Calibration of a STAUFF Flowmeter

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INSTITUTE FOR AEROSPACE RESEARCH

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CALIBRATION REPORT
RAPPORT D'ETALONNAGE

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ABSTRACT

A flowmeter, manufactured by STAUFF, Model VC5, Serial Number 430, has been calibrated for the Quality Engineering Test Establishment of the Department of National Defence (DND). This report contains the calibration results, a brief description of the calibration facility, and a delineation of expected uncertainties, based on calibrations performed at NRC and abroad.

RÉSUMÉ

Le débimètre à turbine, modèle VC5, portant le numéro de série 430, fabriqué par la société Stauff, a été étalonné pour le compte de la société Centre d'essais techniques de la qualité, Ministère de la Défense nationale. Le présent rapport renferme, outre les résultats de l'étalonnage et certaines observations, une description de l'installation utilisée pour l'étalonnage et les marges d'erreur prévues se fondant sur des étalonnages effectués au CNRC et par un organisme indépendant.

CONTENTS

LIST OF ILLUSTRATIONS

CALIBRATION of a STAUFF FLOWMETER

VC5, S/N 430

1.0 INTRODUCTION

The Structures, Materials, and Propulsion Laboratory (SMPL) of the Institute for Aerospace Research, is the custodian of an Omnitrak ballistic calibrator, designed specifically for the calibration of turbine-type flowmeters. After a period of several years, in which the calibrator had been exclusively used for NRC meter calibrations, the service is now extended to include outside clients. A high degree of accuracy is ensured by periodic internal calibrations, traceable to Canadian standards, and by participation in calibration programs, such as one that was performed by the National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards (NBS), Gaithersburg, MD.

This report contains a description of the calibration facility, the expected uncertainty traceable to national standards, and the test procedure. The test results for the client's flowmeter are presented in tabular form.

2.0 DESCRIPTION OF CALIBRATOR

The flowmeter has been calibrated on an Omnitrak calibrator system, Model OT-150, S/N 83110022, manufactured by Flow Technology, Inc., Phoenix, AZ. The system is a precise volumetric calibration device. A detailed description of the device can be found in the users manual (FTI 1982) of the manufacturer. Output from the calibrator was routed to a Digital Equipment Corporation MicroVAX 3100 computer system providing data storage, custom print-outs, plotting, and data reduction facilities.

A summary of pertinent specifications of the calibrator is:

- Flow Range: 0.15 to 150 USGPM or 0.0095 to 9.5 l/s (approximately 60 to 60,000 lbm/h of aviation fuel).
- Flowmeter Size Range: 1/2" to 1½" (13 to 38 mm).
- Flowmeter Assembly Maximum Length: 48" (1219 mm) between 1½", 37° flared tube fittings.

Although various fluids may be used, it was decided to perform all calibrations with the widely accepted calibrating fluid for aircraft fuel system components, MIL-C-7024C, Type II. The specified viscosity of the calibration fluid is 1.17 ±0.05 cSt (1.17 ±0.05 $*10^{-6}$ m^2/s) at 25°C.

3.0 CALIBRATION UNCERTAINTY

When considering the accuracy, or uncertainty, of a calibration, the whole system must be taken into account, including the flowmeter. A flowmeter with worn components would not lend itself to accurate, repeatable performance. Hence, as a basis for a good calibration, it must be assumed that the test specimen is functioning to specifications.

The Omnitrak calibrator was factory-calibrated when purchased. The volumetric resolution, or K-Factor, for this model, was specified as approximately 62,200 pulses per US gallon (PPG). Prior to delivery, the actual calibration constant for this particular calibrator was established by the manufacturer as 62,202 PPG. A careful recalibration by the laboratory yielded an Omnitrak K-Factor of 62,213 PPG (Grabe and Carvish 1988). In two calibration tests, each consisting of eight water draws, the averaged K-Factors, reduced to standard conditions, came to within 0.5 PPG, or ±0.0008%, of each other. A check revealed that the K-Factor increased systematically along the draw tube of the calibrator by 0.08% which was well within the manufacturer's specified limit of 0.1%.

Over the course of some 120 calibrations, on 15 in-house turbine flowmeters, the manufacturer's claimed repeatability of ±0.05% was confirmed, i.e., with few exceptions, calibration points fell within ±0.05% of a best-fit curve.

Finally, the laboratory participated in a round-robin calibration program conducted by the National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards, Gaithersburg, MD. This program was primarily in response to requests by the Department of Defence (US), industrial users, and manufacturers. The data were evaluated by NIST by means of Youden plots (Mattingly 1988). At the high flow point, which yielded more consistent results all around, NRC had a bias, or systematic, error of 0.18% with respect to the median of all calibrators. When compared only with calibrators of the same principle as the Omnitrak, i.e. pulse counts related to volume displacement, the bias error was 0.05%. The precision error was less than 0.05% in either case. This good agreement with the median of 12 other major North American calibrators, including two from NIST, was considered to be a confirmation of the accuracy of NRC's calibration equipment and procedures. It is the intention of NRC to maintain the established link with NIST and continually test the accuracy of its flowmeter calibrator by participation in future calibration programs.

On the basis of the above described uncertainty analyses, the bias error of the calibration, relative to the true value, is expected to be within ±0.18%, with a precision error of ±0.05%, yielding an overall uncertainty of ±0.28%.[1]

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[1] The uncertainty establishment and terminology follows Abernethy, R.B., et al., 1973.

4.0 FLOWMETER CALIBRATION

Information pertinent to the calibration reported:

Job No.:	VC5-430
Calibration Date:	October 27, 1999
Customer:	Quality Engineering Test Establishment

Flowmeter Data

Make/Model:	STAUFF/VC5
Size:	1"
Serial No.:	430
Pickoff Type:	inductive
Pickoff Part No.:	236306460
Calibration Fluid:	MIL-C-7024C, Type II
Relative Density (15.56/15.56°C):	0.7779
Room Temperature (avg) °C:	21.50
Operating Pressure psig:	80.0
kPa:	552

An inspection of the flowmeter, prior to calibration, indicated that the mechanical condition of the unit was satisfactory. The assembly, supplied by the client, comprised a flowmeter body, digital readout and flexible fluid lines. The calibration range, selected by the client, covered flows from approximately 0.4 to 40 USGPM. Twenty three calibration points were taken over the requested range which included repeat tests at various points.

To monitor the flowrate during the calibration, a turbine flowmeter was installed in series with the Stauff meter under test. Two NRC supplied turbine meters, a 1/2" diameter (SN 805889) and a 1" diameter (SN160509) were utilized during the calibration to cover the range of the Stauff flowmeter.

The calibration proceeded from the lowest flow to the highest and back to the lowest in two stages, one with the 1/2" meter and a second with the 1" meter installed. At each stage, a repeat calibration point was taken to ensure repeatability. Room and fluid temperatures were recorded at each test point. The average room and individual fluid temperatures were used to correct the turbine flowmeter K-Factors to standard conditions. The fluid temperature was also used to calculate the fluid viscosity at each calibration point.

Calibration points were displayed on the CRT of the computer immediately following acquisition providing a visual assessment of the calibration in progress. Following the calibration process, a report of the calibration results (Appendix 1), containing turbine flowmeter and calibration data, was printed.

In this test, output from the flowmeter was not recorded automatically by the Omnitrak. Output from the flowmeter was displayed on a readout supplied by the client. Hand recordings were made by the client by visually averaging the results displayed on the readout. The results of these observations are not included in this report.

5.0 COMMENTS

The following comments can be made about the calibration (VC5) of the flowmeter, S/N 430, owned by the Quality Engineering Test Establishment:

- the F RATE (USGPM) data listed in the printouts of appendix 1 can be compared to the results obtained from the readout of the client meter.
- the viscosity of the fluid (1.17 cSt) used during the test is much less than that of fluids normally used with the VC5. (10 to 600 cSt).
- The turbine calibration repeat points were within 0.1% of each other.
- No unusual symptoms of the meter were observed during the calibration.
- The overall uncertainty in the client flowmeter calibration will include contributions from the stated NRC calibrator traceability, the repeatability of the recorded data and any errors associated with reading the flowmeter display.

6.0 REFERENCES

Abernethy, R.B., et al., Thompson, J.W., Jr. 1973. Revised 1980. Handbook, Uncertainty in Gas Turbine Measurements. Engine Test Facility, Arnold Engineering Development Center, Air Force Systems Command, Arnold AFS, TN.

Grabe, W., and Carvish, J. 1988. Calibration of an FTI Omnitrak Ballistic Flow Calibrator System, National Research Council Canada, Engine Laboratory, TR-ENG-002.

Installation, Operation and Maintenance Manual Omnitrak. October 1982. Flow Technology, Inc., 4250 East Broadway Road, Phoenix, AZ 85040.

Mattingly, G.E. 1988. A Round Robin Measurement Testing Program Using Hydrocarbon Liquids: Results for First Phase Testing. US Department of Commerce, National Institute of Standards and Technology (formerly National Bureau of Standards), National Engineering Laboratory, Center for Chemical Engineering, Fluid Flow Group, Chemical Process Metrology Division, Gaithersburg, MD 20899, NISTIR 88-4013.

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TURBINE FLOWMETER CALIBRATION

Customer: DND QETE
Date: 27-OCT-99 Job #: 99-05

CALIBRATOR DATA

Make: Flow Technology Omnitrak Calibrator System   Model: OT-150   S/N: 83110022
Microtrak Constant: 62215   Volume Unit: U.S. Gallon
Calibration Fluid: MIL-C-7024C, Type 2
Specific Gravity(15.56/15.56 Deg.C): 0.7779
Room Temperature (Average)[Deg. C]: 21.50   Operating Pressure [Psig]: 80.00

FLOWMETER DATA

Make/Model : STAUFF   Size : 1"
S/N : VC5-430   Pickoff Type: Inductive
Pickoff P/N: 236306460   Bearing Type: Unknown

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RUN	T VOL	T FMP	# FMP	VOL	FREQ	F RATE	Kcor	FREQ/VISC
1	13.735	13.743	1362.0	0.1	99.105	0.43684	13612.	75.206
2	6.8357	6.8334	1369.0	0.1	200.34	0.87774	13694.	152.03
3	2.7274	2.7284	1368.0	0.1	501.39	2.1999	13674.	380.48
4	1.3659	1.3660	1366.0	0.1	1000.0	4.3927	13658.	759.97
5	0.68500	0.68470	1368.0	0.1	1998.0	8.7591	13685.	1520.6
6	0.69340	0.69350	1369.0	0.1	1974.0	8.6530	13687.	1504.6
7	1.3666	1.3666	1366.0	0.1	999.56	4.3905	13659.	761.88
8	2.7349	2.7342	1367.0	0.1	499.96	2.1939	13673.	381.08
9	6.8390	6.8384	1369.0	0.1	200.19	0.87732	13690.	152.59
10	13.529	13.534	1362.0	0.1	100.64	0.44349	13614.	76.706

T VOL=Time for Displaced Volume [S]   T FMP=Time for Flowmeter Pulses [S]
# FMP=Number of Flowmeter Pulses [ ]   VOL=Volume of Fluid Displaced [U.S. Gal.]
FREQ=Frequency of the Flowmeter [Pulses/S]   F RATE=Flowrate [U.S. Gal./Min.]
Kcor=K-Factor of the Flowmeter Corrected to Standard Conditions [Pulses/U.S. Gal.]
FREQ/VISC=Frequency Divided by the Viscosity of the Fluid at the Temperature of the Run [Pulses/S*cSt]

Calibrated by: Marc Fournier   Certified by: W.F. Mulligan

Figure 1. Calibration Results For Flows Ranging From 0.4 to 9 USGPM

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TURBINE FLOWMETER CALIBRATION

Customer: DND QETE
Date: 27-OCT-99 Job #: 99-06

CALIBRATOR DATA

Make: Flow Technology Omnitrak Calibrator System Model: OT-150 S/N: 83110022
Microtrak Constant: 62215 Volume Unit: U.S. Gallon
Calibration Fluid: MIL-C-7024C, Type 2
Specific Gravity(15.56/15.56 Deg.C): 0.7779
Room Temperature (Average)[Deg. C]: 21.30 Operating Pressure [Psig]: 80.00

FLOWMETER DATA

Make/Model : STAUFF Size : 1"
S/N : VC5-430 Pickoff Type: Inductive
Pickoff P/N: 236306460 Bearing Type: Unknown

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RUN	T VOL	T FMP	# FMP	VOL	FREQ	F RATE	Kcor	FREQ/VISC
1	3.9599	3.9605	2358.0	1.	595.38	15.152	2357.5	455.81
2	2.9573	2.9577	2359.0	1.	797.58	20.289	2358.5	613.30
3	2.3646	2.3655	2360.0	1.	997.67	25.374	2358.9	769.40
4	1.9594	1.9591	2358.0	1.	1203.6	30.622	2358.2	929.58
5	1.6620	1.6623	2358.0	1.	1418.5	36.101	2357.4	1098.7
6	1.5111	1.5108	2358.0	1.	1560.8	39.706	2358.2	1214.2
7	1.5109	1.5114	2359.0	1.	1560.8	39.711	2358.0	1216.0
8	1.6517	1.6517	2357.0	1.	1427.0	36.326	2356.8	1111.8
9	1.9629	1.9627	2358.0	1.	1201.4	30.567	2358.0	937.36
10	2.3524	2.3524	2359.0	1.	1002.8	25.506	2358.8	782.40
11	2.9433	2.9422	2358.0	1.	801.44	20.385	2358.6	626.20
12	3.9285	3.9292	2358.0	1.	600.12	15.273	2357.3	468.90
13	2.3520	2.3529	2360.0	1.	1003.0	25.510	2358.8	783.70

T VOL=Time for Displaced Volume [S]
T FMP=Time for Flowmeter Pulses [S]
# FMP=Number of Flowmeter Pulses [ ]
VOL=Volume of Fluid Displaced [U.S. Gal.]
FREQ=Frequency of the Flowmeter [Pulses/S]
F RATE=Flowrate [U.S. Gal./Min.]
Kcor=K-Factor of the Flowmeter Corrected to Standard Conditions [Pulses/U.S. Gal.]
FREQ/VISC=Frequency Divided by the Viscosity of the Fluid at the Temperature of the Run [Pulses/S*cSt]

Calibrated by: Marcel Fournier Certified by: M.F. Mulligan