TCEQ 2017

The 2016 TNI Chemistry Standard

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Status

- The 2016 TNI standard is final and can be adopted
- But……..
- Some states had objections to a couple of provisions, so there will be a subsequent standard
- These changes are fairly minor and affect only detection/quantitation, but not just editorial, so there will need to be a round of voting
- There are also editorial changes – the most significant is renaming the TNI detection limit as the DL.

Contents of the standard

Sections	Updates
1.1, Introduction; 1.2 Scope; 1.3 Terms and Definitions; 1.4 Method Selection; 1.5.1 Validation	No changes
1.5.2 Detection limit and Quantitation limit	Comprehensive changes and additions
1.5.3 Precision and Bias	No changes
1.5.4 Selectivity	No changes
1.6 Demonstration of capability	No changes

Contents – Initial Calibration

Sections	Updates
1.7.1.1 a, b, c and d Essential elements of initial calibration	Language changes but similar
1.7.1.1.e) Removal and replacement of calibration standards	Comprehensive changes and additions
1.7.1.1 f) Minimum number of calibration standards	Changes
1.7.1.1 g, h, i and j) Calibration range and requirement for acceptance criteria	Language changes but similar
1.7.1.1 k) Requirement for a measure of relative error	Addition
1.7.1.1 l) Single point calibrations	Language changes but similar
1.7.1.1 m) Aroclors	Addition
1.7.1.1 n) ICV	Language changes but similar
1.7.1.1 o) Sensitivity check	Addition
1.7.1.1 p) Linear range	Language changes but similar

Contents – Continuing Calibration

Sections	Updates
1.7.1.2 a and b) Overview	No change
1.7.1.2.c) CCV level	Addition
1.7.1.2 d) When CCV is required	Changes and additions
1.7.1.2.e) Raw data	No change
1.7.1.2 f) Acceptance criteria	Changes

Chemistry Standard Calibration, Section 1.7.1.1.e

Section 1.7.1.1.e
Removal and Replacement of Calibration Standards

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Background

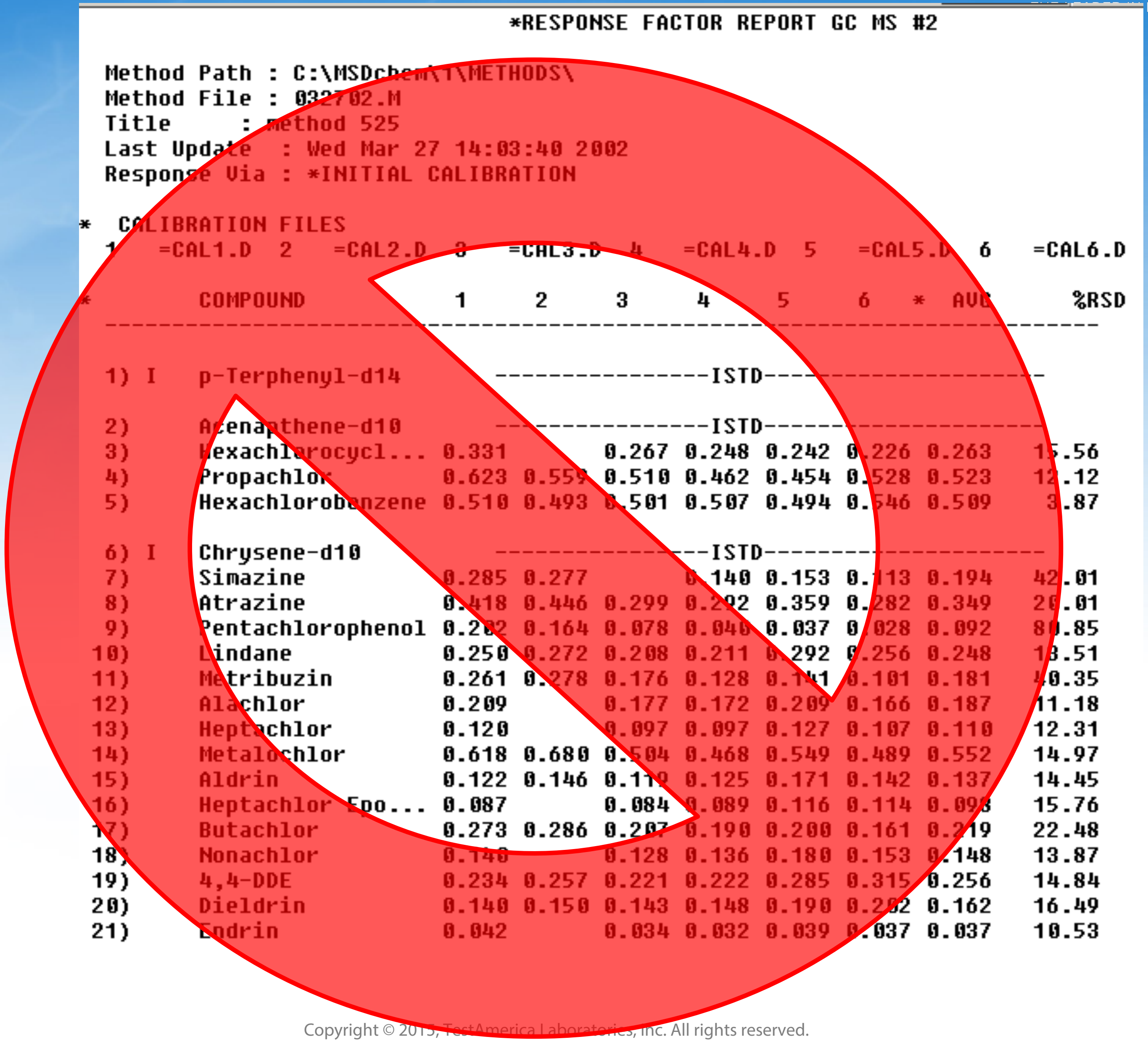
- Section 1.7.1.1.e was written to introduce language that reflected current industry data integrity practices relating to dropping calibration standard.
  - ~ Need a Written Procedure
  - ~ Removal of Calibration Standards
  - ~ Replacement of Calibration Standards
  - ~ Technically Valid Reason for Removal or Replacement of any Interior Calibration Standard (standard, level or point)

Removal

"the action of taking away or abolishing something unwanted"

e) i. The laboratory may remove individual analyte calibration levels from the lowest and/or highest levels of the curve. Multiple levels may be removed, but removal of interior levels is not permitted.

- Whether a single analyte curve (e.g., NO_3) or a multi-analyte curve (e.g., VOA) you can remove the lowest and/or highest calibration standard for any individual analyte, and do it multiple times.
- You can not remove (drop) an interior (e.g., mid-level) calibration standard that is between the lowest and highest calibration standards. Can't selectively drop interior standards so as to appear and pass calibration criteria!



```
                              *RESPONSE FACTOR REPORT GC MS #2

 Method Path : C:\MSDchem\1\METHODS\
 Method File : 032702.M
 Title       : Method 525
 Last Update  : Wed Mar 27 14:03:40 2002
 Response Via : *INITIAL CALIBRATION

*  CALIBRATION FILES
 1    =CAL1.D  2    =CAL2.D  3    =CAL3.D  4    =CAL4.D  5    =CAL5.D  6    =CAL6.D

*      COMPOUND             1      2      3      4      5      6   *  AVG      %RSD
 ---------------------------------------------------------------------------

 1) I   p-Terphenyl-d14         ----------------ISTD-----------------------

 2)     Acenapthene-d10         ----------------ISTD-----------------------
 3)     Hexachlorocycl... 0.331        0.267 0.248 0.242 0.226 0.263    15.56
 4)     Propachlor        0.623 0.559 0.510 0.462 0.454 0.528 0.523    12.12
 5)     Hexachlorobenzene 0.510 0.493 0.501 0.507 0.494 0.546 0.509     3.87

 6) I   Chrysene-d10            ----------------ISTD-----------------------
 7)     Simazine          0.285 0.277       0.140 0.153 0.113 0.194    42.01
 8)     Atrazine          0.418 0.446 0.299 0.292 0.359 0.282 0.349    20.01
 9)     Pentachlorophenol 0.202 0.164 0.078 0.040 0.037 0.028 0.092    80.85
10)     Lindane           0.250 0.272 0.208 0.211 0.292 0.256 0.248    13.51
11)     Metribuzin        0.261 0.278 0.176 0.128 0.141 0.101 0.181    40.35
12)     Alachlor          0.209       0.177 0.172 0.209 0.166 0.187    11.18
13)     Heptachlor        0.120       0.097 0.097 0.127 0.107 0.110    12.31
14)     Metalochlor       0.618 0.680 0.504 0.468 0.549 0.489 0.552    14.97
15)     Aldrin            0.122 0.146 0.119 0.125 0.171 0.142 0.137    14.45
16)     Heptachlor Epo... 0.087       0.084 0.089 0.116 0.114 0.098    15.76
17)     Butachlor         0.273 0.286 0.207 0.190 0.200 0.161 0.219    22.48
18)     Nonachlor         0.140       0.128 0.136 0.180 0.153 0.148    13.87
19)     4,4-DDE           0.234 0.257 0.221 0.222 0.285 0.315 0.256    14.84
20)     Dieldrin          0.140 0.150 0.143 0.148 0.190 0.202 0.162    16.49
21)     Endrin            0.042       0.034 0.032 0.039 0.037 0.037    10.53
```

Removal

"the action of taking away or abolishing something unwanted"

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e) ii. The laboratory may remove an entire single standard calibration level from the interior of the calibration curve when the instrument response demonstrates that the standard was <u>not properly introduced</u> to the instrument, or an <u>incorrect</u> standard was analyzed. A laboratory that chooses to remove a calibration standard from the interior of the calibration shall remove that particular standard calibration level for <u>all analytes</u>. Removal of calibration points from the interior of the curve is not to be used to compensate for lack of maintenance or repair to the instrument.

<u>not properly introduced</u> e.g.,"…bent injection needle on an auto-injector that yields very low responses for all the compound because the injection was not completed…" Ref: EHSG MICE, Email, April 2000

Incorrect

Simple Definition of *incorrect:*

- not true or accurate
- having errors or mistakes
- not proper or appropriate in a particular situation

incorrect e.g., "…single standard that has gone so bad that the difference is obvious to the naked eye…" Ref: EHSG MICE, Email, April 2000

The intent is to allow a laboratory to provide a good and sound documented technical reason for the rare instance of removal of a standard from a curve. For example, there was no standard solution added; the extract spilled; the bottle number was transcribed wrong. Only gross technical errors are to be allowed. It is not intended to allow substitution to improve curve fitting.

Adjust LOQ/RL and Quantitation Range

e) iii. The laboratory shall adjust the LOQ/reporting limit and quantitation range of the calibration based on the concentration of the remaining high and low calibration standards.

If you drop the lowest calibration standard your LOQ or reporting level goes up. Data reported below lowest calibration standard concentration must be qualified.

If you drop the highest calibration standard then your quantitation range goes down. Possible more dilutions and or qualified data if reported above quantitation range.

Replace

“to put something new in the place or position of something”

e) v. The laboratory may replace a calibration standard provided that

a. the laboratory analyzes the replacement standard within 24 hours of the original calibration standard analysis for that particular calibration level;

b. the laboratory replaces all analytes of the replacement calibration standard if a standard within the interior of the calibration is replaced; and

c. the laboratory limits the replacement of calibration standards to one calibration standard concentration.

The BIG Caveat

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e) vi. The laboratory shall document a technically valid reason for either removal or replacement of any interior calibration point.

- You must have a documented <u>technically</u> valid (sound) reason to either remove or replace any interior standard!
- Not to just pass calibration criteria, calibration verification or quality control criteria!, or
- Not to compensate for lack of maintenance or repair to the instrument.
- You better address this in your procedure!

Chemistry Expert Committee
Calibration
Section 1.7.1.1.f – minimum number of standards
Section 1.7.1.1.m- exception for Aroclors

Minimum Number of Standards

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- 1.7.1.1 f) for regression or average response/calibration factor calibrations the minimum number of non-zero calibration standards shall be as specified in the table below.

Type of Calibration Curve	**Minimum Number of Calibration Standards[b]**
Threshold Testing[a]	1
Average Response	4
Linear Fit	5
Quadratic Fit	6

Minimum Number of Standards

a - The initial one point calibration shall be at the project specified threshold level.

b - Fewer calibration standards may be used only if equipment firmware or software cannot accommodate the specified number of standards. Documentation detailing that limitation shall be maintained by the laboratory.

Number of calibration standards

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* Ensures a Minimum of 3 degrees of freedom *

Type of Calibration Curve	Minimum number of calibration standards	Degrees of Freedom
Threshold Testing [a]	1	Not Applicable
Average Response	4	3
Linear Fit	5	3
Quadratic Fit	6	3

The degrees of freedom in the equation scientifically justifies the minimum number of calibrants for all curve fitting routines.

Minimum Number of Standards

- Now has a statistical basis for the minimum number of standards required for each type of calibration
- Is now consistent with the requirements specified in the current EPA SW-846 methods and updates to the EPA 600 series methods for the minimum number of initial calibration standards for the different calibration types.

Minimum number of standards - Aroclors

1.7.1.1 m)

- If the calibration uses a linear through the origin model (or average response factor)
- Minimum requirement
  - Multi point calibration for a subset of Aroclors (eg 1016/1260)
  - Single point for the other Aroclors

Consistent with method 8082

Chemistry

1.7.1.1.k – Requirement for a measure of relative error

Requirement to measure Relative Error

What is Relative Error?

- Error measured as a percentage rather than an absolute value
  - ~ If the true value is 20 and the measured result is 22:
    - Absolute Error is 2
    - Relative error is 10%

Is Relative Error currently used in Environmental Testing?

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Yes:

- Most methods express CCV (Continuing Calibration Verification) limits as relative error:
  - True value +/- 20%

Standard language for Relative Error

j) the laboratory shall use and document a measure of relative error in the calibration.

i. for calibrations evaluated using an average response factor, the determination of the relative standard deviation (RSD) is the measure of the relative error;

If your calibration is evaluated by RSD then no further relative error evaluation is needed

ii for calibrations evaluated using correlation coefficient or coefficient of determination, the laboratory shall evaluate relative error by either:

Option 1: Relative Error

a. measurement of the Relative Error (%RE)

Relative error is calculated using the following equation:

$$\%\ Relative\ Error = \frac{x'_i - x_i}{x_i} \times 100$$

x_i = True value for the calibration standard
x'_i = Measured concentration of the calibration standard

Does that look familiar?

CCV % drift

$$\%\ Drift = \frac{x'_i - x_i}{x_i} \times 100$$

Same formula, but used with an inital calibration standard rather than continuing

Option 1: Relative Error

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This calculation shall be performed for two calibration levels: the standard at or near the mid-point of the initial calibration and the standard at the lowest level.

The Relative Error at both of these levels must meet the criteria specified in the method. If no criterion for the lowest calibration level is specified in the method, the criterion and the procedure for deriving the criterion shall be specified in the laboratory SOP.

Essentially, measure the error at the low point and mid-point of the calibration using the same calculation as for a CCV

Option 2: Relative Standard Error, RSE

$$\% \, RSE = 100 \times \sqrt{\sum_{i=1}^{n} \left[\frac{x_i' - x_i}{x_i}\right]^2 \Big/ (n-p)}$$

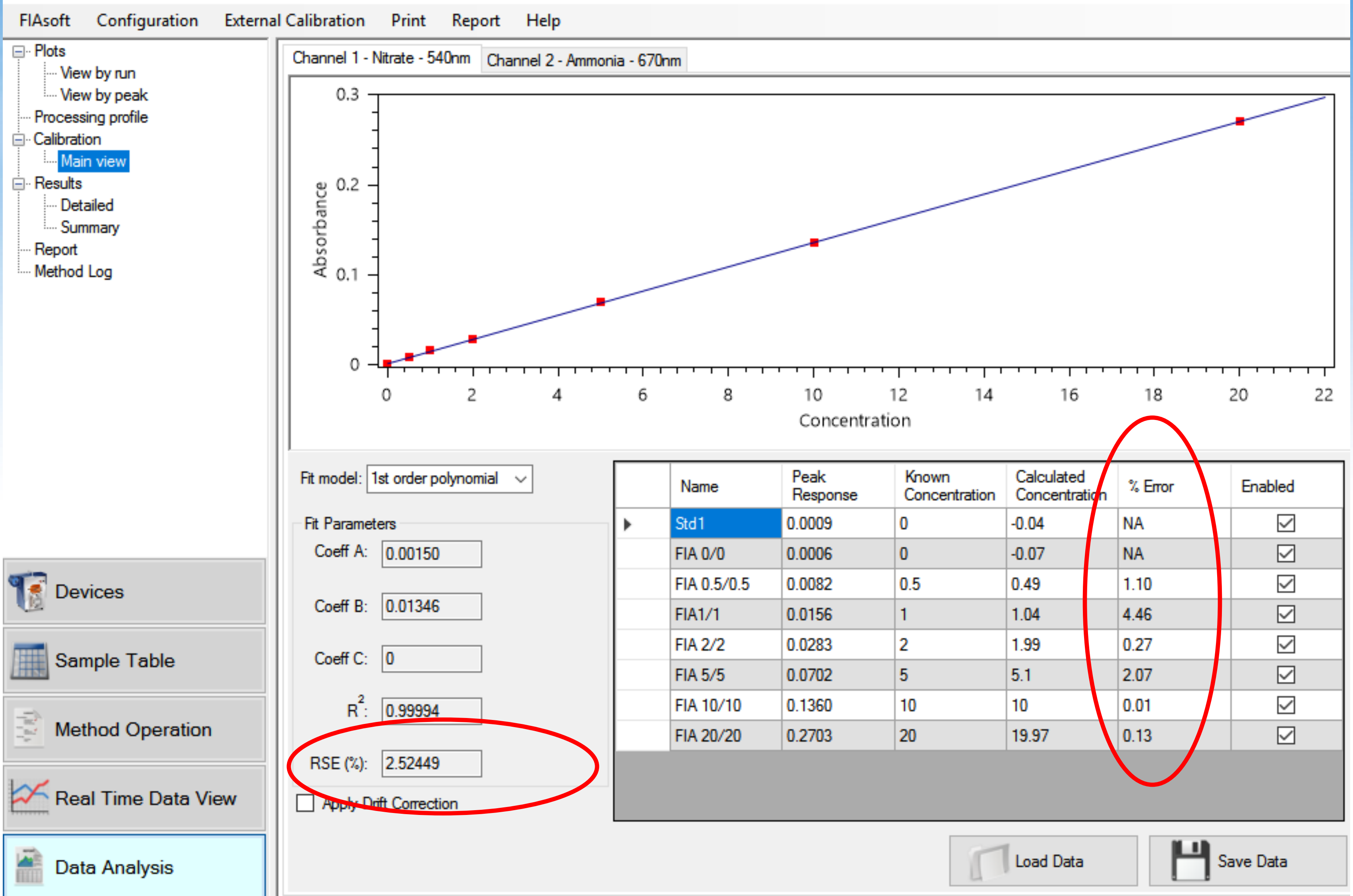
Looks complicated but just like RSD for an average curve

- Provides one number to evaluate the curve (like RSD)
- Not required if relative error has been evaluated using option 1 (also not required if the curve is assessed using RSD)

The Relative Standard Error must meet the criterion specified in the method. If no criterion is specified in the method, the maximum allowable RSE shall be numerically identical to the requirement for RSD in the method. If there is no specification for RSE or RSD in the method, then the RSE shall be specified in the laboratory SOP.

RSE calculator is available on the TNI website

Instrument software example (FIAlab)



Fit model: 1st order polynomial

Fit Parameters

Coeff A: 0.00150

Coeff B: 0.01346

Coeff C: 0

R^2: 0.99994

RSE (%): 2.52449

☐ Apply Drift Correction

Name	Peak Response	Known Concentration	Calculated Concentration	% Error	Enabled
Std1	0.0009	0	-0.04	NA	☑
FIA 0/0	0.0006	0	-0.07	NA	☑
FIA 0.5/0.5	0.0082	0.5	0.49	1.10	☑
FIA1/1	0.0156	1	1.04	4.46	☑
FIA 2/2	0.0283	2	1.99	0.27	☑
FIA 5/5	0.0702	5	5.1	2.07	☑
FIA 10/10	0.1360	10	10	0.01	☑
FIA 20/20	0.2703	20	19.97	0.13	☑

Why do we need to evaluate relative error in a curve?

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Correlation coefficient and coefficient of determination do not effectively control relative error

Without an evaluation of relative error, results especially towards the low end of the calibration can be meaningless

Examples

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Which curve type would you have selected based on “r^2” ???

Fluoride Method 300.0		Relative Error		
			Weighted Curves	
Conc.	**Response**	**Linear**	**Linear 1/x**	**Linear 1/X^2**
0.05	**1497075**			
0.5	**12858983**			
2.5	**67621646**			
5	**1.43E+08**			
10	**3.02E+08**			
	r^2	**0.9994**	**0.9990**	**0.9979**

Which Curve Type??

Propachlor Method 8081		**Relative Error**		
			Weighted Curves	
Conc.	**Response**	**Linear**	**Linear 1/x**	**Linear $1/X^2$**
5	**$2.67X10^6$**			
25	**$9.99X10^6$**			
50	**$1.74X10^7$**			
125	**$3.86C10^8$**			
175	**$5.21X10^8$**			
250	**$7.18X10^8$**			
500	**$1.37X10^9$**			
	r2	**0.999**	**0.997**	**0.991**

Relative error in EPA methods

Method 8000D

Either of the two procedures described in Secs. 11.5.4.1 and 11.5.4.2 may be used to determine calibration function acceptability for linear and non-linear curves

11.5.4.1 Calculation of the % error

Same as TNI Relative error option but required at all points

11.5.4.2 Calculation of Relative Standard Error

Same as TNI RSE

Does "may" mean that one or the other can be used, but one must be?

Does "determine calibration function acceptability" mean that if these options are used, then the COD does not need to be determined?

Relative Error in EPA methods - CFR 40 Part 136.6

- As an alternative to using the average response factor, the quality of the calibration may be evaluated using the Relative Standard Error (RSE). The acceptance criterion for the RSE is the same as the acceptance criterion for Relative Standard Deviation (RSD), in the method. RSE is calculated as:

$$\% \, RSE = 100 \times \sqrt{\sum_{i=1}^{n} \left[\frac{x_i' - x_i}{x_i}\right]^2 \Big/ (n-p)}$$

- The RSE may be used as an alternative to correlation coefficients and coefficients of determination for evaluating calibration curves for any of the methods at Part 136. If the method includes a numerical criterion for the RSD, then the same numerical value is used for the RSE.

Relative Error in EPA methods – Drinking Water

524.4 example

- The initial calibration is validated by calculating the concentration of the analytes for each of the analyses used to generate the calibration curve by use of the regression equations. Calibration points that are ≤MRL must calculate to be within +50% of their true value. All other calibration points must calculate to be within +30% of their true value

Same as the TNI Relative error but required at all levels

Note that correlation coefficient and COD are not included in the method

Chemistry

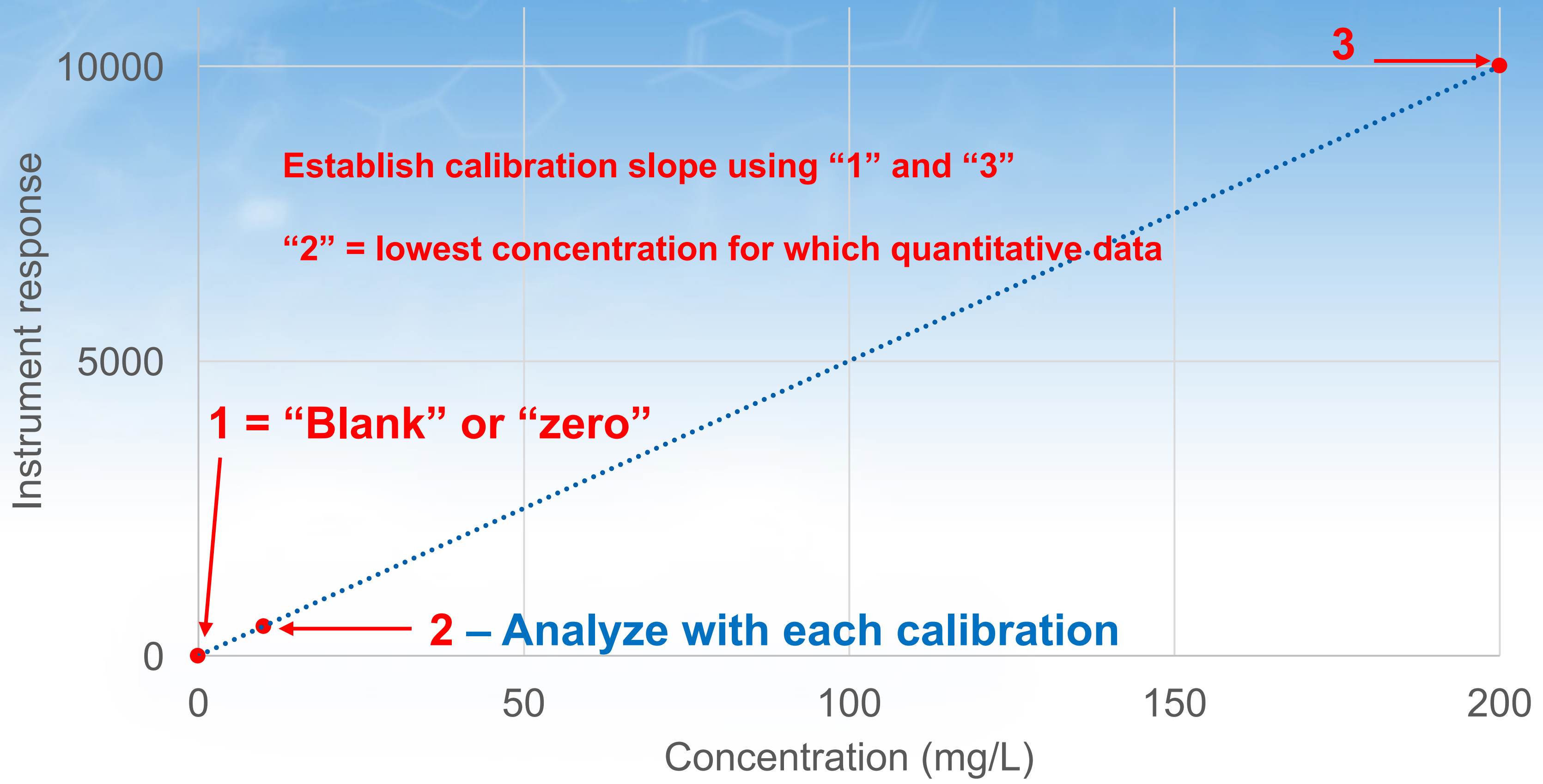
1.7.1.1.l and 1.7.1.1.p

Single point calibration and linear range methods

- Some methods allow calibration with only a blank (or “zero”) and a single calibration standard
- E.g., ICP technology

- 2016 standard requires
  - Single point used to establish the calibration shall be analyzed at least daily
  - Standard at or below the quantitation limit shall be analyzed with each calibration and shall meet recovery limits

Required at least daily:



Establish calibration slope using “1” and “3”

“2” = lowest concentration for which quantitative data

1 = “Blank” or “zero”

2 – Analyze with each calibration

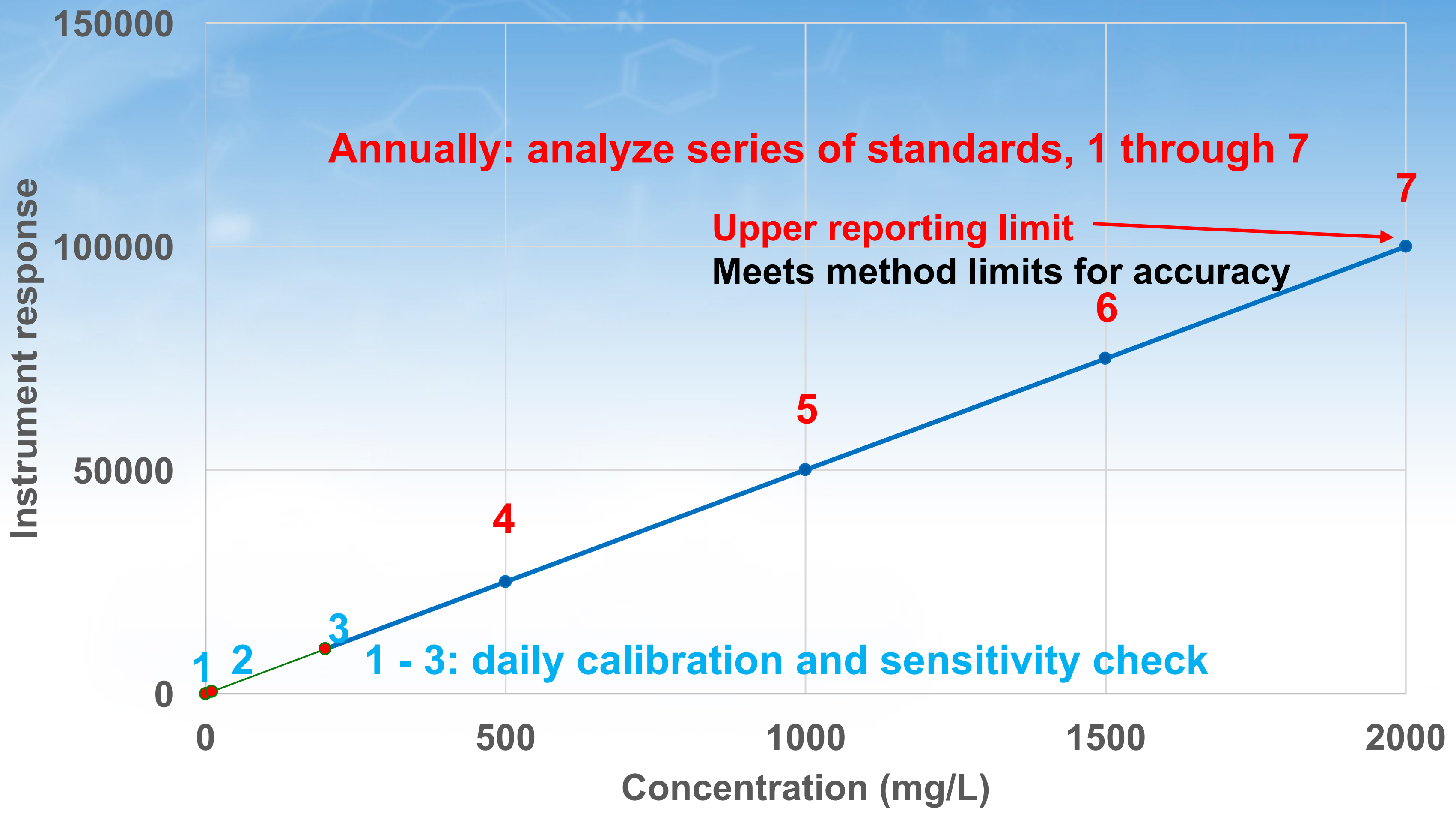
No change from 2009 Standard

If method allows…

… Data within the linear range, but above daily calibration to be reported without qualification:

Establish the linear range using a series of standards

Linear range
Annual requirement



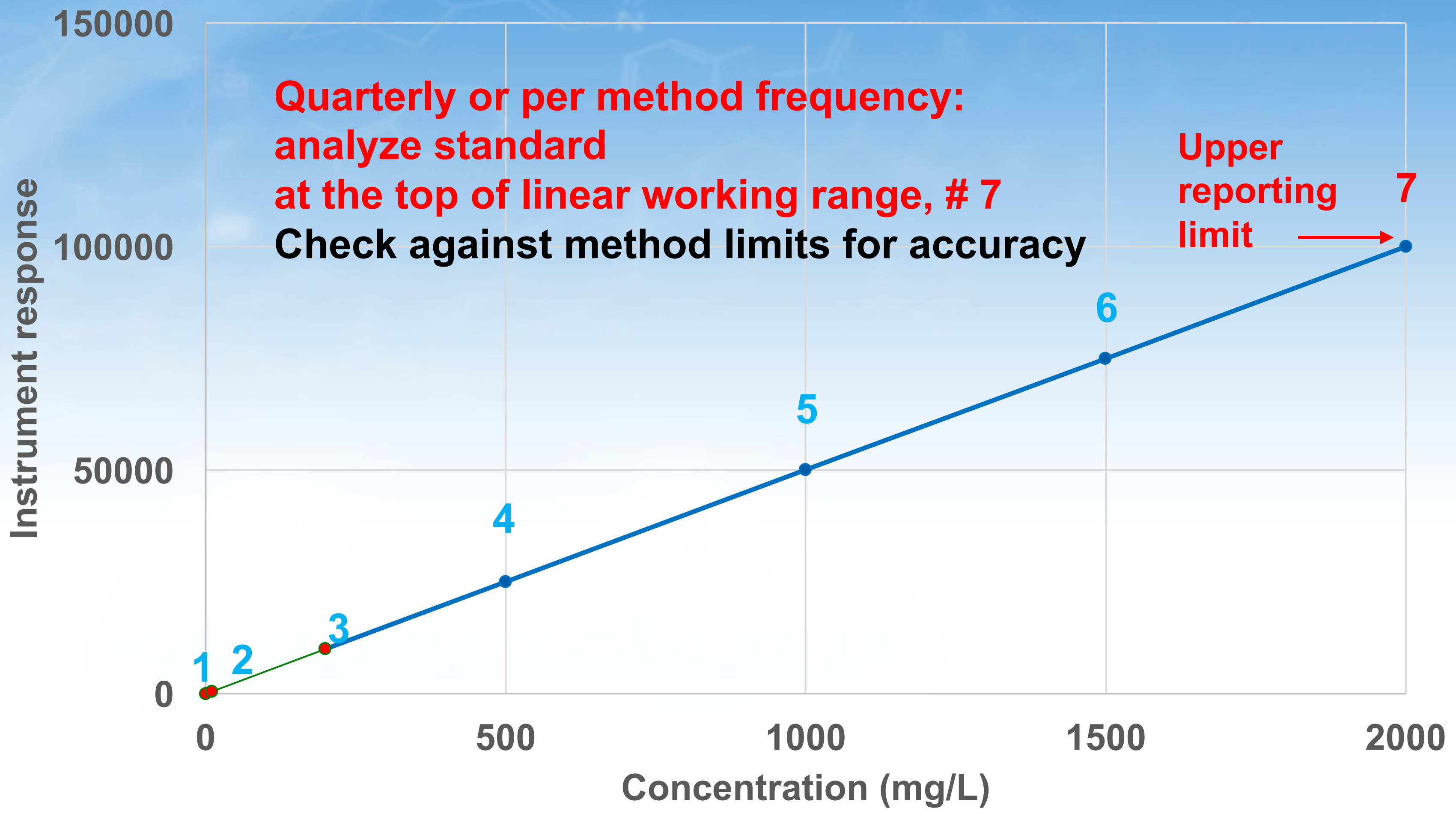
Annually: analyze series of standards, 1 through 7

Upper reporting limit

Meets method limits for accuracy

1 - 3: daily calibration and sensitivity check

Linear range
Quarterly requirement



Quarterly or per method frequency:
analyze standard
at the top of linear working range, # 7
Check against method limits for accuracy

Upper reporting limit

Chemistry Expert Committee

Calibration

Section 1.7.1.1.o – Sensitivity check

Sensitivity check

- for those methods where reporting non-detected analytes based on successful completion of a sensitivity check is allowed (similar to threshold testing but only for non-detects) the requirements of this standard shall not prohibit the practice;

Method 8000D
In order to report non-detected analytes that exceed the lower acceptance criteria (e.g., <-20%), a sensitivity verification standard at or below the LLOQ should be analyzed in the analytical batch. The analyte should be detected in the LLOQ standard and meet all of the qualitative identification criteria that the laboratory routinely uses

V1M4 1.7.2. f

Continuing Calibration Verification (CCV)

Contents – Continuing Calibration

Sections	Updates
1.7.1.2 a, b) General requirements	Language changes but similar
1.7.1.2 c) Required concentration of the CCV	Addition
1.7.1.2 d) Required frequency of the CCV	Changes and additions
1.7.1.2 e) Raw data requirements	No change
1.7.2.1 f) Acceptance criteria	Changes

1.7.2.1 c)
Required concentration

- Concentration shall be equal to or less than half the highest level in the calibration

1.7.2.1 d) Frequency of the CCV

- At the beginning and end of each analytical batch
    - (Ending requirement is waived if internal standard is used and not required by the method)
    - Same as 2009
- Additions
    - Second source ICV that passes CCV criteria may be used in place of a CCV
    - LCS that passes CCV criteria may be used in place of a CCV for methods where the calibration gores through the same process as the LCS

2016 - 1.7.2 f)
Acceptance criteria

- if an **obvious** cause for the calibration verification failure is identified that impacts **only** the calibration verification sample (e.g. a missed autosampler injection), then analysis may proceed if a second calibration verification sample is analyzed immediately and the result is within acceptance criteria. Samples analyzed previously shall be considered valid if bracketed by a passing calibration verification sample (refer to 1.7.2(d)). The cause for the failure of the first calibration verification result shall be documented

2016 - 1.7.2 f) i

CCV fails and only impacts the CCV

- Missed autosampler injection
- Low/no Internal standard in the CCV
- CCV spiked at incorrect concentration(1/2)
- Instrument error on CCV

Document cause of failure and immediately reanalyze a second CCV

2016 - 1.7.2.f) i

if the cause for the calibration verification failure is **not obvious** and/or has the **potential** to have identifiable or has **impacted other samples**, then corrective action shall be performed and documented. Prior to analyzing samples, the laboratory shall demonstrate acceptable performance after corrective action with calibration verification or a new initial calibration shall be performed. Samples analyzed prior to the calibration verification failure shall be **reanalyzed** or the results **qualified** if calibration verification bracketing is required (refer to 1.7.2(d))

2016 - 1.7.2 f) ii

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CCV fails and impacts other samples or cause is unknown

- Just fails
- Poor Peak shape
- Poor response
- Incorrect IS concentration

Perform Corrective Action

- Replace Reagent
- Replace Internal Standard valve
- Clean needle
- Replace injection port liner
- Replace tubing

2016 - 1.7.2 f) ii

Document the corrective action

Demonstrate acceptable performance with new CCV or recalibration

Don’t forget samples before a failing CCV will also need to be reanalyzed if bracketing is required, or qualified as listed in the next section.

2016 - 1.7.2 f) iii
Acceptance criteria

- Data associated with an unacceptable calibration verification shall be qualified if reported, and shall not be reported if prohibited by the client, a regulatory program or regulation.

- Data associated with calibration verifications that fail under the following special conditions shall still be qualified, but may use a different qualifier
  - High bias and non-detects
  - Low bias and above reg limit/decision level

2016 - 1.7.2 f) iii. a

when the acceptance criteria for the continuing calibration verification are exceeded high (i.e., high bias) and there are associated samples that are nondetects, then those non-detects may be reported. Otherwise the samples affected by the unacceptable calibration verification shall be re-analyzed after a new calibration curve has been established, evaluated and accepted; or

2016 - 1.7.2 f) iii. b

when the acceptance criteria for the continuing calibration verification are exceeded low (i.e., low bias), those sample results may be reported if they exceed a maximum regulatory limit/decision level. Otherwise the samples affected by the unacceptable verification shall be re-analyzed after a new calibration curve has been established, evaluated and accepted.

2016 - 1.7.2 f) iii

CCV is out high and samples are non detect

CCV is out low and samples exceed the maximum regulatory/decision level

Reanalyze

2009 vs 2016

2016

- Requires identifiable cause for CCV failure for second CCV to be acceptable. If cause is not identifiable requires corrective action
- Requires only one passing CCV after corrective action.
- States data may be reported un the special conditions unless prohibited by the client, regulatory program or regulation.

2009

- Does not require identifiable cause for CCV failure before analysis of second CCV
- Requires two passing CCVs after corrective action
- States data is fully useable under the special conditions

Items currently under consideration for a revision

- What to call a TNI detection limit?
  - LOD, MDL, DL
- 3X rule for separation of the detection limit and the quantitation limit
- Setting recovery limits for the ongoing LOQ verifications

Guidance document

Seems like a lot?

- Guidance document will be available on the TNI website shortly

Questions?