The Technical Side - Prism Offset

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In this instalment of The Technical Side, we are going to talk about prism offsets and what can happen when you ignore the differences in offsets that exist.

To start off, I will give some background information on prisms that are used with electronic distance meters (EDMs). These prisms are called corner cube prisms or retroreflectors. This is to differentiate them from the ones that Newton used to make rainbows or the one in your survey instrument that makes the image appear right side up. They are called corner cubes because the three surfaces that make up the "pyramid" are at 90 degree angles to each other and thus form the corner of a cube. As you have noticed, light entering the prism is reflected back to its source, even at relatively large angles of incidence. The angle of incidence is the angular difference between the incoming light rays and an imaginary line perpendicular to the face of the prism. A beam of light entering the prism bounces off all three back surfaces and exits at the same angle it entered. Light also slows down when it enters glass. Both of these factors make the distance measured longer than the distance to the front face or even the back of the corner cube. This distance is called the offset. This offset is a constant amount that the distance measured is corrected for a particular prism. Further complicating things is the fact that various manufacturers position the corner cube differently in the prism housing and the speed of light varies with different kinds of glass. This results in a multitude of prism offsets. Below is a chart listing some manufacturers' offsets.

Hewlett-Packard				-28mm
AGA				0mm
Lietz		0mm	-30mm	-40mm
Lewis & Lewis (Retro Ray)			-30mm	-40mm
K & E			-30mm	-40mm
Precision Int'l				-40mm
Kern				-70
Topcon			0mm	-30mm
Zeiss			-23.4mm	-40mm
Omni Optical	0mm	-30mm	-34mm	-40mm
Wild				-34mm

As you can see, offsets vary greatly. There are different reasons for this. Some manufacturers deigned prism offsets in to correct for the difference between the actual plumb line through an EDM and the position of the photodiode in the EDM. Others sought to minimize the effects of having large angles of incidence (not pointing the prism at the gun) on the measured distance. I think some manufacturers just wanted to be different.

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If you are lucky, all your prisms were made by the same manufacturer and have the same offset. Unfortunately, old prisms from that retired EDM are often still around and get pressed into service. What happens to your survey when different offset glass is mixed? We will take the most common offsets, 0mm and -30mm, and throw some numbers around. The difference between the two, 30mm, is about a tenth of a foot. On a relatively short shot, say 300 feet, this gives an accuracy of about 1 in 3,000, not very good. As your distance increases the ratio will increase but never get as good as it could be. Another way to look at that 30mm, or tenth difference, is 100ppm in a 1,000 foot shot. That extra care taken in measuring the temperature and pressure would have been wasted. What if your field procedures allowed that tenth to accumulate? It wouldn't take many shots to build up an error that would be unacceptable even for rough construction staking. In so many words, don't mix glass!

So you aren't going to use all those different prisms with each other. What if you want to check some questionable prisms that aren't marked with an offset? Do they have the same offset as the rest of your glass? Measure the length from the face of the prism to the tip (how tall the "pyramid" is) and call it A. Then measure the distance from the face of the prism to the centre of the 5/8 x 11 thread (it might be easiest to measure from the front of the prism can and subtract the difference from the front of the can to the prism face out) and call this B. The prism offset will be (A x 1.509) - B. The 1.509 is the refractive index (or change in the speed of light) of the most common glass used for prisms. For some prisms this might be different, ranging from 1.50 to 1.57. Prisms from different manufacturing runs can vary about 1mm. As a check, compare EDM measurements to a prism with a known offset with measurements to the unknown prism.

We are going to talk some more about prisms in the next issue of this column. More theory, keeping prisms clean, and some discussion on accuracies will be featured. I invite submissions of any survey related topic for examination in greater detail or any comments on this or previous columns. I also have a diagram and worksheet for computing prism offset if you need further assistance.