Calibration Gas Error Analysis

The derivation of VO2, and similarly VCO2, is complex involving quite a few variables; these variables may either be measured or estimated:

O2 concentration; both inspiratory, fiO2, and expiratory, feO2
CO2 concentration; both inspiratory, fiCO2, and expiratory, feCO2
Calibration Gas
Flow, usually during inspiration and/or expiration
Temperature, Pressure, and humidity at the flow device [used for STPD and BTPS correction]
Sample gas humidity
Time, usually of one inspiration and/or expiration period

Each of these variables has multiple sources of error. To simplify the calibration gas error analysis some assumptions are necessary. For a typical Metabolic Cart assume:

- The Gas Analyzers introduce no error.
- Textbook equations can be applied to derive VO2 and VCO2; another big assumption because most manufacturers do not publish their equations; with the exception of AEI.
- The same O2 analyzer measures both fiO2 and feO2, and the same CO2 analyzer measures both fiCO2 and feCO2.
- One flow device is used for either inspiration or expiration but not both.
- The humidity in the calibration gas equals the humidity in both inspiratory and expiratory gas measurements.
- The error in time measurements is negligible.
- The system incorporates a Mixing Chamber and does not sample directly from the mouth.

VO2, VCO2, and RER Calibration Gas error examples

Utilize the textbook equations for Exercise:

$VO_2 = (Vi * fiO_2) - (Ve_{avg} * feO_2)$;
$VCO_2 = (Ve * feCO_2) - (Vi_{avg} * fiCO_2)$;
Where $Ve = Vi * (100-fiO_2-fiCO_2) / (100-feO_2-feCO_2)$ [Haldane transform]

MOXUS Metabolic Cart Example:

	2 Cal Gases Utilized				
	Expected Values		**Worst Case Values**		
Cal Gases:	O2 High	21.00	O2 High	21.02	
	O2 Low	16.00	O2 Low	15.98	
	CO2 High	4.00	CO2 High	3.98	
	CO2 Low	0.03	CO2 Low	0.03	
	fiO2	20.93	fiO2	20.95	
	fiCO2	0.03	fiCO2	0.03	
	feO2	17.00	feO2	16.98	
	feCO2	4.00	feCO2	3.98	
	Haldane	1.00	Haldane	1.00	
	Vi (L/min)	150.00	Vi (L/min)	150.00	
	Ve	150.08	Ve	149.96	**Cal Gas Error Contributio**
	VO2	5.88	VO2	5.96	VO2 %Error 1.35
	VCO2	5.96	VCO2	5.92	VCO2 %Error -0.58
	RER	1.01	RER	0.99	RER %Error -1.90

Competitive Metabolic Cart Examples:

2 Cal Gases Utilized

	Expected Values		Worst Case Values	
Cal Gases:	O2 High	21.00	O2 High	22.05
	O2 Low	16.00	O2 Low	15.20
	CO2 High	4.00	CO2 High	4.20
	CO2 Low	0.03	CO2 Low	0.03
	fiO2	20.93	fiO2	21.98
	fiCO2	0.03	fiCO2	0.03
	feO2	17.00	feO2	16.20
	feCO2	4.00	feCO2	4.20
	Haldane	1.00	Haldane	0.98
	Vi (L/min)	150.00	Vi (L/min)	150.00
	Ve	150.08	Ve	146.97
	VO2	5.88	VO2	9.16
	VCO2	5.96	VCO2	6.13
	RER	1.01	RER	0.67

Cal Gas Error Contributio	
VO2 %Error	55.75
VCO2 %Error	2.85
RER %Error	-33.97

1 Cal Gas & Outdoor Air Utilized

	Expected Values		Worst Case Values	
Cal Gases:	O2 High	20.93	O2 High	20.93
	O2 Low	16.00	O2 Low	15.20
	CO2 High	4.00	CO2 High	4.20
	CO2 Low	0.03	CO2 Low	0.03
	fiO2	20.93	fiO2	20.93
	fiCO2	0.03	fiCO2	0.03
	feO2	17.00	feO2	16.20
	feCO2	4.00	feCO2	4.20
	Haldane	1.00	Haldane	0.99
	Vi (L/min)	150.00	Vi (L/min)	150.00
	Ve	150.08	Ve	148.94
	VO2	5.88	VO2	7.27
	VCO2	5.96	VCO2	6.21
	RER	1.01	RER	0.85

Cal Gas Error Contributio	
VO2 %Error	23.53
VCO2 %Error	4.24
RER %Error	-15.61

Analysis and Conclusions

The above examples are typical of an Exercise Test. Resting Energy testing would produce much greater error in both examples. The AEI Technologies MOXUS Metabolic Cart calibration gas error is within accepted limits for VO2, VCO2, and RER. Other Metabolic Carts utilizing less accurate calibration gases may have errors far outside of acceptable limits. If the MOXUS Cart or is not calibrated utilizing the MOXUS specified Calibration Gases then errors far outside of acceptable limits may also result.

AEI TECHNOLOGIES
Metabolic Measurement Systems

AEI Technologies, Inc.
1-630-548-3545
Fax: 1-630-548-3546
Sales@aeitechnologies.com
www.aeitechnologies.com