CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES TECHNICAL OPERATING PROCEDURE	Proc. TOP-011 Revision 0 Page 1 of 13

Title

PROCEDURE FOR ASSEMBLING AND INSTALLING HYDRAULIC ANCHOR BOREHOLE EXTENSOMETERS

EFFECTIVITY AND APPROVAL

Revision 0 of this procedure became effective on 8-17-90. This procedure consists of the pages and changes listed below.

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Approvals

Written By	Date	Technical Review	Date
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CNWRA Form TOP-1

PROCEDURE FOR ASSEMBLING AND INSTALLING HYDRAULIC ANCHOR BOREHOLE EXTENSOMETERS

1. PURPOSE

The purpose of this procedure is to establish the requirements and methods for assembling and installing borehole rod extensometers to be used in determining the displacements of rock around underground excavations located at depth in mines.

2. APPLICABLE DOCUMENTS AND REFERENCES

2.1 Center Technical Operating Procedures, including TOP-014, Procedure for Drilling a Borehole for Transient Pore Pressure Piezometer Installation.

2.2 Geokon MPBX (Multiple, or current version - Point Borehole extensometer) Assembly and Installation Instructions.

3. RESPONSIBILITY

3.1 The Element Manager shall be directly responsible for implementation of this procedure. In cases where the Project Engineer is not a member of the CNWRA, the Project/Element Manager shall retain this responsibility.

3.2 Installation team members assigned by the Element Manager are responsible for performing the test activities in accordance with this procedure.

4. DESCRIPTION OF THE EXTENSOMETERS

4.1 General

A rod extensometer is a device used to determine the relative movement of the rock mass at a down-hole location. The rod is anchored to the borehole wall at a down-hole location using an anchor of some type. Anchors available include wedge, hydraulic, snap-ring and groutable. A connecting rod runs from the anchor to the borehole collar, and transmits the displacement by rigid movements along the hole. The displacement at the collar may be monitored manually (using a depth micrometer) or remotely using a transducer such as a linear

potentiometer, LVDT, or vibrating wire transducer. These devices are generally connected to a remote DAS where voltage or frequency is converted to displacement via calibration constants. Procedures are given in section 5 for installing a Geokon Model A-5 hydraulic anchor extensometer which has 5 anchors and connection rods in a single borehole of 3" nominal diameter.

4.1.1 The following procedures for the installation ofborehole extensometer systems results from site specific needs at the Lucky Friday Mine near Mullan, Idaho. Although specific numerical values are identified for clarity in TOP presentation, the cognizant representative for the CNWRA at the field site shall have final approval authority over the installation. This is necessary due to changing conditions in mine operations and the uncertainty of strata characteristics prior to drilling boreholes.

4.2 Site Selection and Drilling of Boreholes for Extensometers

The extensometers (MPBX's) are to be installed in the 5210, 100 and 95 sublevels at the Lucky Friday Mine in Mullan, Idaho. The site is to be chosen close to the stope crosscut, but within good ground in the 5210 sublevel ramp. The exact location is not critical, and may be chosen by the Site Liaison with the approval of the Project Engineer.

At each installation site, five radially-oriented boreholes shall be drilled for installation of the extensometers. The layout of the boreholes at each site is shown in Fig. 1. The boreholes are to be 27 ft in length (2 ft longer than the deepest anchor point), 3 inches in diameter. Drilling shall be either percussion or diamond coring in order to obtain samples. The appropriate method will be selected in advance by the Project Engineer. The following conditions and procedures shall be used for hole drilling:

4.2.1 The Project Engineer shall determine the location of the hole collars. The holes shall be given a

number using the scheme given in Fig. 1 such that the hole in the floor is designated as number 1 and the remaining holes have numbers increasing in the clockwise direction when facing towards the stope. This hole identification number shall be initially sprayed onto the tunnel wall and, later, marked on the head assembly of the extensometer unit with an appropriate stamp or tag. The hole collars shall be located approximately as per Fig. 1.

4.2.2 The rock at each collar location shall be barred down to remove loose rock.

4.2.3 The borehole shall be aligned such that the drill string may be oriented at approximately 90° to the strike of the ramp axis. The angle of the drill string shall be determined using a Brunton-type geologist's compass to within a few degrees of the desired angle. This angle shall be reached for orientation for each borehole.

4.2.4 Once the correct collar location and drill alignment have been set, the holes shall be either percussion or diamond drilled.

(a) Percussion drilling: If boreholes are to be percussion drilled, drilling shall be carried out in accordance with normal mine practice.

(b) Diamond drilling: This method of drilling may be selected in order to obtain core samples from the site, in addition to producing the borehole. Procedures shall be adapted to ensure that the core is obtained, logged, and stored in a suitable manner. These procedures are described in TOP-014, Sections 4.4 through 5.2 inclusive.

4.2.5 After the hole is drilled, its length shall be determined (to ensure that it is long enough) and it shall be washed and blown clean using the drill or a blow-pipe. The length of the hole and its identification number shall be recorded in the Scientific Notebook.

4.2.6 As shown in Fig. 2, a recess in the tunnel floor at the collar of the drill hole shall provide room to recess the instrument head in order to avoid damage from vehicles. A recess hole measuring approximately 2 ft x 2 ft x 2 ft and a shallow trench (for the passage of the cable) shall be mucked-out or blasted in the floor (Fig. 2). The hole shall be collared in the bottom of this recess.

4.2.7 After completion of the drilling, the location of the hole collars shall be identified approximately by tape measurement from the nearest survey plug located in the mine roof. These coordinates shall be written in the Scientific Notebook.

4.2.8 A sketch of the tunnel section where the extensometer holes are drilled shall be made in the Scientific Notebook. Dimensions of the section (sufficient in number to define the shape) shall be measured and marked on the sketch. The hole inclination and collar positions shall be marked on the sketch along with sufficient measurements such as height above floor, distance from wall, etc., to locate the holes.

5. ASSEMBLY AND INSTALLATION

5.1 Procedure

The MPBX's shall be assembled underground, as a unit, in close proximity to the holes. After completion of assembly, the instrument shall be inserted into the borehole and the anchors inflated. The transducers shall be set at their midrange travel position and connected to the DAS for monitoring.

If pre-assembled extensometers (e.g., fiberglass rod type) are used, the units will be coiled but fully assembled ready for installation. Some types of rod extensometers require assembly. Specific assembly procedures for these MPBX's shall be as follows.

5.1.1 Assemble each rod of the extensometer by coupling the individual rod segments which are cut to length and bundled by the manufacturer. Apply a commercial thread seizing compound (e.g., Loctite) to each connection to avoid slippage of the threads. When each rod has been assembled, clean them with a lubricant such as WD40 to ensure all traces of seizing compound have been removed. Lay the rods with head-ends at the same position and measure them to ensure proper relative rod lengths.

5.1.2 Oil the rods using a light weight oil and insert them into PVC conduits, if required.

5.1.3 Cut protective PVC conduits for the rods to length such that 11 1/2" of the stainless measurement rod protrudes from the end of the PVC conduit. Stagger the conduit couplings for the rods by more than 6" to avoid interfering with anchor movement. Cut the PVC conduit to final length upon completion of the head assembly (it is to be left slightly long at this stage). Glue the sections of conduit together using the couplings and PVC cement provided by the manufacturer and allow them to dry. The last section of conduit at the head-end is not glued so that it may later be trimmed to length.

5.1.4 Starting with the shortest rod, couple it to a hydraulic anchor using the thread seizing compound. In turn, going from short to long, thread each rod and conduit through the successive anchors and connect them.

5.1.5 At this point, ensure that the rods are fully connected to their hydraulic anchors and are positioned properly for insertion into the hole. Also ensure that the head-end of the rods are roughly lined up for connection to the head assembly. The following numbering convention, or an equivalent, shall be used for connecting rods to anchors:

Rod/Anchor #		Depth From Collar (ft)
1	shortest rod	5
2		10
3		15
4		20
5	longest rod	25

The rods shall be tagged at this stage to indicate their length using the following scheme.

(a) Affix a single wrap of black electrician's tape around the conduit for each number in the table in Section 5.1.5. In this manner, rod #1 will have a single ring near the head-end, whereas rod #5 will have 5 rings near the head-end.

(b) Tie a metal or plastic tag to the rod, with the rod number and footage imprinted or stamped on it, using electrical cable tie-wraps near the head-end of the conduit. This tie-wrap shall be removed prior to insertion into the hole.

5.1.6 Each hydraulic anchor has its own pressure tubing line which shall be brought out of the borehole inside the collar stabilizer standpipe. These tubes (generally 1/8" diameter) shall be clearly marked with the anchor number at their ends opposite the anchor. Again, two separate markings shall be used in case one should become damaged. The system described in Section 5.1.5 above, or equivalent, shall provide positive identification of the tubes. Uncoil and pull the hydraulic lines parallel to the rods. The lines shall be taped or tie-wrapped to the rods at convenient intervals or locations. Note that the hydraulic lines pass over the anchors.

When the anchors are inflated, the tubes will be

crushed against the wall of the borehole. Consequently, the order in which the anchors are inflated is critical.

5.1.7 Pull the rods and their PVC (if used) conduits through the standpipe with its attached flange. Note that the extensometer head comes assembled from the manufacturer with the linear potentiometers in place and connected to the cabling. This is done so that the internal connections between the potentiometers and cable can be potted in place with a resin to waterproof them. The Geokon model 1500 to be used has the cores of the potentiometer protruding from the head housing. The body of each potentiometer is fixed in place internally with a screw which can be accessed from the exterior of the head if more range is required at some later date. The head also has a threaded end which connects to a standard pipe flange for coupling to a 2'-3' section of 3" pipe which acts as a standpipe or collar stabilizer tube for the head assembly.

5.1.8 The potentiometers are then connected to the proper anchor rod by screwing the potentiometer core down on the rod end. Thread seizing compound shall not be used on this connection. The number of the potentiometer (1 through 5) is stamped on the head assembly at the potentiometer location. This number identifies the number of the anchor rod. The extensometer anchor number, depth from collar and serial number shall be recorded in the Scientific Notebook and checked by the Project Engineer for correctness.

5.1.9 Pull the flange from the collar tube up to meet the flange from the instrument head and bolt the two together.

(a) Check the rods and anchors to ensure that there is no twisting. The rods shall then be taped or tie-wrapped every few feet along their length to retain alignment and to

prevent slippage of the rods from the bundle during installation. The tie-wrapping will be checked to ensure that it does not interfere with free movement of the rod.

(b) The extensometer assembly is complete at this point.

5.2 Installation

5.2.1 The extensometer assembly shall be lifted and inserted into the borehole slowly. In downward directed holes, it is essential that the rods be held securely near the head assembly to ensure that no anchor drops, damaging the potentiometer. The extensometer shall be inserted into the hole until the flange of the collar stabilizer tube contacts the rock surface. A final adjustment of the rods shall be made to ensure that the potentiometer cores have not been pushed too far out during the installation.

(a) Note that minor adjustments to set the response to midrange will be carried out later by repositioning the body of the potentiometer relative to the collar stabilizer tube.

(b) The anchors shall now be expanded and set in the borehole.

5.2.2 Starting with the deepest (longest rod) anchor, the hydraulic line shall be connected to a hand oil pump. Prior to inflation, the Project Engineer shall check to ensure that the proper anchor has been selected. Verbal approval only shall be required to proceed. Each anchor has a check valve which will hold pressure and bleed-off is not a concern. The order of anchor pressurization and setting pressure for each anchor shall be recorded in the Field Notebook. The anchors shall be pressurized sequentially from the deepest (longest rod) to the shallowest using approximately 1400 psi, so that tubes will not be crushed (5.1.6.1).

5.2.3 The linear potentiometers shall now be set in midrange. The manufacturer's suggested excitation voltage shall be applied and the output monitored on a digital voltmeter. The potentiometers shall be set roughly at midrange of the output by:

- Loosening the set screw which holds the body in place and sliding the body in or out, or
- Physically moving the head by moving the collar stabilizer tube in or out.

When the pots have been set, the collar stabilizer tube shall be fixed in place by pressurizing the hydraulic anchors which are connected to it. This shall be carried out in the same manner as with the downhole anchors. A final, accurate determination of the anchor depth from the hole collar shall now be made. The distance from the top of the potentiometer core to the underside of the collar stabilizing tube flange shall be measured to the nearest 0.5 inch. This distance (Fig. 3) shall be subtracted from the length of the anchor rod plus the length of the potentiometer core, i.e.:

$$L = RL + CL - CF$$

where

L = Length to center of anchor from the borehole collar,
RL = Rod length to center of anchor,
CL = Length of core of potentiometer,
CF = Core-flange length.

This calculation shall be presented in the Scientific Notebook for each anchor and shall be checked by the Project Engineer.

5.3 Connection to the DAS

The color code for the wiring for each extensometer head

is supplied by the manufacturer and shall be transferred to the Scientific Notebook and used when connecting to the DAS. The cable shall be run along the tunnel roof to the DAS box. The connection shall be made by connection of the excitation and signal leads to appropriate terminal strips in the DAS box. The Project Engineer shall be responsible for checking the final connection to the DAS. A final check shall then be made through the entire system. Monitoring can start immediately, and the raw output voltages monitored and recorded to ascertain whether or not the transducers are within the proper output range, and that the output is stable with time. Polarity for transducer displacement (inward/outward) shall be determined.

6. RECORDS

6.1 The Scientific Notebook used to record information relating to the extensometer installation shall contain the following: Date, full name, initials or assigned stamp of individual(s) performing the installation, a sketch of the tunnel section, showing dimensions of the tunnel and extensometer hole locations (see Section 4.2.8), depth of each borehole, measured from the collar, equipment used; including trade names, model number, serial number and calibration information, type of drilling used, and numbers of core boxes associated with each hole if diamond drilling used, borehole identification number, anchor number and depth from collar (see Section 5.1.5), depth of collar recess, if recess used (see Section 4.2.6), initial readings of extensometers from the DAS.

6.2 Each project shall have its own controlled Scientific Notebook with bound and numbered pages. Maintenance of the Notebook shall be the responsibility of the Project Engineer/Element Manager until project completion or termination. At that point, the Notebook(s) shall be retained, as QA records in accordance with CQAM Section 17 for six years as primary evidence of work accomplishment.

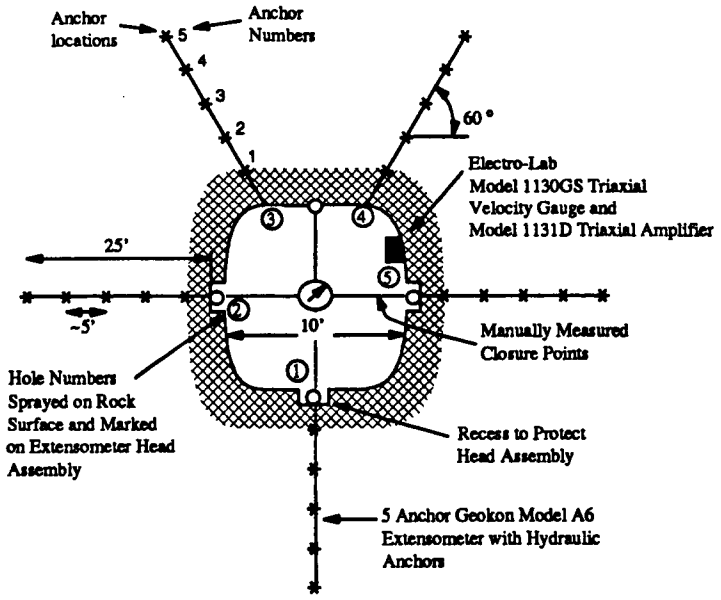

Figure 1. Approximate Locations of Extensometers Relative to Tunnel Cross-section. View Looking Towards the Stope and Away from the Ramp.

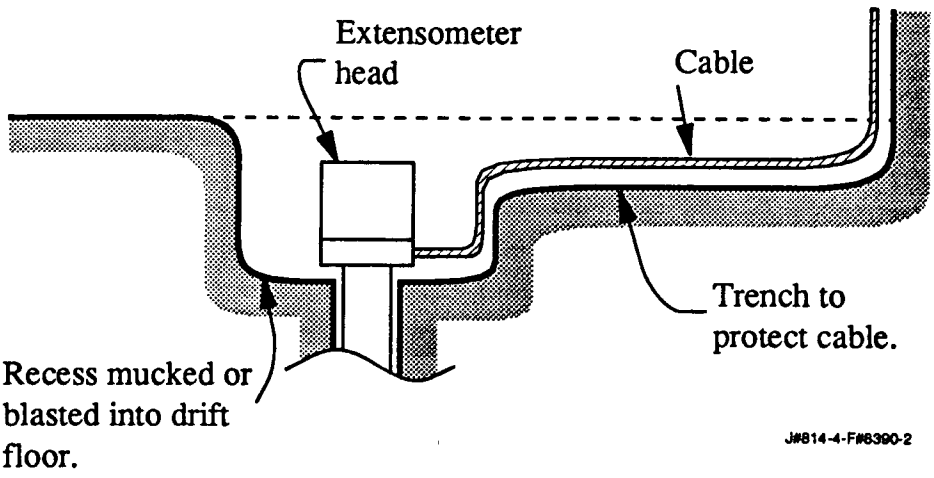

Figure 2. Schematic Through Drift Showing Recess in Floor and the Cable Trench

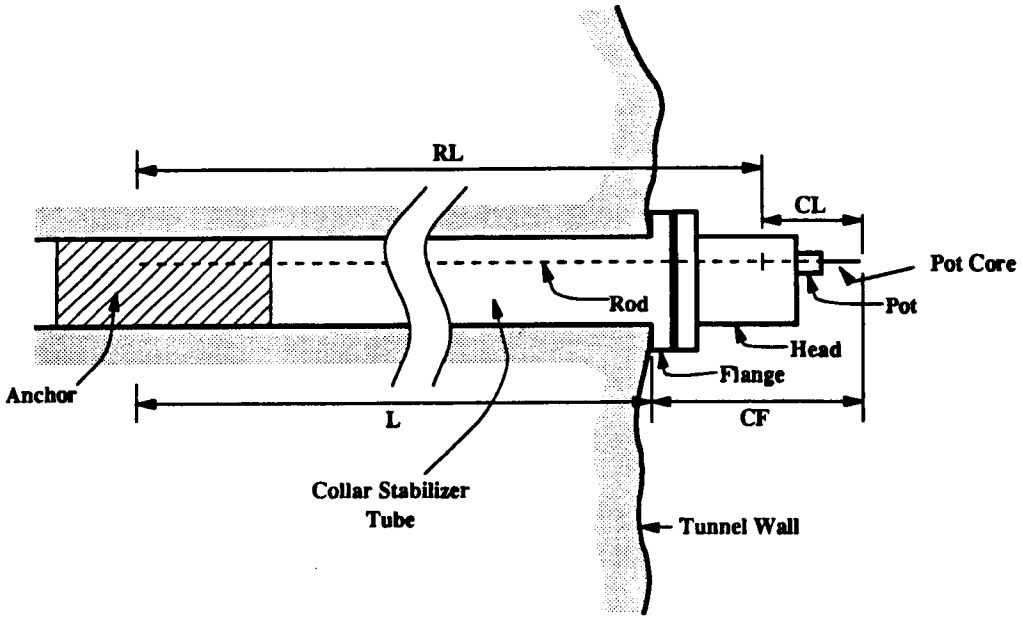

Figure 3. Schematic of Assembly for Measurement of Anchor Depth