November 2019
Warranty and Service Policy

Product Warranty

YieldPoint Inc warrants the instruments described in this manual to be free from defects in materials and factory workmanship to the original buyer. This warranty is contingent upon proper use of the equipment and does not cover equipment that has been modified or has been subjected to abusive physical or electrical stresses. YieldPoint Inc., agrees to repair or replace, at its sole discretion, any instrument that fails to perform as specified within 6 months after date of the original shipment from the factory, or 3 months after the date of installation, whichever date comes first.

Yieldpoint Inc., reserves the right to make substitutions and modifications in the specifications of equipment that do not materially or adversely affect the performance of the equipment.

New equipment may be returned within 30 days of shipment with prior approval. New items which are less than thirty days old after shipment may be returned for credit, less a minimum restocking and testing charge of twenty percent of the list price upon factory approval only, provided the customer pays all shipping and handling charges. Specially ordered, or modified goods, or goods which have been used or have been unpacked, or goods which have been shipped more than thirty days prior are not returnable.

The information contained in this manual is subject to change without notice. YieldPoint Inc. makes no warranty of any kind with regard to this material, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. Further, YieldPoint Inc., assumes no responsibility for any errors that may appear in this manual and makes no commitment to update, or keep current, the information contained in this manual.
The **d-CABLE**

*Principle of operation*

The **d-CABLE** is based on a miniature borehole extensometer recessed inside a surrogate tubular king wire. The instrument will measure how a certain point on the cable bolt (node point) moved in moves or stretches response to loading (Fig. 1).

Up to 6 node points may be specified where the extensometer wires attach to the kingwire. Nodal points may be concentrated at locations where it is predicted that the cable will intersect a known geological structure. By convention, node 1 is closest to the instrumentation head and Node 6 is furthest away.

The translation of the six wires is measured by 6 displacement sensors at the head of the device. As the cable stretches each displacement sensor measures the relative displacement between the head and the nodal point \((u_1, u_2, ..., u_6)\). The difference between adjacent nodal points can be used to calculate the strain of the cable,

\[
\varepsilon_{12}\% = \frac{u_2-u_1 (mm)}{x_2-x_1 (mm)} \times 100
\]

or

\[
\varepsilon_{12} (\mu\varepsilon) = \frac{u_2-u_1 (mm)}{x_2-x_1 (mm)} \times 10^6
\]

Where \(\varepsilon_{12}\) is the average strain between nodes 1 and 2. The corresponding load can be calculated by multiplying the strain \((\varepsilon_{12}(\mu\varepsilon))\) by the stiffness of the cable \((30N/\mu\varepsilon \text{ or } 300kN/%)\).

---

**Image Caption:**

\[
\varepsilon_{12}\% = \frac{u_2-u_1 (mm)}{x_2-x_1 (mm)} \times 100
\]
**Figure 1. d-Cable: Principle of operation**

**Output signal**

The output signal from the *d-CABLE* is a digital signal RS485 serial (9600, 8, N, 1) signal with the Serial Number, Sensor Type and data multiplexed on a single twisted pair. The reading comprises multiple values (one for each displacement sensor) directly in **millimeters** so that the user has a direct and immediate indication of cable deformation without having to enter the data in a spreadsheet.

**NOTE:** The YieldPoint manual readout unit (*d-READER*) outputs displacement directly in millimeters (resolution 0.01mm).

YieldPoint’s d-Cable resolves the following issues found with the SMART cable design:

(i) The voltage readings need to be processed in a spreadsheet prior to interpretation. This prevents instantaneous manual interpretation of deformation or load (i.e. Factor of Safety) and the use of local alarm systems.

(ii) The potentiometer displacement transducers are inaccurate (linearity 5%FS) and are susceptible to water and blast damage.

(iii) The analog voltage signal transmitted is not suitable for the harsh mining environment.

**Manufacturing and Calibration**

Very king wire is stretched to establish that the internal wiring is robust and that the wires are in the correct sequence.

Every *d-CABLE* is individually calibrated over the 125mm strope length of the displacement sensors. The calibration data sheets are shipped with every order. There is no need to apply calibration coefficients to the data.
### Figure 2: A typical calibration result
INSTALLATION OF THE d-CABLE

If there is no need to install a face-plate on the d-CABLE then it can be installed just as regular cable-bolt (HaC)

If a faceplate must be installed it important to inform YieldPoint Inc. at the time the instrument is ordered. The most effective strategy for installing a faceplate is to recess the instrumentation head to the toe of the borehole (HaT) and retrieve the lead-wires through a continuous steel conduit. The steel conduit is attached to the cable with the BLACK cable ties which should not be removed during installation. A slotted plate is provided through which to run the conduit.

For customers using HaT configured cables, contact YieldPoint for information concerning the slotted faceplate.

**Figure 3.** The 3 possible options for installing a d-CABLE. Option 1 is not plated and Option 3 is the preferred option for a plated cable.
Plate thickness = 8-10mm

**Figure 4.** The 3 possible options for installing a d-CABLE. Option 1 is not plated and Option 3 is the preferred option for a plated cable.

**Uncoiling the d-Cable.**

1. Plug the cable into the d-READER and take a reading with the instrument coiled. The instrument will scroll through its anchors. The readings should be approx. 20mm.
2. Cut the smaller white cable ties to release the regular lead wire from the cable.
3. Holding the head of the cable carefully cut the large black cable ties beginning at the toe of the cable. This is most easily accomplished with the cable in an upright orientation. Remember: considerable energy is stored in a coiled cable so care must be taken.
4. Lay the cable straight and if necessary straighten the steel conduit. Do not cut the black cable ties.

**IMPORTANT:** For HaT cables The Yellow tape indicates the end-point of the instrumentation array.
Installing the cable in the borehole:

5. Blow all down-holes and in general make sure the holes are as clean as possible.
6. In poor ground insert a regular (non-instrumented) cable and grout hose to make sure the borehole is viable.
7. Cut a length of grout hole to the appropriate length for the d-CABLE. Remember to cut the end of the grout hose at a 60 degrees angle to make insertion easier.
8. Securely attach the grout hose to the instrumented end of d-CABLE with electrical tape (toe to collar grouting assumed). The angled end of the grout hose should be within 150mm of the capped CPVC tube at the instrument head.
9. Insert into the borehole carefully by pushing on the grout hose. Tape the grout hose to the d-CABLE at regular intervals during insertion.

Best Practises for grouting.

For mines regularly using cables bolts the d-cable should be installed with exactly the same procedures. Information on best practises for grouting can are here.

Selection of a reference Point.

Since bore extensometers measure displacement then the values need to be referenced to a point that is not moving, or that moves least. This should be considered before instrument installation.

The head or any nodal point can be set as the reference point. For HaC installations the reference point will usually be the most distal nodepoint.
DATA REDUCTION FOR THE d-CABLE

The d-CABLE is based on a miniature borehole extensometer manufactured into a surrogate tubular king-wire. A total of up to six wires are fixed to the king-wire at nodal locations $x_1, x_2, ..., x_6$. Node 1 is always closest to the head. The translation of the six wires is measured by 6 displacement sensors at the head of the device. As the cable stretches each displacement sensor measures the relative displacement between the head and the nodal point $(u_1, u_2, ..., u_6)$. The difference between adjacent nodal points can be used to calculate the strain of the cable,

$$\varepsilon_{12}(\%) = \frac{u_2-u_1 (mm)}{x_2-x_1 (mm)} \times 100$$

or

$$\varepsilon_{12} (\mu\varepsilon) = \frac{u_2-u_1 (mm)}{x_2-x_1 (mm)} \times 10^6$$

Where $\varepsilon_{12}$ is the average strain between nodes 1 and 2. The corresponding load can be calculated by multiplying the strain ($\varepsilon_{12}(\mu\varepsilon)$) by the stiffness of the cable (30N/\(\mu\varepsilon\) or 300kN/\%).

The nodal points can be concentrated at locations where it is predicted that the cable may intersect a known geological feature. The location of the nodal points is specified by the customer.

$$F(kN) = \varepsilon_{12} \times 30,000$$

IMPORTANT: Sensor 1 is closest to the head.
The **d-CABLE** can be applied to any type of cable bolt: Plain Strand, Garford Bulb or de-bonded cable, and the data reduction math does not change. It is also applicable to cables that will be spun in resin and that will be twinned. The user can specify the number of displacement sensors to be arranged along the instrument in order to capture the elongation along the entire length of the cable but maybe with some higher coverage near one end or the other.

**Visualization Using VantagePoint**

Vantage point is a powerful visualization tool for displaying data from the **d-CABLE**.

The configuration of the **d-CABLE** is provided on the last page of the calibration sheet.

![Anchor Location Data](image)

The nodal points can be input into the instrument page in VantagePoint.
Additional information can also be added to the database.

**IMPORTANT:** The nodal points must be entered before the temporal and spatial plots will render.

**Temporal plots**

Temporal plots can be selected for displacement, velocity (disp rate), strain and Load.

*A temporal plot for displacement*
**The corresponding temporal plot for strain**

Temporal plots can be used to associate mining activity events (blasts and seismic events) with the development of instrument load.

**Spatial Plots**

For a multipoint instrument such as a d-Cable a spatial plot is used to represent the profile of displacement, strain or load along the length of the instrument.

**The displacement spatial plot**
The load spatial plot with (top) and without a faceplate.

When the graph is rendered the progressive changes are illustrated in sequence.
TYPICAL APPLICATIONS

d-CABLE have been widely used for many application in both civil and mining projects including:

- Slope monitoring.
- Monitoring cable reinforcement in tunnels and drifts
- Monitoring cable reinforcement in stopes and other large openings
- Monitoring cables in fill mats
- Monitoring ground anchors
- Monitoring strand reinforced concrete
- Monitoring tie-backs