

## Application note A141: Steep-sided miniature hemispheres

PGI Dimension – Hemispheres

# Unique measurement capability for steep-sided miniature hemispheres

Lucy Cooper, Applications Engineer

## Introduction

In order to have confidence in a measurement process, it is essential to achieve results which are highly repeatable and also traceable to international standards.

In this Application Note, a traceable calibrated standard is measured on Taylor Hobson's PGI Dimension in order to demonstrate system accuracy, repeatability and the capability of measuring up to 85 degrees slope.

We also identify some of the measurement challenges faced when measuring steep sided samples on a profilometer and explain how Taylor Hobson's PGI Dimension addresses these and provides high quality multi-profile data.

## Challenges

Miniature diameter optics are amongst the most demanding of today's ultra-high precision form and radius measurement applications. They present a number of challenges in obtaining highly accurate and repeatable data. A traceable hemispherical standard is an excellent way of proving the process capability.

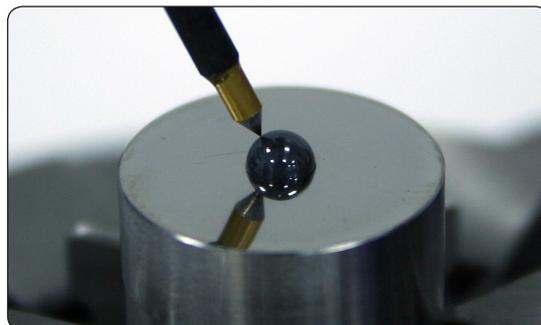


Figure 1: METAS Certificate of Calibration No 115-01450. Mean Diameter – 2.381193 mm

The main challenges are:

**Sample has steep sides** – There are two fundamental issues here, the first is to avoid any stylus flanking at all as this totally invalidates the data set.

Secondly, even if flanking is overcome by a special stylus, many measurement systems will show a progressive deterioration in data quality as the slope gets steeper.

**Alignment** – The measuring instrument needs an alignment capability that ensures that each measurement is taken right over the sample centre. Simply measuring over an ill-defined turning point may yield poor results. The sample must be well aligned to the instrument's rotational axis. This is particularly important if profiles are taken at different angular positions are taken. A measurement taken off axis may result in significant measurement errors. It is therefore critical that the instrument alignment process is repeatable and well defined and that the instrument has high inherent accuracy and stability. The smaller the sample and the steeper the sides the more critical this becomes.

**Measurement repeatability** – As discussed, reliable sample alignment is necessary before repeatable measurements can be made. As we are dealing with such small samples and low tolerances this presents a significant challenge and requires the measurement system be highly capable and highly stable. Instrument set up, environment and alignment are very important factors.

*“Taylor Hobson has designed the PGI Dimension to meet the ever-increasing demands of modern optics applications.”*

**Bob Bennett, Technical Director, Taylor Hobson Ltd.**

## PGI Dimension – The solution

**High quality data on steep sides –**  
By tilting the traverse datum, the PGI Dimension prevents stylus flanking and eliminates the effect of the steep sides

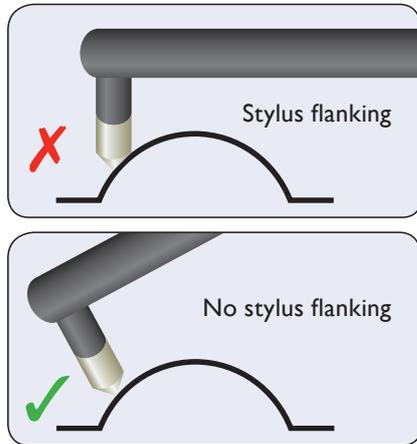


Figure 2: Angled gauge head resolves flanking issue

**High precision alignment –**  
Before the start of the measurement, the sample is aligned using Taylor Hobson's patented 'auto centre' technique to align the sample to the instrument rotational axis.

**Excellent repeatability –**  
PGI Dimension provides superb repeatable results thanks to Taylor Hobson's own highly stable precision measurement datums on a measurement platform which incorporates active anti-vibration.

## Measurement results

A total of 10 measurements were taken at the same angular position on a miniature hemisphere sample in order to show typical form repeatability and radius accuracy. The sample had a slope of 83 degrees.

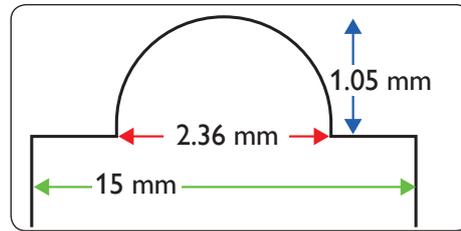


Figure 3: Clear aperture and sag

## Repeatability on steep slopes (83°)

The 10 measurements were compared for repeatability. This is shown in the graph below. The Ls filter used was 0.025 mm. The table below shows the Pt value from the ten measurements.

Certified radius 1.19060 mm											
Measurement	1	2	3	4	5	6	7	8	9	10	Max-Min
Form Error (Pt) nm	30	32	26	27	32	29	27	33	28	25	7
Opt. Base Rad. mm	1.19072	1.19071	1.19070	1.19071	1.19070	1.19070	1.19070	1.19070	1.19070	1.19072	20 nm

Table 1: Form error (Pt) and optimised base radius (mm) results (0–180 deg)

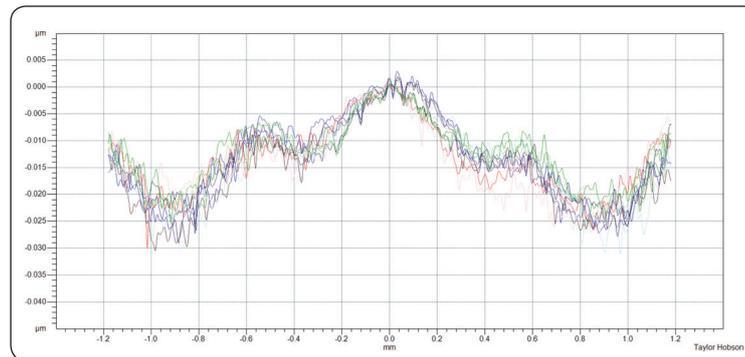


Figure 4: Repeatability measurements

## Conclusion

The PGI Dimension provides a highly stable measurement platform, ideally suited for the measurement of steep-sided miniature hemispheres. The results show excellent radius traceability and form error repeatability. It ensures that the sample axis is correctly centred to the instrument rotational axis and eliminates the data distortion normally seen when profilometers measure steep sides. Its excellent repeatability makes it the perfect instrument for production process control.



**Taylor Hobson UK**  
(Global Headquarters)  
PO Box 36, 2 New Star Road  
Leicester, LE4 9JD, England  
Tel: +44 116 276 3771  
taylor-hobson.sales@ametec.com



**Taylor Hobson France**  
Tel: +33 130 68 89 30  
taylor-hobson.france@ametec.com



**Taylor Hobson Germany**  
Tel: +49 611 973040  
taylor-hobson.germany@ametec.com



**Taylor Hobson India**  
Tel: +91 80 67823200  
taylor-hobson.india@ametec.com



**Taylor Hobson Italy**  
Tel: +39 02 946 93401  
taylor-hobson.italy@ametec.com



**Taylor Hobson Japan**  
Tel: +81 36809 2406  
taylor-hobson.japan@ametec.com



**Taylor Hobson Korea**  
Tel: +82 31 888 5255  
taylor-hobson.korea@ametec.com



**Taylor Hobson China Beijing Office**  
Tel: +86 10 8526 2111  
taylor-hobson.beijing@ametec.com



**Taylor Hobson China Shanghai Office**  
Tel: +86 21 58685111-110  
taylor-hobson.shanghai@ametec.com



**Taylor Hobson Singapore**  
Tel: +65 6484 2388 Ext 120  
taylor-hobson.singapore@ametec.com



**Taylor Hobson USA**  
Tel: +1 630 621 3099  
taylor-hobson.usa@ametec.com