National Personal Protective Technology Laboratory

New CO$_2$ Dead Space Test System
Final Correlation Test Results

Policy and Standards Development Branch

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September 17, 2009

New CO_2 Dead Space Test System Final Correlation Test Results

- Previous updates at December, 2005 and October, 2006 Manufacturer's Meetings

- Why upgrade the CO_2 Dead Space Test System?
  - Improve accuracy in setting test conditions and performing data analysis
  - Reduce variability from test to test
  - Allow manufacturers to duplicate the test system using commercially available components for direct correlation

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- Project Timeline
  - Completed installation – June, 2006
  - Completed shakedown testing – December 2006
  - Completed efforts to equate new system with existing system – December, 2007
  - Completed correlation testing – July, 2008
  - Completed statistical modelling of test results – May, 2009

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- Existing and New Test Systems

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- **Features of New CO_2 Deadspace Test System**

  – Sheffield Head headform and half-torso

  - Face width, 146 mm; face length, 122 mm

  - **Places in cell #7 of the new NIOSH Bivariate fit test panel, representing a medium-sized face**

  – Data monitoring/recording system powered by custom LabVIEW software application

  – Data recording interval is 25 milliseconds or 4 times more frequent than existing test system

  – Mass flow controllers for breathing gas control

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- Features of New CO_2 Deadspace Test System

  — Revised sedentary cam design provides breathing cycle component durations consistent with Leslie Silverman human subject sedentary breathing research

  — Solenoid valve state change data file stamping

  — Excel spreadsheet-based data analysis routine

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- Performance of new CO_2 Deadspace Test System

  – Control peak breathing gas CO_2 concentration at 5.00 ± 0.02%

  – Control sample gas extracted from the breathing zone for analysis at 450 ± 0.7 sccm

  – Consistent blank CO_2 levels generally ranging from 0.39% to 0.44%

  – Precise determination of the start and end of inhalation phase from solenoid valve actuation times corroborated with facepiece resistance
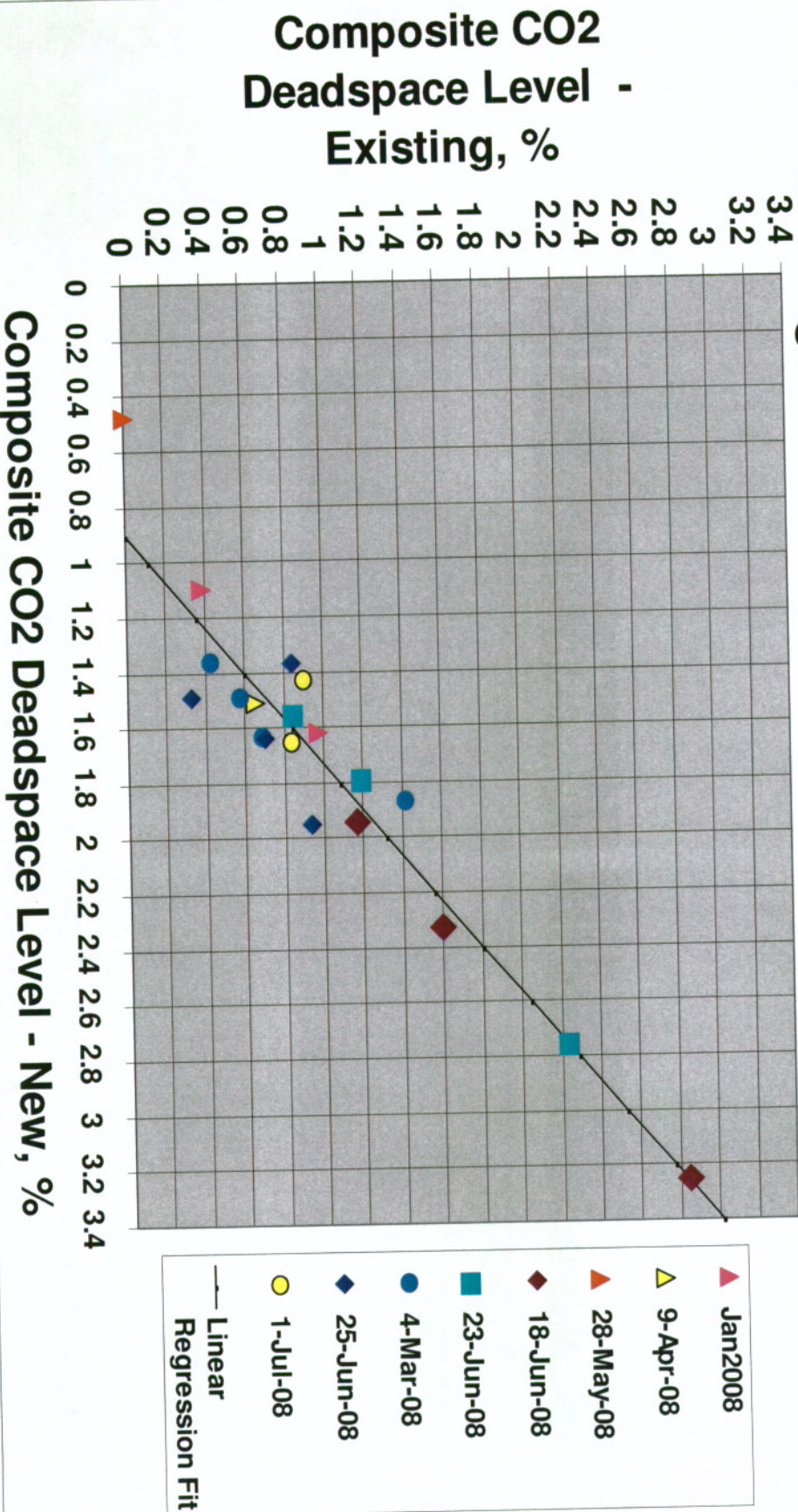
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- **New vs. Existing Correlation Test Data Analysis**

  - Tested 20 respirators at both the existing and new test systems

  - A simple linear regression was subsequently fit to this data to predict CO2 Deadspace Levels for the existing test system as a function of CO2 Deadspace Levels measured at the new system

  - Using the R statistical software package, the optimal y-intercept and slope were calculated to be -1.097 and 1.209, respectively, and the linear regression took the form

    - $CO_{2\ (Existing)} = -1.097 + 1.209 \times CO_{2\ (New)}$

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Final Correlation Testing
Existing vs. New CO2 Deadspace Test Systems

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- **New vs. Existing Correlation Test Data Analysis**

  - Both the intercept and slope of the model were highly statistically significant ($p < 0.001$ for each coefficient)

  - Using this equation to predict the CO_2 level of the existing system (as a function of the new) gives an R^2 value of 0.909, meaning that approximately 91% of the variability in the new system's measurements can be explained by the variability in the measurements of the existing system

- New vs. Existing Correlation Test Data Results

CO$_2$ Deadspace Level, %			P - Pass/F - Fail	
Existing	New	Existing Predicted	Existing	Existing Predicted
0.00	0.48	0.00	P	P
0.38	1.10	0.23	P	P
0.42	1.36	0.55	P	P
0.84	1.37	0.56	P	P
0.91	1.43	0.63	P	P
0.57	1.49	0.70	P	P
0.65	1.51	0.73	P	P
0.33	1.49	0.70	P	P
0.70	1.64	0.89	P	P
0.85	1.55	0.78	P	P
0.97	1.62	0.86	P	P
0.68	1.63	0.87	P	P
0.83	1.65	0.90	P	P
1.20	1.79	1.07	F	F
1.41	1.87	1.16	F	F
0.93	1.95	1.26	P	F
1.17	1.94	1.25	F	F
1.60	2.33	1.72	F	F
2.24	2.75	2.23	F	F
2.85	3.25	2.83	F	F

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- New vs. Existing Correlation Test Data Results

  - 19 of 20 respirators that passed or failed at the existing system, were correctly predicted to pass or fail, respectively, at the new system using the model

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- **Test Procedure for Determining New Test System CO_2 Deadspace Level**

  - Respirators previously approved

- **Measure CO_2 Deadspace Level at new test system**

- **Using linear regression model, determine existing test system equivalent CO_2 Deadspace Level**

- **If existing test system equivalent CO_2 Deadspace Level is less than 1.0%, a passing grade is assigned to the respirator tested**

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- Test Procedure for Determining New Test System CO$_2$ Deadspace Level

  – New respirators

- Use new test system

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Questions?