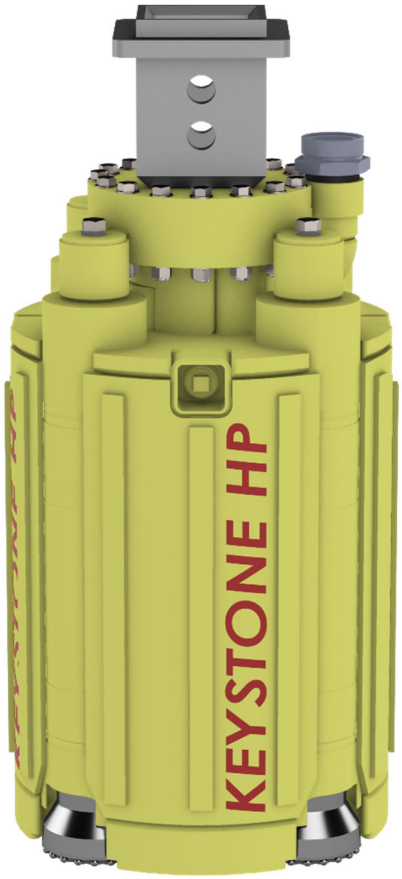
KEYSTONE
HP CLUSTER DRILL

SAFETY, OPERATION, & PARTS MANUAL



- **Integrated "Ratchet" Air Inlet**
- **Easy Access Hammers**
- **150 PSI Operating Pressure**
- **Powerful CS8 Hammers**
- **Low Maintenance Costs**
- **Clean-out Ports**

⚠ Read this instruction manual before operating or servicing this equipment ⚠

Any questions regarding operation, safety or capabilities of this HP Cluster Drill should be directed to:

Keystone Drill Services, Inc.
184 Alisa Street
Somerset, PA 15501
Ph# 800-221-0586
Ph# 814-443-2670
Fax# 814-443-6974
E-mail: sales@keystonedrill.com
www.keystonedrill.com

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

WARRANTY (HP CLUSTER DRILL)

KEYSTONE DRILL SERVICES, INC. WARRANTS THAT EACH ITEM OF EQUIPMENT MANUFACTURED BY IT AND DELIVERED HEREUNDER TO THE INITIAL USER WILL BE FREE OF DEFECTS IN MATERIAL AND WORKMANSHIP FOR A PERIOD OF (1) ONE YEAR FROM THE DATE OF SHIPMENT TO THE INITIAL USER.

THIS WARRANTY DOES NOT APPLY TO FAILURES OCCURRING AS A RESULT OF ABUSE, MISUSE, NEGLIGENT REPAIRS, CORROSION, EROSION AND NORMAL WEAR AND TEAR, ALTERATIONS OR MODIFICATION MADE TO THE PRODUCT OR FAILURE TO FOLLOW THE RECOMMENDED OPERATING PRACTICES AND MAINTENANCE PROCEDURES AS PROVIDED IN THE PRODUCT'S OPERATING AND MAINTENANCE PUBLICATIONS.

KEYSTONE DRILL SERVICES, INC. IS NOT LIABLE FOR ANY CONSEQUENTIAL OR INCIDENTAL DAMAGES. THE TOTAL EXTENT OF OUR WARRANTY IS LIMITED TO THE REPLACEMENT VALUE OF THE HP CLUSTER DRILL. KEYSTONE DRILL SERVICES, INC., AT ITS DISCRETION, MAY ELECT TO REPAIR OR REPLACE THE DEFECTIVE PART OR PARTS.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES (EXCEPT OF TITLE), EXPRESSED OR IMPLIED, AND THERE ARE NO WARRANTIES OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE, AND THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION ON THE FACE HEREOF.

WARRANTY (HAMMERS AND BITS)

EPIROC, A SUBSIDIARY OF ATLAS COPCO, DOWNHOLE HAMMERS AND BITS ARE COVERED BY THE ORIGINAL MANUFACTURER'S WARRANTY PROVISIONS.

HP CLUSTER DRILL SAFETY

- Ensure that the operator, maintenance/service, and all relevant personnel read, understand and follow all information provided in all manuals before operating, servicing and/or maintaining the HP Cluster Drill.
- Carefully read all safety messages in this manual and on your machine's safety labels. Keep safety labels in good condition. Replace all missing or damaged safety labels.
- Replacement safety labels can be obtained at no cost by contacting the factory.
- Learn how to operate the HP Cluster Drill and how to use the controls on the machine properly. Do not let anyone operate this HP Cluster Drill without proper instruction.
- If you do not understand any part of this manual and need assistance, contact your salesman or the factory.
- Keep your HP Cluster Drill in proper working condition.
- Unauthorized modifications to the HP Cluster Drill may impair the function and/or safety and affect the HP Cluster Drill life.
- Make sure all safety devices, including shields are installed and functioning properly.
- Visually inspect the HP Cluster Drill daily before using. Do not operate the HP Cluster Drill with loose, worn, or broken parts.
- Wear APPROVED safety equipment (safety shoes, safety glasses, hearing protection, hard hat, gloves, respirator, etc.) when operating or maintaining the HP Cluster Drill.
- Wear close fitting clothing and confine long hair.
- Operating equipment requires the full attention of the operator. Do not wear radio or music headphones while operating the HP Cluster Drill.

- Before starting work, remember that contact with buried utilities may cause serious injury or death. Electric line contact may cause electric shock or electrocution. Gas line contact may rupture pipe causing explosion or fire. Fiber optic cables can blind you if you look into the laser light in them. Water line rupture may cause a flood and possible ground collapse. Before drilling, check with qualified sources to properly locate all buried utilities in and around drill path. Select a drill path that will not intersect buried utilities. Never launch a drill bit on a path toward electric, gas, or water lines until their location is known. If there is any doubt as to the location of the underground placement, have the utility company shut it off before starting any underground work and excavate to confirm its exact location.

- Electrocution possible. Serious injury or death may result if the machine strikes an energized powerline. Take the following precautions to prevent electrocution. Also refer to the operating instructions.

- Always contact your local utility company when working in the vicinity of utilities.

- Locate underground utilities by qualified persons.

- Do not raise, lower, or move drill guide or boom near power lines.

- Always wear proper electrically insulated linesman's gloves and boots.

- Never touch metal parts on machine while standing on bare ground if machine is in contact with a powerline.

- Always stay in cab during all drilling operations.

- Never step onto or off of a machine if an electric strike occurs.

- Make sure the drill rod to rotary head spindle joint is securely tightened before running the rotary head in reverse rotation. A loose connection could result in the drill rod unscrewing completely. A falling drill rod could strike personnel.

- Never get under a downhole drill to examine the exhaust air; live air is dangerous. Also, part failure could cause the bit to fall out of the downhole drill which could result in bodily injury. A piece of cardboard can be inserted under the bit to check for the lubrication being carried through the downhole drill.

- Make certain that the air line lubricator (or lubrication system) is capable of handling the higher air pressures associated with the downhole drill up to 350 psi air pressure. When pressurized, an unsuitable lubricator could burst and possibly cause injury to the personnel in the area.

- Do not work in trench with unstable sides which could cave in. Specific requirements for shoring or sloping trench walls are available from several sources including Federal and State O.S.H.A. offices, and appropriate governing agency. Be sure to contact suitable authorities for these requirements before working in a trench. Federal O.S.H.A. regulations can be obtained by contacting the Superintendant of Documents, U.S. Government Printing Office, Washington, D.C. 20402. State O.S.H.A. regulations are available at your local state O.S.H.A. office, and the appropriate governing agency.

- Know and obey all Federal, State, and Local, and appropriate governing agency laws and regulations that apply to your work situation.

- Set up orange cones around the work area with warning signs facing outward.

- Place pedestrian and traffic barriers around the job site in accordance with Federal, State, and Local, and appropriate governing agency laws and regulations.

- Be mindful of the environment and ecology.

- Before draining any fluids, find the correct way of disposing them.

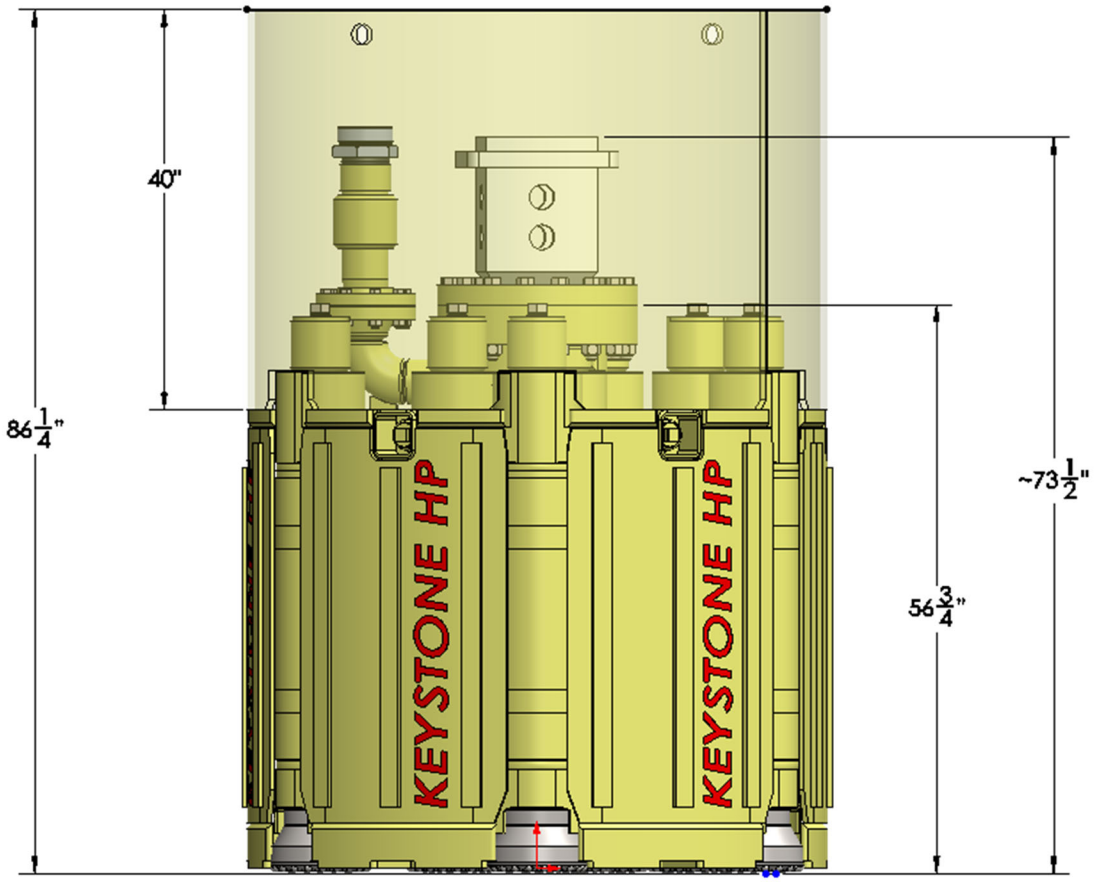
- Observe the relevant environmental protection regulations when disposing of oil, fuel, coolant, brake fluid, filters, and batteries.

- When using any solvent to clean parts, make sure that it is nonflammable, that it will not harm the skin, that it meets current O.S.H.A. standards, and appropriate governing agency, and that it is used in an area that is adequately ventilated.
- Ensure that operator and maintenance personnel are competent and have been adequately trained.
- All federal, state, local and site ordinances, rules and regulations must be followed.
- Do not operate the cluster drill with safety devices bypassed or disconnected.
- Disconnected and/or failed air hoses whip and can cause serious injury or death. Always use approved whip check/cable on hose ends to prevent whipping. Reference *page 23* (Hose Safety Restraints) and Appendix A (Cluster Drill Safety Tie-Down Locations) for guidance.
- Frequently check and tighten all bolts and air line fittings and connections. It is recommended that any air line threaded fittings be secured with welded lock tabs to prevent loosening during operation.
- Keep personnel out of line with and away from the discharge opening of hoses, tools or other points of compressed air discharge.
- Do not engage in horseplay with air hoses as death or serious injury may result.
- Always wear fall protection in situations in accordance with O.S.H.A., state, local, and site standards and ordinances.
- Before servicing any HP Cluster Drill or removing any hoses, all live air lines and manifolds must be drained to 0 PSI.
- Ensure that hoists, chains, and/or slings are rated for the load applied.
- When replacement parts are required for this cluster drill, Keystone recommends using genuine parts from the original manufacturer or parts with equivalent specifications including, but not limited to physical dimensions, type, strength and material. Failure to heed this warning can lead to premature failures, product damage, and/or personal injury or death.

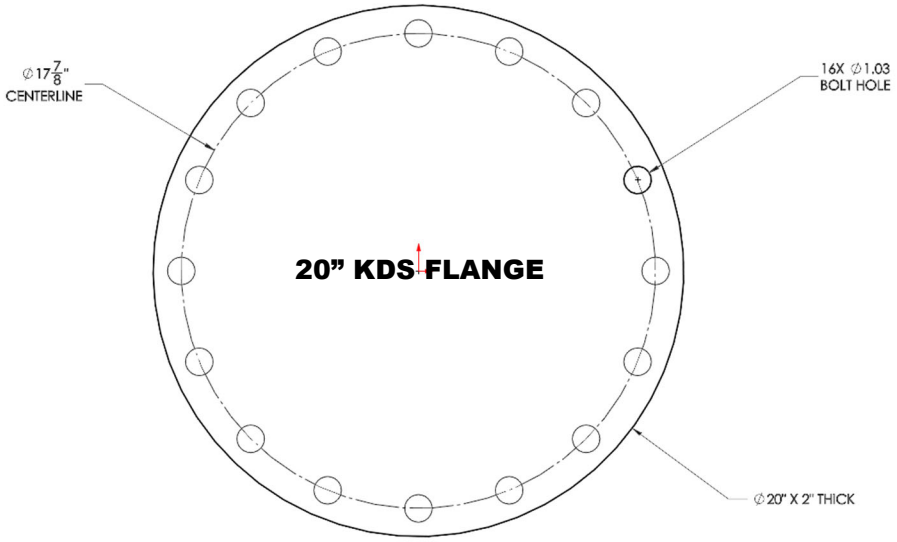
⚠ Failure to follow any of the above safety instructions or those that follow within this manual, could result in serious injury or death. This HP Cluster Drill is to be used only for those purposes for which it was intended as explained in this instruction manual. ⚠

For up-to-date Cluster Drill TSBs (Technical Safety Bulletins) go to our website, www.keystonedrill.com, and select *Technical Safety Bulletins* from *Our Company* drop-down menu.

OVERALL DIMENSIONS



FLANGE DIMENSIONS



HP Cluster Drilling Options

“Ratchet” Drilling

“Ratchet” Drilling is often used in Low Headroom applications where low drill string height is critical. It is also employed when the use of an Air Kelly or Air Swivel is not available or practical. “Ratchet” Drilling is defined by utilizing the alternate air inlet on the HP Cluster Drill Drive Flange and alternating full rotations, clockwise then counterclockwise.

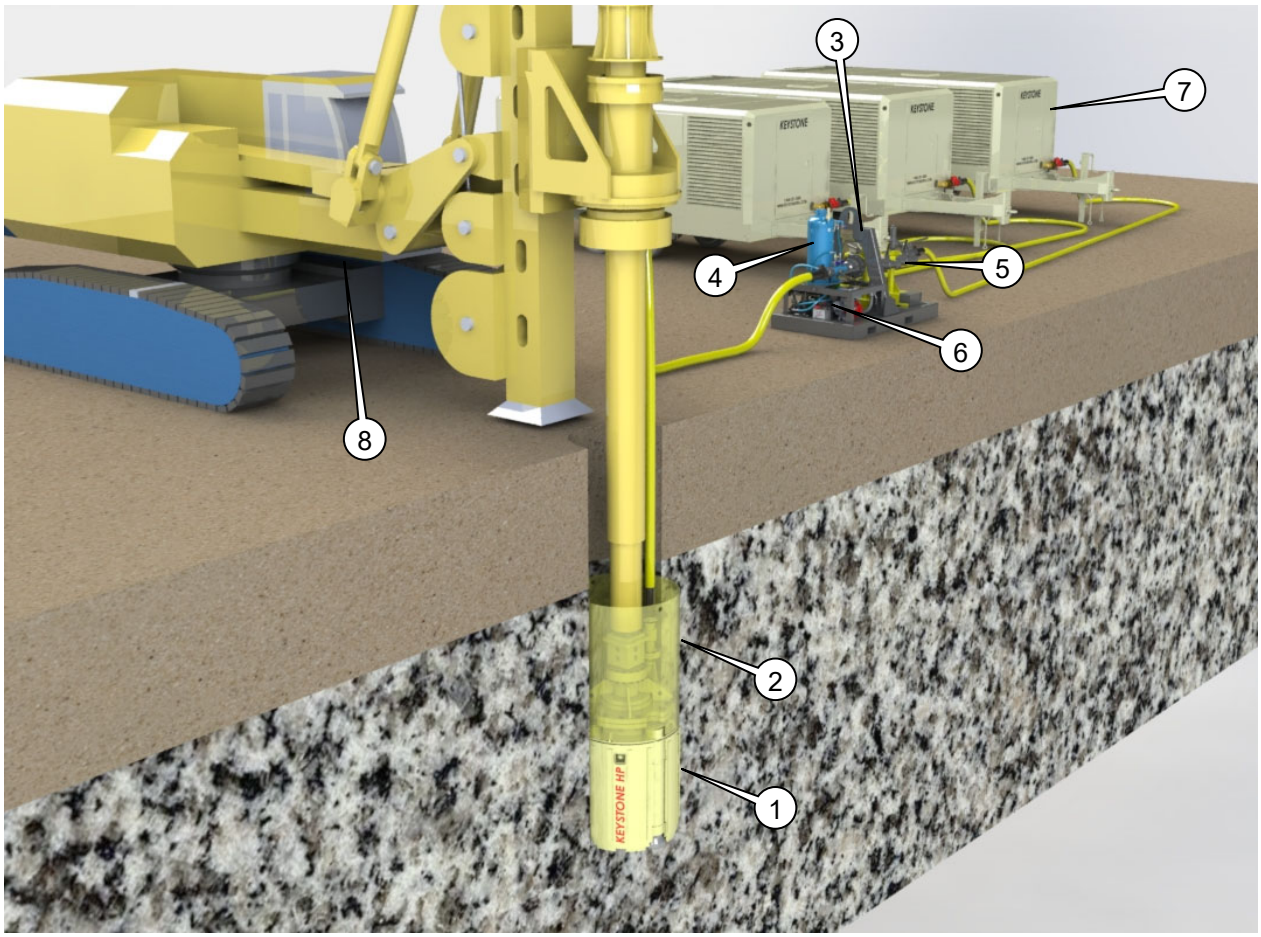


Figure 1: “Ratchet” Drilling Overview

Items in Figure 1:

1. Keystone HP Cluster Drill Canister (“Can”)
2. Calyx Basket
3. Keystone Support Module – Single frame, single lift combination of Air Manifold, Lubricator, and Water Injection
4. Lubricator
5. Air Manifold
6. Water Injection
7. 1600/150 Air Compressor
8. Drill Rig (Conventional or Low Headroom)

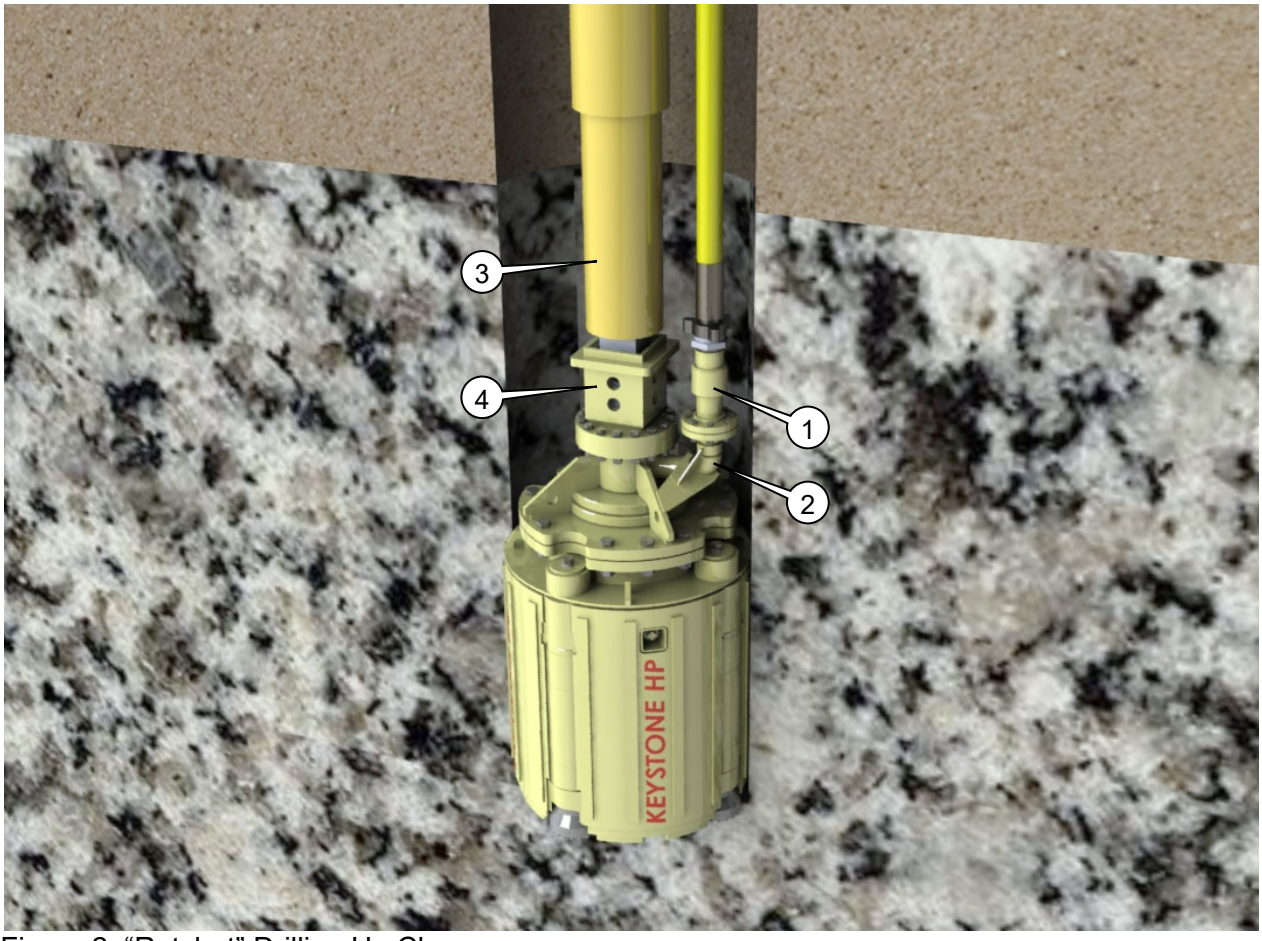


Figure 2: "Ratchet" Drilling Up Close

Items in Figure 2:

1. Air Inlet Swivel
2. "Ratchet" Air Inlet
3. Standard or Telescoping Kelly Bar
4. Kelly Box

Pros of "Ratchet" Drilling:

1. Low drill height. Use with Low Headroom Drill Rigs/Telescoping Kellys.
2. No need for Air Swivels or Air Kelly Bar.

Cons of "Ratchet" Drilling:

1. Cannot drill with continuous rotation.
2. Very tough on air hose and fittings.
3. Can only use for relatively shallow holes.

Swivel Drilling (Air Kelly)

Swivel Drilling with an Air Kelly utilized a hollow Kelly that transports compressed air to the HP Cluster Drill via an Air Swivel at the top of the Kelly. This allows for continuous rotation while drilling.

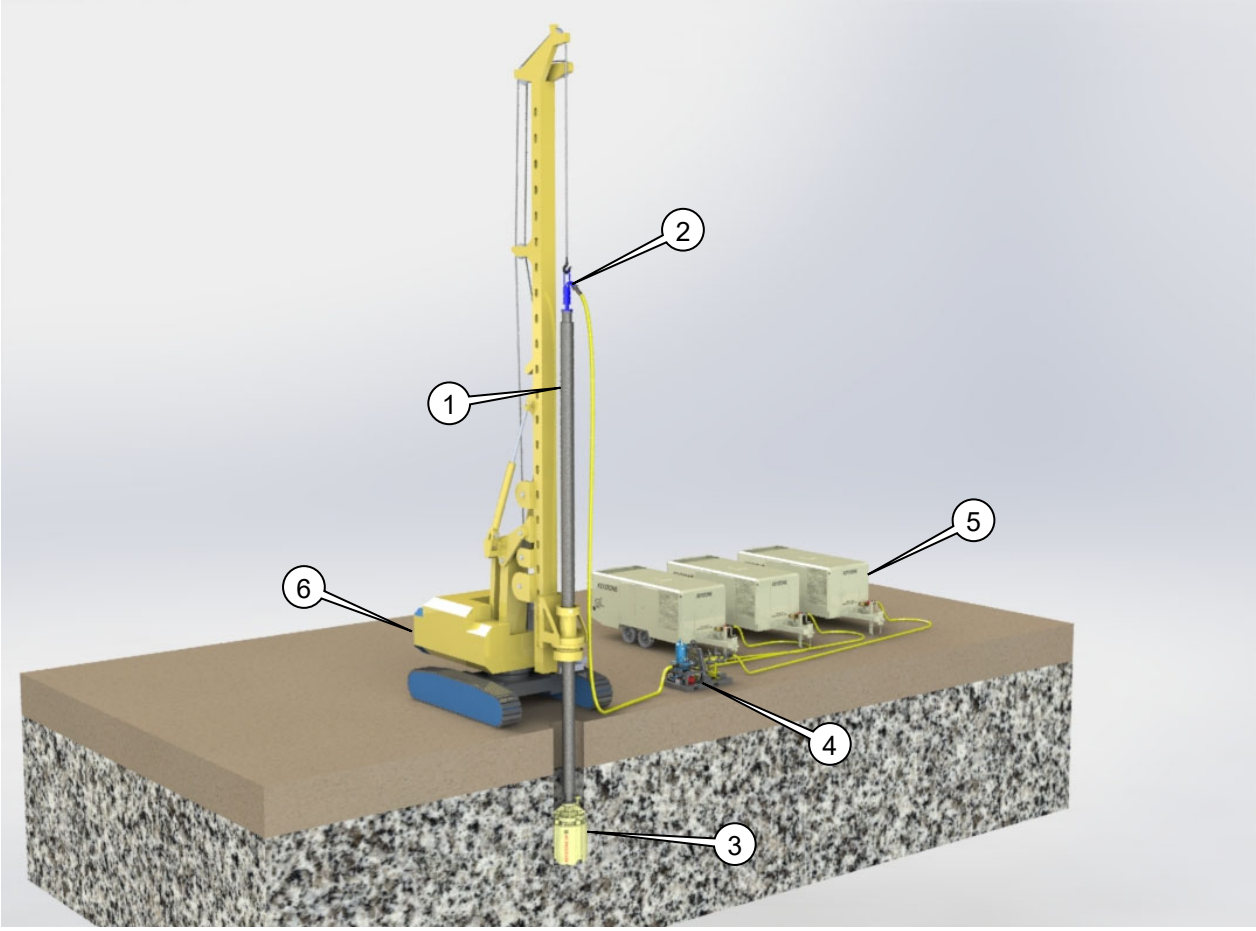


Figure 3: Drilling with Air Kelly overview

Items in Figure 3:

1. Air Kelly
2. Air Swivel
3. Keystone HP Cluster Drill Canister (“Can”)
4. Keystone Support Module – Single frame, single lift combination of Air Manifold, Lubricator, and Water Injection
5. 1600/150 Air Compressor
6. Conventional Drill Rig

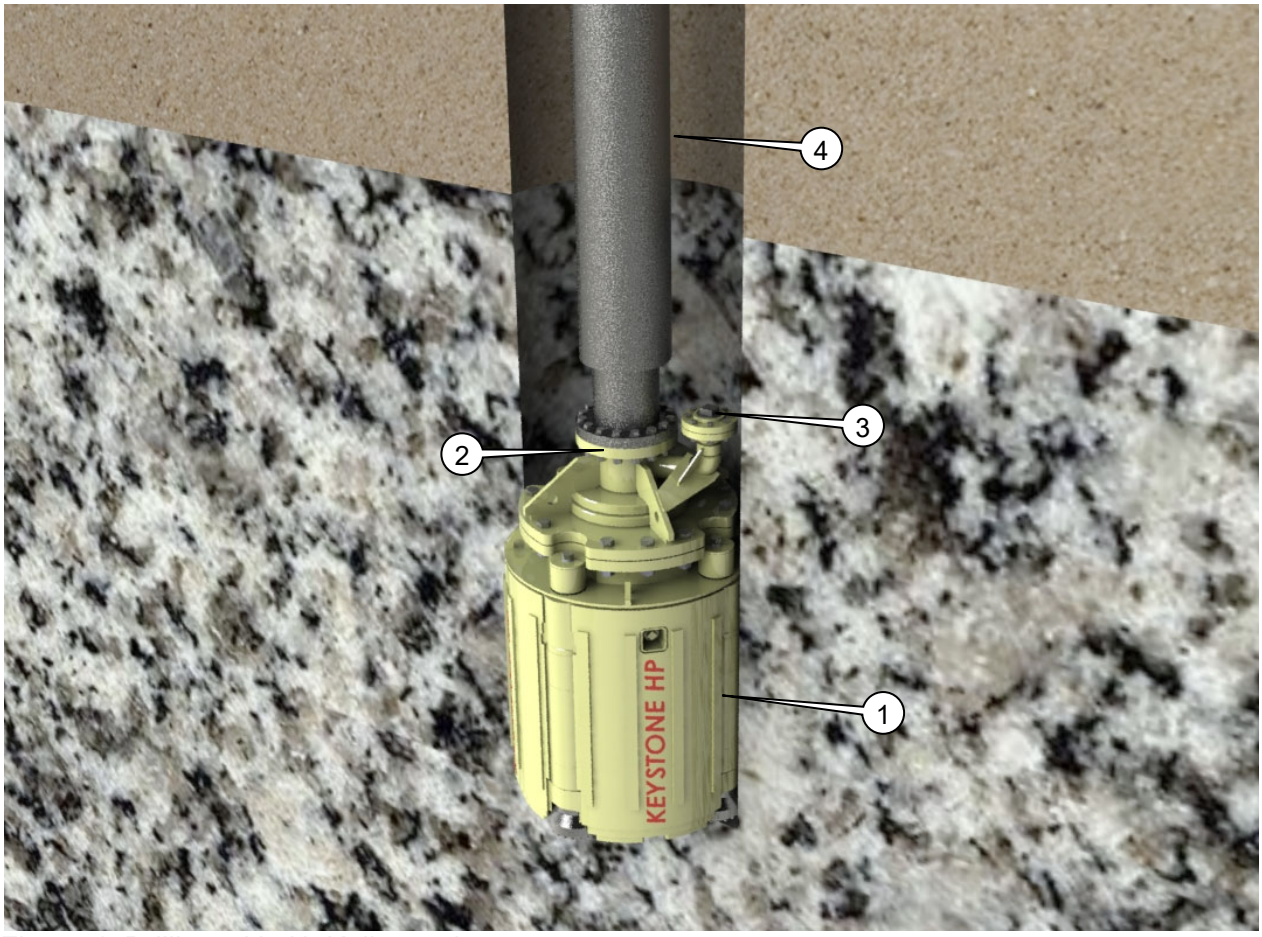


Figure 4: Drilling with Air Kelly up close

Items in Figure 4:

1. Keystone HP Cluster Drill Canister (“Can”)
2. Connecting Flange, Air Kelly to HP Cluster Drill
3. Plugged “Ratchet” Air Inlet
4. Air Kelly

Pros of Air Kelly Drilling:

1. Drill with continuous rotation.
2. Drill without installing air pipe.

Cons of Air Kelly Drilling:

1. Drilling depth limited by length of Air Kelly (without installing drill pipe).
2. Requires Air Swivel

Swivel Drilling (Without Air Kelly)

Swivel Drilling can also be accomplished without an Air Kelly. This method places the Air Swivel below the Kelly Bar in which the torque of drilling is transmitted through the Air Swivel.

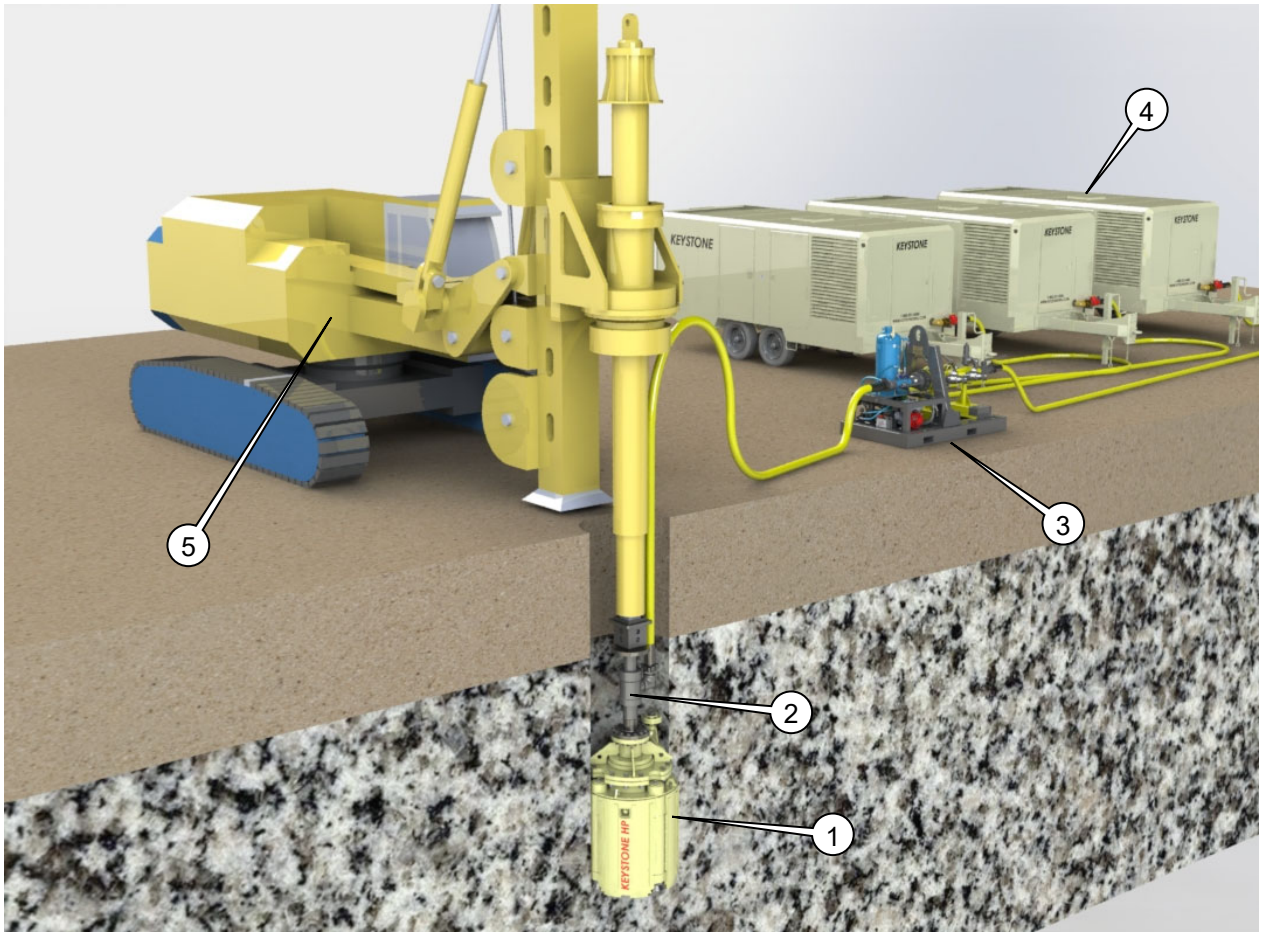


Figure 5: Swivel Drilling without Air Kelly and without Drill Pipe Overview

Items in Figure 5:

1. Keystone HP Cluster Drill Canister ("Can")
2. Air Swivel
3. Keystone Support Module – Single frame, single lift combination of Air Manifold, Lubricator, and Water Injection
4. 1600/150 Air Compressor
5. Conventional or Low Headroom Drill Rig

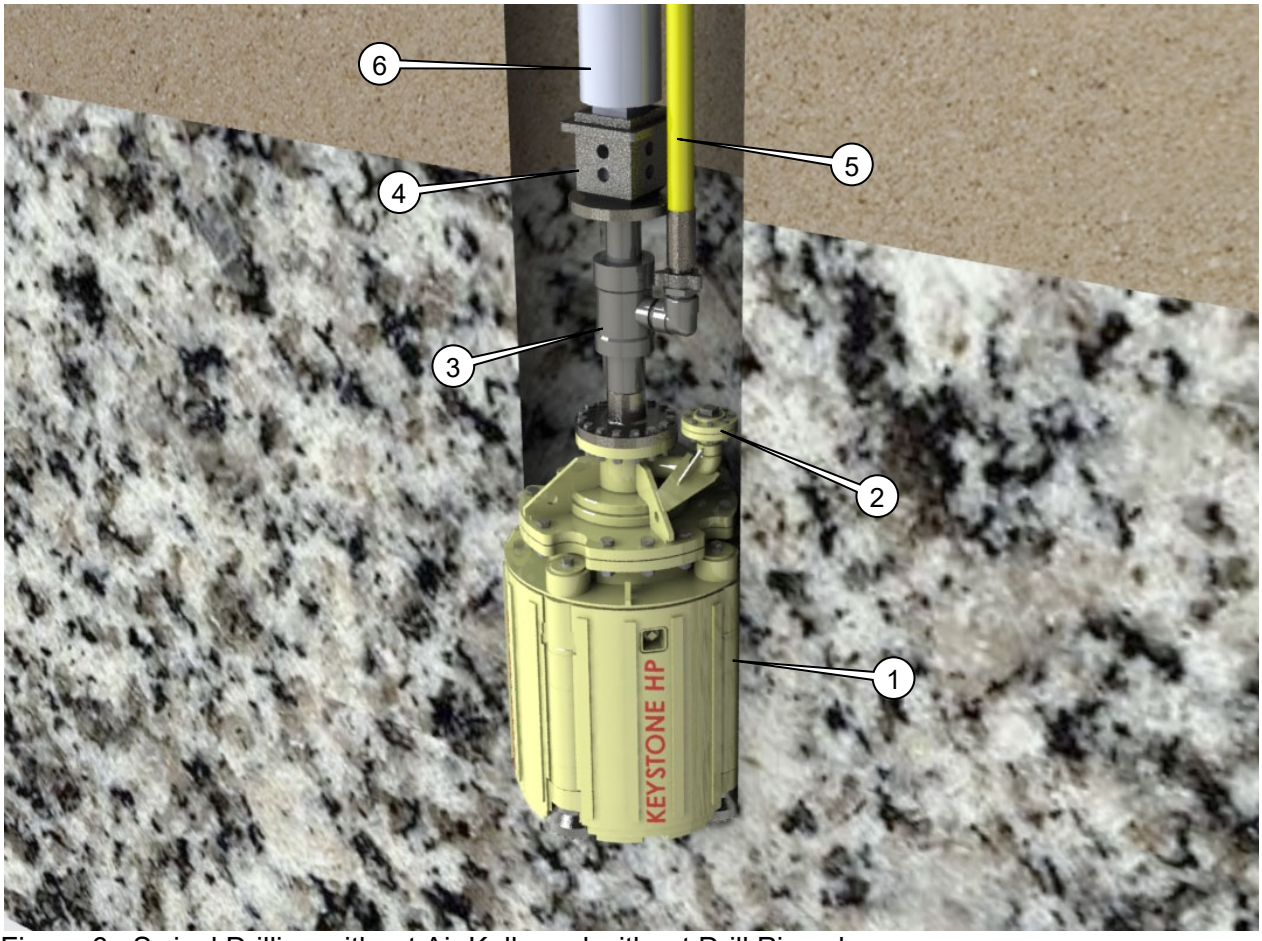


Figure 6: Swivel Drilling without Air Kelly and without Drill Pipe close up

Items in Figure 6:

1. Keystone HP Cluster Drill Canister (“Can”)
2. Plugged “Ratchet” Air Inlet
3. Air Swivel
4. Kelly Box
5. Kelly Bar

Pros of Swivel Drilling without Air Kelly and without Drill Pipe:

1. Do not need an Air Kelly and can use telescoping Kelly Bar.
2. Continuous rotation drilling.

Cons of Drilling without Air Kelly and without Drill Pipe:

1. Drilling depth limited by length of Air Kelly (without installing drill pipe).
2. Requires Air Swivel.
3. Hard on hose since it goes down the hole.
4. Limited torque rating for the Air Swivel.

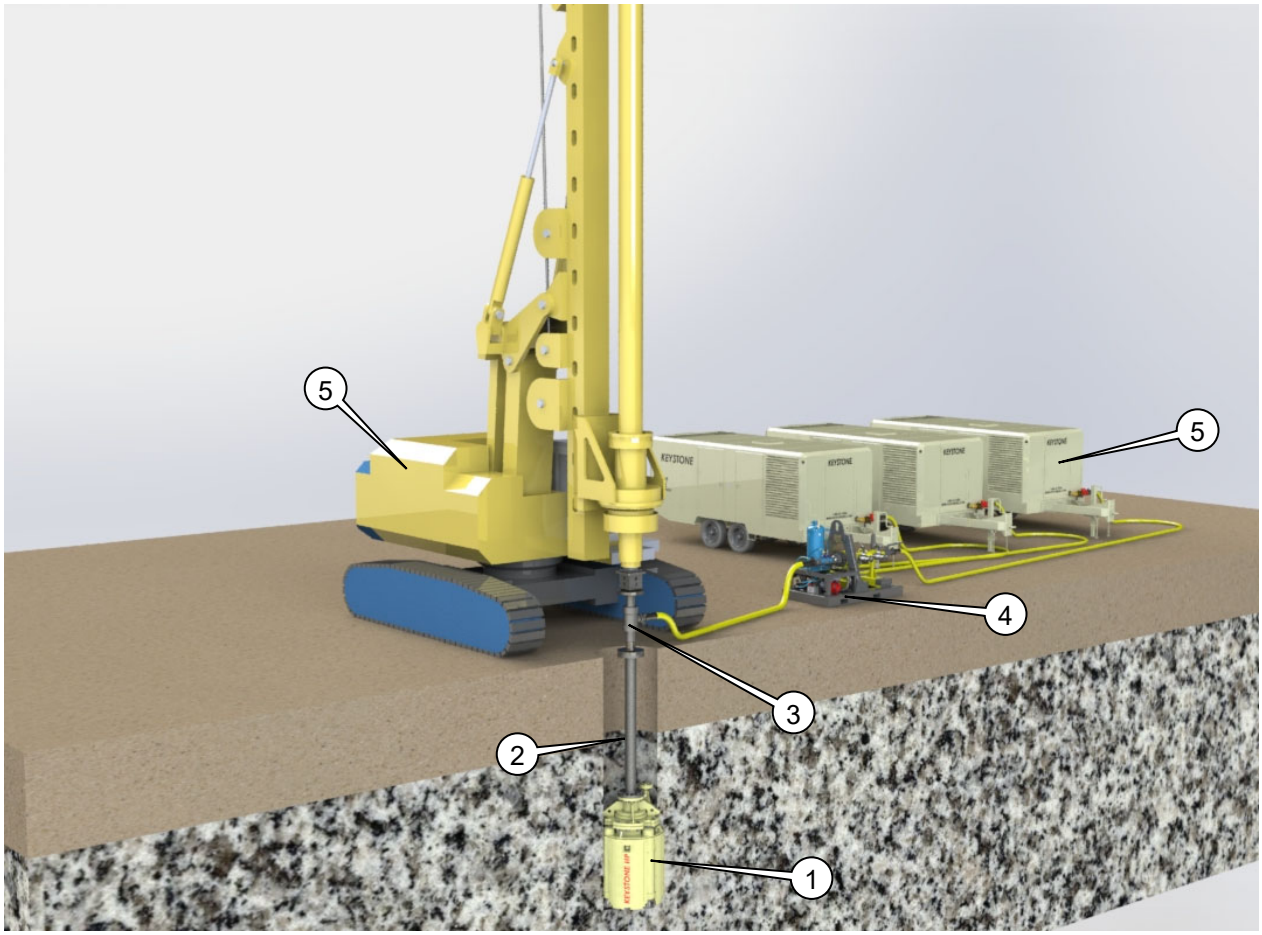


Figure 7: Swivel Drilling without Air Kelly and with Drill Pipe Overview

Items in Figure 7:

1. Keystone HP Cluster Drill Canister (“Can”)
2. Drill Pipe
3. Air Swivel
4. Keystone Support Module – Single frame, single lift combination of Air Manifold, Lubricator, and Water Injection
5. 1600/150 Air Compressor
6. Drill Rig

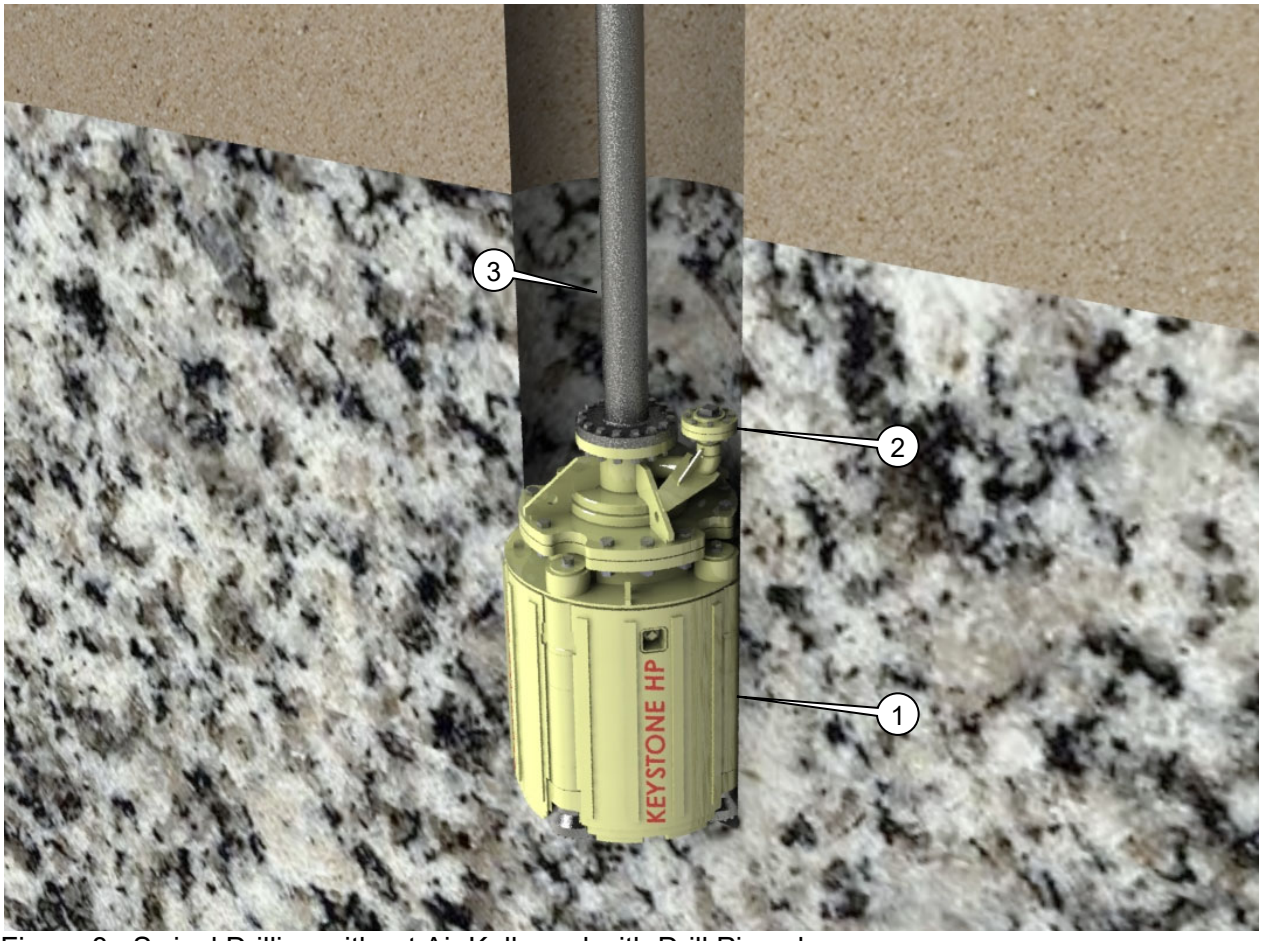


Figure 8: Swivel Drilling without Air Kelly and with Drill Pipe close up

Items in Figure 8:

1. Keystone HP Cluster Drill Canister (“Can”)
2. Plugged “Ratchet” Air Inlet
3. Drill Pipe

Pros of Swivel Drilling with Drill Pipe:

1. Unlimited drilling depth.
2. Do not need an Air Kelly.

Cons of Swivel Drilling with Drill Pipe:

1. May need to connect and disconnect multiple sections of pipe on each trip
2. Air Swivel has a limited torque rating

Reverse Circulation Drilling (With Standard HP Cluster Drill)

Reverse Circulation Drilling with a standard HP Cluster Drill utilizes a Reverse Circulation Air/Cuttings Crossover sub and a Sealing Plate (“donut”) instead of internal channels in the drill. This allows the versatility of using the standard drill for RC drilling or using a Calyx Basket when RC is not feasible.

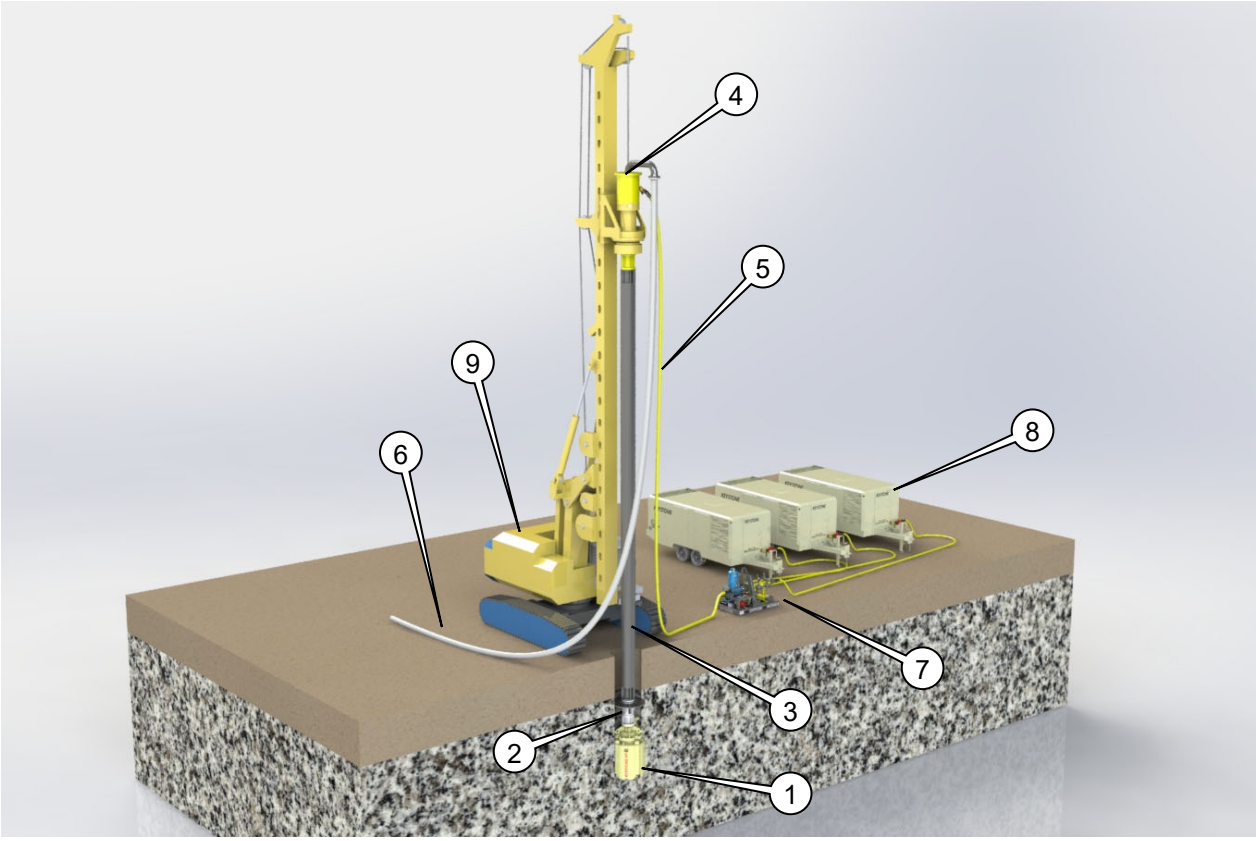


Figure 9: Swivel Drilling without Air Kelly and with Drill Pipe Overview

Items in Figure 9:

1. Conventional Keystone HP Cluster Drill Canister (“Can”)
2. Reverse circulation crossover and “donut” sealing plate
3. Reverse circulation drill pipe
4. Reverse circulation swivel
5. Air hose (yellow)
6. Cuttings discharge hose (gray)
7. Keystone Support Module – Single frame, single lift combination of Air Manifold, Lubricator, and Water Injection
8. 1600/150 Air Compressor
9. Drill Rig

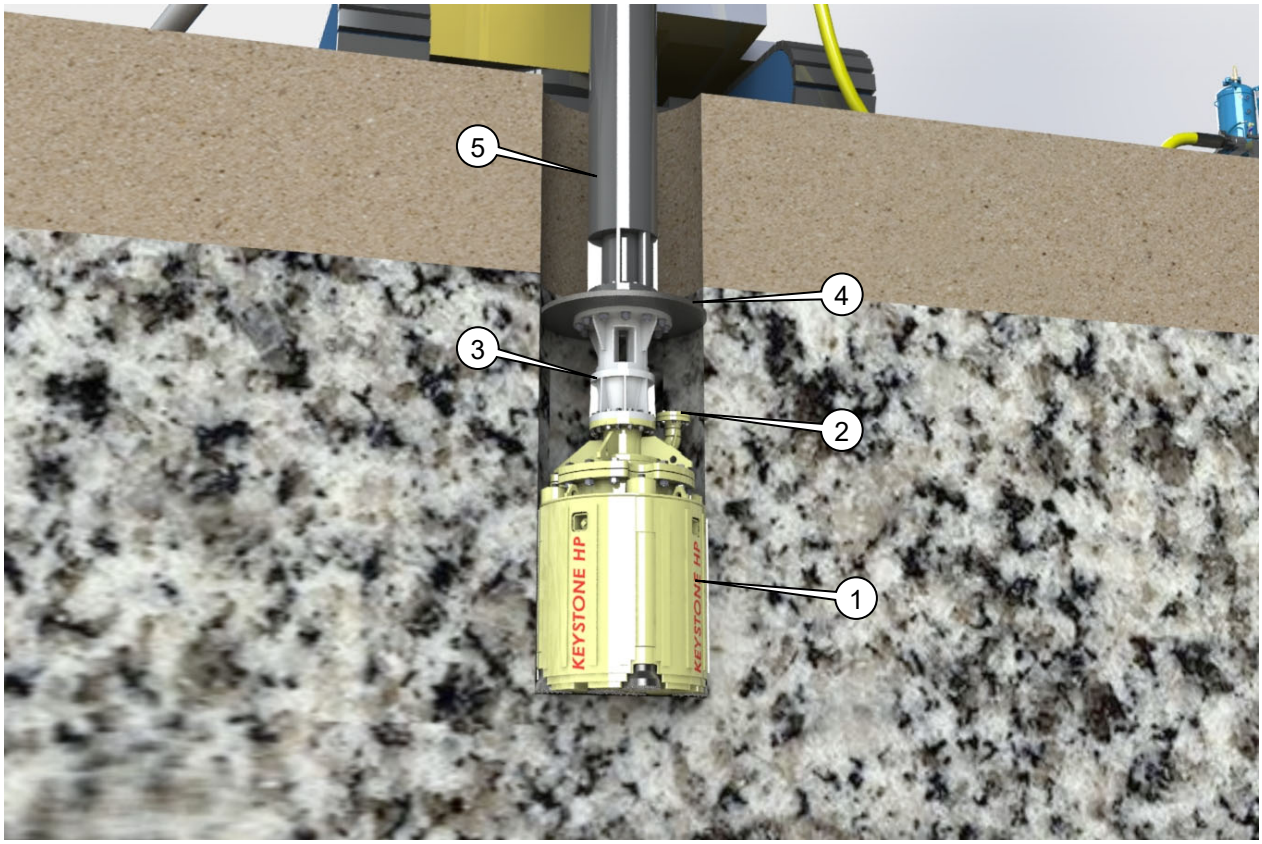


Figure 10: Swivel Drilling without Air Kelly and with Drill Pipe close up

Items in Figure 10:

1. Conventional Keystone HP Cluster Drill Canister ("Can")
2. Plugged "Ratchet" Air Inlet
3. Reverse Circulation Crossover
4. Sealing Plate ("Donut")
5. Reverse Circulation Drill Pipe

Pros of Reverse Circulation Drilling with conventional HP Cluster Drill:

1. Do not need RC Cluster Drill with internal passages for cuttings.
2. Do not need to trip out of hole while drilling.

Cons of Reverse Circulation Drilling with conventional HP Cluster Drill:

1. RC does not function until sealing plate is below ground; cannot RC drill from surface.
2. Requires specialized RC equipment i.e. drill pipe, swivel, crossover, etc.

Reverse Circulation Drilling (With RC Cluster Drill)

Reverse Circulation Drilling with a RC Cluster Drill utilizes internal air/cuttings channels in the Cluster Drill in addition to a sealing shroud that contains the RC Crossover. This allows RC drilling from nearly ground level.

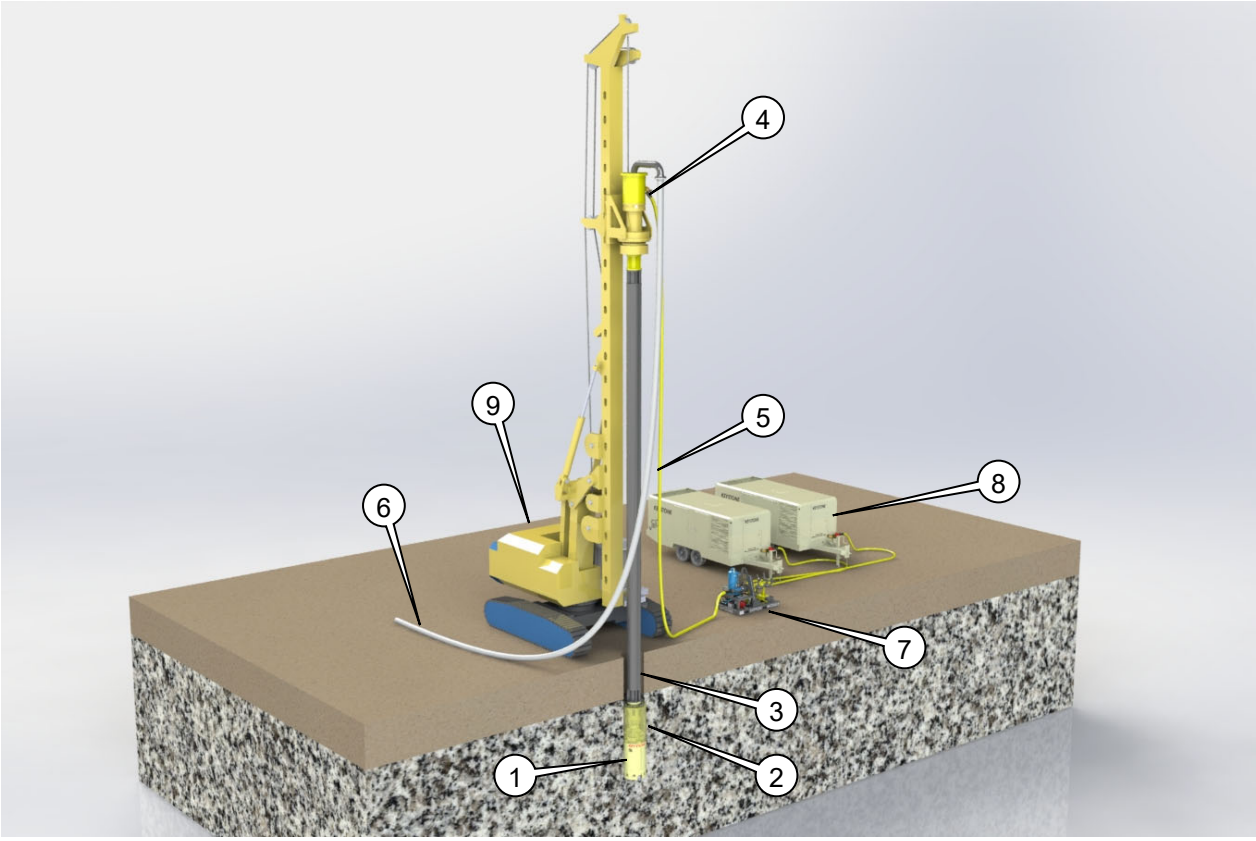


Figure 11: Drilling with Air Kelly overview

Items in Figure 11:

1. Reverse Circulation Keystone HP Cluster Drill Canister (“Can”)
2. Reverse circulation crossover and Shroud
3. Reverse circulation drill pipe
4. Reverse circulation swivel
5. Air hose (yellow)
6. Cuttings discharge hose (gray)
7. Keystone Support Module – Single frame, single lift combination of Air Manifold, Lubricator, and Water Injection
8. 1600/150 Air Compressor
9. Drill Rig

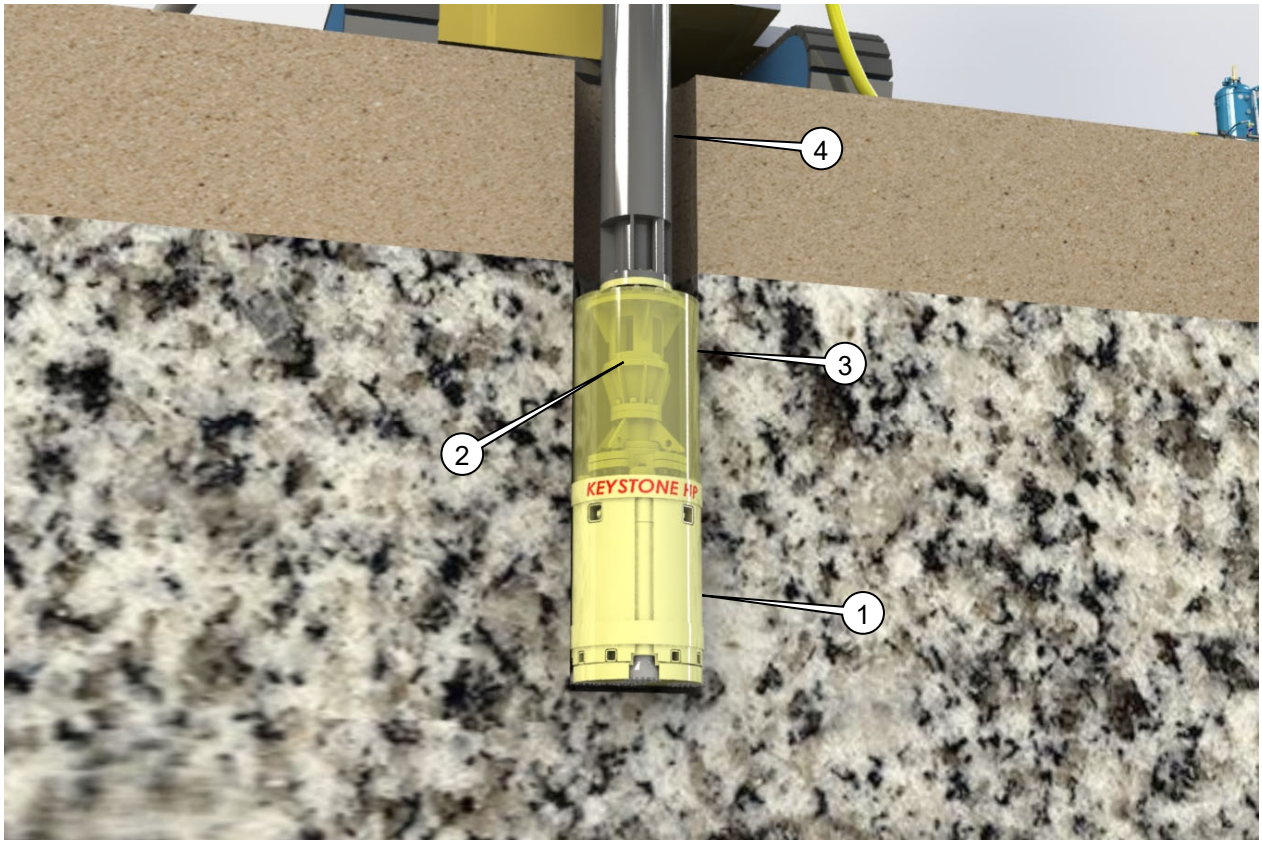


Figure 12: Drilling with Air Kelly up close

Items in Figure 12:

1. Reverse Circulation Keystone HP Cluster Drill Canister (“Can”)
2. Reverse Circulation Crossover
3. Shroud/Crossover Housing
4. Reverse Circulation Drill Pipe

Pros of Reverse Circulation Drilling with RC HP Cluster Drill:

1. Can RC drill nearly from the surface.
2. Do not need to trip out of hole while drilling.

Cons of Reverse Circulation Drilling with RC HP Cluster Drill:

1. Requires specialized RC equipment i.e. drill pipe, swivel, crossover, etc.

Rotation Speed

Rotation speed depends on the hardness of the formation. The harder the rock, the slower the rotation speed is required. Faster rotation does not always mean a higher penetration rate. Rotation speed should be as slow as possible, while maintaining smooth rotation. A general guide to determine RPM's is 300 divided by the HP Cluster Drill diameter (inches).

$$RPM = \frac{300}{\emptyset\ HP\ Drill\ (in)}$$

Torque

The rotation system must be capable of providing sufficient torque to smoothly rotate the HP Cluster Drill at these low speeds. The system generally should be capable of producing at least 1000 ft-lb of torque per inch of hole diameter at the calculated rotation speed.

$$Torque\ (ft-lb) = 1{,}000 \times \emptyset\ HP\ Drill\ (in)$$

Weight on Bit

HP Cluster Drill requires only enough force to close the bits completely in the hammers and to couple the bits firmly to the rock. Often the combined weight of the HP Cluster Drill, Kelly, drill pipe, and other attachments will provide sufficient weight to meet the requirements. A general rule for "weight on bit" is 5,000 lbs per bit in the HP Cluster Drill.

$$Recommended\ Total\ Weight\ (lbs) = 5{,}000 \times Number\ of\ Bits\ in\ HP\ Drill$$

Bailing Velocity

Bailing Velocity is the velocity of the exhaust air through the annulus between the hole I.D. and drill rod O.D. Recommended Bailing Velocity should be at least 3,000 ft/min for proper hole cleaning.

$$Bailing\ Velocity(ft/min) = \frac{Air\ Flow\ (SCFM)}{Annulus\ Area\ (ft^2)}$$

$$Annulus\ Area\ (ft^2) = 0.00545 \times [(Hole\ \emptyset\ (in))^2 - (Rod\ \emptyset\ (in))^2]$$

Equipment

Compressors

Keystone HP Cluster Drills are usually run using one or more portable air compressors to power the air hammers. It is important to provide sufficient pressure and air flow for optimum drill performance. The HP Cluster Drills are designed to operate at 100 to 150 psig. Greater pressure may be required if drilling under a head of water or to significant depths. When combining two or more compressors, it is important that both shut-off and check valves be installed immediately after discharge point of each compressor to avoid the compressors "fighting" each other and the possibility of compressor damage.

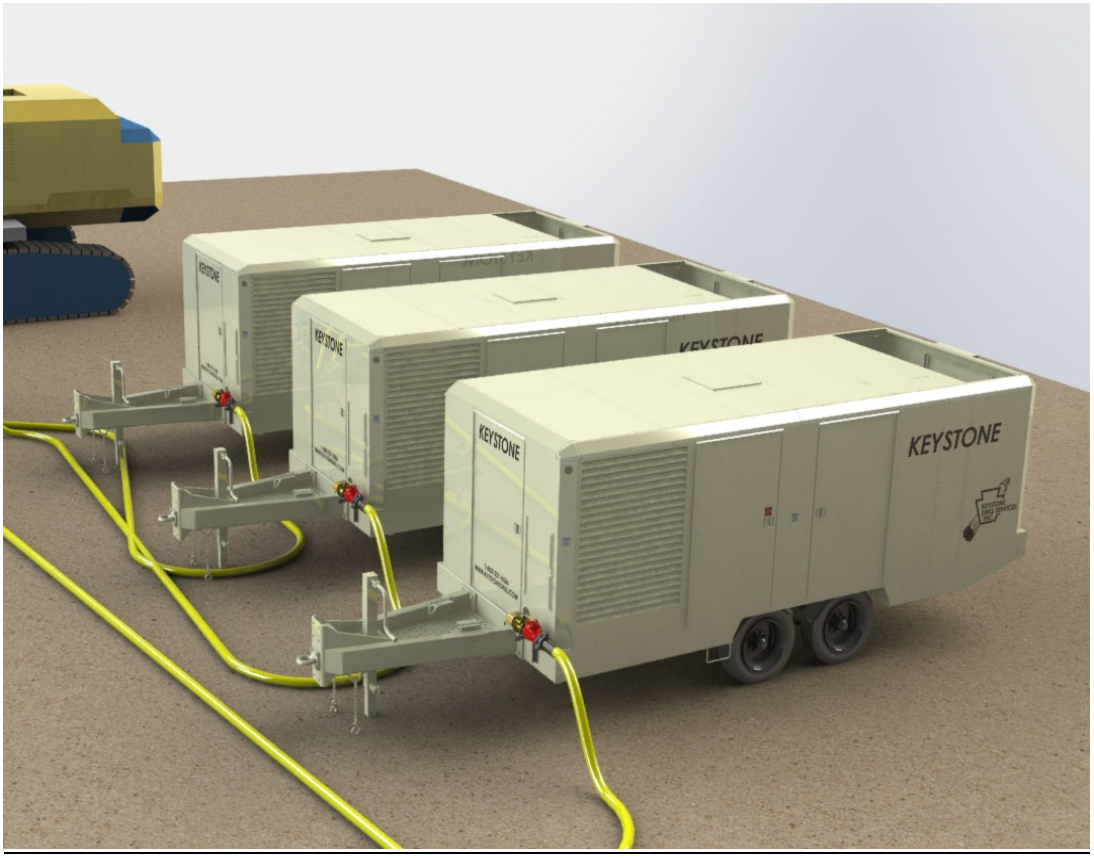


Figure 13: Typical Air Compressor Configuration

Inlet Pressure (PSIG)	Air Requirement Per Hammer (SCFM)
75	191
100	305
125	420
150	534
175	649
200	763
225	878
250	992

Table 1

Air Flow Requirements Per Hammer

Air Hose and Fittings

Quality hose, designed for rock drilling should be rated for the pressures and temperatures of the compressed air. Use the charts on the next page to determine the diameter in order to minimize pressure loss. Hose should be constructed with an outer covering which resists abrasive wear and should be shielded properly from rock cuttings and abrasive wear points. Hose should also have and oil resistant inner tube.

Air fittings installed directly to the HP Cluster drill should be checked frequently for proper tightening or have welded lock tabs to prevent unthreading during drilling.

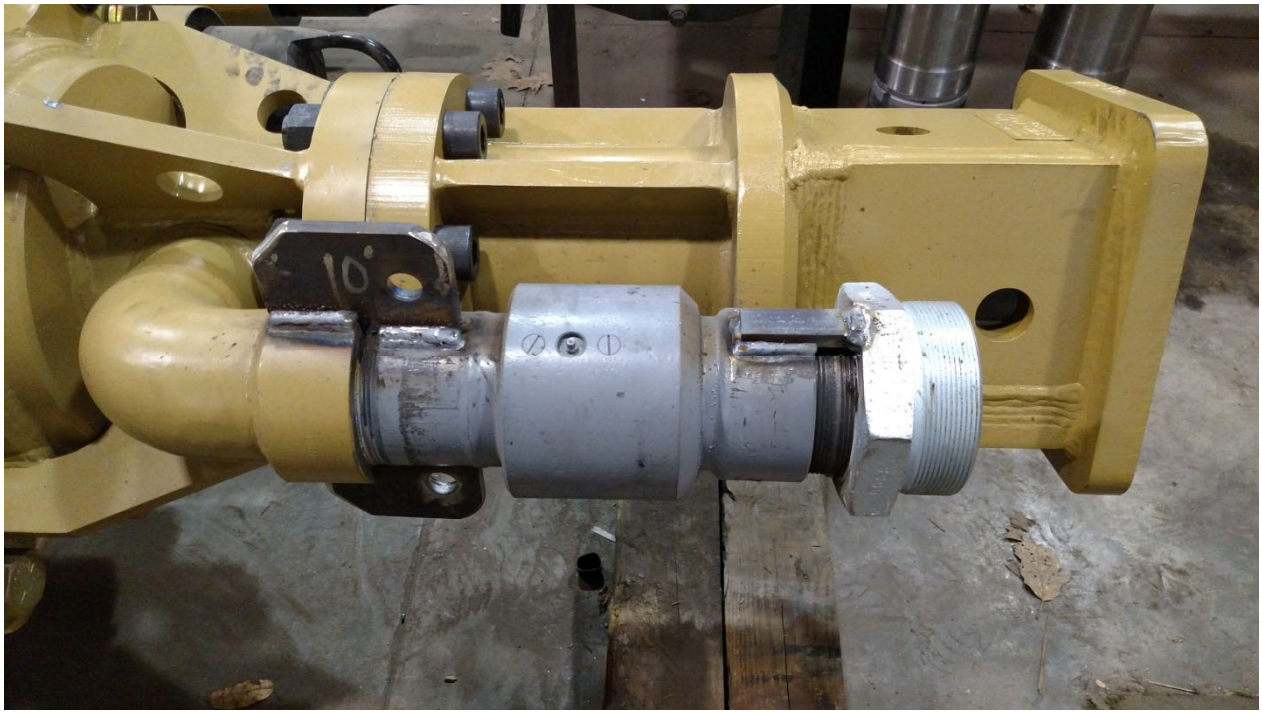


Figure 14: Welded lock tabs for threaded fittings connected to HP Cluster Drill.

Hose diameter and length should be considered when planning a drilling application to limit pressure loss. The following tables gives pressure drops for various pressures and flows for 2", 3", and 4" diameter hoses. Please note the difference in pressure drop of dry air versus lubricated air.

It is the responsibility of the Operator:

- To have properly rated hose, fittings, and safety restraints.
- To frequently check connections and fasteners and ensure they are properly tightened/torqued.
- To ensure that the swivel (if used) is lubricated and rotating.

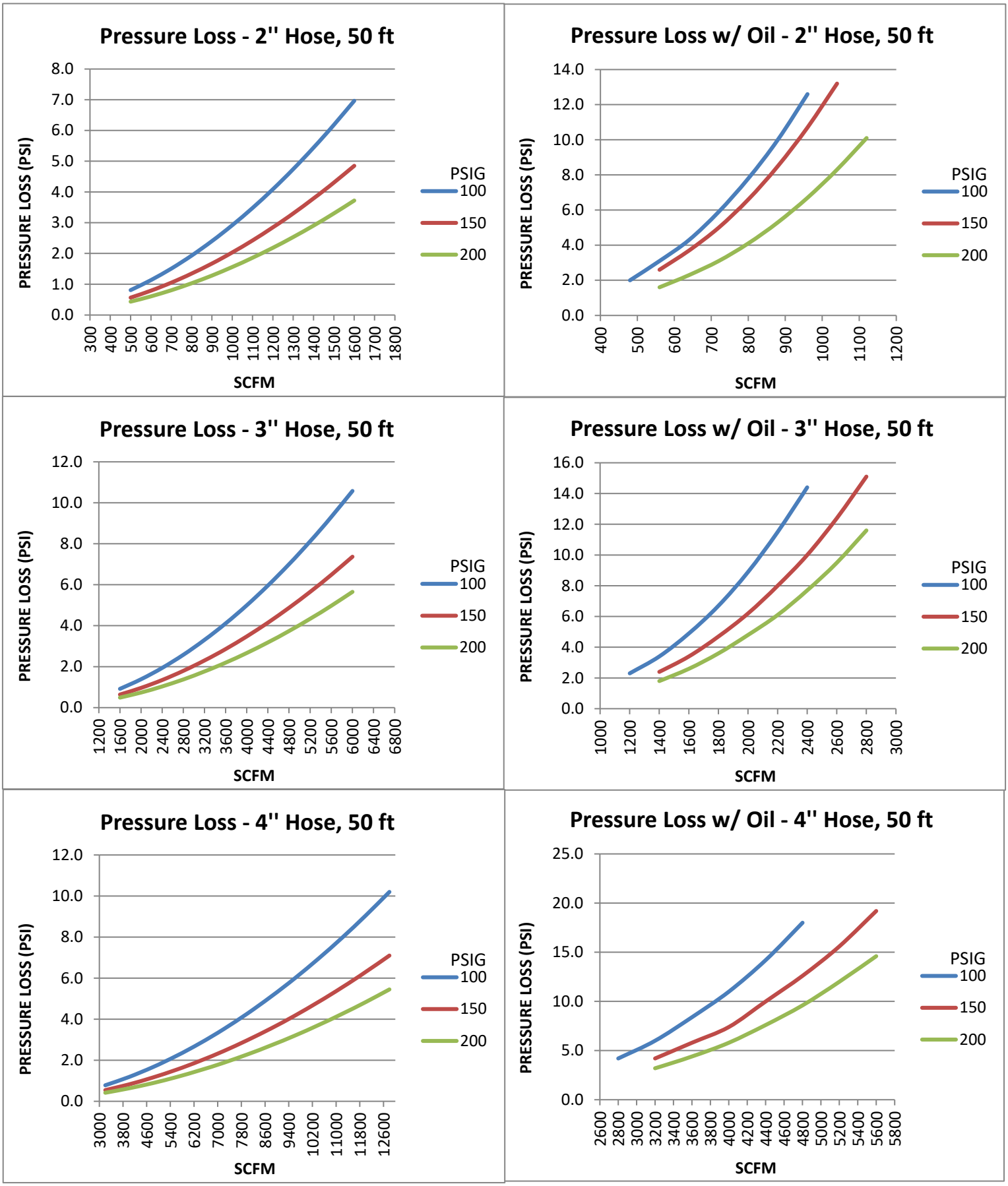


Figure 15: Pressure loss in hose (dry and oiled).

Hose Safety Restraints

Proper hose restraints should always be used in case of hose failure. Hose safety restraints are designed to decrease potential hazards of hose whip, risk to operator and bystanders and decrease potential damage to equipment. Different types of restraints are whip checks, nylon hose restraints, whip chokers, whip stop (sock) systems and hobble clamps.

Follow the below guidelines when selecting and installing your hose restraint:

- Select the restraint type that is best for your application, whether hose-to-hose or hose-to-tool.
- Review pressures and equipment being used to properly size the restraint device. Ensure that the device is rated for the appropriate potential force that your hose system can cause during a failure.
- Hose restraints should be installed in the fully extended position (no slack) for proper safety assurance. As you add slack into your restraint system, it magnifies the kinetic energy during a hose failure, translating to additional force.
    - To calculate your thrust force, divide the hose inside diameter by 2. Multiply that by itself. Multiply that by PI (3.1415). Multiply that by the operating pressure. The answer is your static load rating, or safe working load.
        - Example: 6” hose operating at 150psi = 4,241lb force
    - Add a safety factor of 5 to the static load rating, or safe working load, to ensure a proper minimum breaking load.
- Follow all guidelines and instructions provided by the hose restraint manufacturer.

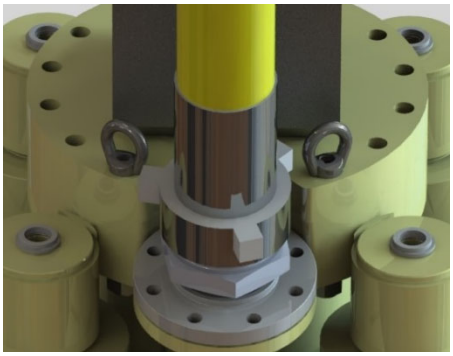
Reference Keystone TSB 2101 – HOSE SAFETY RESTRAINT INSTALLATION

Item	Type	Hose Size	Part Number
1	Whip Check	2"	604674
		3"	604674
		4"	604675
2	Whip Sock	2"	623173
		3"	622918
		4"	622919

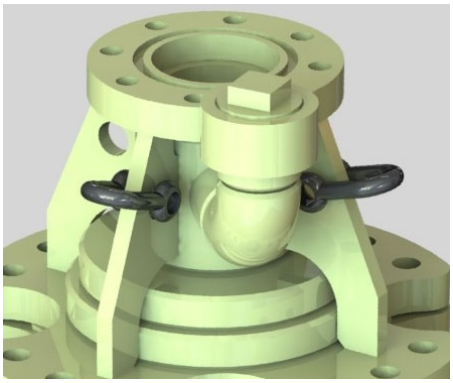
Table 2: Part Numbers for Whip Checks and Whip Socks

Safety Tie-Down Locations

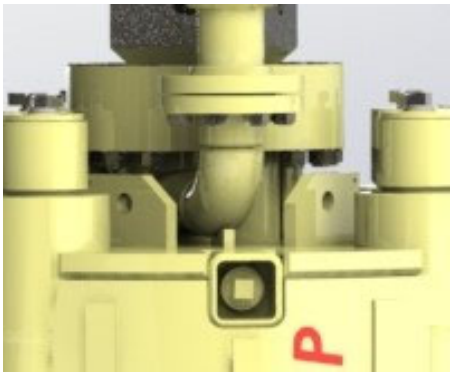
With the various cluster drill designs, the safety tie-down locations and methods differ based on the sizes and design generation. A drawing is created for each method of tie-down and identify the type of cluster drills they cover. The drawing references below are located in Appendix A: TSB 2201 – CLUSTER DRILL SAFETY TIE-DOWN LOCATIONS.



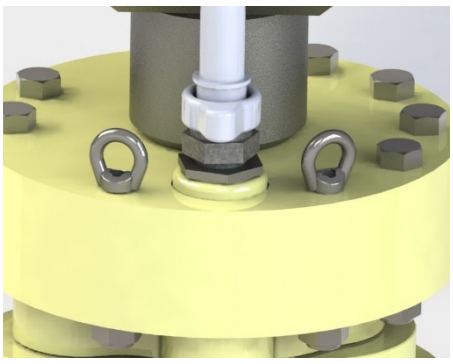
KDT00001: EYE-NUT SAFETY TIE-DOWN
Tie-down method for 2nd Generation cluster drills
Cluster drills 30” to 36”



KDT00002: DRIVE FLANGE SAFETY TIE-DOWN
Tie-down method for 1st Generation cluster drills
All cluster drills that utilize a drive flange



KDT00003: GENERATION 2 SAFETY TIE-DOWN
Tie-down method for 2nd Generation cluster drills
Cluster drills 42” and larger



KDT00004: EYE-NUT SAFETY TIE-DOWN
Tie-down method for 2nd Generation cluster drills
Cluster drills 24” & 26”

Lubrication

HP Cluster Drills should be operated with constant lubrication. Even a few minutes of dry operation generates intense heat that can cause damage to the hammers and/or shorten the lifespan of the hammer. Keystone recommends our Venturi Style lubricator which has no moving parts and connects in-line with the air stream. Before operating the HP Drill for the first time, it is important to flow air and oil (while bits are in the blow position) through the piping/hose system and HP Cluster Drill until oil droplets or mist is observed in the exhaust. If using water injection, always flow lubricated air through the drill for at least ten minutes after water is discontinued. This will clear residual moisture and coat the drill parts with oil, preventing rust. A general rule of thumb is to flow ½ gallon of oil per 1,000 SCFM of dry air. Double this rate when using water injection (1 gallon of oil per 1,000 SCFM of air with water injection).

Figure 16: 12 Gallon, Venturi style Lubricator

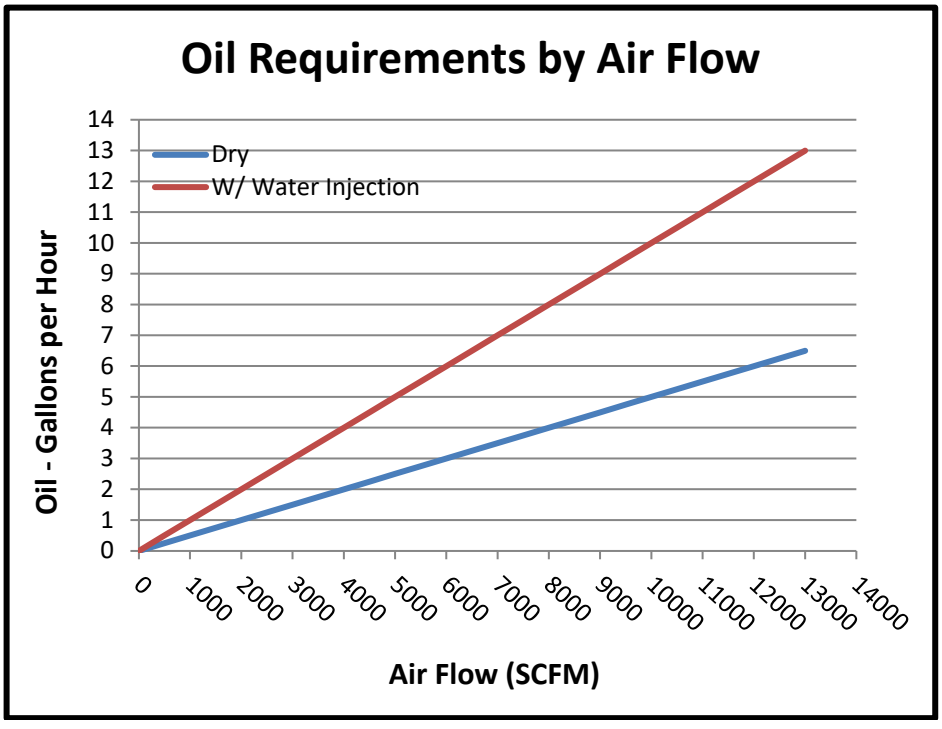
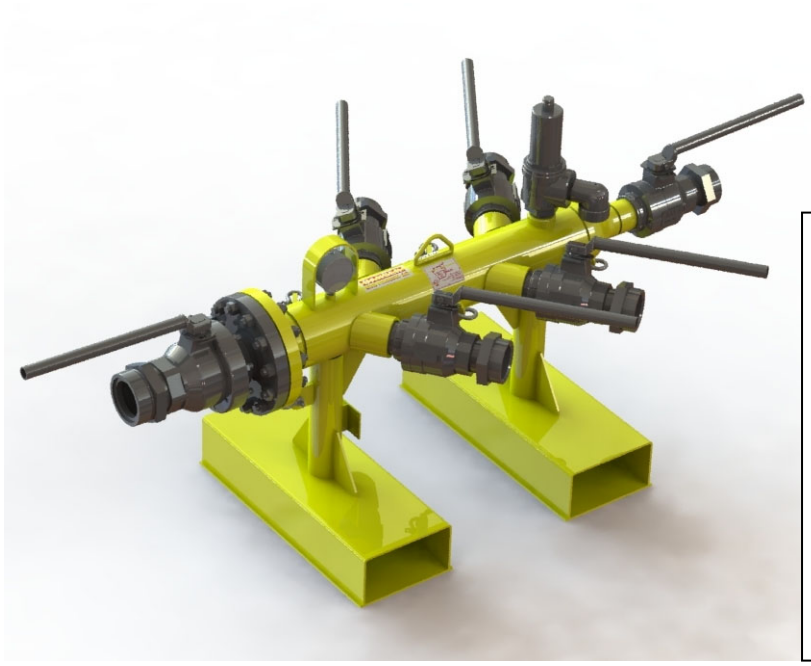


Figure 17: Oil Requirements by Air Flow

Air Manifold

Most HP Cluster Drills will require the use of multiple air compressors that are combined using an Air Manifold.



Manifolds should be rated for the proper pressure and temperature and should also be ASME Certified and National Board Registered for safety.

Figure 18: Air Manifold

Water Injection

Water Injection is often utilized in controlling dust and aiding in hole cleaning. Water Injection should be added to the air stream after the Lubricator.

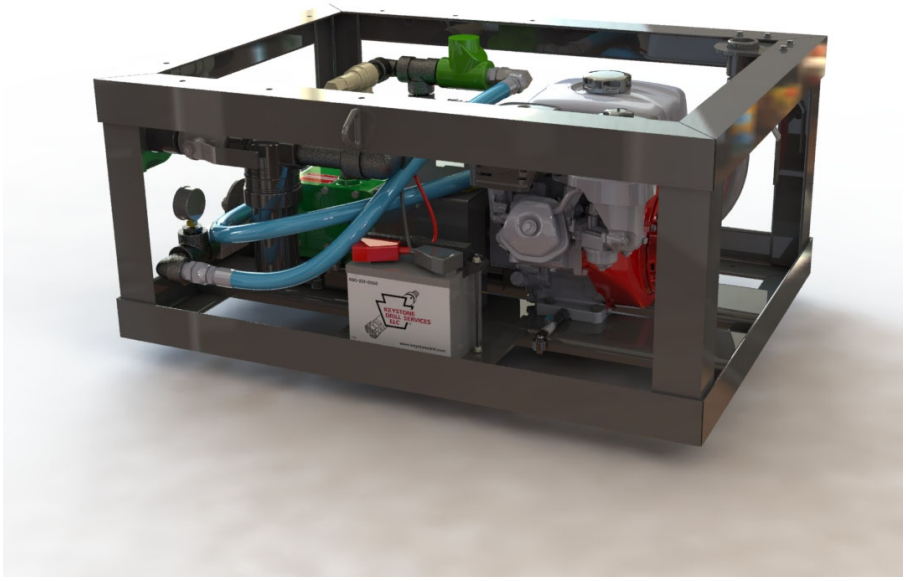


Figure 19: Water Injection System

The use of water, while required in most cases, does reduce component life. To prevent further problems, all water injected should be pH neutral and free from particle contamination. Water present at the impact face of the piston/bit causes cavitation of the bit and piston and jetting or cutting of the exhaust tube, reducing component life. Cluster Drills operated with water injection require drying and lubrication before any period of inactivity which is accomplished by running air/oil through the drill in blow position for several minutes.

Keystone Support Module

The Keystone Support Module is a combination of Air Manifold, Lubricator, and Water Injection combined in one package on a single point lift frame. The Module drastically reduces time in moving equipment and reduces pressure loss by eliminating the air hose between the air manifold and lubricator.

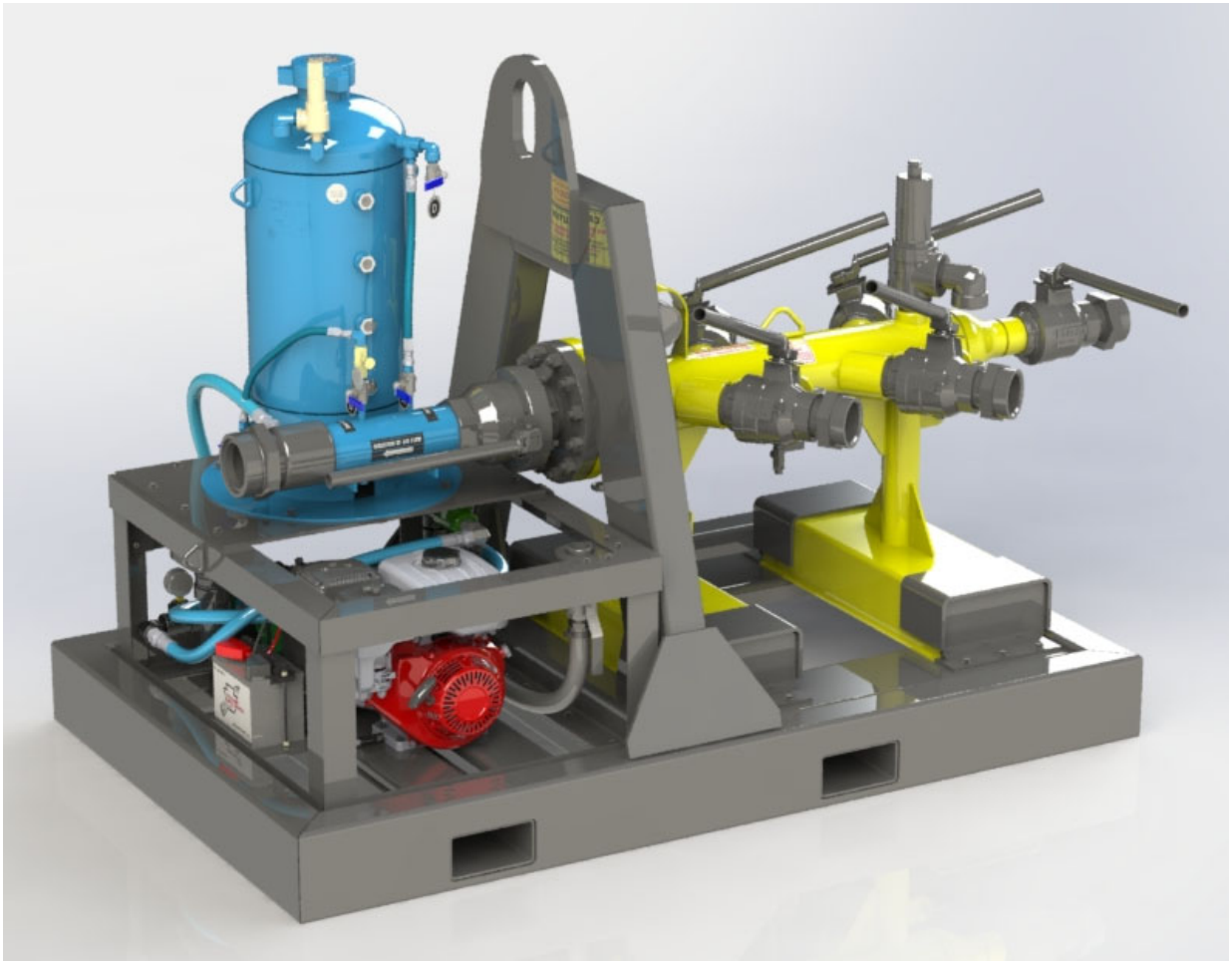


Figure 20: Keystone Support Module

Recommended Accessory Order/Layout

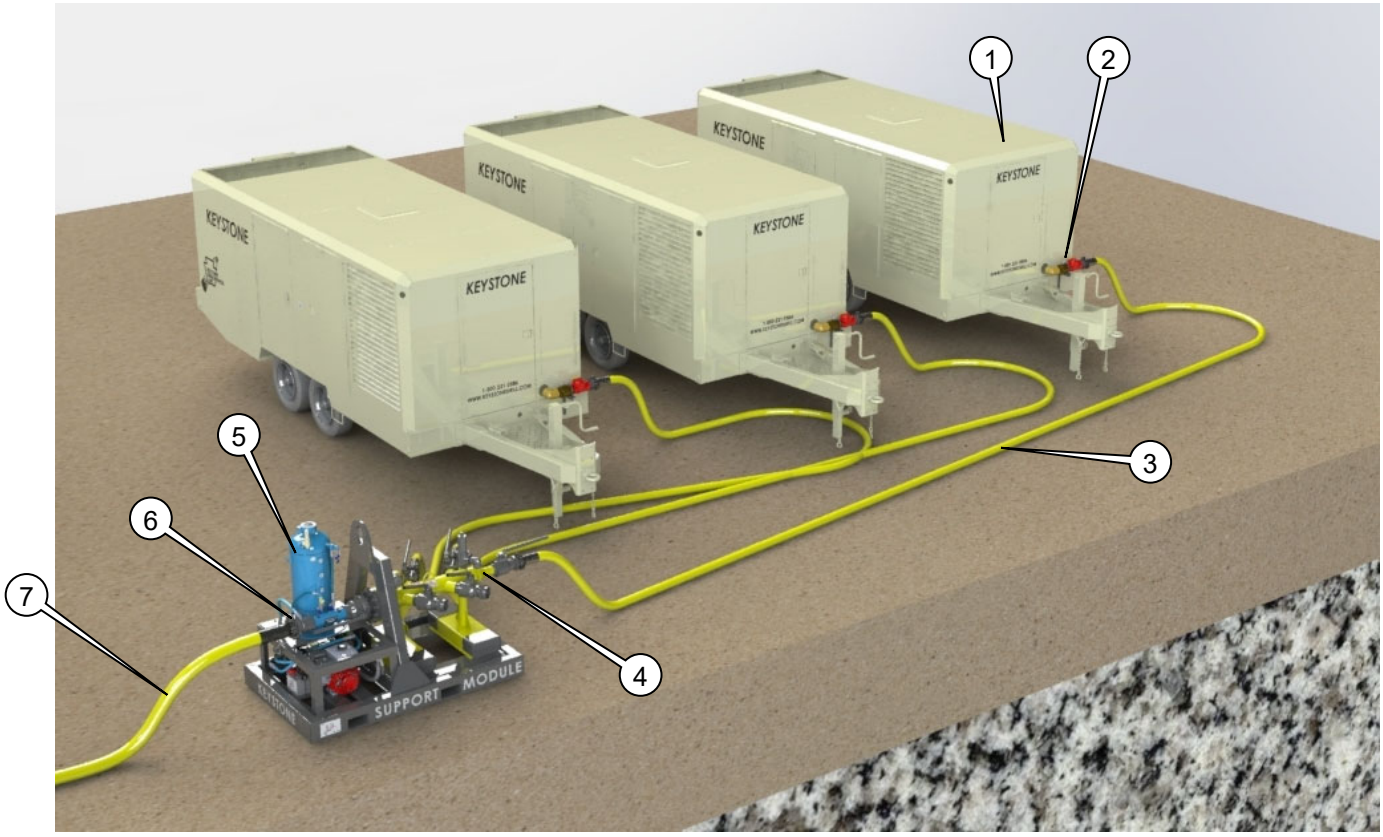


Figure 21: Recommended Accessory Order/Layout

Items in Figure 21:

1. Air Compressor
2. Check Valve
3. Air Hose (Compressor to Manifold)
4. Air Manifold
5. Lubricator
6. Water Injection
7. Air Hose to Cluster Drill or Swivel

Tool Kit

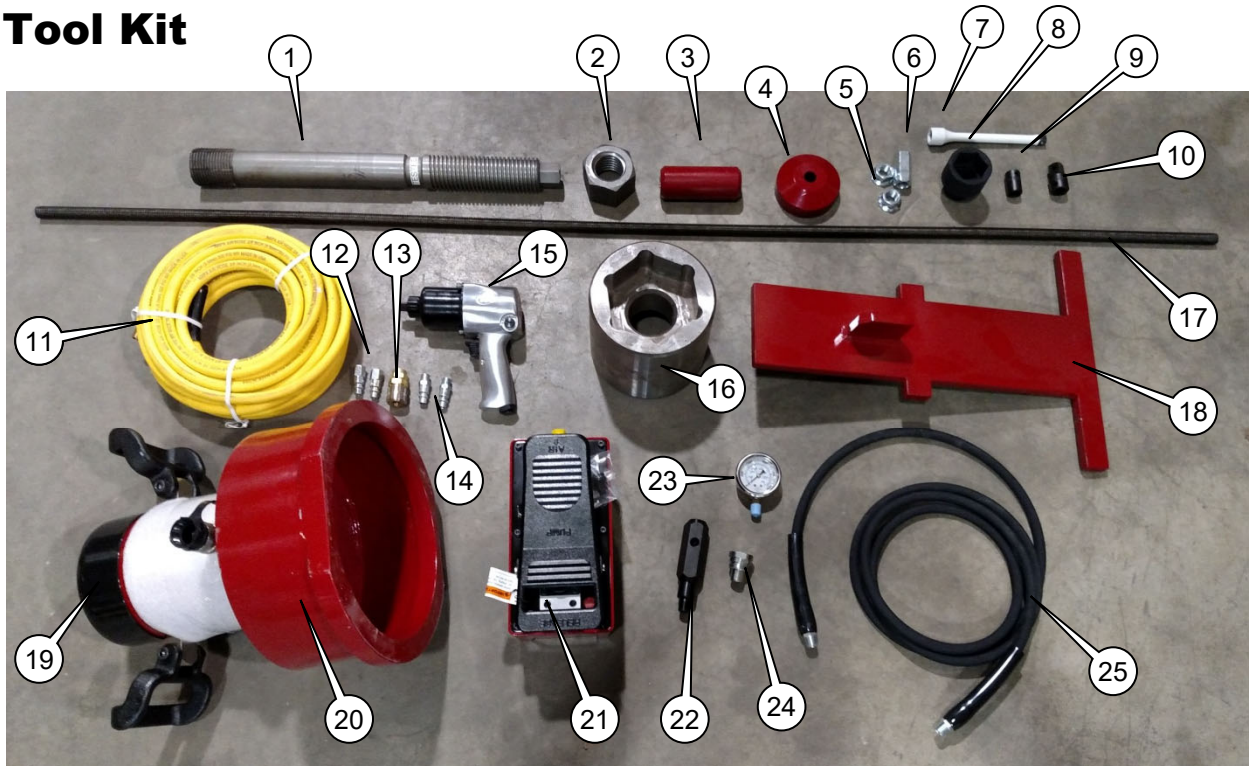


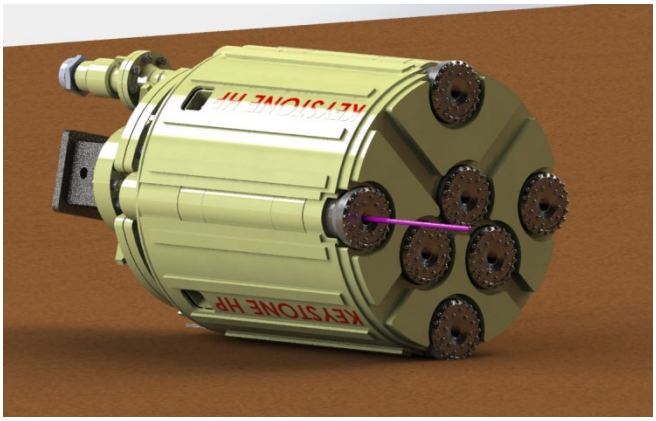
Figure 22: Tool Kit

ITEM #	PART #	DESCRIPTION	QTY	UOM
1	623181	DRAWBAR, CS8 CD, BIT REMOVAL, 7/8" HOLE	1	EA
2	619933	NUT, DRAWBAR, CS8, BIT REMOVAL	1	EA
3	623085	ROD BUSHING, BIT ALIGNMENT	1	EA
4	623084	TOOL, ALIGNMENT, BIT	1	EA
5	623080	NUT, FLANGE, 3/4"	2	EA
6	623138	COUPLING NUT, 3/4" - 10, 2-1/4" L, ZINC	1	EA
7	623087	TORQUE EXTENSION, 120 FT/LB, 1/2" DRIVE	1	EA
8	623086	SOCKET, IMPACT, 3/4" DRIVE, 1-7/8", WW	1	EA
9	623089	SOCKET, IMPACT, 1/2" DRIVE, 9/16", PROTO	1	EA
10	623088	ADAPTER, 1/2" X 3/4", PROTO	1	EA
11	623091	HOSE, AIR, 50', 3/8" I.D., SPEEDAIRE	1	EA
12	430025	DYNAFLO 3/8" X 1/4" FNPT QUICK DISCON	2	EA
13	623093	FITTING, HYDRAULIC, HANSEN 4000	1	EA
14	430028	DYNAFLO 3/8" X 1/4" MNPT QUICK DISCON	2	EA
15	623090	WRENCH, IMPACT, 1/2", IR	1	EA
16	622680	TOOL, BACKHEAD REMOVAL, CS8	1	EA
17	623079	ROD, THREADED, ZINC, 3/4" - 10, 6'	1	EA
18	623081	HAMMER PULLER, T-ROD	1	EA
19	623078	CYLINDER, HYD., 60 TON, 3", S/A, BVA	1	EA
20	623082	ADAPTER, CYLINDER, BIT PULLER	1	EA
21	623075	PUMP, AIR ACTUATED, 10,000 PSI, BVA	1	EA
22	623076	FITTING, GAUGE, 1/4", NPT, BVA	1	EA
23	623092	GAUGE, 10,000 PSI, PRO-201L-254U	1	EA
24	623094	FITTING, HYDRAULIC, STUCCI	1	EA
25	623077	HOSE, AIR, 10', 3/8" NPTF, .25", BVA	1	EA
N/A	623028	TOOL BOX, 48", CLUSTER DRILL ACCESSORIES	1	EA

Table 3: Parts list for Tool Kit

Bit Removal (Quick Change)

Bit removal in the field is possible with the Quick Change option installed in the hammers.



Install all-thread by screwing into tapped hole in Backhead.

Figure 23: Bit Removal: All-thread installed

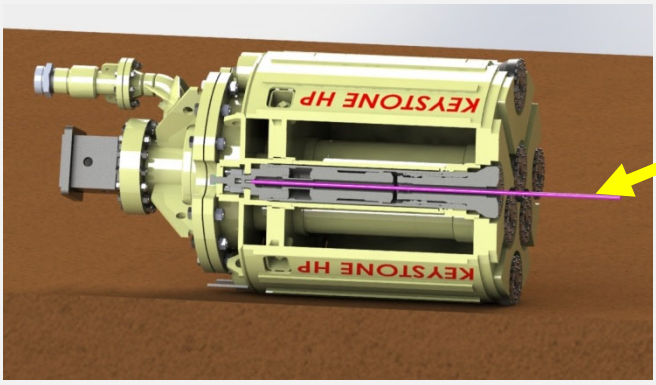
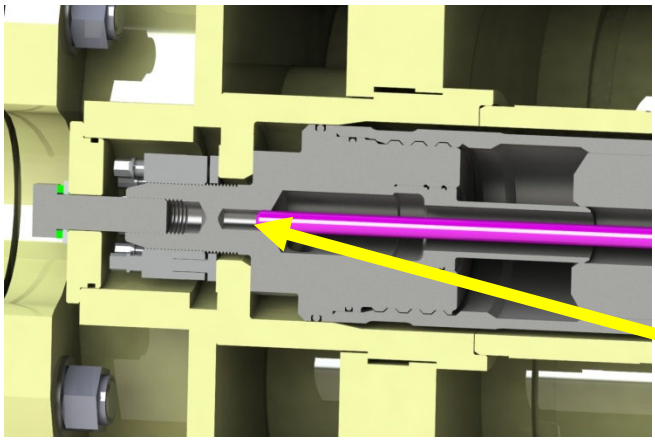
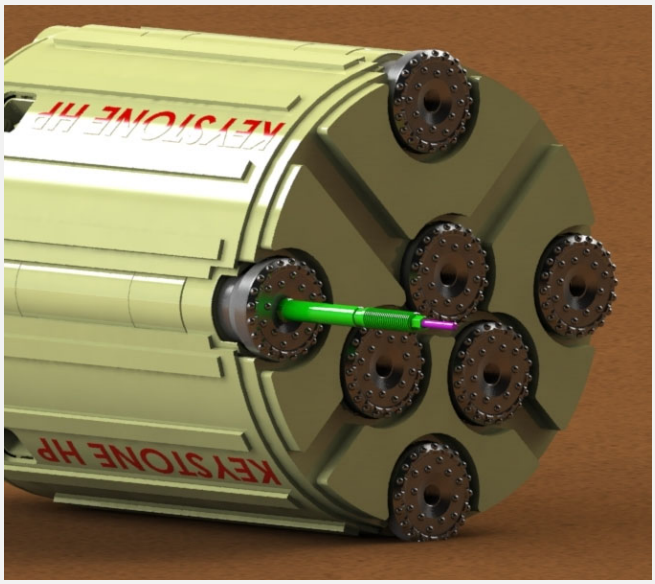


Figure 24: Bit Removal: All-thread installed (cutaway)



Do not screw all-thread in the entire way, only 6 turns are necessary once thread is engaged.

Figure 25: Bit Removal: All-thread installed (cutaway close up)



Install the drawbar by screwing in the larger thread into the bit exhaust. Often times the bit will have built up mud/debris that can be removed by screwing the bar in and out. There are grooves in the threads to allow debris to exit. Screw the bar in until it stops and then back out a quarter turn.

Figure 26: Bit Removal: Drawbar installed

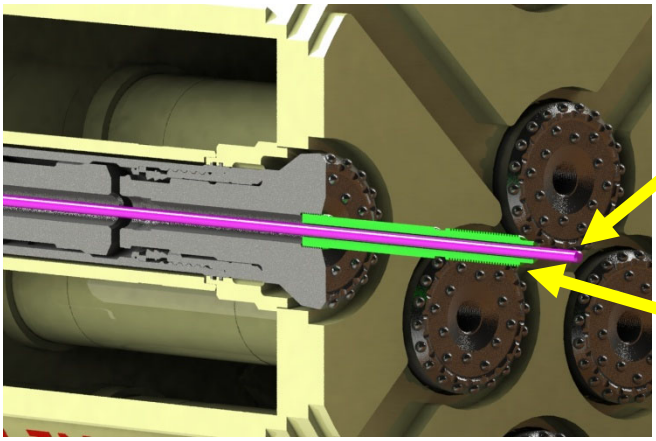
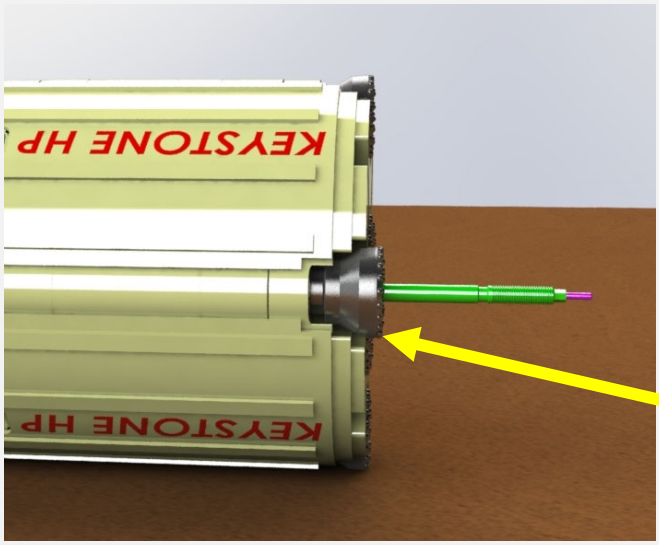


Figure 27: Bit Removal: Drawbar installed (cutaway)



Pull bit out to full extension where bit contacts the catch.

Bit extended

Figure 28: Bit Removal: Drawbar installed; bit extended

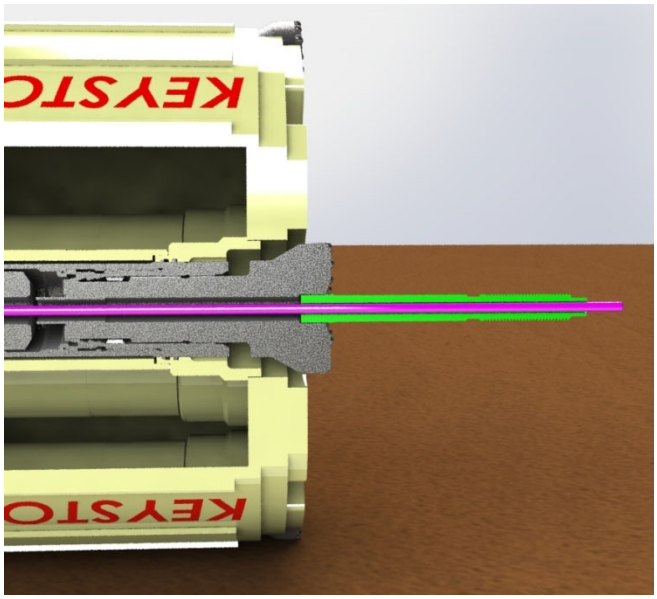
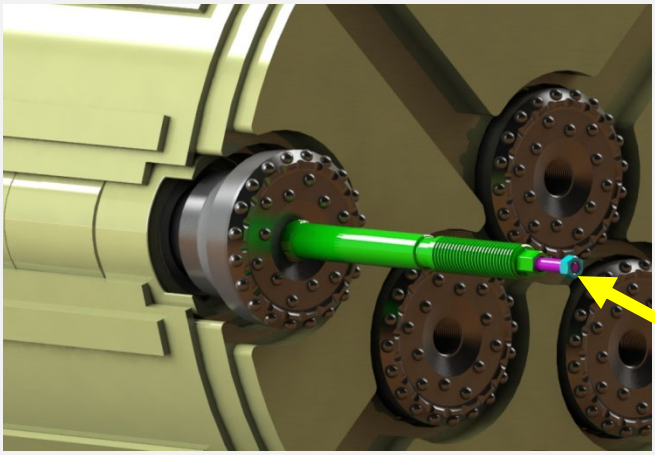


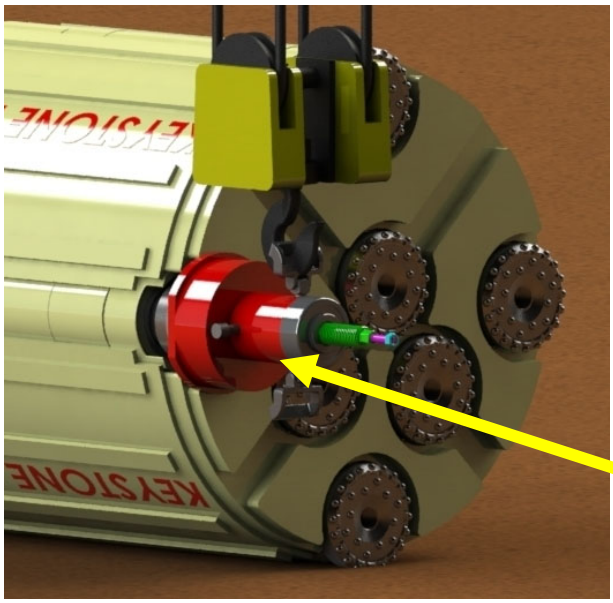
Figure 29: Bit Removal: Drawbar installed, bit extended (cutaway)



Screw on the ¾" nut on the end of the all-thread. This is the safety catch to prevent bit ejection.

¾"-10 Nut

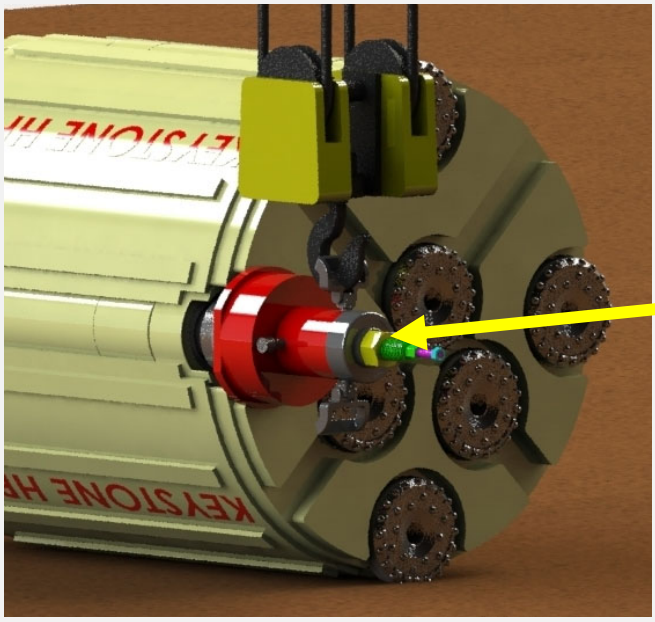
Figure 30: Bit Removal: Drawbar installed, bit extended, safety catch nut installed



Use a crane to install bit removal cylinder over drawbar

Hydraulic Cylinder

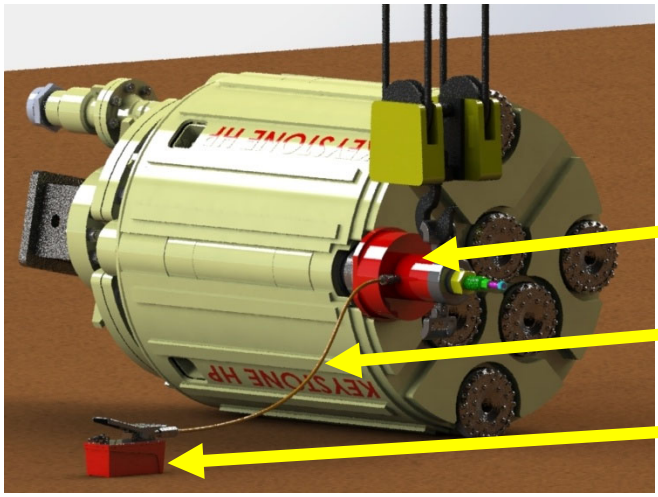
Figure 31: Bit Removal: Cylinder and Acme Nut Installed



Screw on the acme nut hand tight.

Drawbar acme nut

Figure 32: Bit Removal: Cylinder and Acme Nut Installed



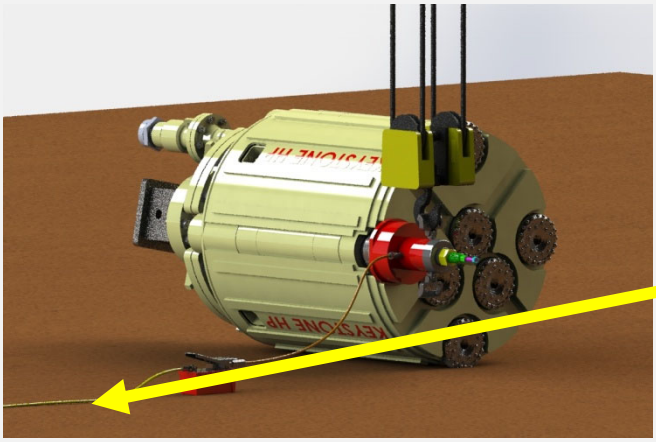
Attach hydraulic line from foot pedal to cylinder.

Hydraulic Cylinder

Hydraulic Hose

Foot Pedal

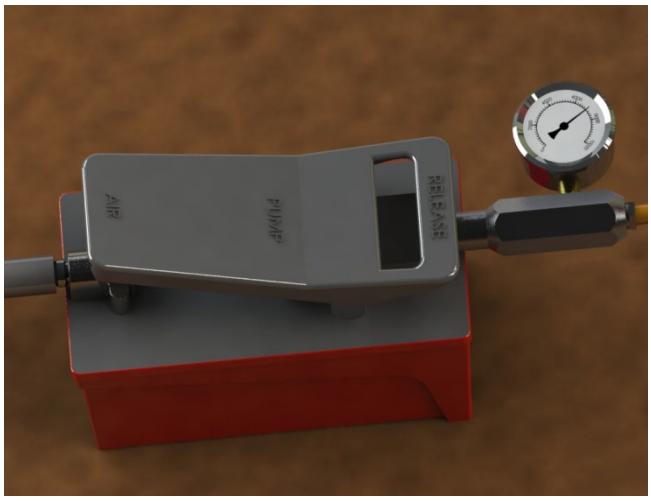
Figure 33: Bit Removal: Hydraulic line connected



Attach air line from compressed air source to foot pedal.

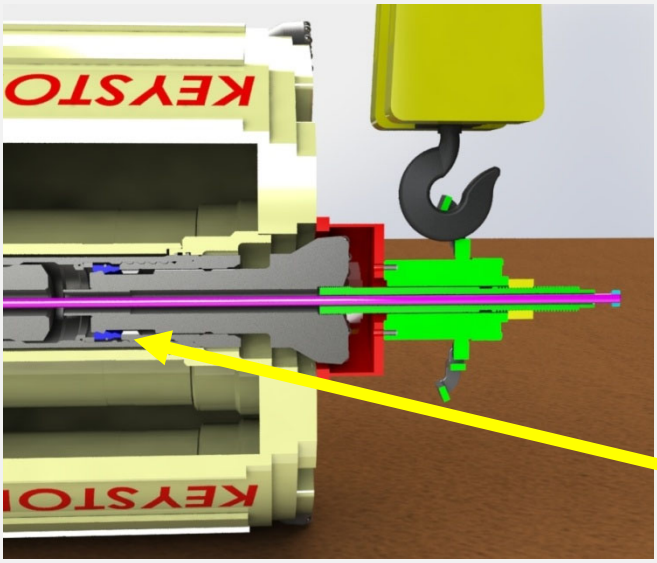
Air Hose

Figure 34: Bit Removal: Air line connected



While standing to the side and ensuring all personnel are not standing in front of the bit, depress the air/pump side of the foot pedal until two loud snaps are heard. The pressure on the gauge will build (up to 8500psi) and sharply decrease with each snap. If pressure builds greater than 8500psi, release and try again. If bit does not pull, the hammer will need removed and chuck removed with a scorpion.

Figure 35: Bit Removal: Foot Pedal close up



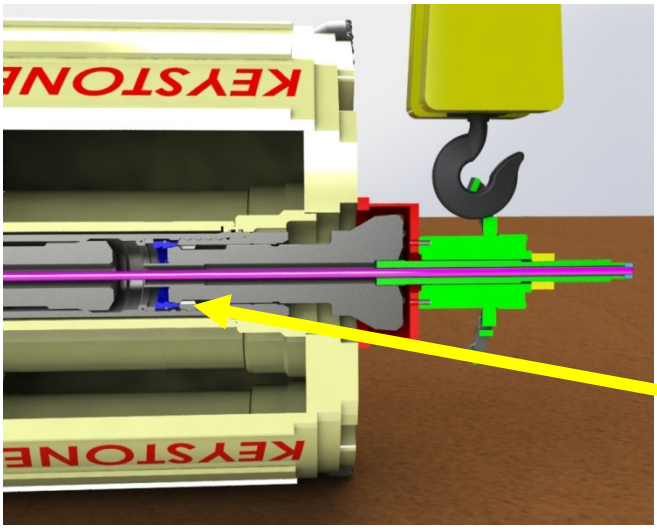
⚠ ⚠

Never stand in front of bit when removing bit. Stand to side of HP Cluster Drill when depressing foot pedal.

⚠ ⚠

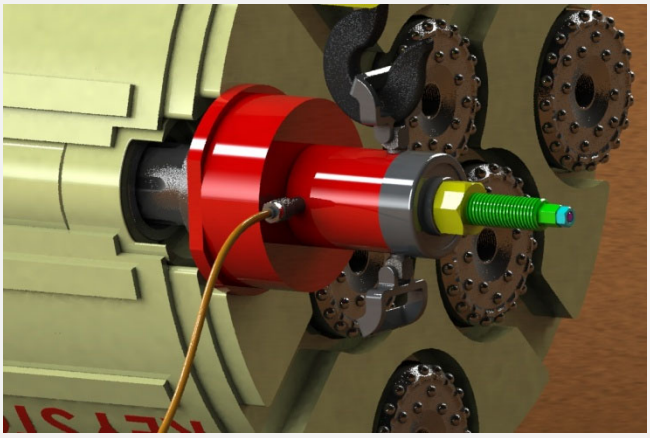
Bit after 1st Catch (Blue)

Figure 36: Bit Removal: Bit after 1st Catch



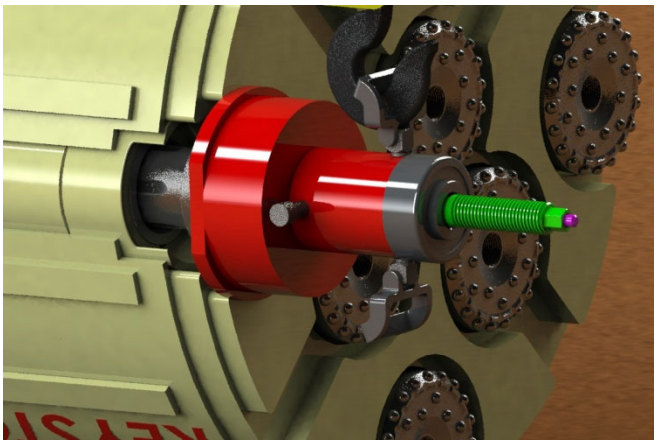
Bit after 2nd Catch (Blue)

Figure 37: Bit Removal: Bit after 2nd Catch



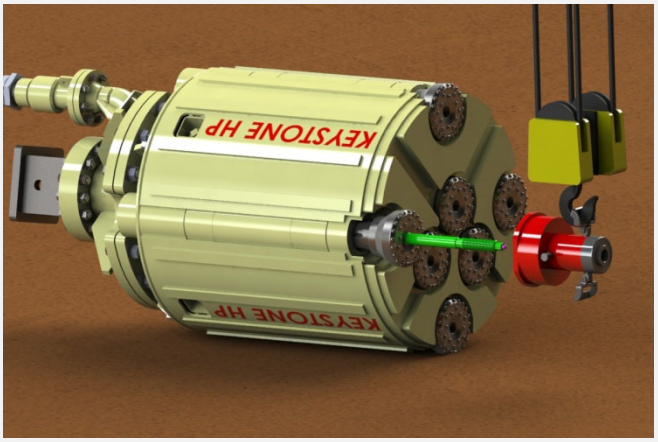
After bit is through the final catch, the drawbar should be near or contacting the ¾" safety catch nut. Occasionally, the bit will come through the final catch and through the splines. The nut is to ensure the bit does not eject.

Figure 38: Bit Removal: Bit after 2nd Catch (2)



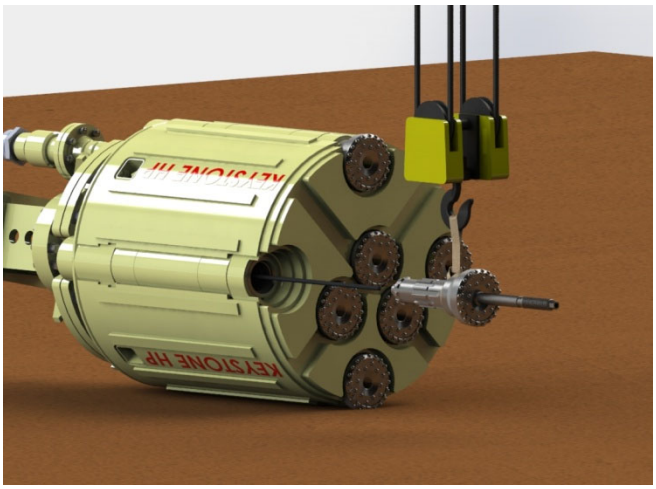
Detach hydraulic line from cylinder. Slowly remove ¾" Nut as there may be some residual spring force from the catch if the all-thread is screwed in too far. Remove the acme nut.

Figure 39: Bit Removal: Remove ¾" Nut and Acme Nut



Remove cylinder from bit and drawbar using a crane or other lifting device.

Figure 40: Bit Removal: Remove Cylinder



Remove bit from hammer using a crane or other lifting device.

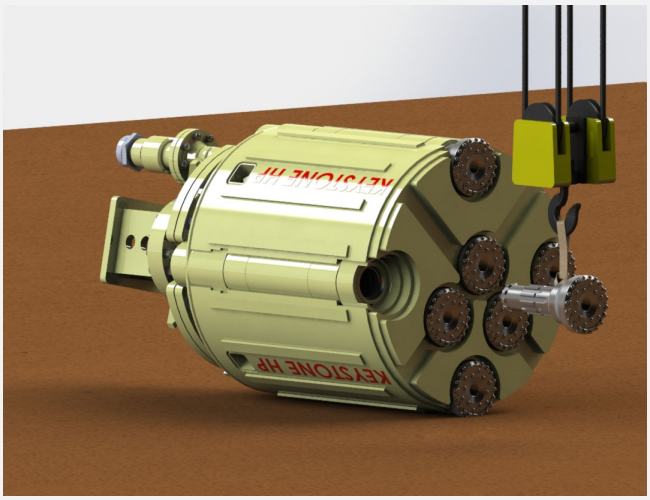
Figure 41: Bit Removal: Remove Bit

Finally, remove all-thread by unscrewing from backhead.

Figure 42: Bit Removal: Remove All-Thread

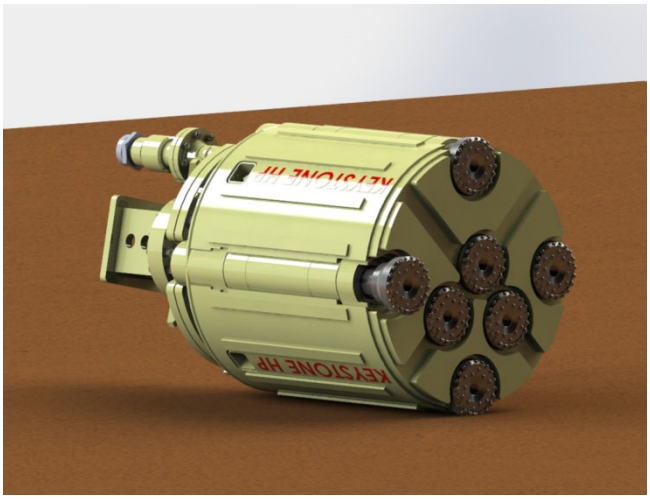
Bit Installation (Quick Change)

Bit installation in the field is possible with the Quick Change option installed in the hammers.



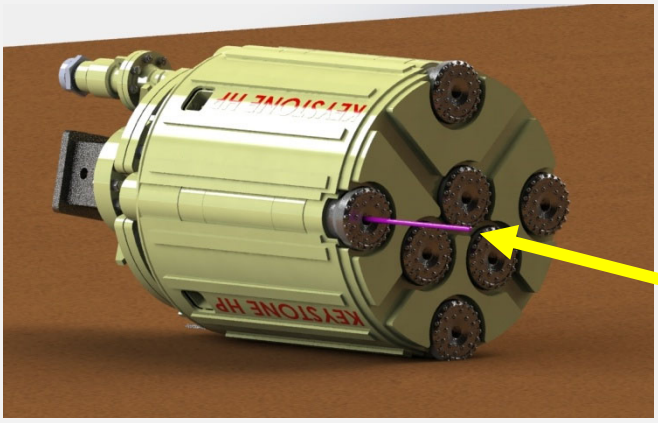
Slide bit into hammer using a sling and crane.

Figure 43: Bit Installation: Install Bit



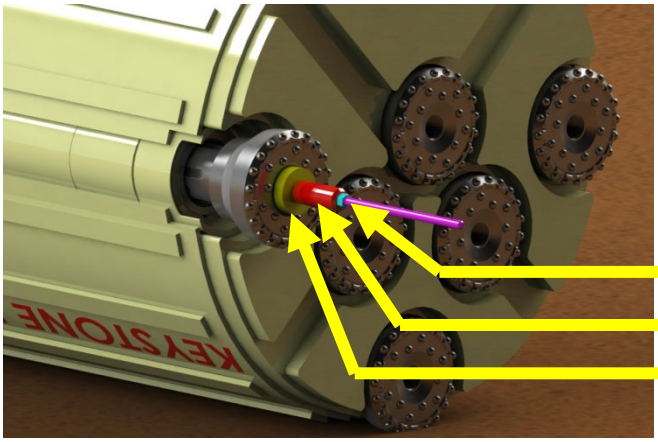
Rotate bit while applying pressure until bit splines slide passed chuck splines.

Figure 44: Bit Installation: Pass Chuck Splines



Install all-thread through bit exhaust and screw into backhead tapped hole.

Figure 45: Bit Installation: Install All-Thread



Install bit installation tools over all thread. This includes the bit alignment tool, rod bushing, and ¾” nut.

Figure 46: Bit Installation: Install Bit Installation Tools

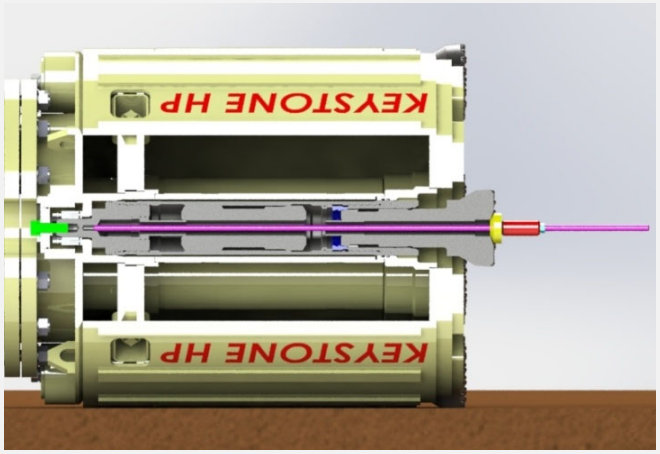
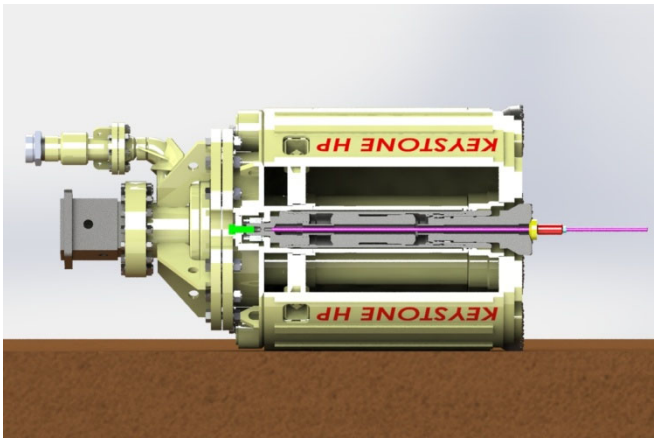
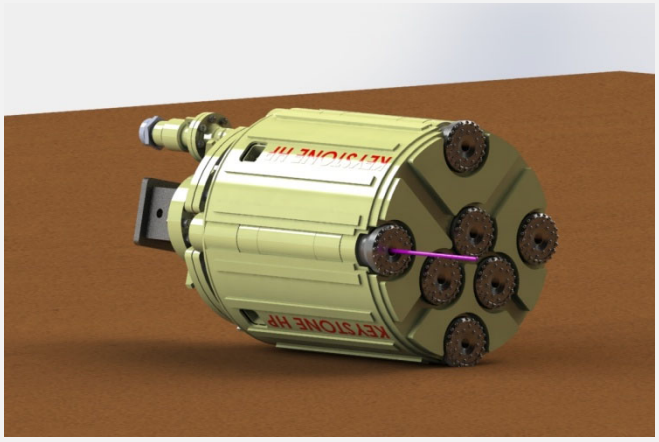


Figure 47: Bit Installation: Bit Installation Tools (Cutaway)



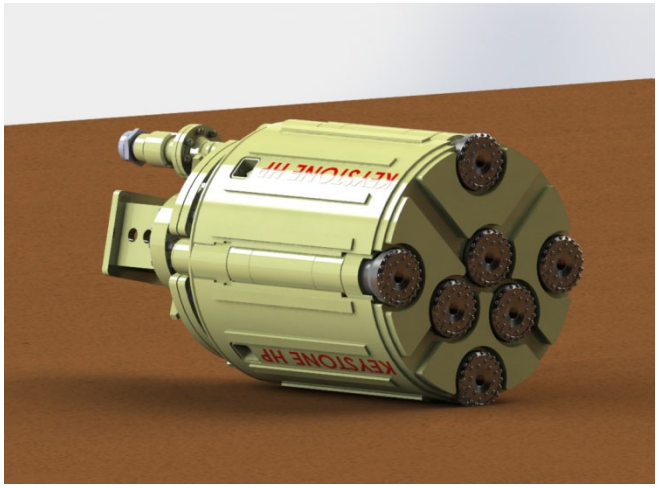
Rotate ¾” nut with wrench until three snaps are heard and the bit is able to slide in freely.

Figure 48: Bit Installation: Installed passed catches



Remove ¾” nut and bit installation tools.

Figure 49: Bit Installation: Bit Installation tools removed



Remove ¾” all-thread. Ready for drilling.

Figure 50: Bit Installation: All-thread removed

Drilling Tips

1. When initiating drilling after a period of inactivity, it is important to establish an oil film in the air line and tools. Flow lubricated compressed air through the drill with the bits hanging until oil is observed beneath the blow holes. Cardboard or wood placed beneath the blow holes give a good indication when oil is passing through the drill.
2. Initiate rock socket by setting the drill on bottom, without rotation, until hammers stop firing. Pick up, rotate slightly, and repeat. Continue until drill is securely collared in rock socket.
3. New chuck and bit splines may rest on each other when bottoming the drill preventing the bit from reaching firing position. While maintaining down force, slowly rotate drill until splines align allowing bits to slide into firing position. Once broken in, bit and chuck splines should align automatically with down force.
4. When starting on sloped rock, it is often easier to collar a hole with a core barrel and auger. Rock sockets need to be deep enough to prevent the HP Cluster Drill from “walking” during hole collaring.
5. Limit HP Cluster Drill operation in soil or loose material as this will cause hammers to fire without solid rock backing. This will shorten the life of bit and hammer components.

Troubleshooting

Trouble	Probable Cause	Remedy
Drill will not start	1. Low air pressure. 2. Plugged bits. 3. Dirty drills. 4. Worn or damaged drill bits. 5. Insufficient lubrication. 6. Excessive lubrication.	1. Increase compressor discharge pressure. 2. Clean bits. 3. Clean drills. 4. Overhaul drills. 5. If drills are receiving adequate lubrication, a fine film of oil is evident on bit splines and exhaust ports. Check oil level in reservoir and refill if necessary. Adjust lubricator to provide adequate supply of lubricating oil. 6. Adjust lubricator valve for proper rate of oil flow.
Insufficient hole cleaning	1. Low air pressure. 2. Low up hole bailing velocity. 3. Dirty hammer and plugged bit exhaust port.	1. Increase compressor discharge pressure. 2. Increase air flow. Use can rod to reduce hole annular area. 3. Clean bit and hammer.
Sporadic operation	1. Dirty hammer and plugged bit. 2. Worn or damaged parts. 3. Broken bit. 4. Insufficient or excessive lubrication.	1. Clean hammer and bit. 2. Overhaul drill. 3. Repair or replace bit. 4. Check oil level in reservoir and refill if necessary. Adjust needle valve for proper rate of oil flow.
Low penetration rate.	1. Low air pressure. 2. Leaking backhead o-rings. 3. Dull bit 4. Dirty hammer. 5. Worn or damaged drill parts. 6. Insufficient lubrication or excessive lubrication.	1. Increase compressor discharge pressure. 2. Replace o-rings. 3. Grind bit. 4. Clean hammer. 5. Overhaul drill. 6. Check oil level in reservoir and refill if necessary. Adjust needle valve for proper rate of oil flow.

Storage

For long-term storage, Keystone recommends the following:

1. If using biodegradable oil, switch to Super-Tac rock drill oil (Light or Medium) and run the drill, without water injection, to drive off as much moisture as possible and to coat the drill internals with oil.
2. Run the drill until oil is observed emerging from each hammer. (Never get under a cluster drill to examine the exhaust air. A piece of cardboard can be inserted under the bits to check for lubrication being carried through the drill.)
3. When storing in conditions below freezing temperatures, the Cluster Drill should be stored in the upright position.
4. All air inlets should be covered or sealed.

Part Number	Description	Storage Temp
609051	OIL, HAMMER, SUPERTAC LIGHT, 5 GALLON	Below 20°F
605547	OIL, HAMMER, SUPERTAC MEDIUM, 5 GALLON	Above 20°F

Keystone Drill Services, Inc.
184 Alisa Street
Somerset, PA 15501
Ph# 800-221-0586
Ph# 814-443-2670
Fax# 814-443-6974
E-mail: sales@keystonedrill.com
www.keystonedrill.com

Inspection

Cluster Drill Can Inspection

Cluster drill can weld inspections should be made periodically. Also, maintenance of the wear strips and wear plates is an important step in ensuring the life of the can. These strips protect the pressurized modules. Routine hard facing is required. Reference the *Service* section on *page 47* for hard-facing information.

Figure 51: Hard Facing Example

Check Valve Inspection

Whenever possible, it is important to inspect the condition of the check valve. The check valve function is to ensure that there is not an influx of debris into the tools. Test the check valve by holding it upright and depressing the “flapper seal” to visually ascertain the seal is closing completely. Always thoroughly clean and oil the check valve before installing into the can.

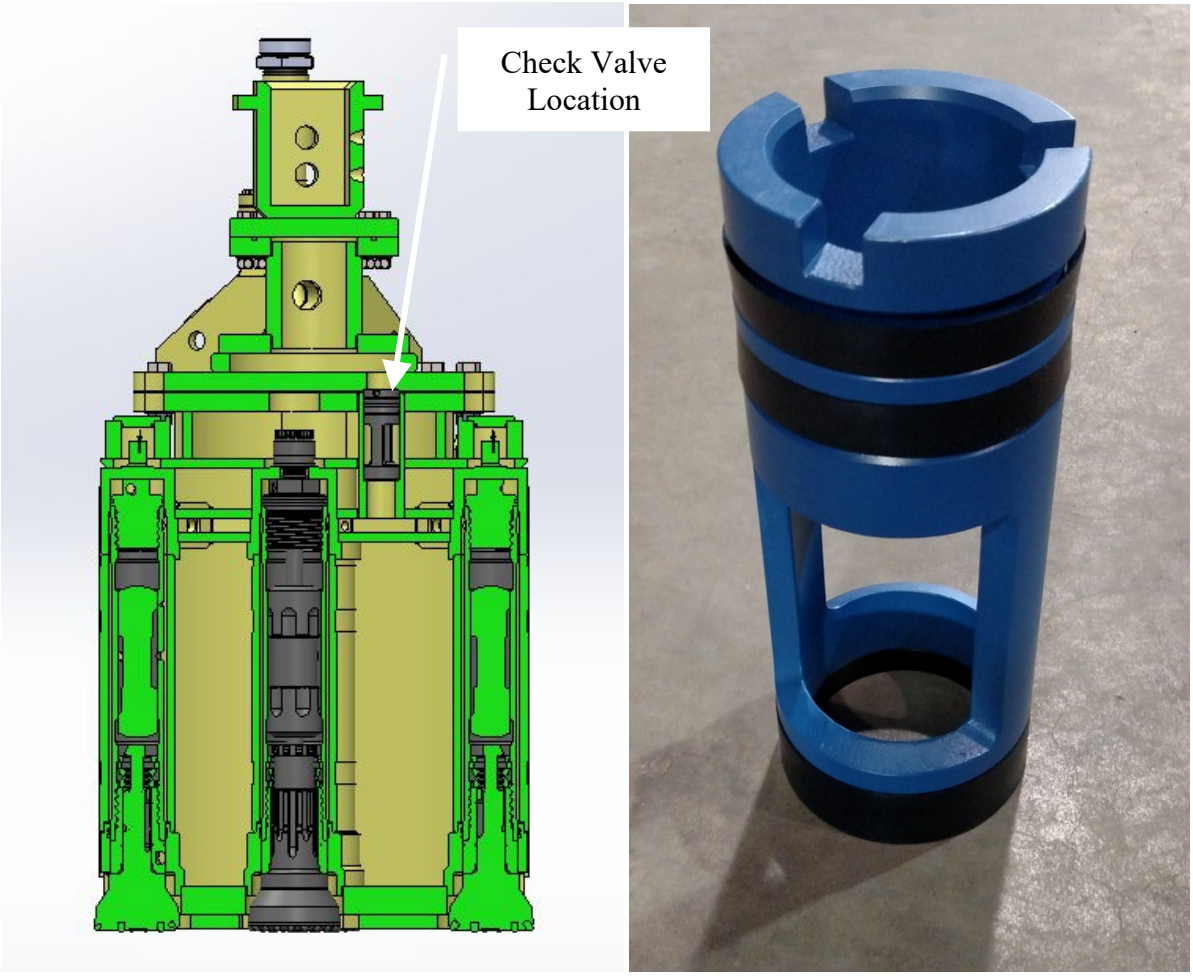


Figure 52: Check Valve Inspection

Hammer Inspection

Make periodic hammer inspections to ensure the hammers are at maximum operating condition. As the gauge row hammers are doing the most work, they should be the best performing. Proper maintenance will ensure this is the case.

Bit Inspection

Maintaining the gauge of the drilled hole is critical on a cluster drill job. Inspect bits each time the can is removed from the hole to ensure that the gauge row is being maintained. Replace or repair any bits with excessive wear.

Bits need to be sharpened and serviced just like any other cutting tool would. The sharper a bit insert is, the faster you will penetrate and the longer your bit will last. A sharper insert will penetrate deeper and generate larger cuttings. The stresses on a sharp insert are lower than those on a dull insert. Lower stresses mean longer insert life and reduced risk of failures.

Sharpen inserts whenever the flat size becomes greater than ¼" using a handheld grinder or water-cooled cup grinder. Sharpen the gauge inserts to ensure pinching does not take place. The cause of carbide pinching is by a wear flat on the side rather than the tip of the insert. This form of wear can lead to carbide fractures if not corrected.

Service

Clean up and Disassembly

Before disassembling the canister, pressure wash the exterior of rock, dirt, and mud. Tipping the can at a slight angle with the bit end down to not force water or dirt up the bit splines or blow hole of the bit. This is the best way to keep from washing dirt up into the hammers.

Hard-face Welding

Hard-facing can increase the overall life of your equipment by reducing the amount of wear on the skin of your drill. While hard-facing is beneficial for reducing wear, it is important to apply it properly and is typically done so when the drill exterior is relatively worn. Please adhere to the following:

- DO NOT cross existing welds
    - Crossing over structural welds of the drill will increase material stresses and increase the potential for future cracking
- DO NOT hard-face the hammer modules, or the wear bars overlapping the hammer modules (if equipped)
    - Applying extra material to these surfaces may create a contact point against the inside of the hole
- DO NOT hard-face within ½" of any structural welds to include hammer module seams and face plate seams
- Preheating is not required, however, ensure the base material is 70-80°F prior to applying hard-face
    - Hard-face preheating requirement is driven by the base material's welding requirements
    - Due to low preheating requirements, hammer removal is not necessary
- Main locations for hard-facing include the outer surface of the wear bars and the bottom surface of the base plate on the drill
    - If the base plate exhibits excessive wear, the side, or outer diameter, of the base plate may also include hard-face within the bottom 3" of the drill
        - If hard-facing the side of the base plate, be cautious not to cross the seam weld of the base plate, as it may be difficult to identify when worn
    - DO NOT hard-face the skin of the drill between the wear bars

- The patterns for applying hard-face should be lines parallel to existing seams (when applicable) or patterns that do not cross
    - No checker or diamond patterns
    - Beads should be spaced ½" to ¾" apart
    - Examples shown below:
    -

Figure 53 – Proper pattern on base plate

Figure 54 – Incorrect pattern on base plate

Figure 55 – Proper pattern on wear bars

Figure 56 – Incorrect pattern on wear bars

Appendix A

TECHNICAL SAFETY BULLETIN

TSB No. 2201	**STATUS:** REVISION 1
SUBJECT: CLUSTER DRILL SAFETY TIE-DOWN LOCATIONS	
PRIORITY: 1-SAFETY	**RELEASE DATE:** 01/21/22

KEYSTONE TECHNICAL BULLETIN INFORMATION

The bulletin was established to provide air inlet safety tie-down locations for various cluster drill models and generations of designs. The methods noted in the drawings are to be used to restrain air hose whip socks at the cluster drill air inlet.

BULLETIN DETAILS

With the various cluster drill designs, the safety tie-down locations and methods differ based on the sizes and design generation. A drawing is created for each method of tie-down and identify the type of cluster drills they cover.

KDT00001: EYE-NUT SAFETY TIE-DOWN
Tie-down method for 2nd Generation cluster drills
Cluster drills 30” to 36”

KDT00002: DRIVE FLANGE SAFETY TIE-DOWN
Tie-down method for 1st Generation cluster drills
All cluster drills that utilize a drive flange

KDT00003: GENERATION 2 SAFETY TIE-DOWN
Tie-down method for 2nd Generation cluster drills
Cluster drills 42” and larger

KDT00004: EYE-NUT SAFETY TIE-DOWN
Tie-down method for 2nd Generation cluster drills
Cluster drills 24” & 26”

The drawings noted above are attached to this TSB for reference.

RELATED EQUIPMENT

Keystone Cluster Drills, Keystone Hole Openers, Keystone Core Barrels