STACK TESTING 101

PRESENTED BY RANDY BARTLEY
MANAGING PARTNER / BAIR

DISCLAIMER

- **The information presented should not be used without nor implented as Standard Operating Procedures**
- **Please consult your company's Environmental and Legal departments regarding test methods for performing stack tests to ensure the most up-to-date methods and practices are being used**

Performing EPA and State Level Stack Testing With Approved Test Methods

OVERVIEW

Applicable Stack Tests

Expectations for Operators and Testing Firms

Responsibilities of Operators and Testing Firms

Testing Methods and the Ability to Perform (Access)

Common On-Site Issues

Revocation of ALT Methods 061 and 087

Fuel Flow Rates vs. Exhaust Flow Rates

90% Load Issues

Measurable Air Quality

Money now or More Money Later

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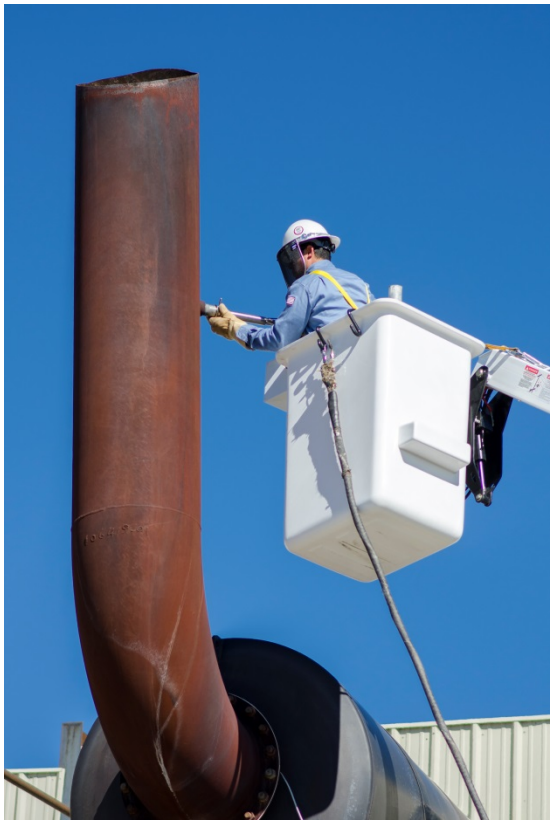
APPLICABLE STACK TESTS

- **40 CFR 60 Subpart JJJJ**
- **40 CFR 63 Subpart ZZZZ**
- **40 CFR 60 Subpart IIII**
- **40 CFR 60 Subpart KKKK**
- **State Required Initial tests as applicable to 40 CFR 60.8**
- **State tests per applicable Administrative Code (i.e. T.A.C. 30 Chapter 117 biennials)**



OPERATOR EXPECTATIONS

- **Stack Testing Firm (STF) should be competent (perhaps have an accreditation (LELAP, NELAP/NELAC)**
- **STF should be knowledgeable of appropriate testing Reference Methods (RM), or ASTM equivalent methods**
- **STF should be equipped to perform all required testing methods (pitot tube, heated lines, calibration gases, etc.)**
- **STF should be able to meet requirements of the MSA including but not limited to insurance requirements and contractor database entities (ISNetworld, PEC Safety, etc.)**
- **STF should be reputable**
- **STF should be ethical**

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STF EXPECTATIONS

- **Operator should be ethical and reputable**
- **Operator should put safety above job completion**
- **Operator should inform STF specifically of the test type needed so the STF can be equipped for the stack test**
- **Operator should have coordination between departments to ensure steady-state conditions during testing**
- **Operator should have a good understanding of the time-frame of appropriate testing**
- **Operator should have the unit ready for testing (running at maximum achievable load, with emission controls installed and functioning)**
- **Operator should buy Stack Tester's lunch!**

OPERATOR RESPONSIBILITIES

- **Designate the type of stack test needed (JJJJ, ZZZZ, etc.)**
- **Specify the Analytes of Interest (NOx, CO, O2, etc.)**
- **Provide permit limits, if different from the applicable standard**
- **Provide Table 29's or equivalent for specific source information (required for reporting purposes)**
- **Provide power supply to STF (optional)**
- **Provide safe access to stack and test ports (required)**
- **Issue Hot Work Permits as applicable and ensure the work area is safe**

OPERATOR RESPONSIBILITIES

- **View of Sample Information Request Page (IRP)**
- **Basic Operator Information**
- **Facility Information**
- **Source Information**
- **Limits of Pollutants**
- **Stack and Flow Information**
- **Submittal of Test Notice as applicable**

OPERATOR RESPONSIBILITIES

View Field Data Sheet (FDS) for Day of Testing Information

- **Operating Data**
  - RPM, Fuel Pressure, Ignition Timing
  - Intake Manifold Temp, Exhaust Temp
  - Suction, Discharge, and Throughput for HP Calcs
  - Differential Pressure across Catalyst
- **Fuel Gas Analysis**
- **Fuel Meter Calibration (if used)**
- **Operator Specific calculations for pertinent Operating Data (HP, BSFC, etc.)**

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STACK TESTER RESPONSIBILITIES

- **Communicate with Operator at various times prior to testing and ensure completion of IRP**
- **Be on time and communicate if there will be a potential delay**
- **Be equipped with all required PPE**
- **Be equipped with all sampling equipment per IRP**
- **Participate in Operator Safety Orientation**
- **Conduct STF JSA**
- **Read STF “Statement of Conditions”**
- **Collect signatures of Attendees**

STACK TESTER RESPONSIBILITIES

Begin Test Procedures

- **Warm up the Analytical and Auxiliary Equipment**
- **Calibrate all Analyzers**
- **Position Equipment for Sampling**
- **Conduct the Test per Applicable Standards**
- **Conduct Post Test Calibrations**
- **Break down all Sampling Equipment**
- **Provide Summary Report as applicable**
- **Terminate Hot Work Permit as applicable**
- **Safely Leave Location**

EPA REFERENCE METHODS (RM) AND ASTM METHODS

- **Reference Methods and ASTM Equivalents**
- **RM 1_Traverse Points**
- **RM 1A_Small Ducts (12 > stack ID ≥ 4 inches)**
- **RM 2_Velocity (S-Type Pitot)**
- **RM 2C_Standard Pitot**
- **RM 3A_CO2, O2 Instrumental**
- **RM 4_Moisture Content**
- **RM 5_Particulate Matter**
- **http://www.epa.gov/ttn/emc/**

EPA REFERENCE METHODS (RM) AND ASTM METHODS

- **RM 7E_NOx Instrumental**
- **RM 10_Carbon Monoxide NDIR**
- **RM 18_VOC by Gas Chromatograph**
- **RM 19_Calculating Exhaust Flow**
- **RM 25A_Gaseous Organic Concentration**
- **RM 320_Vapor Phase Organic & Inorganic Emissions by Extractive FTIR**
- **RM 323_Formaldehyde Measurement Using Derivitization**
- **http://www.epa.gov/ttn/emc/**

EPA REFERENCE METHODS (RM) AND ASTM METHODS

- **ASTM D6348-12E1_Standard Test Method for Determination of Gaseous Compounds by Extractive Direct Interface Fourier Transform Infrared (FTIR) Spectroscopy**
- **ASTM D6522-11_Standard Test Method for Determination of Nitrogen Oxides, Carbon Monoxide, and Oxygen Concentrations in Emissions from Natural Gas-Fired Reciprocating Engines, Combustion Turbines, Boilers, and Process Heaters Using Portable Analyzers**
- **www.astm.org**
- **www.webstore.ansi.org**

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ALTERNATE METHODS 061 AND 087 FOR SINGLE POINT

Below is language from EPA RM 7E FAQs prior to revocation of ALT Methods 061 and 087

- Stratification test of 7E don't do well in small stacks
- Should be well mixed after muffler
- < 4 inches exempt from stratification tests
- Emissions from engines too temporarily variable to render stratification tests meaningful
- Planning to revise JJJJ and ZZZZ to allow single point tests
- "Revisions to Testing Methods and Testing Regulations" in Federal Register by mid-year 2010

REVOCATION OF ALTERNATE METHODS 061 AND 087

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

March 10, 2014

OFFICE OF
AIR QUALITY PLANNIN
AND STANDARDS

SUBJECT: Withdrawal of Broadly Approved Alternative Test Methods 061 and 087 (ALT-061 and 087), Waiver of Stratification Testing for Engines

FROM: Steffan Johnson, Acting Group Leader
Measurement Technology Group (E143-02)

TO: Regional Air Directors and Air Branch Managers

Ms. Alice Edwards, of the Alaska Department of Environmental Conservation, submitted a comment letter to the docket for the Revisions to Test Methods and Testing Regulations proposal (EPA-HQ-OAR-2010-0114) on March 9, 2012. She made two important points regarding simplification of the gas stratification requirements associated with engine testing: 1) that stratification could potentially be introduced by catalytic controls that are being used on some engines and, 2) that there is likely a significant population of internal combustion engines subject to at least one of the three subparts (Subparts IIII and JJJJ in 40 CFR Part 60 and Subpart ZZZZ in 40 CFR Part 63) that have exhaust stacks greater than 12 inches in diameter, which could reasonably be sampled at multiple points.

REVOCATION OF ALTERNATE METHODS 061 AND 087

For the Revisions to Test Methods and Testing Regulations final rule published on February 27, 2014 (79 FR 11228), we decided that for cases where gaseous emissions and diluent gases are being measured from federally regulated engines, we will allow ducts less than or equal to 6 inches in diameter to be sampled at a single point at the centroid of the duct. Ducts greater than 6, but less than 12 inches in diameter, will need to be sampled at three specified traverse points unless they have been demonstrated to be unstratified according to Method 7E. For ducts equal to or greater than 12 inches in diameter, if the sampling port location meets the minimum Method 1 criterion for distance from disturbances (such as catalyst beds), they may be sampled at three points; the two stack diameter distance downstream from the nearest disturbance will provide for gas mixing and, coupled with a three-point traverse, yield a representative sample. If they don't meet the Method 1 criterion for distance from disturbances, ducts equal to or greater than 12 inches in diameter will be subject to stratification testing for determination of sampling points.

Additionally, we now recognize that the broadly applicable alternative test method approvals referred to as ALT-061 and ALT-087 (www.epa.gov/ttn/emc/approalt.html) issued on September 22, 2009, and July 27, 2011, respectively, should be withdrawn. We approved the use of single-point sampling at the centroid of the exhaust when sampling gaseous emissions and diluent gases from federally regulated engines in the *Federal Register* notice dated February 15, 2012.

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REVOCATION OF ALTERNATE METHODS 061 AND 087

However, based on our consideration of the comment letter from Ms. Edwards and our ultimate decision regarding finalization of Revisions to Test Methods and Testing Regulations, we no longer believe that this alternative is appropriate.

Therefore, we are withdrawing the broadly applicable alternatives, ALT-061 and ALT-087, and will post this withdrawal letter on our website at http://www.epa.gov/ttn/emc/approalt.html. Although we have decided to retract these two broadly applicable test methods, we will continue to grant case-by-case approvals, as appropriate, and will (as state, local, and tribal agencies and the EPA Regional Offices should) consider the need for an appropriate transition period for users either to request case-by-case approval or to transition to an approved method.

For any questions or comments, please contact Robin Segall at (919) 541-0893 or at segall.robin@epa.gov. Thank you for your attention to this matter.

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STRATIFICATION TESTING

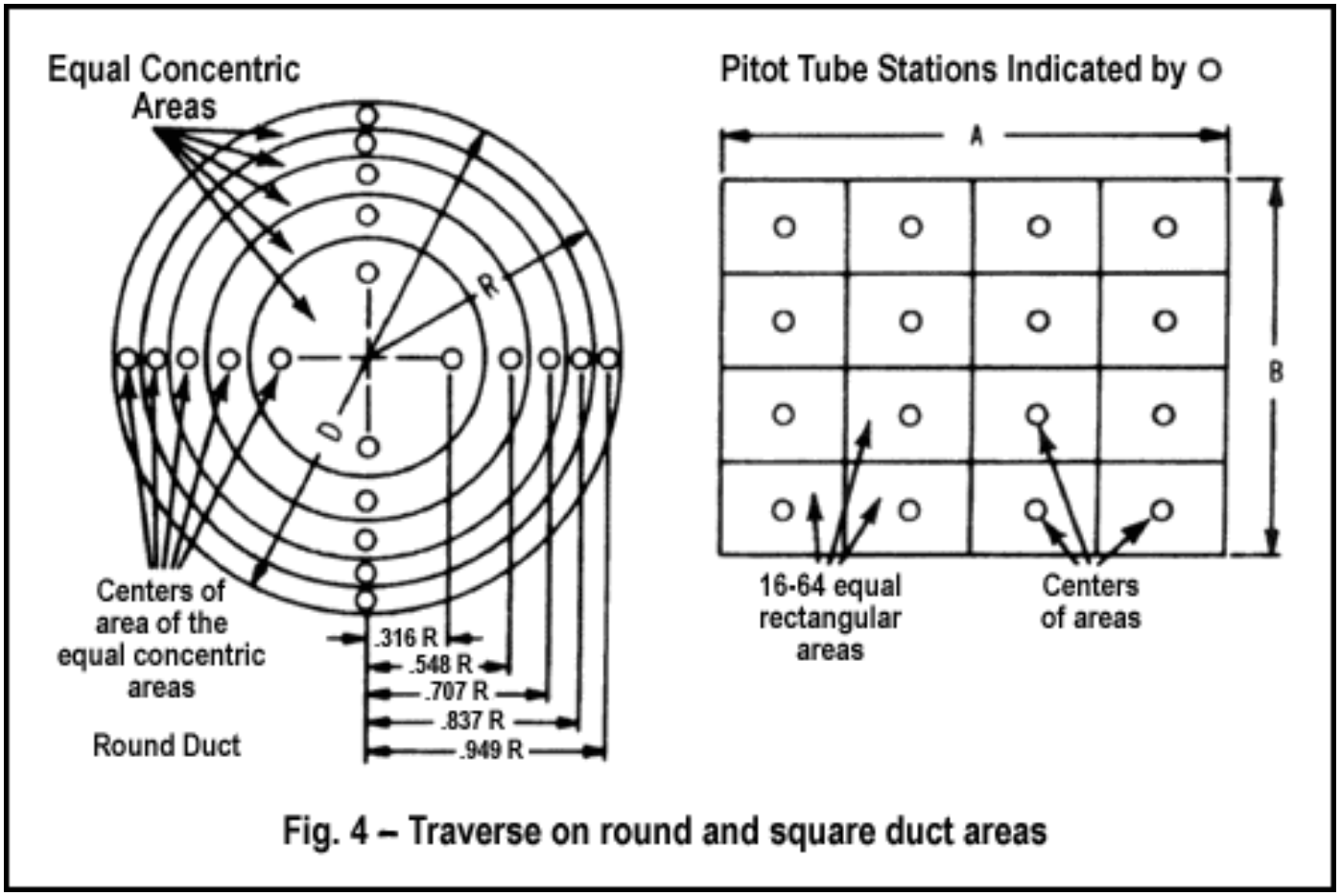

Fig. 4 – Traverse on round and square duct areas

From Dwyer Instruments Webpage

8.1.2 Determination of Stratification. Perform a stratification test at each test site to determine the appropriate number of sample traverse points. If testing for multiple pollutants or diluents at the same site, a stratification test using only one pollutant or diluent satisfies this requirement. A stratification test is not required for small stacks that are less than 4 inches in diameter. To test for stratification, use a probe of appropriate length to measure the NOX (or pollutant of interest) concentration at twelve traverse points located according to Table 1-1 or Table 1-2 of Method 1. Alternatively, you may measure at three points on a line passing through the centroidal area. Space the three points at 16.7, 50.0, and 83.3 percent of the measurement line. Sample for a minimum of twice the system response time (see section 8.2.6) at each traverse point. Calculate the individual point and mean NOX concentrations. If the concentration at each traverse point differs from the mean concentration for all traverse points by no more than: (a) ±5.0 percent of the mean concentration; or (b) ±0.5 ppm (whichever is less restrictive), the gas stream is considered unstratified and you may collect samples from a single point that most closely matches the mean. If the 5.0 percent or 0.5 ppm criterion is not met, but the concentration at each traverse point differs from the mean concentration for all traverse points by no more than: (a)
±10.0 percent of the mean; or (b) ±1.0 ppm (whichever is less restrictive), the gas stream is considered to be minimally stratified, and you may take samples from three points. Space the three points at 16.7, 50.0, and 83.3 percent of the measurement line. Alternatively, if a twelve-point stratification test was performed and the emissions were shown to be minimally stratified (all points within ±10.0 percent of their mean or within ±1.0 ppm), and if the stack diameter (or equivalent diameter, for a rectangular stack or duct) is greater than 2.4 meters (7.8 ft), then you may use 3-point sampling and locate the three points along the measurement line exhibiting the highest average concentration during the stratification test, at 0.4, 1.0 and 2.0 meters from the stack or duct wall. If the gas stream is found to be stratified because the 10.0 percent or 1.0 ppm criterion for a 3-point test is not met, locate twelve traverse points for the test in accordance with Table 1-1 or Table 1-2 of Method 1.

From EPA RM 7E

MEASURING EXHAUST FLOW

Measuring Exhaust Flow

- **RM 2_Velocity (S-Type Pitot)**
- **RM 2C_Standard Pitot**

Picture from Metlab Webpage

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CALCULATING EXHAUST FLOW

Measuring Fuel Rate to Calculate Exhaust Flow

- **Requires onsite Fuel Meter (FM)**
- **Requires Fuel Gas Analysis (FGA)**
- **Insertable FM must be calibrated post test**
- **Stationary FM may be pre or post calibrated**
- **Measured Fuel Rate can calculate the Brake Specific Fuel Consumption (BSFC) for the Source (btu/HP-hr)**
- **http://www.epa.gov/ttn/emc/**

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COMMON ON-SITE ISSUES

- **Access to the source at ground level**
  - Production piping at ground level or production headers
- **Access to the source stack and test ports**
  - Non-OSHA compliant ladders/scaffolding
  - Non-OSHA compliant catwalks/railing systems
  - Catwalks not high enough to reach test ports
  - No test ports
- **Non-compliant stacks for flow disturbances**
  - NOTE: The requirements of this method must be considered before construction of a new facility from which emissions are to be measured; failure to do so may require subsequent alterations to the stack or deviation from the standard procedure. Cases involving variants are subject to approval by the Administrator. From EPA RM 1

COMMON ON-SITE ISSUES

Engine Operation Panel

- **Lack of operational data displayed**
  - Horsepower or Load %
  - Manifold Pressure
  - Ignition Timing
  - Fuel Pressure
  - Fuel Rate
  - Throughput Rate
  - Data for BSFC

90% LOAD CONDITIONS

- **Must test source within 60 days of startup and normal operating conditions**
- **Can test up to 180 days from startup with if experiencing abnormal operating conditions**
- **Sometimes hard to achieve 90% load within timeframes for initial compliance test**
- **Wellhead and gas-lift compression may not ever achieve 90% load conditions**
- **Solution is to test and submit compliance report at Maximum Achievable Load**
- **If this Maximum Achievable Load is increased by 10%, re-initial is required**
- **Over-engineering is common and source should not be de-rated for testing purposes**

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MEASURABLE AIR QUALITY…
…HOW STANDARDS ARE SET

Pollutant [final rule cite]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide [76 FR 54294, Aug 31, 2011]		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead [73 FR 66964, Nov 12, 2008]		primary and secondary	Rolling 3 month average	0.15 µg/m^3 (1)	Not to be exceeded
Nitrogen Dioxide [75 FR 6474, Feb 9, 2010] [61 FR 52852, Oct 8, 1996]		primary	1-hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	Annual	53 ppb (2)	Annual Mean
Ozone [73 FR 16436, Mar 27, 2008]		primary and secondary	8-hour	0.075 ppm (3)	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution Dec 14, 2012	$PM_{2.5}$	primary	Annual	12 µg/m^3	annual mean, averaged over 3 years
		secondary	Annual	15 µg/m^3	annual mean, averaged over 3 years
		primary and secondary	24-hour	35 µg/m^3	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24-hour	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide [75 FR 35520, Jun 22, 2010] [38 FR 25678, Sept 14, 1973]		primary	1-hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

as of October 2011

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MONEY NOW, MORE MONEY LATER

- **EPA and National Ambient Air Quality Standards (NAAQS)**
- **DFW to failed to meet 1997 Ozone attainment and proposed to become Severe Non-Attainment**
- **Review of "As Found/As Left" Statement**
- **Getting a source to pass a stack test 1-4 times a year while running wide open 361 remaining days equals more money in the future**
- **Routine maintenance can feel costly**
- **Emission Controls can feel costly**
- **Ignoring the issue potentially is the most costly**

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CONCLUSION

- **Air Quality**
  - Something easily politicized
  - Not the same as Global Warming
  - Measures harmful pollutants
  - MATTERS
- **Responsibly show that Natural Gas can be a clean burning source of energy**
- **Clean Air Today, Cleaner Air Tomorrow**