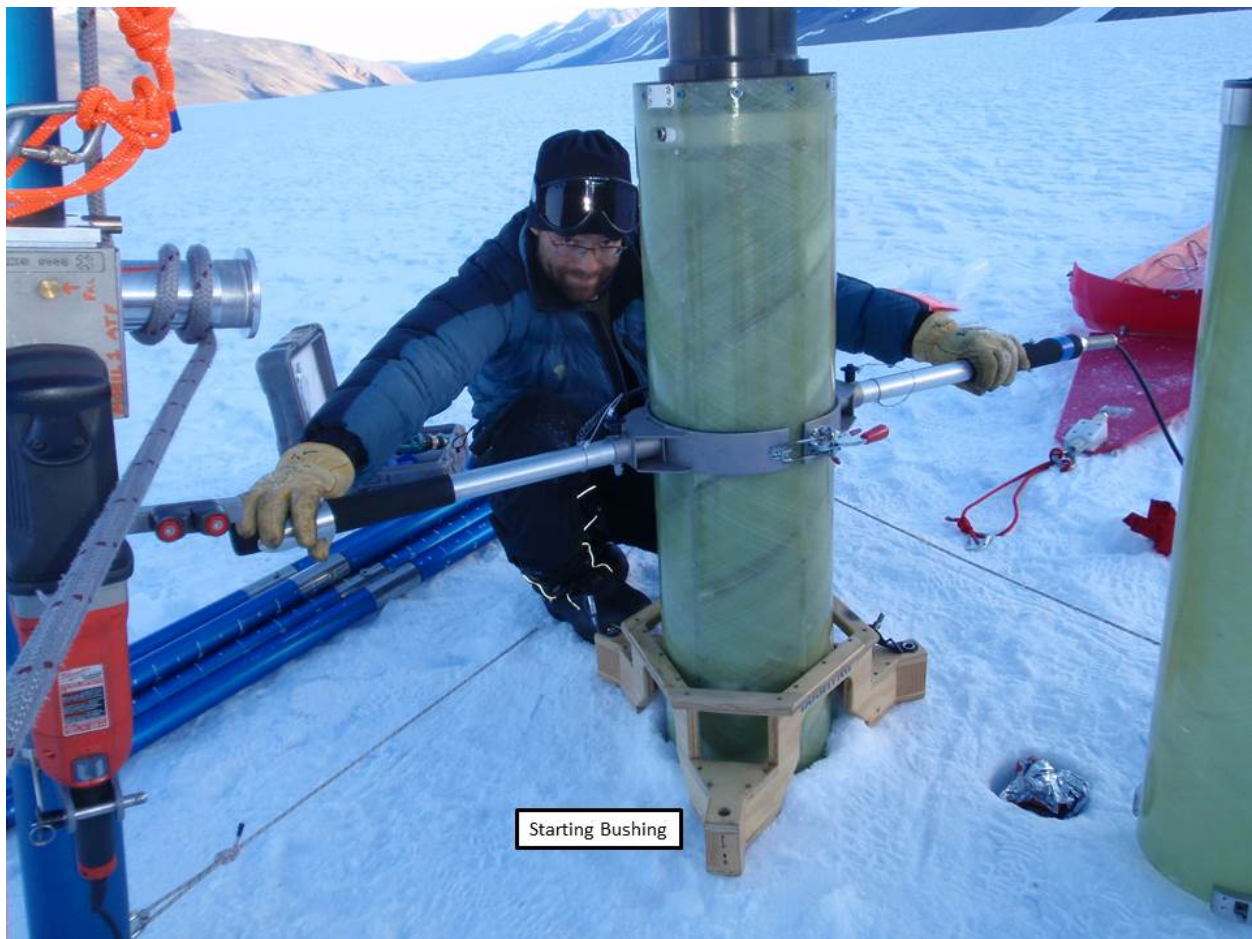


Figure 15: Starting a new borehole with the Starting Bushing and Barrel Clamp with Anti-torque Handles. Note the Interlock Switches on the ends of the Handles.

- Set the Potentiometer for 60 RPM at the Coring Head (refer to Chart in Control Box or divide Motor Speed on VFD Readout by 28) and engage rotation (with Interlock Switches if in REMOTE mode, or with FWD switch if in LOCAL mode). After the Coring Head has ramped up to the set speed, slowly lower the Sonde to engage the Cutter in the ice. Control the descent speed by belaying the Drill Rope at varying rates. A proper lowering speed is indicated by a constant anti-torque force and smooth, consistent Sonde descent. Lowering too fast will cause the Sonde to “jump” or vibrate and will result in poor coring. Limiting the Drill to as little Weight-On-Bit (WOB) as necessary to initiate penetration will result in the best performance. Do not simply let the full weight of the Drill set on the Penetration Shoes. Controlled lowering by the Winch Operator is necessary for proper performance.

- 11.2.2 It is useful to lock the Gibb’s Device Pawl in the unengaged position during coring (and ONLY during coring) to allow both hands to be free to control rate of descent precisely. A small length of elastic cord works well for this.



**CAUTION:** Be sure to release this lock and return the Pawl to normal status before raising the drill. Failure to do so could cause the Sonde to drop accidentally, resulting in damage or injury.

- 11.2.3 Continue coring until the desired length of core has been drilled (by monitoring the Depth Markings on Outer Barrel, Motor Section, Extensions, or marking the Drill Rope), a maximum of 1.15 meter of core has been drilled (in ice; longer cores are possible in firn due to decreased density), or the Motor Power begins to climb appreciably (as indicated by the Motor Power gauge or VFD Read-out).

- Normal Coring Motor Power Range = 0.5 – 1.5 kW (in ice; less in firn)



**WARNING:** Immediately stop rotation if Motor Power spikes suddenly or exceeds 2 kW. This is indicative of a full chip space in the Core Barrel or other impediment to normal operation. Bring the Sonde to the surface, diagnose the problem, and clean the Core Barrel of core and/or chips before continuing another drill run.

- 11.2.4 Allow the Coring Head to rotate for several revolutions after stopping descent to clear chips from the bottom of the kerf. Once done, stop drill rotation by releasing the Interlock Switches or setting direction to Stop on the Control Panel. Turn the Potentiometer to 0. Release the lock on the Gibb's Device Pawl (if engaged). If Core Dogs are not being used, simply energize the Winch Motor with the Footswitch and bring the Sonde to the surface, stopping to remove Extensions, as necessary. With Core Dogs (or Collet) installed in the Coring Head, a core break must be made. Switch the Gear Selector on the Winch Motor to Low. Energize the Winch Motor and begin tensioning the Drill Rope. Tension will build until either the core breaks or the Slide-Hammer set-point is exceeded. The core will almost always break once the Slide-Hammer has fired. Occasionally, it may be necessary to reset the Slide-Hammer by releasing tension on the Drill Rope until the magnets in the Slide-Hammer mechanism reengage. Attempt another core break until successful. Switch the Winch Motor gear selector to High and bring the Sonde to the surface.
- 11.2.5 Once at the surface, apply the Head Cover to the Coring Head, remove the Starting Bushing, and cover the hole with the Hole Cover. The Hole Cover can have a pad attached to the top to provide compliance on unlevel sites. With the Coring Head 1-2 feet above the Hole Cover, slowly rotate the Core Barrel in REV while anti-torquing the Outer Barrel to clear chips off of the flights on the Core Barrel. Stop rotation with the Lock Pins in the Core Barrel Drive Plate aligned with the windows in the Outer Barrel. Slowly lower the Sonde until part of the weight of the drill is resting on the Hole Cover. Lock all three Lock Pins in the retracted position and slowly raise the Sonde, leaving the Core Barrel resting on the Hole Cover. It may be necessary to hold down on the Coring Head initially to separate the Barrels, as the Brush Seal on the top of the Core Barrel is a tight fit in the Outer Barrel. Make sure the second Operator is ready to support the Core Barrel as the Sonde is removed. Raise the Sonde just high enough to clear the top of the Core Barrel and secure the Rope to the Cam Cleat. Carefully tip the Core Barrel on its side and pull out the Chip Separator by the suspending line. Push the Core out with aid of the Push Pole, if necessary. Brush any stuck chips off the Core Barrel flights and Chip Separator. Re-install the Chip Separator, making sure to fully insert the Hook into the hole near the bottom of the chip-fill window in the Core Barrel.



- 11.2.6 To reconnect the Core Barrel in the Sonde, stand the Core Barrel vertically under the suspended Outer Barrel and align the holes in the top of the Core Barrel with the Lock Pins in the Core Barrel Drive Plate. The second Operator must guide the Core Barrel into the Outer Barrel while the Winch Operator slowly lowers the Sonde. At no time should the second Operator put their hands between the two barrels. The best tactic is to place one's fingers on the outside of the Outer Barrel while aligning the Core Barrel with the wrists. Once the Top of the Core Barrel is engaged in the Outer Barrel by a few inches, move hands to the Outer Barrel only and continue to align barrels as the Sonde is lowered. As the top of the Core Barrel nears the Core Barrel Dive Plate, rotate the Sonde as necessary to align the Lock Pins with the holes in the Core barrel. Stop lowering the Sonde as soon as the holes reach level with the Lock Pins, putting as little weight on the Core Barrel as possible. This will greatly aid in final rotational alignment of the Lock Pins. Fully extend and lock each Lock Pin, raise the Sonde until the Coring Head is a few feet off the surface, and secure the Drill Rope to the Cam Cleat.
- 11.2.7 The Coring Head needs to be checked and cleaned of any stuck chips between drill runs. Pay particular attention to the Rake and Clearance Faces of each Cutter and the tips of each Core Dog. Remove any chips from around the Core Dog Springs and Dowel Pins. A plastic toothbrush with the handle-end sharpened to a chisel-point works well for cleaning the Cutters and Core Dogs. Never use metal tools to clean the Coring Head, as they will dull the Cutters and Core Dogs.

**NOTE:** On "clean" projects, be careful to not touch the Coring Head with bare hands or dirty gloves, and use only "clean" tools. Check that each Core Dog pivots freely in its window and seats fully on the stops in the Coring Head.

- 11.2.8 Repeat the above steps for subsequent coring runs. For depths below 2-meters, it will be necessary to switch the Anti-torque Handles to the Extension Adaptor (see IDP Drwg#86800143c\_Extension Assy), connected first to the Stem Mount on the Motor Section (see IDP Drwg#86800214d\_Drive Assy\_No Slide Hammer Version and 86800052d\_Drive Assembly) and then to Extensions. As the hole deepens, Extensions can be left assembled in groups of 2 or 3 to save time. Longer assemblies of Extensions are heavy and can become unwieldy, especially in windy conditions. Keep Extension Couplings and quick-release Pins out of chips/snow to prevent sticking. Pins should be kept in a container when not installed to avoid losing them.
- 11.2.9 The Standard BID Drill System was designed for a maximum depth of approximately 20 meters. Old-style PICO Hand Auger Extensions can be used (with adaptors to join to BID Extensions, included with BID System) to extend the maximum coring depth to approximately 30 meters – the length of the Drill Power Cord held on the Cord Reel.

**11.3** Coring Operations - Motor Section with Anti-Torque Assembly

- 11.3.1 The Anti-Torque Assembly can be used as an alternative to the AT Handles/Extensions. Core recovery can be accomplished with either the Sonde (via Core Dogs or Collet with the Slide-hammer Motor Section) or Core Recovery Tool (CRT). Follow the assembly steps detailed above.
- 11.3.2 Adjust AT Blade pre-load by adjusting the Hinge Plate spacing with the threaded Tie-Rods. The AT Blade pre-load is correct when the Sonde slides in the borehole without binding and does not rotate during coring. Check for Sonde rotation often during coring. A Signal Mirror is useful on sunny days for looking down the borehole.
- 11.3.3 Coring operations are otherwise the same as outlined in the previous section, or as detailed below with the CRT.



Figure 16: Removing the Core Barrel after a coring run with the Motor Section with Anti-Torque Assembly.

## 11.4 Coring Operations with the CRT

- 11.4.1 When cores are to be recovered with the CRT, do not use Core Dogs or a Collet in the Coring Head. After finishing coring, raise the drill to the surface, leaving the core still attached to the underlying ice. At the surface, lift the drill just high enough to slide under a plastic sled, clean flexible fuel berm, or other container to collect the chips brought up from the drill run. Install the Head Cover and slowly rotate the Core Barrel in Reverse to clear the chips from the flights. Raise the Sonde a couple of feet, secure the Drill Rope to the Cam Cleat with a back-up half-hitch knot, and slide the Gibb's Device to the full extent of its travel to take any slack out of the system. Reach into the Coring Head and remove the Twist-lock Carabiner from the Oval Ring. This releases the Bottom Plate, allowing the chips to fall out of the Core Barrel. The Housing of the Chip Separator remains in the Core Barrel. Remove any stuck chips with a clean nylon brush and reinstall the Bottom Plate and Twist-lock Carabiner, making sure to lay the Carabiner flat against the Bottom Plate with the non-opening, long side through the Oval Ring.
- 11.4.2 Secure the suspended Sonde to the Tripod Leg with a strap, and switch the CRT Rope to the Winch Spool, being sure to back-up the Gibb's Device by wrapping the Drill Rope around the Rope Cleat behind the Winch. Lower the CRT down the borehole, being careful not to impact the top of the core at the bottom with excessive force. Slowly remove slack from the CRT Rope with the Capstan Winch until tension begins to build in the rope. Continue winching slowly, allowing the CRT Core Dogs to set fully, until the CRT Side-Push Mechanism actuates and the core is broken-free of the underlying ice. Winch the CRT to the surface, where the second Operator pulls it to the side of the borehole and guides it onto the CRT Unloading Ring (10-inch piece of green sewer pipe). The recovered core normally extends several inches out of the CRT Barrel, and the Unloading Ring allows the CRT to stand upright while the Lock Pins are retracted and the Side-Push Mechanism is removed. Lock-off the CRT Rope to keep the Side-Push Mechanism suspended and out of the snow/chips on the surface. Tilt the CRT Barrel on its side and push out the core. Check the CRT Core Dogs between each run and clean as necessary. Reinstall the CRT Core Barrel on the Side-Push Mechanism, securing each Lock Pin in the fully-extended and locked position. Strap the CRT to the Tripod Leg when not in use.

**NOTE:** If a core less than approximately 0.5-meter in length is drilled, the Short CRT Core Barrel must be used. The Short CRT Barrel can also be used for longer cores if no cracks or other weaknesses are present.

## 11.5 Operation in Warm Conditions

- 11.5.1 Temperatures near or above freezing and/or sunny conditions can complicate coring operations. A warm Sonde will melt chips, both in and out of the borehole, which will quickly refreeze at borehole temperatures. This can lead to sticking Lock Pins, Core Dogs, etc. The most serious threat is a seized Core Barrel, which can cause Gear Reducer damage if the Drill Motor is energized. A warm Sonde can also become stuck in the borehole, necessitating the use of ethanol – a messy and time-consuming process.



**CAUTION:** Ethanol use will cause serious implications for “clean” projects and should be avoided whenever possible.

- 11.5.2 Reducing time with the Sonde on the surface is the best way to mitigate the above hazards. Plan surface operations before bringing the Sonde out of the borehole. Work in a quick and coordinated fashion. Experienced Operators can reduce surface-time greatly when this is made a priority. Remove chips/snow from the Sonde immediately, paying particular attention to the top of the Outer Barrel Drive Plate and Lock Pin Housings in the Core Barrel Drive Plate. Any liquid water that infiltrates the Lock Pin Housing (on both the Sonde and CRT) will cause sticking of the Lock Pins. This has been a major cause of lost-time during previous seasons. Use the Reflective (space blanket) Barrel Cover if the Sonde must remain on the surface for an extended amount of time during sunny conditions. Allow a warm Sonde to cool to borehole temperature by suspending it below the surface for a few minutes before continuing coring operations.
- 11.5.3 Meltwater on the surface can cause serious problems. Never attempt to core in an area where liquid water is present without the proper use of ethanol. An irretrievably-stuck drill could result. Protect boreholes that need to be re-entered from meltwater incursion with plywood sheets painted white or silver-reflective tarps. The plywood or tarps must extend to the surrounding surface to insulate it from thermal-gain and keep it frozen. Absorbent hole-plugs have had some success in previous seasons. They can be made from HW Bucket lids (or other) inside a cotton rock-bag.



**CAUTION:** Do not attempt to ream a borehole that has refrozen meltwater on the walls. Reaming without chips transporting on the barrel flights generates excessive heat that can damage the epoxy used on the Core and Outer Barrels.

- 11.5.4 Surface drilling at depths shallower than 3-meters cannot occur in warm conditions as there are insufficient methods of keeping the drill cool.

## 11.6 Shut-down Operations

- 11.6.1 Clean the Sonde and CRT fully at the end of the shift, paying particular attention to the Coring Head, Core Dogs, and Lock Pins. In warm, sunny conditions or in high winds it is often best to store the Sonde suspended approximately 1-meter below the surface in the borehole. Be sure to seal the opening to the borehole as tightly as possible with a tarp or similar item to stop spindrift from accumulating in the hole, possibly sticking the Sonde. The Sonde can also be stored on the surface, lightly resting on the Hole Cover. In windy conditions, strap the bottom of the Motor Section to each Tripod Leg so that the Sonde remains stationary and vertical. Strap the CRT securely to the Tripod Leg, suspended off the surface. Alternatively, the CRT can be removed and stored in its case.
- 11.6.2 Turn-off the Control Box and E-Stop/VFD switches and power-down the generator, being sure to turn-off the breaker and shut-off the fuel on the generator. Store the generator in a case or wrap securely in a tarp to keep spindrift out. Keep all Electrical Cords plugged-in to the Control Box, or unplug and secure all Dust Caps. Coil all Electrical Cords neatly, consolidate in one area, and mark with a flag in case they become buried. Be careful to not damage Electrical Cords when digging them out following a storm. Electrical Cords can be covered with a tarp or stored in a case, if desired.
- 11.6.3 If extreme winds are expected, stabilize the Tripod with guy-lines and store as much equipment as possible in weathertight cases.
- 11.6.4 Secure all case lids and strap down any loose or light items to anchors in the ice/snow. Store all Extensions in the bag - zipped closed. Mark any items that could be buried by spindrift with flags. Consolidate equipment as much as possible.

## 12.0 DEEP VERSION OPERATIONS

### 12.1 Deep Version Operations

Operation of the Blue Ice Drill with the Deep Winch is basically the same as described in Section 11.0 and can be run either in single barrel operations or with the CRT. Note the following differences though:

- 12.1.1 The drill cable is controlled through either the winch pendant or the manual wheel on the winch motor. If the CRT is being used, it is still run through the Capstan Winch.



**CAUTION:** While the winch is in operation, always be aware that the cable is moving and under tension. Make sure there are no loose items, cords, or hands near to where the cable is being wrapped onto the drum.

- 12.1.2 While the drill is near the surface, winch speeds should be kept below 25 percent.

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- 12.1.3 While the drill is downhole, the winch can safely be ramped up to full speed.
- 12.1.4 On ascent, the winch may or may not be able to reach full speed depending on the site's altitude and the generator used.
- 12.1.5 When reconnecting barrels in a vertical orientation, only use the manual payout wheel as the winch pendant does not go to a low enough speed.
- 12.1.6 When coring, only use the manual payout wheel as the winch pendant does not go to a low enough speed.
- 12.1.7 Break core at the lowest speed of the winch pendant and then proceed to slowly ramp up the speed after a few meters.
- 12.1.8 There is no encoder in the winch, so hole bottom and delta depth of coring are best marked with a piece of flagging tape.
- A short piece of tape should be tied around the metal cable with a single, small knot.
  - At the end of the first coring run when the anti-torque blades are completely below the surface, slide the flagging tape to surface level before breaking core and raising the drill. On the next run (and all future runs), this piece of tape will mark the start drilling depth.
  - On all subsequent runs, descend the drill until the piece of flagging tape is a few cm above the surface and come to a complete stop. Use a measuring stick to slide the tape upwards by the desired core length. Begin coring (using the manual payout wheel) and stop when the flagging tape reaches surface level.
- 12.1.9 Periodic hole depth measurements should be taken with a measuring tape or spool.
- 12.1.10 The standard BID cutters are 60 deg cutters, which is an aggressive design. On deep holes, this has been found to be too aggressive and negatively impact core quality. Therefore there are some 45 deg cutters in regular, scoop, and step style included with the kit. Use these to improve core quality at deeper depths.
- The specific depth will vary from site to site. At Summit Station, Greenland it was about 130-meters. At Taylor Glacier, Antarctica it was about 70-meters.
  - Note that only one of the core dog version cutter heads has been modified to fit these 45 deg cutters.
  - When using step cutters, they should be grouped in sets such that one cutter cuts the inner third of the kerf, one the middle third, and one the outer third. Only one shoe will be used and it will be on the outer third cutter.

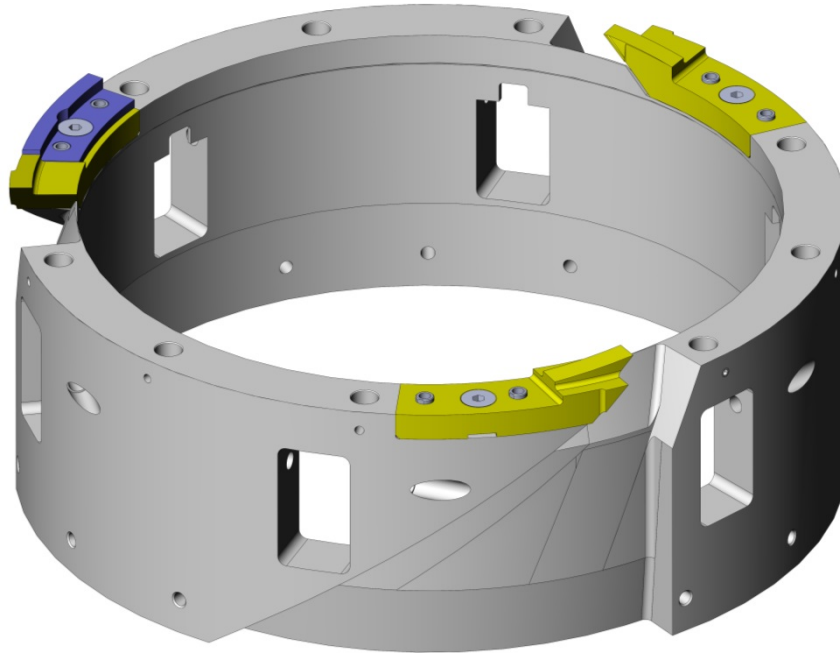


Figure 17: Cutter head setup with step cutters.

### 13.0 DISASSEMBLY AND PACKING

All components must be dry and free of ice/chips/snow build-up before being packed for shipment. Check all cases (including Hardigg Case lids) for snow accumulation before packing. Snow and ice in sealed cases quickly turns to liquid water and then water vapor, as the cargo transits through the Tropics. This situation has ruined entire cases of equipment in past seasons. Ice will sublimate surprisingly quickly from equipment if laid out in sunny and windy conditions. Alternately, take all necessary equipment into a dry, heated space and allow it to dry fully. Under certain field conditions, it may be necessary to pack wet/icy equipment for transit to a station. It is critical to get access to this equipment as soon as possible to dry it before final packing for shipment to CONUS.

- All hardened steel (such as Cutters and Core Dogs) or uncoated steel components must be packed absolutely dry to prevent rust formation. Use desiccants if available, or coat with a light coating of oil and pack in plastic bags. Any oiled parts must be carefully segregated from other equipment and cases to avoid contamination for future “clean” projects.

**NOTE:** Clearly mark any oil-coated parts for easy identification when the cargo is readied for the next project.

### 14.0 RECORDS

Several Blue Ice Drill End-of-Season Reports and Core Logs may be obtained from IDP, if desired, and may assist in operation of this drill system.



15.0 APPENDIX A: REFERENCE DRAWINGS

Drawings referenced within this document may be obtained by contacting IDP, if desired. They are not included in this manual in order to ensure users obtain the most up-to-date drawings once requested.

16.0 APPENDIX B: PITCH, DOC, AND SHIM DATA FOR BID

Blue Ice Drill Penetration Shoe Data												
		Shims Used - 60 Deg Cutters								Button*		
		Original				Flat				mm of shim needed		
Pitch (mm)	Depth of Cut (mm)	0.10 mm	0.15 mm	0.25 mm	0.50 mm	0.10 mm	0.15 mm	0.25 mm	0.50 mm	Button 1	Button 2	Button 3
21	7									3.8	1.9	0.0
18	6			1				1		4.2	2.5	0.9
15	5				1				1	4.5	3.1	1.8
12	4			1	1			1	1	4.8	3.7	2.7
9	3				2	1	3		1	5.2	4.4	3.6
6	2			1	2		2		2	5.5	5.0	4.4
3	1				3		2	1	2	5.9	5.6	5.3
1.5	0.5	1			3			1	3	6.0	5.9	5.8
0.75	0.25		1		3		2		3	6.1	6.1	6.0

		45 Deg Cutters				Pitch & DOC (mm)	45 Deg Cutters			
		Flat or Scoop					Step			
Pitch (mm)	Depth of Cut (mm)	0.10 mm	0.15 mm	0.25mm	0.50 mm	0.10 mm	0.15 mm	0.25 mm	0.50mm	
21	7					7	** Do Not Use Pitch Greater Than 6mm *			
18	6		2			6			3	
15	5	1			1	5		1	3	
12	4		1	1	1	4		1	3	
9	3	2			2	3		2	3	
6	2				3	2		1	3	
3	1		2		3					
1.5	0.5		3		3					
0.75	0.25				4					


\* Use 0.1mm and 1.0mm thick washer shims for button shoes  
 Button 1 location closest to preceding cutter

**17.0 APPENDIX C: DRILL CLEANING PROTOCOL**

The following drill cleaning protocol has been established for projects that require carbon-free sampling:

- Metal parts that come in direct contact with the core (coring heads, cutters, dogs, CRT dogs and holders, hardware for all, mango carabiners and rings, etc.) are ultrasonic cleaned in acetone, then 190-200 proof ethanol, then DI water.
- Fiberglass and plastic parts (core barrels, outer barrels, CRT Barrel, mangoes, CRT unloading ring, etc.) are scrubbed with ethanol, rinsed with DI water, air dried overnight and then wrapped in large lay-flat tubing. It works well to make an "autopsy table" by covering a worktable with plastic formed into a trough with lumber. Incline the table so it drains into a floor drain or bucket.
- Metal parts are baked at 50 deg C overnight in the Tenney environmental chamber at SSEC/IDP. Wait to rinse any non-stainless parts with DI water until right before you put them in the Tenney to minimize rust. Lay parts out on Kimwipes in the Tenney chamber to eliminate contamination. Clean small parts go in clean plastic parts organizers or new plastic Ziploc bags. Coring heads and other large clean parts can be wrapped in large layflat tubing.
- Any existing parts that were not used or handled in previous seasons do not need to be re-cleaned.
- Plastic organizers must be cleaned before putting clean parts in them if they are new or were contaminated during a previous season. Use only ethanol and DI water.
- The remainder of the Sonde(s) should be wiped down with ethanol to degrease before being packed. Anything that goes downhole should be degreased.
- Reassemble clean coring heads, barrel sets and CRT barrels, core dog mounts and then wrap in layflat and pack in cases. Motor/AT sections don't need to be wrapped in layflat.
- Acetone and 190-200 proof ethanol can be obtained through the Purchasing Department from MDS. Approximately 4 gallons of each will be needed for the cleaning process.
- There is a jug for DI water near the BID cabinet at the SSEC/IDP warehouse. DI water is available in the 5th floor assembly lab at SSEC.
- The whole cleaning process takes a few days so plan accordingly.

## 18.0 APPENDIX D: SEASONAL PREVENTIVE MAINTENANCE CHECKLIST

<b>SEASONAL CHECKS (to be performed once per drill season)</b>				
<b>ITEM</b>	<b>ACTION</b>	<b>DATE</b>	<b>INITIALS</b>	<b>COMMENTS</b>
<b>SAFETY EQUIPMENT</b>				
Carabiners	Inspect for damage/wear			
Lifting straps	Inspect for damage/wear			
<b>SONDE</b>				
Connections	Verify secure connections			
Barrel assemblies	Verify smooth rotation/check for damage			
<b>DRILL CONTROL BOX</b>				
Control box wiring	Check for loose connections			
Control box heater	Verify function			
E-Stop	Verify function			
<b>ELECTRICAL</b>				
Power cords	Inspect for damage			
<b>ROPES</b>				
Ropes	Inspect for damage/wear			
Knots	Inspect for damage/wear			
<b>CRT (Ropes version)</b>				
CRT assembly	Verify smooth actuation of side pusher / check for damage			
<b>TRIPOD &amp; WINCH (Ropes version)</b>				
Tripod assembly	Inspect for damage/furntionality			
Fasteners	Inspect for missing hardware and check for tightness			
Drill platform	Check grip tape durability			
Crown sheave	Verify smooth rotation; check before cable is connected			
Cord reel	Verify function/inspect for damage			
Capstan winch	Verify function			
		<b>OVER</b>		

ITEM	ACTION	DATE	INITIALS	COMMENTS
<b>TOWER &amp; WINCH (Deep version)</b>				
Tower assembly	Inspect for damage/functionality			
Fasteners	Inspect for missing hardware and check for tightness			
Crown sheave	Verify smooth rotation; check before cable is connected			
Winch system	Inspect for functionality/damage and brake operation			
Cable/cable termination	Inspect for damage			
Winch control box	Check for loose connections and proper operation			
E-Stops	Verify function			
<b>NOTES:</b>				

19.0 APPENDIX E: WEEKLY PREVENTIVE MAINTENANCE CHECKLIST

<b>WEEKLY CHECKS</b>		<b>WEEK OF: _____</b>		
ITEM	ACTION	DATE	INITIALS	COMMENTS
<b>POWER DISTRIBUTION</b>				
Generators	Inspect for damage/check oil			
Cables	Inspect for cable/insulation damage			
<b>SONDE</b>				
Cutterhead	Check for loose screws			
Cutters & core dogs	Check for wear			
Motor section	Check for damage/loose screws			
Inner & outer barrel	Inspect for damage			
Inner barrel locking pins	Inspect for functionality			
<b>TOOLS</b>				
Tools	Inspect for damaged/missing tools			
<b>TRIPOD/WINCH (Ropes version)</b>				
Crown sheave	Inspect for damage and ice buildup			
Components	Inspect for damage/fluid and ice buildup			
Capstan winch	Inspect for damage/wear			
Hoist rope	Inspect for damage/wear			
Drill platform	Check for loose screws			
Cabling	Inspect for wear/damage at connections			
<b>TOWER/WINCH (Deep version)</b>				
Crown sheave	Inspect for damage and ice buildup			
Components	Inspect for damage/fluid and ice buildup			
Winch	Inspect for damage/wear			
Winch cable	Inspect for wear/damage			
Cabling	Inspect for wear/damage			
<b>DRILL TENT</b>				
Fabric and frame	Inspect for damage and wear			
Ropes and rigging	Inspect for damage and wear			
Ropes and fabric	Check for proper tensioning			
Anchors	Verify anchor points are sound and not coming loose			
<b>NOTES:</b>				