Guideline Document 038
Description of In-Stack Detection Limit

One of the elements of successful compliance testing is the relationship between the in-stack detection limit of the pollutant and the level of the standard. Obviously, if the in-stack detection limit is higher than the level of the standard, compliance cannot be demonstrated. Below is an equation that will help determine in-stack detection limits and thus, help the tester determine various parameters of the test, such as sampling time and the sensitivity of the analytical techniques.

The equation used in determining the in-stack detection limit (ISDL) is as follows:

$$ISDL = \frac{A \times B}{C}$$

where, ISDL = In-stack detection limit
A = Analytical detection limit
B = Amount of analyte analyzed
C = Volume of stack gas sampled

Units of the ISDL will vary with the type of sampling performed. For example, the analytical detection limit for particulate matter will have units of mass while the analytical detection limit for methods that utilize analytical methods other than gravimetric (i.e., ion chromatograph, gas chromatograph) will have units of mass per unit volume.

Three examples are provided below to illustrate better the concept of the in-stack detection limit.

Example 1

A sampling train for particulate matter (PM) samples for three hours in a stack that has a volumetric flow rate of 120,000 dscfm. At the end of the three hours, the train has collected 135 dscf of stack gas. The required minimum amount of PM to be collected on the filter is 20 mg (0.088 gr). What is the in-stack detection limit for this sampling run?

Solution

$$ISDL = \frac{0.088\ gr \times 120{,}000\ \frac{ft^3}{min}}{135\ ft^3} = 78.2\ \frac{gr}{min} = 2.35\ \frac{lb}{hr}$$

The ISDL implies that PM emission rates less than 2.35 lb/hr can not be reliably detected. This value may be lowered by increasing the sampling time, thus increasing the amount of gas sampled, or by accepting a lower minimum amount of PM on the filter.

Ideally, the ISDL should range from a fifth to a tenth of the specified standard or less. Strategies for decreasing the ISDL even further include increasing sampling times or sample volumes, and using more sensitive analytical techniques.

Example 2

A PM sampling train is to be used to determine compliance on a source that has a stack flowrate of 2500 dscfm (150,000 dscfh). The PM standard is 200 g/hr and the ISDL is chosen to be ten percent of the standard or 20 g/hr. What volume of gas should be sampled to collect 20 mg (0.02 g) of PM in the sampling train?

$$C = \frac{A \times B}{ISDL}$$

$$\text{Required Sample Volume} = \frac{0.02g \times 150{,}000\ \frac{ft^3}{hr}}{20\ \frac{g}{hr}} = 150\ ft^3$$

To obtain 20 mg of PM in the sampling train, at least 150 dscf of stack gas must be collected. If the sampling train samples at a rate of 0.75 dscfm, the sampling train will be 200 minutes or 3.3 hours.

<u>Example 3</u>

The specified standard for Cr^{+6} is 0.03 mg/dscm. The ISDL is predetermined to be one tenth of the standard, 0.003 mg/DSCM (3.0E-6 mg/L). The sample will be prepared in a 250 ml (0.25 L) flask and the ion chromatograph used in the sample analysis has a detection limit of 40 ng/ml (0.04 mg/L). What sample volume is required to obtain an ISDL of 0.003 mg/L?

<u>Solution</u>

$$\text{Required Sample Volume} = \frac{0.04g\ \frac{mg}{L} \times 0.250L}{3.0 \times 10^{-6}\ \frac{mg}{L}} = 3333.3\ L = 3.33\ dscm$$

In order for the specified ISDL to be obtained, at least 3.33 dscm of stack gas must be collected in the sampling train.