

## 12.0 Calibrations

Calibration is defined as:

*the comparison of a measurement standard, instrument, or item with a standard or instrument of higher accuracy to detect and quantify inaccuracies and to report or eliminate those inaccuracies by adjustment<sup>1</sup>.*

Prior to the implementation of any ambient air monitoring activities, the sampling and analysis equipment must be checked to assure it is within calibration tolerances, and if it fails these tolerances, must be appropriately calibrated. This function is most routinely carried out at the field monitoring location.

Calibration of an analyzer or instrument establishes the quantitative relationship between an actual value of a standard, be it a pollutant concentration, a temperature, or a mass value (in ppm, °C or Φg, etc.) and the analyzer's response (chart recorder reading, output volts, digital output, etc.). This relationship is used to convert subsequent analyzer response values to corresponding concentrations. Once an instrument's calibration relationship is established it is checked/verified at reasonable frequencies to verify that it remains in calibration.

### Verification Versus Calibration

Since the term calibration is associated with an adjustment in either the instrument or software, these adjustments should be minimized as much as possible. Sometimes performing frequent adjustments to provide the "most accurate data possible" can be self-defeating and be the cause of additional measurement uncertainty. Therefore, quality control procedures that include verification checks and multi-point calibration verifications are considered "checks without correction" and are used to ensure the instruments are within the calibration tolerances. Usually these tolerances have been developed so that as long as the instrument is within these tolerances, adjustments do not need to be made. However, verifications should be implemented at reasonable frequencies to avoid invalidating significant amounts of data.

**NOTE:** When the term "calibration" is used in the remainder of this section, it is assumed that multi-point verification is initially performed and the operator has concluded that calibration (adjustment) is necessary.

**NOTE:** EPA does not recommend post-processing of data to "correct" for data failing one point or multi-point verifications.

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<sup>1</sup> American National Standard Quality Systems for Environmental Data and Technology Programs ANSI /ASQ E4  
<http://www.asq.org/>

Each analyzer should be calibrated as directed by the analyzer's operation or instruction manual and in accordance with the general guidance provided here. For reference methods for CO, NO<sub>2</sub>, SO<sub>2</sub> and O<sub>3</sub>, detailed calibration procedures may also be found in the appropriate reference method Appendix in 40 CFR Part 50<sup>2</sup> and the method guidance and technical assistance documents listed in the fact sheets in Appendix A.

Calibrations should be carried out at the field monitoring site by allowing the analyzer to sample test atmospheres containing known pollutant concentrations. The analyzer to be calibrated should be in operation for at least several hours (preferably overnight) prior to the calibration so that it is fully warmed up and its operation has stabilized. During the calibration, the analyzer should be operating in its normal sampling mode, and it should sample the test atmosphere through all filters, scrubbers, conditioners, and other components used during normal ambient sampling and through as much of the ambient air inlet system as is practicable. All operational adjustments to the analyzer should be completed prior to the calibration (see section 12.7). Some analyzers can be operated on more than one range. For sites requiring the use of FRM or FEMs (NAAQS sites), the appropriate ranges are identified in the *Designated Reference and Equivalent Method List* found on AMTIC<sup>3</sup>. Analyzers that will be used on more than one range or that have auto-ranging capability should be calibrated separately on each applicable range.

Calibration documentation should be maintained with each analyzer and also in a central backup file. Documentation should be readily available for review and should include calibration data, calibration equation(s) (and curve, if prepared), analyzer identification, calibration date, analyzer location, calibration standards used and their traceability, identification of calibration equipment used, and the person conducting the calibration.

## 12.1 Calibration Standards and Reagents

Calibration standards are:

- Reagents of high grade
- Gaseous standards of known concentrations that are certified as EPA protocol gasses
- Instruments and or standards of high sensitivity and repeatability.

### 12.1.1 Reagents

In some cases, reagents are prepared prior to sampling. Some of these reagents will be used to calibrate the equipment, while others will become an integral part of the sample itself. In any case, their integrity must be carefully maintained from preparation through analysis. If there are any doubts about the method by which the reagents for a particular test were prepared or about the competence of the laboratory technician preparing them, the credibility of the ambient air samples and the test results will be diminished. It is essential that a careful record be kept listing the dates the reagents were prepared, by whom, and their locations at all times from preparation until actual use. Prior to the test, one individual should be given the responsibility of monitoring the handling and the use of the reagents. Each use of the reagents should be recorded in a field or lab notebook.

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<sup>2</sup> <http://www.access.gpo.gov/nara/cfr/cfr-table-search.html>

<sup>3</sup> <http://www.epa.gov/ttn/amtic/criteria.html>

Chemical reagents, solvents, and gases are available in various grades. Reagents can be categorized into the following six grades<sup>4</sup>:

1. **Primary standard** - Each lot is analyzed, and the percentage of purity is certified.
2. **Analyzed reagents**- Can fall into 2 classes: (a) each lot is analyzed and the percentages of impurities are reported; and (b) conformity with specified tolerances is claimed, or the maximum percentages of impurities are listed.
3. **USP and NF Grade** - These are chemical reference standards where identity and strength analysis are ensured.
4. **“Pure,” “c.p.,” “chemically pure,” “highest purity”** - These are qualitative statements for chemicals without numerical meaning.
5. **“Pure,” “purified,” “practical grades”** - These are usually intended as starting substances for laboratory syntheses.
6. **Technical or commercial grades** - These are chemicals of widely varying purity.

The reference and equivalent methods define the grades and purities needed for the reagents and gases required in the Ambient Air Quality Monitoring Program.

All reagent containers should be properly labeled either with the original label or, at a minimum, the reagent, date prepared, expiration date, strength, preparer, and storage conditions. Leftover reagents used during preparation or analysis should never be returned to bottles.

### 12.1.2 Gaseous Standards

In general, ambient monitoring instruments should be calibrated by allowing the instrument to sample and analyze test atmospheres of known concentrations of the appropriate pollutant in air. The following is an excerpt from 50 CFR Part 58, Appendix A Section 2.6.1:

*“Gaseous pollutant concentration standards (permeation devices or cylinders of compressed gas) used to obtain test concentrations for carbon monoxide (CO), sulfur dioxide (SO<sub>2</sub>), nitrogen oxide (NO), and nitrogen dioxide (NO<sub>2</sub>) must be traceable to either a National Institute of Standards and Technology (NIST) Traceable Reference Material (NTRM) or a NIST-certified Gas Manufacturer’s Internal Standard (GMIS), certified in accordance with one of the procedures given in reference 4 of this appendix. Vendors advertising certification with the procedures provided in reference 4 of this appendix and distributing gasses as “EPA Protocol Gas” must participate in the EPA Protocol Gas Verification Program or not use “EPA” in any form of advertising.”*

"Traceable" is defined in 40 CFR Parts 50 and 58 as meaning that a local standard has been compared and certified, either directly or via not more than one intermediate standard, to a primary standard such as a National Institute of Standards and Technology Standard Reference Material (NIST SRM) or a USEPA/NIST-approved Certified Reference Material (CRM)". Normally, the working standard should be certified directly to the SRM or CRM, with an intermediate standard used only when necessary. Direct use of a CRM as a working standard is acceptable, but direct use of an NIST SRM as a working standard is discouraged because of the limited supply and expense of SRM's. At a minimum, the certification

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<sup>4</sup> Quality Assurance Principles for Analytical Laboratories, 3rd Edition. By Frederick M. Garfield, Eugene Klesta, and Jerry Hirsch. AOAC International (2000). <http://www.aoac.org/>

procedure for a working standard should:

- establish the concentration of the working standard relative to the primary standard;
- certify that the primary standard (and hence the working standard) is traceable to a NIST primary standard;
- include a test of the stability of the working standard over several days; and
- specify a recertification interval for the working standard.

Table 12-1 suggests the requirements for the certification period for verification and calibration standards used in the ambient air program.

Certification of the working standard may be established by either the supplier or the user of the standard. As describe in CFR, gas supplier advertising “EPA Protocol Gas” will be required to participate in the EPA Protocol Gas Verification Program. Information on this program, including the gas supplier participating in the program, can be found on AMTIC<sup>5</sup>. EPA has developed procedures for the establishment of protocol gasses in the document: *EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards*<sup>6</sup>.

Test concentrations of ozone must be traceable to a primary standard (see discussion of primary standards below) UV photometer as described in 40 CFR Part 50, Appendix D and the guidance document: *Transfer Standards for the Calibration of Ambient Air Monitoring Analyzers for Ozone*<sup>7</sup>.

Test concentrations at zero concentration are considered valid standards. Although zero standards are not required to be traceable to a primary standard, care should be exercised to ensure that zero standards are adequately free of all substances likely to cause a detectable response from the analyzer and at a minimum, below the lower detectable limit of the criteria pollutants being measured. Periodically, several different and independent sources of zero standards should be compared. The one that yields the lowest response can usually (but not always) be assumed to be the “best zero standard.” If several independent zero standards produce exactly the same response, it is likely that all the standards are adequate.

**Table 12-1 Certification Periods for Compressed Gas Calibration Standards in Aluminum Cylinders That Are Certified Under the EPA Protocol Gas Program**

Certified components	Balance gas	Applicable concentration range	Certification period (months)
Ambient nonmethane organics (15 components)	Nitrogen	5 ppb	24
Ambient toxic organics (19 components)	Nitrogen	5 ppb	24
Aromatic organic gases	Nitrogen	>0.25 ppm	36
Carbon dioxide	Nitrogen or air <sup>a</sup>	>300 ppm	36
Carbon monoxide	Nitrogen or air	>8 ppm	36
Hydrogen sulfide	Nitrogen	>4 ppm	12

<sup>5</sup> <http://www.epa.gov/ttn/amtic/>

<sup>6</sup> <http://www.epa.gov/ttn/emc/news.html>

<sup>7</sup> EPA-600/4-79-056. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. September 1979. <http://www.epa.gov/ttn/amtic/files/ambient/criteria/reldocs/4-79-056.pdf>

Certified components	Balance gas	Applicable concentration range	Certification period (months)
Methane	Nitrogen or air	>1 ppm	36
Nitric oxide	Oxygen-free nitrogen <sup>b</sup>	>4 ppm	24
Nitrous oxide	Air	>300 ppb	36
Oxides of nitrogen (i.e., sum of nitrogen dioxide and nitric acid)	Air	>80 ppm	24
Oxygen	Nitrogen	>0.8%	36
Propane	Nitrogen or air	>1 ppm	36
Sulfur dioxide	Nitrogen or air	40 to 499 ppm	24
Sulfur dioxide	Nitrogen or air	>500 ppm	36
Multicomponent mixtures	—	—	See text <sup>c</sup>
Mixtures with lower concentrations	—	—	See text

<sup>a</sup>When used as a balance gas, "air" is defined as a mixture of oxygen and nitrogen where the minimum concentration of oxygen is 10 percent and the concentration of nitrogen is greater than 60 percent.

<sup>b</sup>Oxygen-free nitrogen contains >0.5 ppm of oxygen.

<sup>c</sup>Text refers to Section 2 of EPA Protocol Gas Guidance Document

Certification periods decrease for concentrations below the applicable concentration ranges provide in Table 12-1. For example the certification period for SO<sub>2</sub> standards between 13-40 ppm is 6 months. Also, tank size may affect stability in low level standards. Some gas manufacturers claim that standards supplied in smaller tanks are stable for longer periods of time then the same concentration in larger tanks. Although this claim has not been verified if true it may be helpful in making purchasing decisions.

## Primary Reference Standards

A primary reference standard can be defined as a homogenous material with specific properties, such as identity, unity, and potency that has been measured and certified by a qualified and recognized organization<sup>8</sup>, such as the NIST SRMs. NIST also describes a Primary Reference Standard as a standard that is designated or widely acknowledged as having the highest metrological qualities and whose value is accepted without reference to other standards of the same quantity. For example, the NIST-F1 Atomic Clock<sup>9</sup>, is recognized as a primary standard for time and frequency. A true primary standard like NIST-F1 establishes maximum levels for the frequency shifts caused by environmental factors. By summing or combining the effects of these frequency shifts, it is possible to estimate the uncertainty of a primary standard without comparing it to other standards. NIST maintains a catalog of SRMs that can be accessed through the Internet<sup>10</sup>. Primary reference standards are usually quite expensive and are often used to calibrate, develop, or assay working or secondary standards. In order to establish and maintain NIST traceability the policies posted at the NIST Website<sup>11</sup> should be observed.

<sup>8</sup> Garfield, Frederick M. , "Quality Assurance Principles for Analytical Laboratories" Association of Official Analytical Chemists, Arlington VA, 1984

<sup>9</sup> <http://tf.nist.gov/timefreq/cesium/fountain.htm>

<sup>10</sup> <http://www.nist.gov>

<sup>11</sup> <http://ts.nist.gov/traceability/>

It is important that primary reference standards are maintained, stored, and handled in a manner that maintains their integrity. These samples should be kept under secure conditions and records should be maintained that document chain of custody information.

### 12.1.3 Instruments

The accuracy of various measurement devices in sampling and continuous instruments is very important to data quality. For example, in order to produce the correct flow rate to establish an accurate PM<sub>2.5</sub> cut point, the temperature and barometric pressure sensors, as well as the flow rate device, must be producing accurate measurements. Table 12-2 provides some of the more prevalent instruments that need to be calibrated at a minimum annually or when shown through various verification checks to be out of acceptable tolerances. In addition, the audit standards used to implement the checks and calibrations should be certified annually in order to establish their accuracy and traceability to higher standards (NIST).

**Table 12-2 Instruments and Devices Requiring Calibration and Certifications.**

Criteria	Acceptable Range	40 CFR Reference
<i>Verification/Calibration of devices in sampler/analyzer/laboratory against an authoritative standard</i>		
Barometric Pressure	∇ 10 mm Hg	Part 50, App.L, Sec 9.3
Temperature	∇ 2EC of standard	Part 50, App.L, Sec 9.3
Flow Rate	∇ 2% of transfer standard	Part 50, App.L, Sec 9.2
Design Flow Rate Adjustment	∇ 2% of design flow rate	Part 50, App.L, Sec 9.2.6
Clock/timer Verification	1 min/mo	Part 50, App.L, Sec 7.4
Mirobalance Calibration	Readability 1 Φg Repeatability 1Φg	Part 50, App.L, Sec 8.1
<i>Verification/Calibration of devices in shelter or lab against an authoritative standard</i>		
Lab Temperature	∇ 2EC	not described
Lab Humidity	∇ 2%	not described
Mirobalance Calibration	Readability 1 Φg Repeatability 1Φg	Part 50, App.L, Sec 8.1
<i>Verification/calibration standards requiring certification annually</i>		
Standard Reference Photometer (SRP)	∇4% or ∇4 ppb (whichever greater) RSD of six slopes # 3.7%	not described
SRP recertification to local primary standard	Std. Dev. of 6 intercepts 1.5 New slope = ± 0.05% of previous	not described
Flow rate	∇ 2% of NIST –Traceable Standard	Part 50, App L Sec 9.2
Pressure	∇ 1 mm Hg resolution, ∇ 1 mm Hg accuracy	not described
Temperature	∇ 0.1EC of standard resolution, ∇ 0.5EC 1 mm Hg accuracy	not described
Gravimetric Standards	0.025 mg	not described

## 12.2 Multi-point Verifications/Calibrations

Multi-point calibrations consist of a zero and 4 upscale points, the highest being a concentration between 80 percent and 90 percent of the full scale range of the analyzer under calibration. Multi-point calibrations are used to establish or verify the linearity of analyzers upon initial installation, after major repairs and at specified frequencies. Most modern analyzers have a linear or very nearly linear response with concentration. If a non-linear analyzer is being calibrated, additional calibration points should be included to adequately define the calibration relationship, which should be a smooth curve. Calibration points should be plotted or evaluated statistically as they are obtained so that any deviant points can be investigated or repeated immediately.

Most analyzers have zero and span adjustment controls, which should be adjusted based on the zero and highest test concentrations, respectively, to provide the desired scale range within the analyzer's specifications (see section 12.5). For analyzers in routine operation, unadjusted ("as is") analyzer zero and span response readings should be obtained prior to making any zero or span adjustments. NO/NO<sub>2</sub>/NO<sub>x</sub> analyzers may not have individual zero and span controls for each channel; the analyzer's operation/instruction manual should be consulted for the proper zero and span adjustment procedure. Zero and span controls often interact with each other, so the adjustments may have to be repeated several times to obtain the desired final adjustments.

After the zero and span adjustments have been completed and the analyzer has been allowed to stabilize on the new zero and span settings, all calibration test concentrations should be introduced into the analyzer for the final calibration. The final, post-adjusted analyzer response readings should be obtained from the same device (chart recorder, data acquisition system, etc.) that will be used for subsequent ambient measurements. The analyzer readings are plotted against the respective test concentrations, and the best linear (or nonlinear if appropriate) curve to fit the points is determined. Ideally, least squares regression analysis (with an appropriate transformation of the data for non-linear analyzers) should be used to determine the slope and intercept for the best fit calibration line of the form,  $y = mx + a$ , where  $y$  represents the analyzer response,  $x$  represents the pollutant concentration,  $m$  is the slope, and  $a$  is the  $x$ -axis intercept of the best fit calibration line. When this calibration relationship is subsequently used to compute concentration measurements ( $x$ ) from analyzer response readings ( $y$ ), the formula is transposed to the form,  $x = (y - a)/m$ .

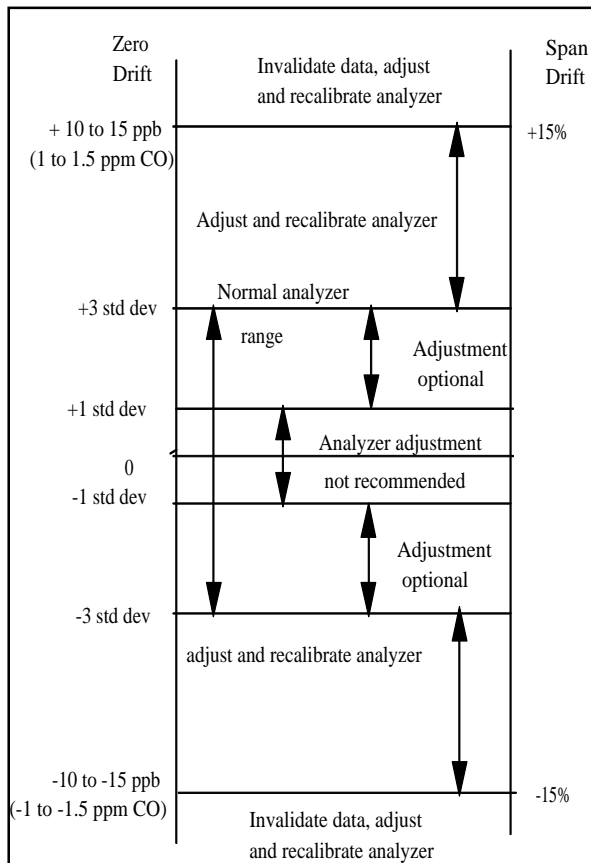
For the gaseous pollutants, the verification/calibration is considered acceptable if all calibration points fall within 2% of the full scale, best fit straight line. For manual samplers, devices (flow rate, temperature, pressure) are checked at different settings. Acceptance criteria for these devices can be found in the MQO Tables in Appendix D.

As a quality control check on calibrations, the standard error or correlation coefficient can be calculated along with the regression calculations. A control chart of the standard error or correlation coefficient could then be maintained to monitor the degree of scatter in the calibration points and, if desired, limits of acceptability can be established.

## 12.3 Frequency of Calibration and Analyzer Adjustment

An analyzer should be calibrated (or recalibrated):

- upon initial installation,
- following physical relocation,
- after any repairs or service that might affect its calibration,
- following an interruption in operation of more than a few days,
- upon any indication of analyzer malfunction or change in calibration, and
- at some routine interval (see below).



**Figure 12.1 Suggested zero/span drift limits**

analyzer may be useful; however, individual units of the same model may perform quite differently. After enough information on the drift performance of the analyzer has been accumulated, the calibration frequency can be adjusted to provide a suitable compromise among the various considerations mentioned above.

To facilitate the process of determining calibration frequency, it is strongly recommended that control charts be used to monitor the zero/span and one-point QC drift performance of each analyzer. Control charts can be constructed in different ways, but the important points are to visually represent and statistically monitor drift, and to be alerted if the drift becomes excessive so that corrective action can be

When calibration relationships are applied to analyzer responses to determine actual concentrations, it is suggested that the analyzer be recalibrated periodically to maintain close agreement. The frequency of this routine periodic recalibration is a matter of judgment and is a tradeoff among several considerations, including: the inherent stability of the analyzer under the prevailing conditions of temperature, pressure, line voltage, etc., at the monitoring site; the cost and inconvenience of carrying out the calibrations; the quality of the ambient measurements needed; the number of ambient measurements lost during the calibrations; and the risk of collecting invalid data because of a malfunction or response problem with the analyzer that wouldn't be discovered until a calibration is carried out.

When a new monitoring instrument is first installed, zero/span and one point QC checks should be very frequent, perhaps daily or 3 times per week, because little or no information is available on the drift performance of the analyzer. With the advancement in data acquisition system technology, many monitoring organizations are running these QC checks daily. However, the QC checks are required to be implemented every two weeks.

Information on another unit of the same model



taken. Such control charts make important use of the unadjusted zero and span response readings.

**NOTE:** Many newer technology analyzers have an “auto-zeroing” function incorporated in the instrument that can be implemented at user defined frequencies. Use of internal auto-zero functions typically does not need any post-processing of the data. EPA finds auto or manual zero adjustment acceptable, but does not recommend making automatic or manual adjustments (corrections) to the span until drift is unacceptable and warrants a calibration.

In continuous monitoring, the total cumulative drift, average of the absolute values of the individual drifts, and the standard deviation of the individual drifts should be calculated on a running basis over the last 100 or so days. Figure 12.1 summarizes some of the ranges and control chart limits that can be used to decide when calibration is warranted.

## 12.4 Adjustments to Analyzers

Ideally, all ambient measurements obtained from an analyzer should be calculated on the basis of the most current multipoint calibration or on the basis of both the previous and subsequent calibrations (see Section 12.5). Some acceptable level of drift (i.e., deviation from an original or nominal response curve) can be allowed before physical adjustments (a calibration) must be made because the calibration curve used to calculate the ambient measurements is kept in close agreement with the actual analyzer response. The chief limitations are the amount of change in the effective scale range of the analyzer that can be tolerated and possible loss of linearity in the analyzer's response due to excessive deviation from the design range. Cumulative drifts of up to 15 percent of full scale from the original or nominal zero and span values may not be unreasonable, subject to the limitations mentioned above.

Due to the advancement in monitoring technologies, ambient air monitors are much more stable and adjustments not as necessary. Earlier versions of this Handbook included sections for zero/span calibrations as well as physical zero/span adjustments. Precise adjustment of the zero and span controls may not be possible because of: (1) limited resolution of the controls, (2) interaction between the zero and span controls, and (3) possible delayed reaction to adjustment or a substantial stabilization period after adjustments are made. Precise adjustments may not be necessary because calibration of the analyzer following zero and span adjustments will define the precise response characteristic (calibration curve). EPA feels that frequent adjustments of instruments should not be necessary and may in fact lead to more data quality uncertainty. EPA does not recommend span adjustments be made between multi-point calibrations but zero adjustments are appropriate.

EPA is no longer including guidance suggesting that the calibration equation be updated after each zero/span check and suggests the ambient readings be calculated from the most recent multipoint calibration curve or from a fixed nominal or "universal" calibration curve (Section 12.5). In this case, the zero and span checks serve only to measure or monitor the deviation (drift error) between the actual analyzer response curve and the calibration curve used to calculate the ambient measurements.

### Automatic Self-Adjusting Analyzers

Some air monitoring analyzers are capable of periodically carrying out automatic zero and span calibrations and making their own zero and span self adjustments to predetermined readings. Automatic zero adjustments are considered reasonable, but EPA discourages the use of automatic span adjustments.

If the automatic zero standards pass through the sample inlet and sample conditioning system and both the adjusted and unadjusted zero response readings can be obtained from the data recording device, then the zero adjustment can be implemented.

## 12.5 Data Reduction Using Calibration Information

As noted previously, an analyzer's response calibration curve relates the analyzer response to actual concentration units of measure, and the response of most analyzers tends to change (drift) unpredictably with passing time. These two conditions must be addressed in the mechanism that is used to process the raw analyzer readings into final concentration measurements. Three practical methods are described below. They are listed in order of preference,

**1) "Universal" Calibration**--A fixed, "universal" calibration is established for the analyzer and used to calculate all ambient readings. All verifications and checks are used to measure the deviation of the current analyzer response from the universal calibration. Whenever this deviation exceeds the established zero and span adjustment limits, the analyzer is recalibrated.

**2) Major Calibration Update**--In this method, the calibration slope and intercept used to calculate ambient measurements are updated only for "major" calibration (i.e., semi-annual or annual multi-point verification/calibrations). All ambient measurements are calculated from the most recent major calibration. Between major calibrations, periodic zero and span calibrations are used to measure the difference between the most recent major calibration and the current instrument response. Physical or automated adjustments of the zero may be appropriate however span adjustment to restore a match between the current analyzer response and the most recent major calibration is not suggested. Whenever this deviation exceeds the established zero and span adjustment limits, the analyzer is recalibrated.

**3) Step-Change Update**-- the adjusted slope and intercept of the most recent calibration are used to calculate all subsequent ambient readings until updated by another calibration (i.e., no interpolation). No unadjusted zero or span readings are used, and ambient measurements can be calculated in real time if desired.

A significant problem with this method is acquiring the requisite calibration data and making sure they are merged correctly with the ambient data to facilitate the required calculations. Some automated data acquisition systems support this application by making special provisions to acquire and process periodic zero and span data. One way to ensure that the zero/span data are correctly merged with the ambient readings is to code the zero and span values directly into the data set at the location corresponding to the time of calibration, replacing the normal hourly reading that is lost anyway because of the calibration. These data can be marked (such as with a negative sign) to differentiate them from ambient data and later deleted from the final report printout. When zero and span data are acquired automatically by a data acquisition system for direct computer processing, the system must be sufficiently sophisticated to:

- ensure that zero or span data is never inadvertently reported as ambient measurements
- ignore transient data during the stabilization period before the analyzer has reached a stable zero or span response (this period may vary considerably from one analyzer to another)

- average the stable zero and span readings over some appropriate time period so that the zero or span reading obtained accurately represents the analyzers true zero or span response
- ignore ambient readings for an appropriate period of time immediately following a zero or span reading until the analyzer response has restabilized to the ambient-level concentration

## **12.6 Validation of Ambient Data Based on Calibration Information**

When zero or span drift validation limits (see Figure 12.1) are exceeded, ambient measurements should be invalidated back to the most recent acceptable zero/span/one-point QC check where such measurements are known to be valid. Also, data following an analyzer malfunction or period of non-operation should be regarded as invalid until the next subsequent calibration unless unadjusted zero and span readings at that calibration can support its validity.

### **Documentation**

All data and calculations involved in these calibration activities should be recorded in the instrument log book described in Section 11.