FRC-He Rebreathing

Explanation of Measurement Program

Many diagnostically important values of the static lung volumes can be determined with the **"FRC-He Rebreathing"** program. It includes the measurement of the functional reserve volume (FRC) according to the He rebreathing method.

Measurement Principle:

Determination of the functional reserve volume (FRC) according to the He rebreathing method.

Measurement Sequence:

The measurement is quite simple to perform. The results, however, depend on the patient's cooperation. The patient is asked to breathe via a mouthpiece attached at the pneumotach.

The patient inhales and exhales ambient air, first. If breathing is stabilized, the He wash-in phase will begin. Now, the patient inhales from a rebreathing bag a gas mixture consisting of about 9 % He and 32 % oxygen. In order to be able to measure even seriously distribution disordered patients, oxygen is supplied in the rebreathing phase (He wash-in phase) and the CO_2 in the breathing gas is absorbed. If an ERV-VC breathing manoeuvre is performed before or after the wash-in phase, the important parameters RV and TLC will be determined additionally. Alternatively, it is possible to read in the ERV-VC parameters from a spirometry measurement which was already performed with the patient and saved in the database.

Evaluation:

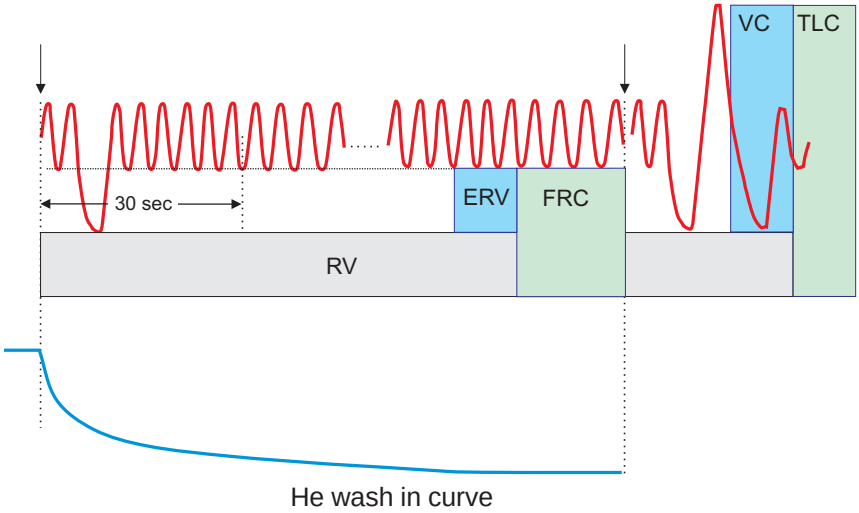
The parameters of each trial are calculated and displayed on the screen with a predicted/actual value comparison.

The assessment of the measuring values as well as the analysis of the He wash-in curve provide information about the presence of possible restrictive or obstructive diseases of the respiratory organs.

The percentage of the functional "residual capaity" in the total capacity is approx. 40 % in a healthy young person. It increases with age at the expense of the vital capacity. Increased values point to a pulmonary emphysema. Wash-in periods of more than 2 min. are signs of a distribution disorder.

In general: The longer the wash-in periods, the more serious the distribution disorder.

Parameter Definition



He wash in curve

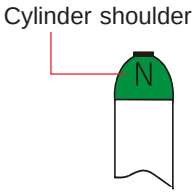
FRC-He	Functional reserve volume
RV-He	Reserve volume
TLC-He	Total lung capacity
T-RB	Duration of rebreathing
V-RB	Sum of rebreathing volume
VO_2	Oxygen uptake
TV	Tidal volume
BF	Breathing frequency
MV	Minute volume
ERV	Expiratory reserve volume
VCIN	Inspiratory vital capacity
VCEX	Expiratory vital capacity
FI He	Inspiratory concentration He
FI O_2	Inspiratory concentration O_2
FA He	Expiratory concentration He
FA O_2	Expiratory concentration O_2

Gas Concentrations and Color-Coding of Gas Cylinders

ATTENTION

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 **VIASYS Healthcare**.

The Euro-Norm EN 1089-3 indicates the color-coding of gas cylinders. It represents a new color-coding system for gas cylinders which provides additional information on the characteristics of the gas in the cylinder (poisonous, flammable, oxidizing, inert).



The color-coding according to this norm is only defined for the cylinder shoulder.

For a transitional period, all new shoulder colors will be marked with a **N** (= New) as far as previous colors are concerned.

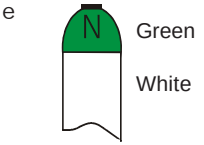
This transitional period ended in June 2006. That means, gas cylinders with different color coding may still be circulating at the moment.

FRC-He Rebreathing with MasterScreen:

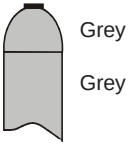
Measuring gas, item no. 892546 (FRC-He gas), 10 Liters

min. 9.0 % He max. 9,5 % He

Rest: synthetic air



New color code

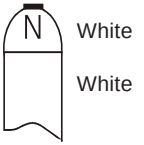


Old color code

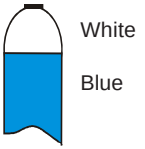
FRC-He Rebreathing with MasterScreen:

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

100 % O_2, medically pure



New color code



Old color code

NOTE

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

ATTENTION

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 every measurement:

1. Is a new, disinfected mouthpiece attached to the new, disinfected pneumo-tach?
2. Are the valves of the Single Breath- and O_2 gas cylinder open?
3. Is the rebreathing bag connected?
4. Are the absorbers checked? (See "Check Absorbers".)

Setting up for the procedure

1. Attaching the pressure reducer

   Before you attach the pressure reducer, **carefully** and quickly open and close the cylinder valve to get rid of any dust which may be in it.

   Screw on pressure reducer. Please make sure that the pressure reducer is gas-tightly connected to the cylinder valve via the attachment nut.

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

2. Open cylinder valve

   The manometer indicates the cylinder pressure.

NOTE

Close the cylinder valve if work is interrupted or ended!

NOTE

Do not empty the gas cylinder completely!
If you get below 10 bars residual pressure, close the cylinder valve, remove the pressure reducer and send the gas cylinder back to **VIASYS**, or whoever your supplier is, to be refilled.

Connection of new gas cylinders

When a new gas cylinder is to be connected, the sealing ring between gas cylinder and **VIASYS** pressure reducer must be replaced. Every **VIASYS** gas cylinders 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 **VIASYS** gas cylinder.

Check List after Preparation

1. Valve head attachment checked?
2. Absorber checked?
3. FRC-RB gas cylinder open?

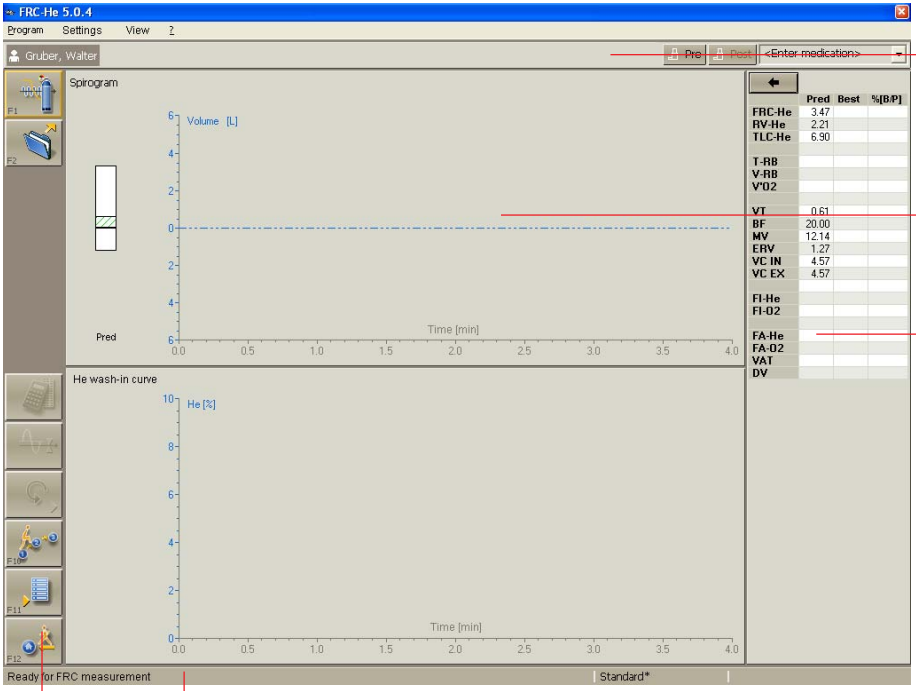
   The pressure must not be changed between calibration and measurement. If pressure is changed, calibration must be repeated. That means, calibration and measurement have to be performed with the same pressure!
4. Filling volume of rebreathing bag entered?
5. If "Oxygen uptake during rebreathing" (option "Complex-FRC") is set, the O_2 gas cylinder is to be opened!

IMPORTANT Check these five points mentioned above prior to every measurement.

Program Start

The **"FRC-He RB"** measurement program is called up from the main group by clicking the appropriate icon.

The program appears as follows:



Menu bar

On-line graphic area

Parameter window

Icon bar

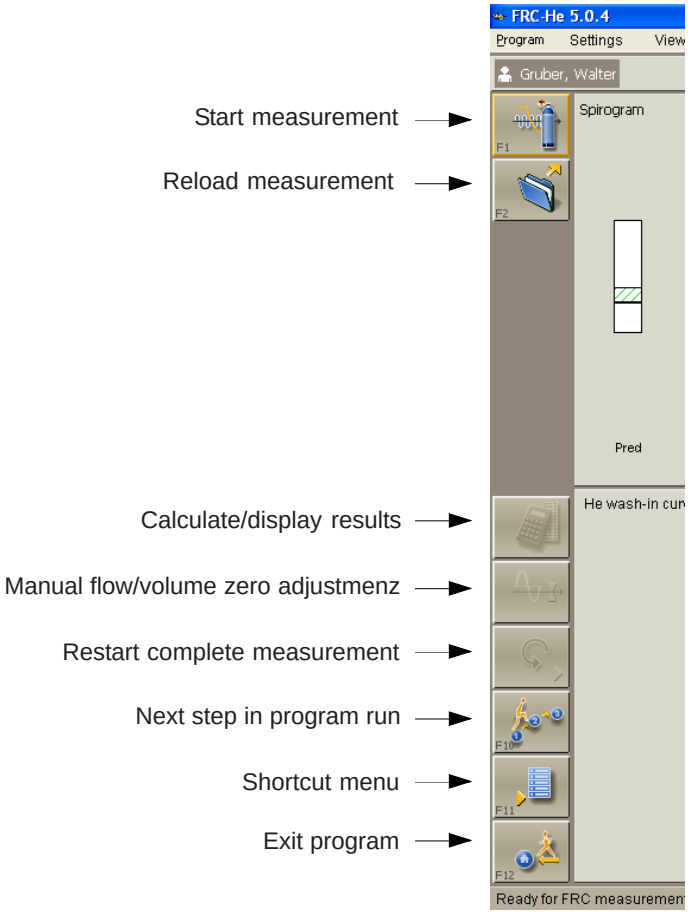
Status line

The screen is divided into four main components:

1. Menu bar — provides the command menus with which the default settings of the program can be determined.
2. On-line graphic area — Display area for the graphics (depending on the current program phase)
3. Parameter window — Predicted values, measuring values (actual values) and predicted value comparison.
4. Icon bar — The icons in the icon bar control the sequence of the measurement program.

Icon Bar

With regard to the current phase of the program, different icons are displayed in the icon bar. Each icon starts a specific routine.



Please note:

If the mouse pointer points to one of the icons, a short text will be displayed in the status line informing you about the function of the respective icon.

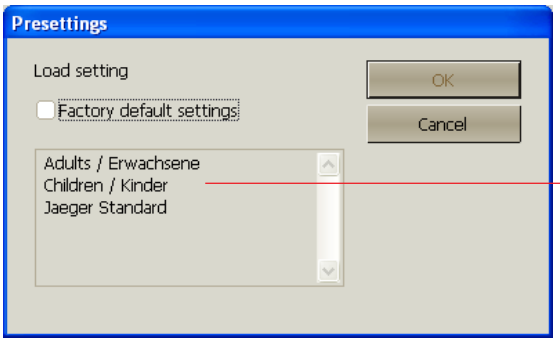
Load Settings

The measurement program **"FRC-He RB"** allows specific modules for different patient groups (for example children, adults) to be generated, saved under a specific name and loaded before starting the measurement.

Default settings are, for example:

- axis scalings
- filling volume

Activate a module by clicking **"Settings..."** in the menu bar.



OK Mark the required module and accept it with (**OK**).

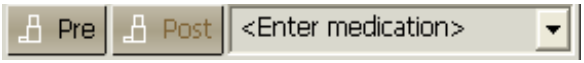
☒ If **"Default setting"** is activated, the Jaeger default setting is used. This default setting cannot be changed.

You will find a detailed description on how to set and change preset modules under "Modify Default Settings".

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 are entered and referenced to the test (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.

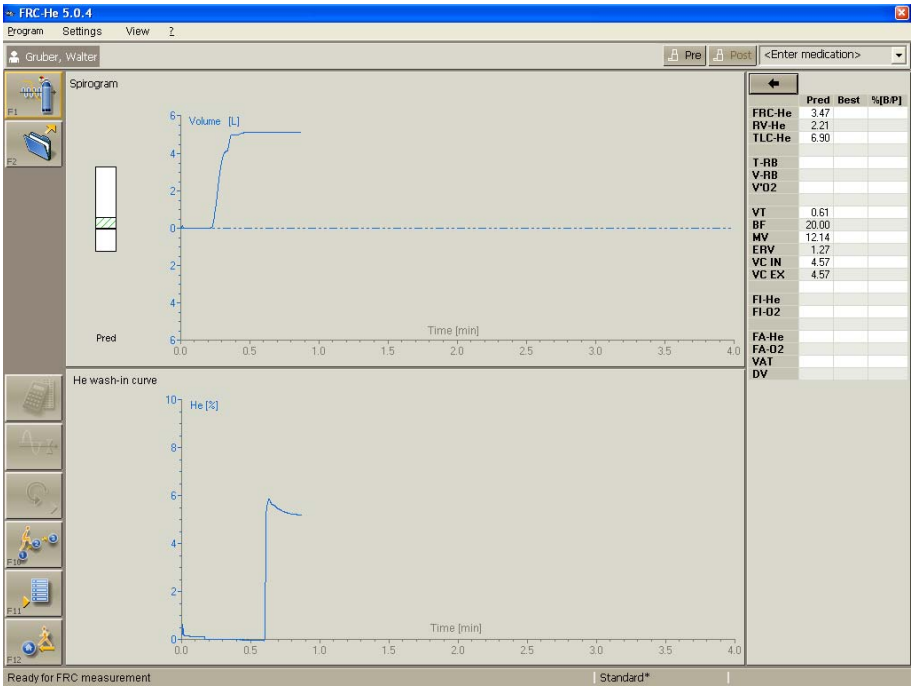
Perform FRC Measurement

In order to calculate the parameters **TLC-He** and **RV-He**, the basic parameters **VCmax** and **ERV** have to be known.

If the current patient has already performed a measurement in one of the other programs, for example **Spirometry, Bodyplethysmography** or **DCO-RB**, this previous measurement can be reloaded with **"F2"**. TLC and RV will be calculated automatically.

If no measurements have been performed with this patient, a spirometry breathing maneuver can be performed following the FRC-He measurement.

When starting the measurement program, the rebreathing bag is emptied, flushed with oxygen and a zero adjustment of the He gas analyzer is performed.



Following that the RB bag will be filled Fi gas (9% He, 35% O_2, rest N_2) according to the preset filling so there is a gas concentration of about 9% He and 32% O_2.

If the preparing phase is ended, the icon shown on the left will appear in the icon bar and the following message will appear in the status line:

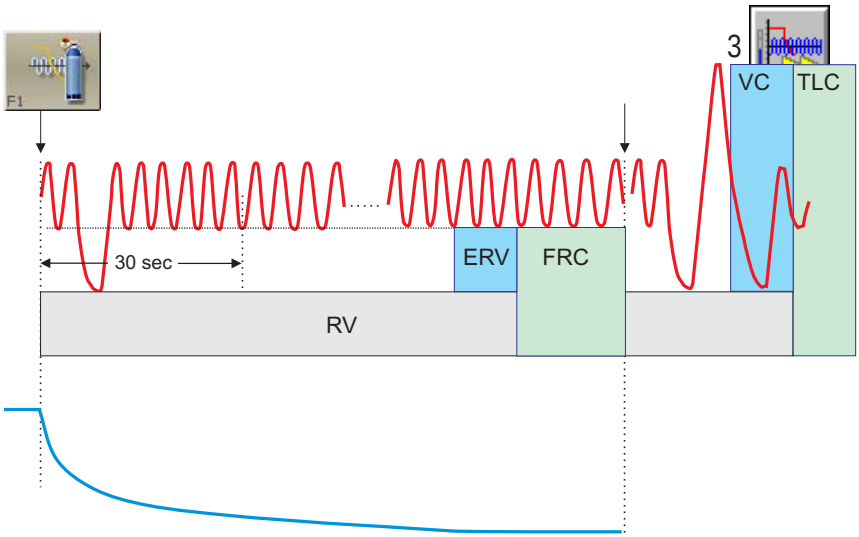
"FRC: inhale and exhale quite normally"

Now ask the patient to close his nose with the nose clip and to approach the mouthpiece.

Please note:

During the following measurement, the patient should sit still so that his oxygen uptake and breathing baseline (FRC level) remain stable.

Graphic display of measurement sequence



He wash-in curve

(Stable He concentration)

If the patient breathes quite normally, the wash-in phase can be started by clicking the "He" icon.

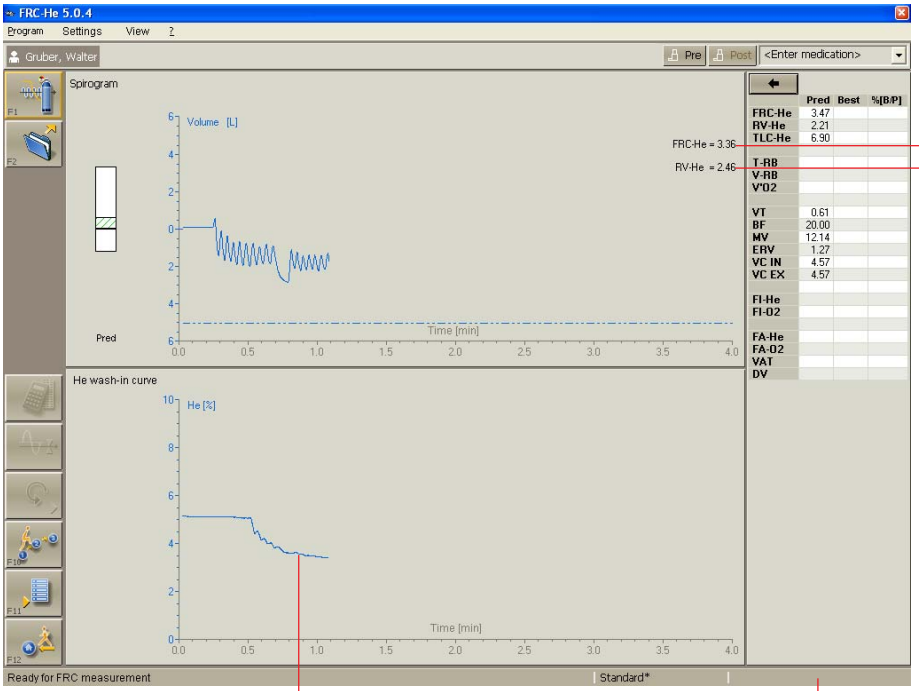
Ask the patient to perform an ERV breathing manoeuvre*[1] within the next 30 secs, i.e. from normal breathing the patient slowly breathes out as deeply as possible and then continues to breathe normally.

The patient breathes the gas mixture consisting of about 9 % helium and 32 % oxygen contained in the RB bag. In order to keep the oxygen content in the RB bag constant, about 250 - 300 ml oxygen per minute will be added.

The inhaled helium gas mixture now spreads out evenly into the lung-spirometer system.

*[1]If "ERV during wash-in" is preset (see page 25 "Spirometry maneuvre style"). If the default setting is changed (e.g. "IC during wash-in"), the patient must slowly inhale to a maximum (IC) from normal breathing and then continue to breath normally.

Now observe the trend of the He wash-in curve, the He value displayed in the status line and the continuously updated FRC value shown in the parameter window.



FRC-He and RV-He values are continuously updated.

He wash in curve

FE-He and FE-O_2 values

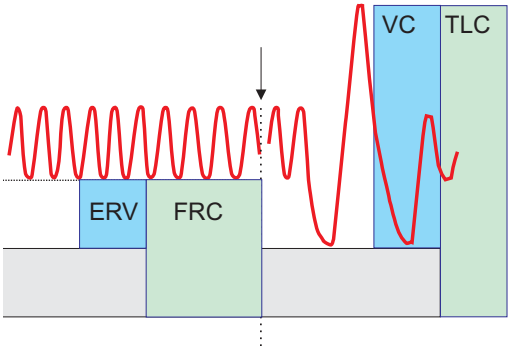
IMPORTANT

A patient with healthy lungs needs about 1 - 2 minutes for washing in He. Wash-in periods of more than 3 - 5 minutes are signs of a distribution disorder. Seriously distribution-disordered patients sometimes need wash-in periods of up to 10 minutes.

If the measured O_2 value is lower than 25 %, oxygen will be supplied automatically.

If the value is lower than 19 %, the measurement will be ended automatically!

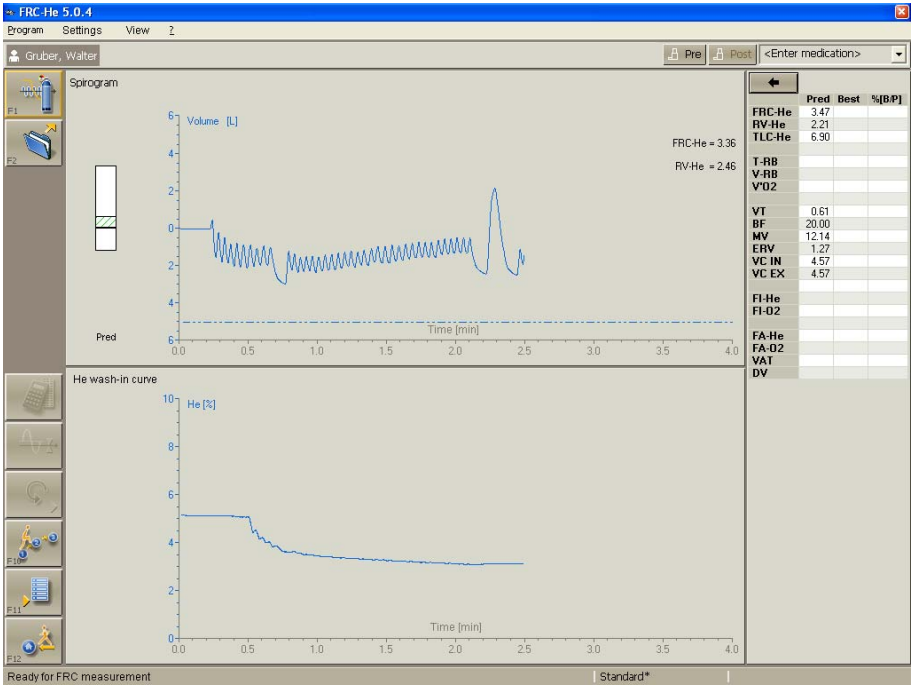
If the He-wash-in curve is horizontal and the He and FRC values are stable, the measurement can be ended with **"F3"**. Continue tidal breathing for at least another minute.



Please note:

If a spirometry measurement has not yet performed with this patient, the parameter VC is missing for calculating the Total Lung Capacity (TLC). In this case, a slow spirometry measurement should be performed, now.

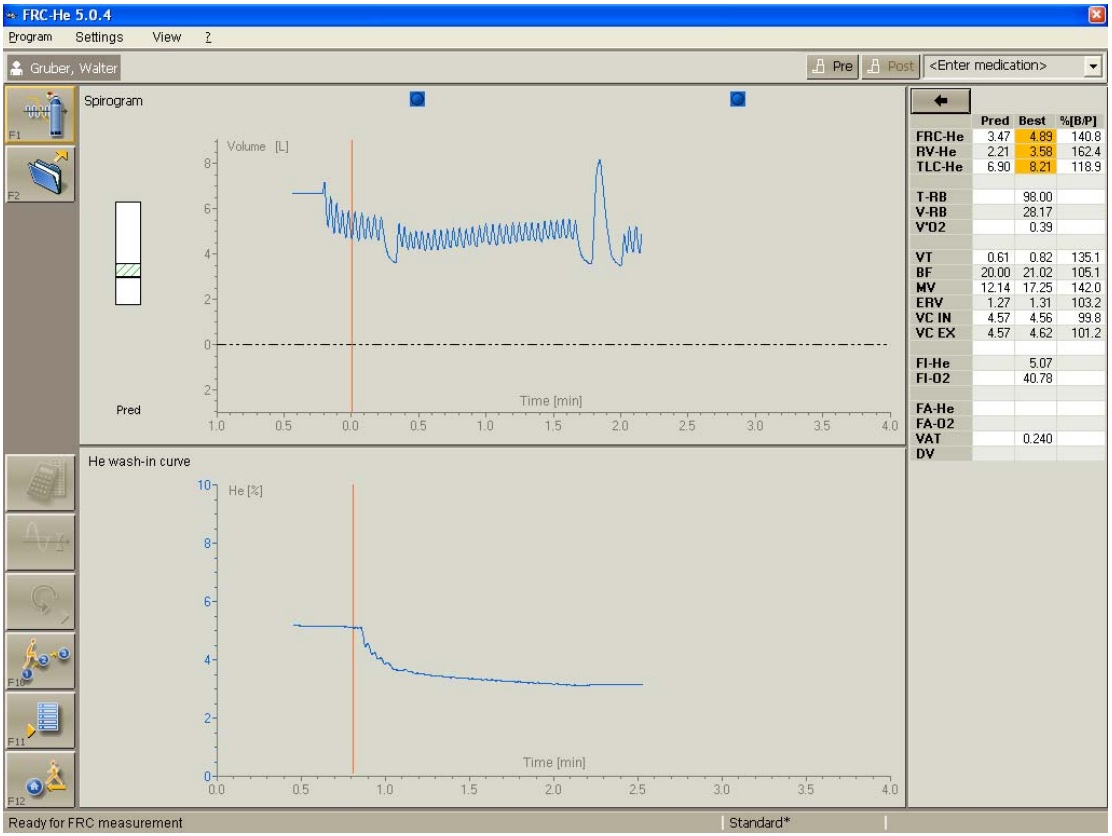
Start with **"F2"**.



Ask the patient to breathe out deeply and completely (ERV), slowly to inhale to a maximum (VCIN) and then to continue to breathe normally.

Click **"F7"** to end the FRC-He measurement.

The parameters will be calculated and displayed on the screen with a predicted/actual value comparison.



Please note:

If another trial is to be performed, a pause of about 10 minutes should be kept (in order to wash out He).

ATTENTION

If the measurement is interrupted or ended, the cylinder valve is to be closed.

Modification

After the measurement the parameters TLC, FRC, ERV, ... can be modified manually.

Please note:

It is still possible to modifiy the parameters after storing the measurement and closing the measurement program.

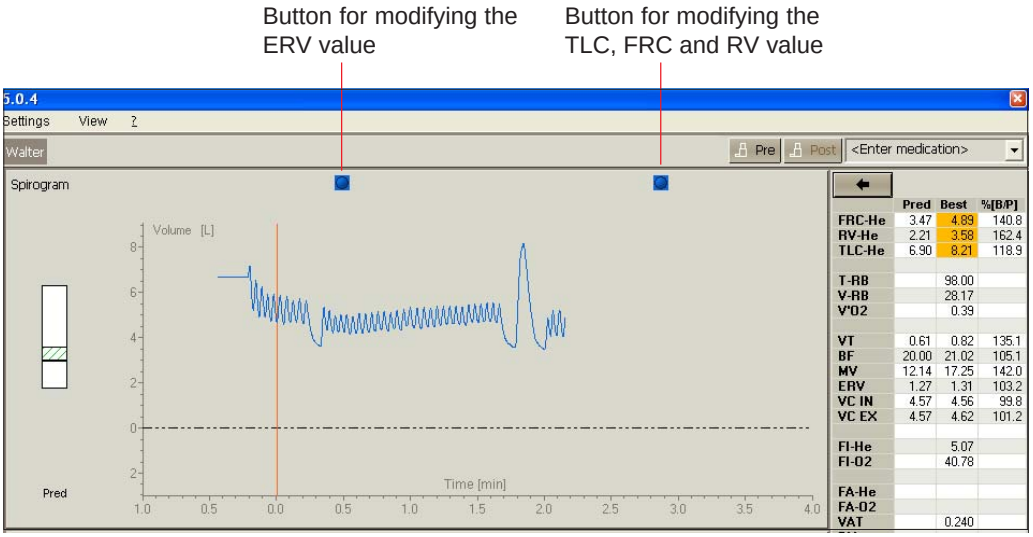
In the measurement program FRC-He Rebreathing any measurement which has been stored completely in the LAB database can be modified.

Proceed as follows:

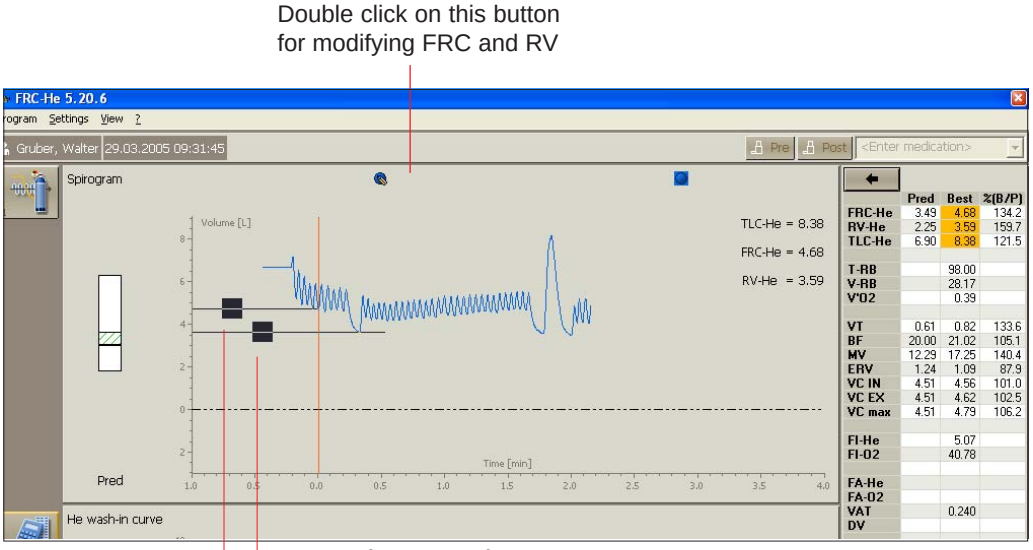
1. Call up the program **"Patient Data"** and load the patient data to be modified.
2. Call up the program **"FRC-He Rebreathing"**.
3. In the command menu **Program** select the entry **"Reanalyse old measurement"** and select the test to be modified in the test list displayed.

OK

Confirm by clicking **(OK)**.



Proceed as follows for modifying the ERV or RV value during the wash-in phase:



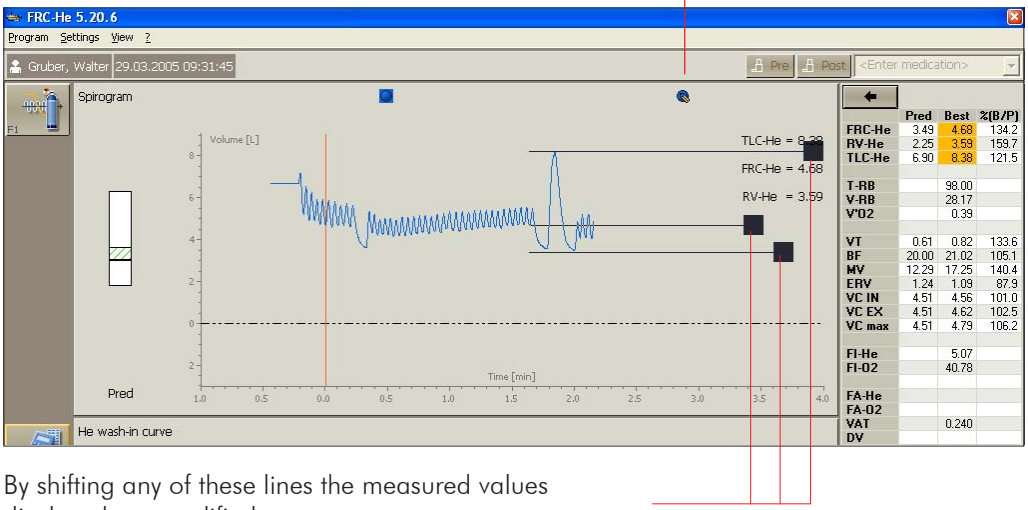
By shifting any of these lines the measured values displayed are modified.

If the **FRC** line is shifted, the FRC value displayed is modified together with all parameters depending on it.

If the **RV** line is shifted, the RV value displayed is modified together with all parameters depending on it.

Proceed as follows for modifying the TLC, FRC and RV value during the wash-in phase:

Double click on this button for modifying TLC, FRC and RV



By shifting any of these lines the measured values displayed are modified.

If the **TLC** line is shifted, the VCmax value displayed is modified together with all parameters depending on it.

If the **FRC** line is shifted, the dFRC and the dERV value displayed are modified.

If the **RV** line is shifted, the VCmax value and the dERV value are modified.

Conglomerate Parameters

If a **spirometry** measurement has already been performed before the **FRC-He** measurement, the program allows to use parameters from both measurement programs.

Proceed as follows:

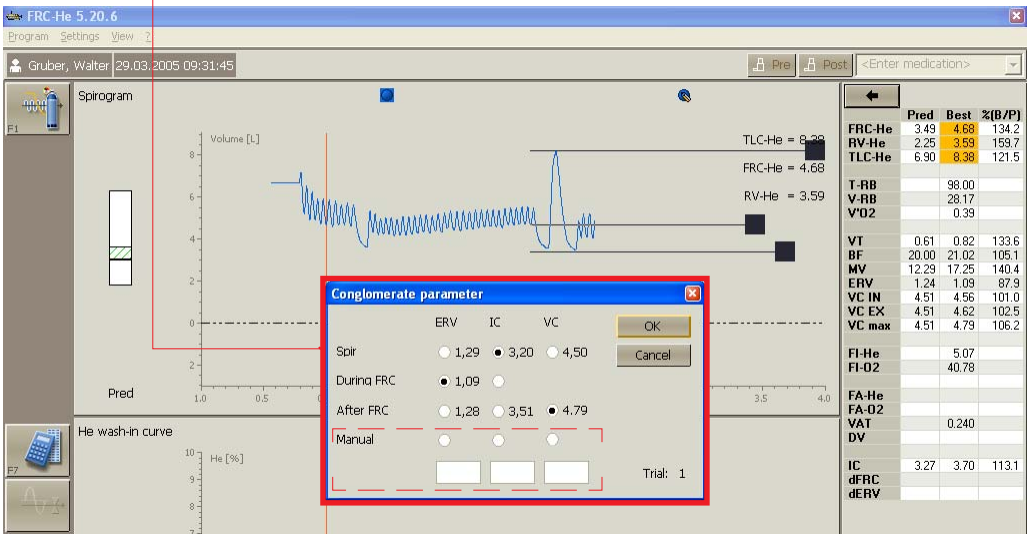
In the command menu **Program** select the entry "Conglomerate Parameter" (only selectable in the "Modification" mode, see fig. below).

The following window will be displayed:

Spir means: Parameters from spirometry measurement

During FRC means: Parameters from the FRC-He wash-in phase

After FRC means: Parameters from FRC



Manual means: The value to be entered manually is accpeted.

OK

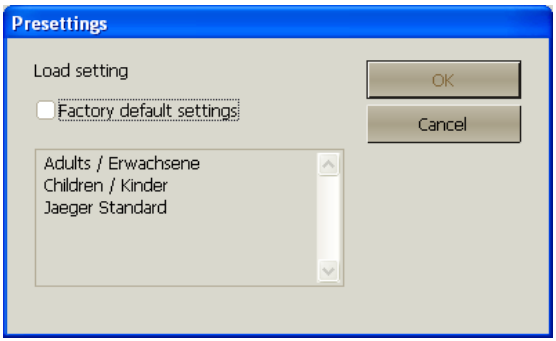
By clicking **(OK)** the marked values or the values which have been entered manually are displayed in the parameter window.

Modify Default Settings

The measurement program **"FRC-He RB"** allows specific setting modules for different patient groups (for example children, adults, ...) to be generated, saved under a specific name and loaded before starting the measurement.

In order to generate setting modules or change existing modules, the menu item **"Modify settings"** in the command menu **Program** is to be activated. A tick in front of the menu item indicates its activation.

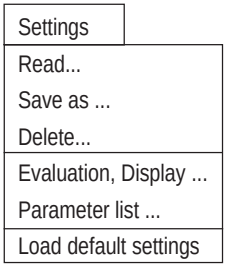
If an existing setting module is to be modified, click the item **"Read..."** in the command menu **Settings**.



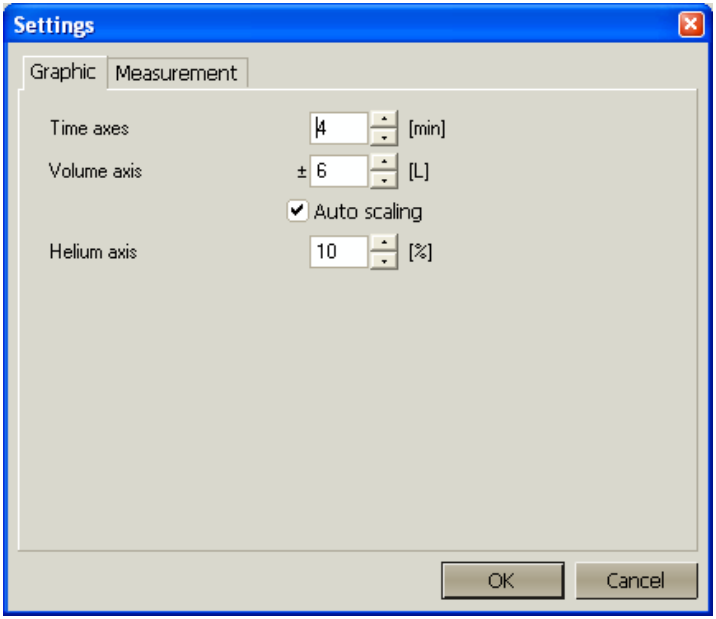
OK (**OK**) and the marked module will be loaded.

Click **Settings** again and the default settings can be changed.

Description of Settings



Select **"Evaluation, Display..."** in the **Settings** command menu.



The settings can be found and changed in so-called "file-cards".

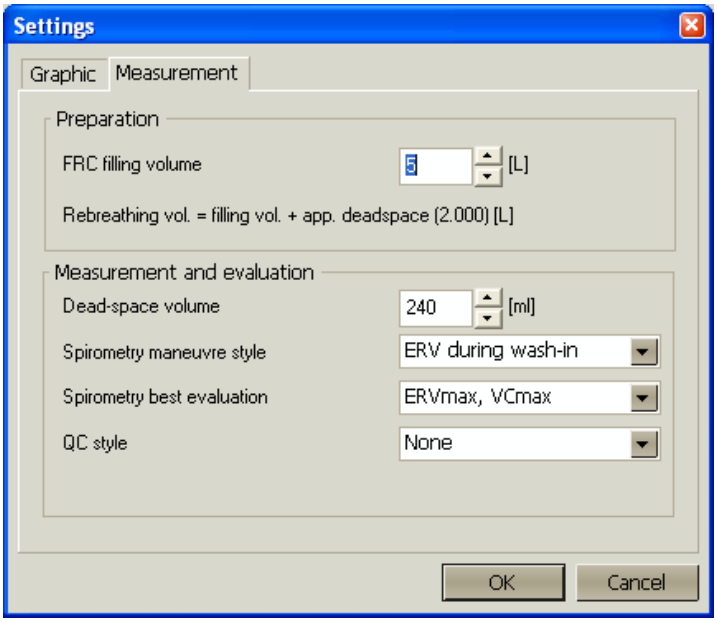
File card "Graphic"

In **"Axis scaling"** the scaling of the volume-, time- and helium axis can be changed.

Presetting:	Time axis	4 min
	Volume axis	6 L
	Helium axis	8 %

☒ If **"Auto scaling"** is selected and the breathing volume is greater than the preset volume axis, the volume axis will be rescaled automatically.

File card "Measurement":



The FRC filling volume can be changed in **"Preparation".**

In case of a FRC measurement, the rebreathing bag will automatically be set to the preset filling volume as soon as the program is started.

Presetting: 5 liters.

If measurements are performed on children, a filling volume of, for example, 3 liters (depending on patient's height) should be set.

In **"Measurement and evaluation"** the following can be set:

Deadspace volume:

If the apparative deadspace is changed, for example for measurements with a preset bacteria filter, the volume of the filter (about 50 ml) will have to be added.

Deadspace volume plus filter = 180 ml

Preset deadspace volume = 130 ml

Spirometry manouvre style:

The parameter ERV can either be determined **"ERV during the wash-in"** or **"at the end of the measurement".** We recommend to determine the ERV during the wash-in phase.

Spirometry best evaluation:

The criteria for calculating the best spirometry measurement are preset.

Presetting: *ERV Vmax, VCmax*

Quality control criterion

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

none

Mayo

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".

OK (**OK**) accepts the setting.

(**Cancel**) without alteration.

All of the settings can be saved and loaded.

Therefore, you can generate settings for different patient groups (e.g. children, adults, ...), save them under any name and load these settings before starting the measurement.

When the program is started, the name of the presetting appears in the status line. If a presetting has been modified, an asterisk "*" is added.

General Notes on Presetting:

1. Even after a measurement, all presettings for a curve display can be changed.

   Settings which influence the type of evaluation/display can only be changed before starting the measurement.

   Example: The displayed curve is outside the visible range or the curve is too small or too large as compared to the scaling.

2. If the changed settings are not saved with **"Save as ..."** in the command menu **Settings**, the question **"Save settings? Yes/No?"** automatically appears when the program is ended.

   With (**Yes**) the settings are saved as default settings.

Chapter 22

Appendix

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 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.
3	No reproducibility: no valid trial
2	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: 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.

Check Absorber

The CO_2 absorber connected to the analyzer unit has to be checked in regular intervals. The absorber vessel is filled with soda lime which chemically absorbs the CO_2 from the breathing gas.

Please note:

The CO_2 absorption capacity decreases from measurement to measurement. An optical check is only possible, if the Jaeger offered soda lime with colour indicator is used.

Due to this indicator, the soda lime changes its colour from white to violet with increasing absorption. Its absorption capacity is completely exhausted if it has a deep violet colour.

A few minutes after a measurement, soda lime loses its colour again so that you cannot recognize whether its absorption capacity is exhausted.

How many measurements can be performed with one filling and when has the filling material to be exchanged?

About 10 measurements with average wash-in periods of 10 minutes can be performed with one filling.

The absorber material has to be exchanged, if it shows a rich change in colour. A slight or no change in colour indicates a still sufficient absorption capacity.

Absorber material which considerably changed its colour once, should be exchanged immediately after the measurement. We point out that we absolutely advise you against mixing exhausted material with new absorber material.

Handling and Storage of Soda Lime

Storage

Soda lime must be protected from moisture loss. Open vessels result in moisture loss so that they should immediately be closed. Sealed vessels are usable for at least one year. High temperatures in the storeroom have no influence on the material. Temperatures below zero, however, result in a decomposition of the granules.

Filling the Absorber Vessel

It is very important to fill the absorber vessel carefully. Only then is good absorption guaranteed. Filling the absorber vessel is quite easy. Fill the soda lime into the absorber vessel by slowly rotating the vessel at the same time. Tap the absorber vessel on the table so that the granules distribute evenly. The absorber vessel should be filled completely but it should not be overfilled. This procedure ensures a regular distribution of the granules and restricts the dust production to a minimum.

First Aid

Should a person get into contact with soda lime, the affected area is to be rinsed with clear water for a long period of time. If even smallest quantities of soda lime - in solid form or in a solution - get into someone's eyes, his/her eyes have to be douched immediately and carefully for at least 15 minutes.

Swallowing soda lime may cause serious acid burns of the oral mucosa, pharyngeal mucosa, esophagus and gastric mucosa. In such a case, a chemical neutralisation should take place. If available, slightly acidic fluids (diluted vinegar, lemon juice, sour milk, acid wine, 5 % ammonium chloride solution) should be administered in sufficient quantities. If such fluids are not available, the patient should immediately drink a large quantity of water. Mucic substances (such as egg-white) give local relief.

Exchange Soda Lime

Procedure:

1. Remove RB bag.
2. Open both clamping levers of the absorber holder.
3. Pull out the absorber holder (see pictures).
4. Remove filter and exhausted soda lime.
5. Insert new filter in the absorber, fill in new soda lime and cover the soda lime with a second filter.
6. Put in absorber holder and fix it with the clamping levers.