CLIMATE SOLUTIONS CONSULTING

HAPEx Pro CAL: user guide

HAPEx Pro CAL checks your HAPEx Pro sensors against three reference sensors that you keep for that purpose, and calibrates the ones that have drifted. For each sensor it tells you PASS or FAIL, stores a correction in the sensor, and writes a calibration certificate.

This guide takes you from an unopened box to a calibrated fleet.

In short

1. Choose three reference sensors and keep them out of the field (once).
2. Install the tool and tell it which sensors are your references (once).
3. Run a calibration with up to 20 sensors in the smoke chamber.
4. Open the recording in the tool: each sensor is PASS or FAIL.
5. Plug each sensor in and press `Send USER calibration`.
6. Record again to confirm.

What you need

Item	Details
HAPEx Pro sensors	Firmware 2.5.0 or later.
Three reference HAPEx Pro	See step 1
A Launcher	Firmware 8.27
A smoke chamber	A closed box that holds all the sensors and the three references at once, with a small fan inside to mix the air, and a smoke source such as an incense stick
A Windows computer	With the tool, and the USB cable of the sensors

What a calibration does, and what it does not

A calibration makes a sensor agree with your reference sensors, from 1,000 to 40,000 µg/m³. After it, all your sensors report the same value for the same smoke, within a few percent.

It does **not** make them an absolute mass measurement. The reference is three HAPEx Pro sensors, not a filter weighed on a balance. Everything rests on those three sensors, which is why step 1 matters most.

Step 1. Choose your three reference sensors

Do this once, before anything else.

Why three. The reference is the average of the three. If one of them changes, it stops agreeing with the other two, and the tool tells you. With a single reference you would never know.

Which ones. Take them from sensors that are new and have never been in the field.

1. Record all the candidate sensors together in the chamber (step 3 explains how).
2. Open the recording in the tool (step 4).
3. In `Settings...`, type the serial numbers of three candidates as reference units.
4. Look at the three rows marked REFERENCE. Each shows how far that sensor is from the average of the three.
5. Try other groups of three. Keep the group whose three rows are the smallest: every figure within about ±3 %.

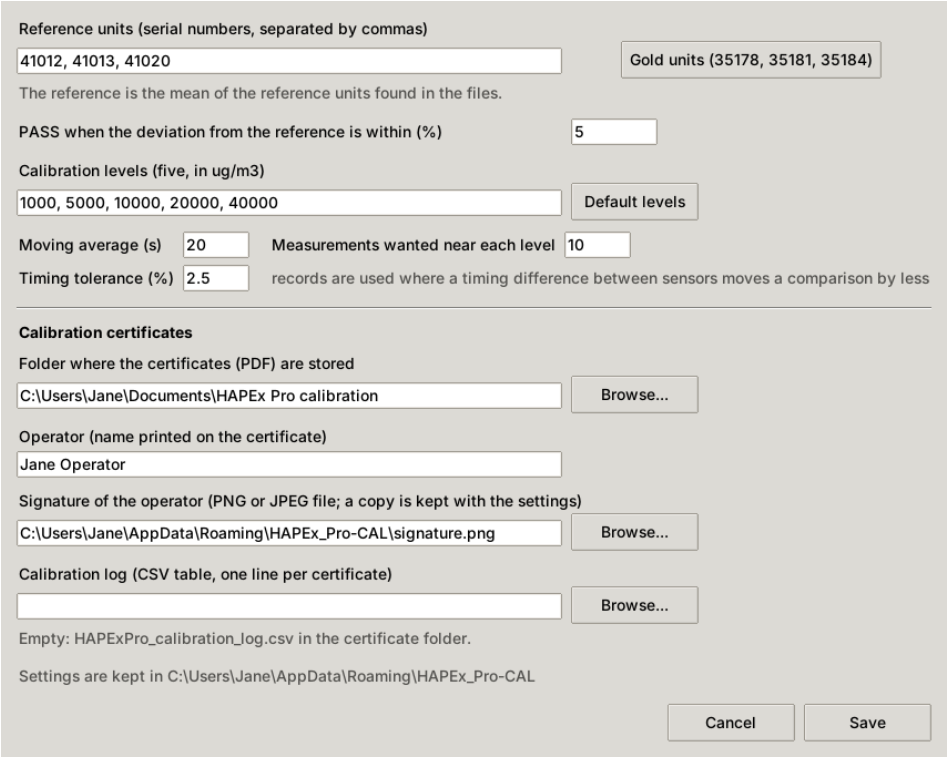
How to keep them.

- Mark them clearly as REFERENCE. Write their serial numbers down.
- **They never go in the field.** A sensor that has spent months in kitchen smoke is no longer a reference.
- Store them clean, in a closed box.
- **Never send them a calibration.** The tool refuses to. They keep the calibration they were delivered with.
- Put all three in the chamber at every session.

If the tool says a reference unit differs from the reference mean: one of the three has moved. Do not calibrate from that session. Find which one disagrees with the other two, replace it with a new sensor, and choose the group again as above.

Step 2. Install the tool and set it up

1. Download `HAPExProCAL.exe` from Climate Solutions website and double-click it. There is nothing to install. The first time, Windows may show “Windows protected your PC”: click `More info`, then `Run anyway`.
2. Click `Settings...` and fill in:



The settings

Setting	What to enter
Reference units	The serial numbers of **your** three reference sensors, separated by commas. The tool comes with the manufacturer's own reference units: replace them
PASS when the deviation is within	The limit you accept, in percent. 10% is the usual value
Folder of the certificates	Where the certificates are saved. If you leave it empty they go to `HAPEx Pro calibration` in your Documents
Operator	The name printed on each certificate
Signature	A picture of the operator's signature (PNG or JPEG)

Leave the other settings as they are. The tool remembers everything for next time.

Every button and every field explains itself: rest the pointer on it for a moment. The `Help` button opens this guide.

Step 3. Record a session in the chamber

A session is one recording of all the sensors together. The quality of the calibration is decided here.

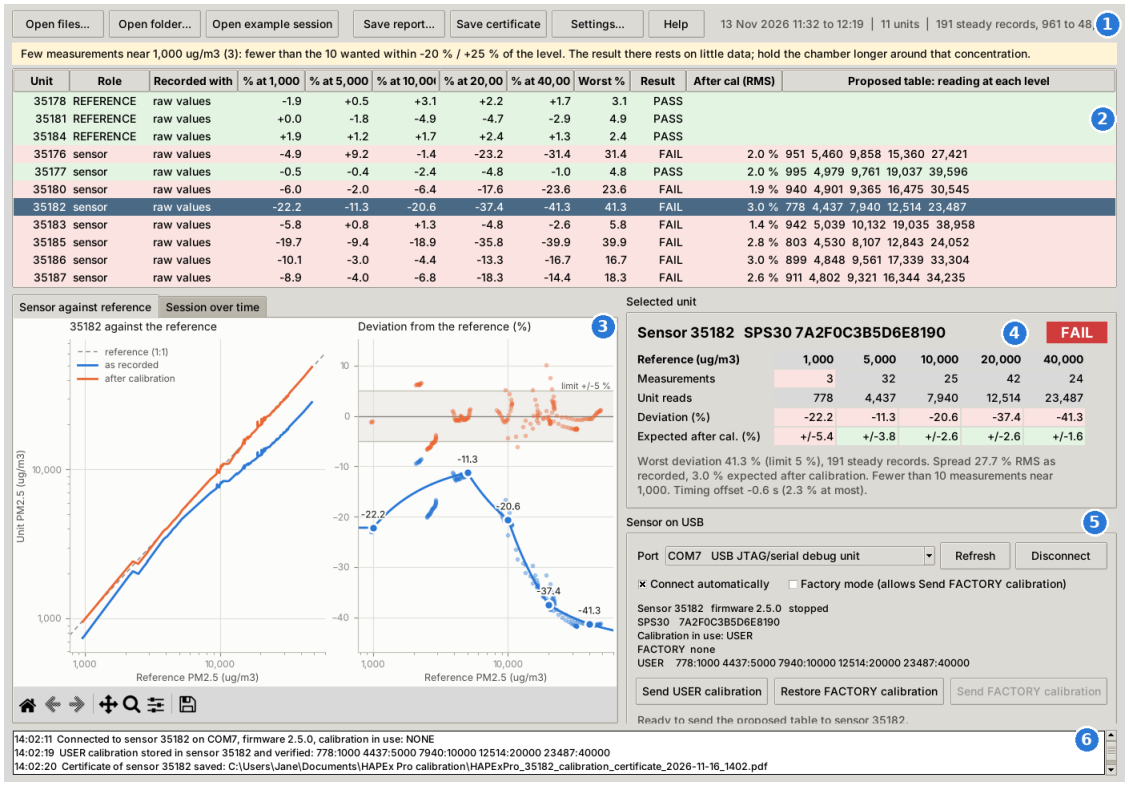
1. **Put everything in the chamber:** the sensors to check and the three references. Switch the mixing fan on.
2. **Start all the sensors with the Launcher,** in continuous mode, logging every 4 seconds.
3. **Make smoke** until the concentration is above 40,000 µg/m³, then take the smoke source out or put it out.
4. **Hold** for two minutes with the lid closed.
5. **Let the concentration fall slowly,** down to about 100 µg/m³. Slowly means that it halves in four minutes or more; the whole fall then takes about twenty minutes. If your chamber is airtight, open a very small gap.
6. **Do not touch or move the sensors** during the session.

7. **Stop the sensors and download them all** with the Launcher. You get one file per sensor.

Why slowly: the tool only uses moments when the concentration is steady or changing gently, because the sensors do not all measure at the same instant. A fall that is too fast leaves it too few measurements.

Step 4. Open the session and read the result

Click `Open files...` and select all the files of the session, the three references included. Or `Open folder...` if they are alone in a folder.



The window

No.	Area	What it shows
1	Buttons	Open a session, save a report or a certificate, settings, help
2	The units	One row per sensor. Green: PASS. Red: FAIL
3	Charts	The selected sensor against the reference: as recorded in blue, after calibration in orange. The grey band is the limit
4	Selected unit	The figures of the sensor you clicked
5	Sensor on USB	The sensor plugged into the computer, and the buttons to calibrate it
6	Log	What the tool did

Reading a row. The five columns `% at 1,000` to `% at 40,000` give how far the sensor is from the reference at each concentration. −20 means it reads 20 % too low. The sensor is PASS when all five are within your limit.

Check before you go on:

- **A yellow band at the top** lists things to check. Read it.
- **The three REFERENCE rows are PASS.** If not, see step 1.

- **The row `Measurements`** of the selected unit has no red cell. A red cell means too few measurements near that concentration: the session fell too fast there, or did not reach it. The result at that level is then uncertain. Record a better session rather than calibrate from this one.

Step 5. Calibrate the sensors

For each sensor that is FAIL (you may calibrate the PASS ones too):

1. **Stop its mission** if it is still recording.
2. **Plug it into the computer** with its USB cable. The tool connects by itself and selects its row.
3. **Click `Send USER calibration`** and confirm.
4. The tool stores the correction, reads it back to check it, saves the certificate and adds a line to the calibration log. It tells you where.
5. **Unplug it** and plug in the next one.

That is all. The sensor now corrects every value it records.

USER and FACTORY. A sensor can hold two calibrations. The FACTORY one is written by the manufacturer. The USER one is yours, and it is the one in use whenever it exists. `Restore FACTORY calibration` erases yours and brings the manufacturer's back. Leave `Factory mode` unticked: it is for the manufacturer.

Step 6. Check

Record a new session with the calibrated sensors and the references, exactly as in step 3, and open it. Every sensor should now be PASS.

Expect agreement within about ±5 %. The references themselves agree with each other only to a few percent, and no check can be finer than that.

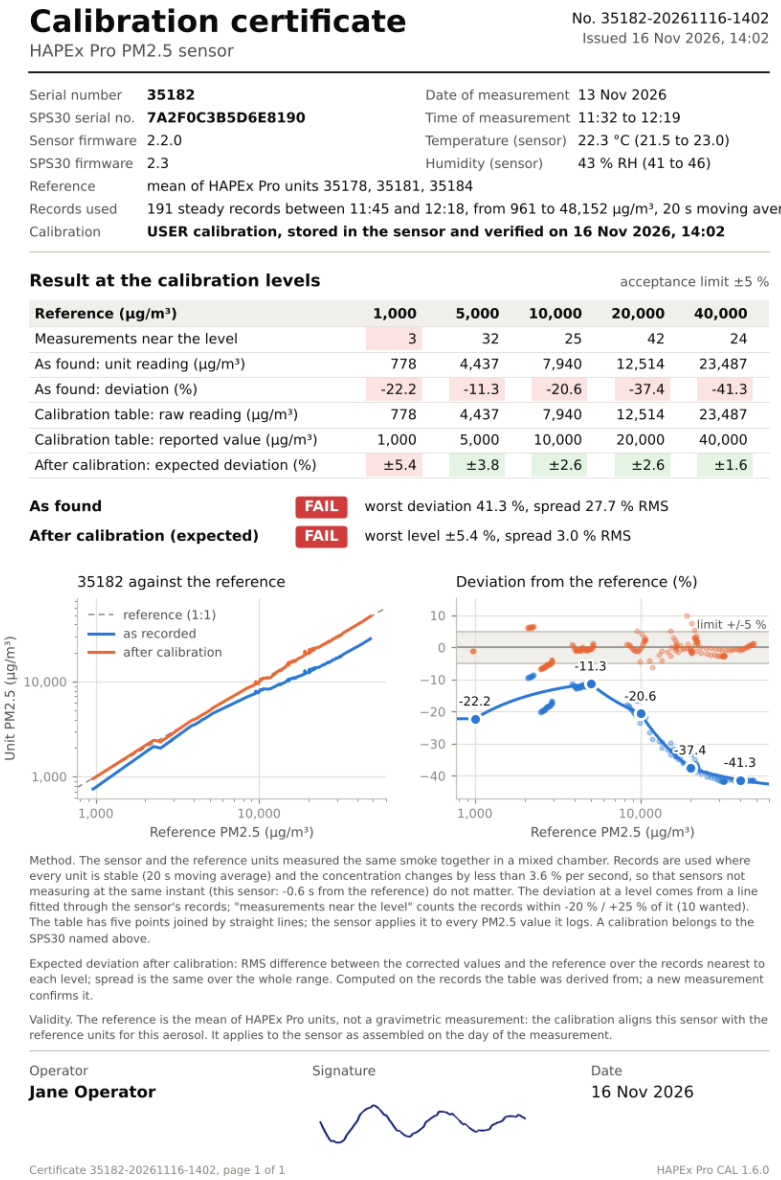
If a sensor is still FAIL, calibrate it again from this new session: the tool knows what is already in the sensor and accounts for it.

When to calibrate again

- When a check session shows a sensor FAIL.
- After a sensor has been opened or repaired, or its particle sensor replaced. The tool warns you when it sees that the particle sensor inside is not the one that was calibrated.
- At the interval your own quality procedure sets, for sensors coming back from the field.

The certificate and the calibration log

Each calibration produces a one-page certificate (PDF) and one line in the calibration log.



Calibration certificate

HAPEx Pro PM2.5 sensor

No. 35182-20261116-1402
Issued 16 Nov 2026, 14:02

Serial number	**35182**	Date of measurement	13 Nov 2026
SPS30 serial no.	**7A2F0C3B5D6E8190**	Time of measurement	11:32 to 12:19
Sensor firmware	2.2.0	Temperature (sensor)	22.3 °C (21.5 to 23.0)
SPS30 firmware	2.3	Humidity (sensor)	43 % RH (41 to 46)
Reference	mean of HAPEx Pro units 35178, 35181, 35184		
Records used	191 steady records between 11:45 and 12:18, from 961 to 48,152 µg/m³, 20 s moving average		
Calibration	**USER calibration, stored in the sensor and verified on 16 Nov 2026, 14:02**		

Result at the calibration levels — acceptance limit ±5 %

Reference (µg/m³)	1,000	5,000	10,000	20,000	40,000
Measurements near the level	3	32	25	42	24
As found: unit reading (µg/m³)	778	4,437	7,940	12,514	23,487
As found: deviation (%)	-22.2	-11.3	-20.6	-37.4	-41.3
Calibration table: raw reading (µg/m³)	778	4,437	7,940	12,514	23,487
Calibration table: reported value (µg/m³)	1,000	5,000	10,000	20,000	40,000
After calibration: expected deviation (%)	±5.4	±3.8	±2.6	±2.6	±1.6

As found FAIL worst deviation 41.3 %, spread 27.7 % RMS

After calibration (expected) FAIL worst level ±5.4 %, spread 3.0 % RMS

Method. The sensor and the reference units measured the same smoke together in a mixed chamber. Records are used where every unit is stable (20 s moving average) and the concentration changes by less than 3.6 % per second, so that sensors not measuring at the same instant (this sensor: -0.6 s from the reference) do not matter. The deviation at a level comes from a line fitted through the sensor's records; "measurements near the level" counts the records within -20 % / +25 % of it (10 wanted). The table has five points joined by straight lines; the sensor applies it to every PM2.5 value it logs. A calibration belongs to the SPS30 named above.

Expected deviation after calibration: RMS difference between the corrected values and the reference over the records nearest to each level; spread is the same over the whole range. Computed on the records the table was derived from; a new measurement confirms it.

Validity. The reference is the mean of HAPEx Pro units, not a gravimetric measurement: the calibration aligns this sensor with the reference units for this aerosol. It applies to the sensor as assembled on the day of the measurement.

Operator **Jane Operator** — Signature — Date 16 Nov 2026

Certificate 35182-20261116-1402, page 1 of 1 — HAPEx Pro CAL 1.6.0

A certificate

The certificate shows the sensor and the particle sensor inside it, the date, time, temperature and humidity of the measurement, the reference sensors, the result at each concentration before calibration, the correction stored, the deviation expected after calibration, and the operator's name and signature.

The log is the file `HAPExPro_calibration_log.csv` in the certificate folder. It opens in Excel and holds one line per certificate, with the same figures: your record of every calibration, over time and per sensor. If it is open in Excel when a calibration is made, the tool keeps the line aside and adds it the next time.

`Save certificate` makes the certificate of the selected sensor again at any time.

Messages, and what to do

The tool says	What it means	What to do
None of the reference units is in these files	The files of your references are not selected, or their serial numbers are not in Settings	Select the reference files too. Check the serial numbers in `Settings...`
Reference unit … not in these files	One or two references are missing; the tool goes on with the others	Put all three in every session
Reference unit … differs from the reference mean	A reference no longer agrees with the other two	Do not calibrate. See step 1
Few measurements near …	The session did not stay long enough around that concentration	Record again, falling more slowly
The reference only reached …	The smoke did not go high enough	Record again, above 40,000 µg/m³
Only … steady records	The concentration changed too fast all along, or the sensors were moved	Record again, as in step 3
These files do not overlap in time	The files are not from the same session	Select the files of one session only
Sensors … hold the same data	One download was saved under the wrong sensor	Download those two sensors again
The sensor is recording a mission	A calibration cannot be stored while the sensor records	Stop its mission, then send again
Sensor … is not in the open session	The sensor plugged in was not in the recording that is open	Open the session it was recorded in
Sensor … is a reference unit	You plugged in a reference	Nothing: a reference receives no calibration
… runs firmware …, which has no calibration	The sensor's firmware is too old	Update the sensor to 2.3.0 or later
Sensor … now holds SPS30 …, but its file was recorded with SPS30 …	The particle sensor was replaced after the recording	Record a new session, then calibrate
No HAPEx Pro answered on …	The tool cannot talk to the sensor	Check the cable. Close any other program using the port

Good to know

- **Where things are kept.** Settings and the history of every calibration are in %APPDATA%\HAPEx_Pro-CAL. Copy that folder to move them to another computer.
- **A calibration belongs to the sensor as it is.** If the sensor is opened, or its particle sensor replaced, calibrate it again.
- **It is valid for smoke like the one you used.** Calibrate with a smoke close to what the sensors will measure.
- **Above 40,000 µg/m³** the sensor extends the correction of the last step. Those values are less certain.
- **To try the tool without a sensor:** click `Open example session`.