



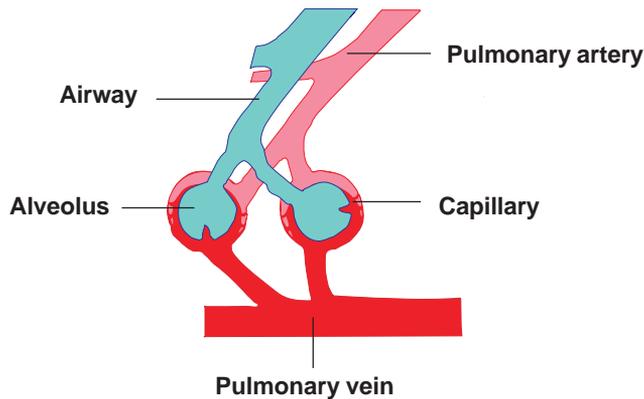
Diffusion SB

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Explanation of Measurement Program

The diffusion capacity of the lung (DCO) is defined as the amount of CO gas which diffuses via the alveolocapillary membrane per time unit and partial pressure difference between alveolar air and pulmonary capillary blood.



The most common method of determining the diffusion capacity is the single breath method. This method also supplies the important parameter V_A = alveolar volume which is important for the clinical assessment.

The measurement is almost the same as the spirometry measurement. Further static lung volumes (R_V , TLC , $V_{IN}...$) are calculated as well.

Principle:

Determination of the CO transfer factor according to the single breath method.

**Measurement Sequence:**

Before starting a measurement, both gas analyzers (CO and He) are zeroed using ambient air.

During the measurement the patient is required to breathe normally, then exhale as deeply and as much as possible and again inhale as much as possible. During inspiration the patient inhales a premixed gas consisting of helium, CO and air directly from a gas cylinder controlled by a demand valve.

After maximal inspiration the patient is prevented from expiration by a shutter and is required to hold his breath for about 10 seconds. The inhaled gas mixture is evenly distributed throughout the lungs and the CO diffuses into the blood via the capillary membrane. After the occlusion the patient should exhale slowly and evenly.

The sampled gas is analyzed. Results are calculated automatically.

Up to ten trials can be compared and saved.

Evaluation:

The parameters of each trial are calculated and displayed on the screen together with an average value as a predicted/actual value comparison. The assessment of the measurement values gives information about the presence of possible restrictive lung diseases (reduced effective lung surfaces).

An alteration in the CO diffusion of the lung is present in:

alveolitis, fibrosis, silicosis, sarcoidosis, radiation injury, ...

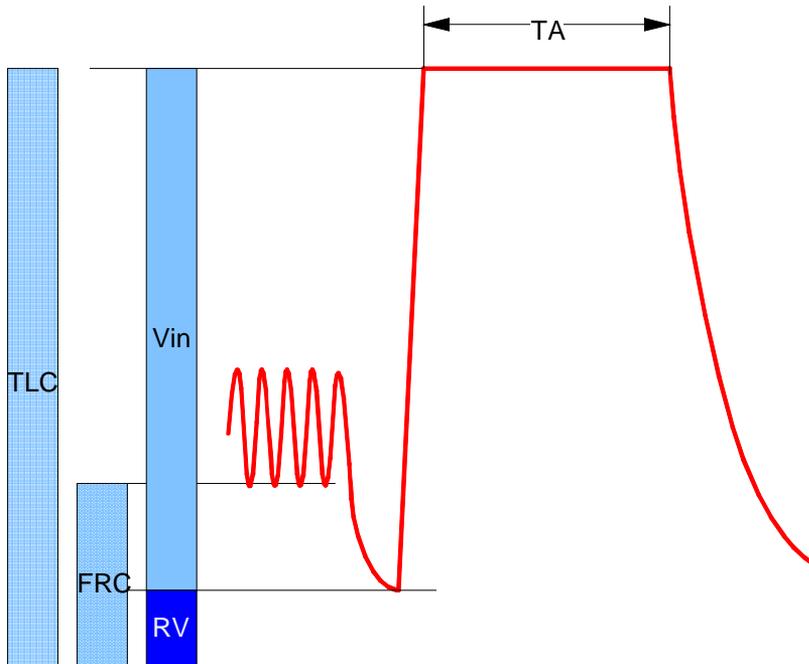
as well as in many other diseases of the lung such as:

pulmonary oedema, vascular occlusions, in many congenital organic heart defects or also in anaemia, ...

A possible distribution disorder influences the diffusion capacity. In this case a bodyplethysmographic examination is necessary.



Parameter Definition



RV-He = Residual volume
 RV%TLC = RV in % of TLC
 TLC-He = Total lung capacity
 TLCOSB = Diffusion capacity
 KCO = TLCO per VA (Krogh factor)
 VA = Alveolar volume
 VIN = Inspiratory volume
 FIHe = Inspiratory concentration He
 FAHe = Expiratory concentration He
 FICO = Inspiratory concentration CO

FACO = Expiratory concentration CO
 TA = Breath holding time
 ERV = Expiratory reserve volume
 FRC = Functional residual capacity
 FRC%TLC = FRC in % of TLC
 Hb = Hemoglobin
 TLCO_c = TLCO, Hemoglobin-corrected
 KCO_c = KCO, Hemoglobin-corrected
 TLC = VCIN (from previous spirometry measurement) + RV (from current TLCO-SB)

All volumes are BTPS-corrected!



Notes on Using CO



Trade name: Carbon Monoxide

Chemical characteristics:

CO, carbon monoxide, very potent haemotoxin, combustible, highly flammable, gaseous, colourless, odourless. It is lethal to inhale large quantities of carbon monoxide. Carbon monoxide may possibly damage the unborn fetus.

Observe the following fundamental rules and regulations.

- Adhere to all applicable trade union rules and regulations.
- Only trained personnel are authorized to perform measurements.
- The CO concentration used for the patient must not exceed 0.3 %.

Safety measures, storage, handling:

Store the container in a well-ventilated area and protect it against flammable sources and interaction with heat.

In the case of accident and fire:

- If a gas leak should occur: Air the room and always use a breathing apparatus which is independent of ambient air.
- Substances to extinguish fire: water vapour, CO₂ extinguisher, dry quenching agent.
- First aid: Bring those who are injured into the fresh air. If breathing stops, give mouth-to-mouth resuscitation or use a respirator. Get help from a doctor immediately.
- Further information for the doctor: oxygen pressure artificial respiration (pressure cabin) with pure O₂ (3 - 3.5 bars), Supraenin or Pervitin is suitable.

Toxicology:

Very potent haemotoxin. During inspiration the gas combines with hemoglobin so that oxygen cannot be absorbed (suffocation).

Toxin class 3 DL50 = 50 to 500 mg/kg

Literature:

- Notes on using CO

Hommel: Handbuch der gefährlichen Güter, Blatt 116

Kühn-Birett: Merkblätter gefährlicher Arbeitsstoffe, Blatt K19



Gas Concentrations and Color-Coding of Gas Cylinders



Only use the indicated min./max. gas concentrations for the individual measurement procedures! For safety reasons we recommend to use ready-mixed gases which can be purchased from **Jaeger**.

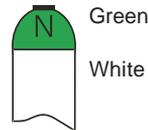
The Euro-Norm EN 1089-3 indicates the color-coding of gas cylinders. This norm, however, is only binding from 1. July 2006. That means two types of color-coding are available at the moment.

Measuring gas, item no. 892533 (SB gas), 10 Liters

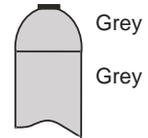
min. 0.25 % CO max. 0.28 % CO

min. 8.9 % He max. 9.7 % He

Rest: synthetic air



New color code



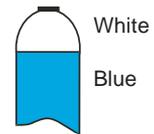
Old color code

Measuring gas, item no. 892501 (oxygen), 10 Liters

100 % O₂ medically pure



New color code



Old color code

NOTE

The pure oxygen (100 %) which is available in hospital can also be used as oxygen.



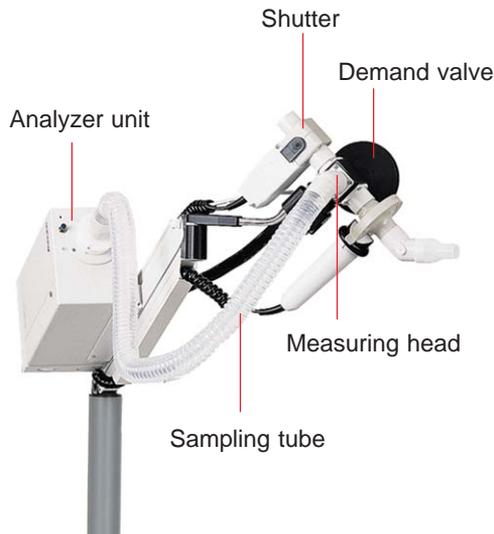
Observe the chapter "Safety Precautions and Operational Procedures" which contains further important information on the safe handling of gases!



Preparing for a Measurement

The following must be checked before conducting a measurement:

- Are the shutter (MS-Diff), demand valve and the pneumotach connected to the system?
- Are the sampling tube (MS-Diff) or the sampling tubes (MS-PFT) connected to the analyzer unit as well as to the measuring head?
- Is the cylinder valve of the SB gas cylinder open and the pressure of the gas cylinder higher than 20 bars?
- Is the RB bag (MS-PFT) disconnected?
- Is the O₂ gas cylinder (MS-PFT) open?



MasterScreen Diff



MasterScreen PFT

**Setting up:**

1. Connection of pressure reducer

Before connecting the pressure reducer **carefully** open and close the cylinder valve in order to get rid of dust.

Connect pressure reducer.

Verify that pressure reducer and cylinder valve are **tightly** connected via the connecting nut.

As a sealing ring ensures the gas-tight connection, the pressure reducer must be attached **carefully**.

2. Open cylinder valve

The pressure manometer indicates the cylinder pressure.

NOTE

Always close the cylinder valve when you are done with your work.

Do not empty the gas cylinder completely!

Pressure must not be below 20 bars in order to guarantee smooth inspiration. If the pressure falls below 20 bars replace the cylinder with a full one. For gas supplies, please contact your local Jaeger representative.

3. Tightness of demand valve

If there is a gas leakage at the demand valve (what cannot be excluded in the case of improper use), please proceed as follows:

Remove the demand valve from the connection block.

Hit the valve as shown below.

The resulting back pressure resets the membrane in the demand valve to a specific position which ensures that the valve is tight.

Connect the demand valve to the connection block.

**Connection of new gas cylinders**

When a new gas cylinder is to be connected, the sealing ring between gas cylinder and **Jaeger** pressure reducer must be replaced. Every **Jaeger** gas cylinder is delivered together with a new sealing ring.

More detailed information can be found in the leaflet "Connecting the pressure reducer to the gas cylinder" which is added to every **Jaeger** gas cylinder.

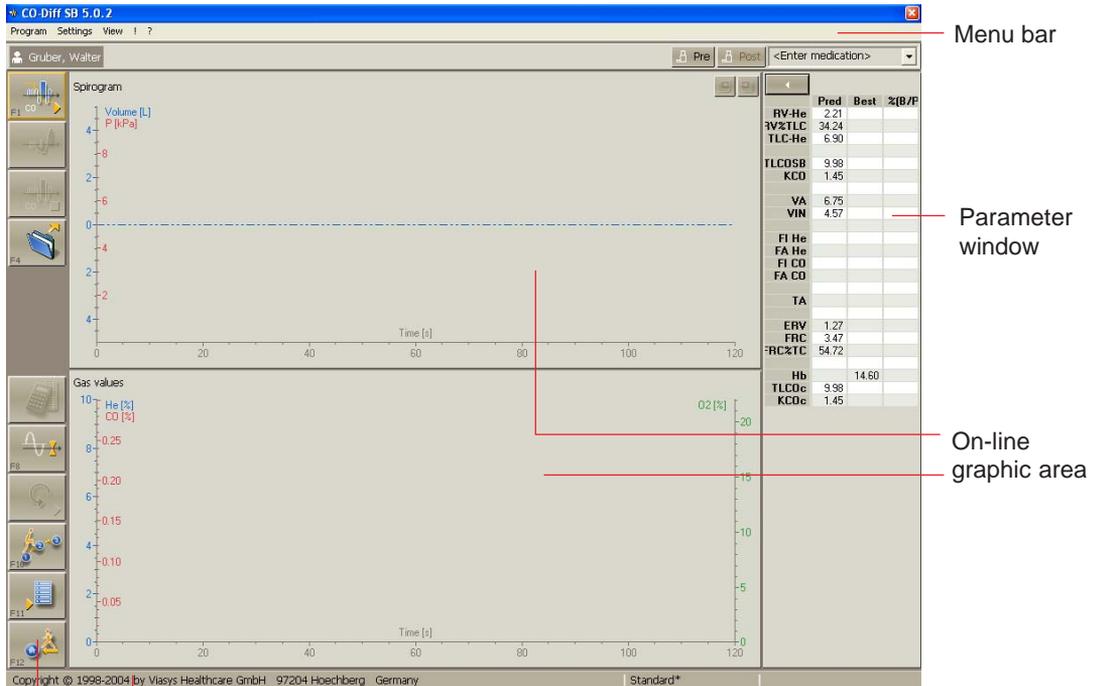


Program Start



The "Diffusion Single Breath" measurement program is called up from the main group by clicking the appropriate icon.

The program appears as follows:



Menu bar

Parameter window

On-line graphic area

Status line

Icon bar

The screen is divided into four main components:

1. Menu bar provides commands used to determine default settings for e. g. discard volume (DV), sample volume (SV) or occlusion time (TA).
2. On-line graphic area The upper window displays the spirogram (volume versus time), the lower window the gas concentrations (He and CO versus time).



3. Parameter window The parameter window lists the parameters including predicted value, actual value and predicted/actual value comparison.
4. Icon bar controls the measurement sequence.

The status line indicates relevant information and notes on the current program phase or the selected symbols. In addition, the current CO and He concentration is displayed.



Icon Bar

The icon bar displays a variety of icons which differ depending on the respective phase of the program. Each icon starts a specific routine.

The screenshot shows the software interface for CO-Diff SB 5.0.2. The title bar includes the program name and menu options (Program, Settings, View, ?). Below the title bar is the user name 'Gruber, Walter'. The main display area is split into two sections: 'Spirogram' and 'Gas values'. The 'Spirogram' section shows a graph of Volume [L] and P [kPa] over time. The 'Gas values' section shows a graph of He [%] and CO [%] over time. The icon bar on the left contains several icons, each with a label and an arrow pointing to it:

- Start measurement → Spirogram icon (F1)
- Start Single Breath maneuver → Spirogram icon (F2)
- End trial prematurely without saving → Spirogram icon (F3)
- Reload measurement → Spirogram icon (F4)
- Calculate/display results → Gas values icon (F8)
- Manual flow/volume zero adjustment → Gas values icon (F9)
- Restart complete measurement → Spirogram icon (F10)
- Next step in program run → Spirogram icon (F11)
- Shortcut menu → Spirogram icon (F12)
- Save data and exit program → Spirogram icon (F13)

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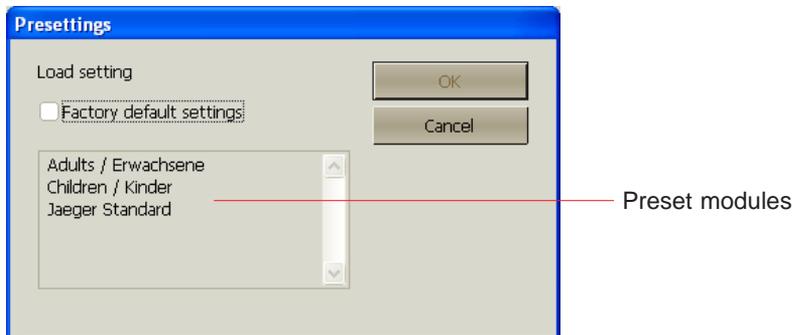
Load Settings

The measurement program "**Diffusion Single Breath**" allows specific setting modules for different patient groups (e. g. children, adults) to be generated, saved under a specific name and loaded before starting the measurement.

Default settings are, for example:

- axis scalings
- occlusion time, discard and sample volume
- Vin limit
- Hb and CO₂ correction
- system and anatomic dead space

Activate a module by clicking "**Settings...**" in the menu bar and then the item "**Read**".



Highlight the required module and accept it with (OK).



Medication

It is easy to enter a so-called "Medication" for any test in each of the Lab measurement programs. Medication means that the medicine, its dose and its concentration entered and referenced to the tests (for example bronchospasmolysis) performed, thereafter.

"Medication" is called up from the command menu bar.



If "Pre" or "Post" is selected in the patient's test list, this indicates that a test has been performed before or after a medication was administered.

If you want to document the administered medication, simply overwrite the <Enter medication> field.

Press the "Return" key and the entry appears in the selection window and is saved automatically in the database.





The basis for bronchial response tests are profound questions as to trend assessment and therapy effectivity of bronchospasmolysis and/or bronchoprovocation tests from the diagnostic point of view.

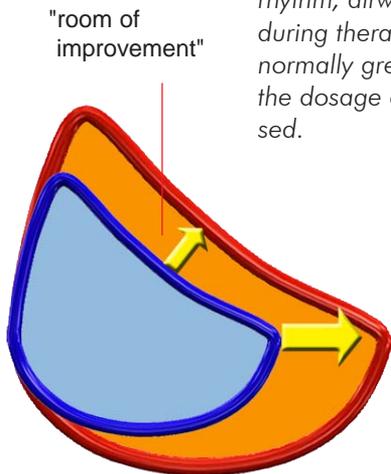
Bronchospasmolysis Test

After an airway obstruction has been detected, the question as to its **reversibility** (curability) becomes essential.

Reversibility of an airway obstruction from the point of view of measuring technology is the indication for a bronchospasmolytic therapy. In addition, it provides an important incentive to the patient.

The immediate bronchospasmolytic effect known as "room of improvement" can be illustrated with the flow/volume curve. The trend of the expiratory portion of the flow/volume curve changes and consequently, a change of the maximal peak flow (PEF) and the peak flows at 50 and 25 % of the thoracic vital capacity (FEF50, FEF25) can be observed.

The extent of the immediate bronchospasmolytic effect depends on circadian rhythm, airway width and to a great extent also on the patient's discipline during therapy. In the morning the immediate bronchospasmolytic effect is normally greater than in the evening. If the patient does not consistently use the dosage aerosol, the immediate bronchospasmolytic effect will be increased.



Flow/volume curve before and after bronchospasmolysis. Before bronchospasmolysis, the curve trend of the expiratory portion is typical for an obstruction of the central and peripheral respiratory tract. After bronchospasmolysis the curve trend returns to normal. During an intrathoracic airway obstruction inspiration will not change.

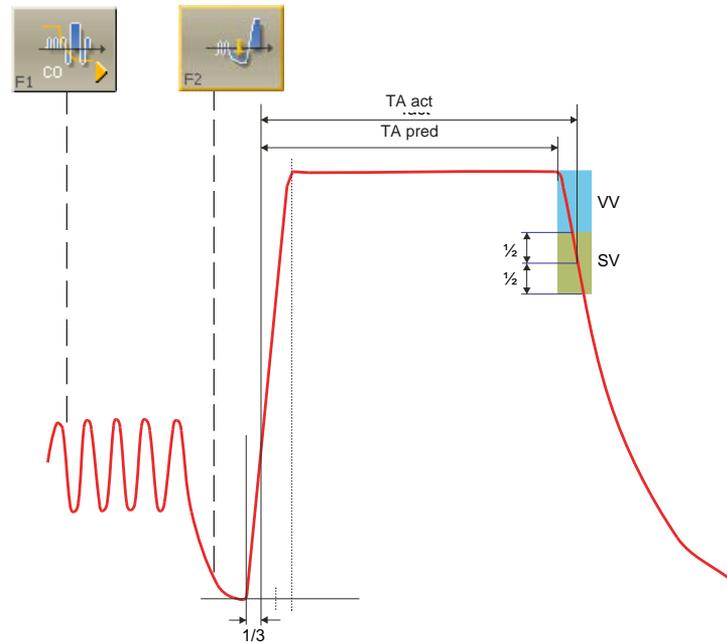
Comparison of predicted and actual values measured for flow/volume key parameters before and after bronchospasmolysis.

How to perform and document a bronchoprovocation test is described in detail in chapter 28 "**Bronchial Test**".



Measurement Sequence

The CO transfer factor (TLCO-SB) is determined via the single breath method.



The measurement consists of several measuring phases:

1. Zero adjustment for CO/He gas analyzers and flow sensor, filling and analysis of FA bag
2. Normal breathing
3. Maximal expiration
4. Maximal inspiration via the demand valve
5. Shutter
6. Expiration, discard volume, sample volume
7. FA gas analysis
8. Results

A zero adjustment for subsequent measurements is not required.

**Short description of the procedure:**

First, the zero point of the gas analyzers and the flow sensor is automatically checked.

The FI bag is emptied and filled (ML, only). The FI gas concentrations are taken over from the gas calibration programs (MS) or are measured (ML).

FI gas concentration: FI CO : 0.2 - 0.3 %

FI He : 7- 10 %

Now, the actual measurement starts. The patient is required to position the mouthpiece and to close his nose with a nose clip. He is asked to breathe quite normally.

From normal breathing he should exhale as much as possible and again inhale to a maximum.

During the single breath maneuver the patient inhales the FI gas concentration directly from the gas cylinder via a demand valve. After a maximal inspiration the patient is required to hold his breath for 10 seconds (if set occlusion time is 10 seconds).

The gas mixture distributes evenly throughout his lungs and the CO diffuses into the blood via the capillary membrane. After the occlusion time is expired, the patient should exhale slowly and evenly. The first sample volume is automatically discarded.

The dead space (mouthpiece, attachment angle, P-tube) is flushed with the discard volume of approx. 0.8 litres (the volume is adjustable). The system dead space is 130 ml. The second sample of the expired volume is collected in the sampling tube (about 0.6 L).

The patient can now leave the mouthpiece. The contents of the sample tube is analyzed, calculated and the results are displayed on the screen.

FA gas concentration in healthy people:

FACO : 0.05 - 0.08 %

FAHe : 5 - 7 %



Training Mode

Normally, patients are quite agitated and nervous and consequently, patient cooperation is often inadequate.

Considering the fact that during a diffusion measurement a He/CO gas mixture is inhaled, it is quite clear that the procedure cannot be repeated very often. So what alternatives do you have?

Start a training phase. The sequence is exactly the same as during the diffusion measurement except that the patient inhales ambient air. This is without risk for the patient and the training phase can be repeated as often as required.

Program
Start diffusion SB measurement
Reanalyse old measurement
SB training mode
Zero
New measurement
Continue sequence
Program selection ...
Exit

In order to start the training phase activate **"SB training mode"** in the **Program** command menu.

Please note:

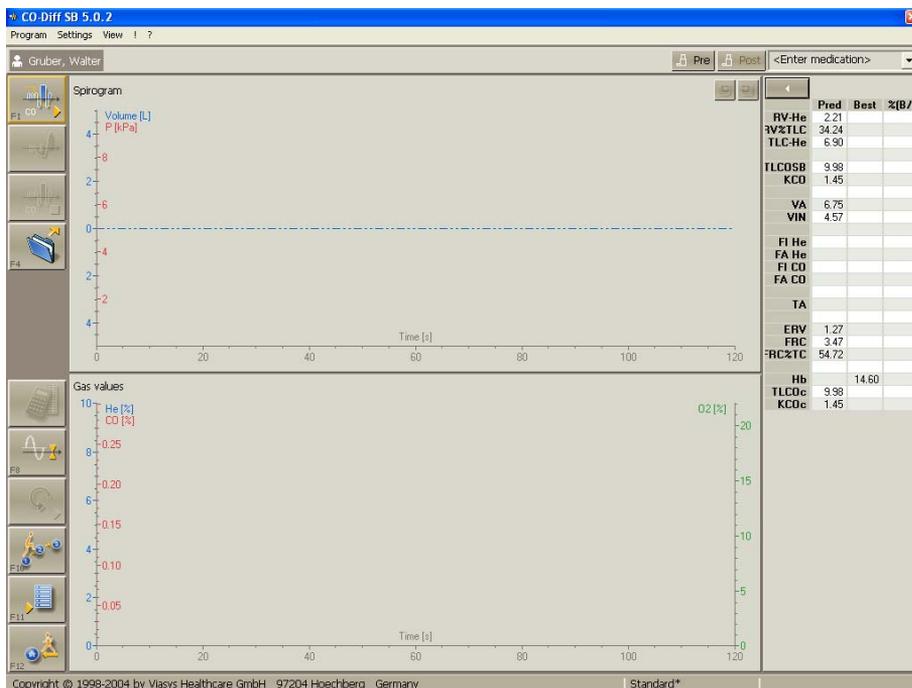
"SB training mode" has to be deactivated before the actual diffusion measurement is started!



Measurement



The measurement program can be started via the "Start measurement" icon or "F1".

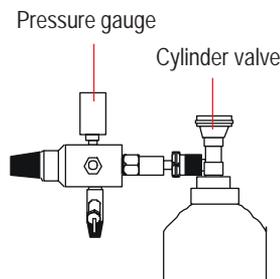
**NOTE****Open Single Breath and O₂ gas cylinder!**

Please observe that the pressure gauge shows a minimum pressure of 20 bars.

If pressure is lower than 20 bars, a measurement **cannot** be performed. Please replace the cylinder with a full one. For gas supplies, contact your local Jaeger representative.

Note on O₂ gas cylinder:

For shutter control and to perform a SB measurement, it is necessary to open the O₂ gas cylinder valve, too.





Zero point check for CO/He

The zero point of the gas analyzers and the flow sensors is then automatically checked.

Possible error message:

No CO/He zero check possible

Solution: Call a service technician to check the analyzers.

Flow (MS-Body)

Solution: Patient should not breathe via the mouthpiece during this phase. Ask the patient to leave the mouthpiece and restart program.

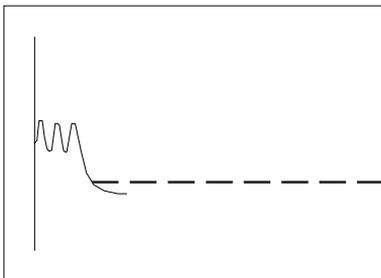
If the values are stable you will automatically move onto the next phase. The following appears in the status line:

Normal breathing, space bar starts maneuver

and "F2" can be selected in the icon bar.

The actual measurement starts. Ask the patient to position the mouthpiece and to close his nose with the nose clip. He should breathe normally. After at least three breaths (necessary for calculating FRC level) ask the patient to exhale as deeply as possible from normal breathing.

Maximal expiration (ERV maneuver)



Press "F2" during expiration or click the "Start Diffusion SB" icon.



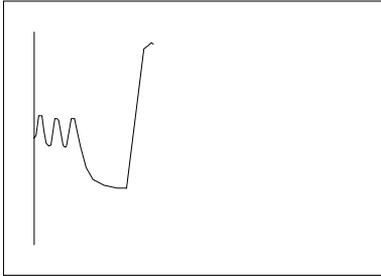
Note:

The measurement can be ended prematurely (e. g. because of inadequate patient cooperation) by pressing "F3" .

The program can be restarted at any time.



Maximal inspiration



After maximal expiration the patient is required to inhale rapidly and as deeply as possible (**VIN**). According to ATS recommendations, inspiration should be completed in less than 2 s in healthy subjects and in less than 4 s in patients with moderate to severe airway obstruction. **The patient now inhales the FI gas.**

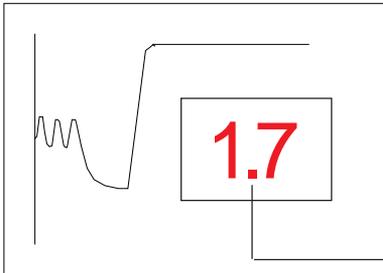
The occlusion time automatically starts after 1/3 of inspiration. At the end of inspiration, the patient is prevented from expiration for the period of time set as occlusion time. **The patient has to keep the mouthpiece in his mouth and hold his breath.**

The pressure curve displayed during the occlusion shows whether the patient has held his breath or whether he has tried to expire despite the occlusion

According to ERS regulations a trial is to be regarded as invalid when pressure is > 3 kPa.

Please note: If a spirometry measurement has been conducted on this patient or a test is loaded in which the parameters VCmax and ERV have already been determined before this measurement, the inspiratory volume (90%VCmax) will be displayed during the inspiration and functional residual capacity is calculated from ERV.

Occlusion



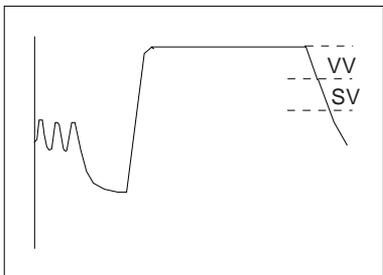
The remaining occlusion time is displayed.

After the set occlusion time has expired, the shutter is opened and the patient is required to exhale smoothly, without hesitation or interruption. In MS systems, discard volume and sampling volume are exhaled via the sampling tube. The gas sample collected for analysis remains in the tube. The remaining air is exhaled via the opened shutter. The sampling valve closes.

Please note:

If the patient's vital capacity is < 2 liters, the wash-out volume and sample volume may be reduced to 0.5 L. Please refer to DLCO settings.

Sample volume





Analysis and calculation

If the patient breathes in during the discard or sample phase, the analysis phase will automatically started. The sample volume will be analyzed and the CO and He (FACO and FAHe) values will appear in the status line.

The patient can now move away from the mouthpiece.

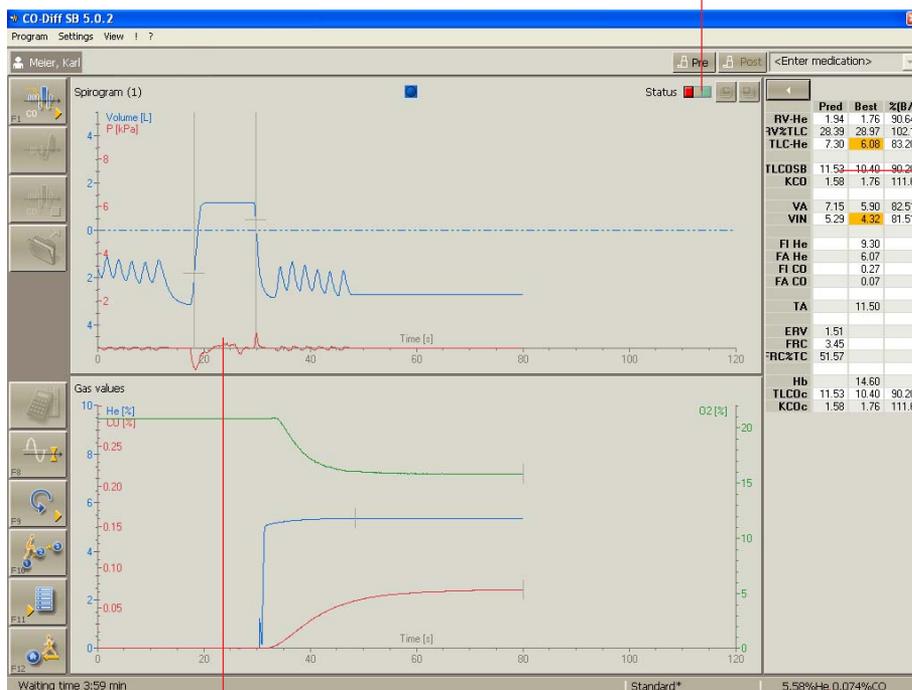
NOTE

If the FA values are constant, the measurement will automatically be ended. The parameters are calculated and displayed on the screen.

End manually: The measurement can also be ended manually with "Result" if stable gas values are not reached. Premature manual ending will result in invalid parameters.

Screen display after the measurement:

Quality indicator of SB measurement



The parameter window lists the measured values including a predicted/actual value comparison.

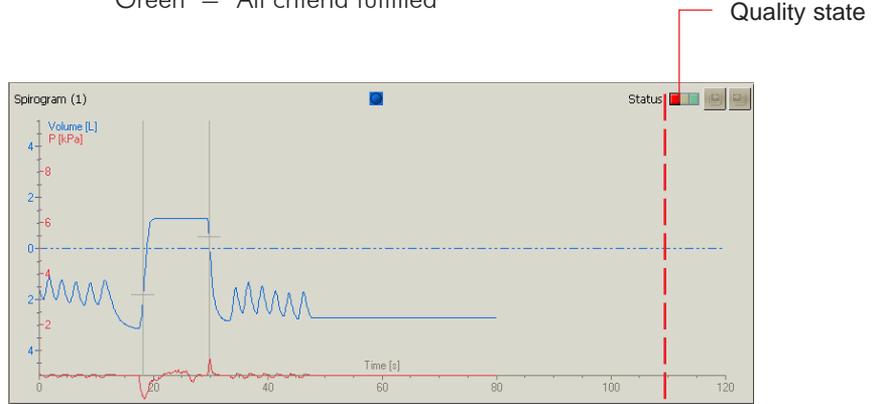
Pressure curve

FAHe/FACO

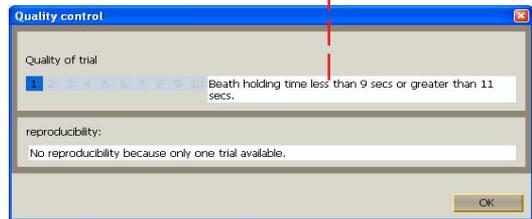


The measurement's quality status depends on the predefined quality criteria.

- Red = Quality criteria not fulfilled
- Yellow = Quality criteria partly not fulfilled
- Green = All criteria fulfilled



Click the status indicator and the following window appears. 1 to 10 are trial numbers. Right of it information on the error that occurred is displayed.



In general:

Up to ten trials can be performed. The eleventh trial deletes that trial which shows the greatest deviation of the TLCO value from the mean value.



How to perform subsequent trials:

NOTE

According to ERS and ATS regulations there must be a minimum pause of four minutes between two subsequent trials!

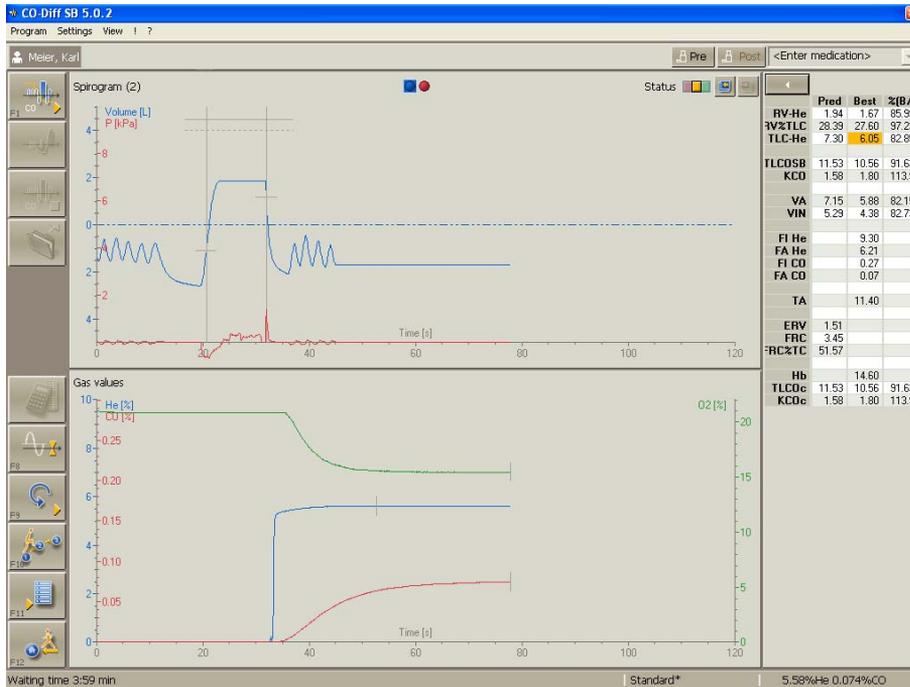


Start with "F1".

For subsequent trials you can do without the zero point check of the gas analyzers.

Perform the measurement as described.

Screen display after second trial:



The values listed in the "Best" column are values averaged over all trials.

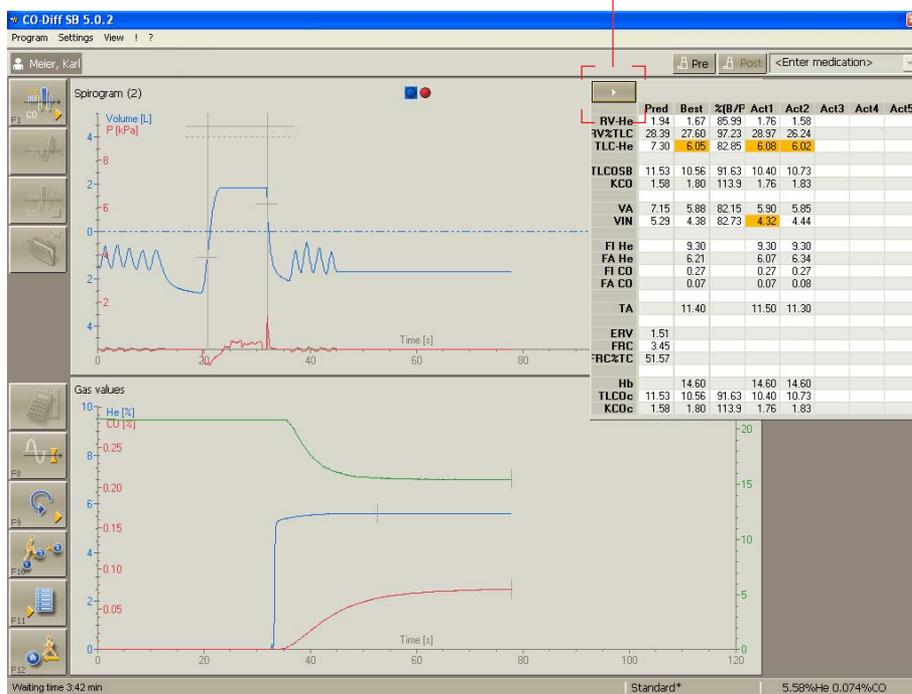


Important: The average values are calculated from primary data.

FICO, FIHe, FACO, FAHe, VIN and TA

Subsequent values are calculated from these average values.

Click the right mouse button in the parameter window or this command button to display the parameters of all trials.



**Please note:**

With **"View"** selected from the command menu or clicking the right mouse button in the upper or lower graphic window, the current display is enlarged so that it fills the entire desktop.

Click the right mouse button again and the screen display returns to its previous size.





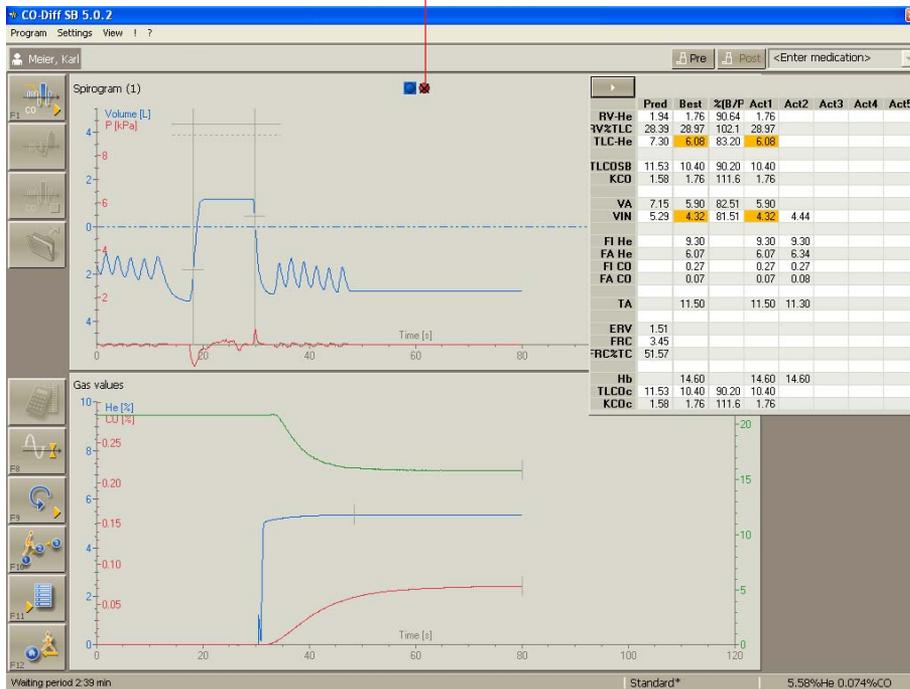
Ignore Bad Trials

Trials can be ignored, if, for example, patient cooperation was inadequate etc.

Example: Trial no. 1 is to be cancelled.

Click the colour-coded trial button with the left mouse button. The button will be deactivated, the curve will be displayed as a broken line and the "Best" parameters will be recalculated.

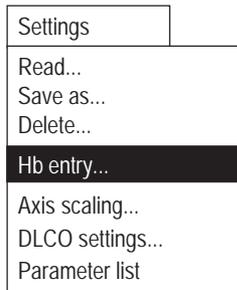
Deactivated trial



The cancelled trial can be reactivated by repeatedly clicking the respective button.



Description of Settings



Hb entry...

For calculating the hemoglobin-corrected parameter TLCOc the hemoglobin concentration of the blood has to be entered manually.

Carboxyhemoglobin correction

The routine DLCO computation assumes that the CO partial pressure in the blood is zero. However, cigarette smoke or other environmental sources influence the CO partial pressure as well as the CO hemoglobin. The same is valid for the DLCO measurement. The COHb increases about 0.7 % with each measurement.

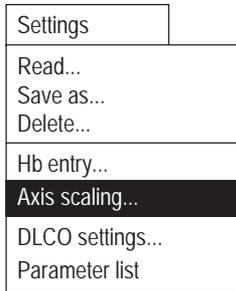
According to ATS, a COHb correction is not required but is recommended when COHb is elevated.

Calculation:

$$\text{COHb}_{\text{corrected}} = \text{DLCO}_{\text{measured value}} (1 + (\% \text{COHb}/100))$$

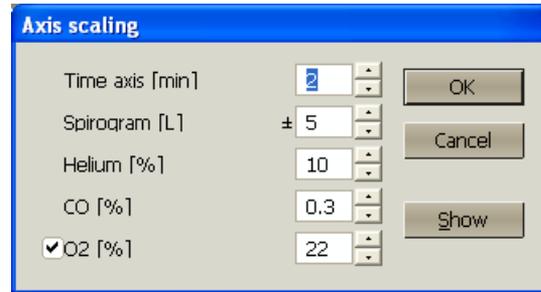
OK

Continue with (OK).



Axis scaling ...

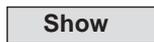
Axis scalings for curves recorded during the measurement and displayed in the result phase can be modified.



O₂ [%]

The expiratory O₂ concentration can be displayed in systems with O₂ sensor (MS_PFT). All other systems do not provide this possibility (i.e. this setting cannot be selected). If the expiratory O₂ concentration is displayed, the parameter FaO₂ will be determined.

Presetting: not selected



If (**Show**) is clicked, the current settings will be accepted and immediately displayed on the screen.



With (**OK**) the current settings are accepted for the measurement.



- Settings
- Read...
- Save as...
- Delete...
- Hb entry...
- Axis scaling...
- DLCO settings...**
- Parameter list

DLCO settings...

1. Measuring sequence

SB settings

Enter dead space	Quality control
Measuring procedure	Corrections
Occlusion time [s]	10
Discard volume [ml]	750
Sample volume [ml]	600
<input type="checkbox"/> Vin limit	
Limit [%]	90
<input type="checkbox"/> Average TLCO, VA	

OK Cancel

Presettings for occlusion time, discard volume and sample volume:

Occlusion time	10 sec.
Discard volume	750 ml
Sample volume	750 ml

Vin limit (not active on MS-Diffusion)

With **Vin limit "On"**, for example 90 % of the inhalation is prevented (occlusion) after the set limit has been reached.

With **Vin limit "Off"** and a set limit, a check is made during inspiration as to whether the breathed volume is larger than the set limit.



TLCO, VA mean values

The parameter values shown in the "Best" column can be calculated as follows:

- The mean values of the primary parameters (V_{in} , TA, F_{iHe} , F_{aHe} , F_{iCO} and F_{aCO}) are calculated from respective values of the individual trials. All other parameters are then calculated from these mean values.
- The secondary parameters (TLCO, VA) are directly calculated from the respective values of the individual trials. All other parameters are then calculated from these mean values.

The primary parameters will not be displayed in the "Best" column.

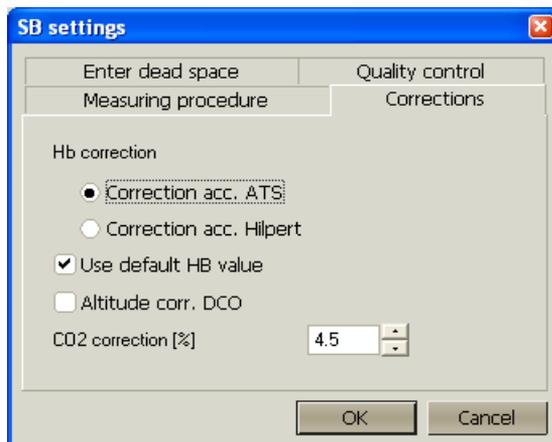
Presetting: not selected

OK

Click **(OK)** and the settings are accepted.



2. Corrections



Hb correction

Hemoglobin-corrected TLCOc can be calculated according to different formulas.

1. **Hb correction according to ATS*** based on a predicted value of 13.4 in females and 14.6 in males.

Formula:

$$\text{TLCOc} = \text{Actual value} / k$$

$$k_{\text{male}} = 1.7 \cdot \text{Hb} / (10.22 + \text{Hb})$$

$$k_{\text{female and teenagers < 15 years}} = 1.7 \cdot \text{Hb} / (9.38 + \text{Hb})$$

2. **Hb correction according to Hilpern**** based on a predicted value of 13.5 in females and 14.6 in males.

Formula:

$$\text{TLCOc} = \text{Actual value} / k$$

$$k_{\text{male}} = 0.0646 \cdot \text{Hb} + 0.0568$$

$$k_{\text{female}} = 0.0646 \cdot \text{Hb} + 0.1279$$

*ATS = (American Thoracic Society)

Literature: Single-breath Carbon Monoxide Diffusing Capacity (Transfer Factor). Recommendations for a Standard Technique-1995 Update. Am J Respir Crit Care Med Vol 152. pp 2185-2198, 1995

** Literature:

The change of the diffusion capacity of the lung for CO due to the haemoglobin concentration of the blood. Respiration 28: 518-525 (1971)

**If no Hb values are entered, use the default values**

If no Hb value is entered, the corrected parameters (for example TLCOc) cannot be calculated. The default values for Hb are used to provide a correction factor of 1.0, i.e. corrected and uncorrected value are identical.

- Do not enter a default value for Hb - TLCOc etc. will not be calculated.
- Use a default value - overwrite this value manually.

Presetting: selected

DLCO altitude correction

According to ATS, the measured DLCO value must be altitude-adjusted with measurements at higher altitudes.

Calculation:

$$\text{DLCO}_{\text{altitude-adjusted}} = \text{DLCO}_{\text{measured value}} * (1+0.0031 (\text{PIO}_2-150))$$

$$\text{PIO}_2 = 0.21 (\text{PB}-47)$$

PB = barometric pressure in mmHg - measured or entered off-line in the "Ambient Data" program.

CO₂ correction

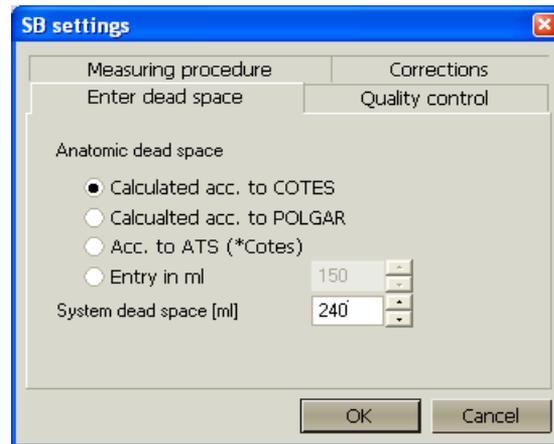
He analyzers have a slight cross-sensitivity to CO₂. Therefore, the measured FA-He values is to be corrected with regard to the CO₂ concentration of the exhaled and analyzed alveolar gas.

The expected CO₂ portion of the exhaled gas has to be entered in the "CO₂ correction" field.

Presetting: 4.5%



3. Entry of dead space



Anatomic dead space

The anatomic dead space can be calculated according to different formulas:

1. Calculation according to COTES: $VDA [ml] = \text{weight} * 2.2$
2. Calculation according to POLGAR: $VDA [ml] = 7.585 * \text{height}^{2.363} * 10^{-4}$
3. Calculation according to ATS: $VDA [ml] = \text{weight} * 2.2$
4. Manual entry: Entry range: 0 - 500 ml

Apparative dead space

An **apparative dead space** of 0 - 500 ml (if, for example, a filter is set in front of the pneumotach) can be entered.

System dead spaces of Jaeger devices:

MasterScreen Diffusion

- old demand valve (not labeled) 240 ml
- new demand valve (labeled with "Demand Valve 2") 165 ml

MasterScreen PFT 130 ml

MS CS-FRC 50 ml



4. Quality control



Quality control criterion

The quality of a measurement can be checked according to several quality criteria. The following quality criteria can be selected:

ATS

ATS and Mayo

ATS/ERS 2005

The quality of the measurement is indicated by a "traffic light" and depends on the preset quality criteria.

Grey = No valid trial

Red = Not reproducible

Yellow = Reproducible, but less than two valid trials.

Green = All criteria fulfilled.

More detailed information can be found under "Appendix: Quality Criteria for the Measurement, Error Code Lists".

Cancel

Clicking the command button (**Cancel**) always cancels without alteration.



Appendix: Quality Criteria for the Measurement, Error Code List

For every possible error message an error code number is saved in the data base. This code number can then be output on screen or printer just like a measuring parameter.

If several error messages apply to one measurement, the corresponding error code numbers are added.

Example:

Code no. 11 means: Code no. 1 **plus** no. 10

ATS:

The American Thoracic Society (ATS) has defined minimum quality requirements for lung function tests. The error code is saved with parameter #45 of the Diffusion SB program; the parameter is determined and saved independent of the selected QC criteria.

Code no.	Description
1	No reproducibility: only one accepted trial available.
2	No reproducibility: no valid trial
3	No reproducibility: TLCO differs too much. The difference between the highest and the lowest measuring value is calculated. The reference value is the mean value calculated from both values. There is no reproducibility if the difference exceeds 10% of the reference value and is greater than 1.0 mmol/min/kPa (3 ml/min/mmHg).
4	No reproducibility: VA differs too much. The difference between the highest and the lowest measuring value is calculated. The reference value is the mean value calculated from both values. There is no reproducibility if the difference exceeds 10 % of the reference value.
10	Inspiration time longer than or equal to 2.0 secs.
20	Expiration time (i.e. time from the opening of the valve until the middle of the sample volume) longer or equal to 15 secs.
40	Breath holding time out of the interval of 9 to 11 secs.
100	Vin lower than 90 % of VCmax. VCmax is calculated from the VCmax measurements of Spirometry/Flow-Volume, Bodyplethysmography, FRC-He and Vin of all other trials.

**Literature:**

Literatur: Crapo, O. et al., "Single-breath Carbon Monoxide Diffusion Capacity (Transfer Factor), 1995 Update", *Am.J.Respir.Crit.Care Med.*, 152, 2185-2198, 1995.

ATS/ERS 2005:**Error code Description:**

- | | |
|-----|---|
| 1 | No reproducibility: only one accepted trial available. |
| 2 | No reproducibility: no valid trial |
| 3 | No reproducibility: TLCO differs too much. The difference between the highest and the lowest measuring value is calculated. The reference value is the mean value calculated from both values. There is no reproducibility if the difference exceeds 10% of the reference value and is greater than 1.0 mmol/min/kPa (3 ml/min/mmHg). |
| 4 | No reproducibility: VA differs too much. The difference between the highest and the lowest measuring value is calculated. The reference value is the mean value calculated from both values. There is no reproducibility if the difference exceeds 10 % of the reference value. |
| 10 | Inspiration time longer than or equal to 4.0 secs. |
| 20 | Expiration time (i.e. time from the opening of the valve until the middle of the sample volume) longer or equal to 15 secs. |
| 40 | Breath holding time out of the interval of 8 to 11 secs. |
| 100 | Vin lower than 85 % of VCmax. VCmax is calculated from the VCmax measurements of Spirometry/Flow-Volume, Bodyplethysmography, FRC-He and Vin of all other trials. |

Literaturhinweis:

Literatur: Series "ATS/ERS Task Force: Standardisation of lung function testing", Edited by Brusasco, R. Crapo and G. Viegi, Number 2 in this Series. *Eur. Respir. J* 2005; 319-338

ATS and Mayo:

Based on the experience of specialists of the Mayo Clinic, a leading hospital in the USA, and the ATS guidelines, extended criteria have been introduced. The error code is saved with parameter #46 of the Diffusion SB program; the parameter is determined and saved independent of the selected QC criteria.



Error code	Description:
1	only one accepted trial available.
2	No reproducibility: no valid trial
3	No reproducibility: TLCOc differs too much. The difference between the highest and the lowest measuring value is calculated. The reference value is the mean value calculated from both values. There are three different ranges depending on this reference value: <ol style="list-style-type: none"> 1. TLCOc < 3.68 mmol/min/kPa (< 10 ml/min/mmHg): The difference is greater than 0.67 mmol/min/kPa (corresponds to 2.0 ml/min/mmHg) 2. TLCOc between 3.68 mmol/min/kPa (10 ml/min/mmHg) and 10.05 mmol/min/kPa (30 ml/min/mmHg): The difference exceeds 10% of the reference value. 3. TLCOc > 10.05 mmol/min/kPa (> 30 ml/min/mmHg): The difference is greater than 1.005 mmol/min/kPa (corresponds to 3.0 ml/min/mmHg)
4	No reproducibility: VA differs too much. The difference between the highest and the lowest measuring value is calculated. The reference value is the mean value calculated from both values. There is no reproducibility if the difference exceeds 10 % of the reference value.
10	Inspiration time longer than or equal to 2.0 secs.
20	Expiration time (i.e. time from the opening of the valve until the middle of the sample volume) longer or equal to 15 secs.
40	Breath holding time out of the interval of 9 to 11 secs.
100	Vin lower than 90 % of VCmax. VCmax is calculated from the VCmax measurements of Spirometry/Flow-Volume, Bodyplethysmography, FRC-He and Vin of all other trials.
1000	The TLC determined in a Single-Breath Diffusion measurement is extremely higher than the TLC determined in a previous Bodyplethysmography measurement, i.e. the difference must be greater than 500 ml.

Literature:

Private communication.



Appendix: Calculation Basis

The CO transfer factor is calculated as follows:

$$\text{TLCO} = \text{VA} * (60 / \text{Tact}) * 0.389 \text{ mmol} / \text{min} / \text{kPa} * \ln (\text{FACO}_o / \text{FACO}_i)$$

$$\text{TLCO} = \text{mmol} / \text{min} / \text{kPa}$$

$$\text{VA} = [\text{FIHe} / (k * \text{FAHe})] * [\text{VIN} - (\text{VDA} + \text{VAT})]$$

$$\text{VA} = [1]$$

k = calculated correction factor from the CO₂- and deadspace settings

$$k = [1 - \text{FE} \text{CO}_2] * [\text{SV} / (\text{SV} - \text{VD})]$$

$$\text{VDA} = 0.15 \text{ L (anatomic deadspace)}$$

$$\text{VAT} = 0.15 \text{ L (apparative deadspace)}$$

VIN = inspiratory volume (corrected from ATPD to BTPS)

$$\text{FACO}_o = \text{FICO} * \text{FAHe} / \text{FIHe}$$

Tact = actual occlusion time, measured after 1/3 of the inspiration time up to the middle of the sample volume (accuracy 10 ms)

$$0.389 = \text{kBS} * 44.6 \text{ mmol} / \text{l} / (\text{B} - 62.5 \text{ hPa})$$

kBS = conversion BTPS toSTPD

$$\text{kBS} = [(\text{B} - 62.5 \text{ hPa}) / \text{B}] * [273 \text{ K} + 37 \text{ K}] * [\text{B} / 1013 \text{ hPa}]$$

VD = apparative deadspace of FAHe nipple (V3)

B = barometric pressure

62.5 hPa = vapour pressure of water at 37 degrees centigrade

44.6 = conversion from L to mmol

1 mmol = 22.4 ml

1000 hPa = 750.2 mmHg

Conversion factor from TLCO [mmol / (min * kPa)] to the previous unit
TLCO [ml / (min * mmHg)] = 2.979



Example of the calculation of the CO transfer factor TLCO:

This calculation is based on the values (DV, SV, CO₂, VD) preset as default settings and the measured primary values (Tact, VIN, FIHe, FAHe, FICO, FACO).

Formula:

$$\text{TLCO} = \text{VA} * (60 / \text{Tact}) * 0.389 \text{ mmol} / \text{min} / \text{kPa} * \ln (\text{FACO}_o / \text{FACO})$$

1. Calculation of the alveolar volume VA:

$$\text{VA} = [\text{FIHe} / (k * \text{FAHe})] * [\text{VIN} - (\text{VDA} + \text{VAT})]$$

$$k = [1 - \text{FCO}_2] * [\text{SV} / (\text{SV} - \text{VD})]$$

$$k = [1 - 0.05] * [0.8 / (0.8 - 0.025)]$$

$$k = 0.9806$$

$$\text{VA} = [0.0938 / (0.9806 * 0.0640)] * [5.378 - (0.15 + 0.15)]$$

$$\text{VA} = 7.583 \text{ Liter}$$

2. Calculation of the CO transfer factor TLCO:

$$\text{TLCO} = \text{VA} * (60 / \text{Tact}) * 0.389 \text{ mmol} / \text{min} / \text{kPa} * \ln (\text{FACO}_o / \text{FACO})$$

$$\text{FACO}_o = \text{FICO} * \text{FAHe} / \text{FIHe}$$

$$\text{FACO}_o = 0.0029 * 0.064 / 0.0938$$

$$\text{FACO}_o = 0.00198$$

$$\text{TLCO} = 7.583 * (60 / 10.56) * 0.39 \text{ mmol} / \text{min} / \text{kPa} * \ln (0.00197 / 0.0008)$$

$$\text{TLCO} = 15.10 \text{ [mmol} / \text{min} / \text{kPa]}$$