

## Hans Rudolph DLCO Simulator Cal Check

### General:

This is an explanation on how to perform a DLCO simulator calibration check with the EasyOne Pro. The EasyOne Pro does not need and cannot be calibrated:



- The flow measuring technology TruFlow is ultra sound transit time based. Evidence for long term stability is well published and available on [www.ndd.ch](http://www.ndd.ch)
- The He is determined by molar mass measurement MolMass, an absolute measurement
- The CO measurement is of the typical NIR technology utilizing air as a zero and patient gas as the high calibration point. Exclusively with ndd however we apply a MolMass measurement of a gas / air mixture to make a unique non linearity correction

The simulator check is to proof that EasyOne Pro measures according to the only available standard world wide. In situations where other brand systems are being used and a possible difference to ndd may be observed this will clarify the situation.

The precision of the applied gases are very important and we recommend to use gases from Hans Rudolph Kansas City USA to have a full control on the variables:

- Simulator test gases (1, 2 or 3 levels may be used depending on the magnitude of the check)
- DLCO test gas is also a key component and we recommend use of Hans Rudolph gas (then a cross check with locally produced gas may be made)
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EasyOne Pro is the first and so far only equipment that has been developed based on ERS / ATS task force guide line 2005 and with the Hans Rudolph simulator.

For calibration check of any equipment other than ndd EasyOne Pro refer to the respective manufacturer's recommendations and follow their guidelines or the ones of Hans Rudolph. ndd has no responsibility, no expertise nor do we offer any comments or suggestions on any results of such testing.

This application note is to help you determine that **EasyOne Pro measures accurately** and that the **test gas** you use is indeed of a **correct concentration** (He and CO).

What O<sub>2</sub>-concentration you should be using at what altitude levels **is not** part of cal check procedure. In case of ndd EasyOne you may use O<sub>2</sub> concentrations between 18 and 25%.

## Preparing the Device for the Measurement:

1. Setup EasyOne Pro (Details see Appendix 1) (including standard DLCO gas connection)
2. Start device
3. Setup DLCO simulator (Details see Appendix 2) (including simulator test gases)
4. Connect handle sensor to the simulator (spirette inserted)
5. Mount DLCO valve on handle sensor (including 1-way-valve and barriette)
6. Navigate to Utilities/Configuration/
  - a. Test/DLCO: Enter the correct gas concentrations:  
Gas concentration Test-Gas (CO, HE, O<sub>2</sub>) and simulator Test-Gas CO<sub>2</sub> (CO<sub>2</sub>, O<sub>2</sub>) (Details see bottle tag)  
(n d d recommends at least **one** test gas)
  - b. Test/DLCO: The following parameters have to be selected

VCin (btps)	STPD	Amb. Temp.	Amb. Press.	BHT	FA He	FI CO	FE CO	VA (btps)	DLCO
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7. Setup EasyOne Pro with appropriate parameter for the n d d analysing tool (Details see Appendix 3)

## Preparing the Analyzing Tool (Details see Appendix 4):

Download Analyzing Tool:

[http://www.ndd.ch/UserData/Download\\_01850\\_00.xls](http://www.ndd.ch/UserData/Download_01850_00.xls)

## Preparing the DLCO Simulator:

The standard DLCO simulator test is done with **3 measurements per simulator test gas** (1300ppm CO, 1000ppm CO and 800ppm CO). A detailed description how to use the simulator can be found in the according documentation from Hans Rudolf which is the manufacturer of the simulator.

8. Empty large syringe completely before each trial: Loosen the adjustable locking collar and make several strokes to flush the syringe
9. Set the adjustable locking collar properly to the 4 liter mark and position the syringe to approx 1 liter
10. Set the gas selection (three pronged valve) to position "inspiratory volume syringe"
11. Flush the system with approx 300 ml of simulator test gas 2 times (fill and empty syringe)
12. Fill the small syringe with the according simulator test gas with minimal 2 liters. Attention: Do not fill it over 2.3 liters!

## Performing the DLCO Simulator Test:

1. Select: **Utilities/Check Calibration/Simulator Cal Check**
2. Press *Start* to add a new trial and follow on-screen instructions until prompted for *Tidal Breathing*
3. Start tidal breathing with the syringe for about 4 strokes
4. Press *Activate* during the full exhalation
5. Move the syringe until locking collar at the 4 liter mark is hit
6. The valve closes automatically
7. As soon as the valve closes, completely inhale (4 liters)
8. During the 10 second breath hold switch the gas selection (three pronged valve) to position "standardized gas syringe"
9. As soon as the valve opens again, completely exhale with the small syringe
10. After the full exhalation end the test with a small inhalation
11. Check the result message and the calculated parameters

## Analyze Test Result:

1. Copy the required parameter values to the prepared excel sheet<sup>1</sup>
2. Download
3. Repeat procedure as required for a complete test cycle
4. Analyze the detail results and check if the simulator test has passed

## Remarks:

- Check always that sensor is mounted correctly with simulator, that spirette and barriette and one way valve are mounted correctly
- Check signal during breath hold to assure a tight system (the CO signal drop during breath hold should be below 200ppm)
- Always close simulator gas bottles at the end of a test session

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<sup>1</sup>As prepared in Appendix 4

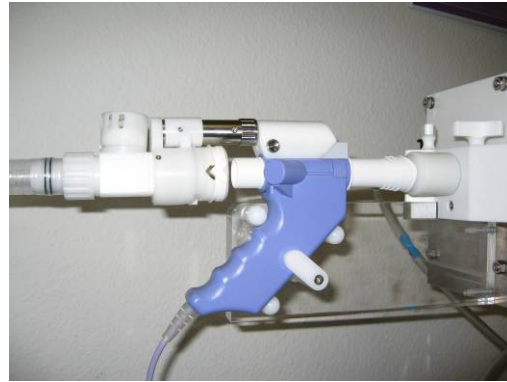
## Appendix 1

### Adapter Flowsensor → DLCO Simulator

To provide a proper connection a special ndd Flowsensor Adapter is used



ndd Flowsensor Adapter



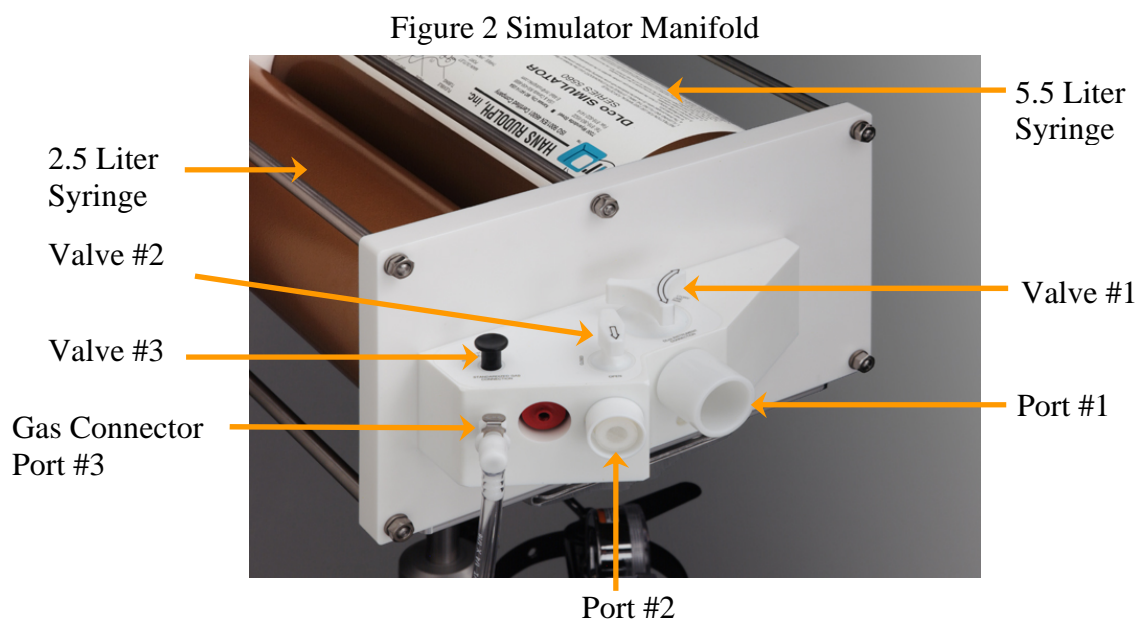
ndd Flowsensor attached

## Appendix 2

Based on Hans Rudolph inc. DLco Simulator Syringes Manual

### A. Simulator Syringe configuration

The DLco simulator (Figure 2) consists of two syringes mounted on a single platform with connecting valves. There are three ports and three valves on the manifold located at the front of the simulator. The valves are on top of the manifold and the ports are on the front of the manifold.



### Syringes

- 1) A large (5.5 liter) syringe used only to simulate a subject's inhalation from the DLco system being tested. The inhaled volume (VI) can be varied to create different DLco target values.
- 2) A smaller (2.5 liter) syringe is used to deliver the simulated alveolar ("standardized") gas (*Primary Plus®*) into the DLco system being tested.

### Ports

#1) A larger diameter white port located in the center of the faceplate. This port is used to connect the simulator to the DLco device being tested. This port is threaded onto the manifold and can easily be removed to install a port that close couples to your equipment to minimize dead space. Contact Hans Rudolph for special size outlets ports.

#2) A smaller white port is just to the left of port #1 (left as you are facing the manifold). This port has a one way valve that allows gas in the smaller syringe to be vented but does not allow entry of room air.

#3) A small quick connect gas connector is located to the left of the gas port; just above this connector is a label "Standardized Gas Connection." The compressed gas (*Primary Plus®*) containing the alveolar sample will be connected here and used to flush and fill the small syringe with simulated alveolar sample gas.

**Valves** (All are located on top of the manifold):

#1) A large, three pronged valve with a curved arrow on it. The arrow indicates the connections. When the valve is turned counterclockwise until it stops, the arrow will indicate a connection between the large syringe and the main port (Port #1). When it is turned fully clockwise, the arrow will indicate a connection between the small syringe and the main port (Port #1).

#2) A small two pronged valve is located just to the left of the three pronged valve. It has a single arrow indicating the direction of the valve connection to positions labeled as "open" (connecting the small syringe to the one way valved port, port #2) or "closed" (closing the connection between the small syringe and port #2).

#3) A black button to the far left of the other two valves. When the alveolar gas source (*Primary Plus®*) is connected to the quick connect gas connector, pressing this valve will allow gas to flow into the small syringe.

## B. Operation of the Simulator Syringes.

Practice operating the valves until you are familiar with all connections.

Step 1. Fill the small syringe with the simulated alveolar *Primary Plus®* gas.

- a. Turn the three-pronged valve to the far counter clockwise position (arrow points from the large syringe to the main port (Port #1)).
- b. Connect the gas cylinder containing the simulated alveolar gas cylinder to the gas port using a standardized gas connector.
- c. Turn the two-pronged valve so the arrow points to open.
- d. Empty the small syringe by pushing the handle all the way to the forward position. Turn the two-pronged valve to the closed position.
- e. Push down the black button long enough to allow 500-600 ml of "alveolar" *Primary Plus®* gas to enter the small syringe. You can watch the numbers on the syringe plunger to see the volume.
- f. Flush the syringe by turning the two-pronged valve to the open position and pushing the small syringe handle to the full forward position.
- g. When the small syringe is empty, quickly turn the two-pronged valve to the closed position and repeat steps e and f until you have flushed the small syringe two times. Then push the black button down and fill the small syringe to approximately the **two-liter mark**. **Do not overfill and pressurize the small syringe.** If you

overflow and pressurize the 2.5 liter cylinder, release the black button, quickly turn the two-prong valve to the "open" position. There is a pressure relief safety valve mounted in communication with the 2.5 liter syringe. When you have finished you will have flushed the syringe and left it nearly full of the simulated alveolar gas.

Step 2. Connect the simulator to the DLco device being tested.

- a. Before making the connections, make sure the syringe volume on the large syringe is set to the proper volume (VI). The white line just distal to the desired volume should just be visible. Set the white locking collar edge (close to syringe) as close to the center of the white graduation line on the piston rod as is visually possible.
- b. Make sure your DLco instrument is properly calibrated and ready for a test to be performed.
- c. Move the large syringe piston to a middle position if your DLco device requires tidal breathing prior to the inhalation of test gas. If tidal breathing is not required, move the piston to the far forward position where the locking collar on the piston rod touches the syringe end plate.
- d. Adjust the height of the simulator until port #1 on the simulator is parallel to the instruments mouthpiece connector. Connect simulator port #1 to the DLco device with the smallest possible connecting tubing (to minimize the needed washout volume). Use straight, not corrugated, tubing. Special size parts are available at Hans Rudolph to mate the simulator directly to your DLco system with minimum dead space.

Step 3. Perform the testing maneuvers.

- a. The three pronged valve should still be in the far counter clockwise position with the arrow indicating connection from the large syringe to the main port (Port #1).
- b. Initiate a DLco test in the device being tested.
- c. If required, simulate tidal breathing by moving the large syringe piston backward and forward about 500 ml per stroke. It might be useful to watch the volume on the simulator syringe volume indicator. End with the piston in the far forward position (completely empty) when coaching typically would encourage a patient to exhale maximally.
- d. When the DLco device indicates that it is time to inhale the test gas, pull the large syringe piston to its full position, simulating the inhalation of the test gas. The piston must move completely from the empty position to the full position to ensure the inhaled gas volume is known. The test gas should be inhaled in 2-4 seconds.
- e. During the ten-second breath-hold, move your right hand to the handle on the small piston. Place your left hand on the three-pronged valve and prepare mentally to turn it clockwise.

Maintain some contact with the simulator to stabilize and prevent movement when you perform step f.

- f. Just as the ten second time for exhalation arrives, turn the three pronged valve to the full clockwise position (connecting the small syringe to the main port, port #1) and smoothly push the small syringe position to the forward position. The simulated exhalation should be smooth and take about one second. The maneuvers for the simulated test are complete.

Step 4. Enter the test results into ndd analysing tool

1. Make sure the device being tested has completed its testing and computing cycles.
2. Print a report for your QC files.
3. Enter the proper final numbers into the simulator software. The following pieces of information from the DLco instrument must be entered into the EasyLab QC software to allow creation of the comparison chart:
  - a. Breath-hold time
  - b. Measured DLco
  - c. Measured VA
  - d. Measured VI
  - e. Measured [CO] %
  - f. Measured [Tracer Gas]%

# Appendix 3

How to select appropriate parameter for the ndd analysing tool

## 1. Utilities



## 2. Configuration



## 3. Select DLCO Tab

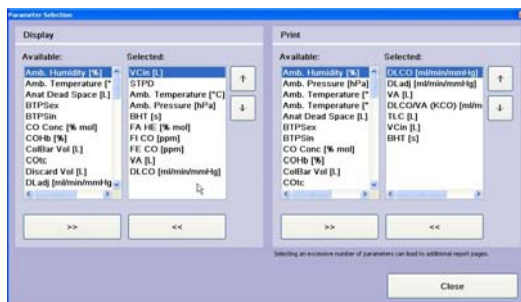


## 4. Press Select

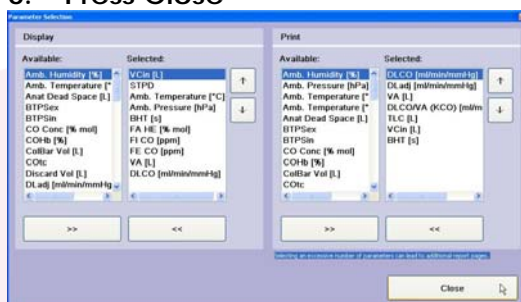


## 5. Choose Parameter as shown:

VCin (btps)	STPD	Amb. Temp.	Amb. Press.	BHT	FA He	FI CO	FE CO	VA (btps)	DLCO
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## 6. Press Close



## 7. Press OK





## Appendix 4

1. Prepare the ndd analysis excel sheet (on a PC/Laptop) and enter the following values into the required cells:

2. Select Test Typ

Select Test Type:

Full Simulator Test with  
3 Calibration Check Gases  
(Standard Test)

Simulator Test with  
2 Calibration Check Gases

Simulator Test with  
1 Calibration Check Gas

3. Enter:

a. Serial number/Test date

<b>SN:</b>	
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b. Simulator test gas at least one of three(as per test report on gas bottle)

Gas #	He%	CO%	O2%	CO2%
<b>Gas 1</b>	7.20	0.080	17.00	5.00
<b>Gas 2</b>	6.50	0.100	17.00	5.00
<b>Gas 3</b>	5.30	0.130	17.00	5.00

c. DLCO test gas (as per test report on gas bottle)

System Parameters	
<b>Vd (instrument + Anatom.)</b>	0.200
<b>FiTr (Inspiratory tracer)</b>	10.000
<b>FiCO (inspiratory CO)</b>	0.300

d. Syringe volume:

<b>VI</b>	4.00
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4. Enter Test results in the blank cells

EasyOne Pro DLCO Simulator Tests															SN: <input style="width: 100px;" type="text"/>																														
Test date: <span style="color: red;">Enter Date</span>										Preferably use of 1% accuracy gas mixtures																																			
<table border="1" style="width: 100%; font-size: x-small;"> <tr><th>Gas #</th><th>He%</th><th>CO%</th><th>O2%</th><th>CO2%</th></tr> <tr><td>Gas 1</td><td>7.20</td><td>0.080</td><td>17.00</td><td>5.00</td></tr> <tr><td>Gas 2</td><td>6.50</td><td>0.100</td><td>17.00</td><td>5.00</td></tr> <tr><td>Gas 3</td><td>5.30</td><td>0.130</td><td>17.00</td><td>5.00</td></tr> </table>					Gas #	He%	CO%	O2%	CO2%	Gas 1	7.20	0.080	17.00	5.00	Gas 2	6.50	0.100	17.00	5.00	Gas 3	5.30	0.130	17.00	5.00	<table border="1" style="width: 100%; font-size: x-small;"> <tr><th colspan="2">System Parameters</th></tr> <tr><td>Vd (instrument + Anatom.)</td><td>0.200</td></tr> <tr><td>FiTr (Inspiratory tracer)</td><td>10.000</td></tr> <tr><td>FiCO (inspiratory CO)</td><td>0.300</td></tr> </table>					System Parameters		Vd (instrument + Anatom.)	0.200	FiTr (Inspiratory tracer)	10.000	FiCO (inspiratory CO)	0.300	VI: 4.00							
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Name	Gas	VI	He Con	CO Con	Theory DLCO	VA (btps)	Measured Data from EasyOnePro										Difference to Theory																												
Test 1	1	4.00	7.20	0.08	#DIV/0!	-0.278	VA (btps)	STPD	Amb. Temp.	Press	BHT	FA He	FI CO	FE CO	VA (btps)	DLCO	DLCO Diff	% Diff	Pass/Fail																										
Test 2	1	4.00	7.20	0.08	#DIV/0!	-0.278																																							
Test 3	1	4.00	7.20	0.08	#DIV/0!	-0.278																																							
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StdDev					###	0.0	###	###	###	###	###	###	###	###	###	###	###	###	###	###																									
Test 4	2	4.00	6.50	0.10	#DIV/0!	-0.308																																							
Test 5	2	4.00	6.50	0.10	#DIV/0!	-0.308																																							
Test 6	2	4.00	6.50	0.10	#DIV/0!	-0.308																																							
Mean					###	-0.3	###	###	###	###	###	###	###	###	###	###	###	###	###	###																									
StdDev					###	0.0	###	###	###	###	###	###	###	###	###	###	###	###	###	###																									
Test 7	3	4.00	5.30	0.13	#DIV/0!	-0.377																																							
Test 8	3	4.00	5.30	0.13	#DIV/0!	-0.377																																							
Test 9	3	4.00	5.30	0.13	#DIV/0!	-0.377																																							
Mean					###	-0.4	###	###	###	###	###	###	###	###	###	###	###	###	###	###																									
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															Mean StdDev of all: ###																														
<table border="1" style="width: 100%; font-size: x-small;"> <tr><th colspan="3">Acceptability</th></tr> <tr><td>Mean DLCO values within +/-</td><td>15</td><td>(DLCO units)</td><td>#DIV/0!</td></tr> <tr><td>Maximal DLCO standard deviation</td><td>10</td><td>(DLCO units)</td><td>#DIV/0!</td></tr> <tr><td>Mean FE CO within +/-</td><td>15.0</td><td>(ppm)</td><td>#DIV/0!</td></tr> <tr><td>Maximal FE CO standard deviation</td><td>10.0</td><td>(ppm)</td><td>#DIV/0!</td></tr> <tr><td>Mean FA He within +/-</td><td>0.15</td><td>(ppm)</td><td>#DIV/0!</td></tr> <tr><td>Maximal FA He standard deviation</td><td>0.10</td><td>(ppm)</td><td>#DIV/0!</td></tr> <tr><td>Mean Volume error within +/-</td><td>3.5%</td><td>(%)</td><td>#DIV/0!</td></tr> </table>															Acceptability			Mean DLCO values within +/-	15	(DLCO units)	#DIV/0!	Maximal DLCO standard deviation	10	(DLCO units)	#DIV/0!	Mean FE CO within +/-	15.0	(ppm)	#DIV/0!	Maximal FE CO standard deviation	10.0	(ppm)	#DIV/0!	Mean FA He within +/-	0.15	(ppm)	#DIV/0!	Maximal FA He standard deviation	0.10	(ppm)	#DIV/0!	Mean Volume error within +/-	3.5%	(%)	#DIV/0!
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