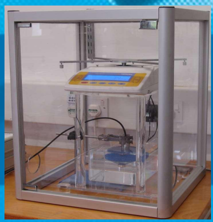


Radiation Balance Force Manual

Radiation force balance with suspended target

Radiation force balance with top pan target

CONTENTS

CONTENTS 3

GENERAL INFORMATION 5

Introduction 5

Specifications 5

Warnings and safety precautions 6

SET-UP AND ASSEMBLY 7

Equipment supplied 7

Assembly FOR TOP PAN SET UP 8

Assembly FOR suspended target SET UP 9

Software Installation 13

SOFTWARE DESCRIPTION 14

Calibration 15

Automatic Analysis 16

Post-Acquisition Analysis and Assessment of Uncertainties 18

Data Storage 20

System Issues 21

MEASUREMENT 22

Automated recording method (via PC) 22

Approximate method 24

Manual recording method (not using PC) 25

FURTHER INFORMATION FOR FORCE BALANCE MEASUREMENT 27

Radiation Force Overview 27

Absorber Material 29

Environmental Conditions 30

Divergent beams 31

Cavitation 31

MAINTENANCE AND CALIBRATION 32

WARRANTY 32

CONTACT AND SUPPORT 32

TROUBLESHOOTING 33

GENERAL INFORMATION

INTRODUCTION

This manual describes the use of the Radiation Force Balance (RFB) to determine total ultrasonic power radiated in the forward direction from transducers operating in the frequency range 1-10 MHz. The force is measured via a change in mass using an analytical balance fitted with a serial interface.

SPECIFICATIONS

<table>
<tr><th>Parameter</th><th colspan="2">Value</th></tr>
<tr><td>Frequency Range</td><td colspan="2">1-10 MHz</td></tr>
<tr><td>Calibrated Dynamic Range</td><td colspan="2">See calibration certificate</td></tr>
<tr><td rowspan="2">Total Measurement Uncertainty</td><td>>50mW</td><td>< ± 7% (95% confidence)</td></tr>
<tr><td><50mW</td><td>< ± 10% (95% confidence)</td></tr>
<tr><td>Maximum Transducer Diameter</td><td colspan="2">Approximately 70% of the target diameter</td></tr>
</table>

NOTE: The RFB may be used outside of this range with increased uncertainty levels.

WARNINGS AND SAFETY PRECAUTIONS

Before using any equipment it is essential that the operator take all necessary safety precautions. Please read relevant safety information in the operating manual for the balance, which has been enclosed.

- Care should be taken when using water in the vicinity of the mains-powered electrical equipment.
- Ensure that the focus of the acoustic field (especially for a strongly focussed transducer) does not lie within the absorber, since high intensities can cause irreversible damage to the absorber.

SET-UP AND ASSEMBLY

EQUIPMENT SUPPLIED

The following equipment is supplied as part of the RFB package:

- Analytical balance and instruction manual
- RFB instruction manual
- Software installation CD
- Serial communication cable (RS232-USB)
- Retort stand and transducer clamp
- Draught shield
- Calibration certificate

Additional items for use with “top” pan use

- Absorbing ultrasound target comprising a lightweight cylindrical container into which is placed a circular piece of acoustic absorber

Additional items for “suspended target” use

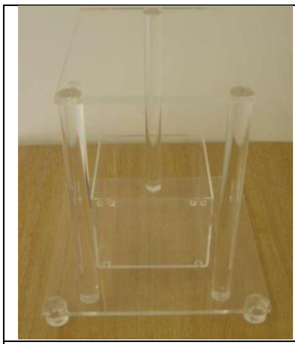
- Plexiglass plinth
- Target support structure (metal cross)
- Absorbing ultrasound target with supporting wires to suspend target
- Water vessel

Users should check the contents of the box upon delivery. If any item is missing or damaged then please contact Precision Acoustics Ltd.

ASSEMBLY FOR TOP PAN SET UP

- Place the balance in a draught-free environment and on a stable surface.
- Use the rotating feet to level the balance using the spirit level at the rear as a guide.
- Place weighing pan on the balance.
- Connect the balance to the PC, using any available *USB port* with the serial communication cable provided.
- Switch on the PC and once Windows has loaded, turn on the balance. For the most accurate measurements, allow at least 1 hour for the equipment to warm up and stabilise.
- Fill the target vessel with degassed water and place it in the centre of the triangular plate of the balance, ensuring that the maximum load on the balance is not exceeded.
- Ensure all bubbles are dislodged from the target. The target should be allowed to soak for at least 20 minutes to allow water absorption to stabilise and air at the surface to dissolve.
- Fit the transducer to be measured into the clamp provided so that its front face is fully immersed and positioned centrally above the absorber. The distance between the transducer and absorber should ideally be about 10mm, but the transducer focus should be positioned within the water to avoid potential damage to the absorber. The transducer should be aligned so that its acoustic axis points vertically downwards.
- Wipe away or dislodge any bubbles that have lodged on the front face of the transducer. This effect can be minimised by immersing the transducer with the face at an oblique angle, aligning it correctly after immersion.
- Tare the balance so that the reading is near zero.
- Place the large draught shield over the acoustic setup allowing all cable to exit via the back.

ASSEMBLY FOR SUSPENDED TARGET SET UP



Place the plexiglass plinth in a draught-free environment and on a stable surface

Ensure the balance plate is installed, but not the pan or standard balance draught shield

Place the balance on the top plate of the plinth and connect the power supply and serial interface cables to the rear of the balance. The exit point of these cables from the draught shield is at the back.

Place the target support structure (metal cross) onto the balance, ensuring that the locating groove is in the correct place

Place the water tank on the bottom plate of the plinth and fill with deionised/degassed water

Place the small absorber pot (without lid) on the base of the tank, ensuring that it is filled with water. This provides temporary support for installation of the suspended target.

Note the small pot is the target for the top pan RFB

Put the target on top of the small absorber pot (in the water tank) with the supporting wires spread out. Placing on the absorber pot and in the water tank reduces stress on the wires during connection of the target to the support structure

- Connect the target to the support structure. Ensure that the target is level and suspended below the top surface of the water. Adjust level of target using the locating screws

- Adjust level of balance using the rotating feet and bubble level
- Connect the balance to the PC, using any available *USB port.*

Position the retort stand with the base located underneath the bottom plate of the plinth

- Switch on the PC and once Windows has loaded, turn on the balance. For the most accurate measurements, allow at least 1 hour for the equipment to warm up and stabilise.
- Ensure all bubbles are dislodged from the target. The target should be allowed to soak for at least 20 minutes to allow water absorption to stabilise and air at the surface to dissolve.
- Hold the transducer to be measured in the clamp provided so that its front face is fully immersed and positioned centrally above the absorber. The distance between the transducer and absorber should ideally be about 10mm, but the transducer focus should be positioned within the water to avoid potential damage to the absorber. The transducer should be aligned so that its acoustic axis points vertically downwards.
- Wipe away or dislodge any bubbles that have lodged on the front face of the transducer. This effect can be minimised by immersing the transducer with the face at an oblique angle, aligning it correctly after immersion.
- Tare the balance so that the reading is near zero.
- Position draught shield, ensuring all cables pass through relevant gaps

•

SOFTWARE INSTALLATION

Insert the “Radiation Force Balance” CD.

Run “\RFB2 Installer.exe” to install the main RFB computer program – a program menu shortcut is created, containing the program.

Run “\Device plugins.exe” to install the balance specific software. Running this executable should automatically extract several files to the “c:\ProgramData\RFB” folder.

Run “\USB-Serial Driver.exe” to extract the RS232-USB adapter driver files and then run “setup.exe”.

Determine the correct serial port from Windows Device Manager (accessed through the Windows Control Panel)

Run the program

Select a directory for the storage of RFB Calibration data

If this is the first time the current balance has been used with this version of the software, enter the calibration information and device ID for the balance. Subsequently, the balance can be selected by serial number from the drop-down menu selector. Once the correct balance has been selected, click the “default balance” control.

If this is the first time this balance has been used with this software, or if the serial port has changed, click on the “Settings” menu and then “Balance Settings”

Select the appropriate serial port from the drop-down list “Balance VISA name”

Ensure that “Simulate” is set to OFF.

Click “Set” to continue. (Note, default analysis settings for “Threshold” and “Offset” can be set here).

Press the “START” button and confirm that the PC is communicating correctly with the balance

SOFTWARE DESCRIPTION

- The software provides acquisition and automated analysis of RFB data.
- Calculated power values are entered into an integrated spreadsheet, which provides a basic statistical analysis facility.

> The automatic analysis algorithm is fairly robust with interactive control of two threshold values from the front panel. These thresholds can be adjusted during live data acquisition, so that changes can be immediately assessed. However the algorithm will not work for all signal sources and/or power levels. In such cases, it will be necessary to carry out manual or semi-automatic analysis – these terms are fully explained later

The software can be summarised as follows:

- Set up the RFB and signal source
- Run the program
- Press the START button
- Turn the signal source on and off, using the methods described in the measurement section of this manual
- The program will monitor the input signal and perform the required analysis
- Press STOP followed by START to reset the display and measurement spreadsheet
- Data can be re-processed and be saved to file when not in live acquisition mode
- Press EXIT button to terminate program

CALIBRATION

The program assumes a single calibration factor for all power and frequency values, calculated as:

$$CF = gc(T)F$$

g = acceleration due to gravity (m/s^2)

c(T) = temperature-dependent speed of sound (m/s), using data from Bilaniuk N. and Wong G.S.K, J. Acoust. Soc. Am. 93 (3), March 1993 pp. 1609-1612

F = average output/input power ratio from the RFB calibration certificate

Calibration data comprising T, Uncertainty (UC), power ratio and g can be entered via the balance selection screen when the software is started up. Simply enter the data in the relevant fields and click "OK". These values are taken from the calibration certificate and are saved to a configuration file and can be restored on subsequent use by selecting the balance (identified by its serial number) from the drop down selector in the balance selection dialogue. To change balance it is necessary to exit and restart the software.

If the balance has been supplied without a calibration certificate, use a value of 1 for the power ratio.

AUTOMATIC ANALYSIS

The graph contains three traces:

1. Raw Data – mass readings from the balance converted to power, using the calibration information
2. Transition Points – marking start and stop of positive and negative power transitions
3. Extrapolated Data – linear least-squares fit to the raw data between the upper transition points, extrapolated to the lower transition points

The graph will be continuously updated until the acquisition is stopped - analysis takes place on live data.

If a valid power on/off cycle has been detected, the calculated power values are automatically entered in the "Per-cycle measurements" spreadsheet. The "Results" spreadsheet will then be updated. This process will continue during the current acquisition, with one line added in the "Per-cycle measurements" spreadsheet for every valid power on/off cycle. There are two values which control the detection of a valid power on/off cycle and these can be adjusted interactively whilst the display is live, but please note that this adjustment will cause ALL THE DATA to be re-analysed:

- **Threshold** controls the amplitude at which a transition is detected – increasing the value reduces the sensitivity of the algorithm
- **Offset** controls the time shift between the detected peak and the true position of the transition points – increasing the value pushes the transition points away from the rising/falling edge of the raw data trace

There are two stages to the automatic data analysis:

- Detection of transition points – this uses the maximum gradient change above a threshold (accessible from the front panel) to indicate the low and high transition points. After candidate transition points have been identified, the algorithm searches for a (positive, negative, negative, positive) sequence of transition points. This indicates a valid power off-on-off cycle. A time offset is applied to these transition points to ensure that transitions occur in the flat regions of the signal.
- Calculation of power – the transition points can be used to calculate the power directly, but this method is very sensitive to the transient response of the signal source during power on. Therefore a least-squares extrapolation method is used instead. This consists of fitting a least-squares line to the acquired data between the two upper transition points. This line is then extrapolated to the times corresponding to the lower transition points. The upper power values are then given by the y-coordinates of the fitted line at these points, with the lower power values given by the lower transition points. The least-squares extrapolation method can cause problems for some types of signal source, so an additional control is provided to disable this feature.

POST-ACQUISITION ANALYSIS AND ASSESSMENT OF UNCERTAINTIES

The automatic analysis does not always work, so semi-automatic and manual analysis methods are provided. These work on static (post-acquisition) data.

Semi-automatic analysis consists of manually defining all the transition points, achieved by turning the "auto transitions" control off. Click on the graph to define four transition points for each power cycle, which will result in power values being written to the spreadsheets – using the least-squares algorithm described above. These transition points cannot be deleted, other than by toggling the "auto transitions" control.

Manual analysis consists of positioning a pair of crosswire cursors on the graph at the lower and upper transition points and recording the difference in power between the two points.

Three corrections can optionally be applied – using methods described in "IEC Standard 61161: Ultrasonics – Power Measurement – Radiation Force Balances and Performance Requirements". For each correction, the ratio of the corrected/uncorrected power value is displayed – each of which can be separately applied or in combination. The correction is only applied if the displayed value is enabled. All three physical phenomena act to reduce the radiation force at the target, so the corrections will always be positive. The three corrections are calculated as follows, by multiplying the uncorrected value with the result of the equation given. The relevant section of the measurement standard is also given:

1. Absorption (B.3.2): energy transferred to the propagation fluid

$$P_{Corr} = P_{Uncorr} \exp\left(2\alpha f^{2} z\right)$$

$\alpha = 2.3\text{x}10^{-4}$ MHz^{-2} cm^{-2}

f is frequency in MHz

z is transducer-target distance in cm

2. Transducer Size (E.1): departure from ideal plane waves

$$P_{Corr} = P_{Uncorr}\left(\frac{1 - J_1(2ka)/ka}{1 - J_0^2(ka) - J_1^2(ka)}\right)$$

k=angular wave number

a=transducer element radius

3. Focussing (B.5): non-normal incident energy

$$P_{Corr} = P_{Uncorr}\left(\frac{2}{1+\sqrt{1-\frac{a^2}{d^2}}}\right)$$

a=transducer element radius

d=geometric focus (radius of curvature)

The uncertainty calculations in the Results spreadsheet are based on the recommendations in "M3003. The Expression of Uncertainty and Confidence in Measurement. UKAS, 1997", using the following definitions:

- $< P >= \frac{\sum_{i=1}^{N} Power_i}{N}$, where <P> is the arithmetic mean of the measured power values and N is the number of measurements
- $RandomUC = \frac{100\sigma_N T_{FACT}}{< P > \sqrt{N-1}}$, where σ_N is the standard deviation and T_{FACT} is the Student's t-factor corresponding to the number of measurements
- $SystemUC = 5\%$
- $TotalUC = \sqrt{\left(F_C SystemUC^2 + CalibUC^2 + RandomUC^2\right)}$, where F_C is the coverage factor and CalibUC is the RFB calibration uncertainty

DATA STORAGE

There are two options for saving data – raw data and a results summary.

The raw data contains a full measurement dataset in CSV (comma-separated text) format, which can be imported directly to Excel. The following information is included:

- Signal source / transducer information
- Calibration data
- Measurements
- Analysis algorithm information
- Raw and analysed data

The results summary contains only configuration settings and the power measurements.

SYSTEM ISSUES

Balance settings can be adjusted via the Settings menu, which contains the following information:

- Acquisition:
  - Balance VISA name - the COM port used for communication with the balance
  - Default Balance
  - Simulate mode – usually off (when making measurements), but it can be turned on to work in demonstration mode by simulating a balance.
- Analysis:
  - Threshold – decrease the setting at lower powers to increase the ability of the analysis algorithm to find upper and lower transition points.
  - Offset – this does not usually need to be changed, but it should always be set so that the lower transition points are in a flat region of the acquired data.
  - Extrapolate – the straight line fit to the upper transition points is usually extrapolated to the times corresponding to the lower transition points, but this is not always desirable.

Default values for any of the settings can be defined with the “Set” button. If values are changed during running of the program, they do not modify the default settings.

MEASUREMENT

The RFB can be used in three different ways depending on the power level to be measured and the required uncertainty level.

AUTOMATED RECORDING METHOD (VIA PC)

This method allows the most accurate determination of the radiation force because it analyses the rate of change of force and uses an extrapolation method to estimate the value at the time when the transducer was actually turned on or off. This provides the best compensation for evaporation and/or other slowly changing forces on the RFB

- Run the software, using the RFB program menu shortcut (following the procedure above if this is the first use of the software or balance).
- Press “START” to begin measurement
- Table 1 below summarises exposure times for different power levels – use the displayed time to monitor the exposure:

TABLE 1	Low output (<1W)	Mid Output (1W-5W)	High output (>5W)
ON time	20s	10s	6s
OFF time	20s	20s	at least 30s
No. ON periods	6-8	4	4

- Prior to turning the power on for the first time on a specified acquisition, allow the system to run with power off for about twice the intended OFF time
- Press “STOP” to end measurement

AUTOMATIC VS MANUAL TRANSITION POINT CALCULATION

When data has been automatically acquired using the RFB software, two analysis methods are available. If the “Auto Transitions” selector (next to the “Results” display) is set to on (green), then the software will attempt to automatically find the on-off transition points within the data and use these to calculate the acoustic power. In some cases (e.g. for low acoustic powers), the transition point identification may be unreliable. In this case, the user has the option to manually identify the transition points used in the power calculations. To do this, once the data acquisition has been “STOPPED” switch the “Auto Transitions” selector to the “OFF” position. All transition points will be cleared. To identify the new transition points:

- Find the point on the graph immediately before the first “switch-on” of the transducer (low-high transition) and click the graph at that point.
- Find the top of the “on transition” and click the graph at that point.
- Find the top of the “off transition” (power goes high-low) and click at that point.
- Find the bottom of the first “off transition” (the end of the high-low transition) and click again.
- Repeat these steps for all of the subsequent “switch-ons” of the transducer.

As you follow this procedure, the “Per-cycle measurements” indicator will be populated, and once three “switch-on”s have been identified, the measurement uncertainties will begin to be calculated.

Note: The IEC correction factors, and the “Threshold”, “Offset” and “Extrapolate” control values still apply to this analysis. However, for any value changes to take effect, it is necessary to click “Re-Process”.

APPROXIMATE METHOD

This is suitable for a quick check to see if the transducer is working or to gain an approximate value for powers above about 100mW (depending on the rate of evaporation).

- Note the balance reading (or tare it to zero).
- Switch on the signal to the transducer
- Wait for 10 seconds
- Note the balance reading
- Turn off the signal to the transducer
- Subtract the first reading from the second and multiply by 14.5 to obtain the equivalent acoustic power in mW)

MANUAL RECORDING METHOD (NOT USING PC)

This method compensates for evaporation by averaging the measurements for both transitions.

- Take a reading at T = 0 seconds and record this value as M(0).
- Switch on the signal to the transducer.
- Take a reading at T = 10 seconds and record this value as M(10).
- Switch off the signal to the transducer immediately.
- Take a third reading at T = 20 seconds and record this value as M(20). A set of OFF-ON-OFF measurements has been completed.
- Repeat this process another three times to complete one full measurement run consisting of four separate OFF-ON-OFF cycles.
- Determine the mean value of the 'OFF - ON' [M(10) - M(0)] and 'ON - OFF' [M(10) - M(20)] differences for each cycle of OFF-ON-OFF measurements. Taking the mean of the 'OFF - ON' and 'ON - OFF' mass values compensates for the loss of water by evaporation.
- Measure the water temperature in the target. Calculate a value for the speed of sound in water at this temperature using the values in table 3.
- Multiply each mean mass value by 14.5 (see section 5.1) to determine the power.
- Calculate the overall mean power and its standard error.

FURTHER INFORMATION FOR FORCE BALANCE MEASUREMENT

RADIATION FORCE OVERVIEW

When an ultrasound wave strikes the target, its momentum is transferred to the target, resulting in a force. This radiation force is present when the transducer is generating ultrasound and absent when it is not: there is a change in the force at the same time as the ultrasound is turned ON or OFF. The RFB measures the mass of the target plus the mass corresponding to the vertical component of the radiation force, and so it is possible to determine the radiation force due to the ultrasound. For an absorbing target perpendicular to the acoustic beam, the total power P_{vert} corresponding to the vertical component of radiation force is related to the mass reading on the balance, m_{rad}, by the equation

$$P_{vert} = m_{rad.} .c.g.F$$

Where:

c = speed of sound in water

g = gravitational acceleration

F=calibration factor for absorbing target (output/input power ratio) – in the range 0.95-1

Using the speed of sound at 20ºC from table 2 and g=9.81 m/s, the following approximation can be made:

$$P_{vert} \cong m_{rad} \, . \, 14.5 \text{ mW mg}^{-1} \quad \text{(at normal room temperature)}$$

However, the RFB is sensitive to the vertical components of all the forces acting on it and there are many reasons apart from radiation force that the total force on the RFB might change.

- For a top pan balance, water evaporation causes a gradual decrease in mass. The rate of mass loss is in the range 0.01-0.1 mg/s and under good experimental conditions it will be approximately constant.

- The apparent change in target mass is measured when the ultrasound is turned ON or OFF. The RFB takes a few seconds to stabilise after a sudden change in the radiation force caused by turning the ultrasound ON or OFF. During this stabilisation time, water continues to evaporate and therefore the apparent mass of the target – for top pan measurement - decreases (by perhaps 0.1 mg to 1 mg, equivalent to approximately 1.5 mW to 15 mW). This means that accurate results cannot be obtained simply by observing the change in the displayed value as this contains contributions from the radiation force and evaporation loss.

Temperature (deg C)	**Speed of Sound (m/s)**
18	1476.05
19	1479.25
20	1482.36
21	1485.39
22	1488.34
23	1491.20

Table 2. Temperature-Dependence of Speed of Sound in Pure Water

ABSORBER MATERIAL

The target material is nearly totally absorbing and non-reflecting to ultrasound in the frequency range 1 MHz to 10 MHz:

	HAM A	F28P
Transmission Loss	30 dB cm^{-1} MHz^{-1}	30 dB cm^{-1} MHz^{-1}
Echo Reduction	40 dB at 1 MHz degrading to 35 dB at 3MHz and continuing at this level to 10MHz	10 dB at 1 MHz increasing to 30 dB at 2MHz and 40dB from 7HMz upwards

Table 3. Absorber Properties

Care should be taken when operating a transducer at higher acoustic power levels (>5 W). The absorbing material is susceptible to damage when exposed to higher levels of acoustic power for prolonged periods. As a guide, for power measurements above 10W, the duration of the OFF time should be at least ten times the ON time.

ENVIRONMENTAL CONDITIONS

It is important to minimise changes in the airflow around the target, as this will cause the rate of evaporation to change in an unpredictable fashion and increase the uncertainties in the measurement of radiation force for a top pan balance. A closed or partially closed container around the target will also reduce evaporation since the atmosphere inside the container will gradually become more saturated. The use of the supplied draught shield with a partial lid thus improves the performance of the RFB in a number of ways and should always be used for lower power measurements.

Other unwanted changing forces which may be detected by the RFB include mechanical vibration of the support, movement or vibration of the transducer, direct wind forces, static electricity, magnetic fields, changing immersion depth of the transducer, changing water temperature, or progressive wetting of the transducer or clamp by capillary action. All of these should be minimised to obtain the lowest uncertainties.

Particular care should be taken to avoid vibration of the supporting surface (which is often caused by people walking heavily nearby, building vibration, fan-cooled equipment on the same surface or pressing the on/off button for the ultrasound) and of the transducer (which is often caused by a disturbed transducer cable, a slipping transducer or a loose clamp). Provided reasonable care is taken, it should be possible to obtain a very consistent rate of change in indicated mass which is due only to controlled evaporation and slow change in the water temperature. The RFB reading should not differ from this downward trend by more than ±0.1 mg. A continued difference from this expected behaviour indicates that there is mechanical movement (often of the transducer) or poor draught shielding.

All RFBs are responsive to vibration and movement. Throughout the set-up and measurement procedure it is important to keep vibration to a minimum by closing all doors to the laboratory, fastening cables with appropriate ties and ensuring no movement occurs to the table which the balance is on. It may be necessary to switch off air conditioning to reduce type B (random) uncertainties for lower power measurements.

DIVERGENT BEAMS

It should also be remembered that the forward ultrasound power (ie the component which is travelling vertically downwards) is always smaller than the total radiated power. For many transducers the difference will be perhaps 2% or less, which is much smaller than the declared uncertainty. However, for very strongly divergent transducers, strongly focused transducers or transducers which radiate in a sector format (for example, curvilinear or phased array imaging transducers) the difference could be much larger.

CAVITATION

In order to eliminate the possibility of cavitation, measurements should be performed in freshly degassed and deionised water. This can be achieved by the addition of 4g of Sodium Sulphite (Na_2SO_4) to one litre of deionised water. Do not add Na_2SO_4 to tap water, since any dissolved carbonates (scale) will precipitate out. The use of degassed water is especially important for measurements at frequencies below 3 MHz and at power levels above 1 W.

It is estimated that water will re-gas over a period of four hours or so. Generally for high power measurements and measurements below 3 MHz, it may be necessary to change the water every 1 to 2 hours.

MAINTENANCE AND CALIBRATION

- It is recommended that the performance of the balance as a basic weighing device is checked regularly with a calibrated mass. When doing this, the RFB target should be removed from the weighing pan, and the calibrated mass placed directly on the pan.

- The linearity of the balance can be checked by using a series of calibrated masses that cover the range of power typically produced by ultrasound fields (1 mg to 1 g).

- The target (in particular the two-layered absorber) should be checked periodically for damage. It should also be cleaned occasionally by removing it from its container and wiping the surface with a soft damp cloth.

- Annual recalibration of the RFB for the determination of ultrasound power is recommended.

WARRANTY

The balance is subject to the warranty of the supplier. The remainder of the system with the exception of the absorbing material is provided with a 12 month warranty from the date of delivery. This warranty does not cover defects in or damage to the system resulting from improper use or neglect. The absorbing material is regarded as a consumable item and replacements are available from Precision Acoustics Ltd. Free software upgrades are available during the warranty period.

CONTACT AND SUPPORT

For support or recalibration please contact Precision Acoustics:

Tel: + 44 1305 264669, Fax: + 44 1305 260866

Technical support email: technical@acoustics.co.uk

Recalibration email: pa@acoustics.co.uk

Precision Acoustics Ltd

TROUBLESHOOTING

- In the event of a suspected fault, first remove the target completely from the balance and check correct operation of the balance by using a known test mass. The internal calibration function can also be used to perform this check.

- Turn off all unnecessary electrical equipment in the area of the balance (including signal sources, power amplifiers, computers etc). Close the draught shield and allow 20 minutes for the balance to equilibrate and then check that the balance reading is stable. When doing this ensure that you do not disturb the balance by getting too close to it. If the balance reading is unstable, it indicates that there are sources of changing electrical charge or vibration. Ensure cables to the balance are prevented from moving but are not under excessive tension. Also check for bubbles in the water, which may become dislodged from time to time.

- Mount an ultrasound transducer so that it is 5mm to 10mm above the surface of the water in the target and repeat the previous test with the draught shield closed as much as possible. The drift will be faster than previously but again it should be consistent - if not there are likely to be significant air currents around the balance or the transducer is introducing a problem. Check that the clamp and transducer are not touching the balance or target.

- Lower the transducer so that the front face is approximately 10mm below the surface of the water and remove any bubbles from the transducer. Repeat the previous test. Ensure the transducer is firmly held and that the clamp itself is stable. It is quite common for the clamp to “creep” allowing slow movement of the transducer over a period of time. This can easily happen on compliant surfaces such as rubber or foam which gradually compress. A certain amount of “creep” is inevitable and is acceptable as long as it is gradual and controlled. Ensure that the transducer cable is immobilised but is not under excessive tension.

- Turn on the electrical equipment used to drive the transducer and repeat the previous test. If this equipment causes vibration, move the balance to a separate table or trolley.

- Now turn on any other equipment which is commonly used (including the PC used for data acquisition) and repeat the test for a consistent rate of mass decrease. If a disturbance is introduced identify the device that is causing it.

- Carry out a measurement run of four ON-OFF periods but DO NOT turn the ultrasound on or off. It is best to stand or sit completely still during a measurement run to ensure that any movement near the balance is kept to a minimum. Now repeat the four ON-OFF periods with the ultrasound turned on and off at the appropriate times. If there is still a problem, ensure that the act of turning the ultrasound on and off does not disturb the balance.

- If these tests have not isolated the problem it may be that there is an electrical interaction between the transducer and the balance. Try a different type of transducer and repeat the process. If it is safe to run the transducer in air, drain the water from the target and carry out the measurement run as normal, but without the water to couple the ultrasound energy to the target. There should be no change in the display when the ultrasound is turned on or off