Pangea Geosystems Prism Study

Abstract

This study presents an overview of the technical considerations involved with making a prism selection for deformation monitoring in a mining environment to ensure the highest quality results. We will investigate the unique design aspects which influence the performance of a prism and which prism attributes best suit the mining conditions.

Introduction

Prisms are an important part of the measuring process. Typically, spatial professionals widely accept that they are an accurate, reliable accessory without much consideration of the influence prism have on the quality of their measurements. Obtaining a high level of accuracy and reliability requires consideration of all possible effects on the measurements. A strong emphasis is placed on the specifications and accuracies of the total station, as it should be, but too often the considerations for prism selection are non-existent or fall back to a fiscal decision.

There are various applications where the required 3D accuracies are in the magnitude of centimetres but tasks such as deformation monitoring require much higher accuracies, in the order of millimetres. To achieve this level of accuracy and reliability we must look at the errors associated with prism selection and the associated effects in the mining environment.

Reflector Types

Most spatial professionals have encountered three typical types of reflectors. Round prism types in varied diameters, 360^{o} prisms and multiples of prism banks.

360^{o} prisms have been developed for use with robotic total stations for increased tracking abilities but do not work well with stationary targets as with deformation monitoring where the EDM is used in a single burst. Multiple banks of prisms will increase the amount of signal available for retro reflection of the EDM, useful if you are only acquiring a distance, but multiple prisms disrupt the ability to make repeatable angular measurements resulting in scattered 3D accuracies. The best reflector type for deformation monitoring is a single 64mm ϕ round prism, aligned perpendicular to the total station. In scenarios where the reflector and/or total station is adversely affected by ambient light or condensation early in the morning, considerations should be made to include a hood on the prisms to increase repeatability of the measurements.

Reflector Accuracies

When a prism is manufactured a piece of glass is ground to establish reflective angles. The quality of the grinding plays a key role when reflecting signals, the more accurate and angle is achieved the better the signal will be returned in the same direction. The intensity of the return signal is also stronger, a crucial point for the mining environment given the climatic conditions.

The deviation between incoming and outgoing beams, known as beam deviation or the stated accuracy, has a critical influence on the measurement range.

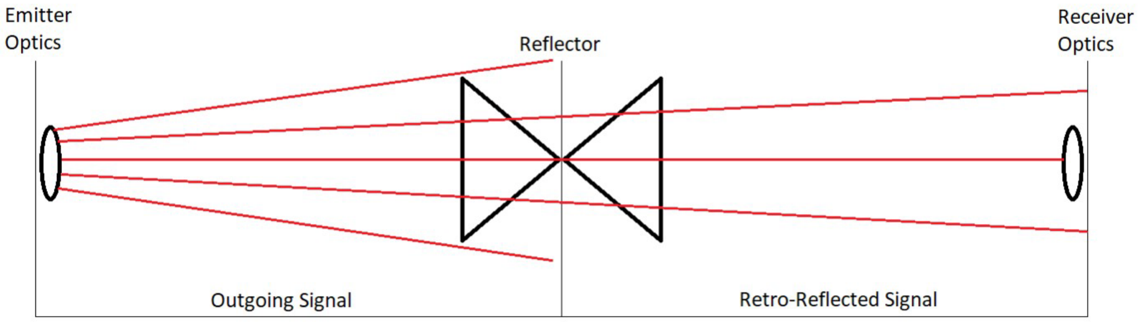

Figure 1

Figure 1 depicts a prism with a small beam divergence, approximately 2 arc seconds or less. The outgoing signal is retro reflected to the emitter optics, total station, with a strong intensity. Note the signal affected by beam divergence out of the total station that misses the reflector as well as signal reflected from the extremities of the prism that is not returned to the receiver optics.

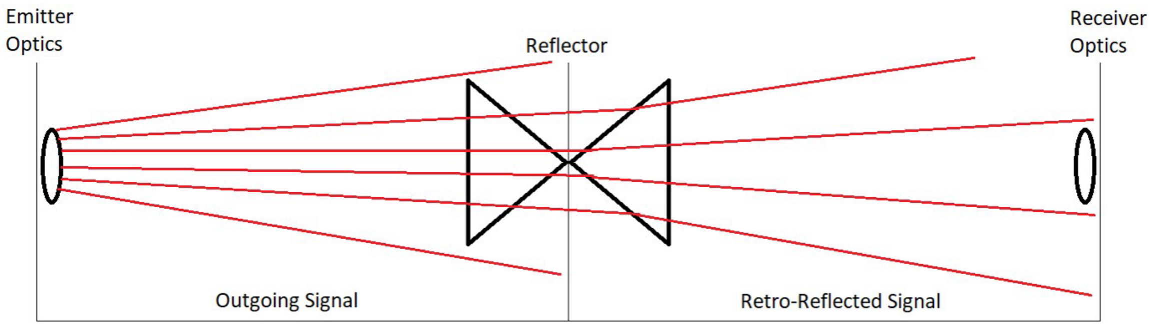

Figure 2

Figure 2 depicts the effects of poor beam divergence from a prism with a greater accuracy of 2 arc seconds. The same amount of signal makes it too the prism as this is a function of the total station but none of the signal is returned or retro reflected from the prism to the receiver optics resulting in measurement failure.

To test and certify a prism at a stated accuracy you must test all six aspects of the glass reflection and qualify the largest rate of divergence as the prism beam divergence. If a prism is stated at 1.5" seconds then all six aspects have performed at or better than 1.5" of divergence.

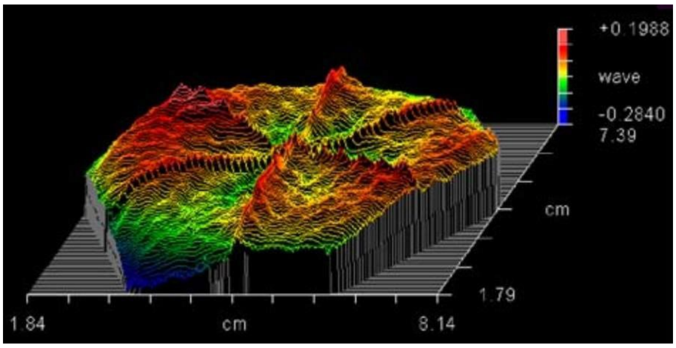

Figure 3

Figure 3 shows the results from an Interferometer measurement taken to determine the homogeneity of all aspects of a prism.

Reflective Coatings

The ability of a prism to return an emitted signal is greatly affected by the reflective qualities of medium or material. While glass ground at angle provides a reflection, prisms benefit from a reflective coating such as gold silver or copper by as much as 30%. The application of this reflective coating enhances the ability of the prism to return a signal with sufficient intensity, hence increasing the operating range of the prism.

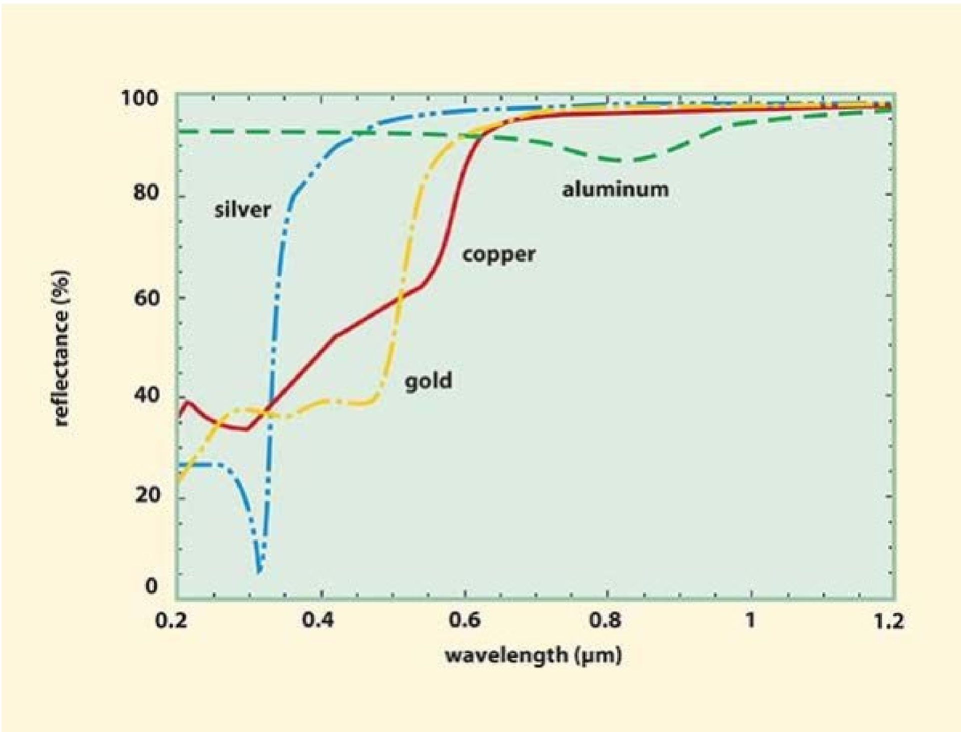

Figure 4

Figure 4 (above) shows the reflective qualities of gold, silver, copper and aluminium coatings at varying wavelengths. Leica instruments used in the field testing of prisms operate between 0.66µm and 0.85µm frequencies. If you plot this wavelength on the chart you will see there is a minimal difference between the performance of gold, silver and copper, all operating at approximately 95%.

For ease of identification Pangea decided to utilise the copper coating which is clearly visible to the naked eye on the translucent glass. It is more difficult to confirm the presence of a silver coating.

Environmental Factors

When manufactures test prisms in real world conditions they are typically in optimal conditions devoid of environmental factors. As such the stated range of a prism comes with a qualification statement that this range is achievable in optimal conditions. These types of conditions are rarely experienced on a mine site. The addition of extreme heat/cold, wind, dust and rain affect the beam divergence and intensity of the signal greatly reducing the operating range of the prism. In these scenarios, the reflective qualities of the prisms are exacerbated.

Due to the environment experienced on a mine site it is crucial to select a prism that will give you the strongest reflective intensity at range. The selection of the correct prism will ensure that the prism works at a range that exceeds the distance required over the projected life of the prism. This can be achieved by selecting a prism with a good reflective coating and small beam deviation, 2 arc seconds or better.

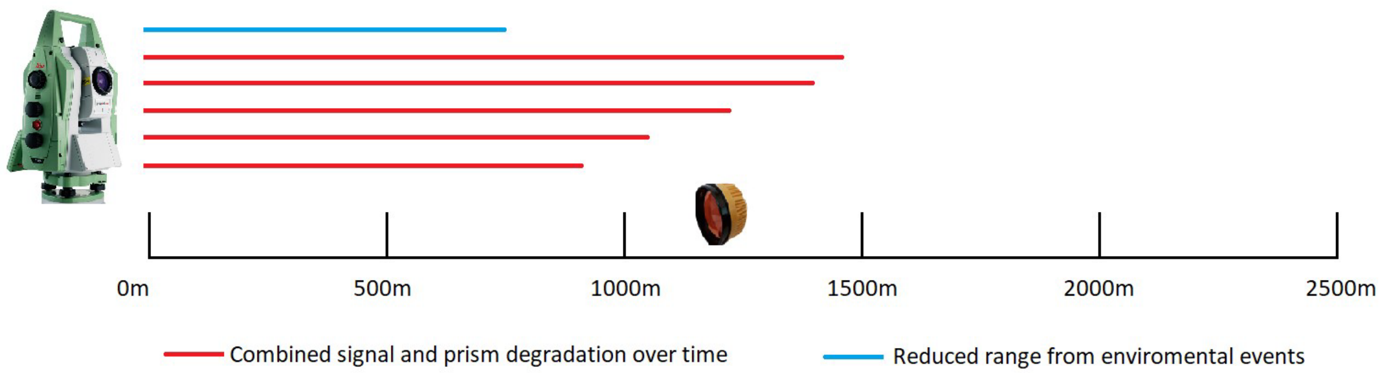

Figure 5

Figure 5 depicts the reduction in range over time due to the degradation in signal strength and reflective qualities from a prism > than 2 arc seconds. If such a prism is placed at the limit of the operating range early in the lifecycle the observations to the prism may start to fail briefly after installation, often as a result of dust settling on the prism lens. Additional to this, repeatability may be compromised if there are environmental events such as those experienced on mine sites, where prism measurements may fail intermittently due to a reduction in range.

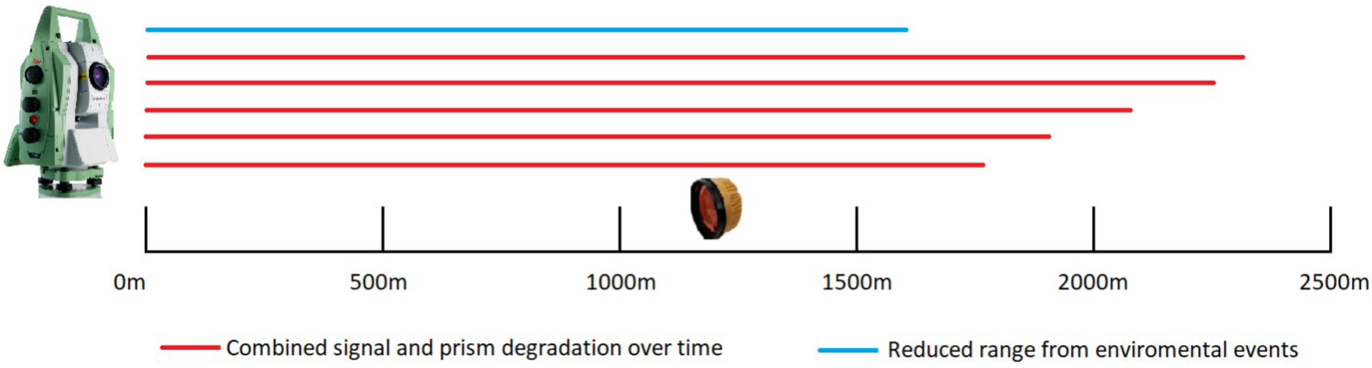

Figure 6

Alternately, figure 6 shows where a prism with < 2 arc seconds of beam deviation has been installed at the same distance with considerations of range over the lifecycle of the prism. Even when affected by environmental events or signal/prism degradation over time the prism continues to provide repeatability throughout its lifespan.

For these reasons, substandard prisms may appear to work while newly installed but begin to fail or have repeatability issues much earlier in the lifecycle in comparison to a considered option.

Field Prism Testing Results

Pangea Geosystems collected prisms from many manufactures with differing qualities. Coating types or a lack there of, accuracy/beam divergence, housing types, backing paint and glass construction were all considerations based around the research undertaken. Once many prisms were collected field testing was conducted to assess the range and performance of similar prisms under the same climatic conditions.

Baselines were established over 1500m, 1900m, 2250m, 2500, 2750m and 3000m and the repeatability of the ATR function and EDM measurement were tested. To achieve a successful reading at range, or pass mark, the prism was required to return greater than 66% of the time.

Results are as follows in Figure 7 (below).

Manufacturer	Accuracy	Coating	Canister	Backing Paint	1500m		1900m		2250m		2500m		2750m		3000m	
					ATR	Distance	ATR	Distance	ATR	Distance	ATR	Distance	ATR	Distance	ATR	Distance
A	4.5”	Silver	Plastic	Y	✓	✓	✓	✗	✓	✓	✗	✗	✗	✗	✗	✗
A	5”	Copper	Plastic	Y	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗
A	4.9”	None	Plastic	Y	✓	✓	✓	✗	✓	✗	✗	✗	✗	✗	✗	✗
A	1.3”	Silver	Plastic	Y	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗
A	1.3”	Copper	Plastic	Y	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗
A	2.6”	None	Plastic	Y	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗
A	2.8”	Silver	Plastic	Y	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗
A	0.7”	Silver	Plastic	Y	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗
A	1.3”	Copper	Metal	Y	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗
A	4.1”	Copper	Metal	Y	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗
B	1.4”	Copper	Plastic	Y	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗
B	4.3”	Copper	Plastic	Y	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗
B	2”	Copper	Metal, Hooded	Y	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗
B	4.4”	Copper	Plastic	Y	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗
C	7”	Silver	Plastic	N	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
C	2”	Silver	Plastic	N	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
D	N/S	None	Plastic	N	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
D	N/S	None	Plastic	N	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
E	N/S	None	Plastic	N	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗

Figure 7

While testing prisms in the field it was also noted that prisms specified to the same specification and accuracy, supplied by the same manufacturer performed differently. Further investigation on the QAQC process of these manufacturers revealed that the accuracy was only tested periodically from the production line, rather than each prism being tested and certified using an Interferometer.

Alignment

Another aspect field tested but not collated in the charted results above was the angle of incidence. All the results above in the chart are when the prism has been aligned perpendicular to the total station. At any distance greater than 1500m, if the angle of incidence was greater than 20^{o} the prism stopped returning the signal.

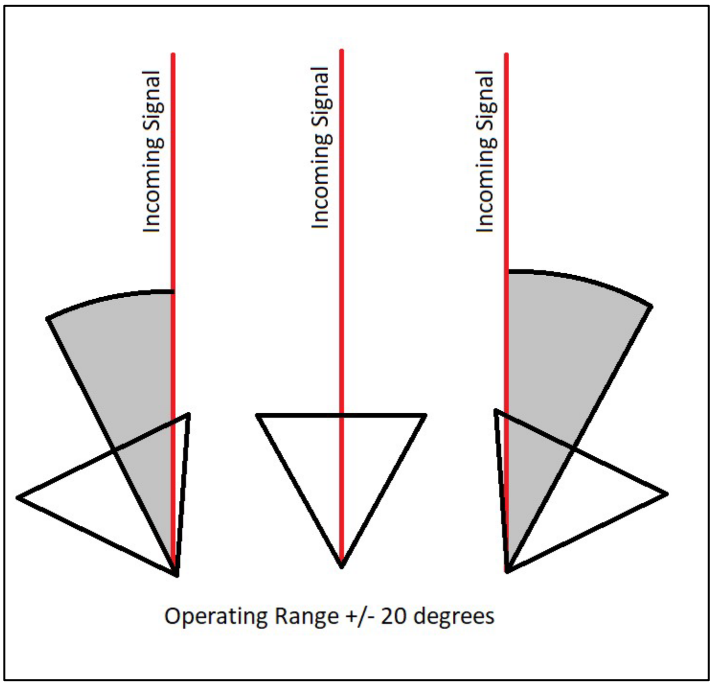

Figure 8

In addition to the angle of incidence required for repeatable measurements, the distance measurement will also be adversely affected when the prism is misaligned with the incoming signal. The rate of distance deviation in relative to the angle of incidence as displayed below in Figure 9.

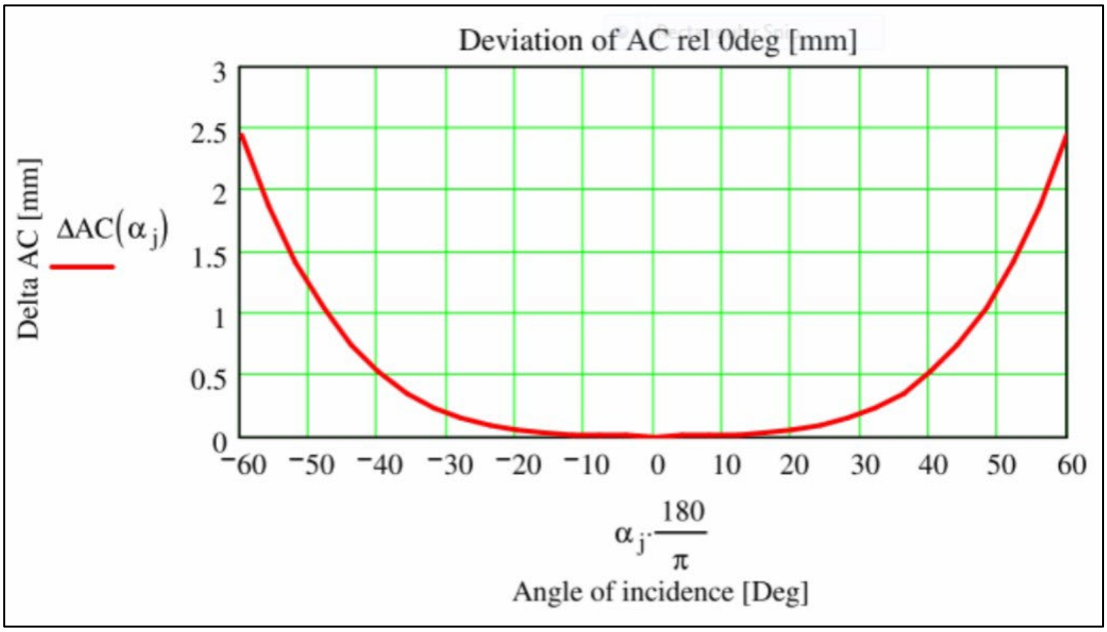

Figure 9

Conclusions

Field prism testing conducted by Pangea Geosystems revealed the design considerations required for accurate, repeatable measurements with prisms. The ideal prism for use in deformation monitoring in the mining environment will possess the following characteristics:

- 64mm ϕ round glass construction,
- coated with either gold, silver or copper (copper being easily identifiable),
- treated with backing paint,
- sealed and weather resistant,
- have an accuracy of 2 arc seconds or better,
- be individually tested and certified, and
- should be installed with a mounting bracket to achieve optimal alignment.

Where prisms possess the above listed characteristics, the highest level of results will be achieved for the longest time, hence underpinning the investment in deformation monitoring systems.

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