SMART CABLE INSTALLATION INSTRUCTIONS

(UNPLATED CONFIGURATION)

Overview

This document describes the installation of Mine Design Technologies' (MDT) SMART Cable Bolts for an un-plated configuration (i.e. instrument head at the hole collar). This document is intended to provide an overview of the installation only. There may be conditions at your operation that require an alternate form of installation, or modifications to this procedure. However, following the instructions contained herein indicate a successful installation procedure, and the one recommended by MDT. It is recommended that you read the entire document prior to attempting installation.

Instrument Description

Each SMART cable consists of 4 main components:

- The cable, which can be either plain strand or bulge configuration. Internal to the cable is a stainless steel tube (king tube), which contains a miniature 6-wire extensometer. Each extensometer wire is anchored at a user-specified point along the length of the king tube. The other end of the extensometer wire is inserted into the instrument head.
- The instrument head, a 33 mm tube containing the electronics for converting the displacements experienced by each of the extensometer wires into a voltage.
- The leadwires, which carry both the excitation voltage for the potentiometers in the readout head and the return voltages registered by each of the anchor positions. To provide protection for the leadwires, a UV-HDPE sleeve is used. This also permits the leadwires to be shotcreted in place if protection from blast damage is required.
- The connector, which is used to connect to an MDT readout unit. A "pig" (female connector on one end and bare wires on the other), which allows the SMART cable to be connected to a third party, supplied data logger, is also available.

All of our SMART cables are carefully manufactured. Once assembled, each cable is laid straight and flat and a set of measurements at each of the anchor locations is taken with a handheld readout unit. The instruments are then coiled on a 1.2 m (4 ft) diameter for shipping, and held together with banding. Each cable is individually coiled and strapped; the coiled leadwires are held to the SMART cable with tie wraps. At this time a second set of readings is taken. Comparison between these two sets of readings allows us to confirm that the cables are performing as designed.

Unit 6, 1045 John Counter Blvd · Kingston, ON, Canada K7K 6C7
tel: (613) 549-5223 · fax: (613) 549-4120 · e-mail: info@mdt.ca · www.mdt.ca

Photo 1: Coiled SMART cable as it arrives on site.

Following testing, the SMART cables are packaged and shipped to the site. Multiple items will be placed in a protective crate or banded to a wooden pallet. It is recommended that you keep the instruments in the crate or pallet until you are ready to install them. If you are installing multiple instruments at the same location and your facilities allow it, you may wish to consider moving all of the SMART cables to the installation site in the shipping crate.

Check Your Holes!

Before you do *anything* else, check that the instrument holes. Make sure they have been drilled to the correct length, and have been drilled at the correct diameter. To check the length, run a length of grout hose up the intended borehole. Wrap a piece of electrical tape around the grout hose where it meets the collar of the hole. Extract the hose, and compare the length to the instrument length shown on the label on the SMART cable head. The hole should be long enough to accommodate the instrument, with the end of the head (nearest the leadwire) recessed in the hole by about three inches.

Check the hole diameter using a ruler. The minimum diameter for a single SMART cable, toe-grouted, is 2 inches; for twin-strand toe-grouted SMART cables, the minimum hole diameter is about 2 ¼ inches.

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Unpacking/Uncoiling

Our SMART cables are designed to survive in the harsh mining environment. However, they are still sensitive geotechnical instruments and must be treated with care during unpacking and installation. Rough handling should be avoided.

Carefully lift the instruments out of the shipping crate, or, where instruments have been shipped individually, cut the plastic and bubble wrap off the outside of the SMART cable. Care should be taken when removing the bubble wrap, as although most of the leadwire is protected with UV-HDPE, there is typically four to five metres of unprotected leadwire between the end of the UV-HDPE and the connector. Nicking or cutting this unprotected wire could allow moisture to enter the system, affecting the instrument readings.

Place the coiled cable on a flat surface in preparation for uncoiling. Ideally, this surface should be clean and dry to prevent mud from getting into the strands of the cable, impacting the bond of the cable with the grout. If it is not possible to uncoil on a clean surface, then the cable, and particularly the bulges, will need to be cleaned before the cable is inserted into the hole. In areas where the drive or drift is very muddy, it may be prudent for a skilled cable bolting crew to uncoil and install a SMART cable from a scissor lift. However, this can be a risky proposition, and is only recommended where a "clean" install from the ground is unlikely, and a skilled crew is used.

To uncoil the instrument, perform the following steps:

1. Cut the cable ties that hold the coiled leadwire to the cable and lay the leadwire off to the side where it won't interfere with the rest of the uncoiling process, or with any vehicular traffic. If the installation is being performed from the bed of a scissor truck, it is best to install the cable first, and then uncoil the readout wire. This will help to keep the deck of the scissor truck less cluttered.
2. Stand the coiled cable in a vertical position with the head positioned on the bottom and parallel to the ground.
3. While one person holds the cable in the vertical position, have a second person cut the banding that holds the cable together starting at the band closest to the head. Keep the band being cut close to the floor of the drift. As each band is cut, the person holding the cable should roll it out along the floor of the drift until the next band is encountered. When all of the bands have been cut in this manner, the SMART cable should be stretched out along the floor of the drift or excavation.

   There is a lot of stored energy in the coiled cables. It is imperative that care be taken during the uncoiling process to ensure that personal injury or damage to the instrument does not result.

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Once the cable has been uncoiled, it is recommended that a reading be taken for all the anchor points. The readings for each anchor should be between 025 and 060 on the handheld readout unit. This will ensure that the instrument is working properly before it is inserted into the borehole. If there are any problems with the SMART cable at this point, contact MDT for further instructions.

Installation

Cable hangers are supplied with each SMART cable. These are normally shipped in a plastic bag in the same crate as the instruments. To install the cable hangers, take two of the spring steel pieces and place over the bolt on the end of the cable. Tighten these to the cable in an X using the supplied nuts (Photo 2).

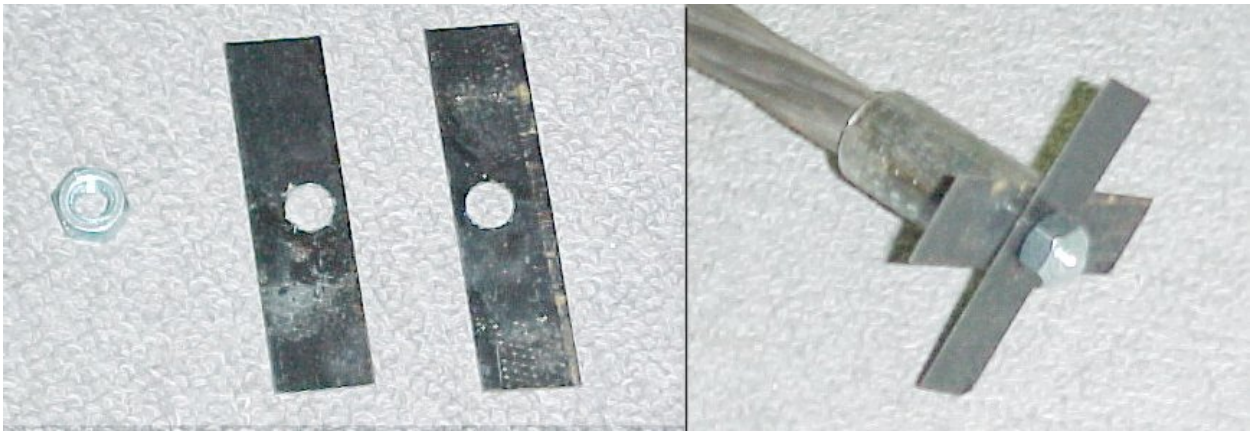

Photo 2: Spring steel cable hangers, unassembled and assembled.

If you are installing bulge cables, use one of the supplied wire cable hangers, as shown. Pass the hanger through a bulge close to the instrument head. This will make sure that the instrument does not slide out of the hole (Photo 3).

Unless this is a special installation, SMART cables should be installed in the same configuration as the other cables at your operation, particularly if they are being installed as part of a regular cable bolt array. At this point, make any adjustments to the cables as required by your operation. This will include attaching a grout hose or a breather hose, and/or the addition of a second cable (for twin-strand installations). When attaching the grout or breather hose to bulge cable, make sure not to tape over any bulges, and ensure that the hose runs at least to the end of the longest cable in the hole.

If twin strand cables are used, attach the second cable to the SMART cable as per your operational specifications. When adding a second cable on site, it may be necessary to flatten a bulge to allow the second cable to run past the SMART cable head to the collar of the hole. Note

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that the second cable should also have end-holding devices attached as discussed above, and should not just be taped to the SMART cable – the weight is too great, and the cables could be pulled from the hole.

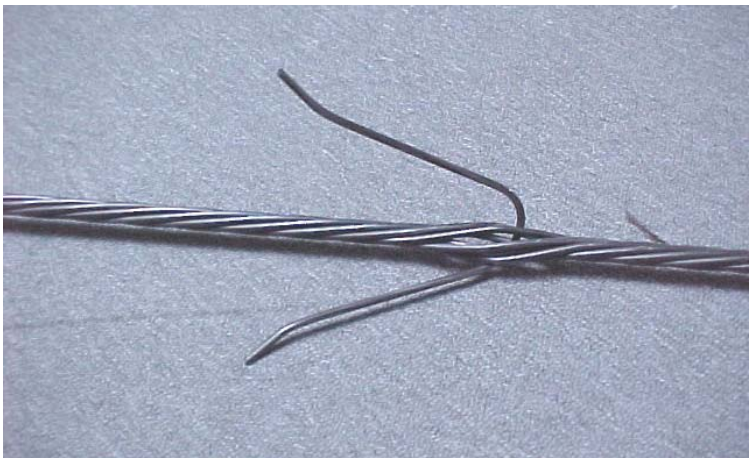

Photo 3: Wire hanger inserted through bulge in cable.

If requested at the time of ordering, MDT will ship cables already twinned and ready for installation. When installing an MDT-prepped cable set, always put the secondary wire hanger (Photo 3) through a bulb on the SMART cable, and not the un-instrumented cable.

Take a moment to make sure that the cable is clean and free from mud or dirt. It is particularly important to make sure that the bulges are clean and free from dirt. Failure to follow this step can result in sections of the cable not bonding properly to the rock. If the cable bulges are filled with debris, no grout will be able to penetrate them. Consequently, when the cable begins to take load, the bulges can collapse, causing the cable to either pull out, or to fail prematurely.

Shove the SMART cable into the hole so that the instrument head is two to three inches inside the collar of the borehole. With the head in this position, the leadwires should come out of the hole at a low angle and be able to lie flat against the rock face. If desired, the instrument head can be held in the hole using wedges. If the leadwires have not been uncoiled already, you can do so now. Tie-wrap the cable to the back (using the procedure described below) for about 1 metre from the collar to keep it out of the way of the borehole collar during grouting.

Grouting

To ensure consistency, especially when installing SMART cables as part of a regular ground support pattern, the SMART cables shout be grouted using the same procedure as for regular cable bolts. This will ensure that the SMART cables are responding in the same fashion as the other cables in an array.

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The two common methods for cable bolt grouting are the breather tube and toe-grouting methods. Tips for each of these methods are presented below:

Tips for breather tube method:

1. The common problem with the breather tube method when installing SMART cables is that it is difficult to "seal" the hole at the collar and still be able to push the SMART cable to the required depth. The most common method of sealing the collar is to wrap burlap around the cable and add the tubes in each successive layer of burlap. If this method is used with SMART cables, the burlap "plug" ends up being about 0.75 metres up the hole, resulting in a head that is debonded. Depending on the anchor locations of the cable, this could also result in the #6 anchor (the one closest to the instrument head) being debonded. To prevent this from occurring, it is recommended that the cable crew install the cable using the 2-hanger method presented above. A small amount of burlap can be pushed in the space around the head and tubes at the collar. The collar can then be foamed with expansive foam to provide the seal.
2. The diameter of the head is 33 mm. As a result, there will be occasions where the head, grout tube, and breather tube will not slide into the hole to the required depth. This is usually because the diameter of the head and the tubes is too large for the hole diameter. To overcome this, flatten the grout tube slightly where it runs alongside the head (making it oval in shape). It is important not to "overflatten" the grout tube as it can become weakened, and rupture during the grouting phase. Under no circumstance should the breather tube be flattened!

Tips for toe-grouting method:

1. The use of wedges at the collar is an effective means to keep the grout in the hole. However, caution is required to make sure that the grout tube is not pinched during the wedging process. As the grout column descends to the collar of the borehole, it hits the restriction of the head-wedge combination and is held in the hole. In order to grout without some form of collar restriction, a 0.35 – 0.38 w:c (water to cement) ratio would need to be pumped. This is a risky proposition, particularly towards the end of a batch where the grout tends to thicken up.
2. If a grout tube bursts, or it becomes apparent that complete full column grouting cannot be achieved with the existing tube, it is possible to introduce a new grout tube. Cautiously remove the wedges and slide a fresh tube up the hole beside the original tube. Push the tube until resistance from the grout column halts penetration. At this point the wedges can be replaced and grouting restarted.

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Securing the Instrument Leadwires

The final step in the installation process is to secure the instrument leadwire to the back or wall of the excavation. The main objective here is to keep the cable tight to the back or wall so that it is out of the way, and cannot be damaged by a passing vehicle.

If there is screen in place, use cable ties to affix the leadwire to the screen. Ideally the cable ties should be placed every 0.25 to 0.5 metres when shotcrete is to be applied, and every 0.75 to 1.0 metres when the leadwires need only to be suspended out of the way. If screen is not being used, try to tie the leadwires to existing ground support, or to services (air and water pipes, for example) that are nearby. When following other services, do not tie the readout wires to other AC electrical conductors as this may introduce electrical "noise" into the instrument readings. Efforts should also be made to "skirt around" electrical substations and transformers.

If you are installing the SMART cables in an area where blasting is occurring (i.e. in a stope, or in a drift where active development is ongoing), it is strongly recommended that the leadwires be shotcreted to the back or walls. It has been our experience that an active blast wave can easily tear the leadwires from the back, thereby affecting the functionality of the SMART cable. While the UV-HDPE covering does provide some protection, it will not protect from these types of damage. If the leadwires are to be shotcreted, they should be attached to the back or walls along a bolt line, where any shearing action along the rock will be minimized. This will help to minimize damage to the leadwires due to movement of the rock itself.

Shotcrete the leadwires in the usual manner, making sure that there are no voids behind the leadwires, and that the leadwires are completely covered.

Initial Instrument Reading

There are three readings taken during the installation of a SMART cable. The first is done after the cable has been uncoiled, either on the scissor truck, the floor of the work area, or up the borehole (before grouting) to check that the instrument is functioning as expected. The second set is taken after the grouting has been completed, and the third is taken 24 hours after grouting has been performed. These three sets of data should be retained and recorded for each instrument as they can be used to help with diagnosing instrument problems should they arise.

The readings taken after 24 hours of grout cure will be used as baseline readings for all the subsequent calculations. Note that in some cases, curing of the grout can put strain on the SMART cable. If the baseline reading is taken before the grout has cured, the resulting strains may appear bizarre, and won't reflect the actual changes in the ground conditions.

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Data Reduction

If required, MDT can prepare Excel™ spreadsheets for the reduction and interpretation of instrument movement. These spreadsheets will be unique to your site and particular installation. If you have multiple instruments, our MINEMonitor instrument database is recommended. This will keep all of your instrument settings and readings in a single Access™ database, with consistent data interpretation and visualization.

Parting Thoughts

An excellent reference for all aspects of cable bolting for mine operations is available. The title of this reference is Hutchinson and Diederichs' Cable Bolting in Underground Mines (©1996, BiTech Publishing Ltd, Richmond, BC, Canada). It is recommended that the operation get a copy of this reference and follow the installation methods described therein. It is also recommended that regular reviews of the site installation methods be conducted to ensure the crews are following the prescribed guidelines.

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WARRANTY:

Mine Design Technologies (MDT) warrants its SMART Cables (the Product) against defects in materials and workmanship for a period of ONE YEAR from the date of purchase. While MDT's products are robust, they are intended for use in extreme environments where damage can occur from situations beyond MDT's control. Unless it can be shown unequivocally that the product was defective at the time of installation, the product warranty is null and void should the instrument fail after installation.

Except for obligations specifically assumed by MDT under warranty, MDT shall not be held liable for any loss, damage, cost of repairs or replacement, incidental or consequential damages of any kind, whether or not based upon expressed or implied warranty, contract, negligence, or strict liability arising in connection with the design, manufacture, sale, use or repair of the Product(s).

This expressed limited warranty is extended by MDT to the original end purchaser only, and is not assignable or transferable to any other party. This is the complete warranty for the Product. MDT assumes no obligations or liabilities for any additions to this warranty unless made in writing and signed by an officer of MDT. Unless made in a separate agreement between MDT and the original end user purchaser, MDT does not warrant the installation, maintenance or service of this product.

THIS WARRANTY DOES NOT COVER:

a) Defects or damage resulting from the use of the Product in other than its normal and customary manner.
b) Defects or damage resulting from misuse, accident, or neglect.
c) Defects from improper testing, operation, maintenance, installation, alteration, modification or adjustment.
d) Product disassembly or repair in such a manner to adversely affect performance or prevent adequate inspection and testing to verify any warranty claim.
e) Any instrument that cannot be accessed to verify any warranty claim.
f) All freight costs to the MDT repair depot.

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