GRUNDOCRACK®

PNEUMATIC PIPE BURSTING SYSTEM

User's Guide & Safety Manual

with replacement parts listings

REVISION 3.0 • 08.16.02

TT Technologies, Inc.

WELCOME GRUNDOCRACK CUSTOMER

This pipe bursting manual is a product of years of actual field experience, from both TT Technologies staff and contractors who have invested in pneumatic pipe bursting. This manual is designed to offer you a basic understanding of pipe bursting operations and safety procedures.

As with other trenchless methods, pipe bursting requires careful planning, preparation, and execution for desired results. Success in pipe bursting is dependent on using the proper equipment and incorporating the user information found in this manual. As in any construction process, quick fixes and oversights can result in failures and lost profits.

TT Technologies' staff has years of experience and offers the largest selection of pipe bursting tools and accessories in the industry. Consult with the TT staff when planning your bursting projects. In turn, please share your job experiences with our staff.

GRUNDOCRACK tools and pneumatic pipe bursting systems are designed to provide you with years of use.

MANUFACTURER'S STATEMENT OF USE

As a manufacturer of trenchless technology equipment for over 30 years, TT Technologies, Inc. does not discriminate against any potential customer. Unlike several pipe rehabilitation product manufacturers, TT Technologies does not license the product which we manufacture, nor do we provide protected territories for our equipment. Method licenses are issued by British Gas, and are required to operate pipe bursting tools.

TOOL LICENSING & ROYALTY REQUIREMENTS

GRUNDOCRACK Pipe Bursting equipment and accessories are subject to an additional 5% royalty charge, not reflected in our pricing. TT Technologies will pass this royalty fee on to British Gas. This royalty charge does not apply to winches or winch booms. As the pipe bursting products are licensed under British Gas patents, you should take this royalty fee into account. Upon purchase of this equipment, a British Gas representative will be contacting you about signing you up as a British Gas method user licensee. For licensee details, contact your British Gas representative:

British Gas c/o Jim Hopwood
5444 West Heimer, Suite #1775
Houston, TX 77056
Phone: 713-622-7176 • Fax: 713-622-7244

Pipe bursting contractors operate under the following method patents: US 4738565, Canada 1195128

As a licensed manufacturer under British Gas equipment patents, TT Technologies operates under the following equipment patents: US 4505302 & 4720211, Canada 1204294

DISCLAIMER FOR BURSTING MANUAL:

NO WARRANTY AS TO MANUAL

TT Technologies makes no warranty that the information provided in this manual is complete, accurate in all respects, or up to date. This manual should be used as a reference work to provide a starting point for addressing pipe bursting situations. Each particular situation is different. The user is responsible for providing the expertise and skill necessary to properly execute a given pipe-bursting job. TT Technologies specifically disclaims all express or implied warranties concerning this manual, including the implied warranties of merchantability and fitness. In no event shall TT Technologies be liable for consequential, special or incidental damages or contingent liabilities (including, without limitation, lost profits or goodwill, whether such claim arises in tort, contract, negligence, strict liability or any other basis) arising in any way out of the use of this manual.

LIMITED WARRANTY AS TO PRODUCTS

TT provides a limited warranty to the original purchaser of its new products that new products will be free from defects in materials and workmanship for 90 days or 500 hours of actual use, whichever occurs first, provided they are properly maintained serviced and used for the intended purpose of the product. (A one year warranty applies to the barrel and piston, otherwise the period is as previously stated.) During the 90 day or 500 hours period, buyer's remedies are limited to repair or replacement, at TT Technologies' discretion.

TT Technologies makes no other warranty, express or implied, and makes no warranty of merchantability or fitness for any particular purpose. No person, representative or agent of TT Technologies has the authority to change this warranty in any manner whatsoever. Any oral or written statements inconsistent with this limited warranty shall not apply.

In no event shall TT Technologies be liable for consequential, special or incidental damages or contingent liabilities (including, without limitation, lost profits or goodwill, whether such claim arises in tort, contract, negligence, strict liability or any other basis) arising in any way out of the use of any product or any parts thereof.

IMPORTANT SAFETY NOTICE

Read all instructions before using the GRUNDOCRACK Pipe Bursting System. Observe all safety information on this page, and note specific safety requirements as explained by procedures called out in this manual. This includes related equipment such as air compressors, digging equipment, etc. Do not deviate from TT Technologies' recommended procedures. Failure to follow these instructions could result in serious personal injury or death. Save this user's guide for future reference.

!CAUTION: Always wear work gloves, safety boots, safety glasses, a hard hat, and hearing protection. Do not wear loose clothing or jewelry; they can become caught in moving parts. Wear high visibility clothing in traffic areas. Keep unauthorized personnel away from the jobsite. In the entry and exit pits, follow all shoring/ sloping procedures as required by OSHA standards.

Favor de leer y comprender todas las instrucciones de operacion y seguridad antes de usar la maquina. Si Ud. no comprende las instrucciones favor de consultarle a su jefe.

WARNING: Electrical equipment is hazardous. Train personnel to use basic safety precautions. Misuse can result in serious personal injury or death.

GRUNDOCRACK Safety Procedures

A. EQUIPMENT MAINTENANCE

Follow the preventative maintenance schedules, and inspect all equipment frequently. Check the winch rope and air hoses for damage. All safety devices must be in place before use. Report any equipment deficiencies.

B. UTILITY LOCATORS

Use joint locating systems before any digging or bursting operations. Damage to surrounding utilities can be costly and dangerous. Contact the utility companies before digging.

C. LIFTING SAFETY

Use proper equipment, slings, and lifting techniques when moving any GRUNDOCRACK hammer, and or accessories.

D. HIGH PRESSURE AIR

Inspect all air hoses for damage and leaks. Never disconnect a hose before the air pressure is relieved. Always secure the GRUNDOCRACK shock valve before testing the air line. Whip checks should be used on all air line connections.

E. GRUNDOWINCH SAFETY

Always secure the GRUNDOWINCH before it is removed from the tow vehicle. Use all four corner jacks before operating the winch. Check all safety devices and never operate the GRUNDOWINCH if a safety device is inoperable. Frayed winch rope is dangerous. Remove and repair any damaged sections of winch rope.

Before transporting the winch, check all towing safety devices, wiring and lights, and the surge brakes for proper operation. Tow the GRUNDOWINCH at a safe speed.

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9. The Bursting Process

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General Information

1.

A. ABOUT TT TECHNOLOGIES, INC.

For more than 30 years, TT Technologies and Tracto-Technik have been leaders in trenchless replacement systems beginning with pneumatic piercing tools. Today, with more than 200 patents worldwide, TT Technologies tools are used in trenchless applications ranging from pipe pulling, pipe ramming, slip-lining, directional drilling and pipe bursting.

The use of pneumatic tools in the pipe bursting application was developed in a joint effort between British Gas Co. and Tracto-Technik, TT Technologies' European counterpart. The quality of this TT Technologies system, combined with the experience of our people will provide you with many years of safe, trouble-free operation of your new GRUNDOCRACK system.

As with all construction operations, safe operational procedures must be observed. The safety alert symbol is used in this manual to advise you of the potential for bodily injury or death.

B. PIPE BURSTING HISTORY

Developed by British Gas, pipe bursting is a "generic" term used to describe a process of cracking or bursting an old pipe, called the host pipe, and replacing it with a new product pipe of the same or larger diameter. This patented process is used to replace sewer, water, gas, storm sewer, telephone, power and chemical production industrial lines (Figure 1).

The GRUNDOCRACK system uses a pneumatic hammer combined with the proper size soil expander and a specially designed winch. The selection of the proper system components is dependent on various job parameters. TT Technologies documents job conditions and equipment usage and maintains this history for customer use.

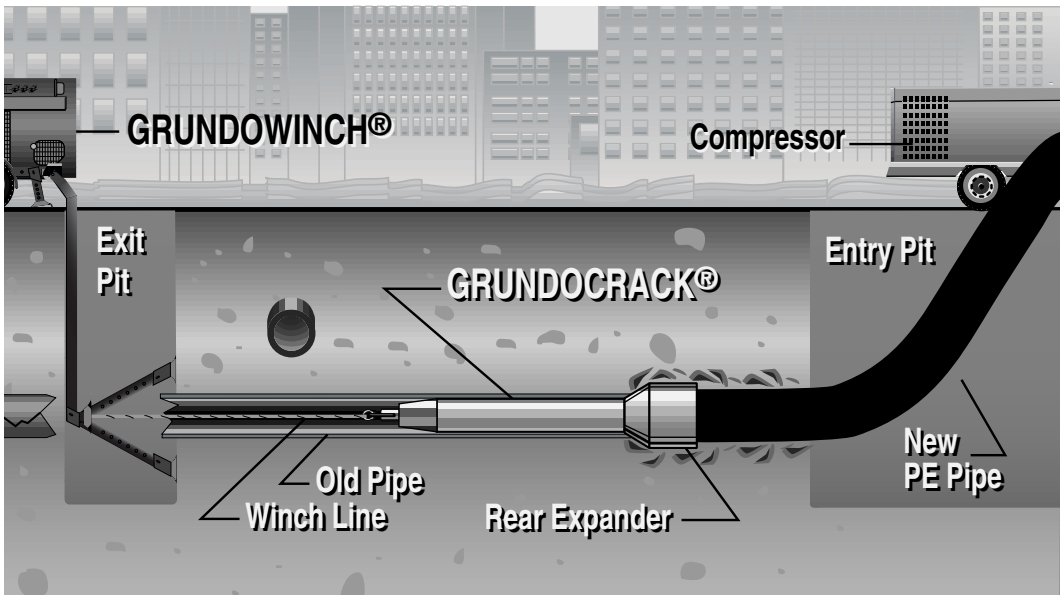


Figure 1. Typical GRUNDOCRACK Setup

C. GRUNDOCRACK APPLICATION CHECKLIST

A checklist for GRUNDOCRACK applications is available to users to document specific job parameters. This checklist can be reviewed by TT Technologies product specialists for feasibility and equipment recommendations. We recommend this checklist be completed and reviewed prior to job commitment. A sample of this checklist is included in Appendix A, pg 36.

Job Parameters and Conditions

2.

A. HOST PIPE MATERIALS SUITED TO THE PIPE BURSTING PROCESS

1) Vitreous Clay Tile-used in diameters from 4" up, clay tile is a common material used in sewer, telephone and power systems. The ability to fracture the pipe and compact fragments into the surrounding soil make it an ideal host pipe. Some concrete reinforced point repairs may slow or stop the bursting process (Figure 2). Newer clay pipe may use PVC gasket or elastomeric sealing material which must be cut during the burst. A schnozz with cutting blades and expander is recommended for this situation.

Figure 2.

2) Concrete Pipe-used in all applications except gas distribution, concrete pipe will have various degrees of reinforcement ranging from wire mesh to steel reinforcement rods. The amount of reinforcement will determine the system selection and burst success probabilities. Reinforced concrete pipe to 48" diameter has been burst. Heavily reinforced pipe may require additional cover to prevent surface disruption.

3) Cast Iron Pipe-used in all applications except telephone. Cast iron fractures well, but requires special lead equipment to protect the winch rope from possible damage. Bell and spigot type joints require a blade-type nose extension to help crack the large cross section of material contained in these joints. Product pipe of at least SDR 17 rating should be used to prevent sharp particles from damaging the new installation (Figure 3). Ductile Iron and some stainless steel repair clamps may resist bursting and require removal prior to or during the burst.

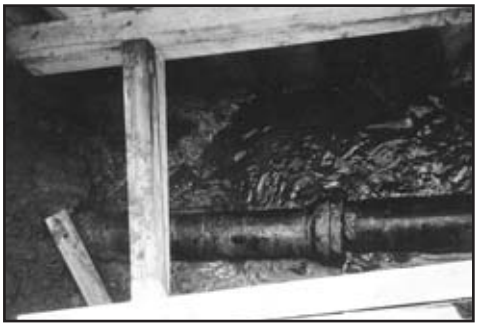


Figure 3.

4) Plastic, including PVC, ABS, PE, etc. - possess varying degrees of "burstability," due to material composition. Most plastic pipe must be split into ribbons using special knife blade equipped nose extensions. The limited ability to fracture these materials into small pieces limits the soil expansion and increases the friction on the product pipe, sometimes reducing the burst length.

5) Transite (asbestos cement) - used in all applications, transite has good bursting potential, similar to clay tile. It is particularly beneficial to burst this pipe, since excavation presents exposure to hazardous asbestos.

Figure 4. Special Nose Tools

B. HOST PIPE SIZE

Host pipe size will affect both hammer/expander combinations and winch selection. Small diameter host pipe in difficult soil conditions can present problems because a larger, more powerful hammer will not fit inside the host pipe. Special nose tools can be adapted to solve these problems (Figure 4). Changes in host pipe diameter in a single run can cause grade problems.

Identify specific conditions within the host pipe before bursting. For example, bad joints, cracks, collapsed sections, line sags, etc. All projects should be video taped before bursting. Any project that cannot be video taped before bursting is considered a risk.

C. HOST PIPE DEPTH

The depth of the host pipe affects the bursting process in the following manner:

1). In some cases the deeper the host pipe, the more difficult the soil expansion process becomes due to the additional weight and density of the surrounding soil.

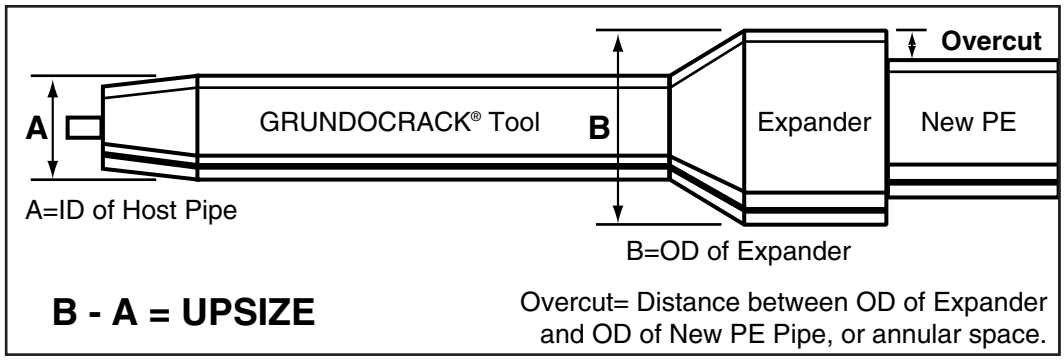


Figure 5. "Overcut" Example

2). As depth increases the "overcut" (difference between the OD of the PE pipe diameter and the OD of the expander diameter) may have to be increased to provide an adequate space for installation of the new pipe (Figure 5).

3). Start and exit pits size increases with depth, as well as shoring, digging equipment and safety procedures.

4). De-watering procedures change with depth, requiring additional equipment.

5). Changes in host pipe profile-due to the inability of the tool assembly to "bend," grade angles cannot be burst and must be exposed.

6). RULE OF THUMB: To determine the Minimum Required Depth, subtract the host pipe size from the OD of the expander. Multiply the result by 10. Example: 14" host pipe, 18" Grundocrack with 20" HDPE (DIPS) and 24" OD expander.
24" - 14" = 10"
10" x 10 = 100" minimum depth

In more compacted soil such as cemented cobble, minimum depth must be increased.

Note: Be aware of pipe measurements in either IPS or DIPS. Use one measurement system when performing calculations.

D. SURROUNDING SOIL TYPES

Since most of this country's utilities were originally installed by some open cut method, at least the top of the host pipe is covered with fill material. In addition, the soil need not be removed, only compacted. Extreme conditions, however, will affect the speed and length of the burst. Extremely hard clay, 80 to 100 blow count densities, will slow the bursting process due to the additional force required to "open" the hole and expand the soil.

Some soils will not remain in the expanded state long enough to allow installation of the new product pipe. In this case, the use of bentonite and polymers can help. Host pipes located below the water table in sand are difficult. The sand is fluid like and grips the HDPE product pipe, increasing friction rapidly.

The host pipe soil bed must be capable of supporting the weight of the tool/expander and product pipe. A pre-burst video may show voids or washouts to be considered. Repairs or pipe collapse may also be viewed in the video.

E. NEW MATERIAL AND SIZE

Most pipe bursting applications use fused lengths of HDPE pipe. Glued PVC, and threaded pipe can also be specified. HDPE wall thickness is determined by its SDR rating. The lower the SDR number, the larger the wall thickness. Specifications and usage information should be obtained from pipe manufacturers prior to installation.

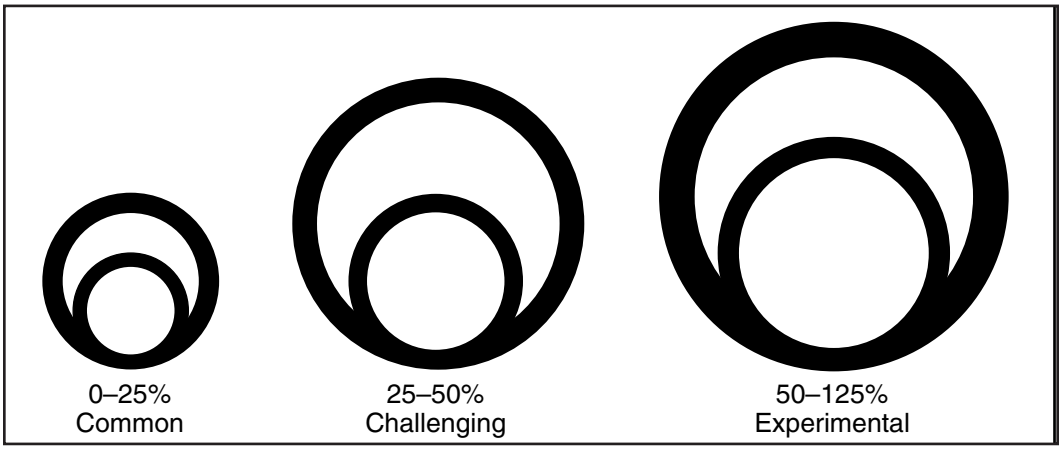


Figure 6. Typical Upsize Examples

The ability to “upsize” or install a product pipe larger than the host pipe is unique to pipe bursting. The amount of upsize is limited by a combination of all the host pipe parameters. Host pipe diameters of 12" and smaller can be upsized by 50% (4" to 6", 6" to 10", 8" to 12") under most situations. Due to the large volume of soil to be compacted in diameters larger than 12", the percent of upsize may not be as large (Figure 6). Another consideration of the new pipe installation is the projected weight of the total installation. Refer to the chart of 100' lengths of various diameter HDPE at SDR 17 (Figure 7) for pipe weights.

PIPE SIZE VS. WEIGHT		
PIPE SIZE	**PIPE WEIGHT (lbs. per ft.)**	**PIPE WEIGHT (lbs. per 100 ft.)**
8" SDR 17	5.65	565
10" SDR 17	8.78	878
12" SDR 17	12.36	1236
20" SDR 17	30.42	3042
36" SDR 17	98.56	9856

Figure 7.

Using 36" SDR 17 HDPE on a 400 ft. burst as an example, the weight of the PE alone would approach 40,000 lbs. The weight of the pipe, the hammer/expander, and friction of the soil all add to the bursting equation.

⚠DANGER: Locate utilities before your dig. GRUNDOCRACK tool contact with power cable can cause injury or death.

F. PERIPHERAL UTILITIES

Utilities near the start and exit pits and along the burst route must be located and, in some cases, exposed prior to bursting. Since start and exit pits and service connections must be excavated, good locates are necessary as with any underground operation.

G. SERVICE EXCAVATIONS

In sewer applications, services or laterals are located by video inspection of the line. In gas applications, electronic locating devices are used. It is recommended all services and laterals be exposed prior to bursting to avoid damage and to reduce service downtime. An exception to this is when bentonite is being used. The service pit should be dug after the burst to prevent filling with bentonite. **Keep these service pits as small as possible to avoid affects on the grade of the new pipe.** Service connections, fittings and equipment are available from various suppliers. Contact TT Technologies for a list of suppliers.

H. START AND EXIT PITS

In sewer applications, pits are usually located in front of manholes to allow gradual entry of hammer/expander and new pipe into the host pipe. A steep entry will place unnecessary strain on the product pipe as it enters the pit. Damaged HDPE pipe, incomplete burst, or pipe not on grade could result (Figures 8 and 9). HDPE pipe can be bent to minimum bend radius approximately 20 to 40 times the pipe diameter. For exact minimum bend requirements see Minimum Bend Radius Calculations in Appendix G, pg 39.

Pneumatic tool must be launched level, not pointing down otherwise grade can be affected.

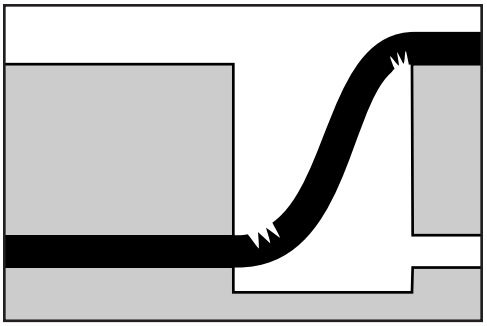


Figure 8. Incorrect; too steep of bend on PE pipe.

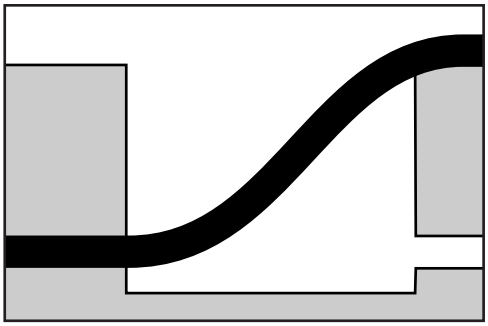


Figure 9. Correct; gradual bend on PE pipe.

Exit pits are sized to facilitate removal of the hammer/expander and allow manhole connections to the new product pipe. Reversible tools can be used in some applications, thus eliminating the exit pit.

For gas and water bursting operations, the service excavations can be used as start and exit pits as needed.

⚠CAUTION: Prepare all pits in a safe and approved manner.

I. MANHOLE PREPARATION

⚠WARNING: All confined space safety procedures apply.

Entry and exit holes must be enlarged to accept the expander and new product pipe as required. Sewer manhole inverts may need modification to allow tool passage and to allow new pipe to remain on grade (Figure 10).

Note: If tool will deflect at invert while going through intermediate manholes then invert must be taken out to avoid affecting grade.

Note: Anytime there is less pressure above the bursting tool and a concrete or dense soil below, grade can be affected.

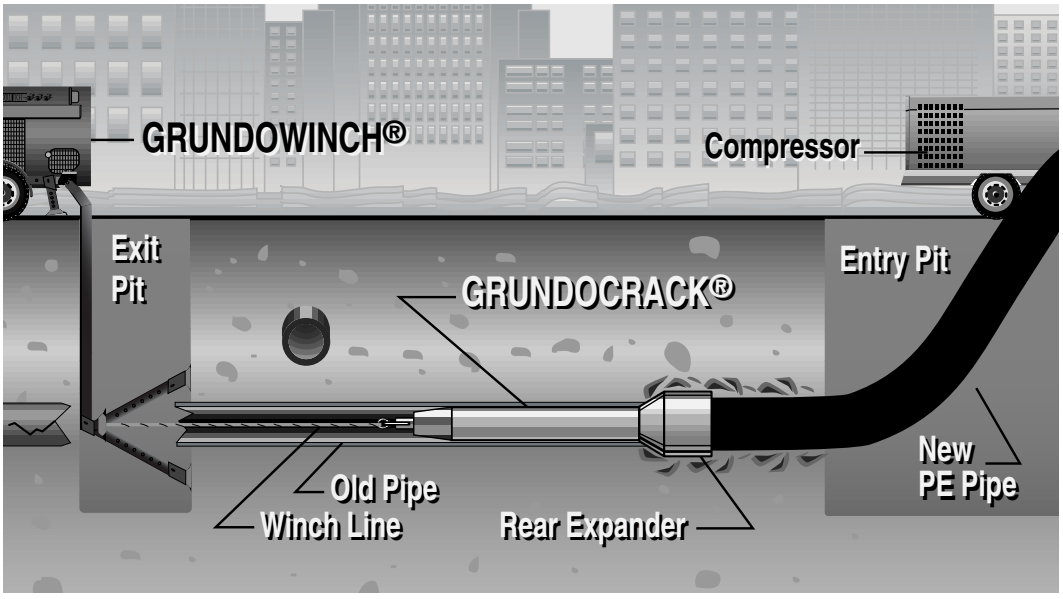


Figure 10. Typical GRUNDOCRACK Jobsite

J. BURST LENGTH

Most proposed sewer bursts are manhole to manhole, but at times it is necessary to extend the burst through an intermediate manhole. The success of this additional length is dependent on the following conditions.

The intermediate manhole must be prepared to provide as little resistance as possible. In some cases a larger overcut will be necessary to provide additional annular space to reduce new product pipe friction.

If the manhole is to be passed through the invert must be removed and enlarged to prevent the hammer/expander from rising in the manhole and adding a speed bump (Figure 11).

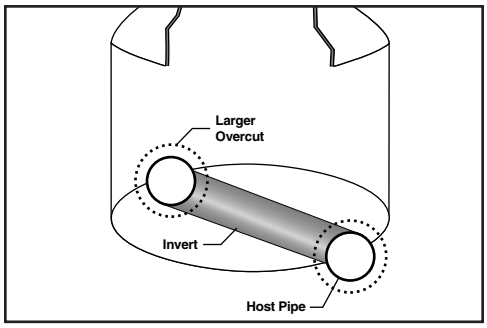


Figure 11. Intermediate Manhole

The use of bentonite is always recommended as a method to increase the burst length, regardless of the host pipe diameter. See “Bentonite Uses” pg. 18.

Bursts performed in similar conditions may give an indication of the total length expected. Documentation is recommended for each bursting project. This information is valuable for later reference in job planning. Contact a TT Technologies product specialist for information on bursting projects completed worldwide.

Expander Types

3.

A. REAR EXPANDERS

Rear expanders slide over the main body of the GRUNDOCRACK bursting tool and are held in position by the hammer’s flared end (Figure 12). The PE pipe is fixed to the rear of the expander by one of the following methods:

Figure 12. Rear Expander

1. Rear Threaded Expander

The supplied PE link is first fused to the PE train. The expander is then rotated to engage the threads on the link. Be careful not to cross thread the expander and link. A strap wrench/spanner wrench combination is used to complete the process (Figures 13 and 14). Useful in “wet applications” to prevent water intrusion into new pipe and tool.

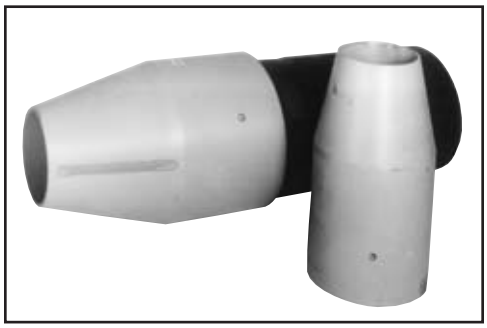


Figure 13. Rear Threaded Expander

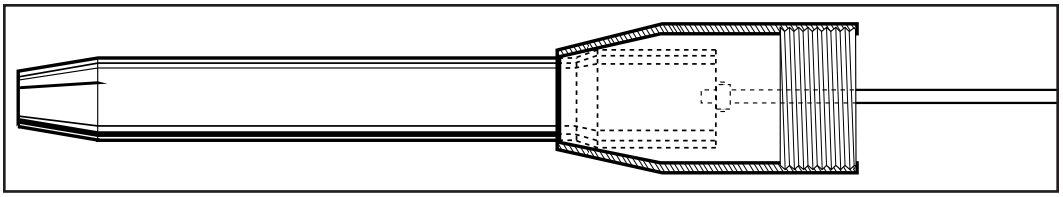


Figure 14. Rear Threaded Expander Assembly

2. Gland Nut A-Style Type

Rear expanders using the gland nut have a special PE link. This link has a machined shoulder that is held in place by the gland nut. The PE link is fused to the PE train with the gland nut facing the expander. A shock ring is used between the rear of the expander and the gland nut to prevent thread damage. A steel insert is placed in the PE link to provide additional strength (Figures 15 and 16).

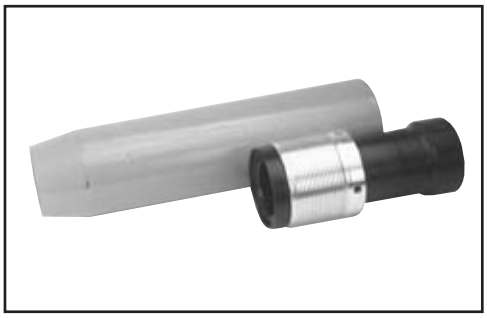


Figure 15. Gland Nut A-Style Rear Expander

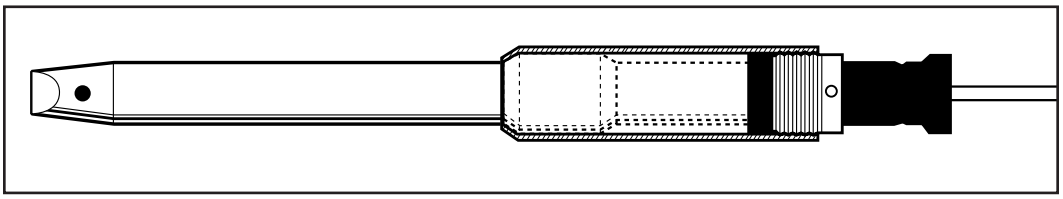
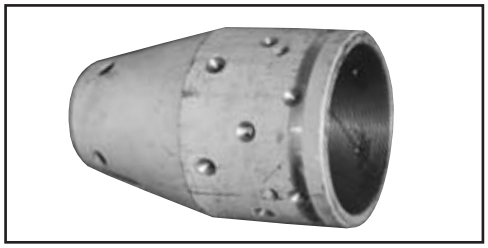


Figure 16. Gland Nut A-Style Rear Expander Assembly

3. Direct Bolt & Strap Type

Direct Bolt Rear expanders provide for the PE pipe to be inserted into the backside of the expander. Flat head screws are installed through tapped holes in the expander through drilled holes in the PE pipe (Figure 17).



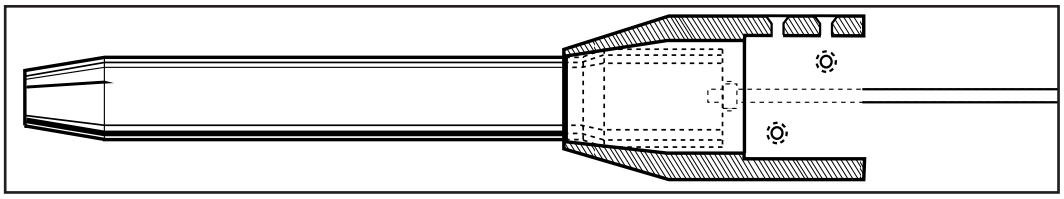
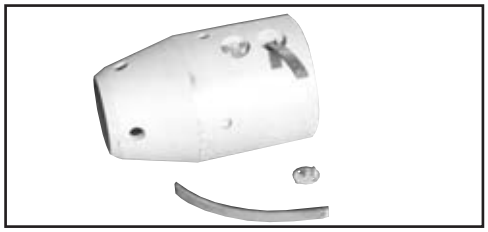


Figure 17. Direct Bolt Rear Expander Assembly

Strap Type Expanders utilize a spline that is inserted through an access port in the expander. The spline interlocks grooves in the ID of the expander and the OD of the PE link. (Figure 18).



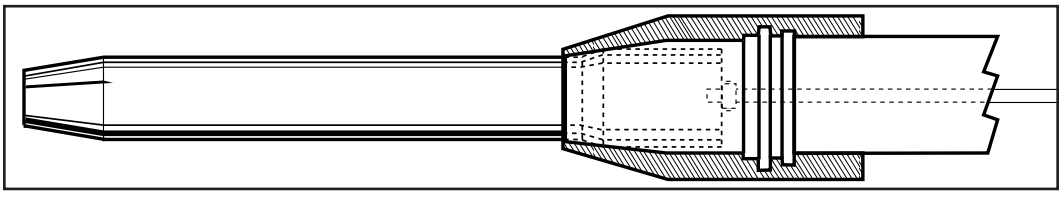


Figure 18. Strap Type Rear Expander Assembly

B. FRONT EXPANDERS

Front expanders fit on the hammers' tapered nose cone. The PE pipe is attached by using a threaded PE link or direct bolt style expanders. The PE pipe's inner diameter must be large enough to fit over the hammer (Figures 19 and 20).

Figure 19. Front Expander

Front expanders can be used to burst the host pipe and then enter the exit manhole. A straight-barrel hammer can be removed by putting the tool in reverse and backing it out of the newly installed pipe. For step by step illustrations of Front expanders on reversible PCG tools, see Appendix D, Page 34.

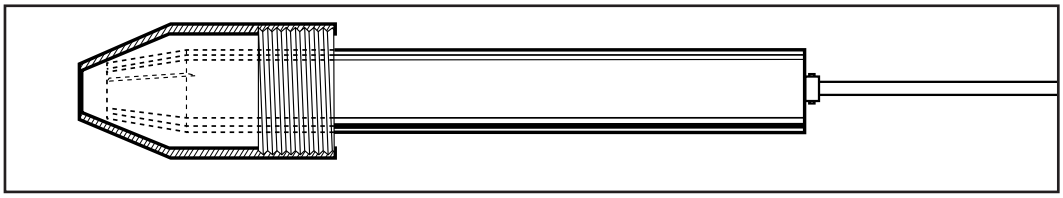


Figure 20. Front Expander Assembly

C. NOSE ATTACHMENT UNITS (GUIDE HEAD ASSEMBLY)

During the bursting process, pieces of the host pipe will often break ahead of the tool and fall in front of the hammer. If these pieces are not pushed aside, the tool will slow down or may even come to a full stop. An extension is attached to the hammer's nose to prevent this (Figures 21–24). This also eliminates the need for bolts or roll pins. Shorter set-up and disassembly times are also possible.

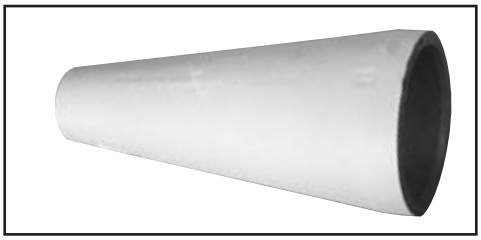


Figure 21. Nose Extension Assembly

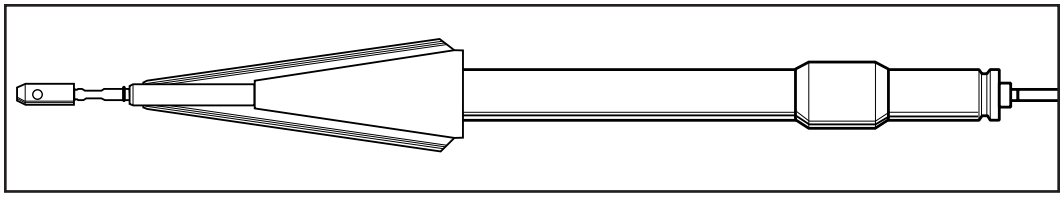


Figure 22. Guide Head (Schnozz) with Cable Hook up and Steel Pin

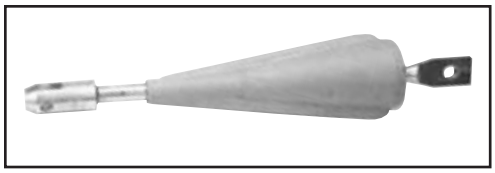


Figure 23. Guide Head (Schnozz) with Cable Hook up & Steel Pin Assembly.

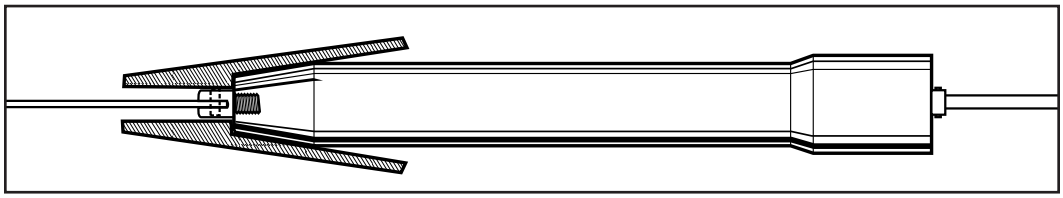


Figure 24. Guide Head (Schnozz) with Cable Hook up and Steel Pin Assembly. Fits on Rammer Style Pipe Bursting Tools with Pulling Eye

Mini-Hammer Uses

4.

The GRUNDOCRACK product line includes three mini-hammers:

A. MINI-ATLAS

Used to burst service pipe and to install new 4" and 6" PE. The reduced length of the tool allows for smaller pits. In some applications, the tool can be removed from a manhole after the burst is complete (Figures 25 A & B).

B. MINI-OLYMPUS

Used to burst 8" and 10" pipe. Shorter pits can be used and in some applications, the tool can be removed from a manhole after the burst is complete.

C. MINI-GIGANT

Used to burst 12" and 14" pipes and replaces 12" and 14" PE. This tool cannot be removed from a manhole due to its length and weight, but the pit size will be considerably smaller.

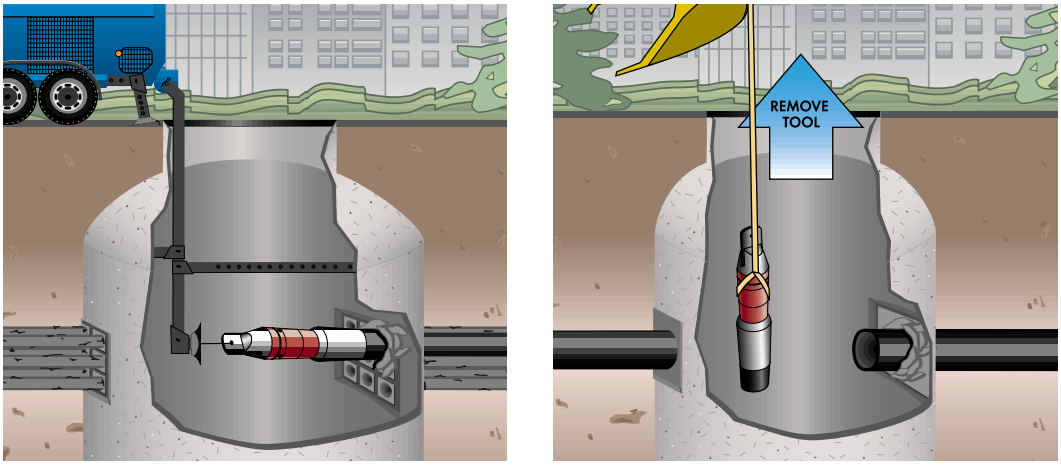


Figure 25 A & B. Mini-Atlas manhole entrance and exit.

GRUNDOCRACK Air Supply and Related Items

5.

A. COMPRESSOR REQUIREMENTS - MINIMUM CFM

All tools should be operated with a compressor outlet pressure of 110-115 psi. Supply hoses provided by TT Technologies are sized to operate the GRUNDOCRACK hammer efficiently and should not be reduced in any manner (Figure 26).

MINIMUM CFM REQUIREMENTS				
Tool Model	**Machine Dia. in (In.)**	**CFM Requirements**	**Hose Size**	**Shock Valve**
PCF 130	5	95	1.25"	1"
PCF 145	5 3/4	140	1.25"	1"
PCF 180	7	160	2.5" F.L.	2"
PCF 220	8	280	2.5" F.L.	2"
Mini-Atlas	5	60	1.25" W.R.	1"
Mini-Olympus	7	124	1.5" W.R.	2"
Olympus	7	177	2.5" F.L.	2"
Hercules	8 1/2	282	2.5" F.L.	2"
Mini-Gigant	10 1/2	353	2.25" F.L.	2"
Gigant	10 1/2	424	2.5" F.L.	2"
Koloss	14	706	2.5" F.L.	2"
Goliath	18	1236	4" F.L.	4"
Taurus	24	1766	4" F.L.	4"
Reversible Tools				
Tool Model	**Machine Dia. in (In.)**	**CFM Requirements**	**Hose Size**	**Shock Valve**
PCG 130	5	95	1.25"	N/A
PCG 145	5 3/4	140	1.25"	N/A
PCG 180	7	159	2.5" F.L.	N/A
HV 220	8.8	282	2.5" F.L.	N/A
PCG 270	11	424	2.5" F.L.	N/A
KV 350	15	706	2.5" F.L.	N/A

Figure 26.

Note: Air pressure will drop approximately 2.5 psi per 100' of air hose.

⚠WARNING: Incorrect hoses may fail. Ensure all hoses are properly rated for the expected pressures. Failure to do so could result in serious personal injury or death.

⚠CAUTION: Do not allow traffic or mobile equipment to drive on air supply hoses, this will prevent damage to the hose.

B. AIR SUPPLY COMPONENTS FOR NON-REVERSIBLE HIGH PRODUCTION GRUNDOCRACK TOOLS

2 ½" flat-lay, double-wall hose has been proven to be durable and easy to place inside the PE pipe. A pull rope is put in the PE pipe using a fiberglass duct rodder or by blowing in the rope with compressed air. A ⅝" or larger rope should be used to handle the weight of the flat-lay hose.

The male coupler of the flat-lay hose should point towards the tool; this end connects to the shock valve. All connections must be tightened before placement in the pipe and care should be taken not to twist the flat-lay hose as it is pulled into the new PE pipe (Figure 27), shows the air connection links in order from the air compressor to the GRUNDOCRACK tool.

After installation of the flat-lay hose, connect it to the air compressor and lubricator. Properly tighten all connections.

⚠WARNING: The hose may burst. Properly inspect the hose and all connections before use. Failure to do so could result in serious personal injury or death.

A special fitting is used from the air compressor to the 7' reinforced hose. This hose has two female ends, one attaches to the special fitting at the compressor, and the other attaches to the GRUNDOCRACK lubricator. The lubricator has an arrow to show the proper air flow direction.

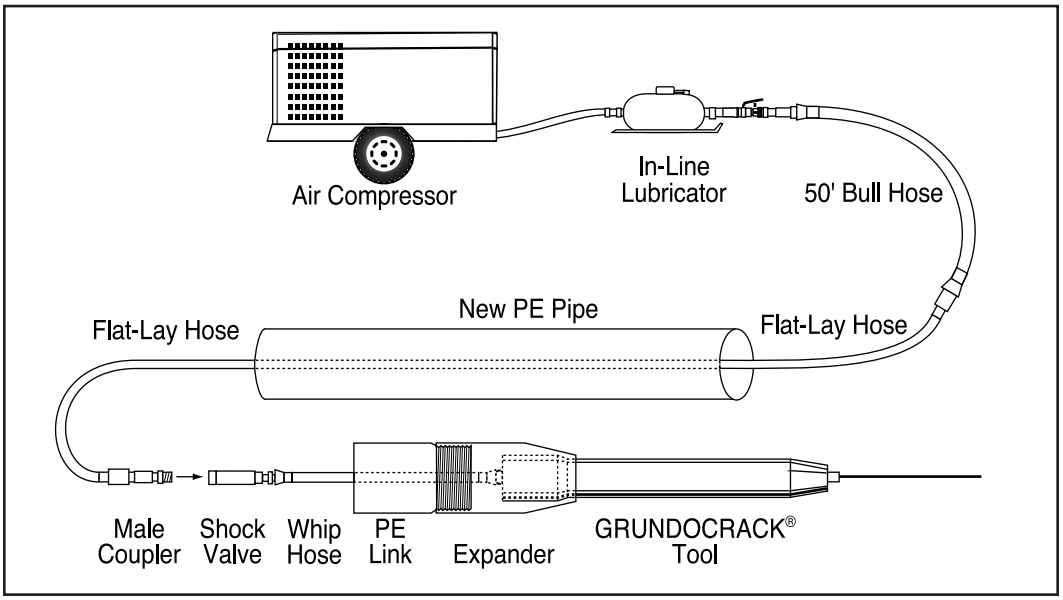


Figure 27. Typical Hose Connections

⚠CAUTION: If not properly lubricated, the GRUNDOCRACK tool could fail. Ensure the air flow through the lubricator is in the correct direction. Failure to do so could result in serious damage to the GRUNDOCRACK tool.

The 50' reinforced bull hose is connected between the lubricator and the flat-lay hose. This reinforced hose is used to prevent abrasions as it is dragged during the bursting process. The flat-lay hose is not made to take abuse and should not come in contact with the ground during the burst. Flat-lay hose is used only inside new pipe being pulled in during the burst.

After all connections to the flat-lay hose are completed, the air compressor should be started to clear debris and remove twists out of the hoses. The shock valve should then be attached between the tool end of the flat-lay hose and the hammer. This completes the hammer/expander/PE assembly.

Note: Machines 8" or greater in diameter use double wall flat-lay hose, smaller machines use a double wire braided hose.

CAUTION

⚠CAUTION: All hose connections must be tight and secure. Use a hose wrench for proper tightening.

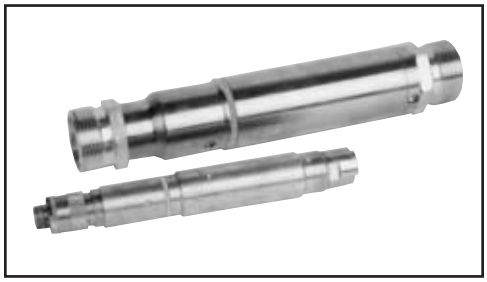


Figure 28. Shock Valve

The GRUNDOCRACK system uses a "shock valve," also known as a booster, to assist in starting the hammer (Figure 28). Connect the shock valve directly between the whip hose of the GRUNDOCRACK tool and the flat-lay air hose. In operation, air is fed through the hose to the shock valve. This valve remains closed until the back pressure builds to approximately 80 psi. The spring loaded valve then releases a "shock" of compressed air and moves the hammer's piston forward. This helps start the hammer's percussive action.

CAUTION

Always connect the shock valve in the proper direction with respect to air flow.

The shock valve is a necessary component and should always be used. If the GRUNDOCRACK assembly is inserted into the host pipe without the shock valve, the system may be impossible to start. The shock valve aids in restarting the GRUNDOCRACK, should it be necessary.

Note: Due to the auto-reverse system, reversible tools do not use shock valves. Consult factory for different hose combinations used on those tools.

Before connecting the flay-lay air hose to the shock valve, turn on the compressor and slowly blow air through the hose to remove any dirt or debris that may have gotten into the air hoses. Secure the hose for stability during this procedure. The shock valve should always be properly lubricated and tested prior to each use as follows: Connect the shock valve to the flat-lay air hose and open the compressed air valve very slowly. The shock valve should open around 80 psi.

1) If the shock valve does not open, use a long round wood dowel (approximately 12 in. long) and slip the shock valve over the wood dowel using the end that would connect to the flat-lay hose.

2) Carefully press the shock valve against the wood dowel until the piston inside the shock valve moves against the spring tension. The shock valve is now ready to be used.

Due to close-tolerance machining, it is necessary to protect the shock valve from contamination. After each use, clean it with diesel fuel, GRUNDO-OIL, air tool oil, or kerosene, install protective caps, and store it in a clean, secure place. This will help prevent components from rusting during storage.

Should the operator require to inspect the shock valve for cleaning and disassembly follow the procedures in Appendix D, pg 38.

GRUNDOCRACK tools used for 12" or larger PE pipe use a threaded PE link, which once installed may be used again, The completed PE train is fused to the hammer/expander/PE link combination. An access hole is opened in the PE at the whip hose/shock valve connection area. Once opened, the air connections are made and the access hole sealed prior to bursting. Two methods are used to seal the opening: PE Seal Fixture & Field Access Door Connections.

1) PE Seal Fixture: A template is provided to accurately cut a round cornered rectangle opening (Figure 29).

2) Field Access Door Connections: A piece of PE smaller than the pipe to be installed is cut approximately 18" long. For 12" PE a piece of 10" PE is used, for 16" PE, 14" is used, etc. This smaller pipe is inserted into the PE train prior to fusing the machine/expander combination on. A similar round cornered rectangle is cut into the new PE to provide an air line hook-up access hole, and the coupon is lag-bolted into position. If this coupon is accessible after the burst, the process is reversed to disconnect the air line/shock valve.

Bentonite Uses

6.

A. GENERAL

BENTONITE or polymer "mud" mixture is used as lubrication fluid in many pipe bursting applications. Bentonite is most commonly used in pipe bursting applications greater than 12" diameter, although it can be equally beneficial in smaller sizes.

Bentonite mixture is pumped into the annular space created by the pipe bursting tool expander (under positive pressure) to reduce friction between the new product pipe and the remains of host pipe and surrounding soil.

B. CONDITIONS REQUIRING USE OF BENTONITE

CAUTION

Refer to your pump manufacturer's operators manual for complete instructions.

The process of pipe bursting can be performed more efficiently through the application of bentonite in almost all sizes. Although bursting experience is the best guide to determine when bentonite is required, the following guidelines can be helpful:

Use bentonite and/or polymers if:

1. Ratio of upsize exceeds 2 inches
2. Length of individual burst exceeds 250 feet
3. Diameter of new pipe exceeds 12 inches
4. Ground water is present at host pipe depth
5. Host pipe is of abrasive nature (i.e. concrete, etc.)
6. Soils surrounding host pipe are granular

C. SELECTION OF BENTONITE AND PUMPING EQUIPMENT

Most bentonite products used as lubrication fluids are extended yield or extra-high yield bentonites. These types of bentonite are usually mixed at a rate of 50 lb. bentonite to 100 gallons of water. This mixture provides higher viscosities at lower concentrations.

In recent years, specifically designed bentonite products have been introduced that provide lower filtration rates, improved wall cake quality, improved gel strengths, and lower viscosity. This allows for heavier bentonite concentrations while maintaining pumpability. This type of bentonite product is referred to as the “single sack” system, because additives are included in each sack to extend the yield.

Bentonite mixture usage can be estimated using the following guidelines. Bear in mind these calculations are only general guidelines, and can be affected by soil conditions.

EXAMPLE:
Dimensions: Burst 8" VCP, upsize to 12" P.E. with run length of 400 feet.
Expander O.D. (annular space)= 15", 12" P.E. = 12.75" O.D.
Equation: Hole size squared, then divided by 25 = gallon/feet ratio.
Math: Annular space: 15" x 15" = 225, divided by 25 = 9 gal./ft.
New pipe: 12.75" x 12.75" = 162.5, divided by 25 = 6.5 gal./ft.

9 minus 6.5 = 2.5 gal./ft. to fill annular space.

2.5 gal./ft. x 400 ft. = 1000 gallons of bentonite mixture for the 400 foot burst.

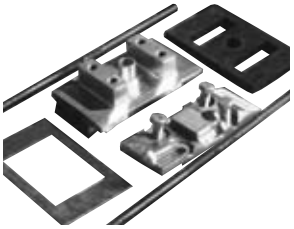
If burst proceeds at 3 feet per minute, the pump has to inject at least 8 GPM to maintain a positive pressure (if no fluid is lost into the surrounding soils). A safe margin would indicate that a 300 gallon system with 15 GPM would handle this job. Water quality is important to proper bentonite mixing. Hard or salty water can cause thickening or separation. Fresh water of a proper pH is a must.

D. LINE AND PORT INSTALLATION

CAUTION

⚠CAUTION: Holes cut in the new pipe or PE link must have rounded corners to prevent weakening of the pipe (Figures 29 & 30).

Lead hose attaches to PE pipe and allows supply hose to be connected from bentonite pump (Figure 31). Secure connections are a must. A template is supplied to ensure an accurate cut for the Bentonite manifold. In most cases, the opening is made on the new PE, a short distance behind the tool. The Bentonite supply hose is threaded on the base of the manifold inside the pipe. A gasket is placed on the base of the manifold before the manifold cover is secured. The manifold cover is placed on top of the gasket and manifold base secured by tightening four anchor screws.



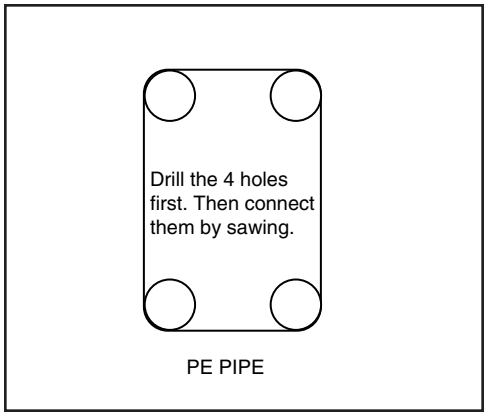


Figure 29. Drill First then Saw

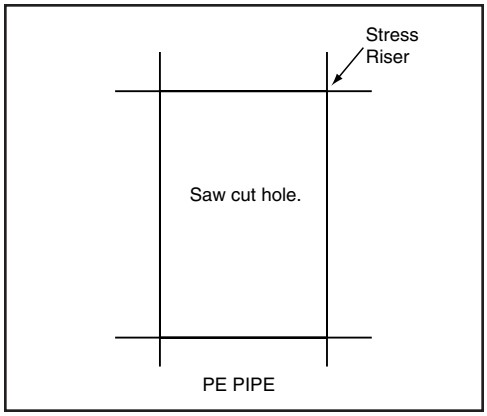


Figure 30. Saw First (Wrong)

CAUTION

Refer to your pump manufacturer's operators manual for complete instructions.

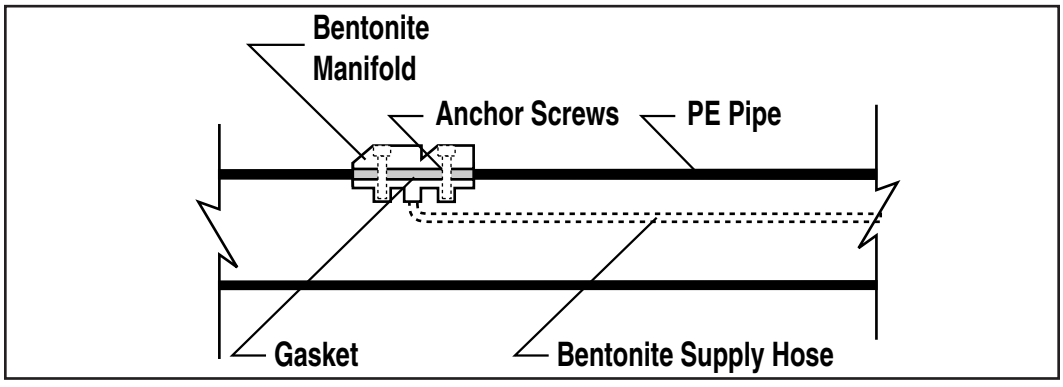


Figure 31. Lead Hose Assembly

E. PUMP OPERATION/MIXING

TT Technologies' GRUNDOMUDD Bentonite Mixing System uses a propeller mixer/filtration system to mix water and bentonite in a matter of minutes, while an in-tank recirculating valve keeps the mixture from settling. Both diaphragm and piston type pumps are utilized on GRUNDOMUDD Bentonite Pumps. Two 50-lb. bags of bentonite combined with 225 gallons of water will yield a 5% mixture.

> Note: Clean-up is faster with a tank isolation valve. It allows pump lines to be cleaned without draining the tank. The unit also provides easy freshwater flushing and simple antifreeze protection.

> Note: Always drain pump unit of fluid when temperatures are below freezing.

F. STANDARD USE DURING THE BURST

Typically, most bentonite pumping/mixing systems are included with the "train" of equipment that follows the pipe bursting pipe string. This may include a flat bed truck, on which the pump and bentonite are stored and mixed (Figure 32). This truck can also pull the compressor and follow the pipe string as it disappears into the ground.

Figure 32. Truck with Bentonite

Job site conditions may prevent the use of the "train" method. If the bentonite pump is spotted in one location for the duration of the burst, additional attention must be paid to sizing the length and diameter of the supply hose to ensure proper operation.

On higher volume- larger diameter pipes, it may be necessary to stage multiple pumps on a manifold system to ensure adequate flows of bentonite.

Constant monitoring of the speed and progress of the burst is required to properly match bentonite flow rates.

GRUNDOWINCH

7. A. SPECIFICATIONS

GRUNDOWINCH SPECIFICATIONS					
	Model RW1500	**Model RW4000**	**Model RW5**	**Model RW10**	**Model RW20**
Winch Capacity	1 1/2 Ton	4 Ton	5 Ton	10 Ton	20 Ton
Maximum Pull	1,500 lbs.	8,000 lbs.	10,000 lbs.	20,000 lbs.	40,000 lbs.
Rope Diameter	5/16"	7/16"	1/2"	5/8"	7/8"
Engine Size/Type	5 H.P. Gas	14 H.P. Diesel	14 H.P. Diesel	19 H.P. Diesel	65 H.P. Diesel
Max. Line Speed	16 FPM	72 FPM	30 FPM	23 FPM	33 FPM
PE Size/Tool Application	4" PE: EPC 085, EPC 095	4" PE: EPC 085, EPC 095 6" PE: PCF 130, PCF 145, PCF 180, Olympus	6" PE: PCF 130, PCF 145, PCF 180, Olympus 8" PE: PCF 180, PCF 220, Hercules 10" PE: PCF 180, PCF 220, Hercules	6" PE: PCF 130, PCF 145, PCF 180, Olympus 8" PE: PCF 180, PCF 220, Hercules 10" PE: PCF 180, PCF 220, Hercules 12" PE: Hercules, Gigant 14" PE: Gigant 16" PE: Gigant, Koloss 18" PE: Gigant, Koloss 20" PE: Koloss	16" PE: Gigant, Koloss 18" PE: Gigant, Koloss 20" PE: Koloss 24" PE: Koloss, Goliath 30" PE: Goliath 36" PE: Goliath 48" PE: Goliath, Taurus 54" PE: Taurus

Figure 33.

B. GRUNDOWINCH SETUP

⚠CAUTION: Read and understand procedures and safety instructions called out in the GRUNDOWINCH User's Manual before operation. Please refer to the GRUNDOWINCH User's Manual for complete operating instructions.

GRUNDOWINCH Operating Safety Procedures

⚠CAUTION: Be familiar with the GRUNDOWINCH's functions and performance specifications. Follow the manufacturer's operating instructions.

⚠CAUTION: Be sure all Confined Space Requirements are observed while setting up winch boom and operating the GRUNDOWINCH.

1. Operate the winch with all safety devices in place.

2. Before operation, make sure all controls and safety devices function properly.

3. Report any deficiencies of safety devices to the site supervisor.

4. Stop operation immediately if any failure occurs.

5. Before leaving the winch at the end of the workday, stop the engine and secure the winch against any inadvertent movement or tampering by unauthorized persons.

6. Position the winch so that it does not hinder normal road traffic. Re-route traffic safely past the work site.

7. Perform repair or maintenance work with all safety devices in place.

8. Prior to pulling, properly secure the winch against rearward movement.

9. Secure the area around all excavations and pits during operation.

10. Inspect the winch rope. Be sure it is clean and free of damage.

11. Inspect and replace the cable connection loop with new crimp if this connection point shows wear. Portable crimping tools are available from TT Technologies to perform field crimps.

12. Use cable eye bushing in connecting to bursting tool whenever possible.

⚠WARNING: Do not remain in the exit pit when the winch is under tension. Severe personal injury or death could result.

C. WINCH BOOM SETUP

The supplied GRUNDOWINCH boom contains the following components: (Figures 34–37).

Figure 34. Boom top - connects to winch tail pulley.

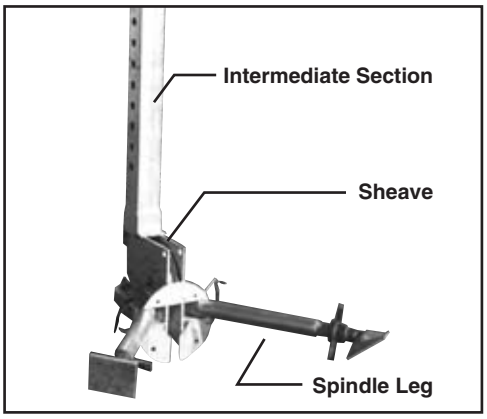


Figure 35. Typical 10-ton boom assembly. Boom extensions are available in various lengths.

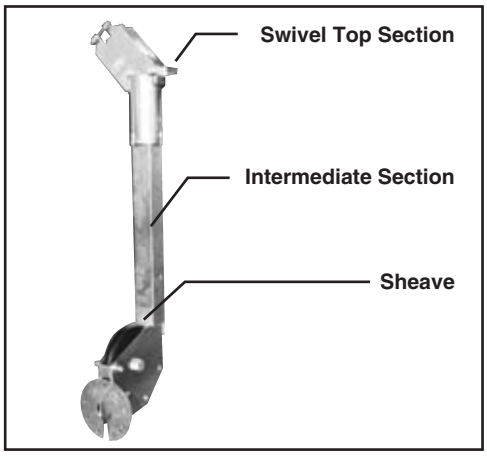


Figure 36. Typical 20-ton swivel boom assembly.

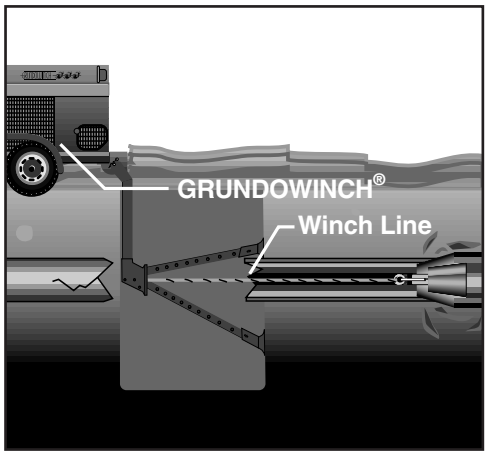


Figure 37. Properly supported bottom of the boom.

Begin winch boom setup by measuring from the manhole invert to ground level. Add the dimension from ground level to the ears on the tail pulley of the winch.

Extend the upper and lower boom pieces to the above measurements. If necessary, add intermediate sections to the boom to reach the total measurement needed. Use fixing clamps to secure the assembly together. The bottom of the boom must be properly supported to prevent damage.

Read the complete GRUNDOWINCH operating manual prior to setup. Keep the winch coupled to the towing vehicle, if possible. Engage the parking brakes on both tow vehicle and winch trailer.

Lower the rear jacks into position, use the pry bar to press the jacks firmly into the ground. On hard pavement, place a block beneath the jacks.

The jacks may be extended rearward if necessary, and pinned into position. Lower or raise the front trailer tongue as necessary to level, and lower the front jack and pin it into place.

To start engine, turn line speed control to zero (clockwise). Start the engine as per operator's manual. The winch rope must be pulled out enough to feed through the assembled boom unit before lowering the unit into the manhole.

To pull winch rope out, press out button, adjust pulling force preselection lever to medium, turn line speed control to full power, grab winch rope and pull out until enough rope has been fed out to feed through the assembled boom. The eye end of the winch rope can be attached to the installed rope in the host pipe, and the boom can be lowered into the manhole.

⚠WARNING: The assembled boom, especially with extensions installed, is too heavy for manual placement. The use of a backhoe to place the boom is recommended to avoid injury. A lifting strap that secures the boom to the backhoe should be used to carefully lower the boom into place.

The winch-boom top assembly has a notch that fits onto the GRUNDOWINCH's tail pulley and is secured with bolts or spring pins. The excess winch rope can be pulled into the host pipe or pulled back into the winch.

Check for alignment of the boom in the manhole. In some cases it may be necessary to reposition the winch at the manhole to provide correct alignment.

⚠WARNING: The trailer tongue is heavy. Use proper equipment and lifting procedures. Failure to do so could result in serious personal injury.

The lower section of the boom must be properly braced. If the dampening plate is larger than the pipe opening in the manhole, no additional bracing is necessary. As tension is applied, the boom assembly will pull against the manhole wall.

If the diameter of the pipe is larger than the dampening plate, blocking can be used from the plate to the wall.

Some winching operations require the boom to be placed back from the manhole entry to allow the product pipe to enter the manhole. Some booms have adjustable leg attachments built in, which are assembled after the boom is placed in the manhole. Others have an add-on plate and leg assembly that is bolted to the lower boom faceplate. In addition, timbers can be used to accomplish moving the boom to the far side of the manhole.

⚠CAUTION: Improper bracing could fail under tension. Ensure that the dampening plate is properly braced. Failure to do so could result in damage to the winch boom assembly.

Burst Preparation- Typical Bursting Setup

8.

Sanitary sewer pipe bursting requires bypass pumping to isolate the section of sewer that is scheduled for bursting. In addition, service lines in the sewer section may need bypass pumps. Also, water lines may require temporary water supply system during the bursting process.

A. ENTRY AND EXIT PITS

Pipe bursting normally requires an entry pit to start the hammer/expander/PE assembly into the host pipe. Host pipe sizes of 10" and smaller will require a pit size of approximately 4' wide by 20' long, usually placed between the entry and exit manholes.

As the depth of the host pipe increases, the pit size will also increase to accommodate the hammer/expander assembly and to allow for a smooth transition from ground level into the host pipe.

⚠CAUTION: Improper entry pits will cause problems. Ensure the entry pit is long enough to allow the PE to enter the host pipe without binding. Failure to do so could damage the PE and reduce the burst length.

The exit pit should not be dug until the burst is complete. If excavated before the burst, the manhole wall may be damaged due to the stresses transferred from the winch boom. The exit pit size is determined by the length of the hammer/expander combination.

In gas and water applications, entry and exit pits can be excavated as desired. The service pits can also be used as entry and exit pits.

Locate services by prior video inspection and expose and disconnect before the burst begins. This prevents damage to service pipes and allows for quick reconnection after the burst is complete.

B. INSTALLATION OF WINCH ROPE IN HOST PIPE

The host pipe must have enough integrity to allow the GRUNDOWINCH's rope to be pulled into it. The host pipe can be mechanically rodded and a ⅝" minimum pull rope placed inside the pipe. The winch rope is then attached to the pull rope. Enough winch rope should be pulled out of the entry pit to allow attachment to the hammer/expander assembly. Use only steel winch line capable of withstanding load ratings for the project. It is strongly recommended that the host pipe to be burst be clean of any collapsed material or debris before attempting the bursting process. It is essential to have the winch cable centered in the host pipe.

C. GRUNDOWINCH/HAMMER COORDINATION

After the winch rope is attached to the hammer assembly, it can be pulled into the entry pit using the GRUNDOWINCH. Heavier hammer/expanders may need to be assisted to prevent diving into the pit floor. This also prevents the winch rope from pulling through the host pipe prior to entry. Retract the winch rope until the nose of the hammer is inserted into the host pipe.

> NOTE: The use of three hand held radios is recommended to coordinate the start of the burst. A radio at the GRUNDOWINCH, at the air compressor, and at the start pit will allow for a smooth start (Figure 38).

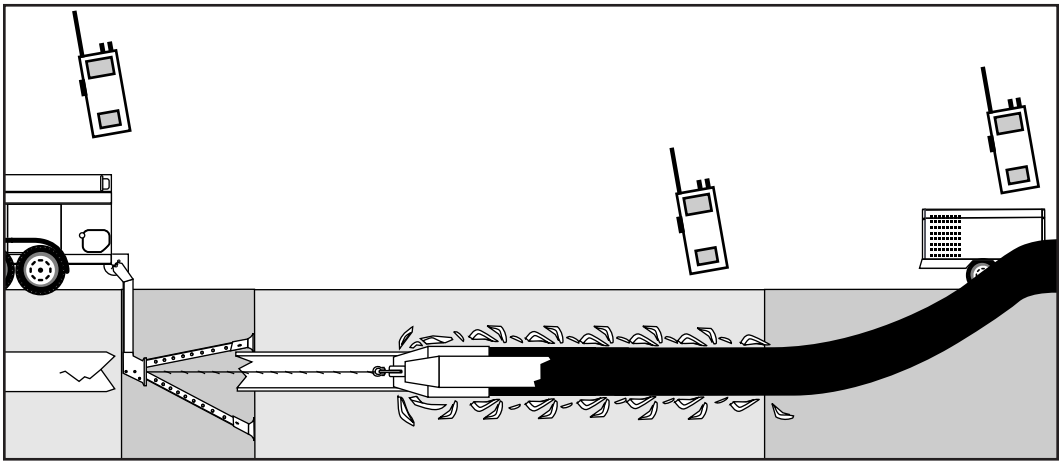


Figure 38. Recommended Radio Placement

Once the hammer assembly is pulled into the host pipe, the pulling tension should be increased to maximum to verify back-bracing integrity and all connections before the burst begins. Its best to remedy any problems at this time.

The Bursting Process

9.

A. STARTING THE BURST

Make a commitment to completing the burst before starting. Remember, the entire bursting process, including tool/expander removal, manhole make up (if necessary) and service/lateral connections must be completed on schedule. Always allow enough time. After verifying that all three positions (winch, air compressor, start pit) are ready, the GRUNDOWINCH can be started, set to approximately 25% of maximum pull, and the air flow to the hammer turned on. As the hammer enters the host pipe, check the start time so that the burst's elapsed time can be monitored.

B. SPEED OF THE BURST

In most cases, speed will vary. Thus, use of a constant- tension variable-speed winch such as GRUNDOWINCH from TT Technologies is important. Point repairs will slow the process as the hammer/expander passes through the repair reinforcement. If the service connections were not disconnected prior to bursting, they may also slow the burst, until the hammer passes them.

Speed variations while bursting cast iron pipe are normal. The hammer has little trouble with the pipe itself, but the bell/spigot joints are naturally more difficult to burst.

The relationship between the hammer's speed and the winch's pulling force is important to achieve maximum efficiency for the burst. Increasing the pulling force will sometimes increase the bursting speed, and in other cases, will actually slow the process. It is advisable to use just enough pulling force to maintain a reasonable amount of speed. Varying the pulling force during the burst is a good way to determine the best speed.

New pipe "upsize" may slow the bursting process. Upsizes of 50% or larger require larger soil displacements, and the new pipe also adds weight.

It is not unusual for the bursting speed to increase suddenly, due to deterioration of the host pipe or a possible void in the surrounding soil. The GRUNDOWINCH is equipped with a constant-tensioning feature that is designed to compensate for the increase in speed and will automatically take up the slack.

C. MONITORING THE BURST

Commit to good preparation before the burst. Once the process is underway, stopping for readjustments can cause burst failure.

In some cases, a service pit or intermediate manhole can be used to check equipment and connections.

As the burst proceeds, check at the air compressor end to ensure the supply hoses are free and clear of obstructions. The 50' reinforced supply hose, often purchased with the GRUNDOCRACK tool, is used to prevent damage to the flat-lay hose.

Check at the winch end for boom integrity, proper pulling tension, correct engine operation, and that the winch rope is winding evenly on the capstans.

D. BURST COMPLETION

As the hammer/expander nears the exit manhole, good communication is a necessity. When the nose of the hammer enters the manhole, stop the winch pressure and air supply, and open relief valve as quickly as possible.

⚠CAUTION: Failure to stop the burst promptly may cause damage to the winch boom and cable or manhole.

To move the tool assembly in small increments, disconnect the winch rope, and only apply air pressure to the tool. Once the tool fires, immediately shut off the air. In most cases the tool will move ahead slightly. Continue this procedure as necessary, until the tool is in the desired position.

E. HAMMER/EXPANDER REMOVAL

As noted in the preparation section of this manual, most exit pits are not dug until the burst is complete. This simplifies the winch boom setup and maintains the integrity of the exit manhole wall. Once the tool is as far into the manhole as necessary, the exit pit is dug to the length of the hammer/expander combination. The PE attachment to the hammer is disconnected, or the PE is cut in back of the expander, at the air hose connection point. Be careful not to damage the air supply hose or shock valve when cutting through the PE. Use a chain saw, circular saw, or reciprocating saw to cut through the PE.

Disconnect the supply hose and remove it from the PE. Remove, cap, and properly store the shock valve.

⚠CAUTION: Air in the supply hose is under pressure. Wear eye protection when disconnecting hoses. Failure to do so could result in severe injury.

Disconnect the winch rope, and remove the winch boom from the manhole. In some cases, the opposite wall of the manhole must have material removed to provide enough space for the PE to enter the manhole.

Lift the hammer/expander assembly from the pit. Its a good idea to hold the hammer up by the pulling eye to drain any material from its backside. Be careful not to set the tool down on the whip hose as it is lowered to the ground. After the burst, place approximately one quart of GRUNDO-OIL into the tool and then apply air to the tool. This will remove any water and condensation from the hammer.

⚠CAUTION: Do not stand behind the tool while flushing with fluid and air.

F. PE CONNECTION TO THE MANHOLE

1. Connect PE Method. Bridge the gap between the newly installed PE and the manhole by cutting a piece of PE, and connecting it to the installed PE by using a band-type fitting or fused butt connector (Figure 39).

2. Pull Into Place Method. In some applications, the PE can be pulled towards the exit manhole and fitted into the manhole opening. This may not be possible in all ground conditions.

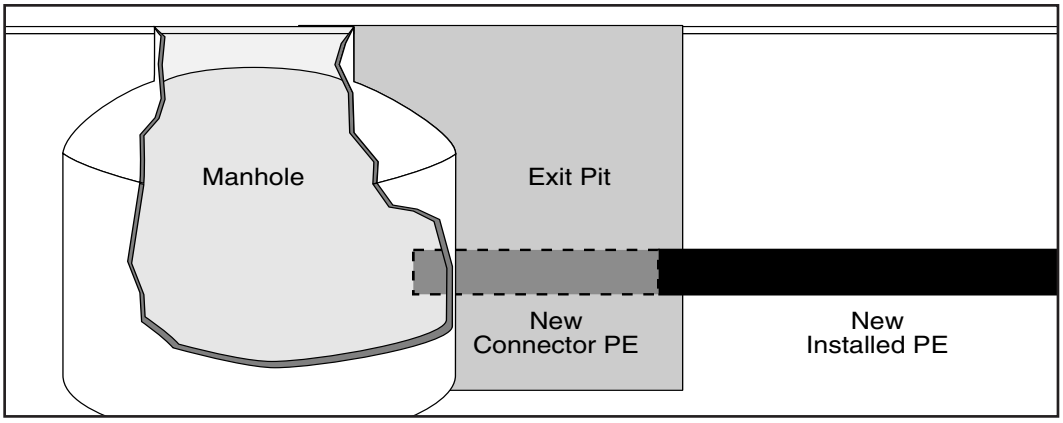


Figure 39. PE Connection to Manhole

3. Overshoot Manhole Method. The winch boom is setup in the normal manner. As the tool enters the retrieval manhole, the tool is stopped and the winch boom is removed from the manhole. In some cases, the opposite wall of the manhole must have materials removed to provide enough space for the PE to enter the manhole (Figure 40).

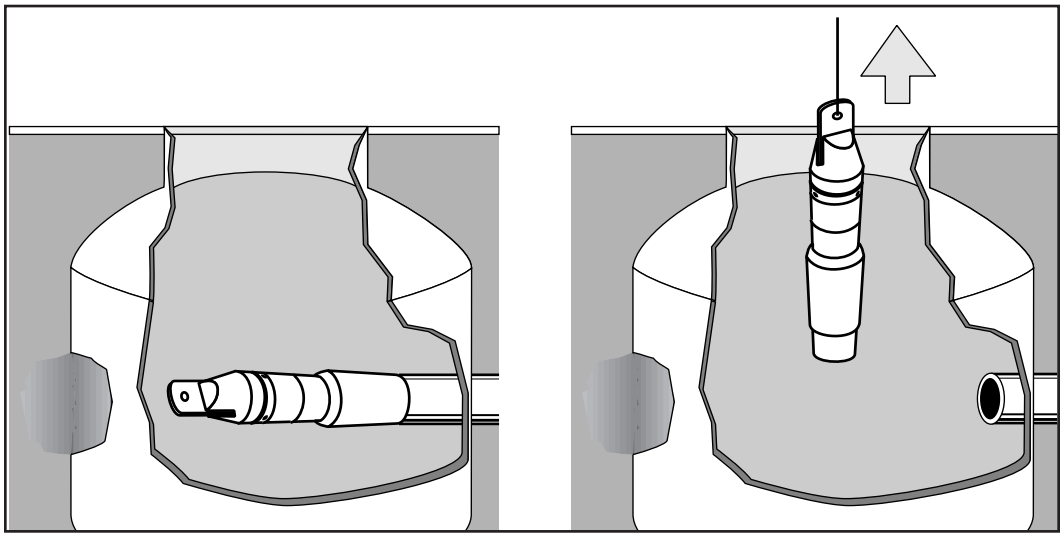


Figure 40. Overshoot Manhole Method

G. SERVICE CONNECTIONS

After the PE has been inserted into each manhole, the service connections can be made. Various products are available to simplify this process and to keep customers' inconvenience at a minimum. Reconnect gas and water services using industry approved connections.

Special Applications

10.

A. MANHOLE REMOVAL

1. Mini-Tools

TT Technologies manufactures Mini-Atlas and Mini-Olympus tools to be used where an exit pit is difficult to dig. Straight-barrel (PCG) reversible tools are available for removal back through the newly installed pipe. Setup of the hammer/expander is similar to full-size tools. The bursting process is also similar. Available space in the exit manhole must be measured. Measuring the diameter of the manhole is sometimes misleading if the pipe entry is not straight into the manhole. An example of this is shown (Figure 41).

The PE is cut and the supply hose can be removed from the installed PE. The Mini-Hammer then can be lifted from the manhole. The hole in the opposite manhole wall is repaired after the burst.

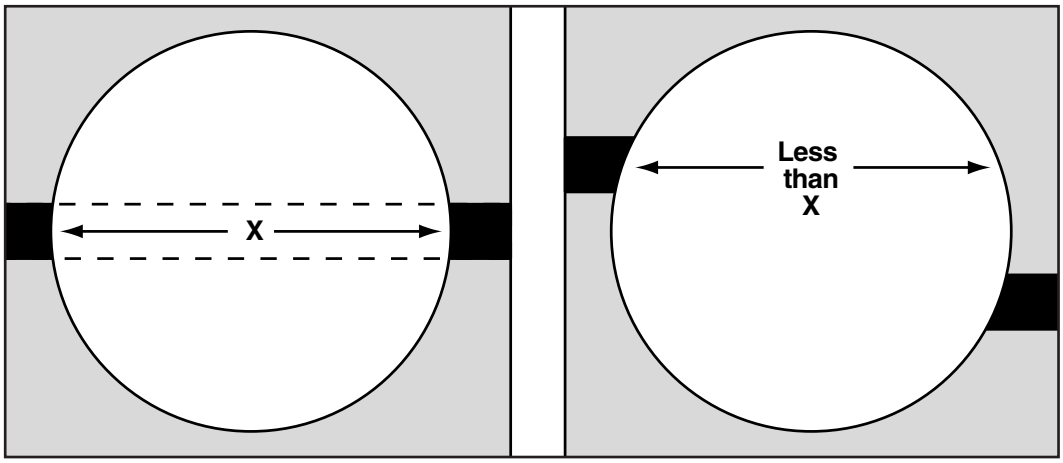


Figure 41. Measuring Diameter of Manhole

In addition to the above usage, the Mini-Hammers can be used in service bursts to reduce the pit dimensions. Information on specific jobs can be given to TT Product Specialists for evaluation and feasibility.

B. WINDOWING* - EXIT MANHOLE -10" AND SMALLER PE

TT Technologies has a method of tool removal which uses a pilot shaft out of the exit manhole.

⚠DANGER: Locate utilities before your dig. GRUNDOCRACK tool contact with power cable can cause injury or death.

This process begins by preparing the opposite wall of the manhole. Create a hole larger than the expander diameter above the outflow pipe. Be careful to ensure that the outflow pipe will not be damaged as the tool is removed. Once the manhole wall opening is complete, create a bore using a 2½ - 3" GRUNDOMAT Piercing Tool from inside the manhole up to the surface at a 20-25 degree angle. Once the pilot hole is in place, open the hole to a usable diameter using a larger tool and expander (Mini-Atlas, Mini-Olympus).

Perform the burst with the normal setup, and once the hammer/expander enters the exit manhole, remove the winch boom, move the winch to the ground level window shaft exit, and secure it. Place the winch rope down the window shaft, and connect it to the hammer's pulling eye. Use the winch to pull the hammer assembly into the window shaft until the new PE is in the manhole. Disconnect the PE from the hammer assembly, and with the air still applied, pull the tool through the window shaft to the surface. Shut off the air pressure, and remove the air hoses and shock valve from either direction (Figures 42–44), for illustrations of windowing from the exit manhole.

*** Patent Pending**

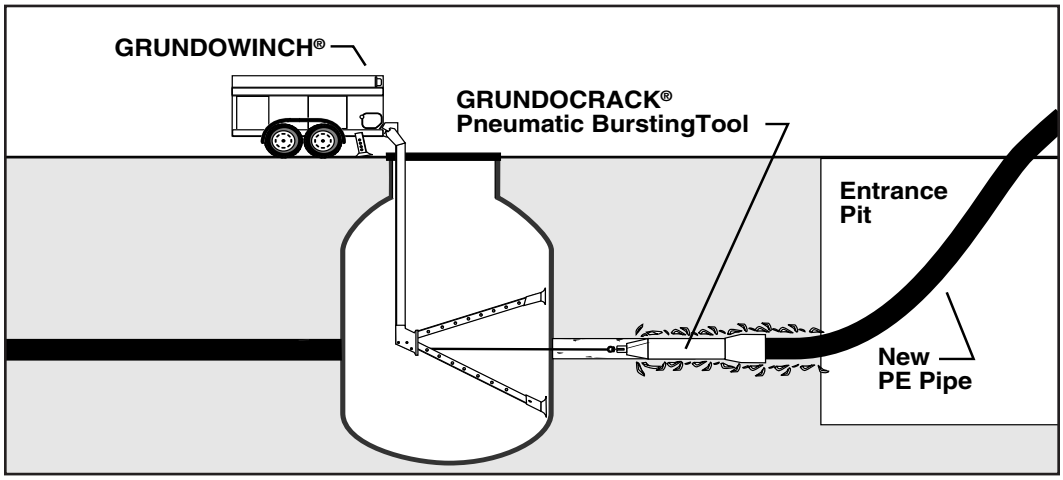


Figure 42. Windowing Exit, Step 1.

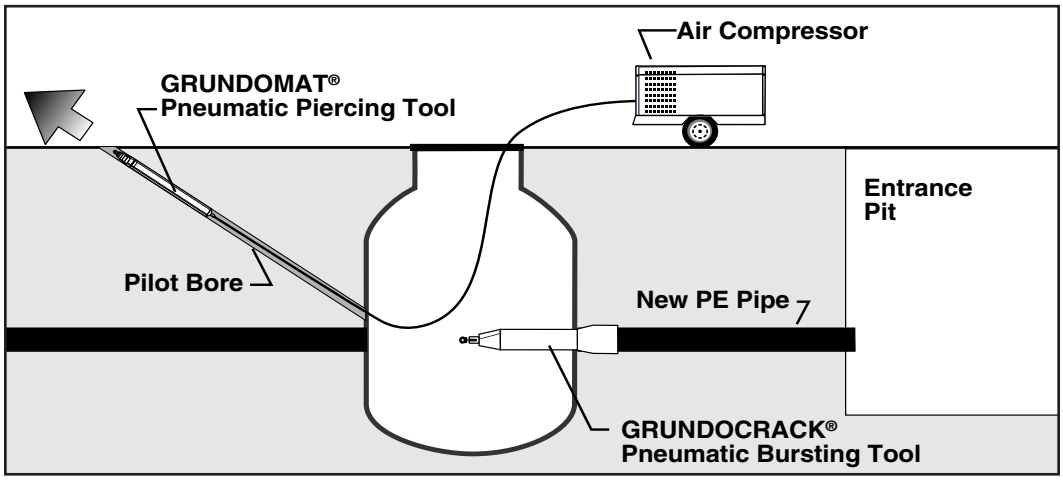


Figure 43. Windowing Exit, Step 2.

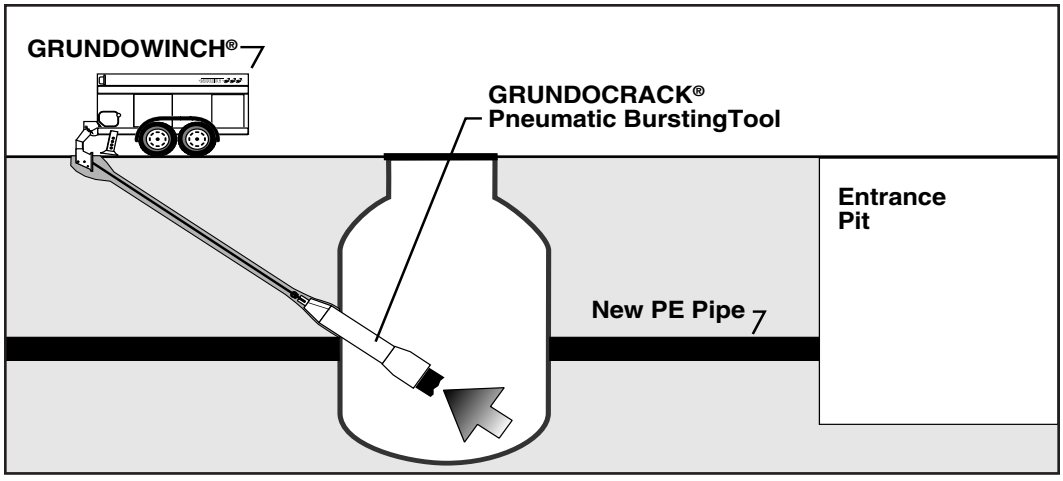


Figure 44. Windowing Exit, Step 3.

C. WINDOWING* - ENTRANCE MANHOLE

Use a similar process to start the hammer/expander/PE assembly into the host pipe.

The angle of the window shaft out of the manhole may have to be smaller to allow the hammer assembly to bend into the host pipe and not dive out. The construction of the shaft is similar, but the amount of material removed above the outflow pipe may be enlarged to allow room for the PE to bend.

The two procedures can be used in combination to provide a trenchless PE installation. Detailed procedures are available from TT Technologies, Inc. In addition, windowing can be used in a slip-lining operation from the entrance manhole (Figures 45–49). Windows can be used on both ends of the job site if needed.

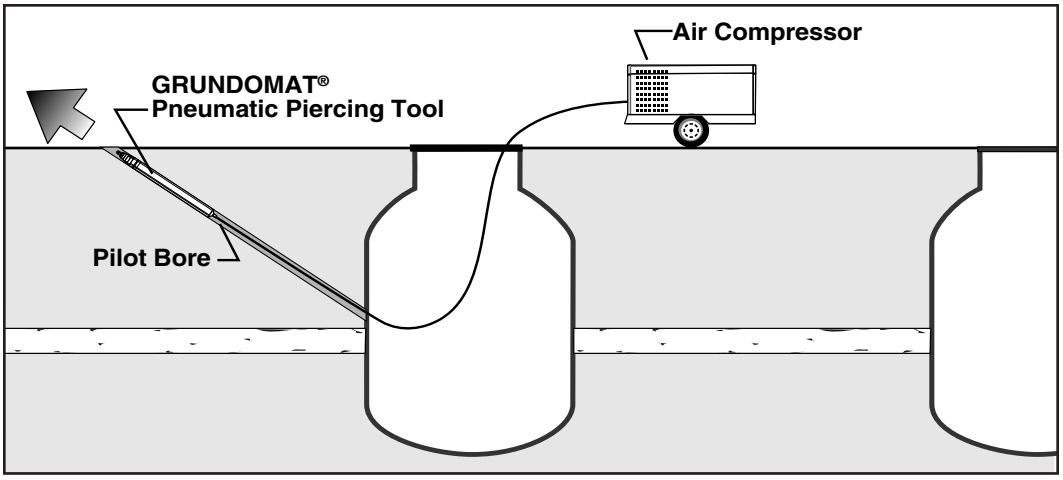


Figure 45. Windowing Entrance, Step 1.

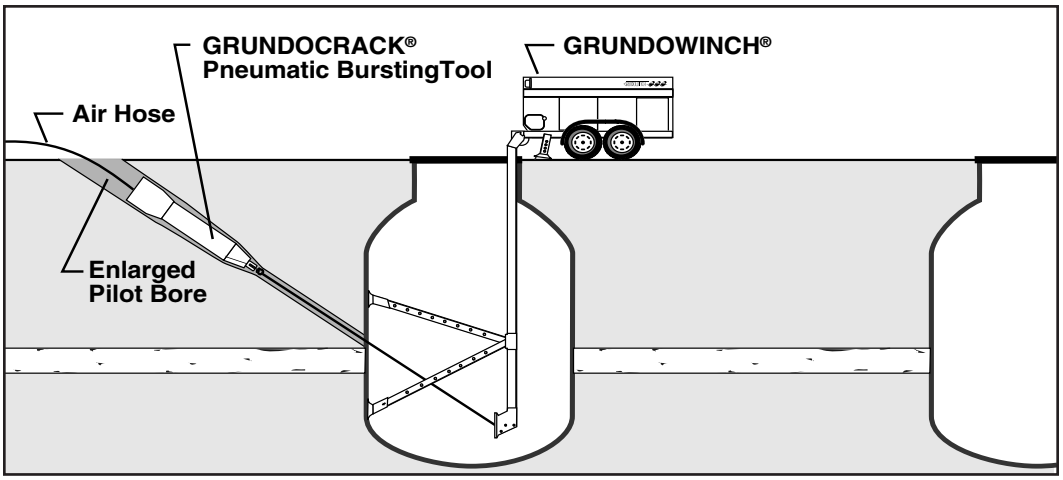


Figure 46. Windowing Entrance, Step 2.

*** Patent Pending**

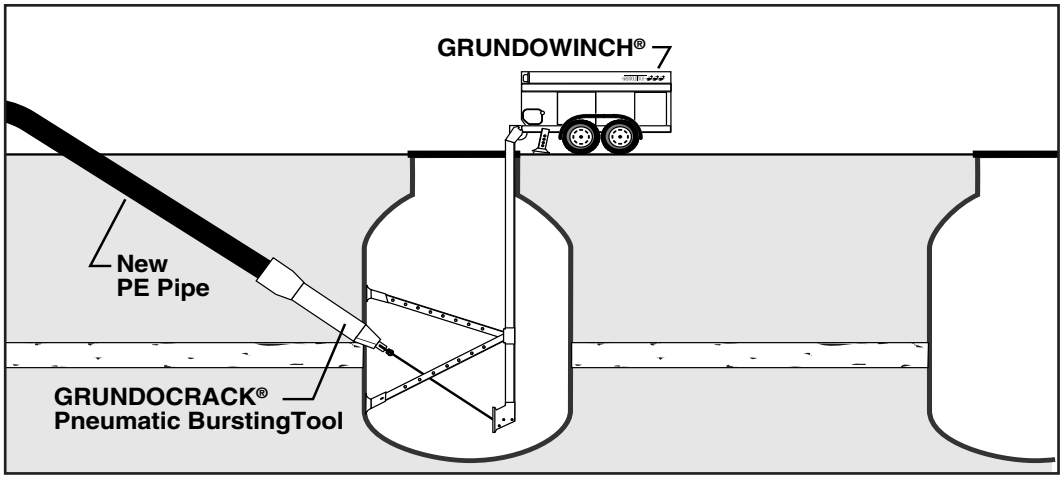


Figure 47. Windowing Entrance, Step 3.

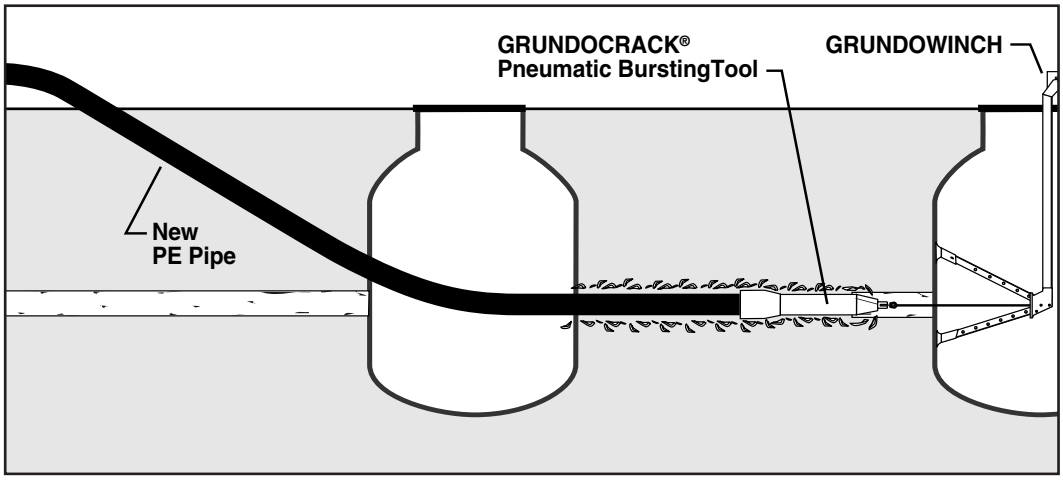


Figure 48. Windowing Entrance, Step 4.

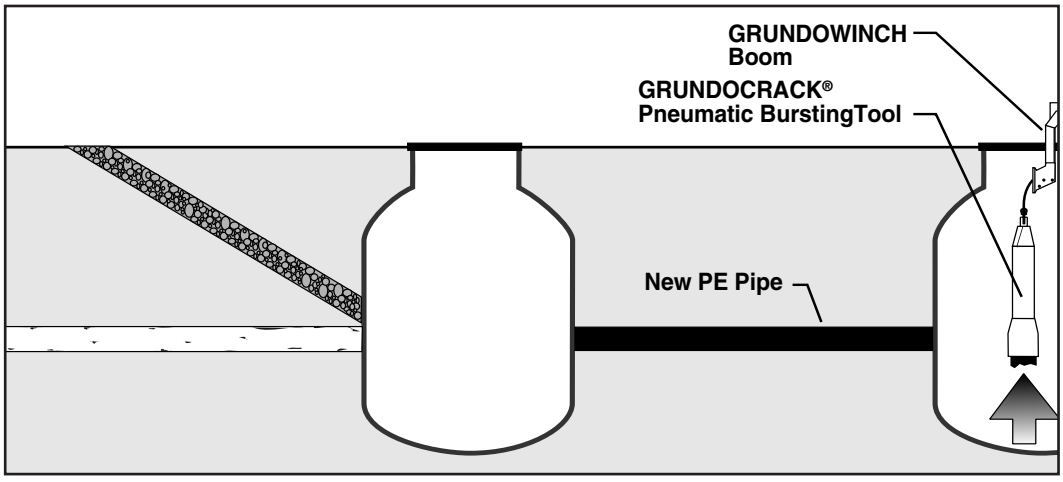


Figure 49. Windowing Entrance, Step 5.

D. REVERSE REMOVAL WITH PCG "STRAIGHT BARREL TOOLS"

GRUNDOCRACK PCG tools can be reversed automatically with a quick throw of a lever on the in-line lubricator. Once the expander is disconnected, the tool is reversed and removed back through the newly installed PE Pipe. Reverse should be used at only 25% power. This method can save time and expense of exit pit removal. Ideal for same-size bursting applications including 6" to 6", 8" to 8", 10" to 10", 12" to 12", 14" to 14", 16" to 16", 18" to 18", 20" to 20", or maximum one-size upsize depending on front expander configuration (Figures 50–53).

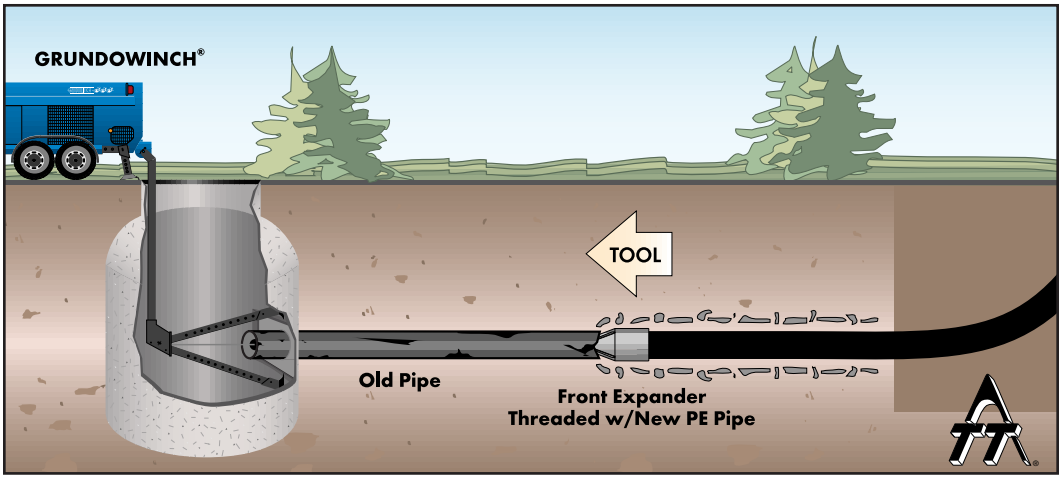


Figure 50. Straight Barrel Removal, Step 1.

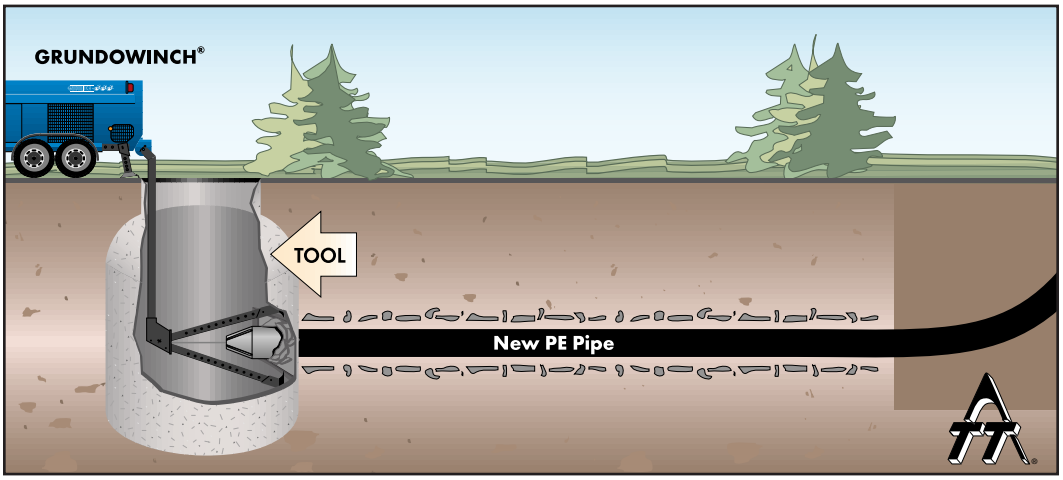


Figure 51. Straight Barrel Removal, Step 2.

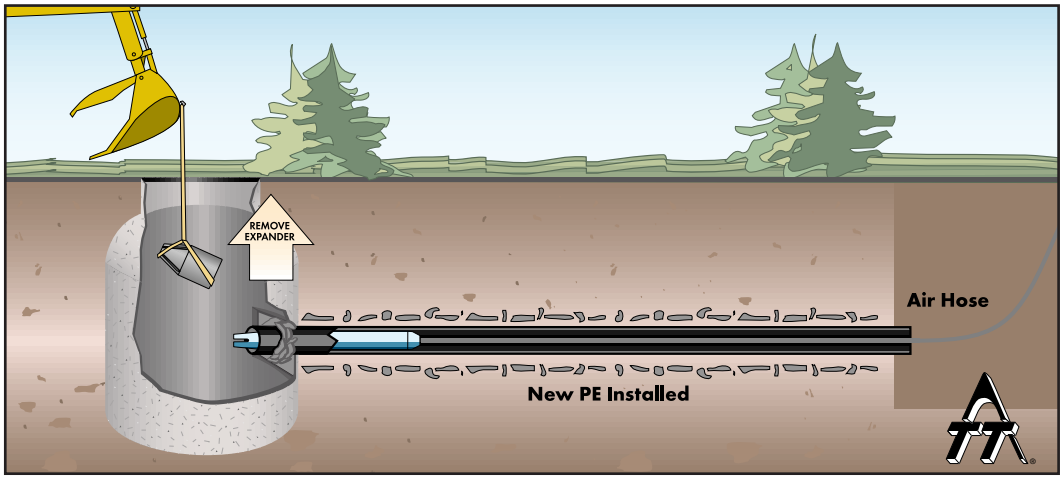


Figure 52. Straight Barrel Removal, Step 3.

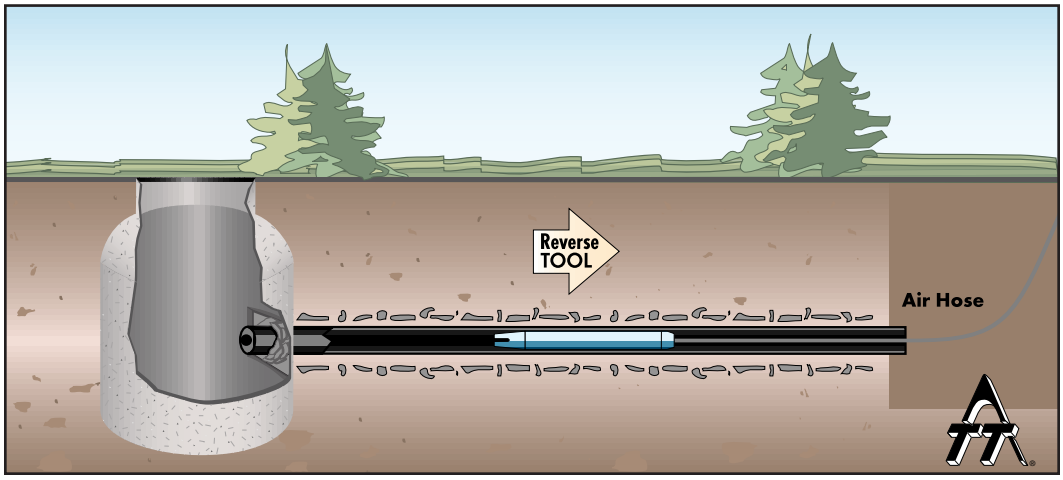


Figure 53. Straight Barrel Removal, Step 4.

Note: Reversible pipe bursting tools often cannot do as long a burst as the rear expander production tools. Revesibles must be smaller than new pipe being pulled in in order to be reversible. Smaller tools mean less power.

E. LATERAL PIPE REPLACEMENT

The GRUNDOCRACK Mini-Atlas and the 2-ton GRUNDOWINCH are ideally suited for 4" and 6" lateral pipe replacements. Nearly any type of host pipe can be burst and replaced with HDPE or PVC pipe. Typical bursts may run from 10-100' in length. By teaming up the Mini-Atlas with the 2-ton GRUNDOWINCH you create an effective, portable and economical way to replace laterals (Figure 54).

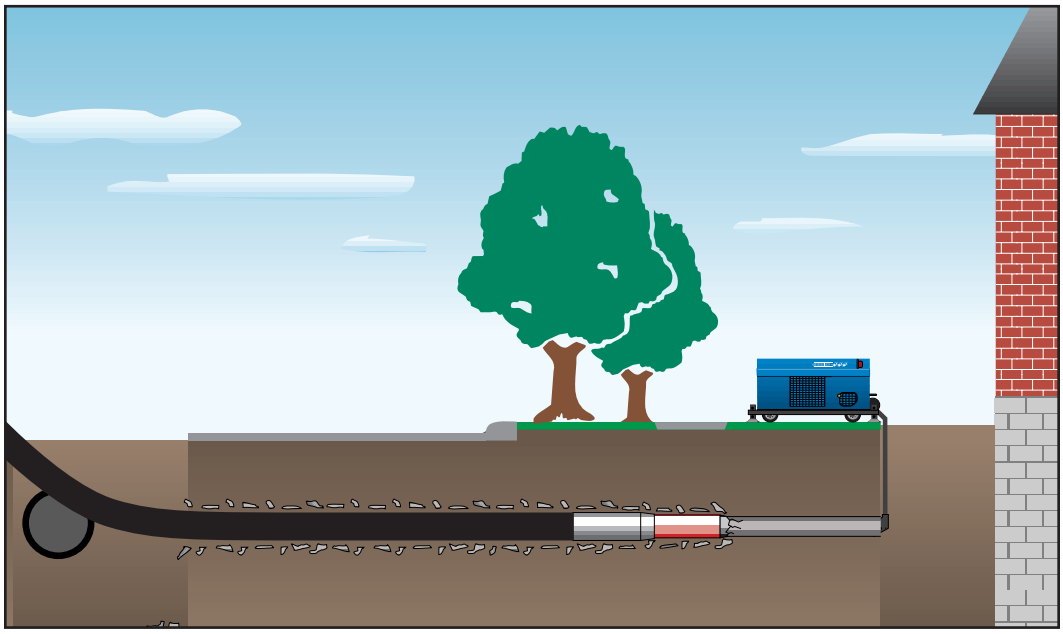


Figure 54. Lateral Pipe Replacement

Appendices

11.

A. GRUNDOCRACK APPLICATION CHECKLIST:

Questions concerning the old pipe:

1. Quality of the old pipe: _____
   A.) Is any of the pipe run collapsed? _____
2. Diameter of old pipes: _____OD _____ID
3. Material of old pipe: _____Clay _____Cast Iron ____Concrete _____PVC_____Other
4. Type of old pipe: _____Pressure Pipe _____Sewage Pipe
5. Number of required house connections:_____
6. Cover Depth _____
7. Has the pipe been inspected with a camera? _____ Yes _____No
   A.) What is the result of the inspection: _____
   B.) If so has a recording been made:_____
   C.) Is copy of the recording available: _____Yes _____No
8. Has the pipe collapsed? _____Yes_____No
   A.) If yes, is there enough room to pass a steel cable through the pipe? ____Yes ____No
9. What sort of bed is the pipe laying on? _____
10. Has the pipe settled in the ground? _____Yes _____No
11. Are the pipe joints broken or misaligned? _____Yes _____No
12. What is the average length of run to be replaced? _____
13. What is the longest length of run to be replaced? _____
14. What is the total footage of the run to be replaced? _____
15. Are tree roots to be expected because of adjacent trees? _____Yes _____No
16. Is this a one-time site only? _____Yes _____No
17. What is the customer's main field of application?_____
18. Is the existing pipe concrete encased? _____Yes ____No
    A.) Is the existing pipe sitting on any footings? ____Yes ____No
    B.) Are they anchored in? _____Yes ____No
19. Are there any bends in the old line between manholes? ____Yes ____No
    A.) If yes explain: _____
20. Does the old line have any voids, holes or missing sections? _____Yes _____No
    A.) If yes explain: _____
21. What is the ovality of the existing line: _____
22. Has the old line been relined, slip-lined or rehabbed before? ____Yes _____No
23. Is the existing pipe bedding supportive of a new pipeline? _____Yes _____No
24. Is there a possible environmental hazard? _____Yes_____No
    A.) If yes explain: _____
25. Is the area considered a wetland? _____Yes_____No
26. Is well pointing needed? _____Yes _____No

Questions concerning the new pipe:

1. Quality of the new pipe: _____
2. Diameter of the new pipe:_____OD _____ID
3. Type of new pipe to be installed: _____
4. Type of pipe connections: _____
5. What is the largest outside diameter of these connections: _____
6. Length of starting pit: _____
7. Length of exit pit: _____
8. Capacity and type of compressor available_____cubic ft/min
9. Is capstan winch available? _____Yes _____No

Questions Regarding the Job:

1. Do the conditions warrant a trenchless method? _____Yes_____No
   A.) If yes explain: _____
   B.) Does the job require urgency for completion? _____Yes_____No

Date: _____Completed By: _____

B. WELDING PROCEDURE TO INSTALL CUTTING BLADES TO EXPANDER

1. Purchase hardened wear-resistant cutting blades from TT Technologies.
2. Clean front face of pipe bursting expander.
3. Three or four cutting blades may be used.
4. Preheat front face of pipe bursting expander (400 degrees).
5. Use low hydrogen welding rod (E7018 welding rod) to attach cutting blades to bursting face.

C. HARD SURFACE PROCEDURE (MAINTENANCE OF EXPANDERS)

1. Clean front face of pipe bursting expander.
2. Preheat area to be hardsurfaced (400 degrees).
3. Weld in a cross hatch pattern in the area needing hardsurfacing.

D. SHOCK VALVE CLEANING AND DISASSEMBLY

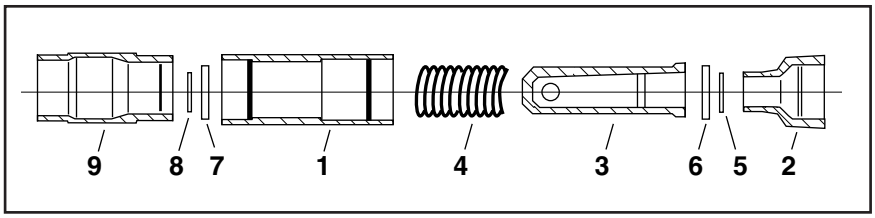


Figure 55. Construction of Shock Valve

1. Casing
2. Front Casing
3. Piston
4. Spring
5. Seal with O-Ring
6. Seal with O-Ring
7. Exhaust Ring
8. O-Ring
9. Casing End

Tool must be in proper working condition to realize maximum operating effectiveness.

1. Clamp the shock valve in a soft claw vice.
2. Quickly pre-heat the threads of the front of the casing to approximately 100° C using a gas burner. The correct temperature can be checked by using conventional colored chalk or crayons.
3. Release the front casing (Item 2) with a C-spanner and a hammer. Unscrew the front casing by hand.
4. Pull out piston (Item 3) and spring (Item 4).
5. Release the remaining part of the casing, turn it, and clamp it again.
6. Quickly pre-heat the threads of the casing end (Item 9) and release it using C-spanner and a hammer. Unscrew the casing end by hand.
7. Remove the exhaust ring (Item 7).
8. Carefully clean all the components. When using degreasing solvents keep to the appropriate regulations.
9. Check whether the seals (Items 5, 6, and 8) are worn out and replace if necessary.
10. Clamp the casing (Item 1) into a soft jaw vice.
11. Push on the exhaust ring (Item 7) onto the casing end.
12. Apply Loctite PST 567 onto the last threads of the casing end and screw it onto the casing by hand.
13. Secure the casing end by applying a few hammer blows onto the C-spanner.
14. Turn the already assembled part of the casing and clamp it again.
15. Slide the spring (Item 4) and the piston (Item 3) onto the casing (Item 1).
16. Apply Loctite PST 567 onto the last threads of the front casing and screw it onto the casing by hand.
17. Secure the front casing by applying a few hammer blows onto the C-spanner.
18. The couplings for the connection to the flat-lay hose can remain in the casing end and front casing during the cleaning process.
19. The shock valve can now be used.
20. After each use, clean the shock valve with diesel fuel, GRUNDO-OIL, air tool oil, or kerosene, install protective caps, and store it in a clean, secure place. This will help prevent components from rusting during storage.

E. NON-TT SUPPLIED EQUIPMENT FOR PIPE BURSTING JOBS

1. Enough labor for the job - TT offers technical support services only.
2. Rubber tired backhoe - necessary to lift hammer, pull PE pipe, install winch boom in manhole, etc.
3. Proper shoring equipment to make all pits safe.
4. Adequate bypass equipment - reversible jobs require extensive manhole preparation; the job cannot be accomplished with sewage running through the manhole.
5. Trash pumps to handle ground water and lateral seepage.
6. A method to pull rope into PE pipe and host pipe to install air hoses and winch rope. A duct rodder will work on PE trains up to 300 feet, but does not work well in large diameter PE (14"+).
7. Two air hose spanner wrenches for flat-lay hose connections - using pipe wrenches will damage the rubber gaskets in the air supply hoses if over-tightened.
8. At least 500 feet of high quality 5/8" or larger rope - any smaller diameter will not last as long or break.
9. Drill, drill bits, hex sockets, and necessary hand tools, including a 25' tape, sledge hammer, digging bar and straps and chains for lifting.
10. Lumber for winch boom standoff, 4"x4", 6"x6". More sizes will be needed if doing a static burst. Plywood and steel plates may also be needed.
11. Hand-held radios - 3 good quality (Nextel cell phones don't work).
12. Chain saw, sawzall, etc to cut PE pipe.
13. Manhole safety equipment, including testers, ventilators, etc.
14. Air compressor sized to the hammer being used, and an additional compressor for manhole work - including hose and jackhammers.

F. STANDARD DIPS DIMENSIONS & WORKING PRESSURE RATINGS (WPR)*

STANDARD DIPS* DIMENSIONS & WORKING PRESSURE RATINGS (WPR)**													
Size		DR 21 WPR @ 80 psi			DR 17 WPR @ 100 psi			DR 13.5 WPR @ 130 psi			DR 11 WPR @ 160 psi		
Nom. Size "DIPS"	OD Size (in)	Avg. ID (in)	Min. Wall (in)	Weight (lbs/ft)	Avg. ID (in)	Min. Wall (in)	Weight (lbs/ft)	Avg. ID (in)	Min. Wall (in)	Weight (lbs/ft)	Avg. ID (in)	Min. Wall (in)	Weight (lbs/ft)
4"	4.80	4.323	0.229	1.44	4.216	0.282	1.75	4.070	0.356	2.17	3.909	0.436	2.61
6"	6.90	6.215	0.329	2.97	6.060	0.406	3.62	5.851	0.511	4.48	5.620	0.627	5.39
8"	9.05	8.151	0.431	5.11	7.950	0.532	6.23	7.675	0.670	7.71	7.375	0.823	9.28
10"	11.10	10.000	0.529	7.68	9.750	0.653	9.37	9.413	0.822	11.60	9.041	1.009	13.95
12"	13.20	11.890	0.629	10.86	11.600	0.776	13.25	11.190	0.978	16.40	10.750	1.200	19.73
16"	17.40	15.675	0.829	18.87	15.285	1.024	23.02	14.750	1.289	28.49	14.170	1.582	34.29
18"	19.50	17.560	0.929	23.70	17.125	1.147	28.92	16.536	1.444	35.78	15.925	1.773	43.07
20"	21.60	19.455	1.029	29.08	18.975	1.271	35.48	18.315	1.600	43.91	17.590	1.964	52.84
24"	25.80	23.238	1.229	41.05	22.668	1.518	50.62	21.880	1.911	62.64	21.014	2.345	75.39

* Ductile-Iron OD Pipe Sizing

** Per AWWA C906, the working pressure rating equals the pressure class, with an allowance included in the WPR for pressure surge.

G. MINIMUM BEND RADIUS CALCULATIONS FOR HDPE PIPE

MINIMUM ALLOWABLE BEND RADIUS for HDPE PIPE @ 73°F										
SDR	7	9	11	13.5	15.5	17	19	21	26	32.5
Minimum Bend Radius, R_a	> 20 x OD	> 20 x OD	> 25 x OD	> 25 x OD	> 27 x OD	> 27 x OD	> 27 x OD	> 28 x OD	> 35 x OD	> 40 x OD

HDPE pipe can be bent to a minimum radius between 20 to 40 times the pipe diameter.

EXAMPLE: For 24" SDR 21 pipe, the minimum bend radius ($R_{a)}$ is calculated as shown:

Where: R_a = radius of pipe curvature (in.) ***and*** OD = the outside diameter of the pipe (in.)

$R_a > 28 \times OD"$ $R_a > 28 \times 24"$ $R_a > 672"$

Thus: The radius of the circular sector (bend) must be greater than 672" (56 ft.)

H. HDPE PIPE SIZE & DIMENSION CHARTS

4" (4.500 OD)				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 7	267 psi	3.214	.643	3.39
SDR 9	200 psi	3.500	.500	2.74
SDR 11*	**160 psi**	**3.682**	**.409**	**2.29**
SDR 13.5	128 psi	3.834	.333	1.90
SDR 15.5*	**110 psi**	**3.920**	**.290**	**1.68**
SDR 17*	**100 psi**	**3.970**	**.265**	**1.54**
SDR 19	89 psi	4.026	.237	1.39
SDR 21	80 psi	4.072	.214	1.26
SDR 26*	**64 psi**	**4.154**	**.173**	**1.03**
SDR 32.5	51 psi	4.224	.138	0.83

6" (6.625 OD)				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 7	267 psi	4.733	.946	7.33
SDR 9	200 psi	5.153	.736	5.93
SDR 11*	**160 psi**	**5.421**	**.602**	**4.97**
SDR 13.5	128 psi	5.643	.491	4.13
SDR 15.5	110 psi	5.771	.427	3.63
SDR 17*	**100 psi**	**5.845**	**.390**	**3.34**
SDR 19	89 psi	5.927	.349	3.01
SDR 21*	**80 psi**	**5.995**	**.315**	**2.73**
SDR 26*	**64 psi**	**6.115**	**.255**	**2.23**
SDR 32.5*	**51 psi**	**6.217**	**.204**	**1.80**

7" (7.125 OD)				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 7	267 psi	5.089	1.018	8.49
SDR 9	200 psi	5.541	.792	6.86
SDR 11	160 psi	5.829	.648	5.75
SDR 13.5	128 psi	6.069	.528	4.78
SDR 15.5	110 psi	6.205	.460	4.21
SDR 17	100 psi	6.287	.419	3.86
SDR 19	89 psi	6.375	.375	3.48
SDR 21	80 psi	6.445	.340	3.16
SDR 26*	**64 psi**	**6.577**	**.274**	**2.58**
SDR 32.5	51 psi	6.685	.220	2.08

8" (8.625 OD)				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 7	267 psi	6.161	1.232	12.43
SDR 9	200 psi	6.709	.958	10.05
SDR 11*	**160 psi**	**7.057**	**.784**	**8.42**
SDR 13.5	128 psi	7.347	.639	7.00
SDR 15.5	110 psi	7.513	.556	6.16
SDR 17*	**100 psi**	**7.611**	**.507**	**5.65**
SDR 19	89 psi	7.717	.454	5.10
SDR 21*	**80 psi**	**7.803**	**.411**	**4.64**
SDR 26*	**64 psi**	**7.961**	**.332**	**3.79**
SDR 32.5*	**51 psi**	**8.095**	**.265**	**3.05**

*** Denotes Standard Sizes**

10" (10.750 OD)				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 7	267 psi	7.678	1.536	19.32
SDR 9	200 psi	8.362	1.194	15.61
SDR 11*	**160 psi**	**8.796**	**.977**	**13.09**
SDR 13.5	128 psi	9.158	.796	10.87
SDR 15.5	110 psi	9.362	.694	9.58
SDR 17*	**100 psi**	**9.486**	**.632**	**8.78**
SDR 19	89 psi	9.618	.566	7.92
SDR 21*	**80 psi**	**9.726**	**.512**	**7.21**
SDR 26*	**64 psi**	**9.924**	**.413**	**5.87**
SDR 32.5*	**51 psi**	**10.088**	**.331**	**4.75**

12" (12.750 OD)				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 7	267 psi	9.108	1.821	27.16
SDR 9	200 psi	9.916	1.417	21.97
SDR 11*	**160 psi**	**10.432**	**1.159**	**18.41**
SDR 13.5	128 psi	10.862	.944	15.29
SDR 15.5*	**110 psi**	**11.104**	**.823**	**13.48**
SDR 17*	**100 psi**	**11.250**	**.750**	**12.36**
SDR 19	89 psi	11.408	.671	11.14
SDR 21*	**80 psi**	**11.536**	**.607**	**10.13**
SDR 26*	**64 psi**	**11.770**	**.490**	**8.26**
SDR 32.5*	**51 psi**	**11.966**	**.392**	**6.67**

14.000 OD				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 7	267 psi	10.000	2.000	32.76
SDR 9	200 psi	10.888	1.556	26.50
SDR 11*	**160 psi**	**11.454**	**1.273**	**22.20**
SDR 13.5	128 psi	11.926	1.037	18.44
SDR 15.5	110 psi	12.194	.903	16.24
SDR 17*	**100 psi**	**12.352**	**.824**	**14.91**
SDR 19	89 psi	12.526	.737	13.43
SDR 21	80 psi	12.666	.667	12.22
SDR 26*	**64 psi**	**12.924**	**.538**	**9.96**
SDR 32.5	51 psi	13.138	.431	8.05

16.000 OD				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 9	200 psi	12.444	1.778	34.60
SDR 11*	**160 psi**	**13.090**	**1.455**	**29.00**
SDR 13.5	128 psi	13.630	1.185	24.09
SDR 15.5	110 psi	13.936	1.032	21.21
SDR 17*	**100 psi**	**14.118**	**.941**	**19.46**
SDR 19	89 psi	14.316	.842	17.54
SDR 21*	**80 psi**	**14.476**	**.762**	**15.96**
SDR 26*	**64 psi**	**14.770**	**.615**	**13.01**
SDR 32.5	51 psi	15.016	.492	10.50

*** Denotes Standard Sizes**

18.000 OD				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 9	200 psi	14.000	2.000	43.79
SDR 11*	**160 psi**	**14.728**	**1.636**	**36.69**
SDR 13.5	128 psi	15.334	1.333	30.48
SDR 15.5*	**110 psi**	**15.678**	**1.161**	**26.84**
SDR 17*	**100 psi**	**15.882**	**1.059**	**24.64**
SDR 19	89 psi	16.106	.947	22.19
SDR 21	80 psi	16.286	.857	20.19
SDR 26*	**64 psi**	**16.616**	**.692**	**16.47**
SDR 32.5	51 psi	16.892	.554	13.30

20.000 OD				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 9	200 psi	15.556	2.222	54.05
SDR 11*	**160 psi**	**16.364**	**1.818**	**45.30**
SDR 13.5	128 psi	17.038	1.481	37.63
SDR 15.5	110 psi	17.420	1.290	33.14
SDR 17	100 psi	17.648	1.176	30.41
SDR 19	89 psi	17.894	1.053	27.42
SDR 21	80 psi	18.096	.952	24.93
SDR 26*	**64 psi**	**18.462**	**.769**	**20.34**
SDR 32.5*	**51 psi**	**18.770**	**.615**	**16.41**

22.000 OD				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 9	200 psi	17.112	2.444	65.40
SDR 11*	**160 psi**	**18.000**	**2.000**	**54.82**
SDR 13.5	128 psi	18.740	1.630	45.56
SDR 15.5	110 psi	19.162	1.419	40.10
SDR 17	100 psi	19.412	1.294	36.80
SDR 19	89 psi	19.684	1.158	33.16
SDR 21	80 psi	19.904	1.048	30.18
SDR 26*	**64 psi**	**20.308**	**.846**	**24.61**
SDR 32.5*	**51 psi**	**20.646**	**.677**	**19.86**

24.000 OD				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 9	200 psi	18.666	2.667	77.85
SDR 11*	**160 psi**	**19.636**	**2.182**	**65.24**
SDR 13.5	128 psi	20.444	1.778	54.21
SDR 15.5	110 psi	20.904	1.548	47.72
SDR 17*	**100 psi**	**21.176**	**1.412**	**43.81**
SDR 19	89 psi	21.474	1.263	39.46
SDR 21*	**80 psi**	**21.714**	**1.143**	**35.91**
SDR 26*	**64 psi**	**22.154**	**.923**	**29.30**
SDR 32.5*	**51 psi**	**22.524**	**.738**	**23.62**

*** Denotes Standard Sizes**

26.000 OD				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 11	160 psi	21.272	2.364	76.57
SDR 13.5	128 psi	22.148	1.926	63.62
SDR 15.5	110 psi	22.646	1.677	56.00
SDR 17	100 psi	22.942	1.529	51.39
SDR 19	89 psi	23.264	1.368	46.30
SDR 21	80 psi	23.524	1.238	42.14
SDR 26	64 psi	24.000	1.000	34.39
SDR 32.5*	**51 psi**	**24.400**	**.800**	**27.74**

28.000 OD				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 11	160 psi	22.910	2.545	88.78
SDR 13.5	128 psi	23.852	2.074	73.78
SDR 15.5	110 psi	24.388	1.806	64.95
SDR 17*	**100 psi**	**24.706**	**1.647**	**59.62**
SDR 19	89 psi	25.052	1.474	53.73
SDR 21	80 psi	25.334	1.333	48.86
SDR 26	64 psi	25.846	1.077	39.88
SDR 32.5*	**51 psi**	**26.276**	**.862**	**32.19**

30.000 OD				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 11	160 psi	24.546	2.727	101.92
SDR 13.5	128 psi	25.556	2.222	84.69
SDR 15.5	110 psi	26.130	1.935	74.56
SDR 17	100 psi	26.470	1.765	68.45
SDR 19	89 psi	26.842	1.579	61.67
SDR 21*	**80 psi**	**27.142**	**1.429**	**56.12**
SDR 26	64 psi	27.692	1.154	45.78
SDR 32.5*	**51 psi**	**28.154**	**.923**	**36.93**

32.000 OD				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 13.5	128 psi	27.260	2.370	96.35
SDR 15.5	110 psi	27.870	2.065	84.87
SDR 17	100 psi	28.236	1.882	77.86
SDR 19	89 psi	28.632	1.684	70.15
SDR 21	80 psi	28.952	1.524	63.84
SDR 26	64 psi	29.538	1.231	52.10
SDR 32.5*	**51 psi**	**30.030**	**.985**	**42.04**

34.000 OD				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 13.5	128 psi	28.962	2.519	108.81
SDR 15.5	110 psi	29.612	2.194	95.81
SDR 17	100 psi	30.000	2.000	87.91
SDR 19	89 psi	30.422	1.789	79.17
SDR 21	80 psi	30.762	1.619	72.06
SDR 26	64 psi	31.384	1.308	58.81
SDR 32.5	51 psi	31.908	1.046	47.43

*** Denotes Standard Sizes**

36.000 OD				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 13.5	128 psi	30.666	2.667	121.98
SDR 15.5	110 psi	31.354	2.323	107.41
SDR 17	100 psi	31.764	2.118	98.57
SDR 19	89 psi	32.210	1.895	88.81
SDR 21*	**80 psi**	**32.572**	**1.714**	**80.78**
SDR 26*	**64 psi**	**33.230**	**1.385**	**65.94**
SDR 32.5*	**51 psi**	**33.784**	**1.108**	**53.20**

1000 mm (39.370 OD)				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 17	100 psi	34.738	2.316	117.88
SDR 19	89 psi	35.226	2.072	106.18
SDR 21	80 psi	35.620	1.875	96.64
SDR 26	64 psi	36.342	1.514	78.83
SDR 32.5	51 psi	36.948	1.211	63.69

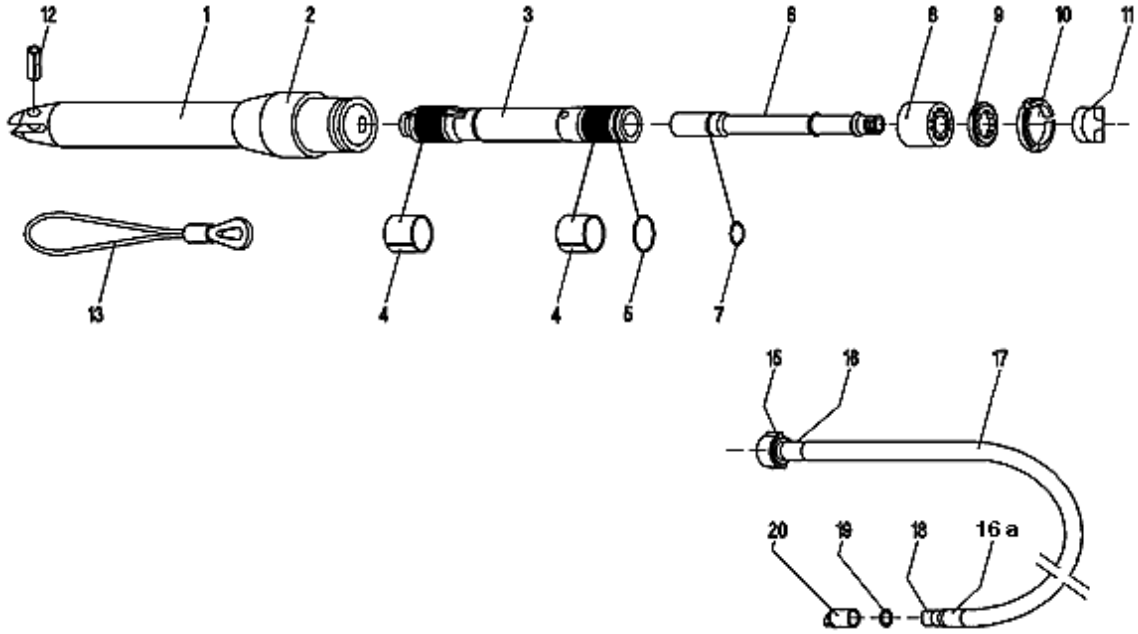
42.000 OD				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 17	100 psi	37.058	2.471	134.16
SDR 19	89 psi	37.578	2.211	120.89
SDR 21	80 psi	38.000	2.000	109.97
SDR 26*	**64 psi**	**38.770**	**1.615**	**89.71**
SDR 32.5*	**51 psi**	**39.416**	**1.292**	**72.37**

1200 mm (47.244 OD)				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 19	89 psi	42.270	2.487	152.94
SDR 21	80 psi	42.744	2.250	139.16
SDR 26*	**64 psi**	**43.610**	**1.817**	**113.53**
SDR 32.5*	**51 psi**	**44.336**	**1.454**	**91.62**

54.000 OD				
HDPE Pipe Size	**WPR**	**Avg. ID (in)**	**Min. Wall (in)**	**Weight (lbs/ft)**
SDR 26*	**64 psi**	**49.846**	**2.077**	**148.33**
SDR 32.5*	**51 psi**	**50.676**	**1.662**	**119.70**

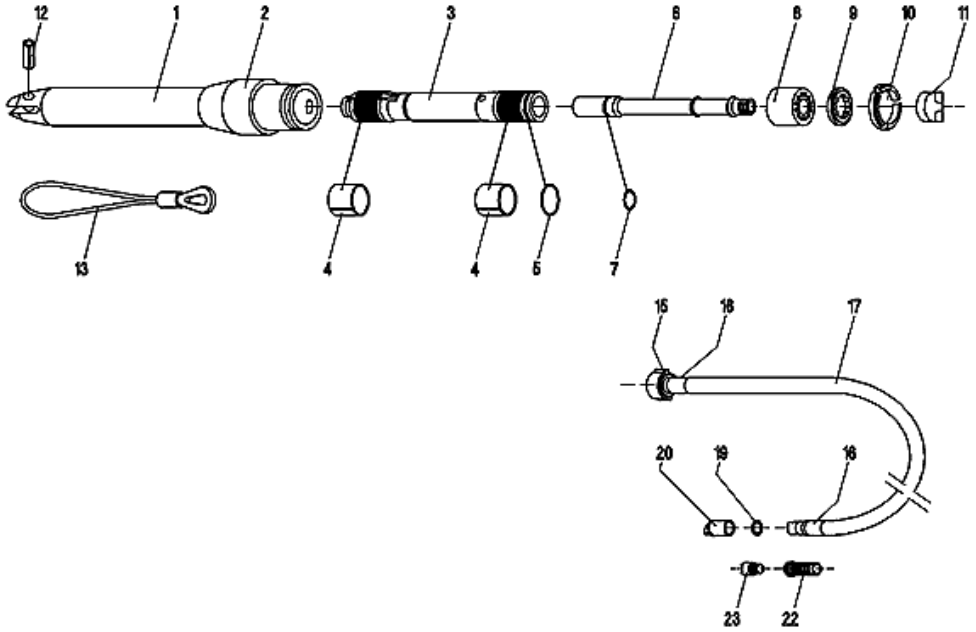
*** Denotes Standard Sizes**

I. PARTS LIST FOR PCF 130



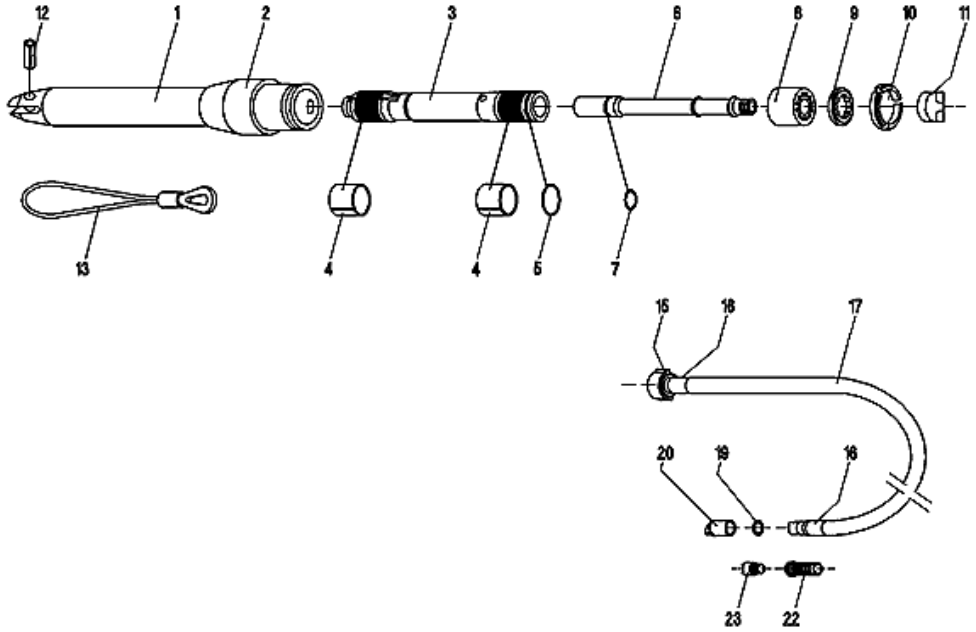
Item No	Description	Qty	Part Number
1-2	Machine body with protection ring (without cable)	1	PCF 1300154
2	Protection ring	1	EPC 1301087
3	Piston	1	G-Z 1305141
4	Piston slide tapes (set)	1	GRS 1305130
5	Piston seal	1	GRU 1305160
6-8	Control tube with elastic block and seal ring	1	AF 1300159
6	Control tube	1	AF 1300160
7	Control stud seal	1	A 1300107
8	Elastic block	1	AF 1300165
9	Support ring	1	AF 1300166
10	Segment ring	1	AF 1300167
w.o. pic.	Rubber buffer	1	AF 1300180
11	Lock nut	1	DF 0950121
12	Lock pin (set)	1	PAA 1300110
13	Steel cable with thimble	1	YY 061935
15-20	Connection air hose, complete	1	PCF 1300170
15	Nozzle with spigot nut	1	YY 191496
16	Swaging socket 50x2,5x60	1	GRU 2002460
16A	Swaging socket with claw	1	YY 192243
17	Connection air hose (without couplings)	1	GRU 2002440
18	Female coupling ND 32 for swaging	1	GRU 2006680
19	Seal for quick-coupling socket DN 32	1	G-E 1452340
20	Sealing cap for quick-coupling DN 32	1	GRU 2006641
—	Seals, (complete set)	1	PCF 1300104
1-20	Grundocrack PCF 130 (Blade head, table and protection ring)	1	PCF 1300007

J. PARTS LIST FOR PCF 145



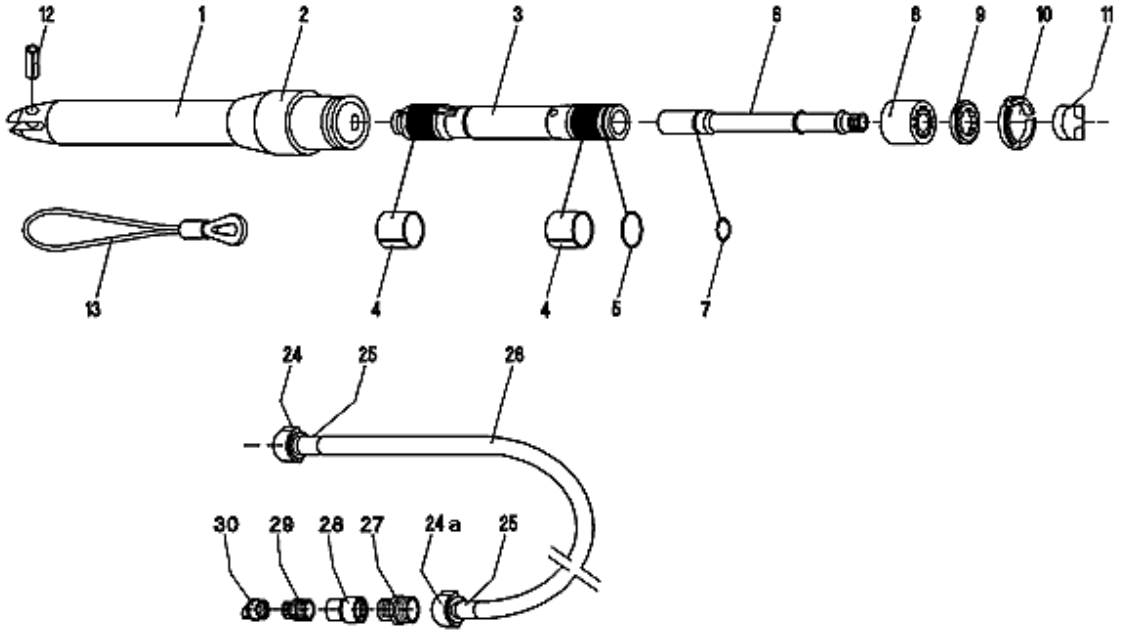
Item No	Description	Qty	Part Number
1-2	Machine body with protection ring (without cable)	1	PCF 1450156
2	Protection ring	1	EPC 1451087
3	Piston	1	G-E 1455141
4	Piston slide tapes (set)	1	G-E 1455130
5	Piston seal	1	G-E 1455160
6-8	Control tube with elastic block and seal ring	1	TF 1450159
6	Control tube	1	TF 1450160
7	Control stud seal	1	T 1450107
8	Elastic block	1	TF 1450165
9	Support ring	1	TF 1450166
10	Segment ring	1	TF 1450167
11	Lock nut with 55x1/6" knurled thread	1	G 2600221
12	Lock pin (set)	1	PAA 1300110
13	Steel cable with thimble	1	YY 061935
15-17, 19-23	Connection air hose, complete	1	PCF 1450170
w.o. pic.	Lock screw with 55x1/6" knurled thread	1	G 2600245
15	Knurled thread coupling with 55x1/6" knurled thread for swaging	1	H 2200211
16	Swaging socket 67x5x80 mm	2	YY 191698
17	Connection air hose (without couplings)	1	PCF 1450160
19	Seal for quick-coupling socket DN 32	1	G-E 1452340
20	Sealing cap for quick-coupling DN 32	1	GRU 2006641
22	Hose socket 1 1/2" with 1" internal thread	1	YY 071779
23	Female coupling with 1" outer thread	1	GRU 2002650
—	Seals, (complete set)	1	PCF 1450104
1-23	Grundocrack PCF 145 (Blade head, table and protection ring)	1	PCF 1450007

K. PARTS LIST FOR PCF 180



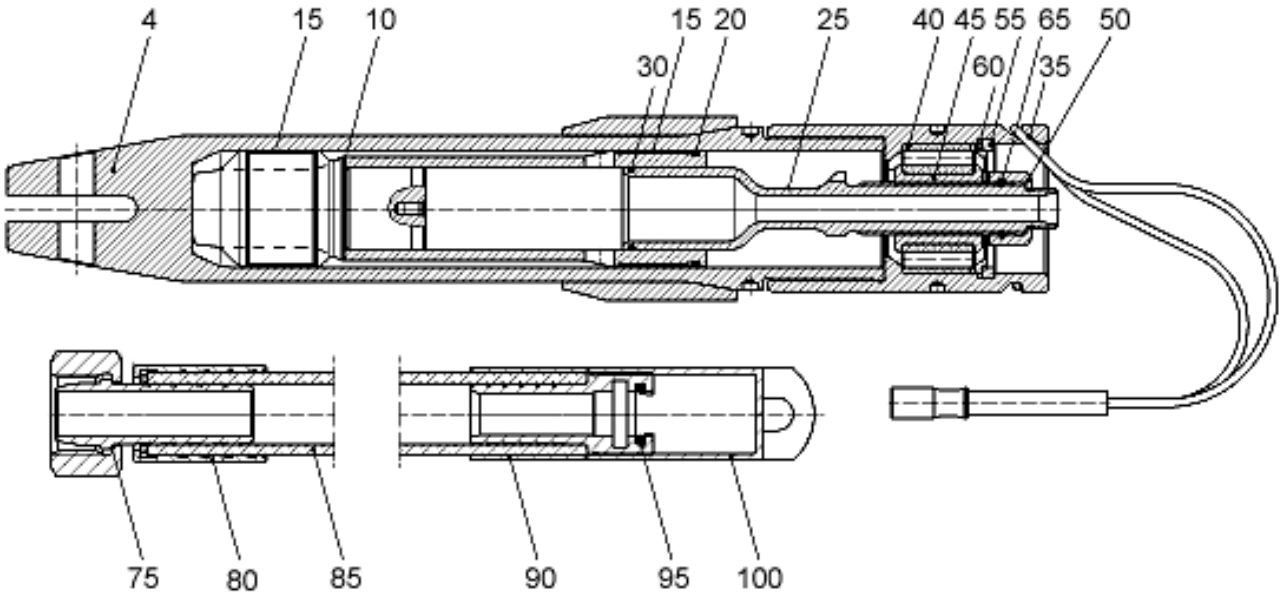
Item No	Description	Qty	Part Number
1-2	Machine body with protection ring (without cable)	1	PCF 1800156
2	Protection ring	1	EPC 1801087
3	Piston	1	O 1800103
4	Piston slide tapes (set)	1	O 1800104
5	Piston seal	1	G-E 1805160
6-8	Control tube with elastic block and seal ring	1	OF 1800159
6	Control tube	1	OF 1800160
7	Control stud seal	1	O 1800107
8	Elastic block	1	OF 1800165
9	Support ring	1	OF 1800166
10	Segment ring	1	OF 1800167
11	Locking nut with 75x1/6" knurled thread	1	G 4500113
12	Lock pin (set)	1	PCF 2200110
13	Steel cable with thimble	1	YY 152135
15-17, 19-23	Connection air hose, complete	1	PCF 1800170
w.o. pic.	Lock screw with 75x1/6" knurled thread	1	G 4500245
15	Knurled thread coupling with 75x1/6" knurled thread for swaging	1	G 2600114
16	Swaging socket for hose 2"	2	YY 192098
17	Connection air hose (without couplings)	1	PCF 1800160
19	Seal for quick-coupling socket DN 32	1	G-E 1452340
20	Sealing cap for quick-coupling DN 32	1	GRU 2006641
22	Hose socket with 1" internal thread	1	YY 151754
23	Female coupling with 1" outer thread	1	GRU 2002650
—	Seals, (complete set)	1	PCF 1800104
1-23	Grundocrack PCF 180 (Blade head, table and protection ring)	1	PCF 1800007

L. PARTS LIST FOR PCF 220



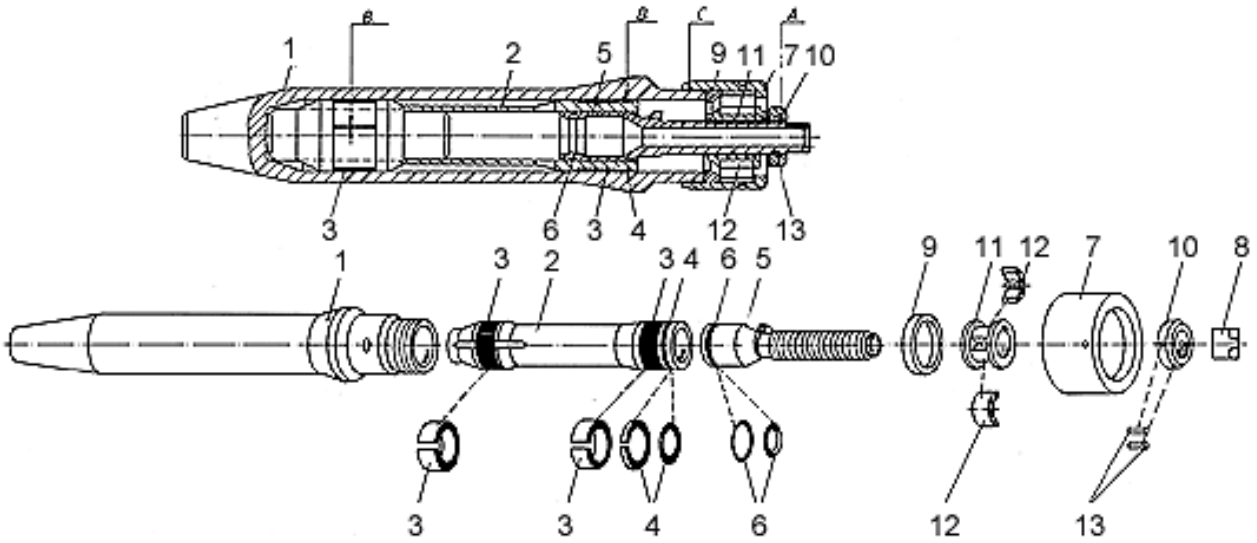
Item No	Description	Qty	Part Number
1-2	Machine body with protection ring (without cable)	1	PCF 2200156
2	Protection ring	1	YY 161049
3	Piston	1	H 2200103
4	Piston slide tapes (set)	1	H 2200104
5	Piston seal	1	H 2200105
6-8	Control tube with elastic block and seal ring	1	HF 2200159
6	Control tube	1	HF 2200160
7	Control stud seal	1	H 2200107
8	Elastic block	1	HF 2200165
9	Support ring	1	HF 2200166
10	Segment ring	1	HF 2200167
11	Lock nut with 75x1/6" knurled thread	1	G 4500113
12	Lock pin (set)	1	PCF 1800110
13	Steel cable with thimble	1	YY 152135
24-30	1 meter compressed air hose 2" knurled thread 75x1/6" internal thread / 55x1/6" external thread	1	GF 4500384
w.o. pic.	Lock screw with 75x1/6" knurled thread	1	G 4500245
24	Knurled thread coupling with 75x1/6" knurled thread for swaging	1	G 2600114
24A	Sleeve with hexagon nut with 75x1/5" knurled thread	1	YY 192315
25	Swaging socket for hose 2"	2	YY 192098
26	Connection air hose (without couplings)	1	PCF 1800160
27	Connection nipple 75x1/6" - 2"	1	G 2600214
28	Sleeve 2" - 1 1/2"	1	H 2200222
29	Connection nipple 55x1/6" - 1 1/2"	1	H 2200212
30	Locking nut with 55x1/6" knurled thread	1	G 2600221
—	Seals, (complete set)	1	H 2200111
1-30	Grundocrack PCF 220 (Blade head, table and protection ring)	1	PCF 2200007

M. PARTS LIST FOR 130 MINI-ATLAS



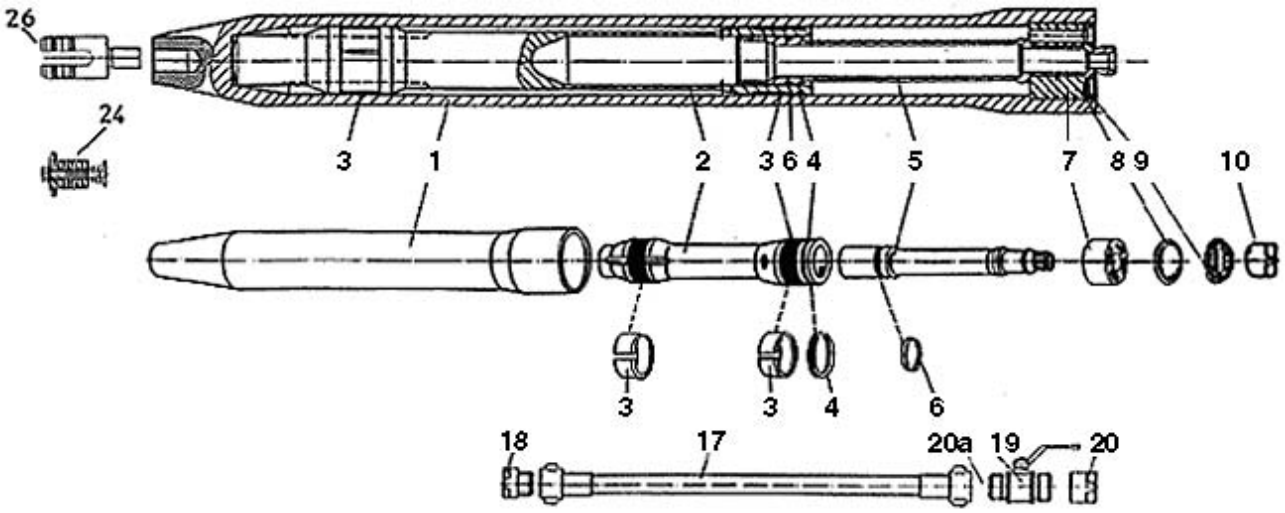
Item No	Description	Qty	Part Number
4	Machine body with knife head and RK reception	1	AM 1300153
10	Piston	1	AM 1300103
15	Piston slide tapes (set)	1	GRS 1305130
20	Piston seal	1	GRU 1305160
25	Control tube for reverse run control	1	AM 1300156
30	Control stud seal	1	A 1300107
35	Casing end with cable connection, without cable	1	AM 1300118
40	Elastic block	1	AM 1300122
45	Adjusting nut for reverse run control	1	AM 1300121
50	Stop nut for reverse run control	1	AM 1300120
55	Segment ring for reverse run control	1	AM 1300125
60	Support ring for reverse run control	1	AM 1300128
65	Pin set (set=2 pieces)	1	AM 1300123
75-100	Connection air hose, complete, 0.3 m long	1	AM 1300160
75	Nozzle DN 25 with ring and spigot nut	1	AM 1300161
100	Sealing cap for quick-coupling DN 25	1	G-E 0902390
15, 20, 30	Seals, (complete set)	1	AM 1300115
4-100	Mini-Atlas 130 with slotted head,10 degrees reception and 1' whip hose	1	AM 1300004

N. PARTS LIST FOR 180 MINI-OLYMPUS



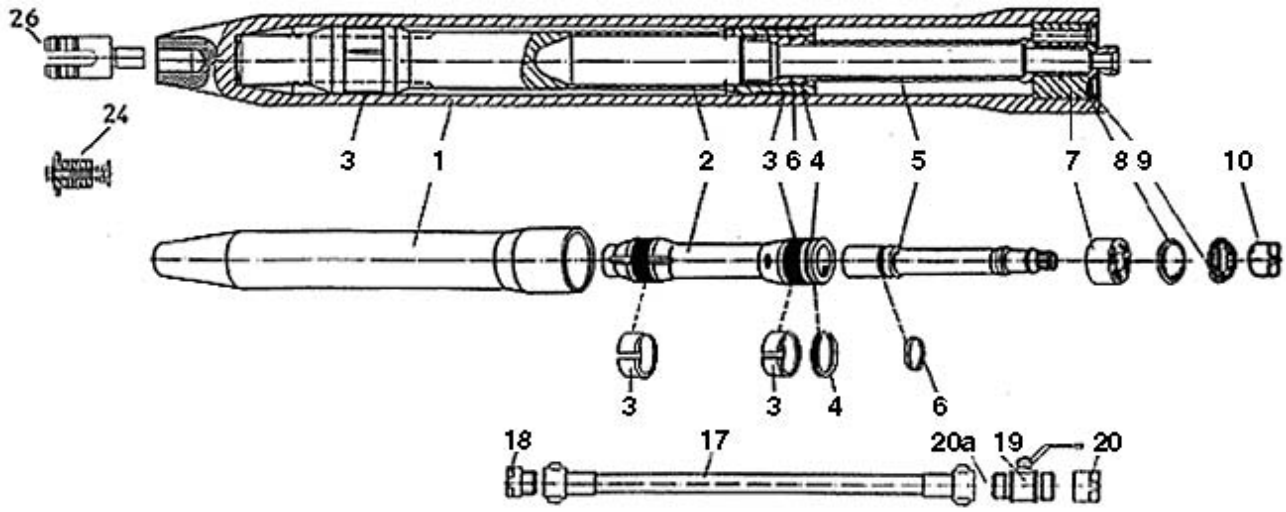
Item No	Description	Qty	Part Number
1	Machine body with thread M 60x3 and vent plug	1	OM 1800157
w.o. pic.	Seal plug, complete, for thread M 60	1	H 2200335
w.o. pic.	Pulling eye (bore-D 30) M 60, complete	1	H 2200319
2	Piston	1	OM 1800103
3	Piston slide tapes (set)	1	OM 1800104
4	Piston seal	1	G-E 1805160
5	Control tube for reverse run control	1	OM 1800156
6	Control stud seal	1	O 1800107
7	Casing end	1	OM 1800125
8	Dust cap with 55x1/6" knurled thread	1	G 2600221
9	Stop ring for reverse run control	1	OM 1800119
10	Stop nut for reverse run control	1	OM 1800120
11	Adjusting nut for reverse run control	1	OM 1800121
12	Aeration block semi-shells (set=2 halves)	1	OM 1800122
13	Pin set (set=2 pieces)	1	OM 1800123
w.o. pic.	Connection whip hose 7', complete without ball valve	1	G 2600223
w.o. pic.	Dust plug with 55x1/6" knurled thread	2	G 2600245
w.o. pic.	Ball valve 55x1/6" knurled thread on both sides with dust caps	1	H 2200242
w.o. pic.	Dust cap with 55x1/6" knurled thread	2	G 2600221
no pos.	Seals, (complete set)	1	OM 1800115
w.o. pic.	Mini-Olympus 180 with 10 degrees reception, thread M 60x3	1	OM 1800005

O. PARTS LIST FOR 180 OLYMPUS



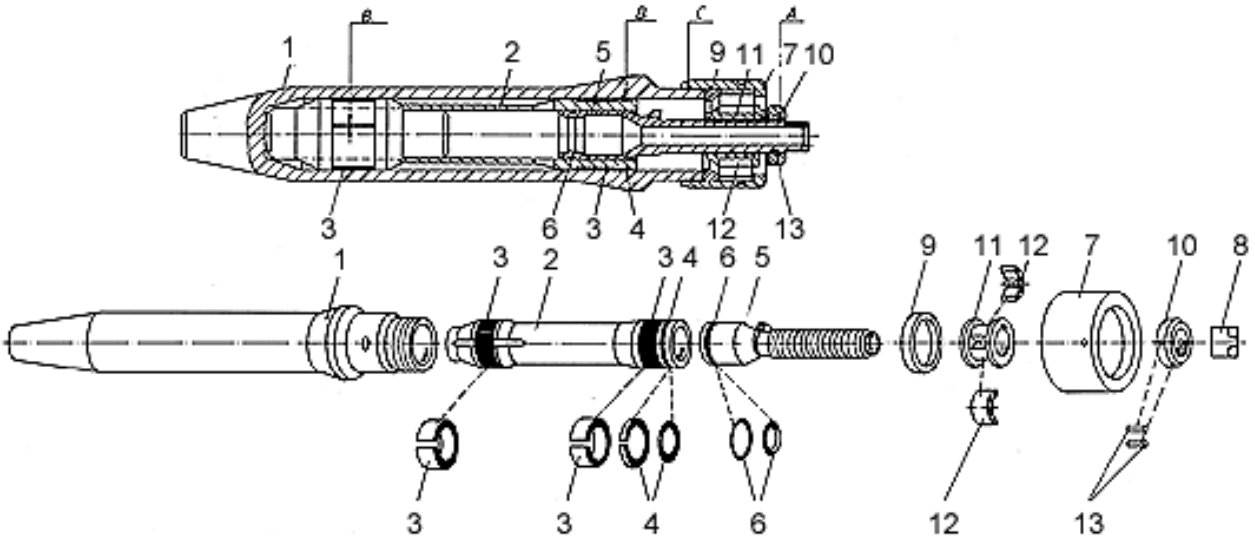
Item No	Description	Qty	Part Number
1	Machine body (front thread M 60, plug)	1	OF 1800152
24	Seal plug, complete, for thread M 60 (from 01.96)	1	H 2200335
26	Pulling eye (bore-D 30) M 60, complete (from 01.96)	1	H 2200319
2	Piston	1	O 1800103
3	Piston slide tapes (set)	1	O 1800104
4	Piston seal	1	G-E 1805160
5-7	Control tube with elastic block and seal ring	1	OF 1800159
5	Control tube	1	OF 1800160
6	Control stud seal	1	O 1800107
7	Elastic block	1	OF 1800165
8	Support ring	1	OF 1800166
9	Segment ring	1	OF 1800167
10	Dust cap with 75x1/6" knurled thread	1	G 4500113
17	7' air hose 2", on both sides knurled thread connection 75x1/6"	1	G 4500381
18	Dust plug with 75x1/6" knurled thread	1	G 4500245
19	Ball valve 1 1/2", on one side 55x1/6", on the other side 75x1/6" knurled thread connection	1	HF 2200241
20	Dust cap with 55x1/6" knurled thread	1	G 2600221
20a	Dust cap with 75x1/6" knurled thread	1	G 4500113
—	Seals, (complete set)	1	O 1800109
—	Grundocrack Olympus 180 F complete (front thread M 60, plug)	1	OF 1800005

P. PARTS LIST FOR 220 HERCULES



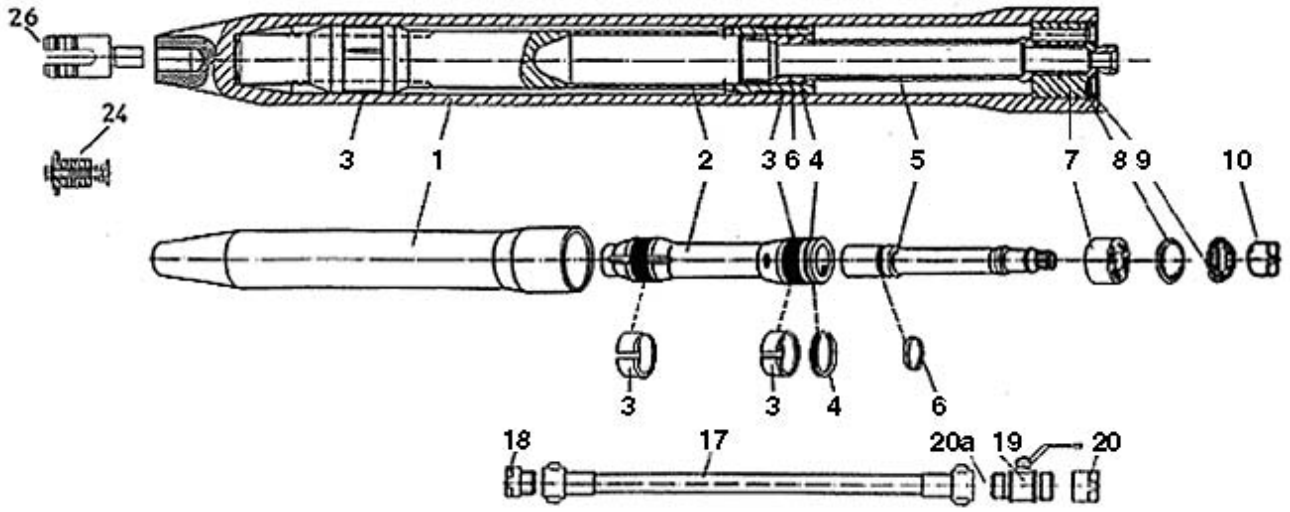
Item No	Description	Qty	Part Number
1	Machine body (front thread M 60, plug)	1	HF 2200152
24	Seal plug, complete, for thread M 60 (from 01.96)	1	H 2200335
26	Pulling eye (bore-D 30) M 60, complete (from 01.96)	1	H 2200319
2	Piston	1	H 2200103
3	Piston slide tapes (set)	1	H 2200104
4	Piston seal	1	H 2200105
5-7	Control tube with elastic block and seal ring	1	HF 2200159
5	Control tube	1	HF 2200160
6	Control stud seal	1	H 2200107
7	Elastic block	1	HF 2200165
8	Support ring	1	HF 2200166
9	Segment ring	1	HF 2200167
10	Dust cap with 75x1/6" knurled thread	1	G 4500113
17	7' air hose 2", on both sides knurled thread connection 75x1/6"	1	G 4500381
18	Dust plug with 75x1/6" knurled thread	1	G 4500245
19	Ball valve 1 1/2", on one side 55x1/6", on the other side 75x1/6" knurled thread connection	1	HF 2200241
20	Dust cap with 55x1/6" knurled thread	1	G 2600221
20a	Dust cap with 75x1/6" knurled thread	1	G 4500113
—	Seals, (complete set)	1	H 2200111
—	Grundocrack Hercules 220 F complete (front thread M 60, plug)	1	HF 2200005

Q. PARTS LIST FOR 260 MINI-GIGANT



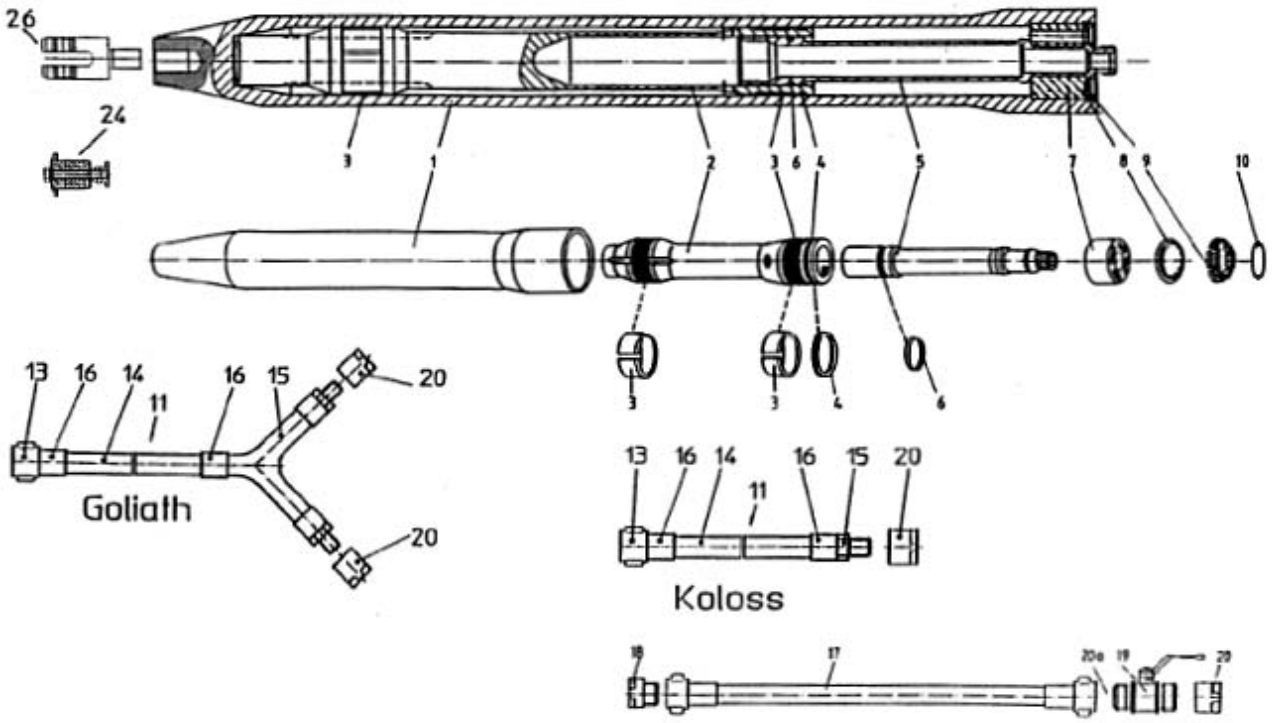
Item No	Description	Qty	Part Number
1	Machine body with bore hole, plug and RK reception	1	on request (4)
w.o. pic.	Seal plug, complete, for thread M 80	1	G 2600331
w.o. pic.	Pulling eye (bore-D 30) M 80, complete	1	G 2600319
w.o. pic.	Lock pin (set)	1	PAA 1300110
2	Piston	1	GM 2600103
3	Piston slide tapes (set)	1	GM 2600104
4	Piston seal	1	G 2600105
5	Control tube for reverse run control	1	GM 2600156
6	Control stud seal	1	G 2600107
7	Casing end	1	GM 2600118
8	Locking nut with 75x1/6" knurled thread	1	G 4500113
9	Stop ring for reverse run control	1	GM 2600119
10	Stop nut for reverse run control	1	GM 2600120
11	Adjusting nut for reverse run control	1	GM 2600121
12	Aeration block semi-shells (set=2 halves)	1	GM 2600122
13	Pin set (set=2 pieces)	1	GM 2600123
w.o. pic	Dust plug with 75x1/6" knurled thread	2	G 4500245
w.o. pic	Ball valve 75x1/6" knurled thread on both sides with locking nuts	1	G 4500217
w.o. pic	Dust cap with 75x1/6" knurled thread	2	G 4500113
no pos.	Seals, (complete set)	1	GM 2600115
—	Mini-Gigant 260 with 10 degrees reception	1	GM 2600005

R. PARTS LIST FOR 260 GIGANT



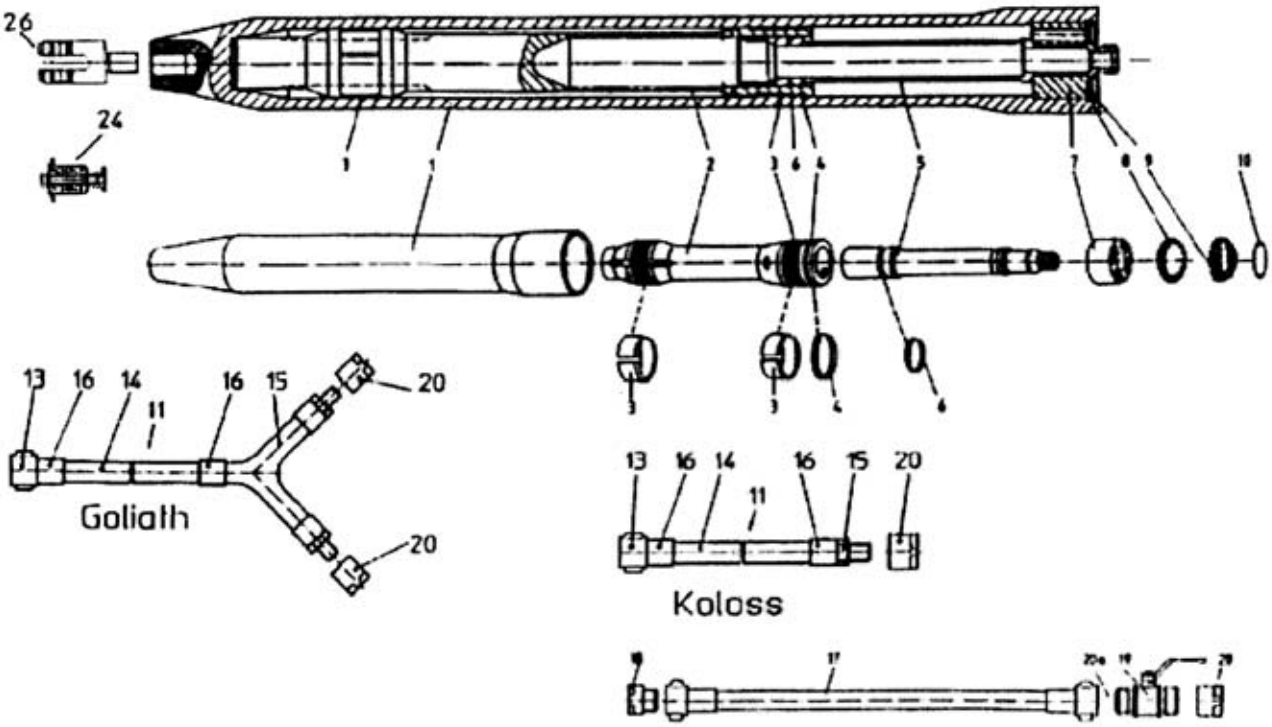
Item No	Description	Qty	Part Number
1	Machine body (front thread M 90, plug)	1	GF 2600152
24	Seal plug, complete, for thread M 90	1	703249
26	Pulling eye (bore-D 30) M 90, complete	1	G 266032
2	Piston	1	G 2600103
3	Piston slide tapes (set)	1	G 2600104
4	Piston seal	1	G 2600105
5-7	Control tube with elastic block and seal ring	1	GF 2600159
5	Control tube	1	GF 2600160
6	Control stud seal	1	G 2600107
7	Elastic block	1	GF 2600165
8	Support ring	1	GF 2600166
9	Segment ring	1	GF 2600167
10	Dust cap with 75x1/6" knurled thread	1	G 4500113
17	7' connection air hose 2", on both sides knurled thread connection 75x1/6"	1	G 4500381
18	Dust plug with 75x1/6" knurled thread	1	G 4500245
19	Ball valve 75x1/6" knurled thread on both sides with locking nuts	1	G 4500217
20	Locking nut with 75x1/6" knurled thread	1	G 4500113
20a	Locking nut with 75x1/6" knurled thread	1	G 4500113
—	Seals, (complete set)	1	G 2600115
—	Grundocrack Gigant 260 F complete (front thread M 90, plug)	1	GF 2600005

S. PARTS LIST FOR 350 KOLOSS



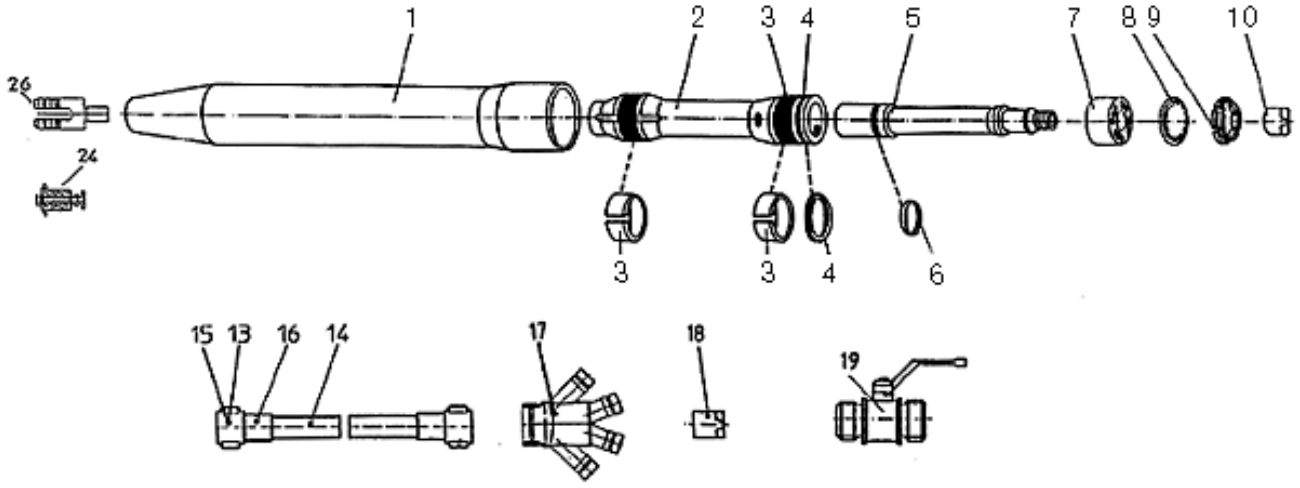
Item No	Description	Qty	Part Number
1	Machine body (front thread M 100, plug)	1	KF 3500152
24	Seal plug, complete, for thread M 100 (from 05/97)	1	GF 4500331
26	Pulling eye M 100 with screw (set) (from 05/97)	1	GF 4500319
w.o. pic.	Screw with nut (set) for towing eye (from 05/97)	1	GF 4500323
w.o. pic.	Lock pin (set) (until 04/97) alternative	1	PAA 1300110
w.o. pic.	Lock pin (set) for towing eye (from 05/97 alternative)	1	GF 4500322
2	Piston	1	K 3500103
3	Piston slide tapes (set)	1	K 3500104
4	Piston seal	1	K 3500105
5-7	Control tube with elastic block and seal ring	1	KF 3500159
5	Control tube	1	KF 3500160
6	Control stud seal	1	K 3500107
7	Elastic block	1	KF 3500165
8	Support ring	1	KF 3500166
9	Segment ring	1	KF 3500167
10	Dust cap, steel	1	GF 4500168
11	Connection whip hose, complete	1	KF 3500100
13	Hose coupling ND 105	1	KF 3500101
14	Connection air hose DN 105, blank	1	G 4500111
16	Swaging socket for hose ND 105	1	KF 3500103
16	Hose clips (set) alternative	1	G 4500110
17	2 meter connection air hose 2", on both sides knurled thread connection 75x1/6"	1	G 4500381
18	Dust plug with 75x1/6" knurled thread	1	G 4500245
19	Ball valve 75x1/6" knurled thread on both sides with locking nuts	1	G 4500217
20	Dust cap with 75x1/6" knurled thread	1	G 4500113
20a	Dust cap with 75x1/6" knurled thread	1	G 4500113
—	Seals, (complete set)	1	K 3500109
—	Grundocrack Koloss 350 F complete (front thread M 100, plug)	1	KF 3500005

T. PARTS LIST FOR 450 GOLIATH



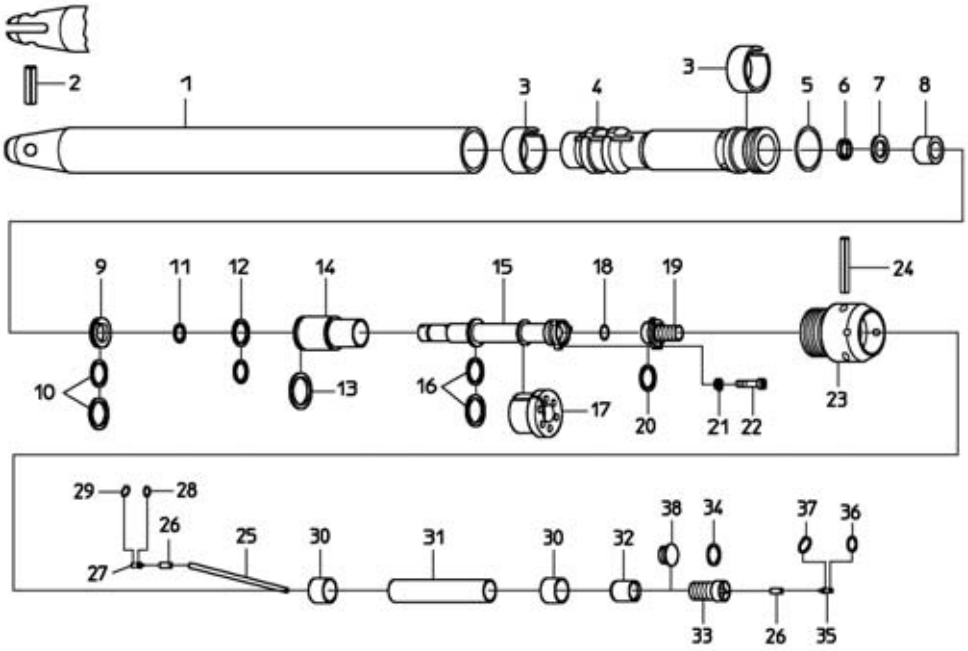
Item No	Description	Qty	Part Number
1	Machine body (front thread M 100, plug)	1	GF 4500152
24	Seal plug, complete, for thread M 100 (from 01/96)	1	GF 4500331
26	Pulling eye M 100 with screw (set) (from 01/96)	1	GF 4500319
w.o. pic.	Screw with nut (set) for towing eye	1	GF 4500323
w.o. pic.	Lock pin (set) for towing eye (alternative)	1	GF 4500322
2	Piston	1	G 4500103
3	Piston slide tapes (set)	1	G 4500104
4	Piston seal	1	G 4500105
5-7	Control tube with elastic block and seal ring	1	GF 4500159
5	Control tube	1	GF 4500160
6	Control stud seal	1	G 4500107
7	Elastic block	1	GF 4500165
8	Support ring	1	GF 4500166
9	Segment ring	1	GF 4500167
10	Dust cap, steel	1	GF 4500168
11	Connection whip hose	1	GF 4500100
13	Hose coupling ND 105	1	KF 3500101
14	Connection air hose DN 105, without couplings, blank hose	1	G 4500111
16	Swaging socket for hose ND 105	1	KF 3500103
16	Hose clips (set) alternative	1	G 4500110
17	2 meter connection air hose 2", on both sides knurled thread connection 75x1/6"	2	G 4500381
18	Dust plug with 75x1/6" knurled thread	1	G 4500245
19	Ball valve 75x1/6" knurled thread on both sides with locking nuts	2	G 4500217
20	Dust cap with 75x1/6" knurled thread	2	G 4500113
20a	Dust cap with 75x1/6" knurled thread	1	G 4500113
—	Seals, (complete set)	1	G 4500109
—	Grundocrack Goliath 450 F complete (front thread M 100, plug)	1	GF 4500005

U. PARTS LIST FOR 600 TAURUS



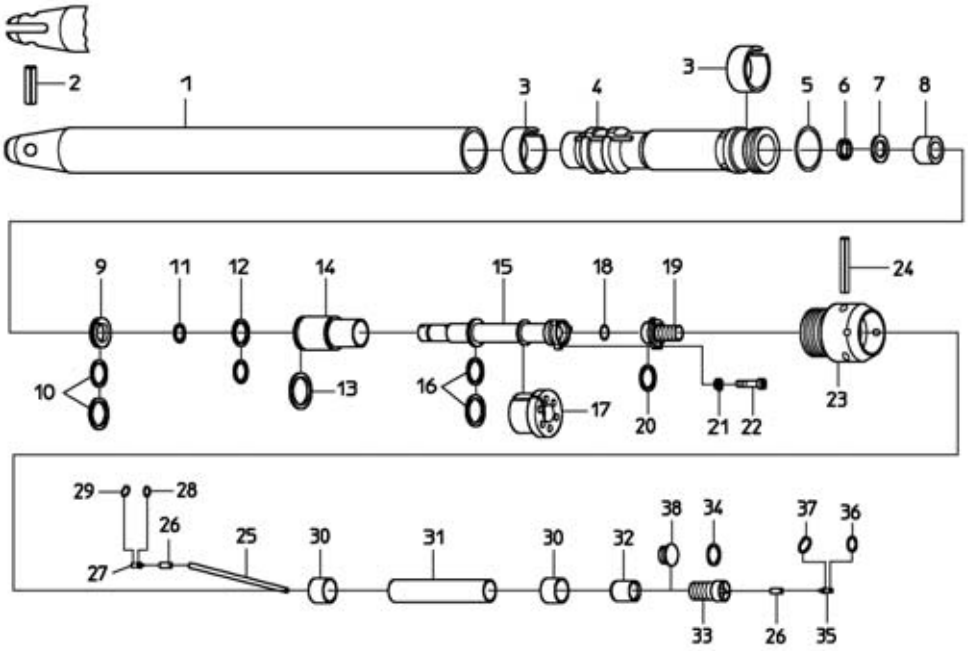
Item No	Description	Qty	Part Number
1	Machine body (front thread M 100, plug)	1	TF 6000152
24	Seal plug, complete, for thread M 100	1	GF 4500331
26	Pulling eye M 100 with screw (set)	1	GF 4500319
w.o. pic.	Screw with nut (set) for towing eye	1	GF 4500323
w.o. pic.	Lock pin (set) for towing eye (alternative)	1	GF 4500322
2	Piston	1	TF 6000103
3	Piston slide tapes (set)	1	TF 6000104
4	Piston seal	1	TF 6000105
5-7	Control tube with elastic block and seal ring	1	TF 6000159
5	Control tube	1	TF 6000160
6	Control stud seal	1	TF 6000107
7	Elastic block	1	TF 6000165
8	Support ring	1	TF 6000166
9	Segment ring	1	TF 6000167
10	Dust cap, steel	1	TF 6000168
13-16	Connection whip hose, complete	1	TF 6000101
13	Hose socket for hose coupling	2	TF 6000171
14	Connection air hose, blank	1	TF 6000111
15	Spigot nut for hose coupling	2	TF 6000170
16	Hose clips (pair)	2	TF 6000110
17	Connection T-piece, complete (incl. 1x Item 10 and 4x Item 18)	1	TF 6000102
18	Dust cap with 75x1/6" knurled thread	4	G 4500113
19	Ball valve 75x1/6" knurled thread on both sides with locking nuts	4	G 4500217
—	Seals, (complete set) (item 3, 4, 6)	1	TF 6000109
—	Grundocrack Taurus 600 F complete (front thread M 100, plug)	1	TF 6000005

V. PARTS LIST FOR PCG 130



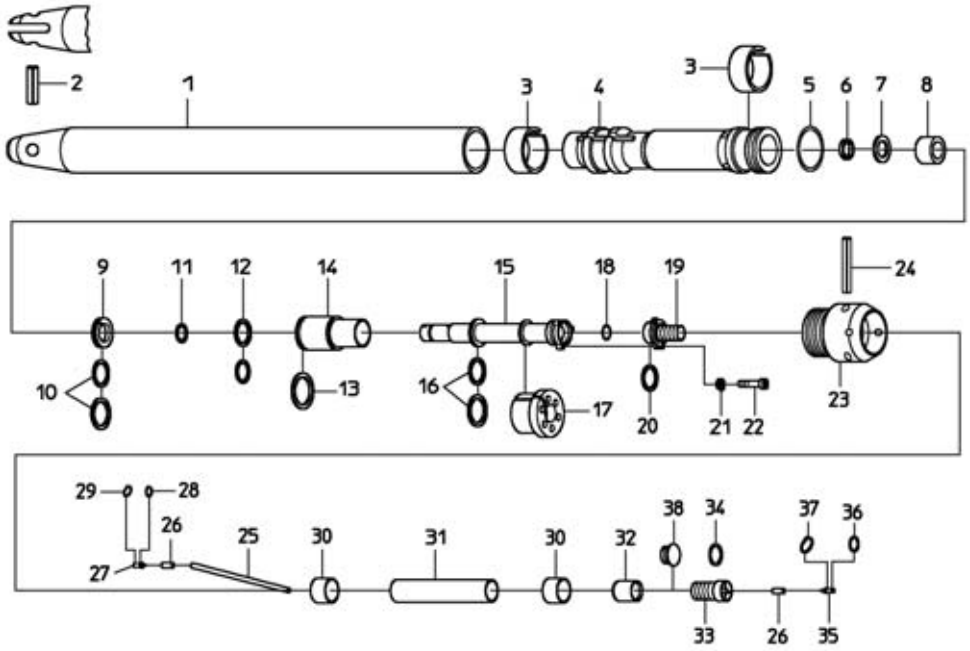
Item No	Description	Qty	Part Number
1	Machine body	1	PCG 1300150
2	Lock pin (set)	1	PAA 1300110
3	Piston slide tapes (set)	1	G-E 1455130
4	Piston	1	G-P 1305141
5	Piston seal	1	G-E 1455160
—	Control stud with connection air hose (Items 6-22, 25-38)	1	G-V 1308000
—	Control stud without connection air hose (Items 6-17)	1	G-V 1308005
6	Segment ring	1	YY 140920
7	Support ring for elastic block	1	YY 140919
8	Elastic block for control sleeve	1	G-V 1308043
9	Stop ring	1	YY 060998
10	Control sleeve seal 1 (set)	1	G-V 1308075
11	O-ring 41x4 mm	1	21252564
12	Seal for control tube (set)	1	G-V 1308070
13	Cylindrical ring for control tube	1	YY 192068
14	Control sleeve	1	YY 060977
15	Control tube	1	YY 060997
16	Control sleeve seal 2 (set)	1	G-V 1308080
17	Elastic block for air-operated control stud	1	G-V 1308025
—	Connection air hose, complete (Items 18-22, 25-38)	1	G-V 1308110
—	Connection air hose, (interior) (Items 18-22, 30-34, 38)	1	G-V 1308150
18	O-ring 32x3 mm	1	21252071
19	Hose connection for connection air hose	1	YY 060975
20	O-ring 49x3 mm	1	21252943
21	Lock washer M 8 DIN 127	3	180127012024
22	Cheese head screw M 8x30 DIN 912	3	180912512137
23	Casing end with additional bore hole D 14	1	PCG 1306451
24	Pin set for casing end	1	PCG 1306452
w.o. pic.	Pin punch with safety impact head 15x18x130x200 mm	1	220410015
—	Control hose (interior) (Items 25-29, 35-37)	1	G-V 1808160
28	O-ring 6,5x2 mm	2	21250387
29	External securing ring 9x1 mm DIN 471	1	180471010009
30	Swaging socket 50x2,5x60	2	GRU 2002460
31	Connection air hose without couplings	1	GRU 2002443
32	Spigot nut for connection hose DN 32	1	YY 060978
33	Hose nipple for sleeve nut ND 32	1	YY 060979
34	Seal	1	YY 061132
36	O-ring 6,5x2 mm	1	21250387
37	External securing ring 12x1 mm DIN 471	1	180471010012
38	Locking nipple for spigot nut DN 32	1	YY 060988
—	Seals, (complete set)	1	GKV 1306325
1-38	Grundocrack PCG 130 with air-operated control stud, casing end pinned, with additional bore hole	1	PCG 1300000A

W. PARTS LIST FOR PCG 145



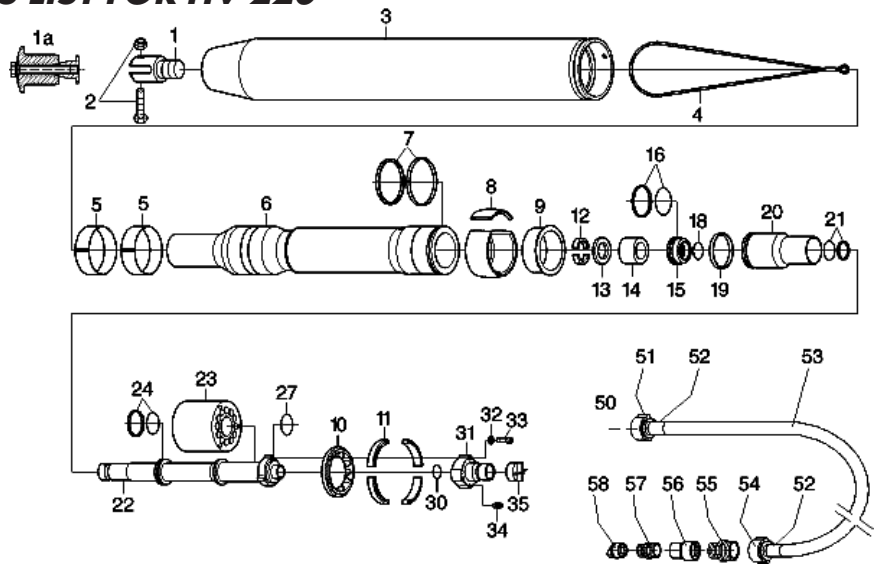
Item No	Description	Qty	Part Number
1	Machine body	1	PCG 1450150
2	Lock pin (set)	1	PAA 1300110
3	Piston slide tapes (set)	1	G-P 1455130
4	Piston	1	G-P 1455141
5	Piston seal	1	G-P 1455160
—	Control stud with connection air hose (Items 6-22, 25-38)	1	G-V 1458000
—	Control stud without connection air hose (Items 6-17)	1	G-V 1458005
6	Segment ring	1	YY 140920
7	Support ring for elastic block	1	YY 140919
8	Elastic block for control sleeve	1	G-V 1608043
9	Stop ring	1	YY 070917
10	Control sleeve seal 1 (set)	1	G-V 1458075
11	O-ring 41x4 mm	1	21252564
12	Seal for control tube (set)	1	G-V 1308070
13	Seal for control sleeve (exterior)	1	YY 192112
14	Control sleeve	1	YY 070916
15	Control tube	1	YY 070915
16	Control sleeve seal 2 (set)	1	G-V 1458080
17	Elastic block for air-operated control stud	1	G-V 1458025
—	Connection air hose, complete (Items 18-22, 25-38)	1	G-V 1608110
—	Connection air hose, (interior) (Items 18-22, 30-34, 38)	1	G-V 1608150
18	O-ring 32x3 mm	1	21252071
19	Hose connection for connection air hose	1	YY 140923
20	O-ring 49x3 mm	1	21252943
21	Lock washer M 8 DIN 127	3	180127012024
22	Cheese head screw M 8x35 DIN 912	3	180912512138
23	Casing end with additional bore hole D 14	1	PCG 1456451
24	Pin set for casing end	1	PCG 1456452
w.o. pic.	Pin punch with safety impact head 15x18x180x300 mm	1	220410020
—	Control hose (interior) (Items 25-29, 35-37)	1	G-V 1808160
28	O-ring 6,5x2 mm	2	21250387
29	External securing ring 9x1 mm DIN 471	1	180471010009
30	Swaging socket 62x2,5x60	2	G-E 1802460
31	Connection air hose without couplings	1	G-P 1802443
32	Sleeve nut ND 40	1	YY 150934
33	Hose nipple	1	YY 150924
34	O-ring 48x3 mm	1	21252911
36	O-ring 6,5x2 mm	1	21250387
37	External securing ring 12x1 mm DIN 471	1	180471010012
38	Locking nipple for spigot nut	1	YY 150935
—	Seals, (complete set)	1	PCG 1456320
1-38	Grundocrack PCG 145 with air-operated control stud, casing end pinned, with additional bore hole	1	PCG 1450000A

X. PARTS LIST FOR PCG 180



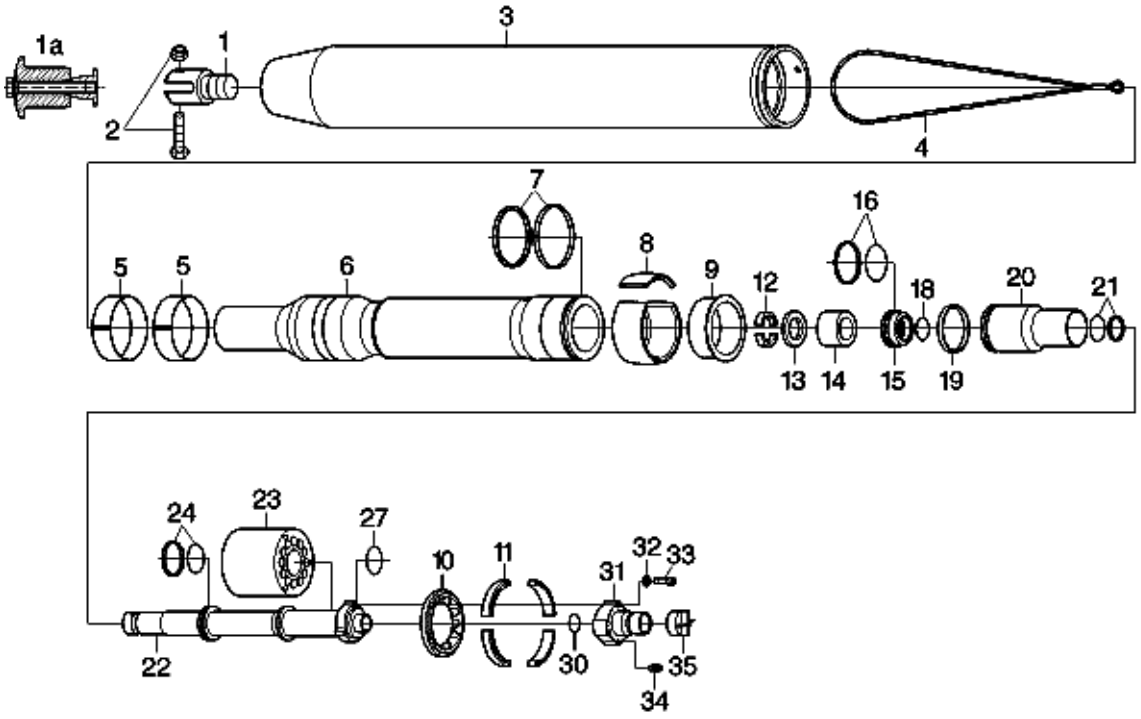
Item No	Description	Qty	Part Number
1	Machine body	1	PCG 1800151
2	Lock pin (set)	1	PCF 2200110
3	Piston slide tapes (set)	1	G-P 1805130
4	Piston	1	G-P 1805141
5	Piston seal	1	G-P 1805160
—	Control stud with connection air hose (Items 6-22, 25-38)	1	PCG 1808000
—	Control stud without connection air hose (Items 6-17)	1	PCG 1808005
6	Segment ring	1	YY 150921
7	Support ring for elastic block	1	YY 150920
8	Elastic block for control sleeve	1	G-V 1808043
9	Stop ring	1	YY 150918
10	Control sleeve seal 1 (set)	1	G-V 1808075
11	O-ring 51x4 mm	1	21253037
12	Seal for control tube (set)	1	G-V 1808070
13	Seal for control sleeve (exterior)	1	YY 192113
14	Control sleeve	1	YY 150917
15	Control tube	1	YY 150915
16	Control sleeve seal 2 (set)	1	G-V 1808080
17	Elastic block for air-operated control stud	1	PCG 1808026
—	Connection air hose, complete (Items 18-22, 25-38)	1	G-V 1808110
—	Connection air hose, (interior) (Items 18-22, 30-34, 38)	1	G-V 1808150
18	O-ring 40x3 mm	1	21252499
19	Hose connection for connection air hose	1	YY 150923
20	O-ring 60x3 mm	1	21253393
21	Lock washer M 10 DIN 127	3	180127012027
22	Cheese head screw M 10x30 DIN 912	3	180912512178
23	Casing end with additional bore hole D 14	1	PCG 1806451
24	Pin set for casing end	1	PCG 1806452
w.o. pic.	Pin punch with safety impact head 15x18x180x300 mm	1	220410020
—	Control hose (interior) (Items 25-29, 35-37)	1	G-V 1808160
28	O-ring 6,5x2 mm	2	21250387
29	External securing ring 9x1 mm DIN 471	1	180471010009
30	Swaging socket 62x2,5x60	2	G-E 1802460
31	Connection air hose without couplings	1	G-P 1802443
32	Sleeve nut ND 40	1	YY 150934
33	Hose nipple	1	YY 150924
34	O-ring 48x3 mm	1	21252911
36	O-ring 6,5x2 mm	1	21250387
37	External securing ring 12x1 mm DIN 471	1	180471010012
38	Locking nipple for spigot nut	1	YY 150935
—	Seals, (complete set)	1	PCG 1806320
1-38	Grundocrack PCG 180 with air-operated control stud, casing end pinned, with additional bore hole	1	PCG 1800000A

Y. PARTS LIST FOR HV 220



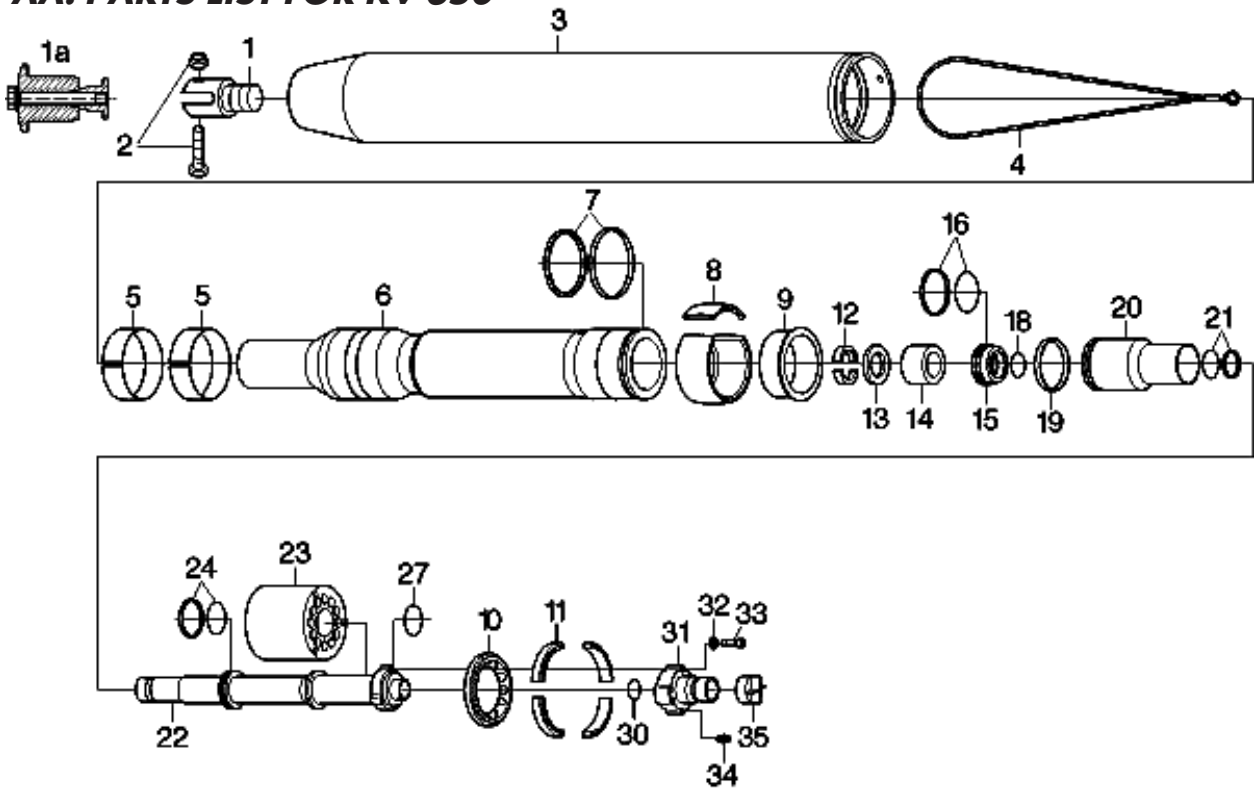
Item No	Description	Qty	Part Number
1A	Seal plug, complete, for thread M 60	1	H 2200335
1-2	Pulling eye (bore-D 30) M 60, complete	1	H 2200319
1-3	Machine body with towing eye M 60, without cable	1	HV 2200151
1A, 3	Machine body with vent plug M 60, without cable	1	HV 2200152
2	Screw with nut (set) for towing eye	1	G 2600323
altern	Lock pin (set)	1	PAA 1300110
4	Steel cable with thimble	1	YY 152135
5	Piston slide tapes (set)	1	H 2200104
6	Piston	1	H 2200103
7	Piston seal	1	H 2200105
8	Stop ring	1	HV 2200170
9	Support sleeve	1	YY 162248
10	Support ring	1	HV 2200166
11	Segment ring	1	HV 2200167
12-35	Servo control stud, complete, with servo control	1	HV 2200158
12	Segment ring for control	1	YY 162210
13	Support ring for control	1	YY 162209
14	Elastic block for control sleeve	1	HV 2208043
15	Stop ring for control	1	YY 162207
16	Control sleeve seal 1 (set)	1	HV 2208075
18	O-ring 56x6 mm	1	21253228
19	Cylindrical ring	1	YY 191654
20	Control sleeve	1	YY 162206
21	Seal for control tube (set)	1	HV 2208070
22	Control tube	1	YY 162205
23	Elastic block	1	HV 2200165
24	Control sleeve seal 2 (set)	1	HV 2208080
27	O-ring 73x4 mm	1	21253878
30	O-ring 46x6 mm	1	21252821
31	Hose connection (Version up to end of 1999)	1	YY 162211
31	Hose connection for NW 12 (Version beginning in 2000)	1	YY 162286
32	Plain washer 13 mm DIN 125	3	180125012024
33	Cheese head screw M 12x60 DIN 912	3	180912512225
34	GE 08 SR-ED OMD (Version up to end of 1999)	1	2014145015
34	Screwing NPTF 3/8-18, UNF 3/4-16 (Version beginning in 2000)	1	1622036
35	Locking nut with 75x1/6" knurled thread	1	G 4500113
50-58	1 meter compressed air hose 2" knurled thread 75x1/6" internal thread / 55x1/6" external thread	1	GF 4500384
50	Lock screw with 75x1/6" knurled thread	1	G 4500245
51	Sleeve with hexagon nut with 75x1/5" knurled thread	1	YY 192315
52	Swaging socket for hose 2"	2	YY 192098
53	Connection air hose (without couplings)	1	PCF 1800160
54	Sleeve with hexagon nut with 75x1/5" knurled thread	1	YY 192315
55	Connection nipple 75x1/6" - 2"	1	G 2600214
56	Sleeve 2" - 1 1/2"	1	H 2200222
57	Connection nipple 55x1/6" - 1 1/2"	1	H 2200212
58	Locking nut with 55x1/6" knurled thread	1	G 2600221
—	Seals, (complete set)	1	HV 2200109
1-58	Grundocrack HV 220 with servo control, complete	1	HV 2200000

Z. PARTS LIST FOR PCG 270



Item No	Description	Qty	Part Number
1A	Seal plug, complete, for thread M 80	1	G 2600331
1-2	Pulling eye (bore-D 30) M 80, complete	1	G 2600319
1-3	Machine body with towing eye M 80, without cable	1	GV 2600151
1A, 3	Machine body with vent plug M 80, without cable	1	GV 2600152
2	Screw with nut (set) for towing eye	1	G 2600323
altern	Lock pin (set)	1	PAA 1300110
4	Steel cable with thimble	1	YY 152135
5	Piston slide tapes (set)	1	G 2600104
6	Piston	1	G 2600103
7	Piston seal	1	G 2600105
8	Stop ring	1	GV 2600170
9	Support sleeve	1	YY 172248
10	Support ring	1	GV 2600166
11	Segment ring	1	GV 2600167
12-35	Servo control stud, complete, with servo control	1	GV 2600158
12	Segment ring for control	1	YY 172210
13	Support ring for control	1	YY 172209
14	Elastic block for control sleeve	1	GV 2608043
15	Stop ring for control	1	YY 172207
16	Control sleeve seal 1 (set)	1	GV 2608075
18	O-ring 76,5x6 mm	1	21254008
19	Cylindrical ring	1	YY 191661
20	Control sleeve	1	YY 172206
21	Seal for control tube (set)	1	GV 2608070
22	Control tube	1	YY 172205
23	Elastic block	1	GV 2600165
24	Control sleeve seal 2 (set)	1	GV 2608080
27	O-ring 94x4 mm	1	21254502
30	O-ring 63x7 mm	1	21253670
31	Hose connection (Version up to end of 1999)	1	YY 172211
31	Hose connection for NW 20 (Version beginning in 2000)	1	YY 172286
32	Plain washer 17 mm DIN 125	3	180125012030
33	Cheese head screw M 16x65 DIN 912	3	180912512308
34	GE 08 SR-ED OMD (Version up to end of 1999)	1	2014145015
34	Screwing NPTF 3/4-14, UNF 1 1/16-12 (Version beginning in 2000)	1	1622037
35	Locking nut with 75x1/6" knurled thread	1	G 4500113
—	Seals, (complete set)	1	GV 2600109
1-35	Grundocrack PCG 270 with servo control, complete	1	PCG 2700000

AA. PARTS LIST FOR KV 350



Item No	Description	Qty	Part Number
1A	Seal plug, complete, for thread M 100	1	GF 4500331
1-2	Pulling eye M 100 with screw (set)	1	GF 4500319
1-3	Machine body with towing eye M 100, without cable	1	KV 3500151
1A, 3	Machine body with vent plug M 100, without cable	1	KV 3500152
2	Screw with nut (set) for towing eye	1	GF 4500323
altern	Lock pin (set) for towing eye	1	GF 4500322
4	Steel cable D 12 mm	1	YY 012219
5	Piston slide tapes (set)	1	K 3500104
6	Piston	1	K 3500103
7	Piston seal	1	K 3500105
8	Stop ring	1	KV 3500170
9	Support sleeve	1	YY 012214
10	Support ring	1	KV 3500166
11	Segment ring	1	KV 3500167
12-35	Servo control stud, complete, with servo control	1	KV 3500158
12	Segment ring for control	1	YY 012210
13	Support ring for control	1	YY 012209
14	Elastic block for control sleeve	1	KV 3508043
15	Stop ring for control	1	YY 012207
16	Control sleeve seal 1 (set)	1	KV 3508075
18	O-ring 108x6 mm	1	21254858
19	Cylindrical ring	1	YY 191658
20	Control sleeve	1	YY 012206
21	Seal for control tube (set)	1	KV 3508070
22	Control tube	1	YY 012205
23	Elastic block	1	KV 3500165
24	Control sleeve seal 2 (set)	1	KV 3508080
27	O-ring 123x7 mm	1	21255200
30	O-ring 94x7 mm	1	21254505
31	Hose connection (Version up to end of 1999)	1	YY 012211
31	Hose connection for NW 20 (Version beginning in 2000)	1	YY 012286
32	Plain washer 17 mm DIN 125	3	180125012030
33	Cheese head screw M 16x70 DIN 912	3	180912512309
34	GE 08 SR-ED OMD (Version up to end of 1999)	1	2014145015
34	Screwing NPTF 3/4-14, UNF 1 1/16-12 (Version beginning in 2000)	1	1622037
35	Lock nut	1	GF 4500168
—	Seals, (complete set)	1	KV 3500109
1-35	Grundocrack KV 350 with servo control, complete	1	KV 3500000

NOTES

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