1.0 INTRODUCTION

The instrument under calibration is a micrometer of 0-25mm range with a vernier scale of 0.001mm resolution.

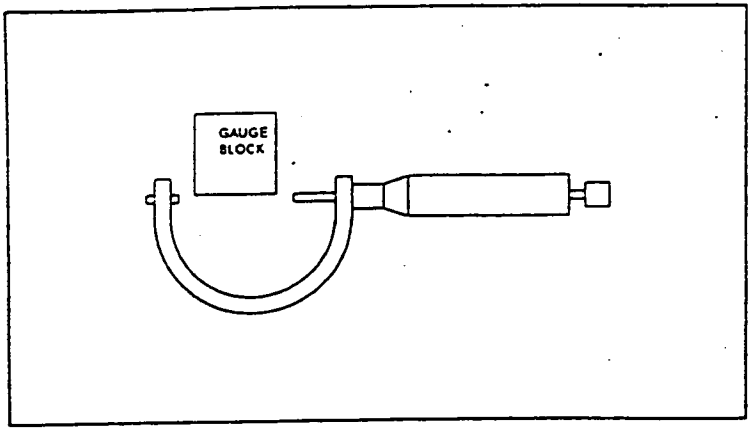

Fig . 1 Micrometer calibration

The error of micrometer screw is calibrated by comparison against gauge blocks of the following sizes :

2.5, 5.1, 7.7, 10.3 , 12.9, 15, 17.6, 20.2, 22 & 25 mm .

2.0 MATHEMATICAL MODEL

$$Y_{UUT} = X_{STD} + \text{Error}$$

where, Y_{UUT} is the micrometer reading, X_{STD} is the gauge block size and Error is the difference between the micrometer reading and gauge block size.

3.0 UNCERTAINTY EQUATION

The combined standard uncertainty equation is given by :

$$u_c(Y_{UUT}) = \sqrt{\left[\left(\frac{\partial Y_{UUT}}{\partial X_{STD}}\right)(u(X_{STD}))\right]^2 + \left[\left(\frac{\partial Y_{UUT}}{\partial Error}\right)(u(Error))\right]^2}$$

4.0 MEASURED RESULTS

Three readings are taken at each size and are tabulated as below :

Gauge Block size mm	Deviation from nominal (mm)			Standard Deviation
	1st reading	2nd reading	3rd reading	μm
2.5	0.001	0	0.001	0.577
5.1	0.001	0.001	0	0.577
7.7	-0.001	0	-0.001	0.577
10.3	0.001	0.001	0.001	0
12.9	0	0.001	0	0.548
15	0.001	0.001	0.001	0
17.6	0	0	0	0
20.2	0.001	0.001	0	0.577
22.8	-0.001	-0.001	-0.001	0
25	0.001	0.001	0.001	0

5.0 TYPE A UNCERTAINTY EVALUATION

Type A uncertainty is derived from the above table with the highest standard deviation.

$$\textit{Standard Uncertainty, } u_M = \frac{\textit{Standard Deviation}}{\sqrt{n}} \quad (\textit{where } n=3)$$

$$= \frac{0.577}{1.73}$$

$$= 0.333 \mu m$$

6.0 TYPE B UNCERTAINTY EVALUATION

The uncertainty quoted in the Gauge block calibration certificate is considered to be type B uncertainty of normal distribution.

$$u_{GB} = \frac{0.03}{2}$$

$$= 0.015\mu m$$

Another Type B uncertainty to be considered is the resolution of the micrometer which is 0.001mm and is considered to be full-width of rectangular distribution.

$$u_R = \frac{1}{\sqrt{12}}$$

$$= 0.289\mu m$$

7.0 UNCERTAINTY BUDGET

Source of Uncertainty	Type	u_i	Uncertainty Value (μm)	Probability Distribution	Degrees of Freedom
Repeatability of micrometer	A	u_M	0.333	t-distribution	2
Gauge Block	B	u_{GB}	0.015	Normal	∞
Resolution of micrometer	B	u_R	0.289	Rectangular	∞

8.0 COMBINED UNCERTAINTY

Combined uncertainty will be

$$u_c(Y_{UUT}) = \sqrt{u_M^2 + u_{GB}^2 + u_R^2}$$

$$= 0.44\mu m$$

9.0 EFFECTIVE DEGREES OF FREEDOM

The degrees of freedom is computed as follows :

$$\nu_{eff} = \frac{u_c^4}{\frac{u_M^4}{n-1} + \frac{u_{GB}^4}{\infty} + \frac{u_R^4}{\infty}}$$

$$= \frac{0.44^4}{\frac{0.333^4}{2}}$$

$$= 6$$

10.0 EXPANDED UNCERTAINTY

From the t-distribution table, k = 2.45 for degrees of freedom υ = 6 for confidence level of approximately 95 %.

The expanded uncertainty,

$$U = ku_c(Y_{UUT})$$

$$= 2.45x0.44$$

$$= 1.08\mu m$$

11.0 REPORTING OF RESULTS

The final result of the calibration may be stated as :

The range of error of the micrometer is 0.002 mm and the uncertainty associated with the calibration is ± 0.001 mm at a level of confidence of approximately 95 %.