gles. There are two big sources of error: not sighting the point correctly and reading the angles wrong. For the best accuracy in sighting the point, I would recommend using some sort of target instead of the centre of the prism. Range poles or the little 'candy cane' sighting poles are often used. There are also targets for prisms. If you are trying to be as accurate as possible, you should be using a target. You will obtain rely even better results if you centre the target using the bifilar side of your reticle instead of the single wire. (Figure 1)

Mistakes in reading the angles also occur. With electronic total stations and data collection so popular, many of these are eliminated, but there are a couple of things you should be aware of if you are using an optical reading theodolite. You can have the same problems with parallax because the angle reading system is combining three or more separate images (the micrometer and both sides of the circle) onto the same focal plane. All of these images should be in sharp focus and without parallax or the instrument may need optical adjustment. If you don't focus exactly onto this plane, you can move your eye and see the circle readings change.

I also mentioned errors from natural causes. I can't help you much with these except to make you aware of them. These are the errors from wind, temperature changes, changes in atmospheric conditions, and ground or tripod settlement. High accuracy surveys require some extra effort to reduce these effects. This includes shading the instrument with an umbrella, using a concrete pillar instead of a tripod, and even making observations at night when atmospheric conditions tend to stabilize. Be aware of them so you can change your procedures if necessary.

If you want to know more, the book *Surveying Theory and Practice* by Davis and Foote contains some excellent information. As always, I welcome your comments, agreements, and disagreements. Send any correspondence to The Technical Side, 1562 Linda Way, Sparks, NV 89431 or fax it to (702) 359-6993.

Environmental Conditions and the EDM

By Martin Crook

Many distance measurement problems encountered when using electro-optical EDMs can be directly related to atmospheric conditions and other interference that can affect the accuracy, repeatability, and proper operation of distance meters. First, a little background on the operation of these units.

Equipment

Most electro-optical distance meters measure distance by using a series of different frequencies (or signals) imposed on a nearly visible carrier wave. These waves are transmitted to a retro prism, which reflects the signal back to the instrument. As each frequency is received, it is compared to an internal standard to determine a phase offset. These several values are used to calculate a distance. In this discussion, we will assume that the EDM is functioning properly and measuring distances accurately. The retro prism must be clear of dirt, fogging, and fractures, and be pointed squarely at the distance meter in order to achieve good results. Most prisms can be removed from their canister and cleaned, but some are sealed into the canister, or "can." Sometimes dirt and/or moisture on the back side of a prism are not very obvious, but they can greatly impair the reflective ability of the glass. Fractures or chips not only cut down the amount of available reflective surface but can also cause the signal to scatter or change direction. The result is a weakened return signal or possibly a false distance. Prism pointing errors can cause small distance errors (less than .05 ft) and a loss of signal return.

Conditions

Any condition that interferes with your ability to see clearly will also impair the EDM in measuring a distance. An EDM signal is not very strong and will dissipate or lose collimation at a great distance. If fog, moisture, heat waves, dust, smoke, snow or any other particles are in the line of sight, the EDM signal can be affected by being blocked or deflected. These types of conditions may require the use of additional prisms to return enough signal to complete the measurement, a different occupation, or even rescheduling. Shooting across a body of water or a boggy area can cause problems due to excessive moisture in the air. Deflected signals can increase a distance measurement by making the path longer. Generally, heat waves deflect or refract a signal path vertically, but if the wind is blowing, a horizontal deflection can also occur. If your vision is influenced by a condition, the EDM will also be affected. Diffraction can cause an EDM signal to completely miss the prism. A rise or a knoll in the line of sight between an instrument and a prism can cause the EDM signal to bend as it passes near the top of the rise. This phenomenon occurs in both directions, going to the prism and coming back to the EDM. This bending can cause the signal to completely miss the prism or EDM, even when the target appears to be in plain sight of the operator. Diffraction also causes intermittent signal return or erratic measurements when a branch, pole, or the edge of a building, is in the line of sight but does not block the beam transmission.

High-voltage power lines can affect such EDM internal components as inductors, coils, capacitors and digital circuits, including the microprocessor. The charge or field that occurs when using EDMs near high voltage not only affects measurement accuracy, but can damage precision internal components. Fortunately, this is a rare occurrence. Taking measurements parallel to high-voltage power lines has produced some interesting, but unreliable, distances. Distances of 400 feet have given errors of up to 10,000 feet. These errors are attributed to "magnetic flux" that resides around high-voltage power lines. An error this large is very obvious but other, smaller errors, may not be. Radar and microwave installations can also affect the accuracy of an EDM. Interaction with this type of high-powered transmitter is rare and is usually limited to areas around airports and microwave sites.

The bottom line is: be aware of atmospheric conditions. local power and transmission influences, and pick occupation and foresight points that give the best, clear line of sight between the EDM and the retro prism.

As always, I welcome your comments, agreements, and disagreements. Send any correspondence to THE TECHNICAL SIDE, 1562 Linda Way, Sparks, NV 99431 or fax it to 702-359-6693.

Upcoming ISTO Events

September 22

* **7th Annual General Meeting**, *Midland*
* **Hands on Equipment Demonstrations with**

Gemini Positioning
Pentax
Norman Wade
Sokkia

September 23

* **GPS for Technicians**, *Midland*
presented by: James Ferguson, OLS

Details on these workshops and others will be in the 1995 Membership Services Kit.

The Technical Side

PPM Correction Variables

By Doug Crook

Calculating and applying the proper atmospheric correction (PPM) to an EDM distance measurement is **extremely** important. The density of the atmosphere varies with changes in atmospheric pressure and temperature. The speed of the EDM light beam used to measure a distance varies with atmospheric density. Take as great a care as practicable when you obtain the atmospheric pressure and temperature. Accuracy of the PPM correction is directly affected by the validity of these two values.

The most accurate atmospheric pressure is obtained by using an altimeter/barometer. The average atmospheric pressure at sea level is approximately 29.92 inches of mercury. As elevation increases, the pressure decreases. The decrease is about one inch of mercury per thousand-foot increase in elevation. At an elevation of 5,000 feet, the actual (uncorrected) atmospheric pressure will be about 24.92 inches of mercury, for example: (29.92) - (5 x 1) = 24.92.

The most accurate temperature can be obtained using a thermometer. The temperature must be taken in the shade in still air to give the most accurate reading.

The temperature and atmospheric pressure are used in combination to give a correction factor stated in parts per million. The correction is applied to the slope distance. Virtually all modern EDM units have a way of entering the PPM correction, either as a PPM value or the raw temperature and pressure.

The error caused by an inaccurate PPM value can be a result of inaccuracies in any one or any combination of temperature, atmospheric pressure, or PPM value.

Some values:

1 Part Per Million = .001 feet per 1,000 feet
10 PPM = 0.01 ft per 1000 feet
2 degrees Fahrenheit = 1 PPM
0.1 inch of mercury = 1 PPM

The best way to test the effect of the PPM correction is to obtain a 1,000 feet distance using 0 (zero) PPM and then shoot the same distance using 100 PPM. You should see a difference in the distance of about 0.1 foot.

Try it, you'll be convinced!

We invite you, the reader, to bring us specific questions and topics to be discussed in this column. Written questions can be mailed to: THE TECHNICAL SIDE, 1562 Linda Way, Sparks, NV 89431 or faxed to (702) 359-6693.