NUMA®

MANUFACTURER OF DOWN HOLE HAMMERS AND BITS

Technical Manual

P. O. Box 348 · 646 Thompson Road · Thompson, CT 06277 USA
U.S. Toll Free: (800) 356-NUMA · Tel: (860) 923-9551 · Fax: (860) 923-2617
E-mail: numa@numahammers.com
Website: www.numahammers.com

MANUFACTURER OF DOWN HOLE HAMMERS AND BITS

Technical Manual
- Table of Contents -

HAMMER SELECTION

Before beginning to drill, there are several factors that must be taken into consideration in order to select the appropriate down hole hammer. Consider the following:

1. **Hole Size:** In most instances, the outside diameter of the hammer closest to the hole size being drilled should be used for most efficient drilling. This reduces the instance of hole collapse and makes cleaning the hole easier. One needs to take into account that there must be sufficient annular area around the hammer to pass the drilled cuttings. This normally will supply the most efficient operating conditions. The Hammer Selection chart on the following page displays Numa hammers and their corresponding bit range.

2. **Air Consumption:** The amount of compressed air available must be taken into consideration when using a down hole hammer. Different size hammers require different volumes and pressures in order to properly operate. Generally, as the size of the hammer increases, higher volume and lower pressure is needed for peak performance. Be sure to refer to the Air Consumption chart or your maintenance manual for the proper air consumption for each hammer.

3. **Rig Capacities:** The larger the bit and hammer, the greater the rotational torque and feed/pull back requirements become. Do not exceed the drill rig's capacity. Please consult your drill rig manufacturer with any questions on rig capacity.

HOLE SIZE AND SELECTING A HAMMER

The following chart lists the Numa Patriot, Champion and Challenger series hammers and the minimum to maximum bit sizes for each hammer. This, combined with the air consumption chart, can be used to select the proper size hammer.

Hammer	Bit Shank	Bit Range	Outside Diameter
• CONVENTIONAL			
Patriot 35A	C35/3.5	3-1/2" - 4-1/8" (89 - 105 mm)	3-1/8" (79 mm)
Champion 40	340A	4-1/4" - 5-1/8" (108 - 130 mm)	3-3/4" (95 mm)
DCS5	QL50	5-1/2" - 6-1/8" (140 - 156 mm)	4-7/8" (124 mm)
Patriot 50	QL50	5-1/2" - 6-1/8" (140 - 156 mm)	4-7/8" (124 mm)
DCS6	QL60	6" - 8-1/2" (152 - 216 mm)	5-1/2" (140 mm)
Patriot 60W	360	6" - 8-1/2" (152 - 216 mm)	5-1/2" (140 mm)
Patriot 60WQ	QL60	6" - 8-1/2" (152 - 216 mm)	5-1/2" (140 mm)
Challenger 6	360	6" - 8-1/2" (152 - 216 mm)	5-3/8" (137 mm)
Patriot 80	380	7-7/8" - 10" (200 - 254 mm)	7-1/8" (181 mm)
Challenger 80	380	7-7/8" - 10" (200 - 254 mm)	7-1/8" (181 mm)
Challenger 80Q	QL80	7-7/8" - 10" (200 - 254 mm)	7-1/8" (181 mm)
Challenger 100	N100	9-7/8" - 15" (251 - 381 mm)	9" (229 mm)
Patriot 120	N11/N120	11-7/8" - 17-1/2" (302 - 445 mm)	10-1/8" (257 mm)
Patriot 125	N125	12-1/4" - 20" (311 - 508 mm)	10-3/4" (273 mm)
Patriot 180	C180	18" - 30" (457 - 762 mm)	15-1/2" (394 mm)
Patriot 240	C240	24" - 34" (610 - 864 mm)	20" (508 mm)
Champion 330	C330	33" - 43" (838 - 1089 mm)	28" (711 mm)
• REVERSE CIRCULATION			
Patriot RC46	PRC46	5" - 5-3/4" (127 - 146 mm)	4-5/8" (117 mm)
Challenger RC100	RC100	10" - 15" (254 - 381 mm)	9-1/2" (241 mm)
Champion RC160	RC160	16" - 20" (406 - 508 mm)	15-1/2" (394 mm)
Champion RC210	RC210	21" - 26" (533 - 660 mm)	20" (508 mm)
Champion RC300	RC300	30" - 36" (762 - 914 mm)	28" (711 mm)

MANUFACTURER OF DOWN HOLE HAMMERS AND BITS

DOWN HOLE HAMMER SPECIFICATION CHART

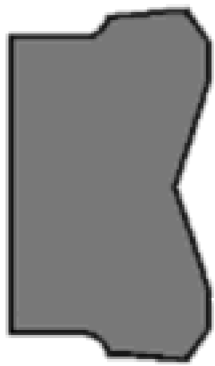
Hammer	Bit Shank	Hole Sizes In	Diameter In	Bore In	Stroke In	Weight Hammer Only lbs	Length Shoulder to Shoulder In	Length Shoulder to Bit Face In	Connection API REG unless specified	Blows/Min @ PSI
CONVENTIONAL										
Patriot 35A	C35/3.5	3-1/2 to 4-1/8	3-1/8	2-1/2	3-1/2	46	28-5/8	31-1/8	2-3/8	1750 @ 350
Champion 40	340A	4-1/4 to 5-1/8	3-3/4	3	4	80	35-3/4	38-3/4	2-3/8	1850 @ 350
DCS5	QL50	5-1/2 to 6-1/8	4-7/8	4	3	136	36-7/16	40-1/8	3-1/2	2050 @ 350
Patriot 50	QL50	5-1/2 to 6-1/8	4-7/8	4	3-1/2	140	36-7/16	40-1/8	3-1/2	1950 @ 350
DCS6	QL60	6 to 8-1/2	5-1/2	4-1/2	3-1/2	182	38-7/8	42-1/2	3-1/2	1850 @ 350
Patriot 60W	360	6 to 8-1/2	5-1/2	4-1/2	4	204	43-3/16	46-13/16	3-1/2	1800 @ 350
Patriot 60WQ	QL60	6 to 8-1/2	5-1/2	4-1/2	4	192	41-3/16	44-13/16	3-1/2	1800 @ 350
Challenger 6	360	6 to 8-1/2	5-3/8	4-1/4	4	258	52	56	3-1/2	1350 @ 350
Patriot 80	380	7-7/8 to 10	7-1/8	6	3-3/4	362	45-1/8	49-7/8	4-1/2	1850 @ 350
Challenger 80	380	7-7/8 to 10	7-1/8	6	4	444	56	61	4-1/2	1550 @ 350
Challenger 80Q	QL80	7-7/8 to 10	7-1/8	6	4	442	54-3/4	59-1/2	4-1/2	1550 @ 350
Challenger 100	N100	9-7/8 to 15	9	7-1/2	5	750	58-1/2	66	6-5/8	1235 @ 350
Patriot 120	N11/N120	11-7/8 to 17-1/2	10-1/8	8-1/2	5	1048	66-3/4	75-3/4	6-5/8	1300 @ 250
Patriot 125	N125	12-1/4 to 20	10-3/4	9-1/4	5	1133	66-3/4	75-3/4	6-5/8	1150 @ 250
Patriot 180	C180	18 to 30	15-1/2	13-1/4	4-1/2	2523	65-15/16	75-15/16	8-5/8	1100 @ 200
Patriot 240	C240	24 to 34	20	15	5	5220	76-1/8	90-1/8	8-5/8	925 @ 200
Champion 330	C330	33 to 43	28	20	5	12556	89-1/2	105-1/2	10 Beco	925 @ 200
REVERSE CIRCULATION										
Patriot RC46	PRC46	5 to 5-3/4	4-5/8	4	4	120	41-13/16	46-15/16	4-1/2 RC	1675 @ 350
Challenger RC100	RC100	10 to 15	9-1/2	8-1/4	4	777	60-1/2	69	7-5/8 RC	1250 @ 250
Champion RC160	RC160	16 to 20	15-1/2	12	5	2875	81-3/4	91-3/4	10 Beco	950 @ 200
Champion RC210	RC210	21 to 26	20	15	5	4397	81	93-1/2	10 Beco	925 @ 200
Champion RC300	RC300	30 to 36	28	20	5	11584	93	110	Several	900 @ 200

MANUFACTURER OF DOWN HOLE HAMMERS AND BITS

METRIC
DOWN HOLE HAMMER SPECIFICATION CHART

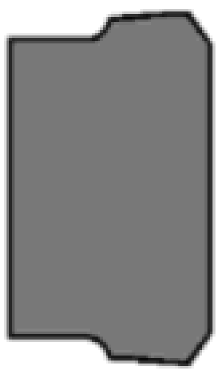
Hammer	Bit Shank	Hole Sizes mm	Diameter mm	Bore mm	Stroke mm	Weight Hammer Only kg	Length Shoulder to Shoulder cm	Length Shoulder to Bit Face cm	Connection API REG unless specified	Blows/Min @ kg/cm^2
CONVENTIONAL										
Patriot 35A	C35/3.5	89 - 105	79	64	89	21	72.7	79.1	2-3/8	1750 @ 23.8
Champion 40	340A	108 - 130	95	76	102	36	90.8	98.4	2-3/8	1850 @ 23.8
DCS5	QL50	140 - 156	124	102	76	62	92.5	101.9	3-1/2	2050 @ 23.8
Patriot 50	QL50	140 - 156	124	102	89	64	93.7	101.9	3-1/2	1950 @ 23.8
DCS6	QL60	152 - 216	140	114	89	83	98.7	108.0	3-1/2	1850 @ 23.8
Patriot 60W	360	152 - 216	140	114	102	93	109.7	118.9	3-1/2	1800 @ 23.8
Patriot 60WQ	QL60	152 - 216	140	114	102	87	104.6	113.8	3-1/2	1800 @ 23.8
Challenger 6	360	152 - 216	137	108	102	118	132.0	142.0	3-1/2	1350 @ 23.8
Patriot 80	380	200 - 254	181	152	102	164	114.6	126.7	4-1/2	1600 @ 23.8
Challenger 80	380	200 - 254	181	152	102	201	142.0	155.0	4-1/2	1550 @ 23.8
Challenger 80Q	QL80	200 - 254	181	152	102	201	139.0	151.0	4-1/2	1550 @ 23.8
Challenger 100	N100	251 - 381	229	191	127	340	149.9	167.6	6-5/8	1235 @ 17
Patriot 120	N11/N120	302 - 445	257	216	127	476	169.5	192.4	6-5/8	1300 @ 17
Patriot 125	N125	311 - 508	273	235	127	514	169.5	192.4	6-5/8	1150 @ 17
Patriot 180	C180	457 - 762	394	337	114	1144	167.5	192.9	8-5/8	1100 @ 13.6
Patriot 240	C240	610 - 864	508	381	127	2368	193.0	229.0	8-5/8	925 @ 13.6
Champion 330	C330	838 - 1092	711	508	127	5695	227.3	268.0	10 Beco	925 @ 13.6
REVERSE CIRCULATION										
Patriot RC46	PRC46	127 - 146	117	102	102	54	106.2	119.2	4-1/2 RC	1675 @ 20.4
Challenger RC100	RC100	254 - 381	241	210	102	353	152.4	175.3	7-5/8 RC	1250 @ 17.6
Champion RC160	RC160	406 - 508	394	305	127	1304	207.6	233.0	10 Beco	950 @ 13.6
Champion RC210	RC210	533 - 660	508	381	127	1994	205.7	242.3	10 Beco	950 @ 13.6
Champion RC300	RC300	762 - 914	711	508	127	5254	236.2	284.5	Several	900 @ 13.6

BIT FACE SELECTION



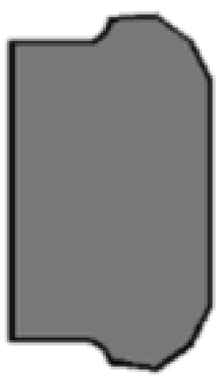
CONCAVE

- Suitable for drilling in all formations.
- Cone shaped depression in the face has centering effect for straighter holes.
- Well suited for soft to medium formations.



FLAT

- Face slots help eliminate bit plugging in softer zones.
- More carbide to surface contact for better rock fracture.
- Well suited for medium to hard formations.



CONVEX

- Fast penetration rates.
- Face design allows for increased body support for gage carbide.
- Hard and abrasive formations.

UPHOLE VELOCITY

Hole cleaning should be taken very seriously when selecting hole size for any particular application. Recommended up hole air velocity is between 4,000 and 7,000 feet (1220 and 2135 m) per minute. Uphole velocity (annular velocity) is dictated by the compressor output (CFM), bit diameter and drill rod diameter. Annular velocity below 4,000 FPM (1220 MPM) can create the following:

1. **Poor Bit Life:** Large diameter cuttings continually fall back to the bottom of the hole and are reground to smaller sizes by the bit until the air velocity is sufficient to lift them to the top. This can cause premature wear.

2. **Reduced Drilling Speed:** Exhaust air at the bit face does not have enough velocity to move the cuttings before the piston strikes the bit again. Therefore, the bit is redrilling the cuttings rather than breaking fresh rock.

3. **Lost Tools:** Cuttings will sometimes flow part of the way up the hole and form what is called a collar. This will block any cuttings from exhausting from the hole and eventually cause the tools to become stuck below the collar.

Annular velocity above 7,000 FPM (2135 MPM) will result in excessive erosion of the down hole hammer, drill bit and drill rod.

HOW TO CALCULATE UPHOLE VELOCITY

To calculate uphole velocity in feet per minute (metres per minute), the following equation can be used.

$$\frac{\text{CFM} \times 183.4}{\text{Bit Dia. Inches}^2 - \text{Rod Dia. Inches}^2}$$

Example:

$$\frac{600\ (\text{CFM}) \times 183.4}{6.125 \times 6.125 - 4.5 \times 4.5}$$

$$\frac{110{,}000}{37.52 - 20.25}$$

$$\frac{110{,}000}{17.27}$$

6,369 Annular Velocity (Ft/Min.)

$$\frac{\text{Litres/Sec} \times 76404.7}{\text{Bit Dia. mm}^2 - \text{Rod Dia. mm}^2}$$

Example:

$$\frac{283\ (\text{L/Sec}) \times 76404.7}{155.58 \times 155.58 - 114.3 \times 114.3}$$

$$\frac{21{,}622{,}530.1}{24{,}205.14 - 13{,}064.49}$$

$$\frac{21{,}622{,}530.1}{11{,}141}$$

1,941 Annular Velocity (M/Min.)

When surplus air volume is available, the hammer can be fine tuned by the use of the interchangeable choke located in the end of the feed tube. The table below shows the additional flow through the orifice (choke).

Flow (CFM) Through an Orifice (Choke)

Inches

	1/8	3/16	1/4	5/16	3/8	1/2	3/4
80 PSI	15	34	60	94	135	240	540
100 PSI	18	41	73	114	163	291	654
125 PSI	22	50	88	138	199	354	796
150 PSI	26	59	104	163	235	417	939
200 PSI	34	76	136	212	306	544	1224
250 PSI	42	94	168	262	377	671	1509
300 PSI	50	112	199	311	449	797	1794
350 PSI	58	130	231	361	520	924	2079

Flow (Litres/Sec) Through an Orifice (Choke)

Millimeters

	3	4	6	8	9	13	19
5.4 Bar	7	16	28	44	64	113	255
6.9 Bar	9	19	34	54	77	137	309
8.5 Bar	10	24	42	65	94	167	376
10.3 Bar	12	28	49	77	110	197	443
13.8 Bar	16	36	64	100	144	257	578
17.2 Bar	20	44	79	124	178	317	712
20.7 Bar	24	53	94	147	212	276	847
24.1 Bar	27	61	109	170	245	436	981

OPERATING UNDER WATER

Drilling under high heads of water creates different parameters concerning pressure requirements. When a hammer is operating under a head of water sufficient pressure is needed to unload the hole. This is often referred to as "peak unloading pressure" and is calculated by the depth of the water in the hole.

One foot of water in the hole is equal to 0.434 psi (0.03 bar). Therefore, if there is 100 feet (30.5 m) of water in the hole there will be 43.4 psi (3 bar) of back pressure.

Once the head of water is broken, the pressure will drop to the drilling operating pressure. If the influx of water into the hole is great, the drill operating pressure will increase and the drill performance will be reduced. In some applications it may be necessary to utilize a high pressure booster compressor to continue drilling.

Head Pressure

Foot of Head = 0.434 psi

0.305 Metres of Head = 0.03 bar

DRILLING WITH FOAM AND POLYMERS

Drilling with foam and polymers has many advantages and may improve drilling in certain ground conditions. Some benefits include:

1. Ability to clean the hole with low annular velocity. Using a quality foam with the correct mixture may allow for sufficient hole cleaning with the annular velocity as low as 150 feet (46 m) per minute.
2. Utilizing a strong foam/polymer mixture, low stability formations can be drilled with minimal borehole erosion. This mixture reduces the need for high annular velocity and will suspend the cuttings during rod changes. The polymer foam will form a filter cake on the borehole wall, reduce hole collapse and inhibit swelling of clays.
3. Foam injection also aids when drilling in boreholes where water intrusion creates high back pressures. The foam mixture will reduce the head pressure lowering the peak unloading pressure and operating pressure.

FOAM MIXTURES

LIGHT MIXTURE CREATES LARGE BUBBLES
LIKE A BUBBLE BATH

HEAVY MIXTURE CREATES SMALL BUBBLES
LIKE SHAVING CREAM

A heavy foam mixture will create the best cutting carrying capabilities and low quality foams will have a tendency to break down quickly in the hole allowing cuttings to fall out of the solution.

Note: When finished drilling with foam, it is necessary to rinse all drilling tools with fresh clean water and lubricate them properly. Prolonged exposure to the atmosphere creates a corrosive reaction between the steel and the foam. Corrosion stress risers are a common cause of drilling tool failures.

EFFECT OF ALTITUDE AND TEMPERATURE

Altitude and temperature have a direct effect on the molecular structure of air. An adjustment in CFM (l/sec) must be made to accommodate such changes and to provide for efficient drilling.

At high altitudes there are less molecules in a given volume of air than in lower altitudes. Therefore, when the compressor displaces a given volume at higher altitude, the air will be less dense. When less dense air is supplied to a down hole hammer a lower operating pressure will result.

> **For example:** Operating a down hole hammer at 15,000 feet (4,572 m) of elevation at a temperature of 50° F (10° C), a down hole hammer would require almost 75% more volume than at sea level to operate at the same pressure.

High ambient temperature has much the same effect on air. At high ambient temperatures the air becomes less dense and at low ambient temperatures the air becomes more dense. These changes also require an adjustment the air supply.

> **For example:** Operating a down hole hammer at sea level with the ambient temperature at 100° F (38° C) versus 0° F (-18° C) would require almost 20% more volume to operate at the same pressure.

The following table may be used as a reference to calculate the air volumes necessary to maintain a given operating pressure at different altitudes and at different ambient temperatures.

NUMA
MANUFACTURER OF DOWN HOLE HAMMERS AND BITS

CFM CORRECTION FACTORS
FOR AMBIENT TEMPERATURE AND ALTITUDE

ALTITUDE Feet		0	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000
Metres		0	305	610	914	1,219	1,524	1,829	2,134	2,438	2,743	3,048	3,353	3,658	3,962	4,267	4,572
Temperature ºF	ºC																
-40	-40	0.805	0.835	0.866	0.898	0.932	0.968	1.004	1.048	1.084	1.127	1.170	1.217	1.266	1.317	1.371	1.426
-30	-34	0.824	0.855	0.089	0.920	0.954	0.991	1.028	1.068	1.110	1.154	1.198	1.246	1.297	1.349	1.403	1.460
-20	-29	0.844	0.875	0.907	0.941	0.976	1.014	1.052	1.092	1.136	1.180	1.226	1.275	1.327	1.380	1.436	1.494
-10	-23	0.863	0.895	0.928	0.962	0.999	1.037	1.076	1.117	1.161	1.207	1.254	1.304	1.357	1.411	1.469	1.528
0	-18	0.882	0.915	0.948	0.984	1.021	1.060	1.100	1.142	1.187	1.234	1.282	1.333	1.387	1.443	1.501	1.562
10	-12	0.901	0.935	0.969	1.005	1.043	1.083	1.123	1.167	1.213	1.261	1.310	1.362	1.417	1.474	1.534	1.596
20	-7	0.920	0.954	0.990	1.026	1.065	1.106	1.147	1.192	1.239	1.288	1.338	1.391	1.447	1.506	1.566	1.630
30	-1	0.939	0.974	1.010	1.048	1.087	1.129	1.171	1.217	1.265	1.315	1.365	1.420	1.478	1.537	1.599	1.664
40	4	0.959	0.994	1.031	1.069	1.110	1.152	1.195	1.241	1.290	1.341	1.393	1.449	1.508	1.568	1.632	1.698
50	10	0.978	1.014	1.051	1.091	1.132	1.175	1.219	1.299	1.316	1.368	1.421	1.478	1.538	1.600	1.664	1.732
60	16	0.997	1.034	1.072	1.112	1.154	1.198	1.243	1.291	1.342	1.395	1.449	1.507	1.568	1.631	1.697	1.766
70	21	1.016	1.054	1.093	1.133	1.176	1.221	1.267	1.316	1.368	1.422	1.477	1.536	1.598	1.662	1.730	1.800
80	27	1.035	1.074	1.113	1.155	1.198	1.244	1.291	1.341	1.394	1.449	1.505	1.565	1.628	1.694	1.762	1.834
90	32	1.055	1.094	1.134	1.176	1.221	1.267	1.315	1.365	1.419	1.475	1.533	1.594	1.658	1.725	1.795	1.868
100	38	1.074	1.114	1.154	1.198	1.243	1.290	1.339	1.390	1.445	1.502	1.560	1.623	1.689	1.756	1.828	1.902
110	43	1.093	1.133	1.175	1.219	1.265	1.313	1.363	1.415	1.471	1.529	1.588	1.652	1.719	1.783	1.860	1.936
120	49	1.112	1.153	1.196	1.240	1.287	1.336	1.336	1.440	1.497	1.556	1.616	1.681	1.749	1.819	1.893	1.970

Instructions:

1. Determine ambient conditions of air temperature (°F or °C) and altitude (Feet or Metres).
2. Find corrections factor from this table.
3. Multiply the correction factor by the SCFM needed to obtain ACFM under conditions given.

MANUFACTURER OF DOWN HOLE HAMMERS AND BITS

DOWN HOLE HAMMER
AIR CONSUMPTION CFM**

Hammer	Hole Size In	Choke In	AIR PRESSURE psi 100	150	200	250	300	350
CONVENTIONAL								
Patriot 35A	3-1/2 to 4-1/8	blank		158	221	290	368	452
Champion 40	4-1/4 to 5-1/8	blank		165	235	310	385	480
DCS5	5-1/2 to 6-1/8	blank		237	320	412	514	632
Patriot 50	5-1/2 to 6-1/8	blank		230	308	403	504	629
DCS6	6 to 8-1/2	blank		360	510	650	800	960
Patriot 60W	6 to 8-1/2	blank		355	500	650	790	945
Patriot 60WQ	6 to 8-1/2	blank		355	500	650	790	945
Challenger 6	6 to 8-1/2	blank		355	470	600	750	950
Patriot 80	7-7/8 to 10	blank		489	701	935	1148	1360
Challenger 80	7-7/8 to 10	blank		575	825	1100	1350	1600
Challenger 80Q	7-7/8 to 10	blank		575	825	1100	1350	1600
Challenger 100	9-7/8 to 15	blank		850	1210	1600		
Patriot 120	11-7/8 to 17-1/2	blank		1065	1500	1900		
Patriot 125	12-1/4 to 20	blank		1300	1800	2300		
Patriot 180	18 to 30	blank	1200	1800	2400			
Patriot 240	24 to 34	blank	1900	2800	3950			
Champion 330	33 to 43	blank	3500	5200	7000			

Hammer	Hole Size In	Orifice "O" Ring	AIR PRESSURE psi 100	150	200	250	300	350
REVERSE CIRCULATION *								
Patriot RC46	5 to 5-3/4	installed		193	272	397	457	566
Challenger RC100	10 to 15	installed		850	1210	1600		
Champion RC160	16 to 20	installed	983	1485	2420			
Champion RC210	21 to 26	installed	1675	2550	3425			
Champion RC300	30 to 36	installed	2400	3600	4800			

*** NOTE:** Numa RC hammers utilize an orifice "O" ring as a choke. Removal of the orifice "O" ring allows additional air to pass through the hammer for hole cleaning/flushing purposes.

**** NOTE:** These figures are nominal. Conditional and circumstances such as choke size, altitude, ambient temperature, back pressure, formation etc. can and will alter these figures.

MANUFACTURER OF DOWN HOLE HAMMERS AND BITS

DOWN HOLE HAMMER
AIR CONSUMPTION l/sec**

Hammer	Hole Size mm	Choke mm	AIR PRESSURE bar 6.8	10.2	13.6	17	20.4	23.8
CONVENTIONAL								
Patriot 35A	89 - 105	blank		75	104	137	174	213
Champion 40	108 - 130	blank		78	111	146	182	227
DCS5	140 - 156	blank		112	151	194	243	298
Patriot 50	140 - 156	blank		109	145	190	238	297
DCS6	152 - 216	blank		170	241	307	378	453
Patriot 60W	152 - 216	blank		168	236	307	373	446
Patriot 60WQ	152 - 216	blank		168	236	307	373	446
Challenger 6	152 - 216	blank		168	22	283	354	448
Patriot 80	200 - 254	blank		231	331	441	542	642
Challenger 80	200 - 254	blank		271	389	519	637	755
Challenger 80Q	200 - 254	blank		271	389	519	637	755
Challenger 100	251 - 381	blank		401	571	755		
Patriot 120	302 - 445	blank		503	708	897		
Patriot 125	311 - 508	blank		614	850	1086		
Patriot 180	457 - 762	blank	566	850	1133			
Patriot 240	610 - 864	blank	897	1322	1864			
Champion 330	838 - 1092	blank	1652	2454	3304			

Hammer	Hole Size mm	Orifice "O" Ring	AIR PRESSURE bar 6.8	10.2	13.6	17	20.4	23.8
REVERSE CIRCULATION *								
Patriot RC46	127 - 146	installed		91	128	187	216	267
Challenger RC100	254 - 381	installed		401	571	755		
Champion RC160	406 - 508	installed	455	701	1142			
Champion RC210	533 - 660	installed	790	1203	1616			
Champion RC300	762 - 914	installed	1133	1700	2267			

*** NOTE:** Numa RC hammers utilize an orifice "O" ring as a choke. Removal of the orifice "O" ring allows additional air to pass through the hammer for hole cleaning/flushing purposes.

**** NOTE:** These figures are nominal. Conditional and circumstances such as choke size, altitude, ambient temperature, back pressure, formation etc. can and will alter these figures.

TOTAL WEIGHT ON BIT / FEED PRESSURE

Due to the short rapid blows of the piston in a down hole hammer, the need for high amounts of weight on the bit has been eliminated. A down hole hammer needs only sufficient weight to keep the bit tight on the bottom.

The Numa hammers are often said to have different operating characteristics than other competitive hammers. This is primarily due to the following:

1. **Heavy piston weight**
2. **Longer and less frequent strokes**
3. **Higher kinetic energy developed**

Due to these characteristics, total weight on bit may have to be increased to eliminate drill string bounce. Drill string bounce can be noticed at the surface when drilling shallow holes. However, on deep holes the total weight on bit may need to be calculated to find the correct amount of weight.

Remember that the hydraulic pressure indicated on the gauge is not the actual weight on the bit in pounds (kgs). Actual weight on bit will vary from rig to rig depending on the diameter of the hydraulic cylinders and the weight of the drill string. It may be necessary on deep holes to use hold back to maintain proper weight on bit. This depends upon the weight of the drill string.

A good rule of thumb - a starting weight on bit is 500 lbs. per inch bit diameter.
(9 kg per mm bit diameter)

Example:	360	6-1/2" bit	500 X 6.5 = 3,250 lbs.
	360	165 mm bit	9 X 165 = 1485 kg

Remember this is only a rule of thumb for a starting point, drilling conditions can vary on every hole. Adding more weight or feed pressure does not increase the penetration rate. Drilling with excessive weight on bit can only decrease bit life and increase the torque loading on the drill string.

Although drilling with too much weight is detrimental, drilling with insufficient weight on bit is equally as detrimental. The common terms used for insufficient weight on bit are:

"RUNNING LOOSE" or **"DRILLING LIGHT"**

Drilling under these conditions can generate several operational problems such as:

1. **Carbide Pop Out -** When the piston strikes the bit without the bit being tight against the bottom of the hole, inertia can force the buttons to pop out of the sockets.

2. **Bit Shank Failure** - If the bit is not held firmly against the bottom of the hole excessive longitudinal movement between the bit splines and the chuck splines can generate extreme temperatures. This can cause a transfer of metal between the bit and chuck commonly known as cold welding. Once heat damage has occurred failure is inevitable.

3. **Residual Stress Failures -** If the hammer is not held firm against the formation, the energy generated by the piston can not be transmitted correctly and a large portion will remain in the piston. These energy vibrations can initiate failures in many different ways including piston, feed tube and/or top head drive failures.

ROTATION SPEED

Correct rotation speed has a direct effect on both bit life and hammer performance. Proper rotation is essential for long hammer and bit life. Some common elements involving rotation speed are:

- **Bit Life**

1. **Rotation Too Slow** - The main purpose of rotating a down hole hammer and bit is to index the carbide button inserts to fresh rock on every impact. If the rotation is too slow the buttons may tend to bury themselves and this will result in an erratic rotation. Slow rotation can also result in the recrushing of the rock, also known as regrinding, which results in a rapid carbide wear.

2. **Rotation Too Fast** - Increasing the rotation speed will not necessarily increase the penetration rate. It will usually result in rapid gage carbide wear due to the high scraping forces rather than a crushing force.

- **Hammer Performance**

Rotation when drilling with a down hole hammer serves only two simple purposes.

1. Turning in a clockwise direction keeps the tool joints tight.

2. Rotation indexes the carbide buttons to fracture fresh rock with each impact.

Note: Reverse rotation and impact without rotation may cause tool joints to become loose. Loose joints may cause drilling equipment to break free and be lost down the hole.

An operator must learn to have a feel for finding the proper rotation speed that will deliver optimum penetration rate without sacrificing bit life. As a starting point an operator can use the following:

R.P.M. = 1/2 Penetration rate per hour in Feet
R.P.M. = 1.6 X Penetration rate per hour in Metres

As an example, if the average penetration rate is 60 feet (18.3 m) per hour, the revolutions per minute should be around 30 (29.3).

Note: This is just a guideline. Many factors need to be taken into account for proper rotation speed such as ground conditions, formation hardness, abrasiveness, etc.

ROTATION TORQUE REQUIREMENTS CLASSIFIED BY BIT SIZE

Bit Size	Torque Required at Operating RPM
4" (102 mm) Class	500 ft. lbs. (69 KGM)
5" (127 mm) Class	650 ft. lbs. (90 KGM)
6" (152 mm) Class	800 ft. lbs. (111 KGM)
8" (203 mm) Class	1,500 ft. lbs. (207 KGM)
10" (254 mm) Class	2,000 ft. lbs. (277 KGM)
12" (305 mm) Class	5,000 ft. lbs. (691 KGM)
20" (508 mm) Class	8,000 ft. lbs. (1106 KGM)
22" (559 mm) Class	10,000 ft. lbs. (1386 KGM)
24" (610 mm) Class	12,000 ft. lbs. (1659 KGM)
30" (762 mm) Class	20,000 ft. lbs. (2765 KGM)
36" (914 mm) Class	28,000 ft. lbs. (3871 KGM)
43" (1092 mm) Class	40,700 ft. lbs. (5629 KGM)
48" (1219 mm) Class	50,688 ft. lbs. (7011 KGM)
54" (1372 mm) Class	64,152 ft. lbs. (8873 KGM)
60" (1524 mm) Class	79,200 ft. lbs. (10,954 KGM)

Note: The above figures are estimated at operating RPM. Bit sizes from 4" through 12" (102 - 305 mm) diameter may require a stall torque factor of three or four times the normal operating range. Bit sizes above 12" (305 mm) in diameter may require a stall torque factor of one and one half to two times the normal operating range.

Remember: This table is only a guide. Torque requirements may vary according to down hole conditions.

LUBRICATION / CORROSION / CONTAMINATION

• Lubrication

Down hole hammers require a continuous supply of the correct type of rock drill oil to operate efficiently. Proper lubrication of a down hole hammer is the most important and least expensive maintenance item on the drill rig. The following chart lists the minimum amount of rock drill oil required for the operation of all Numa hammers.

• CONVENTIONAL

Patriot 35A	1 qt. per hr.	1 litre per hr.
Champion 40	1 qt. per hr.	1 litre per hr.
DCS5	2 qts. per hr.	2 litres per hr.
Patriot 50	2 qts. per hr.	2 litres per hr.
DCS6	2 qts. per hr.	2 litres per hr.
Patriot 60W/WQ	2 qts. per hr.	2 litres per hr.
Challenger 6	2 qts. per hr.	2 litres per hr.
Patriot 80	3 qts. per hr.	3 litres per hr.
Challenger 80/80Q	3 qts. per hr.	3 litres per hr.
Challenger 100	4 qts. per hr.	4 litres per hr.
Patriot 120	5 qts. per hr.	5 litres per hr.
Patriot 125	5 qts. per hr.	5 litres per hr.
Patriot 180	10 qts. per hr.	10 litres per hr.
Patriot 240	16 qts. per hr.	15 litres per hr.
Champion 330	20 qts. per hr.	19 litres per hr.

• REVERSE CIRCULATION

Patriot RC46	2 qts. per hr.	2 litres per hr.
Challenger RC100	4 qts. per hr.	4 litres per hr.
Champion RC160	10 qts. per hr.	10 litres per hr.
Champion RC210	16 qts. per hr.	15 litres per hr.
Champion RC300	20 qts. per hr.	19 litres per hr.

Listed below are several acceptable rock drill oils that are available.

Company	Medium SAE 30	Heavy SAE 50
Exxon/Esso	Aroc 150	Aroc 302
Shell	Torcula 150	Torcula 320
Texaco/Caltex	Rock Drill Lube 100	Rock Drill Lube 320
Chevron	Vistac 150	Vistac 320

Testing down hole hammers without lubrication has proven that in less than one minute of drilling, temperature of the piston surface can exceed 1400° F (752° C). These excessive temperatures generate heat checks (fine cracks) on the surface finish that may propagate through impact and initiate piston failure.

Decarburization also occurs as a result of high temperatures which greatly reduces the tensile strength of the material allowing fractures to initiate.

- **Corrosion**

Corrosion is the deterioration of a material due to a reaction with its environment. Air, water and most of the drilling fluids and polymers are all corrosive.

The most detrimental type of corrosion encountered in down hole hammers is oxidation cavitation (finite notches in the material surfaces). The easiest areas for this condition to exist are in the non-moving areas of the hammer. For example, thread roots and "O" ring grooves are common places to find oxidation cavitation.

Rinse all drilling equipment thoroughly upon completion of drilling with foams/polymers in order to help reduce the occurrence of corrosion.

The best preventative action against corrosion is to keep the down hole hammer well lubricated with rock drill oil.

> Note: When finishing drilling with foam, it is necessary to rinse all drilling tools with fresh clean water and lubricate them properly. Prolonged exposure to the atmosphere creates a corrosive reaction between the steel and the foam. Corrosion stress risers are a common cause of drilling tool failures.

- **Contamination**

Contamination from foreign material entering the hammer is the second most common cause of down hole hammer and bit failure. Foreign material enters the hammer or drill string when connections are being made. Be sure to keep all connections covered and clean at all times.

When connecting a hammer to a drill string, it is usually a good idea to cover the connection to the hammer and blow high pressure air and water through the drill string for several seconds to remove any loose scale, rust or other foreign material.

When installing a bit in the hammer, take care to remove any cuttings or foreign material from the bit shank.

HAMMER STORAGE

When storing a down hole hammer, it is important to take the necessary steps in order to insure a smooth operation after restarting.

When the hole is completed and the hammer is to be inactive for several weeks or longer, the following steps should be followed:

1. Each drill rod should be blown clear of all water. During this process, turn on the in-line lubricator and blow until the rock drill oil can be seen from the bottom end of each drill rod.

2. Each rod (pin and box end) should be wiped clean and capped to prevent foreign contaminates from sticking to the connector ends.

• Short Term Storage

When a down hole hammer will be stored for only a short period of time, the following steps should be take:

1. Blow the hammer clear of all water.

2. Pour one quart (1 litre) of rock drill oil into the backhead. See Lubrication for suitable rock drill oils.

3. Turn the air on and cycle for 10 seconds. This will lubricate the internal parts.

4. Cap the backhead and chuck end.

5. Store the hammer horizontally in a dry environment.

• Long Term Storage

When a down hole hammer will be stored for a long period of time, the following steps should be taken:

1. Blow the hammer clear of all water.

2. If at all possible, the backhead and chuck should be broken loose on the drill rig, this is much easier than trying to do so in the shop.

3. Disassemble the hammer.

4. Inspect and wipe all the parts clean.

5. Lubricate all the internal parts with rock drill oil. See Lubrication for suitable rock drill oils.

6. Cap the backhead and chuck ends.

7. Store the hammer horizontally in a dry environment.

- **Restarting**

Before restarting the hammer after prolonged periods of inactivity, disassemble and inspect all internal hammer parts.

If any internal hammer parts have oxidized, use an emery cloth to polish each part. Wash each hammer part, wipe dry, relubricate with rock drill oil and reassemble the hammer.

Note: Failure to check internal parts before restarting the hammer may cause serious damage to the hammer.

GENERATED TORQUE CHART
NUMA HAMMER BENCH

PULL DOWN

Applied Hydraulic Pressure PSI	Petol DA4171-L21 Wrench Lb Ft	Petol VTDA 116H Wrench Lb Ft
500	9,425	14,138
750	14,138	21,206
1000	18,850	28,275
1250	23,563	35,344
1500	28,275	42,413
1750	32,988	49,481
2000	37,700	56,550
2250	42,413	63,619
2500	47,125	70,688

CONVERSION CHART

To Convert	Into	Multiply By
Bar	PSI	14.70
Centimetres	Inches	.3937
CFM	L/Sec	.4719
CFM	m^3/min	.02832
Cubic Feet	Cubic Metres	.02832
Cubic Metres	Cubic Feet	35.3145
Feet	Metres	.3048
Ft Lbs	KGM	.1383
Gallons	Litres	3.7853
Inches	Millimetres	25.4
Inches	Centimetres	2.54
KGM	ft lbs	7.231
Kilograms	Pounds	2.2046
Kilometres	Miles	.6214
L/Sec	CFM	2.119
Litres	Gallons	.2642
Litres	Quarts	1.0567
m^3/min	CFM	35.32
Metres	Feet	3.2808
Metres	Yards	1.0936
Miles	Kilometres	1.6093
Millimetres	Inches	.03937
Mega Pascals (MPa)	PSI	145.04
Pounds	Kilograms	.45359237
PSI	Bar	.06804
PSI	Mega Pascals (MPa)	.006895
Quarts	Litres	.9463
Square Centimetres	Square Inches	.1550
Square Feet	Square Metres	.09290
Square Inches	Square Centimetres	6.452
Square Metres	Square Feet	10.7639
Ton (US)	Ton, Metric	.90718
Ton, Metric	Ton (US)	1.1023
Yards	Metres	.9144