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CALIBRATION CERTIFICATE

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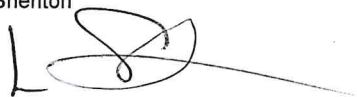|	
Certificate No:	2403010
Issue Date:	07 March 2024
Calibration Date:	07 March 2024
Technician:	R Moore

Equipment number: TM0457

Description:	A 5000 N compression and tension strain gauged load cell, used with an associated digital indicator, both manufactured by Interface.
Identification:	1203804 on load cell. (TM0457) J92180 on indicator. (TM0458) CT-177-10 on cable.
Basis of Calibration:	BS EN ISO 376:2011 Increasing Forces Only
Calibration Location:	Element Sheffield (address shown in header)
Classification:	The force proving instrument satisfies the requirement of BS EN ISO 376:2011 for the following classification range:-

Compression   **Class 0.5 ,**   **5000 N down to 100 N**

Tension,   **Class 0.5 ,**   **5000 N down to 100 N**

Issued by:

L Shenton

Senior Force Calibration Technician

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Method:

The calibration was made in the laboratory's No. 4 and No. 5 Force Standard Machines in terms of the SI unit of force, the newton (N). The uncertainty of the forces applied during the calibration is ± 1 part in 5 000 (±0.02%).

An overload test as specified in Clause B.1 of Annex B of BS EN ISO 376:2011 was carried out prior to the calibration.

A creep test as specified in Clause 7.4.4 of BS EN ISO 376:2011 was performed for between 30 and 300 seconds at maximum load after the final pre-load, the results of which were within the classification parameters stated in Clause 8.2.5 table 2 of BS EN ISO 376:2011.

Two tests were made in compression followed by two tests in tension. Two further tests were then made in compression followed by two further tests in tension. The forces were applied to the device in compression through a soft pad, provided by Element, placed centrally on the domed upper loading boss. In tension the forces were applied to the device through adaptors, also provided by Element.

Measurements:

1. The bearing pad test, Clause B.2 of Annex B of BS EN ISO 376:2011, was carried out during a previous calibration dated February 2022, certificate serial no. 2202038. The force proving instrument satisfies the requirements of the bearing pad test for the following classification range(s):-

    Class 0.5   5000 N down to 100 N

2. The temperature during the calibration tests varied between 20.2°C and 20.7°C.

3. Before calibration commenced the device was zeroed using the Tare button. The no-load reading for compression and tension are shown in the table below. The results on the following pages have been adjusted using a linear progression between the initial and final zero values based on these zero readings.

	Compression				Tension			
	Run 1	Run 2	Run 3	Run 4	Run 1	Run 2	Run 3	Run 4
Initial Zero	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final Zero	-0.05	0.02	-0.14	-0.05	0.06	0.10	-0.03	0.17

4. The forces applied and the resulting deflections are given in Tables 1 and 2: no correction for temperature has been applied to the results.

![element logo]

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5. For calibration in the compression mode in increasing forces, the estimate of the mean deflection was calculated as the mean of the tests 1, 3 and 4.

6. The procedure above was repeated for the calibration in the tension mode.

    For each mode of application of force, the coefficients of a third degree equation relating the estimate of the mean deflection as a function of the applied calibration force were calculated by the method of least squares. The differences between the mean value of deflection with rotation for each force and the computed value of deflection given by the equation were used to determine the relative interpolation error. The coefficients of a third degree equation relating a given applied force to the estimate of the mean deflection were also calculated.

Notes:

1. Clause 8.3.2 of BS EN ISO 376:2011 states that the maximum period of validity of the calibration of a force proving instrument shall not exceed 26 months. The force proving instrument shall be recalibrated if it sustains an overload which exceeds the maximum force by 12%.

2. Clause 9 of BS EN ISO 376:2011 states that the force proving instrument shall be loaded in accordance with the conditions under which it was calibrated. Precautions shall be taken to prevent it from being subject to forces greater than the maximum force to which it is classified.

3. If given or calculated forces are required to be in terms of one of the technical units of force, then the following conversion factors may be used:

Required unit of force	Factor by which the force in newtons must be multiplied
kilogram-force (kgf)	101.972×10^{-3}
pound-force (lbf)	224.809×10^{-3}
ton-force (tonf)	100.361×10^{-6}

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Results   Table 1 : Compression

Test Number	1	2	5	6	Unbiased estimate of mean	Expanded Uncertainty N	Expanded Uncertainty %
Orientation	0°	0°	120°	240°			
Force (N)	Deflection (N)					±	
100	-99.99	-100.00	-99.97	-99.99	-99.98	0.071	0.00071
200	-199.99	-200.00	-200.03	-200.02	-200.01	0.068	0.00034
500	-500.05	-500.05	-500.01	-500.01	-500.03	0.143	0.00029
1000	-1000.09	-1000.08	-1000.04	-1000.05	-1000.06	0.239	0.00024
1500	-1499.99	-1499.92	-1499.85	-1499.92	-1499.92	0.410	0.00027
2000	-1999.90	-1999.89	-2000.15	-2000.12	-2000.05	0.588	0.00029
2500	-2499.49	-2499.40	-2499.77	-2499.85	-2499.71	0.613	0.00025
3000	-2999.30	-2999.19	-2999.58	-2999.77	-2999.55	0.739	0.00025
3500	-3499.19	-3499.02	-3499.44	-3499.50	-3499.38	0.837	0.00024
4000	-3999.14	-3998.87	-3999.35	-3999.44	-3999.31	0.975	0.00024
4500	-4499.14	-4498.90	-4499.56	-4499.56	-4499.42	1.090	0.00024
5000	-4999.55	-4998.85	-4999.61	-4999.63	-4999.60	1.387	0.00028

Maximum Relative Uncertainty =   0.07%

Coefficients

For a given applied force F (in N), the expected deflection D (in N) OR For a given deflection D (in N), the applied force F (in N) is calculated from the following:

$$D=B_0+B_1F+B_2F^2+B_3F^3 \qquad F=A_0+A_1D+A_2D^2+A_3D^3$$

where:

$B_0 =$ 9.31815E-02 $A_0 =$ 9.31900E-02

$B_1 =$ -1.00048E+00 $A_1 =$ -9.99521E-01

$B_2 =$ 3.37168E-07 $A_2 =$ 3.37249E-07

$B_3 =$ -4.57248E-11 $A_3 =$ 4.57401E-11

If the expanded uncertainty is required for forces other than above it can be calculated from the following:

$$U_{exp}=(C_0+C_1F+C_2F^2)\times2$$

where:

$C_0 =$ 0.00000E+00

$C_1 =$ 1.02717E-04

$C_2 =$ 4.52146E-09

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Results   Table 2 : Tension

Test Number	3	4	7	8	Unbiased	Expanded Uncertainty	Expanded Uncertainty
Orientation	0°	0°	120°	240°	estimate	N	%
					of mean	±	
Force (N)			Deflection (N)			±	
100	100.03	100.01	99.99	100.06	100.03	0.106	0.00106
200	199.99	199.96	199.94	200.00	199.98	0.071	0.00035
500	500.07	500.04	500.05	500.08	500.06	0.128	0.00026
1000	1000.14	1000.15	1000.13	1000.14	1000.14	0.333	0.00033
1500	1500.43	1500.38	1500.50	1500.51	1500.48	0.419	0.00028
2000	2001.01	2000.87	2001.30	2001.41	2001.24	0.720	0.00036
2500	2501.17	2500.91	2501.72	2501.26	2501.38	0.752	0.00030
3000	3001.81	3001.62	3002.12	3002.18	3002.04	0.791	0.00026
3500	3502.28	3502.04	3502.32	3502.33	3502.31	0.859	0.00025
4000	4002.73	4002.50	4002.68	4002.80	4002.74	0.961	0.00024
4500	4502.82	4502.67	4502.88	4502.95	4502.88	1.077	0.00024
5000	5003.16	5002.92	5003.22	5003.21	5003.20	1.193	0.00024

Maximum Relative Uncertainty =   0.11%

Coefficients

For a given applied force F (in N), the expected deflection D (in N) OR For a given deflection D (in N), the applied force F (in N) is calculated from the following:

$$D = B_0 + B_1F + B_2F^2 + B_3F^3 \qquad\qquad F = A_0 + A_1D + A_2D^2 + A_3D^3$$

where:

$B_0 = $ -1.72363E-02 $A_0 = $ 1.73291E-02

$B_1 = $ 9.99941E-01 $A_1 = $ 1.00006E+00

$B_2 = $ 3.84073E-07 $A_2 = $ -3.83302E-07

$B_3 = $ -4.93660E-11 $A_3 = $ 4.92370E-11

If the expanded uncertainty is required for forces other than above it can be calculated from the following:

$$U_{exp} = (C_0 + C_1F + C_2F^2) \times 2$$

where:

$C_0 = $ 0.00000E+00

$C_1 = $ 1.60709E-04

$C_2 = $ -9.71250E-09