



2023 ERS/ATS Lung Volume Technical Standard

What do we need to do differently?

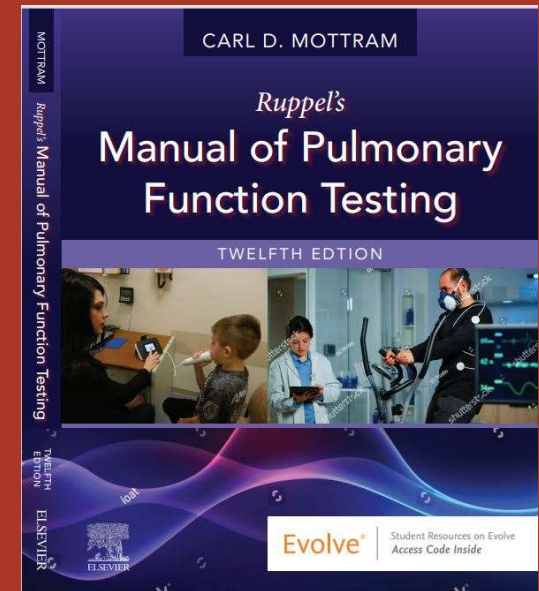
Carl D. Mottram RRT RPFT FAARC

Associate Professor of Medicine

President – PFWConsulting LLC

Disclosures

- Author of Ruppel's Manual of Pulmonary Function Testing 12th Edition 2022 Elsevier



- Chief Scientific Advisor – Vitalograph LTD
- Faculty member - MGC Cardiopulmonary Seminar





 **EUROPEAN RESPIRATORY *journal***
FLAGSHIP SCIENTIFIC JOURNAL OF ERS

search 

[Advanced Search](#)

[Home](#) [Current issue](#) [ERJ Early View](#) [Past issues](#) [ERS Guidelines](#) [Authors/reviewers](#) [Alerts](#) [Subscriptions](#)

 **European Respiratory Society/American Thoracic Society technical statement:
standardisation of the measurement of lung volumes, 2023 update**

Nirav R. Bhakta, Aisling McGowan, Kathryn A. Ramsey, Brigitte Borg, Jana Kivastik, Shandra Lee Knight, Karl Sylvester, Felip Burgos, Erik R. Swenson, Kevin McCarthy, Brendan G. Cooper, Francisco García-Río, Gwen Skloot, Meredith McCormack, Carl Mottram, Charles G. Irvin, Irene Steenbruggen, Allan L. Coates, David A. Kaminsky

European Respiratory Journal 2023 62: 2201519, DOI: 10.1183/13993003.01519-2022



October 2023

Open access!!

Statements, Guidelines, and Standards



- Recommendations/Statements/Guidelines:
 - “a general rule, principle, or piece of advice”
 - Suggested “best practice”
- Standard:
 - something considered by an authority as an approved model
 - “Shalls” and “Musts” versus “Should”
- ATS and ERS now publishes “standards” to reduce variability.

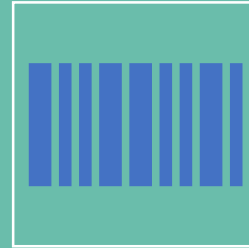


Definition of Calibration vs Quality Control



Calibration

Using a standard to calibrate an instrument.



Quality Control

a system for ***verifying*** and maintaining a desired level of quality in an instrument.





Key Updates

- Emphasis on importance of linked manoeuvres for determining lung volumes after measurement of functional residual capacity (FRC)
- For standardisation of linked spirometry, the method that is expected to be achievable by most patients is recommended.
- Emphasis on importance and limitations of biological controls for quality assurance assessment
- New equipment quality control and validation recommendations, including a requirement for isothermal lung mechanical models for calibration and verification of body plethysmographs
- Emphasis on pant frequency and recommendations on measuring airway resistance using body plethysmography. Comment on panting vs tidal breathing.
- Generalised concept of multiple breath washout (MBW) beyond nitrogen
- Updates on MBW technique based on recently published technical standards
- Differentiation between inert-gas dilution equipment that use volume-based vs flow-based spirometers
- A new acceptability and grading system for assessment of the quality of lung volume measurements. Examples of tracings distinguishing manoeuvres of different grades.
- Recommendation for using Global Lung Initiative lung volume reference values
- Updates on measurement of lung volumes by imaging and other new techniques
- Data file requirements, standardised operator comments, and sequence of lung function measurements

Techniques to Measure Lung Volumes

- Body plethysmography
- Dilutional gas techniques
 - Helium dilution (closed circuit)
 - Nitrogen washout (open circuit)
- Imaging (x-ray e.g. planimetry) and CT
- MiniBox
 - In the supplement



Clinical Utility of Lung Volume Measurements

- Add important diagnostic information to what can be deduced from spirometry alone.
- A reduced TLC establishes the presence of a restrictive ventilatory defect.
- Lung volume measurements may also enhance the assessment of obstructive ventilatory defects through the detection of air trapping and hyperinflation



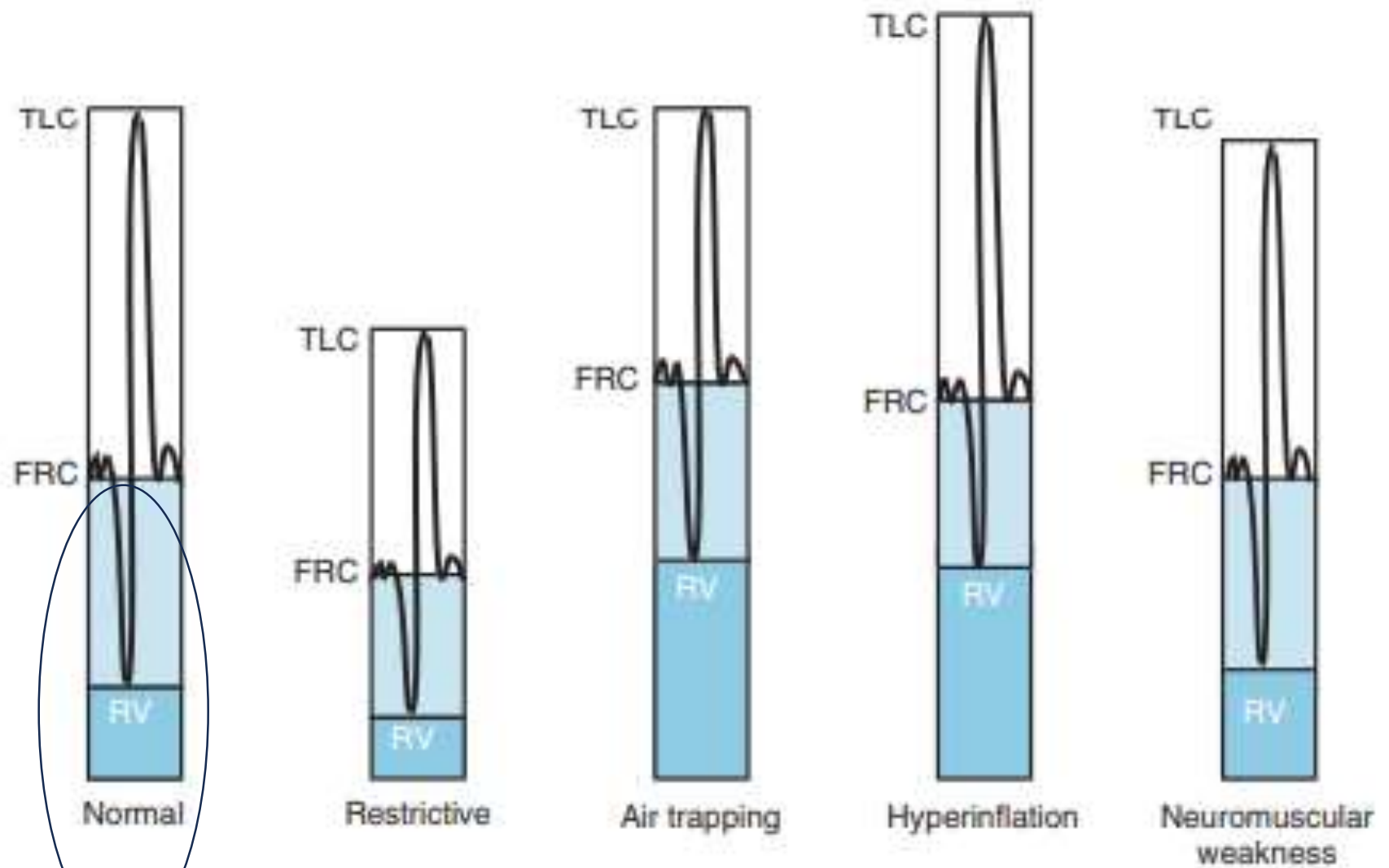
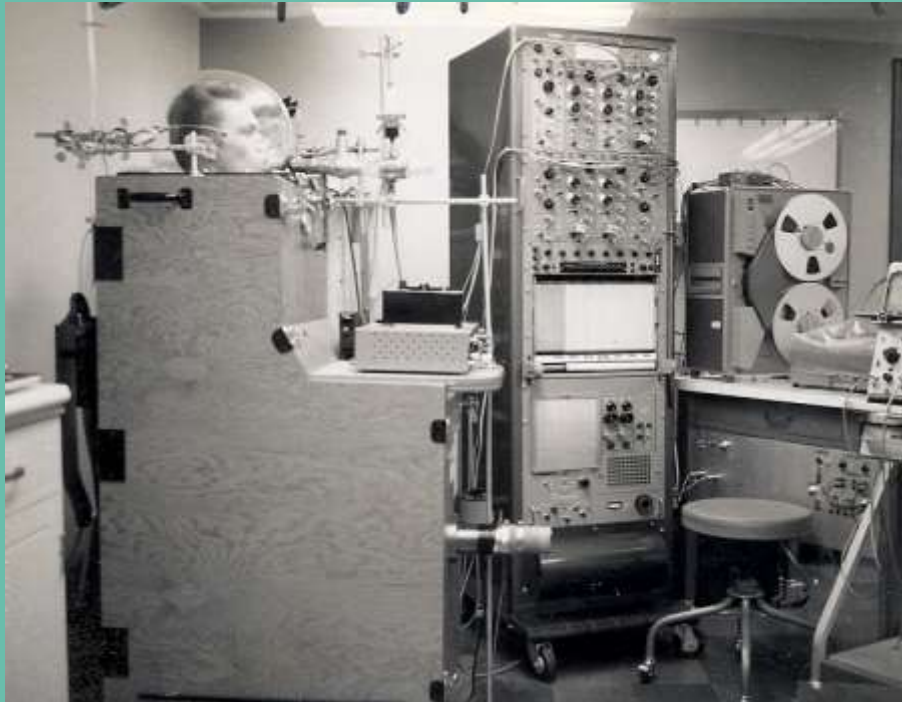


FIG. 4.8 Lung volumes in normal, restrictive, obstructive, and



Mayo Clinic PF Lab 1970's



2023 ERS-ATS Lung Volume Technical Standards: Plethysmography

Post-door closure

- Close door and wait 30 secs -2 minutes for thermo-equilibration
- Quiet breathing until a stable end-expiratory level is achieved (cheeks supported)
- Close shutter at or near FRC
 - Approx 2-3 seconds
 - Gentle pants $\pm$ 10 cmH₂O
 - 0.5 to 1 Hz (30-60 breaths per minute)**
 - > 1.5 Hz may lead to errors
 - < 0.5 Hz may cause problems with the controlled leak



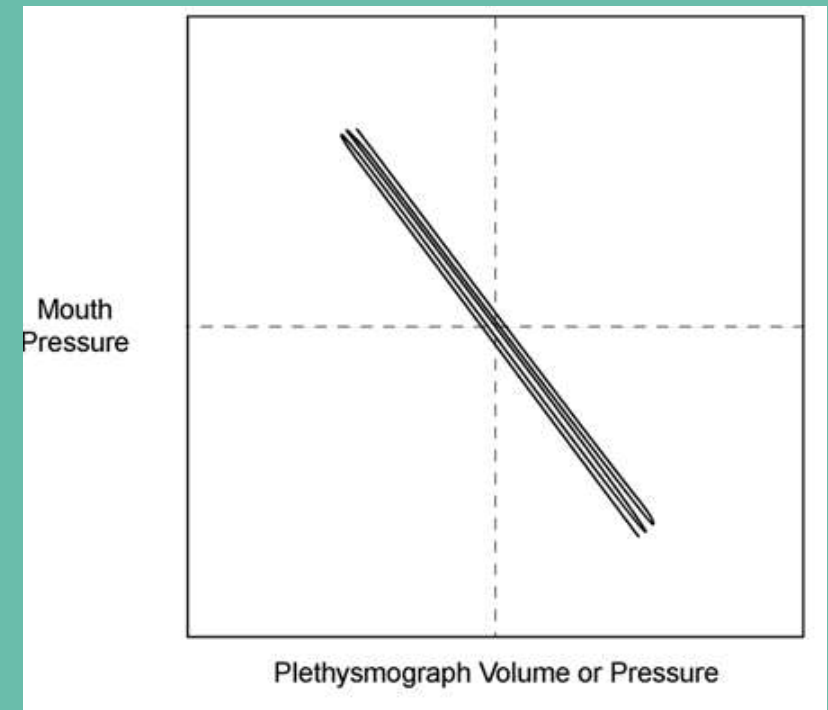
Cheek support



2023 ERS-ATS Lung Volume Technical Standards: Plethysmography

Measurement technique – Plethysmography (cont)

- 3-5 technically satisfactory panting maneuvers
- Patient then performs an IC followed by a linked SVC



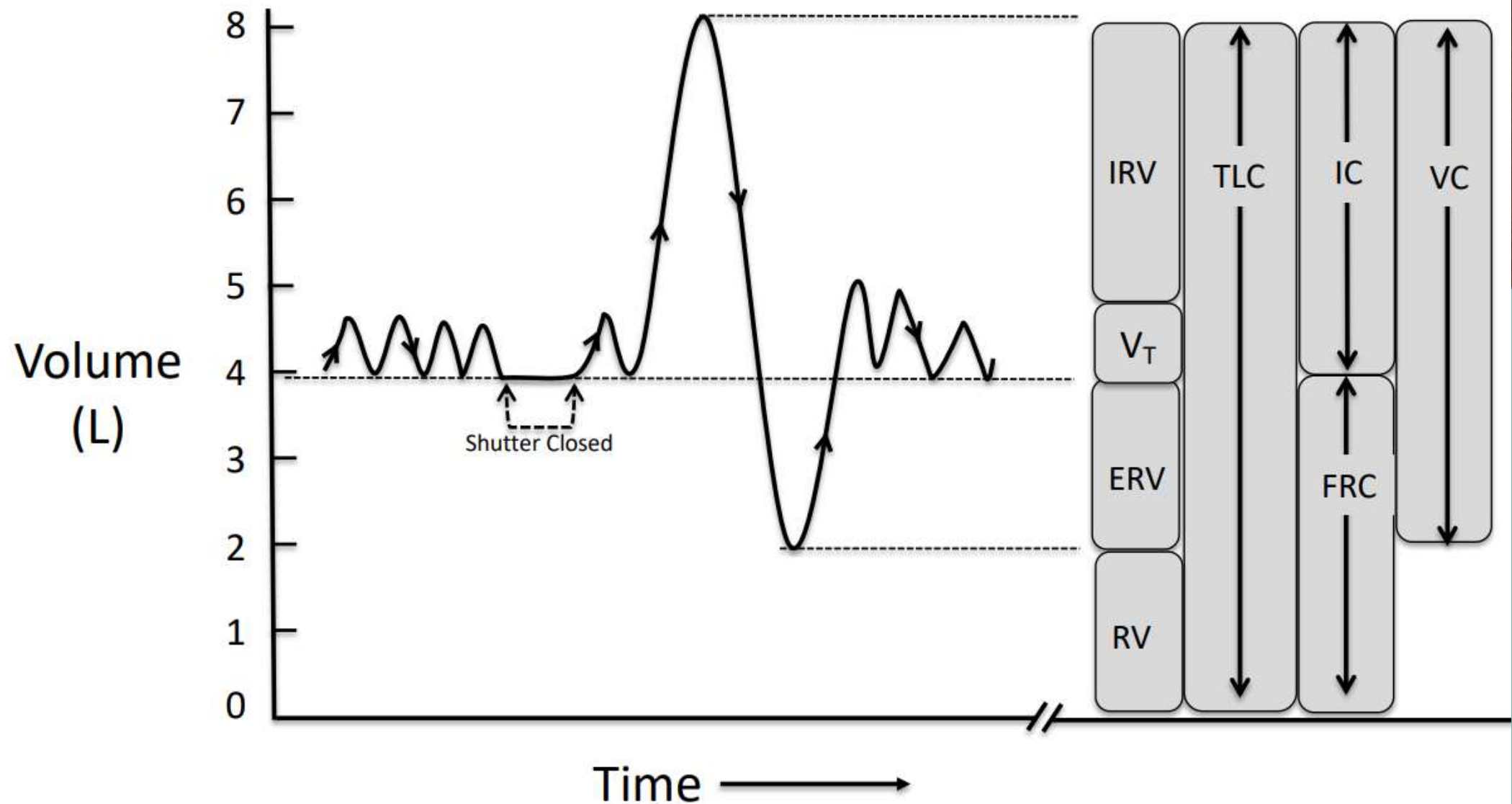


Figure 2: Volume–time display showing the sequence of quiet breathing and, after stable end-

Unlike 2005 there is no preferred or alternative methods, rather only one method!

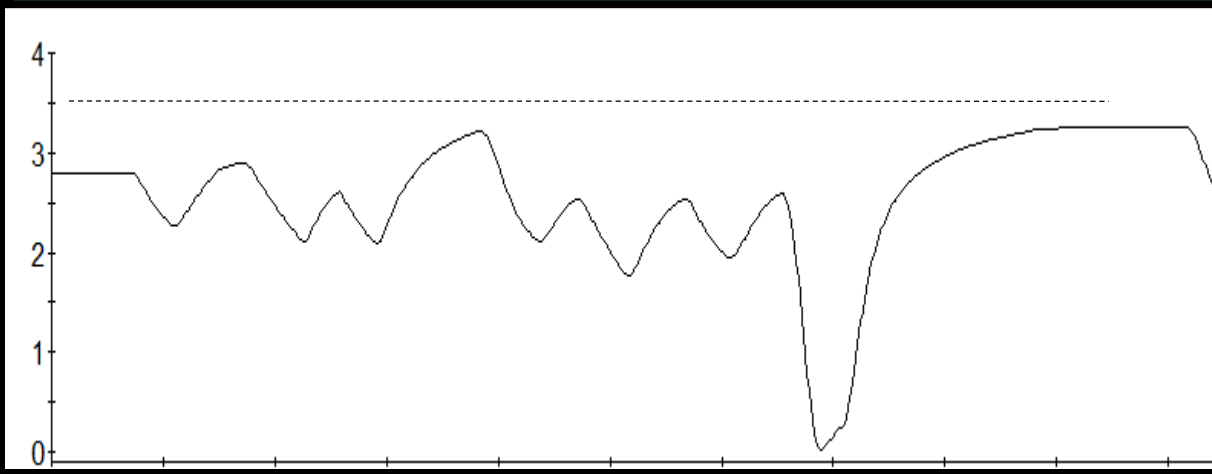
2023 ERS-ATS LV TS: Pleth Acceptable and Usable



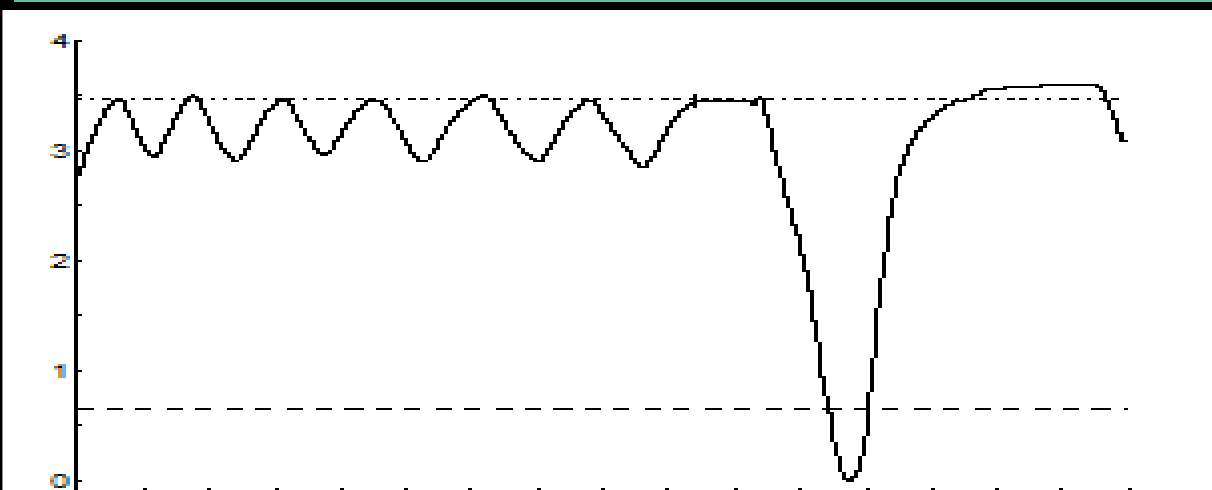
	Table 2: Acceptability Criteria for TGV (FRC) Measurement by Body Plethysmography
Classification	<i>Tidal breathing prior to shutter closure and pants/small breaths during shutter closure</i>
Acceptable	Pre-shutter closure: • Stable end-tidal lung volume* During shutter closure: • Closed pants • Overlapping straight lines with no thermal drift • Straight lines with minimal thermal drift • Pant frequency 0.5-1 Hz OR • Pant freq > 1.0-1.5 Hz with no or minimal obstruction on spirometry
Useable	Any of: Pre-shutter closure: • Unstable end-tidal lung volume* without significant shift in either direction During shutter closure: • Portions of closed pants • Portions of overlapping straight lines • Parallel straight lines (thermal drift) • Pant frequency > 1.5-2.0 Hz with no or minimal obstruction on spirometry
Not acceptable or useable (reject)	Any of: Pre-shutter closure: • Unstable end tidal lung volume* with significant shift in either direction (e.g., increase in end expiratory lung volume with each breath) During shutter closure: • Open pants • No straight lines • Excessive thermal drift • Pants are clipped (mouth pressure transducer range exceeded) • Pant frequency < 0.5 Hz, > 2.0 Hz, or > 1.5 Hz and evidence of significant obstruction on spirometry

Useable – interpret with caution.

Plethysmography Technique: Evaluating Tidal Breathing



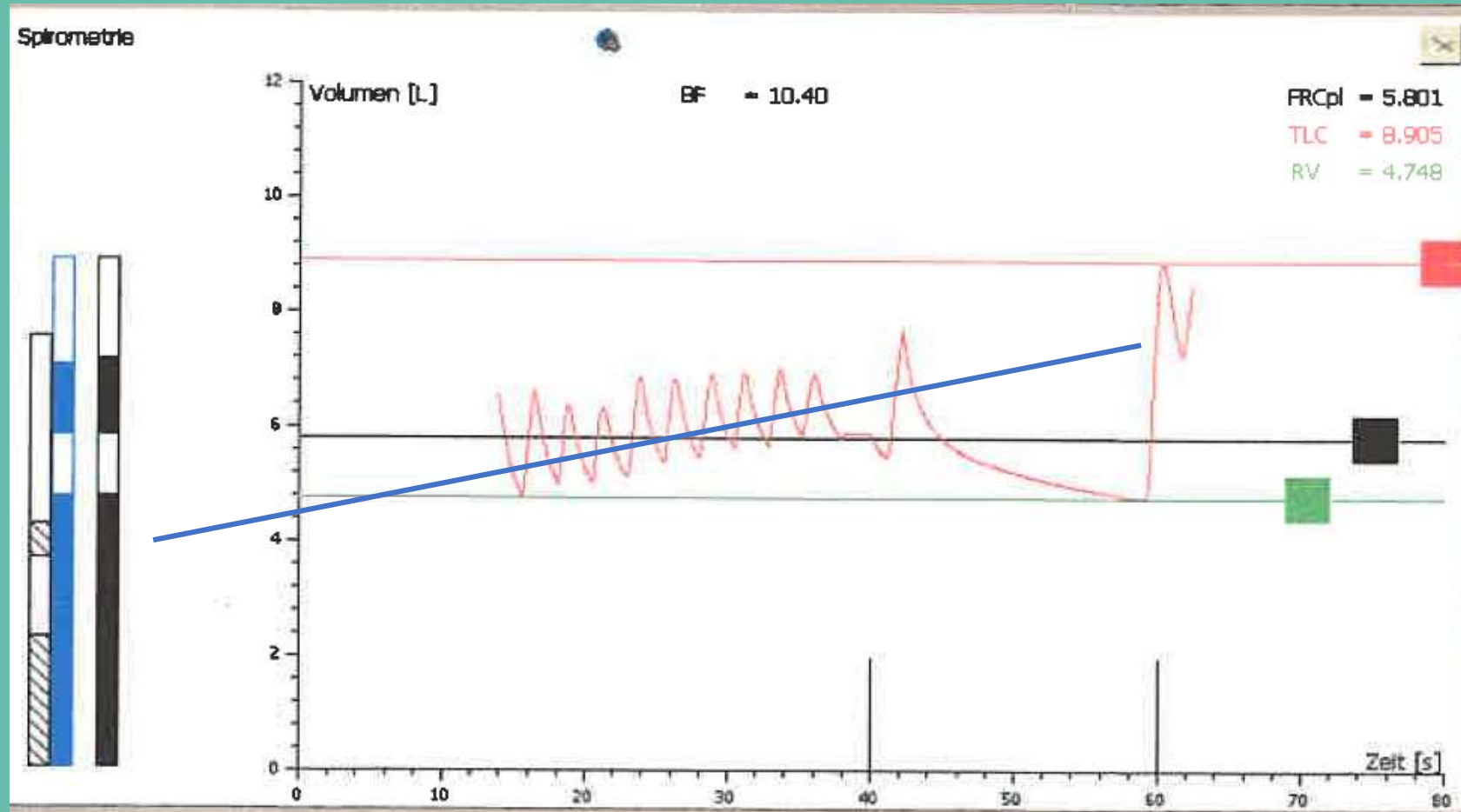
Unstable Tidal Breathing
with variable FRC (usable)



Stable Tidal Breathing
with consistent FRC
(acceptable)



Plethysmography Technique: *Evaluating Tidal Breathing*

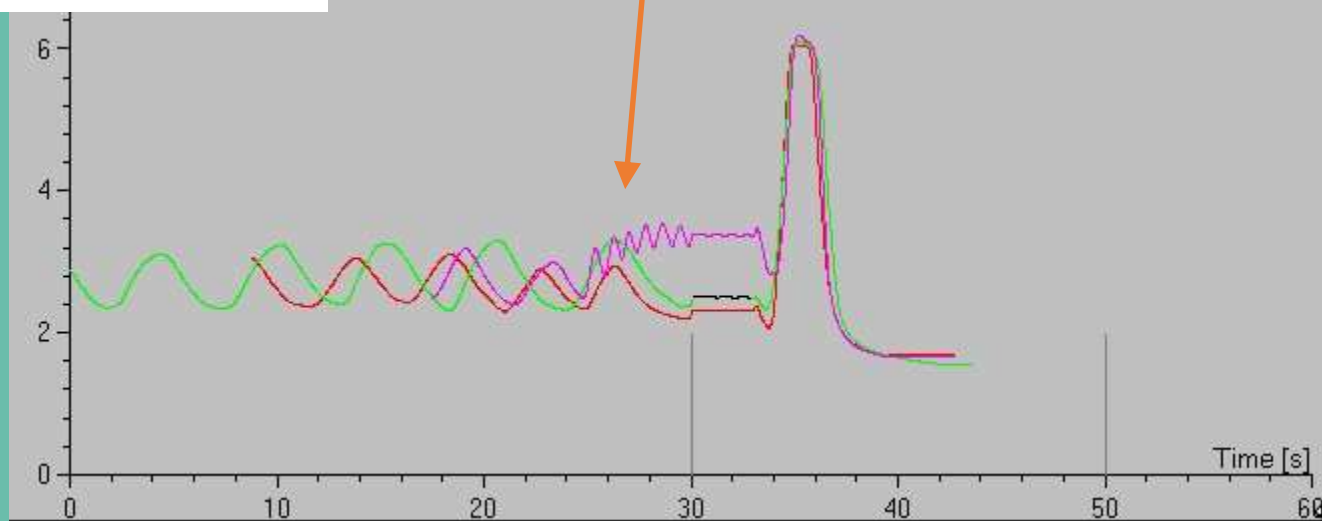


“Unusable”

	Pred	Best	%Pred	Act1	Act2	Act3	Act4
TLC	6.24	6.11	97.9		6.05	6.09	6.19
VC	4.34	4.52	104.2		4.37	4.52	4.52
VCref		4.52					
IC		3.49			3.73	3.73	3.01
RV	1.90	1.59	83.5		1.68	1.57	1.67
TGV		2.62			2.32	2.35	3.19
BF TGV				93.75	67.57	72.12	81.82
ETmayo				0	0	0	0
TGV'		3.84		3.84			
sR mid	4.7	3.9	84.8	3.1	4.2		3.8
BF res		96		100	94		100
dVol				0.00	0.00	0.15	0.19
ERmayo				1	0		0
mSlope		0		0	10	0	0
mBest		0					

Pant prior to shutter closure

Target: < 200 mls
switch-in error



2023 ERS-ATS Lung Volume Technical Standards: Plethysmography

Lung volume reporting

Repeatability: Obtain ≥ 3 FRC_{pleth} values that agree within 5%

- Largest FRC – smallest FRC
mean FRC
- Reported TLC is the reported value for RV plus the largest of the technically acceptable IVC's
- Results with repeatability exceeding 5% may still be of use.



“Musts” related to testing technique

- The operator **must** review the placement of tangent lines on the panting loops. Adjust the tangent lines only if the software placement appears to be in error.
- Measurement of airway resistance **must not be performed** during the same manoeuvre performed to measure lung volumes because the optimal panting frequencies are different and increased time on the mouthpiece increases opportunity for leak which can compromise accurate measurement of lung volumes



2023 ERS-ATS LV TS: Pleth Grading scheme

Table 6: Grading System for a Lung Volume Test Performed by Body Plethysmography

Grade	Number of FRC [†] measurements	Number of SVC measurements	Repeatability* of FRC
A	≥ 3 acceptable	≥ 3 acceptable	Within 5%
B	≥ 2 acceptable	≥ 2 acceptable	Within 5%
C	≥ 2 acceptable	≥ 2 acceptable	Within 10%
D	≥ 1 acceptable AND ≥ 1 useable	≥ 1 acceptable AND ≥ 1 useable	Within 10%
E	1 acceptable AND 0 useable	1 acceptable AND 0 useable	N/A
U	0 acceptable AND ≥ 1 useable	0 acceptable AND ≥ 1 useable	Within 10%
F	0 acceptable or useable		



Reference Values

. Eur Respir J 2021; 57

Official ERS technical standard: Global Lung Function Initiative reference values for static lung volumes in individuals of European ancestry

Graham L. Hall^{1,2}, Nicole Filipow³, Gregg Ruppel ⁴, Tolu Okitika¹,
Bruce Thompson⁵, Jane Kirkby⁶, Irene Steenbruggen ⁷, Brendan G. Cooper⁸,
Sanja Stanojevic³, on behalf of the contributing GLI Network members⁹





“Some battles you win and others you end up compromising”

“ended up” in the technical supplement

2023 ERS-ATS LV Technical Standard

Airway resistance

- Raw may be sensitive to small and rapid changes,
 - Can play a part in recognition of response to a bronchodilator,
 - Can contribute to the diagnosis and differentiation of obstructive airways diseases.
-
- Characterize the non-specific pattern
 - Reduced FVC and FEV1 with a normal TLC



2023 ERS-ATS measurement technique – Airway resistance



- Open-shutter panting maneuver shows a relatively closed loop, particularly in the range of +0.5 to -0.5 L/s
- Pant rate of 1.5-2 per second (90-120) with a VT of 50 to 150 mL.
- TGV after open panting for sRaw and sGaw
 - 30-60 pant rate
- The median value of up to five technically acceptable loops should be taken. The aim should be to report the mean of the results from at least three acceptable manoeuvres.

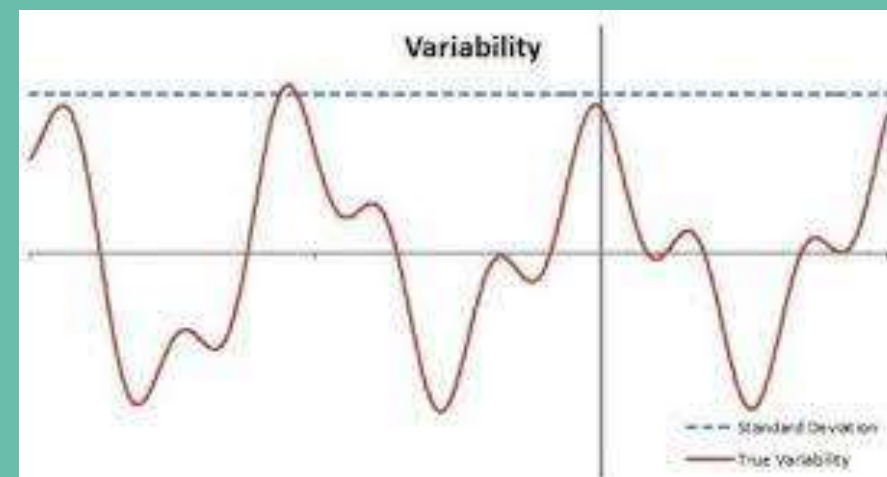
Pulmonary airway resistance variability in normal biologic quality control subjects among pulmonary function testing systems across British Columbia.

Mottram CD, McCaskill T, Road J., Rakhra N.

College of Physicians and Surgeons of British Columbia Diagnostic Accreditation Program. BC, Canada

	Panting Technique, 18 systems		Tidal Breathing Technique (TB), 10 systems	
	Raw	sGaw	Raw	sGaw
Mean CV	7.62	8.52	10.25	13.74
Min CV	2.99	5.34	4.74	5.74
Max CV	13.1	12.75	39.6	40.8

European Respiratory Journal 58 (suppl 65).
November 2021



2023 ERS-ATS measurement technique – Airway resistance



- Reference values for airway resistance from body plethysmography. “ The availability of reference values for airway resistance parameters was limited to relatively small sample sizes”

2023 ERS-ATS LV TS: Multiple Breath Washout (MBW) “Nitrogen Washout”

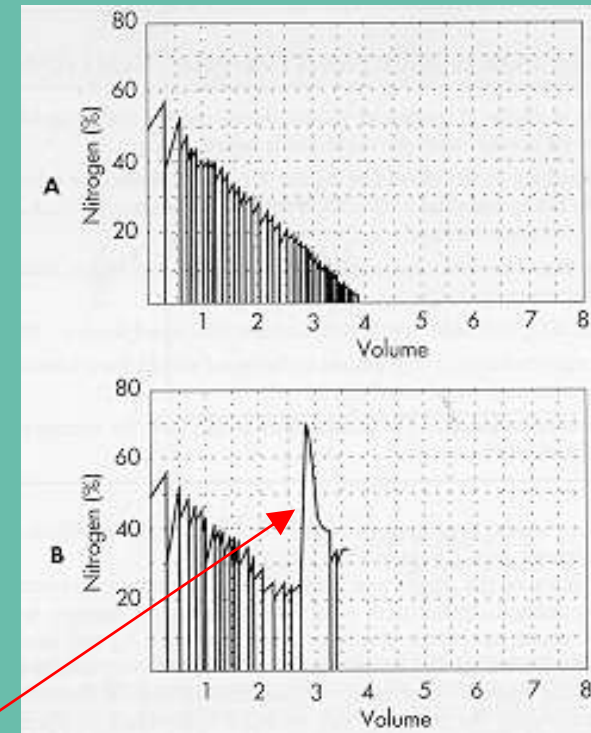
- 100% oxygen to washout the nitrogen of the lung.
 - “Open circuit technique”
 - or an exogenous gas (e.g., sulfur hexafluoride) washed out using room air



2023 ERS-ATS Technical Standards: *MBW*

Measurement technique Use earplugs for perforated eardrum

- Quiet breathing for 30-60s to establish a baseline FRC
- Switch patient into 100% O₂
- The patient is instructed to breathe regular tidal breaths without sighs, cough, or apnea.
- The washout is complete when the end-tidal tracer gas concentration is below 1/40th of the starting concentration for at least three consecutive tidal breaths.
- Once measurement of FRC is complete, the patient is instructed to perform a linked manoeuvre.
- N₂ rise > 1% or sudden larger increase indicate leak



2023 ERS-ATS Technical Standards: *MBW*

Measurement technique

- Optimally measure at least 2 technically satisfactory measurement
- A waiting period of at least twice the washout time is recommended between manoeuvres. Longer waiting periods may be required in patients with severe obstructive or bullous disease
- If more than 1 trial is performed the FRC_{MBW} should be the mean of technically acceptable results that agree within 10%



2023 ERS-ATS LV Technical Standard Helium Dilution

- Closed-circuit technique
 - Helium gas 10% mixture
 - CO₂ and H₂O absorber
 - Oxygen source

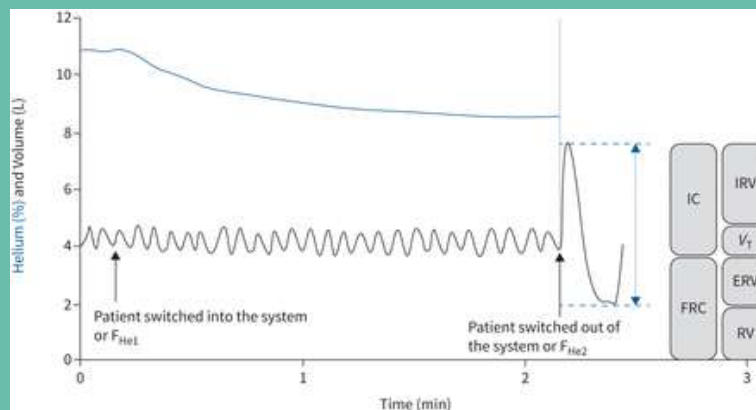


2023 ERS-ATS LV Technical Standard

Helium Dilution

He dilution

- Use earplugs for perforated eardrum
- Quiet breathing for 30-60s to establish a baseline FRC
- Turn in patient at the end of normal TV (FRC)
- The patient is instructed to breathe regular tidal breaths.
- He equilibration complete when change is $< 0.02\%$ for 30 sec.
- A sudden drop in helium indicates a system leak and will result in an overestimation of FRC.
- A waiting period of at least twice the dilution time is recommended between manoeuvres.



2023 ERS-ATS LV Technical Standard Helium Dilution

Measurement technique

- Optimally measure at least 2 technically satisfactory measurements
- A waiting period of at least twice the washout time is recommended between manoeuvres. Longer waiting periods may be required in patients with severe obstructive or bullous disease
- If more than 1 trial is performed the FRC_{He} should be the mean of technically acceptable results that agree within 10%
- Grading scheme for both MBW and He dilution



2023 ERS-ATS LV TS MBW Acceptable and Usable



	Table 3: Acceptability and Grading Criteria for FRC Measurement by Multiple Breath Washout
Classification	<i>Tidal breathing prior to washout and washout phase characteristics</i>
Acceptable	Pre-switch-in: - Relaxed tidal breathing with stable end-tidal lung volume* During washout: - Relaxed tidal breathing without sigh, cough, or breath-hold - Flow is stable with no forced breathing or signs of hyperventilation (CO₂ within 4-6% range if available) - No evidence of leak - End of test criteria met (three consecutive tidal breaths under target concentration) When performed: - Adequate wait time between MBW manoeuvres (≥ twice the washout time; longer with obstructive lung disease)
Useable	As for acceptable except any of: Pre-switch-in: - Unstable end-tidal lung volume* without significant shift in either direction - Irregular tidal breaths (swallow, small breath) in pre-phase During washout: - Irregular first breath of washout (swallow, small breath) - Sigh, cough, or breath-hold in rest of washout but no increase in end-tidal tracer gas concentration - End-tidal lung volume is unstable during washout but no increase in end-tidal tracer gas concentration
Not acceptable or useable (reject)	Any of: Pre-switch-in: - Unstable end tidal lung volume* with significant shift in either direction (e.g., increase in end expiratory lung volume with each breath) - Flow is highly erratic with or without forced breathing or hyperventilation (CO₂ outside 4-6% range if available) - Sigh, cough, or breath-hold During washout: - Sigh, cough, or breath-hold in first breath of washout - Sigh, cough, or breath-hold in rest of washout resulting in increase in end-tidal tracer gas concentration† - Significant shifts in end-tidal lung volume during washout resulting in increase in end-tidal tracer gas concentration† - Flow is highly erratic with or without forced breathing or hyperventilation (CO₂ outside 4-6% range if available) - Evidence of leak - End of test criteria not met: manoeuvre does not have three consecutive tidal

2023 ERS- ATS LV TS He Dilution Acceptable and Usable



Table 4: Acceptability and Grading Criteria for FRC Measurement by Helium Dilution	
Classification	<i>Tidal breathing prior to dilution phase and dilution phase characteristics</i>
Acceptable	Pre-switch-in: • Stable end-tidal lung volume* During dilution: • Relaxed tidal breathing without sigh, cough, or breath-hold • Stable end-tidal lung volume • No leak • End of test criteria met: ($\Delta[\text{He}] < 0.02\% \times 30 \text{ sec.}$) When performed: • Adequate wait time between manoeuvres ($\geq$ twice the dilution time; longer with obstructive lung disease)
Useable	As for acceptable except any of: Pre-switch-in: • Unstable end-tidal lung volume* without significant shift in either direction During dilution: • Non-uniform dilution curve • Minimally unstable end-tidal lung volume • Sigh, cough, or breath-hold with no leak
Not acceptable or useable (reject)	Any of: Pre-switch-in: • Unstable end tidal lung volume* with significant shift in either direction (e.g., increase in end expiratory lung volume with each breath) During dilution: • Unacceptable breathing pattern • Evidence of leak • Failed end of test When performed: • Inadequate wait time between manoeuvres

2023 ERS-ATS LV TS: MBW, He Dilution Grading scheme

Table 7: Grading System for a Lung Volume Test Performed by MBW or Helium Dilution

Grade	Number of FRC† measurements	Number of SVC measurements	Repeatability* of FRC
A	≥ 2 acceptable	≥ 2 acceptable	Within 10%
B	1 acceptable AND ≥ 1 useable	1 acceptable AND ≥ 1 useable	Within 10%
C	≥ 2 useable	≥ 2 useable	Within 10%
D	≥ 2 acceptable OR useable	≥ 2 useable	Within 25%
E	1 acceptable AND 0 useable	1 acceptable AND 0 useable	N/A
U	0 acceptable AND 1 useable	0 acceptable AND 1 useable	N/A
F	0 acceptable or useable		



Quality Control Sources of Error

- Equipment
- Testing personnel
- Subject



Equipment - Plethysmograph



Environmental Effects

Room
temperature

Ventilation

Door
opening



2023 ERS-ATS Standards

Standardization of Lung Volumes

Quality Control - Plethysmography

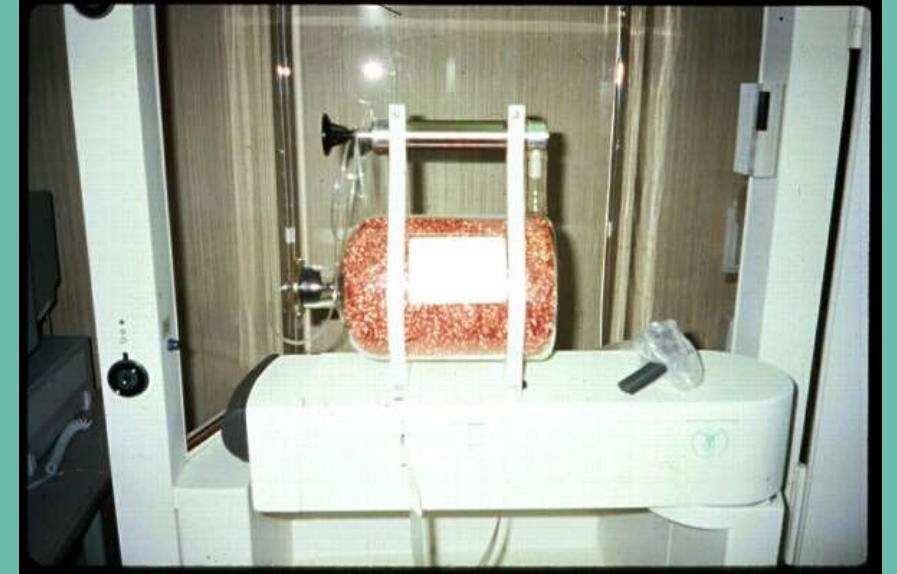
- Flow and volume meet criteria set in the spirometry standards
- Mouth pressure transducer is calibrated daily
- Plethysmograph signal should also be calibrated daily using a volume signal of similar magnitude and frequency used during testing



2023 ERS-ATS Lung Volume Technical Standard

Quality Control - Plethysmography

- A validation of accuracy using a known volume *must* be performed monthly, when new software uploaded, or a problem is suspected.
- This can be carried out using a “model” lung or container of known volume, ideally of two different sizes
- Accuracy 50 ml or 3%



2023 ERS - ATS Lung Volume TS

“BIOLOGICAL CONTROL SUBJECTS”

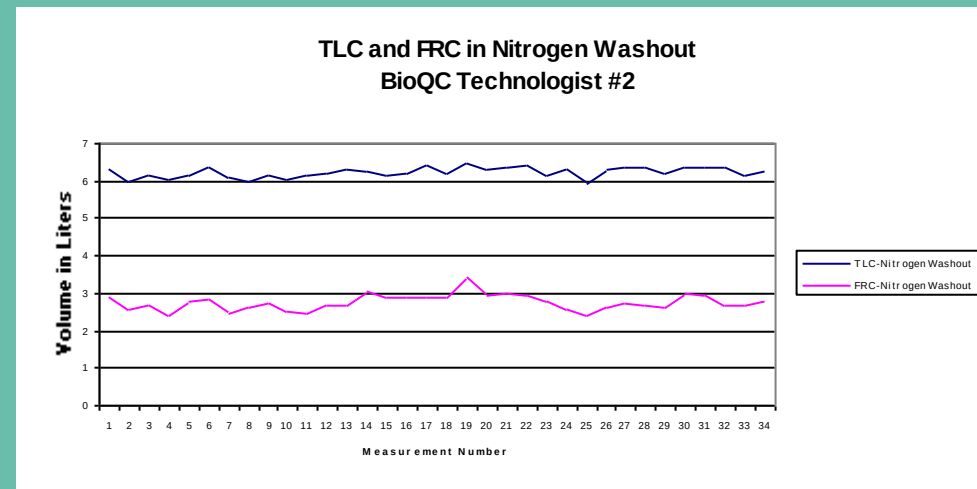
- At least monthly, or whenever errors are suspected, two healthy non-smoking reference subjects (biological controls) should undergo body plethysmography.
- Two individuals minimum to avoid noncompliance during absences.
- Establish mean, SD and CV
 - 10 samples (5-6 minimum)
 - TLC and FRC CVs $\leq 5\%$
 - ERV and AR CVs $\leq 10\%$ (suggested)



2023 ERS-ATS Lung Volume Technical Standard

Quality Control – N₂ washout

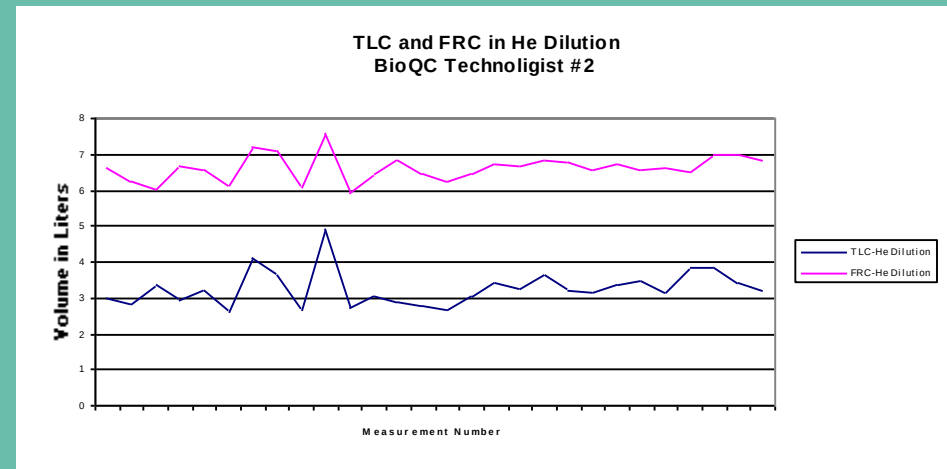
- N₂ analyzer should be zeroed prior to each test
- Initially and every 6 months confirm analyzer linearity
- At least monthly or whenever errors are suspect 2 reference subjects (biologic controls) should be tested



2023 ERS-ATS Lung Volume Technical Standard

Quality Control – He dilution

- Systems that can have gas filling volume checks should be checked for leaks at least once per month and after tubing or canister changes.
- The stability of the helium analyzer should be confirmed weekly (it should not drift $> 0.02\%$ in 10 min)
- At least monthly or whenever errors are suspect 2 reference subjects (biologic controls) should be tested



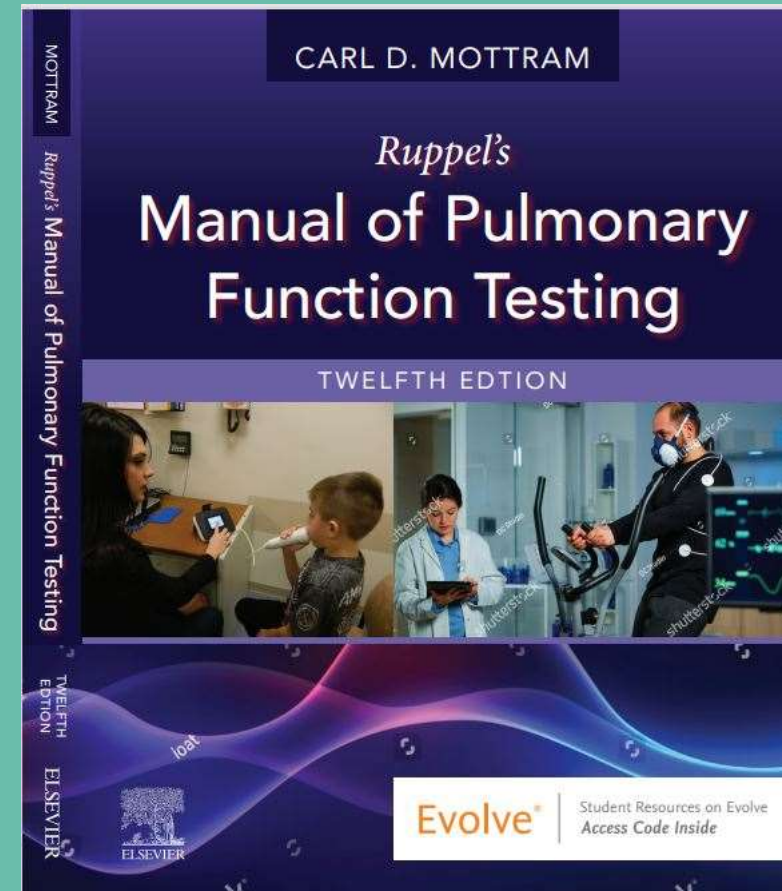
The AACR Congress 2023 logo is a shield-shaped emblem. It features a brown background with a faint, stylized image of a DNA double helix. The letters 'AACR' are prominently displayed in the center in a white, serif font. Below this, a dark red horizontal band contains the word 'CONGRESS' in white, sans-serif capital letters. At the bottom of the shield, the year '2023' is written in a white, sans-serif font. The shield is bordered by a thin white line and is set against a background of vertical stripes in teal, brown, and black.

Pulmonary Function - New Equipment Acceptance Testing																													
Facility Name: Hospital 15 - new equipment															Do not enter data in these cells. They fill in automatically.														
Current Equipment															New Equipment														
Equipment Purchase Date		2012													Equipment Purchase Date		May 21												
Equipment Name		Jaeger													Equipment Name		Vyntus Body Box												
Equipment Make		Jaeger Body Box													Equipment Make		Vyaire												
Equipment Model		Masterscreen													Equipment Model		Body box												
Software Version		5.71.0													Software Version		SP 3.20.1												
Parameter	Target CV%	1	2	3	4	5	6	7	8	9	10	Average	Standard Deviation	Coefficient of Variation	Parameter	Target CV%	1	2	3	4	5	6	7	8	9	10	Average	Standard Deviation	Coefficient of Variation
Biological QC/Gender															Biological QC/Gender														
Testing Therapist															Testing Therapist														
Date															Date														
Time															Time														
BODY PLETHYSMOGRAPHY															BODY PLETHYSMOGRAPHY														
FRC Pleth															FRC Pleth														
TLC(Bo)															TLC(Bo)														
Pant Frequency															Pant Frequency														
Switch-In Volume															Switch-In Volume														
TLC(Bo)-VA															TLC(Bo)-VA														
SVCmax (Bo)															SVCmax (Bo)														
SVC-FVC															SVC-FVC														
ERV(Bo)															ERV(Bo)														
IC(Bo)															IC(Bo)														
RAW eff															RAW eff														
Average															Average														
Standard Deviation															Standard Deviation														
Coefficient of Variation															Coefficient of Variation														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6														
0.03															0.03														
1.08															1.22														
1.94															1.38														
1.66															1.65														
12															12														
108															108														
128															128														
3.54															2.62														
0.05															0.18														
1.47															6.79														
5.00															4.05														
0															0														
150.00															114.00														
48.99															37.48														
32.66															32.87														
520															390														
2.57															2.6</														

Summary

- Requires linked-SVC maneuvers
- Separation of lung volumes from airway resistance
- Requires mechanical and biological QC testing
 - Onboarding verification process
- New acceptability and usability criteria with a grading scheme
- GLI reference





PFWConsulting@gmail.com

507-261-4525