Pulse - Air Permeability Measurement System

MODEL: BTS-Pulse 2.0

Instruction Manual and Safety Guidelines

Version 6.2

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Contents

1 General Information

Thank you for choosing the Pulse air permeability measurement system, a low pressure Pulse (LPP) technology.

The Pulse 2.0 product includes a variety of features and testing options to allow for the safe and efficient testing of the air leakage characteristics of buildings and enclosures.

This manual provides factory prescribed operation and maintenance procedures for a Pulse 2.0 LPP Unit. The procedures illustrated in this document are only to be performed by competent, authorised personnel. For further information regarding the procedures outlined in this document please contact BTS Ltd before proceeding.

We strongly recommend you read this guide thoroughly before attempting to use the Pulse unit. It is also recommended that you receive approved training prior to the use of this technology.

Support and Manufacturers Details

Pulse is a technology manufactured by Absolute Air & Gas Ltd, and supplied by Build Test Solutions Ltd

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2 Warranty and Supply Information

2.1 Warranty

All Pulse Units are supplied with a 12 month manufacturer's warranty from the date of purchase, when purchased, installed and maintained in accordance with the manufacturers guidelines. Only genuine service parts should be used and no modifications made. For further information please contact BTS Ltd.

2.2 Supply

All Pulse LLP Units, are securely packaged in bespoke strong cardboard boxes for shipping. Upon receipt please check immediately to establish whether damage has occurred to the external packaging and if the damage extends to the Pulse components inside. If there is damage to the unit, contact the relevant supplier immediately and do not attempt to use the product. **Using a damaged Pulse unit can lead to irreparable functional faults or cause serious physical harm.**

3 Important Safety Instructions

This equipment has been designed and manufactured to meet strict international safety standards yet, like any electrical and pressurised apparatus, due care must still be taken by the operator.

For your own safety, when carrying out work using a Pulse LPP unit, all relevant national safety regulations must be complied with relating to pressurised and electrical systems.

3.1 Intended use of Pulse

Pulse is exclusively intended for determining the air leakage and/or background air change rates of buildings and enclosures.

Pulse is portable equipment and must be stored in a dry, stable environment; protected at all times from extreme conditions and weather.

Pulse must be operated only as intended and in accordance with the manual within the constraints of the data on the product information plates located on the air receiver, controller and compressor, respectively.

Any operations that do not comply with those stated on the Pulse rating label will render the warranty void.

3.2 General Safety Information

- This instrument is for professional use only.
- Use only as described in this manual.
- Do not handle plug or instrument with wet hands.
- Read carefully and understand the instructions before using the equipment.
- Do not expose this apparatus to rain or moisture. For indoor use only.
- Do not remove any screws or non-operator accessible covers.
- Do not insert any metallic objects.
- Do not allow liquid to spill into cabinet openings. Resting drinks or other liquids on top of any of the product components is strongly discouraged and will void warranty.
- Do not allow anything to rest on or strain the power cords or air hose and ensure all cables are routed to prevent damage, accidental contact or trip hazards.
- Do not continue to operate the equipment if you are in any doubt about it working normally, or if it is damaged in any way. Switch off, then withdraw the mains plug and consult your service agent.
- Ensure all parts, including the controller case lid, are securely attached before transporting or carrying the instrument.
- Store the instrument indoors. Do not use or store this instrument below 0ºC (32ºF). Ensure that the instrument is at room temperature before operating.
- Do not unplug by pulling on cable. To unplug, grasp the plug, not the cable
- Do not pull or carry by the power supply or data cables, use cables as a handle, close a door on cables, or pull cables around sharp edges or corners. Do not squash the cables with any of the equipment and keep the cables away from heated surfaces.
- Keep all parts of body away from the air nozzle during use as it can get very cold during and after air release.
- Do not block, or place objects near to, the nozzle: the force produced by air exiting the unit can cause objects to be toppled, or even be projected.
- Take extra care when moving the instrument on stairs. Do not work with the instrument above you on the stairs.
- Keep the air receiver and compressor components on the floor. Do not raise onto chairs, tables etc.
- Do not shake the instrument or expose it to ongoing lengthy vibration.
- Seek manual lifting and handling training before attempting to move this unit. If you are unsure as to your ability to move the unit, do not attempt to. Seek help or procure a lifting aid.
- Do not lubricate any parts or carry out any maintenance or repair work other than that advised in this manual, or as advised by Build Test Solutions Ltd operatives.
- When transporting the unit, ensure the compressor, air receiver and controller are all secured into place.
- No modifications must be made to any part of the Pulse system, any modifications may reduce the operational safety of the unit and invalidate the manufacturer's warranty.

- Ensure that the equipment is depressurised and electrically isolated prior to carrying out any of the scheduled maintenance instructions specified within this user guide.

3.3 External Power Supply – 230v and 110v operation

In the event of a hazard or malfunction, the power should be switched off at the socket before being unplugged from the mains.

The power lead should only be plugged into the air receiver power input socket. Check to ensure your electricity supply matches that shown on the rating plate.

The power supply will provide adequate power for the instrument. The user should ensure that all other auxiliary apparatus, drawing power from the host, does not overload the power supply.

A damaged mains cord should be replaced by the user.

The air receiver and controller operate on a 24v DC supply, managed by a power supply unit built into the air receiver body that accepts a 110/230v universal input. The power to the controller is delivered via power over ethernet (PoE). A relay within the air receiver assembly separately diverts the mains 110/230v supply directly to the compressor via the 'power out' port on the air receiver top plate. In order for the system to safely operate at either a 110 or 230 voltage, the compressor pump motor must be rated to the correct corresponding input voltage. A 230v compressor is supplied with a Pulse 2.0 system as standard but a 110v version of the same compressor is also available upon request.

3.4 Connections

Interconnection to other equipment via the externally accessible ports or wireless connectivity on the instrument must only be made as follows:

Power Supply Input and compressor power output: As described in Section 3.3

USB: A storage device can be used to export test data as per the export protocol detailed in Section 8.3.1. It is strongly suggested that any storage device connected to the Pulse Control Unit is scanned for viruses or, preferably, formatted before use. The Pulse control software may not have sufficient malware protection to prevent the software being altered or deleted by any malware present on an inputted USB device, requiring the unit to be returned to the service provider for repair.

Ethernet: To connect from an air receiver to the controller and/or from an air receiver to an additional auxiliary air receiver. All described in section 7.3.

4 Technical Information

4.1 Technical Specification

	Pulse 2.0
Maximum Operating Pressure	10 Bar / 145 Psi / 1,000 kPa
Operating Voltage	220-240V 50Hz (110v available)
Max Power Consumption	569W, 2.63A (compressor)
Min Operating Temperature	4°C (frost free)
Max Operating Temperature	40°C
Outlet Filtration	5µm (particulate)
Communications	2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE
Storage	8GB (up to 20,000 test files)
External Dimensions	Air receiver: Ø 386 x 900 (H) mm Controller: 305 (L) x 270 (W) x 144 (H) mm Compressor: 350 (L) x 150 (W) x 370 (H) mm
Weight	Air receiver: 14.0kg Controller: 3.0kg Compressor: 16.0kg
Ancillaries Supplied	1x 3m IEC to mains plug cable; 1x 2m IEC compressor power cable; 1x 2m air delivery hose; 1x 4m Controller CAT5e data cable
System Outputs	Air Leakage rate (m^3/h) Air Leakage per hour, Q (m^3/h) Air changes per hour Q (h^-1) Effective Leakage area (m^2) Air Permeability (m^3/m^2h) Achieved Pressure Range (Pa)

4.2 Equipment

The Pulse device comprises the following fundamental components which are supplied by BTS.

4.2.1 Pulse Air Receiver

The Pulse Air Receiver contains:

- 39.8 litre air receiver tank and connections
- Air nozzle silencer for main air release
- Analogue pressure gauge
- Charge port for compressor connection
- Drain valve port (in the base of the unit)
- Absolute pressure and temperature sensor
- Interface panel
- Control PCB

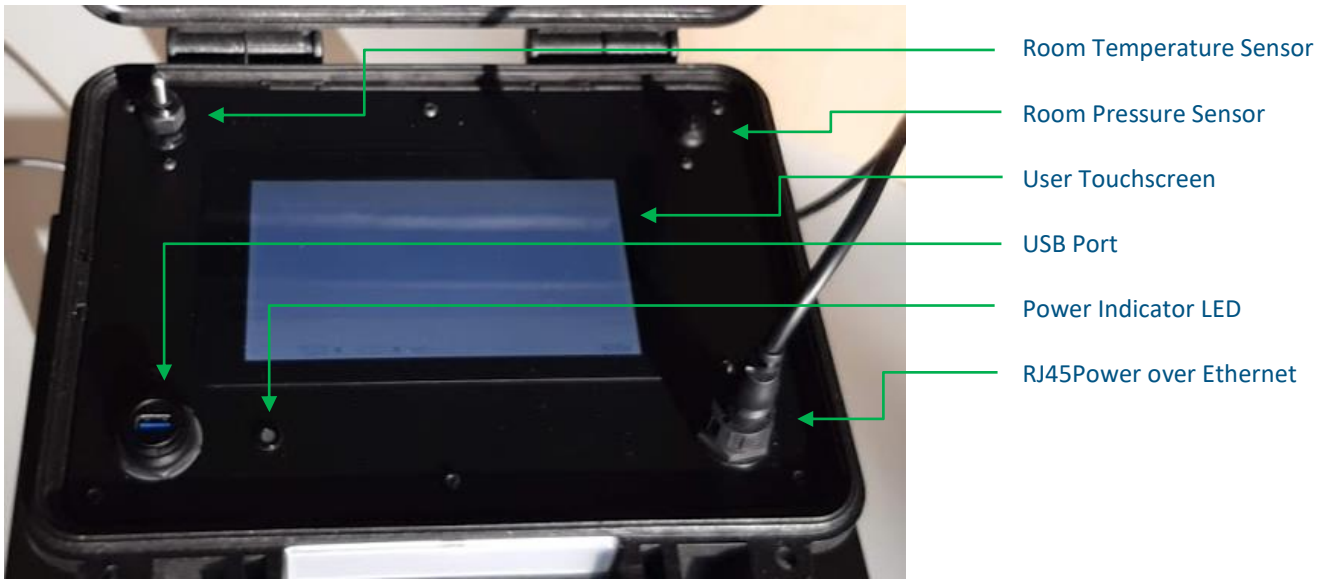
Connections are labelled below:

4.2.2 Pulse Control Box

The Pulse Control Box contains:

- Control panel touch screen
- Control electronics including control PCB
- Enclosure pressure and temperature sensing equipment
- Power Indicator LED
- Power over Ethernet and USB ports

The diagram shows the components in place:



4.3 Compressor unit

The compressor is used to pressurise the air receiver, to a maximum pressure of 10bar by medium of a charging hose. Charing of the air receiver may take place on site within the building or enclosure under test, onsite but outside the space to be tested (e.g. to minimise disruption or the time in the property) or if air receivers are suitably secured, it is also possible to charge air receivers in transit via a suitably configured compressor.

First, ensure the electrical supply voltage matches the Pulse compressor operating voltage.

With power supplied, the primary intended mode of operation is for the compressor to be switched on at the pressure switch (red dial) and then for the compressor power input to be regulated by the controller software via a relay in the air receiver. This allows a user to set a desired target pressure and the system will then automatically cut out when this pressure is reached. The alternative is to set the software at the maximum 10bar pressure and then to use the manual pressure switch dial to turn the compressor on and off as required.

The compressor and hose supplied by BTS has been selected for its minimal maintenance requirements, low charge time, low noise and high durability, we therefore recommend using this compressor with the Pulse unit. However, if compressors not supplied by Build Test Solutions are used to charge the instrument it is imperative that the compressor is approved and configured for charging to no greater than 10Bar and that the correct couplings necessary for connection to the Pulse unit are used (Prevost S1 series euro connectors). It's also recommended that the air pumped into the Pulse unit is pre-dried as far as practicable to reduce the risk of the solenoid valve freezing during multistep Pulse testing and to generally minimise migration of moisture into the air receiver side of the system.

4.4 Other equipment

There are other pieces of optional ancillary equipment which may be necessary for air tightness testing regimes:

- A laser distance meter or other relevant tool for measuring building geometry
- An anemometer for measuring wind speed to assess external test conditions
- Camera for making records of testing and site conditions
- Personal protective clothing (PPE) as stipulated by your employer, client or a risk assessment.

These items are not included as standard with the Pulse unit but can be purchased off-the-shelf.

5 Service & Maintenance Requirements

The Pulse unit requires regular maintenance and calibration to ensure correct measurement. The following service schedule should be maintained for all testing. A fully serviced Pulse unit is mandatory for regulatory testing and where testing results are intended to be used to demonstrate improvements which may be later monetised or promoted.

Please contact BTS Ltd directly to discuss your intended use of the system and the associated servicing, calibration, user training and test regime requirements.

5.1 User Maintenance and Inspection

To assure that all testing is carried out safely and accurately, and to ensure that your Pulse unit maintains its performance for as long as possible, please follow the schedule below:

Action	How Often	Notes	Guidance
Drain Main Tank	Weekly	When filling the main tank, moisture from the air will collect in the tank, this needs to be removed weekly to ensure optimum performance and accuracy.	Trigger the 'drain air receivers' setting while the tank is pressurised at around 2-5Bar. Note the drain is in the base of the unit and a pool of moisture may be released so take care if draining on carpets or wooden floors.
Hose, connectors and cables check	Weekly	Check all hoses, data cables, connectors and electrical cables for security, damage or wear and replace if damaged.	This is to ensure safe and efficient operation but also poor data connections can lead to missing data packets and unnecessary failed tests.
System airtightness test	Annually	Ensuring there are no leaks in your system will ensure fast charging and maximised testing accuracy.	Charge the tank to 10bar, leave the full system (air receiver and compressor) pressurised for 2-3hours, observe any pressure changes with the live feed of the tank pressure on the screen. Report leaks to service provider.
Self-calibration checks	6 monthly	Ensuring the system is providing results in line with a correctly calibrated system.	Using a self-calibration known-opening panel, carry out testing as per description in Appendix A – Annual Self Calibration Check

5.2 Expert Servicing and Calibration

It is the responsibility of users to service and report servicing to any authorised regulatory body for which system calibration is a requirement.

Regulatory bodies may prescribe their own calibration requirements, otherwise, BTS recommends the following expert/third-party calibration.

Component	Description	Range	Accuracy	Calibration standard required	Calibration Frequency
Full System	Full system test in a fully characterised enclosure	±25 Pa	±5%	Calibration checked as a whole system, traceable to national standards.[1] Individual sensors calibrated to UKAS.[2]	24 Months
Air receiver temperature sensor	Measuring temperature inside the receiver (i.e. inside the pressurised air tank)	-40°C to 60°C	± 0.5 °C		24 Months
Air receiver pressure sensor	Measuring pressure inside the receiver	1-11 bar (Absolute)	±0.1 bar		24 Months

Component	Description	Range	Accuracy	Calibration standard required	Calibration Frequency
	(i.e. inside the pressurised air tank)			Results and the date of last service and calibration check should be recorded and reported with the test results.	
Room pressure transducer (Control module)	Measuring the pressure difference between building pressure and reference tank pressure i.e. ΔP	±25 Pa	Full scale error ±0.5%, measurement error ±1%		24 Months
Room temperature sensor	Measuring the ambient temperature in the room	0-40℃	± 0.5 °C		24 Months
Reference system check	Differential pressure sensor component that ensures accurate and reliable measurement of absolute room pressure. System isolated and pressure leak checked as part of bi-annual service.				24 Months
Software updates	Software system updates issued by BTS to all Pulse customers. Adding features and new functionality.				As issued
Pressure system service	The Pressure Equipment Directive (PED) defined system inspection and testing criteria. Air receiver, compressor and ancillaries.				24 Months

For further details please contact BTS Ltd direct.

5.3 Cleaning the Air Receiver unit.

DO NOT allow any water to ingress beyond the fabric exterior. Remove any dust or dirt from the fabric using a damp cloth that has previously been dipped in mild soap and water. Wring out thoroughly to remove excess water before use.

DO NOT use solvents, cleaning fluids or abrasives. These materials could damage the unit and any exposed contacts.

5.4 Cleaning of the touch screen

To avoid scratches, use a soft, lint-free cloth to gently wipe the screen. If dirt is persistent, dampen the cloth with water or a lens cleaner, DO NOT apply liquids directly to surface.

6 Scope of Use

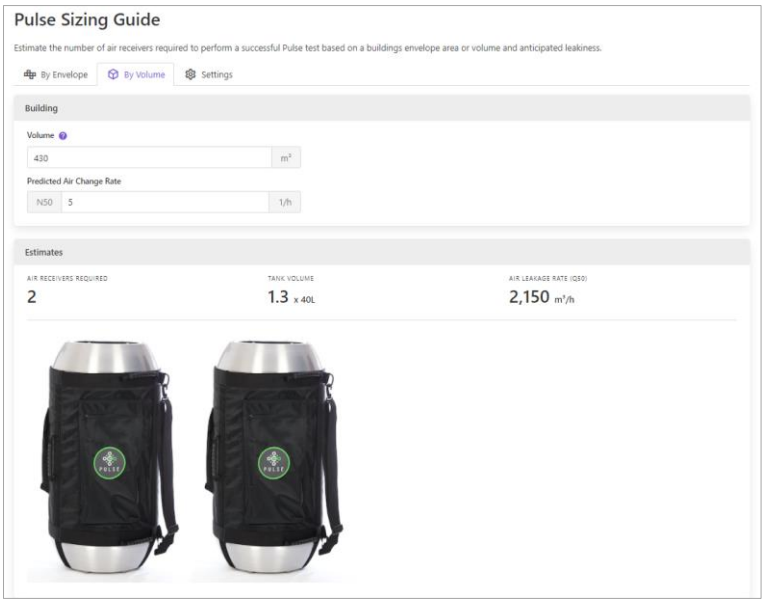
Key applications for the Pulse technology includes:

- Establishing the air permeability of existing domestic and non-domestic buildings to quantify energy losses and to identify ventilation risks.
- To demonstrate the improvements achieved with the installation of measures that improve air tightness.
- Pre-compliance quality assurance checks on new build commercial and domestic properties.
- Testing the integrity of other enclosures where air tightness may be critical such as containment labs, clean rooms, gaseous fire suppression rooms and refrigeration chambers.

6.1 Pulse Property Size Limitations

Much like other air permeability testing methods, only a guideline can be offered as to the suitability of Pulse for a given application. Due to varying levels and leakage characteristics of buildings, results may not be obtainable even for properties within the following guidelines. To ensure successful testing, it is recommended that users oversize the Pulse unit to be used.

Build Test Solutions maintain a publically accessible Pulse system sizing guide available online here: https://www.pulseairtest.com/sizing-guide.html



Above: Example screenshot of the online Pulse system sizing tool. Available at www.pulseairtest.com/sizing-guide.

6.1.1 Estimate Pulse Unit Needed by Calculation

The Pulse air receiver delivers a flow rate of 322 m3/hr @ 4Pa with system capacity simply increasing by this same amount for each additional air receiver added:

Size of Air Receiver, Charged to 10Bar	Flowrate @4Pa (m^3/hr)
Single 40L Pulse Air Receiver Unit	323
One Additional Air Receiver (80L total)	646
Two Additional Air Receivers (120L total)	969

The flowrate needed for any 4Pa Air Change per Hour (ACH_4) and Building Volume (V) can be found by the following calculation:

$$Flowrate = ACH_4 \times V$$

The flowrate needed for any 4Pa Air Permeability (AP_4) and Building Envelope Area (A_E) can be found by the following calculation:

$$Flowrate = AP_4 \times A_E$$

For example, a property which just exceeds the minimum regulatory backstop (AP_{50} = 7, $AP_4 \approx 1.3$), 3-bedroom house with an envelope area of 230m^3 requires a flow rate of

$$Flowrate\ (m^3/hr) = 1.3 \times 230 = 299$$

In this case a single standard 40L air receiver unit will be applicable, but an experienced tester may bring an additional Air Receiver to ensure a successful test e.g. if the property is more found to be bigger or leakier than expected.

6.1.2 Conversion of 50Pa figures to 4Pa

The UK Building Regulations and Pulse Online currently uses the following conversion formula derived by calculating the ratio of the measured air permeability at 4Pa (AP4) from the Pulse test to the measured air permeability at 50Pa (AP50) from a fan test across a large sample with a wide range of leakage rates.

AP50 = AP4 x 0.9241 x 5.2540

An alternative method of comparison would be to use the air flow exponent (n) and air flow coefficient from a blower door fan test and extrapolate down to 4Pa using the Power Law.

It should be noted in all cases however that the performance of a building at 4Pa does not correlate directly with its performance at 50Pa: The conversion required is specific to the building and the types of leakage occurring.

Air leakage pathways vary based on the air flow and pressure exerted on them and the mounting of a blower door fan itself can cause for variations; the mounting method tending to introduce additional leakage in the case of high performing air tight doors and reducing leakage where the door is otherwise poorly fitting or incorporating a letterbox or similar.

This relationship is separately being research further by Build Test Solutions the University of Nottingham and others.

7 Operation

7.1 Assembly and First Use

No first-use assembly is required for the Pulse unit to be operational. The equipment supplied fully assembled, tested and ready to operate.

It is recommended that a test release of the instrument, following the guidelines in this section, is carried out to ensure the unit is in working order before use in the field.

7.2 Transport

The Pulse unit is designed for portability, allowing for its use in almost any location. However, is a measurement instrument and consideration should be given to sensitive nature of the on-board sensors which may be affected by large impacts. For this reason, it is recommended that the Pulse unit is handled with due care.

When transporting in a vehicle, it is advised that precautions are made to ensure the unit cannot move around within the vehicle, by strapping or otherwise.

When manually handling the instrument, please ensure you have received the correct manual handling training and, if necessary procured the necessary lift aids as per your personal requirements or risk assessment.

7.3 Initial Setup

When used correctly, Pulse creates an instantaneous pressure difference across the entire space; however, it is possible to cause testing inaccuracies unless the Pulse is positioned such that the unit has free airflow to the whole space. It is advised that the nozzle has at least 1 metre clearance around it to allow for unhindered air dispersal and the air receiver is placed centrally in the building or enclosure under test.

The Pulse control system should also be positioned as far away from the main unit as possible to prevent the air release from affecting the sensors contained within it. A 4m control cable is provided to allow for this, and it is advised that, where possible, the unit should be positioned around a corner, or behind objects, to ensure the best results. Some operators may also choose to stand between the main case and the control case during testing to prevent the air flow from directly impacting the control system. Like the air receiver, it is also important that the controller is not too close to walls, where air waves can reverberate off the surface and effect the sensor pressure readings. Here we advise 0.5m clear air around the controller where possible.

The Pulse control system should also be positioned so that the temperature sensor (labelled in section 4.2.1) is not in direct sunlight to ensure a correct reading of room temperature is taken.

7.4 Charging the Air Receivers

The Pulse unit has a quick-connect charge port coupling fitted as per the diagram in Section 4.2.1.

To begin charging, connect your compressor to the main air receiver charge port via the quick-connect connections using the supplied air hose and switch the compressor on.

	
Compressor charge hose connection to air receiver	*Compressor charge hose with push-fit fittings*

NOTE: FOR THIRD PARTY SUPPLIED COMPRESSORS, ENSURE YOUR COMPRESSOR IS SET TO CHARGE TO 9-10BAR TO ENSURE THE TANK'S SAFETY VALVE IS NOT TRIGGERED.

When the air receiver has reached fully-charged, the compressor will switch off automatically. This should take approximately 8 minutes for a single standard 40L air receiver to fully charge from empty to its max 10 bar capacity. Please note: For testing with lower tank pressures, the user can set the pressure from within the software options and the system will switch off the compressor once the desired pressure is reached.

7.5 Test Preparation

Prior to testing, normally while the air receiver(s) are charging, the following actions should be carried out.

- Open all interior doors and openings to allow for flow of air between the spaces to be tested.
- Close or seal up any purpose provided ventilation as per the testing protocols being followed (e.g. CIBSE TM23 2021, ATTMA TSL1, ISO 9972).
- Inform current building occupants of the imminent testing. You may also wish to warn them of the noise made during testing as some occupants may find this disconcerting if they are not warned. In occupied premises where pets are present, it is advised for them to be kept away from the air release to avoid distress.
- You may wish to place signs on external doors to ensure nobody enters during testing, which in turn could render a test as void.
- Input all the required test details and building parameters as per control system instructions in section 8.

7.6 Launching the Pulse test

It is strongly recommended that records are kept of each test to allow for reporting or compliance needs. The following information is likely to be useful when keeping records:

- Tester ID number
- Test time
- Weather conditions on site
- Test location (i.e. address)
- Notable site conditions and building information
- Sealing protocol followed

The Pulse control system has the capability to record this information, but you may choose to make additional records as deemed appropriate.

When launching a test, first ensure the air receivers are charged to sufficiently high pressure by observation of the on-screen tank pressure feeds, or by observation of the mechanical tank pressure gauge in the top of the air receiver. (This can be pre-set in the control software).

Use the control system to set up the test and input testing parameters. Section 8 provides comprehensive guidance on using the control system. When "start test" shows on the screen, the test is ready to launch.

PLEASE NOTE: Testing without inputting building envelope area and volume will mean test results will not be provided on-screen and will require calculation later. Free online Pulse software is available to all Pulse customers for this.

Advise occupants that the test is about to start and that there will be some noise and a gush of air. Ask that movement to be kept to a minimum during the test, which will take a total of 15 seconds for a 3-step test.

Upon pressing the button to launch the test, a 5-second countdown commences, during which, the operator should step away from the unit.

IMPORTANT: THE USER AND OCCUPANTS SHOULD NOT MOVE DURING THE TEST: Highly accurate air pressure readings are taken throughout the test (not just during the air Pulse), movement may cause air flow or changes to the building envelope (e.g. stepping on a suspended floor may flex it) which could affect the test. The user should also ensure they do not touch, hold or move close to the pressure sensor outlet.

The Pulse test cycle itself then commences, with three main phases for a standard 2 step test:

- 2 second background pressure sampling – during which there is no air released, the device takes air pressure readings.
- 1.5 second release of air, during which time a noise and draught will be felt.
- A further 1.5 second background pressure sampling – during which time the system records external and internal air pressure.
- A second 1.5 second release of air, this time a lesser velocity than the previous.
- A final 2.5 second period of background pressure sampling. Again, no air is released but important background pressure readings are being taken.

For a three step test, an additional release of air and 1.5 second background pressure sampling phase will be observed.

The test is complete with results and feedback now presented on the screen.

7.7 Step tests

Pulse can enact between 1 and 3 air releases (steps) in one test. The three steps release differing amounts of air as the tank is drained from one step to the next. This allows for a wider spread of data to be gathered over a range of induced pressure differences, thus more reliable results.

Selecting how many steps to include in the test will depend upon the tank size and building volume/leakiness (see section 6.1). If the Pulse unit is oversized for the property, a 3-step Pulse is advised, if the Pulse is comfortably within range, a 2-step Pulse is advised, if the Pulse system to hand is at its limit for testing, a single-step Pulse should be used.

For very air tight properties, it is necessary to increase the valve open duration from 1.5 seconds to 4.0 seconds under the advanced settings page of the main settings menu. Corresponding offset timings may also need to be adjusted, although this can be done retrospectively on the Pulse Online dashboard.

7.8 Results

The screen will display the test results:

- ALR – Air leakage rate (m^3/h)
- Air Leakage per hour, Q (m^3/hr)
- ACH – Air changes per hour (h^{-1})
- ELA – Effective Leakage area (m^2)

- AP – Air Permeability (m^3/m^2h)
- Achieved Pressure Range (Pa)

A test ID will also be displayed, this should be noted for records.

At the end of the test the results are automatically captured in the unit's memory. These may be exported as .csv or .Pat file (depending on the version of Pulse unit and software you are running) by plugging in a USB and following export guidelines in section 8.3.

Alongside all results, feedback on the quality of the test is also presented. This feedback is informed by a number of test quality indicators and includes the following advice:

Feedback	**Comment**
Valid test	A high quality successful test, proceed accordingly
Warning: Low achieved pressure	A test status warning is given where the achieved pressure range does not span 4Pa. The warning will state 'low pressure' if the maximum of the range is below 4Pa and 'high pressure' if the minimum of the range is above 4Pa. This does not invalidate the test but means that the result at 4Pa has had to be inferred based on the available data. This is then reflected in the calculation uncertainty. Where these instances occur, the closer the achieved pressure range is to 4Pa, the better. A low achieved pressure is as a result of the building under test being either too big and or too leaky for the Pulse equipment in use. To increase the achieved pressure, the air receiver should be charged to a higher starting pressure and if this was already the case, an additional air receiver should be added in order to increase the total air flow release.
Warning: High achieved pressure	A test status warning is given where the achieved pressure range does not span 4Pa. The warning will state 'low pressure' if the maximum of the range is below 4Pa and 'high pressure' if the minimum of the range is above 4Pa. This does not invalidate the test but means that the result at 4Pa has had to be inferred based on the available data. This is then reflected in the calculation uncertainty. Where these instances occur, the closer the achieved pressure range is to 4Pa, the better. A high achieved pressure is as a result of the Pulse equipment releasing too much air into the building under test for its given size and/or leakiness. In these instances the operative could use fewer air receivers and/or carry out the test from a lower air receiver charge level i.e. fewer bars.
Invalid r^2 Threshold	The correlation coefficient, or r^2, is indicative of the accuracy with which a curve fitting equation can be applied to a set of results. With high frequency 50Hz data collection, 25 reference points are collected per step and it is recommended that an overall r^2 value of greater than 0.96 is required for a test to be deemed valid. Where all combinations of the test steps are analysed yet none are able to achieve the minimum 0.96 threshold, the test is flagged as invalid. The quality of the data points and trendline can be viewed in the 'Air Flow' chart of the View Test page of Pulse Online, with poor r^2 tests typically presenting a distorted series of data points. These distortions will typically be as a result of either: • Adverse environmental conditions e.g. strong gusting winds; • Poor test conditions e.g. a loose or moving element of the building fabric that is constantly moving and changing or reacting to the Pulse of air inconsistently; • Sub-standard test setup e.g. distorted air flow and reverberations as a result of the air receiver or controller being too close to a wall or window.

Invalid Exponent (n) Threshold	The air flow exponent, n, is used to describe the airflow regime through the gaps and holes in the building fabric. Values must range between 0.5 and 1.0. An n value approaching 0.5 signifies turbulent flow, representing high flow through large apertures. An n value approaching 1.0 will indicate a more laminar flow, characteristic of more air tight structures or those with much smaller gaps and holes. A test would fail on this criteria if the n exponent is outside of the 0.5 to 1.0 range. A value that is below 0.5 would typically be caused by a building having a series of very large openings. This could be as basic as there being an open window or chimney but it could also simply mean that the building is just too leaky overall and outside of the operating range of the Pulse equipment in hand. It is very rare for an n exponent of more than 1.0 to be recorded but if it is, we advise assessing the achieved pressure range, perhaps repositioning the equipment e.g. ensuring the controller is not in the turbulent flow from the air receiver nozzle, then retesting.
Invalid Steps	As with the test as a whole, individual steps have their own pass and fail criteria, however one step failing doesn't mean that other steps have also failed. If a test presents an 'Invalid steps' fail message, then this means that the final result calculation included at least one step which failed. The reasons for why steps have failed will be displayed on the 'Parameters' tab when viewing a test in Pulse Online.

7.9 After testing

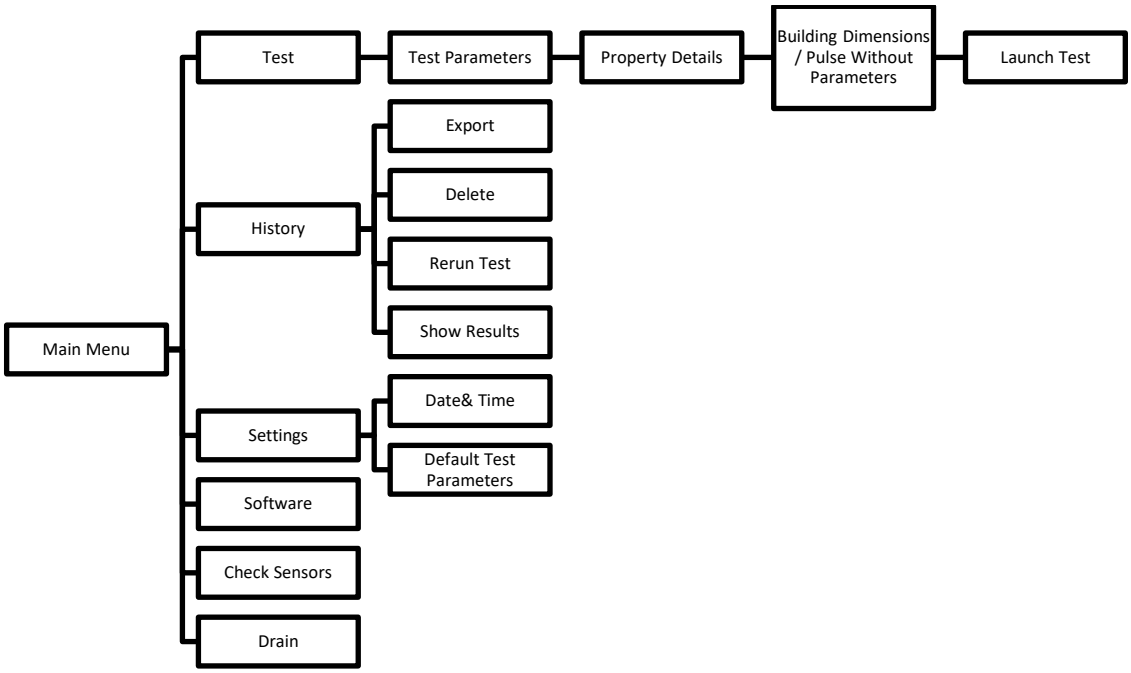
When all testing is complete, we advise draining the air receiver prior to transport. Draining is best achieved by draining the air receiver using the dedicated function on the control system (see section 8.3).

Switch-off the unit, unplug all wires and store.

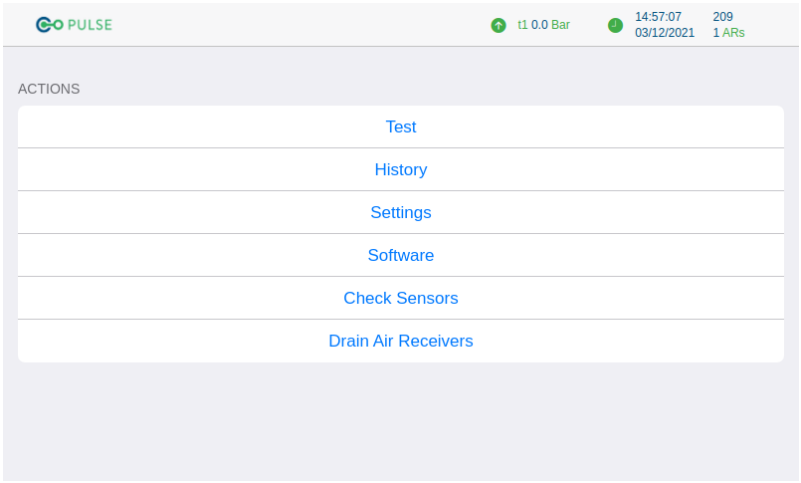
Pulse is now ready for transport.

8 Control Box Menu Controls

8.1 Menu Map



The main menu screen appears as follows. Top right we see the number of connected air receivers, current date and time and the real-time pressure in each air receiver presented in Bar.



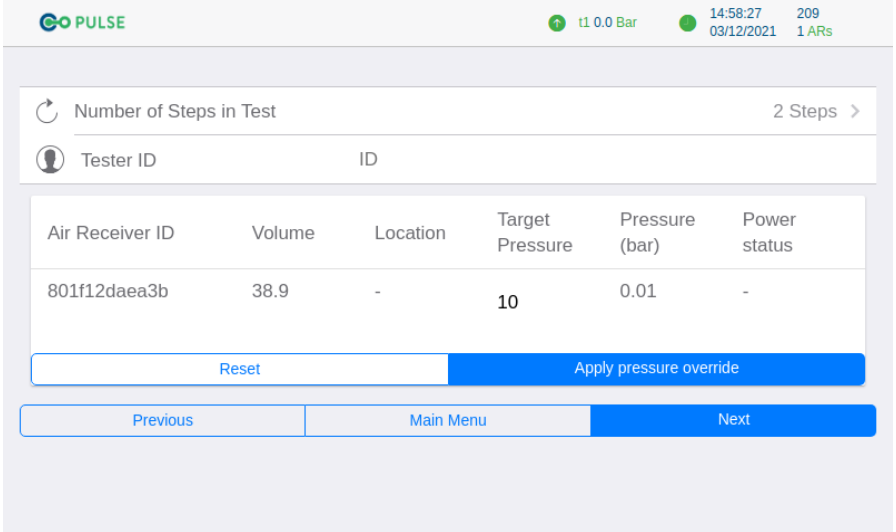
8.2 Test

To carry out a Pulse test:

1. Select “Test” in the main menu.

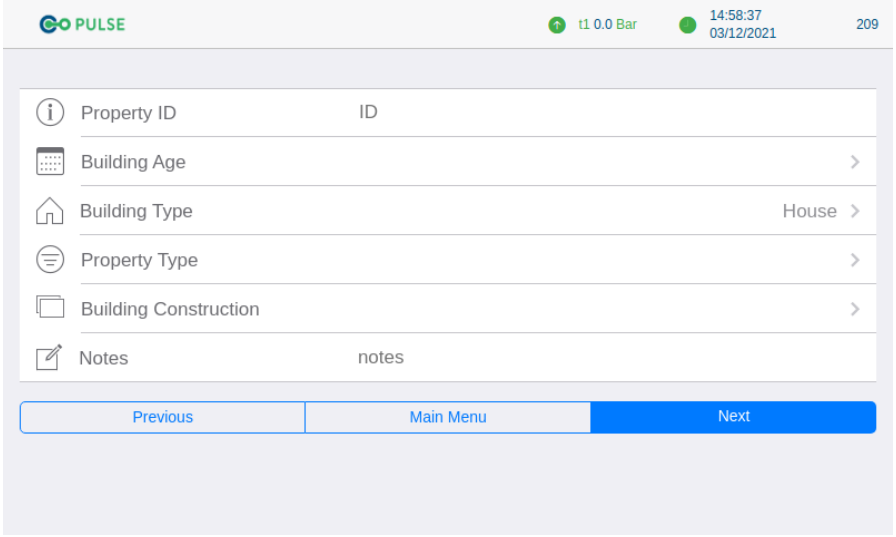
2. Input:
    a. Number of steps to be carried out in the test (1-3), see section 7.7 for guidance.
    b. Input tester ID as per your organisation’s convention.
    c. The air receivers successfully connected to the controller should display in the table in the bottom half of the page. Here you can electronically set a target charge pressure override by entering a new target pressure value and confirming this by pressing ‘Apply Pressure Override’. The compressor will automatically cut out at this set target pressure.

Click “Next”



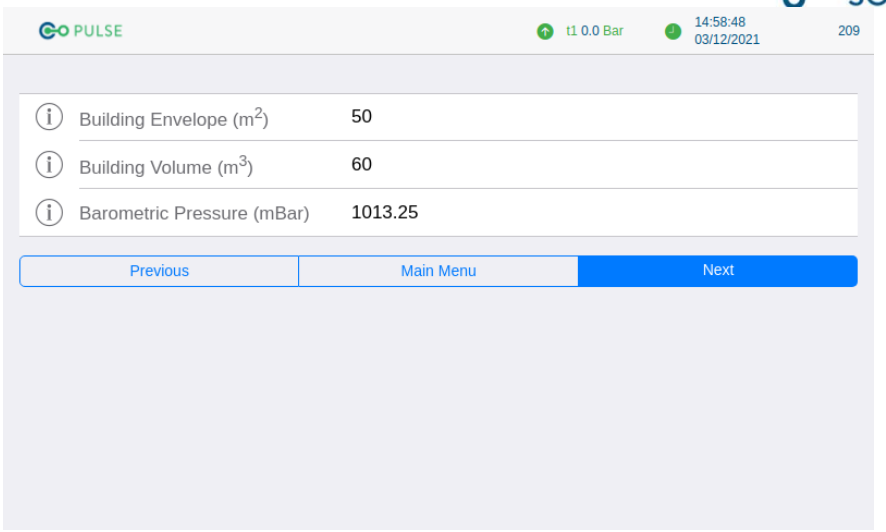
3. Input:
    d. Property ID as per your organisation’s convention.
    e. Building Age (list of drop down options appear).
    f. Building Type (list of drop down options appear).
    g. Property Type (list of drop down options appear).
    h. Building Construction (list of drop down options appear).
    i. Notes – free text field for any additional notes you may wish to input.

Click “Next”

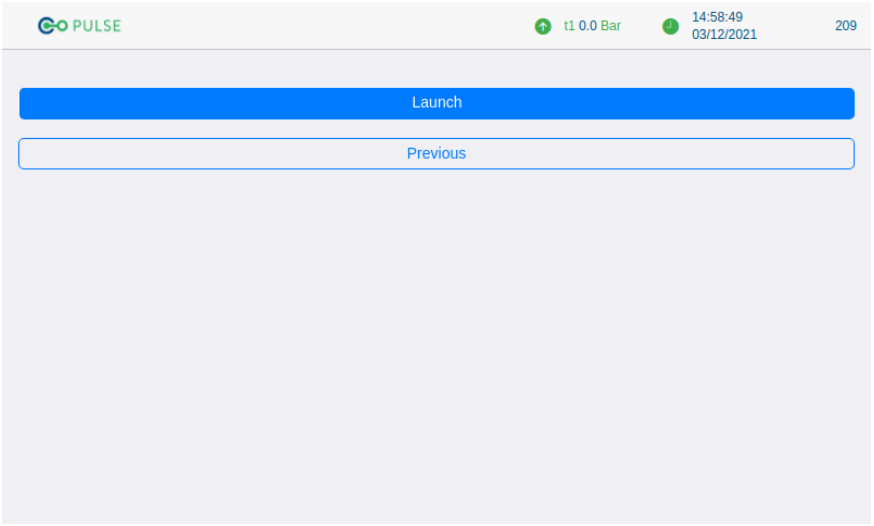


4. To carry out a test with building dimensions inputted (provides results on-the-spot), input the following measurements:
    j. Building Envelope Area (m^2)
    k. Building Volume (m^3)

Click “Next”

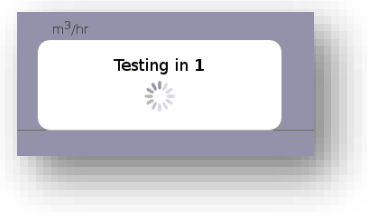


5. The launch screen will appear, select launch to begin the test algorithm

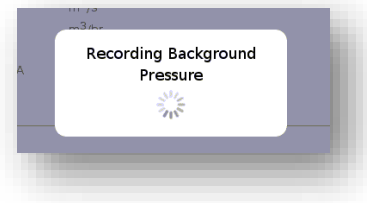


The test will then launch, showing the following messages on screen:

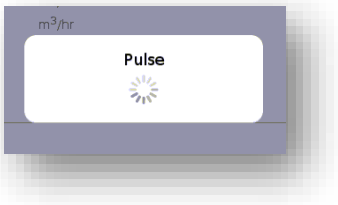
1. “Testing in 5, 4, 3, 2, 1”



2. “Recording Background Pressure”

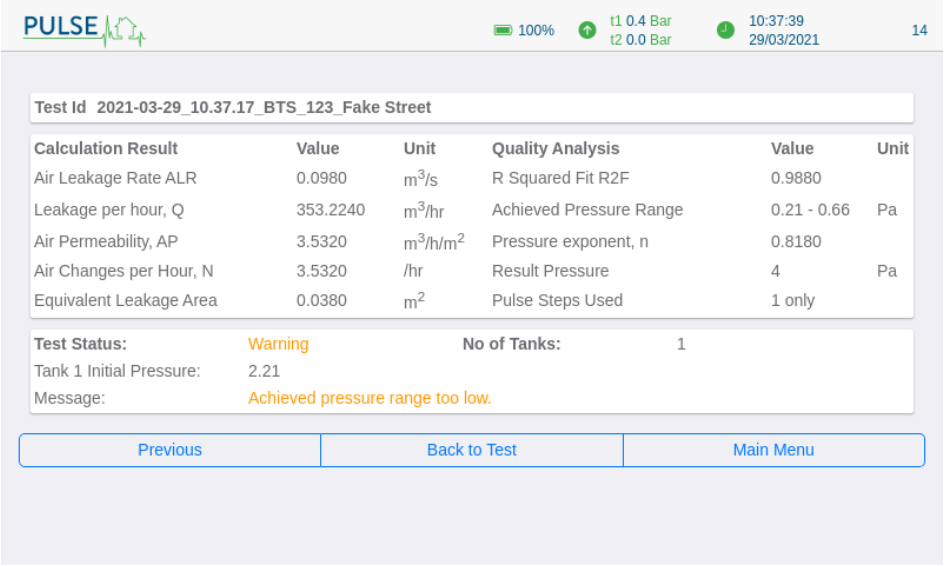


3. Pulse 1



4. Steps 2 and 3 will repeat for additional Pulses in the test
5. “Recording Background Pressure”
6. Test Complete

The screen will then present test results (unless a test has been fired without parameters). Also presented is “Test Status” information, with feedback to the quality and success of each step in the test, and the test as a whole. Further training can be provided for a deeper understanding of this feedback.



Select one of the following options:

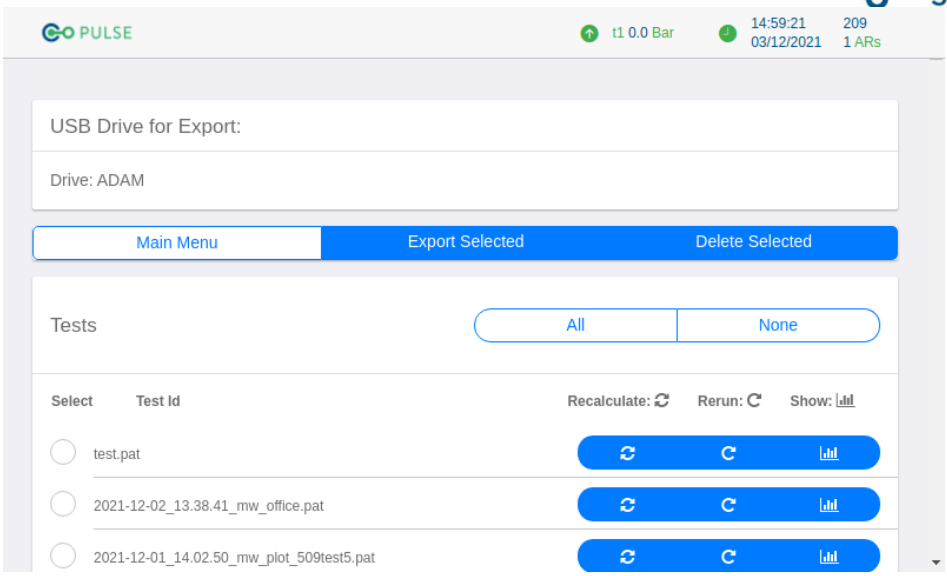
- “Back to Test” will re-open the testing menu
- “Main menu”

8.3 History and back-up

This menu can be used to back-up and export testing data (in either .pat or .csv format depending on Pulse model and software version being used) to a USB stick, delete testing data, re-run tests, or show historic results.

Whilst the memory capacity of the Pulse system is significant and can support upward of 150,000 tests, we recommend as a general rule that a back-up of all test results is made at the end of each day’s testing by exporting your tests to a USB stick. This will minimise the risk of tests being accidently deleted or being corrupted should there be any issues with the unit software.

NOTE: it is strongly advised that a freshly formatted USB stick that has been scanned by reputable virus and malware protection software is used in order to minimise the risk of corrupting the Pulse operating system.



To exit this menu, select “Main Menu” at the bottom of the page, below the stored tests.

8.3.1 Export/Delete

Tap each test that you wish to export or delete, or if you would like to act upon all tests, select “All”, to remove your selections, press “none”.

Once the correct tests have been selected, choose “Export” to move the test files to USB, or “Delete” to delete them from the system memory.

WARNING: Pulse has no recycle bin or undo function, only delete data when you are sure that it is no longer useful as it will be <u>permanently deleted.</u>

8.3.2 Rerun

To save re-inputting settings for a test that has been carried out previously, selecting the “Rerun” icon next to a test will take you to the test screen with all settings and parameters inputted as per the test chosen, allowing for quick repetition.

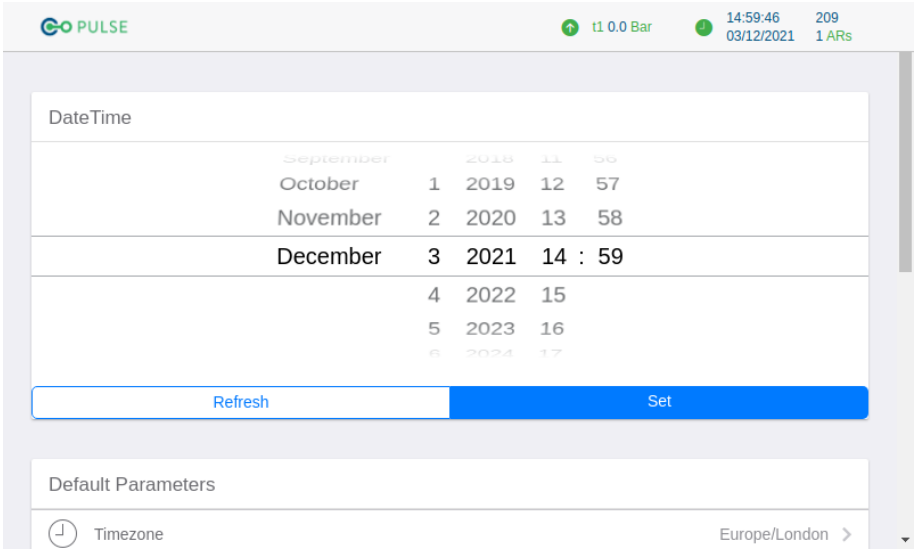
Note: Pulse will automatically remember and populate test settings as per the last test carried out, until it is switched off, so this feature is not required for consecutive repeated testing.

8.3.3 Show

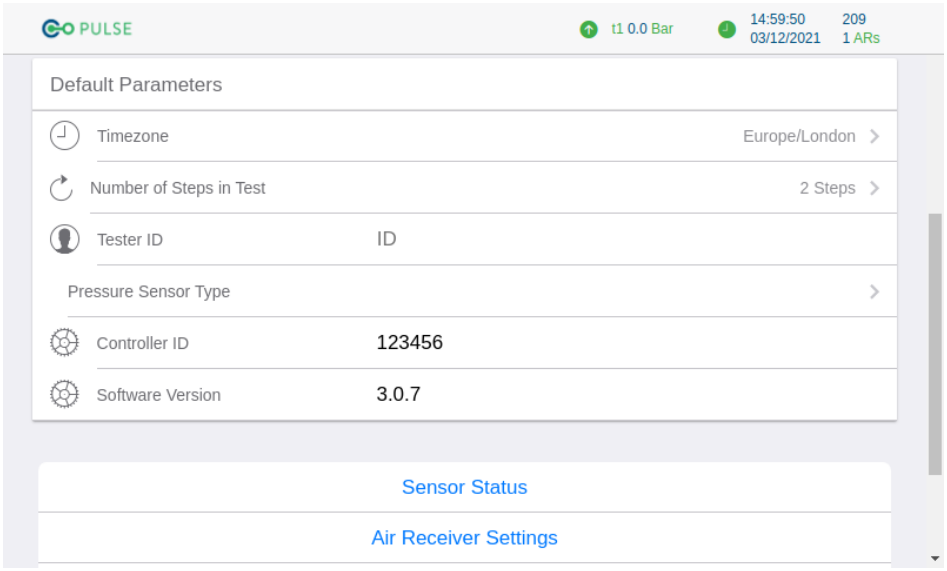
To revisit the results from a past test, select the “Show” icon next to a test, the results will be displayed again.

8.4 Settings

- Setting date and time can be achieved by moving the dials to the correct figures and selecting “Set”.



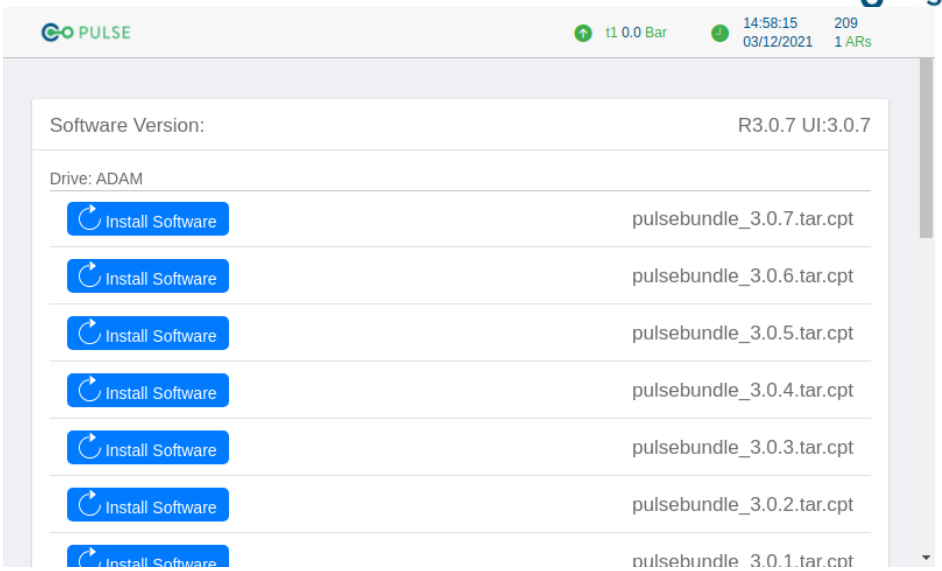
- Default parameters allow the user to input standard parameters that are normally used in testing, allowing for greater efficiency. Alter these figures by tapping on them and making changes.



Select “Save Changes” after any changes have been made to save them to system memory. To discard changes and exit settings, select “Main Menu (without save)”

8.5 Software

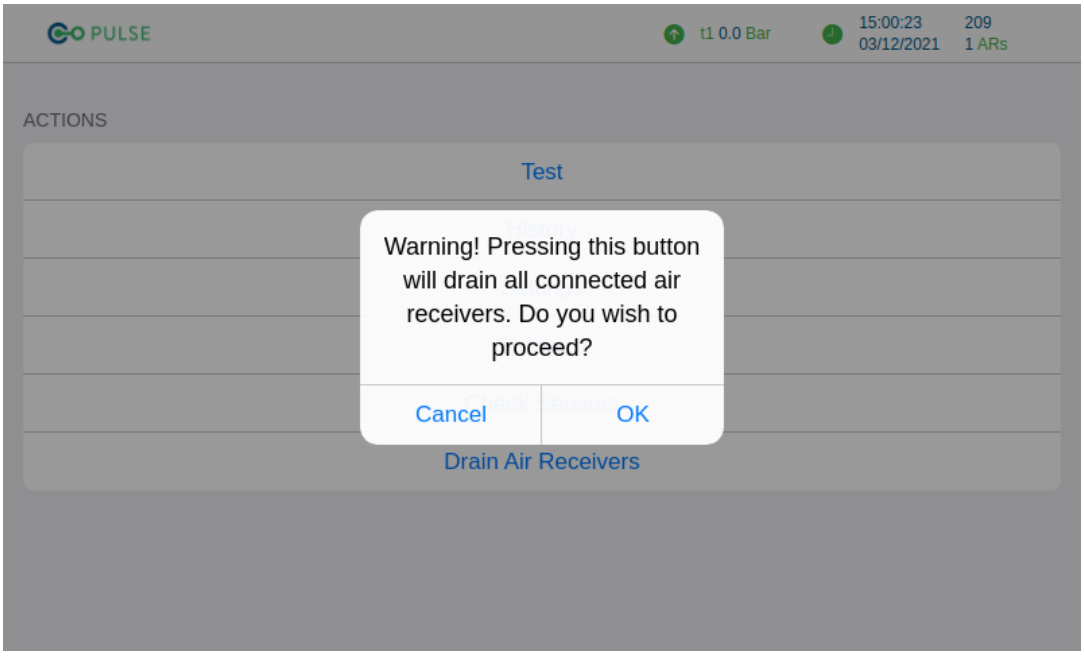
- The software screen will show the current software version



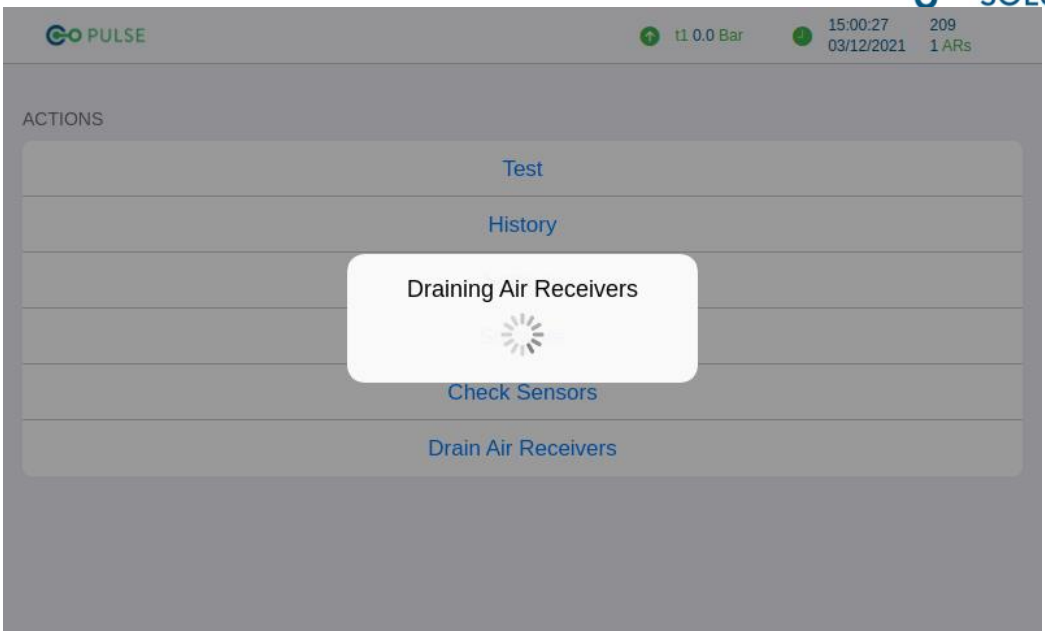
- The current software version can be seen at the top of the screen
- When a USB drive with a software version held on the device is inserted, these are recognised by the Pulse controller and listed.
- Select install and the system will automatically install the software and reboot.
- Once rebooted, return to the software screen to check that the current software version reads as you expect it to.

8.6 Tank Drain

Selecting drain will present a dialogue box asking “Drain Tank”



- Select cancel to return to menu
- Select “OK” to drain tanks, the main nozzle will open for 20 seconds, quickly draining the air from the tank.



9 Technical Support and Troubleshooting

This section is in addition to the dedicated FAQ and help section on www.pulseairtest.com. Any issues not covered by this manual or the online help directory should be directed to enquiries@buildtestsolutions.com or via our dedicated technical support line on 01455 883 250.

Problem	Possible Causes	Fixes
Tank pressure readings not displaying on the screen	Tank control data cable not properly connected	Check the air receiver is recognised on the controller. Remove the data cable connection, power the air receiver down and reconnect the data cable.
Nozzle failing to open	Tank control data cable not properly connected	Check the air receiver is recognised on the controller. Remove the data cable connection, power the air receiver down and reconnect the data cable.
Controller display and LED not powering up	Not plugged in or no power supply (via the data cable)	Switch on the power supply to the air receiver. Check MCB of the mains circuit. Disconnect and reconnect the controller data cable, ensuring it is twist locked into place at each end. Possible failed electronics, contact BTS.
Nozzle freezing and failing to close after an air release	Dryer column in unit not fully functioning or high relative humidity in your test environment. Too many tests in succession	Turn the air receiver off and on again in order to reseat the valve. Drain the air receiver from 10 bar to flush excess moisture in the air receiver and associated plumbing. In addition, check for excess moisture build up in the compressor charge hose and the moisture separator bowl within the compressor chassis. Leave unit idle for 15 minutes for compressor to cool and for temperatures to stabilise Enquire with BTS to service the equipment and replace the dryer column
Zero or invalid results	Check test feedback on results screen for issues	Take on board feedback provided and retest from a higher or lower pressure.

	of over or under pressurisation or for air flow/test data errors (n coefficient and r2). Calculation error caused by operating conditions	Check connections, consider repositioning of the unit and retest.

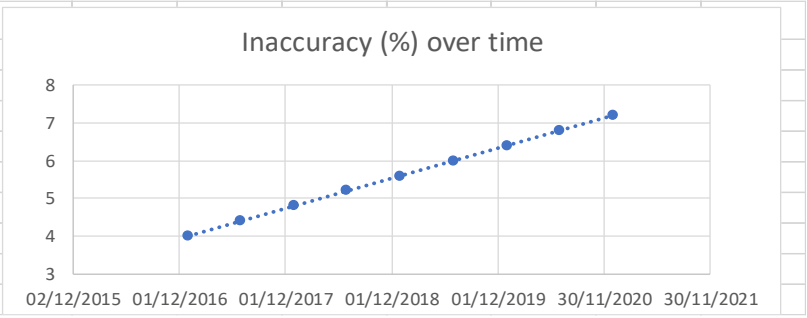
10 Appendices

10.1 Appendix A – Annual Self Calibration Check

It is suggested that users carry out a periodic check to ensure the device is measuring correctly. This would not be as a replacement to any calibration required for regulatory testing requirements, nor omit the need to periodic servicing. Such self-calibration check testing can however provide peace of mind and confidence that a Pulse device and all of its main sensor components are working correctly.

The process is a whole system check whereby the user tests a room or building on a still day with a BTS supplied "known-opening panel". If measurements fall within an agreed range, the device is confirmed as functioning correctly. However, it might be, subject to the nature of use, some trends can be observed e.g. if over the last year it's lost 4%, and the limit is 5%, then it fails as it's trending towards failure and will likely be inaccurate before the next check. As a basic example of this, a user might expect to observe either a very flat trend line or worse case, a performance decay trajectory:

Check Date	Test Error (%)
01/01/2017	4
01/07/2017	4.4
01/01/2018	4.8
01/07/2018	5.2
01/01/2019	5.6
01/07/2019	6
01/01/2020	6.4
01/07/2020	6.8
01/01/2021	7.2



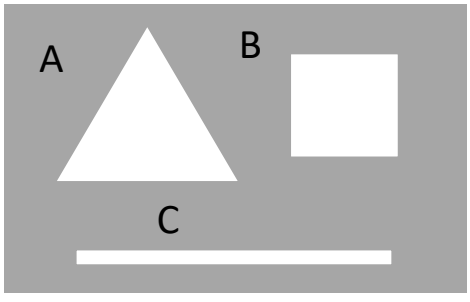
Above: example for illustration only, whereby a customer could use self-calibration checks on their own equipment where high precision is essential or if there is suspected damage or a fault.

Known Opening Test

This is to be carried out in a room with consistent & known leakage, or a custom-built sheltered test chamber sited within another building, to remove the need to test on days with less wind.

The "known-opening panel" would include 3 openings with known flowrates at 4Pa. The LPP is then used to measure the changes in flowrate when each opening (or a combination of 2/3, giving 8 flows) is uncovered, correctly to within a given range (e.g. 2%).

The known opening panel example:



The panel supplied by BTS is pre-tested in a suitably calibrated lab so that the 4Pa flow rates of each hole are precisely known. The Pulse customer then executes a test with different combinations of holes covered. This gives a multi-point check (8 possibilities) which means the testing can happen in any room with background leakage present, providing that a baseline test is taken before the known opening test panels are opened up.