5700A/5720A ARTIFACT CALIBRATION MAC WORKGROUP STUDY

~~March 5, 2008~~

Purpose of Study

This MAC workgroup was formed to focus on the performance enhancement offered by artifact calibration for the Fluke 5700A and 5720A calibrators. A2LA presently accepts Fluke's claim for specifications based on the calibration cycle of its artifact calibration, provided the instrument is given a classical external calibration at least bi-annually. The task group's intent is to determine what should be done, if anything, to help verify those claims. Task group members are: Ray Kletke, S. Dizor, D. Deaver, and M. Duffin. Bill Sorrells volunteered later.

Description of Fluke Artifact Calibration

The referenced Fluke calibrators contain a dc reference standard, dc resistance standards, switching matrix, a high resolution DAC, and the capability to make precision measurements. During calibration, these components are used to automatically set up the zeros and gains of all the DC active components as well as the precision dividers used to control the output values of the output DC Voltage, DC current and Resistance relative to the internal standards. Additionally, during Artifact Calibration, three calibrated external standards including a 10 VDC source, a 1 Ohm standard resistor and a 10 kOhm standard resistor are applied to the unit's output terminals. The internal Artifact Calibration system calibrates the internal standards against the three external standards. The result is traceable calibration for all dc parameters.

AC calibration includes two functional steps. First, the internal amplifier gains and divider networks used for AC Voltage and AC Current generation are set at DC just like the DC components described above. Then the AC-DC difference for these components is measured using a special internal multirange thermal voltage converter (TVC) standard. The resulting difference data is used to adjust the flatness of these components across the specified bandwidth. Actually, Fluke assumes the low frequency performance of these networks below 1 kHz will be essentially the same as for DC. Therefore, the flatness correction data is measured using a low-frequency-AC to AC comparison.

AC calibration during Artifact Calibration differs from DC calibration in that no external, traceable AC standard is applied. This clouds Fluke's claim that Artifact Calibration is a valid, traceable process for all DC and AC parameters.

Evaluation of Artifact Calibration by National Laboratories

An evaluation of the Fluke 5700A Series II Calibrator was performed by 3 National Metrology Institutes including NMi Van Swinden Laboratorium B.V., the Netherlands, SP Swedish National Testing and Research Institute, Sweden, and the Phsicalisch Technische Bundesanstalt, Germany. A document describing their analysis of the performance and acceptability of Artifact Calibration is documented in a book published November, 1999, titled "Artifact Calibration – An evaluation of the Fluke 5700A Series II Calibrator" (ISBN 90-9013322-4.

Important final observations from this study include the following:

- For Direct Voltage, Direct Current and Resistance, the Artifact Cal procedure makes a traceable calibration of the calibrator. Thus for these functions, there is an unbroken traceability chain.
- The Artifact Cal procedure does not realize a traceable calibration of the AC functions in the Artifact Cal process. DC external reference standards are used and an internal AC/AC sensor. The later is not calibrated to an external reference during the Artifact Cal procedure. However, the Artifact Cal procedure does increase the confidence in the AC part of the calibration. It does adjust the calibrator within the 24 hour specification of the calibrator provided that the characteristics of the internal AC/AC transfer sensor have not changed significantly since the last external verification.
- The calibration report produced by the Artifact Cal procedure accurately reflects the changes at the binding posts of the calibrator due to the adjustment, except for the opposite sign (in voltage and current). Thus, the Artifact Cal calibration report is very well suited as reference document for building up history of the calibrator.
- Strictly speaking, Artifact Cal is not equal to a (conventional) calibration since it does not produce measurement values. (shifts are mentioned in the Artifact Cal calibration report) and uncertainties. Furthermore, it does not make a separate uncertainty evaluation for each measurement it performs. However, in practice Artifact Cal measurement values can be deduced using the values of the constants in the raw constants report. Furthermore the specifications may be regarded as the final total uncertainty of the complete Artifact Cal process. Viewed from this side, Artifact Cal is very similar to a calibration (combined with an adjustment).

Recommendations by National Lab Study

Important recommendations from this study include the following:

- Full calibrations should be made at least every two years
- The Artifact Cal report complete with shift data for all parameters should be stored by the user
- The user of an instrument should be able to justify the calibration interval he has chosen.

The National Lab study presented the following recipe as an example of how to collect data that could justify a longer overall calibration interval. (A) is Artifact Calibration and (C) is full external calibration.

Table 1: National Lab Guideline for 5700A/5720A Calibration Scheduling

EA 1 year	CAC				CAC				CAC				CAC				CAC				CAC
Fluke 1 year	AC				A				AC				A				AC				A
Study 1 year	AC				AC				A				AC				A				AC
Study 90 Day	AC	AC	A	AC	A	A	A	AC	A	A	A	A	A	A	A	AC	A	A	A	A	A
	0	3m	6m	9m	1yr	3m	6m	9m	2yr	3m	6m	9m	3yr	3m	6m	9m	4yr	3m	6m	9m	5yr

Note that when the laboratory wants to use the 90d specifications (last row), the calibration results are verified against the 90d specifications, even when this calibration is only performed once a year.

Task Group Recommendations

The Task Group recommends that Artifact Calibration be accepted provided that the recommendations made above by the National Lab Study are followed. It is not necessary, however, to follow the above recipe exactly. What is important, is to schedule A and AC so that the performance at the desired calibration interval is confirmed by the "As Found" data from C. Furthermore, the "Final "data should confirm that Artifact Calibration has pulled the instrument back into better than 90 day performance limits. For example, if it is desired to perform Artifact Calibration every 180 days and claim 180 day performance (as published in the Fluke spec sheet), a full external calibration (C) should be performed 180 days after an Artifact Calibration has been performed. The "As Found" data collected during (C) must fall within the specification limits published for the Fluke calibrator for all parameters. Furthermore, the "Final" data should confirm operation well inside the instrument's 90 day specifications. These validations should be completed before 180 day performance specifications are accepted by the A2LA assessor. Furthermore, it should be repeated at every external calibration (C). An example of appropriate calibration scheduling is given in Table 2.

Table 2: MAC Workgroup Guideline for 5700A/5720A Calibration Scheduling

CAL PERIOD													
12 Mo	AC				AC				A				AC
6 Mo	AC		A		AC		A		A		A		AC
3 Mo	AC	A	A	A	AC	A	A	A	A	A	A	A	AC
Mo	0	3	6	9	12	15	18	21	24	27	30	33	36
Yr	0				1				2				36

Another important requirement is that the artifact calibration Cal Shift report, complete with shift data for all parameters, should be collected after every Artifact Calibration and used to confirm operation within the specifications claimed by the user. It should then be properly stored. Care must be taken during the calibration to set the 5700A/5720A to the

proper specification. For example, if Artifact Calibration is performed every 90 days and the 90 day, 99% CL performance is claimed for the 5700A or 5720A standard by the user laboratory, make sure the 90 day, 99% CL performance is selected during the Artifact Calibration. This is necessary since the reported shifts in parameter values are given as a percentage of specification. The user must also be aware that the specification used in the Artifact Calibration Shift Report will always be the 99% CL specification even if the 95% CL is chosen by the user. **Therefore, the user must be careful to either claim only 99% CL performance, or must change the Artifact Calibration Shift Report by multiplying the reported Shift (% spec) by the factor 1.3, which is the coverage factor for 99% CL divided by the coverage factor for 95% CL. Or alternatively, the accepted shift limit should be reduced from 100% to 77%.** A sample from a Cal Shift Report is attached.

The user should also be aware that the report called Artifact Calibration Report, often issued after artifact calibration, is a summary report that only includes the data for the parameter that has shifted the most. Care must be taken to obtain the required Cal Shift report which contains shift data for all parameters.

It also is important to verify that the "As Found" data collected during the full external calibration (C) be checked against the performance claimed by the user (90 days, 95% or whatever). Normally, this data is only compared to the one year, 99% CL specification in the calibration supplier's calibration report.

ATTACHMENT 1
Sample Page from Calibration Shift Report

EXTERNALLY CALIBRATED INTERNAL REFERENCES

REFERENCE	Most Recent	Previous	Shift (ppm)
6.5 V DC Reference 13	6.911804	6.911804	0.0C
V DC Reference	13.819903	13.819903	0.0C
Resistance Reference	0.9999824	0.9999824	0.0C
1.0 Ohm Resistor	1.0000267	1.0000267	0.0C
1.9 Ohm Resistor	1.9000295	1.9000295	0.0C

DC VOLTAGE OUTPUT SHIFTS

RANGE	Point	Zero Shift		Full Scale Shift				Spec (+/-)	Shift (% spec)
220 mV	+FS	0.00000	mV	0.00006	mV	0.28	ppm	11 . 27 ppm	2.45
	-FS	-0.00000	mV	-0.00006	mV	-0.28	ppm	11.27 ppm	-2.45
2.2V	+FS	0.0000000	V	0.0000000	V	0.00	ppm	6.36 ppm	0.03
	-FS	-0.0000000	V	-0.0000000	V	0.00	ppm	6.36 ppm	-0.03
11V	+FS	0.000000	V	0.000000	V	0.00	ppm	4.27 ppm	0.04
	-FS	-0.000000	V	-0.000000	V	0.00	ppm	4.27 ppm	-0.04
22V	+FS	0.000000	V	0.000000	V	0.00	ppm	4.23 ppm	0.00
	-FS	0.000000	V	0.000000	V	0.00	ppm	4 . 23 ppm	0.00
220V	+FS	0.00000	V	0.00000	V	0.00	ppm	6.23 ppm	0.03
	-FS	-0.00000	V	-0.00000	V	0.00	ppm	6.23 ppm	-0.03
1100V	+FS	0.0000	V	0.0000	V	0.00	ppm	8.45 ppm	0.02
	-FS	-0.0000	V	-0.0000	V	0.00	ppm	8.45 DDm	-0 O?