How Does Your EDM Measure Up

James P. Reilly, PhD

Electronic Distance Meters (EDMs) have an accuracy and precision specification. It is given in every sales brochure by every manufacturer, but what does it mean? Keep in mind that precision describes the repeatability of an instrument; accuracy, the ability to measure the correct distance. The accuracy and precision specification for an EDM is given as two numbers. A typical specification is:

± (5mm + 5ppm)

The first number, ± 5mm, describes the precision - indicating that the distances measured should not vary more than ± 5mm from the mean of a group of measurements. The second number, ± 5ppm, describes the accuracy - indicating that the distances measured can vary from the true distance by ± 5 parts per million of the distance measured.

Each EDM is calibrated by the manufacturer before being delivered to dealers and distributors for sale to the surveying and engineering community, and all meet or exceed the specifications.

How can you, as the user of an EDM, check the accuracy and precision of your EDM to see if it meets factory specifications or is in need of adjustment?

Accuracy

You can take your instrument to one of the National Geodetic Survey (NGS) calibrated baselines and check the measured distance against the calibrated distance. The location of the NGS calibrated baseline in your area can be obtained by calling Dr. Dale Pursell, NGS, at 301/443-8640.

Prior to going to a test range, check all optical plummets to make sure they are in adjustment. If the EDM requires a screwdriver or special tool to make offset changes, be sure you have it available. And read the paragraph in the instrument instruction manual that describes the process for changing offsets. The prism(s) that will be used to calibrate the instrument on a daily basis.

1. Position the EDM directly over the "O" monument of the calibrated baseline and level the instrument.

2. Position a prism directly over the first monument on the range (150 meters is most cases). Make certain the prism has the proper target configuration for the EDM.

3. Switch the EDM to metric measuring mode (if possible).

4. Check to see if the prism offset set in the EDM matches that of the prism at the 150 meter monument.

5. Measure and record 10 to 15 measurements (in normal measuring mode). Be sure the temperature and atmospheric pressure reading in the EDM are correct.

6. Compute the mean reading of all the measurements and compare to the true value on the information sheet for the calibrated baseline. Be careful: generally, the baseline distances are horizontal, and if the baseline is not on level ground, you may need to reduce your measured distance to horizontal distance.

7. If the measured distance is not correct, the instrument offset must be changed. Even though the actual prism offset may be - 30mm, it will have to be some other number to get the correct distance. The procedure for changing the prism offset will vary depending on the type of EDM, and your dealer will be able to assist you with this adjustment.

8. Move the prism to the 800 meter monument. Measure and record 10 to 15 measurements (making sure the temperature and atmospheric pressure corrections are input correctly). Remember that the 5ppm part of the accuracy statement for this distance would be ± (5mm + 4mm). If the spread of your measurements falls within these limits, the instrument is within specifications.

9. Move the prism to the 1400 meter monument. Measure and record 10 to 15 measurements (making sure the temperature and atmospheric pressure corrections are input correctly). The 5ppm part of the accuracy statement is 7mm at 1400 meters, so the accuracy statement for this distance would be ±(5mm + 7mm).

If the spread of the measurements made on a calibrated range is greater than the manufacturer's specifications (which rarely happens with the newer EDMs), it will have to be adjusted by a service technician. On an older instrument, a larger spread usually indicates that the diodes or high-frequency unit inside the instrument have weakened and are in need of replacement.

Precision

Determining the **precision** of an EDM does not require a calibrated test range. It can be done by following these steps:

1. Place the EDM on a sturdy tripod.

2. Position prism 100 yards away on a prism pole (firmly secured) or tribrach.

3. Switch distance readout to meters (if possible).

4. Measure and record 10 to 15 measurements (in normal measuring mode). Double-check the first few measurements to see if they are consistent. Never accept the first measurement after an EDM is turned on.

5. Compute the mean of these measurements and compare the mean to each measurement. If the instrument specification is ± (5mm + 5ppm), do any measurements deviate more than 5mm?

6. If the answer is yes, your instrument is out of specification and requires service.

7. If the answer is no, you can determine the spread and compute the standard deviation.

With the knowledge of how to determine the accuracy and precision of both theodolites and EDMs, how do you compare a theodolite with a precision of 10 seconds-of-arc to an EDM with a specification of ± (5mm + 5ppm? The answer to this question can be stated as follows:

The relative error in distance should equal the angular error in radians.

To refresh your memory, 1 radian = 57.2957795... degrees; there are 2 Pi radians in a circle. The table in Figure 1 (based on Brother B. Austin Barry's table in "Engineering Measurements) shows the relationship between precision in direction (angle) and precision in distance. And, since the precision of an EDM varies with the distance measured, the minimum distance required to meet these specifications - for an EDM with a precision of ± (5mm + 5ppm) - is also included.

TABLE 1

Precision in Direction	Precision in Distance	Minimum Distance to meet Distance Precision at ± (5mm + 5ppm)
1 minute-of-arc	1:3440	60 feet
30 seconds-of-arc	1:6870	115 feet
20 seonds-of-arc	1:10310	170 feet
10 seconds-of-arc	1:20620	375 feet
6 seconds-of-arc	1:34380	685 feet
3 seconds-of-arc	1:68700	1700 feet
1 second-of-arc	1:206200	cannot be reached

TABLE 2

Precision in Direction	Precision in Distance	Minimum Distance ()(5mm + 1ppm) ft.	Minimum Distance ()(1mm + 1ppm) ft.
1'	1:3440	55	12
30"	1:6870	115	23
20"	1:10310	170	35
10"	1:20620	345	70
6"	1:34380	590	120
3"	1:68700	1210	240
1"	1:206200	cannot be reached	860

The numbers in Figure 1 can help you select the theodolite or total station needed to achieve a particular precision, say in traversing, and minimum length of sides measured by the EDM. For example, if the requirement for a particular job is 1:20000, the fourth line of Figure 1 tells you that the precision in angles must be 10", and each distance measured with an EDM must be at least 375 feet in length. This shows the importance of chaining the short sides of a lot survey, because of the minimum distance required to maintain the precision specifications of an EDM.

Figure 1 is based on an EDM with a specification of ± (5mm + 5ppm). In the EDMI survey in October-November 1987 issue of P.O.B. magazine, there were 25 EDMs listed and 15 have this accuracy specification. The others fall into one of the following accuracy specifications:

± (5mm + 1ppm) ± (5mm + 2ppm) ± (5mm + 3ppm) ± (3mm + 2ppm) ± (1mm + 1ppm)

It should be noted that an increase in accuracy and precision also means an increase in price. Most EDMs in this group have long ranging capabilities, but you still have a **minimum distance required** to match the angular accuracy of theodolites. Figure 2 lists the minimum distance required for two of the above instruments, one with a precision of ± (5mm + 1ppm), and one with a precision of ± (1mm + 1ppm).

As can be seen from Figure 2, you must have a very accurate, high-priced EDM to exceed the 1" precision of a theodolite. Notice how the increase in precision from ± 5mm to ± 1mm significantly reduces the minimum distance required to meet specifications. Increasing the accuracy from 5ppm to 1ppm does reduce the minimum distance required to meet specifications (compare 1 to Figure 2), but this is not noticeable on distances less than 2000 feet. **This points out again the need to measure very short lines with a steel tape.**

A Florida surveyor reminds his people of this rule with a message written in very bold letters on his blackboard:

"I don"t want to see, or hear tell of, any one using an EDM to shoot distance less than 200 feet..."