TST – Total Station Training

TOTAL STATION USE FOR THE STRUCTURAL SPECIALIST

October 13, 2007

Session 1-1 **Basics of the NPL-352 and Theodolite Use**
Classroom - 45 minutes

Session 1-2 **Basic Field Set-up and Theodolite Use**
Field - 60 minutes

Session 1-3 **Initial Configuration and Basic EDM Use**
Classroom - 60 minutes

Session 1-4 **Basic Field Use of the EDM**
Field - 60 minutes

Session 2-1 **Advanced Use of Total Station**
Classroom - 30 minutes

Session 2-2 **Advanced Use of Total Station**
Field - 120 minutes

Session 2-3 **Use of Total Station for US&R**
Classroom - 30 minutes

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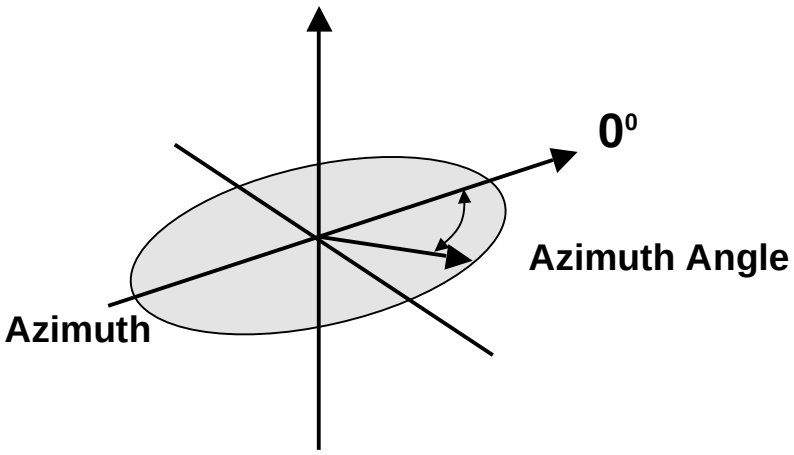
Session 1-1 Measurement Basics and Theodolite Use

Basic Measurement Tools

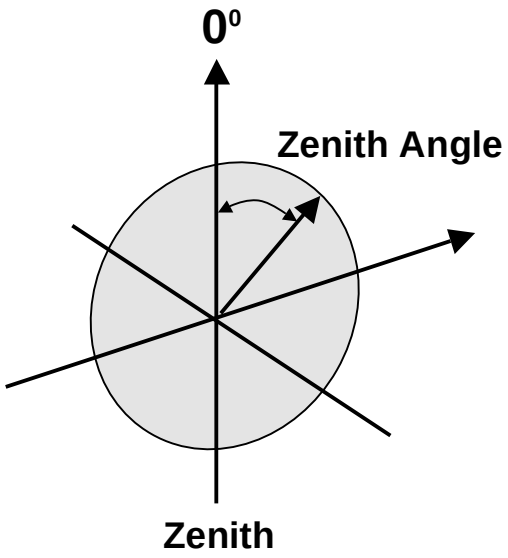
Theodolite vs. Total Station

1) Theodolites measure horizontal and vertical angles.
2) Total Stations combine theodolites with the ability to measure distance.
3) Both can be used as simple point observation devices

Angular Measurement



Azimuth
- Horizontal plane
- 0^o, 360^o is straight ahead
- Angles are measured clockwise



Zenith
- Vertical plane
- 0^o is straight up, usually
- Angles are measured down from vertical

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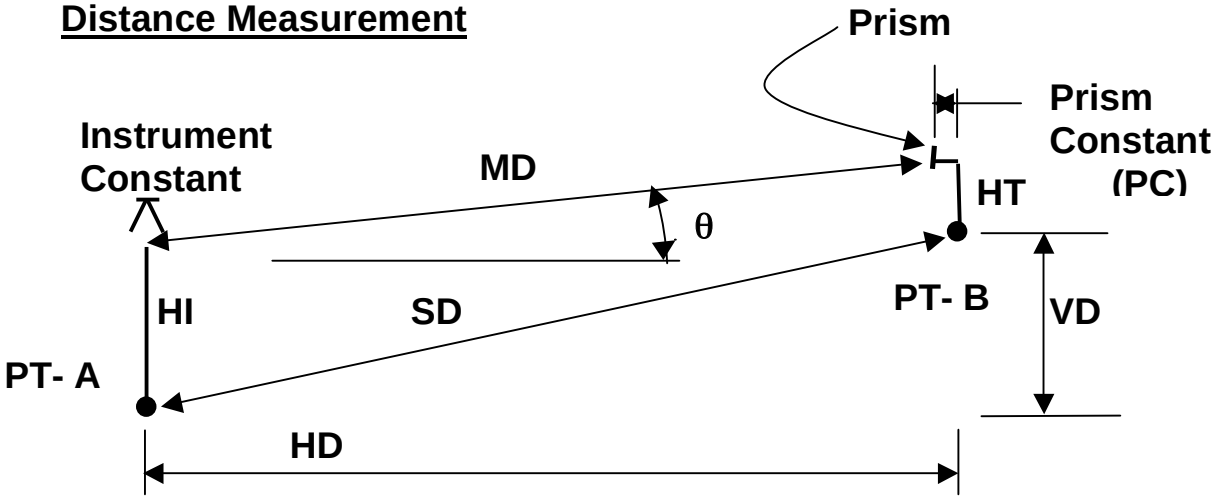
Distance Measurement



HI = the height of the instrument (vertical distance from station point at Point A to axis of telescope).

HT = the height of the target (vertical distance from measured point at Point B to the prism).

MD = the distance measured by the EDM (measured distance from the total station axis to the prism focus).

SD = the slope distance (computed distance along the inclined line from the station point to the measured point).

θ = the angle of the instrument relative to horizontal (90^{o} - Zenith Angle).

HD = the horizontal distance from the station point to the measured point.

VD = the vertical distance from the station point to the measured point.

PC = the prism constant, obtained from the manufacturer of the prism, usually etched on the prism frame. Prisms have different constants (PC):

- Large prism = 30 mm (Not part of cache)
- Mini prism = 18mm
- Reflector sheet = 0 mm
- Prism-less = 0 mm

Instrument Constant = Property of the instrument set at the factory.

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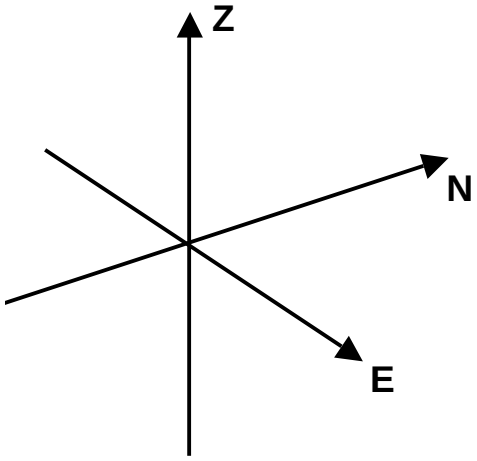
Location Measurement In 3 Dimensions

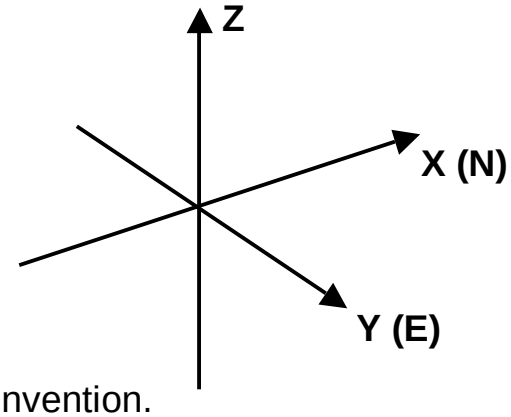
The conventional survey coordinate order is N E Z and the total station normally outputs coordinates as N, E, Z:

- N is Northing (0^o on the azimuth)
- E is Easting (90^o to Northing)
- Z is elevation above N - E plane



Total station can output coordinates as X, Y, Z, but if the coordinate order is set to N E Z then:

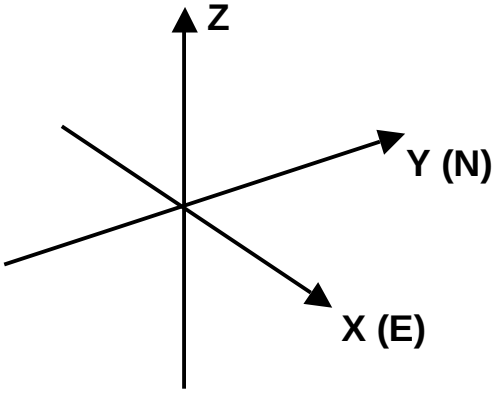
X = N
Y = E
Z = Z



This is different from the normal engineering convention.

To maintain the engineering convention, the coordinate order should be set to E N Z so that:

X = E
Y = N
Z = Z



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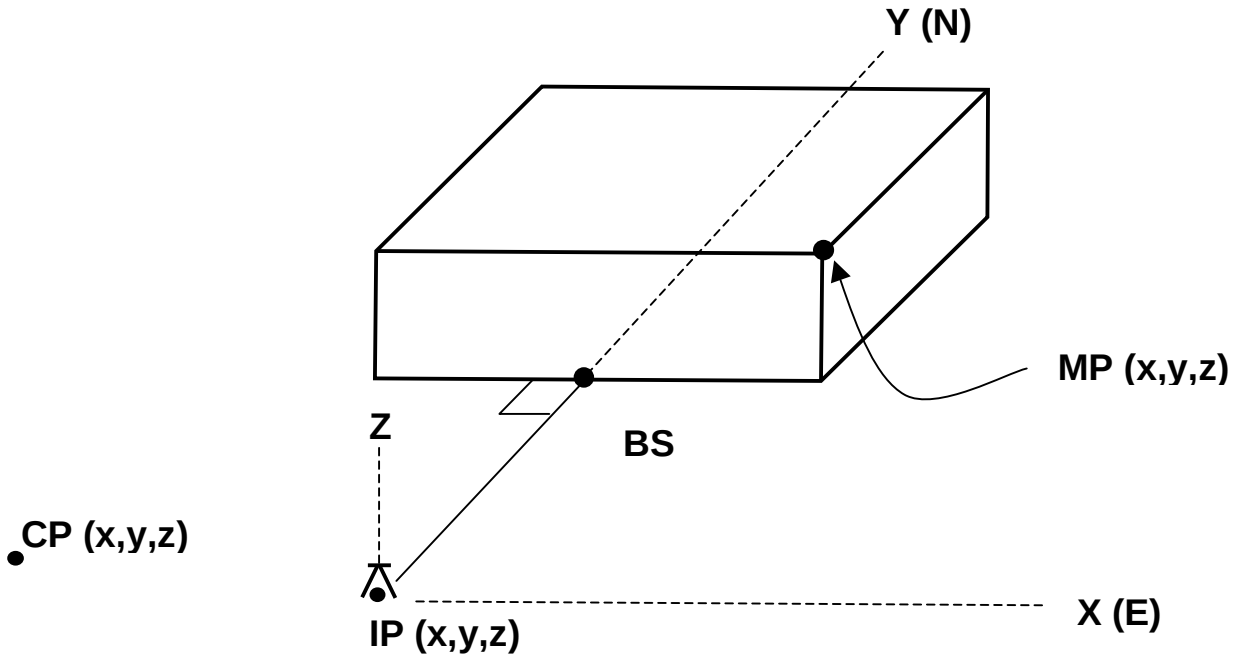
Location Measurement In US&R



MP = Monitoring Point **IP** = Instrument Point **CP** = Control Point

Current thinking for US&R is to set the X axis parallel to the side of the building facing the instrument and the Y axis perpendicular to the building. To do this, a location on the structure is used to set the azimuth angle to 0^o (the instrument refers to the point used to set the azimuth as the back sight, **BS**). The location must be chosen such that the 0^o azimuth is perpendicular to the side of the building facing the instrument.

If creating a new coordinate grid, give the new station widely different coordinates such as: X = 1000.00 Y = 3000.00 Z = 5000.00 Significantly different coordinates are beneficial in the event that E, N, Z is mixed up with N, E, Z. This difference helps the StS quickly translate a change in coordinates to a magnitude and direction of movement.

Once established on a station, set several Control Points (**CP**):

1. They can be used as alternate instrument stations.
2. This allows options if some sites are blocked by equipment or if you need to set up the instrument at a new remote location.
3. This allows choices if reestablishing the grid from a new location not previously located by survey.

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Theodolite vs. Total Station

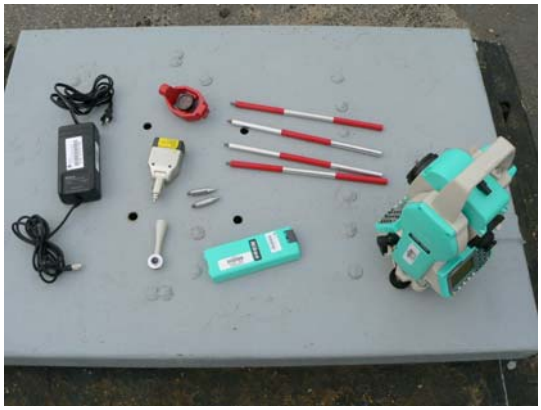
1. Theodolites measure horizontal and vertical angles

2. Total Stations combine theodolites with the ability to measure distance.

Infra-red Light Emitting Diode uses a continuous signal and measures the shift between light emitted by the EDM and the reflected signal to measure distance. A reflecting target such as a prism or reflector sheet is used.

Pulse Laser Diode transmits a timed-pulse infrared signal and measures the time required for the pulse of infrared light to travel from the instrument to the target and back to determine distance. A prism is not necessary, however, this technology has limited distance capability (about 300 feet).

Tools Contained in the Case



1) Nikon NPL-352
2) Mini Prism, Pole, and Tips
3) Batteries and Charger
4) Power Inverter
5) Shoulder Straps
6) User's Manual
7) Instrument Rain Cover
8) Right Angle Eyepiece:

The right angle eyepiece is used when sighting points at angles greater than 45° to the horizontal. The existing eyepiece must be unscrewed from the unit and placed onto the sighting end of the right angle eyepiece.

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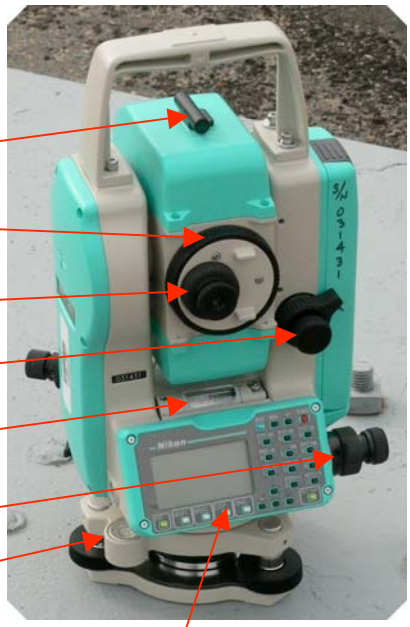
The 2 Faces of the Nikon NPL-352

1) Face 1 of the instrument is the face with the tangent screws.



Tangent screws are not endless

Face 1

Face 2 of the instrument is with the optical plummet eyepiece.

Face 2

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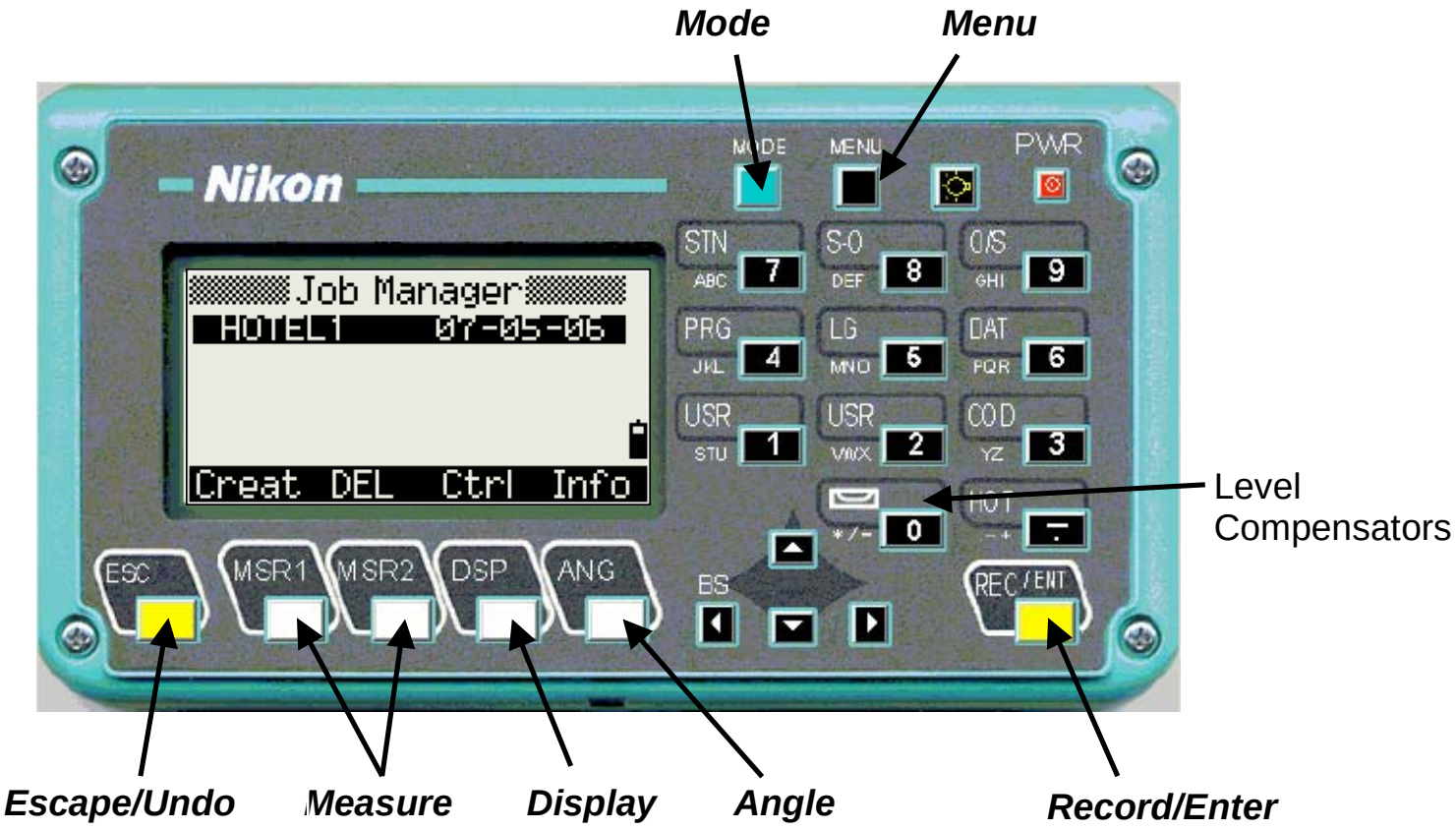
Nikon NPL-352 Key Layout



Added Key Functions

1 - Second Keys

Certain keys have additional functions when pressed and held for one second or more. Nikon refers to these as **1 - Second Keys**. The **MSR**, **DAT**, **DSP**, **USR** and **S-O** keys are all 1-Second Keys. We will address the alternate functions of the keys in a later section of this class.

Soft Keys

The **MSR1**, **MSR2**, **DSP** and **ANG** keys perform additional functions when certain screens are displayed. These keys are referred to by Nikon as **Soft Keys**. For example, in the **Job Manager** screen shown above, pressing the **MSR1** key would perform the function **Creat** displayed in the screen above it, creating a new job. Likewise pressing the **MSR2** key would **DEL**, deleting the highlighted job displayed on the screen. The other soft keys function similarly.

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Packing Up the Nikon NPL-352

1. Adjust the level screws and the tangent screws to the neutral position.
2. Put the telescope in the Face 1 position.
3. Place the instrument in the box with the battery-side up.

If damp, leave the box open overnight to prevent condensation.

The instrument is not watertight with the battery removed, therefore store it with the battery installed.

Keep the spare battery charged in the box.

It is suggested that the batteries for the NPL-352 be marked with the serial number of the machine they are packed with to assure that batteries stay with their respective machines. Likewise the purchase date should be marked to give an age of the batteries for future replacement scheduling. Marking one of the batteries that comes with the NPL-352 as the "A" battery and the other as the "B" battery makes it easier to track that the batteries are being cycled through the charger on a regular basis.

It is a good idea to have a spare lens cap in the box in case the one that comes with the machine gets lost. Any 52mm standard camera lens cap will work.

The container that the right angle eye piece comes in is a flimsy paperboard box. It is suggested that a better container be acquired to store the eye piece in. The right angle eye piece is usually not needed, but when it is, it is essential and deserves better storage than a plastic bag in an unmarked paperboard box.

Remember the primary sources of error are:

1. **The instrument or the prism was not correctly set over the station.**
2. **Sighting on the reference point was off.**
3. **Sighting on the measuring point was off.**

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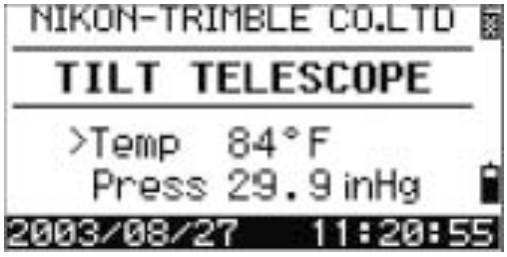
Use of Total Station as Theodolite

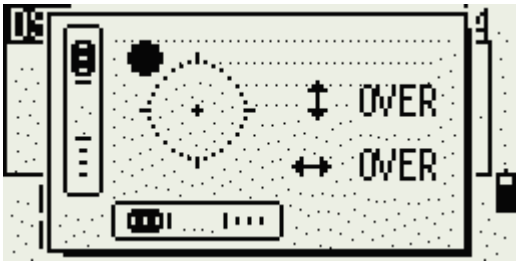
Theodolites are still valuable for monitoring structures. Total stations can be used as simple theodolites. This section shows how to start up the NPL-352 and use it as a theodolite.

After leveling the instrument with the bull's-eye level, turn on the instrument.

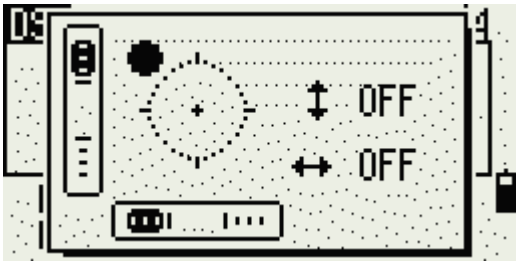
The first screen that comes up requires that the 0^{o} zenith angle (vertical reference) be set. This is done by simply tilting the telescope up and down slightly. Current temperature and pressure can be set at this time also.



Tilting the telescope will bring up the basic measurement screens unless the instrument is not leveled within the tolerance range of the level compensators.



For classroom use we will turn off the compensators using the left or right scroll keys. After turning off the compensators you use the **ESC** key to return to the Basic Measurement Screens (BMS)



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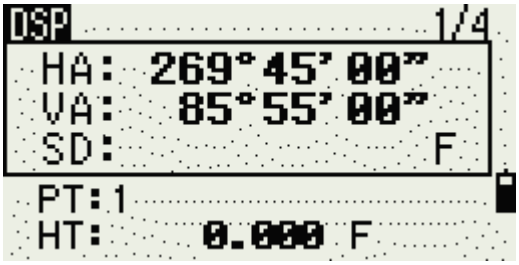
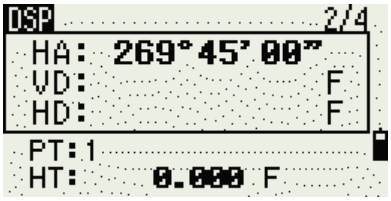
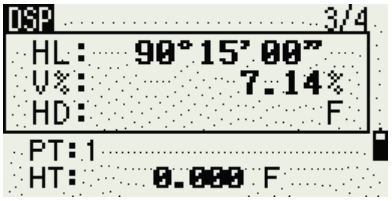
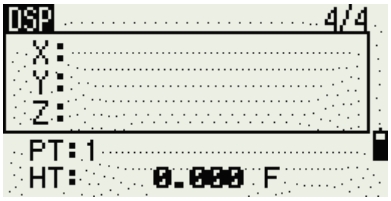
There are four BMS screens which are viewed in order by pressing the **DSP** key repeatedly. When the NPL-352 is used as a theodolite, only the first screen is needed.

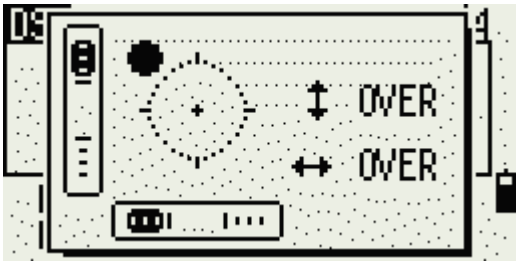


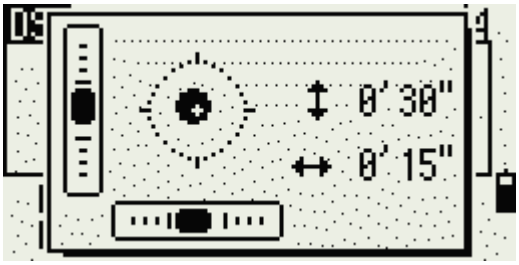




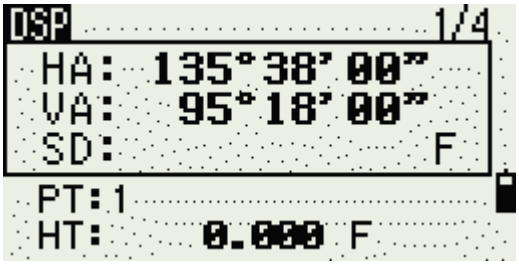


After leveling the instrument with the bull's-eye level, turning it on, and before tilting the telescope, the instrument may need to be fine leveled using the electronic angle compensators. Fine leveling is done using the three leveling screws under the leveling base. Again, return to the BMS screen by using the **ESC** key and tilt the telescope to establish the zero zenith (vertical) angle.





Monitoring points with the theodolite is done by sighting on a point to be monitored and recording the horizontal angle (**HA**) and the vertical angle (**VA**). Several points can be monitored from a single location this way. As long as the instrument is not moved, this can be an adequate method of monitoring a structure. If the instrument must be removed from its location, it must be reset exactly in its horizontal and vertical location or the previous monitoring data cannot be repeated.



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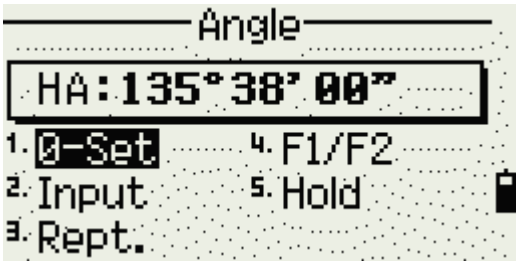
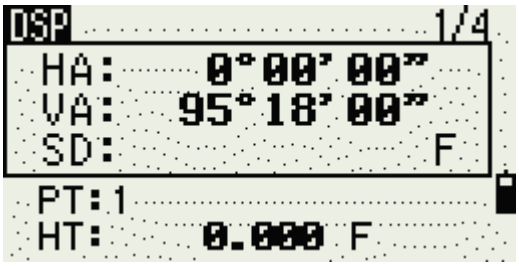
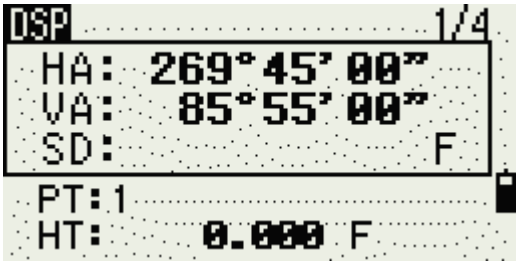
It is necessary to establish a reference point to set as the position of the zero horizontal angle. This is commonly referred to as the Backsight (**BS**) although the BS may be, and often is, located forward of the instrument location.



The horizontal angle is set to zero through the Angle menu which is accessed by pressing the **ANG** key. Scroll to the **0-Set** option and press the **REC/ENT** key or press the **1** key. This will set the current orientation of the telescope as the zero horizontal angle.



Points to be monitored are sighted and their HA and VA recorded on monitoring forms or field books. Field books with waterproof paper are recommended.



Once the HA and VA are known, the points can be monitored by turning the telescope back to their last recorded location using the tangent screws of the instrument until the output screen of the instrument has the desired readings. After returning the instrument to the prior recorded HA and VA settings, the object is sighted through the telescope and movement can be immediately ascertained by seeing if the crosshairs of the telescope are still centered on the point being monitored. It should be noted that the accuracy of a 5 second theodolite or total station is approximately 1/8" for a point 400 feet distant. Although the NPL-352 is rated as a 5 second machine, its performance is always better than this. This level of accuracy should be more than sufficient for the purposes of monitoring points in the US&R environment.