MUD ROTARY TECHNIQUES

Presenter: Roger E. Renner

Master Groundwater Contractor

Roger E. Renner, MGWC

- President of E.H. RENNER & SONS, INC.
- Past President of NGWA 2001
- Past President of Minnesota Water Well Association 1990
- Chairman of Minnesota Dept. of Health Advisory Council on Wells and Borings Licensing Board

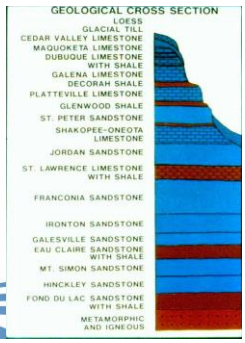
MUD ROTARY DRILLING

In this session on mud rotary drilling,

we will present general information on mud rotary drilling, safety around the drill rig, and selecting proper size tools and their use. Safe equipment operation will be addressed, in addition to advantages and disadvantages of this drilling method. We will also discuss terms used, good care, and maintenance of tools.

MUD Rotary Drilling Method

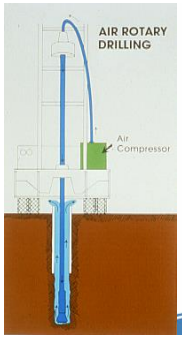
KNOW YOUR GEOLOGIC FORMATIONS and Expected Water Levels



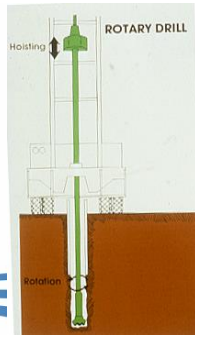
Rotary Well Rig

- Drills using rotating bit and downhole percussion
- Air or designed "mud" as a circulating and cooling fluid
- Drill pipe is 15-20' long
- Drills in a variety of formations depending on technology used
- Typically faster completions

Rotary Drill

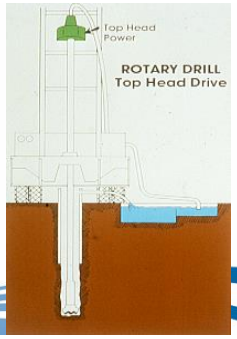


Air



Top Head Drive Mud Rotary

Mud or Air Rotary



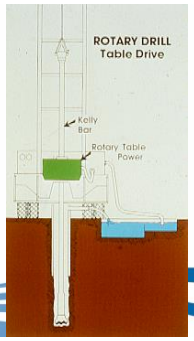
Top Head Rotary

Carousel option automatically handles drill rod for faster operation and ease of use

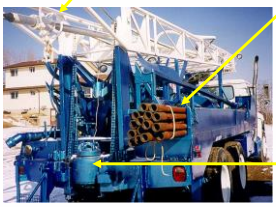
Top head drive delivers rotary action and down pressure to drill stem

Mud Rotary Table Drive

- Drive shaft turns the rotary table
- Kelly is fluted
- Driven by kelly bushing



Kelly bar provides down pressure

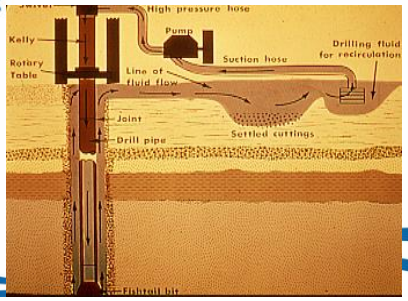


Drill pipe loaded manually non-automated

Table drive provides rotational torque

Table Drive Rotary

Mud Rotary Drilling



Larger diameter and depth of well requires larger circulation pits.

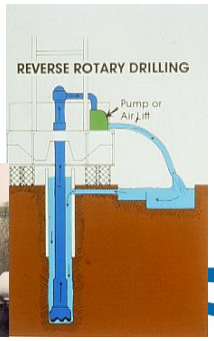
In ground mud pits

De-sanders used to reduce recirculation of drill cuttings

Steel tank pits

Air Assist

- 750 cm
- 300 psi



Typical residential water well

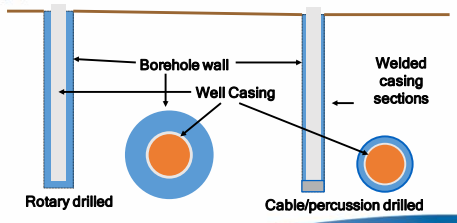
Residential well site

- WATER TRUCK
  - Water
  - Pipe
  - Bentonite
  - Cement Grout
  - Air Compressor
  - Welder
  - Safety Equipment

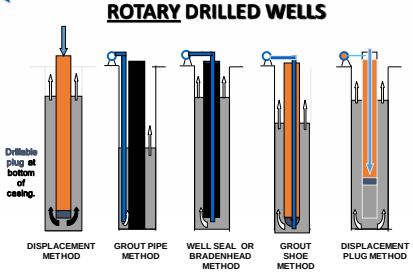
Grouting Techniques

Grouting open annulus required that would otherwise allow migration of pollution into the aquifer

Examples of Annular Space



GROUTING METHODS FOR ROTARY DRILLED WELLS



Size of Borehole

R 325.1663 Rule 133a (3)

A permanent casing shall be installed in a borehole that has a diameter of not less than 2 inches larger than the nominal size of the permanent casing, except as provided in sub rule (4) of this rule and R325.1635.

Rule 133a (4)

When grout is placed through a grout pipe outside the permanent casing, the borehole diameter shall be not less than 2 7/8 inches larger than the nominal casing size.

Grouting Techniques

GROUT

- Neat Cement Grout
- Concrete Grout
- Bentonite Grout

Neat Cement Grout

- 6 gallons of water/94 lbs of Portland cement
- < 5% bentonite (4.7 lbs)

- 21.2 sacks/yard = 202 gals of grout

MUD DENSITY

- Weight of grout (14-15 lbs/gal)
- Using mud balance

CONCRETE GROUT

- 94 lbs of Portland cement (94 lb sack)
- 1.1 cubic feet of sand
- 6 gallons of water

- Density is approx. 17.5 lbs/gal

NOMINAL CASING DIA.	CUBIC YARDS	# OF 94 LB BAGS	# OF 47 LB BAGS	GAL OF WATER	GAL OF GROUT
COMBINATION SIZES					
6" X 2"	0.6007	13.81	27.62	82.89	121.34
8" X 4"	0.8841	20.33	40.66	122.01	178.59
10" X 6"	1.1500	26.45	52.90	158.70	232.00
12" X 6"	2.0385	46.88	93.76	281.32	411.77
12" X 8"	1.4300	42.90	85.80	197.30	288.90
14" X 8"	2.0556	47.27	94.54	283.67	415.23
16" X 10"	2.4185	55.63	111.26	333.75	487.83
18" X 12"	2.7410	63.04	126.08	378.22	553.68
20" X 14"	3.5280	81.14	162.28	486.84	712.66
24" X 18"	4.3759	100.65	201.30	603.87	883.93
30" X 24"	5.6500	129.95	259.90	779.70	1,141.30
36" X 30"	7.0400	161.92	323.84	971.52	1,422.00

BENTONITE GROUT

- 1 sack of bentonite (50 lbs)
- 50 lbs of sand or
- 50 lbs of cuttings
- 48 gallons of water

- Density is approx. 10.5 to 11 lbs/gal

High Solids Bentonite Grout

- 50 lbs of bentonite
  - (15% bentonite by weight minimum)
  - Contains no additives

- 283 pounds of water (34 gallons)

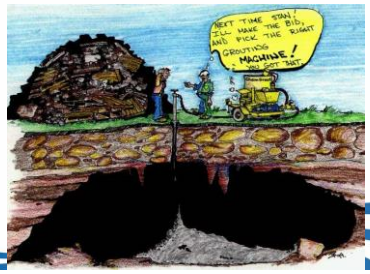
USEFUL FORMULA

- Gallons per 100' = 4.08 x (Inside Hole or Casing Diameter)^2
- Cubic feet or grout per 100 feet = .55 x (Inside Hole or Casing Diameter)^2
- 1 cubic foot of water = 7.481 gallons and weighs 62.32 pounds
- 1 gallon of water = 0.1337 cubic feet and weighs 8.33 pounds
- 1 cubic yard = 202 gallons
- 1 cubic yard = 27 cubic feet
- Volume of cylinder or pipe = 0.78 x height x (diameter)^2

TYPICAL QUANTITY OF GROUT FOUND NECESSARY TO FILL WELLS IN THE SEVEN COUNTY METROPOLITAN AREA

Wells Completed in Geologic Formation	Volume (Does not include blasted and bailed sections of wells)
Drift	1 x Calculated Borehole Volume x Depth
Platteville Limestone	3 x Calculated Borehole Volume x Depth
St. Peter Sandstone	1.2 to 1.3 x Calculated Borehole Volume x Depth
Shakopee Dolomite	2.5 x Calculated Borehole Volume x Depth
Jordan Sandstone	1.2 x Calculated Borehole Volume x Depth

The annular space between the outer casing and borehole walls are then grouted with bentonite or cement grout.



Advantages & Disadvantages

Advantages to Rotary Drilling

1. Speed
   - 5 to 7 times faster than cable tool rig.
   - Capable of drilling several hundred feet per day.
2. Design Options
   - Conventional telescoped screens.
   - Pipe sized screens and separated screens.
   - Filter (gravel) packing.
   - Ability to use any casing material.
   - Downhole casing hammer.
3. Grouting
   - Tremie pipe in oversized borehole.
   - Grout can be placed thru casing.

Disadvantages to Rotary Drilling

1. Cost of equipment--new drill rigs can cost between $250,000 and $750,000. And rig tender units can range from $75,000 to $200,000.

2. Cost of drill rod and bits also more costly.

Disadvantages to Rotary Drilling

3. Rotary rigs consume much more fuel than cable tools.

4. Rotary rigs have more moving parts and pumps to service, leading to higher maintenance costs.

Rotary Principles

A thimble or conductor pipe is shoved into ground. This will carry drilling fluid and cuttings from the borehole to the mud pit.

Next: a high viscosity bentonite is mixed with a nozzle venture assembly. The bentonite will lubricate the drill head, stabilize the borehole with a "filter cake wall," and carry the cuttings out of the borehole.

Once bentonite fluid is mixed, a stabilizer and drill bit are made ready to start drilling an oversized borehole.

Stabilizers vary in length from 6' (shown left) to 20' and are used to keep borehole straight and plumb. The longer the stabilizer, the straighter the borehole.

Importance of proper bit selection

Tricone drill bits are one of the most common rotary drill bits. When drilling, the bit is rotated clockwise with down pressure. As the bentonite fluid passes thru the center of the bit and special portholes, each cutting head also turns.

After drilling commences, bentonite fluid is circulated thru drill pipe past drill bit and up annular space between borehole and drill pipe. The fluid comes out spindle and into mud pit where cuttings fall out and are removed. Once fluid is free of cuttings, it is circulated downhole.

Drilling fluid circulating thru the drill pipe and out of spindle into mud pit.

Sand formations are removed by circulating bentonite fluid thru a desander, which separates the sand from the bentonite fluid.

Samples on a mud rotary can be obtained by screening flow out of spindle, or pulling cuttings from discharge of desander.

After determining the formation that will be used, the bentonite is flushed from hole. The drill rod and stabilizer and bit are removed from borehole. Casing and screen (if used) are set thru mud, and a tremie pipe is installed to pump grout.

After tremie is in, the screen (if used) and casing are set into the borehole.

Filter pack sand (if used) and HTH are poured around the screen up to a maximum of 10' above screen. The chlorine will help disinfect the filter pack and well itself.

Disinfecting well casing

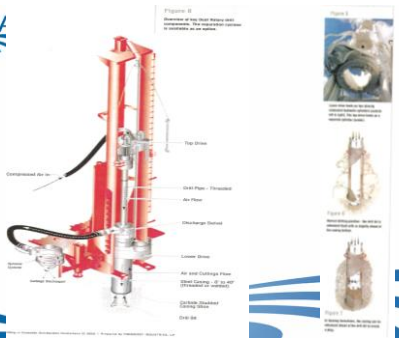
During transport, store in a clean area and maintain a protective cover.

Dual Rotary Drilling

TOP HEAD DRIVE – DRILL TOOLS

TABLE DRIVE – CASING ADVANCE

DR-12 shown with optional cyclone collection system.



Carbide studded casing shoe being welded onto casing prior to drilling operation.

Casing jaw secures pipe for advancement as you drill.

ADVANTAGES:

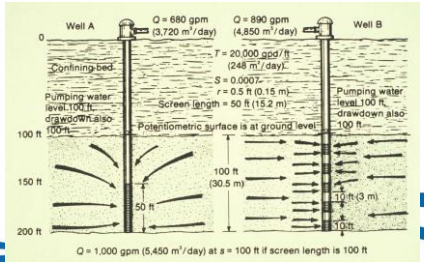
- SPEED of drilling/casing advancement
- Casing extraction
- Sampling
- Screen installation
- Heaving formations

DISADVANTAGES

- Extreme capital investment
- High maintenance and operational costs
  - Downtime waiting for parts
  - 3-4 man crews w/support vehicles
- Minimum diameter well of 6”
- No PVC cased wells except dual liners
- Freezing temperatures and hydraulics
- Costly drill shoe needed

Screen Selection for Natural Developed Wells

Location of Screens



Well Screen Length

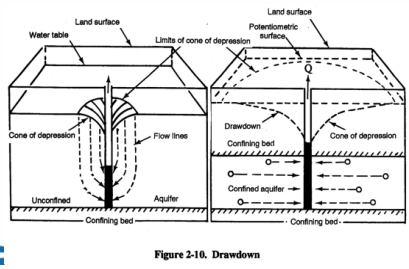
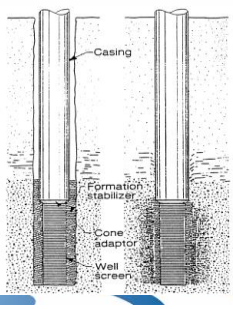


Figure 2-10. Drawdown

Filter Pack vs Stabilizer Gravel

- Stabilizer gravel fills the annulus between the screen and formation.
- Filter pack stabilizes the formation and prevents fine particles from entering the well.



Finally the well is developed and pumped.

MUD ROTARY TECHNIQUES

Roger E. Renner,
NGWA-Certified
Master Groundwater Contractor
rerenner@ehrenner.com