

Specifications for Seismic Instrumentation Boreholes

Albuquerque Seismological Laboratory

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1. Drilling and Borehole Criteria

We recognize that the drilling contractor is an independent contractor and is free to drill and complete the borehole in any manner that he sees fit as long as it results in a properly cased and cemented borehole that meets all of the requirements listed in these specifications.

We are interested only in the results and we hold the drilling contractor responsible for delivering to us a properly cased and cemented borehole of the assigned depth that is water tight. Only then will payment be made to the drilling contractor.

It is the drilling contractor's responsibility to prepare for any situation that might occur. He must have sufficient equipment and supplies on location, including surface conductor and surface casing to case off any surface alluvium that might be present. He must have sufficient lost circulation material on location to meet any demands. He must have sufficient cement on location and a proper pump to pump it with, to cement off any lost circulation zones as stated under section c. If the drilling contractor is in an area where cement service companies are readily available, then a cement service contractor may be used.

- a. A borehole shall be drilled to a depth of 400 feet (122 meters) from ground level with an angle of inclination not to exceed four degrees, cased, cemented and finished to be permanently sealed against water seepage from bottom to top. The main objective is to obtain a cased water tight usable hole 105 meters in depth. This borehole will be referred to as the "deep borehole" for the remainder of this document.
- b. A second borehole shall be drilled to a depth of 145 feet (45 meters) with an angle of inclination not to exceed two degrees, and finished to a usable depth of 30 meters. This borehole will be referred to as the "shallow borehole" for the remainder of this document.
- c. The holes shall be drilled no smaller than 8.5 inches (21.6 cm) and no larger than 10-5/8 inches (26.7 cm).
- d. In order that the boreholes can be cemented, from bottom to top satisfactorily as specified, each water or lost circulation zone shall be plugged or cemented off, or sealed with lost circulation material before drilling ahead.
- e. The vertical offset or drift for the deep borehole shall not exceed four (4) degrees from true vertical measurement at any point from the top to the bottom of the cased hole. The vertical offset or drift for the shallow borehole shall not exceed two (2) degrees from true vertical measurement at any point from the top to the bottom of the cased hole. It is suggested that this be achieved as follows: While drilling, pull-down pressure on the Kelly should be avoided. Drill pressure should be provided solely by the weight of the drill collars. An appropriate device, such as a Baker Tool TOTCO Recorder shall be used during the drilling to insure that the hole is not drifting from vertical.

- f. A driller's log shall be required to show the continuous geological conditions of both holes from the surface to total depth. All pertinent information shall be included in this log such as bit record, drilling time, lost circulation, material and equipment used, lost time, etc. When total depth is reached at the proper diameter, circulation shall be maintained for approximately one (1) hour to assure that the hole is free of cuttings and cavings.
- g. The boreholes shall be cased to their total depth using a seven inch OD standard American Petroleum Institute (API) J-55 or equivalent seamless steel casing, with standard threads and collars, not to exceed 26 pounds per foot or have an ID less than 6.276 inches (15.94 cm). The 20 or 23 pounds per foot casing is preferred since this gives a larger ID. The casing string shall be made up of the same type of casing for the total depth. The casing joints may be any standard length but must be straight and free of burrs and irregularities which would cause the casing string to fail certain acceptance tests. A certificate of drifting and "Tubescoping" would be preferred. All threaded joints must be coated with a high quality, API type Thread compound (pipe dope) and made up with 1,000 foot-pounds of torque. An in-place casing collar tally shall be required to show the number and depth location of all collars in the casing strings. The tally shall be accurate to within 1 foot (15.24 cm).
- h. The bottom of each casing string shall be fitted with a seven inch Halliburton Super Seal Float Shoe. A Halliburton Super Seal Float Collar Type 'E' (M&F) shall be added to the top of each shoe joint (first joint). The shortest length of casing shall be used for the shoe joint H, and is to be no longer than 20 feet. If you are using range three casing, one joint shall be cut and threaded and fitted with a collar to provide a short joint. A Halliburton Latch-Down Baffle shall be installed in the top of the float collar. The threaded joints of the float shoe, float collar and latch down baffle must be coated with Halliburton weld-A cement and made up with 1,000 foot pounds of torque. Four Halliburton Model S-3 Centralizers shall be installed on the bottom four casing collars, and one model S-3 centralizer shall be placed on alternate collars for the remainder of the casing strings.
- i. Immediately prior to cementing, a turbulent flow of clear water and a cleaning solution shall be circulated down the casing and up the annulus to clean out any mud and debris that is present to secure a good cement bond.
- j. The casing strings shall be supported approximately 26 feet (8 meters) above the bottom of the hole during cementing of the casing.
- k. The cement slurry used shall be made up of cement, water and five pounds (2.27 kilograms) of fine common salt to each 100 pounds (45.36 kilograms) of cement. The salt produces linear expansion of at least 0.05 percent after one week and will assure there is no micro annulus around the casing that may affect seismic coupling. Certification and samples of the slurry materials to produce this expansion shall be required. The water used for mixing the cement shall have a pH in the range of 6.5 to 8.0, and shall have no more than 1,000 PPM of chlorides, 3,000 PPM sulfates, class "A", 1,500 PPM sulfates, class "C". NOTE: It is preferable to contract with a service company such as

Halliburton or BJ to cement the casing.

- l. It is entirely the drilling contractor's responsibility if he attempts to cement the casing string within the vertical tolerance when the uncased borehole is not vertical to within the verticality specifications for each borehole.
- m. Each borehole shall be cemented from bottom to top. The cement slurry with sufficient volume to fill the annulus with at least 25% excess shall be pumped into the casing. Then the Halliburton latch down plug shall be inserted into the casing and washed down with clear water. When the plug reaches the baffle, normally 1,000 pounds per square inch of pressure should force the latching nose of the plug into the baffle and lock it in place. Once the plug is seated, all pressure must be released to check for zero backflow, this will prove that the one-way valves are holding.
- n. When zero backflow is obtained, the cement slurry shall be allowed to cure for 24 hours under no pressure. After 24 hours, the casing shall be scraped, brushed and emptied of all fluids and loose solids.
- o. If the cement level drops in the annular space between the pipe and the hole, additional cement slurry may be added around the casing directly from the surface.
- p. A straight test cylinder 12 feet (3.7 meters) long and 6 inches (15.24 cm) in diameter, provided by the drilling contractor, must pass freely from the surface to the total depth of the cased borehole. This is to insure that there are no constrictions or angular deviations that would prevent the installation of the holelock and seismometer.
- q. The boreholes shall be checked for leaks. Each borehole shall be filled with water, capped and pressurized to 600 pounds per square inch (psi), sealed off and allowed to stand. At the end of 24 hours, pressure must not have decreased by more than 10 percent. Upon completion of this test, the water shall be removed, the holes blown dry and left clear over the total depth.
- r. The top of the landing (top) casing for each borehole shall extend approximately 18 inches (45 cm) above ground level and be threaded with external standard 8-round threads per inch. A thread protector and steel plate shall be fitted onto the top of each casing as protection against objects falling into the holes.

2. Acceptance Requirements, Tests and Reports

The driller shall be directly responsible for all the critical items outlined below and for preparing written reports of the results of the various required tests. Rejection of the entire borehole configuration is possible if any of the following criteria are not satisfied.

- a. The finished deep borehole must be watertight with an offset from vertical of four degrees or less. To be safe and ensure the hole is not drifting, verticality measurements shall be made at a minimum of 50-foot intervals, and deviation from vertical in every case

must not exceed four degrees.

- b. The finished shallow borehole must be watertight with an offset from vertical of two degrees or less. To be safe and ensure the hole is not drifting, verticality measurements shall be made at a minimum of 30-foot intervals, and deviation from vertical in every case must not exceed two degrees.
- c. A 12 foot (3.7 meters) x 6 inch (15.24 cm) test cylinder must pass freely through the total casing string for the deep and shallow boreholes.
- d. Both boreholes shall be checked for leaks as described in 1.p.
- e. A cementing report shall include certification and samples of all cementing and additive materials, water chemistry, listing of water-to-cement ratio, notation of pumping rates and pressures, and any abnormal or unusual events encountered during the cementing operation.
- f. A driller's log to show the continuous geological conditions of both the shallow and deep boreholes from the surface to total depth is required. All pertinent information shall be included such as bit record, drilling time, lost circulation, material and equipment used, lost time, etc.
- g. No cores will be required but samples of drill cuttings shall be taken every 20 feet (6 meters), identified in numbered geological sample bags and retained at the site.
- h. An in-place casing collar tally is required to show the number and depth location of all collars in each casing string. The tally shall be accurate to within \pm foot (15.24 cm).
- i. All casing, collars, components, materials, and supplies required under this contract shall be new and first grade.
- j. The contractor shall procure and convey to the drilling site all water needed for his operations.

3. Care of Property and Removal of Debris

- a. Damage to Property - Care shall be taken at all times during the work described in these specifications to conduct the work in such a way as to prevent undue damage to the property on which the work is being performed.
- b. Property Restoration and Cleanup - After completion of the work described in this specification, the area shall be thoroughly cleaned of all residual material resulting from the drilling operation or the equipment. The surface shall be free of drilling mud, cuttings, scrap equipment, foliage, packing, and related items. The surface shall be smoothed to its original contours with all vehicle ruts covered. The drilling report shall include photo-documentation before and after the drilling to ensure adequate restoration

has been performed.