HIGH PRESSURE AIR AND ITS APPLICATION TO DTH HAMMER

DRILLING FOR A PROFIT

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This paper was written in 1996 and some of the hammer models have changed although all of the principles remain the same.

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TRENDS IN DRILLING WITH COMPRESSED AIR

Increasing Sample Quality - Reverse Circulation gives a good volume of representative sample..
Penetration Rates - with rising air pressures
Reduction in, in hole problems - less disturbance of drilled structures Improved life of consumables - fewer trips in and out of hole Accurate dry sample from below water table in many cases
Safety considerations - reduced rod handling
Improved Non Drilling tool accessories - blowdown subs
- cyclones
Decreasing overall project costs due to greater numbers of meters drilled in given time.

We will discuss in some detail the application of progressively greater air pressures to the drilling process.

The reasons for and limitations when using higher air pressures i.e. the specific effect of higher pressures on individual parameters are:

a) Sufficient energy must be provided by the compressed air to drive the piston into the bit and ensure that the all cutting elements (buttons) on the bit actually cut (crush) the material being drilled on every blow. If insufficient energy is applied to the bit, small cuttings, slow penetration, regrinding, higher drill string toque, premature hammer wear due to high temperatures resulting from friction generated in the hole all occur - bottom line you get frustrated and make slow progress and small profits.

b) Too much air pressure - sensational penetration rates are possible but severe physical damage to drilling tools will quickly ensue. Shanked bits, smashed pistons and excessive time spent tripping in and out of the drill hole are great time waste at depth.

C) Hammer manufacturers at present appear to have developed tools capable of sustaining operation up to a pressure drop of 350 - 400 psig across the actual tool in suitable strata.

This last point is the real crux of the matter. All the additional pressure above 350 - 400 psig not absorbed by parasitic losses encountered in the drilling process will serve only to waste money refer (b).

At this point it must be pointed out that the author is not an engineer and this information is empirical. A rigorous analysis may reveal errors in specific details however, the explanations set out have over a long time proved capable of yielding good results whilst being intelligible to the important people - the drill crews and possibly the geologists who after all authorise the payments received in return for the superior numbers and quality of samples being produced.

ENERGY IS USED i.e. PRESSURE LOSS OCCURS

- Between booster discharge and inlet of hammer;
- Across the hammer - useful work done during the drilling process;
- After air is exhausted from hammer and until the air passes out of cyclone vent.

Each of these areas of loss will now be examined in detail.

FOR A GIVEN SYSTEM

LOSSES BETWEEN BOOSTER DISCHARGE AND HAMMER INLET ARE

1. Friction loss in hose to rig
2. Losses through rig air valve and through air swivel which often has very restrictive air passages.
3. Friction losses as the high pressure air passes down the annulus of the drill string to the hammer inlet.
4. Friction loss across the hammer inlet check valve.

Of all these items the major variable is the line losses which change as hole depth increases and vary from manufacturer to manufacturer. Unfortunately at this time no reliable standard is known to the author to quantify rodline friction losses.

Pressure drop across the hammer is dependent on the hammer design, volume of air available and inlet air pressure at the hammer and any back pressure.

After the air is exhausted from the hammer the following losses must be allowed for.

5. Water Table.
6. Inner tube friction losses.
7. Losses through the head assembly.
8. Losses through sample hose and cyclone.

All of the losses before and after the hammer must be overcome before any energy becomes available for useful drilling.

A final point before we work through a typical application of high pressure air to down hole hammer drilling. When designing a layout we must know the following: -

- Target Depth
- Approximate Water Table
- Have some basic idea of rock strength to be encountered on the way down and at the bottom of the hole.

Using item three we must decide from experience the minimum air pressure which will enable drilling to proceed economically in the strata at the bottom of the hole. Let us make some assumptions at this point plus select our drill string and hammer.

Target Depth 220 meters

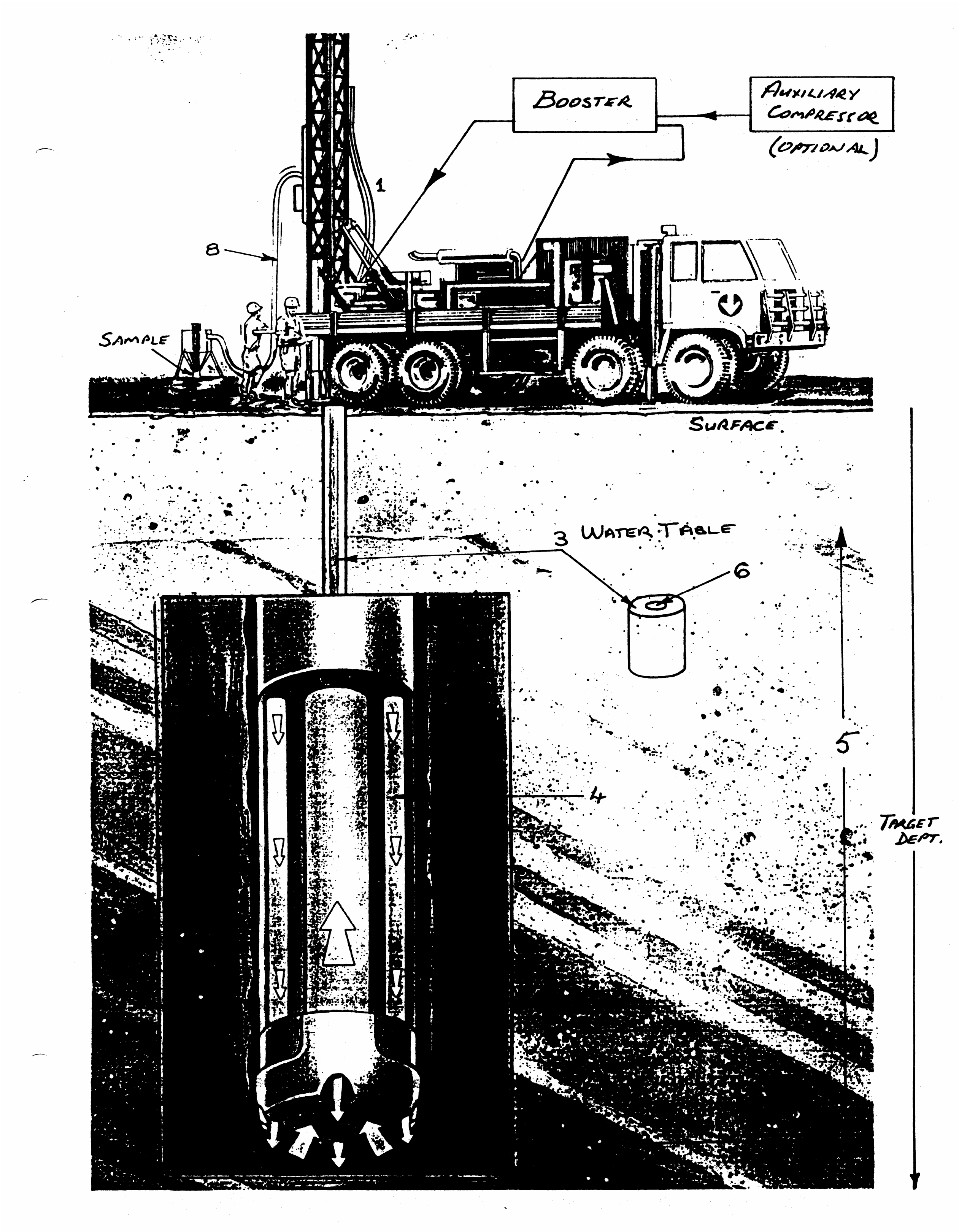
Water Table 60 meters

Minimum pressure drop across the hammer at bottom of the hole 280 psig.

4" RC Drill string to be used.

A 5¼° hole to be drilled from the surface with a 4 ⅜ " hole at target depth.

A TYPICAL RC DRILLING SETUP



PSIG AIR PRESSURE DROP ACROSS HAMMER

TOOL	200	250	300	350
TRC42	280	350	450	650
TRC47	475	600	700	760

Let us now estimate the pressure losses between the booster discharge and hammer inlet including hammer check valve.

Loss in hose to rig say 20m of 50mm bore hose	5
Losses through rig air valve up to and through swivel	5
Losses down annulus of drill string for 4" RC pipe allow 4m per psig so for 220m total loss	55
Hammer check valve	2
TOTAL	67 psig

Now let us estimate the losses in the return after the air is exhausted from the hammer: Water table allow 1 psig per meter of water in the hole hence*

220 - 6- = 160m a 160 psig	160
Inner tube friction losses (2" Bore Inner Tube) allow 1 psig per 3m	73
Losses through head assembly	5
Losses through sample hose and cyclone	10
TOTAL	248 psig

Thus total losses before any useful drilling can occur at the bottom of the hole *will* be about 315 psig. To arrive at a minimum acceptable pressure to drill this hole we must add the 280 psig required for reasonable drilling to be accomplished at the bottom of the hole, we then arrive at an inlet pressure of 595 psig.

* I can hear the purists groaning about the loss of head due to aeration and or if water flow is small total removal of water head. Again, this is for people with dirty hands and based on proven procedures, any errors will result in better than expected drilling rates.

We must now arrive at a suitable volume of air. For a down hole hammer to operate successfully the chambers above and below the piston must be filled with compressed air on soft cycle.

It gets a little confusing here because as the pressure at the hammers exhaust Increases due to return losses the pressure at the inlet increases *so* in simple terms if we double the system pressure we must double the air volume (scfm) if everything is to work.

If we go to the table for the TRC42 we will discover that at 300 psig 540 cfm are required to drill. Double this to obtain air consumption at 600 psig. With a primary supply of 1150 scfm@ 350 psig feeding into a booster which will supply up to 600 psig discharge at the nominated inlet conditions we can expect good drilling performance right to the bottom of the hole.

Likewise for the TRC47 we could estimate the total air at 300 psig being 700 cfm. Double that and we arrive at 1400 cfm to do the job. See graph of hammer air consumption.

Let us not overlook the possibility of using both hammers as it is generally true that under similar conditions the bigger hammer is stronger and drills faster than the small one so if we had a limited primary air supply we might choose to start the hole with the TRC47 and drill until the penetration begins to fall off - you can work that out for yourselves (answers in bar or fax me) then pullout and complete the hole with the TRC42. Diamond Drillers have been reducing tool sizes as holes get deeper for years. The graph of hammer air consumption also covers this point clearly.

One can graph out the hammer manufacturers air consumption figures as shown below to use in estimating air usage at higher pressures again this method is not absolutely accurate and the hammer manufacturers may take issue with me but again, it works.

Returning to the point (b) at the start of this paper one must now commence to drill with 350 psig and note the penetration rate obtained. As drilling progresses the air pressure can be increased to maintain constant penetration rates, the increasing pressure merely offsetting parasitic losses. **Keep in mind you want to achieve a constant penetration rate throughout the hole or until your primary air supply becomes inadequate.**

You use a lot more air at high pressures so please, use a lot more hammer oil and maintain your hammers and bits very carefully as they have to work very hard when supplied with high pressure air.

Use the check list before using high pressure air as it is a lethal power source that can earn you great profits if used well, but equally kill you and inflict heavy losses if misapplied.

All the foregoing is based on personal observations over a lifetime of involvement in the drilling industry. If in doubt ask someone and use experienced crews.

No responsibility for or warranty as to the performance of a particular system can be given or accepted by the author but the sensible application of the information in this paper has in the past yielded good results for many people.

BRIEF CHECK LIST

Steps to cover before embarking on your first high pressure project.

1. Audit all hoses and connections from compressor/booster outlet to air swivel inlet for pressure and temperature rating.

2. All flexible hoses to be restrained at both ends.

3. All fittings in the oil and water injection circuit to be checked.

4. Check rating and correct function of oil and water injection systems.

5. Check all relief and check valves.

6. Establish that your air swivel is suitable for the maximum air, pressure that can be supplied by plant to be used.

7. Check emergency shutdowns in addition to engine/compressor protection systems.

8. Ensure all personnel on site can competently shutdown plant in the event of an accident.

9. Have fire extinguishers on rig as high pressure air leaks support combustion of flammable material.

10. Main air valve to be progressive in operation of a sudden on/off valve will ensure damage results to separator.

11. Ensure inner tubes and o rings are in good order.

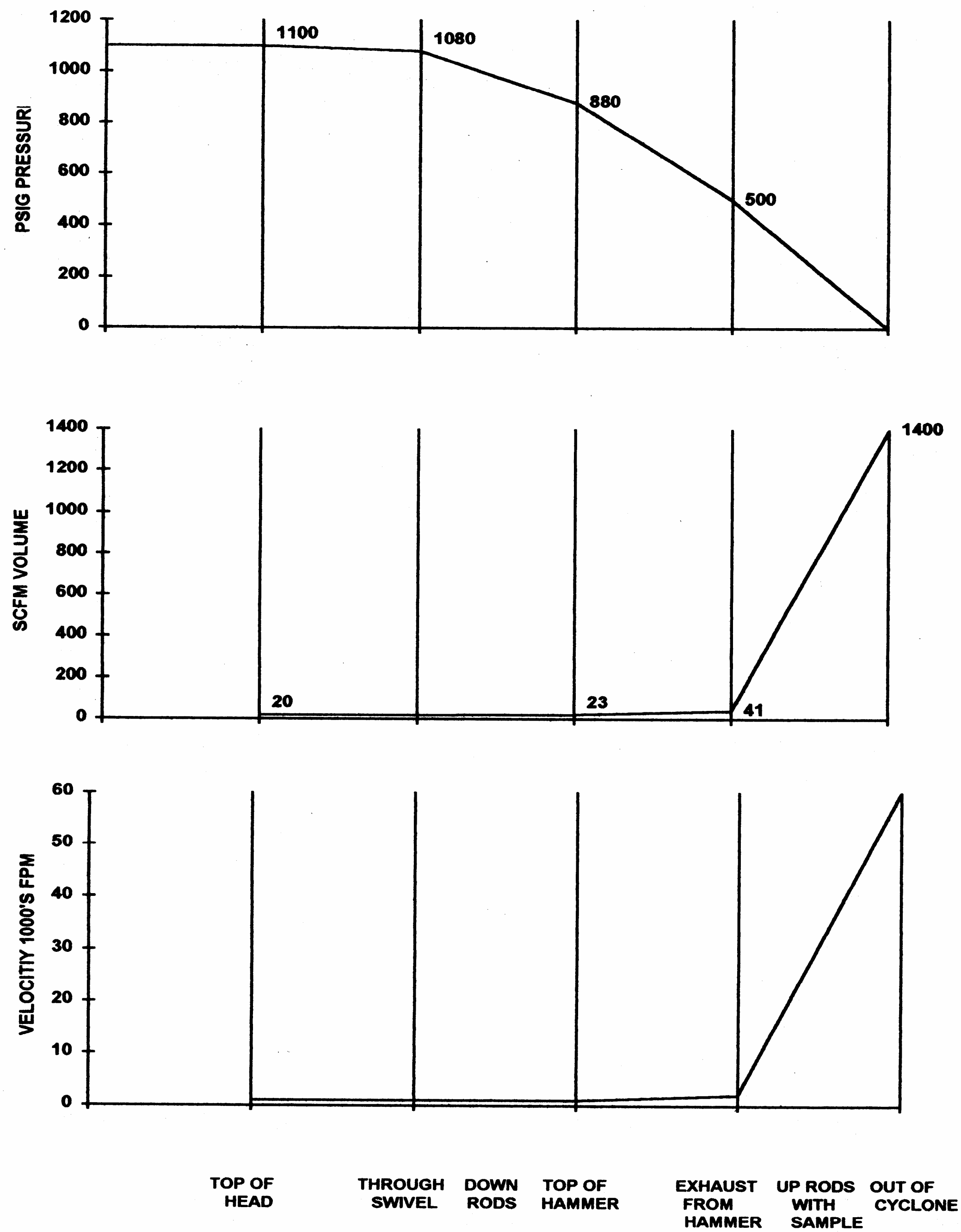
12. If a blowdown sub is fitted above rotation head and remotely operated the attachment of the blowdown valve assembly to drill string or rotation head must be rated to safely handle all forces generated if full system air pressure is applied due to a blocked bit, hammer or rods.

13. Blow back subs represent a real risk and are not recommend as they present unique hazards due to wear items (sample hose and couplings) which are not pressure rated and in many cases not adequately secured potentially being exposed to very high air pressures.

14. Use crews trained in safe operation of rig and familiar with all the tooling and plant involved. Wear protective equipment as extremely loud noises and high velocity particles can occur during drilling operations.

15. The next three graphs are provided to stimulate a little thought and are the authors way of thinking about what is going on in the drilling system at any one location in time. Note carefully where the losses occur and how the higher pressures in the annulus result in low velocities, also how large the velocities become near the discharge hence the huge wear problems.

EXAMPLE 1400 CFM @ 1100 PSIG AIR SUPPLY INTO AN RC DRILL APPLICATION AT ABOUT 800 METRES DOWN WITH 233 METRES OF WATER USING 1 PSI/4M ANNULAR LOSS, 1 PSI/M OF WATER



HAMMER AIR CONSUMPTION GRAPHS

PLOT YOUR HAMMERS PUBLISHED PERFORMANCE DATE AND EXTEND THE LINE OF BEST FIT TO ESTIMATE TOTAL AIR CONSUMPTION AT HIGHER PRESSURES. SEE HOW A SMALLER HAMMER CAN MAINTAIN A GREATER PRESSURE DROP FOR A GIVEN AIR VOLUME.