



National Engineering
Laboratory

CERTIFICATE OF CALIBRATION

Certificate No: **2022_401**

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Ref: OP091-f08, v 1.7

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Date of Issue: 19-Jul-22

Title: **Calibration of a 2-inch Coriolis Meter S/N: 22016006**

Customer: **Oxford University**

Date Received: 17-Jun-22

Address: Oxford
OX12 2JD
United Kingdom

Date of Test: 14-Jul-22

Test No: 10817-s1

Job/Project No: UNO019

Responsible Operator: R. Hone

Test Meter:

Description: Coriolis Flowmeter
Manufacturer: Systec Controls
Type/ Model: SMF016
Output Signal Type: Pulse
Nominal Size: 2-inch
Serial No: 22016006
Condition & Treatment: "As found"

Additional Information On Device:

Configuration Settings: Meter re-zeroed prior to start.
Flow Calibration: FC2: 10.2827
Density Calibration: DC2: -540201 DC4: 6662.54
Output Settings: Pulse: Mass Flow (Nominal K-Factor = 2000 pulse/kg)

Test Conditions:

Flow Range, Min: 0.22 kg/s (Approximate specification)
Max: 4.18 kg/s
Nominal Temperature: 20 °C
Nominal Pressure: 3 barg
Test Fluid: Kerosene
Nom. Viscosity: 2.77 cSt at 20 °C
Nom. Density: 801.246 kg/m³ at 20 °C

Additional Test Information:

Pipe Straight Lengths: Upstream: 21 D Downstream: 11 D (diameters)

Distribution:

No.of copies: 1 NEL Project File Format: Electronic
1 Oxford University PDF

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1. TEST FACILITIES, MEASUREMENTS AND METHOD

The flowmeter package was installed in the TUV NEL National Standards Oil Flow Measurement Facility, as shown in Figure 1.

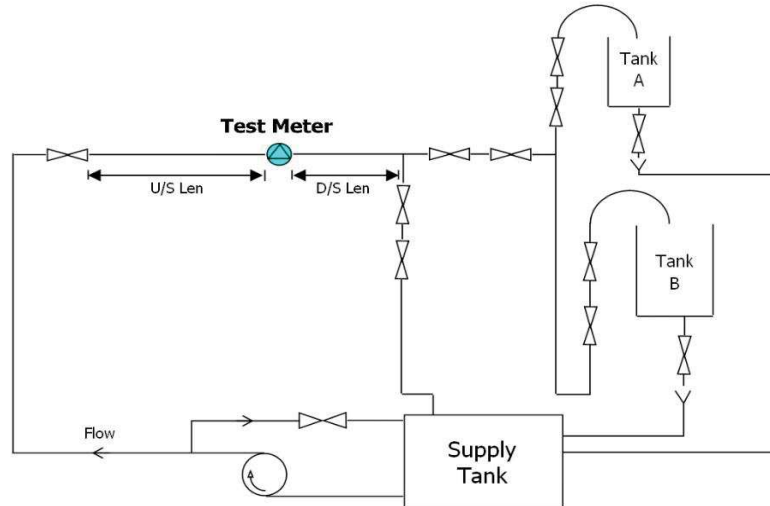


Figure 1: Schematic Diagram of Gravimetric Test Circuit

The device was calibrated by comparison of the output value with the value derived from a reference gravimetric weighing system. The method used was a standing-start-and-finish technique where the flow was started quickly and stopped at the end of the test.

The flowrate was calculated using the time taken for the quantity of fluid to pass through the meter. All measurements are fully traceable to National Standards.

The K-Factor (K) of the device under test was derived from the total number of pulses (P) output by the device divided by the reference quantity (Q):

K = P / Q (1)

The percentage error was calculated for the indicated quantity (Qi) from the device under test with respect to the reference quantity (Q):

E = (Qi - Q) / Q * 100 per cent (2)

2. UNCERTAINTY

The uncertainty estimates reported on the last page(s) of this calibration certificate are the total uncertainties, U_tot, for the calibration process incorporating the uncertainty of the reference values, U_CMC, and the repeatability of the calibration process, U_rep, for each group of flowrates.

The estimate of repeatability of the calibration process is calculated from the variance in the mean of a group of test points. Test points are considered a group when they are consecutive and are at similar conditions. The repeatability at singular test points not part of a group is estimated from the group(s) closest to their operating conditions.

The estimates of standard uncertainty for these sources are combined using the root sum square method to give the total standard uncertainty. The total standard uncertainty is then multiplied by the corresponding coverage factor based on the t-distribution, using effective degrees of freedom calculated by the Welch-Satterthwaite formula to give the total expanded uncertainty for each group. The uncertainty estimate has been carried out in accordance with the methods recommended in international standards (GUM and ISO 5168), also in accordance with UKAS requirements.

3. RESULTS

The results are tabulated in Table 1 and shown graphically in Figure 2. The total uncertainties for the flow calibration are tabulated in Table 2. The total uncertainties for the density calibration are tabulated in Table 3. Test Point numbering may be non-consecutive due to intermediate checks, which are not shown.

(End of Text)



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For: Oxford University

Using: NEL Oil Flow Facility UKAS [calibration laboratory]No.0005 Date of Issue: 19-Jul-22

Table 1: Table of Results

Summary Report

Test Desc: Calibration of a 2-inch Coriolis Meter S/N: 22016006

Facility: NEL Oil Flow Facility

Quantity Type: Mass

Device Under Test:

Description: Coriolis Mass Flowmeter

Serial No: 22016006

NEL DAQ ID: 26

Fluid Properties:

Density @ 20°C: 801.245636 kg/m³

Exp. Factor: -0.000935779 /°C

Test Details:

Project No.: UNO019

Test No.: 10817-s1

Test Date: 14-Jul-22

Operator: R. Hone

Calib. Method: Gravimetric

Line ID: B

Test Point	Tank Fill s	Ave. Temp. °C	Press.g U/S barg	Press.g D/S barg	Fluid Density kg/m³	Fluid Kin. Viscosity cSt	Total Corr. Mass kg	Ref. Mass Flow kg/s	Meter Signal pulse	K Factor pulse/kg	% Error (Ref.Mass) %
1	193.472	19.89	3.02	2.98	801.535	2.78	42.145	0.218	84218	1998.270	-0.087
2	193.401	19.92	3.02	2.98	801.513	2.77	42.123	0.218	84193	1998.721	-0.064
3	193.150	19.95	3.02	2.98	801.493	2.77	42.073	0.218	84078	1998.367	-0.082
4	146.112	19.96	3.11	3.06	801.489	2.77	42.576	0.291	85137	1999.647	-0.018
5	145.847	19.99	3.10	3.06	801.469	2.77	42.498	0.291	84954	1999.017	-0.049
6	146.104	20.00	3.10	3.06	801.458	2.77	42.568	0.291	85095	1999.037	-0.048
7	180.312	19.99	3.17	3.11	801.471	2.77	76.326	0.423	152570	1998.924	-0.054
8	180.952	20.01	3.17	3.11	801.458	2.77	76.624	0.423	153169	1998.957	-0.052
9	180.466	20.00	3.17	3.11	801.465	2.77	76.426	0.423	152734	1998.451	-0.077
10	141.010	20.01	3.23	3.06	801.459	2.77	115.678	0.820	231332	1999.798	-0.010
11	141.429	19.99	3.23	3.06	801.469	2.77	115.932	0.820	231789	1999.354	-0.032
12	141.918	19.97	3.23	3.06	801.486	2.77	116.302	0.820	232539	1999.434	-0.028
13	114.173	20.01	3.36	3.01	801.461	2.77	144.072	1.262	288091	1999.631	-0.018
14	113.647	20.00	3.36	3.01	801.466	2.77	143.383	1.262	286678	1999.386	-0.031
15	113.646	19.99	3.36	3.01	801.471	2.77	143.317	1.261	286556	1999.456	-0.027
16	436.617	19.89	3.58	3.00	801.558	2.78	739.064	1.693	1478342	2000.288	0.014
17	435.961	19.93	3.58	3.00	801.527	2.77	737.742	1.692	1475681	2000.266	0.013
18	436.549	19.95	3.58	2.99	801.513	2.77	738.663	1.692	1477480	2000.210	0.010
19	323.986	19.98	4.09	3.07	801.506	2.77	738.262	2.279	1476567	2000.057	0.003
20	324.647	19.97	4.09	3.07	801.520	2.77	739.444	2.278	1479120	2000.314	0.016
21	324.732	19.96	4.09	3.07	801.521	2.77	739.384	2.277	1479038	2000.365	0.018
22	252.043	20.02	4.61	2.97	801.497	2.77	740.726	2.939	1480605	1998.855	-0.057
23	251.546	20.03	4.60	2.97	801.489	2.77	738.844	2.937	1477262	1999.425	-0.029
24	251.804	20.02	4.60	2.97	801.492	2.77	739.784	2.938	1478905	1999.103	-0.045
25	210.269	20.05	5.14	2.86	801.485	2.76	739.624	3.518	1480096	2001.147	0.057
26	210.744	20.04	5.14	2.86	801.495	2.77	741.326	3.518	1482818	2000.225	0.011
27	210.172	20.05	5.14	2.85	801.487	2.77	739.182	3.517	1478153	1999.715	-0.014
28	178.030	20.02	4.96	1.82	801.466	2.77	743.928	4.179	1488766	2001.224	0.061
29	178.535	20.04	4.96	1.81	801.452	2.77	745.971	4.178	1493237	2001.737	0.087
30	177.923	20.06	4.96	1.81	801.438	2.76	743.307	4.178	1487489	2001.176	0.059

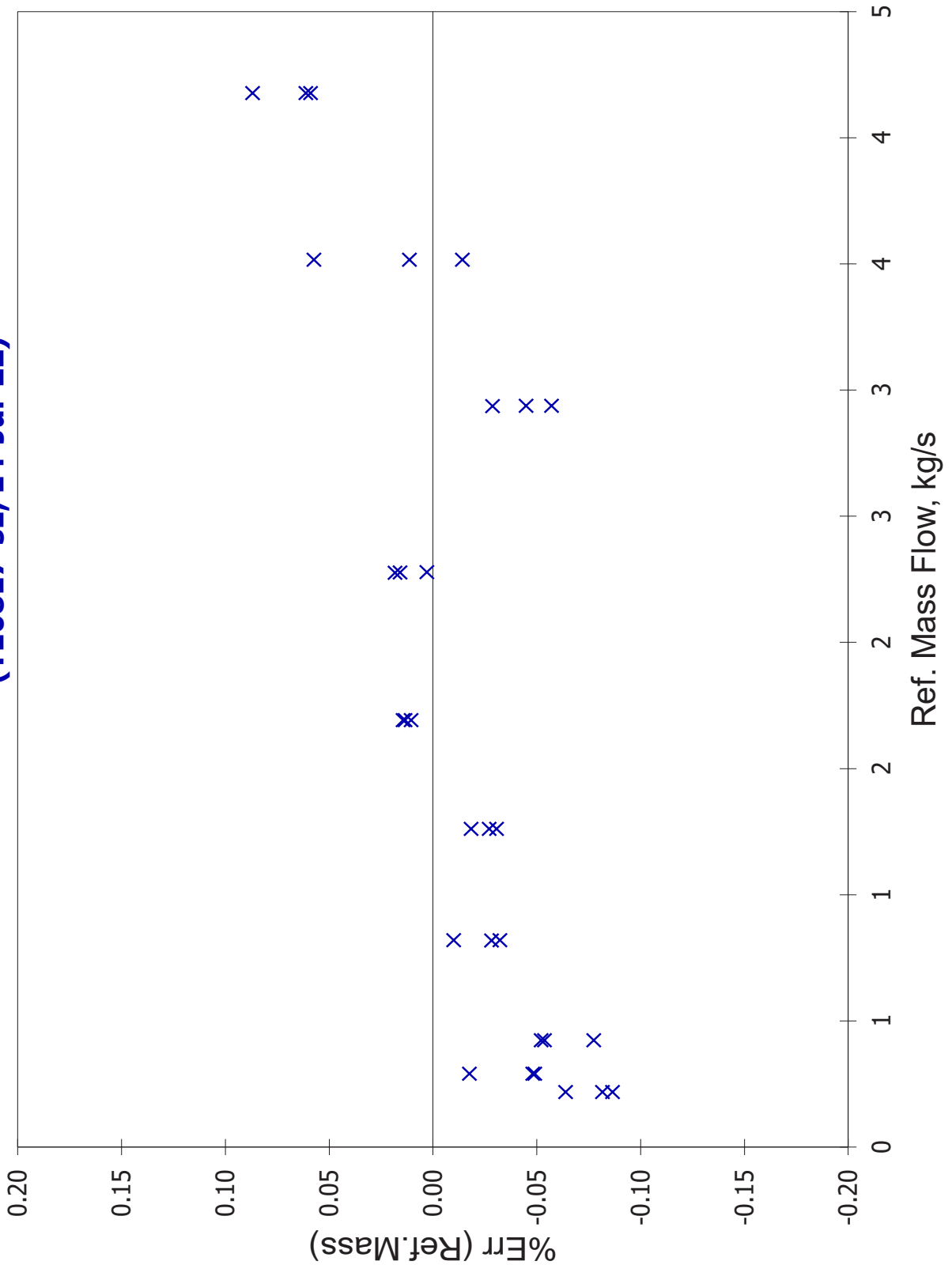
(End of Table)



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Figure 2: Calibration Results

Coriolis Mass, s/n: 22016006
(T10817-s1, 14-Jul-22)



(End of Chart)



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Title: **Calibration of a 2-inch Coriolis Meter S/N: 22016006**

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For: **Oxford University**

Using: **NEL Oil Flow Facility**

UKAS [calibration laboratory]No.0009

Date of Issue: **19-Jul-22**

Table 2: Total Uncertainty for the Flow Calibration Process

Test Point	Ref. Mass Flow kg/s	K Factor pulse/kg	Average Ref. Mass Flow kg/s	Average K Factor pulse/kg	u_{rep} %	U_{CMC} %	U_{tot} %	v_{eff} -	k -
1	0.218	1998.270	0.218	1998.453	0.007	0.03	0.034	66	2.04
2	0.218	1998.721							
3	0.218	1998.367							
4	0.291	1999.647	0.291	1999.234	0.010	0.03	0.039	19	2.14
5	0.291	1999.017							
6	0.291	1999.037							
7	0.423	1998.924	0.423	1998.778	0.008	0.03	0.035	38	2.07
8	0.423	1998.957							
9	0.423	1998.451							
10	0.820	1999.798	0.820	1999.529	0.007	0.03	0.034	67	2.04
11	0.820	1999.354							
12	0.820	1999.434							
13	1.262	1999.631	1.262	1999.491	0.004	0.03	0.031	640	2.00
14	1.262	1999.386							
15	1.261	1999.456							
16	1.693	2000.288	1.692	2000.255	0.001	0.03	0.030	54341	2.00
17	1.692	2000.266							
18	1.692	2000.210							
19	2.279	2000.057	2.278	2000.246	0.005	0.03	0.032	236	2.01
20	2.278	2000.314							
21	2.277	2000.365							
22	2.939	1998.855	2.938	1999.128	0.008	0.03	0.035	37	2.07
23	2.937	1999.425							
24	2.938	1999.103							
25	3.518	2001.147	3.517	2000.362	0.021	0.03	0.074	4	2.87
26	3.518	2000.225							
27	3.517	1999.715							
28	4.179	2001.224	4.178	2001.379	0.009	0.03	0.037	28	2.09
29	4.178	2001.737							
30	4.178	2001.176							

(End of Table)

Results contained in this certificate relate only to the test device detailed on Spec sheet.



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Title: **Calibration of a 2-inch Coriolis Meter S/N: 22016006**

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For: **Oxford University**

Using: **NEL Oil Flow Facility**

UKAS [calibration laboratory]No.0009

Date of Issue: **19-Jul-22**

**Table 3: Total Uncertainty for the Flow
Calibration Process**

Test Point	Ref. Mass Flow kg/s	% Error (Ref.Mass) %	Average Ref. Mass Flow kg/s	Average % Error (Ref.Mass) %	u_{rep} %	U_{CMC} %	U_{tot} %	v_{eff} -	k -
1	0.218	-0.087	0.218	-0.077	0.007	0.03	0.034	66	2.04
2	0.218	-0.064							
3	0.218	-0.082							
4	0.291	-0.018	0.291	-0.038	0.010	0.03	0.039	19	2.14
5	0.291	-0.049							
6	0.291	-0.048							
7	0.423	-0.054	0.423	-0.061	0.008	0.03	0.035	38	2.07
8	0.423	-0.052							
9	0.423	-0.077							
10	0.820	-0.010	0.820	-0.024	0.007	0.03	0.034	67	2.04
11	0.820	-0.032							
12	0.820	-0.028							
13	1.262	-0.018	1.262	-0.025	0.004	0.03	0.031	641	2.00
14	1.262	-0.031							
15	1.261	-0.027							
16	1.693	0.014	1.692	0.013	0.001	0.03	0.030	54314	2.00
17	1.692	0.013							
18	1.692	0.010							
19	2.279	0.003	2.278	0.012	0.005	0.03	0.032	236	2.01
20	2.278	0.016							
21	2.277	0.018							
22	2.939	-0.057	2.938	-0.044	0.008	0.03	0.035	37	2.07
23	2.937	-0.029							
24	2.938	-0.045							
25	3.518	0.057	3.517	0.018	0.021	0.03	0.074	4	2.87
26	3.518	0.011							
27	3.517	-0.014							
28	4.179	0.061	4.178	0.069	0.009	0.03	0.037	28	2.09
29	4.178	0.087							
30	4.178	0.059							

(End of Table)

Results contained in this certificate relate only to the test device detailed on Spec sheet.

End of Calibration Certificate