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How to Calculate Cumulative Deflection using an In-Place Inclinometer

MultiLogger Application Note #13

Overview

In-Place Inclinometers are used to provide borehole deformation information by interconnecting a series of inclination sensors using rigid tubing. A deflection profile is constructed by using the cumulative sum of the segment deflections starting with the bottom segment up to the top segment. This Multilogger Application Note will provide information to configure a calculation which represents the sum deflection of the borehole as measured from the top of the borehole referenced to the bottom (which is assumed to have base fixity).

Note: The instruction file referred to in this MultiLogger Application Note was included in MultiLogger beginning with version 3.1.3

MultiLogger Configuration

The configuration involves 3 steps;

1) Configuration of the individual channels, or sensors measuring the angle of each segment.
2) Selection and configuration of the Processing File for each sensor string.
3) Configuration of the Input Location to view and store the result.

Configuration of the Individual Channels

Multiplexers to which the instruments are wired are configured using the **Program | Multiplexers** menu option in the Logger form. Press the **Edit Channels** button to customize each channel. Select the appropriate **Gage Type | Make | Model** for each channel. **Note: The output units for each channel must be in angle, in degrees, for the Processing File to reduce the readings to deflection and then accumulate over the length of the string so be sure to enter the appropriate coefficients to provide for output in degrees. Contact Canary Systems if other units are to be used.**

Selection and Configuration of the Processing File

Processing Files are designed to provide additional measurement reduction, in this case to calculate deflections at each sensor location and provide for accumulating these deflections into an overall deflection for the string.

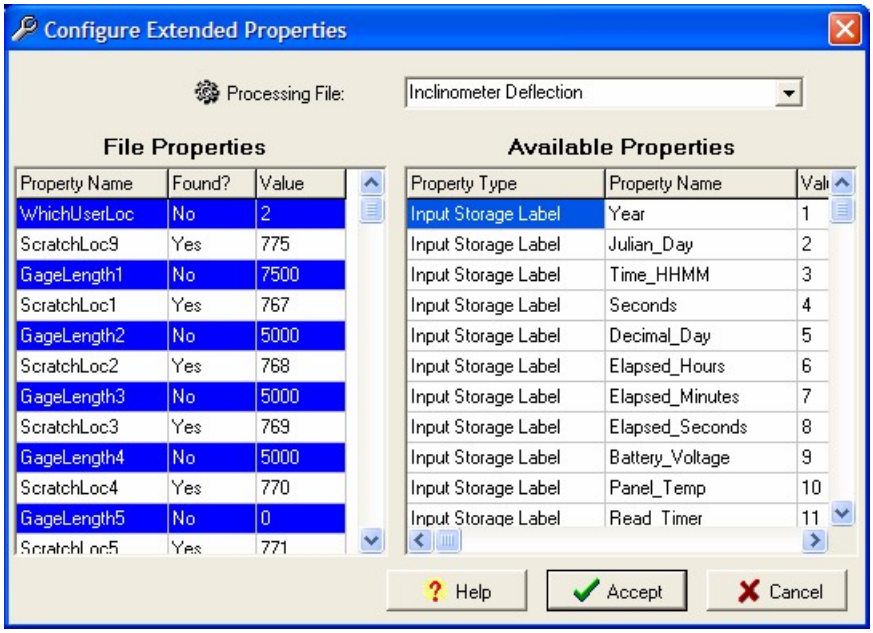
To select a particular Processing File press the Extended Properties button  located to the left of the Model selection on the Channel Configuration form. **(Note: Make this selection on the FIRST channel of each inclinometer string. ALL inclinometer sensors should be wired to the multiplexer from bottom to top, in order.)** This will display the Extended Properties form which allows you select a Processing File and then enter required properties, or values, associated with the Processing File. The default Processing File selected should be **None**, scroll through the drop-down list and select **Inclinometer Deflection**.

Note: If this option does not appear in your list then you will need to obtain an updated version of MultiLogger. Contact Canary Systems or your software vendor to obtain the latest version of MultiLogger.

Once the Inclinometer Deflection option is selected you will see the **File Properties** list shown on the left of the form populated with various File Properties that either have been resolved to a value or need a value.

Note the properties shown in blue in the **File Properties** list, these are properties found in the Processing File that were NOT resolved to a value, they must have a value entered for the Processing File to operate properly.

The display at right illustrates the form with values entered.

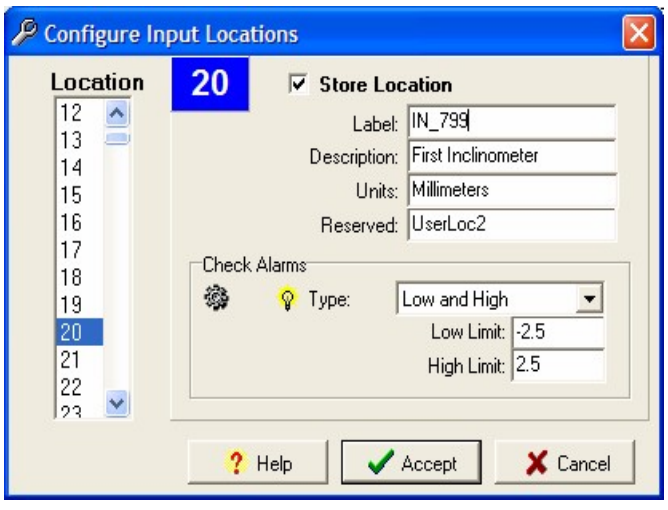


WhichUserLoc describes where to copy the accumulated deflection result, meaning which Input Location to use. Enter a number between 1 and 12. Note: For systems equipped with the VWDSP Vibrating Wire Interface, User Location 1 is generally used to display the Quality value from the VW measurement, so the range of values that can be used is 2 through 12.

The **GageLengthN** values refer to the gage lengths for the individual segments of the Inclinometer String. Units are to be the same as the resultant accumulated deflection, for example if in inches then gage lengths must be entered in inches, if in millimeters then gage lengths must be entered in millimeters. Up to 8 gage lengths may be entered. Enter 0 for gage lengths that will not be used, for example if the inclinometer string consists of 6 segments then enter 0 for GageLength7 and GageLength8. Values are entered by positioning the cursor in the appropriate cell in the Value column, scroll down to access all the values.

Configuration of the Input Location to Store the Result

The third step is configuration of the Input Location which will be used to store the result of the deflection accumulation, or the sum of all the individual deflections calculated from each sensor. Use the **Program | Input Locations** menu option to display the Configure Input Locations form, scroll down the numbered list on the left to location 19. This represents the first of twelve User Locations, or locations available to the user for custom calculations or other outputs. If the system includes a VWDSP Vibrating Wire Interface it is recommended to use locations beginning at 20, since the first User Location is used to provide a vibrating wire measurement quality metric. The screenshot illustrates configuring User Location 2 as an inclinometer deflection location, it also details the optional configuration of alarms.



Inclinometer Deflection Instruction File

The following listing details the contents of the Inclinometer_Deflection.ins instruction file.

```
;---------------------------------------------------------------
;Accumulates Deflection for an Inclinometer String
;All instruments must be on the same multiplexer
;Input is in Angle
;Output is in Deflection - Units dependent upon gage length
;Alex Neuwirt - Canary Systems, Inc. - Oct 15, 2004
;Enter WhichUserLoc for result (corresponds to UserLoc locations)
;Up to 8 Gage Lengths may be accumulated - Enter lengths below
;---------------------------------------------------------------
;Enter WhichUserLoc this is (for UserLoc usage)
;---------------------------------------------------------------
P30    Z=F    ;
1:[WhichUserLoc        ]   F      ;
2:[0                   ]   Exponent of 10      ;
3:[ScratchLoc9         ]   Z Loc  ;
;---------------------------------------------------------------
;Enter Gage Lengths
;---------------------------------------------------------------
;Enter Gage Length #1
P30    Z=F    ;
1:[GageLength1         ]   F      ;
2:[0                   ]   Exponent of 10      ;
3:[ScratchLoc1         ]   Z Loc  ;

;Enter Gage Length #2
P30    Z=F    ;
1:[GageLength2         ]   F      ;
2:[0                   ]   Exponent of 10      ;
3:[ScratchLoc2         ]   Z Loc  ;

;Enter Gage Length #3
P30    Z=F    ;
1:[GageLength3         ]   F      ;
2:[0                   ]   Exponent of 10      ;
3:[ScratchLoc3         ]   Z Loc  ;

;Enter Gage Length #4
P30    Z=F    ;
1:[GageLength4         ]   F      ;
2:[0                   ]   Exponent of 10      ;
3:[ScratchLoc4         ]   Z Loc  ;

;Enter Gage Length #5
P30    Z=F    ;
1:[GageLength5         ]   F      ;
2:[0                   ]   Exponent of 10      ;
3:[ScratchLoc5         ]   Z Loc  ;

;Enter Gage Length #6
P30    Z=F    ;
1:[GageLength6         ]   F      ;
2:[0                   ]   Exponent of 10      ;
3:[ScratchLoc6         ]   Z Loc  ;

;Enter Gage Length #7
P30    Z=F    ;
1:[GageLength7         ]   F      ;
2:[0                   ]   Exponent of 10      ;
3:[ScratchLoc7         ]   Z Loc  ;
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```
;Enter Gage Length #8
P30    Z=F    ;
1:[GageLength8          ]   F      ;
2:[0                    ]   Exponent of 10      ;
3:[ScratchLoc8          ]   Z Loc  ;

;-------------------------------------------------------------
;Obtain Sin and Multiply by Gage Length
;-------------------------------------------------------------
P87    Beginning of Loop   ;
1:[0                    ]   Delay  ;
2:[8                    ]   Loop Count    ;

P48    Z=SIN(X)      ;
1:[MuxReadingLoc++--    ]   X Loc  ;
2:[ScratchLoc10         ]   Z Loc  ;

P36    Z=X*Y  ;
1:[ScratchLoc10         ]   X Loc  ;
2:[ScratchLoc1--        ]   Y Loc  ;
3:[ScratchLoc1--        ]   Z Loc  ;

P95    End    ;
;-------------------------------------------------------------
;Now accumulate
;-------------------------------------------------------------
P30    Z=F    ;
1:[0                    ]   F      ;
2:[0                    ]   Exponent of 10      ;
3:[ScratchLoc10         ]   Z Loc  ;

P87    Beginning of Loop   ;
1:[0                    ]   Delay  ;
2:[8                    ]   Loop Count    ;

P33    Z=X+Y  ;
1:[ScratchLoc1--        ]   X Loc  ;
2:[ScratchLoc10         ]   Y Loc  ;
3:[ScratchLoc10         ]   Z Loc  ;

P95    End    ;

;-------------------------------------------------------------
;Now copy the result to the appropriate location
;-------------------------------------------------------------
P89    If (X<=>F)    ;
1:[ScratchLoc9          ]   X Loc  ;
2:[1                    ]   Comparison Code Option (=) ;
3:[1                    ]   F      ;
4:[30                   ]   Command Code Option (Then Do)     ;

P31    Z=X    ;
1:[ScratchLoc10         ]   X Loc  ;
2:[UserLoc1             ]   Z Loc  ;

P95    End    ;

P89    If (X<=>F)    ;
1:[ScratchLoc9          ]   X Loc  ;
2:[1                    ]   Comparison Code Option (=) ;
3:[2                    ]   F      ;
4:[30                   ]   Command Code Option (Then Do)     ;
```

```
P31    Z=X    ;
1:[ScratchLoc10        ]   X Loc  ;
2:[UserLoc2            ]   Z Loc  ;

P95    End    ;

P89    If (X<=>F)    ;
1:[ScratchLoc9         ]   X Loc  ;
2:[1                   ]   Comparison Code Option (=) ;
3:[3                   ]   F      ;
4:[30                  ]   Command Code Option (Then Do)    ;

P31    Z=X    ;
1:[ScratchLoc10        ]   X Loc  ;
2:[UserLoc3            ]   Z Loc  ;

P95    End    ;

P89    If (X<=>F)    ;
1:[ScratchLoc9         ]   X Loc  ;
2:[1                   ]   Comparison Code Option (=) ;
3:[4                   ]   F      ;
4:[30                  ]   Command Code Option (Then Do)    ;

P31    Z=X    ;
1:[ScratchLoc10        ]   X Loc  ;
2:[UserLoc4            ]   Z Loc  ;

P95    End    ;

P89    If (X<=>F)    ;
1:[ScratchLoc9         ]   X Loc  ;
2:[1                   ]   Comparison Code Option (=) ;
3:[5                   ]   F      ;
4:[30                  ]   Command Code Option (Then Do)    ;

P31    Z=X    ;
1:[ScratchLoc10        ]   X Loc  ;
2:[UserLoc5            ]   Z Loc  ;

P95    End    ;

P89    If (X<=>F)    ;
1:[ScratchLoc9         ]   X Loc  ;
2:[1                   ]   Comparison Code Option (=) ;
3:[6                   ]   F      ;
4:[30                  ]   Command Code Option (Then Do)    ;

P31    Z=X    ;
1:[ScratchLoc10        ]   X Loc  ;
2:[UserLoc6            ]   Z Loc  ;

P95    End    ;

P89    If (X<=>F)    ;
1:[ScratchLoc9         ]   X Loc  ;
2:[1                   ]   Comparison Code Option (=) ;
3:[7                   ]   F      ;
4:[30                  ]   Command Code Option (Then Do)    ;

P31    Z=X    ;
1:[ScratchLoc10        ]   X Loc  ;
2:[UserLoc7            ]   Z Loc  ;
```

```
P95    End    ;

P89    If (X<=>F)    ;
1:[ScratchLoc9          ]   X Loc  ;
2:[1                    ]   Comparison Code Option (=) ;
3:[8                    ]   F      ;
4:[30                   ]   Command Code Option (Then Do)    ;

P31    Z=X    ;
1:[ScratchLoc10         ]   X Loc  ;
2:[UserLoc8             ]   Z Loc  ;

P95    End    ;

P89    If (X<=>F)    ;
1:[ScratchLoc9          ]   X Loc  ;
2:[1                    ]   Comparison Code Option (=) ;
3:[9                    ]   F      ;
4:[30                   ]   Command Code Option (Then Do)    ;

P31    Z=X    ;
1:[ScratchLoc10         ]   X Loc  ;
2:[UserLoc9             ]   Z Loc  ;

P95    End    ;

P89    If (X<=>F)    ;
1:[ScratchLoc9          ]   X Loc  ;
2:[1                    ]   Comparison Code Option (=) ;
3:[10                   ]   F      ;
4:[30                   ]   Command Code Option (Then Do)    ;

P31    Z=X    ;
1:[ScratchLoc10         ]   X Loc  ;
2:[UserLoc10            ]   Z Loc  ;

P95    End    ;

P89    If (X<=>F)    ;
1:[ScratchLoc9          ]   X Loc  ;
2:[1                    ]   Comparison Code Option (=) ;
3:[11                   ]   F      ;
4:[30                   ]   Command Code Option (Then Do)    ;

P31    Z=X    ;
1:[ScratchLoc10         ]   X Loc  ;
2:[UserLoc11            ]   Z Loc  ;

P95    End    ;

P89    If (X<=>F)    ;
1:[ScratchLoc9          ]   X Loc  ;
2:[1                    ]   Comparison Code Option (=) ;
3:[12                   ]   F      ;
4:[30                   ]   Command Code Option (Then Do)    ;

P31    Z=X    ;
1:[ScratchLoc10         ]   X Loc  ;
2:[UserLoc12            ]   Z Loc  ;

P95    End    ;
```