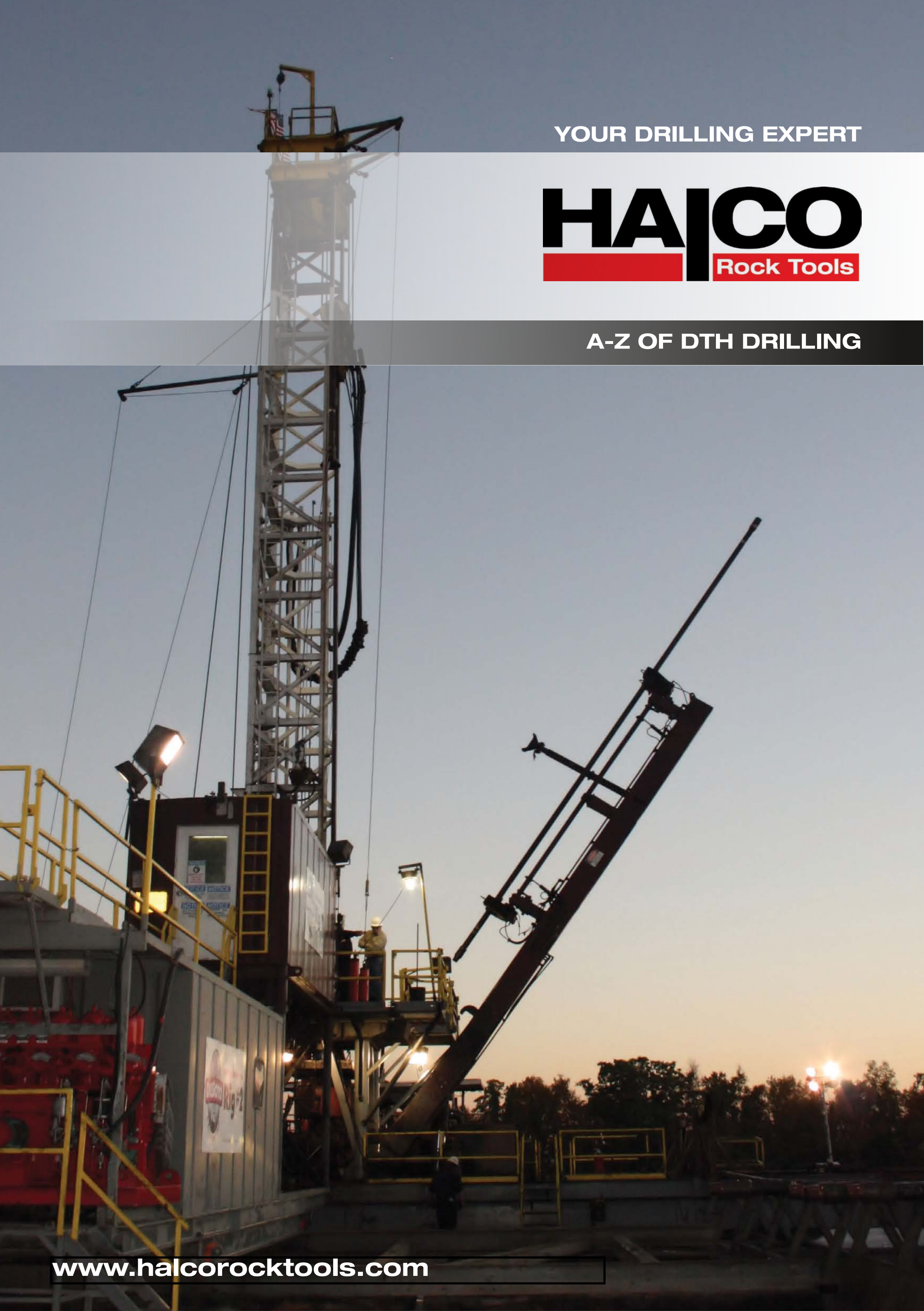
YOUR DRILLING EXPERT

HALCO Rock Tools

A-Z OF DTH DRILLING



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HAMMER DEVELOPMENT

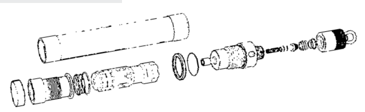
The down-the-hole or DTH hammer is used for drilling holes through a wide range of rocks and associated materials. The variety of applications to which it can be put has extended and continues to extend well beyond the original conception of primary blast-hole drilling.

Andre Stenuick of Stenuick Freres pioneered the development and distribution of the DTH hammer primarily throughout the UK, Australia, New Zealand, Africa, and India in the 1950s.

Prior to their introduction in the early 1950s, blast hole drilling was normally carried out with drifter equipment whilst water well drilling in hard formations done by cable tool rigs or rotary rigs using rock roller bits (tricone).

Drifter drilling becomes progressively slower with increasing depth. DTH hammers however, can drill in one day what a cable tool rig would take weeks to complete. The quarrying, water well, site investigation, civil engineering and mining industries throughout the world have become more and more aware of the advantages to be gained from using DTH hammers, not only as an alternative to drifters but because of higher performance when compared to conventional rotary drilling.

Valved Hammer



The DTH hammer concept proved so popular that established manufacturers of drifter steels, bits and accessories, followed Halco's lead and developed their own range of DTH hammers and bits.

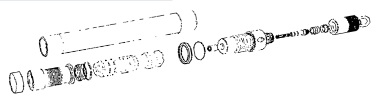
"Down-the-hole" refers to where the hammer action occurs when compared to top hammers, which hammer on top of the drill string. The DTH hammer piston always makes direct contact with the drill bit and there is generally no loss of transmitted energy as the hammer drills deeper, as is the case with drifter (top hammer) rigs.

Penetration rates with DTH hammers are almost directly proportional to air pressure therefore doubling the air pressure, will result in approximately double the penetration.

The first ever hammers were of 'valved' design and had an internal liner. This valved technology, together with compressor availability limited the air pressure capability of early hammers, which were incapable of withstanding air pressures above 12 bar (170 psi).

The valve itself had operational problems because hammer malfunction occurred when large volumes of water were passed through the hammers if grit entered the hammer.

Valveless Hammer



Modern hammers are generally valveless in design with fewer internal parts requiring little maintenance. The removal of the valve has eliminated the operational problems previously experienced.

Modern hammers are also of a rigid construction enabling them to withstand air pressures as high as 28 bar (400 psi).

The further development of DTH hammers will be in terms of their design related to achieving lower drilling costs for the user, by increasing rates of penetration with longer life in the hole.

Increases in penetration rates will require the investigation of delivering yet higher air pressures to the hammer as in conventional designs, or the use of alternative power sources such as water or oil.

To help achieve a longer life in hammer components, research of wear and impact resistant materials not normally associated with traditional hammer manufacture, will be essential.

Water powered hammers are being developed for use in underground mines.

Although performance results are encouraging, the design of the hammer is limited to use on sites where large amounts of water are available and can be tolerated and most importantly handled and cleaned for return to the hammer.

Hydraulic oil powered hammers have been tested in some quarries but these need a specially adapted drill rig, drill tubes and coupling system.

Spillage and potential contamination of the ground is a major consideration. Furthermore a separate air supply is needed in order to flush the hole.

Because of these limitations, water and oil powered hammers are slow to gain ground and air driven hammers still have the competitive edge.

The immediate opportunity for DTH hammers is in developing their use for applications normally drilled using other methods, for example shallow oil and gas field development, shallow wide hole piling, continuous drilling and casing systems, reverse circulation chip sampling, mole drilling and applications where holes in excess of 900 mm (36") diameter are required in mining, civil engineering and construction applications.

Although DTH hammers started life in quarries, they are now appreciated throughout the drilling industry where they have become the preferred option due to their significant advantages over other systems, in particular:

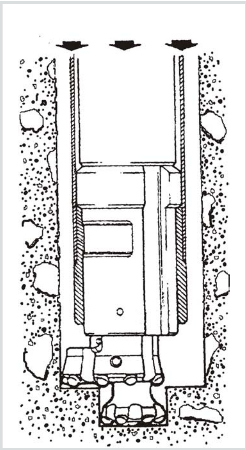
- **Capable of drilling in almost all rocks, hard, medium to soft.**
- **Penetration rates that can outstrip other systems.**
- **Reduced costs.**
- **Straighter/cleaner holes.**
- **Wide range of hole sizes available, without high expenditure.**
- **Quieter than other percussive systems.**

APPLICATION OVERBURDEN SYSTEMS

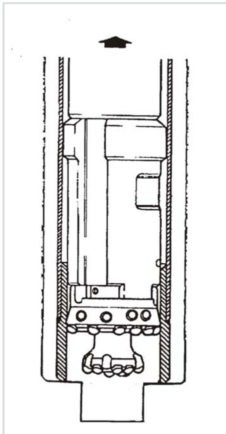
Soft soil is normally drilled with augers or by the rotary method but DTH hammers have adapted to soft conditions by being able to drill and case the hole simultaneously using an eccentric bit which can be withdrawn on completion of the bore hole, leaving the casing in situ, thus preventing hole collapse.

The systems achieve this by enabling the down the hole drill string and casing to be lowered simultaneously. A down the hole hammer is used to which is fitted a driver and eccentric bit.

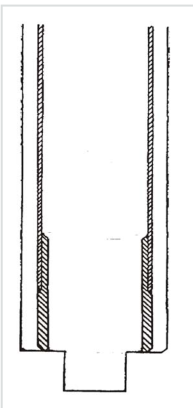
① Drilling into the ground, the eccentric bit rotates outwards to drill a larger diameter hole than the following casing.



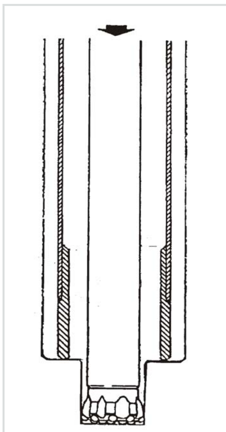
② After reaching the required cased depth the drill string is rotated in the opposite Direction, the eccentric bit is then withdrawn into the Casing.



③ This enables the entire drill string to be pulled out, leaving the casing in situ in the bedrock.



④ Drilling can then be continued using a standard DTH button bit through the casing.



REVERSE CIRCULATION

Reverse circulation hammers can in most instances carry out continuous sample collection in a fraction of the time necessary with conventional or wireline coring.

CONVENTIONAL HAMMERS

Some applications for conventional DTH hammers include blast hole drilling, water well and geothermal drilling, mineral exploration, seismic investigation, intermittent sampling and a wide variety of civil engineering and underground mining applications.

Civil engineering applications include piling, site investigation, ground consolidation and anchoring, post holes, de-watering, earthing rod installation, micro-piling and monitoring ground movement and ground contamination.

Underground mining applications include rock bolting, cable anchoring, blasting, cut out raises, communication and ventilation raises, rescue shafts, instrumentation installations and underground service passages.

The down-the-hole hammer is now probably the most versatile drilling method available for most applications because it can be used in medium and hard formations enabling them to be used in conditions previously exclusive to rotary, drifter and coring techniques.

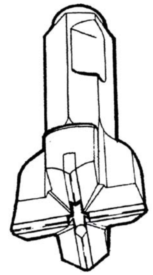
DRILL BIT DEVELOPMENT

Rapid advances in drill bit technology have also occurred throughout the last 40 years. The first type of drill bit used with down the hole hammers was a “cross bit” design.

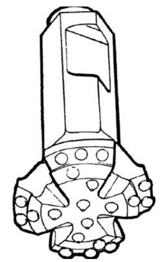
Four chisel shaped lengths of tungsten carbide were brazed into the bit body. The action of brazing preset stresses within the drill bit thereby limiting its life.

A further disadvantage of the cross bit was that the majority of the carbide was situated around the centre of the bit face and not towards the outer edge of the drill bit where there is the most rock to cut.

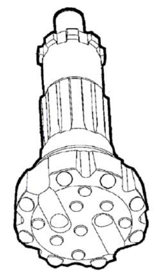
1960s DESIGN CROSS BIT



1960s DESIGN BUTTON BIT



MODERN DESIGN BUTTON BIT



In the late 1960's however, the button bit was introduced and this was a landmark in the progress of DTH equipment which led to bit lives previously unheard of.

The button bit design eliminated the primary shortcomings of the cross bit.

Cylindrical button inserts are precision ground to extremely close tolerances and pressed into the drill bit as an interference fit. This resulted in improved carbide insert retention by eliminating brazing stresses and other defects associated with brazing and braze materials.

Button inserts are distributed more efficiently than cross bit inserts by providing more cutting power where it is needed at the outer edge of the drill bit face.

In many cases, the need to sharpen the drill bit was eliminated with the arrival of the button bit and the improved cutting action provided increased drilling rates particularly in hard rocks.

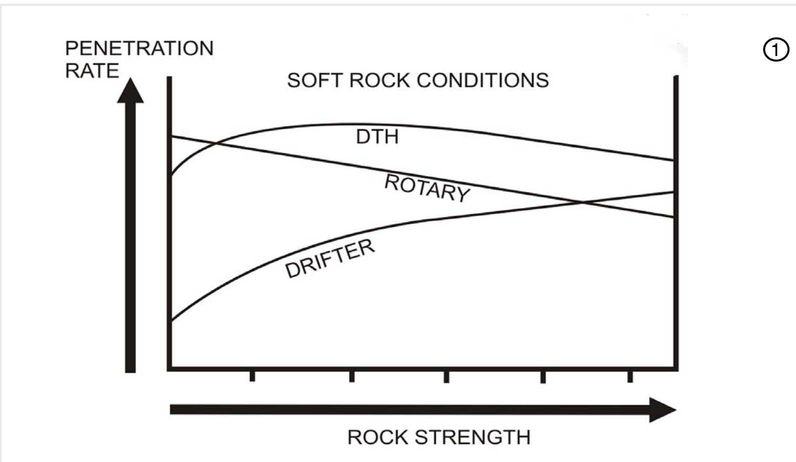
Whilst the cross bit design is still used in some rotary and drifter applications where the rock is very soft, the button bit is now used in virtually every DTH application.

COMPARATIVE VERSATILITY

'Rotary' systems work well in soft conditions, the rate decreasing as hardness increases.

'Drifter' systems do not drill well in soft conditions but drill better as the rock hardens and becomes more solid.

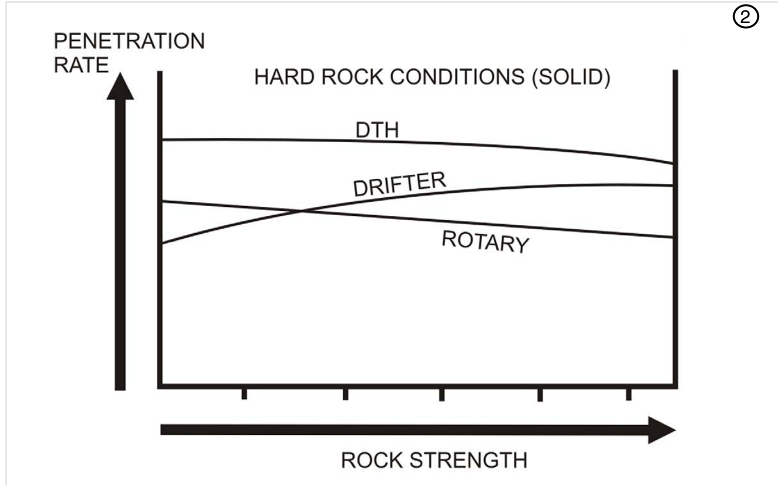
'DTH' systems are less efficient at the lower end of the scale but work extremely well at a consistent level in all other conditions.



'Rotary' systems are more affected as the rock hardens.

'Drifter' systems work well in solid conditions with high drilling rates on shallow holes.

'DTH' systems are at the peak of efficiency being less affected than other systems in these condition.



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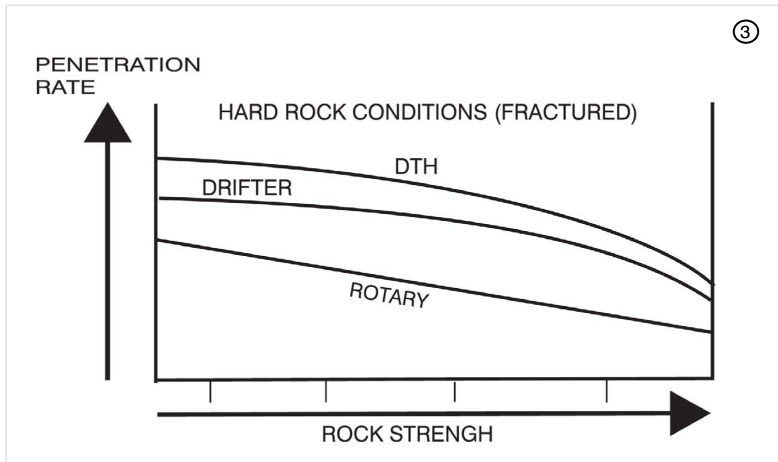


ADVANTAGE OF DTH HAMMERS OVER ROTARY DRILLING

Rotary Drilling relies upon high rotational speeds and thrust without percussion to achieve the desired effect and outputs. Heavy drill collars are sometimes needed to add extra thrust to the bit.

Rotary machines are usually large self contained hydraulically powered units with sufficient weight to provide the thrust on the drill bit to drill the hole.

The harder the rock the greater the thrust required, the heavier the machine, the greater the initial capital outlay, the higher the operating costs.

The same factors apply when hole diameters are increased.

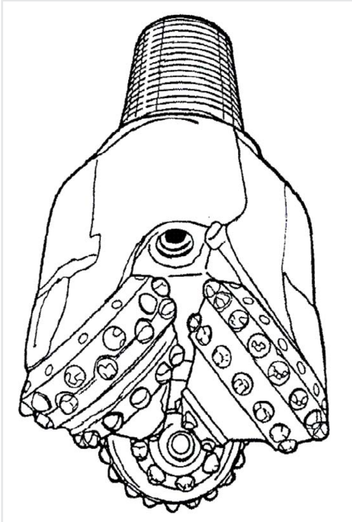
Excessive thrusts can lead to deviation of the bore hole particularly when drilling at angles in bedded formations.

Rotary drilling can be cost effective in soft/medium low abrasive formations but not in medium hard abrasive conditions.

Tricone rotary bits are not suited to holes below 140mm (5 1/2") diameter due to the premature destruction of the bearings within the bit and drag bits are only successful in soft formations.

DTH hammers do not require the powerful down thrust and torque of the rotary rig and therefore can be used on lighter, less expensive and more mobile machines.

The low torque and thrust required by the DTH hammer means that rotation head vibration is appreciably less than that created by the rotary method.



Because minimal thrust is applied to the DTH hammer, it deviates from its course very little and drills a straighter hole than the rotary bit.

DTH offers longer bit life and faster penetration rates in medium to hard rock at any depth.

DTH hammers drill mixed, hard and medium formations more efficiently than rotary equipment.

ADVANTAGE OF DTH HAMMERS OVER DRIFTER EQUIPMENT

Drifter Drilling uses high energy drill mast mounted hammers to drive the drill string and bit into the rock.

There are both air powered and hydraulically powered versions. Hydraulic drifter hammers are faster and more economical than air powered ones. In each case the hole is flushed clean with air or water.

There are 2 main types of drifter systems - “Conventional Drifter” and “Tube Drifter”.

“Conventional Drifters” are designed for short hole drilling in medium to hard conditions with maximum hole diameter to 115mm (4 1/2”). They use slender drill rods for ease of handling which have a relatively small flushing hole for air to pass through to the drill bit to clear debris from the hole.

The diameter of these rods leads to flexing within the bore hole which in turn leads to hole deviation which is accentuated by depth.

“Tube drifters” using heavy wall tubes in an attempt to provide a more rigid drill string, are designed to drill deeper with larger diameters. Tube drifters are always hydraulically driven from self contained automatic machines.

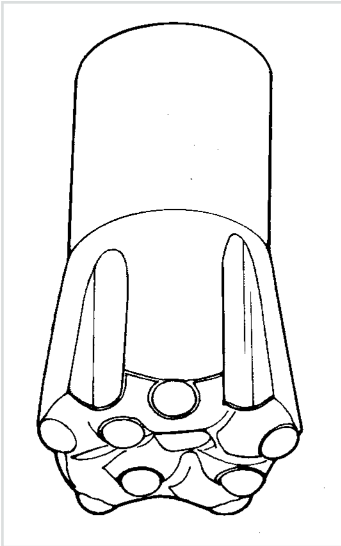
Even with tube drifters experience has shown that the high impact on the drill bit can still cause deviation of the bore hole and in broken ground the drill bit can easily jam.

The high energy impact can also have the detrimental effect of destroying the drill tubes to give a low finite life for these expensive components.

Drifters are more successful in solid rocks and less so in soft, variable and fractured rocks.

The drilling rate however within the bore hole will decrease as the hole deepens due to energy loss in the rods and couplings as the drill bit gets further away from the energy source.

With DTH hammers, there is little or no reduction in penetration rate as the hammer drills deeper in solid rock. Whatever drilling speeds can be obtained at a depth of 10 metres (30ft) can generally, subject to compressor capacity, be obtained at a depth of 100 metres (330ft) because the hammer piston always directly strikes the drill bit, unlike the drifter system whose rods and couplings absorb blow energy resulting in progressively slower drilling as more rods are added.



ADVANTAGE OF DTH HAMMERS OVER DRIFTER EQUIPMENT CONT.D

With DTH, the operator works in relative comfort because the sound of the hammer is muffled in the hole. With the drifter hammer, the operator may be continuously subjected to intense noise.

Clearance of cuttings is more effective with DTH resulting in less recrushing of rock and therefore more efficient drilling.

This is achieved in two ways:

a) By utilising a smaller annulus between the drill string and the bore hole.

b) By making a greater volume of air available at the rock face than can be passed through the narrow duct in a drifter rod.

Because they are unable to clear cuttings efficiently at depth, drifters often have to do a certain amount of non productive drilling per hole to ensure they achieve the full required depth.

Larger diameter holes can be drilled with DTH usually with the same size of rig. Drill tube changing is easier and quicker with DTH because DTH tubes are lighter and do not absorb percussive energy as do drifter rods and couplings which become heated and are far more subject to wear on the threads. Consequently DTH drill tubes can last for years, whereas drifter rods and couplings are regarded as major consumable items.

DTH hammers can make use of high pressure air whilst drifters are unable to do so because of the limitations of the drill steel bore.

DTH hammers are kinder to the drill rig because their energy is transmitted to the rock and most vibration is absorbed down the hole. The drifter's initial transfer of energy takes place on the mast which can be subjected to heavy vibration.

With DTH hammers the operator is immediately aware of any malfunction, such as binding or insert breakage, by the sound emitted from the bore hole but this is not possible with the drifter due to the intense noise from the drifter head. In the event of changing a DTH hammer, either for servicing or fitting a different size or type, the DTH conversion can be carried out in a short time without immobilizing the rig. This is not the case with the drifter hammer.

Generally speaking, DTH hammers give way to drifters at depths of less than 10 metres where hole diameters below 100mm (4") are required due to the faster penetration speeds of the drifter in these conditions.

Many drifter drill rigs can be converted to the advantages of DTH hammer by equipping the drill rig with a rotation gearbox, enabling the rig to drill larger diameter holes than previously possible with a drifter head. On blasting applications, the subsequent increase in burden and spacing provided by a larger diameter hole can result in more rock being produced at less cost and without the capital outlay of a new drill rig.

The ability of the DTH hammer however to generally drill a straighter hole, its quieter operation, lower air consumption than an air powered drifter and more efficient hole cleaning capability are points worthy of consideration, even for short holes of small diameter.

COST COMPARISONS - DTH HAMMER - TUBE DRIFTER - ROTARY

The 3 main principles of drilling are:

ROTARY

DRIFTER (TOP HAMMER)

DOWN-THE-HOLE

In some applications it is not easy to make direct comparisons between the different principles of drilling because of the variation in conditions.

In open pit mining operations where conditions are more stable and the work repetitive, the comparisons are easier to make.

In an attempt to make a comparison between each system we use figures obtained in a hard limestone quarrying application where 6 1/2" (165mm) diameter holes are being drilled for blasting purposes based on 2015 prices.

Material & Conditions	Carboniferous Limestone Medium/Hard Crushing strength - 190-200 MPa (28,000-32,000 psi) Silica - 1% to 2% Hole Diameter - 165mm (6 1/2") Face Depth - 18 Metres (60ft) Sub Grade Drilling - 1 Metre (3ft) Angle of Hole - 10 degrees Burden and Spacing - 5.5m x 5.5m (18ft x 18ft) Specific Gravity - 2.55 Tonnes per m^3 Yield per Metre Drilling with Sub Grade - 73 Tonnes Some Fissures with Clay present on top levels Bedding Horizontal 1500 Drilling Hours per Year	
Results of costing comparison as detailed in following pages 14-16.		
Yearly Output	Average Cost Per Tonne*	Capacity of one machine
(Drilling)	Single Shift	
DTH System	4.80 Pence/Tonne	4,380,000 Tonnes/Year
Rotary System	5.90 Pence/Tonne	2,628,000 Tonnes/Year
Drifter (Top Hammer) System	6.78 Pence/Tonne	3,832,500 Tonnes/Year

Further comparisons done in other types of formations will similarly reveal the cost effectiveness and performance which can be attained with DTH systems.

Rotary drilling can offer attractive results in soft, non abrasive conditions but it is unlikely to be competitive in the medium & hard formations.

*** Dependant on application and ground condition.**

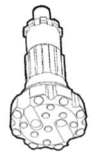
Whilst Drifter drilling in most formations will slow down the deeper it goes and is not suited to drilling in soft or broken ground it can, for short-hole drilling in very hard solid rocks, offer some advantages.

Down-the-hole has the capability of drilling right across this spectrum of hardness and ground conditions efficiently and economically at a constant rate throughout.

DTH HAMMER SYSTEM OVERALL DRILLING RATE

40 M/HR CARBONIFEROUS LIMESTONE

Self Contained Blast Hole Rig 24 Bar (350 psi)
Air Pressure 165 mm (6 1/2") diameter holes



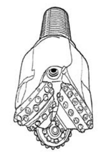
£

		Cost per hour
Depreciation	£ 300,000.00 written off over 14000 hours	£21.42
Repairs & Services	Assessment	£ 12.00
Hammers	6" Hammer £ 3,600.00 written over 12000 Metres x 40m per hour	£ 12.00
Drill Bits	165mm diameter £450.00 written off over 5000m x 40m per hour	£ 3.60
Drill Tubes	7.6m long x 114mm - 3 off x £600.00 each. £1,800.00 written off over 12000m x 40m per hour	£4.00
Dust Collection	Filters, Hoses, General Maintenance assessed	£0.75
Labour	1 Man x £25.00 per hour	£25.00
Fuel	90 ltrs/hour x 66 pence/ltr	£59.40
Lubricants	For Rig, Compressor and Hammer	£2.20
Total Hourly Cost		£140.37
Cost per Linear Metre 40m drilled for £140.37		£3.50 per Linear Metre
Yield per Linear Metre	= 73 Tonnes	
Cost per Tonne	£3.50 / 73	= 4.80 pence/Tonne

ROTARY DRILLING OVERALL DRILLING RATE

24 M/HR CARBONIFEROUS LIMESTONE

40,000 to 50,000lb Self Contained Rotary Drill, 165mm (6 1/2") diameter holes



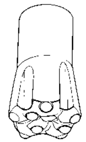
£

		Cost per hour
Depreciation	£ 240,000.00 written off over 14000 hours	£17.14
Repairs & Services	Assessment	£ 9.50
Drill Tubes	7.6m long x 114mm - 3 off x £600.00 each. £1,800.00 written off over 12000m x 40m per hour	£0.90
Drill Bits	165mm diameter £600.00 written off over 3000m x 24m per hour	£ 4.80
Drill Subs	800 (Top & Bottom) 750 hours life	£1.06
Dust Collection	Filters, Hoses, General Maintenance assessed	£0.75
Labour	1 Man x £25.00 per hour	£25.00
Fuel	64 ltrs/hour x 66 pence/ltr	£42.24
Lubricants	For Rig, Compressor and Hammer	£2.00
Total Hourly Cost		£103.39
Cost per Linear Metre 24m drilled for £103.39		£4.30 per Linear Metre
Yield per Linear Metre	= 73 Tonnes	
Cost per Tonne	£4.30 / 73	= 5.90 pence/Tonne

DRIFTER (TOP HAMMER) DRILLING
OVERALL DRILLING RATE

35 M/HR CARBONIFEROUS LIMESTONE

2000 Drifter (Top Hammer) Self Contained Drill 165mm (6 1/2”) diameter holes



£

		Cost per hour
Depreciation	£ 340,000.00 written off over 14000 hours	£24.28
Repairs & Services inc. Hammer	Assessment for contact	£ 15.00
Drill Tubes	7.6m long x 3 off x £2.300.00 each. £6,900.00 written off over 3000m x 35m per hour	£53.66
Shank Adaptors	£740.00 written off over 4000m x 35m per hour	£ 6.47
Drill Bits	£450.00 written off over 5000m x 35m per hour	£3.15
Dust Collection	Filters, Hoses, General Maintenance assessed	£0.75
Labour	1 Man x £25.00 per hour	£25.00
Fuel	65 ltrs/hour x 66 pence/ltr	£42.90
Lubricants	For Rig, Compressor and Hammer	£2.20
Total Hourly Cost		£173.41
Cost per Linear Metre 35 m drilled for £173.41		£4.95 per Linear Metre
Yield per Linear Metre	= 73 Tonnes	
Cost per Tonne	$\frac{£4.95}{73}$	= 6.78 pence/Tonne

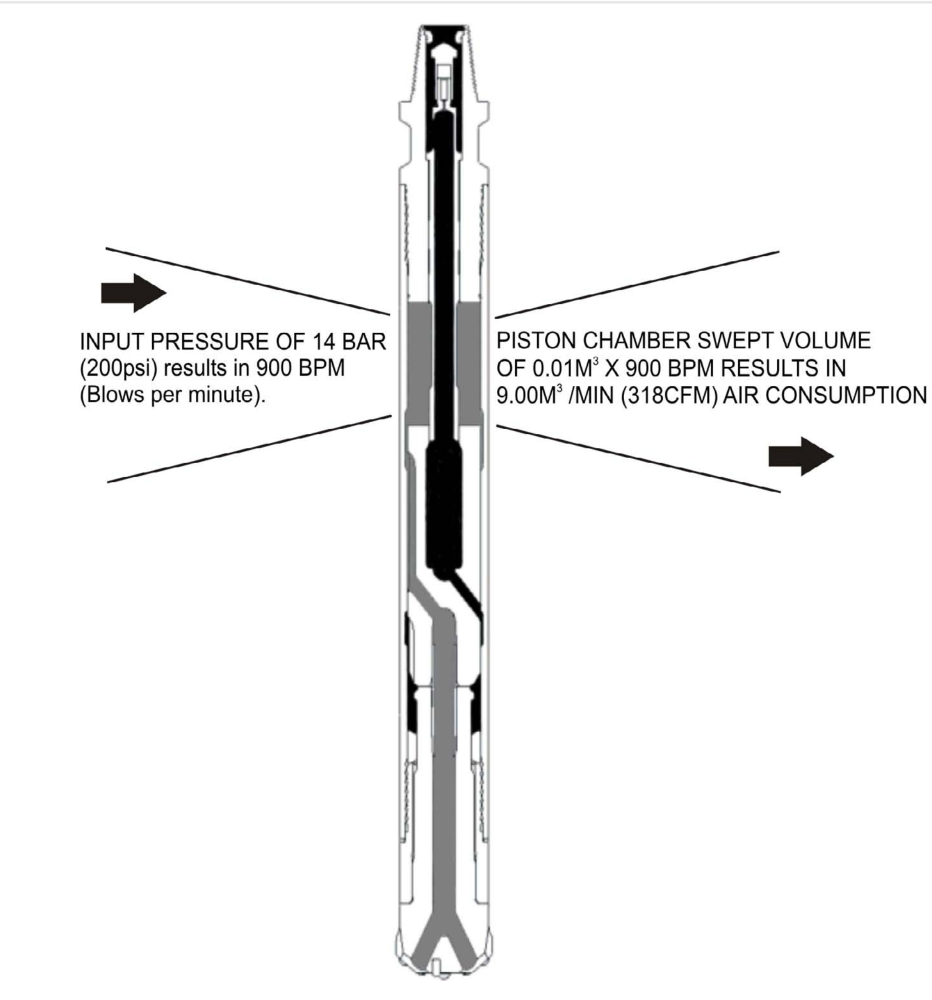
COMPRESSED AIR

AIR PRESSURE
AIR VOLUME
ALTITUDE
UPHOLE VELOCITY

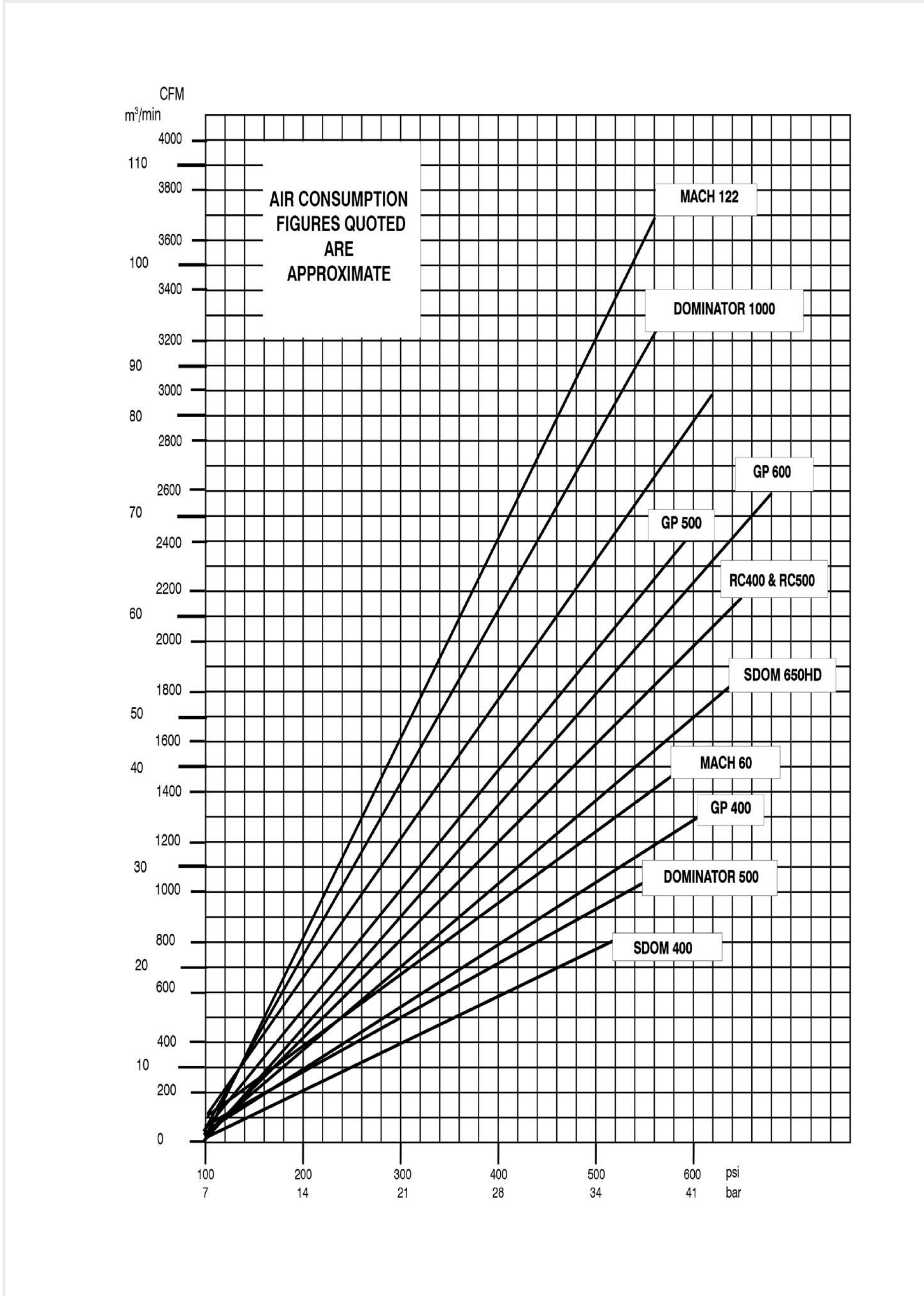
AIR PRESSURE VERSUS AIR VOLUME

Air pressure is the primary motivating force in the performance of a down-the-hole hammer. It is air pressure which dictates the impact energy and blow frequency, providing that adequate air volume exists to maintain the pressure.

The air volume passed by the hammer (air consumption) expressed in CFM (cubic feet per minute) or m^3/min (cubic metres/minute) is a result of the number of blows per minute multiplied by the swept volume of the hammer (the chamber above the piston). Please refer to the graph opposite for typical hammer air consumption of various hammer sizes.



AIR CONSUMPTION GRAPH



In selecting any air compressor capacity, the compressor therefore ideally should have a volume equivalent to the hammer air consumption at the required output pressure plus a minimum extra volume of 20% for contingency purposes.

Further allowances however, should be made for the effects of operating at high altitude, where air is thinner, in determining the correct output pressure and volume of the compressor.

FEET		SEA	1000	3000	5000	7000	9000	11000	13000	15000
METRES		LEVEL	305	915	1524	2134	2744	3354	3963	4573
TEMPERATURE										
F°	C°									
-40	-40	0.805	0.835	0.898	0.968	1.043	1.127	1.217	1.317	1.426
-30	-34.4	0.824	0.855	0.92	0.991	1.068	1.154	1.246	1.349	1.460
-20	-28.9	0.844	0.875	0.941	1.014	1.092	1.18	1.275	1.380	1.494
-10	-23.3	0.863	0.895	0.962	1.037	1.117	1.207	1.304	1.411	1.528
0	-17.8	0.882	0.915	0.984	1.060	1.142	1.234	1.333	1.443	1.562
10	-12.2	0.901	0.935	1.005	1.083	1.167	1.261	1.362	1.474	1.596
20	-6.7	0.920	0.954	1.026	1.106	1.192	1.288	1.391	1.506	1.630
30	-1.1	0.939	0.974	1.048	1.129	1.217	1.315	1.420	1.537	1.664
40	4.4	0.959	0.994	1.069	1.152	1.241	1.341	1.449	1.568	1.698
50	10	0.978	1.014	1.091	1.175	1.266	1.368	1.478	1.600	1.732
60	15.6	0.997	1.034	1.112	1.198	1.291	1.395	1.507	1.631	1.766
70	21.1	1.016	1.054	1.133	1.221	1.316	1.422	1.536	1.662	1.800
80	26.7	1.035	1.074	1.155	1.244	1.341	1.449	1.565	1.694	1.834
90	32.2	1.055	1.094	1.176	1.267	1.365	1.475	1.594	1.725	1.868
100	37.8	1.074	1.114	1.198	1.290	1.390	1.502	1.623	1.756	1.902
110	43.3	1.093	1.133	1.219	1.313	1.415	1.529	1.652	1.783	1.936
120	48.9	1.112	1.153	1.240	1.336	1.440	1.556	1.681	1.819	1.970

EXAMPLE: At 14 bar (200 psi) AIR PRESSURE, Halco Dominator 600 hammer requires 14.10 m³/min (500 CFM).

At 915m (3000ft), 10°C (50°F) - correction factor is 1.091, therefore in these conditions Dominator 600 would require 15.38m³/min (14.10 x 1.091), which is equivalent to 543 cfm.

If the compressor selected has an air volume of less than that required by the hammer at a given pressure, a lower air output pressure will result.

For example, a compressor output of 24 bar (350 psi) and 27m³/min (950 cfm) will not hold 24 bar (350 psi) working pressure with a hammer which normally needs 30m³/min (1050cfm) at 24 bar (350 psi) pressure.

There are other factors to consider in selecting a suitable air compressor and these are dealt with on pages 23-25.

HIGH AIR PRESSURE WILL PROVIDE:

- Faster penetration rates, particularly in hard rock. Higher pressures, in soft rocks, will not always result in increased speeds where the exhausting air volume is insufficient to keep the hole clean and re-drilling of the cuttings occurs.
- Better drill bit life in hard rocks. The number of metres drilled and the time spent drilling both affect overall drill bit life. A drill bit will spend approximately only half of the time drilling 100 metres (330ft) at 24 bar (350 psi) pressure than it would drilling 100 metres (330ft) at 12 bar (170 psi) in the same conditions.

NOTE: It is important that a hammer is not operated at air pressures above its maximum recommended pressure as damage to components could result, unless any excess pressure serves only to overcome water back pressure.

AIR PRESSURE INCREASE WILL ASSIST IN:

- Overcoming external water back pressure - A head of 10 metres (30ft) of water in a bore hole exerts 1 bar (14.5 psi) of back pressure to the hammer. Where the theoretical working pressure of the hammer, based on the water depth, would drop below the minimum recommended pressure for the hammer, the hammer could stop operating. By increasing the air pressure, the hammer would continue to operate. The use of foam, in these conditions can be beneficial because an air pressure increase alone will not always lift the drilling debris through water.
- Increasing penetration speeds, particularly in hard rocks.
- Improving up-hole velocity where this is insufficient to clean the bore hole. An increase in air pressure will result in a corresponding increase in air volume providing the compressor has sufficient volume. There are other solutions to improving uphole velocity which are dealt with overleaf.

NOTE: In most cases, it is essential that any increase in compressor air pressure is accompanied by an increase in air volume, otherwise, except where water back pressure is being overcome, the actual working pressure at the hammer. will not increase.

AIR PRESSURE - HOW TO INCREASE, WHERE AIR VOLUME IS INSUFFICIENT

- Besides substituting the compressor for a unit which delivers a higher output pressure and volume, there are some conditions where a pressure increase can be achieved by other means.
- By changing the hammer for a unit which consumes less air to sustain a given pressure. This is useful in conditions where the output pressure of the compressor in use cannot be sustained because its volume is insufficient for use with the original hammer.
- On large diameter applications where up-hole velocity is very low, a second compressor with identical output pressure can be introduced in parallel. This will have the effect of allowing the large hammer to sustain a higher pressure as the increased air volume will support it.

HIGH PRESSURE IS NOT RECOMMENDED WHERE

- The drilling conditions are so soft that the bore hole is being blasted away by the exhausting air.
- The top of the hole is so unstable that it is being destroyed by the high air pressure. It is usual, in these conditions, to temporarily reduce the air pressure until the top of the bore hole is stabilised, after packing, where necessary, the top of the bore hole with clay. This is known as collaring the bore hole.
- The drilling conditions are such that the drilling rate is so fast that the exhausting air cannot clear the drilling debris from the hole resulting in the hammer becoming buried.
- A new hammer is being “run in” during the first hour of operation.

AIR PRESSURE REDUCTIONS - CAUSES

- Unwelcome air pressure reductions or pressure drops can happen in certain conditions resulting in impaired performance. These can be observed by comparing what the compressor’s actual output pressure is to the pressure actually registering on the drill rig’s air pressure gauge Water in the bore hole exerting back pressure.
- Insufficient compressor volume to sustain the hammer’s required operating pressure.
- Where chokes or vents in use have bled so much air volume direct to exhaust that the remaining compressor volume is insufficient to maintain the hammer’s required operating pressure.
- Where chokes or vents are in use because drilling air and choke/vent air exhaust through the same ports. This can lead to back pressure and a drop in air pressure at the hammer.
- Worn or damaged compressor components.
- Air leaks in the compressed air delivery line and drill pipe joints.
- Hammers which are badly worn internally.
- Voids or fissures in the rocks causing loss of air circulation.
- Operating at high altitudes above sea level where air density is lower.
- Pressure drop to the hammer can occur on air powered drill rigs where the compressed air demands of the rig reduce the compressed air volume available to the hammer to a level which is insufficient to sustain the air pressure.

NOTE: Air pressure at the hammer automatically falls when lifting the hammer to flush.

REDUCING AIR PRESSURE INTENTIONALLY

Having accepted that the higher the air pressure, the faster the hammer will drill, in most conditions, there are other priorities to consider which in certain instances are more important than outright penetration rates.

Hole destruction because of excess pressure. Reducing the air pressure may provide a better more useable bore hole.

Excessive wear of the base of hammer where in very abrasive conditions, consumable spares cost replacement is a feature to consider alongside drilling rates.

To prevent a compressor engine working continuously at full speed, which would shorten its service life and increase maintenance costs. A compressor generally runs in a fuel efficient manner at approximately 80% of maximum.

UPHOLE VELOCITY

The exhausting air from a down-the-hole hammer is used as the flushing air to clear the rock cuttings from the bore hole.

To provide an adequate rate for cutting evacuation, an acceptable uphole velocity must be maintained which is 900-1800 m/min. (3000-6000 ft/min).

The actual uphole velocity will be determined by the hole size, drill tube diameter and air consumption of the hammer in use.

The function of a DTH hammer and drill bit is to break the rock and remove the cuttings from the bore hole immediately they are formed. If a hammer fails to fulfil this function because the uphole velocity is insufficient there are several alternatives, although operating conditions may only allow some of these.

Increase the drill tube diameter - on very large hole diameters, shrouded drill tubes, near to the drill bit diameter, may be used. In these conditions a sleeve or shroud can be fitted around the hammer of the same diameter as the drill tubes. The use of upset drill tubes which cause turbulence and a reduction in uphole velocity should be avoided.

DECREASE THE DRILL BIT DIAMETER.

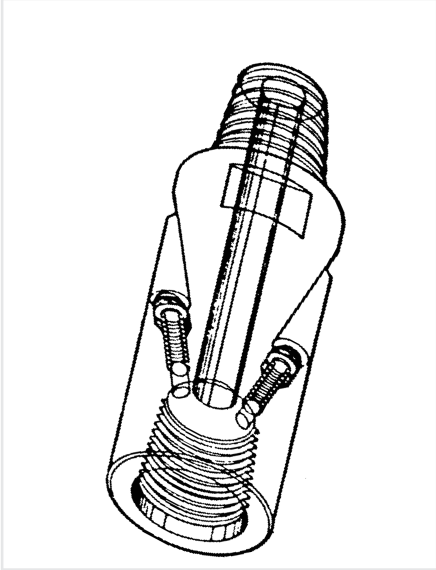
Use foam to assist in cutting evacuation from the bore hole. This is explained in detail, separately. Increase the flushing air available.

This can be done in 3 ways

1. Intermittently- by simply repeatedly lifting the hammer up from the rock face, the percussion action will cease and extra air, up to twice the normal volume, will pass through the hammer to clean the hole, providing that the compressor has a sufficient reserve of volume.
2. By using a choke or vent in the hammer. Dependent on hammer make, this can either be a plugged orifice in the piston or a bleed facility in the non return valve, bottom bush or bit retaining rings.
3. By using an air bypass sub adaptor above the hammer. 2 holes angled upwards are machined in the adaptor and these bleed extra air upwards to increase the uphole velocity although this air bypasses the face of the drill bit where it would be most effective.

It is important to ensure that when using air bypass sub adaptors, chokes or vents that the compressor in use has a sufficient reserve of air volume available over and above that needed to sustain its output pressure with the selected hammer, otherwise a pressure reduction will occur in addition to the effect of any back pressure caused by the use of the vent or choke.

The pressure reduction will lead generally to a decrease in penetration speed.



UP HOLE VELOCITY

THE FORMULA FOR CALCULATING UP HOLE VELOCITY IS AS FOLLOWS:

METRIC $vm = x(m^3) \times 1{,}305{,}096 / DM^2 - dm^2$

IMPERIAL $vf = y\ (CFM) \times 183.40 / DI^2 - di^{2i}$

Where -

VM = Velocity in metres per minute.

X(m^3) = m^3/Min. of air volume passed by the hammer at the selected air pressure.

DM^2 = Diameter of hole - squared (in millimetres).

dm^2 = Diameter of drill tube squared (in millimetres).

VF = Velocity in feet per minute.

Y(CFM) = Volume of CFM of air passed by the hammer at the selected air pressure.

DI^2 = Diameter of hole - squared (in inches)

di^2 = Diameter of drill tube squared (in inches)

AN ALTERNATIVE METHOD OF CALCULATING UP HOLE VELOCITY WITH HAMMERS IS AS FOLLOWS:

A. Establish the volume of air in m^3/Min. being passed through the hammer.

B. Establish the velocity per m^3 of air, from chart across, with relevant tube and hole diameter.

C. Multiply A x B = answer in metres/minute.

D. If feet per minute required - multiply metres/minute x 3.28

WITH HALCO HAMMERS FOR EXAMPLE

DOMINATOR 600 @ 14 bar (200psi) = 14.10 m^3/min AIR CONSUMPTION 114mm (4 1/2") TUBE/165mm(6 1/2") BIT = 89 m/min VELOCITY FOR 1 m^3/MIN UPHOLE VELOCITY = 14.10 x 89 = 1255 m^3/min

HAMMER AIR CONSUMPTION

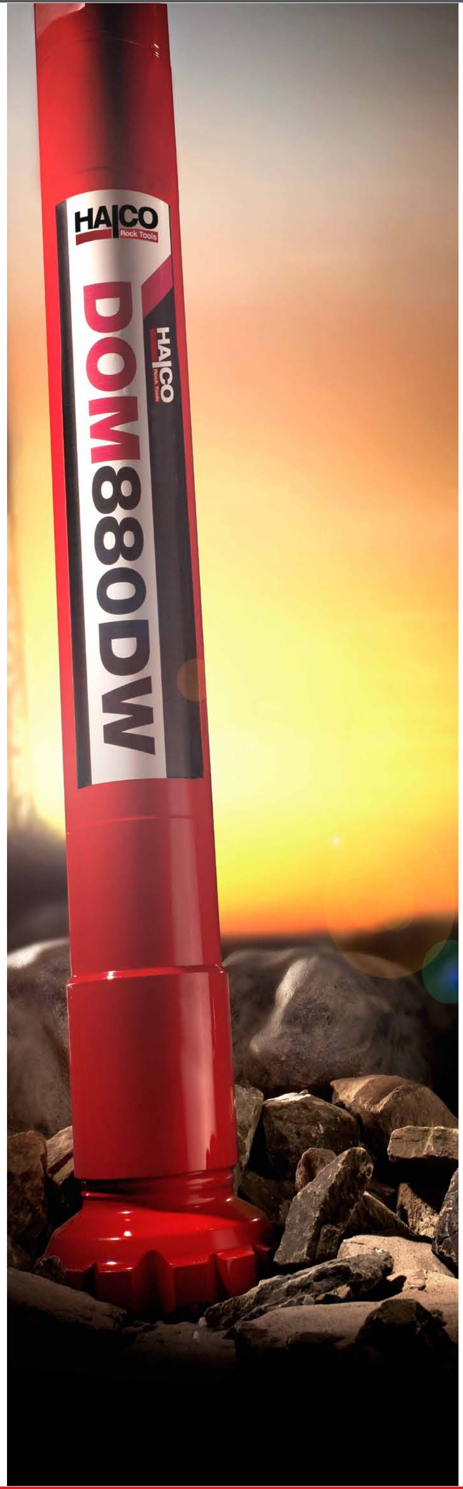
Hammer Model	7 Bar (100 PSI)	10.5 Bar (150 PSI)	14 Bar (200 PSI)	17 Bar (250 PSI)	24 Bar (350 PSI)	30 Bar (435 PSI)	35 Bar (500 PSI)	55 Bar (800 PSI)
DOM 10	1.7	2.6	3.5	4.5	-	-	-	-
DOM 20	2	3.8	5.8	7.6	-	-	-	-
DOM 30	2.5	4.7	7.0	9.3	13.8	-	-	-
MACH 303	2.8	4.4	5.9	7.3	10.0	-	-	-
Super Dominator 400	5.2	7.5	9.9	12.2	17	-	-	-
Super Dominator 450	4.3	6.5	11.0	13.2	15.5	-	-	-
MACH 44	4.8	7.0	9.5	12.0	17.2	-	-	-
GP 400	3.5	5.7	7.9	10.3	15.3	20.0	22.4	-
RC 400	2.3	5.6	8.8	12.2	16.4	22.7	29.7	50.9
MACH 50	5.7	7.2	11.0	14.9	23.4	-	-	-
Dominator 500/SDOM 500/SDOM 550 HD	6.5	8.5	12	15.6	22.65	28.67	-	-
GP 500	5	8.7	12.3	15.9	23.2	30.5	34.2	34.2
RC 500	5.1	8.4	11.8	15	22.4	22.7	33.98	63.71
Dominator 600/SDOM 600/SDOM 650 HD	4.1	9.3	14.1	19.5	30	38.72	-	-
MACH 60	5.1	7.9	12.5	16.4	25.5	43.22	-	-
GP 600	6	10	14	17.5	26	33.9	37.9	37.9
Dominator 750	9.9	15.7	21.5	27.3	38.5	48.54	-	-
Dominator 800	6.5	10.8	15.1	19.3	27.9	39.19	-	-
Dominator 850	11	16.8	22.5	28.2	39.6	49.71	-	-
Dominator 880	10.9	16.6	22.4	28.1	31.44	38.88	-	-
Dominator 880 DW	14.6	23.5	32.5	41.5	59.4	74.44	-	-
Dominator 1000	15.6	24	40.3	48.5	56.6	70.47	-	-
MACH 120	15.35	21.95	28.3	35.4	48.1	59.55	-	-
MACH 122/132/142	19.8	29.45	39.05	48.1	70.8	88.97	-	-

The chart below lists the velocity in metres per minute for each 1m³ of air passed through the hammer, for each drill tube and drill bit diameter combination.

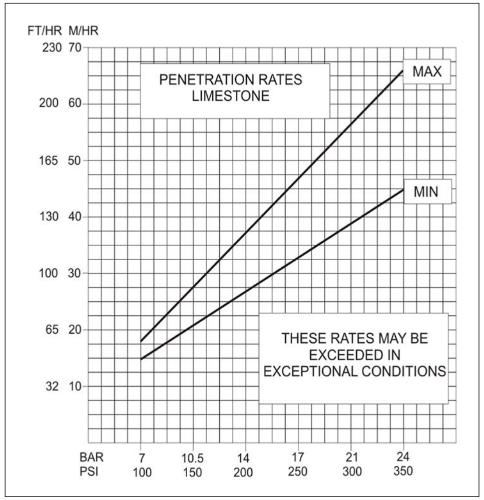
DRILL BIT DIA.		DRILL TUBE DIAMETER							
inch		2 1/8	2 3/4	3	3 1/2	4	4 1/2	5	5 1/2
	mm	54mm	70mm	76mm	89mm	102mm	114mm	127mm	140mm
2 3/4	70	642							
3 1/3	85	295	548	880					
3 1/2"	90	254	420	607					
3 15/16	100	180	249	304					
4 1/8	105		208	243	410				
4 1/4	108		188	218	340				
4 1/3	110		177	201	305	751			
4 1/2	115		153	171	240	451			
4 3/4	120		134	148	196	319	907		
5	127		113	123	155	222	407		
5 1/8	130		106	114	142	196	326		
5 1/2	140		87	92	109	138	193	367	
6	152		70	73	83	99	125	179	
6 1/8	156		66	69	78	92	114	158	
6 1/4	159		63	66	74	86	105	140	
6 1/2	165		57	59	66	76	89	115	
6 3/4	171		52	54	59	67	78	96	
7	178				54	60	69	82	105
7 1/2	191				45	49	55	63	90
7 7/8	200				40	43	47	53	62
8	203				38	41	45	51	58
8 1/2	216				33	35	38	42	47
8 7/8	225				30	32	34	37	41
9 5/8	245				24	26	27	29	32
10	254				22	24	25	26	28
11	279				18	19	20	21	22
11 7/8	300				15	16	17	17	18
12 1/4	311				14	15	15	16	16
13	330						13	14	14
14 3/4	375						10	10	11
15	381						10	10	10
17 1/2	445						7	7	7
18 1/2	470						6	6	6
20	508						5	5	5
22	559						4	4	4
24	610						4	4	4

EQUIPMENT SELECTION

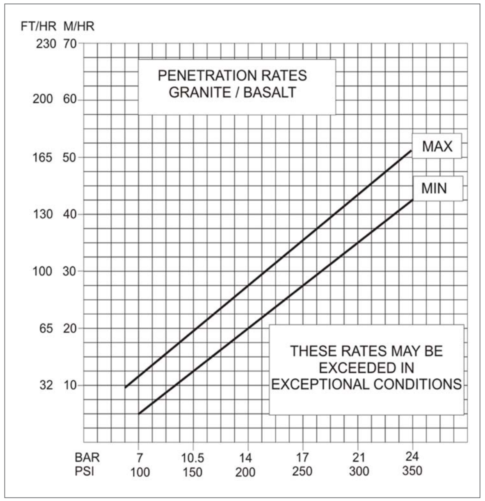
HAMMER / DRILL BIT / DRILL TUBE AND COMPRESSOR SELECTION



NORMAL BIT DIAMETER / AIR PRESSURE SELECTION



Penetration rates are generally dictated by air pressure. The higher the air pressure the faster the hammer will drill.



For example, if a hole diameter of 165 mm (6 1/2") and a penetration rate of 30 m/hr drilling in granite was needed, then an air pressure of around 17 bar (250 psi) would be necessary.

Having selected the hole diameter required for the application in hand, for example 165mm (6.1/2"), choose a hammer whose outside diameter is smaller than but the closest to the hole size to be drilled, for example Halco DOMINATOR 600.

This will allow the use of a nominal or standard bit diameter for the chosen hammer in order to achieve the best transmission of blow energy and optimum penetration rate.

HAMMER SIZE / DRILL TUBE DIAMETER SELECTION

Recommended Hammer Nominal Bit Diameter/Drill Tube Diameter Combination

Nominal Hole Dia	Hammer Approx Outside Dia.	Recommended Drill Tube Dia.*	Suitable Halco Hammer Models
85 mm	77mm	70mm	DOM 30
90 -100 mm	77mm	70 - 76 mm	DOM 30
90 - 104 mm	81 mm	70 - 76 mm	DOM 30
105 - 108 mm	95 / 98 mm	70 - 76 mm	MACH44/SDOM400/GP400
110 - 120 mm	95 / 98 mm	76 - 90 mm	MACH44/SDOM400/GP400
110 - 120 mm	100.5 mm	76 - 90 mm	SDOM450
127 mm	114 / 118 mm	76 - 90 mm	MACH 50/SDOM500.DOM500**
135 - 146 mm	114 / 118 mm	90 - 114 mm	MACH 50/SDOM500.DOM500
152 mm	139 mm	102 - 114 mm	SDOM600/DOM600/MACH60/GP600
165 178 mm	139 / 172 mm	114 mm	DOM600/650HD/SDOM600/GP600/DOM750
203 - 279 mm	182 mm	114 mm ***	DOM800/880/880 DW
203 - 279 mm	192 mm	114 mm ***	DOM850
254 - 300 mm	230 mm	114 mm ***	DOM1000/SDOM1000
311 - 381 mm	273 mm	114 mm ***	MACH120/122/132
444 - 508 mm	273 mm	114 mm ***	MACH142

* Drill tube diameter should not be too big so as to result in too high up hole velocity.
** DOMINATOR 500 /127mm (5") diameter bits subject to drilling conditions.
*** or as large as possible - subject to hammer diameter.

Having selected the main drilling elements for example - Hole diameter 165mm (6 1/2") Hammer type - DOMINATOR 600, drill tube diameter 114 mm (4 1/2") Air Pressure - 17 bar (250 psi), the chosen compressor should have an adequate air volume. A DOMINATOR 600 operating at 17 bar (250psi) air pressure would require a basic drilling air volume of 20 m^3/min. (700CFM).

Most applications, however, dictate the need for greater air volume for contingencies such as flushing or altitude. When drilling under a high head of water, higher air pressure may be required to overcome the effect of water back pressure. These instances are dealt with overleaf.

If, for example, an existing 17 bar (250 psi) capacity compressor is available but its output volume is insufficient, for example 17 m^3/min. (600CFM), a more fuel efficient hammer may be selected, such as the MACH60 which consumes less air than the DOMINATOR 600 at any given air pressure. Individual drilling conditions, however will always dictate the final hammer model choice, irrespective of compressor volume available because any hammer of any make will perform differently in different rock conditions.

Where drilling conditions are extremely abrasive, a heavy duty hammer with thicker outer casing components, such as the Halco DOMINATOR 650HD, may be selected to further resist the onset of external wear due to abrasion.

The need to use, wherever possible, a nominal or standard diameter bit rather than an oversize bit, cannot be stressed too strongly, in order to achieve overall optimum.

Oversize drill bits are generally used for overburden drilling in relatively soft conditions, but are sometimes used for production drilling in hard rock, although they are not designed for hard rock drilling. A disproportionately high head/shank diameter ratio increases the risk of excessive spline wear and/or shank breakage under high torque conditions.

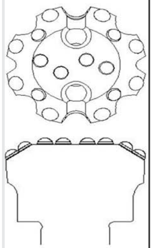
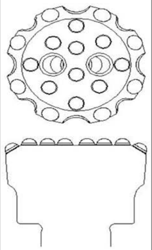
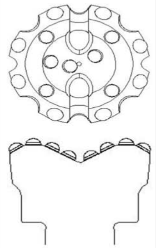
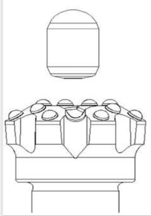
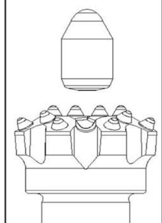
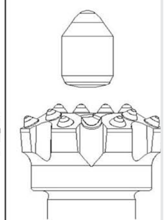
OVERSIZE DIAMETER BITS

HAMMER MODELS	OVERSIZE DIA.(mm)
MACH44 / SDOM400	127-150
DOM500/SDOM500/MACH50	150 - 165
DOM600/SDOM600/MACH60	178 - 300
DOM750	300 - 311
DOM800/850/880/880DW	300 -411
DOM1000 / SDOM1000	305 - 381
MACH120/122/132	445 - 610*
MACH 142	559 - 610*

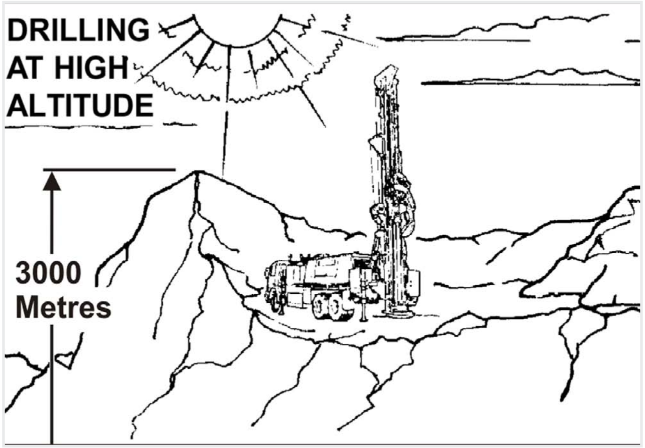
*** or larger**

DRILL BIT HEAD DESIGNS / INSERT TYPES

Many drill bit manufacturers offer a choice of both head designs and insert types to suit varied drilling applications.

HEAD DESIGNS			INSERT TYPES		
CONVEX	FLAT FACE	CONCAVE	DOMED INSERTS	BALLISTIC INSERTS	SEMI-BALLISTIC INSERTS
					
STRONG DESIGN FOR ALL CONDITIONS ESPECIALLY HARD ABRASIVE ROCKS. GOOD BALANCE OF FAST DRILLING AND LONG	ALTERNATIVE DESIGN FOR ALL ROCK CONDITIONS ESPECIALLY FRACTURED AND FISSURED ROCKS AND CHANGING FORMATIONS	ALTERNATIVE DESIGN FOR ALL ROCK CONDITIONS PARTICULARLY DEEP HOLE DRILLING CAN IMPROVE HOLE ALIGNMENT AS A RESULT OF THE INVERTED PILOT	STRONG RUGGED SHAPE FOR HIGH PERFORMANCE AND GOOD SERVICE LIFE IN ALL CONDITIONS PARTICULARLY SUITABLE FOR VERY HARD ABRASIVE ROCKS AND DEEP HOLE DRILLING	SUITABLE FOR SOFT/MEDIUM COMPACT LOW ABRASIVE ROCKS PRODUCING LARGE CUTTINGS. NOT SUITABLE FOR BADLY FRACTURED ROCKS.	SUITABLE FOR ALL SOFT/MEDIUM ROCK CONDITIONS INCLUDING FRACTURED AND FISSURED ROCKS.

COMPRESSOR CONTINGENCIES AFFECTING FINAL CHOICE



High Altitude

Working at high altitude requires a higher air volume to sustain a given pressure, merely because the air is thinner as altitude progressively increases. Please refer to page 20.

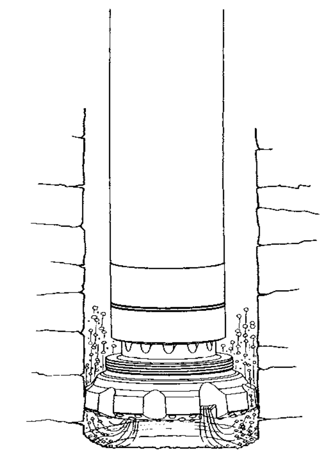
COMPRESSOR SELECTION

FLUSHING

It is normal practice to have a reserve of air volume of at least an extra 20% above that needed for the normal operation of the hammer.

This can be useful where repeated intermittent flushing is carried out to blow the hole clean in difficult conditions.

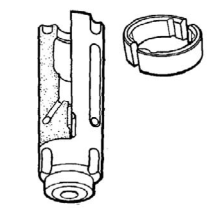
Most DTH hammers can pass up to 70% extra air, when lifted up slightly so that the drill bit falls into the flushing position.



VENTS / CHOKES

When using vents or chokes in the hammer, it is important to ensure that there is sufficient extra volume to bleed direct to exhaust. If the vent or choke facility bleeds too much air, the resultant air volume from the compressor may be insufficient to sustain the required air pressure at the hammer, leading to a drop in performance.

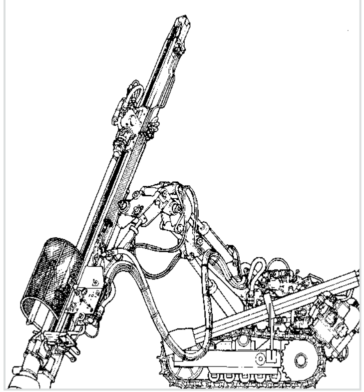
VENT / CHOKE

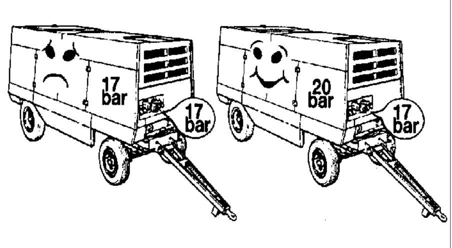


DRILL RIG COMPRESSED AIR REQUIREMENTS

If the drill rig is powered by compressed air, extra air volume will be required to cater for the needs of the drill rig's motors.

Generally, $1m^3$/min (35 cfm) is required for each 0.75Kw (1 hp) of motor power. An air powered rotary head with 4Kw (5.30 hp) would need approx. $5.40m^3$/min. (190 cfm) at full power/rotation speed. An air powered Dust Collector generally needs $4.50\text{-}5.50m^3$/min (150-200 cfm). The drill rig's feed system generally manages on less than $1m^3$/min (35 cfm). All rig functions generally operate within air pressures of 7 - 55 bar (100 - 800 psi).

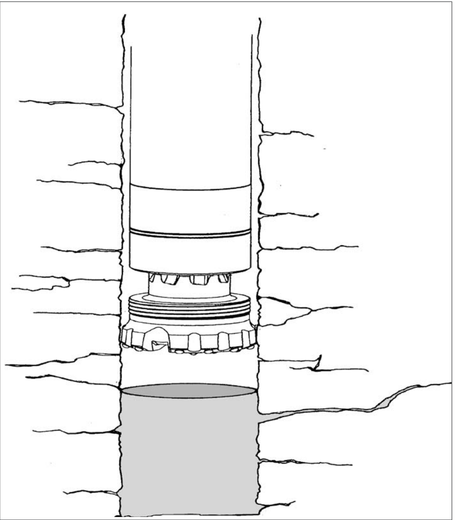




COMPRESSOR LIFE

To provide an optimum service life for a compressor, it should generally work at only 8% of its full capacity.

It may be advisable therefore to select a compressor with a larger pressure capability than that needed in order to increase its service life.

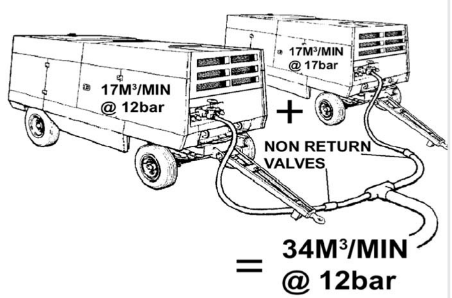


GROUNDWATER IN THE BORE HOLE

Water in the bore hole exerts a back pressure of 1 bar (14.5 psi) for every 10m (33ft) of water present.

To sustain therefore an air pressure of 17 bar (250 psi) under 70m (230ft) of water, a compressor output pressure of 24 bar (350 psi) would be required, although, the air volume needed would only be that necessary to sustain an air pressure of 17 bar (250 psi).

MULTIPLE COMRESSORS



MULTIPLE COMPRESSORS

Water in the bore hole exerts a back pressure of 1 bar (14.5 psi) for every 10m (33ft) of water present.

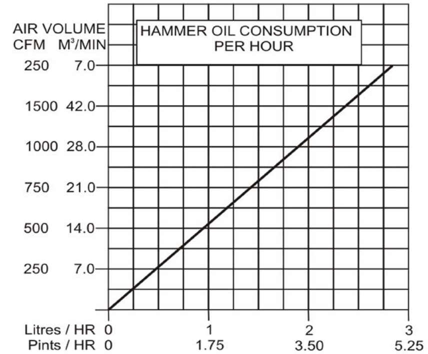
To sustain therefore an air pressure of 17 bar (250 psi) under 70m (230ft) of water, a compressor output pressure of 24 bar (350 psi) would be required, although, the air volume needed would only be that necessary to sustain an air pressure of 17 bar (250 psi).

For example:

17 m^3 @ 12 bar + 17 m^3/min @ 17 bar = 34 m^3/min @12 bar

(600 cfm @170 psi + 600 cfm @ 250 psi = 1200 cfm @ 170 psi)

LUBRICANTS



DTH hammers need:

- 1/3 of an imperial pint of oil per hour per 100 cfm of air consumed.

or

- 0.20L of oil per hour per 3 m^3/min of air consumed.

Up to double the amount of oil is required when used with water injection.

At temperature below 5°C oil with an antifreeze additive may be required.

LUBRICATING OIL

Just like any other piece of precision machinery, the DTH hammer must be lubricated and small quantities of oil should be injected into the air stream at regular intervals, whilst the hammer is working. Rock drill oils are recommended because they contain the emulsifying and viscosity additives necessary to deal with huge pressure and high air flow conditions and in which water is usually present, if only from condensation in the air line.

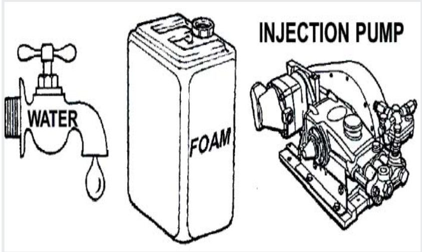
Oil not only provides slip to prevent pick up and premature failure of components but it also acts as a seal on the surface of running parts to use air efficiently without pressure loss. It is of paramount importance that the correct grade of oil is used at the appropriate consumption rate to suit volume and pressure. In line with the manufacturers guidance.

Most hammers when operating at high pressures need a heavy oil providing of course that ambient temperatures allow the oil to run through the airline.

Halco recommend the following lubricants:

Lubricating Oils

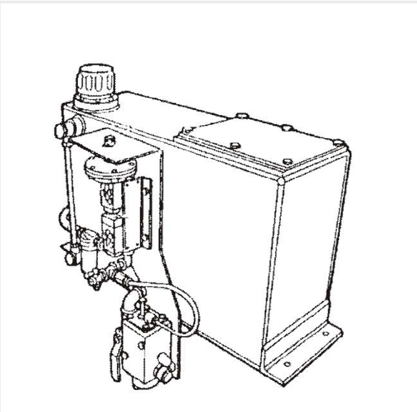
MAKE	AMBIENT TEMPERATURE			HAMMER GREASE	
	BELOW 10°	FROM 10°C to 32°C	ABOVE 32°C	HAMMER THREAD GREASE	HAMMER O'RING GREASE
HALCO	HS3	HS200	HS200	FAXENE CP COMPOUND	FAXANE H76
MOLYBOND	MOLYHAMMER 320			GOG	-
BP	ENERGOL RD-E 100	MACCURAT D220	MACCURAT D220	ENERGREASE AS 11	-
CASTROL	RD OIL 100	RD OIL 150	RD OIL 150	-	RED RUBBER GREASE
MOBIL	ALMO 527	ALMO 529	VACTRA OIL NO.4	MOBILTEMP SHC460	-
SHELL	TORCULA 100	TONNA TX220	TONNA TX220	HIGH PRESS THREAD	-
TEXACO	ARIES 100	WAY LUBRICANT X220	WAY LUBRICANT X220	-	-



FOAM

Where drilling conditions dictate the need, foam should be made available together with a suitable injection pump and water supply.

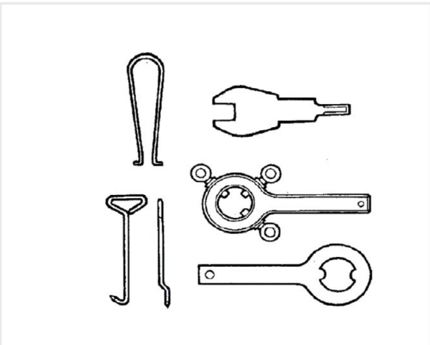
Details on application/conditions where water/foam injection would be beneficial can be found on page 53.



HAMMER LUBRICATORS

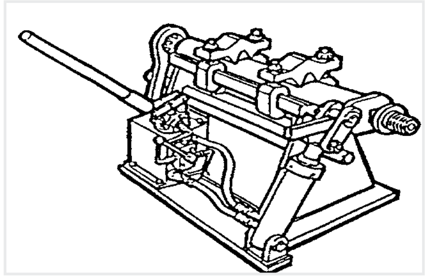
An air line lubricator should be available to continually inject oil into the air stream whilst the hammer is operating.

Not only should the lubricator be in working order but it should be designed to cope with compressor air pressure, which can be up to 24 bar (350 psi) or even higher.



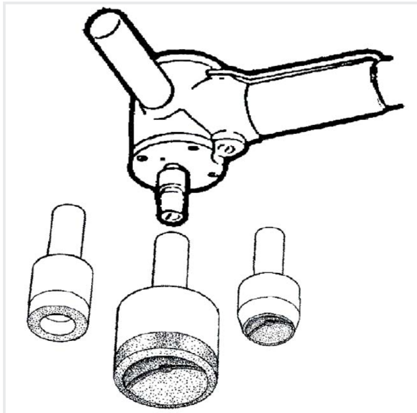
SERVICE TOOLS

To avoid damage to hammers during servicing, it is advisable to ensure that the correct service tools are available.



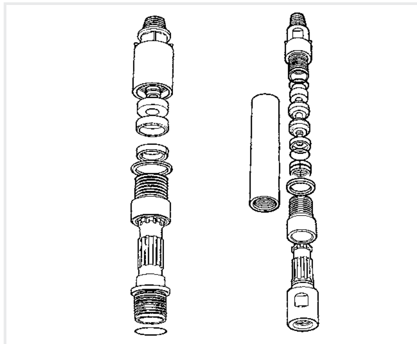
HAMMER DISMANTLING

A purpose built hammer stripping bench is advisable in order to avoid damage to hammers.



GRINDING EQUIPMENT

In abrasive conditions, wear to the tungsten carbide buttons can destroy a drill bit within a short period of time. It is advisable therefore, when drilling in abrasive conditions that suitable grinding equipment is available.



SHOCK ABSORBERS

Hammer shock absorbers are recommended for use particularly on lightweight rigs to protect the drill tube threads and rotary heard from impact vibration. This will reduce maintenance and drill tube costs.

They can also be used to reduce the noise level from the hammer where environment conditions demand it.

OPERATING DTH EQUIPMENT

COMMISSIONING

OPERATING CYCLE

PENETRATION RATES

ROTATION SPEEDS

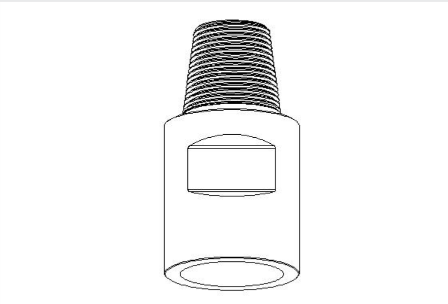
THRUST / HOLDBACK / TORQUE

DEPTH CAPABILITIES

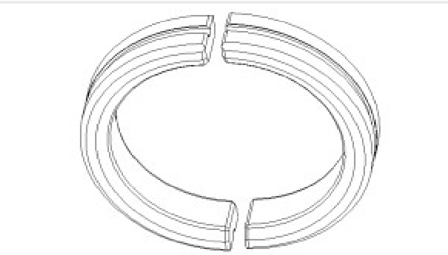
RECOMMENDATIONS AND COST SAVING HINTS

COMMISSIONING DTH HAMMERS AND DRILL BITS

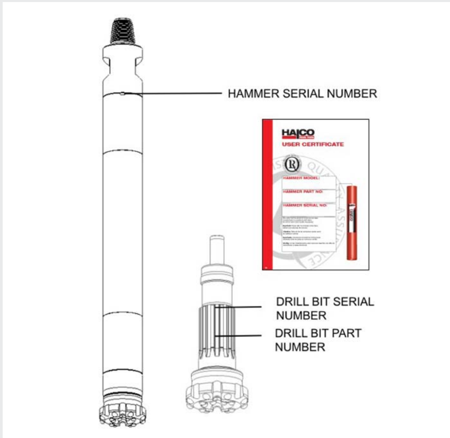
SAFETY
Always wear the correct safety equipment.



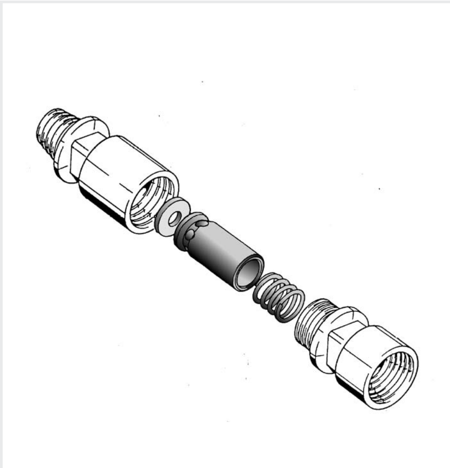
SUB ADAPTOR
A sub adaptor will be required if the hammer top thread differs to the drill tube thread.



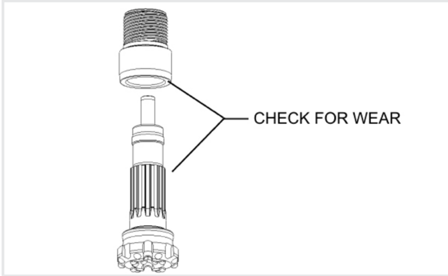
BIT RETAINING RINGS
Never mix pairs of retaining rings which generally are manufactured as matched pairs and always re-fit them in the same position as when dismantled from the hammer.



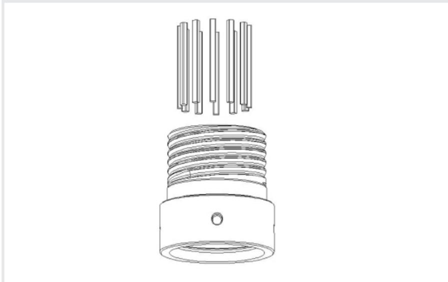
IDENTIFICATION NUMBERS
- Keep a note of equipment serial numbers for future reference.
- Retain the test certificate and spare parts list supplied with the hammer.



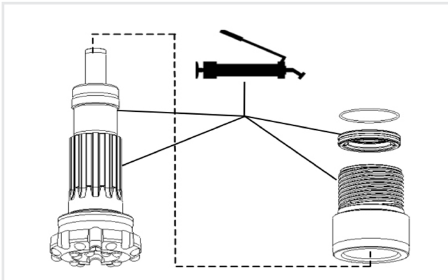
NON RETURN VALVE
You may remove the non return valve in dry conditions to give a slight increase in performance.



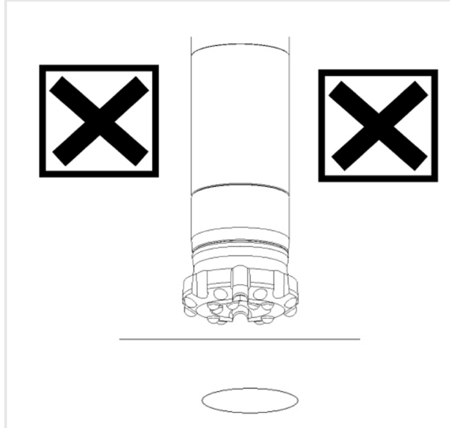
NEW HAMMER OR CHUCK WITH USED DRILL BIT
Check the drill bit splines for wear, otherwise damage to the new chuck could occur.



HAMMERS EQUIPPED WITH SPLINE RIVE PINS
Always ensure that a full set of serviceable drive pins are fitted to these hammers before operating, otherwise damage to splines will occur. In these circumstances, warranty from the manufacturer will not apply.



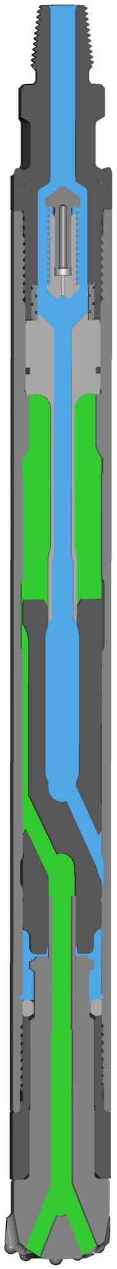
GREASE COMPONENTS
Grease all threads and splines when assembling drill bit into hammer.



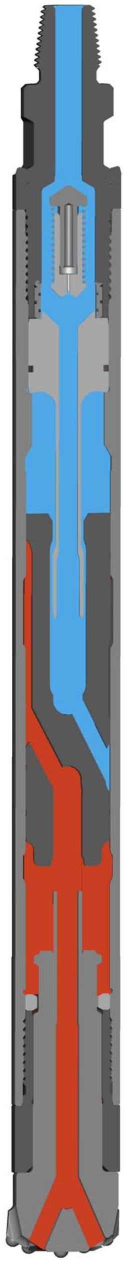
CHECK DRILL BIT DIAMETER
Never try to use a drill bit which is larger in diameter than a partially drilled hole.

COMMISSIONING
- Ensure the hammer lubricator is working.
- Pour 1/2 pint (0.30 litres).of air line oil into the hammer.
- When attached to the drill rig, blow through with air to ensure all internal parts are lubricated.
- Operate at low pressure initially. Progressively increasing, during the first hour, in order to run in the hammer.

VALVELESS HAMMER OPERATING CYCLE



1.
With the piston resting on the bit and the hammer in the drilling position, high pressure air is directed on the piston striking face and lifts the piston. This movement commences the cycle.

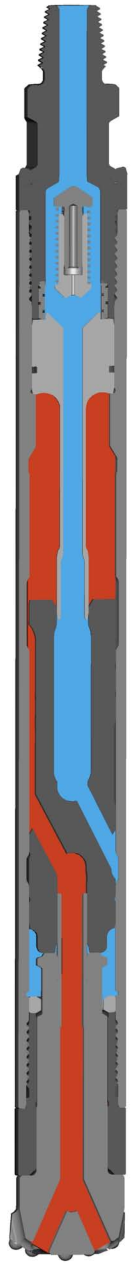


2.
As the piston travels upwards it covers the top exhaust chamber. Further piston movement covers the live air port to the bottom of the piston and uncovers the foot valve, allowing the expanding air to exhaust through the bit. At the same time, high pressure air is being directed above the piston from the piston reservoir chamber via the now unsealed air distributor, which commences the power stroke..

High Pressure Air

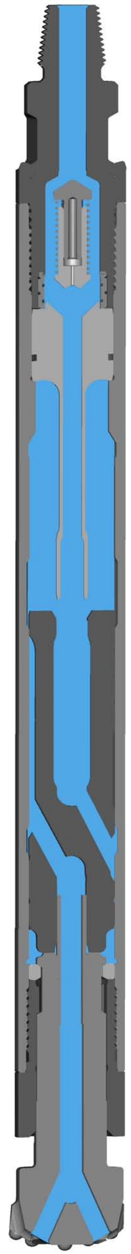
Exhaust Air

Atmospheric Air



3.
During the power stroke the piston covers the foot valve and the expanding air below the piston stops exhausting through the bit. Further piston movement closes the piston reservoir chamber from the power chamber.

With the piston resting on the bit and the hammer in the drilling position, high pressure air is directed on the piston striking face and lifts the piston. This movement commences the cycle.



4.
Lifting the hammer off the bottom of the hole allows the drill bit to drip onto the bit retaining rings. The piston follows the bit to rest on the bit striking face. High pressure air is then directed through the drill bit via the main exhaust holes in the piston and through the bottom chamber, which normally feeds the piston for the return stroke.

The hammer is now in the maximum flushing position.

To resume drilling the hammer is again lowered to the bottom of the hole. This results in the bit and piston being pushed up into the normal drilling position. The hammer cycle then resumes.

OPERATING DTH HAMMERS

PENETRATION RATES with down-the-hole hammers are directly proportional to air pressure and, therefore, increasing the pressure will increase the drilling speed as illustrated in the graphs opposite.

Modern valveless hammers are products of precision engineering and are of a strong robust design with few internal parts making them economically attractive and easy to service. Air pressure is applied alternatively to both ends of the hammer piston by means of a system of ports and channels in the piston and cylinder to change the direction of the air. The valveless hammer operating cycle is described in the previous pages.

DTH hammers are primarily percussion tools and penetrate more by shattering materials than by tearing it. The same air which passes through the hammer causing the piston to reciprocate and strike the bit also serves to expel cuttings from the bore hole and therefore maximum utilisation of the air is achieved.

TOOL LIFE

AVERAGE TOOL LIFE LIMESTONE

HAMMER LIFE 6000 - 8000 METRES*
(20000 - 26000 FT)

DRILL BIT LIFE 3000 - 5000 METRES*
(10000 - 16000 FT)

*** TOOL LIFE OF AROUND TWICE THESE AVERAGES MAY BE ACHIEVED IN SOME FAVOURABLE CONDITIONS.**

GRANITE / BASALT

In hard abrasive drilling conditions, it is wear on the external components which will govern the life of the hammer.

AVERAGE TOOL LIFE GRANITE / BASALT

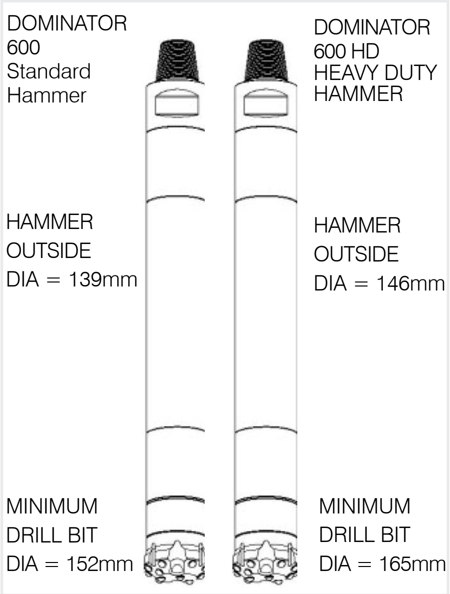
HAMMER LIFE 3000 - 5000 METRES*
(10000 -16000 FT)

DRILL BIT LIFE 600 - 1500 METRES*
(2000 - 5000 FT)

*** TOOL LIFE UP TO 20% GREATER MAY BE ACHIEVED IN SOME FAVOURABLE CONDITIONS.**

LIMESTONE

In non abrasive drilling conditions, where the expected life of the hammer is governed by wear on the internal components, hammer life in excess of 15,000m (50,000ft) is achievable if the hammer is correctly maintained and lubricated.

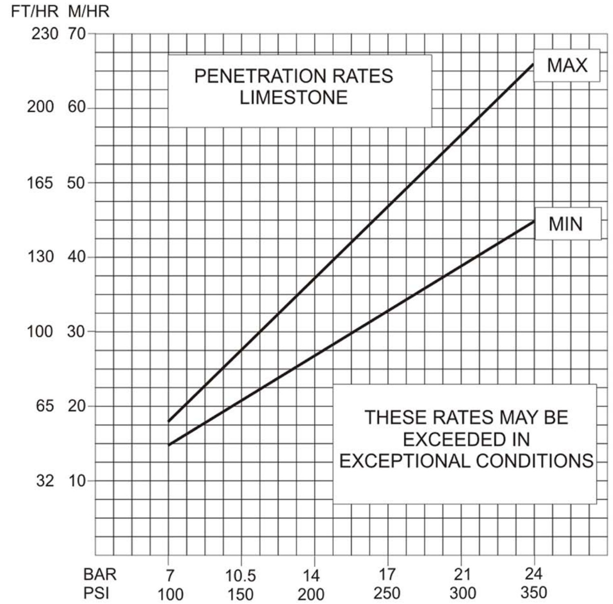


HEAVY DUTY HAMMERS

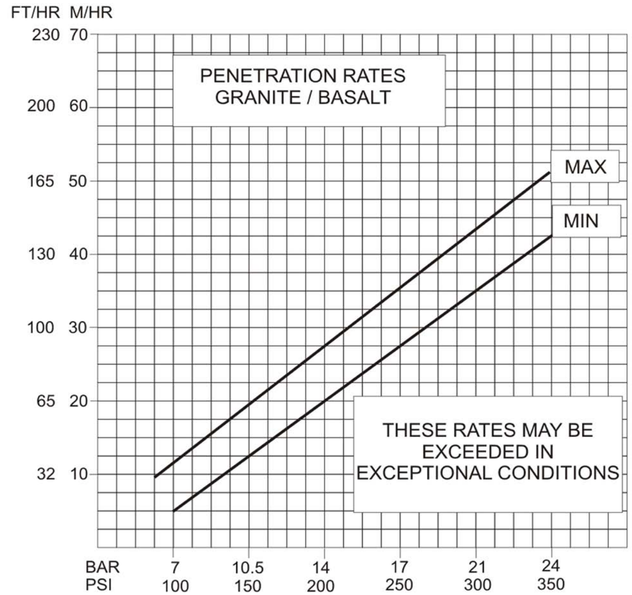
Heavy duty hammers have thicker wall outer components which can provide extra resistance to the onset of external wear. A recent case history revealed that a DOMINATOR 650HD heavy duty hammer, drilling in ironstone, achieved a life in excess of 9,000m (30,000ft) compared to little more than 4,000m(13,000ft) achieved with a standard hammer.

AVERAGE PENETRATION RATES

LIMESTONE



GRANITE / BASALT



ROTATION SPEEDS

Where drill bit life and cost is the prime consideration on a drill site, rotation speeds should be carefully monitored.

DTH drill bits are rotary - PERCUSSIVE tools with the emphasis on PERCUSSIVE. Their function is to fracture the material being drilled which should then be immediately carried away by the exhaust air.

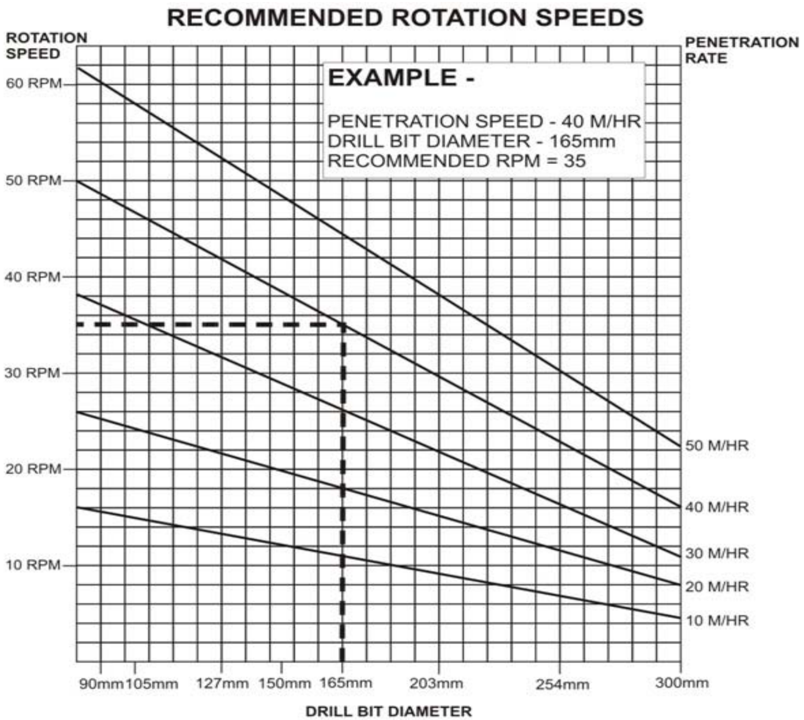
Button bits have no cutting or tearing action as such and the effect of rapid rotation can be prejudicial rather than beneficial to the life of the bit, especially in abrasive rock which wears away fast moving peripheral inserts or in solid dense material which causes the peripheral inserts to overheat and spall due to friction.

If the string is rotated too slowly, this will cause the buttons to impact previously chipped areas of the hole with a resultant drop in penetration speed.

As a general guide - the harder the rock or the larger the bit diameter -the slower the rotation speed required.

It may be necessary however to increase the rotation speed where the rock is badly fissured in order to prevent stalling.

It should be remembered however that stalling in the bore hole could be the result of a very badly worn bit and increasing the rotation speed in these circumstances will only accelerate the problem.



THRUST (PULLDOWN) / HOLDBACK / TORQUE

Thrust should be kept as low as possible at all times avoiding excessive vibration in the drill string. Hold back should be increased more and more as additional rods are added, as drilling progresses.

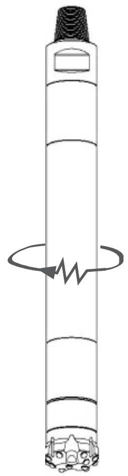
DTH drilling is primarily percussive drilling using the energy imparted by the hammer piston to the rock through the bit and any attempts to apply too much weight could damage the bit, hammer and drill string and impair the drilling rate.

Although the base of the hammer should maintain contact with the drill bit, there should be neither excess thrust or vibration due to reaction between the hammer and drill bit. Insufficient thrust will cause the hammer to bounce resulting in a low blow energy to the rock causing vibration and also possible damage.

Recommended Thrust Capacities

Hammer Size	Min. Thrust	Max. Thrust
3"	150KG (330 Lbs)	300KG (660 Lbs)
4"	250KG (550 Lbs)	500KG (1100 Lbs)
5"	400KG (880 Lbs)	900KG (1980 Lbs)
6"	500KG (1100 Lbs)	1500KG (3300 Lbs)
8"	800KG (1760 Lbs)	2000KG (4400 Lbs)
12"	1600KG (3520 Lbs)	3500KG (7700 Lbs)

When the total weight of the drill string including the weight of the rotary head exceeds the optimum thrust level, the drill string should be put in tension by gradually applying holdback as more tubes are added.



Recommended Torque Ratings

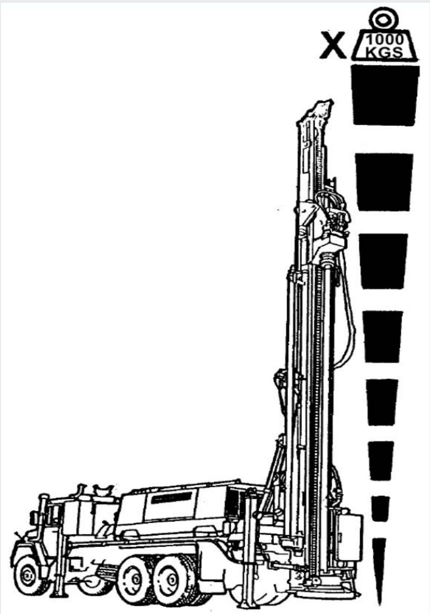
Down the Hole drill bits unlike rotary tricones require very little rotation torque.

Drill Bit Dia.	Torque (Recommended)
105mm (4 1/8")	50KGM (360 Ft/Lbs)
127mm (5")	120KGM (865 Ft/Lbs)
165mm (6 1/2")	250KGM (1800 Ft/Lbs)
200mm (7 7/8")	300KGM (2170 Ft/Lbs)
300mm (11 7/8")	350KGM (2530 Ft/Lbs)
445mm (17 1/2")	425KGM (3075 Ft/Lbs)

DRILLING DEPTH CAPABILITY

The depth capability with down-the-hole hammers is governed by two main factors, sufficient air volume to keep the hole clean and the drill rig's lifting power i.e. its ability to withdraw the drill string from the finished bore hole. The question of hole cleaning or uphole velocity is dealt with in Part 2 - compressed air.

Crawler mounted drill rigs working on quarries or open pit mining applications are generally designed with sufficient lifting power or pullback capability to lift the weight of the drill string from the completed bore hole which on these types of applications rarely exceeds 35 metres(115ft.) On deep hole applications, such as water well drilling, it is essential that the selected drill rig has sufficient lifting power with a reserve of power (safety factor) for contingencies such as the drill rig's hydraulic system inefficiency, the weight of the rotary head, friction in the bore hole, potential hole collapse etc.



The above factors combine to reduce the amount of lifting power available for drill tubes and consequently the achievable drilling depth with any particular drill rig.

In reality only around half the gross lifting power 1 can be used. The average weight of 90 -114mm (3 1/2" - 4 1/2") dia. drill tubes around 20 kg per metre (13 lbs per ft) therefore to account for the 50% reduction for safety factor, this figure of 20kg per metre should be doubled to 40kg per metre (26 lbs per ft).

- **Hydraulic system inefficiency 20%**
- **Weight of rotary head / hammer / drill bit 5%**
- **Contingencies for friction / potential hole collapse 25%**
- **Total reduction 50%**

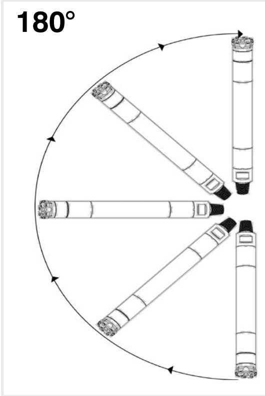
For example therefore a drill rig with a gross lifting power of 8000kg (17,600 lbs) would have a safe theoretical depth capability of 200 metres (660ft). Equally to drill a 350 metres (1150ft) deep well with a DTH hammer would require a rig with a gross lifting power of 14000kg (30,800 lbs).

A safety factor of 50% should be considered as a maximum. With good drilling conditions and/or an experienced drilling crew, theoretical depths will be regularly exceeded. On very deep hole applications a common practice in order to increase the drilling depth capability of the drill rig is to attach the casing winch cable to the rotary head and pull simultaneously with the feed system and the winch. Whilst the theory behind this practice appears sound, the reality is that no make of drill rig can "holdback" more weight during drilling, than it can actually lift out on completion of the bore hole. Damage to DTH hammers & bits due to excess thrust(pulldown) being applied during drilling is a common result of this practice.

OPERATING RECOMMENDATIONS / COST SAVING HINTS

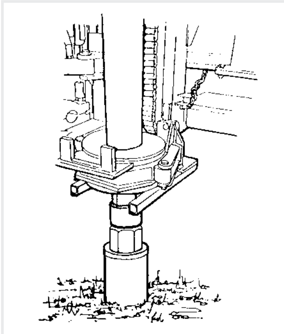
DRILLING VERSATILITY

The term "down-the-hole is somewhat misleading as hammers can drill upwards and horizontally providing wide versatility.



COLLARING THE HOLE

When commencing the hole, reduce the air pressure so as not to destroy the hole wall, particularly when drilling through soft overburden. Once the top of the hole is completed and cased if necessary, adjust the air pressure to the normal operating level.

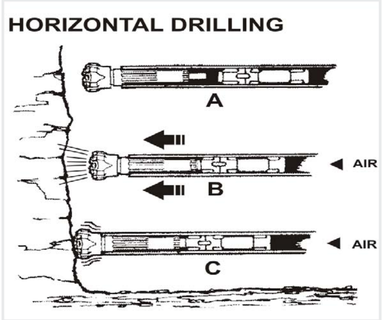


HORIZONTAL DRILLING

When positioning the mast to commence a horizontal hole, it is possible for the piston to slide inside the hammer mid-way between the upstroke and firing position (A). If the bit is then brought into contact with the rock face and the bit shoulder makes contact with the hammer before the air is switched on, the hammer may not start. To remedy this -

Draw back from the rock face, switch on the air and blow through the hammer to force the piston down to the bit (B).

Feed into the rock face with the air switched on (C). The hammer will then operate normally.

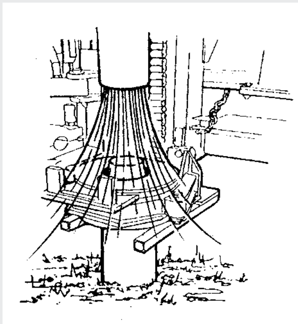


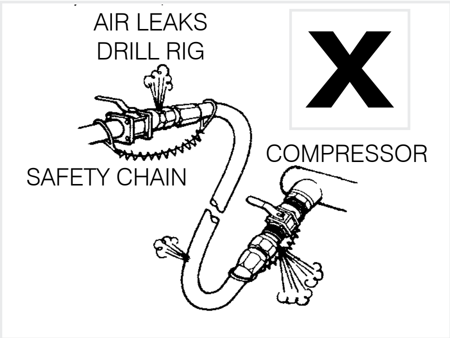
ADDING DRILL TUBES

Before connecting up the first or subsequent drill tube -

A) Cover the top tool joint in the breakout table with a thread protector.

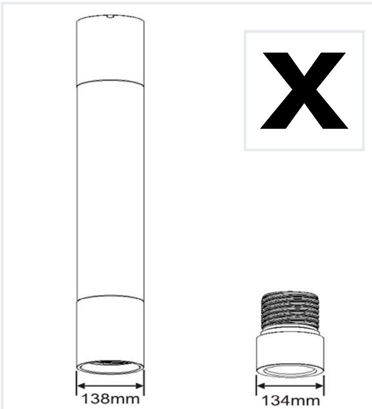
B) Blow through the tube with compressed air. This will minimise the chance of foreign matter entering the hammer and causing malfunction or damage.





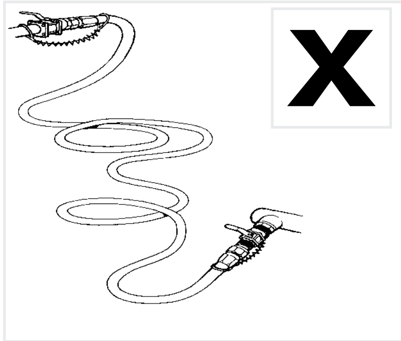
AIR LEAKS

Always ensure that hose couplings are tight to prevent air leaks otherwise air pressure drops will occur and penetration rates will reduce. Always use safety chains on air hoses and periodically check the condition of hoses for leaks.



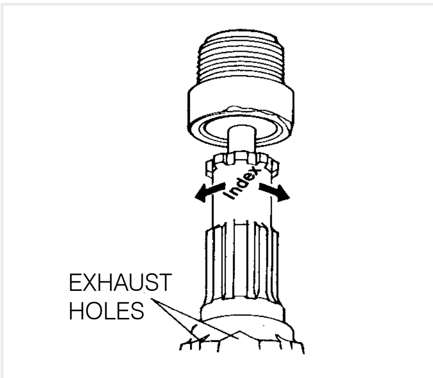
CHUCK DIAMETER VERSUS CYLINDER DIAMETER

It is more economical to replace chucks rather than cylinders therefore always fit a new chuck, whenever a cylinder is replaced to prevent carryover of wear from a used chuck to a new cylinder which is larger in diameter. By monitoring the chuck and cylinder outside diameter to ensure that the chuck outside diameter is always equal or greater than the cylinder outside diameter, the service life of the cylinder will be prolonged.



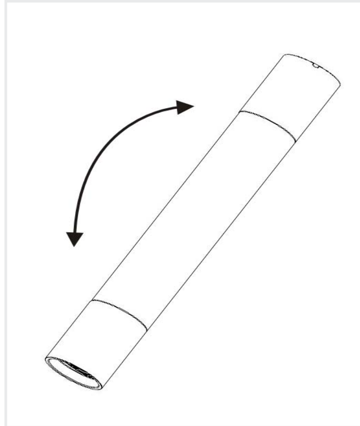
HOSES

Always use as short a hose as possible, between the compressor and drill rig, with an adequate internal diameter to minimise frictional pressure loss. reductions in penetration rate and a consequent wastage of fuel. Long hoses, furthermore, result in a build up of water in the airline which can damage hammer components.



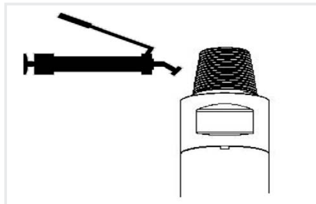
INDEX THE BIT

In hard abrasive drilling conditions, chuck wear will be concentrated on the areas which coincide with the drill bit exhaust grooves. In order to prolong chuck life, the drill bit should be indexed so that the exhaust grooves are adjacent to those areas of the chuck with less wear. Indexing the bit will also even out chuck and drill bit spline wear.



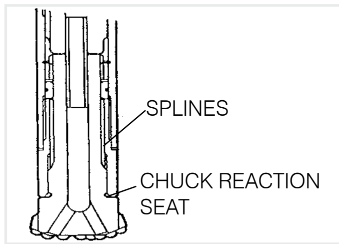
REVERSIBLE CYLINDERS

Where the cylinder can be reversed on any particular hammer, the life of the hammer can be prolonged particularly in abrasive rock conditions.



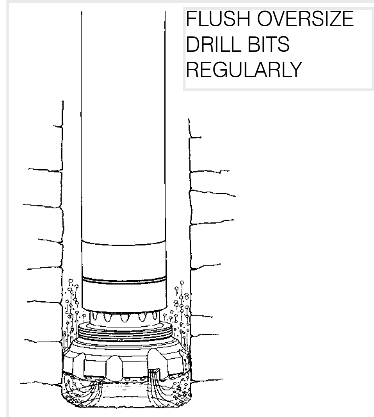
GREASE THREADS

Always ensure that hammer and drill pipe threads are greased before use as this will prolong thread life.



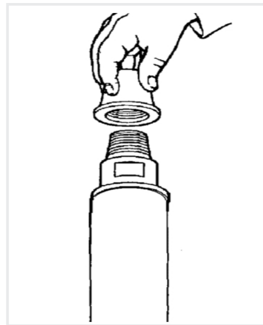
EXCESSIVE THRUST (PULLDOWN)

Excessive and/or erratic thrust exerted by the drill rig's feed system will cause distortion at the chuck reaction seat and reduce the service life of the chuck and the drill bit splines. Always ensure that the correct thrust is smoothly applied.



DRILLING WITH OVERSIZE BITS

When drilling with oversize bits, lift the hammer off the bottom of the hole and flush regularly allowing up to twice the air volume to pass through the hammer to assist with hole cleaning. This helps to remove the cuttings left in the hole due to the reduced up-hole velocity caused when drilling with oversize bits and to prolong drill bit life. The use of foam may in many instances be beneficial.



PROTECTIVE CAPS

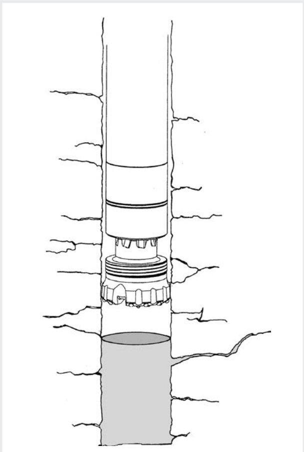
Always fit protective dust caps to DTH hammers and drill tubes when not in use. If cuttings are allowed to enter the hammer, the internal components could be worn and/or damaged thereby increasing maintenance costs. The performance of the hammer may reduce, leading to lower drill bit life.

GROUND WATER IN THE BORE HOLE

INCIDENTS OF WATER IN A BORE HOLE FALL INTO TWO DISTINCTIVE CATEGORIES

- Where there is existing groundwater which has to be overcome.
- Where it has been intentionally injected through the drill string into the bore hole on specialised applications and operating conditions.

EXISTING GROUNDWATER



SMALL AMOUNT OF WATER IN BORE HOLE

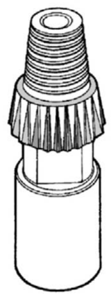
A small amount of water at the bottom of the bore hole turns the cuttings into a paste, thereby inhibiting the free ejection of the cuttings. If the material being drilled is abrasive, a grinding paste is formed at the bottom of the hole causing premature bit wear and if the amount of water is limited, mud will line the sides of the hole causing collaring giving rise to difficulties when withdrawing the hammer.

When drilling in these conditions therefore, it may be desirable to pass water through the hammer to thin down mud and clean the side of the bore hole. This can be done, even if there is no pump available, by simply uncoupling the uppermost drill tube and filling the drill string with clean water which can then be forced through the hammer by reconnecting the drill string and opening the air supply. Whilst water itself will not harm a hammer, any grit carried by the water can score or otherwise damage the working parts of what is a product of precision engineering.

Paste or mud at the bottom of the bore hole can also plug the exhaust hole of the bit. The addition of extra water into the bore hole will also ease this problem.

Some hammers are fitted with "Retrac inserts" to facilitate withdrawal in these conditions. In addition a Retracting Coupler can be used which will also facilitate withdrawal.

RETRACTING COUPLER



EXCESSIVE AMOUNTS OF WATER IN THE BORE HOLE

When drilling under a head of water, back pressure is exerted against the air pressure at the hammer and as the air pressure less the back pressure approaches the minimum operating pressure of the hammer, penetration rates will gradually fall to zero. A 10m (33ft) head of water exerts a back pressure of approximately 1 bar (15 psi) and therefore if, for example, a hammer with a minimum effective working pressure of 7 bar (100psi) were used with a compressor unloading at 14 bars (200 psi), it would be possible for that hammer to work down to 70m (230ft) below the head of water.

Whilst an increase in air pressure, where possible, will assist the hammer in overcoming the back pressure caused by the head of water, the use of foam injection will assist in lifting the cuttings through the head of water.

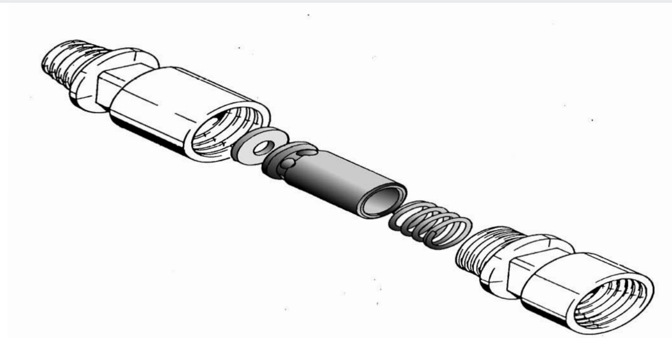
INTER-TUBE NON RETURN VALVE

The valve takes the form of a short drill tube which follows the drill string down the hole and to the top of which other drill tubes are attached as drilling progresses.

When the rotation head is detached from the drill string for the purpose of adding drill tubes, the benefits of the valve are that:

- It eliminates any suction effect at the hammer.
- It maintains a column of pressurised air above the hammer which counters the water pressure outside the hammer.
- By conserving air under pressure in the drill string, the hammer will function immediately the air supply is restored and not spend time rotary drilling until the air pressure builds up sufficiently to make the piston strike the bit.

On very deep holes, several inter-tube non return valves may be fitted in the drill string at regular intervals, particularly on applications where water is continuously filling the bore hole.



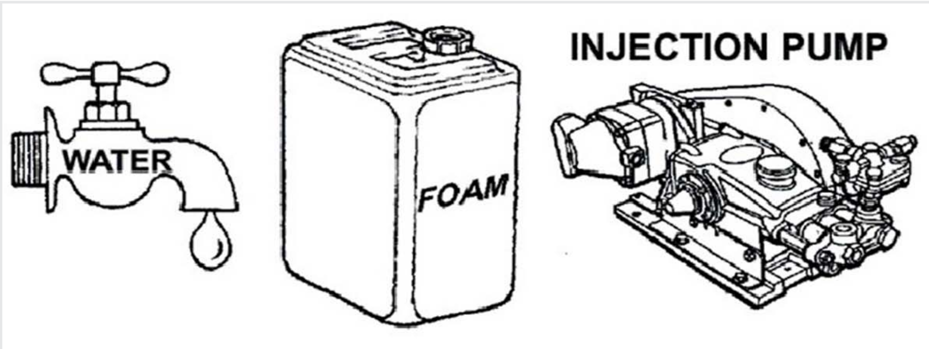
Most makes of hammers are offered with internal non-return valves for drilling under water but in addition to these, INTERTUBE NON-RETURN VALVES are available as an extra precaution to prevent internal contamination of the hammer and are fitted to the top of the drill string once water is encountered in the hole and not before.

In very wet drilling conditions, lift the hammer at least 3 metres(10ft) off the bottom of the hole, when drilling is discontinued overnight or for a long period of time. This minimises the chance of cuttings entering the hammer or of the hammer being buried through bore hole collapse.

INJECTING WATER/FOAM ESSENTIAL APPLICATIONS/CONDITIONS

There are several circumstances where it is necessary to inject water or a water / foam solution through the drill string into the bore hole.

Generally foam is injected via a pump although in an emergency the liquid can be poured down the drill string prior to re-coupling the rotary head and switching on the air.



INJECTION METHOD

Generally by triplex piston pump injecting into the air line, after the lubricator, at an input pressure at least 3 bar (44 psi) higher than the air pressure.

INJECTION QUANTITY (DEPENDENT ON AIR PRESSURE AND APPLICATION)

HAMMER SIZE	APPROX.INJECTION/RATE
3”	1-3 Litres/Min. (0.25 - 0.65 galls/min)
4”	3-7 Litres/Min. (0.65 - 1.55 galls/min)
5”	5-8 Litres/Min. (1.10 - 1.75 galls/min)
6”	7-10 Litres/Min. (1.55 - 2.20 galls/min)
8”	8-15 Litres/Min. (1.75 - 3.30 galls/min)
12”	12-24 Litres/Min. (2.65 - 5.30 galls/min)

FOAM MIXING/INJECTION RECOMMENDATIONS

Foam to Water Mixing Ratio - 0.50 to 2.00 litres (0.10 - 0.45 galls) Foam per 100 litres (22 galls) water dependent on application and density of drilled material, although a mixing ratio of 0.50 litres foam /100 litres (0.10 galls foam / 22 galls) water will be sufficient in the vast majority of cases.

INJECTING WATER/FOAM ESSENTIAL APPLICATIONS/CONDITIONS

APPLICATIONS / CONDITIONS WHERE WATER / FOAM INJECTION REQUIRED

There are numerous conditions where it is advisable to inject water only or a mixture of water and foam into the airstream. Foam is non toxic and dissipates on standing and therefore does not introduce a health hazard or affect the utilisation of the bore hole.

CONTINUOUS CASING APPLICATIONS

On continuous drilling and casing applications the use of water/foam injection into the air stream is beneficial because the foam lubricates the outside of the casing and reduces friction between the casing and the ground, as the casing advances.

DUST SUPPRESSION

On surface and underground mining applications water is injected into the airstream to suppress dust for environmental and health reasons.

SOFT CLAY

Soft clay generally does not respond to percussive action and due to its “plastic” nature tends to reconstitute itself as part of the clay mass. Polymer foam coats the clay pieces and allows them to be evacuated from the bore hole.

HOLE STABILISATION

When drilling with a DTH hammer through unstable ground, foam/water solution injected into the air stream can, by coating the wall side, stabilise the hole, eliminating, in many instances, the need for casing the hole or for using mud circulation.

LOW UP-HOLE VELOCITY

Where up-hole velocity is low and drilling debris is not being cleared from the bore hole at an acceptable rate, the injection of a water/foam solution into the airstream will create bubbles which develop sufficient surface tension to lift the cuttings out of the hole. Low up-hole velocity is generally caused by insufficient air volume at low pressure or when drilling large diameter bore holes in relation to drill tube diameter.

DRILL STRING JAMMING IN THE HOLE/HOLE COLLAPSE

Because very little down thrust is used on DTH hammers and because they usually create good uphole velocity to clear cuttings, the DTH drill bit is less likely to be forced into fissures or to jam in the bore hole than other types of drilling equipment. Nevertheless, if this does happen, a possible means of freeing the bit is simply to pour household soap powder or concentrated foam down the drill string followed by a bucket of water.

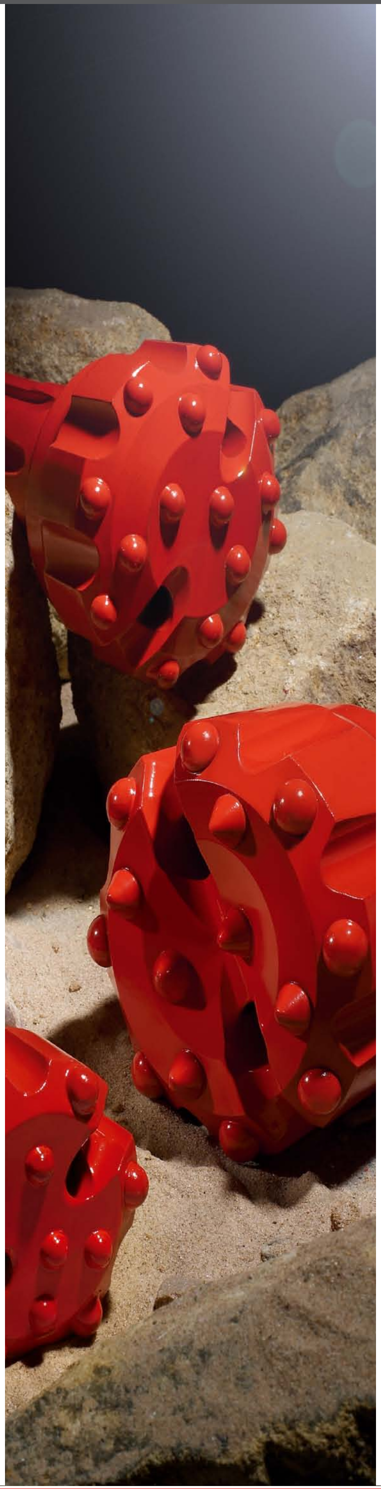
By then reconnecting the rotary head and switching on the air, the air pressure circulation could free the drill string. This can be repeated until the drill string is free. In extreme cases, water and foam can be injected into the airstream where a suitable injection pump can be made available.

LUBRICATION

Where water is injected into the bore hole, for any reason; up to double the amount of hammer lubricating oil will be required because water will act as a dispersant on the oil, depriving the hammer of lubrication.

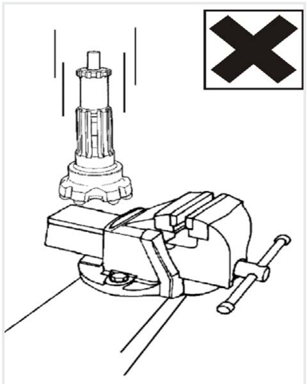
DRILL BIT CARE

DRILL BIT HANDLING
INSPECTION
RE-GRINDING

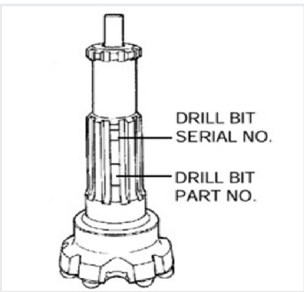


DRILL BIT HANDLING

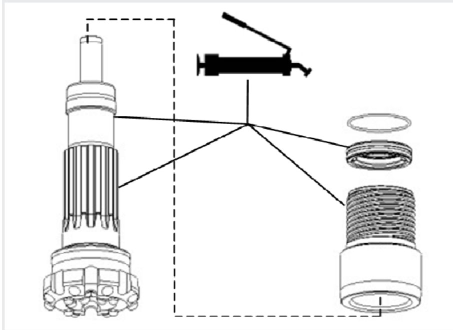
Poor drill bit performance or premature failure is generally caused by not re-grinding at predetermined intervals in line with the wear pattern caused by the actual drilling conditions or by not handling/or operating the drill bits correctly.



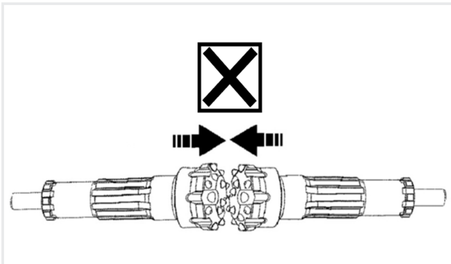
Ensure that drill bits (particularly tungsten carbide buttons) do not come into contact with a metal surface.



Inspect the drill bit, before use for any damage which may have occurred during transportation and prior to commissioning, take a note of the drill bit part number and serial number for future reference.



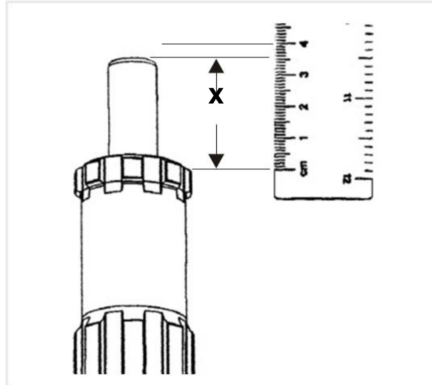
Before assembling into the hammer, ensure that the drill bit splines are thoroughly greased.



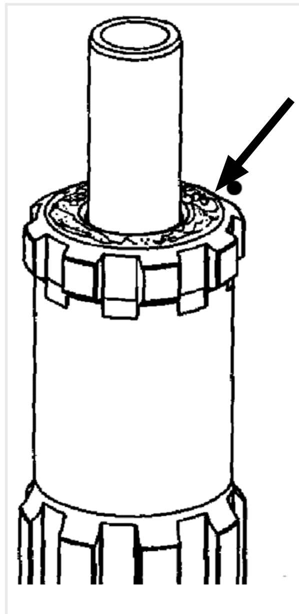
Do not allow tungsten carbide buttons to come into contact with each other.

STRIKING END / FOOT VALVE

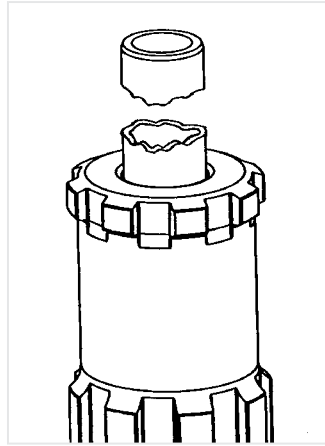
Check that the foot valve is correctly located in its housing and that the protrusion length is correct.



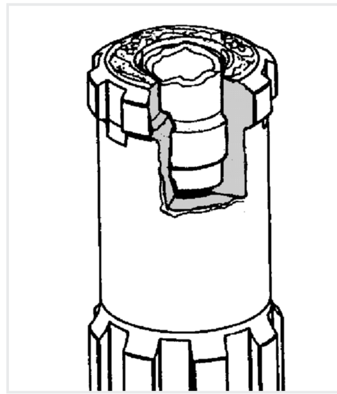
Inspect the striking end for damage or corrosion, generally caused by lack of lubrication or foreign particles caught between the piston and striking end.



Ensure that the foot valve is not broken. This is generally caused by a worn piston or cylinder bore causing misalignment, lack of lubrication causing pick up or corrosion of water.

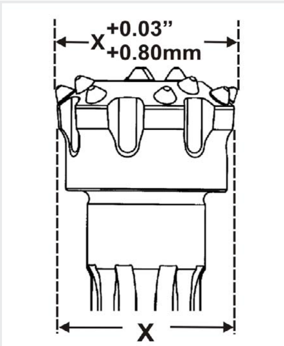


A broken striking end is caused generally by a badly worn piston, chuck, bottom bush or retaining ring.

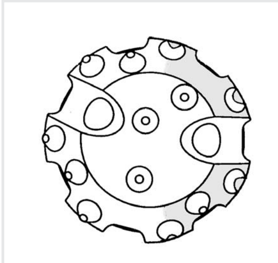


DRILL BIT HEAD

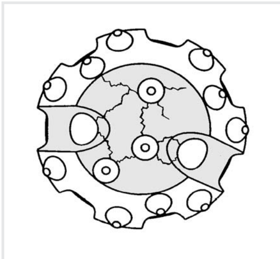
The diameter across the buttons should be 0.80mm (0.03") greater than the diameter across the gauge so that peripheral buttons protrude beyond the gauge and do not bind in the bore hole. Wear around the gauge usually happens in abrasive rocks. A 'barrelling' or anti- taper develops which reduces the clearance around the gauge and peripheral row of carbide buttons.



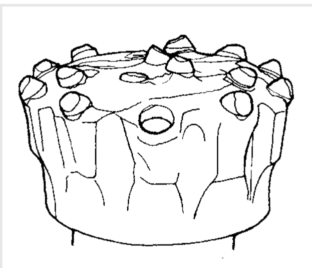
In highly abrasive conditions, the metal may wear more quickly than the carbide inserts. This is known as 'body wash' and in order to minimise carbide breakages, the carbide should be ground so that it does not protrude more than 9mm (0.35") above the metal surface.



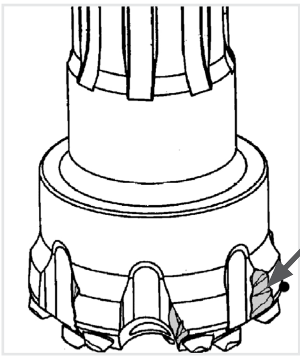
If the head is unevenly worn, the most likely causes are incorrect regrinding, bent drill tubes or drill string not being centralised in the drill rig table.



Excessive feed force can cause cracks on the face of the drill bit which can lead to large pieces of metal breaking off.

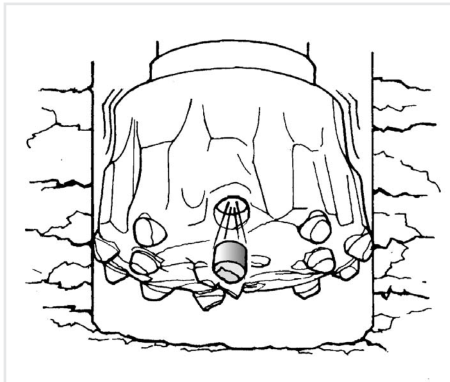


The depth of flushing grooves must be monitored as abrasion and/or high RPM wears away the drill bit body. The grooves must be regularly ground to ensure that drilling debris can adequately escape.



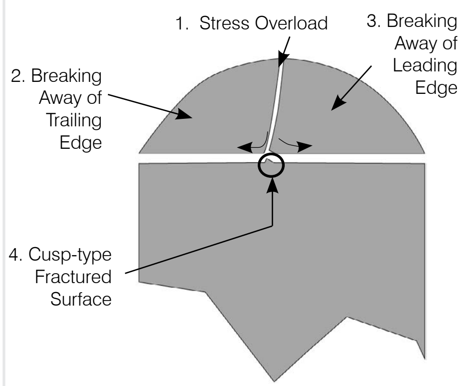
Re-drilling caused by poor hole cleaning and also high abrasion can result in deformation around the edges of exhaust holes and flushing grooves. These should be ground to ensure a clean obstruction free passage for exhausting air.

High levels of body wash and energy produced by the piston striking the drill bit can cause buttons to be hammered outof the bit body. This is known as button 'pop-out'. Button 'pop-out' can also occur even in drill bits with little body wash, where drilling in very soft conditions is being carried out and constant flushing is necessary because the drill bit face is not in constant contact with the bedrock.



Carbide breakage due to stress overloading generally results in a cusp-type (forming a peak) fracture (shown as 4. in figure below). The first phase of this type of failure is usually indicated by breakage of the trailing edge of the button insert (2. in figure below). Figure below demonstrates the progression of cracking that ultimately leads to the cusp-type fracture.

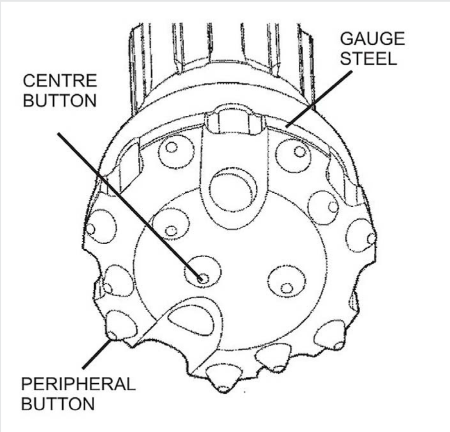
Stress overload on the top surface of the button leads to a fracture of the trailing edge followed by a fracture of the leading edge, whch results in the cusp-type fracture surface. This type of failure can be avoided by reducing the hold down pressure, increasing the rotation speed of the bit and/ or by using a carbide button with greater toughness properties.



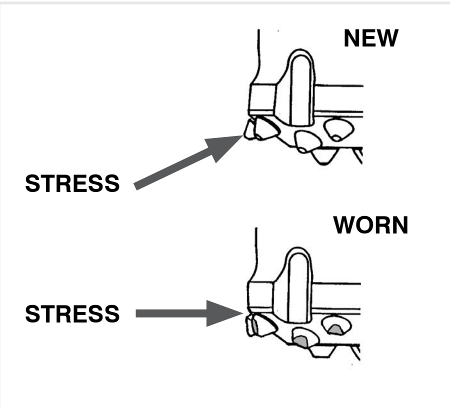
Progression of cracking leading to cusp-type of fracture surface

TUNGSTEN CARBIDE WEAR / BREAKAGE

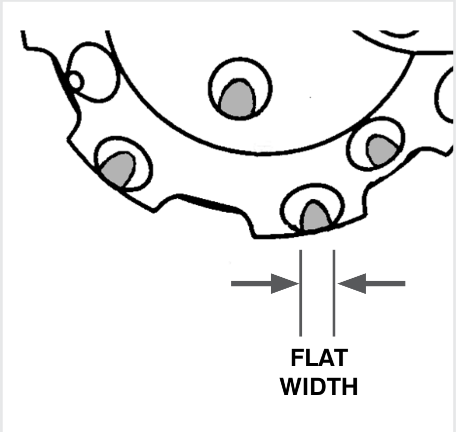
The gauge or peripheral buttons are the ones which suffer the most wear because these are being rotated at a faster speed and cut more rock than the centre buttons. Worn peripheral buttons and the loss of gauge steel on the drill bit head lead to jamming, reduction in drilling speed and premature button breakage.



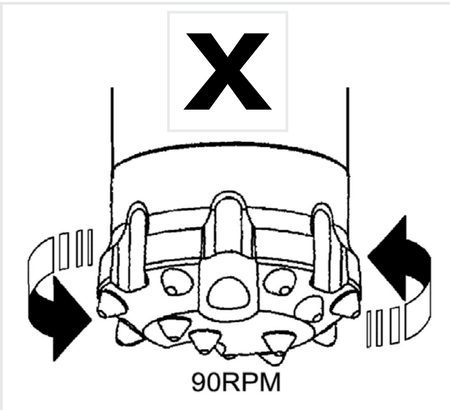
New tungsten carbide inserts work in compression where they are strong. As the carbide wears, flat spots appear leading to a horizontal or 'shear' load on the button.



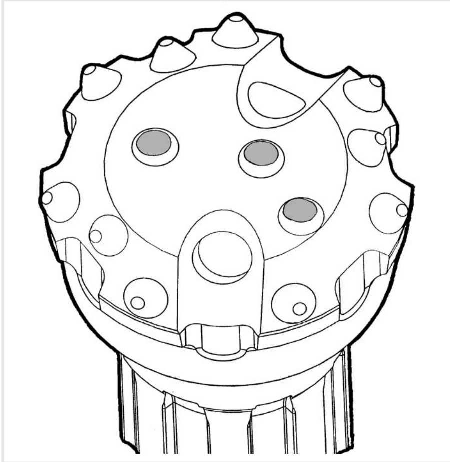
In abrasive conditions, it is advisable to monitor the rate of wear over a measured depth drilled to determine the frequency of re-grinding necessary. It is recommended that flat widths should generally not exceed 25% of the button diameter although this varies from manufacturer to manufacturer..



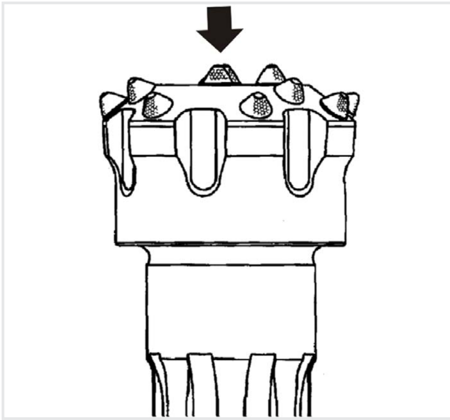
Rotating the bit faster than necessary will not generally increase penetration speed but it will increase the wear rate, particularly in abrasive rock.



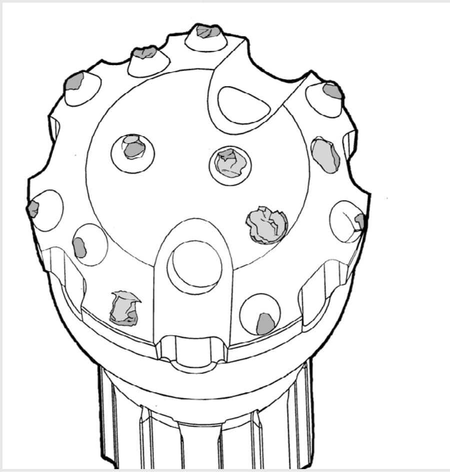
Face buttons which are flat generally indicate a lack of hammer blow energy or insufficient thrust.



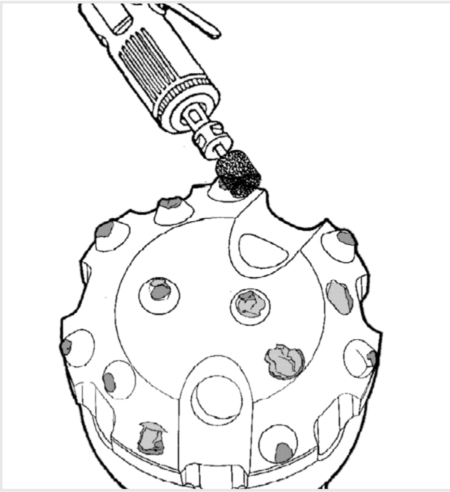
On inspecting the drill bit, observe if there exists any signs of minute thermal cracking of the buttons, resembling a 'snake skin' or a collection of very fine surface skin cracks caused by overheating of the carbide buttons. If this condition is not remedied, the cracks can cause small surface spalls and eventually lead to complete button failure. 'Snake skin' can occur in certain rock conditions long before excessive flat widths appear and can be remedied by grinding very lightly over the affected area.



Broken inserts are generally caused by overdrilling the drill bit before reconditioning, reaming the hole, using excessive feed forceor where there are existing tungsten carbide or other metal particles in the hole.

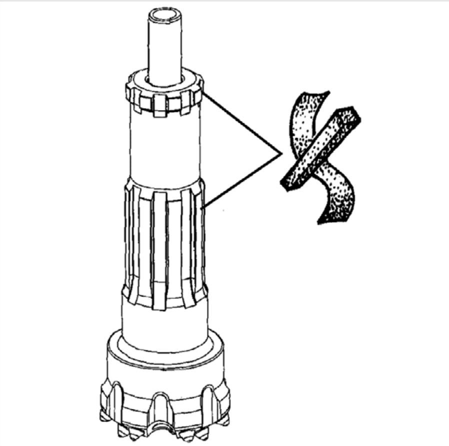


A DTH button bit can continue to drill with one or more broken buttons, but at a reduced penetration rate. Broken buttons should be ground off to prevent additional button particles breaking off and damaging other buttons.

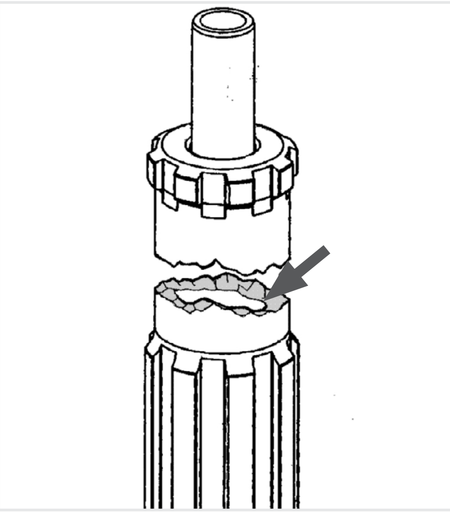


DRILL BIT SHANK / SHOULDER

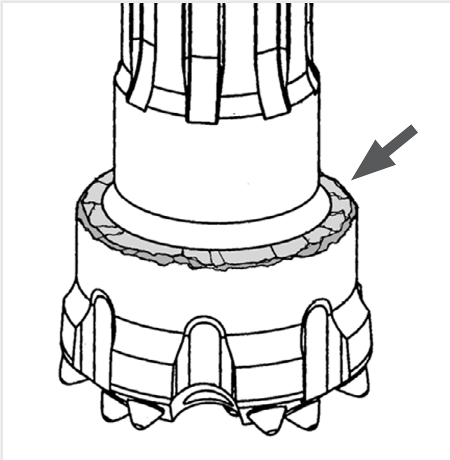
Regularly inspect the drill bit splines and remove any sharp edges or burrs with a file or emery stone. Heavy spline wear is usually caused by a badly worn chuck, excessive thrust, very high rpm or application of high torque in very difficult drilling conditions.



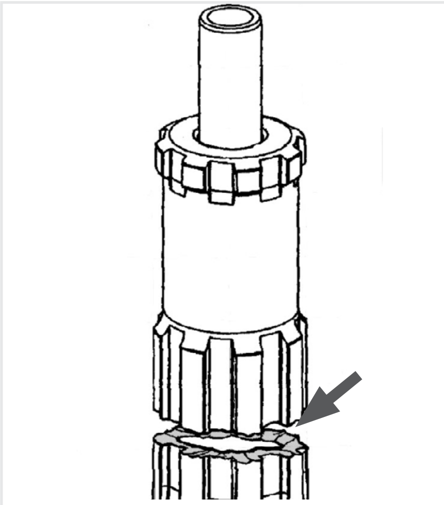
Shank breakage across the shank retaining ring diameter is generally caused by lack of lubrication or worn bit retaining rings, bit guide bush or bottom spacer.



Damage to the shoulder is usually caused by excessive or insufficient thrust.



Shank breakage across the splines is generally caused by using a worn chuck, excessive torque or incorrect use of oversize drill bits.

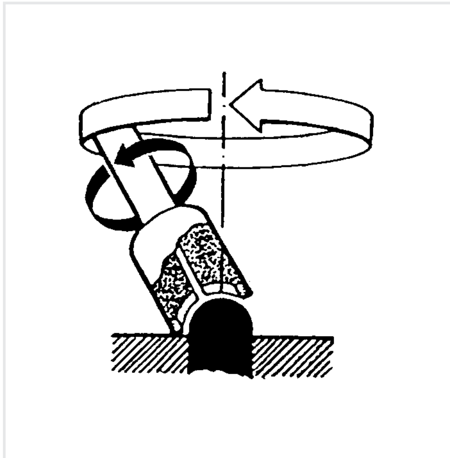


DRILL BIT GRINDING

When using grinding equipment, always wear a safety mask and breathing apparatus as necessary.

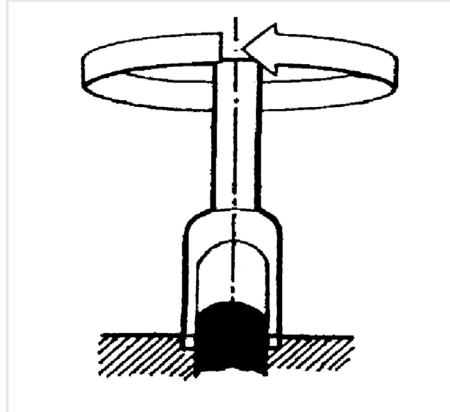
GRINDING STEEL BASE - DIAMOND CUP GRINDER

The grinding tool must be kept in direct line with the button axis at all times. If the tool is rocked from side to side, the button could be damaged.



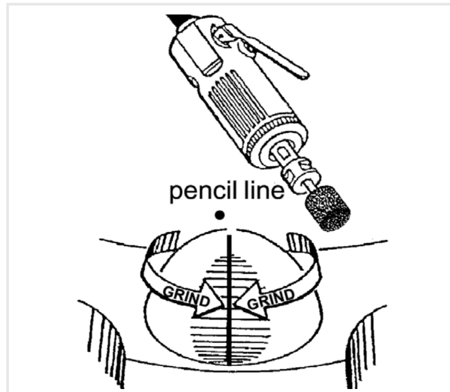
BUTTON GRINDING - DIAMOND CUP

The best results are achieved by rotating the grinder in a cylindrical manner to provide a good finished shape with the grinding tool.



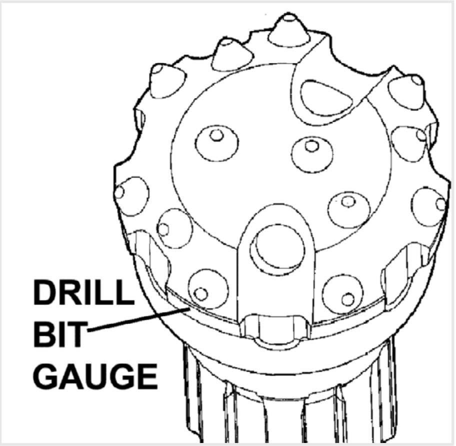
BUTTON GRINDING METHOD - DIE GRINDER

Draw a pencil line across the flats, thereby dividing the button into two symmetrical halves. Gently grind on each side of the pencil flat, leaving the pencil line untouched. Finally, gently blend the pencil line, removing as little carbide as possible from this area. The aim of the technique is to remove as little carbide as necessary so that when grinding is completed the re-sharpened button will be spherical and slightly smaller than new.



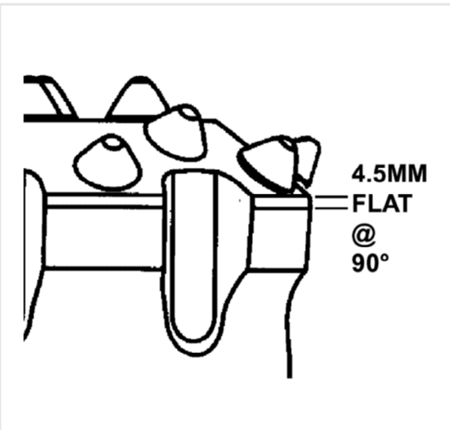
RE-FACING THE DRILL BIT GAUGE

Particularly in abrasive drilling conditions, not only will the peripheral buttons wear, but also the body of the bit just below the buttons. Excessive wear can result in the diameter across the buttons being the same as the diameter of the steel body (gauge). This causes 'binding' or tightness of the bit in the hole. This is remedied as follows:



GAUGE GRINDING

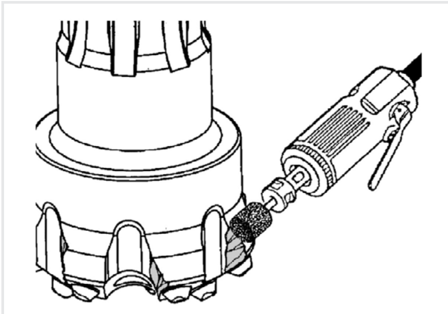
Grind a flat 4.5mm (0.18") in length, around the drill bit head, and at 90 degrees to the drill bit face.



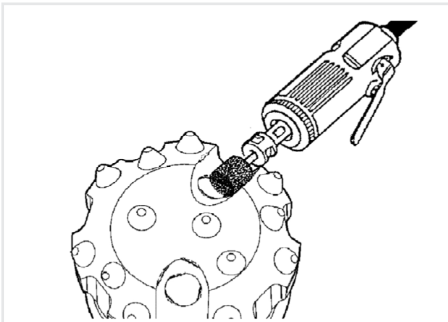
TAPER RELIEF GRINDING

Grind the taper relief, if necessary, at a 4 degree angle from the bit axis.

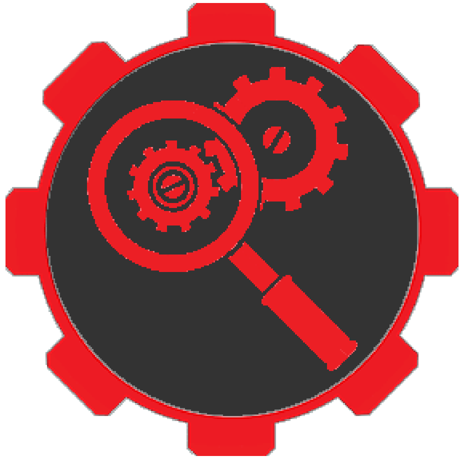
Ensure that the depth of flushing grooves is adequate and re-grind them regularly to allow free evacuation of the drilling debris.



Ensure that the flushing holes are not deformed and grind them if necessary.



TROUBLESHOOTING



HAMMER MALFUNCTION

FAULT	CAUSE	SOLUTION / ACTION
Hammer does not start operating after tube change.	• Excess oil drained down into hammer. • Foreign particles in hammer. • Hammer filled with water and mud, especially if drilling under water level.	• Lift off and flush. Add small amount of diesel to flush through if necessary. • Pull out and inspect hammer. • Pull out and clean hammer. Ensure that hole is clean' before uncoupling tubes for tube change. Ensure non-return valve is fitted to hammer or fit intertube non return valve, if drilling in deep water.
Hammer operates on the surface but fails to work when lowered into the hole.	• Drill bit flushing holes blocked with clay, or debris whilst lowering into the hole. • Lowering into soft clay or similar, thereby not allowing bit to be pushed up into the hammer.	• Inspect and strip if necessary. • Increase rotation speed and perhaps thrust to force through soft ground, keeping full air on at all times and lifting constantly to flush. Water injection can be used to break up soft clay.
Hammer operates intermittently on surface test or down-the-hole.	• Hammer parts worn, broken or seized. • Hammer incorrectly assembled. • Dirt or foreign particles in hammer. • Excessive lubricating oil or other oil coming through the system. • Excessive water in the compressed air.	• Strip, Inspect and service. • Strip and re-assemble correctly. • Strip, clean and re-assemble • Check quantity of lubricating oil and for signs of compressor oil in the air line. • Check moisture trap and water injection pump, if in use. • Use antifreeze type oil - check for signs of Excessive water in system.
Hammer does not operate on surface test or down-the-hole.	• Insufficient or no air reaching hammer. • Hammer incorrectly assembled. • Dirt or foreign particles in hammer. • Retained oil or anti-sieze grease in hammer. • Hammer parts worn, broken or siezed up. • Blockage in shock absorber. • Flushing holes in drill bit blocked.	• Check compressor operation Strip and re-assemble correctly. Strip, clean and re-assemble. • Flush through hammer by lifting off the bottom of the hole. • Add a small amount of diesel to the hammer to clear the oil. • Strip, inspect and service. • Unscrew hammer and check. Strip shock absorber if necessary. • Clean out holes.

HAMMER MALFUNCTION

FAULT	CAUSE	SOLUTION / ACTION
Hammer deviates at the start of hole	• Breakout table bushes not being used or ones in use badly worn. • Mast not secured. • Machine not stable. • Jacklegs creeping due to slow loss of hydraulic oil. • Obstruction at the top of the hole causing the hammer to deviate. • Too high feed force (thrust).	• Fit or replace bushes. • Secure mast. • Ensure machine is rigid. Place wood blocks under jack leg if ground is soft. Ensure there is sufficient weight on jack legs. • Repair jackleg. • Remove any obstructions before drilling continues. • Reduce feed force to correct level.

ROTATION

FAULT	CAUSE	SOLUTION / ACTION
Rotation stiff or stalls easily.	• Excessive feed force. • Collar or stone in hole, which is binding on the drill tubes. • Drill Bit is worn. • Hole has moved 'out of line'. • Faulty rotation head.	• Reduce feed force to recommended level. • Lift to flush clear. Pull out if necessary. • Pull out and re-grind or renew drill bit. • Re-align machine over hole carefully. Pull out if necessary. • Repair of adjust rotation head.

VIBRATION

FAULT	CAUSE	SOLUTION / ACTION
Vibration / Squealing noises from the bore hole.	• Too low a feed force. • Too high a rotation speed. • Difficult ground conditions. • Drill Bit is worn out. • Drill bit is broken in the hole. • Obstruction in the hole. • Loss of gauge on drill bit head. • Metal particles in the bore hole.	• Adjust feed force to recommended level. • Reduce rotation speed to recommended level. • Drill carefully, flushing often and keeping feed force and rotation speed low. • Pull up and re-grind or renew drill bit. • Pull up and check. Pull back to allow obstruction to fall below hammer. • Re-face gauge with die grinder. • Pull out drill string and use magnet to retrieve particles from hole.

FLUSHING

FAULT	CAUSE	SOLUTION / ACTION
Flushing air insufficient for good hole cleaning.	• Operating pressure at hammer too low. • Too low a up-hole velocity. • Collar or blockage in hole. • Flushing air being lost in fissures.	• Check air pressure as near to hammer as possible. • Check compressor operation. Dependant on possibilities: • Increase air volume or air pressure. • Increase drill tube diameter. • Reduce drill bit diameter. • Flush more regularly. Check for air leaks. • Pull drill string up past blockage to clear collar. • Drill slowly until beyond fissures. Flushing then returns.
Flushing of debris from hole reduces or stops completely	• Collar or blockage in hole. • No air to hammer. • Build-up of debris. • Ground water reached causing mud collar.	• Pull drill string up past blockage to clear collar. • Check compressor operation. • Lift and flush, pull up as far as required to resume flushing. • Lift and flush, pull up to clear. If necessary • Use foam, if available.
Flushing action of hammer not working when hammer lifted into flushing position.	• Insufficient or no air reaching hammer. • Hammer incorrectly assembled. • Dirt or foreign particles in hammer. • Drill bit not dropping into flushing position. • Blockage in shock absorber. • Flushing holes in drill bit blocked.	• Check compressor operation. • Strip and reassemble correctly. • Strip, clean and reassemble. • Remove drill bit and chuck to ascertain cause. • Unscrew hammer and check. Strip shock absorber if necessary. • Clean out holes.

PENTRATION RATES

FAULT	CAUSE	SOLUTION / ACTION
Penetration rates low or zero.	• Low operating pressure. • Hole not clear. Blocked with drilling debris. • Hard band of rock. • Hammer blocked, parts worn, seizing up or broken. • Drill bit excessively worn or broken. • Too low a rotation speed. • Excessive lubricating oil or water • Injection being used. • Faulty feed mechanism on drill rig. • Large head of water in hole.	• Check air pressure at hammer and compressor operation. • Check for air leaks in air line. • Lift and flush, pull up to clear. • Time the penetration rate over next two drill tubes and compare with expected penetration rate. • Pull up and inspect. • Pull up, check drill bit. Re-grind if necessary. Keep rotation speed to recommended level. • Check quantities of both being injected. • Check drill rig feed operation. • Flush to see how much water in hole. Increase operating pressure to compensate if possible use foam to assist with cutting evacuation.

DRILL TUBE AND DRILL BIT OPERATION

FAULT	CAUSE	SOLUTION / ACTION
Drill bits difficult to strip due to tightness of chuck joint.	• Too high a feed force. • Bad ground requiring high torque. • Insufficient anti-seize grease on thread	• Adjust feed force to recommended level. • Drill through bad ground carefully keeping a clean hole. • Use correct anti-seize grease on chuck thread when screwing in the drill bit and chuck.
Drill bit and chuck becomes unscrewed or lost in the hole	• Hammering with no rotation, • Reverse rotation or back-hammering • Chuck or cylinder thread worn out.	• Always keep rotation to the right or clockwise when hammering. • Renew chuck or cylinder or both.
Drill tube joints excessively tight especially the last few near to the hammer.	• Excessive feed force. • Collaring in the hole. • Worn or broken drill bit. • Insufficient anti-seize grease on thread joints. • Excessive tightening when making-up joints with rotation head.	• Adjust feed force to correct recommended level. • Flush regularly in order to keep hole clear. • Pull out, re-sharpen or renew. • Clean and re-grease all joints. • Tighten sufficiently. Do not apply full forward rotation torque to joint.

APPENDICES

CONVERSION TABLES

THREAD IDENTIFICATION

DRILL BIT SHANK IDENTIFICATION

OUR COMMITMENT TO YOU

CONVERSION TABLE

Air Volume	Example
1 cc = .001 litre	1000cc = 1 litre
1 litre = .001 m³	1000 litres = 1 m³

Air Flow	Example
1 cfm = 0.0283 m³/min	100 cfm = 2.83 m³/min
1 cfm = 0.4719 litre/sec	100 cfm = 47.19 litre/sec
1 m³/min = 35.315 cfm	10 m³/min = 353.15 cfm
1 m³/min = 16.667 litre/sec	10 m³/min = 166.67 litre/sec
1 litre/sec = 2.1189 cfm	100 litre/sec = 211.89 cfm
1 litre/sec = 0.0600 m³/min	100 litre/sec = 600 m³/min

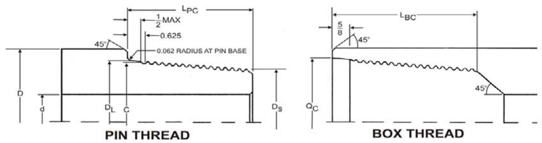
Air Pressure	Example
1 psi = 0.0689 bar	100 psi = 6.89 bar
1 psi = 0.0703 kg/cm²	100 psi = 7.03 kg/cm²
1 psi = 0.0680 atm (Atmosphere)	100 psi = 6.80 atm
1 bar = 14.504 psi	10 bar = 145.04 psi
1 bar = 1.0197 kg/cm²	10 bar = 10.197 kg/cm²
1 bar = 0.9869 atm	10 bar = 9.869 atm
1 atm = 14.696 psi	10 atm = 146.96 psi
1 atm = 1.0132 bar	10 atm = 10.132 bar
1 atm = 1.0332 kg/cm²	10 atm = 10.332 kg/cm²

Velocity	Example
1 m/min = 3.2808 ft/min	1000 m/min = 3280.80 ft/min
1 m/min = 0.0167 m/sec	1000 m/min = 16.70 m/sec
1 ft/min = 03048 m/min	1000 ft/min = 304.80 m/min
1 ft/min = 0.0051 m/sec	1000 ft/min = 5.10 m/sec
1 m/sec = 60.00 m/min	10 m/sec = 600 m/min
1 m/sec = 196.85 ft/min	10m/sec = 1968.50 ft/min

Torque	Example
1 lb/ft = 0.1383 kgm	1000 lb/ft = 138.30 kgm
1 lb/ft = 1.3558 Nm	1000 lb/ft = 1355.80 Nm
1 lb/ft = 12.00 lb/in	1000 lb/ft = 12,000 lb/in
1 kgm = 7.233 lb/ft	100 kgm = 723.30 lb/ft
1 kgm = 9.8067 Nm	100 kgm = 980.67 Nm
1 kgm = 86.796 lb/in	100 kgm = 8679.60 lb/in
1 lb/in = 0.0833 lb/ft	1000 lb/min = 83.30 lb/ft
1 lb/in = 0.0115 kgm	1000 lb/in = 11.50 kgm
1 lb/in = 0.1130 Nm	1000 lb/in = 113 Nm

THREAD IDENTIFICATION

THREAD IDENTIFICATION API STANDARDS

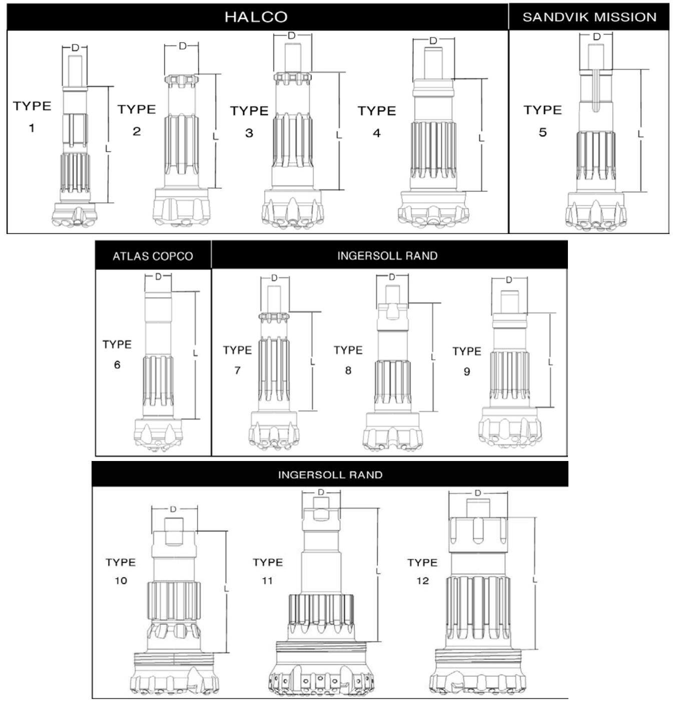


All dimensions in inches

				Thread Data			Pin			Box	
Tool Joint Design t'un	Outside Dia of Pin & Box	Inside Dia of Pin & Box	Pitch Dia of Thread at Gauge Point	Threads per inch	Taper inches per foot on Dia	Thread Form	Large Dia of Pin	Small Dia of Pin	Length of Pin	Depth of Pin	Box Counter-bore
	± 1/32	+ 1/64 - 1/32							+ 0 -1/8	+3/8 -0	+0.03 -0.016
							D_1	D_2	L_{PC}	L_{BC}	Q_C
REGULAR (REG.) STYLE											
2 3/8 REG	3 1/8	1	2.36537	5	3	V-0.040	2.625	1.875	3	3 5/8	2 11/16
2 7/8 REG	3 3/4	1 1/4	2.74037	5	3	V-0.040	3.000	2.125	3 1/2	4 1/8	3 1/16
3 1/2 REG	4 1/4	1 1/2	3.23987	5	3	V-0.040	3.500	2.562	3 3/4	4 3/8	3 /9/16
4 1/2 REG	5 1/2	2 1/4	4.36487	5	3	V-0.040	4.625	3.562	4 1/4	4 7/8	4 11/16
5 1/2 REG	6 3/4	2 3/4	5.23402	4	3	V-0.050	5.520	4.333	4 3/4	5 3/8	5 37/64
6 5/8 REG	7 3/4	3 1/2	5.75780	4	2	V-0.050	5.992	5.159	5	5 5/8	6 1/16
7 5/8 REG	8 7/8	4	6.71453	4	3	V-0.050	7.000	5.688	5 1/4	5 7/8	7 3/32
8 5/8 REG	10	4 3/4	7.99958	4	3	V-0.050	7.952	6.608	5 3/8	6	8 3/64
FULL-HOLE (FH) STYLE											
3 1/2 FH	4 5/8	2 7/16	3.73400	5	3	V-0.040	3.994	3.056	3 3/4	4 3/8	4 3/64
4 FH	5 1/4	2 13/16	4.07200	4	2	V-0.065	4.280	3.530	4 1/2	5 1/8	4 11/32
4 1/2 FH	5 3/4	3 5/32	4.53200	5	3	V-0.040	4.792	3.792	4	4 5/8	4 7/8
5 1/2 FH	7	4	5.59100	4	2	V-0.050	5.825	4.992	5	5 3/8	5 29/32
6 5/8 FH	8	5	6.51960	4	2	V-0.050	6.753	5.920	5	5 5/8	6 31/32
INTERNAL-FLUSH (IF) STYLE											
3 3/8 IF	3 3/8	1 3/4	2.66800	4	2	V-0.065	2.876	2.376	3	3 5/8	2 15/16
2 7/8 IF	4 1/8	2 1/8	3.18300	4	2	V-0.065	3.391	2.808	3 1/2	4 1/8	3 29/64
3 1/2 IF	4 3/4	2 11/16	3.80800	4	2	V-0.065	4.016	3.349	4	4 5/8	4 5/64
4 IF	5 3/4	3 1/4	4.62600	4	2	V-0.065	4.834	4.084	4 1/2	5 1/8	4 29/32
4 1/2 IF	6 1/8	3 3/4	5.04170	4	2	V-0.065	5.250	4.500	4 1/2	5 1/8	5 5/16
5 1/2 IF	7 3/8	4 13/16	6.18900	4	2	V-0.065	6.397	5.564	5	5 5/8	6 29/64
NUMBER (NC) STYLE											
NC26	3 3/8	1 3/4	2.66800	4	2	V-0.038R	2.876	2.376	3	3 5/8	2 15/16
NC31	4 1/8	2 1/8	3.18300	4	2	V-0.038R	3.391	2.808	3 1/2	4 1/8	3 29/64
NC35	4 3/4	2 11/16	3.53100	4	2	V-0.038R	3.739	3.114	3 3/4	4 3/8	3 13/16
NC38	4 3/4	2 11/16	3.80800	4	2	V-0.038R	4.016	3.349	4	4 5/8	4 5/64
NC40	5 1/4	2 13/16	4.07200	4	2	V-0.038R	4.280	3.530	4 1/2	5 1/8	4 11/32
NC44	6	2 1/4	4.41700	4	2	V-0.038R	4.625	3.875	4 1/2	5 1/8	4 11/16
NC46	6	3 1/4	4.62600	4	2	V-0.038R	4.834	4.084	4 1/2	5 1/8	4 29/32
NC50	6 1/8	3 3/4	5.04170	4	2	V-0.038R	5.250	4.500	4 1/2	5 1/8	5 5/16
NC56	7	3 3/4	5.61600	4	3	V-0.038R	5.876	4.626	5	5 5/8	5 15/16
NC61	8 1/4	3	6.17800	4	3	V-0.038R	6.438	5.063	5 1/2	6 1/8	6 1/2
NC70	9 1/2	3	7.05300	4	3	V-0.038R	7.313	5.813	6	6 5/8	7 3/8

(i) The length of perfect threads in box shall not be less than maximum pin length (LPC) plus 1/8".

DRILL BIT SHANK IDENTIFICATION



MODEL	COMPANY	SHANK TYPE	SHANK LENGTH (L)	SHANK END DIAMETER (D)	NUMBER OF SPLINES
DOM 10	HALCO	1	168mm (6.61")	29mm (1.14")	10
DOM 20	HALCO	2	165mm (6.50")	40mm (1.57")	6
MACH 303	HALCO	3	170mm (6.69")	51mm (2.00")	8
COP 32	ATLAS COPCO	6	215mm (8.46")	45mm (1.77")	8
DHD 3.5	INGERSOLL RAND	7	181mm (7.12")	52mm (2.05")	8
NT4/ HALCO 4	HALCO	4	210mm (8.27")	62mm (244")	12
MACH 44	HALCO	3	245mm (9.65")	63mm (2.48")	8
A34-15 / SD4	SANDVIK MISSION	5	260mm (10.24")	57mm (2.24")	8
DHD340A	INGERSOLL RAND	7	210mm (8.27")	63mm (2.48")	8
COP 42	ATLAS COPCO	6	190mm (7.48")	64mm (2.52")	7
TD40	INGERSOLL RAND	9			
MACH 50/500	HALCO	3	266mm (10.47")	80mm (3.15")	8
A43-15 / SD5	SANDVIK MISSION	5	260mm (10.24")	70mm (2.76")	8
DHD350R	INGERSOLL RAND	7	261mm (10.28")	77mm (3.03")	8
QL50	INGERSOLL RAND	9	240mm (9.45")	76mm (2.99")	12
MACH 60/66	HALCO	3	320mm (12.60")	90mm (3.54")	8
A53-12 / SD6	SANDVIK MISSION	5	322mm (12.68")	88mm (3.46")	8
DHD360	INGERSOLL RAND	8	306mm (12.05")	80mm (3.15")	8
COP 62	ATLAS COPCO	6	265mm (10.43")	88mm (3.46")	9
QL60	INGERSOLL RAND	9	254mm (10.00")	92mm (3.62")	12
MACH 80/88	HALCO	3	350mm (13.78")	123mm (4.84")	8
A63-15 / SD8	SANDVIK MISSION	5	320mm (12.60")	100mm (3.94")	8
DHD380	INGERSOLL RAND	7	350mm (13.78")	127mm (5.00")	10
QL80	INGERSOLL RAND	9	332mm (13.07")	118mm (4.65)	16
TD90	INGERSOLL RAND	9			
SD10	SANDVIK MISSION	5	356mm (14.01")	139mm (5.47")	8
DHD112	INGERSOLL RAND	10	491mm (19.33")	153mm (6.02")	8
DHD112S	INGERSOLL RAND	11	636mm (25.04")	153mm (6.02")	12
A100-15 / SD12	SANDVIK MISSION	5	470mm (18.50")	158mm (6.22")	8
QL120	INGERSOLL RAND	12	492mm (19.37")	187mm (7.36")	12

OUR COMMITMENT TO YOU

Our aim is to provide excellent service that reflects your needs and exceeds your expectations.

Our trained customer support team is dedicated to providing you with what you want and when you need it.

With over 65 years experience in assisting customers with their drilling applications, our support team has gained the expertise to provide an accurate and timely response.

Warranty

Our warranty on hammers and bits provides you with an ease of mind that any problem that might occur will be solved quickly and effectively by our experienced customer support team.

Training Sessions

Training is available at any of our locations. Our distributors are trained and available locally for support as well. Training includes selection, service, maintenance and repair.

Technical Support

Technical support is always ready to assist you. Whether you need service or maintenance tips, troubleshooting, or even advice on a repair. Our help is only a phone call away.

Our service engineers are happy to make on-site visits too.

Publications

When you want to learn more about DTH drilling or product maintenance to improve efficiency, we have two books for you:

- A to Z of DTH Drilling
- DTH maintenance manual

We are committed to help our customers realise their full potential. Just as we constantly innovate and improve our hammers and bits, we want to continually evolve our company to be in the best position to offer new technologies as they emerge, which will better serve our customers.

NOTES

United Kingdom

Halco Rock Tools Ltd
Armytage Road
Brighouse
West Yorkshire
HD6 1QF

Tel: +44 (0)1422 399900

Email: salesuk@halcorocktools.com

USA

Halco America LLC
2720 Fallon Drive
Sherman
TX 75090

Tel: +1 903 893 2300

Email: salesusa@halcorocktools.com

IADC MEMBER

Halco Rock Tools
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is Certified to ISO9001:2008

Certification No. LRQ 0850659

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