

3-01 General

Tools, supplies, and equipment will be required for nearly all surveying operations. Some tasks may require more specialized equipment, such as GPS packages. See Figures 3-3 for a list of equipment and supplies.

3-02 Care of Equipment

If the equipment you use is to function as it is intended, you must take proper care of it. All survey equipment used for horizontal and vertical control must be checked against a standard. Keep records of survey instrument checks and calibrations in the project office, and in the Surveyor's Daily Report (Form 237-010 EF).

3-02.1 Total Station and Level

Total stations and levels are delicate and precise tools and should be handled accordingly. When an instrument is being removed from its case or tripod, it should never be lifted by the scope or horizontal axis. The only exception is that a level may be lifted by the scope.

Never leave the instrument unattended when not in use. Never set an instrument behind a vehicle. If it is to be left near a vehicle, set it in view where the driver can easily see it.

When the tripod is not in use, the cap should be fastened snugly. The threads on the tripod head should be kept clean. The graphite from a black stake pencil makes a good lubricant for the threads on the tripod and the instrument. Use a dry lubricant if available, not oil or grease that will trap grit and result in unnecessary wear on the threads. A plastic cover should be placed over the instrument when it is not being used or if it is raining. A hot sun will affect the instrument. Use shade to protect the instrument. Use an umbrella if you must measure in the rain. If the instrument does become wet, air dry it (out of its case) overnight.

3-02.2 Hand Level, Clinometer, Compass and Other Small Instruments

Hand levels, clinometers, and right-angle prisms should be kept in their cases when not in use. Right-angle prisms should be closed when not in use. Hand levels should be taken apart and cleaned when they become wet or dirty. Check hand levels and clinometers periodically for accuracy. Especially when these items are new, or dropped. To clean a lens, use a lens cloth or tissue, not a cotton swab. Remove dried concrete with a piece of copper wire. Check compass declination; refer to the latest appropriate USGS quad map for correct declination.

3-02.3 Level Rod and Prism Pole

The leveling rod and prism pole must be properly maintained if good quality data are to be collected. The rod-person should guard the rod against physical damage and protect it from the effects of exposure to the outdoor environment. Rods should be placed in a dry place at night if they have been used in wet conditions. Rods should be stored in a vertical position or lying fully supported in a horizontal position. Do not use the rod for a pole vault or to beat down brush. Keep fingers off the face of the level rod as much as possible. Excessive handling will wear off the numbers. Striking the rod against rocks, trees, signs, vehicles, etc., can chip the special material used for rod scales, making it

Equipment

difficult to continue observing precisely and efficiently. Keep the screws on the level rod hardware snug, but do not over tighten. The tape on the Lenker rod should be checked frequently. If a tear develops, the tape should be replaced. Check multi-section rods occasionally and adjust as needed.

3-02.4 Steel Chain

- Never pull a chain around a post, stake, or other sharp object.
- Do not allow the chain to be run over by any vehicles.
- Be very careful to avoid kinks or sharp bends in the chain.
- Do not hold the chain by bending it around your hand or standing on it.
- Use the chaining clamps.

When the chain gets wet, it should be wiped dry and treated with a rust preventive spray. A chain on a reel should be wound backwards until the chain is loose and then be sprayed. The chain does not have to be dry since the spray will displace the water. If the chain is muddy, wash it before treatment. After a while, the spray will cause the chain to get oily and hard to read; therefore, periodically wipe it with a clean dry cloth. A chain cared for in this manner will last for many years, even when it is used daily in coastal areas.

3-03 Adjustment of Equipment

In order to obtain consistent results from your survey instruments they must be kept in good adjustment. Trained personnel must do some adjustments in a shop. Total stations should be sent in once a year for cleaning and adjustment. However, most common adjustments can be taken care of in the field. The following data is generally applicable to most instruments. For individual brands and types consult the manufacturer's recommendations, if available.

3-03.1 Preadjustment steps

Before you decide to adjust your instrument you should test it in the proper manner to make sure adjustment is necessary. The following steps are recommended. Choose a cloudy day if possible. Heat waves make it nearly impossible to obtain accurate readings. See that the tripod is in good condition. Tighten the shoes and all other hardware. Set up on firm ground where you can see at least 200 feet in each direction and where the ground is fairly level. Do not set up on asphalt on a warm day as the instrument may settle during the test. Spread the legs uniformly and set them firmly in the ground. Set up so that the tripod is nearly level. Level up the instrument. Allow the instrument to set up for a few minutes to allow it to adjust to the outside temperature.

3-03.2 Testing and Adjusting the Optical Plumbum

The method of adjusting an optical plummet involves moving the adjusting screws. The configuration of adjusting screws is not standard among the manufacturers. The adjusting screws are either capstan screws with four holes in the caps that allow you to insert an adjusting pin, or slotted screws that can be turned with a screwdriver. Whatever configuration the adjusting screws, the process of adjusting the optical plummet is as follows:

Mount one tribrach on the tripod with the adjusting adapter in place. Mark a point on the ceiling above the tripod. Place the tribrach to be adjusted on the adapter in an inverted position. Using the lower tribrach put the cross line on a point directly on the ceiling point. Rotate the upper tribrach 180°. Adjust one half of the error with the adjusting screws. The other half of the error is adjusted with the lower tribrach (foot) screws. Check in each quadrant and adjust as necessary. The above procedure is for use with a special adapter and two tribrachs. Other optical plummet adjustments (an alidade with a plumb bob or without a special adapter) are outlined in the instrument manual.

3-03.3 Testing and Adjusting the Self-Leveling Level

There are several different makes in use throughout the state. You should consult the manufacturer's instructions before any adjustments are made. Most procedures are the same for all makes but the adjusting screws may be in different locations. Before adjusting the level, follow the pre-adjustment steps shown above. Now you are ready to make the tests to see if adjustment is required.

(a) To see if the circular bubble stays centered when the level is rotated

This is very important because to get the maximum benefit out of the compensator mechanism the bubble should be in adjustment.

TEST: Turn the telescope until it is parallel with two leveling screws. Center the bubble as close as you can. Turn the telescope 180° until it is parallel with the same leveling screws. The bubble should remain centered.

ADJUSTMENT: You will have to check the individual instrument for the location of the adjusting screws. For example on the Zeiss level, you remove the observation prism or unscrew the flat guard ring around the bubble. There are three screws for adjustment. Loosen each screw and then retighten each one evenly, finger tight. Repeat the test. If the bubble is not centered, bring it half way to center with the leveling screws. Bring it the rest of the way by tightening the most logical screw. Do not loosen any of them. Repeat the test. If it does not center, repeat the adjustment until the bubble remains centered when the level is rotated.

(b) To make the line of sight level

These are the adjustments usually performed in the field. If you have dropped or otherwise damaged your instrument and cannot get it to come into proper adjustment do not try to take it apart and fix it. Send it to an authorized shop for repairs and adjustment.

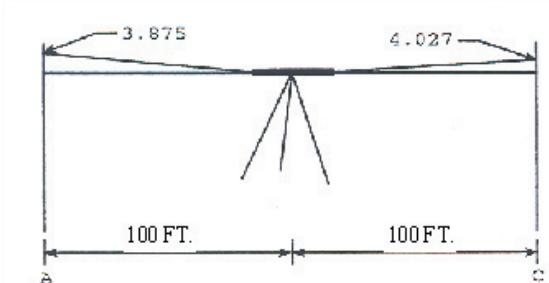
TEST: The peg method is described below:

Set up the level on fairly level ground. The test is best done on a cloudy cool day.

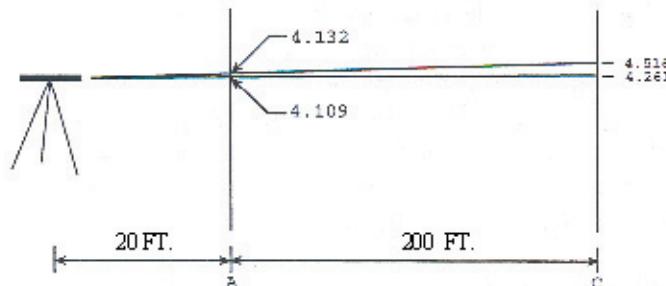
Drive two stakes 100 feet in each direction from the level. These are points A and C in Figure 3-1.

Equipment

Take a rod reading in each direction (with the same rod or a matched pair). Read the rod carefully estimating to the nearest 0.001 foot. Compute the difference between the two readings. This is the true difference in elevation between the two stakes. In Figure 3-1 the true difference in elevations is $4.027 - 3.875 = 0.152$. Next, set up about 20 feet (10 percent of total distance) behind one of the stakes. See Figure 3-2. Read the rod on the near stake. In the example, 4.132 at A. The rod reading at C should equal the rod reading at A plus the true difference in elevation ($4.132 + 0.152 = 4.284$). The difference between this number and the actual rod reading at C is the error to be corrected by adjustment. Loosen the top (or bottom) capstan screw holding the cross hairs of the eyepiece, and tighten the bottom (or top) screw to move the horizontal hair up or down and give the required reading on the rod at C. Several trials may be necessary to get an exact reading.



**Peg Method, Setup #1
Adjusting the Self-Leveling Level**
Figure 3-1



**Peg Method, Setup #2
Adjusting the Self-Leveling Level**
Figure 3-2

3-03.4 Testing and Adjusting the Hand Level and Clinometer

The hand level can be adjusted by the peg method. You should check it frequently. Peg the hand level at 50 feet as follows:

- Set two stakes 50 feet apart.
- Position yourself halfway between them to determine difference in elevation. Do not hold the hand level.
- Use a stand.
- Stand at one stake and shoot the other. Adjust the adjusting screw until the same difference in elevation is read. The screw is located in the objective end. You will have to remove the glass lens. You can also check your hand level against a level when this is convenient.

The clinometer should be pegged or checked against a level when you use it. Set the vernier at zero degrees and peg it the same as a hand level. If it requires adjustment there are adjusting screws on the level bubble tube.

3-03.5 Verification of Calibration of the EDM

If the electronics of an EDM require adjustment or repair, only a qualified technician with the proper equipment should do it.

WAC 332-130-100 requires annual calibration of distance measuring devices. To calibrate an EDM, follow the procedures in NOAA Technical Memorandum NOS NGS-10.

Set the instrument up on a calibrated test range and check the distances measured to the different distance monuments. If the measured distances fall within the manufacturer's tolerances, note the measurement differences for correcting field measurements. If the measured distances exceed the tolerances, have the instrument checked for faulty electronics. Make sure that the errors are not due to faulty field procedures. Some of these errors are:

- Instrument or prism not exactly above points.
- Prism not matched to instrument.
- Atmospheric corrections not set in.
- Errors in height of instruments of reflectors.
- Instrument has not been given sufficient time to adjust to local temperature/pressure/humidity. Let the instrument warm up before measuring.

To adjust the optical plummet of the tribrach, see Testing and Adjusting the Optical Plummet earlier in this chapter. Before checking an EDM on a certified calibration base line, consider the following:

- Legs on the tripod tight?
- Tribrachs in adjustment?
- Barometer set correctly? (not corrected to sea level)
- Thermometer correct? (1° C can change reading by 1 PPM)
- Atmosphere corrections set in EDM?
- EDM given time to warm up and adjust to local atmospheric conditions?
- Prism matched to EDM?
- Prism and EDM at same HI? (If not, EDM with slope correction)

Equipment

Surveying Equipment

Survey vehicle with adequate storage capacity
Total station with a minimum of two batteries
Automatic electronic digital level with -
2 rods and turtles
Automatic level
Data collector (2)
Tripod legs (5)
Tribrachs (5)
Single prisms with targets (5)
Triple prism with targets (1)
Extendable prism poles (3)
Rain covers for survey instruments
Umbrella sun shade
Two-way radios with -
Speaker mikes 1½ mile range (3)
Philadelphia rods (2)
Lenker rods (2)
25' pocket tape (3)

100' steel chain
Chain clamps
50' and 100' fiberglass reinforced cloth tapes
Range poles or pickets
Clinometer
Fiberglass rod (25') w/prism adapter
Magnetic compass w/declination adjustment
Right angle prism
Calculator with trig functions
Thermometer
Barometer
Rod fisheye-level
Plastic targets
1 foot targets
Plumb bob with sheath
Hand level with sheath
Metal locator
Carsonite markers w/driver
Stamping dyes

Supplies

Spray paint (PINK)
P.K. nails
Plumb bob string
Keel (blue, yellow)
Hub tacks
Wooden guineas
Duct tape
Hubs – 4 inch, 6 inch, 12 inch
Wooden stakes
Wooden lath
Ribbon (red, white, blue, yellow, etc.)

Railroad spikes
RP aluminum tags
Aluminum nails
Box nails and double headed nails
Oil or silicone spray (WD-40)
Dry lubricant (for instrument screws)
Extra plumb bob points
Lens cloth/tissue(s)
Plastic target
Tack container
5-gal. water container (potable)
5 rebar and caps

Office Equipment / Library

Highway Surveying Manual
Highway Engineering Field Tables
Standard Plans
Construction Manuals
Field book w/codes-tips
State road map(s)
Project package (plans/grades, etc.)
Laptop w/ survey/engineering software
Portable printer
Cell phone

All-weather paper
Pencils
Pens
IDR
Scale
Paper pad
WSDOT field forms
Stapler
Hole punch
Rubber bands

Surveying Equipment List

Figure 3-3a

Tools

Tool kit	Pick
Digital camera	Claw hammer
Tribrach adjusting hub	Hand saw
Axe	Files
2 lb. hammer	Small whisk broom
8-12 lb sledge hammers (2) and extra handles	Machete or brush axe
Frost pins	Jumper cables
Shovel, digging bar	Tow cable

Personal Equipment

Toilet paper	Boots
Rain gear	Pocket knife

Emergency Protocol Procedure(s)

Phone list/regional emergency list	Railroad-certified
First aid-certified	S.F. 136 Vehicle Accident Checklist*
Flagger-certified	S.F. 137 Vehicle Accident Report

Safety Equipment

Flares	Survey vest (reflectorized)
STOP and SLOW paddles	Eye and ear protection
Flashlight	Gloves (leather and cloth)
First aid kit (16-unit minimum)	Required signs and standards
Fire extinguisher	Insect repellent
Traffic cones (24") 15 min	Toxic vegetation barrier cream
Hard hat and liners	Wool blanket

* Form S.F. 136 is available from Central Stores:
Commodity Code 7540-005-205

Surveying Equipment List

Figure 3-3b

Equipment