

RECENT IMPROVEMENTS IN AIR FLOW CALIBRATION REFERENCE INSTRUMENTS

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INTRODUCTION AND HISTORY

A key element in radiation protection programs at commercial nuclear power plants, nuclear research facilities, fuel fabrication plants and regulatory agency oversight programs of licensees is management's ability to validate the accuracy of the many air sampling instruments utilized in the facility's radiation protection air monitoring programs.

The volume of air sampled in each sample event is responsible for the quantity of radioactive pollutants deposited on the filter media utilized in each of the specific air sampling events. The quantitative value of the volume of air determined in the air sampling events must be as accurate as reasonably possible. Thus, nuclear facility departments responsible for the air monitoring programs should be utilizing the "Best Available Technology" that is reasonably affordable in order to periodically validate the accuracy of the many air sampling instruments in the field. These air sampling instruments are determining the air sample volumes for the purpose of computing the radioactive pollutant concentrations in the effluent pathways and in work area atmospheres.

This periodic validation process is called calibration-verification. It requires utilization of a reference air flow instrument (REF) sometimes referred to as an air flow calibrator. The value of the air sampling instrument's flow measurement device under test (DUT) is compared to the output of the reference air flow calibrator. The output of the REF is considered to be a conventionally true value (CTV) when both are placed in series and measuring the same volume of air per unit time.

It is a scientifically accepted principle that the measured volume of a gas (air in our case) can only be quantitatively defined if the temperature and pressure at which the volume of the gas is determined are also defined.

If one is to compare a series of different flow rates (volume per unit time) as is done in the calibration-verification process, one must normalize to the same temperature and pressure the flow rate of both the air flow calibrator and the air sampler output value when simultaneously measuring the identical volume of air per unit time. Thus, the output values of the REF and DUT must be normalized to an internationally recognized standard of temperature (T) and pressure (P) often referred to as Standard Temperature and Pressure (STP).

In our case, it doesn't matter which of the several reference standards we use as long as the output values of the DUT and REF are corrected to the same T and P values. This results in a true comparison of the DUT and REF output values for flow rate. It is pertinent to note that the purpose of the calibration-verification process is to determine whether the air sampler's reported flow rate values within the air sampler's operating range are within the manufacturer's stated accuracy criteria.

Prior to the 1990's the air sampling instruments and air flow calibration instruments utilized in radiation protection applications were usually analog instruments whose outputs were not corrected to any reference T and P. Manual calculations using the Ideal gas law equations had to be performed manually and required one to measure the pressure at the flow sensors point of measurement and the temperature of the air flowing through the reference calibrator and air sampling instrument. Adherence to these scientific details usually were omitted in the interest of time and convenience. In the early 1990's, nuclear industry suppliers started manufacturing air flow calibrators and air samplers that reported flow rates and accumulated sample volumes corrected to one or more internationally recognized standards of T and P. Most of the early microprocessor controlled instruments did not provide operator selectable reference standards. A reference standard selected by the manufacturer was usually set at the factory.

These early advanced-technology air flow calibrators also has limited operator selectable choices of engineering units for temperature, pressure and flow rate.

The early designs usually had a one or two-line liquid crystal display and were not designed for an international market. They were primarily designed for use in the manufacturer's own country and in many cases specifically directed to a certain industry segment, such as NPP radiation protection departments.

The nuclear industry is a global industry evidenced by the fact that commercial nuclear power plant component manufacturers from the USA, Germany, Canada, Russia and France have supplied NPP designs and major components outside of their territorial borders. Many times the equipment utilized in the radiation protection departments were recommended by the architect engineer consulting firms responsible for constructing the plants. Thus it wasn't unusual for air monitoring specialists to be using foreign made instruments in their air sampling programs.

Air sampling specialists throughout the world have always wanted manufacturers of air flow measurement instruments to provide them the ability to customize the instrument for their particular requirements through operator selectable options.

For example, the option of selecting:

1. The engineering units of choice for temperature, pressure and flow rate
2. The reference temperature and the reference pressure to which the flow rates are to be normalized
3. The language for the text to be displayed by the air flow measurement instrument
4. The ability to select either mass flow or volumetric flow
5. The selection of the gas the user is utilizing in his application
6. The volumetric flow corrected to local ambient conditions in lieu of normalizing the flow to a recognized standard of T and P

This wish list also included the desire for a lightweight, portable and reasonably priced instrument. In the last decade manufacturers of air flow measurement instruments have provided one or two of the desired wish list features. Some of these features had to be factory settable, but none the less, it was a step in the right direction.

In general, the many nuclear industry laboratories throughout the world have continued to operate with the limitations inherent in the air flow measurement products available in the market place.

RECENT DEVELOPMENTS

An air flow calibration system has been introduced to the nuclear industry global market place by a small nuclear industry air flow instrument supplier located in the United States.

F&J SPECIALTY PRODUCTS, INC. located in Ocala, Florida, USA is a supplier to the worldwide nuclear industry. It has manufactured digital air flow calibration and digital air sampling instruments since 1990. This manufacturer has implemented new advances in hardware and software technology into its air flow measurement product lines for nuclear industry radiation protection air sampling applications.

This innovative air flow calibration system implements nearly all the items on the air flow calibration specialist's wish list. The air flow calibrator is small, lightweight and interfaces to any windows PC with a Windows 98, XP, Vista, Windows 7 or Windows 10 operating system.

This versatile and powerful instrument utilizes a PC program which enables the operator to visually view in one display the pertinent information, applicable to a task.

The calibration technician has the opportunity to select in the USER SETTINGS screen

1. The specific engineering units for measured and calculated air flow parameters
2. The language of choice for the text displayed on the PC screen
3. Mass flow or volumetric flow
4. The type of gas the technician is utilizing with his application
5. The Reference temperature
6. The Reference pressure
7. Full Scale accuracy or At Reading accuracy

In addition to the above operator selectable features, the World Calibrator measures and/or calculates the following parameters which are displayed on the DATA INTERFACE screen

1. air flow temperature
2. barometric pressure
3. air flow corrected to local ambient conditions

Refer to Display Screen on page 6 to view the World Calibrator User Settings screen.

The opportunity to select the engineering units for flow rate and the specific T and P standard for normalization enables an air flow calibration specialist to easily match the reported value of any "Smart" air sampler that corrects to an internationally recognized T and P reference standard.

In the case where the DUT is an analog air sampler which does not correct its flow rates to a reference T and P, the calibration technician can physically measure the absolute pressure of the air flow at the location of the analog flow sensor for purposes of correcting to a Reference

P. The air flow temperature measured by the World Calibrator is assumed to be the same temperature value as that going through the analog flow sensor, thus it can be utilized to correct to any specific reference T.

The World Calibrator (the REF) air flow data automatically downloads to the PC program's Data Interface screen for comparison against the manually inputted air flow data of the analog DUT. Both "At Reading" and "Full Scale" comparisons are made for the calibration technician to view.

The World Calibrator PC Program computes the difference in air flow between its value and the value of the DUT as well as the % deviation between the conventionally true value (CTV) of the REF and the output of the DUT.

This high IQ instrument also determines whether the deviation is within the DUT's stated accuracy value by displaying a pass or fail next to each different air flow measurement point in the calibration-verification process. The user has the option in the set up to select the type of calibration-verification he wants; At Reading or Full Scale.

Refer to Display Screen on page 7 for the typical view of the Data Interface screen.

The World Calibrator has two additional features which are very useful to the organization's air monitoring program.

1. The ability to print a professional looking calibration certificate (illustrated on page 8)
2. The ability to archive, electronically, every calibration-verification performed for retrieval at a later date, if necessary

Semi-automatic calibration-verification can be performed if the DUT is an F&J digital air sampler or digital calibrator. In this case, the F&J digital air sampler's RS232 port is connected to the World Calibrator's second RS232 port using the appropriate cable.

The F&J digital air sampler flow rate is passed seamlessly through the World Calibrator to the PC program which automatically displays simultaneously the flow rates of the DUT and REF on the DATA INTERFACE PC screen. The deviation between the CTV of the REF and the DUT flow and the % deviation is also computed automatically along with the instantaneously PASS or FAIL confirmation of whether the DUT accuracy is within the tolerance accuracy value assigned to the specific DUT.

Refer to page 9 to view a DF-1 Series calibration setup for a typical low volume air sampler calibration-verification setup.

The current users of F&J digital air samplers will benefit greatly by utilizing the World Calibrator as their calibration-verification air flow reference instrument.

Another nice feature of the World Calibrator is that it comes standard with $\pm 1.0\%$ Full Scale accuracy.

The World Calibrator utilizes a movable flow sensor tube that can be oriented in any direction or reasonable height from the calibrator's support surface. Another plus is the two year warranty provided by the manufacturer.

The entire package of features provided by the World Calibrator is quite remarkable for a lightweight portable device that only needs a PC to function. Normally, a calibration system with these features is an expensive fixed-station laboratory style instrument package. The World Calibrator is also available with a four line by 24 character display and with multi-flow range sensors.

This new gas calibration instrument provides all the features an NPP air flow calibration specialist would need to validate the manufacturer's stated accuracy of the many air sampling devices utilized inside the plant as well as the air sampling instruments in the environmental (REMP) sampling programs. Different air sampler flow ranges may require different models of the World Calibrator having different flow sensor ranges, but the same PC program can be utilized with any World Calibrator model.

In summary, the World Calibrator is an example of a new generation of instruments for NPP applications that will go hand-in-hand with the new generation of NPP power reactor technology.

Display Screen

User Settings

Language

- English
- Nederlands
- Français
- Deutsch
- Español
- Русский
- Български

Flow Type

- Volumetric
- Mass

Accuracy Type

- Full Scale
- At Reading

Temperature

- °C
- °F

Pressure

- atm
- InHg
- mmHg
- bar
- kPa
- mbar
- hPa

Flow

- CFM
- LPM
- cc/min
- m³/hr
- m³/min

Mass Flow

- g/min
- lbs/hr
- kg/hr

Tube

- Tube #1
- Tube #2
- Tube #3
- Tube #4

Reference Temp.

- 32°F, 0°C
- 59°F, 15°C
- 68°F, 20°C
- 70°F, 21°C
- 77°F, 25°C

Reference Press.

- 1 atm, 29.92 InHg, 760 mmHg, 1.013 bar, 101.3 kPa
- 0.987 atm, 29.53 InHg, 750 mmHg, 1 bar, 100 kPa

Utilize ENTER and ESC keys

OK

Cancel

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Display Screen

F&J Data Interface
- [] X

Air Calibrator Data Interface V1.07.02

Setup Communication

Setup Certificate

User Settings

Temperature 25.0°C	Sensor Pressure 30.01 InHg	Ambient Flow 1.96 CFM	Standard Flow 1.92 SCFM
World Calibrator: Model #: <input type="text"/>	Barometric Pressure 29.87 InHg	Last Calibrated: <input type="text" value="21 FEB 2015"/>	

Device Under Test (DUT):

Enable Serial Connection to DUT (F&J Air Sampler)

Air Sampler port is not selected, use Setup Communication

Serial #: <input type="text" value="20058"/>	Serial #: <input type="text"/>	Full Scale (DUT): <input type="text"/>	Accuracy [%]: <input type="text"/>
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DUT [SCFM]	Calibrator [SCFM]	Deviation [SCFM]	Accuracy [% of Full Scale]	Pass / Fail	Date
<input type="text" value="1.92"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text" value="30 MAR 2015"/>
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
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<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Average Deviation Across the Range at Full Scale [%]:

User Settings:	Volumetric, Accuracy Type: Full Scale, Ref. Temp.: 20°C, Ref. Press.: 29.92 InHg, Tube #3 (828)
Status:	Data from Calibrator is OK (Battery option, Charge: 32%, Estim. run time: 2hr 45min)

Hint:
 Click User Settings to change language, engineering units and reference temperature and pressure. Enter instrument identification, Full Scale flow value and Accuracy. Use TAB to terminate entries. Click Record Data to save current flow value in the data table.

Record Data	Clear Last Data
Save Data File	Load Data File
Print Certificate	New Calibration

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**CERTIFICATE
OF
CALIBRATION**

F&J SPECIALTY PRODUCTS, INC.

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Email: fandj@fjspecialty.com www.fjspecialty.com
THE NUCLEUS OF QUALITY AIR MONITORING PROGRAMS

MODEL #: DF-1 **SERIAL #:** 10222

REFERENCE INSTRUMENT: WG-812-PC CALIBRATION DATE: 23 MAY 2011
REFERENCE SERIAL #: 20033 RECALIBRATION DATE: 09 AUG 2012
REFERENCE CALIBRATED: 18 APR 2011

FLOW TYPE: Volumetric ACCURACY TYPE: Full Scale
REFERENCE TEMPERATURE: 77°F REFERENCE PRESSURE: 29.92 InHg

INSTRUMENT FULL SCALE: 115.0 [SLPM]
INSTRUMENT ACCURACY AT FULL SCALE: ± 4.00 [%]

	DEVICE UNDER TEST	REFERENCE INSTRUMENT	DEVIATION AT READING	ACCURACY AS % of F.S.	PASS OR FAIL
	FLOW [SLPM]	FLOW [SLPM]	[SLPM]	[%]	
1.	107.1	107.4	-0.3	-0.26	Pass
2.	82.8	83.4	-0.6	-0.52	Pass
3.	66.6	65.9	0.7	0.61	Pass
4.	42.1	42.5	-0.4	-0.35	Pass

AVERAGE DEVIATION ACROSS THE RANGE AT FULL SCALE [%]: 0.43

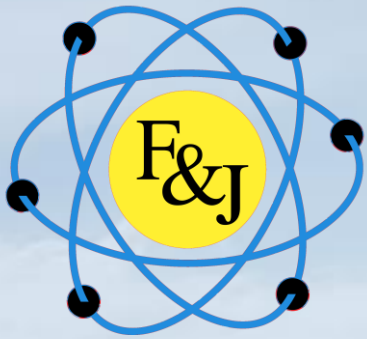
This is to certify that the instrument identified on this certificate has on this date certified to be within the instrument accuracy specified above. The Reference Flow Device bears letters of certification traceable to the National Institute of Standards and Technology (NIST).

CALIBRATED BY: _____ MKR/K

Calibration Software and Equipment provided by F&J SPECIALTY PRODUCTS, INC. (V1.06.02)
404 Cypress Road, Ocala, FL 34472, USA Tel: +1 352 680-1177 Fax: +1 352 680-1454 www.fjspecialty.com

DF-1 Series Calibration Setup





F&J WORLD CALIBRATOR PC VERSION

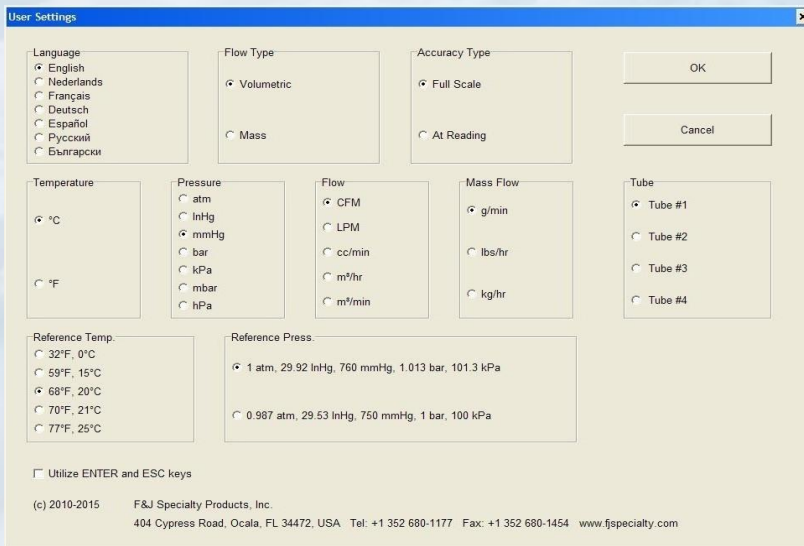
THE NUCLEUS OF QUALITY AIR MONITORING PROGRAMS

Notable Features:

- PC Interface
- Operator Selectable Options
 - Multiple language options; European or Asian Version
 - Volumetric or mass flow
 - At Reading or Full Scale Accuracy Calibration Type
 - Reference T and Reference P
 - Engineering units for all reported parameters
- Semi-Automatic calibration-verification when used with F&J digital air samplers
- Customizable calibration report
- Accuracy: $\pm 1.0\%$ Full Scale (F.S.)
- Two Year Warranty



Complimentary Storage Case!



Contact F&J @

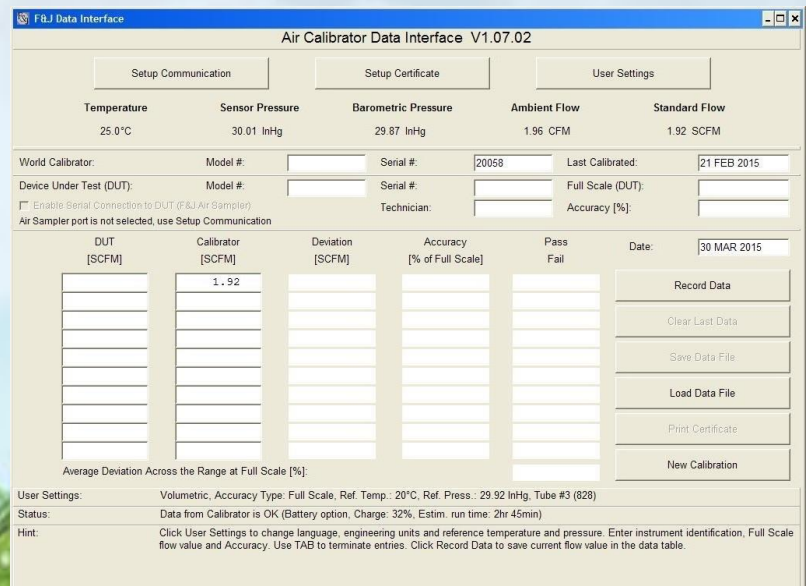
Tel: 352.680.1177

Fax: 352.680.1454

Email: fandj@fjspecialty.com

Web: www.fjspecialty.com

PC program will work with Windows 98, Windows XP, Vista and Windows 7 operating systems.



MEASUREMENT PRINCIPLE

Flow Sensor: Differential Pressure Sensor
 Standardization: Operator selectable values for reference temperature and pressure
 Flow Curve linearization: Individually calibrated and software corrected

MEASUREMENT RANGES

Air flow: Various flow ranges available
 Temperature: -40° – 122° F (-40° – 50° C)
 Barometric pressure: 30 – 22 In-Hg (760 – 559 mm-Hg); (101.325-74.5 kPa)
 approx. Sea level to 5900 ft. (1800 m) elevation above sea level

MEASUREMENT ACCURACY

Air flow: ± 1.0% of full scale
 Temperature (Typical): 1°C over range -20°C to 50°C
 Barometric pressure: ± 1% over measurement range

STANDARD TEMPERATURE and PRESSURE CHOICES:

Temperature 32°F (0°C) 59°F (15.0°C) 68°F (20.0°C) 70°F (21.1°C) 77°F (25.0°C)
 Pressure 29.92”Hg (1 atm, 760mm Hg, 1.013 bar, 101.325 kPa)
 1 bar, (100kPa, 750mm Hg, 0.987 atm 29.53”Hg)

PARAMETERS and RESOLUTIONS DISPLAYED on the PC SCREEN

	Parameter	Engineering Unit	Resolution	
Flow Options {	CFM	Cubic feet per minute	0.01	CFM
	LPM	Liter per minute	.1	LPM
	m ³ /min	Cubic meter per minute	0.0001	m ³ /min
	m ³ /hr	Cubic meters per hour	0.001	m ³ /hr
	cc/min	Cubic centimeter per minute	1	cc/min
Temperature {	F	Degree Fahrenheit	0.1	Degree F
	C	Degree Celsius	0.1	Degree C
Pressure {	In-Hg	Inches of Mercury	0.01	In-Hg
	mm-Hg	Millimeters of Mercury	1	mm-Hg
	kPa	Kilo pascals	0.1	kPa
	atm	atmospheres	0.001	atm
	bar	bar	0.0001	bar

GENERAL

Power requirements: Max 0.6A; 100–120 VAC;50/60Hz 0.3 Amps max; 220-240 VAC/50Hz
 Operating temperature: -4°F – 122°F (-20°C – 50° C)
 Storage temperature: -20°F- 158°F (-29°C – 70° C)
 Dimension (L×W×H) 8.625”×3.75”×8.375” (219×95.25×213mm)
 Weight: 8 lbs. 6 oz. (3.8 Kgs.)
 Installation Category: Pollution Degree 2
 Enclosure Rating: IPXO
 Communications Port: Dual RS232; (DB9) one Mini-USB

CALIBRATION

Factory re-calibration is recommended once per year

OPTIONS

Battery operable option with on-board charging system

FLOW RANGES

100-120 VAC

220-240 VAC

Model	Flow (SLPM)	Model	Flow (SLPM)
WC-801-PC	3 - 30	WC-801E-PC	3 – 30
WC-802-PC	6 - 60	WC-802E-PC	6 – 60
WC-812-PC	15 - 115	WC-812E-PC	15 – 115
WC-828-PC	30 - 300	WC-828E-PC	30 – 300
WC-814-PC	40 - 420	WC-814E-PC	40 – 420
WC-530-PC	150 - 850	WC-530E-PC	150 – 850
WC-550-PC	150 – 1400	WC-550E-PC	150 - 1400
WC-870-PC	240 - 2000	WC-870E-PC	240 - 2000

NOTE:
 For orifice flow sensors, add '-O' to above part numbers

WORLD CALIBRATOR

Vacuum Fluorescent Display (VFD) Version



Notable Features:

- Vacuum Fluorescent Display (4 lines×24 characters)
- 4 button key pad for standalone operation
- Mass flow or Volumetric flow
- Volume Totalization Feature
- Operator selectable Reference T and P
- Operator selectable engineering units
- Multi gas option
- ± 1.0% Full Scale (F.S.) Accuracy
- User customizable calibration report
- Semi-Automatic calibration-verification when used with F&J digital air samplers
- PC Interface program: Western or Asian languages
- Two Year Warranty
- Complimentary Storage Case