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Sharewell, LP

LoTorque Hole Opener

User Operating Manual

Operating Procedures, Installation, and Maintenance Guide

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Hole Opening Planning and Procedures

Proper planning is vital to the HDD hole opening operations. It is important that in the planning stage as much information as possible be gathered on both the surface and subsurface material present. Understanding the mechanism by which the area was formed can be a good starting point, i.e. airborne, gravity, river or water, or glacial type processes. Topographical information can also be helpful as to the individual planes of the various formations. It is also recommended that geotechnical information be gathered from soil and core samples taken along the proposed bore path. These can generally be divided into two broad categories, soil and rock. For this particular manual, we will concentrate on the rock classification.

Measurements of unit weight, rock quality and hardness are desired in rock conditions. The Mohs Scale of Hardness is used to measure the hardness of various types of rock formations. Rock quality is determined by modified core recovery ratio known as the Rock Quality Designation (RQD). The RQD is the determined by a percentage ratio between the total pieces of the core that are a minimum of 4 inches long, hard and solid and the length of the core drilled. Figure 1-1 and 1-2 below illustrate both the Mohs scale and the RQD. Undefined compression testing of rock specimens to determine the shear strength is generally adequate.

Figure 1-1
Mohs Hardness Scale

Rock Type	Mohs Hardness
Talc	1
Gypsum	2
Calcite	3
Fluorite	4
Apatite	5
Orthoclase	6
Quartz	7
Topaz	8
Garnet	9
Diamond	10

Figure 1-2
Rock Quality Description

RQD (%)	Rock Quality
90 to 100	Excellent
75 to 90	Good
50 to 75	Fair
25 to 50	Poor
0 to 25	Very Poor

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Hole Opening Planning and Procedures

One of the first decisions to be made in the hole opening procedure will be determining the final hole size. The pilot hole size is necessary to determine the size of hole opener bodies to be used for the first pass, while the final hole size allows for the planning of the steps necessary between the pilot hole and the final hole size.

The final hole size is generally dictated by the size of the product line being installed. The final service parameters of the product line, such as, the wall thickness and the specified minimum yield strength are generally determined by applicable codes and regulations, but loads and stresses imposed by the horizontal drilling method should be taken into account. The tension required to pull the product line through the hole is derived from the frictional drag, friction between the pipe and wall of the hole, fluidic drag, the drag of the pipe being pulled through the drilling fluid trapped in the hole, and unbalanced gravity, weight effects pulling the pipe at different elevations. The bending endured by the pipe as it negotiates the curves in the hole, as well as, the pressure exerted from the drilling fluid around the pipe in the annulus of the hole. Some other factors such as, ground conditions and the product line material may weigh on this decision.

The combination of all of these factors will determine the stresses and failure potential of the pipe being installed. Therefore, all of these factors must be considered together and not calculated individually.

The formulas in Figure 1-3 are some basic formulas to help in the planning of the radius of the hole, as well as, the final hole size.

Figure 1-3

Pipe Stress Formula

S = E x C / R

S = Stress
E = 29,000,000
C = O.D. of pipe in feet / 2
R = Radius

Recommended formula to determine radius:

Diameter of the pipe x 100 = Radius of hole
Ex: 36” x 100 = 3600 foot radius

Rule of thumb formula for determining radius of 20,000 PSI of developed stress

Radius of the pipe x 125 = radius of hole
Ex: 18” x 125 = 2250 foot radius

Rule of thumb formula to determine final hole size:

Diameter of pipe x 1.5 = final hole size
Ex: 36” x 1.5 = 54 inch final hole size

Hole Opening Planning and Procedures

Figure 1-4 and 1-5 show the various pilot hole sizes necessary and the final hole sizes that can be achieved using both the LoTorque and "Jumbo" LoTorque hole openers

Figure 1-4

Lo-Torque Hole Opener

FOR UNDERGROUND CONSTRUCTION

- Designed to ream in any formation
- Lowers drill string torque allowing small rigs to ream in rock formation
- Single tool body can open up to four different hole sizes
- Sealed journal bearing cutters are field replaceable while on drill string
- Unique slick body design decreases common repair costs associated with conventional reamers and hole openers
- Available in push or pull style bodies
- All cutters gage protected for optimum wear resistance
- Cutters are available in milled tooth for soft to medium rock formations or Tungsten Carbide Inserts (TCI) for hard rock formation

BODY					CUTTERS				
Minimum Pilot Hole	Approx. Length	Approx. Weight	Connections Pin	Connections Box	Number Of Cutters	Hole Sizes			
2 1/2"	15"	30	2 IF	2 IF	3	6"			
4 1/2"	26"	100	2 3/8 IF	2 3/8 IF	3	8"	10"	12"	
6 1/2"	31"	200	3 1/2 IF	3 1/2 IF	3	12"	14"	16"	
8 1/2"	36"	450	4 1/2 IF	4 1/2 IF	3	16"	18"	20"	22"
16"	42"	1000	7 5/8 reg	7 5/8 reg	3	24"	26"	28"	30"
24"	42"	1200	7 5/8 reg	7 5/8 reg	4	32"	34"	36"	38"
32"	42"	1400	7 5/8 reg	7 5/8 reg	4	40"	42"	44"	46"
40"	42"	1600	7 5/8 reg	7 5/8 reg	4	48"	50"	52"	54"
48"	42"	2000	7 5/8 reg	7 5/8 reg	5	56"	58"	60"	62"

Figure 1-5

LTX "Jumbo" Lo-Torque Hole Opener

- Heavy duty construction, ideal for pipeline projects.
- Larger cutters and bearings for longer run life.
- No "Arms" to wear out.
- Each body can open four different holes sizes.
- Sealed journal bearing cutters.
- Available in either push or pull style bodies and cutters.
- Gage protected cutters for optimum wear.
- Cutter sets are available in either milled tooth for soft to medium rock or Tungsten carbide insert for hard rock formations.
- Field changeable cutters for each hole size.
- Custom TCI insert patterns available for harder and more abrasive formation.

BODY						CUTTERS			
Minimum Pilot Hole	Body Style	Body Length	Body Weight	Connections Box	Connections Pin	Hole Sizes			
12"	LTX10	48	850	6 5/8 reg	6 5/8 reg	22"	24"	26"	28"
20"	LTX18	53	1915	7 5/8 reg	7 5/8 reg	30"	32"	34"	36"
26"	LTX24	53	1958	7 5/8 reg	7 5/8 reg	36"	38"	40"	42"
32"	LTX30	53	2569	7 5/8 reg	7 5/8 reg	42"	44"	46"	48"
44"	LTX42	53	3290	7 5/8 reg	7 5/8 reg	54"	56"	58"	60"

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Hole Opening Planning and Procedures

The type of insert is determined by the type and hardness of the formation. Figure 1-6 illustrates the different cutter types necessary for different formations.

Figure 1-6

0 to 10,000	psi compressive strength	Milled tooth cutters
6,000 to 15,000	psi compressive strength	Type 5 inserts
12,000 to 25,000	psi compressive strength	Type 7 inserts
25,000 to 45,000	psi compressive strength	Type 8 inserts

In the recommendations above, notice that there are overlaps. The overlaps are there to allow considerations for the actual drilling conditions, as well as, the type of rock being cut. If a decision must be made early on due to logistics it is recommended that the next step up be chosen

Ex: Rock of 15,000 psi, a type 7 should be chosen if the decision must be made before the actual drilling conditions can be accessed during the pilot hole operation.
Also, more abrasive formations may dictate the next step up in order to provide cutters with a better gauge protection for wear protection on the outside edges of the cutters.

Milled tooth cutters are designed for formations from 0 to 10,000 psi compressive strength. They can be used successfully in compacted sands and clays, as well as, soft rock formations. The cutter teeth are milled steel with hard metal applied to the leading edge of the teeth. Care must be taken in clay formations to prevent balling.
Milled tooth cutters have also had some success in gravel and cobble type formations. These formations are generally very destructive to TCI type cutters.

Tungsten Carbide Insert (TCI) cutters are used for rock formations ranging from 6,000 to 45,000 (plus) psi compressive strength. Figure 1-7 below provides information on these types of cutters.

Figure 1-7

CUTTERS

Now the Best Rock Hole Opener in the HDD Industry is even better!

Sharewell now offers Lo-Torque Hole Opener Cutters to match the formation hardness of your bore.

The Lo-Torque Tungsten Carbide Cutter types now range from medium to extremely hard rock formations. Close attention to insert material composition of gage, inner row and base areas of the cutters optimizes their performance in the wide range of rock conditions encountered in horizontal drilling.

TYPE 5 (IADC)
Medium Rock
6,000 - 15,000 PSI Compressive Strength Rock
Formation Types: Limestone, Sandstone, and Shale.
TCI teeth are aggressive conical shaped for aggressive penetration rates in medium type rock.

TYPE 7 (IADC)
Medium – Hard Rock
12,000 - 25,000 PSI Compressive Strength Rock
Formation Types: Granite, Marble, and Dolomite.
TCI teeth have moderate extensions. Gage area has all dome type cutters to maximize cutter gage life.

TYPE 8 (IADC)
Hard Rock
25,000 - 45,000 PSI Compressive Strength Rock
Formation Types: Quartz, Basalt, and Quartzite.
TCI teeth are all hemispherical shape, providing a longer cutter life in extremely hard rock.

Hole Opening Planning and Procedures

Once the final hole size is decided it is then time to decide on the number of hole opening passes required to reach that size. This may be planned in advanced, but may need to be modified based on the pilot hole drilling conditions, as well as, the conditions of the first ream pass. The size of the each hole opening pass is determined by many factors. The type of formation being drilled, the amount of mud volume capability, and type of hole opener being used.

For the LoTorque, it is recommended that the hole opening passes are made to utilize no less than 50% of the height of the cutter. This places an even load on the bearings promoting a longer bearing life and preventing premature failure of the cutters.
Figure 1-8 provides information on the height of each individual LoTorque cutter size and the minimum cut that should be made.

Figure -1-8

Cutter Size	Cutter Height	Minimum Cut per side
A cutter	4”	2”
B cutter	5	2.5”
C cutter	6”	3”
D cutter	7”	3.5”
E cutter	8”	4”
F cutter	9”	4.5”

Ex: 36” hole opener pass from 30” hole (3” cut per side)
LTX24 with “C” cutters (3” cut per side) correct
LTX 18 with “F” cutters (4.5” cut per side) in correct

Note: Performing hole opener passes utilizing less than 50% of the cutter height is possible, but the bearing life will be shortened and cutter performance can be jeopardized.

The formula below is to calculate the cubic feet of material being cut with each individual hole opening pass.

Cubic Foot of Material	Formula
Hole size being cut:	Dia. /2 x Dia. /2 x 3.281
Pilot hole	Dia. /2 x Dia. /2 x 3.281
Material per foot	Hole Size – Pilot Hole size

Hole Opening Planning and Procedures

Once the sizes and number of passes has been decided, you must decide the amount of cutters necessary to complete each pass. There are several factors that are going to contribute to this decision. The formation hardness and more importantly the formations abrasiveness are key factors in the time involved with each pass. The amount of material being moved with each pass and the amount of fluid pumping capability also contribute. Figure 1-9 below shows the estimated bearing life for each size of LoTorque cutter. These numbers are basic references and based on optimal conditions. It is recommended that the cutters be pulled from the hole within the time periods to be visibly checked and changed if necessary. If conditions are abnormal, it may be necessary to pull the cutters earlier.

Figure 1-9

Cutter Size	Estimated Bearing Life (drilling hours)
LT4	20 to 25 hours
LT6	25 to 35 hours
LT8	35 to 40 hours
LT9	70 to 90 hours

Now you must calculate the estimated time it will take to complete each pass. Ideally you would like to find a rate of penetration that will keep your solids at or below 20%. Figure 1-10 are reaming calculations.

Figure 1-10

Fluid Volume of hole: Dia. x Dia. x .0408 (in Gallons)

Percent of Solids: P = V1 x S / V2

Travel Speed: S = V1 / V2 x P

Legend

D = Diameter
P = percent of solids
V1 = Volume per foot of hole
V2 = Volume pumped
S = Travel Speed

Note: The calculated penetrations rates (travel speed) may not be attainable due to formation restraints. It is always better to go slower than faster.

Hole Opening Planning and Procedure

Once you have established the estimated reaming times and you know the estimated bearing life of the cutters, you can gather the appropriate equipment for the project. LoTorque hole opener bodies are designed for numerous runs, but they should be inspected and repaired as necessary. Depending on the abrasiveness of the formation, as well as, your ability to keep the hole clean, you will most likely need to replace the hard metal gauge protection on the pilot hole guides and the back out blades after a couple of jobs. This is a relatively basic procedure, and can be performed on location.

Now that you are ready to begin the hole opening procedure, the cutters must be attached to the body. Care should be taken to properly torque the cutters to the body. It is recommended that a hydraulic device be used so that the proper torque can be achieved. If that is not possible, and a crane or back hoe is to be used, it is recommended that a load cell be placed on the cutter installation wrench to accurately gauge the amount of torque being applied to the cutters. Figure 1-11 shows the proper torque to apply to each size cutter.

Figure 1-11

Journal Size	Recommended Torque
LT4	1,500 ft. lbs.
LT6	4,500 ft. lbs.
LT8	12,000 ft. lbs.
LT9	24,000 ft. lbs.

If a torque unit or a load cell is not available on location, it is recommended that a bi-directional cutter be used in order to lessen the possibility of the cutters unscrewing down hole. However, it is recommended that even with bi-directional cutters, that the proper torque be applied during installation. Figure 1-12 shows the torque values for the back up bolts on the bi-directional cutters.

Figure 1-12

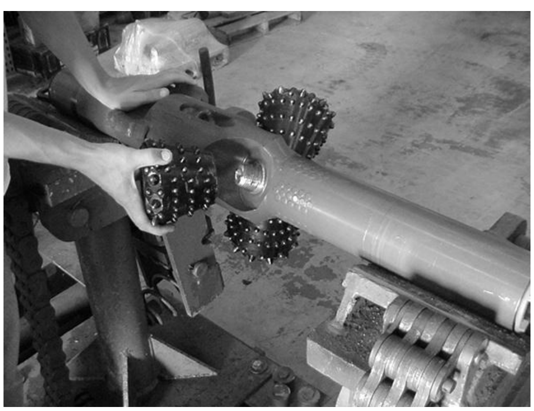
Cutter Size	Screw Type	Recommended Torque
LT4	5/8" Cap ½" – 13 tpi (3" long)	283 ft. lbs.
LT6	7/8" Cap 5/8" – 11 tpi (3" long)	688 ft. lbs.
LT8	1-1/4" Cap 1" – 8 tpi (3" long)	2,080 ft. lbs.
LT9	2-1/8" Cap 1" – 8 tpi (3" long)	3,335 ft. lbs.

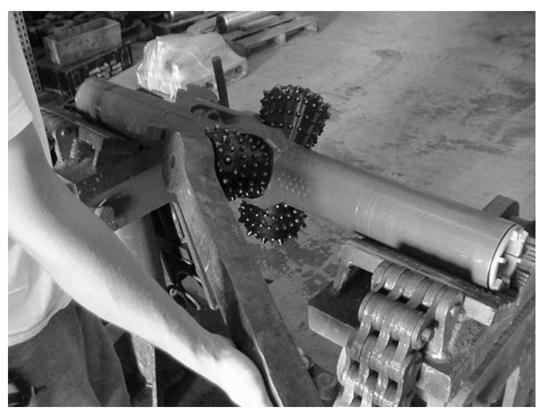
Hole Opening Planning and Procedure

ADDING NEW CUTTERS TO THE BI-DIRECTIONAL LO-TORQUE HOLE OPENER

Clean and liberally dope spindle threads with a quality pipe thread compound (not grease).

Add new cutter by slipping the journal of the cutter over the spindle and turning clockwise. Insert cutter adapter until flush with the journal face and using the wrench tighten the cutter to the designated torque. Insert retaining bolt and turn counter clockwise (This is a left hand thread bolt). Tighten this bolt to the designated torque

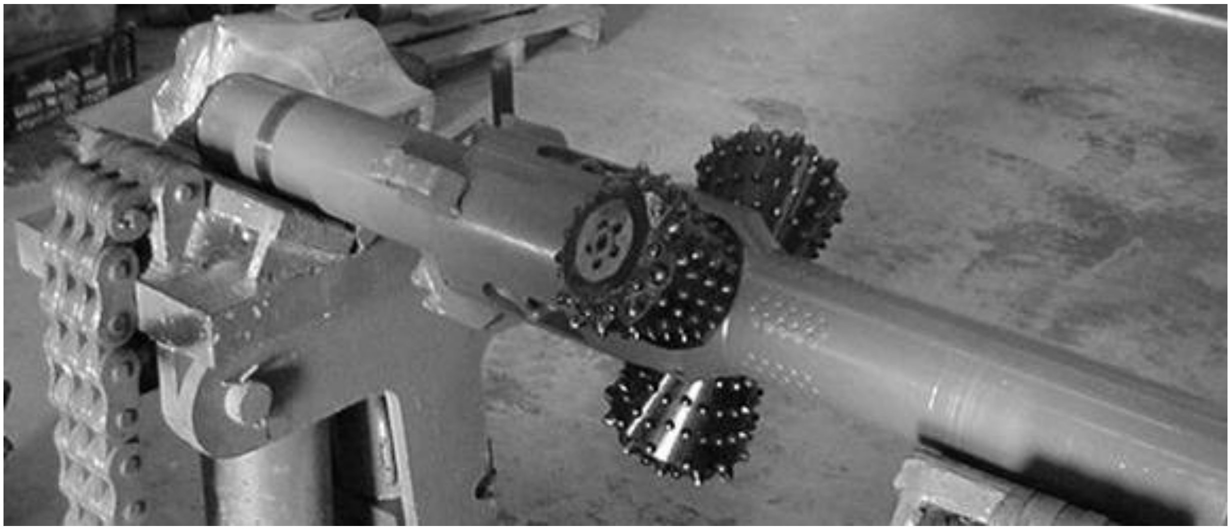




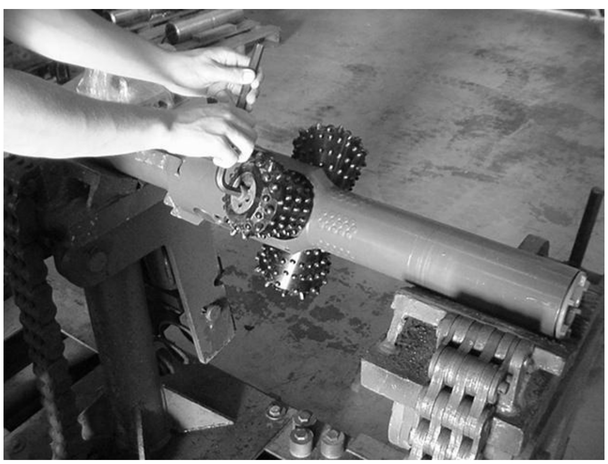
Hole Opening Planning and Procedure

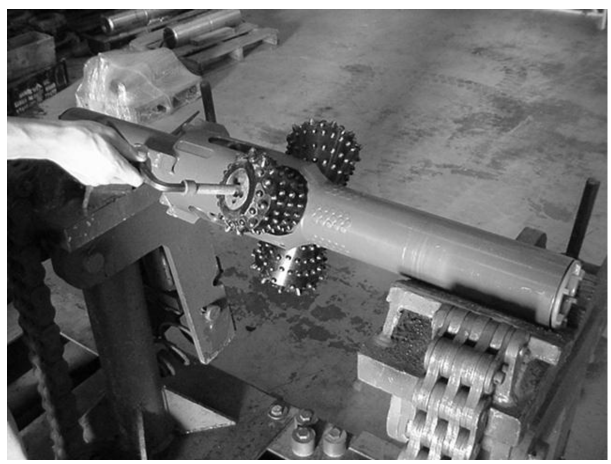
Below you will find instructions for removing cutters from the bi-directional LoTorque hole opener. Again for simplicity of demonstration, an LT4 body was used. The procedure is identical regardless of the body size; the only variation is the torque requirements listed on the previous pages.

Using a hex head wrench remove the retaining bolt from the center of the cutter spindle. NOTE: This is a left hand thread bolt and must be turned clockwise to un-tighten.



The following pictures illustrate how retainer bolt is removed.





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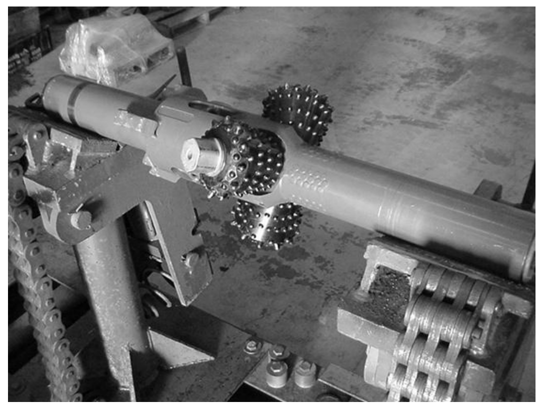
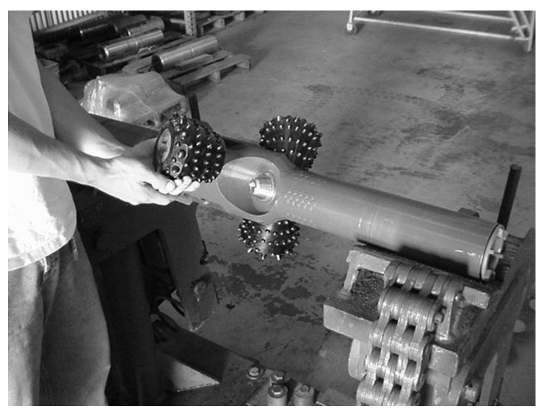
Hole Opening Planning and Procedure

Using the special cutter spanner type adapter, loosen each cutter from the hole opener body (turn in a counter clockwise motion to loosen).

Note: The adapter should be inserted and kept flush between the pins and the cutter journal when tightening or loosening to avoid breaking the pins. The adapters are based on the LoTorque body size, therefore, a LT4 uses an LT4 adapter, an LT6 uses an LT6 adapter, an LT8 and larger uses an LT8 adapter and an LT9 adapter is used for all LT9 "Jumbo" cutters.



The following photos show a cutter being removed from the spindle.



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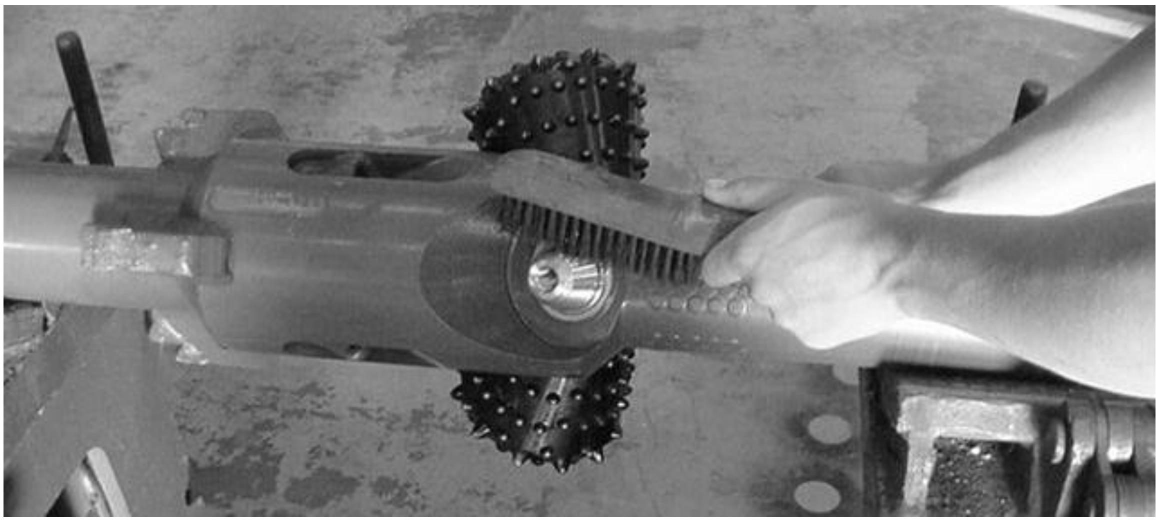
Hole Opening Planning and Procedure

The spindle should be cleaned and visually inspected for damage to threads (in hard formations where hole opener is subjected to severe beating the spindle should be non-destructively tested using dye penetrant or mag-particle tests).



After you are satisfied that all the spindles are in good condition new cutters can be reattached to the hole opener.

Check to make sure each cutter will rotate and that the bearings and/or journal have not been pinched or overtoruqed by rotating each cutter.

Notice that the bi-directional hole openers have two box (female) connections. This allows the operator to either push or pull the hole opener by only using one pin to pin crossover sub.

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Hole Opening Planning and Procedure

Now that you have attached the cutters to the body, you are ready to begin the reaming process. The hole opener is placed in the drill string either on the exit side or entry side depending on whether or not you intend to push or pull ream. This is a matter of preference or right-of-way availability. Pull reaming is considered the better of the two because of the control the driller has over the pull force.It is important to note that you do not push during a push ream process. The normal procedure for a push ream is to have a piece of heavy equipment on the pipe side capable of pulling the drill string and the reamer. The driller at the rig pushes enough to release the brakes on the rig and controls the rotation of the reamer.

It is strongly recommended that centralizers be used either in front, behind, or in both places when the ream passes become larger than 20 inches. The centralizer hold the hole opener in the center of the hole and allow the cutters to pass evenly across the face of the formation. Centralizers should be between 1 to 2 inches smaller than the hole.

Now that the hole opener is in the string and you are ready to begin reaming. The string should be cradled as the reamer enters the ground to allow for the proper angle of entry. This will create a cleaner transition for the product line to be pulled in the hole, as well as, put less stress on the drill pipe.

As you begin to ream, it is important to closely monitor the torque, rpm's of the string, and the amount of pull force being applied. Figure 1-13 shows the recommended weight on bit and rpm's for each cutter type and size. These are guidelines and can be adjusted depending on the formation, but should not be changed drastically.

Figure 1-13

	Mill Tooth		TCI	
Body Size	WOB (1000's)	RPM's	WOB (1000's)	RPM's
LT4	5 to 10	50 to 70	7 to 12	40 to 70
LT6	10 to 13	50 to 70	12 to 17	40 to 70
LT8	15 to 20	40 to 60	15 to 25	35 to 60
LTX10	25 to 35	40 to 60	25 to 45	35 to 60
LTX18	25 to 35	40 to 55	25 to 45	35 to 55
LTX24	25 to 35	40 to 50	25 to 45	35 to 50
LTX36	25 to 35	40 to 50	25 to 45	35 to 45
LTX42	25 to 35	35 to 45	25 to 45	35 to 40
LTX48	25 to 35	30 to 40	25 to 45	30 to 40

Note: These are guidelines and may need to be modified and adjusted to provide based on the actual drilling conditions.

Hole Opening Planning and Procedure

It is recommended that after each drill stem has been reamed that it be back reamed in order to stir the cuttings up and move them back away from the face. The rate at which this is done will need to be adjusted based on the circumstances of the hole. Performing this operation is based on the formation and may not be necessary in all circumstances.

It would also be recommended that in between each hole opening pass that a swab (barrel reamer or fly cutter) be run the entire distance of the hole. This can provide the driller with real feedback as to the condition of the hole, as well as, cleaning the hole. This may not be necessary in every hole and will need to be determined based on the amount and size of cuttings being removed, as well as, the distance and diameter of the hole.

Lastly, in the event that the mud weight and/or sand content becomes too high, it may be necessary and would be recommended that a “bottoms up be performed in order to replace all of the mud in the hole with new clean mud to provide maximum efficiency and carrying capacity.

Figure 1-14 provides you with basic formulas to calculate the amount of fluid being pumped by the mud pump being used, as well as, the formula for calculating the hole volume and time needed to perform a “bottoms up.”

Figure 1-14

Triplex Pump Calculation

(Dia x Dia.) x .000243 x L = Bbl’s per stroke
Bbl’s per stroke x 42 = gallons per stroke
GPS x number of strokes = Gallons per minute

Dia. = diameter of plungers in inches
L = Length of Stroke
Bbl = Barrels

Note: The gallons per minute should be figured at no more than 85% to allow for the inefficiency of the mud pump.

Hole Volume Calculation

(D1 x D1)-(D2 x D2) / 1029 = Bbl’s per foot
Bbls per foot x 42 = gallons per foot
Gallons per foot x hole distance= bottoms up time

D1= diameter of hole
D2 = diameter of pipe

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Hole Opening Planning and Procedure

In summary, do to many advancements in down hole rock tooling, rock drilling processes have been made possible and quite normal in today's HDD market. The LoTorque hole opener was designed and modified based on years of rock drilling experience. It is a superior product and can lower cost and wear and tear on you drilling equipment when properly run.

It is recommended that as much information of the soil conditions and formations is gathered. It is advisable that core samples are taken and formation changes be mapped on the profile to allow the driller to know when he will be entering and leaving different formations.
so that the proper tooling can be available for the project.

Once the soil conditions are established it is necessary that the pilot hole be planned and the size of the product line be established to allow for preliminary planning of the necessary hole opener passes and final hole size. Now the proper size and cutter configuration can be established and the hole openers can be ordered.

Once the hole openers are on location, they should be dressed with the proper cutters and installed with the proper torque applied. This will allow optimal performance and cutter life.

When the hole opening begins and throughout the hole opening process, it is vital that the hole openers be operated within the recommended specifications. This will provide maximum efficiency and cut the cost of the hole opening operation. The cutters should be removed from the hole at the recommended intervals to check the condition and change the cutters as necessary. At these intervals, you will also need to access the condition of the bodies and perform any necessary repairs.

Note:

All formulas and recommendations contained in this document are, to the best of our knowledge, industry standards. Due to multiple factors, including but not limited to, equipment and tubular condition, and variations of formations, Sharewell, LP cannot express or imply warranty for results. We believe the information contained in this document, used as guidelines, will improve chances of success in your operation if followed properly. Proper pre-planning of operations with a qualified Sharewell, LP representative continues to be the best way to optimize results. For verification and clarification of any information contained in this document, please contact your local Sharewell representative.

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