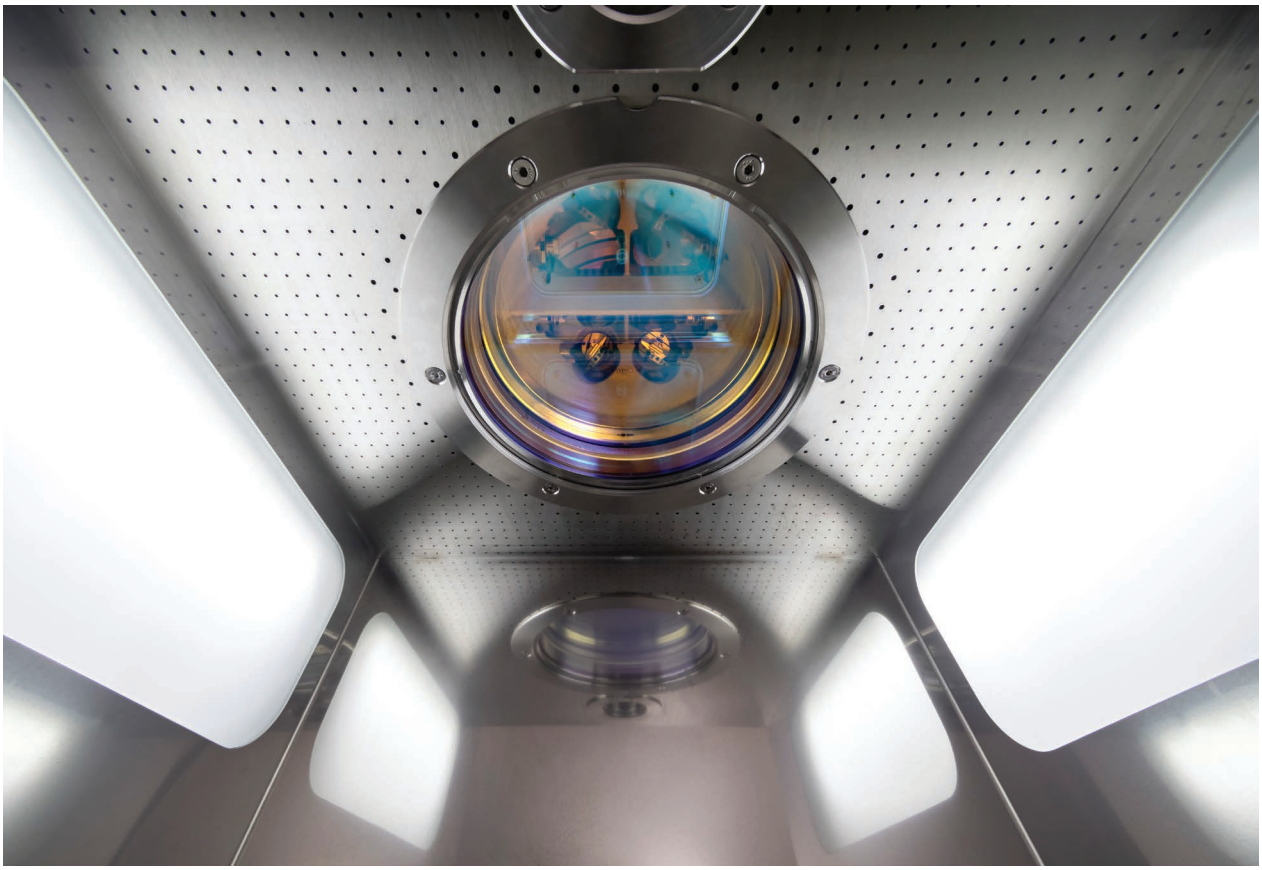
User guide

RENISHAW
apply innovation™

RenAM 500 series additive manufacturing system



ORIGINAL INSTRUCTIONS

www.renishaw.com/additivemanufacturing

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1. Legal notices

1.1 Terms and conditions and warranty

Unless you and Renishaw have agreed and signed a separate written agreement, the equipment and/or software are sold subject to the Renishaw Standard Terms and Conditions supplied with such equipment and/or software, or available on request from your local Renishaw office.

Renishaw warrants its equipment and software for a limited period (as set out in the Standard Terms and Conditions), provided that they are installed and used exactly as defined in associated Renishaw documentation. You should consult these Standard Terms and Conditions to find out the full details of your warranty.

Equipment and/or software purchased by you from a third-party supplier is subject to separate terms and conditions supplied with such equipment and/or software. You should contact your third-party supplier for details.

1.2 Patents

Features of the RenAM 500 series additive manufacturing system, and other similar systems, are the subject of one or more of the following patents and/or patent applications:

CA 2738618	EP 2331232	IN 394466	US 10335901	US 8753105
CA 2738619	EP 2875855	IN 411680	US 10493562	US 8794263
	EP 2956261		US 10639879	US 9114478
CN 102186554	EP 2956262	JP 6482476	US 10933620	US 9669583
CN 105102160	EP 3007879		US 10974184	US 9849543
CN 105228775	EP 3119587		US 10994335	
CN 105492188	EP 3221073		US 11033968	
CN 106457393	EP 3299110		US 11040414	
CN 107107193	EP 3323533		US 11104121	
CN 108189390	EP 3323534		US 11167497	
CN 108349005	EP 3325240		US 11305354	
CN 108515182	EP 3357606		US 11358224	
CN 109177153	EP 3377252		US 11478856	
CN 109937101	EP 3377253		US 11565346	
CN 111491777	EP 3482909		US 11752694	
CN 111545754	EP 3538295		US 12030245	
CN 112703074	EP 3566798		US 2021-0308769	
CN 115867402	EP 3849733		US 2022-0168813	
CN 115943048	EP 3930999		US 2022-0203451	
CN 118080891	EP 4023387		US 2023-0302538	
	EP 4175781		US 2024-0083108	

1.3 Declaration of conformity

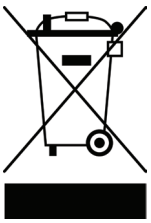
Renishaw plc hereby declares that the RenAM 500 series is in compliance with the essential requirements and other relevant provisions of:

- The applicable EU directives
- The relevant statutory instruments under UK law
- The product regulatory laws of Australia and New Zealand

The full text of the declaration of conformity is available at:

Product compliance – Additive manufacturing (renishaw.com)

1.4 WEEE directive



The use of this symbol on Renishaw products and/or accompanying documentation indicates that the product should not be mixed with general household waste upon disposal. It is the responsibility of the end user to dispose of this product at a designated collection point for waste electrical and electronic equipment (WEEE) to enable reuse or recycling. Correct disposal of this product will help to save valuable resources and prevent potential negative effects on the environment. For more information, please contact your local waste disposal service or Renishaw distributor.

1.5 Battery safety

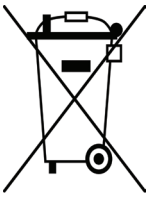
This product is supplied with non-rechargeable lithium metal batteries. These batteries are embedded in the machine and should only be replaced by a Renishaw Service Engineer.

- Do not attempt to recharge the batteries.
- Do not disassemble, apply excessive pressure, pierce, deform or subject the batteries to impact.
- Dispose of waste batteries in accordance with your local environmental and safety laws.

Ensure that you comply with international and national battery transport regulations when transporting this product with the batteries inserted.

Lithium metal batteries are classified as dangerous goods for transportation and require labelling and packaging in accordance with the dangerous goods regulations before being offered for transportation. To reduce the risk of shipment delays, should you need to return this product to Renishaw for any reason, do not return any batteries.

1.6 Disposal of batteries



The use of the crossed out wheeled bin symbol on the batteries, packaging or accompanying documents indicates that used batteries should not be mixed with general household waste. Please dispose of the used batteries at a designated collection point. This will prevent potential negative effects on the environment and human health which could otherwise arise from inappropriate waste handling. Batteries may contain hazardous materials such as lithium, nickel, cobalt, graphite, cadmium and lead. These cause soil and water contamination when disposed of incorrectly. Lead, cadmium and nickel are toxic to human and animal life. Lithium may cause a flammability hazard when placed in general waste sites.

Please contact your local authority or waste disposal service concerning the separate collection and disposal of batteries.

Lithium batteries are highly flammable when exposed to heat. All lithium chemistry batteries must be protected from short circuit (by placing in a sealed bag or placing insulation tape over both terminals) prior to being offered for recycling. In addition, all rechargeable lithium batteries must be discharged.

1.7 FCC information (USA)

1.7.1 47CFR section 15.19

This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

1.7.2 47CFR section 15.21

The user is cautioned that any changes or modifications not expressly approved by Renishaw plc or authorised representative could void the user's authority to operate the equipment.

1.7.3 47CFR section 15.105

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at their own expense.

1.8 REACH

Information required by Article 33(1) of Regulation (EC) No. 1907/2006 (“REACH”) relating to products containing substances of very high concern (SVHCs) is available at:
Product Environmental Compliance – Additive manufacturing (renishaw.com)

1.9 Control of pollution, applicable in the People’s Republic of China

Renishaw have prepared a table in accordance with the provisions of SJ/T 11364. This is available on request from Renishaw.

1.10 China RoHS

For more information on China RoHS, visit:

Product compliance – Additive manufacturing (renishaw.com)

1.11 Industrial, Scientific and Medical Equipment (ISM) (Canada only)

This ISM device complies with ICES-003(A) / NMB-003(A).

Cet appareil ISM est conforme à la norme ICES-003(A) / NMB-003(A).

1.12 Changes to equipment

Renishaw reserves the right to change equipment specifications without notice.

2. Introduction

The Renishaw additive manufacturing (AM) process allows you to create homogeneous solid metal components directly from 3D CAD data using high-powered laser energy to melt fine metal powder. This manufacturing process is known as Laser Powder Bed Fusion (LPBF).

The RenAM 500 series is a complex and sophisticated AM machine designed to support the Renishaw AM process. This user guide provides information on the basic operation and safety procedures necessary for handling the AM system and its associated materials. Due to the complexity and potential dangers associated with the raw materials used in the RenAM 500 series system, it is important to follow the safety and handling protocols outlined in this user guide to mitigate risks and ensure safe operation.

NOTE: The procedures and information contained in this user guide do not apply to the RenAM 500M additive manufacturing system. This user guide is applicable only to the RenAM 500 series, which includes the RenAM 500Q/D/S Flex, RenAM 500Q/D/S, and RenAM 500Q/D/S Ultra systems.

2.1 Intended use

The Renishaw RenAM 500 series machines are a complex piece of AM equipment used for supporting the Renishaw AM process. They use the industry-leading gas flow system, precision dynamic control and software for connected digital workflows for scaling your AM application.

NOTE: The system must be operated only by staff who have completed a Renishaw-approved training course, and in accordance with the instructions and advice contained in this user guide. Operation of the RenAM 500 series system by operators who have not completed a Renishaw-approved training course will invalidate the warranty on the RenAM 500 series system.

2.2 RenAM 500 series models

Renishaw's RenAM 500 series is a comprehensive platform of multiple-laser digital AM machines, each designed with unique features and capabilities. The series includes the following variants:

- **RenAM Flex models (RenAM 500S Flex, RenAM 500D Flex, RenAM 500Q Flex)**: These models are equipped with a flexible total-loss powder management system, providing a high degree of adaptability in managing the powder used in the manufacturing process.
- **RenAM 500 Ultra models (RenAM 500S Ultra, RenAM 500D Ultra, RenAM 500Q Ultra)**: These models come with on-board powder filtration and recirculation systems. They also feature advanced TEMPUS™ technology and have LaserVIEW™ and MeltVIEW™ hardware installed as standard, enhancing the precision and efficiency of the manufacturing process.
- **RenAM 500 models (RenAM 500S, RenAM 500D, RenAM 500Q)**: These models are equipped with on-board powder filtration and recirculation systems. However, unlike the Ultra variants, they do not include the TEMPUS technology, LaserVIEW, and MeltVIEW hardware as standard features.

The ‘S’, ‘D’ and ‘Q’ in the model names denote the number of laser system used:

- ‘S’ stands for a Single (1) laser system.
- ‘D’ stands for a Dual (2) laser system.
- ‘Q’ stands for a Quad (4) laser system.

In summary, the RenAM 500 series offers a range of configurations, each tailored to meet specific manufacturing needs and requirements. From flexible powder management to advanced on-board filtration and recirculation systems, and from single to quad laser systems, the RenAM 500 series system provides a comprehensive solution for digital AM.

2.3 Reference documentation

In addition to this user guide, refer to the following documents for information about other aspects of the RenAM 500 series system:

- RenAM 500 series additive manufacturing system site preparation and installation guide (Renishaw part no. H-5800-3692)
- RenAM 500 series additive manufacturing systems data sheet (Renishaw part no. H-5800-4030)
- TEMPUS™ technology data sheet (Renishaw part no. H-5800-6860)
- RenAM 500 Flex material change process user guide (Renishaw part no. H-5800-4755)
- RenAM 500 and RenAM 500 Ultra batch material change process user guide (Renishaw part no. H-5800-6826)
- RenAM 500 and RenAM 500 Ultra sieve mesh replacement user guide (Renishaw part no. H-5800-6859)

NOTE: To access the latest Material data sheets and Safety data sheets for each of the metal powders developed for the RenAM 500 series system, go to **Material and safety data sheets - Additive manufacturing (renishaw.com).**

2.4 Training schedule

Renishaw provides a basic level of training to operate the RenAM 500 series system safely. Renishaw also offers extended training courses for operators and process engineers. Please refer to this user guide (Renishaw part no. H-5800-3693), the RenAM 500 series additive manufacturing system – Site preparation and installation guide (Renishaw part no. H-5800-3692) and the training guide supplied as part of the user training course that all users must complete before using the RenAM 500 series system.

2.5 Critical information in this guide

Within this user guide additional information that is important to read and understand is presented as a Warning, Caution or Note. The definition of each of these and an example of each is given below.

2.5.1 Warning

An example of a Warning is as follows:

WARNING: A warning is to tell the end user that there is a possibility of injury to themselves or other people in the vicinity if the described course of action is not followed.

2.5.2 Caution

An example of a Caution is as follows:

CAUTION: A Caution is to tell the end user that there is a possibility of damage to the equipment if the described course of action is not followed.

2.5.3 Note

An example of a Note is as follows:

NOTE: A Note is to advise the end user of important information that is related to, or will assist them in the task or activity they are carrying out.

3. Safety

3.1 General safety information

For the secure installation, operation and/or maintenance of your RenAM 500 series machine, it is the responsibility of the equipment owner to make sure that each person who operates the system reads and understands the manufacturer's instructions. This includes the labels applied on the equipment as well as the user manuals.

WARNING: Ensure all operators have completed a Renishaw-approved training course before operating the RenAM 500 series system. Operating the system without completing a Renishaw-approved training course may not only invalidate the system's warranty, but also potentially cause damage to the system and pose a serious risk of injury to the operator and others in the vicinity.

CAUTION: Any use of controls, adjustments, or procedures not explicitly specified in this manual may result in hazardous radiation exposure. Follow the instructions provided in this guide to ensure safety.

3.1.1 Read instructions

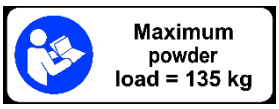
WARNING: Before installing, operating and/or maintaining the RenAM 500 series system or the ancillary equipment, you must read the manufacturer's instructions. If the instructions are not followed, you may injure yourselves or others, or cause damage to the equipment.

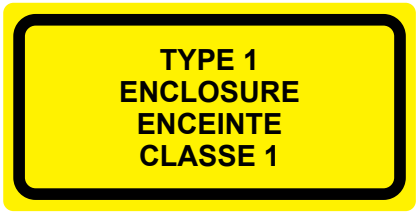
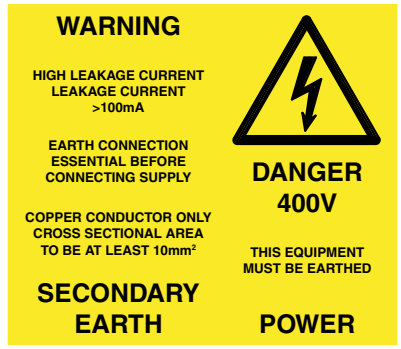
3.1.2 Safety signs and laser safety labels

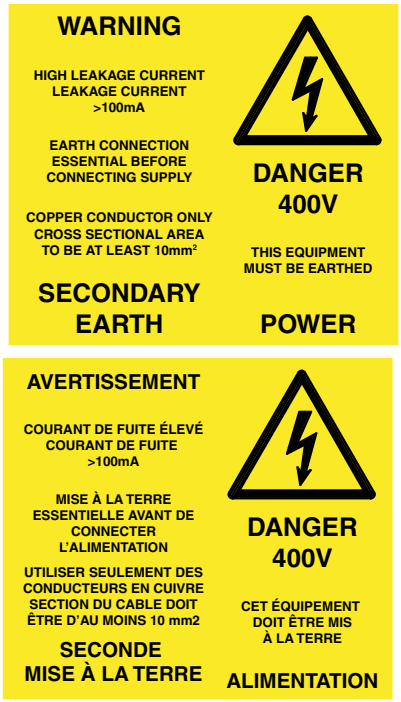
There are various safety signs and laser labels fitted to the RenAM 500 series system. They warn of hazards from the system and advise on laser safety. Replacement safety signs can be ordered from Renishaw.

NOTE: Safety signs and laser labels fitted to the RenAM 500 series machine are in accordance with the mandatory language requirements of TÜV SÜD and CE. Safety signs and laser labels in non-mandatory languages are available by request.

The safety signs and their location are described in the table below:

Safety sign	Description and location
	**Read the manual before proceeding** One sticker, on the front of the RenAM 500 series to the left of the reset button below the touch screen control panel. Part no.: M-6252-0264
	RenAM 500 Flex only: One sticker, on the powder loading arm. Part no.: M-6810-2051
	RenAM 500 Flex only: One sticker, on the powder feed hopper. Part no.: M-6810-1047
	Two stickers, on the top panel next to the argon gas exhaust. Part no.: M-6521-3811
	**WARNING: HIGH VOLTAGES PRESENT** **WARNING: ISOLATE MACHINE BEFORE OPENING** Two × two stickers, on the front electrical cupboard door, next to the two security locks. Two × two stickers, on the rear electrical cupboard door, next to the two security locks. Two × two stickers, on the rear centre electrical and recirculation pump access door next to the two security locks. Three × two stickers, one on each of the three top panels. Part no.: M-5774-1710
	**WARNING: DANGER OF ASPHYXIATION** One sticker, on the top panel next to the argon gas exhaust. Part no.: M-5774-0657

	**TYPE 1 ENCLOSURE** Fitted to the nameplate on the rear of the system. Part no.: M-5778-8904
	**WARNING: HIGH LEAKAGE CURRENT** **EARTH CONNECTION ESSENTIAL BEFORE CONNECTING SUPPLY** One sticker on the rear of the system as part of the system nameplate. Part no.: M-5774-5558
	**Forklift here** Two stickers on the front of the system low down above the plinth, indicating where a forklift should lift the system if required. Part no.: M-5778-8915
 	**DANGER 400V** **THIS EQUIPMENT MUST BE EARTHED** One label on the left-hand side of the system at low level where argon gas and power enter the system. Part no.: M-6521-1391



WARNING: HIGH LEAKAGE CURRENT.

LEAKAGE CURRENT >100mA

EARTH CONNECTION ESSENTIAL BEFORE CONNECTING SUPPLY

COPPER CONDUCTOR ONLY

CROSS SECTIONAL AREA TO BE AT LEAST 10mm²

One label on the left-hand side of the system at low level where argon gas and power enter the system.

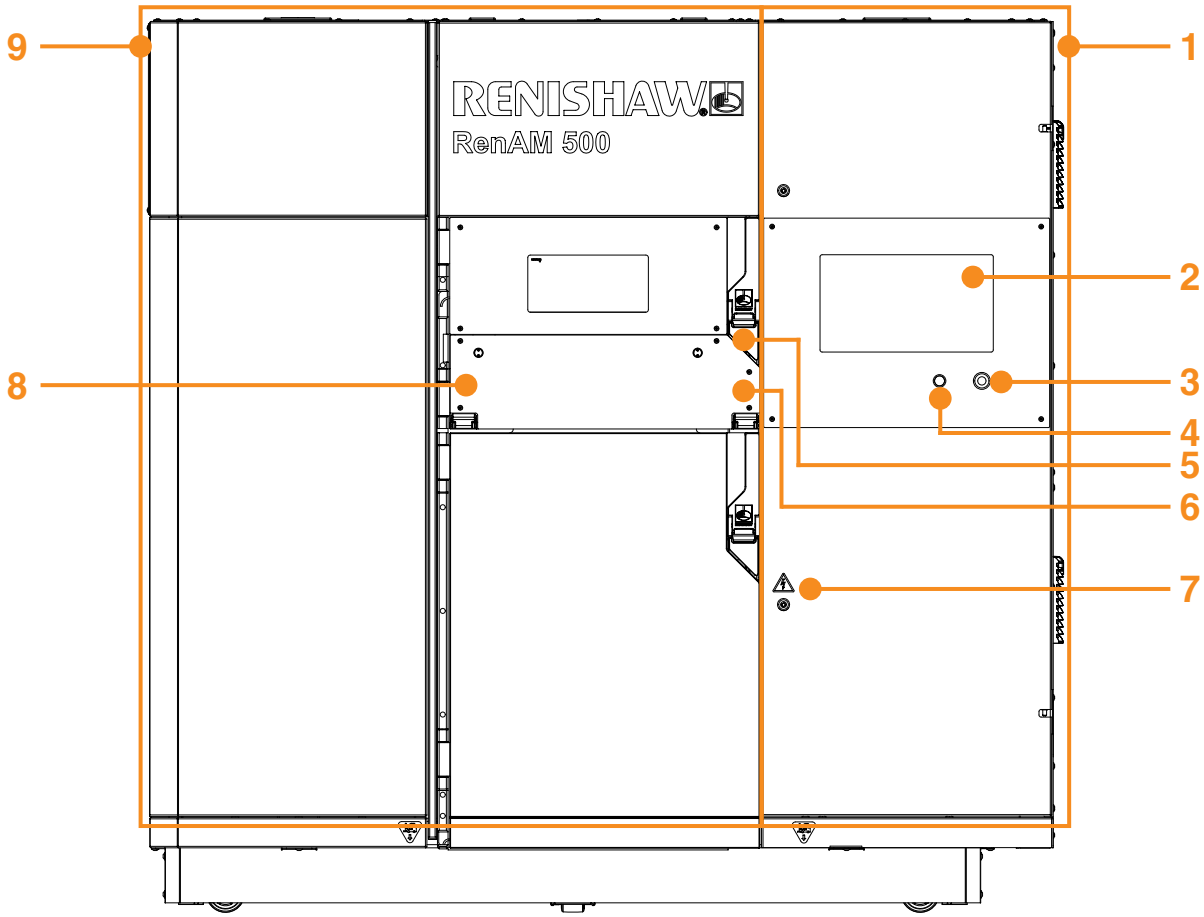
Part no.: M-6521-1391

3.1.3 Safety function diagrams

The following figures illustrate the safety functions of the RenAM 500 series AM systems.

NOTE: The following figures show the front, rear and plan views of the RenAM 500 only. However, the same safety functions are found in the same locations on the RenAM 500 Flex and RenAM 500 Ultra.

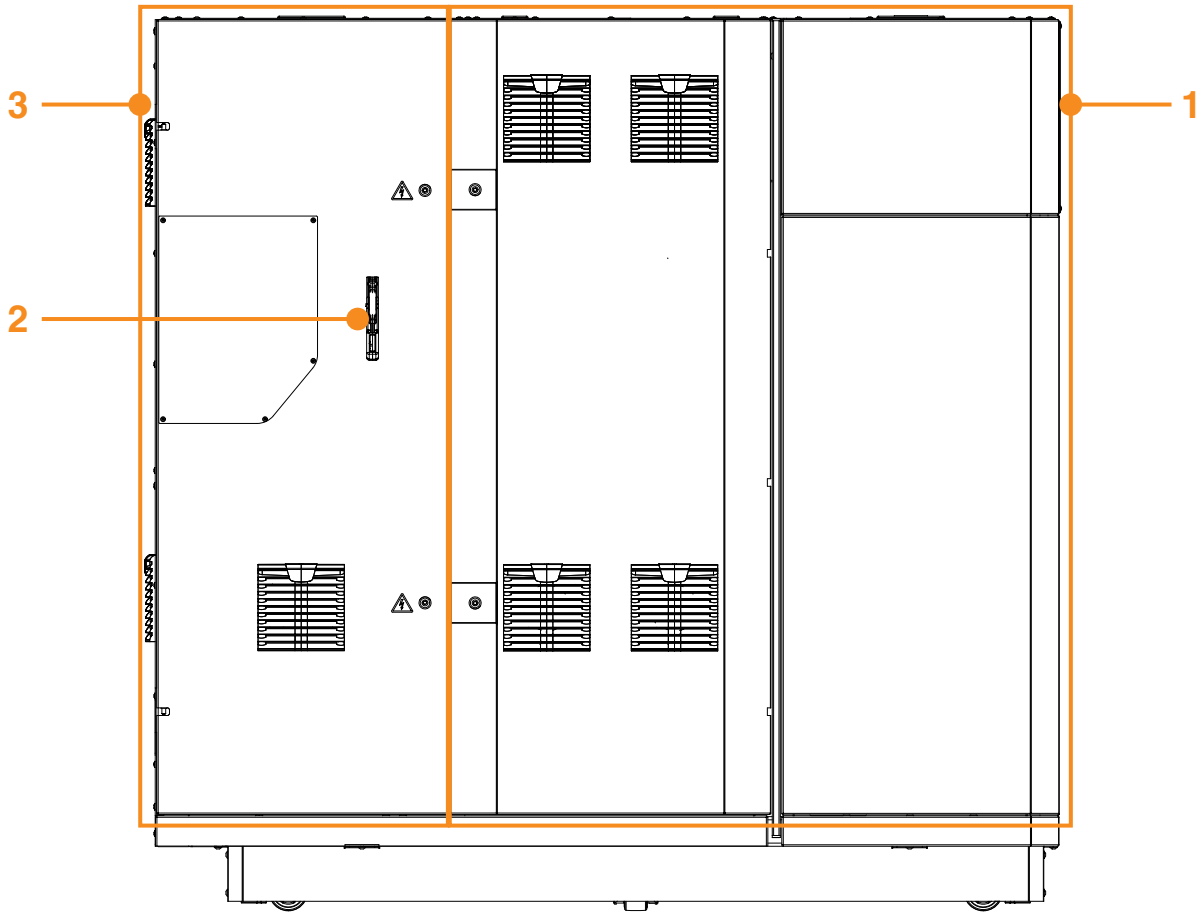
3.1.3.1 RenAM 500 front view – safety functions



1	Hazard zone 2: electrical control cabinet	6	Mechanical door lock
2	Operator touch screen control panel	7	Service mode switch
3	“Emergency Stop” button	8	Glovebox door magnetic switch
4	“Reset” button	9	Hazard zone 1: work/maintenance area
5	Build chamber door magnetic switch		

Figure 1 RenAM 500 front view – safety functions

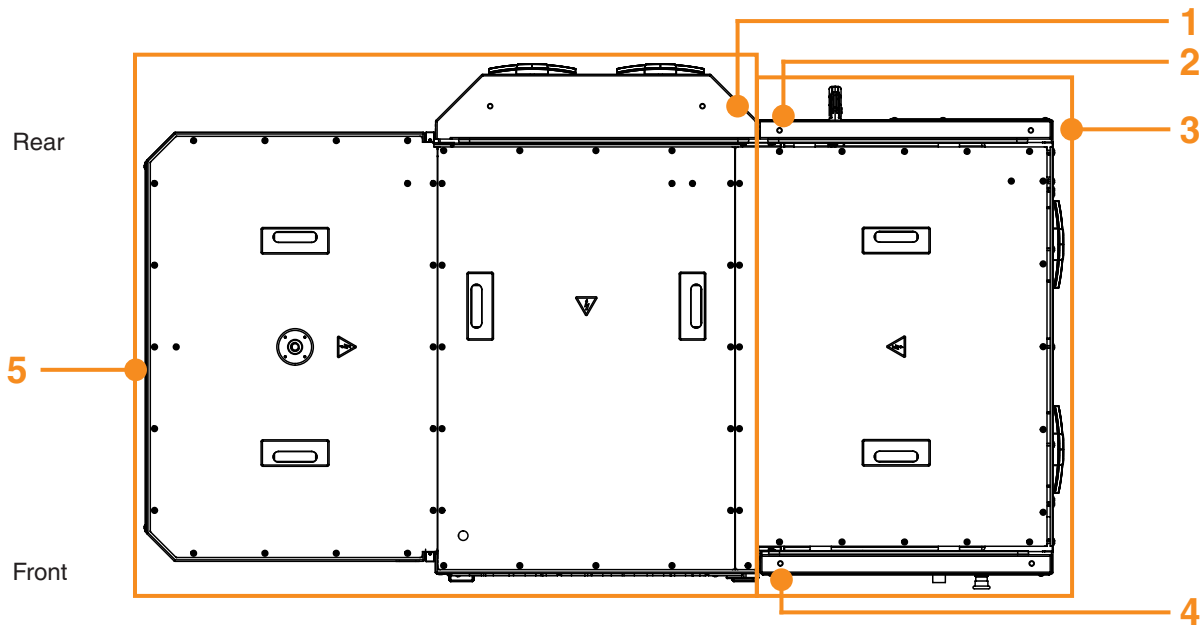
3.1.3.2 RenAM 500 rear view – safety functions



1	Hazard zone 1: work/maintenance area
2	Hazard zone 2: electrical control cabinet
3	Electrical isolator

Figure 2 RenAM 500 rear view – safety functions

3.1.3.3 RenAM 500 top view – safety functions



1	Lockable door
2	Lockable door
3	Hazard zone 2: electrical control cabinet
4	Lockable door
5	Hazard zone 1: work/maintenance area

Figure 3 RenAM 500 top view – safety functions

3.2 Safety information for the system

The RenAM 500 series has been designed with safety in mind and has a number of in-built safety features. However, there are risks involved, but with sufficient planning and careful management these can be mitigated. RenAM 500 series safety features include:

- Sealed argon environment for processing.
- RenAM 500 and RenAM 500 Ultra only: Four oxygen sensors (two are SIL rated) and a chamber pressure sensor.
- RenAM 500 Flex only: Three oxygen sensors (one is SIL rated) and a chamber pressure sensor.
- RenAM 500 and RenAM 500 Ultra only: Fully sealed powder environment with automated recycling.
- Environmentally sealed powder flasks for powder filling.
- Powder adaptor for decanting powder from suppliers' powder bottles into powder flasks.
- Glovebox allowing the majority of powder handling to be carried out under argon.
- Interlocked Class 1 laser enclosure.

- Large SafeChange™ filters are flooded with water to make safe before disassembly.
- Renishaw approved and recommended ancillary equipment to simplify and facilitate the process of operating the machine and producing builds.

3.2.1 Transport and system relocation

If your RenAM 500 series system is to be moved to an alternative production facility or resold, Renishaw is happy to assist and advise. With this in mind, please inform us at your earliest convenience.

CAUTION: The transportation of the RenAM 500 series should only be carried out following the advice and recommendations of Renishaw plc.

3.2.2 Responsibilities

This document is intended as a guide. It is not intended as a complete work instruction for the installation of a system. Equipment installation and commissioning will be carried out by a Renishaw service engineer.

As an equipment owner, you must make sure that all the necessary local and national legislation, regulations, procedures and requirements have been considered and adhered to. Although not exhaustive, the list may include:

- Fire safety.
- Risk assessments.
- Management of hydrogen potentially generated by wet powder.
- Electrical wiring.
- Walkway clearances and fire exits.
- Air handling and filtration.
- Storage of compressed gas.
- Suitable lifting equipment.
- PPE – must not generate static charge.
- Filing of Safety data sheets.
- Provision of operator work instructions.
- Completion of an explosion prevention document.

NOTE: Read this guide thoroughly and ensure that all instructions are followed. Also, make sure to complete and submit the checklist contained in the RenAM 500 series additive manufacturing system site preparation and installation guide (Renishaw part no. H-5800-3692) to Renishaw. This process ensures that you have all the necessary resources, skills, facilities, equipment, services, systems and processes for the successful installation and commissioning of your RenAM 500 series system at your facility.

Should you require it, Renishaw can assist you in completing this checklist. This will help ensure a smooth process when receiving, installing, and operating the machine and its ancillary equipment. Since Renishaw's guidance is specific to the supplied equipment, it is essential that the equipment installer takes responsibility for planning the overall installation.

3.2.3 Basic safety measures

Relevant national legislation and internal company policies will dictate normal minimum requirements for health and safety. Risk assessments must be carried out prior to operating the system.

All end user companies must undertake a full risk assessment to establish the requirement for additional measures such as a COSHH and DSEAR assessment. This will subsequently inform the provision of correct PPE and site operating conditions and procedures for safe use of the equipment, storage and handling of raw materials and waste product. Any ancillary equipment must be selected giving due consideration to these requirements.

Governing and regulatory bodies will differ depending upon the geographic location where the RenAM 500 series is located. The appropriate governing and regulatory bodies must be identified for the geographic location where the RenAM 500 series is located. Considerations need to include regulations governing:

- Machinery safety.
- Electrical safety.
- EMC.
- The operation of lasers.
- The use of fine metallic powders.
- The use, storage and monitoring of inert gas.
- Small quantities of waste product including nanoparticles captured by the filter system and its correct disposal.
- The management of electrostatic charge.

Review all Safety data sheets for the materials being used.

By following the correct procedures, it is possible for most powder handling to be executed under an inert atmosphere; however measures must be taken to minimise exposure to any airborne metallic powder produced during the handling and processing of builds by the use of the appropriate PPE and other equipment as the components are removed from the system.

If in doubt about the health and safety issues and your legal obligations, our recommendation is to engage the services of a competent person.

3.2.4 Explosion prevention

The system, components and accessories are not suitable for operation or storage in areas containing explosive gases. Renishaw recommends that you develop and maintain an explosion prevention document in accordance with the applicable local legislation in the geographic area where the RenAM 500 series is located. In the absence of applicable local legislation, Renishaw recommends that you refer to the applicable DSEAR (ATEX 137) or NFPA standard (NFPA 484) and develop your explosion prevention document in accordance with one of these standards.

3.2.5 Emergency response

In case of emergency, immediately press the Emergency Stop button located on the front panel of the RenAM 500 series to stop the system. After operation of the Emergency Stop button, take action in accordance with the local rules and procedures for dealing with an emergency event. Operation of the Emergency Stop will stop the build.



Figure 4 Emergency Stop button on front of RenAM 500 series system

3.2.6 Normal operation

WARNING: During the operation of equipment and/or ancillary equipment, no safety devices may be removed or disabled. If the safety devices are removed or disabled, you may injure yourselves or others, or cause damage to the equipment.

The equipment may only be operated from the area directly in front of the touch screen. Operating the system from any other location is unsafe. The operating staff must ensure that no unauthorised persons enter the working area of the system, if it is unsafe to do so.

3.2.7 Hazards due to unexpected malfunctions

WARNING: Make sure all safety protocols are followed, and remain attentive during system operation. Non-compliance with these safety measures could lead to serious injury.

Although this equipment has been rigorously tested, the danger of unexpected malfunctions cannot be entirely ruled out when working on the equipment. Malfunctions may occur as a result of:

- Failure of the control system.
- Restoration of the power supply after a power failure.
- External influences on electrical equipment.

3.2.8 Approvals, compliance and certification

Information about the approvals, compliance and certification of the RenAM 500 series can be found on the declaration of conformity. The declaration of conformity will be supplied with your RenAM 500 series system.

3.2.9 Residual risks, maintenance and protective measures

Ensure that risk assessments have been carried out to ensure that the Renishaw RenAM 500 series system operates in a safe manner under normal defined operating conditions.

Ensure that the risk assessments are reviewed regularly and revised as necessary, particularly if any process variables change, such as new materials, changes to the type of inert gas used and other material changes to the operating conditions, as these can affect the control measures and equipment used when operating the system.

3.2.10 Housekeeping

Renishaw recommends a comprehensive schedule of the following to ensure your RenAM 500 series system and all ancillary equipment (for example, suitable lifting equipment, Ruwac vacuum cleaner, etc) function safely and as designed:

- Maintenance (user)
- Housekeeping (user)
- Servicing (Renishaw Service engineer)
- Calibration (Renishaw Service engineer)

Records of the above activities should to be made. Contact Renishaw if you need advice or assistance.

3.2.11 Electro-magnetic compatibility

WARNING: The RenAM 500 series is industrial in design and not intended for use at any time in a residential environment or to be powered from the public low-voltage mains.

3.2.12 Decommissioning

There are no known residual risks associated with the RenAM 500 series systems. However, when decommissioning the system, the following steps must be taken:

- Inert and remove the large SafeChange filter/filters, if installed.
- Remove all powder, clear the system of powder and clean to remove any residual powder.

  WARNING: Before starting this task, ensure you are wearing the correct PPE: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

  NOTE: Renishaw recommends that full-length clothing is made from non-static-generating fabric such as cotton (avoid wool and synthetic fabrics). Avoid turn-ups or pockets that may trap powder. Refer to NFPA 484 for details.
- Clean the system of any residual dirt or process emissions.
- Shut off the inert gas supply and open the gas inlet valve to de-pressurise the system.
- Remove the inert gas supply hose.
- Follow the PC shutdown procedure.
- Isolate electrical power to the RenAM 500 series system.
- Drain down the system coolant.

WARNING: Refer to any applicable PPE requirements for handling system coolant.

It is the user's responsibility to document the powder types that have been used in the system and highlight any that may pose a residual risk. Contact Renishaw for packaging, and relocation or disposal guidance.

3.3 Safety information for the lasers

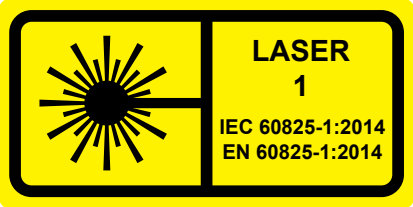
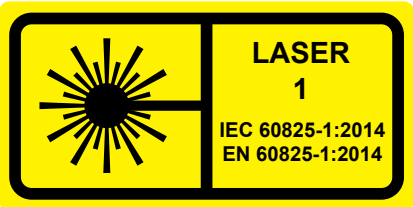
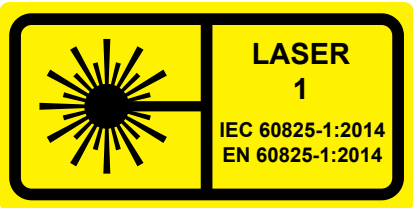
In order to comply with international standards, the Renishaw RenAM 500 series carries various laser safety labels regarding the emission of laser light. These labels form part of the safety information and it is recommended that users regularly check the condition and presence of the labels in the locations shown in the following images.

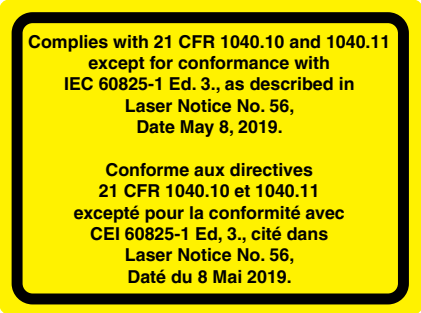
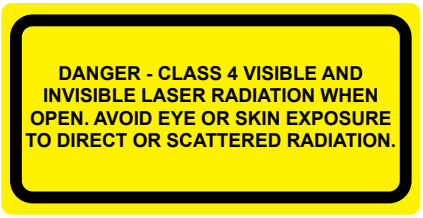
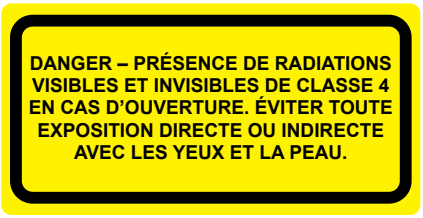
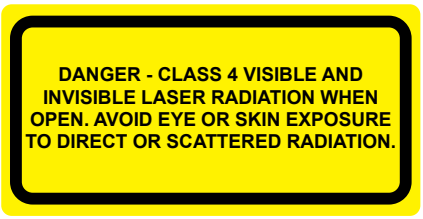
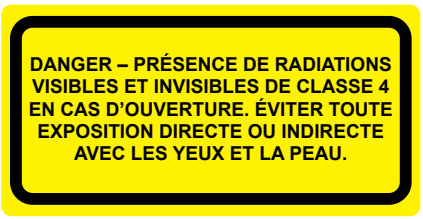
The higher the laser power Class number, the greater the laser radiation hazard. Refer to international standard IEC 60825 for details. The Renishaw RenAM 500 series in normal operation is classified as Class 1 according to the Standard EN 60825-1, edition: 2014, Safety of Laser Equipment – Part 1.

A summary of the standard is as follows:

Laser Class	Definition
Class 1	Output power is below the level at which it is believed eye damage will occur. May contain laser systems of a higher Class with adequate engineering control measures to ensure that access to the beam is not reasonably likely.
Class 1M	Can be harmful to the eye if the beam is viewed using magnifying optical instruments.
Class 2	More powerful than Class 1, natural aversion (blink response) should terminate the eye exposure before eye damage can occur. Repeated, deliberate exposure to the laser beam may not be safe.
Class 2M	Similar to a Class 2 laser product. However, these products can be harmful to the eye if the beam is viewed using magnifying optical instruments or for long periods of time.
Class 3R	Users must avoid viewing the beam directly. Although the risk of eye injury is low, the power exceeds the maximum permissible exposure for accidental viewing and can potentially cause eye injuries.
Class 3B	Class 3B lasers may have sufficient power to cause an eye injury, both from the direct beam and from reflections.
Class 4	Class 4 lasers are capable of causing injury to both the eye and the skin, and may also present a fire hazard.

The laser safety labels and location are described in the following table. Replacement laser safety labels can be ordered from Renishaw.

Laser label	Description and location
	Laser 1 classification label. Laser 1. IEC 60825-1:2014. EN 60825-1:2014. Fitted to the nameplate on the rear of the system. Part no.: M-5774-0561
	Laser 1 classification label. Laser 1. IEC 60825-1:2014. EN 60825-1:2014 Fitted to the three cover panels (front, back and top) of the optical module. Part no.: M-5774-0561
	Laser 1 classification label. Laser 1. IEC 60825-1:2014. EN 60825-1:2014 Fitted to the front of the system, in the top right-hand corner of the top door. Part no.: M-6521-0561

Laser label	Description and location
	Conformance label. Complies with 21 CFR 1040.10 and 1040.11. Except for deviations pursuant to Laser Notice No. 56 Date May 8, 2019. Fitted to the nameplate on the rear of the system. Part no.: M-6521-1961
 	Class 4 classification label. DANGER – CLASS 4 VISIBLE AND INVISIBLE LASER RADIATION WHEN OPEN. AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION. Fitted to the three cover panels (front, back and top) of the optical module. Part no.: M-6521-2102
 	Class 4 classification label. DANGER – CLASS 4 VISIBLE AND INVISIBLE LASER RADIATION WHEN OPEN. AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION. Fitted to the four beam delivery optic (BDO) cover panels. Part no.: M-6521-2102

3.4 Personal safety instructions

3.4.1 Manual handling

Operation and servicing of the RenAM 500 series will necessitate a certain amount of manual handling. Where this is necessary, the weight to be moved will be specified. Renishaw recommends purchasing suitable lifting equipment to move heavy items, such as the large SafeChange filters when full of water, and full powder flasks; specification can be supplied upon request. Renishaw recommends carrying out a risk assessment of all manual handling tasks to ensure they comply with applicable local legislation and guidelines.

RenAM 500 Flex only: A Renishaw universal lifter is included as standard equipment upon purchase of a RenAM 500 Flex for moving heavy items, such as the large SafeChange filters and full powder flasks. This equipment is also required for ergonomically difficult tasks such as the installation and removal of the feed hopper during material change. Specification can be supplied upon request.

3.4.2 Fire-fighting

Do not place yourself at risk. In all cases when tackling a fire, the first action is to call the emergency services. At all stages, the fire-fighting method must be appropriate for the material concerned and the Safety data sheets should be consulted before assigning particular fire-fighting equipment to the areas where the materials are stored and used.

In all cases, Renishaw recommends that specialist fire-fighting advice is sought before commencing operation of the RenAM 500 series.

In general, metal powder fires should be isolated and contained rather than extinguished. This can usually be accomplished by surrounding the fire with an inert material such as sand or salt, or using a type D powder fire extinguisher.

WARNING: Do not use water or pressurised fire extinguishers, as there is a risk that the metal powder could be forced into a dust cloud.

WARNING: In all cases of fire, call the emergency services and advise on the exact nature of the materials being processed and those in storage.

CAUTION: Always use caution when cleaning up burned metal powder, as re-ignition of unburned material is possible.

Place the following safety sign and warning notice on all access doors to the process room.



OPEN FLAMES, SMOKING AND FIRE ARE PROHIBITED

Figure 5 Fire safety sign

An assessment of the risks from fire should form part of the risk assessment you carry out before commencing operation of the RenAM 500 series.

3.4.3 Laser safety precautions

When operating or maintaining laser equipment, any local regulations or legislation take precedence over these instructions.

WARNING: Maintenance work on the laser system may only be carried out by employees of Renishaw or Renishaw authorised service personnel.

Normal system maintenance can be undertaken without risking exposure to laser light. Under no circumstances will it be necessary for maintenance to be undertaken with laser covers removed.

The RenAM 500 series has a Class 4 laser enclosed in a Class 1 system.

WARNING: Do not defeat or override safety interlocks.

3.4.4 Oxygen level monitoring within the process room

The end user must carry out risk assessments to determine whether or not there is a need for low-level oxygen level monitoring within the process room in case of an argon leak. A small amount of argon gas is discharged into the process room when the top door is opened. Additionally, while the system is purging, argon is exhausted to the atmosphere.

WARNING: Renishaw strongly recommends that a process room oxygen sensor is installed.

WARNING: If a furnace has been purchased, Renishaw strongly recommends that a process room oxygen sensor is installed, as the furnace emits more argon than the RenAM 500 series system.

3.4.5 Training

The RenAM 500 series has the potential to injure personnel if it is incorrectly operated. The RenAM 500 series system can only be operated by users who have completed a Renishaw-approved training program. Training is included in the scope of supply of the Renishaw RenAM 500 series, unless the user indicates that no training is required, for instance where a local Renishaw-approved trainer already exists.

WARNING: Operation of the RenAM 500 series is only permitted by operators who have completed a Renishaw-approved training program.

3.4.6 Correct usage

The Renishaw RenAM 500 series is designed for the construction of components from metal powder.

Acceptable metal powder is provided by Renishaw, or a specification can be provided for third-party supply.

It is recommended that the use of other metal powders is discussed in advance with Renishaw to ensure safe processing, and the appropriate processing parameters are used, if available. Renishaw powders have been tested and validated for use in the RenAM 500 series system.

Successful part production depends upon the system being properly serviced and maintained, and the use of Renishaw process parameters.

Where Renishaw materials and process parameters are NOT used, users must satisfy themselves that the necessary material validation is carried out. Renishaw cannot be held liable for performance when third-party materials or process parameters are used.

Where non-Renishaw metal powder is being used, always refer to the applicable Safety data sheets and carry out a risk assessment before using the non-Renishaw metal powder. As an example, non-Renishaw metal powder may produce laser spectral emissions that exceed the attenuation specification of the glass panel fitted to the top door on the RenAM 500 series system. This must be risk assessed and the risks understood before using the non-Renishaw powder. Contact Renishaw for further advice.

3.4.7 Improper use

Anything that contravenes or is not specifically mentioned in this manual can be described as improper use, in particular the following:

- The use of non-approved or highly toxic metal powders and other hazardous substances not approved by Renishaw. For system servicing purposes, Renishaw requires full knowledge of all the materials that have been used in the system in order to protect our staff.
- The removal of system components and/or the operation of system components in a position other than the one prescribed for them.
- Disabling the safety devices.
- Warning and safety instructions not properly maintained.
- Modifications to hardware components that have not been authorised by Renishaw.

- Modifications to software elements that have not been authorised by Renishaw.
- Operation without a suitable and approved shielding gas such as argon.
- The fitment of unapproved/unauthorised parts or the making of unapproved/unauthorised modifications to the RenAM 500 series system without the prior approval of Renishaw.

3.4.8 Personal protective equipment (PPE)

Renishaw recommends that full PPE is worn when handling metal powder, a minimum of the following:

WARNING: Customers must perform a risk assessment when changing the hot-chamber access settings. Depending on the user-defined access temperature, the risk assessment must identify the need for, and rating of, heat resistant gloves. It is then the customer's responsibility to procure applicable heat-resistant gauntlets of the required rating."

- Gloves/gauntlets – if a furnace has been specified, heat-resistant gauntlets are required. They may also be required if the Hot Chamber Access settings have been set to elevated temperatures.
- Eye protection.
- Full face respirator conforming to EN143 Type P3 (dust protection factor) + A1 (gas/vapour protection factor when using IPA or solvent cleaners).
- ESD dissipative safety footwear with toe protection (essential for ATEX zones and recommended for all areas).
- Full-length clothing, made from non-static-generating fabric such as cotton (avoid wool and synthetic fabrics). Avoid turn-ups or pockets that may trap powder. Refer to NFPA 484 for details.



Figure 6 Example of suitable PPE

WARNING: It is the responsibility of the end user to ensure the correct PPE is available for every operator and that it is worn correctly.

Wash any metal powder contaminated clothing separately from other clothing.

WARNING: PPE used in an ATEX-rated area (for example, battery-operated respirators) must be ATEX rated.

WARNING: Wear protective eyewear, full-face respirator (conforming to EN143 Type P3 + A1) and suitable protective clothing.

WARNING: Do not allow the metallic powder or waste products to form a dust cloud.

WARNING: Never eat, drink or smoke in the vicinity of the Renishaw AM system or components produced by the process that have not been properly cleaned.

WARNING: Wash hands thoroughly with water and soap after disposal of metal powder.

3.4.9 Toxicity and personnel exposure

Some metal powders may be harmful to health. This can only be ascertained by consulting the Safety data sheets and once again going through the risk assessment procedure and taking note of the guidance and procedures. Regular health surveillance should be carried out on employees who use the equipment and materials. In general, metal powders create a family of hazards (harmful or not), for example:

- Fine airborne solids can create a nuisance dust and prolonged exposure may cause lung irritation. Many powders have a maximum permissible Workplace Exposure Limit of 0.5 mg/m^3 (WEL 8 hour limit). The recommended Workplace Exposure Limit will be indicated on the Safety data sheet for each respective powder.
- Eye contact may cause irritation and burning. In the event of such exposure, the procedure indicated on the Safety data sheet should be followed.
- If skin is exposed, the procedure indicated in the Safety data sheet should be followed.
- If large quantities of powder are inhaled, the procedure indicated in the Safety data sheet should be followed.

Measures should be taken to minimise contact with metal powders and monitor the environment:

- PPE for all regular operators. Regular maintenance and inspection of PPE is necessary.
- Training to avoid powder spillages. Any spillage must be immediately cleaned up using appropriate equipment.
- Regular housekeeping and auditing to ensure dust or powder does not accumulate.
- Regular air quality monitoring.
- Annual spirometry (lung capacity) tests should be considered for all regular operators.
- Personnel must be trained, including awareness of the Safety data sheet before using a new material.

3.4.10 Thermal hazards

If work is to be carried out on the RenAM 500 series, the equipment must be isolated and a period of time should be allowed for hot parts of the equipment to cool. Care must also be taken if unplanned work is to be carried out.

WARNING: Hot surfaces can cause injury. Take care when using the glovebox to access the build chamber.

3.4.11 Hazards due to latent energy sources

Isolated equipment may still present hazards to maintenance technicians. Some typical examples of latent energy sources are as follows:

- Heated components will remain hot. The period of time required to cool to a safe temperature of ≤ 60 °C (≤ 140 °F) is dependent on the material of construction and the shape and mass of the component.
- Some components may continue in motion after a process has halted. The period of time required for the component to become stationary is dependent on the shape and mass of the component.
- Some components may be stopped in positions which make them unsafe.
- Sealed pneumatic lines will remain pressurised.
- Other fluid lines may remain pressurised.
- Capacitors may remain charged in electrical circuits.
- Risk assessments and method statements for maintenance work should identify any latent hazards and the steps required to nullify them.

3.4.12 System ergonomics

NOTE: Space in the build chamber is limited, especially for two-handed working. To reach some areas of the build chamber, you may need to adopt an awkward body position. Minimise the time you spend in awkward body positions and take a break if you feel discomfort. As far as is practical, carry out tasks with one hand at a time, especially when working through the glovebox, and ensure you change hands regularly.

3.5 Safety information for inert gas

WARNING: The concentration of inert gas in the ambient air needs to be monitored and a low oxygen concentration (< 19.5%) indicated by a visible and audible warning means.

The RenAM 500 series is designed to consume minimal amounts of inert gas. It is possible to use either argon or nitrogen to create an inert atmosphere, but the RenAM 500 series has been qualified using argon gas only. As a consequence of this low gas consumption, Renishaw recommends using argon gas, which offers the additional benefit of being compatible with materials that are nitrogen reactive.

CAUTION: It is possible that nitrogen gas may give you build results which are more suitable for your AM application. The RenAM 500 series has been qualified using argon gas and Renishaw recommends the use of argon gas during builds.

WARNING: It is the user's responsibility to ensure the correct gas is used for the material being processed. Failure to do so may result in damage to the RenAM 500 series system and hazards to health.

WARNING: Nitrogen gas is not inert with all metals and may react exothermically.

When the RenAM 500 series is in use, a small amount of inert gas is emitted from the two gas outlets located on the top of the system. DO NOT connect the two gas outlets to any form of extraction system and DO NOT obstruct the two gas outlets.

Argon gas is odourless, heavier than air and, as it displaces oxygen, is an asphyxiant. This creates a potential hazard and, although the concentration of argon gas under normal operation is low, there is a potential danger of suffocation. On this basis, Renishaw recommends that the process room is well-ventilated in accordance with local regulations and requirements from Renishaw.

Under normal use with argon, ground level oxygen level monitoring is advised.

WARNING: Argon gas cylinders are heavy. Ensure gas cylinders are correctly secured to prevent them from falling over. Use suitable equipment and processes to move cylinders. Consider contacting your argon gas supplier for equipment, information and advice on handling gas cylinders.

3.6 Safety information for metal powder

3.6.1 Metal powder handling advice

WARNING: The following constitutes general advice. Always consult the Safety data sheet for specific handling and safety information for each material.

WARNING: Ensure you are wearing the correct PPE: ESD safety footwear, eye protection, full face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

NOTE: Renishaw recommends that full-length clothing is made from non-static-generating fabric such as cotton (avoid wool and synthetic fabrics). Avoid turn-ups or pockets that may trap powder. Refer to NFPA 484 for details.

WARNING: Always identify and label hazardous metal powders.

WARNING: In areas where powder is not expected to be present but may be present for short periods, all equipment (including portable) must be electrically bonded and earthed. Renishaw recommends that all portable equipment is fitted with static dissipative wheels. Renishaw recommends that all portable equipment is also grounded with an external ground wire. Renishaw recommends giving consideration to the creation of an ATEX zone 22 or NFPA 484 in powder-handling areas.

WARNING: ATEX vacuum cleaner nozzles, hoses and fittings must be conductive (electrostatic-dissipative) and non-sparking. Never use insulating plastic or domestic nozzles, or make any unapproved modifications.

WARNING: ATEX vacuum cleaner ESD fittings should be clearly marked (with yellow tape and ESD symbol) to ensure they are not to be mixed with non-ESD plastic fittings.

WARNING: Components/build plates being vacuumed should be earthed. Practically, this can be achieved by constructing benchtops and worktops from conductive material (non-sparking metal, for example aluminium, or ESD matting) which is earthed. Metallic benches must be earthed.

WARNING: Renishaw recommends fitting supplementary bonding between the ATEX vacuum cleaner and the object being vacuumed (build plate, bench top or AM system). Renishaw or Ruwac can provide a supplementary bonding lead (Ruwac part no. 59803 for NA7).

WARNING: A routine inspection, testing and maintenance program including testing of electrical continuity (bonding between pieces of equipment) and earthing/grounding (resistance to ground) should be implemented. ESD-dissipative materials typically have a resistance of 10^6 and 10^8 ohms. The lower limit (10^6 ohms) is specified to protect personnel from electrocution due to inadvertent contact with energised electrical equipment, while the upper resistance limit (10^8 ohms) is specified to ensure adequate charge dissipation. Flooring or footwear may have a lower resistivity, but not below 2.5 × 104 ohms, provided the total resistance to earth is sufficient to prevent electrocution (typically 1 megohm or greater) and dissipate charge (typically less than 100 megohms).

WARNING: As much powder as possible must be removed within the AM build chamber. Where practical, powder must be swept up using non-sparking receptacles and brushes with natural fibre bristles (non-static-generating). Vacuuming is only permitted for residual powder that cannot be removed using the previous methods.

WARNING: Do not use compressed air for powder removal or cleaning, as it will generate a dust suspension.

WARNING:

All metal powders are potentially combustible. The user must review the Safety data sheet and ensure that the correct handling procedures are followed.

Combustible metal powders must be used, stored and disposed of in non-sparking (anti-static) or approved containers.

Powder must be stored in a sealed dry container, as damp or humid power may give off flammable hydrogen gas.

Containers containing combustible metal powders must be labelled to identify a “Flammable Solid”.

Combustible metal powder must not be stored in plastic bags because of the possibility of electro-static discharge.

Always keep combustible metal powders away from any sources of ignition.

When cleaning up spills of combustible metal powders, ensure that the cleaning equipment is safe to use.

Never use compressed air to clean spills or residual traces of combustible metal powder, as this could cause a potentially explosive dust cloud to form.

Do not brush combustible metal powders for long distances, as this could cause electrostatic charges to be formed.

Where multiple powder types are used in the same facility, Renishaw strongly recommends labelling and colour-coding powder flasks and other equipment to identify the powder type. In addition, robust procedures to ensure powder type segregation should be implemented.

We recommend the following safety equipment:

- ATEX vacuum cleaner, suitable for use with combustible metal powder with a gas ventilation capability.
- Washbasin with eye washing station.
- Non-sparking containers for the storage of waste powder residues.

WARNING: Always risk-assess the handling of metal powder. The risk assessment should include, but not be restricted to: careful examination of the appropriate Safety data sheet, the processes that will be followed, applicable legislation and local rules.

Some metal powders are reactive and spontaneously form a hard, protective oxide film on contact with oxygen. This oxygen may be in the form of a gas (air, for instance), or in some other form, for example water.

The ability to rapidly oxidise necessitates careful handling of metal powder. The potential for fire exists, because the oxidation of the powder gives off heat and, in some cases, explosive gas and is therefore potentially volatile and self-sustaining. Avoid disturbing powder, particularly in an oxygen-rich atmosphere. Risk assess any metal powders by careful examination of the appropriate Safety data sheet.

3.6.2 Flammability

The fire risks of handling powder should be assessed before use and the Safety data sheets must be reviewed to ensure that the correct handling procedures are followed. Metal powders burn rapidly, at elevated temperatures, and can produce noxious gases. Metal powder in layers or in bulk may catch fire and burn if subject to a sufficiently energetic ignition source. Airborne suspensions above the limits indicated in the Safety data sheet can pose a dust explosion hazard. Minimum ignition values for a range of powders are available on request.

3.6.2.1 Combustibility

The fire triangle demonstrates the three prerequisites for a fire. All elements and molecules that react with oxygen are combustible and are a source of fuel. Most metals in solid form are not normally considered a fire risk due to their poorly mixed fuel-to-air ratio. Metal powders will burn readily if subjected to a high ignition temperature.

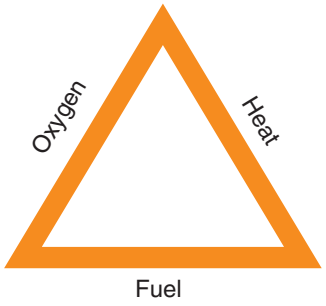


Figure 7 Fire triangle

3.6.2.2 Explosivity

An explosion is caused by rapid burning – as the fuel burns, heat and expanding gases are released, creating pressure. The explosion pentagon demonstrates the five prerequisites for an explosion. To cause an explosion, the fuel and oxygen must be sufficiently well mixed in the correct proportions. Fine dusts, such as metal powders suspended in air, will propagate a flame readily – generating an explosion.

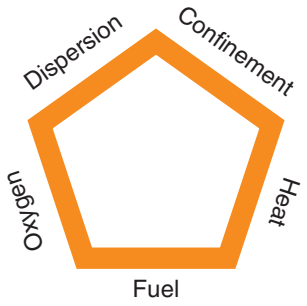


Figure 8 Explosion pentagon

In the correct ratio, a dust cloud can be ignited by electrical spark. The Minimum Ignition Energy (MIE) varies by powder type. Titanium powder requires ESD precautions to be in place. Other metal powders may have a higher ignition energy (are less likely to ignite), but observing the MIE for titanium is a good benchmark standard.

Metal dimensions	Overall surface area	Active source of ignition	Effect
Metal cube 1 cm^3 (0.4 in × 0.4 in × 0.4 in)	6 cm^2 (0.93 in^2)	Extreme heat or flame	Burns with difficulty
Metal powder 30 µm (0.001 in) spheres	1 000 cm^2 (155 in^2)	Flame, hot surface	Burns
Metal powder 30 µm (0.001 in) spheres in suspension in air	1 000 cm^2 (155 in^2)	Sparks or static discharge	Explosive
Nanoparticles and condensate (black deposits in filter)	> 30 000 cm^2 (4650 in^2)	Sparks or static discharge	Explosive

3.6.3 Safe disposal of waste products

All waste products must be disposed of in a safe and environmentally friendly manner in accordance with local regulations.

WARNING: The substances indicated below must be disposed of in a safe manner. They must not be allowed to contaminate the environment.

Disposal of metal powder, whether new, used, or in the form of contaminated components, cleaning materials and filters, must be done in accordance with the relevant Safety data sheet and/or the local or national requirements. Similarly, metal powders should be handled with caution at all times due to their combustible nature in a normal atmosphere, in accordance with DSEAR guidelines. Disposal of waste product, including process emissions and unused waste powder, must be in accordance with local regulations for hazardous waste.

Before disposal, waste products should be stored in an appropriate manner, in practical terms:

- Solid waste that accumulates on the sieve mesh, waste from the oversize separator, waste from the cyclone separator or spilt powder can be swept, using a non-static-generating brush, into a non-sparking receptacle (metal or approved plastic – NEVER plastic bags or non-approved plastic containers due to the risk of static sparks). This should then be stored dry in a sealed container. Alternatively, waste, and waste powder, can be vacuumed up using an ATEX vacuum cleaner, as supplied by Renishaw. NEVER use any other type of vacuum cleaner.
- Filters must be immersed in water, then stored immersed in water in a ventilated drum in a well-ventilated area.
- ATEX vacuum cleaner fluid should be stored in a ventilated drum in a well-ventilated area as there is a possibility of hydrogen gas being generated, see section 3.6.10, “Hydrogen gas”.
- Where practical, measures should be taken to segregate metal types to aid recycling.

3.6.4 Handling and processing

Avoid contact of metal powders with potential ignition sources (for example flames or sparks).

Ensure that any vacuuming of powder is kept to a minimum – ideally only vacuum what cannot easily be collected by brushing. Brushing must only be done with non-sparking tools and avoiding the creation of a dust cloud, see section 3.6.6, “Spills”. Only ever use an ATEX vacuum cleaner approved for use with combustible metal dusts.

Stagnation points should be minimised.

Good housekeeping measures should be implemented and adhered to, with regular and thorough cleaning regimes in place at all times.

Generating airborne dust clouds of metal powder must be avoided.

Avoid the creating of static sparks – the use of static dissipative footwear or inserts is recommended.

Methods of transport of metal powders are dependent on the type of material. Consult the Safety data sheet. Note that original containers may have been inert gas purged.

All hazardous shipments need to quote a hazardous material classification code (UN/US Department of Transport) and a proper shipping name.

Some metal powders, for example titanium powder, are subject to export control regulations.

3.6.5 Storage

Generally, metal powder should be stored in a cool dry place in hermetically sealed non-flammable containers away from ignition sources. Bulk storage should be in accordance with local building and fire codes. Consider zone-classified storage cabinets. Refer to the Safety data sheet supplied with the metal powder.

3.6.6 Spills

Avoid contact of spilled material with greases, oils, solvents or combustibles.

Spills of powder should be immediately cleaned up by gentle sweeping using a non-synthetic non-static-generating brush into a metal receptacle (anti-static dustpan and brush).

Small amounts of residual material may be removed using an ATEX vacuum cleaner approved for use with combustible metal dusts. Ensure that any vacuuming of powder is kept to a minimum – ideally only vacuum what cannot easily be collected by brushing.

WARNING: Do not use compressed air to clean up spills of metal powder.

3.6.7 Metal powder safety checklist

- Have you informed your insurance provider of the powder on site and process being used?
- Have you read and understood the metal powder's physical and chemical properties and the associated hazards from the supplied Safety data sheet and other product information?
- Are you compliant with all national, regional, and local building and fire codes for the handling and storage of metal powder? For example, in the United Kingdom refer to the National Fire Protection Association (NFPA), International Building Code® (IBC), and International Fire Consultants (IFC).
- Are there other flammable materials stored in this area?
- Is the metal powder stored under proper conditions and isolated from:
  - Fuels
  - Strong oxidising agents
  - Steam
  - Oils
  - Grease
  - Water
- Are the metal powder storage area doors kept closed?
- Does the metal powder storage area have limited access?
- Is the metal powder inventory controlled?
- Have you contacted the local fire protection agency to make them aware of the specific fire-fighting procedures and equipment required in the event of a metal powder fire?
- Have you contacted the local fire protection agency to make them aware of the type and quantity of metal powder used on your site?
- Have you supplied the local fire protection agency with a copy of the Safety data sheet?

- Have area personnel been trained to handle small metal powder fires?
- Do personnel know whom to contact if they are unable to isolate and contain a metal powder fire?
- Are emergency contact phone numbers posted?
- Are correct metal powder fire-fighting materials readily available to isolate and handle small fires?
- Does your business have written standard operating procedures for all aspects of metal powder handling and processing, including proper risk assessment, control of substances hazardous to health assessment, and personal protection equipment assessment?
- Is there a written procedure in place or engineering controls present to address the reduction or elimination of metal powder dust formation during handling?
- Are employees appropriately trained on workplace hazards?
- Are written procedures in place which address safety issues to be considered during maintenance and repair activities in metal powder storage or processing areas?
- Is there a written procedure for metal powder shipping that meets international standards?
- Are correct containers available?
- Are there written procedures in place for spillage clean-up and waste disposal for metal powder?
- Is the ancillary equipment, such as an ATEX vacuum cleaner, approved for use with the materials in use?
- If multiple powder types are being used in a facility, has the powder handling equipment been labelled and colour coded for each powder type?
- If multiple powder types are being used in a facility, are there robust procedures in place to ensure powder type segregation?
- This checklist, along with any other documents relating to risk management, should be stored in your organisation's explosion prevention document.

3.6.8 Hazards due to fire or explosion

Metal powders may produce flammable or explosive events under certain conditions. All measures must be taken to ensure that the conditions required to cause such an event are understood by the operators so that the possibility does not arise. In order for a fire or explosion to occur, the following basic elements must be present:

- A combustible powder or inflammable substance.
- An oxygen source (air).
- An ignition source.

An explosion risk assessment will define the risk of an explosive event and the requirement for definition of zone classifications.

WARNING: Fire and/or explosions may cause serious injury or death to personnel and damage to property.

WARNING: ATEX and DSEAR regulations require risk assessments to determine the required area zone classification before putting the equipment into use.

3.6.9 Identifiable ignition sources

All potential ignition sources should be listed in accordance with BS EN 1127-1:2011:

- Hot surfaces.
- Flames and hot gases, including hot particles.
- Mechanically generated sparks.
- Electrical apparatus.
- Stray electric currents, cathodic corrosion protection.
- Static electricity.
- Lightning.
- Radio frequency (RF) electro-magnetic waves from 10^4 Hz to 10^{11} Hz.
- Electro-magnetic waves from 3×10^{11} Hz to 3×10^{15} Hz.
- Ionising radiation.
- Ultrasonics.
- Adiabatic compression and shock waves.
- Exothermic reactions, including self-ignition of dusts.
- Laser energy.
- Electrostatic discharge – electrostatic discharge is recognised as an initiator of fires or explosions when the correct amounts of combustible dust (metal powder), or any other hazardous substances, and oxygen are present. All equipment and ancillary equipment must be at the same electrical potential as everything within the area zone classification, including the operators and any other personnel authorised to be in the area. All electrical earth bonding straps must be in place and maintained. All operators and any authorised personnel must wear anti-static footwear and clothing.
- Only tools and other items that are suitable for the zone classification may be used in that area.

WARNING: Ensure PPE is worn to reduce the risk of a spark from electrostatic discharge.

3.6.10 Hydrogen gas

Wet metal powder may react to liberate hydrogen gas. The reaction rate is dependent on a number of factors – metal type, particle size, water pH, and temperature. The Ruwac ATEX vacuum cleaner has ventilation valves to prevent the concentration of hydrogen gas from building up. The following precautions should be taken:

- Regularly check the Ruwac ATEX vacuum cleaner ventilation valves are functioning correctly.
- Use Hydra-Sol-MAG additive when vacuuming aluminium alloy powder.
- Avoid repacking damp or wet powder in sealed containers.
- Store in well-ventilated areas, and dispose of in accordance with applicable national and local regulations.

NOTE: For information about Hydra-Sol-MAG additive, refer to the Safety data sheet.

NOTE: Always operate and maintain the ATEX vacuum cleaner in accordance with the manufacturer's instructions. Refer to the manufacturer's website **www.ruwac.de** for details.

WARNING: Water-based fire extinguishers and sprinkler systems may also provide a source of water, and hydrogen, in some cases. Refer to NFPA 484.

3.6.11 Safety data sheets

Safety data sheets can be found on the Renishaw website, **www.renishaw.com/amdatasheets**.

In addition to metal powder, the information for fluids and additives used within Renishaw equipment such as Hydra-Sol MAG vacuum cleaner additive and Nalco chiller fluid can be found here.

WARNING: Always risk assess any powders by careful examination of the appropriate Safety data sheet.

3.6.12 Metal condensate

NOTE: Processes requiring the removal of components for clean-down or service can lead to localised exothermic reactions. These rare events are expected and should not cause alarm. Some processes may instruct the closure or opening of valves etc to ensure the reaction remains localised. Any risks can be further mitigated by maintaining a high standard of cleanliness of the machine and the working environment.

During the AM process, rapid heating of metal powder occurs and, as a result, some of the metal powder is vaporised. This smoke-like emission is composed of fine metal particles often referred to as metal condensate, metal fume, process emissions, sooty deposit, or soot. It is removed using an inert gas stream and collected in a disposable filter inside the sealed system.

Ordinarily, energetic metals form an oxide skin, called a passivation layer, which protects from any further oxidisation. As these emissions are produced in an inert atmosphere, they are partially passivated but can still react on exposure to oxygen. As they also have a high surface area, this exothermic reaction is a potential spontaneous ignition hazard.

Higher processing rates and longer builds at lower in-chamber oxygen levels contribute to the condensate risk. The build chamber clean-down procedure will limit the risk and ensure condensate can be safely removed.

Evidence indicates that condensate (smaller particle) has a lower minimum ignition energy (MIE), making it more susceptible to static ignition (less than 1 mJ ignition energy).

CAUTION: Isolate and remove SafeChange filter assemblies prior to machine maintenance to make sure they are not affected by any localised exothermic reactions.

4. System overview

This section provides a detailed overview of the RenAM 500 series system and its user-accessible hardware features. It also lists the technical specifications of the RenAM 500 series system, offering a comprehensive understanding of its capabilities.

4.1 Model configuration

Machine	Single laser	Dual laser	Four lasers	Powder recirculation	CameraVIEW	LaserVIEW and MeltVIEW	TEMPUS technology
RenAM 500S Flex	✓				✓	*	*
RenAM 500S	✓			✓	✓	*	*
RenAM 500S Ultra	✓			✓	✓	✓	✓
RenAM 500D Flex		✓			✓	*	*
RenAM 500D		✓		✓	✓	*	*
RenAM 500D Ultra		✓		✓	✓	✓	✓
RenAM 500Q Flex			✓		✓	*	*
RenAM 500Q			✓	✓	✓	*	*
RenAM 500Q Ultra			✓	✓	✓	✓	✓

* Model can be upgraded to support this technology.

4.2 Technical specification

The technical specification of the RenAM 500 series system is available in the RenAM 500 series additive manufacturing systems data sheet (Renishaw part no. H-5800-4030). Any specification not listed in the data sheet is available upon request; see section 12, “Customer support”, for the contact details of your local Renishaw office.

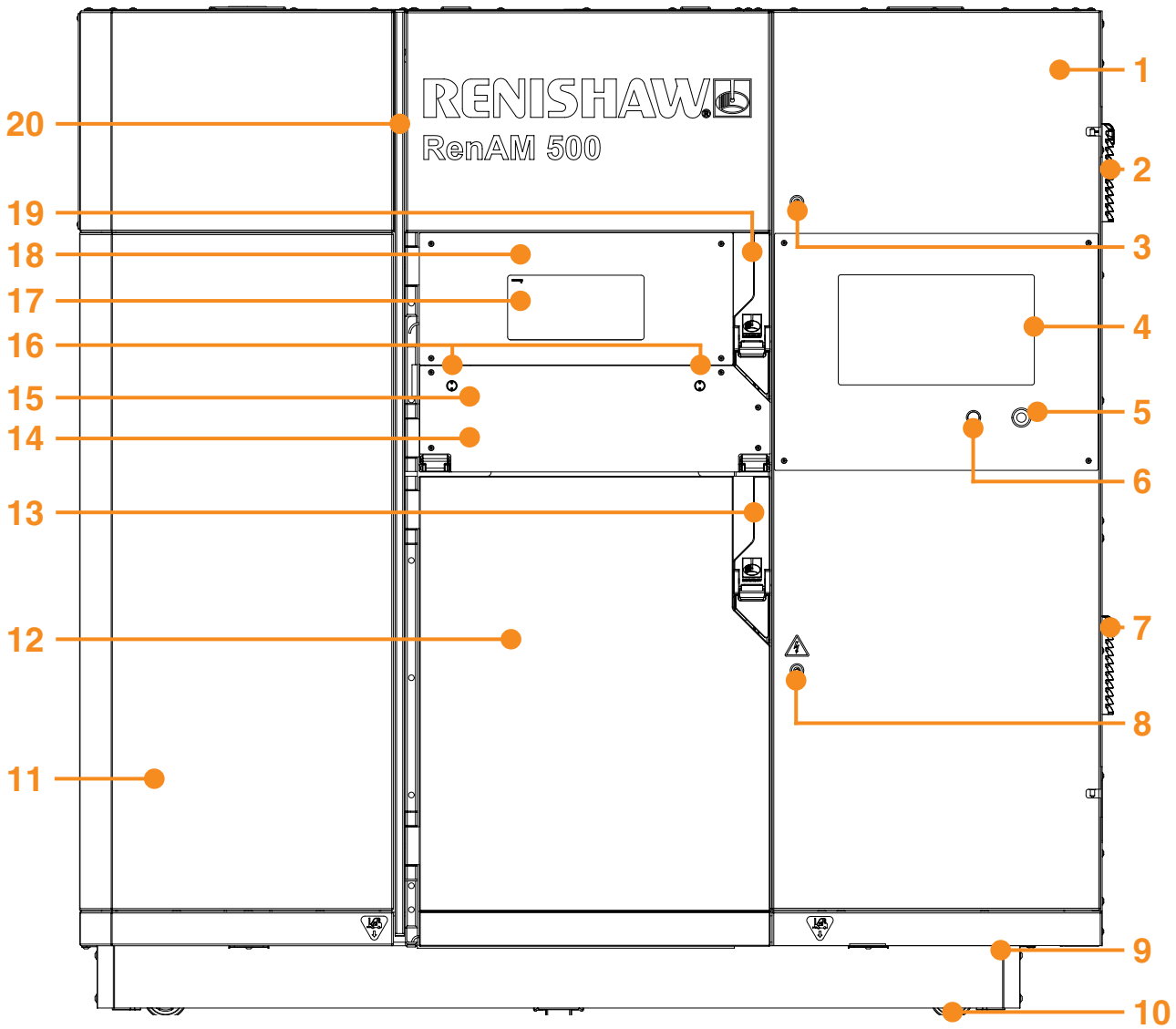
NOTE: Technical specifications may change from time to time. Renishaw reserves the right to change any technical specification at any time.

4.3 Hardware overview

The images of components and the user interface shown in this document are only examples. The appearance of these images may vary according to your system configuration.

NOTE: The features shown apply to RenAM 500, RenAM 500 Flex and RenAM 500 Ultra.

4.3.1 RenAM 500 front view

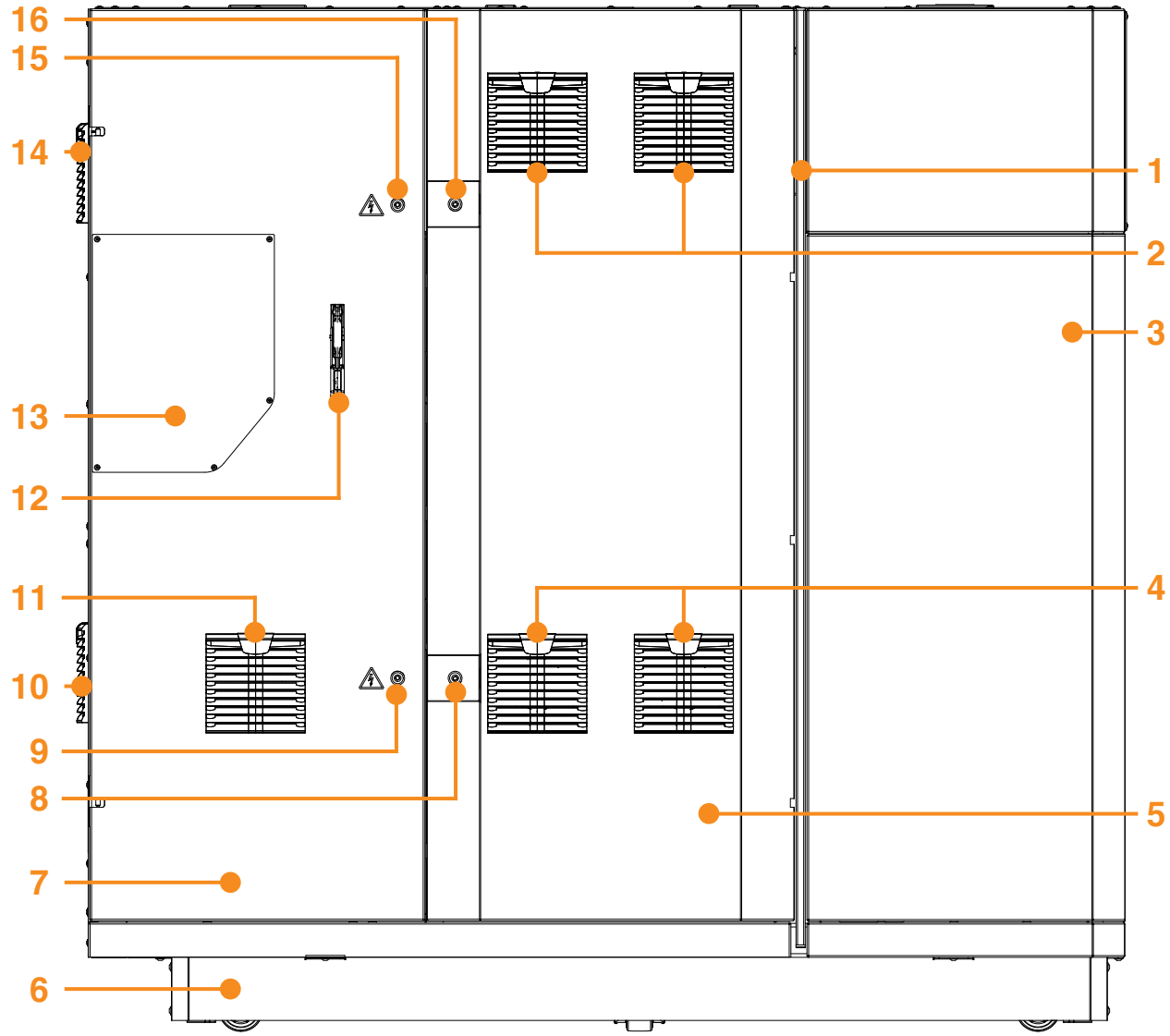


1	Front right-hand electrical cupboard door	11	Front left cupboard door – powder fill/overflow and large SafeChange filter change, if applicable.
2	Air vent	12	Bottom door
3	Security lock	13	Bottom door handle with interlock
4	Operator touch screen control panel	14	Glovebox lockable door with interlock
5	“Emergency Stop” button	15	Build chamber access gloves (behind door)
6	“Reset” button	16	Glovebox door locks
7	Air vent	17	Build chamber viewing window
8	Security lock	18	Top door
9	Plinth (covering combined castor and adjustable jacking feet)	19	Top door handle with interlock
10	Combined castor and adjustable jacking feet (behind plinth) × 5	20	LED strip light

Figure 9 RenAM 500 front view

4.3.2 RenAM 500 rear view

NOTE: The features shown apply to RenAM 500, RenAM 500 Flex and RenAM 500 Ultra.

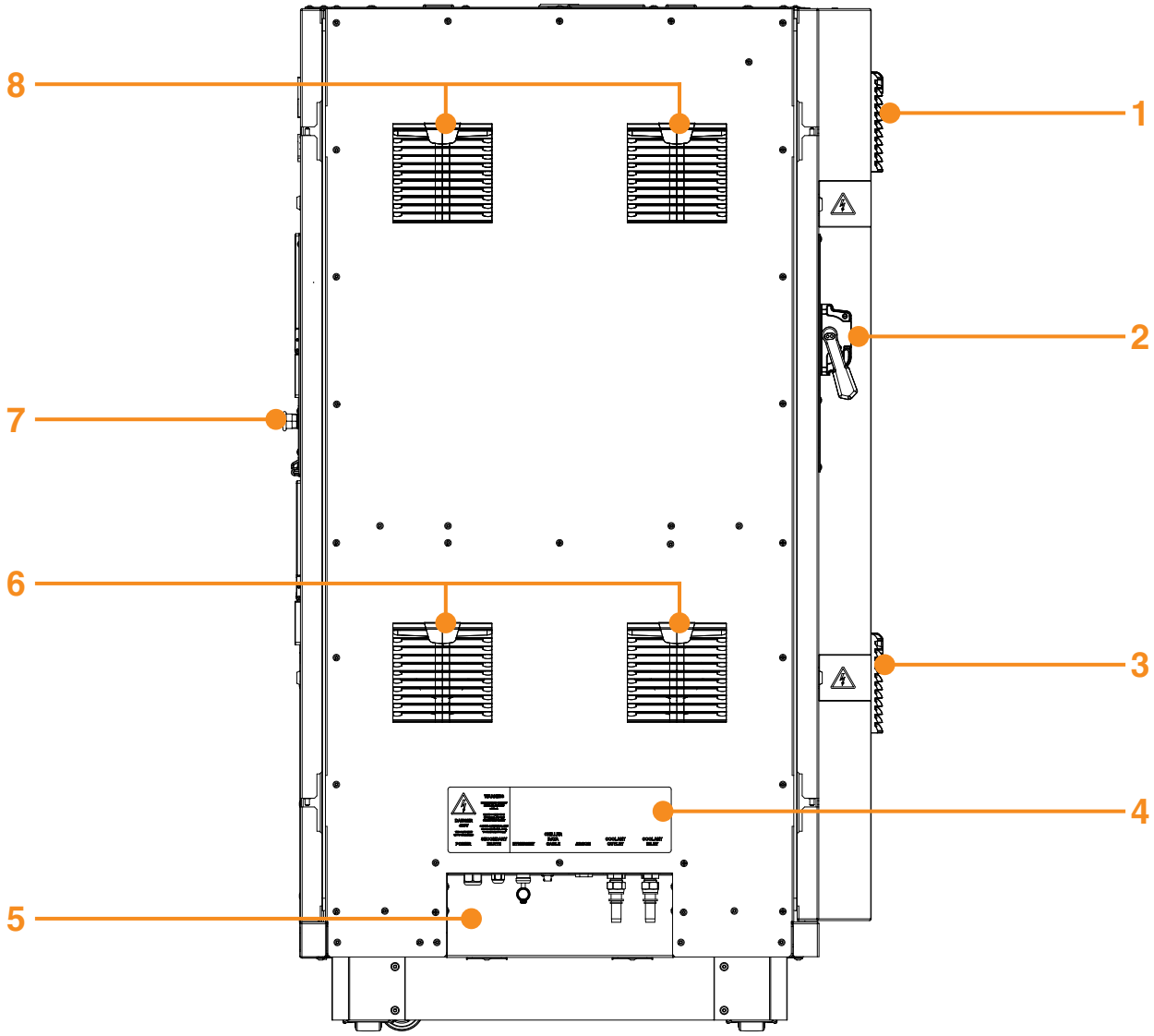


1	LED strip light	9	Security lock
2	Air vents	10	Air vent
3	Rear right-hand door	11	Air vent
4	Air vents	12	Main isolating switch
5	Rear centre equipment cupboard door	13	System nameplate
6	Plinth (covering combined castor and adjustable jacking feet)	14	Air vent
7	Rear left-hand electrical cupboard door	15	Security lock
8	Security lock	16	Security lock

Figure 10 RenAM 500 rear view

4.3.3 RenAM 500 right-hand end view

NOTE: The features shown apply to RenAM 500, RenAM 500 Flex and RenAM 500 Ultra.

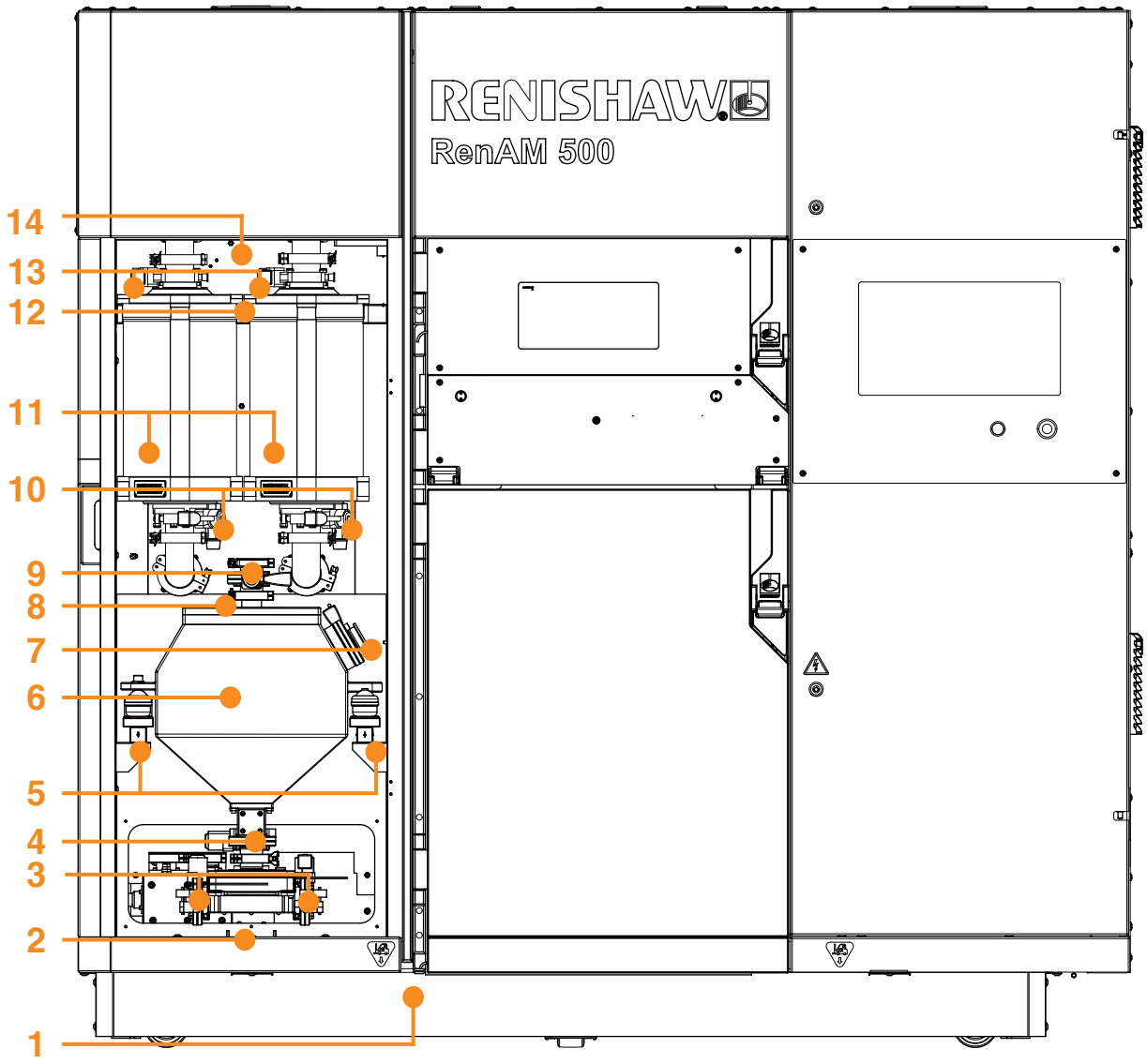


1	Air vent
2	Main isolating switch
3	Air vent
4	External services label
5	System external connections (electrical power, secondary earth, Ethernet, chiller data cable, argon inlet, coolant inlet and coolant outlet)
6	Air vents
7	“Emergency stop” button
8	Air vents

Figure 11 RenAM 500 right-hand end view

4.3.4 RenAM 500 front view with powder fill and large SafeChange™ filter door open

NOTE: Some of these features are not present in the RenAM 500 Flex, or in systems equipped with a Long-Life Filter. These features are indicated in the table below.

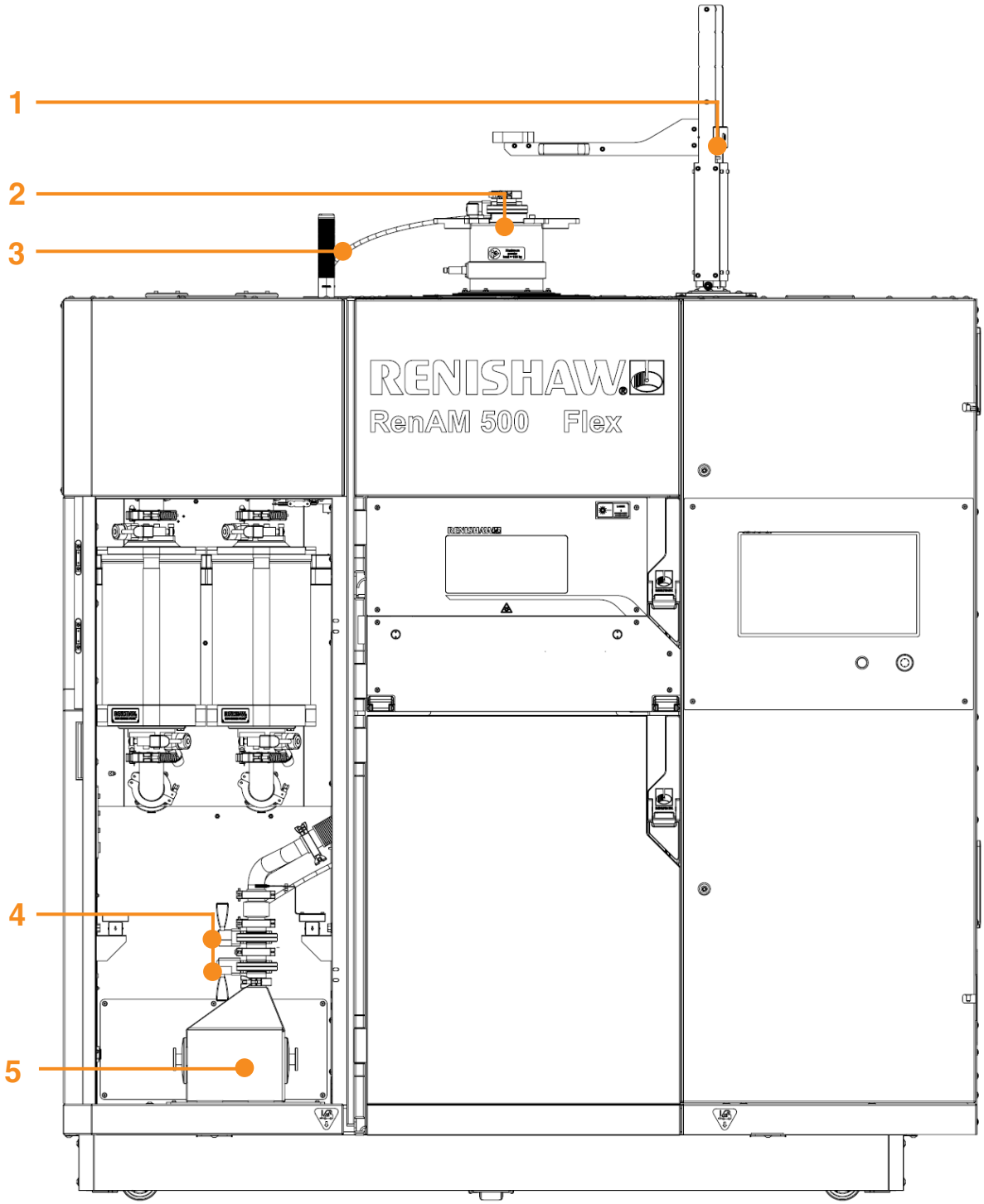


1	Powder fill and large SafeChange filter left-hand door open (shown removed)	8	Load hopper filling point isolation valve (not present on RenAM 500 Flex)
2	Ultrasonic sieve system (not present on RenAM 500 Flex)	9	Load hopper filling point (not present on RenAM 500 Flex)
3	Powder system isolation valves (not present on RenAM 500 Flex)	10	Large SafeChange filter lower isolation valves (not present when equipped with Long-Life Filter)
4	Powder metering screw feeder (not present on RenAM 500 Flex)	11	Large SafeChange filter number 1 (left- hand) and large SafeChange filter number 2 (right-hand) (not present when equipped with Long-Life Filter)
5	Load hopper level load cells (not present on RenAM 500 Flex)	12	Large SafeChange filter status indicator (not present when equipped with Long-Life Filter)
6	Load hopper (not present on RenAM 500 Flex)	13	Large SafeChange filter upper isolation valves (not present when equipped with Long-Life Filter)
7	Powder return pipe	14	Oversized particle collection point

Figure 12 RenAM 500 front view with powder fill and large SafeChange filter door open

4.3.5 RenAM 500 Flex front view with overflow and large SafeChange™ filter door open

NOTE: The features shown apply to the RenAM 500 Flex only. These features do not apply to the RenAM 500 or RenAM 500 Ultra.

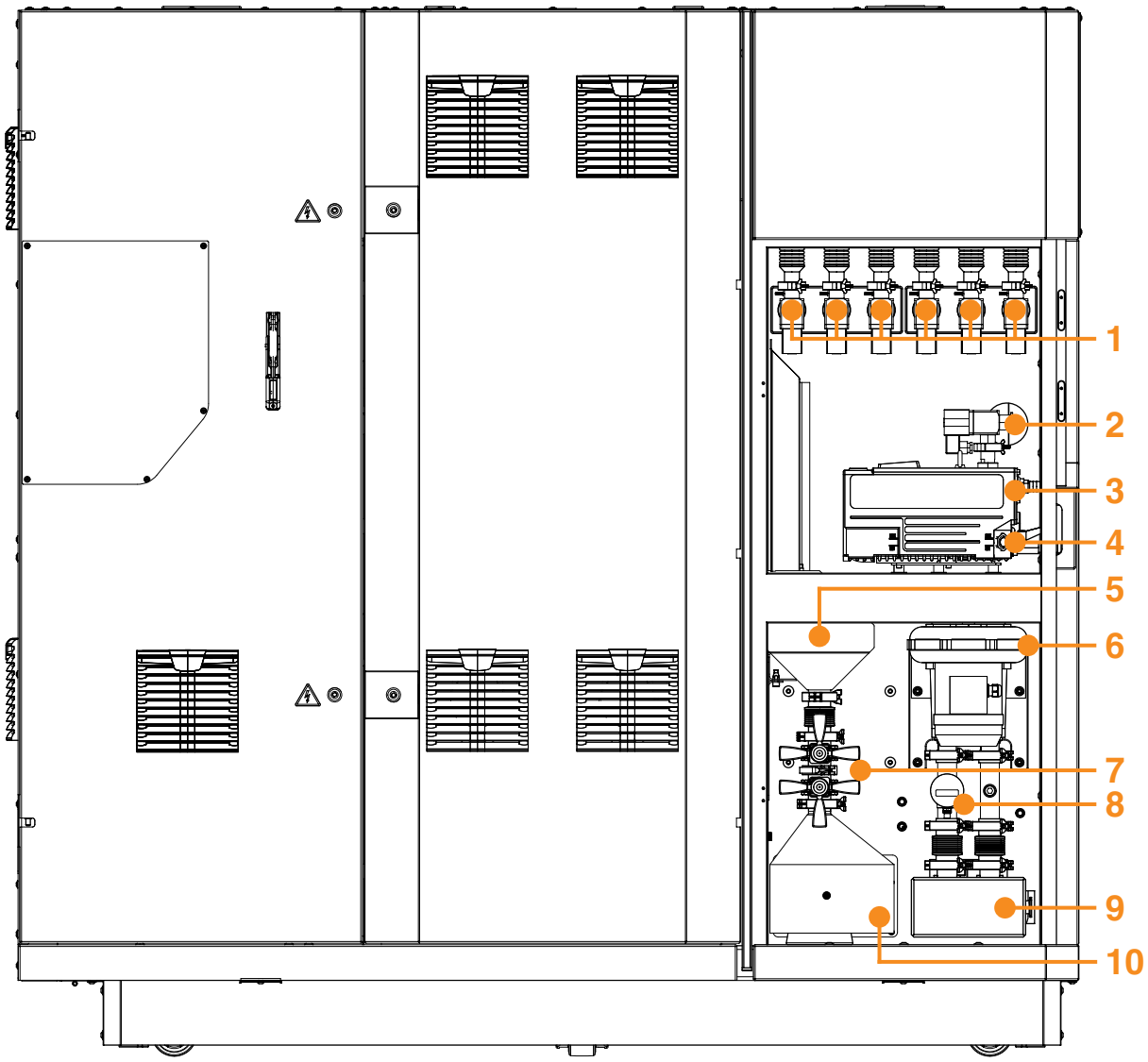


1	Powder loading arm	3	Beacon tower	5	Powder overflow flask (10 L flask shown)
2	Feed hopper (small size shown)	4	Powder overflow isolation valves		

Figure 13 RenAM 500 Flex front view with overflow and large SafeChange filter door open

4.3.6 RenAM 500 rear view with rear right-hand cupboard door open

NOTE: Some of these features are not present in the RenAM 500 Flex. These features are indicated in the table below.

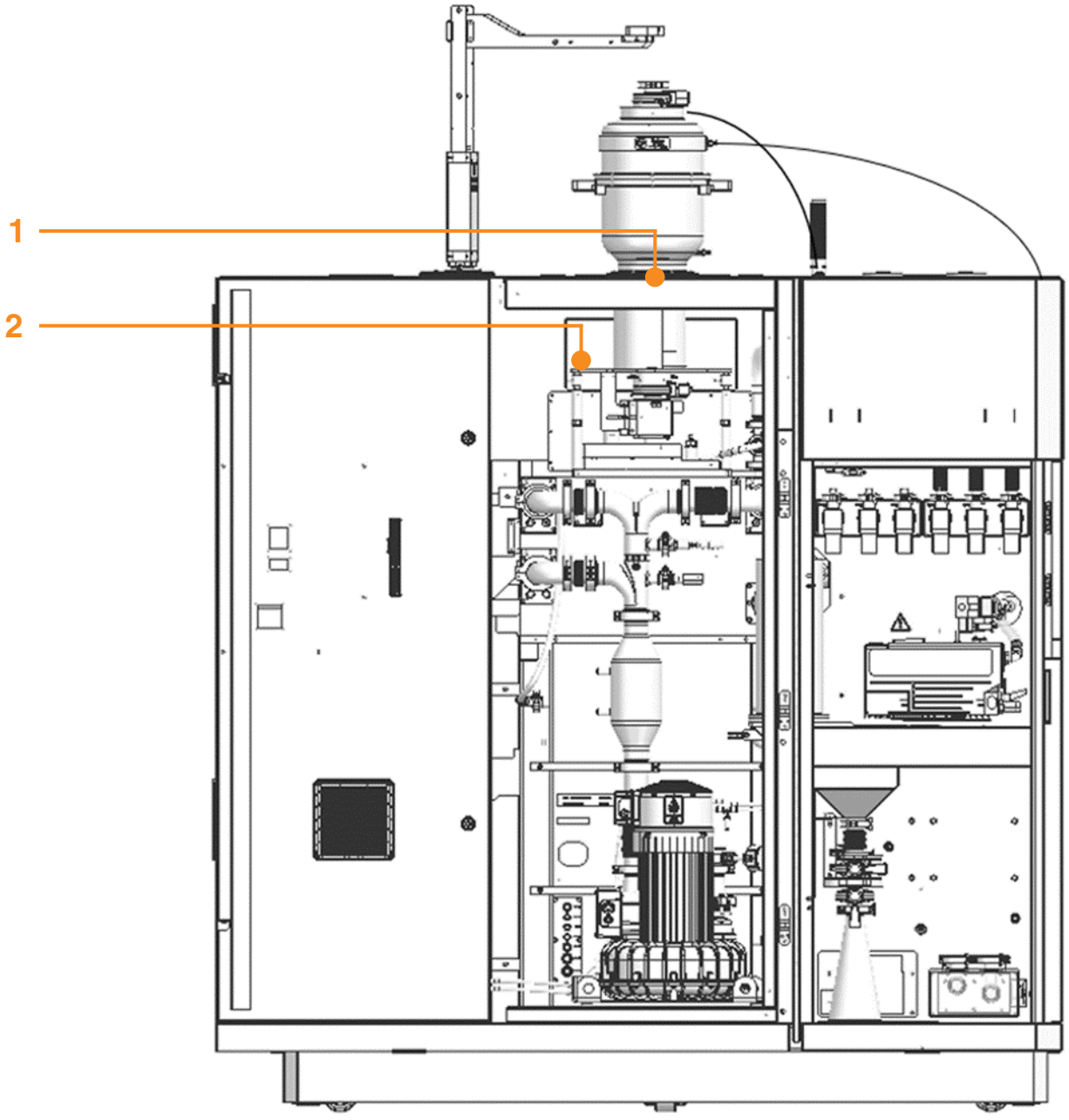


1	Solenoid valves	6	Powder recirculation pump (not present on RenAM 500 Flex)
2	Solenoid valves	7	Cyclone separator isolation valves
3	Vacuum pump	8	Flow switch (not present on RenAM 500 Flex)
4	Vacuum pump oil level viewing window	9	Right-hand manifold
5	Cyclone separator (lower section)	10	Cyclone separator collection flask

Figure 14 RenAM 500 rear view with rear right-hand cupboard door open

4.3.7 RenAM 500 Flex rear view with rear right-hand and middle cupboard doors open

NOTE: The features shown apply to the RenAM 500 Flex only. These features do not apply to the RenAM 500 or RenAM 500 Ultra.

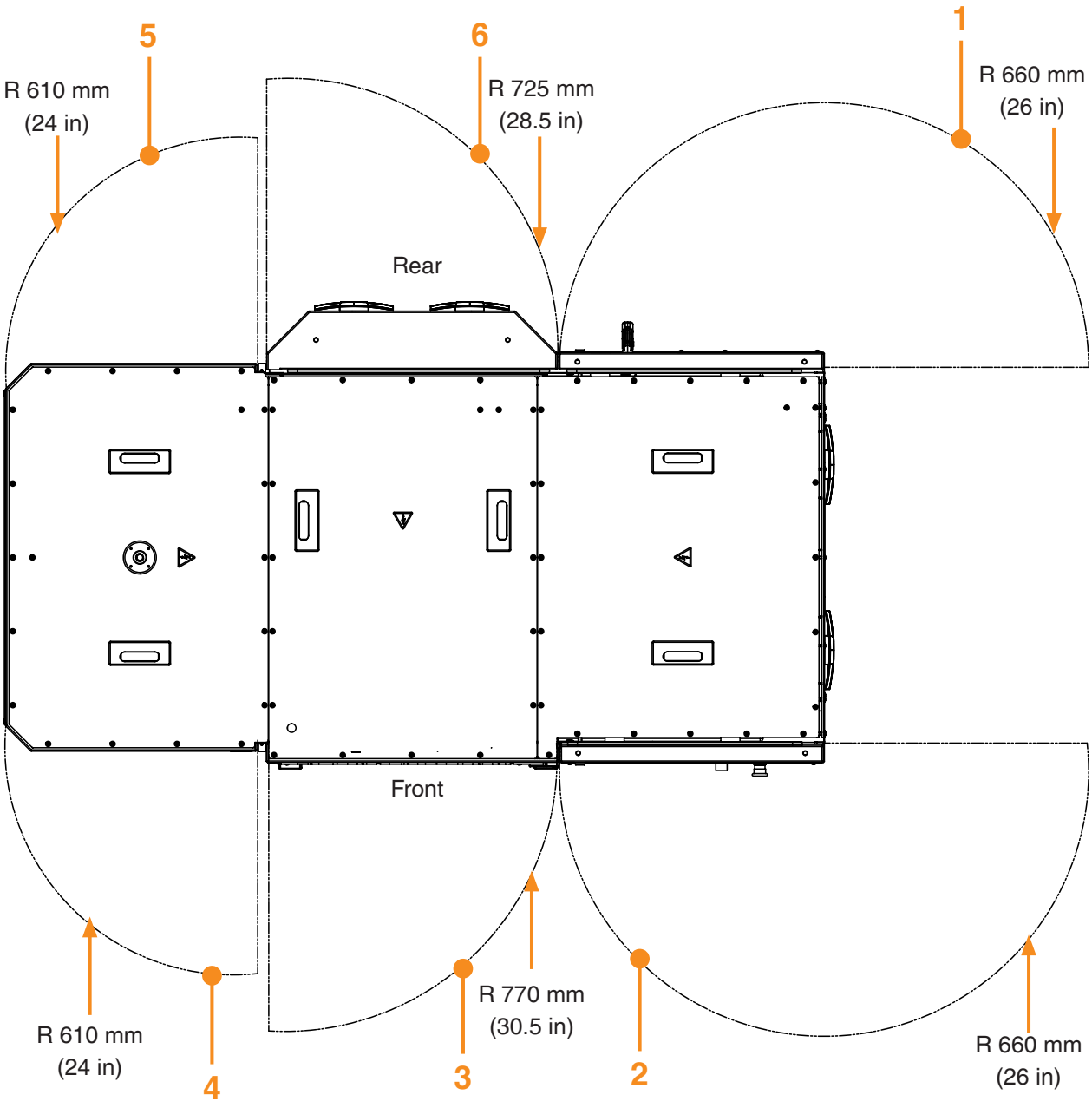


1	Feed hopper skirt	2	Feed hopper level load cells

Figure 15 RenAM 500 Flex rear view with rear right-hand and middle cupboard doors open

4.3.8 RenAM 500 plan view

NOTE: The measurements shown apply to the RenAM 500, RenAM 500 Flex and RenAM 500 Ultra.



1	Service access – rear left-hand electrical cupboard door	4	Operator access – front left-hand cupboard door
2	Service access – front right-hand electrical cupboard door	5	Operator access – rear right-hand cupboard door
3	Operator access – top and bottom doors	6	Service/Technician access – rear centre equipment cupboard door

Figure 16 RenAM 500 plan view

5. Build plate specification

The RenAM 500 series build plates can be re-ground or re-manufactured using the specifications provided in this section. After milling, the build plates develop a reflective top surface. This can cause high levels of laser reflection during the initial layers of a build execution and damage the optical system. Therefore, it is important to prepare the build plate surface to reduce reflectivity and prevent damage to the machine's optical system. This can be achieved by shot blasting or using an abrasive pad to achieve a surface roughness (Ra) ranging between 1.6 µm and 3.6 µm.

The images below illustrate the difference between a milled and shot-blasted top surface of the build plate.

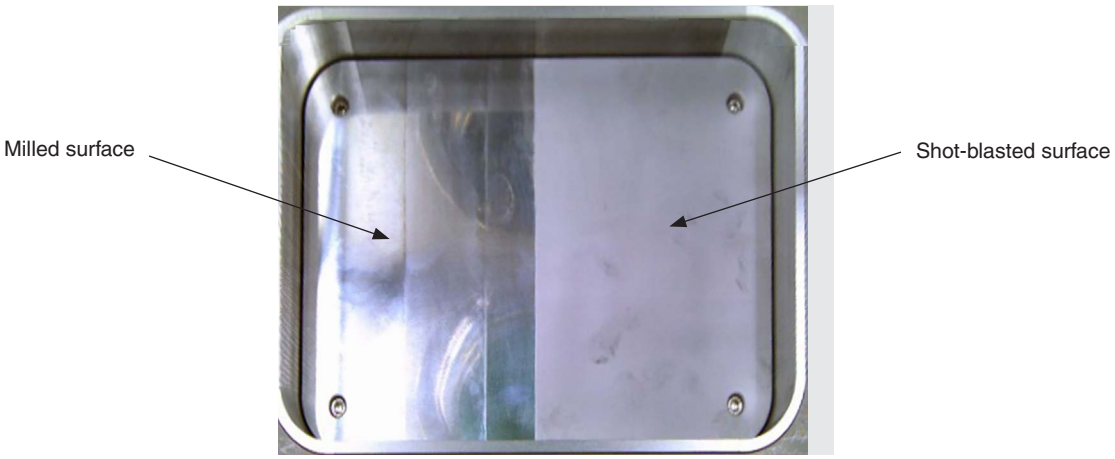
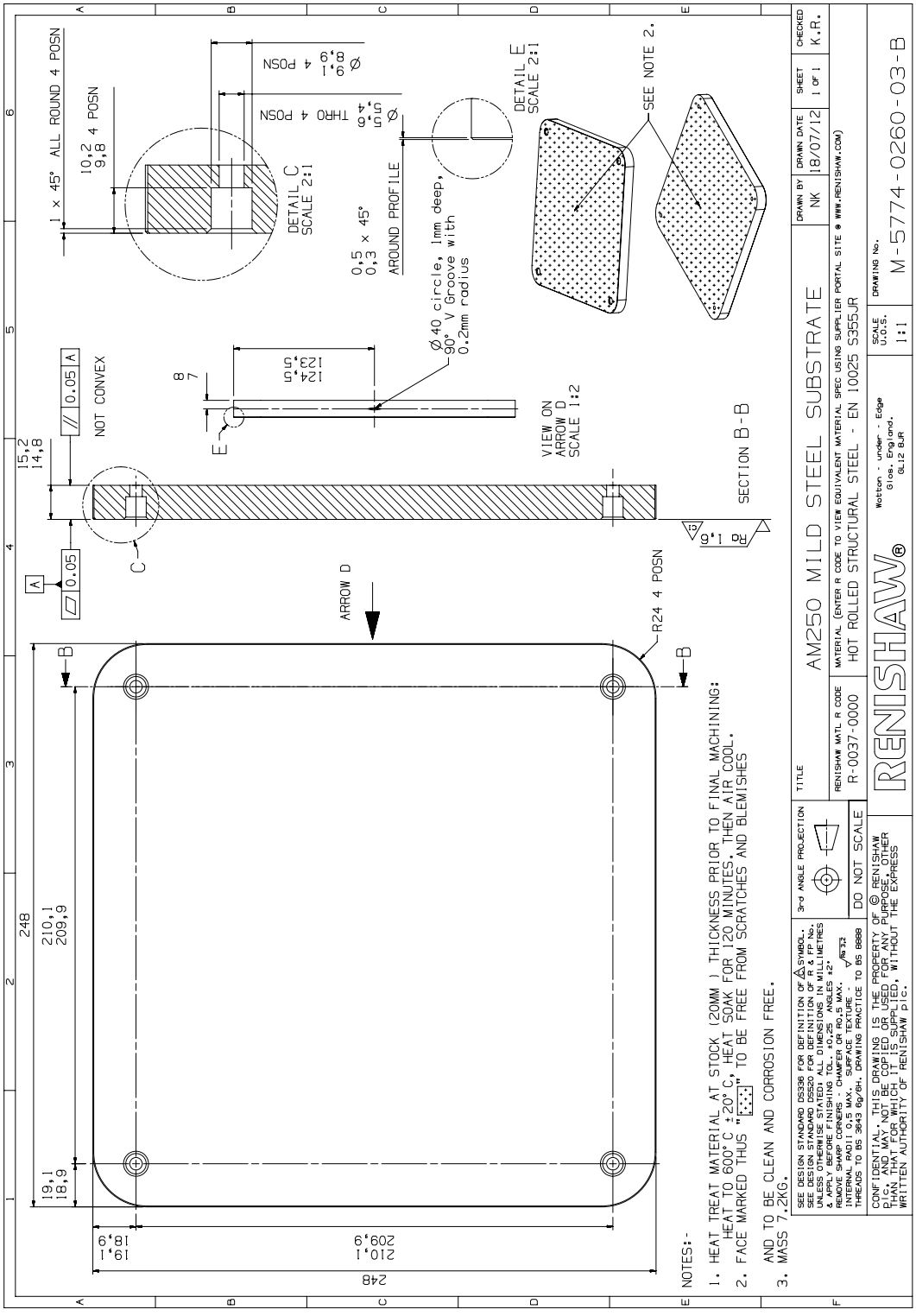


Figure 17 Build plate surface

It is recommended to prepare the surface of the following build plates before executing the builds.

Part number	Description
A-5771-0001	248 × 248 × 15 mild steel substrate box of 3
A-5771-0003	248 × 248 × 15 mild steel substrate individually boxed
A-5771-0004	248 × 248 × 15 stainless steel substrate box of 3
A-5771-0005	248 × 248 × 15 stainless steel substrate individually boxed
A-5771-0008	248 × 248 × 15 aluminium substrate box of 3
A-5771-0009	248 × 248 × 15 aluminium substrate individually boxed
A-6521-6500	246 × 246 × 34 stainless steel substrate individually boxed
A-6521-6502	248 × 248 × 34 stainless steel step substrate individually boxed
A-6521-6506	246 × 246 × 34 mild steel substrate individually boxed
A-6521-6508	246 × 246 × 34 aluminium substrate individually boxed
A-6521-6509	248 × 248 × 34 aluminium step substrate individually boxed
A-6521-6510	246 × 246 × 34 titanium substrate individually boxed
A-6521-6512	248 × 248 × 34 mild steel step substrate individually boxed
A-6521-6514	246 × 246 × 15 titanium substrate individually boxed
A-6521-6515	246 × 246 × 15 titanium substrate box of 3
A-6521-6517	248 × 248 × 34 titanium step substrate individually boxed

5.1 Standard build plate – mild steel



Uncontrolled issue for reference only

Figure 18 Standard build plate – mild steel

5.2 Standard build plate – stainless steel

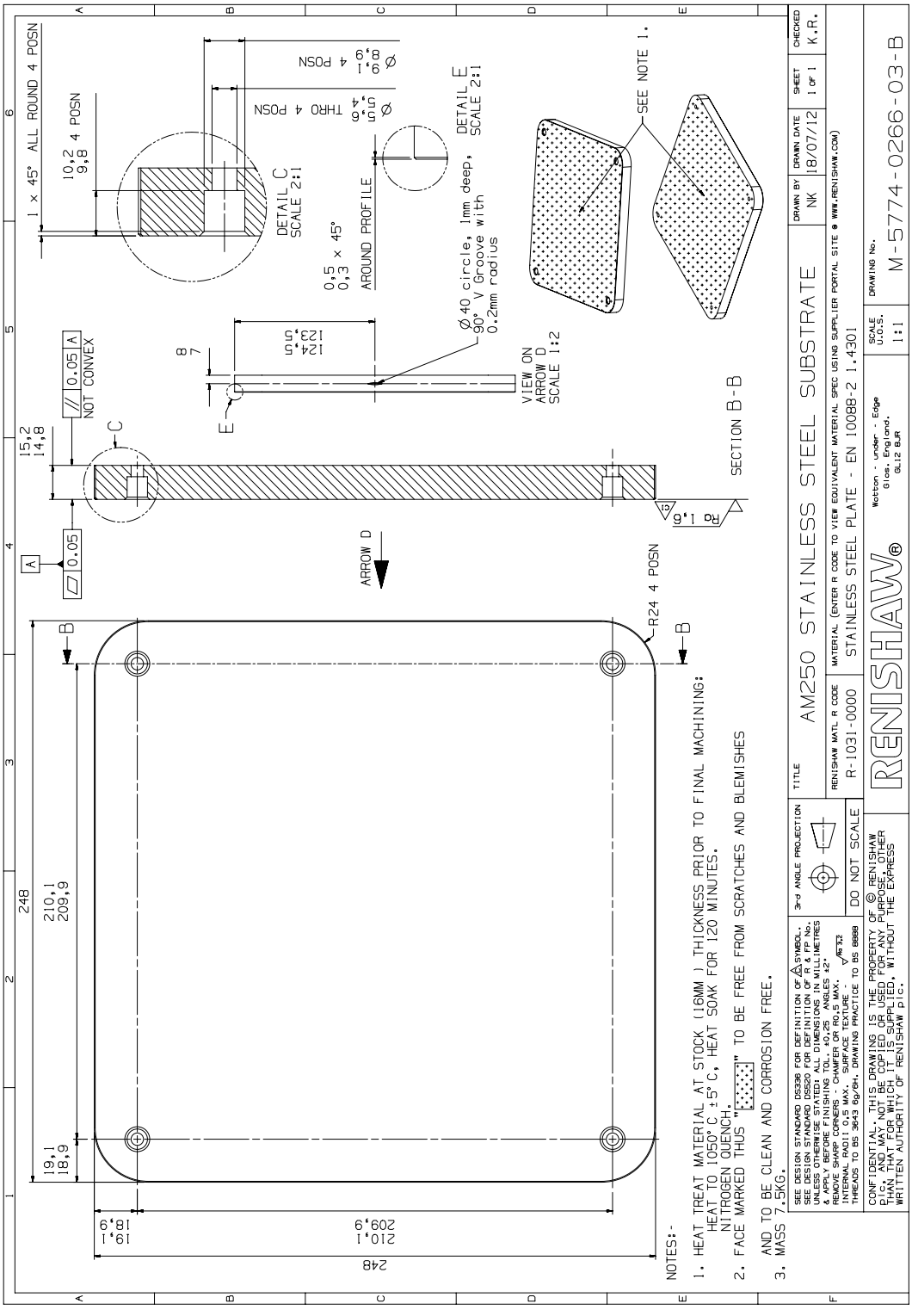
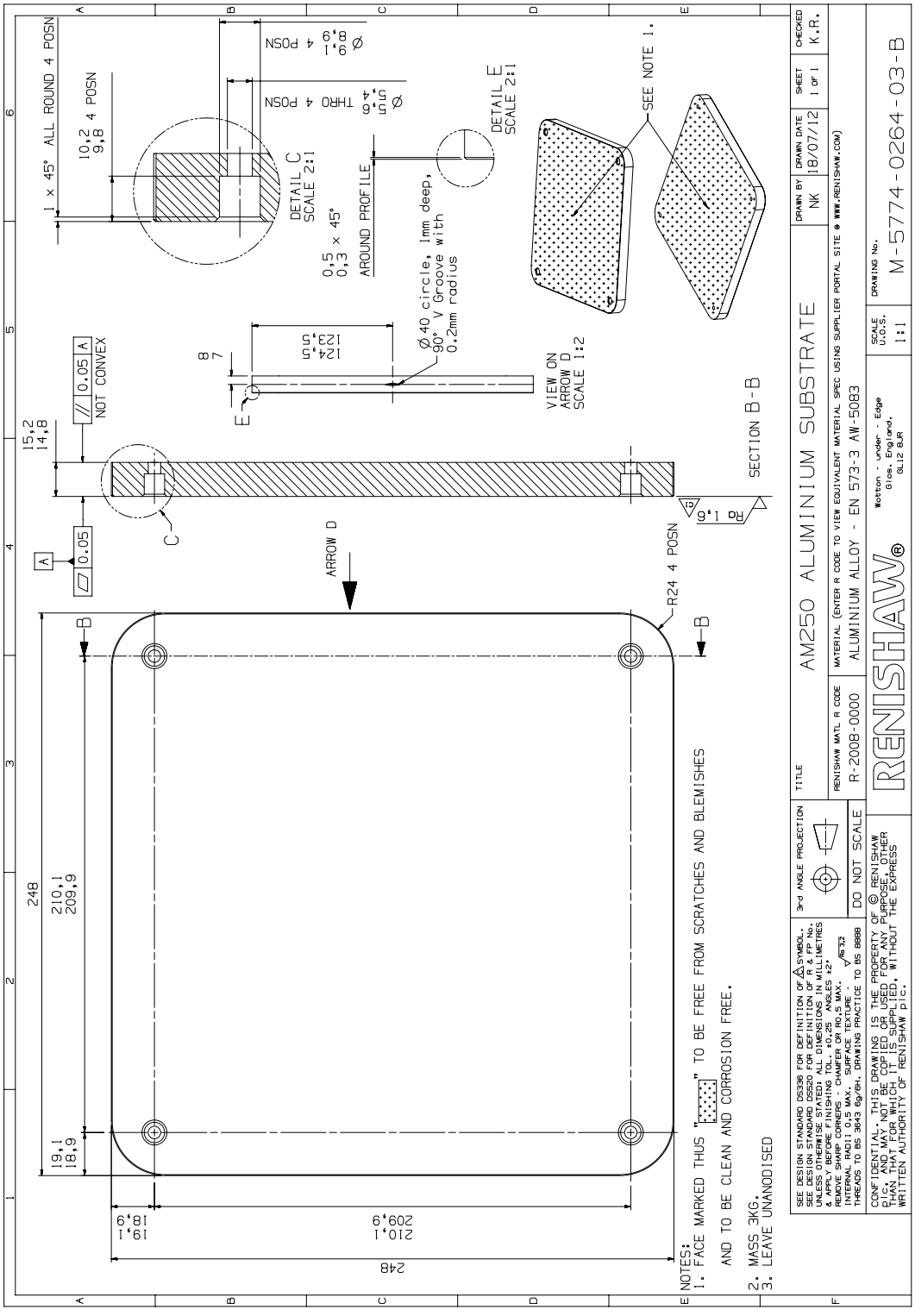


Figure 19 Standard build plate – stainless steel

5.3 Standard build plate – aluminium



Uncontrolled issue for reference only

Figure 20 Standard build plate – aluminium

5.4 Standard build plate – long life stainless steel

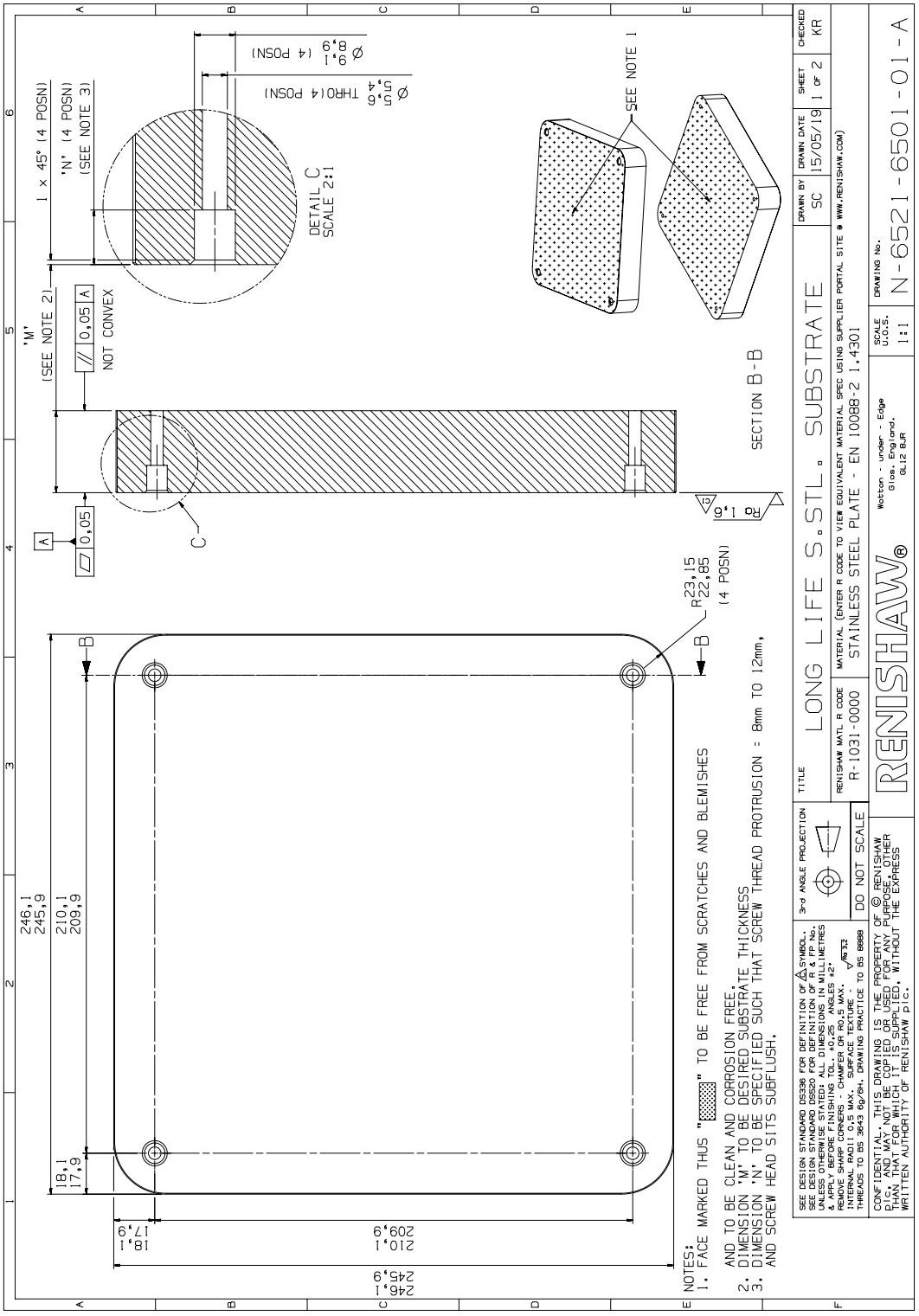
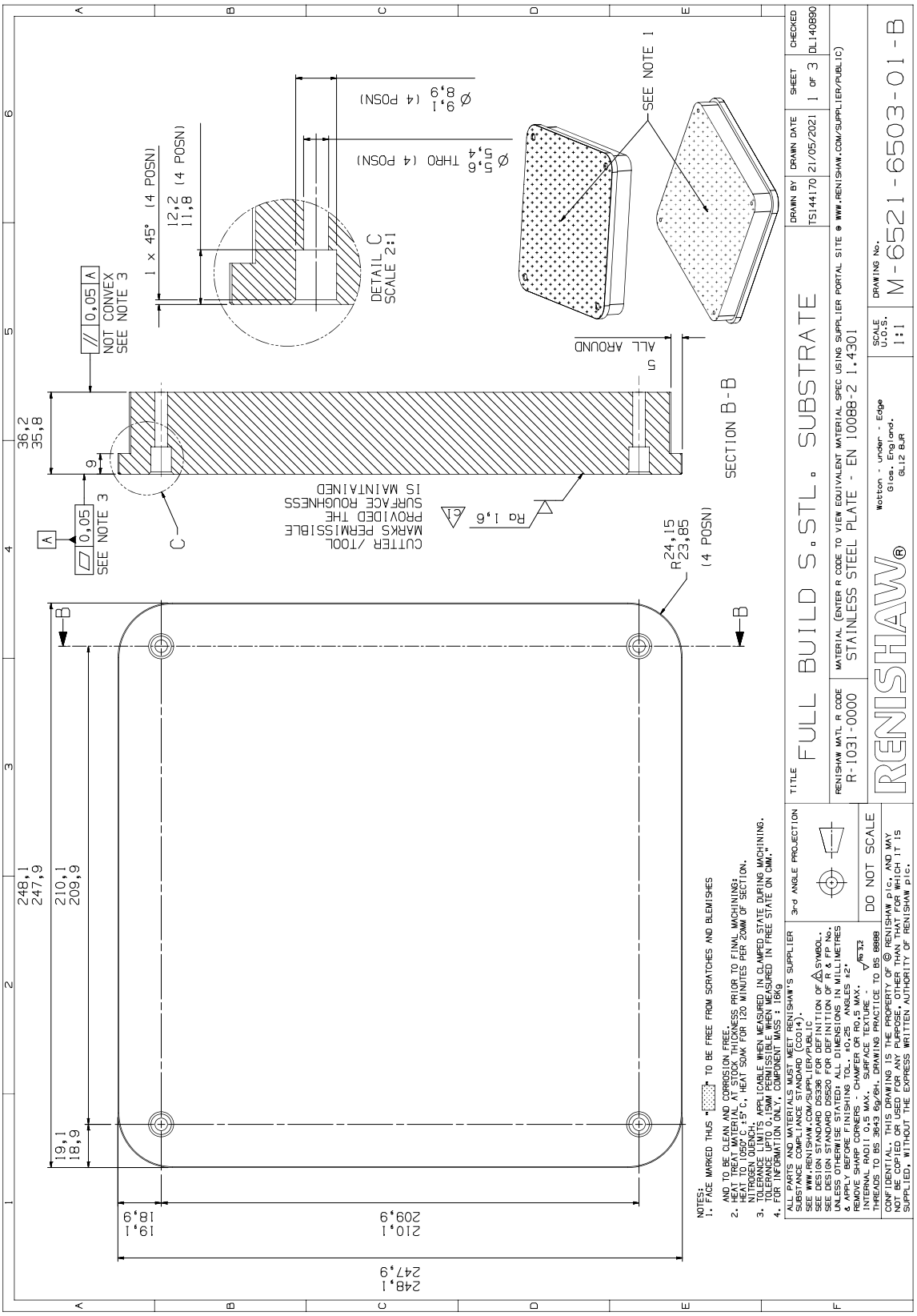


Figure 21 Standard build plate – long life stainless steel

Uncontrolled issue for reference only

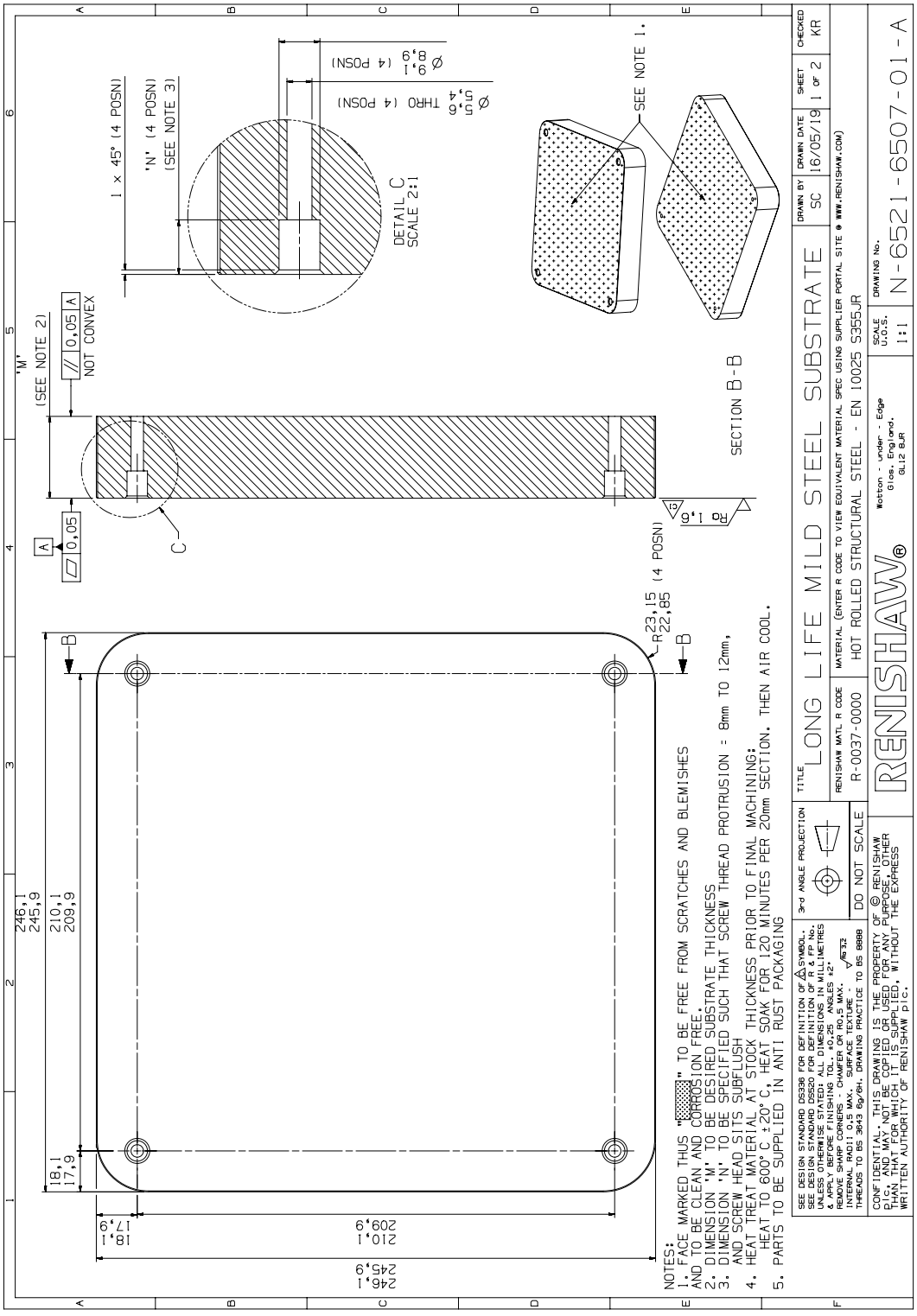
5.5 Standard build plate – full build stainless steel



Uncontrolled issue for reference only

Figure 22 Standard build plate – full build stainless steel

5.6 Standard build plate – long life mild steel



Uncontrolled issue for reference only

Figure 23 Standard build plate – long life mild steel

5.7 Standard build plate – long life aluminium

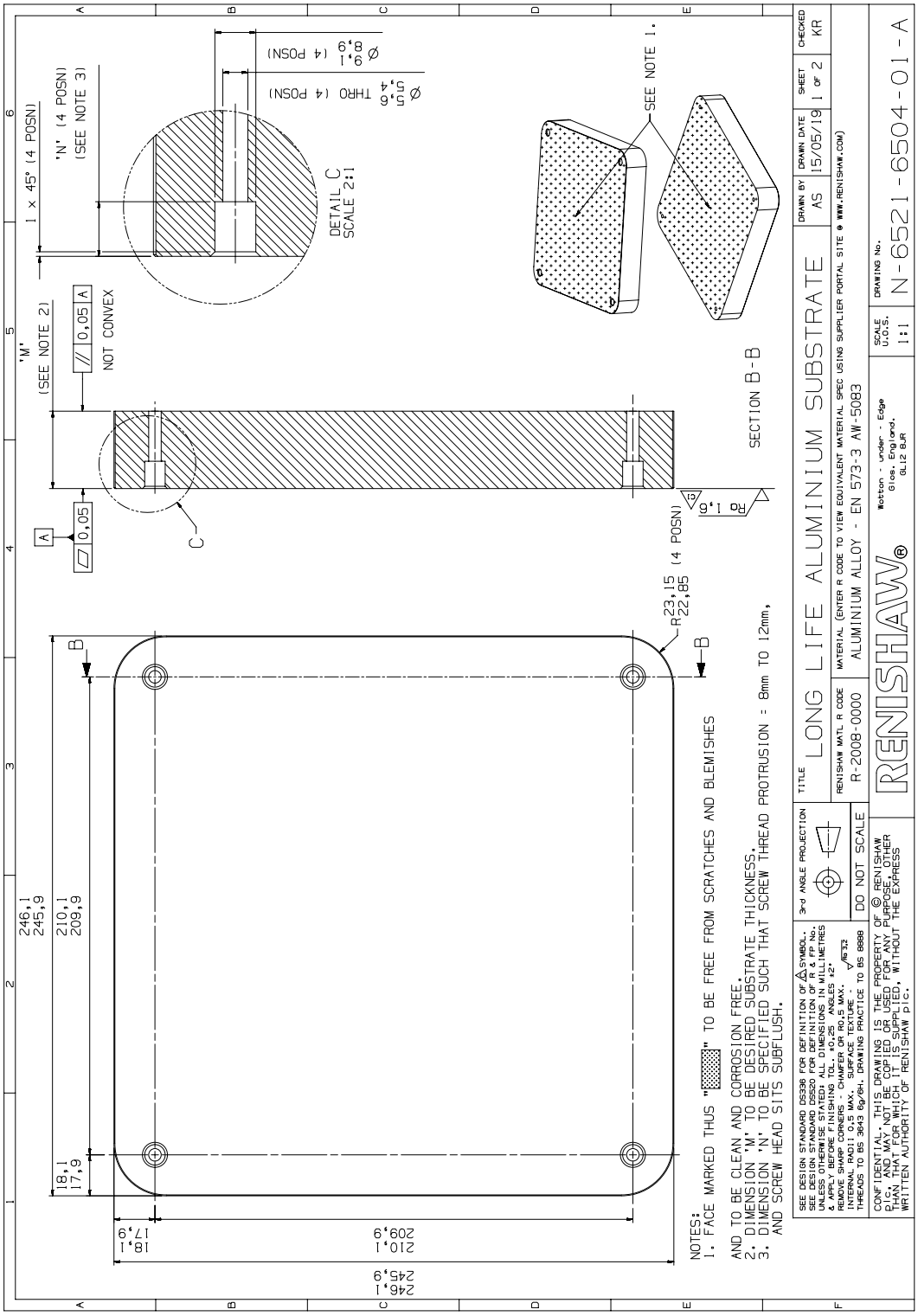


Figure 24 Standard build plate – long life aluminium

5.8 Standard build plate – full build aluminium

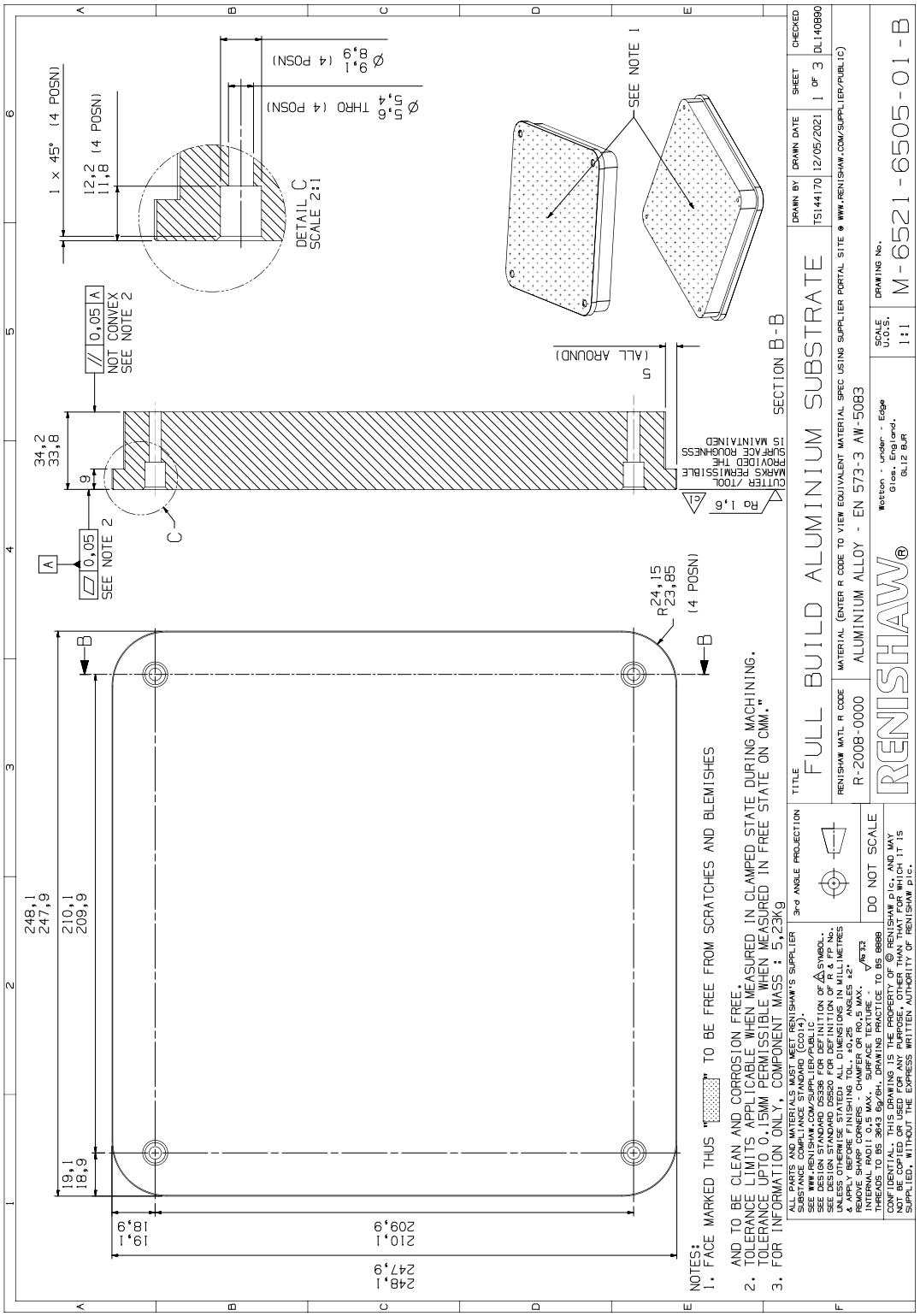


Figure 25 Standard build plate – full build aluminium

Uncontrolled issue for reference only

5.9 Standard build plate – long life titanium

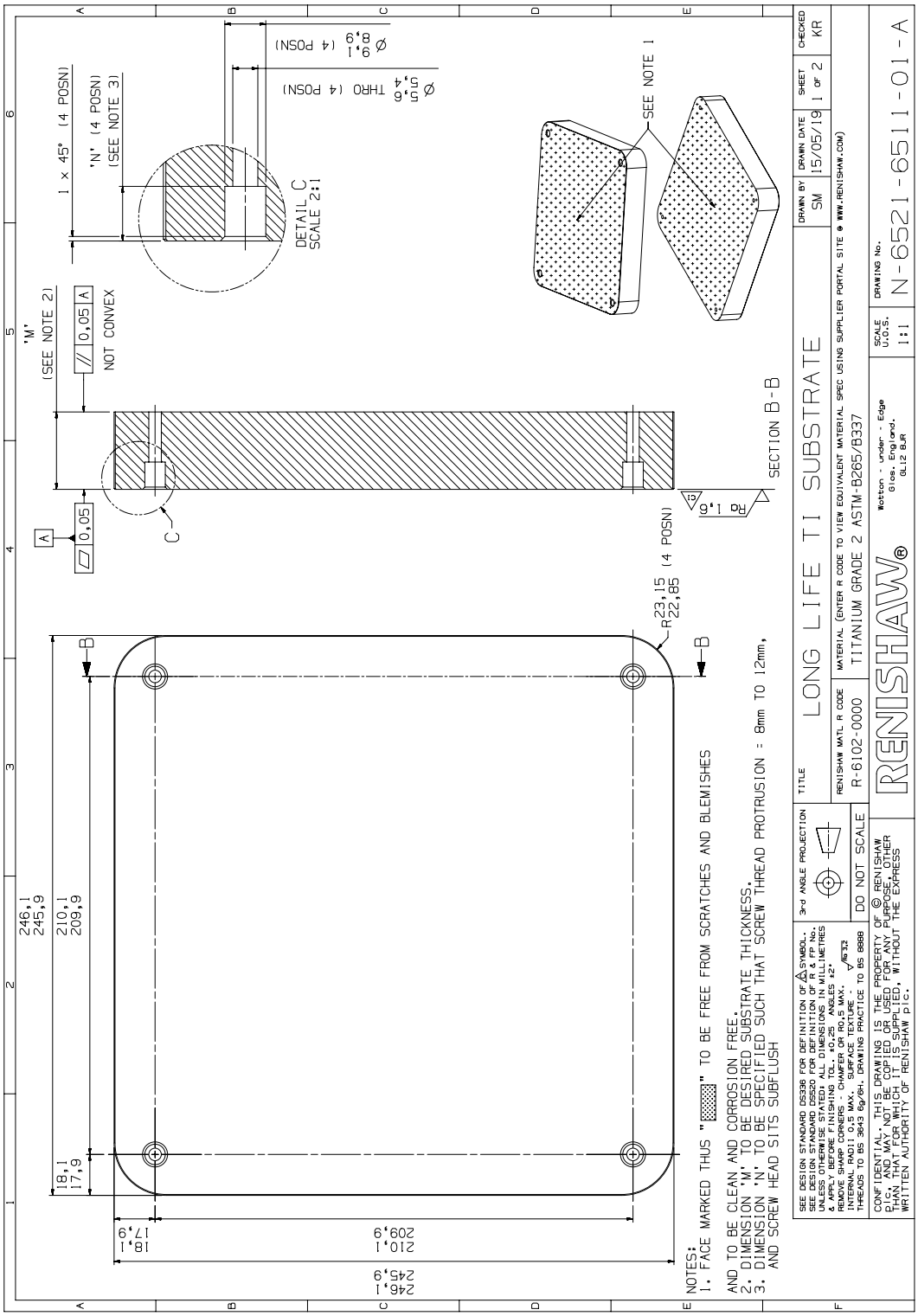
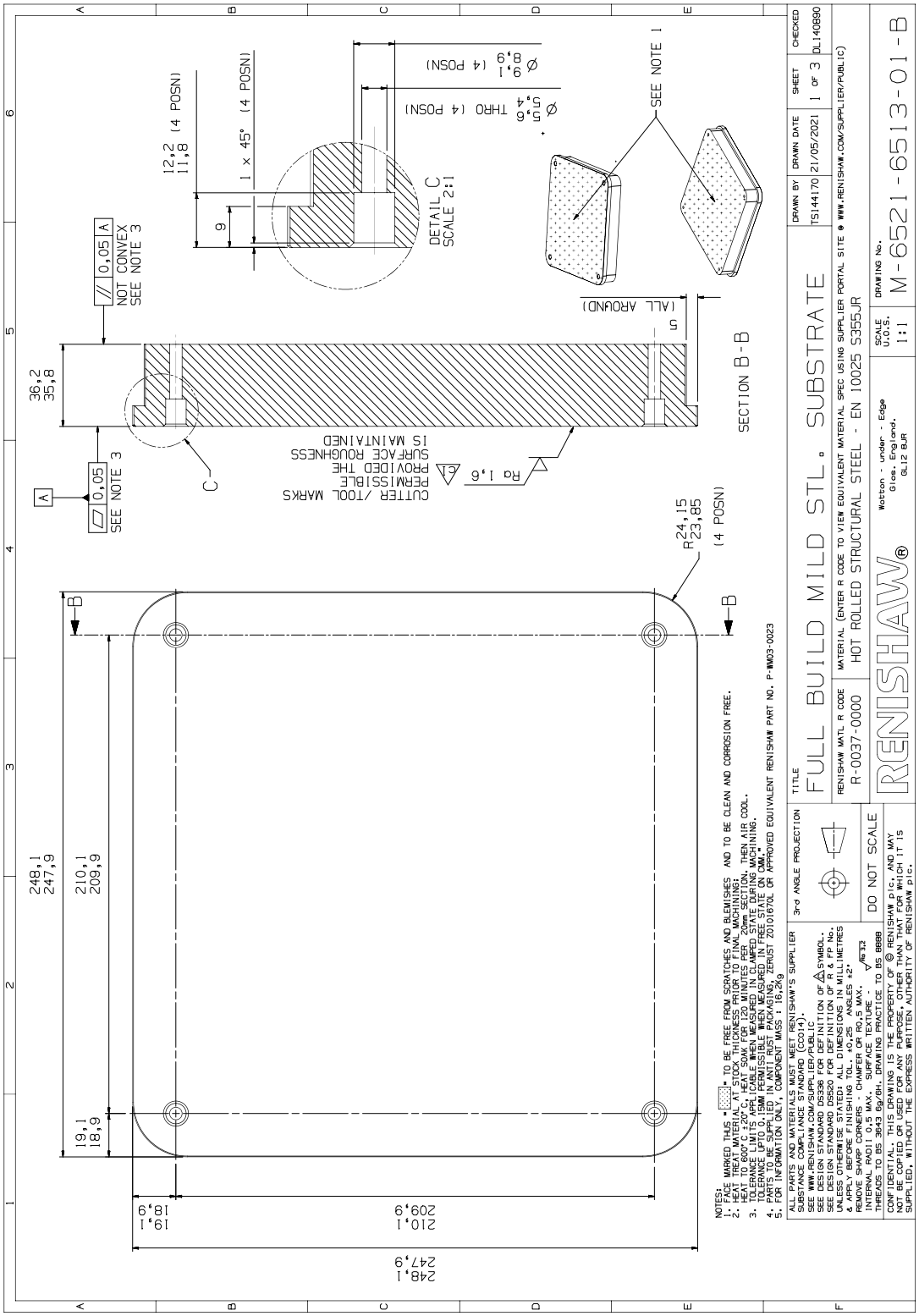


Figure 26 Standard build plate – long life titanium

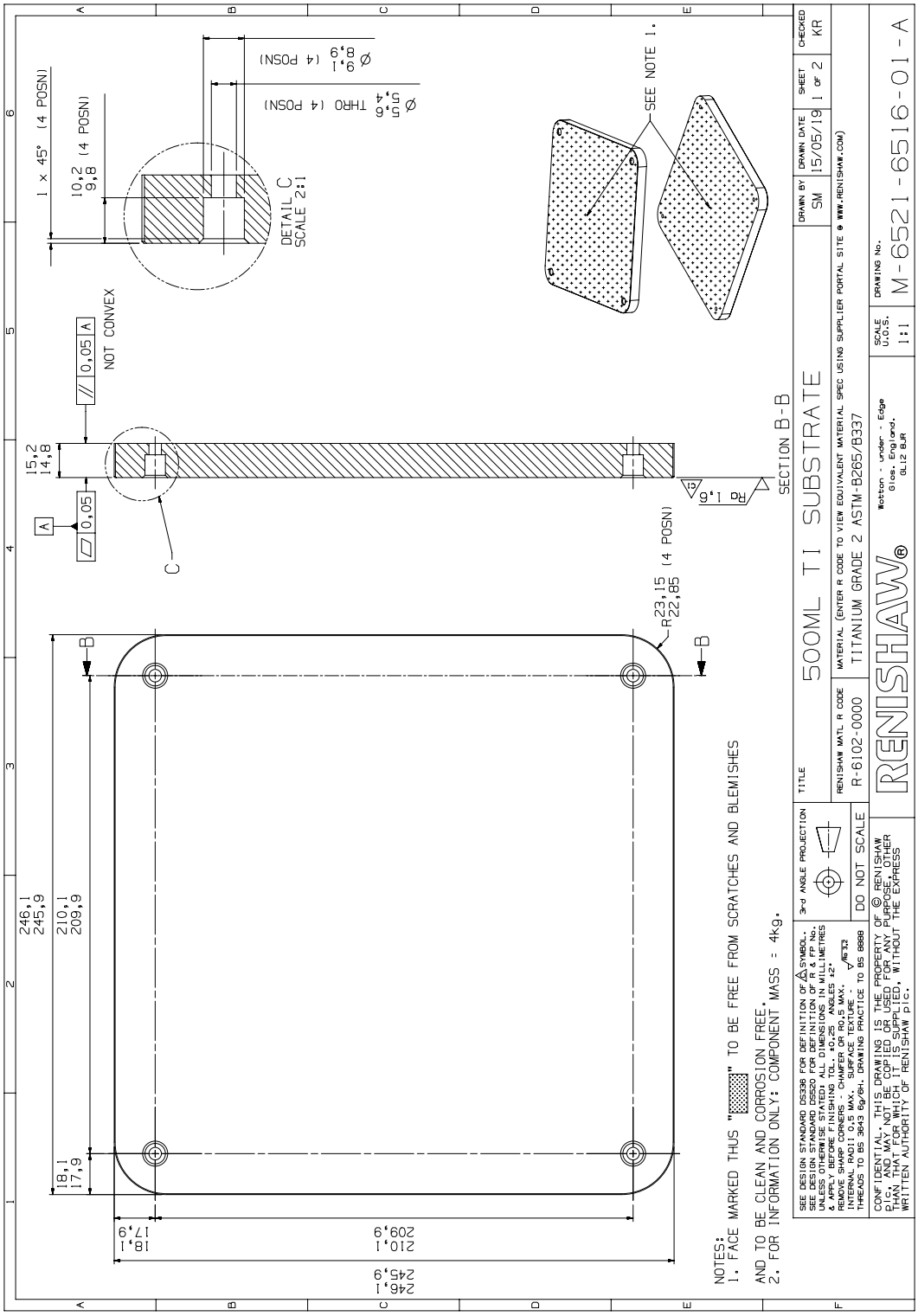
5.10 Standard build plate – full build mild steel



Uncontrolled issue for reference only

Figure 27 Standard build plate – full build mild steel

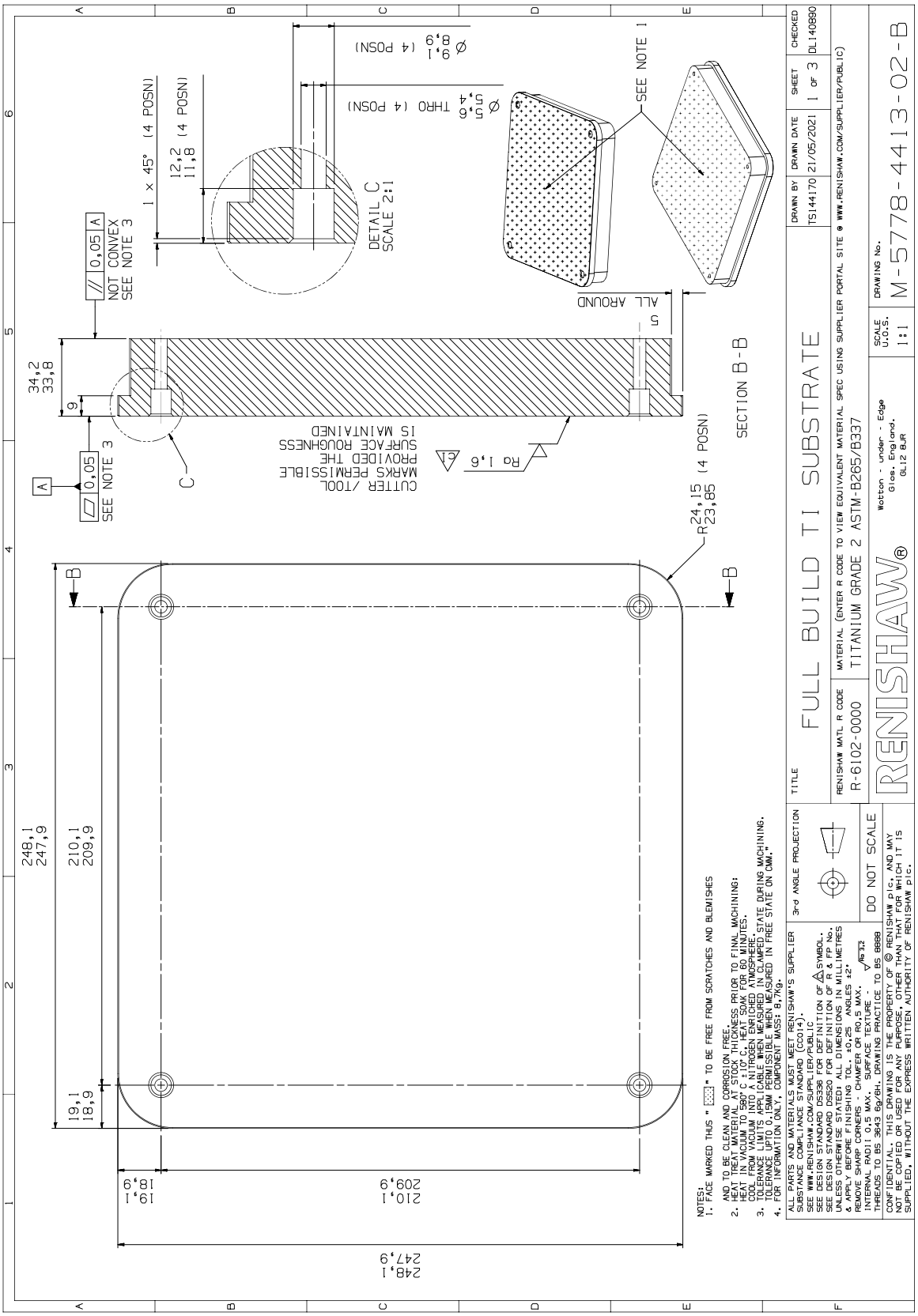
5.11 Standard build plate – titanium



Uncontrolled issue for reference only

Figure 28 Standard build plate – titanium

5.12 Standard build plate – full build titanium



Uncontrolled issue for reference only

Figure 29 Standard build plate – full build titanium

6. System description

This section gives a brief introduction to some of the major systems, sub-systems and components integrated into the RenAM 500 series hardware and software.

6.1 Main isolating switch

The equipment main isolating switch is located on the rear left-hand side of the RenAM 500 series cabinet. Raising the switch to the On position (Figure 30 – left) energises the system electrical circuits. The controller and the main computer will then begin their start-up routines. Moving the switch down to the Off position (Figure 30 – right) immediately disables power to the system. The controller and the main computer are immediately shut down, and do not carry out their shutdown routines. Using the isolating switch to shut down the RenAM 500 series should be avoided and the correct shutdown process should be followed.

WARNING: Operating the equipment main isolating switch isolates the electrical supply to the entire RenAM 500 series system.

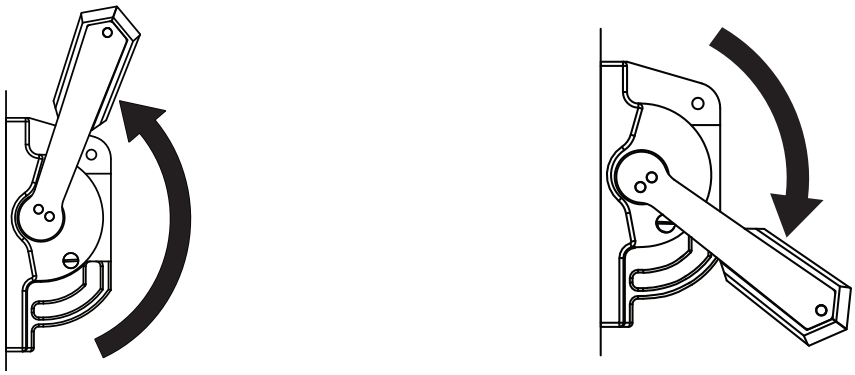


Figure 30 Main isolating switch On (left) and Off (right)

6.2 Emergency Stop button

The Emergency Stop button is located on the front right-hand side of the RenAM 500 series cabinet (Figure 31). After the controller and main computer have started, the system is ready for operation. To operate the equipment, unlatch the Emergency Stop button, situated below the touch screen on the front of the cabinet, by rotating it clockwise. To enable the safety relay, press the blue Reset button next to the Emergency Stop button (Figure 31).



Figure 31 Emergency Stop and Reset buttons on front of RenAM 500 series system

CAUTION: DO NOT leave the Emergency Stop button in the latched position for long periods of time. Ensure that the laser key switch is in the On position.

Pressing the Emergency Stop button at any time during a build cycle will stop the additive manufacturing process. The laser and mechanical components will be inoperable. The main computer and controller will be available to the operator; however their functionality will be disabled until the alarm messages have been cleared. The argon atmosphere will remain in place to retain a safe inert atmosphere inside the build chamber. If the Emergency Stop button is pressed, to enable the safety relay, press the blue Reset button next to the Emergency Stop button.

6.3 Operator touch screen control panel

The additive manufacturing build process is controlled from a 480 mm capacitive touch screen control panel built into the front of the RenAM 500 series cabinet (Figure 32). The touch screen shows the RenAM 500 series operating system called RenAMP.

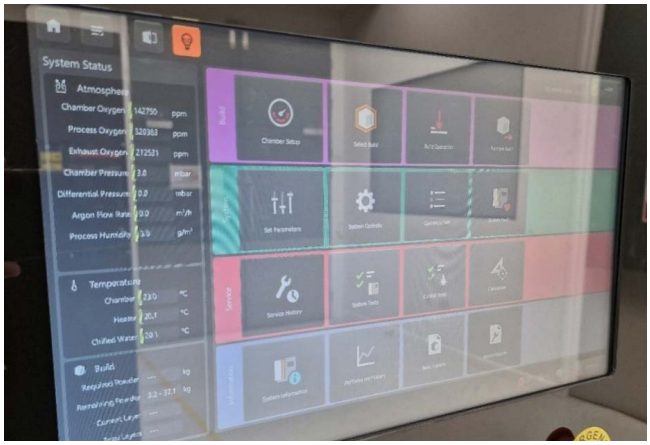


Figure 32 Operator touch screen control panel

6.4 RenAMP operating system

The RenAM 500 series features an operating system software called RenAMP, accessed via the touch screen control panel. It has been designed and built as a modular platform so that individual updates can be added as and when new system features become available.

RenAMP is used extensively to control many of the functions of the RenAM 500 series system. The home screen, and a basic description of some of the UI elements, are explained below (Figure 33).

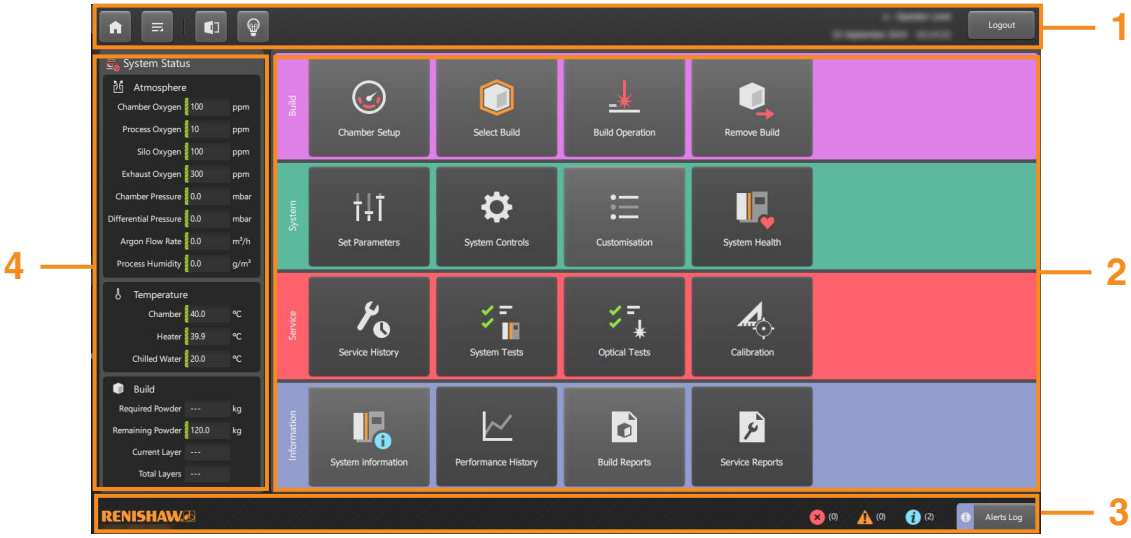


Figure 33 RenAMP Home screen

1. Access bar: The access bar enables you to navigate to the Home page during any stage of the operation. Additionally, the access bar displays your User ID and the current date and time, and provides buttons to access the Help document, PC control and About information. From the Access bar you can also take a screen capture, unlock the top door and enable/disable the backlight.

2. Workflow pane: Displays the tools and functions required to work on the RenAM 500 series system. These tools are categorised in four coloured panes – Build, System, Service and Information.

3. Status bar: Displays information about the system status and offers the option to view alert logs.

4. System Status pane: Displays various system parameters in real time.

6.4.1 RenAMP access control

Access to RenAMP is restricted and controlled by service access levels defined as login levels. Login levels are the central element of the RenAMP authorisation system. RenAMP users are primarily identified by their unique user ID and password, and are assigned a login level that controls their access to the various functions within RenAMP.

Mapping between user ID and login level is achieved using the 'Customisation' button available on the Home page under the 'System' banner. This button also allows you to create, delete and edit user IDs, passwords and login levels.

NOTE: You are allowed to perform a specific administrative task if your user ID is assigned to a login level required for the associated operation.

NOTE: The system does not allow you to create a new user with the same user ID after deleting an existing one. The individual operator's unique user ID can have up to a maximum of six alphanumeric characters, and it is recommended that passwords contain at least eight alphanumeric characters.

There are three login levels to the RenAMP software:

- **Operator – Level 1** – Enables the user to operate the RenAM 500 series system to build parts. This includes build preparation, post-build functions and occasional tasks.
- **Technician – Level 2** – Enables the user to carry out more advanced tasks on the RenAM 500 series system, including basic fault-finding and maintenance.
- **Service (also known as Administrator) – Level 3** – Enables the user to carry out the full range of tasks on the RenAM 500 series system, including calibration, system testing, configuration, material change and annual maintenance.

The following table gives an overview of service levels and their authorised function:

Authorised function	Login level			Accessibility
	Operator	Technician	Service	
Build configuration and execution including: • Chamber Setup • Select Build • Build Operation • Remove Build	✓	✓	✓	Home
Create new user with operator/technician level access		✓	✓	Home > Customisation > User
Create new user with operator level/ technician/service level access			✓	Home > Customisation > User
Configure sensor warning set points for: • High temperature limits • Low flow rate limits • Chamber pressure limits		✓	✓	Home > Set Parameters > Sensors
Configure humidity and argon consumption set points			✓	Home > Set Parameters > Sensors

Authorised function	Login level			Accessibility
	Operator	Technician	Service	
Configure system settings, such as: • Chamber settings • Atmosphere settings • Heater settings • Gas recirculation settings • Filter conditioning settings		✓	✓	Home > Set Parameters > System
Configure user settings, such as: • Lights auto switch-off • HMI auto lock • Date, time and time zone		✓	✓	Home > Set Parameters > System
Configure powder settings, such as: • Powder loss settings • Build pause settings (applicable for RenAM 500 Flex only) • Hopper and flask settings		✓	✓	Home > Set Parameters > Powder Settings
View remaining powder calculations		✓	✓	Home > Set Parameters > Powder Settings
Configure elevator position settings and recoater position settings		✓	✓	Home > Set Parameters > Positions
Configure recirculation system controls, such as: • Gas recirculation controls • Powder recirculation controls (auto/manual)		✓	✓	Home > System Controls > Recirculation
Add/update custom material information		✓	✓	Home > System Controls > Recirculation
View powder information and update powder batch number		✓	✓	Home > System Controls > Recirculation
Configure manual system controls, such as: • Valve controls • Pump controls		✓	✓	Home > System Controls > Manual
Manual operation of filter, argon and vent valves			✓	Home > System Controls > Manual
Enable/disable FTP and SMB services		✓	✓	Home > Customisation > Network
Configure the WAN ports (network configuration)			✓	Home > Customisation > Network
View the system health including: • Sensor status • Laser system • Optics monitor		✓	✓	Home > System Health

Authorised function	Login level			Accessibility
	Operator	Technician	Service	
Execute system test for the chamber, such as: • Vacuum test • Overpressure test • Gas flow test			✓	Home > System Tests > Chamber
Execute system test for mechanical components, such as: • Z-axis test • Recoater test • Empty silo test			✓	Home > System Tests > Mechanical
Execute all the optical tests including: • Laser power • Focus • Scanfield		✓	✓	Home > Optical Tests
Apply measurement file and perform laser calibration			✓	Home > Calibration > Measurement / Calibration
View calibration history			✓	Home > Calibration > Calibration History
View system information	✓	✓	✓	Home > System Information > Overview
View all the ancillary software and configure the related display settings	✓	✓	✓	Home > System Information > Ancillary Software
View the performance history of the machine			✓	Home > Performance History > Overview
View build history and build reports	✓	✓	✓	Home > Build Reports
Configure the system to automatically pause the build on low powder level		✓	✓	–
Configure the system to automatically pause the build on powder overflow (RenAM 500 Flex only)		✓	✓	–
Access to hot chamber	✓ *	✓ *	✓	–
Manually override safety operations using service key (for example, running wiper elevator with door open.)			✓	–

* Only for selected users that have their access granted by a user with a service-level log-in.

NOTE: You will not be able to access the service history or service reports from the Home page of RenAMP. It is disabled for all the users by default.

6.4.2 System and software information

On your RenAM 500 series machine, the RenAMP software is capable of presenting information about the system, as well as details about the system's software and hardware. It also shows the ancillary software installed on the system and their status, which is essential for the system's efficient operation.

You can access the system information from the home screen of the RenAMP software. To view the regulatory and license information on the RenAMP software, use the 'Function' button located in the upper left corner.

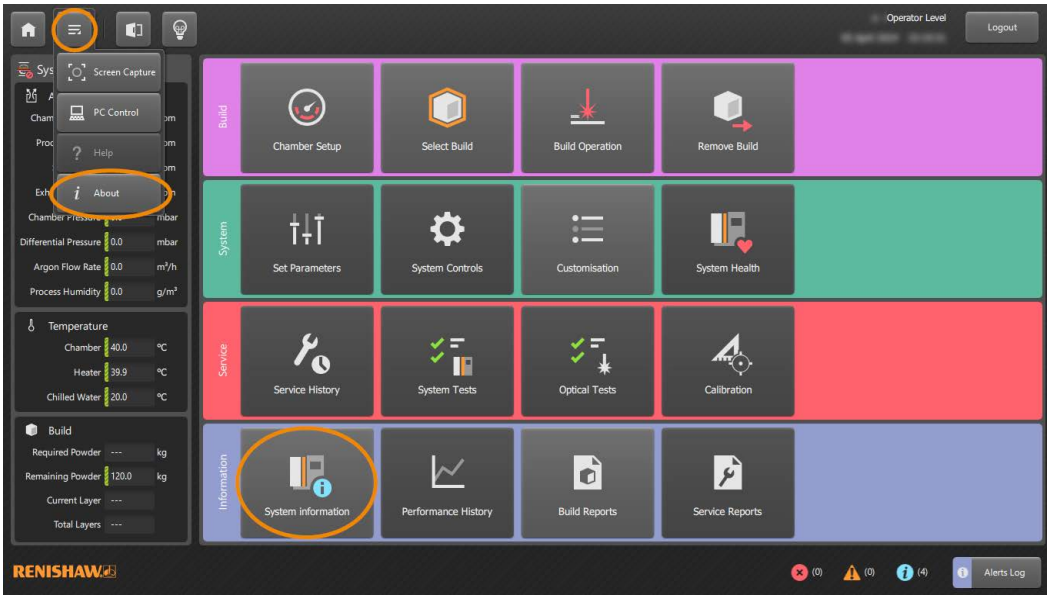


Figure 34 Accessing system information page

The system information screen is organised into two tabs as follows:

a. Overview: This tab provides a comprehensive summary of the machine's details. It displays critical information about the system, including the operating system version, details of the Programmable Logic Controller (PLC), Safety Programmable Logic Controller (SPLC) network settings, and other relevant data. This information is crucial for understanding the machine's configuration.

b. Ancillary Software: This tab displays the details of the secondary or supportive software programs installed on the RenAM 500 series main computer. It includes utilities for system management, tools for troubleshooting and maintenance, and applications for data analysis and visualisation. These software components play a crucial role in optimising the performance of the RenAM system, ensuring its stability, and extending its capabilities to meet specific user needs.

6.4.2.1 Overview

The ‘Overview’ tab of the system information screen displays the following machine Information:

a. Machine: Shows the machine’s details such as MSS version, installation date, serial number, and machine variant and installed lasers.

b. PLC: Shows the PLC version, manufacturer, and type.

c. SPLC: Shows the SPLC version, manufacturer, and type.

d. PC: Shows the application name, application version, launch date of the application, last power cycle, and IP address.

e. Network: Shows the IP addresses of the connected external network.

f. Others: Shows the versions of the laser controller, build processor, and QLMC.

6.4.2.2 Ancillary software

The ‘Ancillary Software’ tab of the system information screen displays the version and status of the following ancillary software installed on your RenAM 500 series machine:

a. DTS (Data transfer system): Allows build specific data files to be transferred from the machine to a customer configured server.

b. MSSI (Machine software suite interface): Operates behind the scenes to allow communication between the various software components of the RenAM 500 series system.

c. Camera (Renishaw camera service): Facilitates the operation of the build chamber camera.

d. Central (Renishaw central): Facilitates a connection with Renishaw Central.

You can enable the ‘Floating Display’ toggle button to view the status of ancillary software in real time while working with RenAMP software. The status of these software programs can assist you in quickly analysing machine problems. A green icon indicates that the specific service is configured correctly and is currently running, while a red icon indicates that the service has stopped due to an error or has been manually stopped. Additionally, you can use the ‘Alignment’ toggle button to position the floating display at either the top or bottom of the RenAMP screen.

6.5 InfiniAM® Suite

During the build process, certain key process variables are directly correlated with the material properties of the parts that are being manufactured. The RenAM 500 and RenAM 500 Flex can be optioned with Additive Manufacturing Process Monitoring (AMPM) hardware to identify and monitor these key process variables. All AMPM hardware comes as standard in RenAM 500 Ultra models.

The InfiniAM suite of software tools allow the user to view the data captured from the AMPM hardware on an external computer. The included analysis functions provide detailed information for each part and can reduce post-process inspection costs.

6.5.1 InfiniAM® Camera

InfiniAM Camera software gives the user the ability to quickly review the camera images taken by the CameraVIEW™ hardware module during the build process in near real time (Figure 35). The CameraVIEW module captures images of every new layer of powder and completed build layer. InfiniAM Camera contains an analysis tool (RMS) that looks for differences between consecutive images to help detect anomalies.

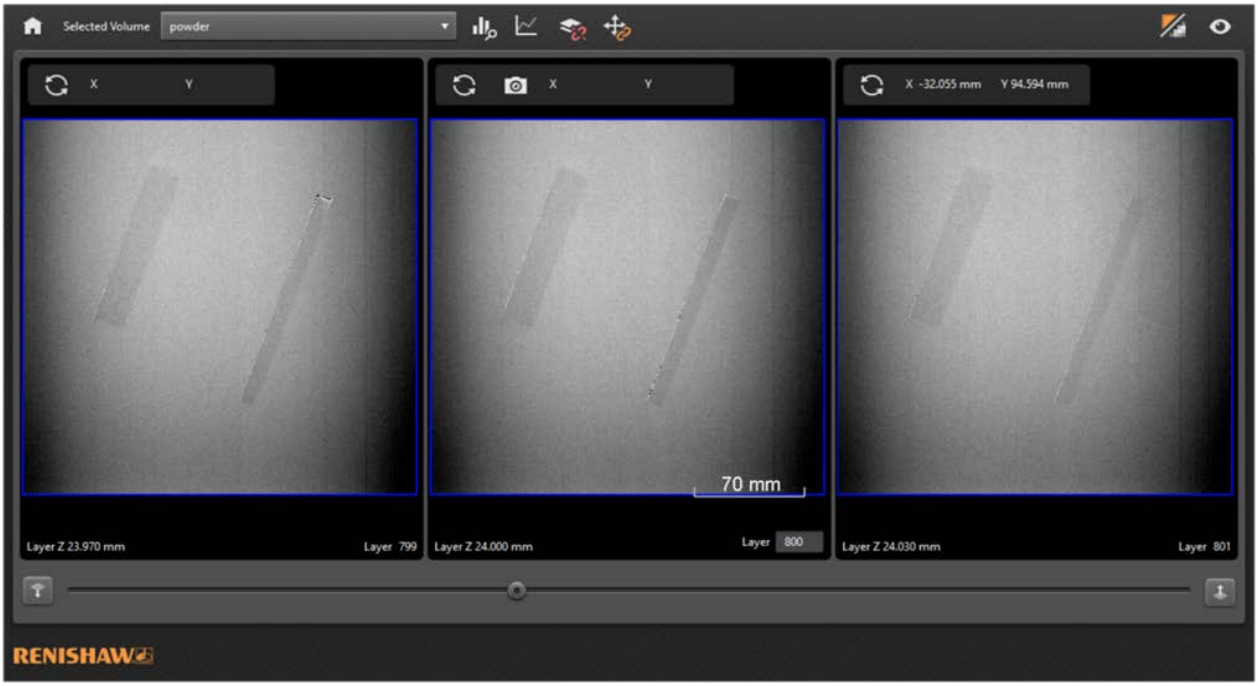


Figure 35 InfiniAM Camera UI

For more information on InfiniAM Camera, refer to the InfiniAM Camera user guide (Renishaw part no. H-5800-4675).

6.5.2 InfiniAM® Spectral

InfiniAM Spectral is designed to operate with Renishaw's LaserVIEW and MeltVIEW hardware modules to provide feedback on energy input and melt-pool spectral emissions during the AM build process. The software interprets this data into 2D and/or 3D views of the build in near real time (Figure 36). This feedback allows the user to monitor laser and melt-pool characteristics throughout the build to better understand component quality.



Figure 36 InfiniAM Spectral UI

For more information on InfiniAM Spectral, refer to the InfiniAM Spectral user guide (Renishaw part no. H-5800-3919).

6.6 Renishaw Central

Renishaw Central software collects and provides visibility of process data from every connected Renishaw device across the factory floor. Users can view live information from connected RenAM 500 series systems for data analysis and status monitoring remotely, providing an insight into AM system performance and individual sensors (Figure 37). Should an error be detected, Renishaw Central will show the error message and an appropriate operator can be deployed to the affected machine.

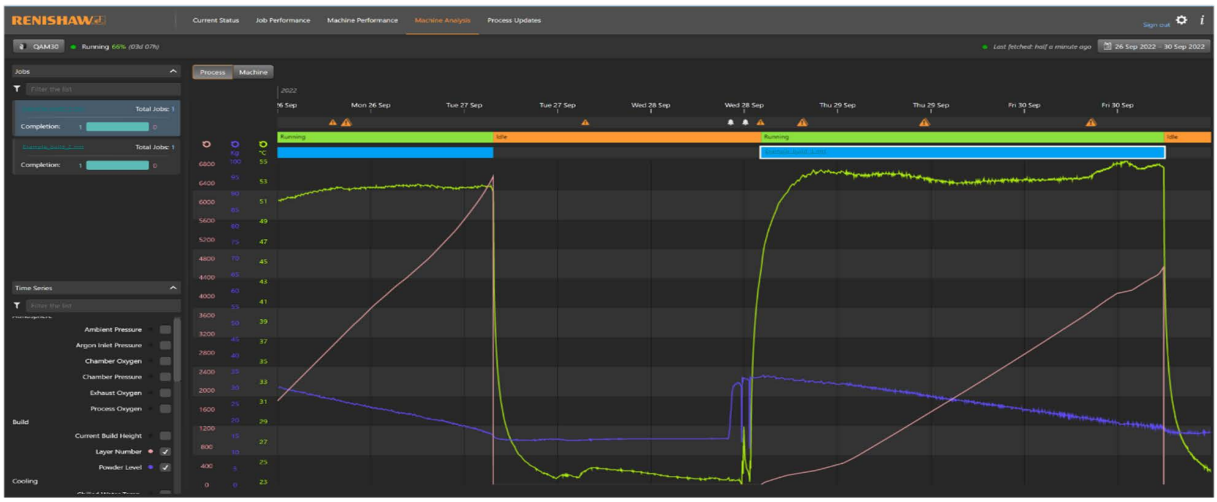


Figure 37 Renishaw Central displaying data from a RenAM 500Q

Multiple RenAM 500 series systems, as well as many other devices from Renishaw's other product lines (for example, CMM, CNC and machine tools), can simultaneously connect to Renishaw Central (Figure 38).

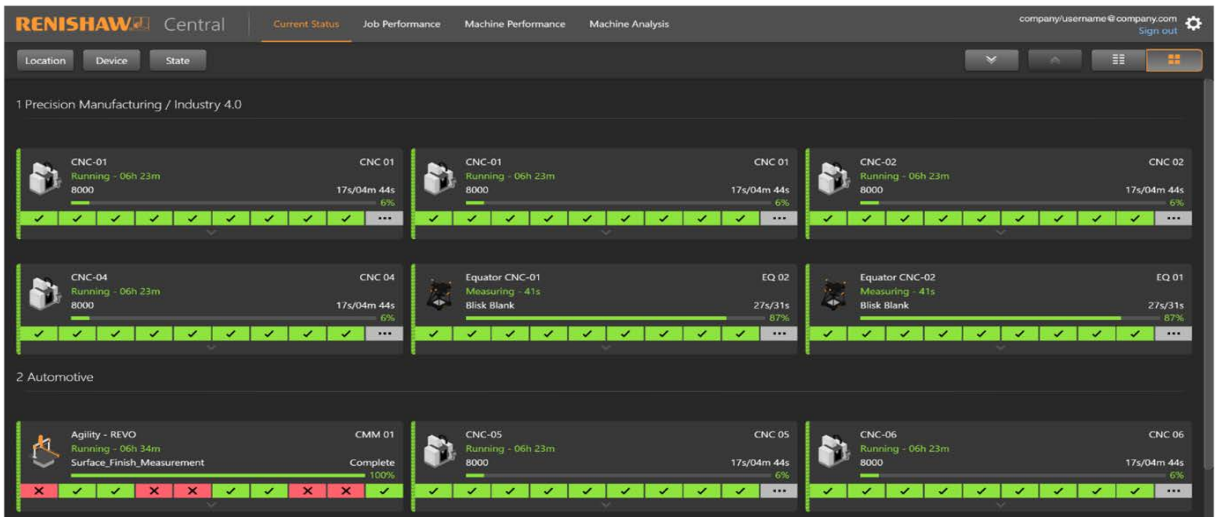


Figure 38 Renishaw Central Current Status screen showing connected Renishaw products

For more information, refer to the Renishaw Central data sheet (Renishaw part no. H-6428-8200) and the Renishaw Central user guide (Renishaw part no. H-6428-8520).

6.7 TEMPUS™ technology

TEMPUS technology is an upgrade package for the RenAM 500 series that can deliver up to a 50% reduction in build times (depending on part geometry) without compromising on part quality. It is installed as standard on the RenAM 500 Ultra, but is also available as an option on the RenAM 500 and RenAM 500 Flex.

TEMPUS technology synchronises the control of the lasers and recoater assembly so that the lasers can fire onto the powder bed whilst the recoater is moving across it. This means that the machine no longer has to wait for the recoater to finish spreading a new layer of powder before starting the next layer. Instead, the lasers can immediately start melting the next layer by strategically moving around the recoater as it deposits fresh powder (Figure 39).

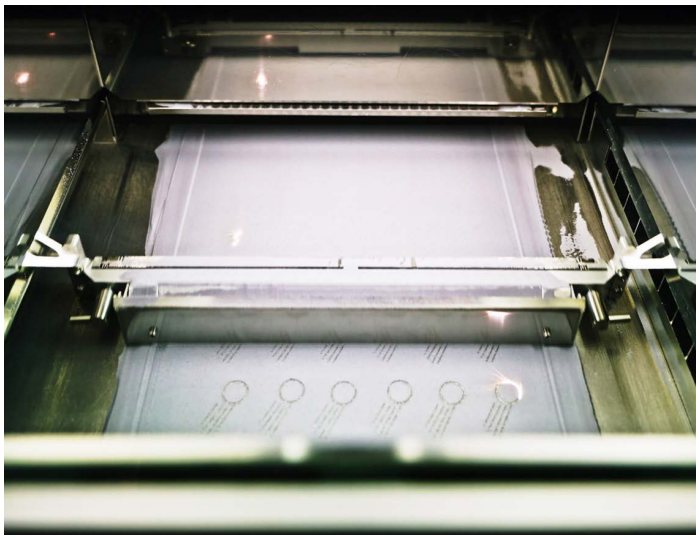
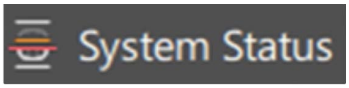
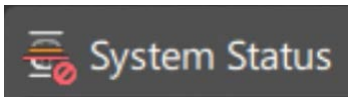


Figure 39 Lasers firing as the recoater deposits a new layer of powder

To check whether TEMPUS technology is active in your machine, view the icon next to “System Status” on RenAMP (Figure 40).



Tempus active



Tempus not active

Figure 40 TEMPUS activation icon

For more information, refer to the TEMPUS technology data sheet (Renishaw part no. H-5800-6860).

NOTE: TEMPUS technology can only be applied to build files of the renam file format. For more information, refer to the QuantAM V6.0 build preparation software quick-start guide (Renishaw part no. H-5800-1158).

6.8 Programmable logic controller

The programmable logic controller (PLC) controls the system operation and the mechanical and monitoring functions of equipment, including the recoater assembly, elevator, pumps and valves. The PLC is located within the RenAM 500 series electrical cabinet and is not normally accessed by the operator.



Figure 41 Programmable logic controller

6.9 Network topology

The RenAM 500 series requires a network connection to function, and it supports the configuration of networking environment.

The machine has a network port to allow connection to networks. The network port on the machine is known as a Wide Area Network (WAN) port or Ethernet port. The following sub-section describes the network topology of the RenAM 500 series system.

Refer to section 8.7.1, “ST-005 – Network configuration – WAN or Ethernet”, for details on how to configure a network.

NOTE: Although the machine needs to be connected to a network to function, the network does not need to be connected to the internet. The internet is illustrated to help you understand the option of running Renishaw Central in the cloud. Renishaw Central is an optional service that allows the user to view machine status and sensor data via a web browser-based interface. It can run either in the cloud or on an on-site server.

6.9.1 Basic connection – simple network

The diagram below is an example of a simple set-up where all appliances are on the same network. This solution only requires the use of the WAN port on the RenAM 500 series.

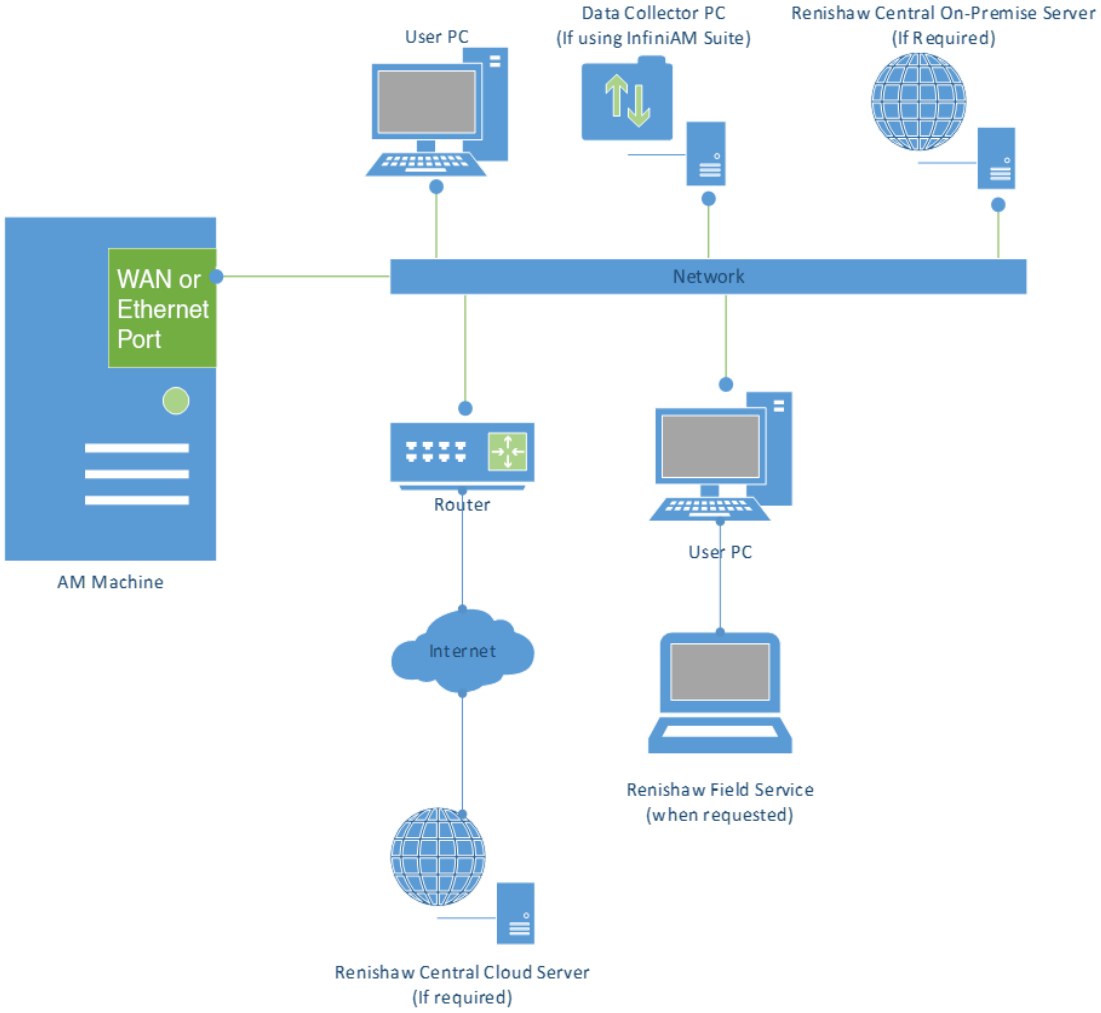


Figure 42 Basic network set-up using the WAN port

6.9.2 Physical location of WAN port

The WAN or Ethernet port is on the lower access panel on the right-hand side of the RenAM 500 series (circled in Figure 43).

NOTE: Although the figure below shows the RenAM 500Q, the WAN or Ethernet port is found at the same location on all models in the RenAM 500 series.

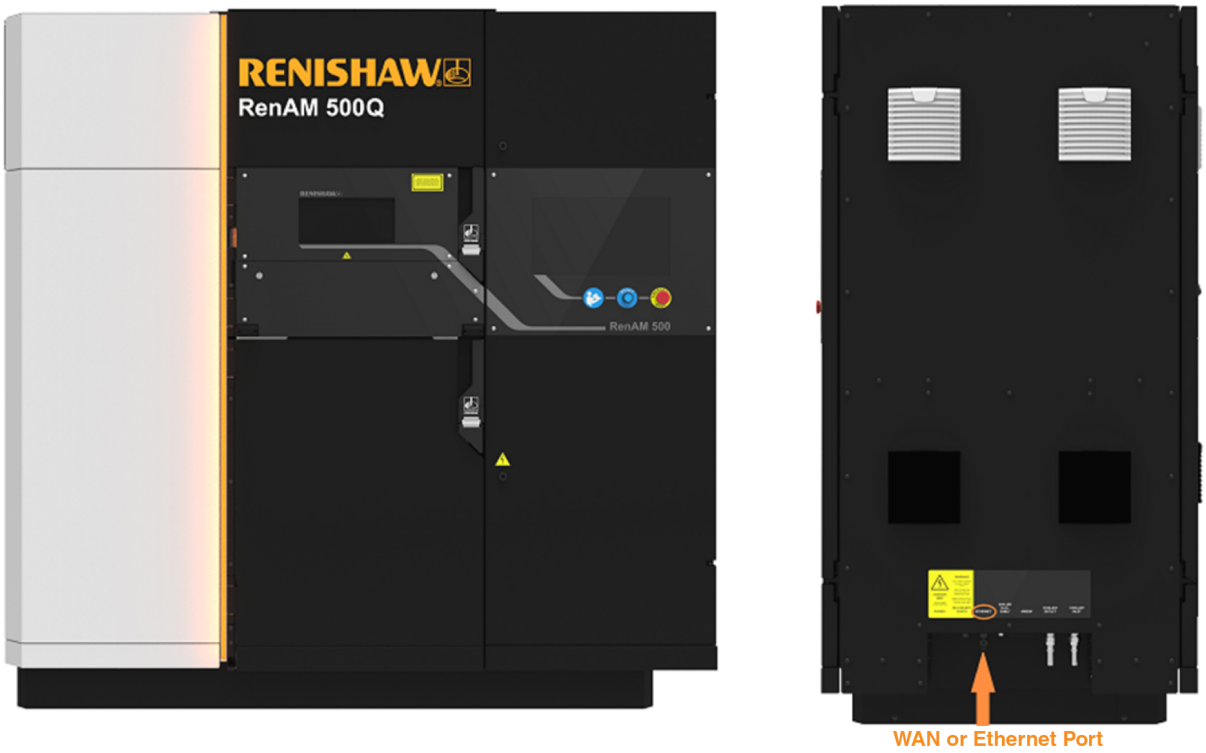


Figure 43 WAN port location on the RenAM 500Q

In the older RenAM 500 series systems, the router is located inside the front electrical cabinet. In the newer systems, these routers are replaced with Ethernet ports on the main computer.



Figure 44 Router (left) and Ethernet port on main computer (right)

6.10 Keys and user accessibility

There are three access area types:

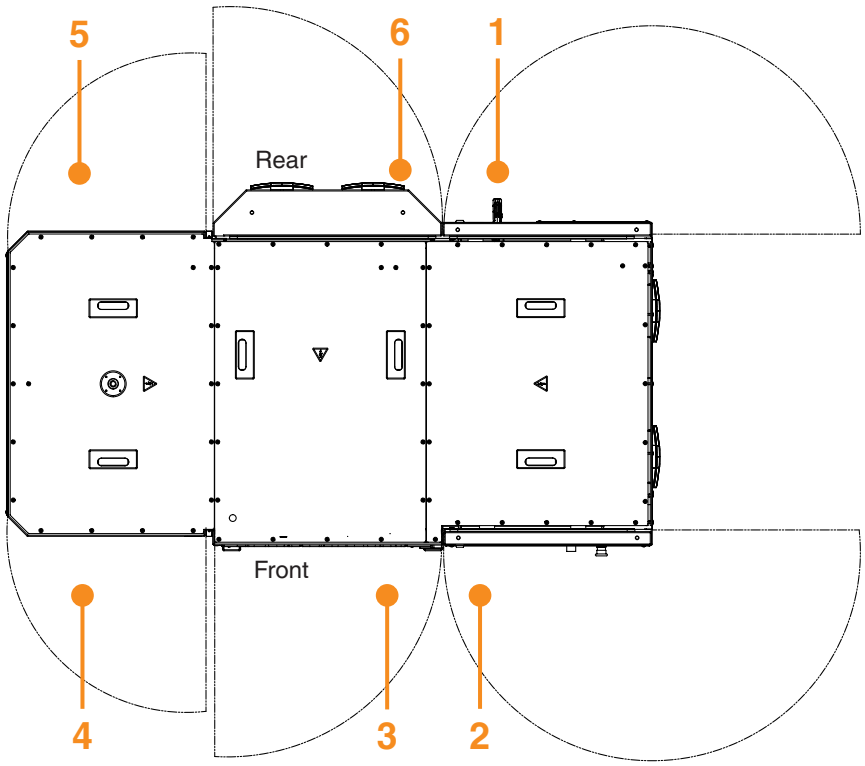
- Operator – a trained operator can access the following doors: top, glovebox, bottom, front left-hand cupboard (loading powder, replacing filters, etc) and rear right-hand cupboard (pneumatic connections, vacuum pump and recirculation pump).
- RenAM 500 Flex only: Material Change – Operators/technicians trained in the material change process can access the rear centre equipment cupboard door.
- Service – a Renishaw Service engineer/Technician can access the following doors: rear left-hand electrical cupboard, front right-hand electrical cupboard and rear centre equipment cupboard.

Access to these areas is controlled as follows:

- The top and bottom doors are secured by the RenAMP software and safety controller.
- The glovebox door is secured with security screws that require a special tool to open them.
- The front left-hand and rear right-hand cupboard doors are secured with mechanical latches.
- The rear centre equipment cupboard door is secured with two security locks.
- The rear left-hand electrical cupboard and the front right-hand electrical cupboard are each secured with two security locks.

NOTE: Keys to the electrical enclosure door locks and special tools to open the glovebox should only be allocated to personnel who have received adequate training to operate the RenAM 500 series.

WARNING: Isolate the electrical supply to the RenAM 500 series before opening the doors to the electrical enclosure. The electrical enclosure must remain locked during operation and access must be restricted to trained personnel.



1	Service access – rear left-hand electrical cupboard door	4	Operator access – front left-hand cupboard door
2	Service access – front right-hand electrical cupboard door	5	Operator access – rear right-hand cupboard door
3	Operator access – top, glovebox and bottom doors	6	Service/Technician access – rear centre equipment cupboard door

Figure 45 User accessibility

6.11 Main computer

The build and process control software runs on the main computer (Figure 46), which is located within the RenAM 500 series electrical cabinet. In normal use there are no input or output devices for human intervention. The main computer is a Windows-based PC and starts up as soon as it receives power from the main isolating switch. It should be shut down in the same manner as any PC before removing power from the AM system. See section 8.3.10, “PB-009 – RenAM 500 series system – Shut down” for more details.



Figure 46 Main computer

6.12 Lasers

The lasers provide the energy source for the additive manufacturing process. The lasers are located in the right-hand rear of the RenAM 500 series cabinet (Figure 47). The laser system includes one or four 500 W lasers which have been specifically designed and engineered for this application. The lasers are 500 W ytterbium fibre type, with dynamic focusing carried out in the optical module. Further information about the lasers can be obtained from Renishaw upon request. Located above the lasers is the laser power supply.

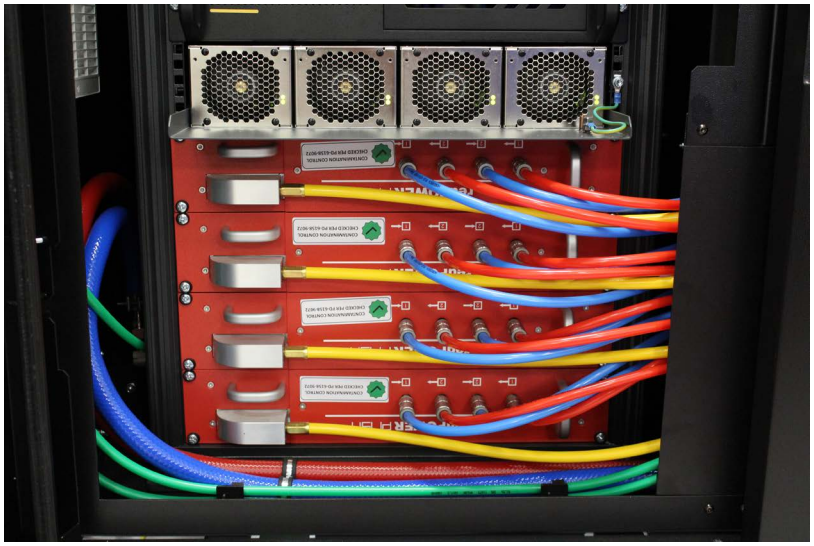


Figure 47 Four PRISM lasers with laser output and cooling connections

6.13 Lens protection window

The dynamic focusing lens is located in the optical system and focuses the laser beam on to the metal powder surface on the build plate located in the build chamber. The lens protection window (Figure 48) protects the focusing lenses and steering mirrors from contamination. The lens protection window should only be cleaned in accordance with the procedures in Chapter 9, “Operation”. A cleaning kit is available from Renishaw.

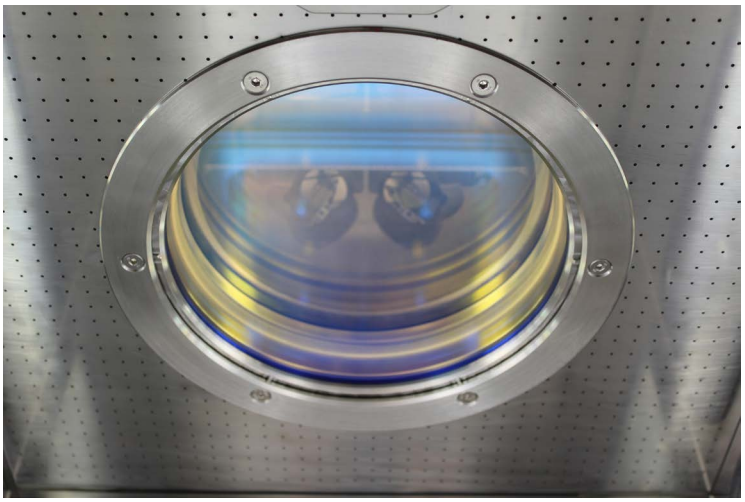


Figure 48 Lens protection window

6.14 Build chamber viewing window

The top door of the RenAM 500 series features a viewing window and a protective insert (Figure 49). This meets the standard ANSI Z136.1 – 2007 and is specified to protect the user against scattered laser radiation for the wavelength used in the RenAM 500 series. The viewing window is located in the top door and in this application permits a Class 1 laser specification to be achieved.



Figure 49 Build chamber viewing window

6.15 Load hopper (RenAM 500 and RenAM 500 Ultra only)

The load hopper is located at waist height, behind the left-hand door (Figure 50). To add new powder, a standard powder flask is attached to the load hopper isolation valve on the load hopper filling point. The load hopper capacity is sufficient for a build equal to the maximum elevator travel. The material type is input via the touch screen control panel. This enables the RenAM 500 and RenAM 500 Ultra to continually track the mass of powder in the load hopper using the output of the load cells located under the load hopper.

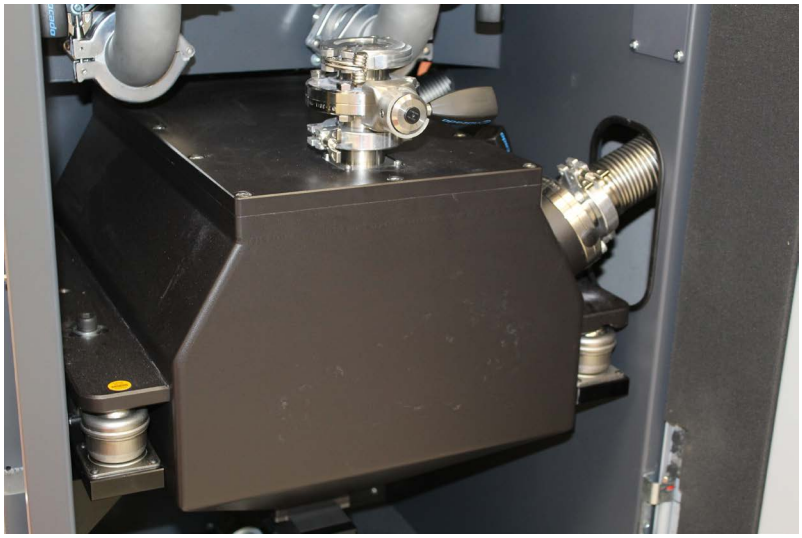


Figure 50 Load hopper

6.16 Powder recirculation system (RenAM 500 and RenAM 500 Ultra only)

The RenAM 500 and RenAM 500 Ultra feature an on-board powder sieving and recirculation system. The main components of this system are the load hopper, dosing silo, powder level detection system, ultrasonic sieve, oversize powder storage (for removal of waste), cyclone separator and powder recirculation pump.

6.17 Feed hopper (RenAM 500 Flex only)

The feed hopper is located on the top of the dosing silo, behind the rear centre equipment door, extending through the roof panel to the top of the machine (Figure 51). To add new powder, a standard powder flask is attached to the feed hopper isolation valve via the powder loading arm.

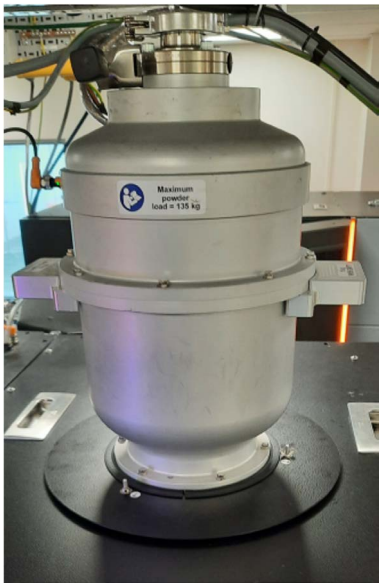


Figure 51 RenAM 500 Flex large feed hopper as fitted

There are three available sizes of RenAM 500 Flex feed hopper: small, medium and large. The table on the following page indicates the maximum available volume, and an approximate total mass of powder that can be added to each hopper for Renishaw supplied materials.

NOTE: The table shows the absolute maximum possible to fit into each hopper. Differences in the packing density of material and the amount of any material already present in the hopper before adding more may mean that the hopper sensor reads as full before it reaches the amount stated in the table.

NOTE: The machine can be run while a powder flask remains fixed to the top of the feed hopper to allow an additional 1.7 L (103 in^3) of powder to be utilised once the hopper sensor reads as full.

		Small hopper	Medium hopper	Large hopper
Hopper volume [1]		7.5 L (457 in³)	10.6 L (646 in³)	22.1 L (1 348 in³)
Total volume [2]		10.2 L (622 in³)	13.6 L (829 in³)	24.8 L (1 513in³)
Total volume + 1.7 L (103 in³) flask		11.9 L (726 in³)	15.3 L (933 in³)	26.5 L (1 617 in³)
Total mass in Renishaw materials [3]	AlSi10Mg	19.1 kg (42.1 lb)	24.6 kg (54.2 lb)	42.6 kg (93.9 lb)
	Ti6Al4V	31.6 kg (69.6 lb)	40.6 kg (89.5 lb)	70.3 kg (154.9 lb)
	SS 316L	57.0 kg (125.6 lb)	73.3 kg (161.5 lb)	127.0 kg (279.9 lb)
	M300	57.8 kg (127.4 lb)	74.4 kg (164.0 lb)	128.8 kg (283.9 lb)
	In718	58.5 kg (128.9 lb)	75.2 kg (165.7 lb)	130.2 kg (287.0 lb)
	CoCr	59.3 kg (130.7 lb)	76.2 kg (167.9 lb)	132.0 kg (291.0 lb)
	In625	60.3 kg (42.1 lb)	77.5 kg (710.8 lb)	134.4 kg (296.3 lb)
Height to top of hopper [4]		2 358 mm (92.8 in)	2 523 mm (99.3 in)	2 604 mm (102.5 in)
Height to top of flask [5]		2 699 mm (106.2 in)	2 864 mm (112.7 in)	2 945 mm (115.9 in)

1 Volume of powder contained within the hopper only.

2 Volume of powder contained within the hopper and silo parts.

3 Mass of powder contained within Total volume + 1.7 L (103 in³) flask, assuming 60% packing density.

4 Height from floor to top KF flange on the hopper. Space to allow filling from powder flask will also be required.

5 Height from floor to top of 1.7 L (103 in³) powder flask fitted to hopper (341 mm (13.42 in) from flask base to top of flange clamp).

A capacitive sensor near the top of the feed hopper is used to alert the user when there is no longer capacity to add a full flask of powder in order to minimise risk of powder spillage. There are load cells under the hopper platform to provide an accurate measurement of powder mass (Remaining powder) to make sure there is enough powder to complete the build. The “Powder Settings” within the “Set Parameters” page of RenAMP shows how the remaining powder within the hopper and silo is calculated (Figure 52).

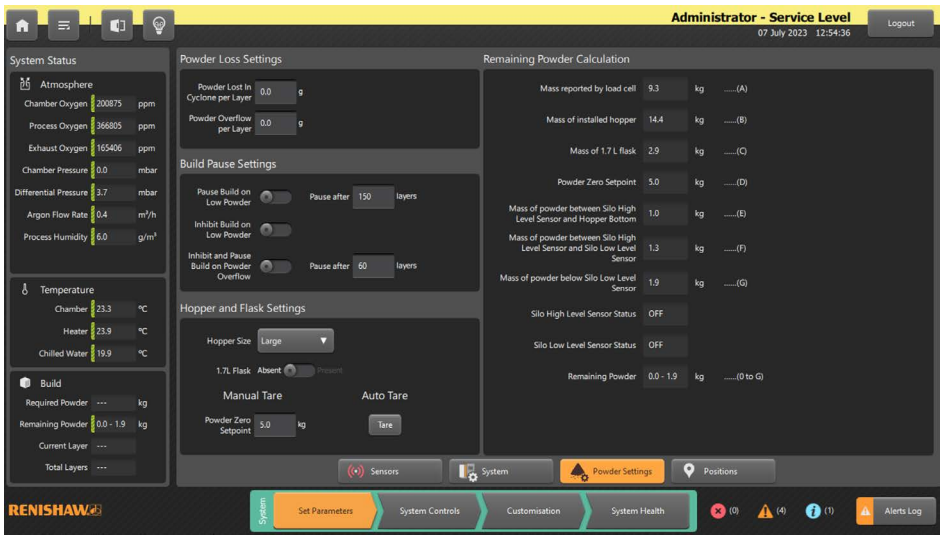


Figure 52 ”Powder Settings” page within RenAMP

When there is powder present in the hopper and silo, “Remaining Powder’ is reported as a singular value. When there is powder in the silo only, “Remaining Powder’ is reported as an estimated range.

Within “Hopper and Flask Settings”, the user can compensate for the weight of a 1.7 L (103 in³) flask on top of the feed hopper by sliding the toggle switch. The user can also use the “Manual Tare” or “Auto Tare” functions when installing an empty hopper to compensate for any potential drift of the load cell system over time.

6.18 Dosing silo (RenAM 500 and RenAM 500 Ultra only)

There are level sensors located in the dosing silo (Figure 53). They accurately sense the level of powder to ensure the dosing silo is at the optimum level. When the powder level goes down to halfway, the mid-level sensor is triggered and requests more metal powder from the load hopper. This sets off the powder sieving and pneumatic transfer processes which deliver powder to the dosing silo. A low-level sensor, if triggered, will alert the system that there is not enough powder, pausing the build process.

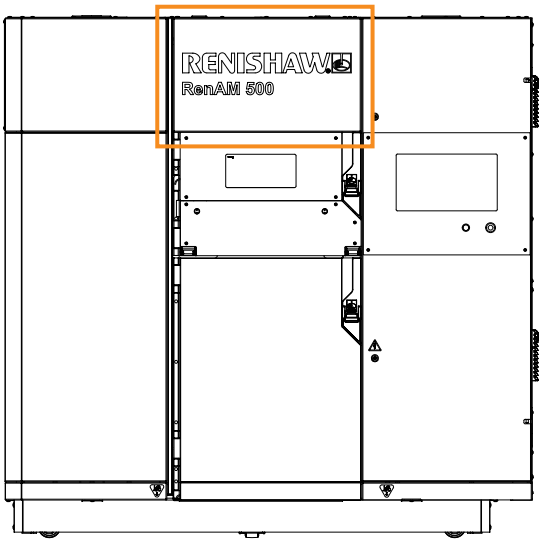


Figure 53 Dosing silo behind system panels

6.19 Dosing silo (RenAM 500 Flex only)

There are level sensors located in the dosing silo (see Figure 53). They accurately sense the level of powder to ensure the dosing silo is at the optimum level. When the powder level goes down to halfway, the mid-level sensor is triggered, and an alert is displayed on the HMI suggesting additional powder be added to the feed hopper. A low-level sensor, if triggered, will either pause the build or continue to alert the user that powder is required, depending on user preference (For more information, see section 8.5.2, “TT-002 – Pause build on low powder level”).

NOTE: If the low-level sensor behaviour is set to allow the build to continue without pause, it is possible for a build to fail due to running out of powder. This setting should only be used if the user is confident that the remaining powder in the silo will be sufficient to finish the build.

6.20 Renishaw ultrasonic sieve (RenAM 500 and RenAM 500 Ultra only)

The Renishaw ultrasonic sieve (Figure 54) features a powder metering screw that controls the rate at which powder is fed through to the ultrasonic sieve. Alongside all the used material returned from the build process, all powder loaded into the load hopper is fed through the ultrasonic sieve before being transported to the dosing silo.

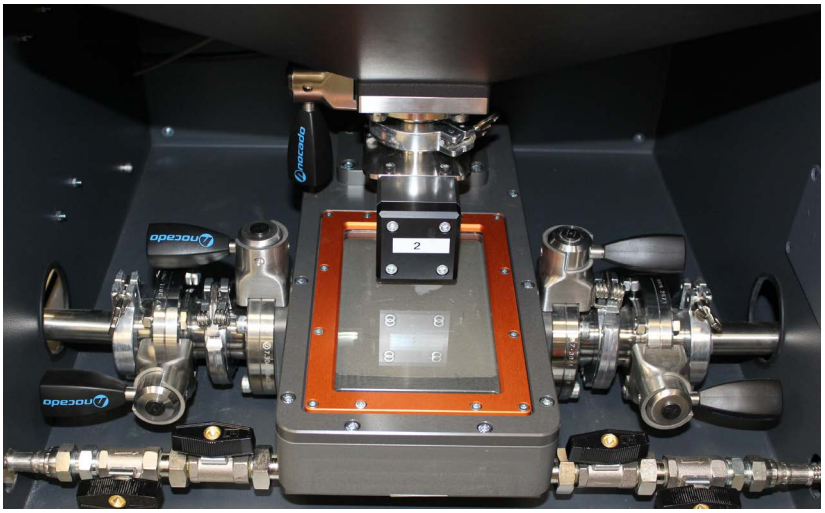


Figure 54 Renishaw ultrasonic sieve

To replace the mesh in the Renishaw ultrasonic sieve, refer to the RenAM 500 and RenAM 500 Ultra sieve mesh replacement user guide (Renishaw part no. H-5800-6859).

6.21 Pneumatic transfer (RenAM 500 and RenAM 500 Ultra only)

After sieving, the usable powder and oversize powder are transported separately in streams of high purity argon gas (Figure 55). The usable powder is transferred into a holding vessel above the dosing silo so that it can be transferred to the dosing silo in a controlled manner. Powder in the dosing silo is then precisely fed into the build process by Renishaw's proven powder dosing system. The oversize powder is transferred into a powder receiver ready to be removed when required.

1. Metal powder is loaded into the load hopper.
2. Metal powder is sieved ultrasonically, and oversized powder is separated from the usable powder.
3. Oversized powder is pneumatically transferred to a powder receiver at the top centre of the front left cupboard. Oversized powder is removed at a convenient time by fitting a powder flask using the KF40 flanges and a quick-release clamp.
4. Sieved powder is pneumatically transferred to a holding vessel ready to be fed into the dosing silo.
5. Powder is dosed on to the build plate.

6. Any unmelted powder in the gas flow exiting the build chamber is separated from the gas flow in the cyclone unit and then collected for removal at a convenient time by fitting a powder flask using the KF40 flanges and a quick-release clamp. The gas flow then passes through the large SafeChange filters (or Long-Life Filter system, if equipped) for removal of condensate.

7. Unmelted powder is transferred back into the load hopper to be sieved and the cycle continues.

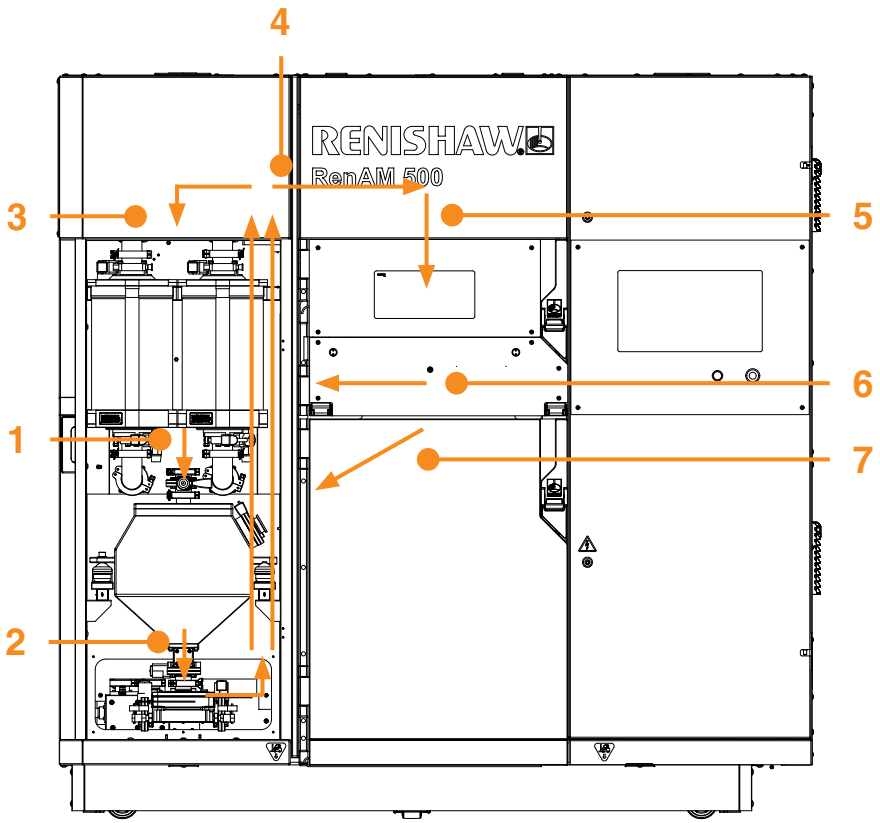


Figure 55 Pneumatic transfer of powder

6.22 Powder delivery

The powder delivery mechanism is situated inside the chamber and dispenses a dose of metal powder on to the rear edge of the build chamber process plate. The mechanism can be configured to vary the amount of powder dosed. The percentage dosage can be entered using the operator touch screen control panel (see section 8.1.17, “AB-015 – Powder dose – Set up” for more details).

6.23 Recoater assembly

The recoater assembly comprises the recoater arm, pulleys and toothed belts concealed behind sheet metal covers (Figure 56). The recoater traverses the base of the build chamber, distributing a uniform layer of metal powder over the top of the build plate. Excess powder is discharged through front and rear overflows in the process plate and is fed back into the powder recirculation system. The recoater blade assembly is secured to the recoater arms by a kinematic mounting system. This ensures that the recoater can be replaced quickly without the need for tools, to speed up system turn-around time between builds, and accurately, as no adjustments are required.

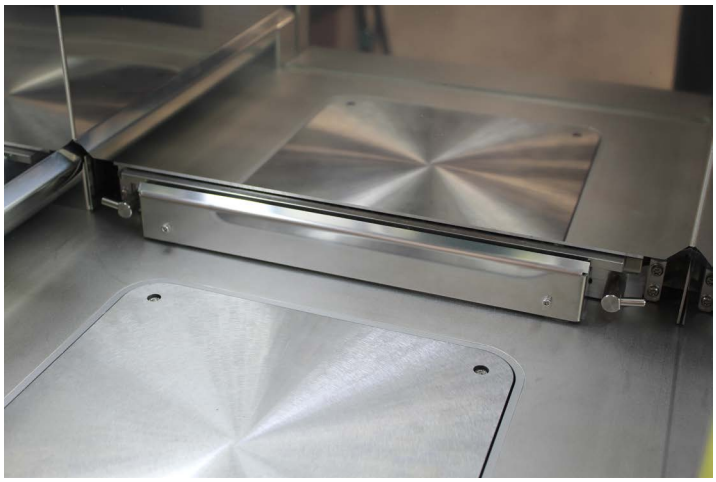


Figure 56 Recoater assembly

6.24 Overflow flasks (RenAM 500 Flex only)

Two 1.7 L (103 in³) (Figure 57) or 10 L (610 in³) flasks located in the front left-hand door are used to store any excess material deposited during the build process or during de-build operations. Stainless steel pipework between the flask and the build chamber houses a capacitive sensor used to alert the user or pause the build when the overflow is full and requires emptying. Lifting points on 10 L (610 in³) flasks engage with the Renishaw universal lifter for secure handling.



Figure 57 1.7 L overflow flasks

6.25 Powder loading arm (RenAM 500 Flex only)

Located on the top of the machine, on the right-hand roof panel, the powder loading arm (Figure 58) is used to aid the user in loading powder into the RenAM 500 Flex feed hopper. The arm rotates out over the front and back of the machine to reduce the reach required for loading a flask, then rotates and lowers into position to connect the KF flange from the flask to the feed hopper. The powder loading arm supports loading from 0.85 L (52 in^3) and 1.7 L (103 in^3) flasks, and can be configured for use with small, medium or large feed hopper variants.



Figure 58 Powder loading arm

6.26 Heating/temperature control

There is a heater built into the elevator table which can be used to heat soak the build plate. The temperature can be set in degrees on the thermostat (170 °C (338 °F) maximum) via the touch screen control panel. The material parameters file supplied with the Renishaw metal powder you have purchased will give you the specific temperature to be used for heat soak, if heat soak is required.

6.27 Oxygen monitoring sensors

The oxygen levels in the chamber and the gas recirculation circuit are continuously monitored at multiple separate points in the circuit. If the oxygen level exceeds the maximum value set in the user interface, the system will add inert gas. The process will pause briefly until the required level is achieved. In practice, oxygen levels are generally maintained well below 500 ppm or 0.05%. The default setting is 1 000 ppm (0.1%) before the build will commence, and the upper safe threshold is 5 000 ppm (0.5%). Two of the oxygen sensors fitted are Safety Integrity Level (SIL) rated.

6.28 Gas circuit

Gas enters the build chamber from the top and lower right-hand sides of the build chamber (Figure 59). It creates a flow of gas directed across the build plate from right to left. The finest metal powder and nanoparticles (known as condensate) produced during the build process are collected and directed to a port on the lower left-hand side of the build chamber which is connected via a cyclone separator to either:

- the two large SafeChange filters located through the left-hand door of the system cabinet. The large SafeChange filters are replaced when indicated on the touch screen control panel, or
- the Long Life Filter system, if equipped. For more information, see section 7.10, “Long-Life Filter (optional)”.

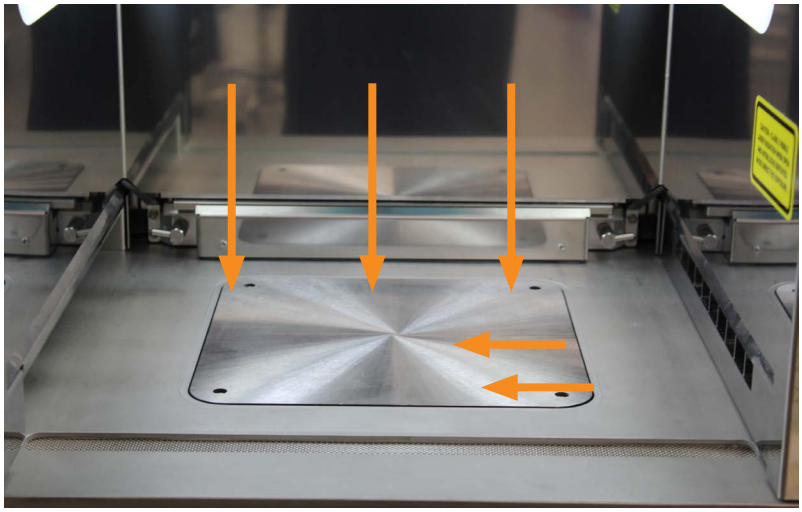


Figure 59 Gas circuit

6.29 Build plate

The build plate is the surface upon which the build process takes place. It is bolted to the top surface of the elevator table using four M5 screws and is housed in the lower chamber. The build plate is covered by progressive layers of metal powder. The powder is then selectively melted, fusing it first to the build plate then to the previous layer to create a homogeneous solid component. Each powder type requires a compatible build plate material. The build plate can be installed in any of four positions, but the build plate is marked with a shallow blind hole or slot in the centre of the front edge (Figure 60).



Figure 60 Build plate front edge indicator – shallow blind hole left image and slot right image

Ideally all build plates should be indelibly marked (for example engraved or stamped) on their edge to indicate their material composition. Build plates should be refurbished after use by grinding, milling or turning. It is particularly important to ensure that the underside of the build plate is not convex, as this can have a negative effect on the flatness of the upper working face when installed in the system. This can lead to failed builds because of uneven powder distribution on the initial layers and poor adhesion to the plate. After any machining, all cutting fluid residue must be removed using an appropriate cleaning medium, normally ethanol or IPA. Depending upon the application, a build plate thicker than standard may be required, to ensure the internal stress in the part is adequately resisted. This is typically only when very large and particularly dense parts are being built. If in doubt, contact Renishaw.

6.30 Large SafeChange™ filter (LSCF50)

CAUTION: This does not apply to RenAM 500 series systems equipped with the external Long-Life Filter system. For more information, see section 7.10, “Long-Life Filter (optional)”.

The RenAM 500 series system features a recirculating gas flow across the build area, flowing from right to left. The rate of flow can be altered from the touch screen control panel. The finest metal powder and nanoparticles that are emitted from the build process are carried by the flow of gas and captured in one of the two large SafeChange filters housed in an aluminium cylinder located behind the left-hand door of the cabinet (Figure 61). The filtered inert gas is then recirculated through the system to maintain an extremely low oxygen content. The large SafeChange filter housings can be isolated using the upper and lower isolating valves and then removed by releasing the KF50 flanges on the upper and lower isolating valves.



Figure 61 Large SafeChange filter (LSCF50)

When indicated by the filter graphic on the touch screen control panel, the large SafeChange filter assembly must be removed from the RenAM 500 series and the filter made inert by filling it with water. The filter assembly is then disassembled and the used filter placed in a ventilated drum containing water. When processing aluminium, a 5% solution of Hydra-Sol-MAG additive (part no. P-LU08-0004) must be added to the water in the filter storage drum. See Chapter 9, “Operation”, for full details.

NOTE: RenAM 500 series large SafeChange filters (LSCF50) feature 50 mm (2 in) KF flanges and are not interchangeable with filters from AM 250, AM 250/400, AM 400 or RenAM 500M.

NOTE: It is recommended to apply the appropriate material labels on the RenAM 500 series large SafeChange filters to prevent powder contamination that can occur if the SafeChange filters are used on the wrong machine.

The RenAMP software automatically controls the rate at which the changeover from a dirty to a clean SafeChange filter occurs – this function is called switching type. Switching type helps to negate any sudden pressure or gas flow fluctuations caused by suddenly switching from a dirty to a clean filter. Both clean filters are automatically preconditioned by exposing them to the finest metal powder and nanoparticles at the start of the build. One of the filters is then automatically isolated from the gas flow and the pre-conditioned filter held in an inert argon gas atmosphere until it is required by the build.

Switching type is particularly useful when running long builds where dirty SafeChange filters may need to be swapped out periodically for clean filters without waiting for the airflow to reduce to a level where it must be changed, for example near the end of a shift.

There are four modes of switching type (Figure 62).

- Slow Switch – Switch to Other (left or right) Filter after purge and conditioning
- Fast Switch – Switch to Other Filter skip conditioning time
- Slow Open – Open Other Filter after purge and conditioning, keep Current Filter open
- Fast Open – Open Other Filter skip conditioning time, keep Current Filter open

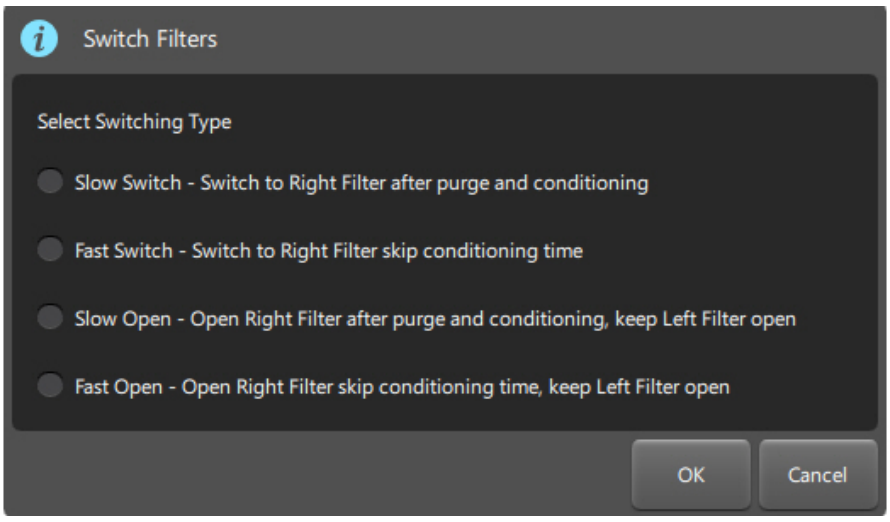


Figure 62 Switching type dialog box with four choices of switching type

6.31 ESD and earth bonding points

The RenAM 500 series is fitted with two ESD and earth bonding points. One is located in the front left cupboard on the left-hand side next to the large SafeChange filter (Figure 63). One is located in the rear right-hand cupboard at the top on the left-hand side (Figure 63). The ESD and earth bonding points enable users to fit an earth bond between the ATEX vacuum cleaner, a build plate, or themselves and the RenAM 500 series system when carrying out tasks where there is a risk of electrostatic discharge.



Figure 63 RenAM 500 series earth bonding point on left-hand side of the filter cupboard and left-hand side of the rear electrical cupboard

Fitting an earth bond between the ATEX vacuum cleaner, a build plate, or the user and the RenAM 500 series system allows any electrostatic charge that builds up to be discharged. It is mandatory to fit an earth bond whenever the ATEX vacuum cleaner is being used to remove metal powder from the build chamber, when removing the built component from the build chamber, during post-build tasks (for example build plate removal) or system cleaning. Use the supplementary bonding cables supplied.

6.32 Laser controller

The RenAM 500 series is fitted with a laser controller (Figure 64) that controls the one or four lasers fitted. The laser controller is located in the electrical cupboard.

NOTE: A RenAM 500 series machine with less than four lasers installed and running on Machine Software Suite (MSS) v2.2.0 or later must connect a blanking pin or 37 – pin connector to the QC box to manage the FCMS signal for uninstalled lasers; otherwise, the safety controller will not display the lasers as healthy.



Figure 64 RenAM 500 series laser controller

6.33 Cyclone

The purpose of the cyclone separator (Figure 65) is to pre-filter the gas leaving the build chamber before it reaches the large SafeChange filters (or Long-Life filter, if equipped). This is done in order to minimise the load on the filter cartridges and extend the length of time the system can run unattended.

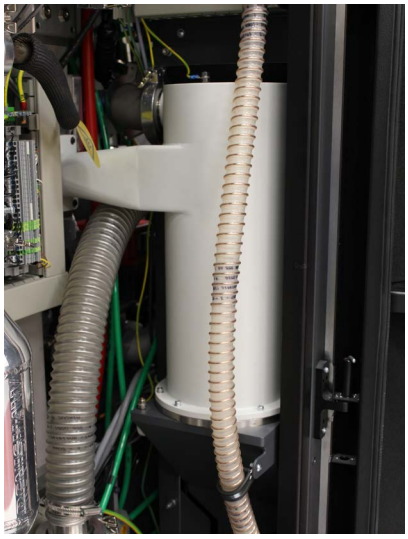


Figure 65 RenAM 500 series cyclone separator

The operating principle of the cyclone is as follows: gas containing powder particulate enters tangentially and a vortex is established inside the body of the cyclone separator. Powder particles are moved centrifugally to the cyclone wall, as they are denser than the gas. They are transported around and down the wall and are deposited at the exit, while the gas travels up the centre of the body and out of the top.

The cyclone is connected directly to the build chamber outlet. The cleaned gas exits at the top and enters the filter manifold. The hopper is designed to accommodate two different sizes of container – standard powder flasks which have a capacity of 1.7 L (103 in^3) of powder and a larger square flask which can hold 10 L (610 in^3).

6.33.1 Cyclone level sensors

There are two level sensors located inside the cyclone powder hopper – one at the bottom and one at the top. Once the powder flask is connected to the hopper and it becomes full, the powder will start to back up into the hopper and the lower sensor will detect the powder. When the hopper is approximately 80% full, the upper sensor will detect the powder. When the connected flask is full and powder has started to back up into the hopper, the low-level sensor will detect the powder and switch. A warning will be shown to the user to recommend replacing the flask. When the hopper is full, the high-level sensor will switch. This will stop the machine and advise the user to replace the flask and resume the build.

6.34 Intercooler

The intercooler, or charge air cooler (Figure 66), is used to reduce and stabilise the temperature of the argon gas between the outlet of the recirculation pump and the inlet of the build chamber. Heat energy from the argon gas flow is transferred to the internal fins, which are chilled by a supply of coolant from the chiller. The intercooler is supplied with coolant by the chiller at a constant rate.



Figure 66 RenAM 500 series intercooler

6.35 Electrical cabinets

The RenAM 500 series has two electrical cupboards located at the rear left-hand and front right-hand of the system. Each electrical cupboard is secured with two security locks which are operated by a key. Access to the electrical cupboard is restricted to Renishaw Service Engineers and Technicians. There are no user operable, serviceable or repairable parts in the electrical cupboards.



Figure 67 RenAM 500 series electrical cupboard rear left-hand (left) and front right-hand (right)

6.36 Beacon light

The RenAM 500 system supports beacon lights with four colours (red, amber, green and blue) which are used to give a visual indication of the status of the machine. The colours of the light represent the following:

Colour	Machine status	Explanation
Red	Emergency stopped	Indicates that the Emergency button has been pressed or is faulty. The user should resolve the issue that required the button to be pressed, being aware of any hazards.
Amber	Error present	Indicates an error on the system, which could include sensors outside limits. User action may be required to resolve the error.
Green	Normal process running	Indicates that a process is currently running on the machine, which could include a pre-build process.
Blue	User action required	Indicates that an action is required by the operator for the machine to continue operation.

The light will turn off when the indicated status is no longer present. For red, this will be when the emergency stop condition is reset, for yellow it will be when the error has cleared, for green it will be when the running process ends, and for blue it will be when the user action has been completed.

Red light – Emergency stop

The emergency must be dealt with and then a machine reset is required.

The red light will be illuminated whenever the machine is e-stopped and has entered a safe state condition. Once the Emergency stop button is released, the red and blue lights will show to indicate that the machine is in a safe state and the operator needs to reset the machine before using it. Upon releasing the Emergency stop button and pressing the reset button, both red and blue lights will go out.

There are two possible outcomes from pressing the Emergency stop button:

- If the Emergency stop button is pressed properly (it is latched) – the red light will turn on. At this point, only the red light will be on, reflecting that the machine is not ready to use.
- If the Emergency stop button is not pressed hard enough (safe state is triggered but the mechanism has not latched) – the red and blue lights will turn on (red indicating that the safe state has been achieved, and blue indicating that the operator needs to reset the machine before using it).

Amber (or yellow) light – Error present

This indicates sensor errors, servo errors or inverter errors. Other than the general sensor errors, if there is a breach in any of the reading limits that might cause harm to the system (warning and shut-down limits), the amber light will turn on.

User action may be required, depending on the type of error, and the build may stop if necessary. It is advisable to resolve all the issues before starting a build.

Green light – Normal process running

Green indicates that a process is currently running on the machine. The processes include atmosphere purge, heat soak, heater auto-tune, build running, system tests (empty silo, wiper, elevator, optical, vacuum, gas flow), powder recirculation.

Blue light – User action required

The blue light turns on whenever the situation requires action from the operator, which includes low powder in the hopper, filter change required, cyclone or oversize flasks need emptying, manual build pause, chiller disconnected, argon line pressure not in limits. The blue light will also be illuminated when the Reset button is flashing.

Multiple lights

It is possible for multiple lights to be illuminated, for example, green with blue and amber while the build is in progress, which might mean that a powder top-up is required and also there is a sensor level warning. This can be easily identified by looking at the active alerts on the Alerts Log page.

When the red light is on, the only other light that can be on is the blue light, so if there is a sensor error but the Emergency stop button is pressed, the amber light will be off, but it will come on again once the machine is reset, if the error is still present.

Example process

The following table is for reference only and is an example of how the beacon will behave under certain conditions. The conditions may change, but the correct alerts are reflected in the RenAMP software.

For any alert there are four potential effects:

- When an alert is raised, which light should turn on (shown in the table below by “Raise on”).
- When an alert is raised, is there any light that should turn off (shown in the table below by “Raise off”).
- When the alert is cleared, which light should turn on (shown in the table below by “Clear on”).
- When the alert is cleared, which light should turn off (shown in the table below by “Clear off”).

This can be explained with a few examples:

- On pressing ESTOP, the alert “ESTOP Activated” will be triggered and this will turn on the red light. After the machine is reset, the “ESTOP Reset” alert will be triggered and the red light will be turned off. So, the red light turning on and off is dependent on two different alerts and two different states that are captured in the table below.
- If the alert “Chamber Temperature Sensor Error” is triggered, the amber light will turn on. When the error is resolved, the alert will be cleared, which will automatically turn off the amber light. This state is dependent on a single alert, which is cleared when the action is taken.
- The start of the chamber preparation will raise an alert “Chamber Preparation in Progress” which will turn on the green light. The chamber preparation can have two possible outcomes – either it will inert the chamber or it will fail / be aborted. In either case there will be an alert message – either “Inert Chamber Achieved” or “Chamber Preparation Aborted”, which will turn off the green light.

The logic to raise or clear alerts is shown in the table below.

Alert title	Type	Raise on	Raise off	Clear on	Clear off	Logic to raise alarm	Logic to clear alarm
ESTOP Activated	Error	🔴	-	-	-	ESTOP (red) button pressed and latched	ESTOP or external ESTOP buttons are released and machine is reset
ESTOP Reset	Info	-	🔴	-	-	ESTOP circuit reset (can only be done when the ESTOP button is not latched on)	Not applicable
Chamber Temperature Sensor Error	Error	🟡	-	-	🟡	When any of start-up error, sensor error, over range or under range error present	When all four types of error are no longer present
Heater Temperature Sensor Error	Error	🟡	-	-	🟡	When any of start-up error, sensor error, over range or under range error present	When all four types of error are no longer present
Chiller Not Running or Data Disconnected	Warning	🔵	-	-	🔵	Chiller running signal input is false	Chiller running signal input is true. The user should check that the chiller is running and correctly connected to the AM system.
Argon Line Pressure Low	Warning	🔵	-	-	🔵	Pressure below threshold when gas inlet closed Threshold value is 3.5 bar (50 psi)	Pressure back above threshold. The user should check that the argon supply is not empty.
Argon Line Pressure High	Warning	🟡	-	-	🟡	Pressure above threshold Threshold value is 7 bar (101 psi)	Pressure back below threshold
Vacuum Pump Timeout	Warning	🟡	-	-	🟡	PLC logic timeout of continuous operation of the vacuum pump, using value "Vacuum Cycle Timeout in Minutes" from the config file + 5 s buffer	Click Reset Alarms on alerts page
Chamber Temperature Above Shutdown Limit	Error	🟡	-	-	🟡	Chamber temperature above threshold for shut-down	Temperature below shut-down threshold and then Reset Alarms clicked
Powder Recirculation Pump Inverter Error	Error	🟡	-	-	🟡	If inverter is not ready or inverter is in fault state	If inverter is ready and inverter not in fault state
Service Port Coolant Flow Rate Sensor Error	Error	🟡	-	-	🟡	If sensor input disconnected or raw input out of measuring range	When sensor is connected, and raw input is within measuring range
Optics Flow Sensor Error	Error	🟡	-	-	🟡	If sensor input disconnected or raw input out of measuring range	When sensor is connected, and raw input is within measuring range
Laser Flow Sensor Error	Error	🟡	-	-	🟡	If sensor input disconnected or raw input out of measuring range	When sensor is connected, and raw input is within measuring range
Oversized Particle Separator Powder Level High	Warning	🔵	-	-	🔵	When the oversize particle sensor is triggered	The user should empty the oversize particle flask

Alert title	Type	Raise on	Raise off	Clear on	Clear off	Logic to raise alarm	Logic to clear alarm
Intercooler Flow Sensor Error	Error	●	-	-	●	If sensor input disconnected or raw input out of measuring range	When sensor is connected, and raw input is within measuring range
Cyclone Hopper Full	Warning	●	-	-	●	When cyclone top sensor detects powder	When cyclone top sensor detects no powder. The user should empty the cyclone hopper.
Cyclone Hopper Nearly Full	Warning	●	-	-	●	When cyclone bottom sensor detects powder	When cyclone bottom sensor detects no powder. The user should empty the cyclone hopper.
Powder Recirculation Temperature sensor error	Error	●	-	-	●	If sensor input disconnected or raw input out of measuring range	When sensor is connected, and raw input is within measuring range
Chamber Preparation in Progress	Info	●	-	-	-	As soon the chamber preparation starts	Not applicable
Chamber Preparation Aborted	Info	-	●	-	-	Chamber prep can be aborted because of: 1. Powder recirculation test in progress 2. Silo, vacuum, process or filter oxygen sensor in error state 3. Manual stop of chamber preparation	Not applicable
Inert Chamber Achieved	Info	-	●	-	-	Once the chamber is inert	Not applicable
Build Started	Info	●	-	-	-	Fresh build start (after loading the build)	Not applicable
Build Resumed	Info	●	-	-	-	Manual or auto resume of build	Not applicable
Build Stopped	Info	-	●	-	-	Stop build (also from process stop)	Not applicable
Build Complete	Info	-	●	-	-	Build completion	Not applicable
Build Paused – High Oxygen Level AUTOPAUSE	Warning	-	●	-	-	Build auto pause due to high oxygen	Not applicable
Build Paused – Powder Level Empty AUTOPAUSE (RenAM 500 and RenAM 500 Ultra) / PAUSE (Flex)	Warning	-	●	-	-	Powder is below the silo low level sensor	Clears when the build is resumed
Silo Powder Level Empty AUTO PAUSE	Warning	-	●	-	-	The powder level is low, or powder sensor is in error state	Not applicable

Alert title	Type	Raise on	Raise off	Clear on	Clear off	Logic to raise alarm	Logic to clear alarm
Build Paused MANUAL PAUSE	Warning	🔵	🟢	-	🔵	Manual pause after pressing the button	Clears on resumption of build
Build Paused – Overflow Flasks Full	Warning		🟢			When one of the overflow flasks is full and build is configured to pause	Clears on resumption or stop of build
Insufficient Powder to Complete the Build	Warning	🔵	-	-	🔵	If the powder is insufficient to complete the build	The alert will be cleared as soon there is sufficient powder. The user should add powder to the system.
Build Paused – Cyclone Hopper Full	Warning	🔵	🟢	-	🔵	The Cyclone top sensor is triggered	Clear on manual resumption of the build
						The build is paused and needs to be resumed manually	Modified Logic: Clear on manual resumption of the build, or on Stop (and E-stop)
New Filter Needed	Warning	🔵	-	-	🔵	The filter differential pressure is above the warning limit AND the other filter is either not installed, or is already dirty, or both filters are active	A new filter is installed by the user.
Build Paused – Filter Dirty	Warning	🔵	🟢	-	🔵	The differential pressure across the filters is above the build limit.	A new filter is installed by the user.
Heat Soak in Progress	Info	🟢	-	-	-	Whenever heat soak started	Not applicable
Heater Auto Tuning in Progress	Info	🟢	-	-	-	The heater auto tune starts	Not applicable
Heat Soak Completed	Info	-	🟢	-	-	Heat soak complete	Not applicable
Heater Auto Tuning Completed	Info	-	🟢	-	-	The heater auto tune is complete	Not applicable
Heater Auto Tune Aborted	Info	-	🟢	-	-	The heater auto tune is aborted/stopped	Not applicable
De-build Purge Started	Info	🟢	-	-	-	De-build purge start	Not applicable
De-build Purge Complete	Info	-	🟢	-	-	De-build purge complete	Not applicable
De-build Purge Aborted	Info	-	🟢	-	-	De-build purge stopped/ aborted	Not applicable
Laser Coolant Flow Rate at Warning Limit	Warning	🟡	-	-	🟡	If laser coolant flow is below the warning limit	The flow rate is achieved
Optics Coolant Flow Rate at Warning Limit	Warning	🟡	-	-	🟡	If flow in the optics is below the warning limit	The flow rate is achieved
Intercooler Coolant Flow Rate at Warning Limit	Warning	🟡	-	-	🟡	If intercooler coolant flow is below the warning limit	The flow rate is achieved

Alert title	Type	Raise on	Raise off	Clear on	Clear off	Logic to raise alarm	Logic to clear alarm
Powder Recirculation Warning	Warning	●	-	-	●	Hopper contents less than 5 L	Hopper contents more than 5 L. The user should add powder to the system.
Empty Silo Test Started	Info	●	-	-	-	Start of empty silo test	Not applicable
Empty Silo Test Stopped	Info	-	●	-	-	Empty silo test stopped/ aborted (including Process stop)	Not applicable
Empty Silo Test Complete	Info	-	●	-	-	Completion of empty silo test	Not applicable
Focus Test Started	Info	●	-	-	-	Start of laser focus test	Not applicable
Focus Test Stopped	Info	-	●	-	-	Stop/abort of laser focus test (including Process stop)	Not applicable
Focus Test Complete	Info	-	●	-	-	Completion of laser focus test	Not applicable
Very Low Available Primary (C:) Drive Memory	Warning	●	-	-	●	When C drive memory is less than the memory threshold Note: If both the secondary drive and C drive memory are below the threshold, then a secondary drive warning will appear once the C drive warning has been cleared.	When C drive memory is more than the memory threshold
Low Available Primary (C:) Drive Memory	Warning	●	-	-	●	When C drive memory is less than the drive memory low warning threshold	When C drive memory is more than the drive memory low warning threshold
Very Low Available Secondary (D:) Drive Memory	Warning	●	-	-	●	When secondary drive memory is less than the memory threshold.	When secondary drive memory is more than the memory threshold.
Low Available Secondary (D:) Drive Memory	Warning	●	-	-	●	When secondary drive memory is less than the drive memory low warning threshold	When secondary drive memory is more than the drive memory low warning threshold

7. Ancillary equipment

The RenAM 500 series requires the use of supplementary or ancillary equipment to simplify and facilitate the process of operating the machine and producing builds. The equipment described in this section plays a crucial role in streamlining and supporting the overall AM process.

WARNING: Read the manufacturer's instructions before operating and/or maintaining the ancillary equipment. If the instructions are not followed, you may injure yourselves or others, or cause damage to the equipment.

WARNING: Before operating the ancillary equipment, ensure that an earthing connection is properly established. Failure to do so can result in severe injury or damage to the equipment.

The Renishaw RenAM 500 series system actively supports the use of the additional ancillary equipment listed in the table below for its operation.

Equipment name	Function	Availability
ATEX vacuum cleaner	Used to safely remove small amounts of metal powder that may become lodged in difficult-to-access areas of the system.	Mandatory
Chiller	A cooling system that efficiently removes heat from the RenAM 500 series system by circulating a refrigerant through its components, including the optical system.	Mandatory
Bead blaster and extractor	A blaster is used to modify the surface finish of AM parts. The extractor filters the dust-filled air from the blast cabinet.	Optional
Furnace	Used for heat treating AM parts.	Optional
Universal lifter	Enables you to lift and transport heavy items. It is particularly useful when loading powder into the machine, as well as carrying out service tasks, which include both maintenance and repair.	Recommended (mandatory for RenAM 500 Flex)
Hopper trolley	Aids you in transporting the hopper to and from the RenAM 500 and RenAM 500 Ultra systems.	Recommended for RenAM 500 and RenAM 500 Ultra
Powder recovery system (sieve)	Used to remove oversized particles from metal powder before it is loaded into the RenAM 500 series system.	Recommended (mandatory for RenAM 500 Flex)
Working platform	Used to carry out general tasks that require elevated access around the machine.	Recommended (mandatory for RenAM 500 Flex)
Optical System Verification (OSV)	This toolset is required for measuring and calibrating the laser power, focal point and positional accuracy.	Recommended

7.1 ATEX vacuum cleaner (mandatory)

WARNING: Do not store the ATEX vacuum cleaner in a closed unventilated space.

WARNING: Read the manufacturer's instructions before operating and/or maintaining the ancillary equipment. If the instructions are not followed, you may injure yourselves or others, or cause damage to the equipment.

CAUTION: Always use the manufacturer's genuine parts. Using parts other than those provided by the manufacturer may result in damage to the equipment. Contact Renishaw for replacement parts.

The Renishaw RenAM 500 series system mandates the use of an ATEX vacuum cleaner. The Renishaw recommended ATEX vacuum cleaner is a Ruwac model NA7. This vacuum cleaner is used to clean small residues of material and waste process emissions. These materials are potentially dangerous and the appropriate procedures as detailed in the manufacturer's instructions must be observed. For more details, refer to the manufacturer's website (**www.ruwac.de**).

NOTE: Contact your local Customer Service Center (CSC) for the electrical specifications of the ATEX vacuum cleaner.



Figure 68 Ruwac model NA7 ATEX vacuum cleaner

7.1.1 Technical specification

Equipment	Ruwac ATEX vacuum cleaner – model NA7
Electrical requirements EU/US	230 V, 50 Hz, single phase, 16 A (7.6 A consumption) 115 V, 60 Hz, single phase (21.3 A consumption)
Size: depth × width × height	705 mm × 480 mm × 755 mm (28 in × 19 in × 30 in)
Weight, gross	95 kg (210 lb)
Liquid capacity	7 L (427 in^3)
ATEX rating	 II 3D

7.1.2 ATEX vacuum cleaner safety

WARNING: Never use an unapproved vacuum cleaner to clean away powder or waste product.

Two main hazards exist:

1. The potential for powder explosion due to static charge caused by powder in suspension. To control and mitigate this hazard, an ATEX vacuum cleaner is used to extinguish any potential ignition while vacuuming the material. Renishaw recommends fitting an earth bond between the ATEX vacuum cleaner and the earthing point on the RenAM 500 series system when using the ATEX vacuum cleaner.

2. The use of water potentially causes a secondary hazard with some materials, where the reaction between the material and water causes a chemical reaction that can lead to the generation of hydrogen gas, which is flammable.

    - To control and mitigate this hazard, the ATEX vacuum cleaner features a ventilation valve which remains normally open when the cleaner is not being used.
    - For the ventilation valve to function effectively, it is essential to store the ATEX vacuum cleaner in a well-ventilated area.
    - When processing aluminium, use of a 5% solution of Hydra-Sol-MAG additive (Renishaw part no. P-LU08-0004) will help to inhibit the generation of hydrogen.

    NOTE: For information about Hydra-Sol-MAG additive, refer to the Hydra-Sol-MAG additive Safety data sheet (Renishaw part no. H-5800-4019).

7.1.3 ATEX vacuum cleaner operation

WARNING: You must complete the appropriate Renishaw training course before handling oxygen-reactive metals. Among other recommendations, this will specify the need to add a 5% solution of Hydra-Sol-MAG additive (part no. P-LU08-0004) to the Ruwac ATEX vacuum cleaner when processing aluminium.

WARNING: Depending on the metal powder (particularly aluminium alloy) and local water hardness, it may also be necessary to add 0.1% by volume of anti-foaming agent (part no. 792322000). It is essential that foam is not allowed to build up, as it will be drawn into the cleaner, resulting in corrosion.

There are essential tasks that must be completed before and after the ATEX vacuum cleaner is operated. These include but are not restricted to the following:

- Carry out the safety checks in accordance with the manufacturer's instructions.
- Ensure the ATEX vacuum cleaner is electrically earthed – < 1 megohm between plug and components.
- Ensure the earth bond is fitted between the ATEX vacuum cleaner and the earthing point on the RenAM 500 series system.
- Ensure the fluid level is checked before every start-up and top up as necessary.
- Ensure the correct additives are used, if required.
- Check the hydrogen ventilation valves work before start-up by pressing them and ensuring they spring back (open).
- Ensure the ATEX vacuum cleaner is emptied and cleaned after every shift. Ensure any waste water is stored in a ventilated drum in a well-ventilated area (preferably outdoors) until it can be recycled.

  NOTE: For information about Hydra-Sol-MAG additive, refer to the Safety data sheet.

7.2 Chiller (mandatory)

WARNING: Read the manufacturer's instructions before operating and/or maintaining the ancillary equipment. If the instructions are not followed, you may injure yourselves or others, or cause damage to the equipment.

CAUTION: Always use the manufacturer's genuine parts. Using parts other than those provided by the manufacturer may result in damage to the equipment. Contact Renishaw for replacement parts.

The RenAM 500 series requires a chiller to supply temperature-controlled water to keep the lasers and optical components at a stable temperature. The SMC Pneumatics air-cooled and water-cooled chillers are approved and supplied by Renishaw. Both the chillers operate on a closed-loop cooling circuit and are directly connected to the RenAM 500 series system, enabling the viewing of status updates and warnings via the touch screen control panel. For more details, refer to the manufacturer's website (**www.smcpneumatics.com**).

NOTE: Install the SMC chiller in accordance with the instructions supplied by SMC with the chiller.

NOTE: Contact your local Customer Service Center (CSC) for the electrical specifications of the SMC Pneumatics HRSH090-AF-40 chiller.

NOTE: Alternative chillers are available for use with the RenAM 500 series. Contact Renishaw for guidance on selecting an appropriate chiller.

NOTE: The inlet and exhaust vents of the cooling unit must not be obstructed. There must be a minimum distance of 500 mm (19 in) (front), 300 mm (12 in) (back) and 800 mm (31.5 in) (both sides) from walls or other equipment.

NOTE: The chiller is not supplied with a power cable or secondary earth cable. A suitably skilled and locally qualified electrician should select a suitable power cable and secondary earth cable. A power cable of 3×5.5 mm^2 (3×0.21 in^2 CSA and a secondary earth with a total CSA of 14 mm^2 (0.55 in^2) must be fitted.

NOTE: The chiller must be installed at the same floor level as the AM machine, and the piping length between the SMC chiller and the RenAM 500 series system must be limited to 20 m (66 ft).

7.2.1 Air-cooled chiller – technical specification



Figure 69 SMC Pneumatics model HRSH090-AF-40 chiller

Equipment	SMC Pneumatics – model HRSH090-AF-40
Electrical requirements	380 V to 415 V, 50 Hz to 60 Hz, three phase, 20 A
Chiller fluid	Nalco (supplied pre-mixed)
Size: depth × width × height	970 mm × 377 mm × 1 080 mm (38 in × 15 in × 42.5 in)
Weight	130 kg (287 lb) net
Pump capacity	20 L/min (0.7 cfm) to 60 L/min (2.11 cfm)
Heat output	8.5 kW
Noise	66 dB to 68 dB

7.2.2 Water-cooled chiller – technical specification



Figure 70 SMC Pneumatics model HRSH090-W-40 chiller

Equipment	SMC Pneumatics – model HRSH090-WF-40
Electrical requirements	380 V to 415 V, 50 Hz to 60 Hz, three phase, 20 A
Chiller fluid	Nalco (supplied pre-mixed)
Size: depth × width × height	970 mm × 377 mm × 1 080 mm (38 in × 15 in × 42.5 in)
Weight	121 kg (266 lb) net
Pump capacity	20 L/min (0.7 cfm) to 60 L/min (2.11 cfm)
Heat output	< 2.5 kW
Noise	66 dB to 68 dB

7.3 Bead blaster and extractor (optional)

WARNING: Read the manufacturer's instructions before operating and/or maintaining the ancillary equipment. If the instructions are not followed, you may injure yourselves or others, or cause damage to the equipment.

CAUTION: Always use the manufacturer's genuine parts. Using parts other than those provided by the manufacturer may result in damage to the equipment. Contact Renishaw for replacement parts.

An optional bead blaster and extractor can be supplied with the RenAM 500 series system to quickly modify the surface finish of parts after the build is complete. The optional bead blaster is a Guyson model Euroblast 4AM. The optional extractor is a Guyson model C400. For more details, refer to the manufacturer's website (**www.guyson.co.uk**).



Figure 71 Guyson Euroblast 4AM bead blaster (left) and C400 extractor (right)

NOTE: Contact your local Customer Service Center (CSC) for the electrical specifications of the Guyson Euroblast 4AM and C400 bead blaster and extractor.

7.3.1 Technical specification

Equipment	Guyson Euroblast 4AM and C400 cartridge filter dust collector with HEPA
Electrical requirements	230 V, 50 Hz, single phase, 13 A
Gas supply	Compressed air – dry and oil free 5.5 bar (80 psi) pressure (max) Flow rate 27.2 m^3/hour (960 ft^3/hour) (max)
Footprint (blaster)	815 mm × 560 mm (32 in × 22 in)
Footprint (dust collector)	770 mm × 460 mm (30 in × 18 in)
Weight	140 kg (309 lb)

7.4 Furnace (optional)

WARNING: Read the manufacturer's instructions before operating and/or maintaining the ancillary equipment. If the instructions are not followed, you may injure yourselves or others, or cause damage to the equipment.

CAUTION: Always use the manufacturer's genuine parts. Using parts other than those provided by the manufacturer may result in damage to the equipment. Contact Renishaw for replacement parts.

An optional furnace can be supplied with the RenAM 500 series system to enable parts to be rapidly and easily heat-treated after the build is complete. The recommended furnace is a Nabertherm model N41/H. For more details, refer to the manufacturer's website (**www.nabertherm.com**).



Figure 72 Nabertherm N41/H furnace

NOTE: Contact your local Customer Service Center (CSC) for the electrical specifications of the Nabertherm N41/H furnace.

7.4.1 Technical specification

Equipment	Nabertherm furnace – model N41/H
Electrical requirements	400 V, 50 Hz to 60 Hz, three phase, 32 A
Gas supply	Argon – typically < 20 L/min (42 ft³/hr) – max 40 L/min (85 ft³/hr) Flow regulator or meter to suit 0 L/min to 40 L/min (0 ft³/hr to 85 ft³/hr) (Suitable suppliers; BOC 6000 series, Weldability AU300)
Flooring	Non-flammable surface (fire safety Class A EN 4102) Example: concrete, tiles, glass, aluminium or steel, so that any hot material falling from the furnace cannot ignite it
Footprint	1 150 mm × 950 mm (45 in x 38 in) **NOTE:** The controller can be removed for delivery. Width is then 840 mm (33 in). No combustible materials within perimeter of at least 500 mm (19.6 in). Dependent on application, a greater distance may be required.
Weight	260 kg (573 lb)

7.4.2 Furnace argon gas consumption

Argon gas usage is primarily dependent on the material and heat cycle; see the following table for estimates. Gas usage can be minimised by wrapping the part in heat treatment foil (part number P-HT01-0001).

Material	Approximate cycle length (hrs)	Approximate gas usage L (ft³)
Aluminium	20	12 000 (424) full cylinder (w type)
Inconel	21	12 600 (444) full cylinder
Stainless steel	6	3 600 (127)
Titanium	5	6 000 (212)

7.5 Universal lifter (recommended for RenAM 500 and RenAM 500 Ultra) (mandatory for RenAM 500 Flex)

WARNING: Read the manufacturer's instructions before operating and/or maintaining the ancillary equipment. If the instructions are not followed, you may injure yourselves or others, or cause damage to the equipment.

A Renishaw universal lifter is mandatory equipment for the RenAM 500 Flex and is included with the first machine installation. The Wilmat 207/S universal lifter is a general hydraulic lifting and transportation device used to move heavy items to and from the RenAM 500 series system. It is a pedestrian propelled lifter with a lifting mast, without tilt, with load-bearing outriggers, equipped with fork arms, a platform, or other load-handling device. The universal lifter is designed to be manually pushed, pulled and steered by one pedestrian operator. It is supplied with a lifting attachment and can be used to move a variety of items such as completed builds, 10 L (610 in^3) powder flasks, RenAM 500 Flex feed hoppers, or a large SafeChange filter. For more details, refer to the Wilmat 207/S universal lifter operation and maintenance manual.

NOTE: It is recommended to fully service and inspect any lifting equipment at regular intervals. Regularly maintaining your lifting equipment will prevent failures and thus reduce operating costs.

NOTE: The Renishaw universal lifter replaces the previously available silo lift. All tasks previously performed by the silo lift can also be performed by the universal lifter. Operation and maintenance of the silo lift is described in the silo lift user guide (Renishaw part no. H-5800-4480).



Figure 73 Universal lifter with lifting attachment fitted

7.6 Hopper trolley (recommended for RenAM 500 and RenAM 500 Ultra)

WARNING: Read the user guide (Renishaw part no. H-5800-4481) before operating and/or maintaining the hopper trolley. If the instructions are not followed, you may injure yourselves or others, or cause damage to the equipment.

The hopper trolley is a metal framed trolley used for transporting the hopper to and from the RenAM 500 or RenAM Ultra system.

It is fitted with the following items for ease of use:

- Four castors for ease of positioning.
- Two latches to secure the hopper trolley to the Renishaw AM system.
- One latch to secure the batch control hopper to the trolley.
- Eight rollers to ease loading of the hopper onto the trolley.



Figure 74 Hopper trolley

7.6.1 Technical specification

Equipment	Renishaw hopper trolley
Size (depth × width × height)	810 mm × 500 mm × 1 070 mm (32 in × 19.5 in × 42 in)
Maximum rated capacity	320 kg (705 lb)
Unladed weight	30 kg (66 lb)

7.7 Powder recovery system (sieve) (recommended for RenAM 500 and RenAM 500 Ultra) (mandatory for RenAM 500 Flex)

WARNING: Read the user guide (Renishaw part no. H-5800-4613) before operating and/or maintaining the Renishaw powder recovery system (PRS). If the instructions are not followed, you may injure yourselves or others, or cause damage to the sieve.

WARNING: Before you begin any operational procedure with the powder recovery system, ensure you are wearing the correct PPE: eye protection, full face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing made from non-static-generating fabric such as cotton (avoid wool and man-made fabrics), and avoid turn-ups or pockets that may trap powder. Refer to NFPA 484 for details.

WARNING: Always keep body parts away, while the sieve is in operation. When in operation, the body of the powder recovery system (sieve) moves relative to the support frame. There is a possibility of body parts getting trapped between the sieve body and support frame.

A powder recovery system is required to remove oversized particles from powder that has been used in the chamber. The RenAM 500 Flex does not have a powder recovery system integrated into the machine, hence an external sieve is mandatory for operation. A stand-alone sieve is recommended if the user wants to re-use powder that is entrained in the chamber gas flow and ends up in the prefilter cyclone on all models of the RenAM 500 series.

CAUTION: Always use the manufacturer's genuine parts. Using parts other than those provided by the manufacturer may result in damage to the equipment. Contact Renishaw for replacement parts.



Figure 75 Powder recovery system

NOTE: To minimise the risk from argon leakage, Renishaw recommends using a small argon gas cylinder of approximately 1 000 L (35 cu/ft). It is also recommended to use a trigger-type gas valve to prevent the gas supply being accidentally left on.

7.7.1 Technical specification

Equipment	Russell Finex Powder Recovery System
Size (depth × width × height)	850 mm × 450 mm × 1 450 mm (33.5 in × 18 in × 55 in)
Weight	70 kg (154 lb)
Electrical requirements	415 V, 50 Hz, three phase, 6 A

7.8 Working platform (recommended for RenAM 500 and RenAM 500 Ultra) (mandatory for RenAM 500 Flex)

WARNING: Failing to exercise caution while climbing, dismounting, or standing on the working platform can lead to injury and/or death.

WARNING: Special care should be taken while manoeuvring any mobile safety steps or working platforms. Always make sure that the pathways are free of obstacles or other people before moving any equipment.

The 1.3 m (4.26 ft) working platform can be used for general tasks that require elevated access around the machine. For the RenAM 500 Flex, it is required to safely complete powder-loading activities, and can be used throughout the material change process if necessary.



Figure 76 1.3 m working platform

NOTE: It is recommended that any mobile safety steps or platforms are fully serviced and inspected at regular intervals as specified in the manufacturer's instructions. By maintaining your equipment regularly, you will prevent failures and thus reduce operating costs.

7.8.1 Technical specification

Equipment	1.3 m (4.26 ft) working platform
Size (depth × width × height)	1 358 mm × 850 mm × 2 250 mm (53.5 in × 33.5 in × 88.5 in)
Unladen weight	59 kg (130 lb)

7.9 Optical System Verification (OSV) (recommended)

OSV is a process designed to measure and calibrate the lasers in the RenAM 500 series system. The OSV toolset includes everything needed to check laser power output, focal point and positional accuracy across the entire powder bed surface.

CAUTION: OSV is only compatible with RenAM 500 series machines running Machine Software Suite (MSS) 1.6.2 or later, with a V5 controller and three-slot kinematic heater plate installed. RenAM 500 machines purchased after July 2022 will have these prerequisites installed as standard. Contact Renishaw for more information.

NOTE: OSV is required for many of the system optical tests.

NOTE: OSV is highly recommended when using material files optimised for multiple lasers per part.

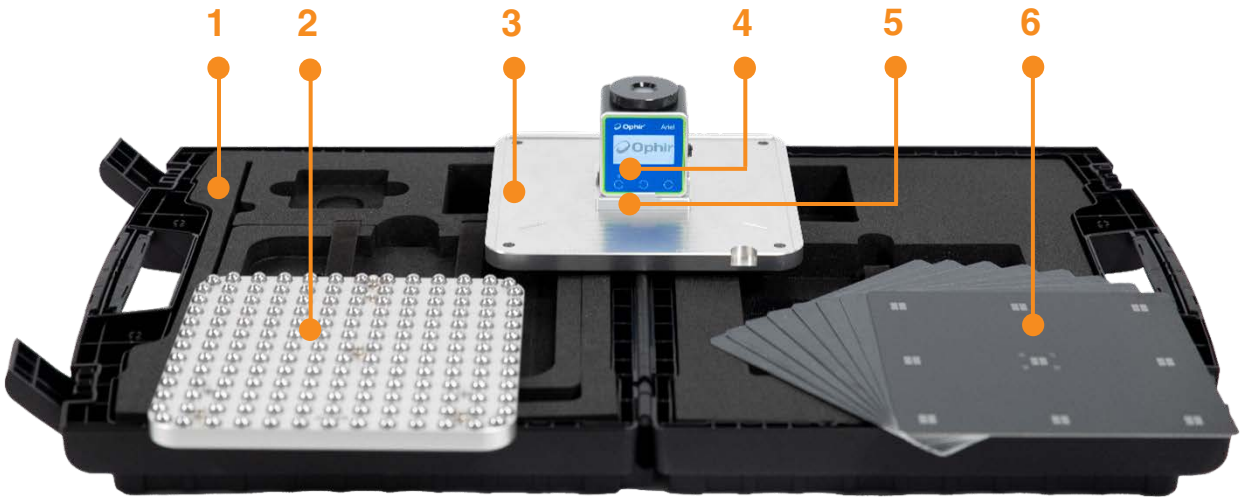


Figure 77 OSV toolset with included equipment displayed

The equipment included in the OSV toolset includes:

1. Protective case
2. Sphere array
3. Commissioning plate
4. Ophir Ariel (sold separately)
5. Ophir Ariel tooling plate
6. Eight marking plates

For more information on OSV, visit **www.renishaw.com/osv**.

7.10 Long-Life Filter (optional)

WARNING: Read the following manufacturer's instructions before operating and/or maintaining the ancillary equipment:

- Operating instructions FlushPACK Filtersystem (Renishaw part no. H-5800-6601).
- Flushpack Display User Manual Gen3 (Renishaw part no. H-5800-6611).

If the instructions are not followed, you may injure yourselves or others, or cause damage to the equipment.

WARNING: The Long-Life Filter requires increased clearances around the machine to operate safely. See the RenAM 500 series additive manufacturing system installation guide (Renishaw part no. H-5800-3692) for more information.

CAUTION: The Long-Life Filter is only compatible with RenAM 500 series machines running Machine Software Suite (MSS) 2.4.0 or later. Contact Renishaw for more information.

The Long-Life Filter for the RenAM 500 series is an external filter unit designed as a set-and-forget system to support uninterrupted production. It provides continuous filtering via a multi-stage approach that includes an automated cleaning cycle to simplify maintenance and improve health and safety.

The system removes metal condensate from the argon gas that has passed through the build chamber. Once the condensate is removed, the system uses mineral oil as a passivation and disposal medium.

NOTE: The Long-Life Filter is designed to last 4 000 hours before changing the contaminated oil and/or filter elements. Therefore, these service activities are intended to be completed by a Renishaw service engineer during an on-site machine check-up every six months.



Figure 78 Long-Life Filter next to a RenAM 500Q system

7.10.1 Functional description

The Long-Life Filter system contains three filter units inside. During operation, each filter unit will cycle through four active stages to filter the incoming gas and automatically clean itself. These stages are Filter, Oil fill, Backflush and Oil drain (see Figure 79).

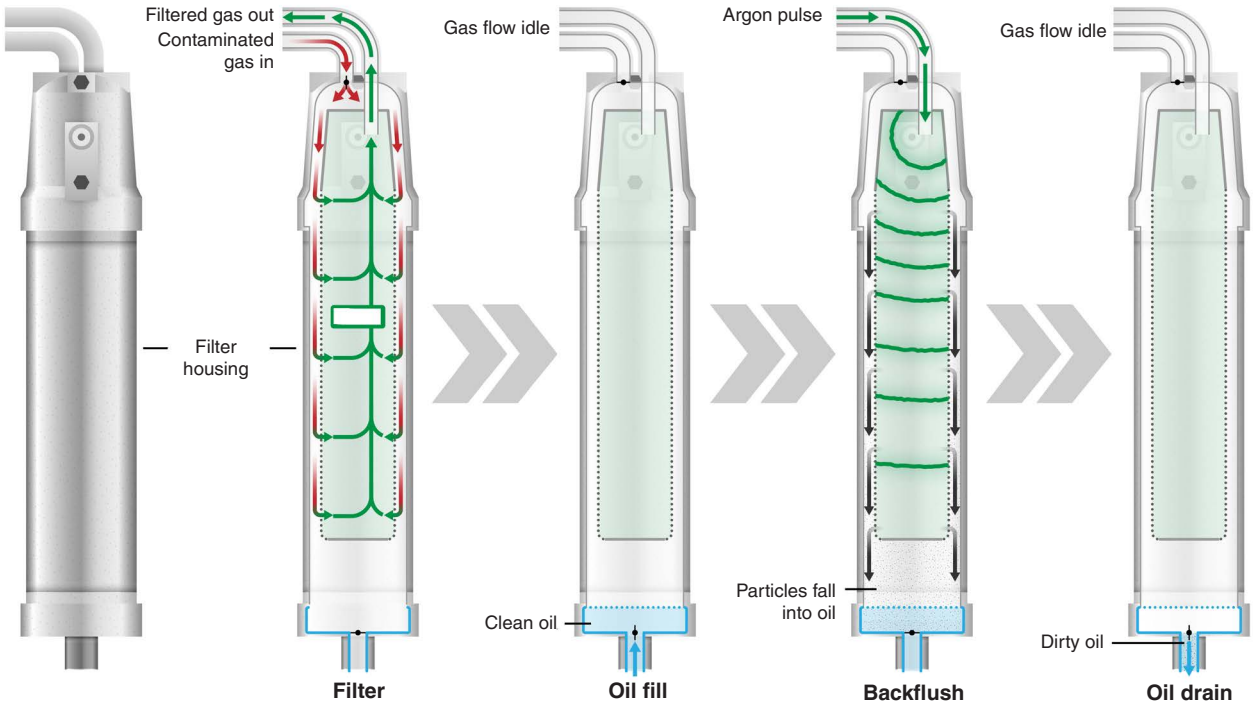


Figure 79 Four operating stages of an internal filter unit inside the Long-Life Filter

The filter stage pulls contaminated argon gas from the RenAM 500 series system through the filter membrane to remove condensate. This stage stops once the differential pressure between the filter inlet and outlet reaches a certain limit, which initiates the self-cleaning stages. This starts by shutting off the gas flow through the filter, after which a small amount of oil is pumped into the bottom of the unit. Pulses of argon blast through the filter from the inside during the backflush stage, dislodging the metal condensate. This falls into the oil, which passivates the condensate and, once drained, is stored for later disposal. The unit is now ready to start filtering the incoming gas again.

7.10.2 Technical specification

Equipment	Hydac Long-Life Filter
Dimensions (depth × width × height)	1 535 mm × 1 110 mm × 2 200 mm (60.4 in × 43.7 in × 86.6 in)
Gap between Long Life Filter and RenAM 500 series	450 mm (17.7 in)
Material compatibility	All metal powders supported by the RenAM 500 series.
RenAM 500 series software compatibility	Machine Software Suite (MSS) 2.4.0 or later
Service interval	4 000 hours **NOTE:** The actual filter life depends on machine usage, powder material and part geometries.

7.10.3 Consumables

Part number	Description
P-LU01-0026	White mineral oil
(Customer-sourced)	212 L barrel, 610 mm (24.0 in) diameter × 800 mm (31.5 in) height (UN 1A2/Y1.5/150 or UN 1A2/X240/S certified)

7.10.4 Supporting equipment (mandatory)

The following equipment is needed to support the service activities of the Long-Life filter.

7.10.4.1 Long-Life Filter Lifter

The Long-Life Filter lifter is a manual lifter designed to aid moving the individual filter units located inside the Long-Life Filter.

NOTE: This equipment is only needed during service activities. For sites with many RenAM 500 series machines equipped with Long-life filters, only one Long-Life Filter lifter is needed per site.



Figure 80 Long-Life Filter lifter

Equipment	Long-Life Filter lifter
Renishaw part number	P-LE10-0012
Dimensions (depth × width × height)	737 mm × 586 mm × 1 505 mm (29.0 in × 23.0 in × 58.3 in)

7.10.4.2 Barrel lifter

A barrel lifter is needed to replace the oil barrel inside the Long-Life Filter.

NOTE: This equipment is only needed during service activities. For sites with many RenAM 500 series machines equipped with Long-life filters, only one Barrel lifter is needed per site.

NOTE: It is the customers responsibility to source this equipment. Any manufacturer of barrel lifter is suitable so long as the lifter fits the specification below.

Equipment	Barrel lifter
Minimum load rating	250 kg (550 lbs)
Minimum lift height	550 mm (21.7 in)
Straddle width	800 mm (31.5 in)

7.10.4.3 Manual pallet truck

A manual pallet truck is needed to move the Long-Life Filter and the internal barrel sled during service.

NOTE: This equipment is only needed during service activities. For sites with many RenAM 500 series machines equipped with Long-life filters, only one Manual pallet truck is needed per site.

NOTE: It is the customers responsibility to source this equipment. Any manufacturer of manual pallet truck is suitable so long as the pallet truck fits the specification below.

Equipment	Manual pallet truck
Minimum load rating	2 500 kg (5 500 lbs)
Fork length	1 150 mm (45.3 in)
Width	550 mm (21.7 in)

8. Operation

This chapter aims to list and describe the operational tasks that you must complete before starting and after completing builds, as well as other tasks you must perform to successfully build components on the RenAM 500 series system.

The chapter is divided into seven sections as follows:

- Pre-build tasks
- Monitoring the build
- Post-build tasks
- Occasional tasks
- Technician level tasks
- Optical tests
- Network settings

Pre-build tasks are operator tasks that must be carried out before the build is started. Pre-build tasks are numbered using the prefix “AB” followed by a number, for example, “AB-001”.

Post-build tasks are operator tasks that must be carried out after the build has completed and before the next build can be started. Post-build tasks are numbered using the prefix “PB” followed by a number, for example, “PB-001”.

Occasional tasks are operator tasks that need to be carried out occasionally. Occasional tasks are numbered using the prefix “OT” followed by a number, for example, “OT-001”.

Technician level tasks are tasks that can be carried out before a build is started on a RenAM 500 series machine. Technician level tasks are numbered using the prefix “TT” followed by a number, for example, “TT-001”

Optical tests allow customers to measure and calibrate key laser machine characteristics. This includes service level tasks, numbered using the prefix “ST” followed by a number, for example, “ST-001”, and Technician level tasks, numbered using the prefix “TT” followed by a number, for example, “TT-005”.

The section on network settings covers network configuration and file transfer settings.

8.1 Pre-build tasks

8.1.1 Pre-build tasks (RenAM 500 and RenAM 500 Ultra only)

The table below lists all the operational tasks that need to be executed in the specified order before starting a build on either a RenAM 500 or RenAM 500 Ultra system.

Task number	Task title	User level
AB-001	Chiller fluid level – Check	Operator
AB-002	Argon gas supply – Set up	Operator
AB-003	Chiller – Power up	Operator
AB-004	Large SafeChange filter assemblies – Check	Operator
AB-005	RenAM 500 series system – Power up	Operator
AB-006	RenAM 500 series system – Log in	Operator
AB-007	Build chamber – Set up	Operator
AB-008	Build plate – Install	Operator
AB-009	Recoater blade – Install	Operator
AB-010	Recoater assembly – Install	Operator
AB-011	Load hopper – Fill (RenAM 500 and RenAM Ultra only)	Operator
AB-012	Valves – Set up (RenAM 500 and RenAM Ultra only)	Operator
AB-013	Build platform heat soak process – Set up	Operator
AB-014	Build chamber atmosphere – Set up	Operator
AB-015	Powder dose – Set up	Operator
AB-016	Build file – Transfer	Operator
AB-017	Build file – Select	Operator
AB-018	Suppress part	Operator
AB-019	Cyclone particle collection flask – Fit	Operator
AB-020	Pre-build checklist – Review (RenAM 500 and RenAM 500 Ultra only)	Operator
AB-021	Build – Start	Operator

8.1.2 Pre-build tasks (RenAM 500 Flex only)

The table below lists all the operational tasks that need to be executed in the specified order before starting a build on a RenAM 500 Flex system.

Task number	Task title	User level
AB-001	Chiller fluid level – Check	Operator
AB-002	Argon gas supply – Set up	Operator
AB-003	Chiller – Power up	Operator
AB-004	Large SafeChange filter assemblies – Check	Operator
AB-005	RenAM 500 series system – Power up	Operator
AB-006	RenAM 500 series system – Log in	Operator
AB-007	Build chamber – Set up	Operator
AB-008	Build plate – Install	Operator
AB-009	Recoater blade – Install	Operator
AB-010	Recoater assembly – Install	Operator
AB-022	Feed hopper – Fill (RenAM 500 Flex only)	Operator
AB-023	Overflow flasks – Fit (RenAM 500 Flex only)	Operator
AB-024	Valves – Set up (RenAM 500 Flex only)	Operator
AB-013	Build platform heat soak process – Set up	Operator
AB-014	Build chamber atmosphere – Set up	Operator
AB-015	Powder dose – Set up	Operator
AB-016	Build file – Transfer	Operator
AB-017	Build file – Select	Operator
AB-018	Suppress part	Operator
AB-019	Cyclone particle collection flask – Fit	Operator
AB-025	Pre-build checklist – Review (RenAM 500 Flex only)	Operator
AB-021	Build – Start	Operator

8.1.3 AB-001 – Chiller fluid level – Check

CAUTION: Replace the chiller fluid and flush the system with cleaner, according to the coolant manufacturer's guidelines. Failure to do so may result in system malfunction or damage.

NOTE: The following instructions describe an SMC Pneumatics model HRSH090-AF-40 chiller. Alternative chillers may be used, in which case follow the manufacturer's instructions supplied with the chiller for chiller set-up.

1. On the chiller, ensure the fluid level is between the L and H marks on the level gauge.

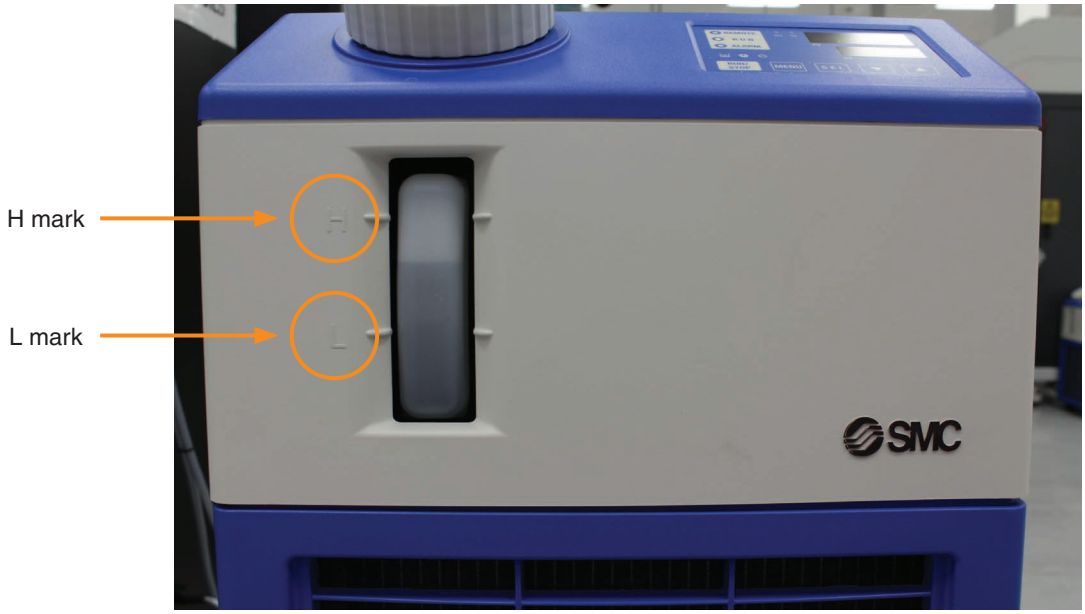


Figure 81 Front of SMC Pneumatics chiller

2. If the chiller fluid level is between the L and H marks, continue to carry out the pre-build tasks that apply to your RenAM 500 series system.

3. If the chiller fluid level is below the L mark, top up the chiller in accordance with task "OT-001 – Chiller fluid level – Top up".

   NOTE: Check the expiry date of the cooling fluid and record it before filling the chiller unit.

4. If the chiller fluid level is above the H mark, drain the excess fluid in accordance with task "OT-009 – Chiller fluid – Remove" until the level is below the H mark. Dispose of any drained fluid in accordance with applicable local legislation and rules.

8.1.4 AB-002 – Argon gas supply – Set up

1. Completely open the valve controlling the argon gas supply to the RenAM 500 series system and then close the valve by half a turn.

2. The argon gas supply needs to be regulated between 3.5 bar (50 psi) and 7 bar (101 psi). Setting the supply regulator to 5 bar (72 psi) while the AM machine is in an idle state is recommended to maintain the operating pressure.

   CAUTION: Do not exceed 10 bar (145 psi) gas supply pressure to the RenAM 500 series system. Exceeding 10 bar (145 psi) will cause the RenAM 500 series system to stop due to a gas overpressure alarm.

3. A minimum argon gas pressure of approximately 50 bar (725 psi) is recommended at the start of a build. If the argon supply is depleted, the build process will pause and an alarm will sound. If the argon pressure is below 50 bar (725 psi) at the start of a build, consider replenishing the gas supply.

   NOTE: Argon gas can be supplied in a cylinder, bank, or Cryospeed (liquid), allowing you to choose the method that best suits your needs.

4. With the argon gas supply to the RenAM 500 series system on, listen for any leaks. If leaks are heard, rectify as necessary.

8.1.5 AB-003 – Chiller – Power up

NOTE: The chiller must have been running for a minimum of three hours before starting a build. This is to ensure that the optical module is at the optimum operating temperature.

CAUTION: The optical system on the RenAM 500 series requires a supply of cooling water to keep it at a constant temperature. The cooling water for the optical system is provided by a chiller. To ensure that the optical system is always at the optimum operating temperature, the chiller must be powered up before the RenAM 500 series is powered up. The chiller must remain switched on even if a build is not going to be started. The chiller must be left running between builds. Failure to power up the chiller while the RenAM 500 series is powered up may result in premature failure of RenAM 500 series optical system components.

NOTE: The following instructions describe an SMC Pneumatics model HRSH090-AF-40 chiller. Alternative chillers may be used, in which case follow the manufacturer's instructions supplied with the chiller for chiller power-up.

1. Ensure that the chiller main power lead is connected to a suitable power supply.

2. On the rear of the chiller, operate the miniature circuit breaker (MCB), circled (Figure 82) and move it to the On position – up.



Figure 82 Power supply MCB on rear of SMC Pneumatics chiller

3. On the chiller front control panel (Figure 4) press the Run/Stop button (circled) once to switch on the pump. The Run light (circled) will illuminate.

4. Ensure the SV (Set Value) temperature, circled (Figure 83) is set to 20 °C (68 °F).



Figure 83 Run/Stop button and SV temperature on SMC Pneumatics chiller control panel

8.1.6 AB-004 – Large SafeChange™ filter assemblies – Check

CAUTION: This procedure does not apply to RenAM 500 series systems equipped with the external Long-Life Filter system. For more information, see section 7.10, “Long-Life Filter (optional)”.

1. Open the left-hand door at the front of the RenAM 500 series system.

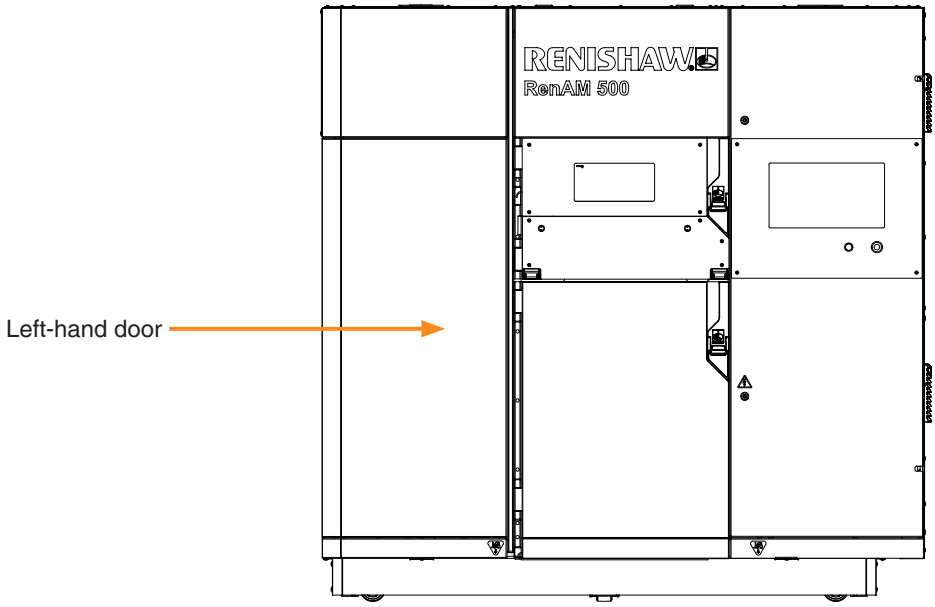
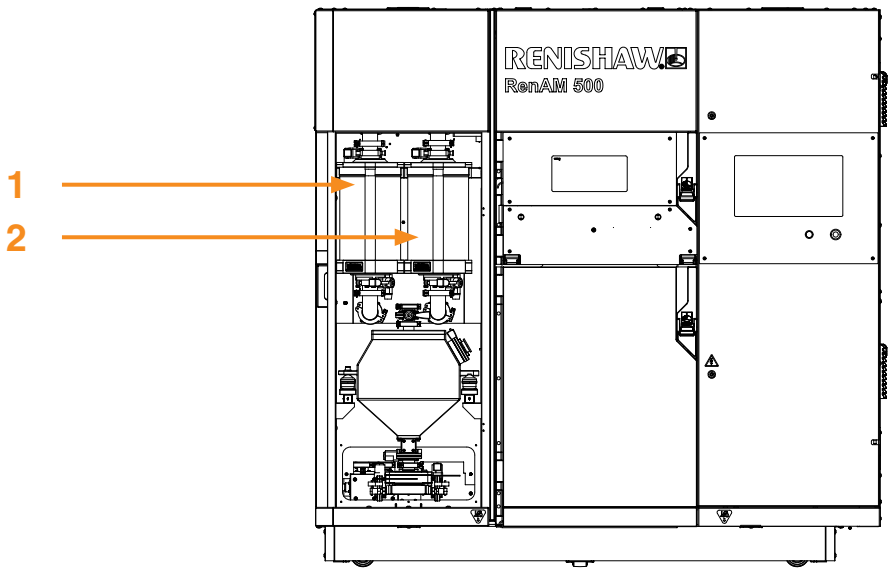


Figure 84 Left-hand door

2. Ensure there are two large SafeChange filter assemblies fitted. If either of the two large SafeChange filters assemblies is missing, fit a replacement filter assembly in accordance with task “OT-008 – Large SafeChange™ filter assembly – Refit”.



1	Large SafeChange filter 1
2	Large SafeChange filter 2

Figure 85 Large SafeChange filter assemblies shown without oversized particle collection flask

3. For RenAM 500 and RenAM 500 Ultra systems only: Ensure the oversized particle collection flask IS NOT fitted. If the oversized particle collection flask is fitted, remove it in accordance with task “PB-015-02 – Remove”. Ensure a blanking plate IS fitted to the oversized particle outlet and secured with a quick-release clamp.

4. Close the left-hand door.

8.1.7 AB-005 – RenAM 500 series system – Power up

CAUTION: To prevent premature failure of the RenAM 500 series optical system components:

- Ensure the chiller is powered up before powering up the RenAM 500 series.
- Keep the chiller switched on even if a build is not going to be started.
- Leave the chiller running between builds.

Failure to follow these instructions may result in damage to the optical system.

1. Locate the equipment main isolation switch on the rear left-hand side of the RenAM 500 series cabinet.

2. Raise the switch from the Off position to the On position. This enables power to the system electrical circuits. The controller and the main computer will then begin their start-up routines.



Figure 86 Equipment main isolation switch – Off left and On right

8.1.8 AB-006 – RenAM 500 series system – Log in

1. When the controller and main computer have completed their start-up routines, the login screen is displayed. If the login screen is not displayed, press the ‘Login’ button at the top right-hand side of the screen.

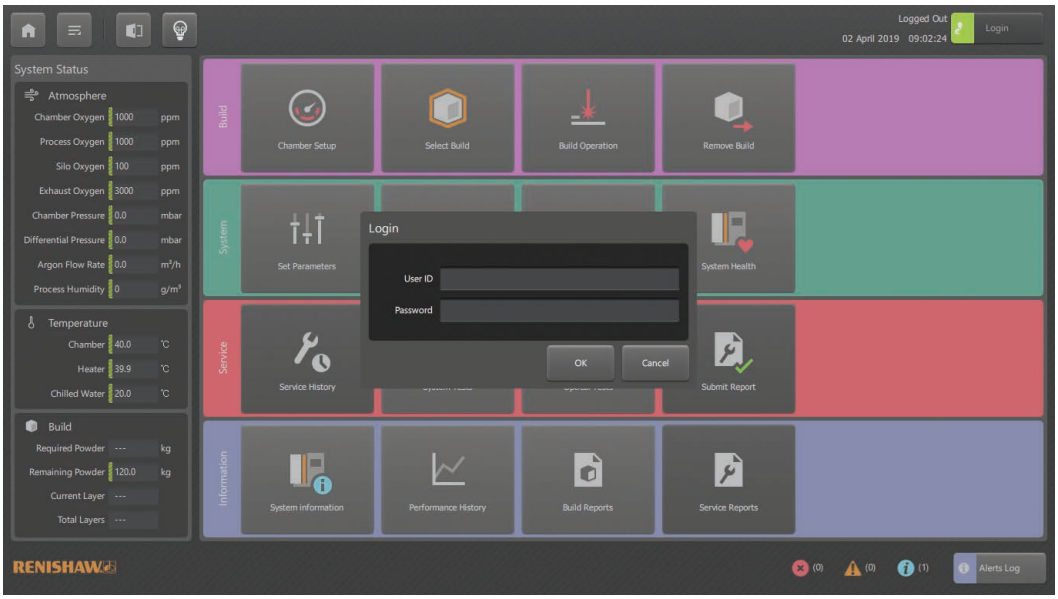


Figure 87 Login screen

2. On the login screen, enter your RenAMP user ID and password using the on-screen keyboard. Press ‘OK’ to confirm.



Figure 88 Login screen with on-screen keyboard

3. After a successful login, the home screen is displayed. Complete the three stages of the build preparation process (Chamber Setup, Select Build and Build Operation) before starting a build.

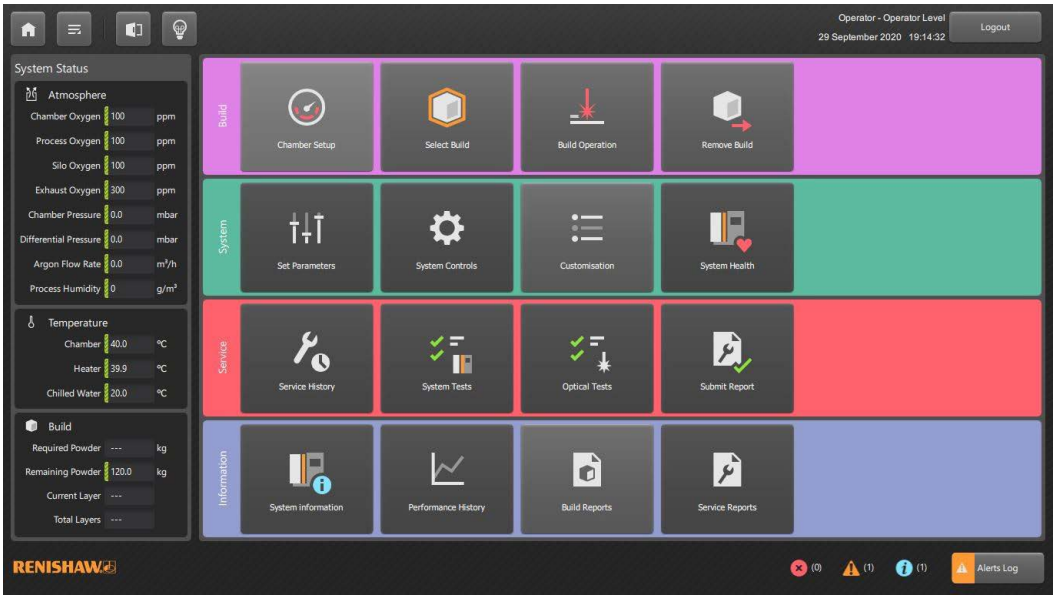


Figure 89 Home screen

8.1.9 AB-007 – Build chamber – Set up

1. From the home screen, select ‘Chamber Setup’ to open the ‘Chamber Setup’ screen (Figure 91). This is the first of the three stages of build preparation.

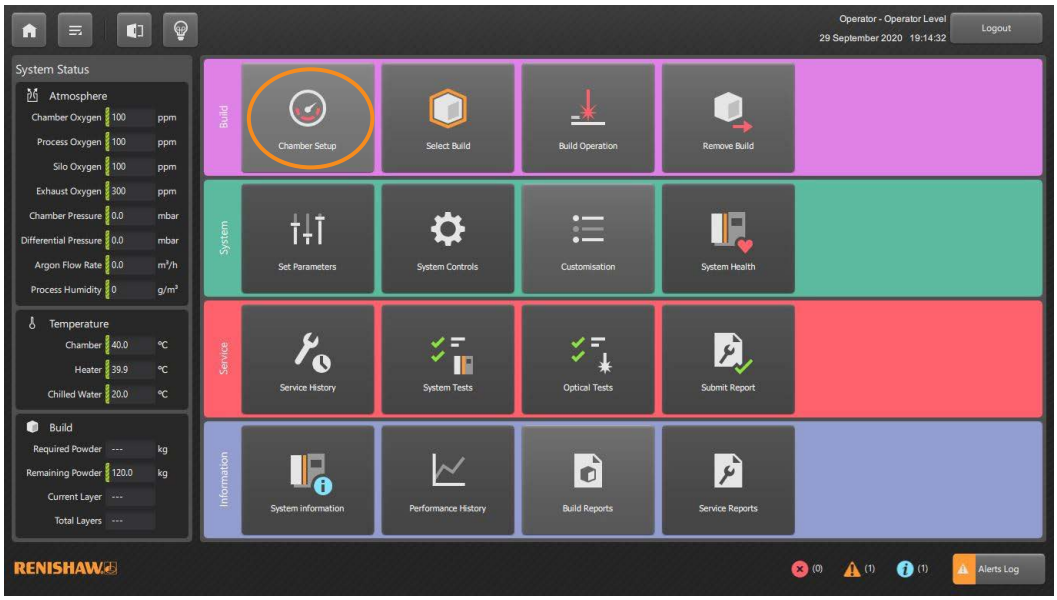


Figure 90 Home screen with Chamber Setup circled

2. The ‘Chamber Setup’ screen (Figure 91) contains five panes that enable you to control various parameters of the build. The five panes are: ‘Filters’, ‘Recoater’, ‘Elevator’, ‘Heater’ and ‘Atmosphere’.



Figure 91 Chamber Setup screen and five panes

3. Press the maximise button available in the upper right corner of each pane to display the pane in a larger view and gain access to more control options (Figure 92). The ‘Filters’ pane cannot be maximised.



Figure 92 Minimised pane and Maximise buttons

4. Once the pane is maximised, select the minimise button to set the pane back to the default view.

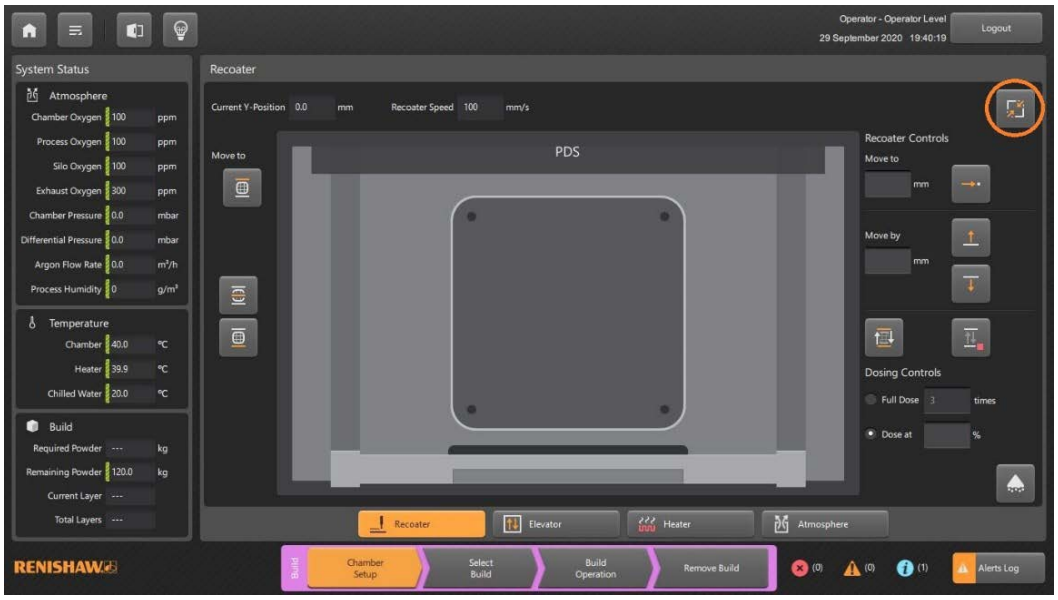


Figure 93 Maximised Recoater pane and Minimise button

5. From the access bar, select the Open Door button > Unlock Top Door (Figure 94). Then, press the blue Reset button on the machine. After the door is released, firmly pull the door handle towards you.



Figure 94 Open Door and Unlock Top Door buttons

6. On the System Status Atmosphere pane (Figure 95), verify that the build chamber pressure is zero and the chamber oxygen level is greater than 170 000 ppm.

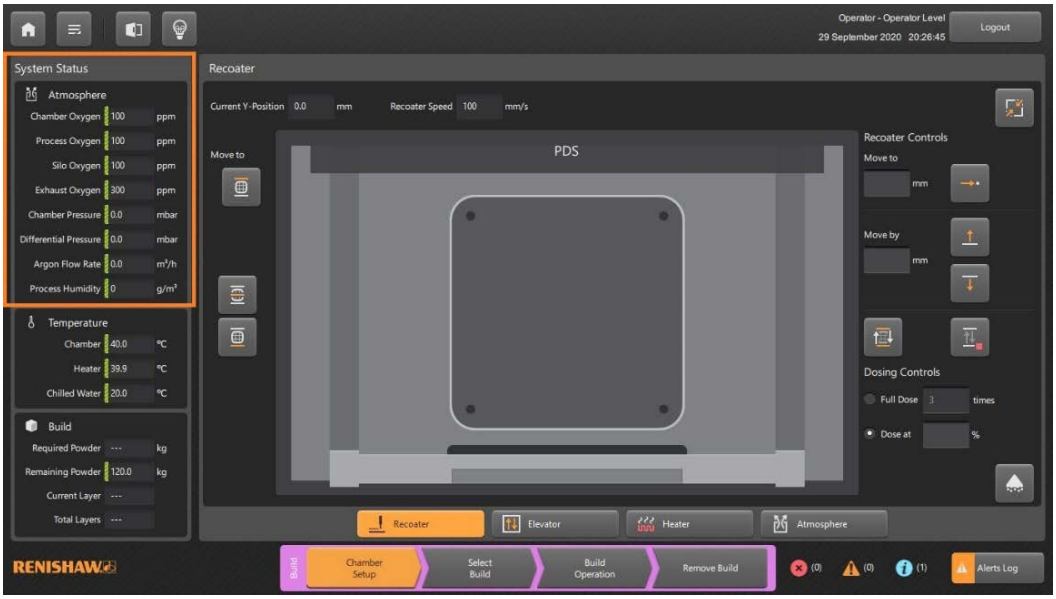


Figure 95 System Status Atmosphere pane

7. Clean the build chamber in accordance with the instructions given in section 8.3, “Post-build tasks”.

8. Check that the front and rear overflow mesh filters are present in the build chamber and make sure they are clean and free of damage

9. Close the top door.

10. From the Recoater pane, select the Send Recoater to Rear of Chamber icon (Figure 96).



Figure 96 Send Recoater to Rear of Chamber button

8.1.10 AB-008 – Build plate – Install

1. With the recoater at the rear of the build chamber, install the build plate as follows.

2. From either the maximised or minimised view of the Elevator pane, raise the elevator to the top position by selecting the Absolute Top button (Figure 97).



Figure 97 Absolute Top button

3. Open the top door.

4. Select a build plate in a suitable material for the powder being processed.

   WARNING: Build plates can be heavy. A 15 mm (0.6 in) stainless steel build plate weighs 7.5 kg (16.5 lb), titanium 4 kg (9 lb) and aluminium 3 kg (7 lb). Thicker build plates are significantly heavier than this. Handle build plates carefully to avoid injury and damage to the build plate. For build plates thicker than 15 mm (0.6 in), consider using suitable lifting equipment, such as a Renishaw universal lifter, to load the build plate into the build chamber.

   CAUTION: Check the edges of the build plate being installed and ensure there are no burrs, damage or defects that stick out from the edge and could cause damage to the inside of the build volume.

5. Clean down the build plate with Class 3 IPA and a disposable wipe to remove any machining fluid residue. Take care to ensure that the surface is completely dry.

   WARNING: Always clean away Class 3 IPA residues to avoid chemical reactions with carbon steel.

6. Using a suitable calibrated measuring device such as a micrometer or digital calliper, measure the build plate thickness at all four corners (Figure 98).



Figure 98 Measure the four corners of the build plate

7. Take an average of the four readings. Ensure that the mean reading does not deviate more than 0.05 mm (0.002 in) between the highest and lowest measurements. If in doubt, see the drawings in Section 6.2, “Build plate specifications”, for details.

8. From either the maximised or minimised view of the Elevator pane, select Build Plate Thickness. This will open a keypad dialog box (Figure 99).

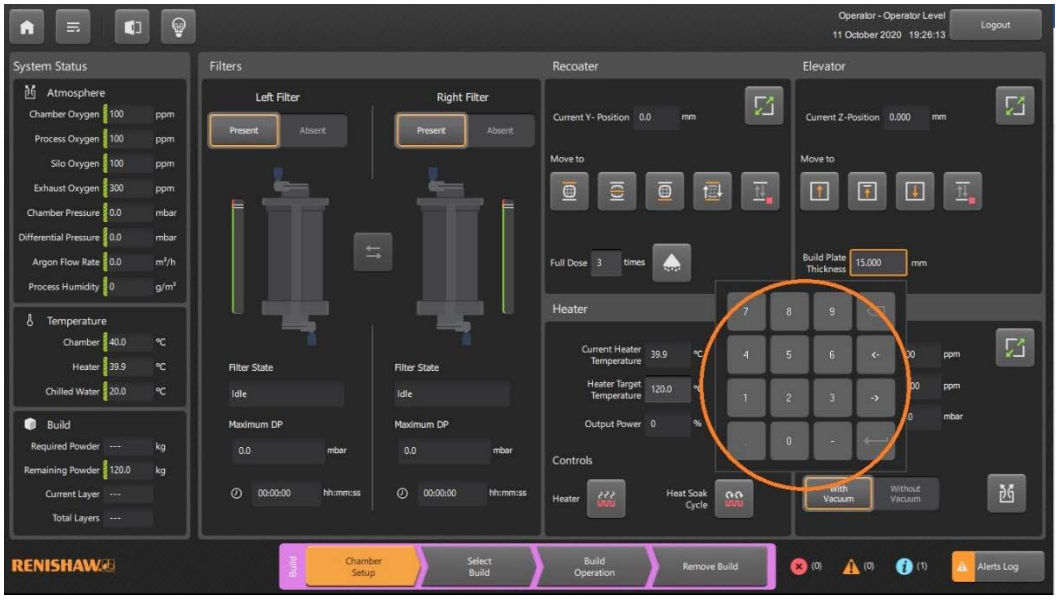


Figure 99 Build Plate Thickness keypad dialog box

9. Enter the build plate thickness measured previously (Figure 99) and select Return (Figure 100).



Figure 100 Keypad dialog box Return key

10. Place the build plate on the platform with the counter-bored holes facing upwards.

CAUTION: Ensure a build plate is fitted, as building directly on to the system platform will damage the platform and elevator of the RenAM 500 series system.

CAUTION: Although the build plate can be installed in any of four positions, the front of the build plate is marked with a shallow blind hole or slot in the centre of the front edge (Figure 101).

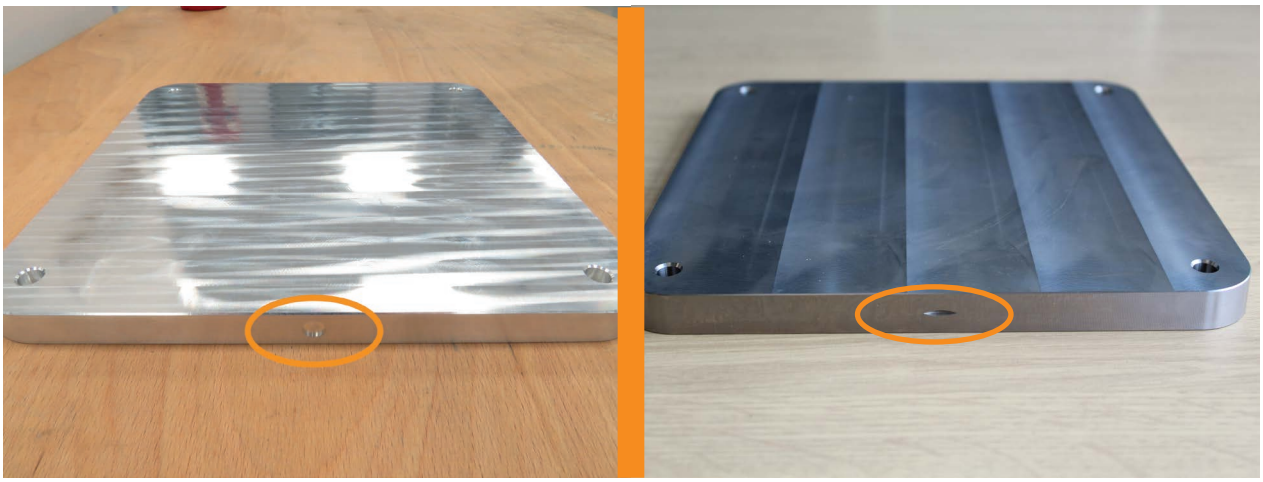


Figure 101 Front of build plate – shallow blind hole left image and slot right image

WARNING: Do not use zinc passivated screws to secure the build plate to the elevator. There is a possibility of zinc fumes being emitted and the screws becoming brittle when the build plate is heated before the build commences.

11. Insert four M5 screws and tighten to between 3 Nm (2.2 lbf/ft) and 5 Nm (3.7 lbf/ft) using a 4 mm (0.15 in) hexagon key and a suitable torque wrench. Tighten opposing corners in pairs.

12. Close the top door.

13. From either the maximised or minimised view of the Elevator pane, send the elevator to the top of the Z-axis by pressing the Build Plate Top button (Figure 102).

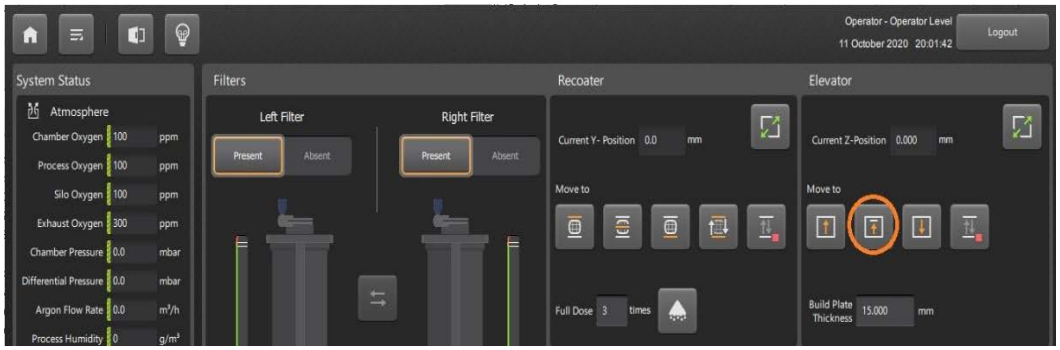


Figure 102 Build Plate Top button

14. With the build plate at the top position, from the maximised view of the Elevator pane, select the Move by button (Figure 103).

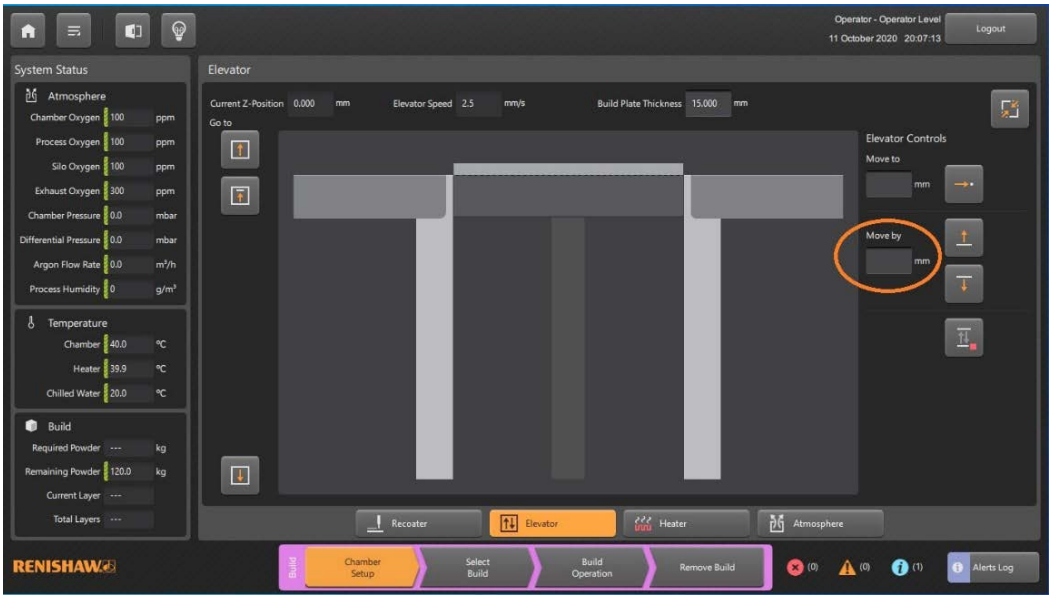


Figure 103 Move by button

15. This will open a keypad dialog box (Figure 104). Enter a value of 0.5 mm (0.02 in) and select the downwards arrow button to move the elevator down by the amount entered (Figure 104).

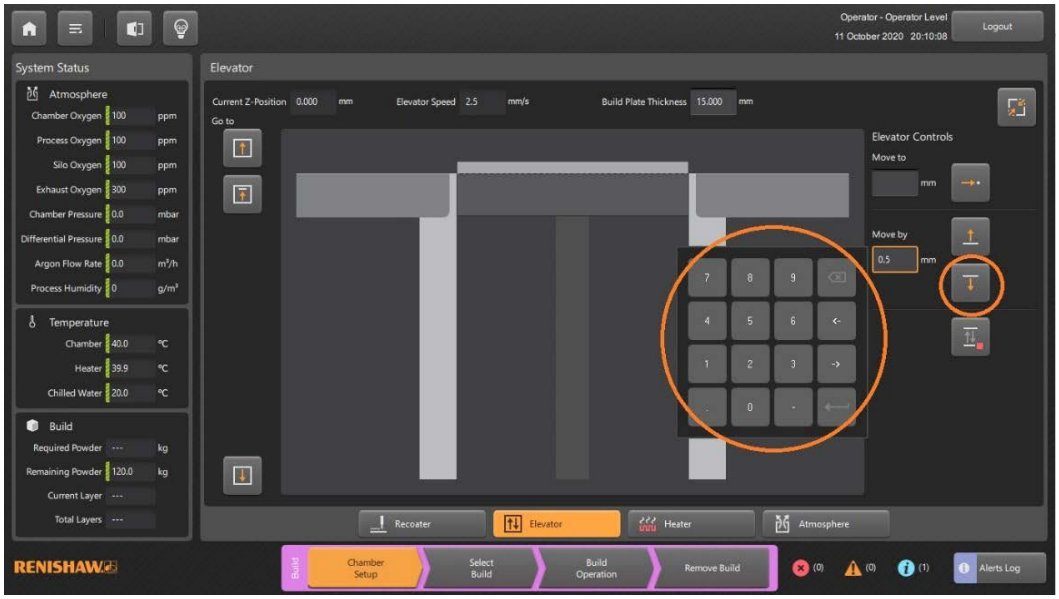


Figure 104 Move by keypad dialog box and downwards arrow button

16. The build plate installation is now complete.

8.1.11 AB-009 – Recoater blade – Install

NOTE: The recoater assembly is made from three pieces of aluminium alloy. Two pieces, complete with the silicone recoater blade, form the recoater blade assembly, and the third piece is the recoater carrier.

1. Open the top door.

2. On the recoater assembly, twist the two thumbscrews – one on the left-hand end and one on the right-hand end of the recoater – a quarter turn so that the handles point upwards, and separate the recoater blade assembly from the recoater carrier (Figure 105). If a new recoater blade has already been installed, skip the remaining steps and proceed to task “AB-010 – Recoater assembly – Install”.

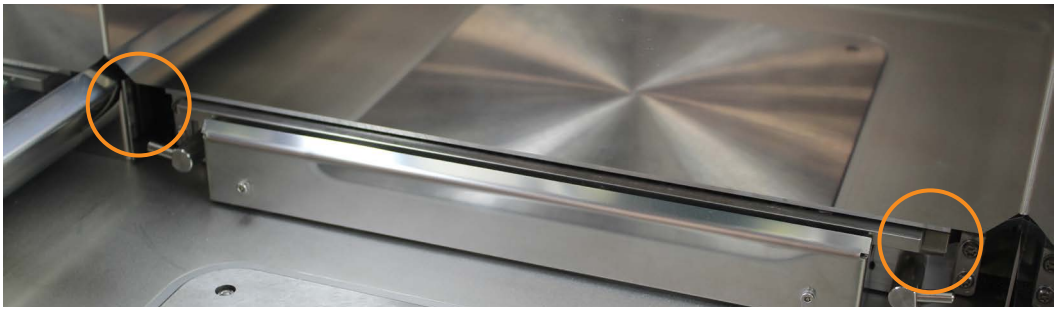


Figure 105 Recoater assembly two thumbscrews, left-hand and right-hand sides

3. The two halves of the recoater blade assembly are secured together with M4 cap screws. Loosen the five M4 cap screws along the entire length of the recoater blade assembly and remove and discard the used recoater blade.

4. A replacement silicone recoater blade is available from your local Renishaw office (Renishaw part no. A-5771-0025).

5. Measure a length of silicone recoater blade to 259 mm ±1 mm (10.15 in to 10.23 in) using a suitable measuring device (Figure 106).



Figure 106 Measure the silicone recoater blade

6. Cut the silicone recoater blade using a pneumatic pipe cutter or scalpel (Figure 107).

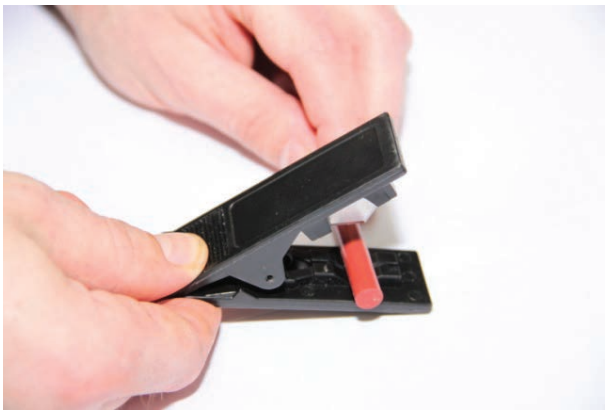


Figure 107 Cut the silicone recoater blade

7. Check the cut length of recoater blade against the recoater blade assembly – it should just fit in the chamfer (Figure 108). If it is too long, it will deform, so re-cut it.

NOTE: An oversize recoater blade can distort in the recoater assembly and this can give a poor powder surface and lead to a failed build.

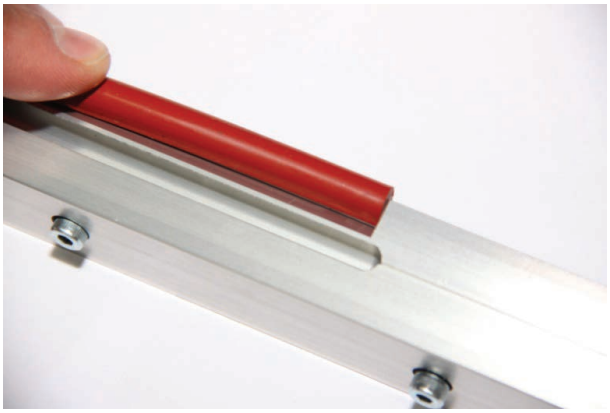


Figure 108 Gauge the length of the cut recoater blade

8. Unscrew the bolts until the head is proud of the recoater blade assembly, but do not remove them completely (Figure 109 and Figure 110).

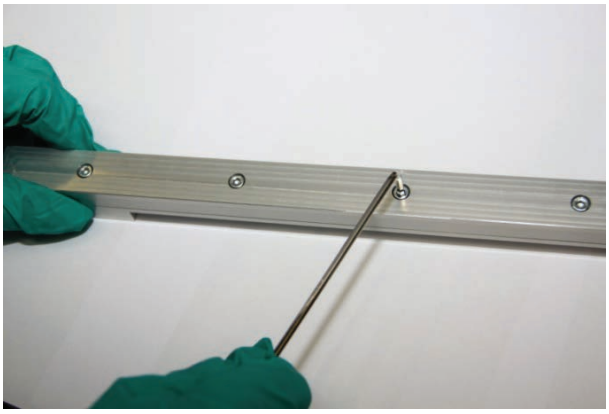


Figure 109 Loosen the bolts in the recoater blade assembly



Figure 110 Bolt head proud of the recoater blade assembly

9. Insert the cut length of silicone recoater blade into the recoater blade assembly (Figure 111).



Figure 111 Insert silicone recoater blade into recoater blade assembly

10. Check the gap left at both ends of the silicone recoater blade – it should not pass the start of the radius (arrowed) on the recoater blade assembly (Figure 112 and Figure 113).

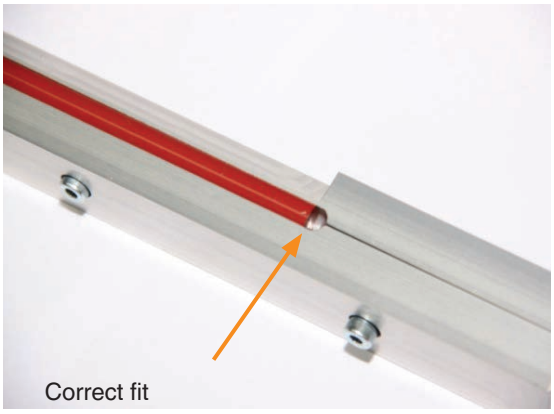


Figure 112 Correct alignment of silicone recoater blade end with recoater blade assembly

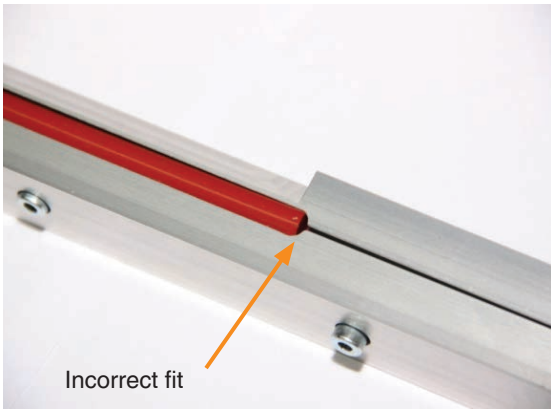


Figure 113 Incorrect alignment of silicone recoater blade end with recoater blade assembly

11. Place the recoater blade assembly on a flat surface such as a surface table. Press down firmly on the reverse side of the recoater housing. Starting at the centre, tighten the five M4 cap screws using a 3 mm (0.11 in) hexagon key and a suitable torque wrench. Tighten to a maximum of 2 Nm (1.5 lbf/ft). Do not overtighten (Figure 114).



Figure 114 Tighten the bolts and clamp the silicone recoater blade into the recoater blade assembly

8.1.12 AB-010 – Recoater assembly – Install

1. Ensure that the build plate thickness has been entered and that the build plate is at the top position.
2. Close the top door.

NOTE: The recoater is interlocked to the top door and will not move while the top door is open.

3. From either the maximised or minimised view of the Recoater pane, send the recoater to the rear of the build chamber by selecting the Send recoater to rear of chamber button (Figure 115).



Figure 115 Send recoater to rear of chamber button

4. Open the top door.
5. Offer up the recoater assembly to the recoater carrier. The recoater assembly locates on the front of the recoater carrier. The thumbscrews should point up to engage with the carrier.
6. Secure the recoater assembly to the recoater carrier by pushing and turning the two thumbscrews a quarter of a turn. There is one thumbscrew on the left-hand end and one on the right-hand end of the recoater (Figure 116 and Figure 117).



Figure 116 Recoater assembly two thumbscrews

NOTE: The recoater blade height is not adjustable and is fixed via the kinematic mounting (thumbscrews) to provide a consistent repeatable relationship between the optical system and the powder bed.

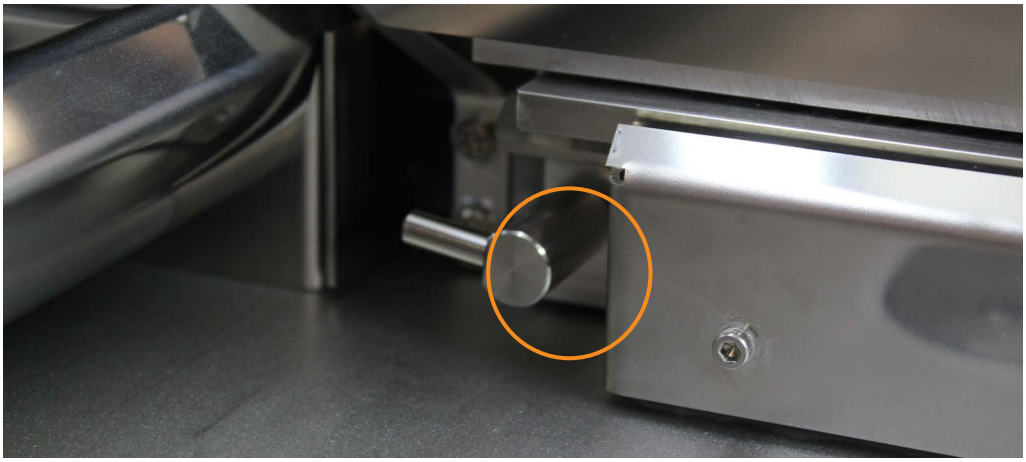


Figure 117 Recoater assembly thumbscrew

7. Close the top door.
8. The recoater assembly is now installed.

8.1.13 AB-011 – Load hopper – Fill (RenAM 500 and RenAM 500 Ultra only)

WARNING: Before starting this task, ensure you are wearing the correct PPE: eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and cotton or fire-retardant overalls with full-length sleeves (made of static-dissipative material).

WARNING: Do not load powder directly from the supplier's container into the RenAM 500 / RenAM 500 Ultra load hopper. Powder must first be decanted into a powder flask to minimise the risk of spillage.

NOTE: Ensure there is a minimum of four full flasks of powder in the RenAM 500 / RenAM 500 Ultra system before starting the build process. Each full powder flask is approximately 5% of the load hopper capacity. The load hopper can be filled while the build process is running – but not during task "AB-014 – Build chamber atmosphere – Set up". The load hopper fill level can be viewed in the System Status panel on any screen, under Remaining Powder, displayed in kilograms. The full hopper powder weight is displayed on the Build Operation Monitoring page and the System Controls Recirculation page.

1. Ensure the four powder flasks are filled from supplier's containers, in accordance with task "OT-003 – Powder flask – Fill".

2. Remove the quick-release clamp securing the blanking plate to the load hopper filling point isolation valve (Figure 118).

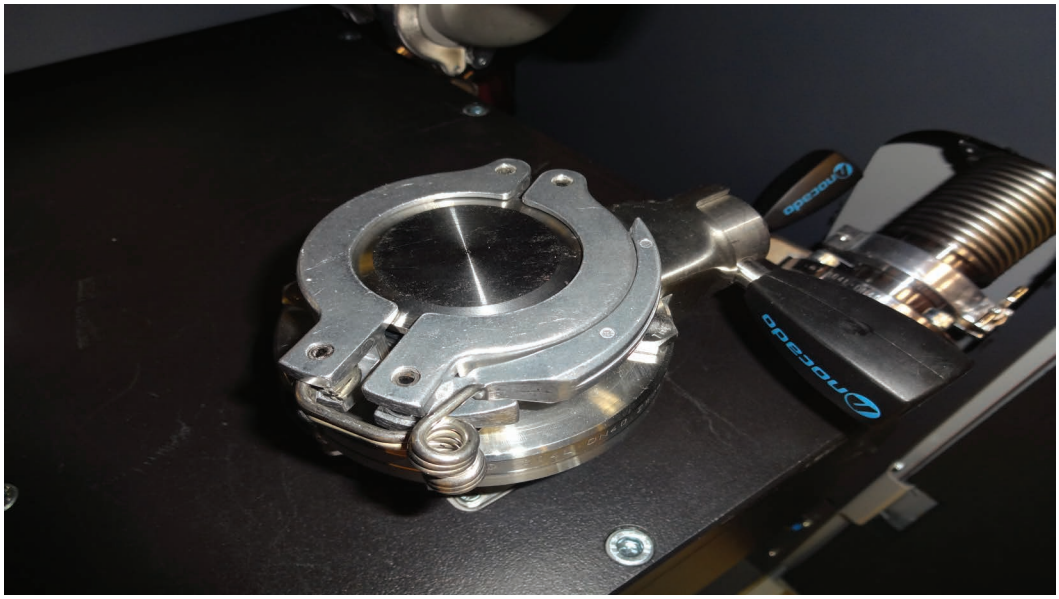


Figure 118 Quick-release clamp and blanking plate fitted to load hopper filling point isolation valve

3. Place a clean centring ring on the KF40 flange of the load hopper filling point isolation valve (Figure 119).

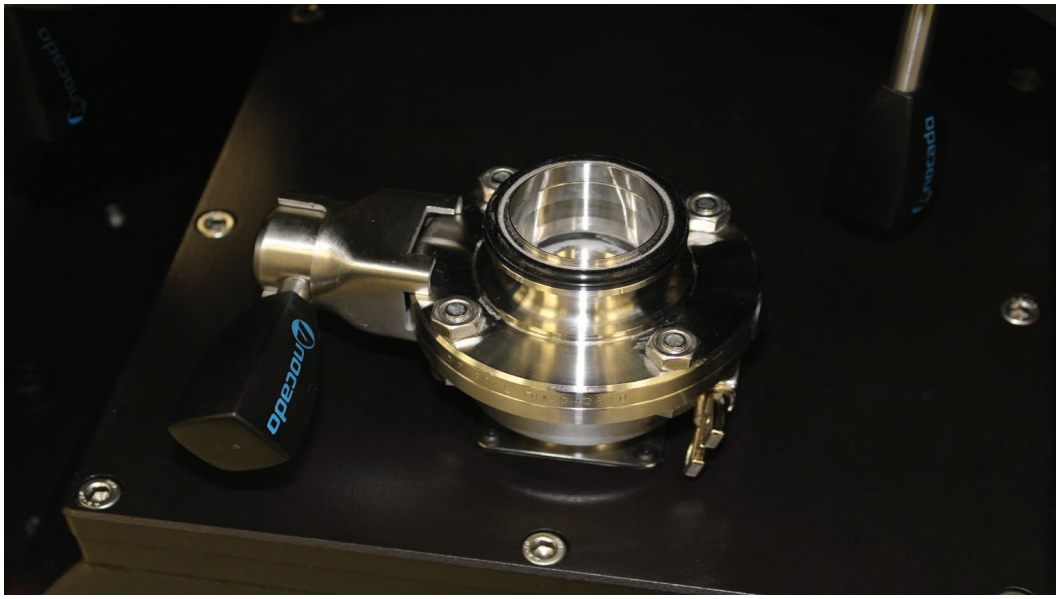


Figure 119 Centring ring on KF flange and load hopper filling point isolation valve closed

4. Ensure that the powder flask isolation valve and load hopper filling point isolation valve are both in the closed position (handle perpendicular to the direction of flow).
5. Place the powder flask on top of the centring ring on the KF40 flange. Slide half the collar of the quick-release clamp over the edge of the flanges.
6. Close the second half of the quick-release clamp, attach the spring-loaded lever and close the quick-release clamp.
7. Open the isolation valve on the powder flask first, and then open the isolation valve on the load hopper filling point.
8. Wait until the powder flask has emptied into the load hopper. Check by tapping the powder flask gently.
9. Close the isolation valve on the powder flask first, and then close the isolation valve on the load hopper.
10. Remove the quick-release clamp and remove the empty powder flask from the system.
11. Repeat the process for the remaining powder flasks until there is sufficient metal powder in the RenAM 500 / RenAM 500 Ultra system.

12. Place a clean centring ring on the KF40 flange of the load hopper filling point isolation valve and refit a blanking plate. Secure with a quick-release clamp (Figure 120).

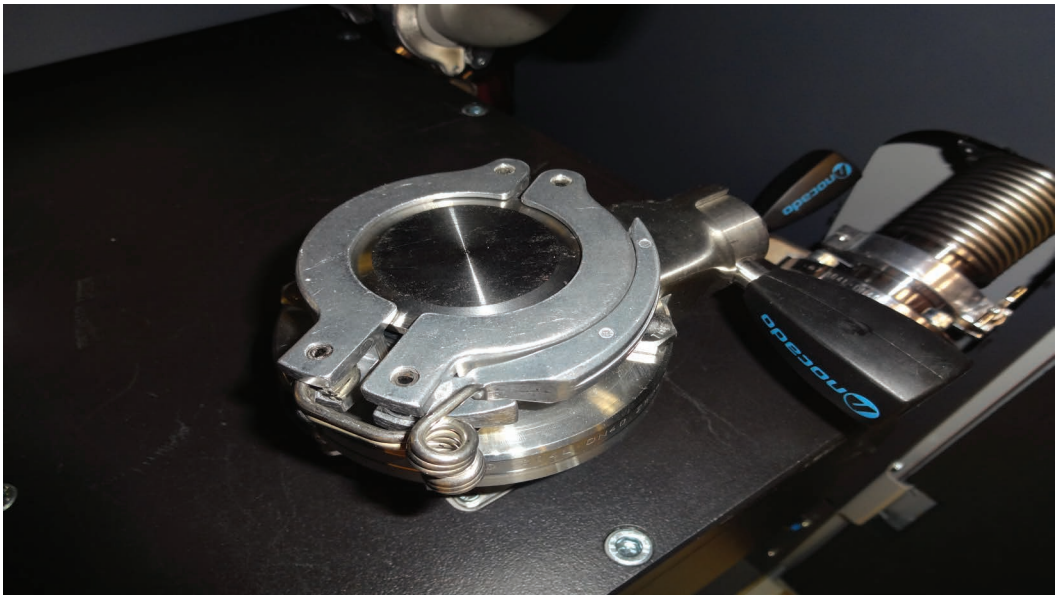


Figure 120 Quick-release clamp and blanking plate fitted to load hopper filling point isolation valve

8.1.14 AB-012 – Valves – Set up (RenAM 500 and RenAM 500 Ultra only)

1. On the RenAM 500 / RenAM 500 Ultra, behind the left-hand door, check that the following valves are in the correct position:

CAUTION: This step does not apply to RenAM 500 series systems equipped with the external Long-Life Filter system. For more information, see section 7.10, “Long-Life Filter (optional)”.

- Large SafeChange filter upper isolation valves (2 off) are open (1 and 2) (Figure 121) – valves in line with pipework.
- Oversized particle collection point blanking plate (3) is fitted and secured with a quick-release clamp (Figure 121).

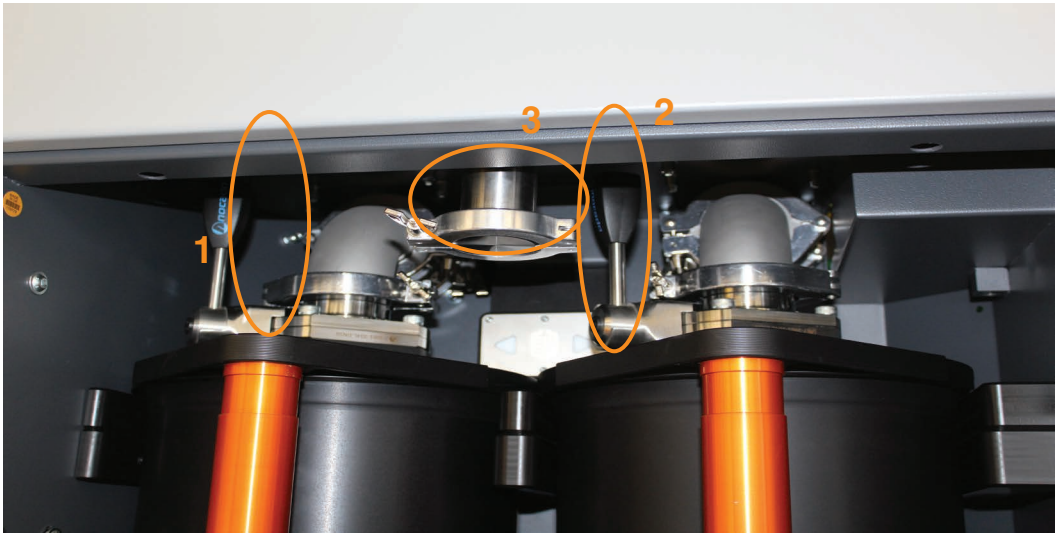


Figure 121 Large SafeChange filter upper valves (1 and 2) and oversized particle collection flask (3) valves

CAUTION: This step does not apply to RenAM 500 series systems equipped with the external Long-Life Filter system. For more information, see section 7.10, “Long-Life Filter (optional)”.

- Large SafeChange filter lower isolation valves (2 off) are open (4 and 5) (Figure 122) – valves in line with pipework.
- Load hopper filling point isolation valve is closed (6) (Figure 122) – valve at 90° to the pipework.
- Powder overflow return valves (2 off) are open (7 and 8) (Figure 122) – valves in line with pipework.

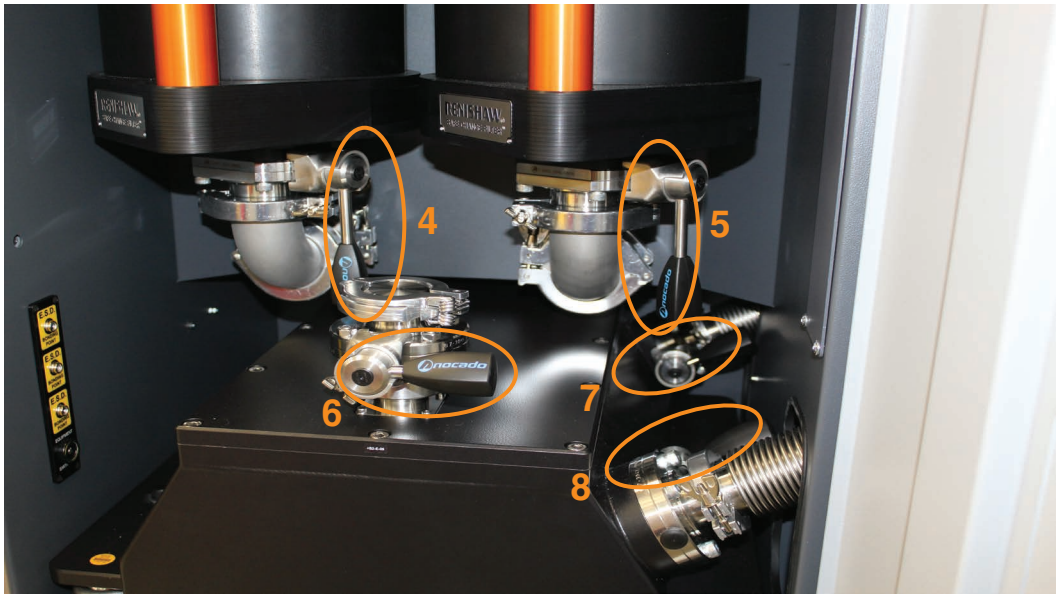


Figure 122 Large SafeChange filter lower isolation, load hopper filling point isolation and powder overflow return valves

- Sieve inlet valves (2 off) (9 and 10), large gas inlet valves (2 off) (11 and 12) and large gas outlet valves (2 off) (13 and 14) are open (Figure 123).

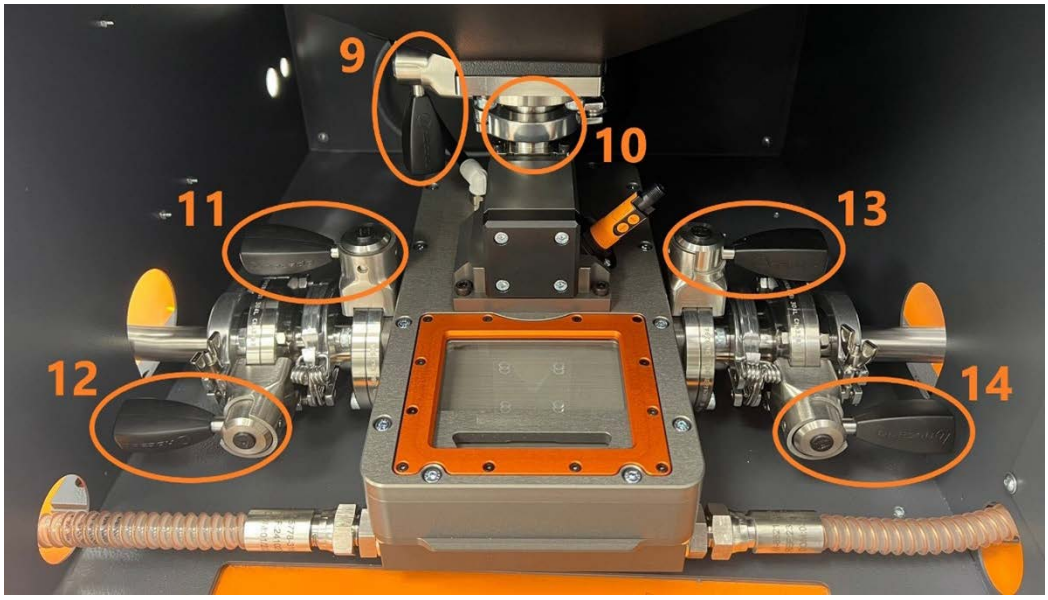


Figure 123 Sieve and gas inlet and outlet valves

8.1.15 AB-013 – Build platform heat soak process – Set up

NOTE: The use of the build platform heater is guided by the choice of material. It can aid material flow and assist the processing of some materials.

NOTE: At build chamber temperatures above 60 °C (140 °F), the top door remains interlocked and cannot be opened.

WARNING: It is possible to access the build chamber via the glovebox while the heater is switched on. Always check the temperature of the heater using the touch screen control panel before opening the glovebox door. When the glovebox door is open, proceed with caution.

1. From either the maximised or minimised view of the Heater pane, select Target temperature. This will open a keypad dialog box (Figure 124).

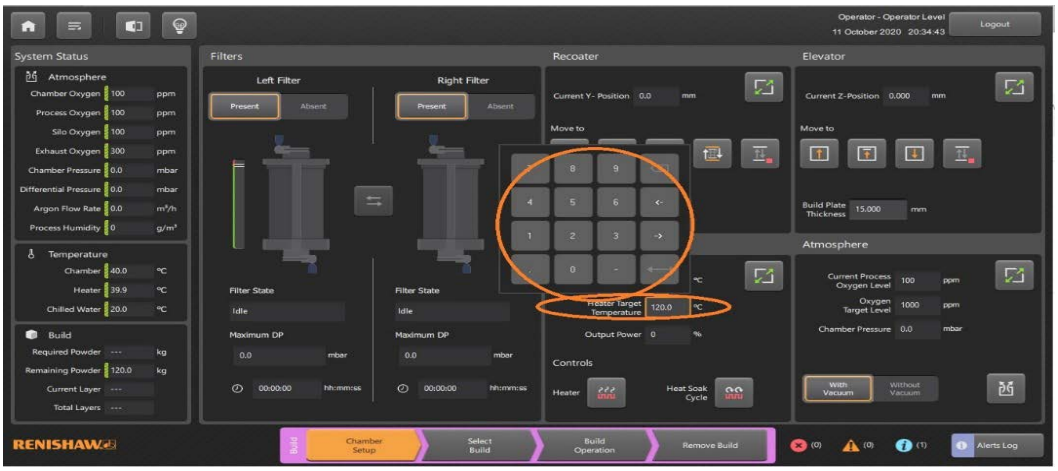


Figure 124 Target temperature button and keypad

2. Using the keypad (Figure 124) enter the required material temperature for the heat soak. Refer to the material parameters file supplied with the metal powder you have purchased for the specific temperature to be used for heat soak.

3. From either the maximised or minimised view of the Heater pane (Figure 125), select the Start the heat soak button to start the heat soak process.



Figure 125 Start the heat soak button

4. The heat soak process will take at least one hour depending upon the starting temperature – this is to allow an even temperature throughout the build chamber.

8.1.16 AB-014 – Build chamber atmosphere – Set up

1. From either the maximised or minimised view of the Atmosphere pane, check the Oxygen Target Level.

2. The Oxygen Target Level is 1 000 ppm (0.1%) (Figure 126).



Figure 126 Oxygen Target Level

3. From the Chamber Setup page, go to Filters (Figure 127).



Figure 127 Filters

CAUTION: This step does not apply to RenAM 500 series systems equipped with the external Long-Life Filter system. For more information, see section 7.10, “Long-Life Filter (optional)”.

4. The Filters pane (Figure 128) enables you to set the presence of the two large SafeChange filters. On Filters 1 and 2 use the toggle switches and set the filters to Present.



Figure 128 Filters pane

5. From the Chamber Setup screen Atmosphere pane (Figure 129), ensure the With/Without Vacuum switch is set to With Vacuum. Select the Generate Chamber Atmosphere button to begin generating the inert atmosphere in the build chamber.

CAUTION: Avoid opening or closing any valves during chamber preparation as it may cause damage to the machine.

NOTE: You will not be able to select Without Vacuum unless three of the oxygen sensors are below 1.1%.



Figure 129 Atmosphere pane, With/Without vacuum and Generate chamber atmosphere button

6. When the oxygen level reaches 1 000 ppm (0.1%) the chamber is ready for a build.

7. Check that the Current Heater Temperature and Heater Target Temperature are reading the same (Figure 127).

8.1.17 AB-015 – Powder dose – Set up

1. From either the maximised or minimised view of the Recoater pane, set the number of doses to 3 and dose the build plate (Figure 130).

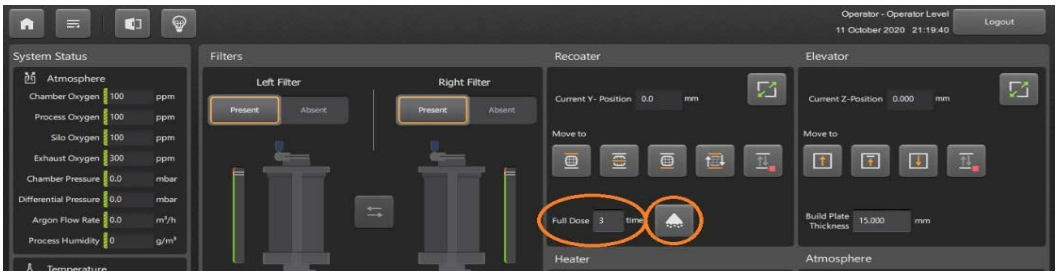


Figure 130 Number of doses and Dosing button

2. From either the maximised or minimised view of the Recoater pane, select the Move to front and then rear button (Figure 131).



Figure 131 Move to front and then rear button

3. Observe the recoater travelling across the build plate. The aim of the dosing process is to create a first layer that is an even dusting across the entire build plate (Figure 132).

NOTE: It is unlikely that the first layer will dose correctly.

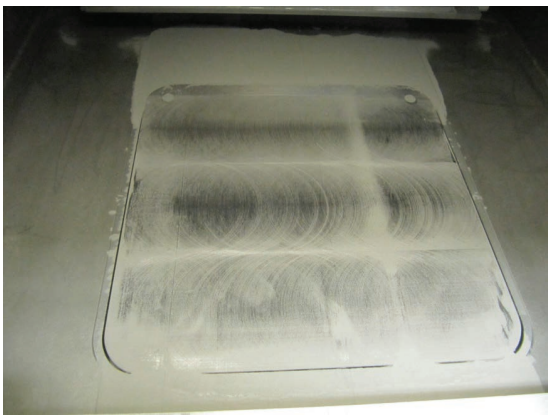


Figure 132 First powder layer on build plate

4. If the layer is not an even dusting, from the maximised view of the Elevator pane, select the Move by edit box (Figure 133).

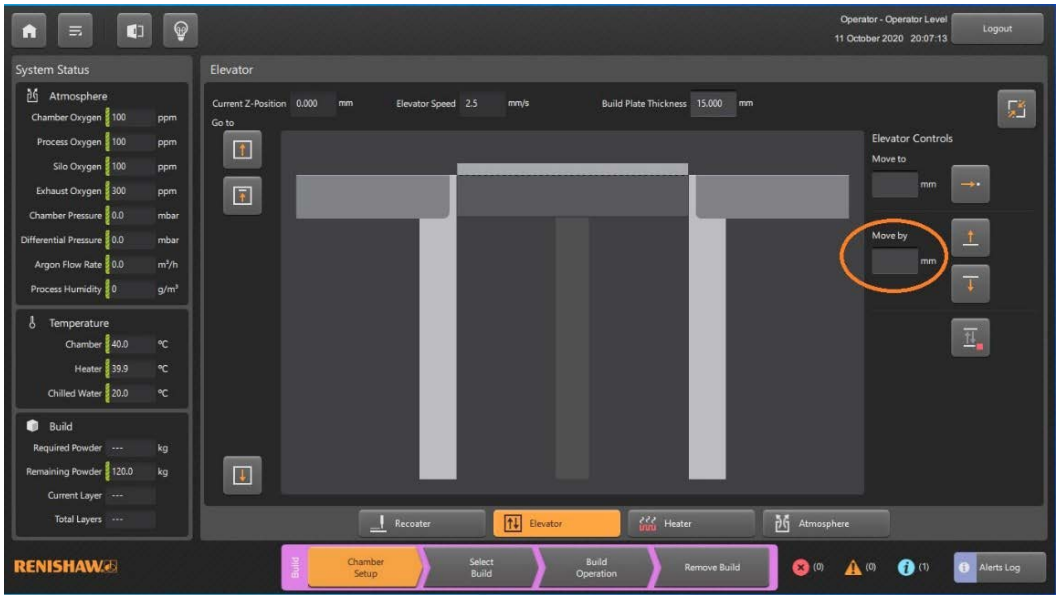


Figure 133 Move By edit box

5. This will open a keypad dialog box (Figure 134). Enter a value of 0.1 mm (0.004 in) and select the upwards button to move the elevator up by the amount entered (Figure 134).

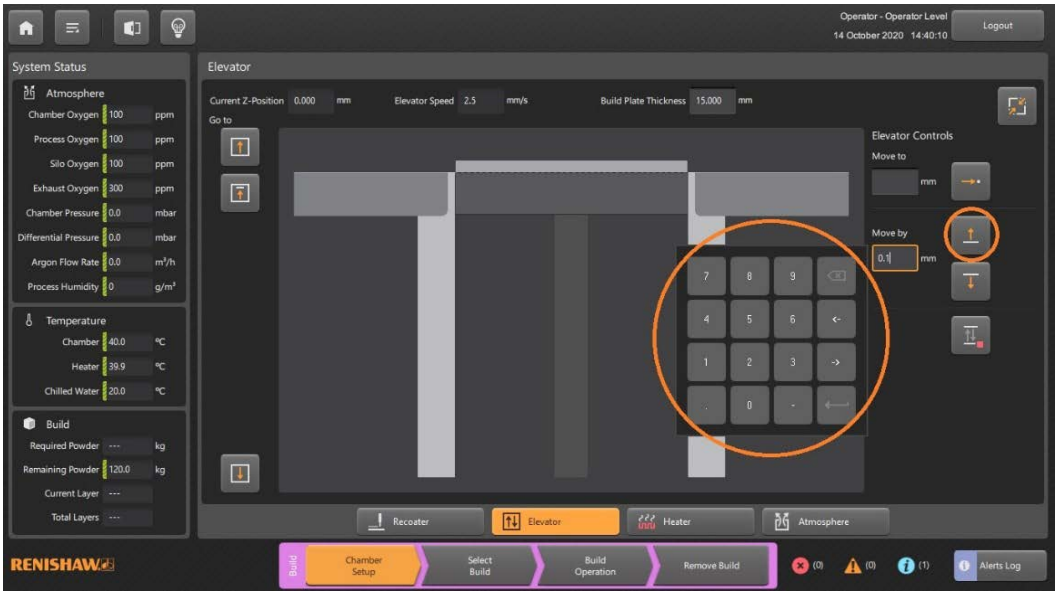


Figure 134 Move by keypad dialog box and upwards arrow button

6. From either the maximised or minimised view of the Recoater pane, set the number of doses to 3 and dose the build plate (Figure 130).

7. From either the maximised or minimised view of the Recoater pane, select the Move to front and then rear button (Figure 131).

8. Observe the recoater travelling across the build plate. The aim of the dosing process is to create a first layer that is an even dusting across the build plate (Figure 135).

9. Repeat steps 4 to 8 until there is a first layer that is an even dusting across the entire build plate (Figure 135).

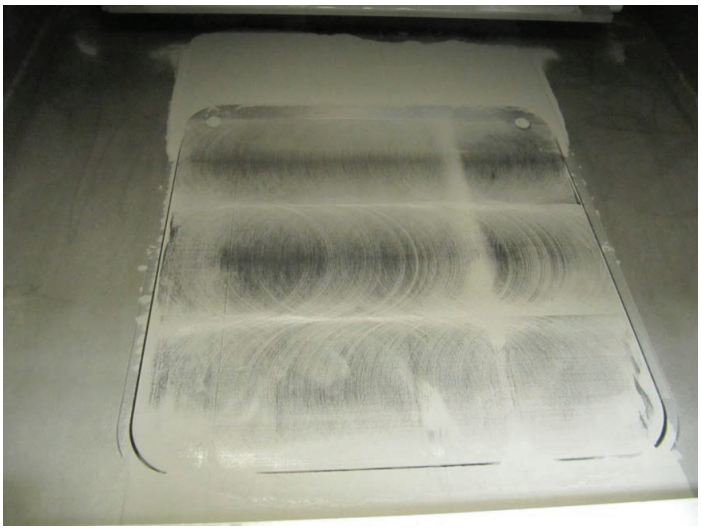


Figure 135 First powder layer on build plate

8.1.18 AB-016 – Build file – Transfer

To perform a build file transfer from an external computer to a RenAM 500 series system, you must transfer the build files to the system folder: **D:\AMResources\Builds** using File Transfer Protocol (FTP) and/or Server Message Block (SMB) protocol (also known as Windows file share). For more information on transferring files, refer to section 8.8, “Transferring files”.

To enable or disable FTP or SMB file transfer capabilities using RenAMP, refer to Section 8.7.2, “TT-009 – File transfer settings”. Either one or both of the settings must be active at any time.

NOTE: A Renishaw service engineer will install and configure the build file transfer services when the RenAM 500 series system is installed and commissioned.

8.1.19 AB-017 – Build file – Select

‘Select Build’ is the second stage of build preparation. This stage displays a build file table on the left side and a preview segment on the right side of the pane.

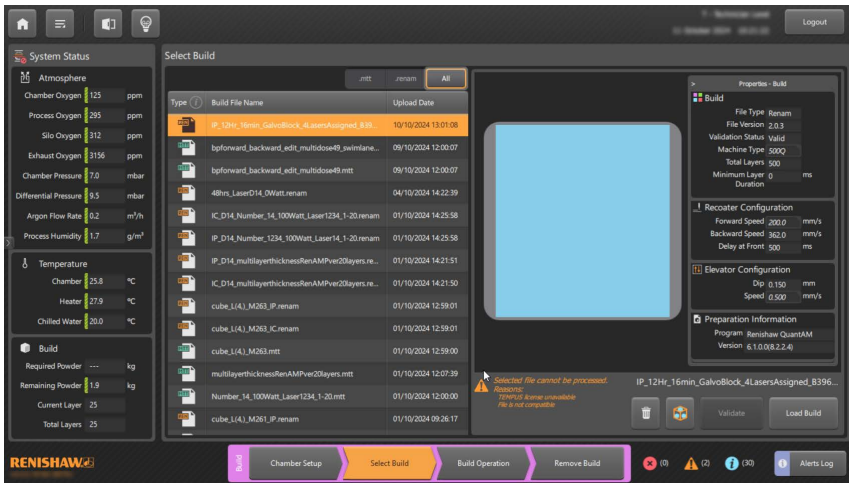


Figure 136 Select Build page

All the build files transferred from an external computer to the RenAM 500 series are listed in the table along with the corresponding build file status, file type, file name, and upload date and time. You can use the filter buttons available on the top of the build file table to visualise only a desired build file type or all build files. Each build file type and its status are represented with a different icon in the ‘Type’ column of the build file table. The icons and their description can be viewed by clicking the information button in the ‘Type’ column header.

The preview segment on the right-hand side displays the preview of the selected build file and provides an overview of errors if the selected build file is invalid. You can tap anywhere on the ‘Properties - Build’ bar to view the properties of the selected build file in the flyout menu. Additionally, the preview segment provides you the buttons to delete, show extends, validate and load a build.

NOTE: A build file is compatible with a RenAM 500 series machine only if all the lasers assigned in the build file are installed on the machine.

NOTE: If there are parts in the build file that do not have an assigned laser, the system will automatically assign the highest available laser to these parts. For example, on a RenAM 500Q machine, if a build file with four parts has lasers L1, L2, and L3 assigned to three parts and one part is unassigned, the system will assign the highest laser, L4, to the fourth part.

NOTE: You will not be able to load a renam build file if RenAMP is in RBV mode.

NOTE: If TEMPUS technology is not enabled on your RenAM 500 series system, you will not be able to load a renam build file. To enable TEMPUS technology on your RenAM 500 series system, contact Renishaw service. For the contact details of your local Renishaw office, see section 12, “Customer support”.

1. From the Chamber Setup screen (Figure 137), select Select Build.

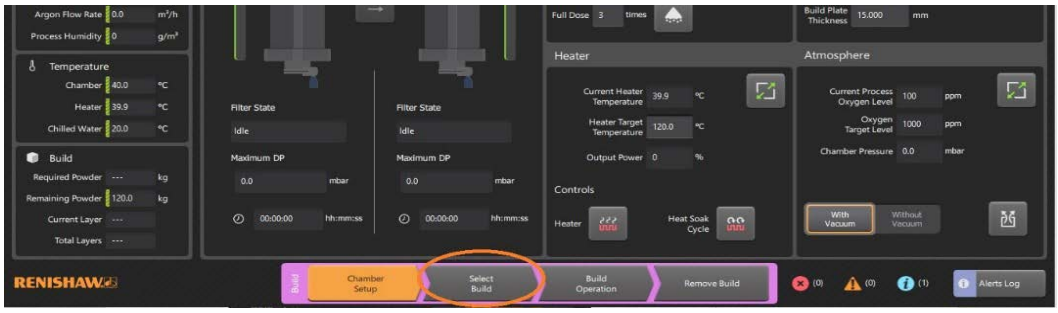


Figure 137 Chamber Setup screen Select Build button

2. Select the required build file from the build file table on the left-hand pane and press the ‘Validate’ button. The validation processing activity is indicated by a progress bar under the build file name.

NOTE: You can skip the validation if you want to start the build operation at your own risk.

NOTE: In the event of build validation failure, a summary of errors will be displayed at the bottom of the preview tab.

NOTE: Any parts that are positioned outside the substrate or over the bolt holes will highlight the substrate in red. These parts cannot be built until they are moved to buildable areas of the substrate.

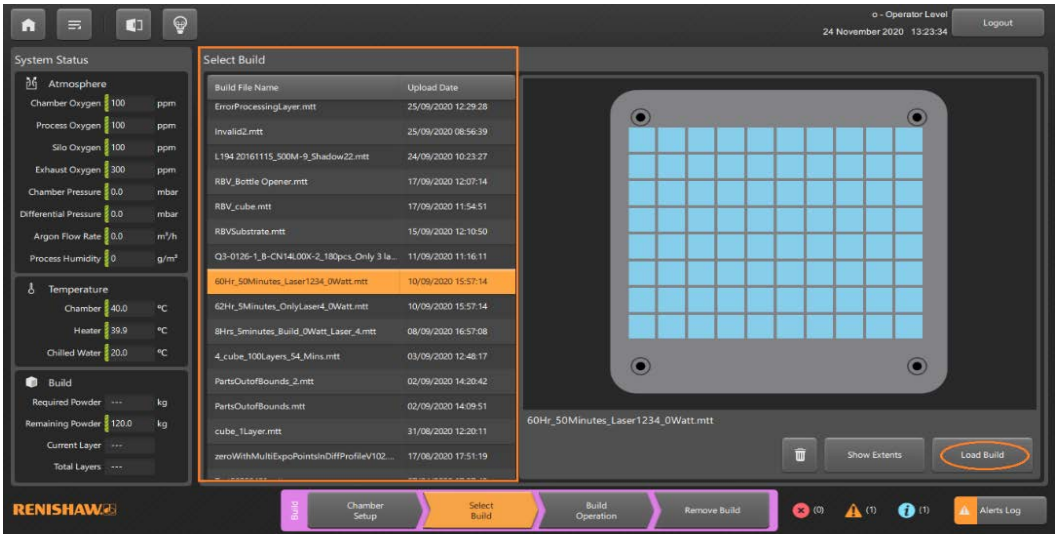


Figure 138 Select Build screen Load Build button

CAUTION: Ensure the build file is loaded every time, even when running the same build multiple times.

3. Once the build is successfully validated, select the ‘Load Build’ button.

8.1.20 AB-018 – Suppress part

This is an optional operation which is available for cases where the operator wants to omit some of the parts from the build file. This can also be done during the build. Reasons can include the following:

- A part has started to fail during the build.
- A part from the build file always fails.
- Out of x number of parts, only a few parts are to be built and so instead of creating a new build file the same build file can be used.

NOTE: When using an mtt build file, suppressing a part during the build process will stop the machine from building the suppressed part immediately. This will reduce the remaining build time by the time taken to build the remainder of the suppressed parts.

NOTE: For renam build files, suppressing a part during the build process will stop the machine from building the selected part after 60 seconds of build time. Suppressing parts does not reduce the remaining build time for renam files. During the suppression, the lasers that would have fired on the suppressed part simply remain idle.

1. After the build is loaded, the screen automatically moves to the Build Operation page (Figure 139).

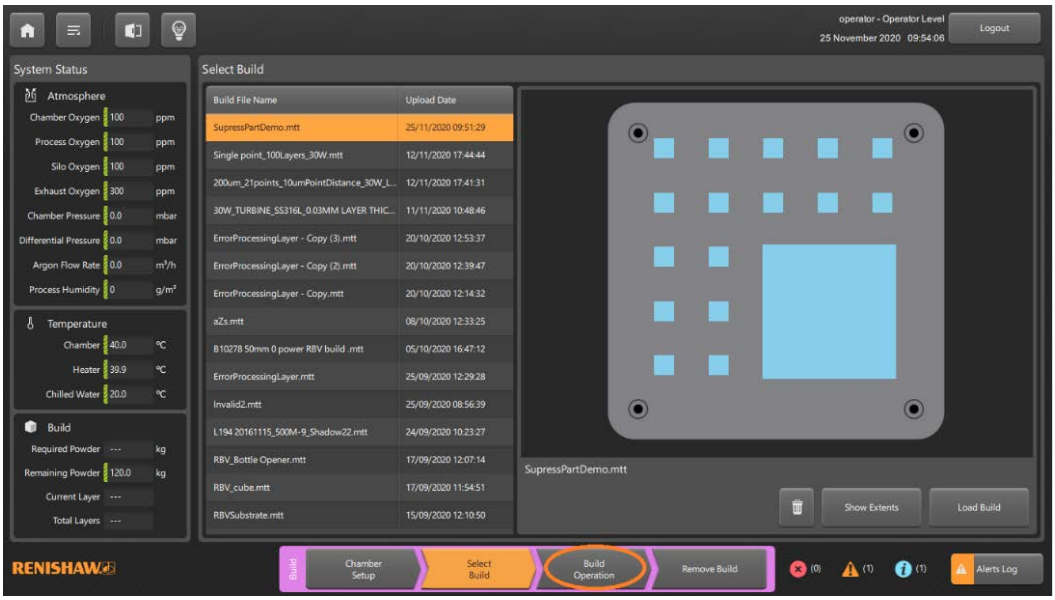


Figure 139 Select Build screen Load Build button

2. Press the Suppress Part button (circled) on the screen (Figure 140). The Suppress Part table can be seen as shown in Figure 140 below.

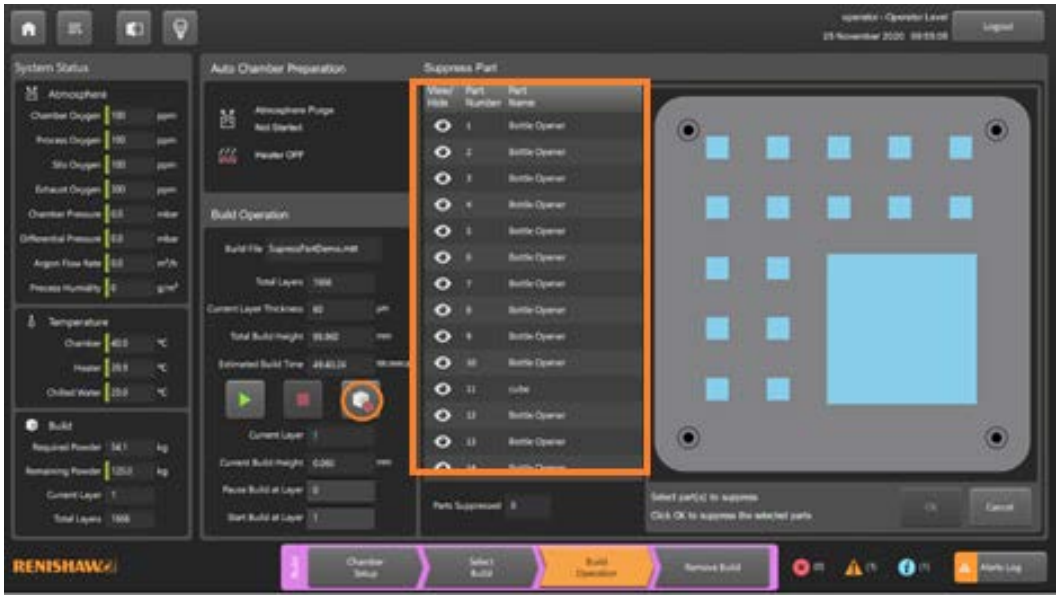


Figure 140 Suppress Part table

3. Selecting a part in the graphical view selects the corresponding part in the suppress part table, and vice versa.

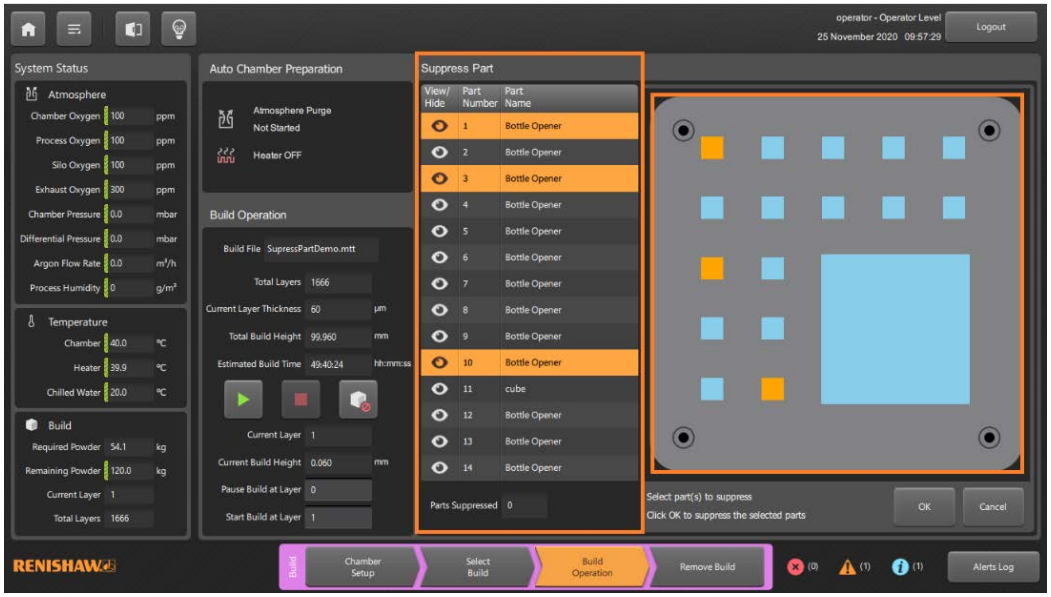


Figure 141 Selection of part from the table or from the graphics view

4. The View/Hide icon shown circled in Figure 142 below allows the operator to toggle hiding a part to allow you to view another part that had been obscured.

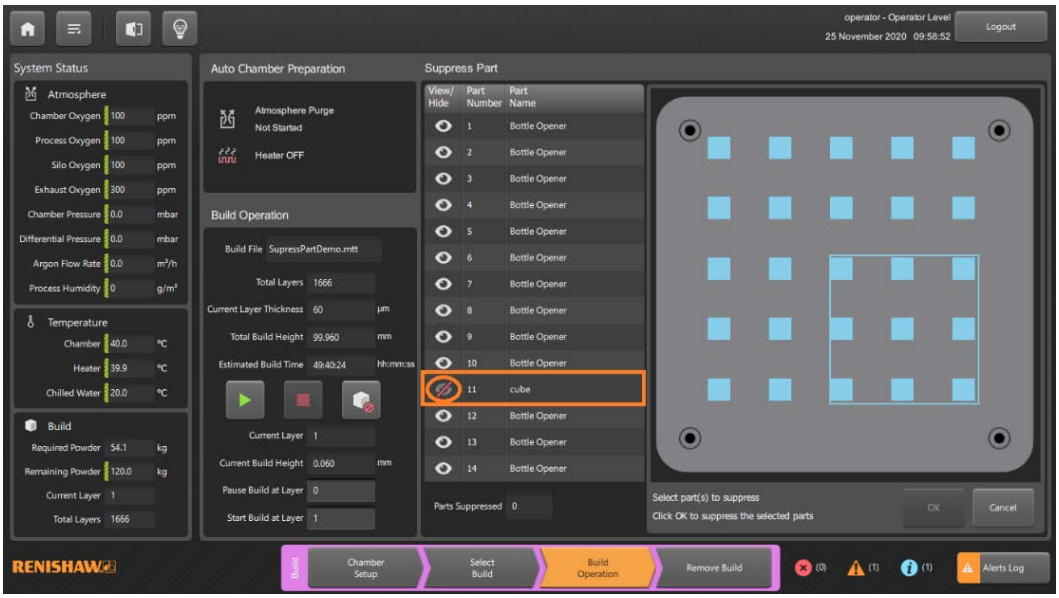


Figure 142 Hide/View toggle

5. Select OK (circled) to suppress the selected parts (Figure 143). A dialog box will then appear asking you to confirm your selection (Figure 144).

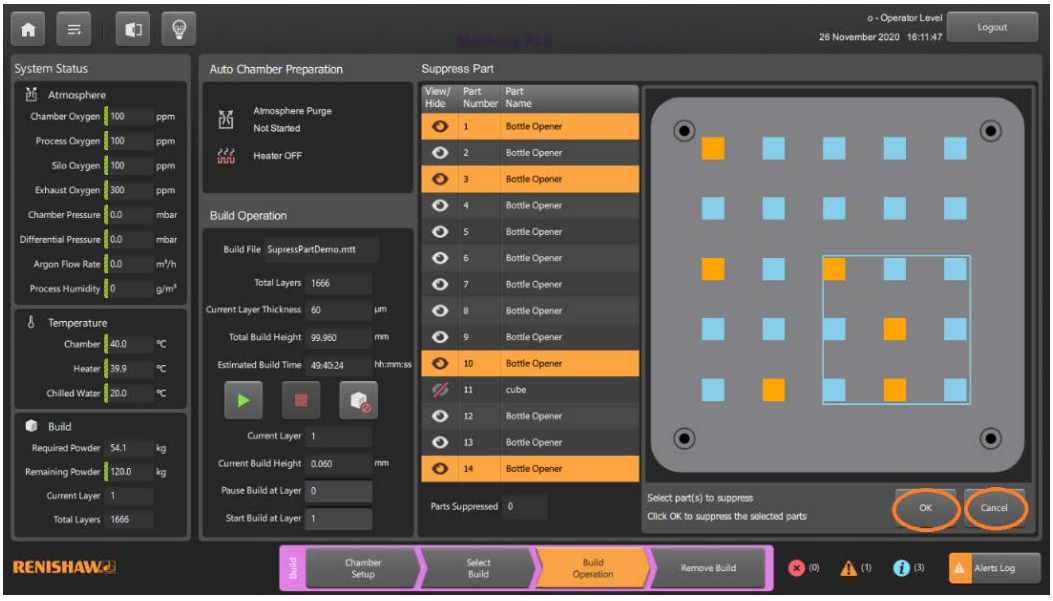


Figure 143 Selecting parts to suppress

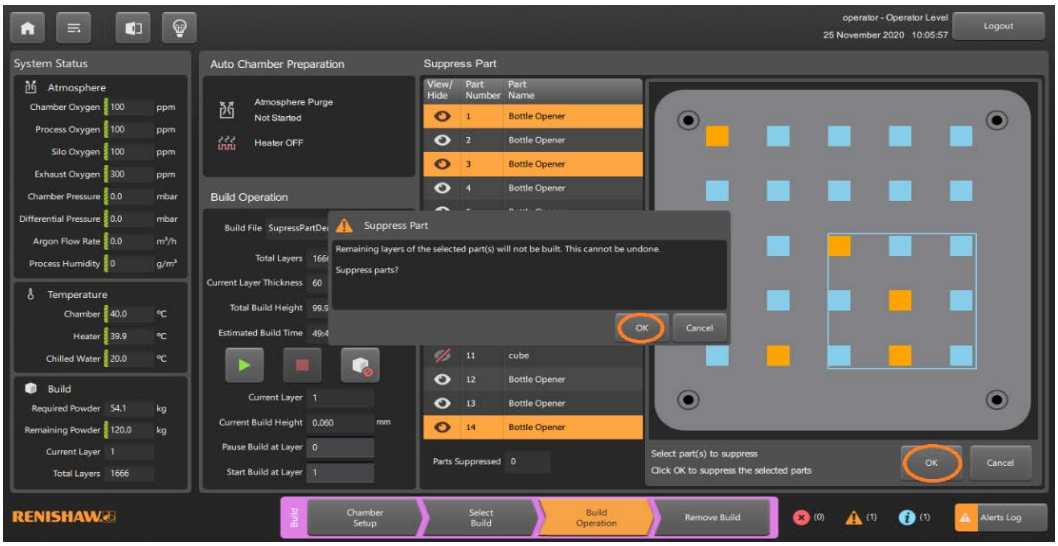


Figure 144 Confirmation of the suppressed parts

6. Selecting OK on the confirmation dialog box (Figure 144) brings the suppress part task to an end and the screen displays the suppressed parts in a different colour from the available ones (Figure 145). Selecting Cancel on the confirmation dialog box retains the choice of parts to suppress, but does not apply it.

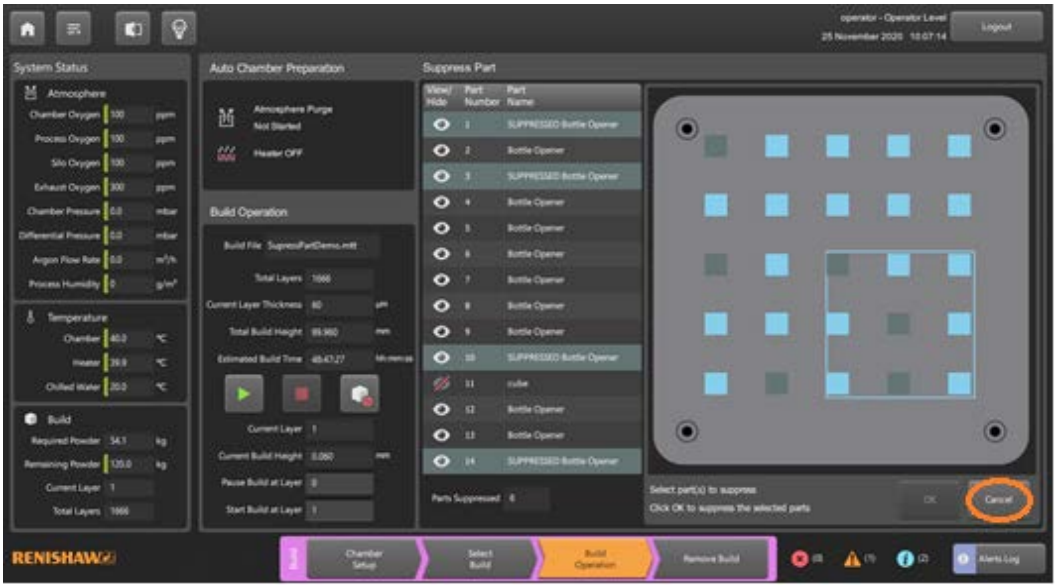


Figure 145 Part suppression complete

7. Once part suppression is complete, click the Cancel button (circled on Figure 145 above) to return to the build monitoring pages.

NOTE: Once a part is confirmed as suppressed, it cannot be unsuppressed without reloading the build.

NOTE: A part can be suppressed at any time during the build. The suppression will take effect the next time a layer is loaded (due to layer caching, this might take two layers). However, once all layers of a part are built, that part cannot be suppressed.

8.1.21 AB-019 – Cyclone particle collection flask – Fit

The cyclone filters out particles from the gas flow system that do not meet the physical criteria for use within the RenAM 500 series system.

The cyclone particle collection flask is located in the rear right cupboard behind the door.

WARNING: Ensure the cyclone particle collection flask is completely empty before it is attached to the RenAM 500 series system.

WARNING: Ensure you are wearing the correct PPE: ESD safety footwear, eye protection, full face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

1. Take a cyclone particle collection flask, fit a centring ring and an isolation valve and secure with a quick-release clamp. Ensure the isolation valve is closed. Fit a centring ring to the KF flange on the isolation valve fitted previously to the cyclone particle collection flask.
2. On the RenAM 500 series, remove the quick-release clamp securing the blanking plate to the cyclone particle outlet and remove the blanking plate.
3. Grip the neck of the cyclone particle collection flask and offer up to the KF flange on the isolation valve on the cyclone particle outlet on the RenAM 500 series system.
4. Open the plastic cover (Figure 146) and fit a quick-release clamp around the two KF40 flanges.
5. Close the quick-release clamp to secure the cyclone particle collection flask to the RenAM 500 series (Figure 146). The cover is spring-loaded and self-closes.

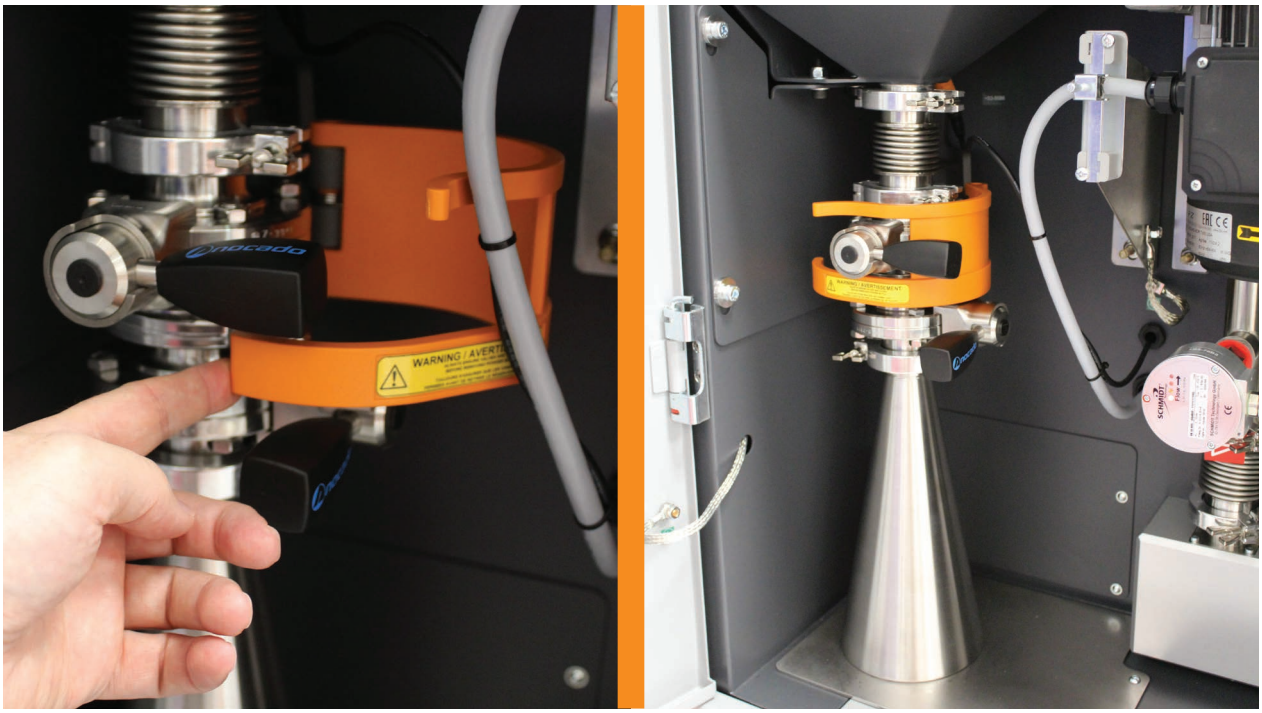


Figure 146 Cyclone filter particle collection flask – isolation valves plastic cover (left-hand) and isolation valves in the closed position (right-hand)

8.1.22 AB-020 – Pre-build checklist – Review (RenAM 500 and RenAM 500 Ultra only)

Before starting the build, check and confirm all the following steps have been completed.

Serial number	Equipment	Completed?
1	Check the chiller fluid level is between the L and H mark.	
2	Check the regulated argon gas pressure is correct.	
3	If using bottled argon gas, check there is sufficient gas pressure in the bottle.	
4	Check the chiller is running correctly.	
5	Check that there are two large SafeChange filters fitted.	
6	Log into RenAMP software using the touch screen control panel, open the top door and after 30 seconds confirm that the chamber pressure is zero.	
7	Check the system build chamber has been cleaned down.	
8	Check the bottom door is closed.	
9	Check that a suitable build plate has been installed and the thickness entered.	
10	Check that a recoater blade has been installed.	
11	Check the large SafeChange filter upper valves (2 off) are open.	
12	Check the oversize particle collection point blanking plate is fitted and secured with a quick-release clamp.	
13	Check the large SafeChange filter lower valves (2 off) are open.	
14	Check the powder overflow return valves (2 off) are open.	
15	Check the load hopper filling point valve is closed and a blanking plate is fitted and secured with a quick-release clamp.	
16	Check the sieve inlet valves (2 off) are open.	
17	Check the large gas inlet valves (2 off) are open.	
18	Check the large gas outlet valves (2 off) are open.	
19	Check the small gas inlet valves (2 off) are open.	
20	Check the small gas outlet valves (2 off) are open.	
21	Check that the heat soak procedure has completed.	
22	Check that the build chamber atmosphere set-up has completed.	
23	Dose the powder and check for even distribution.	
24	Check that a suitable build file has been selected and loaded.	
25	On the touch screen control panel, check the powder level in the load hopper is sufficient for the build.	
26	Check that the cyclone particle collection flask is fitted, is empty and the two isolation valves are open.	
27	Check that none of the beacon lights are on before starting the build.	
28	Start the build.	

8.1.23 AB-021 – Build – Start

1. From the Chamber Setup screen (Figure 147), select Build Operation. This will launch the Build Operation screen.



Figure 147 Chamber Setup screen

2. The Build Operation screen (Figure 148) allows you to view various parameters of the build such as Job Reference, Total Layers, Layer Thickness, Total Build Height, Current Layer, etc.

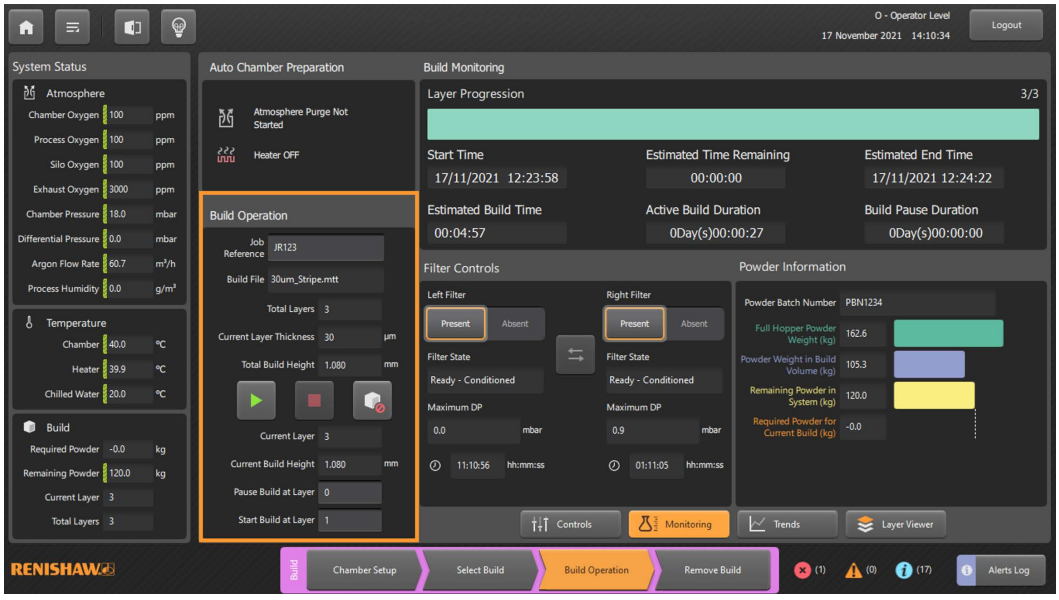


Figure 148 Build Operation screen

3. Provide a text value as Job Reference in the editable box in the Build Operation pane (highlighted in Figure 71). The job reference is used to quickly identify a build when searching within RenAMP. It is not mandatory to assign a job reference to each build, however, if a job reference is used, the text value must be entered before the start of the build. This value is cleared when a new build is loaded onto the AM machine.

4. The Powder Batch Number (circled in Figure 71) is an optional field that can only be edited by technician level or service level users. Using a powder batch number allows the user to easily trace the batch of powder used for each build, and should be changed when a different batch of powder is loaded into the RenAM 500 series hopper. The value entered persists across multiple builds until the value is changed within RenAMP.

NOTE: The text values entered for both the job reference and powder batch number cannot be changed once the build is in progress.

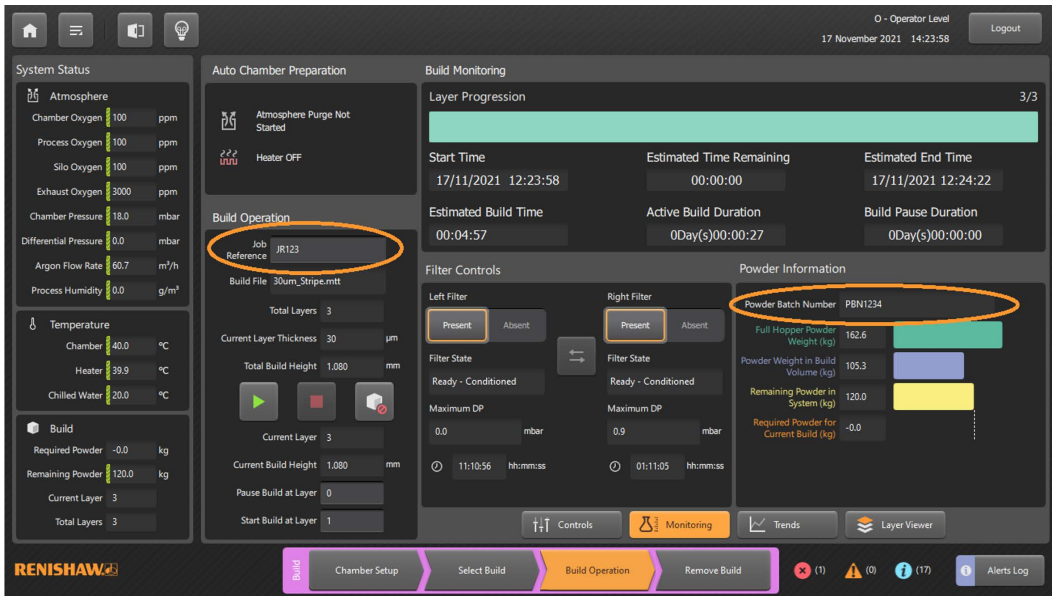


Figure 149 Job Reference and Powder Batch Number

5. The values of both the job reference and the powder batch number are shown in the build report under Build Summary and Machine Information respectively. Refer to task “PB-002 – Build report – View or generate” for how to generate a build report.

6. There are four tabs in the Build Operation screen (Figure 150) – Controls, Monitoring, Trends and Layer Viewer. They enable you to view and control various parameters of the build.

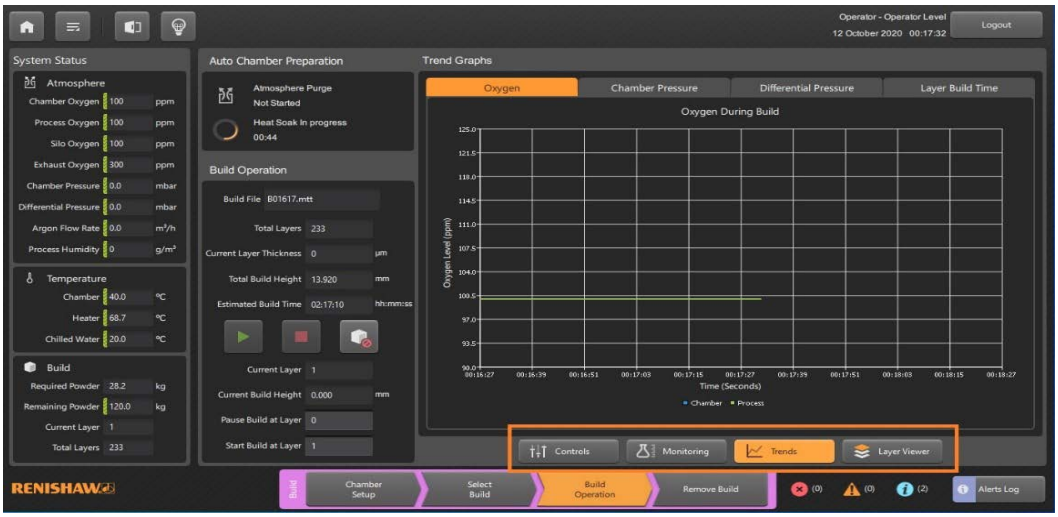


Figure 150 Build Operation screen

7. When the build platform heat soak process and atmosphere generation are complete, press the Play button to start the build (Figure 151).

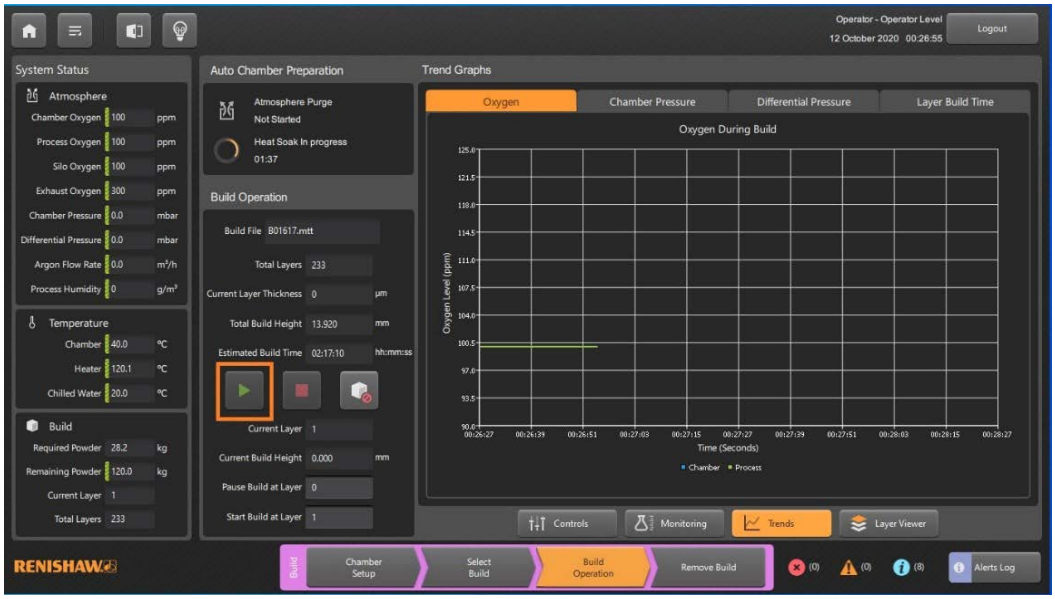


Figure 151 Build Operation screen – Play button

8.1.24 AB-022 – Feed hopper – Fill (RenAM 500 Flex only)

WARNING: Before starting this task, ensure you are wearing the correct PPE: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and cotton or fire-retardant overalls with full-length sleeves (made of static-dissipative material).

WARNING: Ensure the area around the RenAM 500 flex is free of any other persons to avoid any risk of injury from dropped items, powder or powder flasks.

WARNING: Do not load powder directly from the supplier's container into the RenAM 500 Flex – powder must first be decanted into a powder flask.

WARNING: Always use the powder loading arm when filling the RenAM 500 Flex feed hopper. Failure to do so may result in musculoskeletal injury due to location and reach required to attach powder flasks.

WARNING: The powder loading arm is designed specifically for use with Renishaw powder flasks A-6252-0570 and A-6252-0696 only. Using any other flask presents a drop risk and may cause injury.

WARNING: Full 1.7 L (103 in^3) powder flasks can weigh up to 10 kg (22 lb) in Renishaw standard materials. Do not carry more than one flask up to the working platform at one time. This ensures that three points of contact can be maintained during ascent and minimises the risk of injury.

WARNING: The feed hopper is fitted with a sensor to monitor powder level. When triggered, an alert will appear on the HMI stating "Powder hopper is full". Attempting to load a flask of powder when this alert is displayed can result in a flask not emptying fully and leading to significant powder spillage into the atmosphere and should be avoided.

WARNING: The powder loading arm is rated to take a maximum powder load of 10 kg. (22 lb) Some non-Renishaw supplied materials may cause this mass to be exceeded before the hopper is full. For these materials, care should be taken to monitor the mass of powder being loaded. Exceeding this load may cause damage to the machine and present a drop risk that may result in injury.

CAUTION: The feed hopper and its supporting bracket are rated to take a maximum powder load of 135 kg (297.6 lb). Some non-Renishaw supplied materials may cause this mass to be exceeded before the hopper is full. For these materials, care should be taken to monitor the mass of powder being added to the system. Exceeding this load may cause damage to the machine.

CAUTION: Do not attempt to add powder while the machine is undergoing chamber preparation or during task "AB-014 – Build chamber atmosphere – Set up". Doing so may cause damage to the machine.

WARNING: The RenAM 500 series roof panels are not structural and are not designed to support any significant load. Do not place heavy items (such as full powder bottles) onto (or lean on) the top of the machine. Doing so may result in injury or damage to the machine.

NOTE: The feed hopper can be filled while the build process is running – but not during task "AB-014 – Build chamber atmosphere – Set up". The estimated feed hopper fill level (shown as "Remaining Powder") can be viewed in the System Status panel on any screen, and is displayed as a range in kilograms. More detail on estimated powder weight is displayed on the Build Operation Monitoring page and the System Controls Recirculation page.

1. Ensure that all powder flasks to be loaded are filled from supplier's containers, in accordance with task "OT-003 – Powder flask – Fill".
2. Position the working platform at the front of the RenAM 500 Flex machine.
3. Ensure the powder loading arm is positioned so that the flask grip overhangs the RenAM 500 Flex machine.
4. Ensure that the powder flask isolation valve and feed hopper filling point isolation valve are both in the closed position (handle perpendicular to the direction of flow).
5. Remove the quick-release swing clamp, centring ring and blanking cap from the feed hopper filling point KF40 flange.
6. Carry one full flask to the top of the working platform.
7. Invert the flask and place into the flask grip on the powder loading arm (Figure 152).

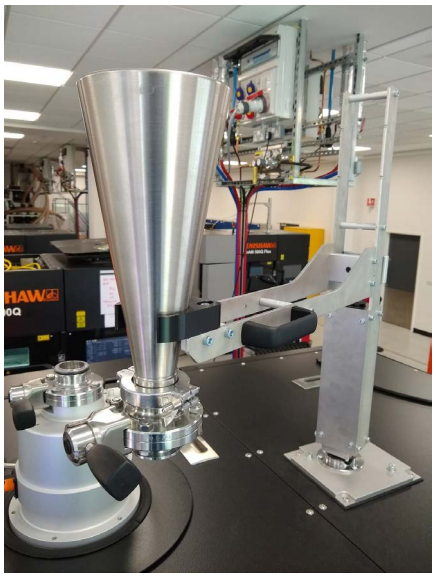


Figure 152 Powder flask in powder loading arm

8. Place a clean centring ring on the KF40 flange on the feed hopper top isolation valve.

9. Rotate the powder loading arm until the flask is over the feed hopper and it lowers into position (Figure 153).

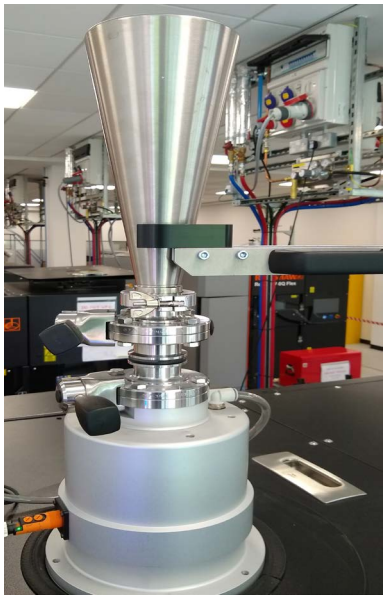


Figure 153 Flask in position on top of the feed hopper

10. Ensure the centring ring is seated correctly between the isolation valves of the feed hopper and the powder flask.

11. Slide half the collar of the quick-release clamp over the edge of the flanges.

12. Close the second half of the quick-release clamp, attach the spring-loaded lever and close the quick-release clamp (Figure 154).

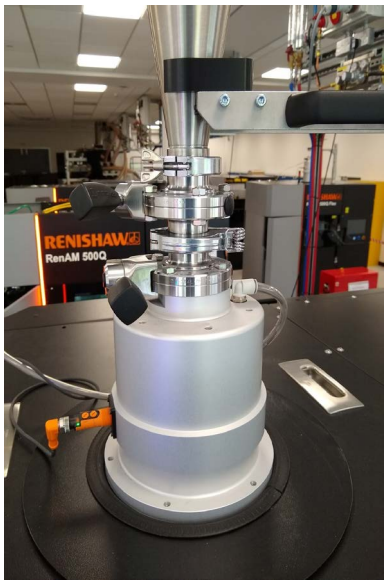


Figure 154 Powder flask on feed hopper with swing clamp connected

13. Open the isolation valve on the powder flask first, and then open the isolation valve on the feed hopper (Figure 155).



Figure 155 Powder flask and feed hopper valves open

14. Wait until the powder flask has emptied into the feed hopper. Check by tapping the powder flask gently.

CAUTION: Do not excessively hit or shake the hopper, as this can damage the feed hopper load cells. If the load cells are not reporting an accurate estimate of “Remaining Powder” in RenAMP, they can be re-tared in the “Powder Settings” page.

15. Close the isolation valve on the powder flask first, and then close the isolation valve on the feed hopper.

16. Remove the quick-release clamp, lift the powder loading arm and rotate and then remove the empty powder flask.

WARNING: Always ensure both the powder flask isolation valve and the feed hopper filling point isolation valve are closed before removing the quick-release clamp. Failure to do so while the machine is running could result in powder spillage or expulsion into the atmosphere, or air being drawn into the machine, resulting in an interruption to the build process.

17. Expand the Alerts panel on the HMI and check if the Powder Hopper Full alert is displayed and active. If it is, do not add additional powder, and proceed to Step 19.

18. Repeat the process for the remaining powder flasks until there is sufficient metal powder in the RenAM 500 Flex system. Use the ‘Remaining Powder’ value to determine how much powder is the in system (Figure 156).

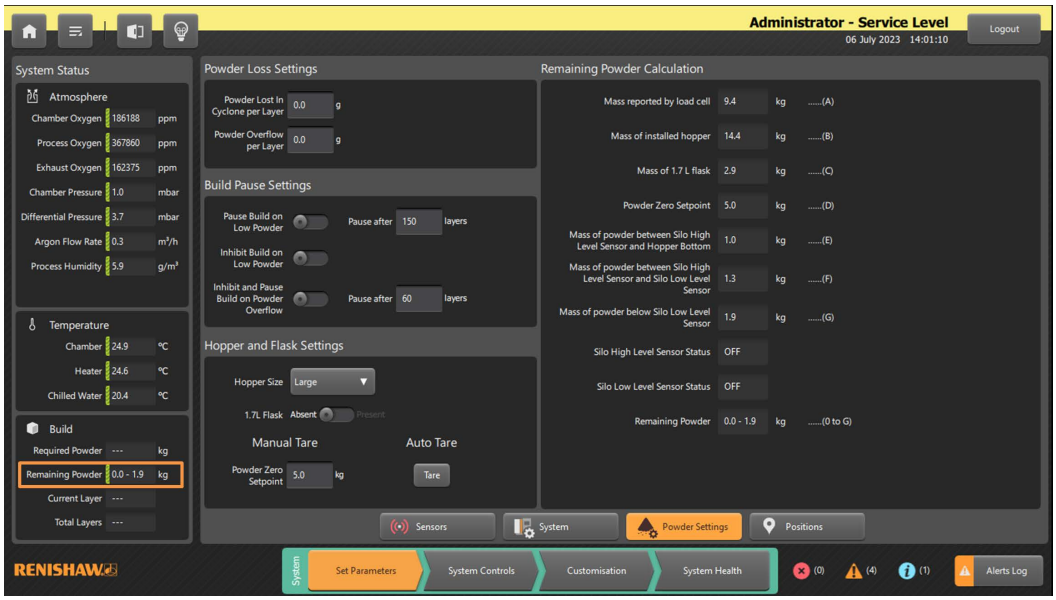


Figure 156 ”Remaining Powder” value in the “System Status” feedback

19. Place a clean centring ring on the KF40 flange of the feed hopper filling point isolation valve and refit a blanking plate. Secure with a quick-release clamp.

8.1.25 AB-023 – Overflow flasks – Fit (RenAM 500 Flex only)

The overflow flasks store excess powder dosed from the system until the end of the build, at which point the material can be sieved to remove any oversized particles ready for re-use.

The overflow flasks are located in the front left cupboard behind the door.

NOTE: If fitting an empty overflow flask while the machine is running, for example, to change a full overflow during a build, it is recommended that an inert, argon-filled, flask be fitted to the machine, if possible, and a suitable process is in place.

WARNING: Ensure you are wearing the correct PPE: eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and cotton or fire-retardant overalls with full-length sleeves (made of static-dissipative material).

1. Take an overflow flask, fit a centring ring and an isolation valve and secure with a quick-release clamp, if not already present.
2. Ensure the isolation valve is closed and fit a centring ring to the KF flange on the flask isolation valve.
3. Place the flask in the cabinet then it slide towards the rear overflow pipe and offer the flask up to the KF flange on the isolation valve of the overflow pipe (Figure 157).

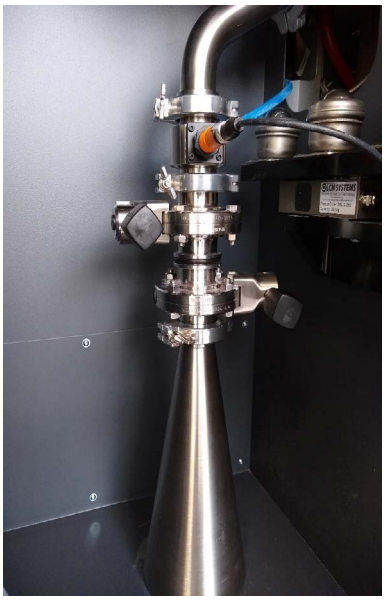


Figure 157 Rear overflow flask

4. Fit a quick-release clamp around the two KF40 flanges.

5. Close the quick-release clamp to secure the overflow flask to the RenAM 500 Flex (Figure 158).

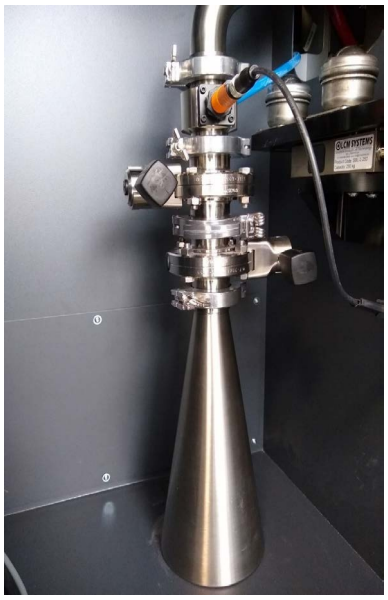


Figure 158 Overflow flask with swing-clamp attached

6. Repeat the process for the front overflow flask (Figure 159).



Figure 159 Overflow flasks

8.1.26 AB-024 – Valves – Set Up (RenAM 500 Flex only)

1. On the RenAM 500 Flex, behind the left-hand door, check that the following valves are in the correct position:

CAUTION: This step does not apply to RenAM 500 series systems equipped with the external Long-Life Filter system. For more information, see section 7.10, “Long-Life Filter (optional)”.

- Large SafeChange filter upper isolation valves (2 off) are open (1 and 2) (Figure 160) – valves in line with pipework.



Figure 160 Large SafeChange filter upper valves (1 and 2)

CAUTION: This step does not apply to RenAM 500 series systems equipped with the external Long-Life Filter system. For more information, see section 7.10, “Long-Life Filter (optional)”.

- Large SafeChange filter lower isolation valves (2 off) are open (3 and 4) (Figure 161) – valves in line with pipework.

- Overflow pipe isolation valves (2 off) (5 and 6) and overflow flask isolation valves (2 off) (7 (not shown) and 8) are open (Figure 161) – valves in line with pipework.



Figure 161 Large SafeChange filter lower isolation valves and overflow flask isolation valves

- Feed hopper filling point isolation valve is closed (Figure 162) – valve at 90° to the pipework.

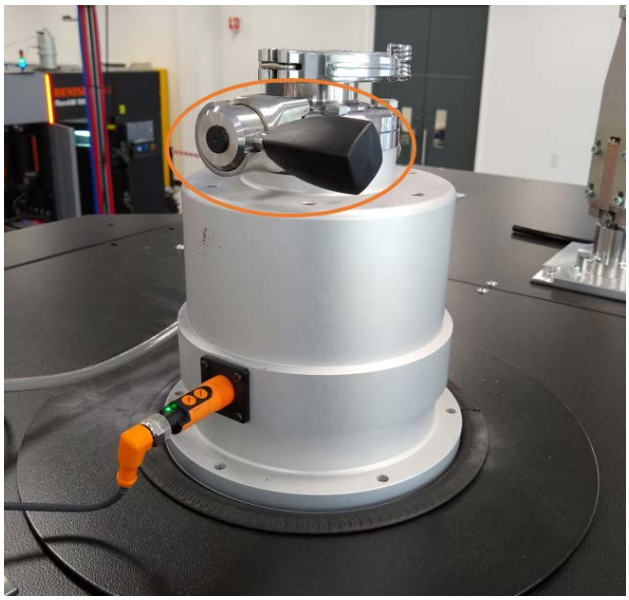


Figure 162 Feed hopper filling point isolation valve

8.1.27 AB-025 – Pre-build checklist – Review (RenAM 500 Flex only)

Before starting the build, check and confirm all the following steps have been completed.

Serial number	Equipment	Completed?
1	Check the chiller fluid level is between the L and H mark.	
2	Check the regulated argon gas pressure is correct.	
3	If using bottled argon gas, check there is sufficient gas pressure in the bottle.	
4	Check the chiller is running correctly.	
5	Check that there are two large SafeChange filters fitted.	
6	Log into RenAMP software using the touch screen control panel, open the top door and after 30 seconds confirm that the chamber pressure is zero.	
7	Check the system build chamber has been cleaned down.	
8	Check the bottom door is closed.	
9	Check that a suitable build plate has been installed and the thickness entered.	
10	Check that a recoater blade has been installed.	
11	Check that two overflow flasks have been fitted.	
12	Check the large SafeChange filter upper valves (2 off) are open.	
13	Check the large SafeChange filter lower valves (2 off) are open.	
14	Check the powder overflow flask valves (2 off) are open.	
15	Check the powder overflow pipe valves (2 off) are open.	
16	Check the feed hopper filling point valve is closed and a blanking plate is fitted and secured with a quick-release clamp.	
17	Check that the heat soak procedure has completed.	
18	Check that the build chamber atmosphere set-up has completed.	
19	Dose the powder and check for even distribution.	
20	Check that a suitable build file has been selected and loaded.	
21	On the touch screen control panel, check the powder level in the load hopper is sufficient for the build.	
22	Check that the cyclone particle collection flask is fitted, is empty and the two isolation valves are open.	
23	Check that none of the beacon lights are on before starting the build.	
24	Start the build.	

8.2 Monitoring the build

WARNING: If the machine has Large SafeChange filters installed, do not remove them while a build is running unless instructed to do so on the touch screen control panel.

NOTE: Once the build has started, observe the first few minutes of the build process and check that the gas flow is correct from right to left, the quality of the part appears to be acceptable, the powder is dosing correctly, and the laser appears to be functioning correctly.

WARNING: Do not stare at the build for long periods of time, as the light emissions from the melting process are very bright and can flash. It is safe to view the build through the window in the top door for brief time periods.

Once started, the RenAM 500 series system will run automatically.

During the build, monitor the touch screen control panel for any alarms. If any alarms are generated, respond to them appropriately. The most likely alarms are:

- Low metal powder – if this alarm is displayed, refer to task “TT-002 – Pause build on low powder level”, and fill the load/feed hopper with metal powder in accordance with task “AB-011 – Load hopper – Fill (RenAM 500 and RenAM 500 Ultra only)” or “AB-022 – Feed hopper – Fill (RenAM 500 Flex only)”.
- Cyclone particle collection flask full – if this alarm is displayed, empty the cyclone particle collection flask in accordance with task “PB-017 – Cyclone filter particle collection flask – Remove and empty”.
- Overflow flask full (RenAM 500 Flex only) – if this alarm is displayed, empty the overflow flasks in accordance with task “PB-018 – Overflow flask – Remove and empty (RenAM 500 Flex only)”.
- Large SafeChange filter airflow low – if this alarm is displayed, the affected filter assembly must be replaced.
- High process humidity and/or high powder humidity – if this alarm is displayed, refer to Section 8.2.7, “Humidity control”.

8.2.1 Alerts log

During the build process, alerts raised by the software are displayed in the ‘Alerts Log’ page. This page is accessed by pressing the ‘Alerts Log’ button at the bottom right-hand corner of the screen (Figure 163).

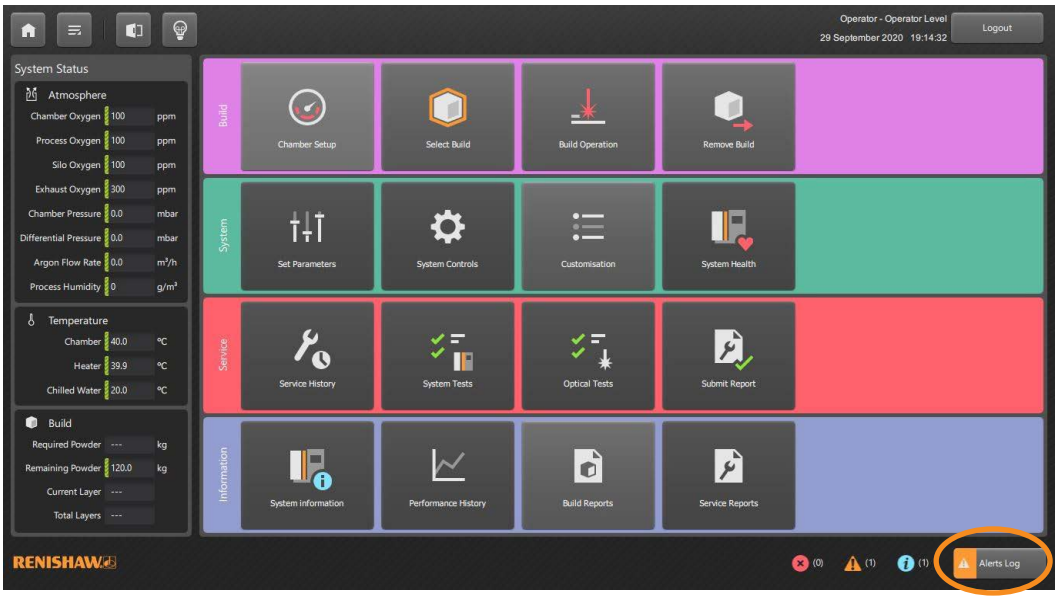


Figure 163 Alerts Log

There are three types of alert:

- Information
- Warning
- Error

An alert may have a suggested action (Figure 164) which can be accessed by expanding the alert statement.



Figure 164 Suggested action for an alert

If the Alerts Log page is not open, the user is notified of the alert by a pop-up message at the bottom right-hand corner of screen. This message vanishes after a few seconds.

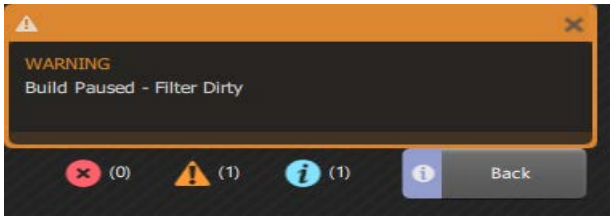


Figure 165 Alert pop-up

Some alerts are recurring, which mean they keep popping up every few seconds to catch the operator's attention.

Pop-ups can be disabled from the Alerts Log page. After the first occurrence of the alert, the icon will appear at the end of the alert (highlighted in Figure 166).

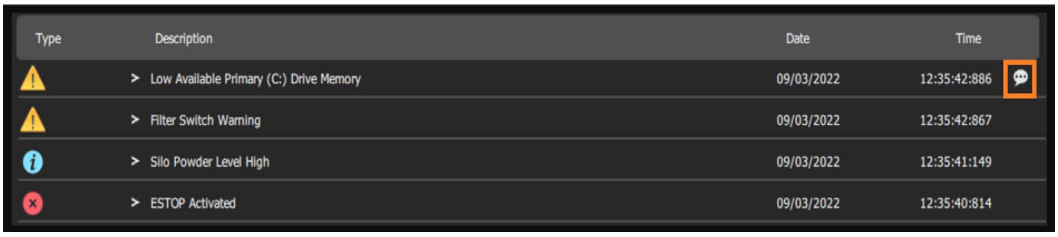


Figure 166 Recurring icon in Alerts Log

The icon indicates whether the pop-up notification for this alert is enabled.



The notification for this alert is enabled. When the alert is raised, the pop-up will be displayed. This is the default status.



The notification for this alert is disabled. A pop-up will not be displayed when alert is raised.

Clicking on the icon toggles the notification status.

The state of the notification is not stored and is reset to the default the next time the software is launched.

8.2.2 Exporting logs

The alerts raised by the software indicate various conditions such as system errors, maintenance requirements, or deviations from expected performance parameters. The RenAM 500 series system enables you to access and transfer the logs to an external machine for further analysis and investigation. These logs can then be utilised for understanding the system's performance and can assist you in troubleshooting and preventive maintenance. It also helps in optimising the manufacturing process by providing insights into the system's operation.

To access and export the logs to an external computer, follow the instructions given below:

1. Click the 'Alerts Log' button located at the bottom right-hand corner of the RenAMP screen.

2. In the ‘Alert Logs’ screen, click the ‘Export’ button.

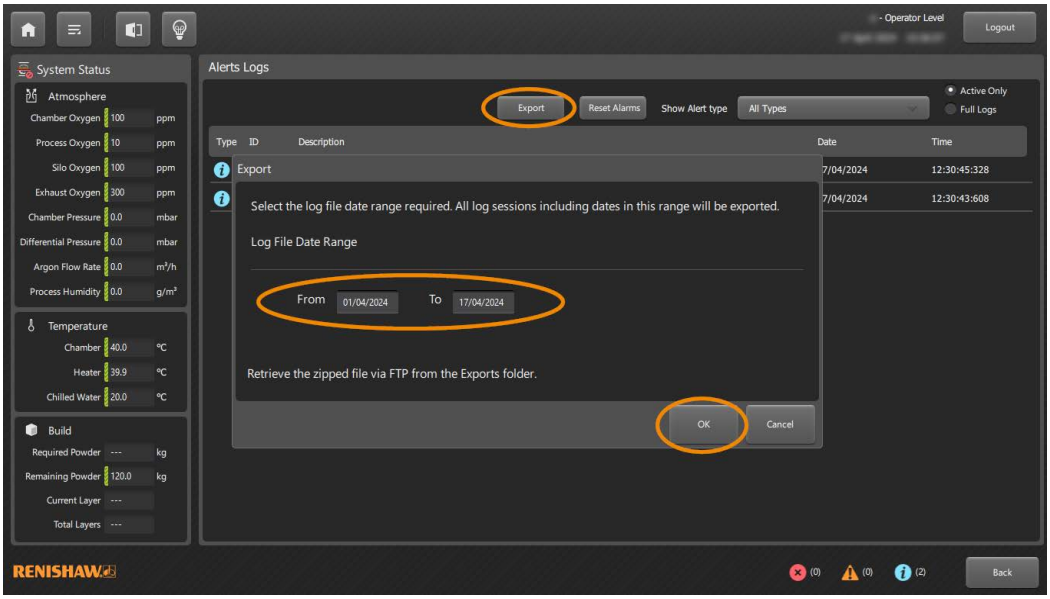


Figure 167 Alert logs screen

3. Use the ‘From’ and ‘To’ fields in the ‘Export’ dialog box to specify the date range for which you need the logs.

4. Click ‘OK’ and wait for the system to complete the export.

5. After successfully completing the export, an information alert ‘Export Operation Completed’ is displayed and the export file is saved as a compressed archive folder in the location **D:\AMResources\Exports**.

6. To transfer log files from the RenAM 500 series system to an external computer, you must use File Transfer Protocol (FTP) or Server Message Block (SMB) protocol. For more information, see section 8.8, “Transferring files”.

8.2.3 SafeChange™ filters

CAUTION: This does not apply to RenAM 500 series systems equipped with the external Long-Life Filter system. For more information, see section 7.10, “Long-Life Filter (optional)”.

On the Chamber Setup screen (Figure 168), the large SafeChange filters are displayed in graphic form. As the build progresses, the filter will slowly fill with nanoparticles from the AM process. As a result of the filter filling, the airflow through the filter will reduce. The airflow is displayed in the form of a green, amber and red band against the filter graphic (Figure 168).

Using the information on the touch screen control panel, identify the affected filter assembly, isolate the filter and remove it in accordance with task “OT-005 – Large SafeChange™ filter assembly – Remove”. Fit a clean filter assembly in accordance with task “OT-008 – Large SafeChange™ filter assembly – Refit”. The filter element in the removed filter assembly must be removed and replaced in accordance with tasks “OT-006 – Large SafeChange™ filter element – Remove” and “OT-007 – Large SafeChange™ filter element – Refit”, which can be done when time permits.

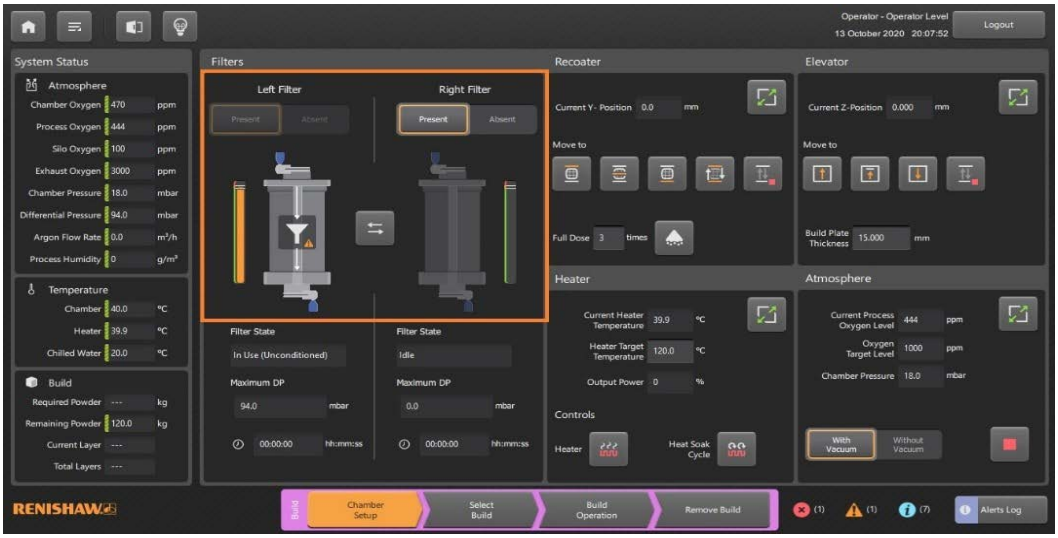


Figure 168 Chamber Setup and SafeChange filters graphic

The RenAMP software automatically controls the rate at which the changeover from a dirty to a clean SafeChange filter occurs; this function is called switching type. Switching type helps to negate any sudden pressure or gas flow fluctuations caused by suddenly switching from a dirty to a clean filter.

After a build is started, the filter will be held partially open for 10 minutes to condition the filter, exposing it to the finest metal powder and nanoparticles. This allows the filter to perform at optimum efficiency for the rest of its lifetime.

The machine will automatically use the left filter first unless it is shown as Absent or Dirty. If both filters are likely to be needed for a build, they can both be preconditioned by using the Filter Switch button and selecting Slow Open. The filters will then run in parallel until the Filter Switch button is used to close one filter.

Manual switching is particularly useful when running long builds where dirty SafeChange filters may need to be swapped out periodically for clean filters without waiting for the airflow to reduce to a level where it must be changed, for example near the end of a shift.

There are four modes of switching type (Figure 169).

- Slow Switch – Switch to Other (left or right) Filter after purge and conditioning
- Fast Switch – Switch to Other Filter skip conditioning time
- Slow Open – Open Other Filter after purge and conditioning, keep Current Filter open
- Fast Open – Open Other Filter skip conditioning time, keep Current Filter open

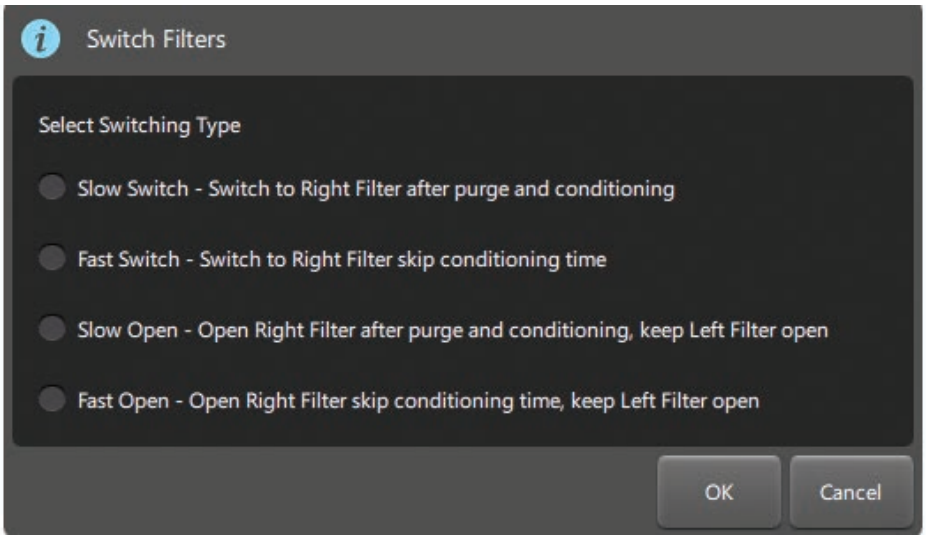


Figure 169 Switching type dialog box with four choices of switching type

If you need to replace a large SafeChange filter before it reaches the end of its life, from the Chamber Setup screen (Figure 168), identify the filter you need to replace by selecting the bidirectional arrow button between the two large SafeChange filter graphics. From the Switch Filters dialog box (Figure 169), select the Switching Type you want and select OK to confirm. Ensure the switch is complete. The filter must not be isolated if the state is “Purging”, “In Use” or “Conditioning”. Isolate the filter, remove it in accordance with task “OT-005 – Large SafeChange™ filter assembly – Remove” and fit a clean filter assembly in accordance with task “OT-008 – Large SafeChange™ filter assembly – Refit”. The filter element in the removed filter assembly must be removed and replaced in accordance with tasks “OT-006 – Large SafeChange™ filter element – Remove” and “OT-007 – Large SafeChange™ filter element – Refit”, which can be done when time permits.

NOTE: In the event of an incident, press the Emergency Stop button to stop the RenAM 500 series. Following assessment of the situation, either perform a restart procedure, if safe, in accordance with task “OT-010 – RenAM 500 series system – Build recovery” or, if not recoverable, abort the build and clean down the system in accordance with the post-build tasks.

8.2.4 Powder dosing (RenAM 500 Flex only)

As the RenAM 500 Flex machine uses a total loss powder system, whereby all deposited but unmelted material is transferred to overflow flasks for offline sieving, it is important that the powder dose settings for any given build are set correctly.

A dose setting too high can lead to an increased rate of overflow flasks filling up and an increased rate of consumption of powder from the feed hopper. Both these scenarios will require additional operator intervention to either empty overflow flasks or top up the feed hopper with additional material to complete the build.

A dose setting too low can result in the incomplete deposition of material across the entire build plate (short dosing). This can lead to failed builds and, in severe cases, where incomplete melting causes delamination of the build part, may result in damage to the machine.

The optimum dose setting is dependent on the individual machine, the material used, the layer thickness and the specific build geometry at any given layer. The first time a specific build is run on a machine, it may require regular observation to avoid any minor or major short dose events (Figure 170).

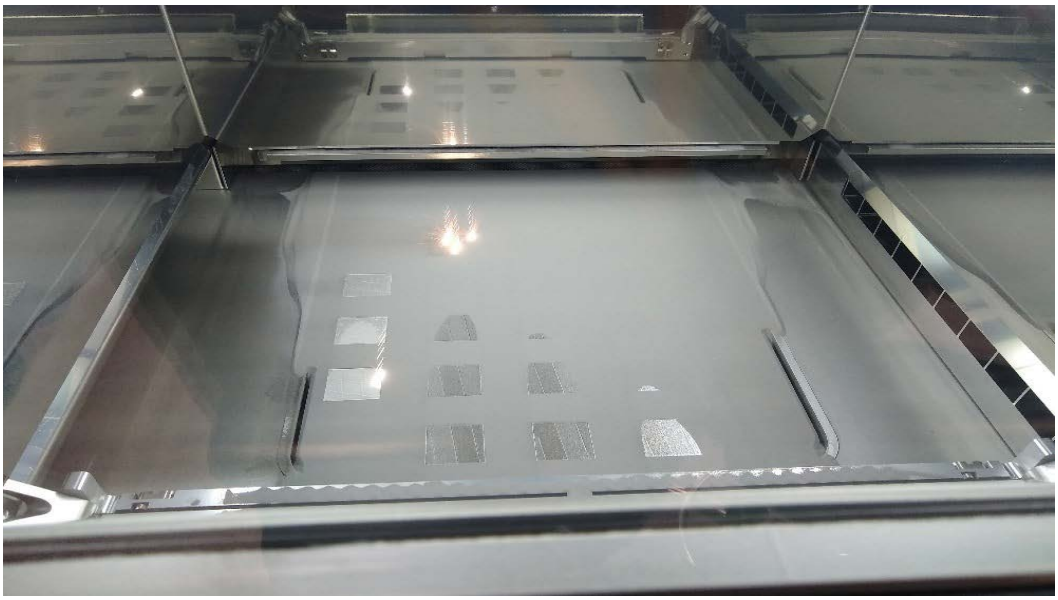


Figure 170 Major short dose

During this first build, a baseline dosing setting can be determined for future repeats of that build following the process below:

1. During the largest section of the build, gradually reduce the dose setting by 1% per layer until a very minor short dose is evident by a slight lack of powder on the front edge of the build volume. Note the dose percentage value at which the short dose occurred.

2. Increase the dose setting by 10% for the next two layers to ensure the build recovers.

3. Return the dose setting to 1% higher than the noted short dose setting.

4. Observe the build for 5 to 10 layers to gain confidence that no further, persistent, short dosing will occur.

5. Increase the dose setting a further 5% and note the dose percentage as the “baseline dose” setting for future use. This should allow enough powder overdosing to recover from unexpected short doses that may occur due to significant changes in geometry or powder consistency.

NOTE: Baseline settings generated using the described method aim to provide a balance between mitigating short doses and minimising powder consumption and overflow flask fill rate. However, they cannot be guaranteed to be appropriate for all scenarios. Depending on specific geometry and material properties, short dose events could still occur.

CAUTION: Consistent insufficient powder dosing for several layers may lead to delamination of the part(s) being built. In some cases, this can cause damage to the machine, requiring repair by a Renishaw service engineer. If delamination of a build is observed, the build should be stopped via the HMI and all post-build tasks completed before setting the machine up to build again.

8.2.5 Overflow flasks (RenAM 500 Flex only)

During the build process, excess powder dosed from the silo will be deposited in the two overflow flasks. Depending on the height of the build and the chosen dose percentages, these flasks may require emptying as the build continues. The capacitive sensors in the overflow pipework will alert the user via the HMI and beacon light and, after a short delay, pause the build. The pause is to ensure that powder does not continue to back up through the overflow pipework and into the chamber where it can prevent the recoater movement, which will cause the build to fail and potentially damage the machine. The pause can be disabled in the “Set Parameters” menu, at the user’s own risk.

When emptying the overflows during a build, it is recommended to change both flasks at the same time, and to fit a spare empty flask once the full ones are removed. This will allow the build to continue uninterrupted while the full flasks are emptied and sieved.

8.2.6 Feed hopper (RenAM 500 Flex only)

If completing large builds on a RenAM 500 Flex, it is possible for the feed hopper to have insufficient volume to store enough powder to complete the build without intervention. Point level sensors in the silo will alert the user when the powder level in the machine is running low, and then, if configured to do so, pause the build when powder is critically low.

A capacitive sensor in the feed hopper will alert users via the HMI when it is full. Any time that the feed hopper is not full, as measured by the capacitive sensor, at least one full 1.7 L flask of powder may be added by following process “AB-022 – Feed hopper – Fill (RenAM 500 Flex only)”. This can be completed during a build without interrupting the process, allowing for large builds to be completed without pause due to low powder.

The “Remaining Powder” value in the “System Status” screen shows an accurate measurement of powder mass held within the hopper using feedback from the hopper load cell (Figure 171).

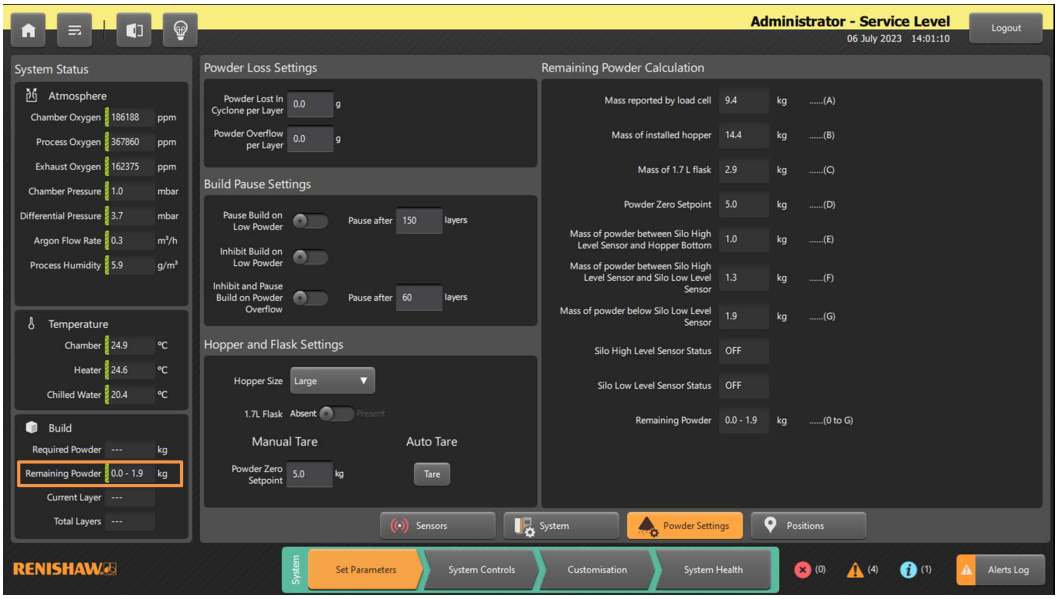


Figure 171 “Remaining Powder” value in “System Status”

NOTE: The machine can be run while a powder flask remains fixed to the top of the feed hopper to allow an additional 1.7 L (103 in³) of powder to be utilised once the hopper sensor reads as full. This flask should not be removed until the sensor switches off again.

8.2.7 Humidity control

During the build process, the humidity of the argon gas and powder can vary inside the machine. High humidity decreases the flowability and spreadability of the powder, which can lead to an unwanted increase in build porosity.

Humidity sensors are used to record the humidity inside the gas circuit and the powder recirculation circuit in the machine. The sensor reading from the gas circuit is referred to as the process humidity, which shows the humidity in the build chamber. The sensor in the powder recirculation circuit shows the powder humidity (not available on the RenAM 500 Flex or while using the Reduced Build Volume build method).

There are two humidity threshold settings that can be configured by the user to help control the humidity levels during a build: the Warning threshold and the Re-Purge At threshold. These threshold settings can be configured on each of the process and powder humidity readings separately. When the Warning threshold is exceeded for either the process or powder humidity readings, a high-humidity alert is shown to the operator. When the Re-Purge At threshold is breached, the machine will perform an argon gas purge, which can sometimes have the effect of reducing the humidity.

NOTE: Renishaw recommends setting the ‘Re-Purge At’ targets to a default value of 12 for both the ‘Process’ and ‘Powder’. This value will effectively control humidity levels and minimise argon consumption.

To change the humidity threshold settings, follow the steps in the process below.

NOTE: When the machine performs an argon gas purge, it will consume a large quantity of argon gas. Reducing the threshold values from the default values could cause the machine to consume an even larger quantity of argon gas. The threshold values should be modified in combination with the argon gas consumption thresholds.

NOTE: The Warning and Re-Purge At threshold settings can be configured by a service-level user only.

1. From the Home screen (Figure 172), select Set Parameters (circled). This will open the Set Parameters screen (Figure 173).

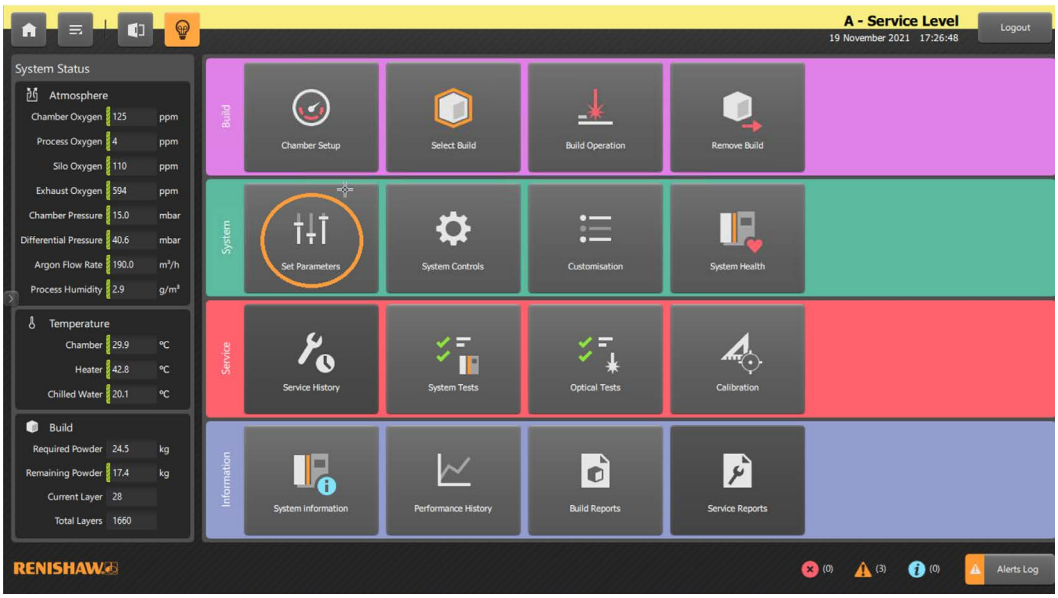


Figure 172 Home screen with Set Parameters circled

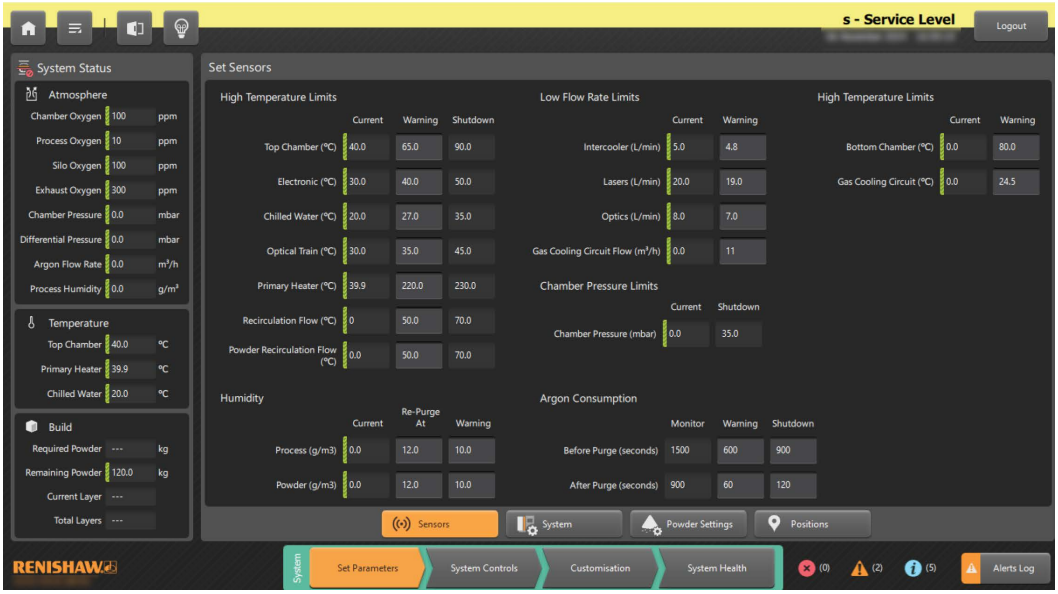


Figure 173 Set Parameters screen and Sensors screen

2. The Set Parameters screen (Figure 173) contains three buttons. Select the Sensors screen (circled).

3. View the current humidity settings (circled) on the Sensors screen. The Process value indicates the current in-chamber humidity and the Powder value indicates the current humidity in the powder recirculation loop (Figure 174).

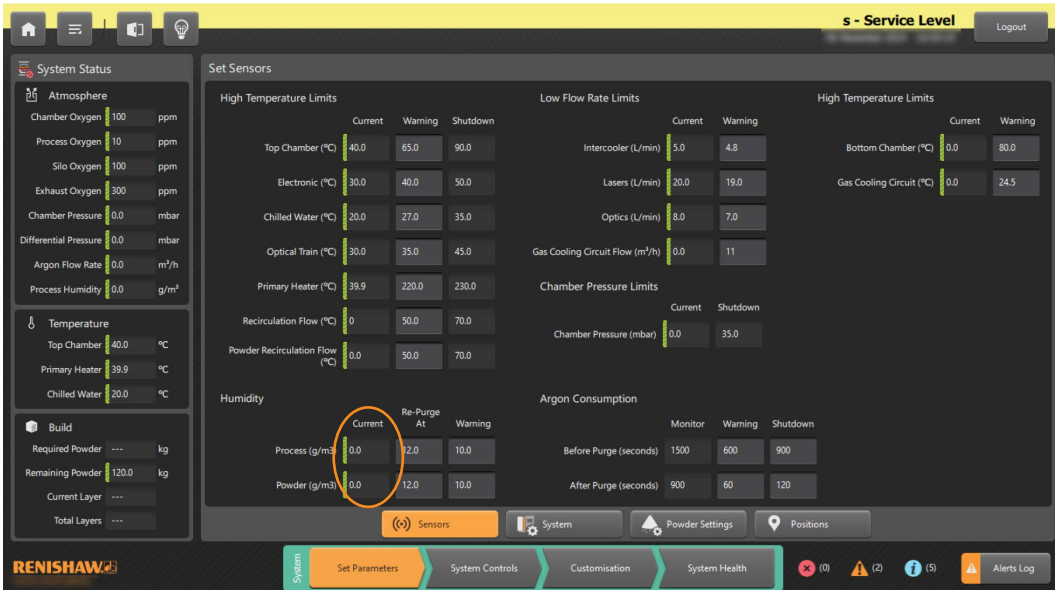


Figure 174 Humidity parameters on Sensors screen

4. Change the Warning and Re-Purge At threshold values for the process or powder humidity readings by editing the two text boxes (circled on Figure 175).

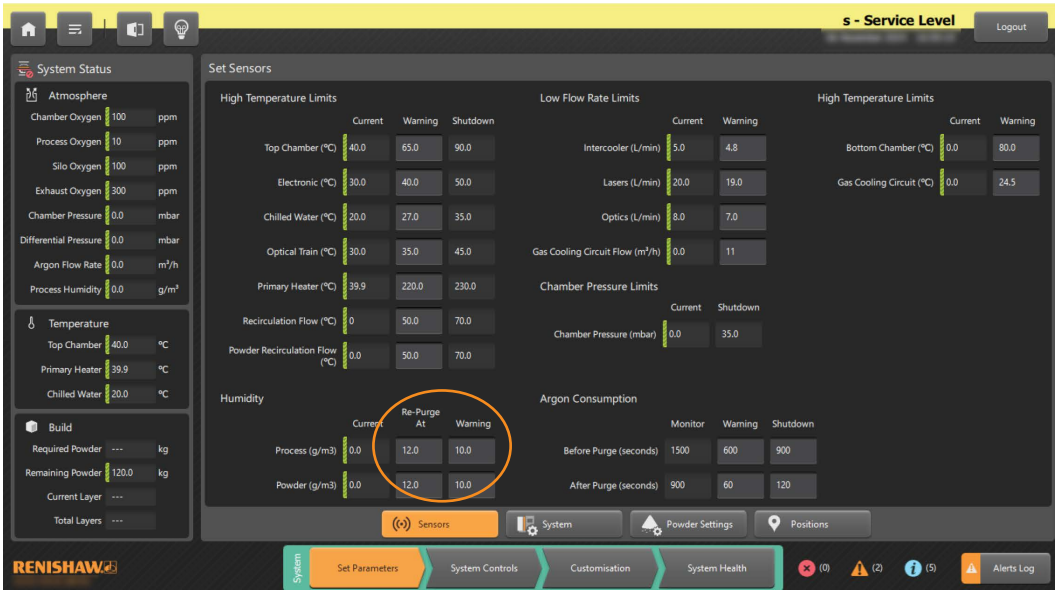


Figure 175 Humidity parameters on Sensors screen

8.2.8 Argon consumption monitoring and control

During the chamber preparation and between build cycles, there is a possibility of residual impurities being introduced into the chamber due to incomplete purging, loose connections or leaks. These impurities, particularly minor variations in oxygen content, can adversely affect the mechanical as well as chemical properties of the build material. To mitigate this, argon is supplied to the build chamber to maintain an inert pressurised atmosphere free from impurities, thereby ensuring that the final product adheres to quality standards and avoids potential issues like discolouration or poor fatigue resistance.

Monitoring and controlling the amount of argon consumed by the RenAM500 series machine during chamber preparation and the build process is important. It not only helps in the early detection of system issues such as loose connections or leaks, but also prevents accidental leaks or excessive exposure to personnel. By ensuring the right amount of argon is used, you can avoid unnecessary operational costs and maintains stable build chamber conditions. Additionally, fluctuations in argon flow can impact temperature control during the AM process.

The system monitors argon usage by continuously measuring the duration for which the gas inlet valve remains open. This measurement occurs within the default ‘Monitor’ time, as specified in the ‘Argon Consumption’ settings, both before and after the purging process. Two threshold settings can be configured to control the flow of excessive Argon: the ‘Warning’ threshold and the ‘Shutdown’ threshold. The following settings are available for argon consumption configurations:

- Monitor time: This is a rolling time period, with a default duration of 1 500 seconds before purge and 900 seconds after purge. During this time, the consumption of argon is continuously tracked. This involves the constant monitoring of the argon gas inlet valve to determine whether it is ON or OFF. Unlike a discrete time window, a new 1 500-second monitoring window starts every subsequent second, not every 1 500 seconds.
- Warning threshold: This is the time limit beyond which, if the argon gas inlet valve remains open within the monitoring window, RenAMP issues a warning without taking any corrective action.

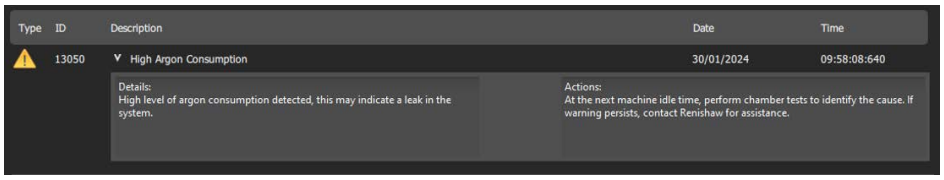


Figure 176 RenAMP alert for argon consumption beyond warning threshold

- Shutdown threshold: This is the time limit beyond which, if the argon gas inlet valve remains open within the monitoring window, RenAMP will raise an error alert and take the corrective action of stopping the active processes on the machine.

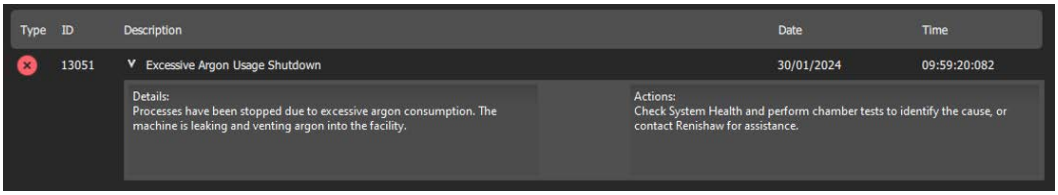


Figure 177 RenAMP error for argon consumption beyond shutdown threshold

To configure the warning and shutdown threshold in argon consumption configurations, follow the instructions given below:

NOTE: Only a service-level user can configure the warning and shutdown thresholds in the argon consumption configuration settings.

NOTE: Renishaw recommends setting the warning and shutdown threshold values as shown in Figure 178. This value will effectively control humidity levels and minimise argon consumption.

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1. From the RenAMP home screen, click ‘Set Parameters’ button.

2. Select the ‘Sensors’ tab at the bottom of the screen to open the ‘Set Sensors’ screen.

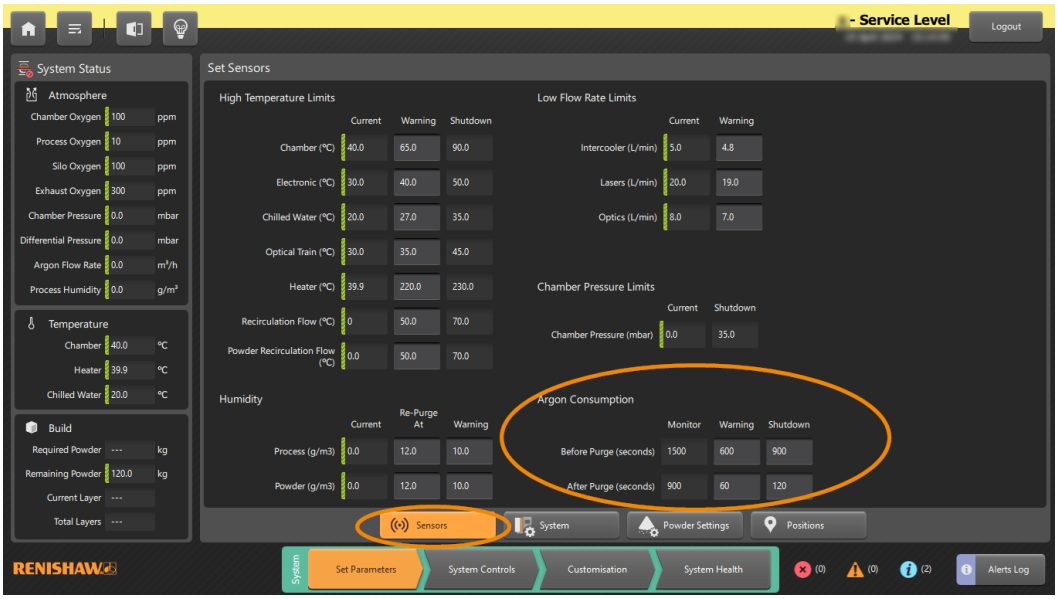


Figure 178 RenAMP error for argon consumption beyond shutdown threshold

3. Locate the ‘Argon Consumptions’ settings.

4. Click the corresponding field to modify the ‘Warning’ and ‘Shutdown’ threshold values both before and after the purge, and input the values using the on-screen keyboard.

8.3 Post-build tasks

8.3.1 Post-build tasks (RenAM 500 and RenAM 500 Ultra)

The following table lists all the operation tasks that must be carried out AFTER a build is completed on a RenAM 500 or RenAM 500 Ultra system. The tasks must be completed in the order specified in the table below before the next build can begin.

Task number	Task title	User level
PB-001	Build plate – Cool down	Operator
PB-002	Build report – Generate	Operator
PB-003	Build chamber metal powder – Remove	Operator
PB-004	Build plate – Remove	Operator
PB-005	Build chamber – Clean	Operator
PB-016	Lens protection system – Inspect	Operator
PB-007	Lower chamber – Clean	Operator
PB-008	Recoater blade – Remove	Operator
PB-015	Oversized particle collection flask – Refit, remove and empty	Operator
PB-017	Cyclone filter particle collection flask – Remove and empty	Operator
PB-009	RenAM 500 series system – Shut down	Operator
PB-010	RenAM 500 series system – Power down	Operator
PB-011	Chiller – Power down	Operator
PB-012	Build plate parts – Remove	Operator
PB-013	Build plate – Refurbish	Operator
PB-014	Heat treatment of parts (optional) – Set up	Operator

8.3.2 Post-build tasks (RenAM 500 Flex only)

The following table lists all the operation tasks that must be carried out AFTER a build is completed on a RenAM 500 Flex system. The tasks must be completed in the order specified in the table below before the next build can begin.

Task number	Task title	User level
PB-001	Build plate – Cool down	Operator
PB-002	Build report – Generate	Operator
PB-003	Build chamber metal powder – Remove	Operator
PB-004	Build plate – Remove	Operator
PB-005	Build chamber – Clean	Operator
PB-016	Lens protection system – Inspect	Operator
PB-007	Lower chamber – Clean	Operator
PB-008	Recoater blade – Remove	Operator
PB-017	Cyclone filter particle collection flask – Remove and empty	Operator
PB-018	Overflow flasks – Remove and empty	Operator
PB-009	RenAM 500 series system – Shut down	Operator
PB-010	RenAM 500 series system – Power down	Operator
PB-011	Chiller – Power down	Operator
PB-012	Build plate parts – Remove	Operator
PB-013	Build plate – Refurbish	Operator
PB-014	Heat treatment of parts (optional) – Set up	Operator

8.3.3 PB-001 – Build plate – Cool down

1. After the build has completed, the build plate heater will switch off automatically.

   NOTE: If you do not have hot chamber access, the system will not allow you to open the top door if the heater temperature is above 60 °C (140 °F).

2. In the System Status pane (Figure 179) is the temperature pane; look down the list and check the heater temperature.

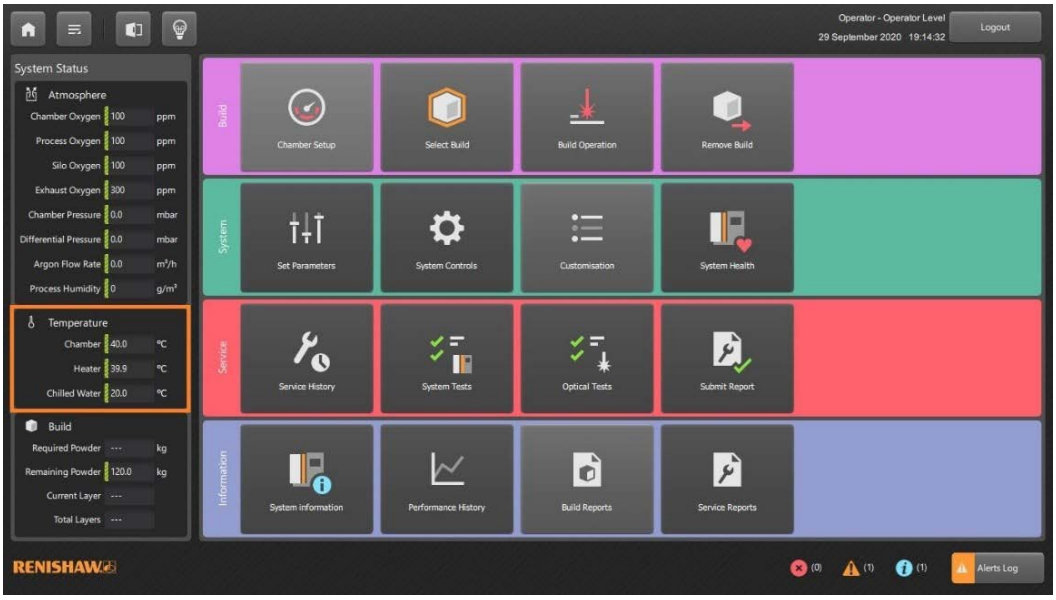


Figure 179 System Status pane and equipment temperature pane

WARNING: The level of heat retained by the part and surrounding unused powder depends on the build geometry and powder type. Take extra care to assess the burn risk for each build removal. Ensure sufficient time has elapsed to allow the part and surrounding unused metal powder to cool sufficiently before handling the build or removing the metal powder.

8.3.4 PB-002 – Build report – View or generate

NOTE: Build reports are automatically generated at the end of any build for system installed with MSS version 2.2.0 or later.

CAUTION: Do not generate a build report during an active build. This action must only be performed when the machine is idle to ensure accurate data processing.

1. From the RenAMP Home page, select the Build Reports button, circled (Figure 180).

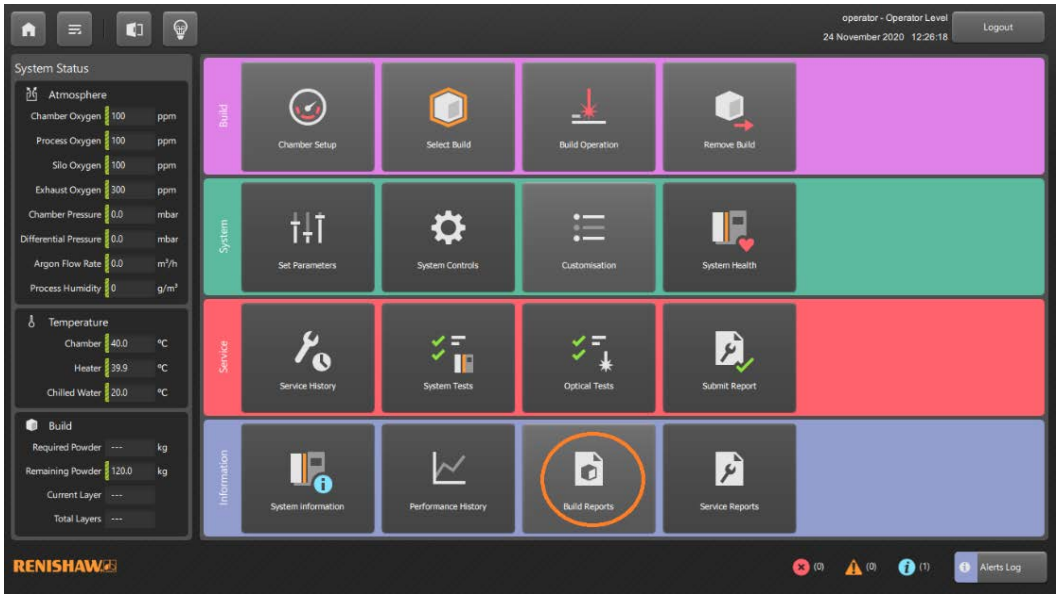


Figure 180 RenAMP Home page and Build Reports button

2. The 'Build History' pane displays the available build reports for the completed builds (Figure 181).

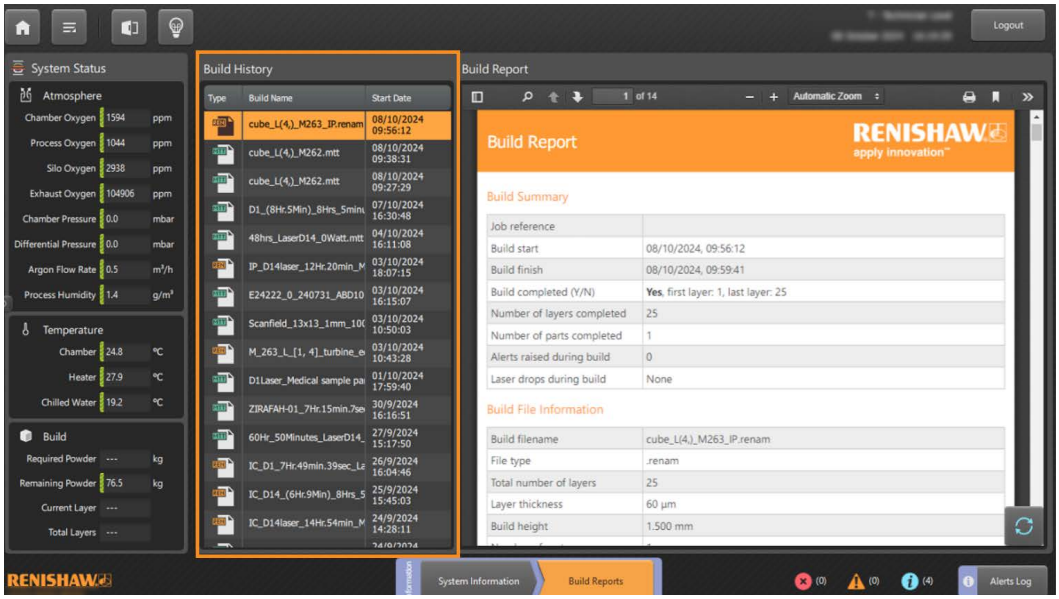


Figure 181 Build History and Build Reports

3. Click the required build file name to generate or view the build report (Figure 182).

NOTE: If the build report is not generated automatically or translated after changing the UI language, click the refresh button to regenerate the build report.

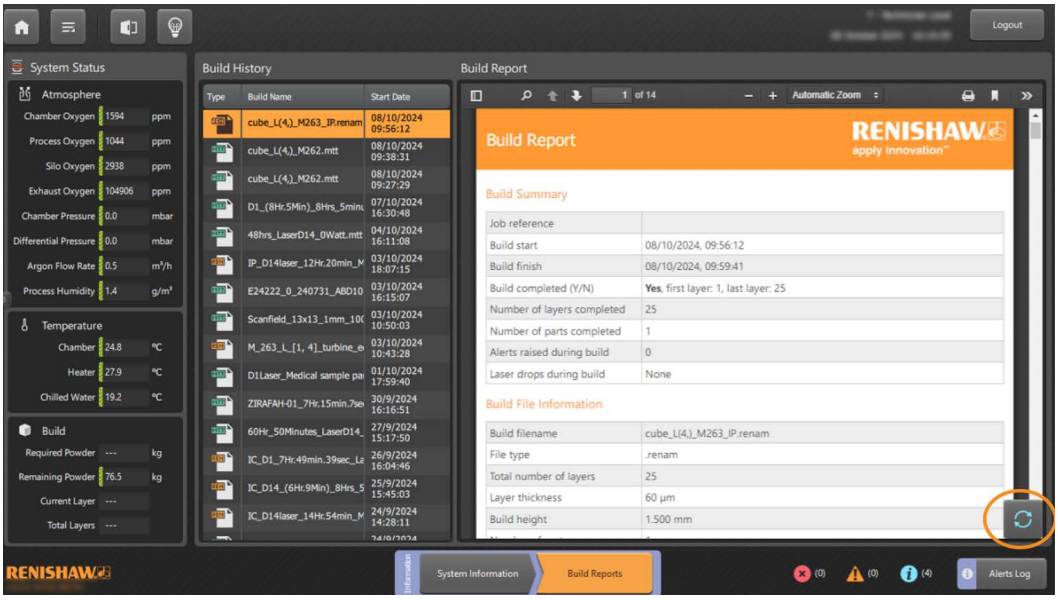


Figure 182 Generate Build Reports

4. Build reports generated can be extracted from the system folder **D:\AMResources\reports** using File Transfer Protocol (FTP) and/or Server Message Block (SMB) protocol (also known as Windows file share). For more information on transferring files, refer to section 8.8, “Transferring files”.

8.3.5 PB-003 – Build chamber metal powder – Remove

WARNING: Do not vacuum unpassivated metal condensate.

WARNING: The build chamber will contain a large amount of powder at this stage. Before starting this task, ensure that the correct PPE is being worn before opening the top door. Ensure you are wearing eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and cotton or fire-retardant overalls with full-length sleeves (made of static-dissipative material).

WARNING: The vacuum pump should not be started if the build chamber contains powder.

WARNING: The build chamber will be full of argon gas at this stage. This will be released when the top door is opened.

NOTE: As much powder as possible should be removed from the build before it is removed from the build chamber.

NOTE: (RenAM 500 Flex only): Overflow flasks may become full during debuild. An alert will be displayed to the user on the HMI and the flasks should be emptied according to task “PB-018 – Overflow flask – Remove and empty (RenAM 500 Flex only)”.

1. Carefully and slowly open the top door, to avoid disturbing powder in the build chamber. If any metal powder falls from the RenAM 500 series build chamber, immediately vacuum it up using the ATEX vacuum cleaner.
2. Leave the top door open for five minutes to allow a passivation cycle to occur. Allowing the oxygen to rise slowly should help to passivate any condensate by allowing it to oxidise at a controlled rate. Do not leave the RenAM 500 series unattended while this is happening.
3. After 5 minutes, vacuum the top door seal using the ATEX vacuum cleaner.

4. On the recoater assembly, twist the two thumbscrews – one on the left-hand end and one on the right-hand end of the recoater – half a turn anti-clockwise, and separate the recoater blade assembly from the recoater carrier (Figure 183).



Figure 183 Recoater thumbscrews

5. Using the ATEX vacuum cleaner, remove any metal powder from the recoater assembly. For selection and correct use of the ATEX vacuum cleaner, refer to the manufacturer's instructions. Set the recoater assembly aside until required for the next build.

6. Using the ATEX vacuum cleaner, remove powder from the front, left-hand and right-hand sides of the build chamber (Figure 184). For selection and correct use of the ATEX vacuum cleaner, refer to the manufacturer's instructions.

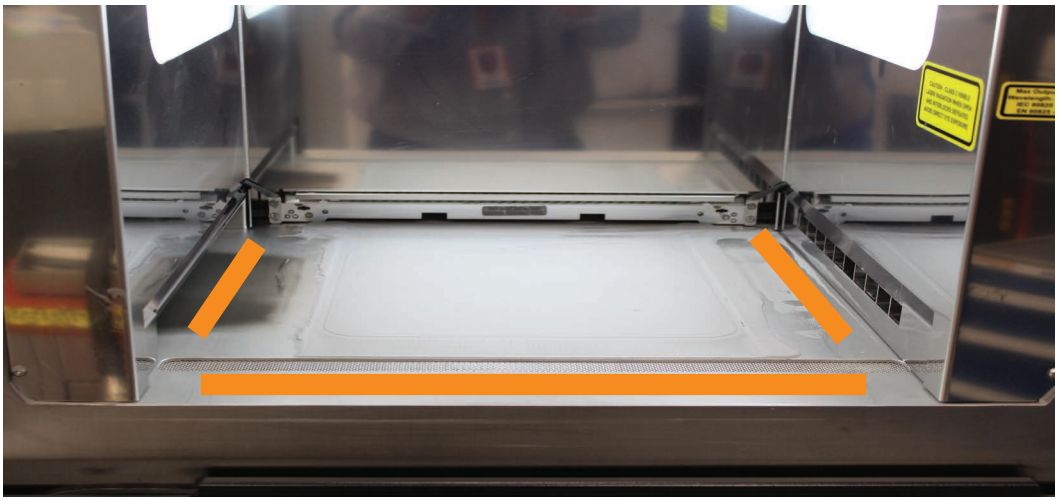


Figure 184 Front, left-hand and right-hand areas to be vacuumed, highlighted in orange

7. Place suitable tools for the material type being used, such as non-static-generating brushes, scrapers, 4 mm (0.15 in) hexagon key and blower into the build chamber (Figure 185). The tools are used during build chamber clean-down.

NOTE: If multiple powder types are being used in a facility, Renishaw strongly recommends that all powder-handling equipment is labelled and colour-coded for each powder type.



Figure 185 Suitable tools for cleaning the build chamber

8. Close the top door.

9. On the touch screen control panel, re-inert the build chamber to an oxygen level of less than 7% (70 000 ppm) as follows. From the Home page, select Remove build, then from the Atmosphere pane, select the De-Build Purge button (Figure 186).

WARNING: The build chamber oxygen level must be less than 7% before beginning chamber clean-down.

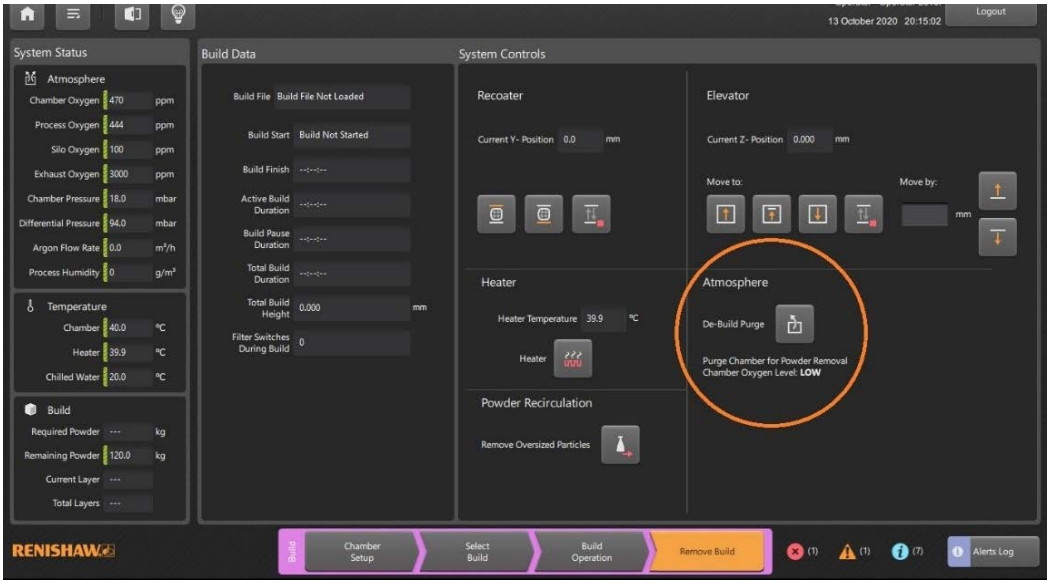


Figure 186 Atmosphere – De-build Purge button (right)

10. When the oxygen level in the build chamber reaches 7%, start removing metal powder from the build volume as follows.

NOTE: To remove metal powder from the build volume, the elevator needs to be raised in stages.

11. On the touch screen control panel, from the Home page, select Remove Build (Figure 187).

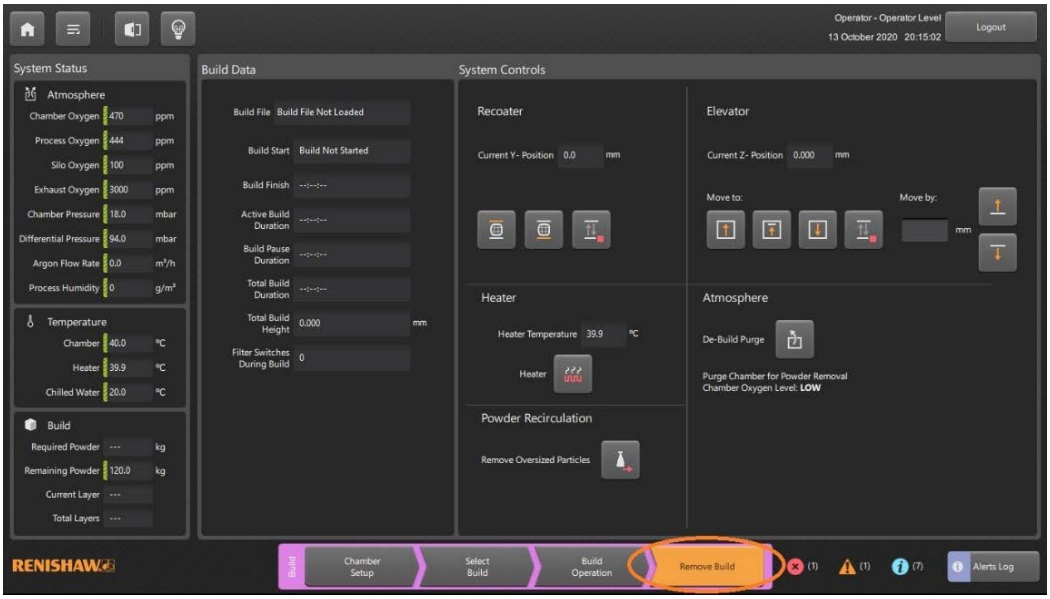


Figure 187 Home page and Remove Build

12. From Remove Build, click in the Move by box (Figure 188).

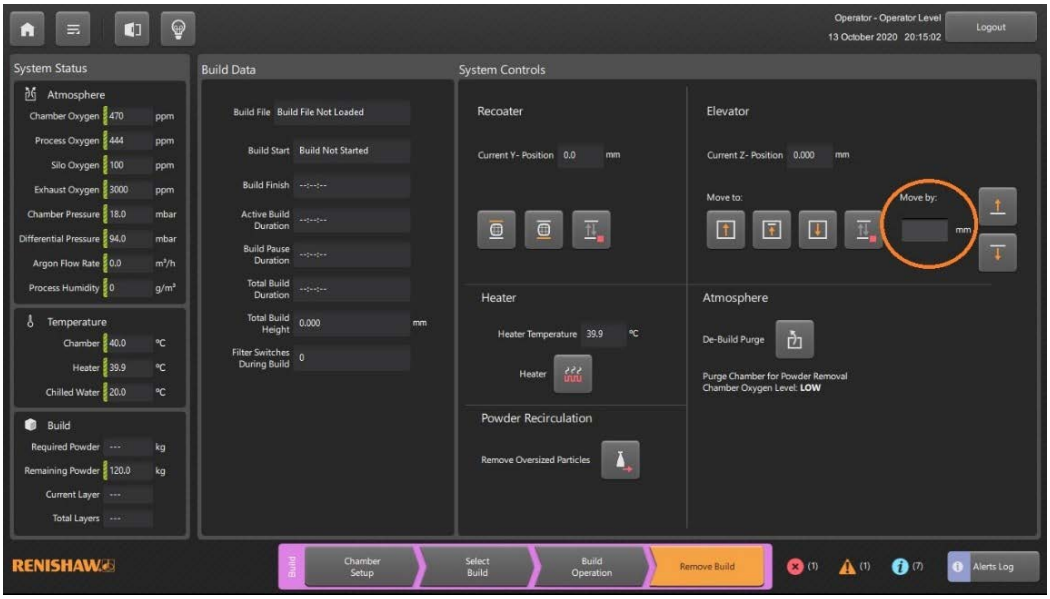


Figure 188 Remove Build and Move by box

13. This will open a keypad dialog (Figure 189).

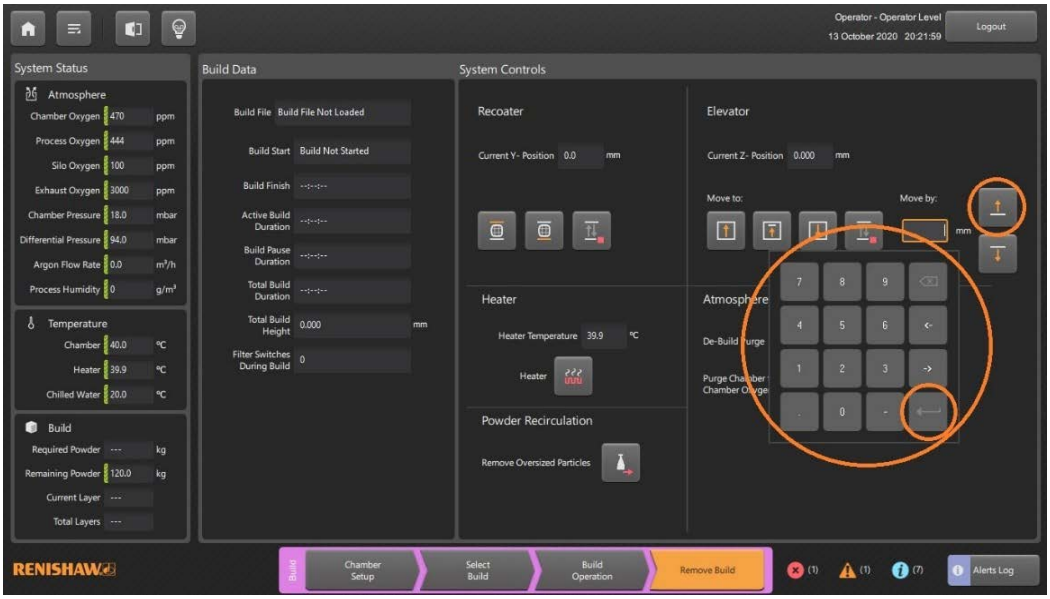


Figure 189 Remove Build keypad dialog, Return button and Move elevator up button

14. Enter a suitable value of up to 60 mm (2.4 in), select the return button and select the Move elevator up button (Figure 189).

15. This will raise the elevator by the value specified.

16. The build chamber will be at a positive pressure of up to 30 mbar-gauge (0.43 psi-gauge). To prevent the gloves from inflating outwards when the glovebox door is opened, it is necessary to equalise the pressure in the build chamber. To do this, on the touch screen control panel select the Open door button. The Unlock Top Door button will appear. Select the Unlock Top Door button, which will operate the build chamber vent valve and equalise the pressure, without opening the build chamber door.

    WARNING: Do not press the blue Reset button, as this will open the build chamber door when the build chamber is full of powder.

17. Open the glovebox door, insert your hands into the gloves and, using the non-static-generating brush and scrapers, push the exposed powder from the build down the front overflow. If you have a modified recoater with a 5 mm (0.19 in) gap under it, push the exposed powder down the front and rear overflows equally.

18. Pull the gloves from the build chamber and hold the glovebox door shut to make the interlock switch which allows elevator movement. On the touch screen control panel, select the Move elevator up button (Figure 190).

NOTE: It is not necessary to refit and secure the glovebox door retaining bolts.

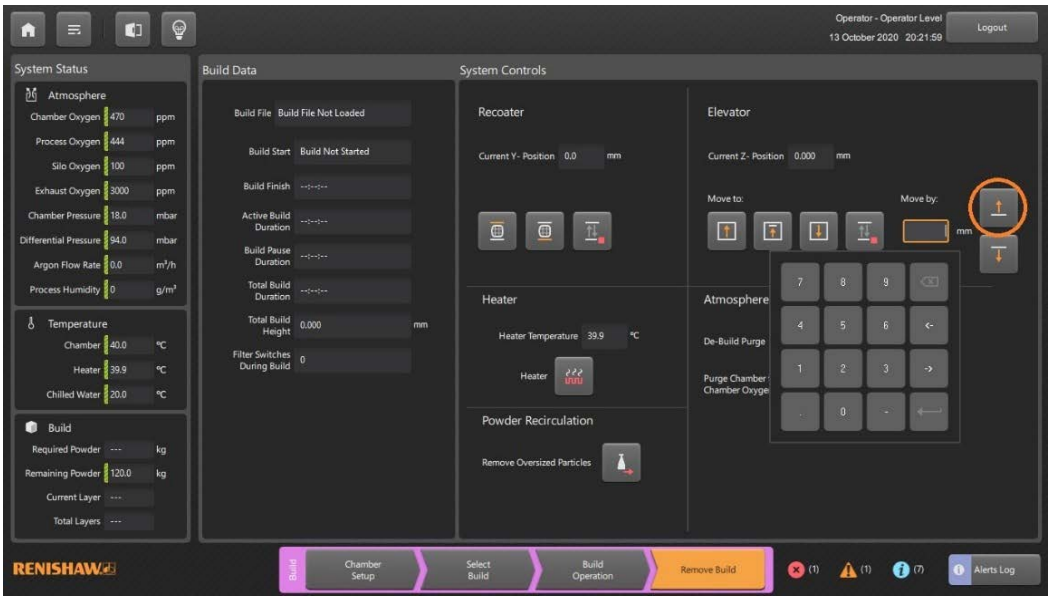


Figure 190 Remove Build and Move elevator up button

19. This will move the elevator up by the value entered and expose more powder.

20. Repeat the steps to raise the elevator and brush powder down the overflows until the elevator is at the top of the z-axis and there is no more powder on the build plate.

CAUTION: Do not touch the lens protection system window during powder removal.

21. Using the blower (Figure 191) placed in the build chamber previously, clear powder from the heads of the four build plate securing bolts.



Figure 191 Blower to remove powder from build plate bolts

22. To raise the build plate out of the build volume, from Remove build, select the Send elevator to absolute top button (Figure 192).

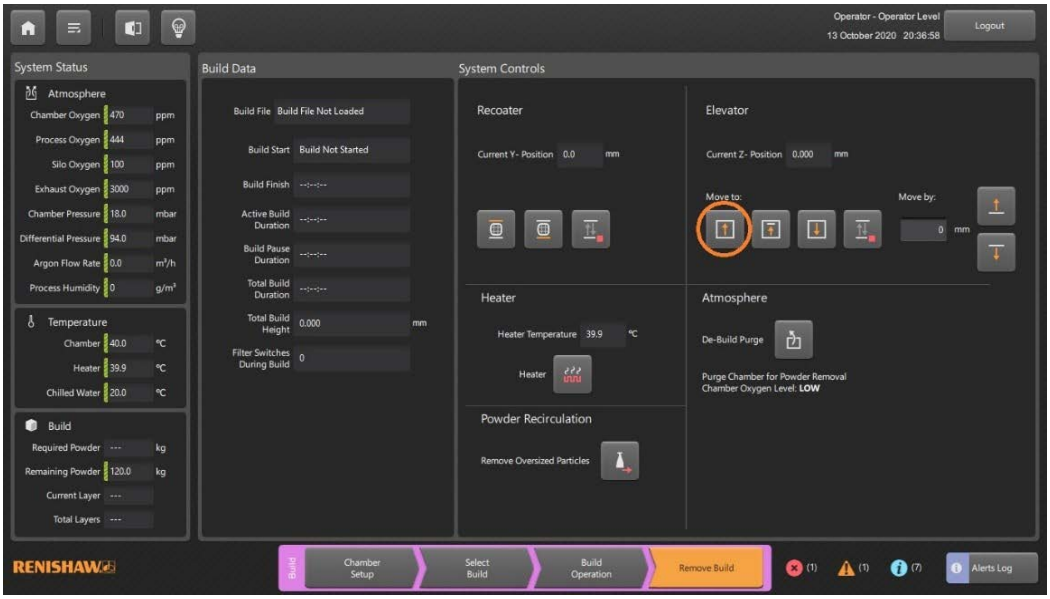


Figure 192 Remove build, Absolute Top button

23. Brush any remaining powder from the build plate down the front overflow.

8.3.6 PB-004 – Build plate – Remove

NOTE: (RenAM 500 Flex machines only). The supplied overflow caps should be fitted to the front and rear overflow slots prior to starting this task.

1. Using the glovebox and 4 mm (0.15 in) hexagon key, remove all four bolts that secure the build plate (Figure 193).



Figure 193 Removing the four build plate securing bolts

2. Place the bolts in a secure location in the build chamber until they are required for fitting the next build plate.

   CAUTION: Build plate securing bolts must be checked after every use for damage and wear. Replace damaged or worn bolts as necessary. Regardless of damage or wear, build plate securing bolts should be replaced on a regular basis.

3. Lift the build plate and tip any powder remaining inside the build down the front overflow (Figure 194).



Figure 194 Tip any remaining powder down the front overflow

WARNING: The build plate and build are heavy. Exercise care when lifting the build plate and tipping powder down the front overflow.

4. Ensure you have a firm grip on the build plate, and shake the build plate to allow any trapped powder to be removed from the build.

5. Once as much powder as possible has been removed and deposited down the front overflow, place the build plate back on the elevator.

8.3.7 PB-005 – Build chamber – Clean

1. The internal surfaces of the build chamber need to be clear of any metal powder residue and condensate (black deposits).

2. Open the top door.

   WARNING: The operator, build, RenAM 500 series, ATEX vacuum cleaner and bench must all be earthed when removing the build from the build chamber and when cleaning the build chamber.

3. Remove the completed build from the build chamber. Use suitable lifting equipment such as a Renishaw universal lifter to move heavy builds.

   WARNING: The completed build may be very heavy. Use suitable lifting equipment such as a Renishaw universal lifter to remove the completed build from the build chamber.

   NOTE: CAD data and material properties information can be used to calculate the exact weight of a completed build, however, the amount of support added will affect the calculated weight.

4. Using the ATEX vacuum cleaner (refer to the manufacturer's instructions for information about the safe operation of the ATEX vacuum cleaner), attachments, scrapers and a 19 mm (0.75 in) non-static-generating brush, clean all metal powder from the build chamber.

5. Starting at the top, clean the entire build chamber, paying particular attention to:

   - Door seals, along the edge of build chamber and bottom chamber door seals
   - Gas inlets and outlets
   - Build chamber platform
   - Front and rear overflows

   CAUTION: Do not touch the lens protection system window during cleaning. Touching the lens protection system window may damage it and necessitate its replacement.

6. Using the ATEX vacuum cleaner, ensure that the bolt holes on the build platform are completely clear of powder.

   NOTE: Apply small amounts of Class 3 IPA to a cloth. Do not apply it directly to RenAM 500 series components.

7. When as much of the powder and residue as possible has been removed with the non-static-generating brush and ATEX vacuum cleaner, the next step is to clean the build chamber surfaces with Class 3 IPA and a disposable cloth.

8. Apply Class 3 IPA to a disposable cloth and wipe down all the internal surfaces of the build chamber. Start at the top of the build chamber, work downwards and ensure all internal surfaces are clean and free of any metal powder residue and condensate (black deposits).

9. Apply Class 3 IPA to a disposable cloth and wipe down the inside of the build chamber viewing window and the top door seal.

WARNING: After every clean-down of the top door, inspect the build chamber viewing window. If the window is damaged, stop using the RenAM 500 series system and contact Renishaw for a replacement window.

8.3.8 PB-007 – Lower chamber – Clean

1. Before the RenAM 500 series system can be used for the next build, the lower chamber must be cleaned of any metal powder or process emissions.

   WARNING: Do not interfere with the elevator motor or brake (Figure 195) when cleaning the lower chamber.

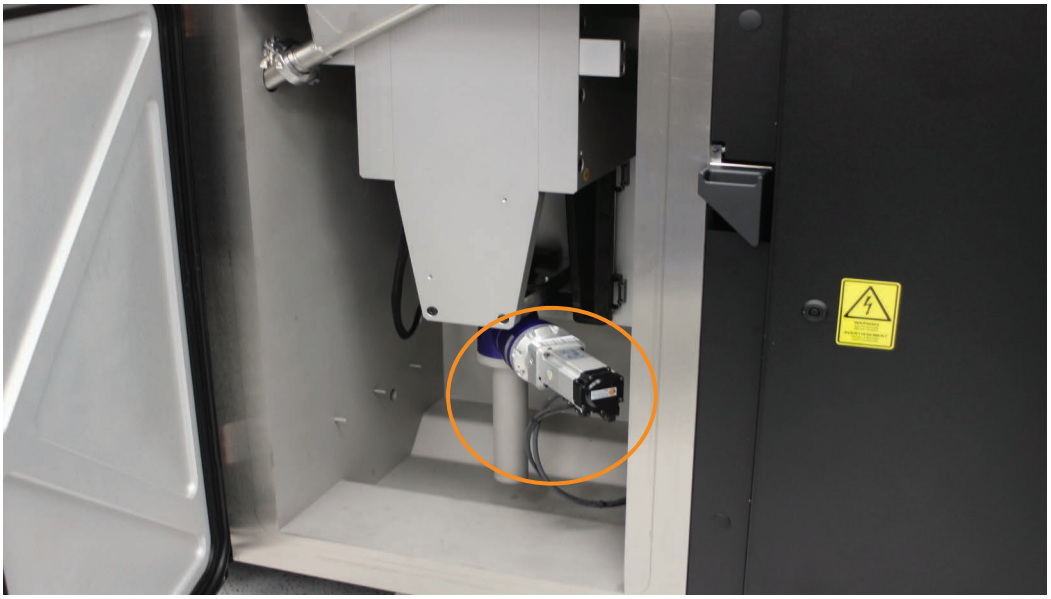


Figure 195 Lower chamber elevator motor and brake assembly

2. In normal operation a small amount of metal powder may bypass the build platform seals and be seen in the lower chamber. If significant quantities of metal powder are seen, it may indicate build platform seal wear – contact your local Renishaw Service team.

3. Leave the top door open and open the bottom door. Using a 19 mm (0.75 in) round non-static-generating brush and ATEX vacuum cleaner, remove all powder residue and process emissions from the lower chamber. Refer to the manufacturer's instructions for information about the safe operation of the ATEX vacuum cleaner.

4. Apply Class 3 IPA to a disposable cloth and clean down all surfaces in the lower chamber.

5. Clean the door seal by vacuuming away loose powder, and then wipe down using a disposable cloth and Class 3 IPA.

6. When the lower chamber cleaning is complete, close the bottom door.

8.3.9 PB-008 – Recoater blade – Remove

1. Ensure you are wearing the correct PPE for the cleanliness of the recoater blade assembly.
2. On the recoater blade assembly that was removed and set aside previously, loosen the five M4 bolts of the recoater blade housing using a 3 mm (0.12 in) hexagon key (Figure 196).

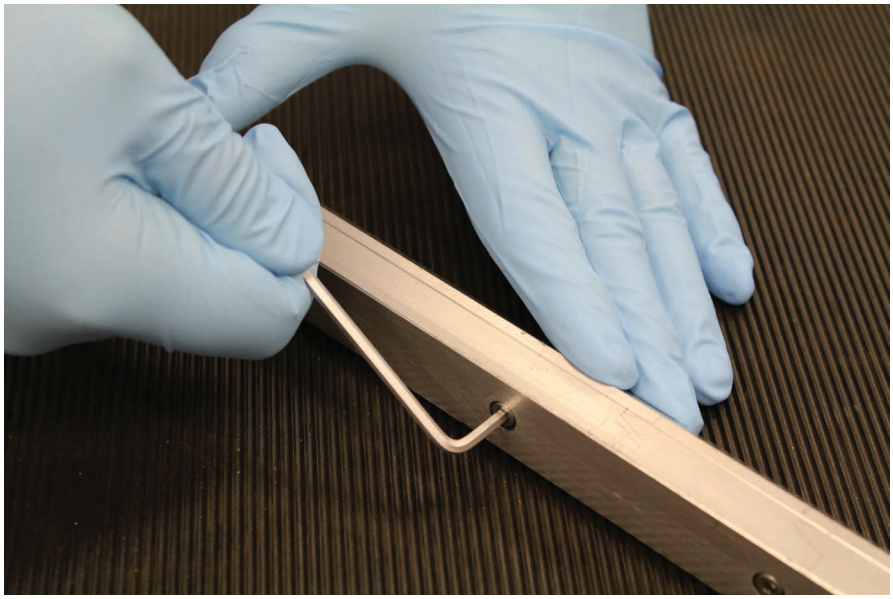


Figure 196 Recoater blade assembly M4 bolts

3. Remove the used recoater blade and dispose of it in accordance with the applicable local rules for the safe disposal of contaminated waste.
4. Wipe down the recoater housing using a disposable cloth and Class 3 IPA.
5. Set aside the recoater housing in a clean location until it is required for the next build.

8.3.10 PB-009 – RenAM 500 series system – Shut down

NOTE: If another build is to be built on the RenAM 500 series system immediately, ignore this task and proceed to the next task.

1. From any RenAMP screen, select the Function button, circled in the upper left-hand corner (Figure 197).

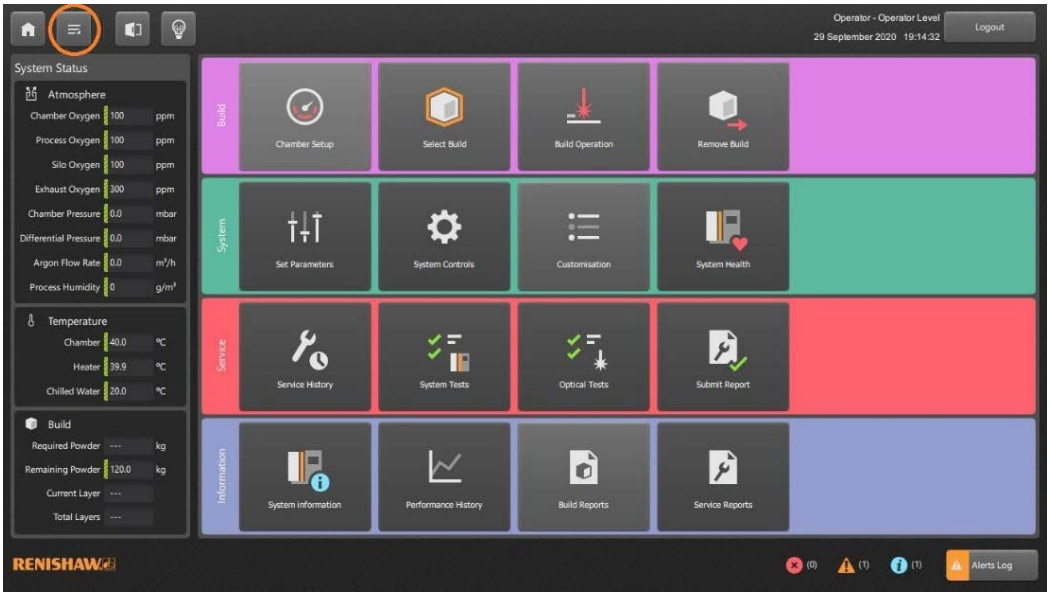


Figure 197 RenAMP Home page and Function button

2. This will display the Function menu (Figure 198).

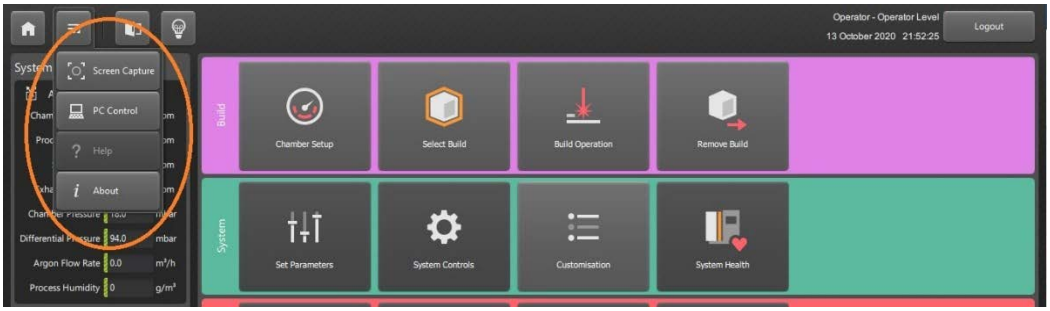


Figure 198 RenAMP Function menu

3. Select PC Control. This will display the PC Control dialog box (Figure 199). Select Shutdown to shut down the PC.

NOTE: Do not carry out the task “PB-010 – RenAM 500 series system – Power down” until the PC has shut down completely.

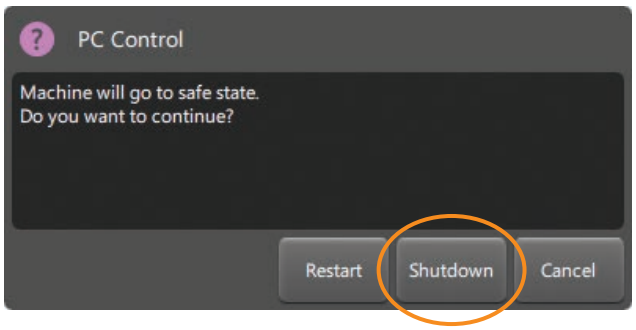


Figure 199 PC Control dialog box Shutdown button

8.3.11 PB-010 – RenAM 500 series system – Power down

NOTE: If another build is to be built on the RenAM 500 series system immediately, ignore this task and proceed to the next task.

1. The equipment main isolation switch is located on the rear left-hand side of the RenAM 500 series cabinet.
2. Move the switch from the On position (Figure 200 – left) to the Off position (Figure 200 – right). This disables power to the system electrical circuits.

NOTE: When the RenAM 500 series system has been powered down, do not power it up for at least five minutes; this is to enable the system to reset and enable automatic power-up of the PC.

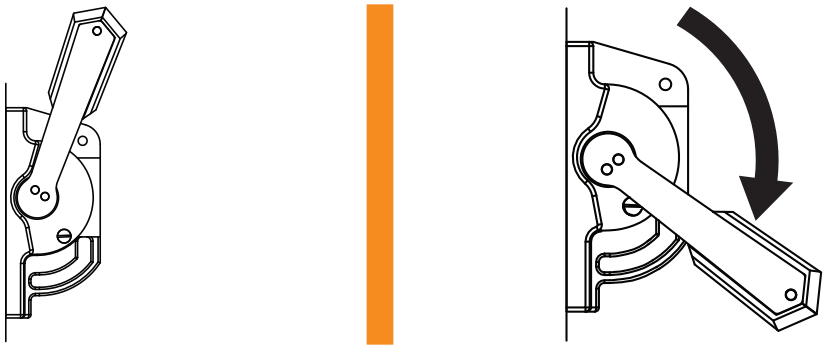


Figure 200 Equipment main isolation switch – On left and Off right

8.3.12 PB-011 – Chiller – Power down

NOTE: If another build is to be built on the RenAM 500 series system immediately, ignore this task and proceed to the next task.

NOTE: The chiller must have been running for a minimum of 3 hours before starting a build. This is to ensure that the optical module is at the optimum operating temperature. Consider leaving it running in between builds.

1. On the chiller front control panel (Figure 201), press the Run/Stop button (circled) once to switch off the pump. The Run light (circled) will extinguish.



Figure 201 Run/Stop button and Run light on SMC Pneumatics chiller control panel

2. On the rear of the chiller, operate the miniature circuit breaker (MCB), circled (Figure 202) and move it to the Off position – down.



Figure 202 Power supply MCB on rear of SMC Pneumatics chiller

8.3.13 PB-012 – Build plate parts – Remove

Once the build plate has been removed from the build chamber and has cooled, the parts can be removed.

The choice of removal method (water jet, bandsaw, wire erosion, etc) is dependent upon the build material, type of build, etc.

If you need advice or assistance in selecting the correct method of part removal to suit your AM application, contact Renishaw. For more information see, section 12, “Customer support”.

8.3.14 PB-013 – Build plate – Refurbish

Build plates must be cleaned up after use and before they are reused. They can be cleaned up by grinding, milling or turning.

The cleaned-up plates should maintain a tolerance of 50 µm for flatness and parallelism over their thickness, and a surface finish of up to 1.6 µm Ra (ground finish).

It is especially important to ensure that the underside of the build plate is not convex, as this can have a detrimental effect on the flatness of the upper working face when installed in the system. This can lead to failed builds because of uneven metal powder distribution on the initial layers and poor adhesion to the build plate.

After machining, all cutting fluid residue must be removed using an appropriate cleaning medium – ethanol or Class 3 IPA is suitable.

NOTE: Build plate thickness must be measured prior to final fixing onto the build table. Failure to input the correct thickness value may result in damage to the system or process inconsistency.

NOTE: Depending upon the application, a build plate thicker than standard may be required to ensure the internal stress within the built part is adequately resisted – this is typically only when very large and particularly dense parts are fabricated. If in doubt, contact Renishaw. For more information, see section 12, “Customer support”.

To regrind or remanufacture RenAM 500 series build plates, see section 5, “Build plate specification”, for build plate specifications.

8.3.15 PB-014 – Heat treatment of parts (optional) – Set up

WARNING: Ensure you are wearing the suitable PPE for handling hot parts when carrying out this task.

PB-014-01 – Introduction

It is outside the scope of this User guide to define heat treatment methods and processes for AM parts once they have been built. However, the following considerations should be made:

- Thick sections may have higher stress and require a normalisation or annealing heat treatment.
- Builds with a large cross-sectional area will have a longer period between laser passes and require heat treatment.
- Some materials, such as titanium alloy, may have higher internal stress following build and require heat treatment as soon as the build finishes.
- Almost all alloys will oxidise at elevated temperatures. It is essential that heat treatment is carried out under vacuum or inert gas. For metals that are susceptible to nitrogen embrittlement (titanium and INCONEL® for example), it is essential that the inert gas is argon.
- Renishaw can supply furnace foil wrap (part no. P-HT01-0001). This is used to provide an extra layer of protection when used in conjunction with an inert gas box.

For detailed furnace programming and operating instructions, refer to the user guide for your furnace and any applicable local procedures.

PB-014-02 – Wrapping parts prior to heat treatment

Renishaw recommends that parts are wrapped in furnace foil wrap as follows:

1. Ensure enough foil is used to wrap the part (Figure 203).

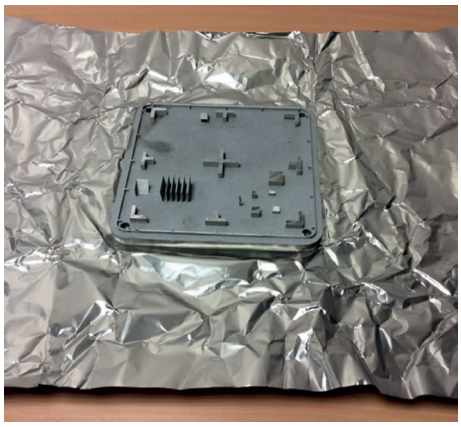


Figure 203 Amount of foil to wrap the part

2. Fold and cover approximately one quarter of the part (Figure 204).



Figure 204 Fold and cover

3. Flip the part over and fold the remaining foil under (Figure 205).



Figure 205 Fold remaining foil under

4. Crimp any open ends of the foil parcel (Figure 206).



Figure 206 Crimp any open ends

5. Flip the part over again (Figure 207).



Figure 207 Flip over part again

6. Fold over the edges (Figure 208).



Figure 208 Fold over edges

7. The part is now fully wrapped (Figure 209).



Figure 209 Part fully wrapped

8. Place the fully wrapped part in a furnace box (Figure 210).

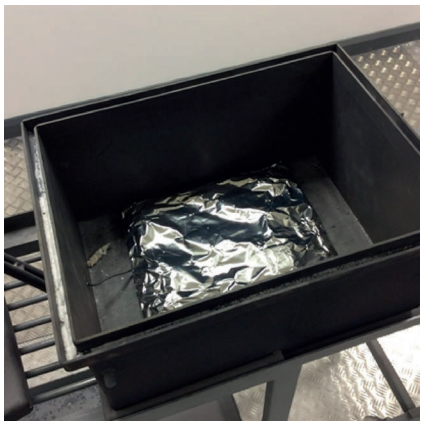


Figure 210 Place the part in furnace box

9. With the part in the furnace box, cover with an additional piece of furnace foil that extends to the edges of the furnace box (Figure 211).

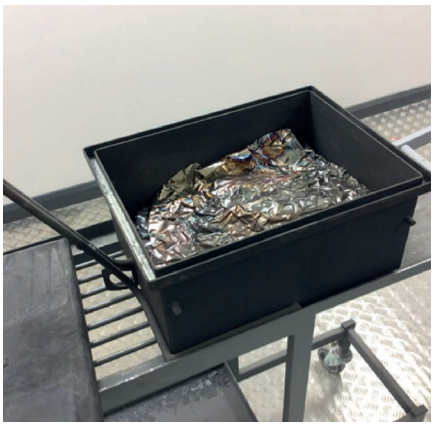


Figure 211 Cover the part in furnace box

10. Fit the lid to the furnace box and place the box in the furnace (Figure 212).

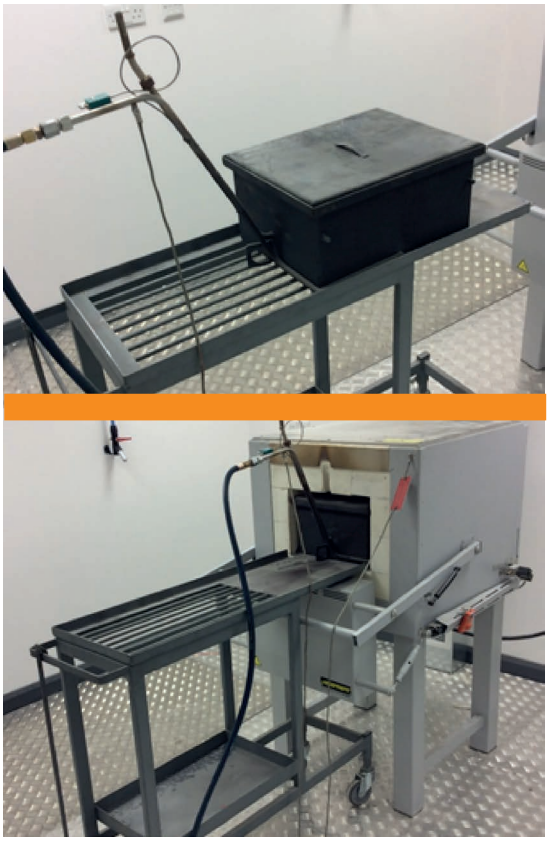


Figure 212 Fit the lid to the furnace box and place in furnace

WARNING: Ensure the furnace is operated in accordance with the manufacturer's instructions.

WARNING: Ensure that heat treatment is carried out in accordance with best practice or local procedures for the material being heat-treated.

8.3.16 PB-015 – Oversized particle collection flask – Refit, remove and empty (RenAM 500 and RenAM 500 Ultra only)

The oversized particle collection flask collects oversized particles from the powder distribution system that do not meet the physical criteria for use within the RenAM 500 and RenAM 500 Ultra system.

The oversized particles should be emptied from the RenAM 500 / RenAM 500 Ultra after every build.

The oversized particle collection flask is located at the top centre of the front left-hand cupboard.

WARNING: Ensure the powder flask used to collect the oversized particles is completely empty before it is attached to the RenAM 500 / RenAM 500 Ultra system.

WARNING: Ensure you are wearing the correct PPE: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

PB-015-01 – Refit

1. Take an oversized particle collection flask, fit a centring ring and an isolation valve and secure with a quick-release clamp. Ensure the isolation valve is closed. Fit a centring ring to the KF flange on the isolation valve fitted previously to the oversized particle collection flask.

2. On the RenAM 500 / RenAM 500 Ultra, remove the quick-release clamp securing the blanking plate to the oversized particle outlet and remove the blanking plate.

3. Grip the neck of the oversized particle collection flask and offer up the KF flange on the isolation valve to the KF flange on the oversized particle outlet on the RenAM 500 / RenAM 500 Ultra system.

4. Fit a quick-release clamp to the KF flanges, close it and secure the powder flask to the RenAM 500 / RenAM 500 Ultra (Figure 213). Ensure the isolation valve is in the isolated position with the handle at 90° to the pipework.

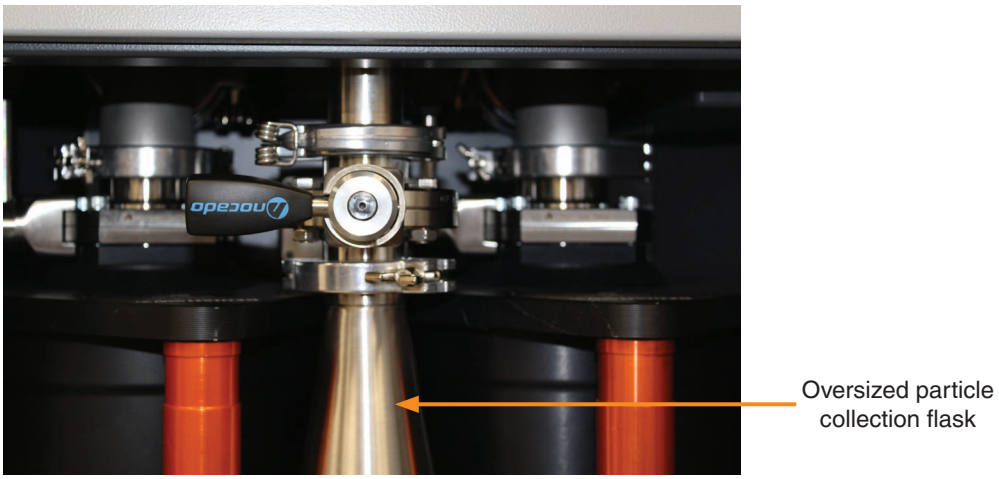


Figure 213 Oversized particle collection flask

5. From the RenAMP Home page select Remove Build (Figure 214).

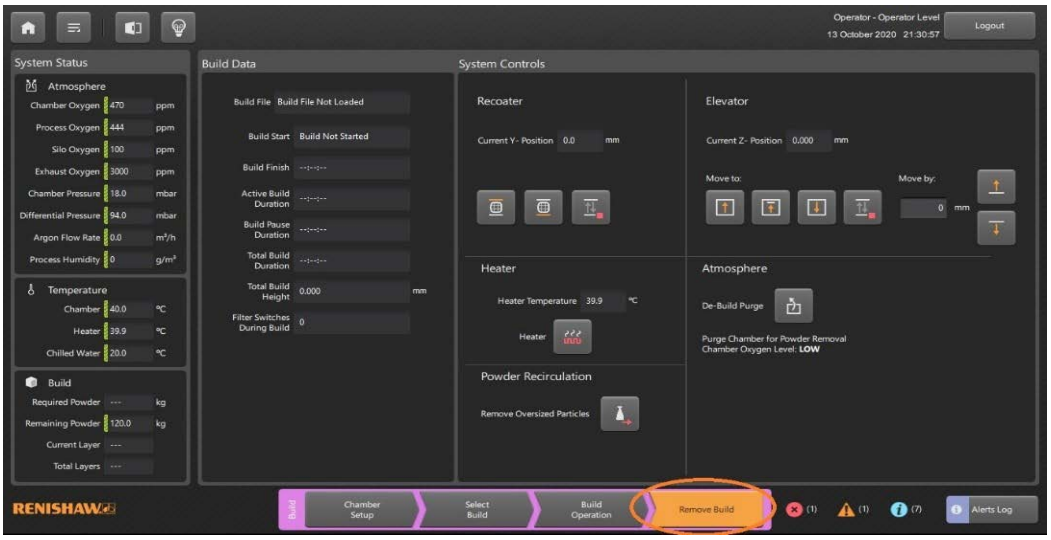


Figure 214 Remove Build

6. From the Remove Build page (Figure 215) select the Remove Oversized Particles button.

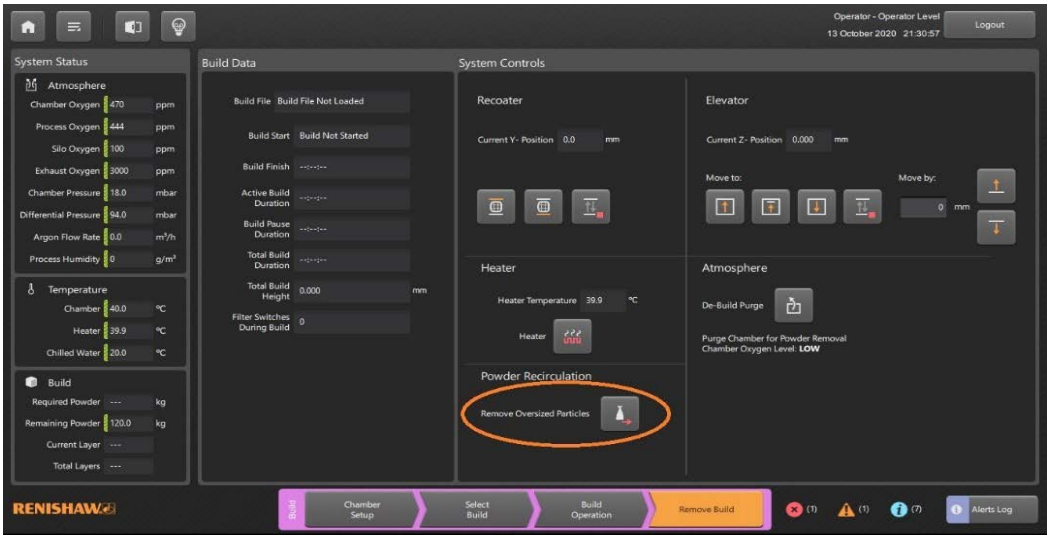


Figure 215 Remove Build and Remove Oversized Particles button

7. This will display a confirmation dialog box (Figure 216). Select Yes, and the process to remove oversized particles will begin.

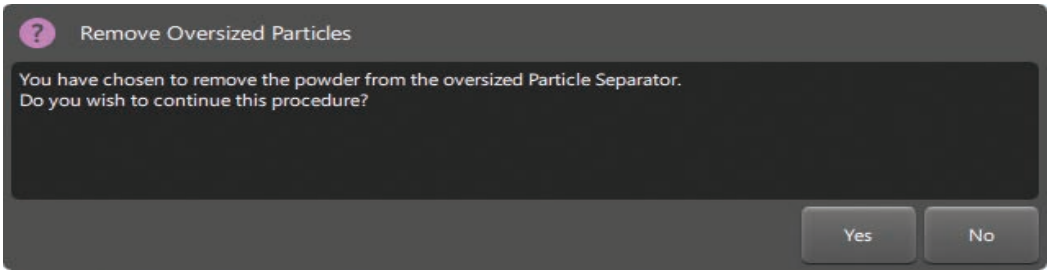


Figure 216 Remove oversized particles confirmation dialog box

8. A further confirmation dialog box (Figure 217) will display. Select Confirm to confirm that an empty powder flask has been connected to the motorised valve (the flask was fitted in steps 1 to 4 previously).

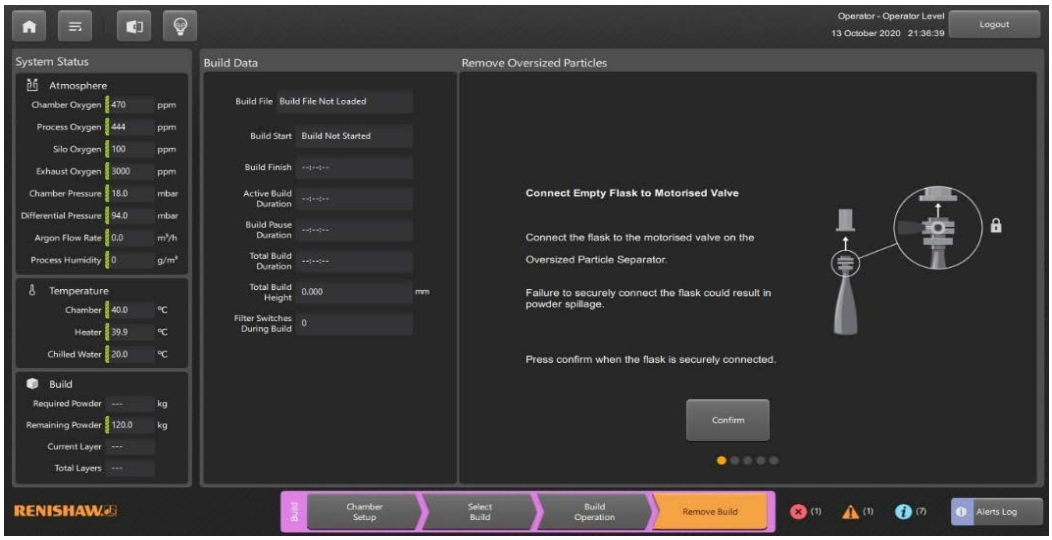


Figure 217 Connect Empty Flask to Motorised Valve confirmation dialog box

9. On the powder flask fitted previously, open the isolation valve. The handle will be in line with the pipework. On the dialog box (Figure 218) confirm that the isolation valve has been moved to the open position.

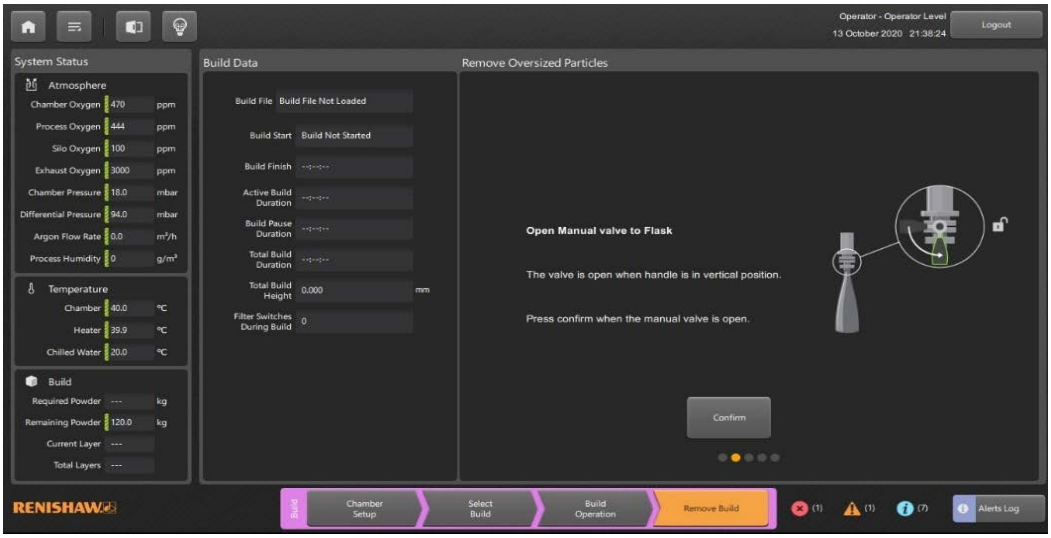


Figure 218 Open Manual Valve to Flask confirmation dialog box

10. A dialog box will display, advising that the oversized particles are being transferred to the powder flask (Figure 219) and indicating how long this will take in seconds.

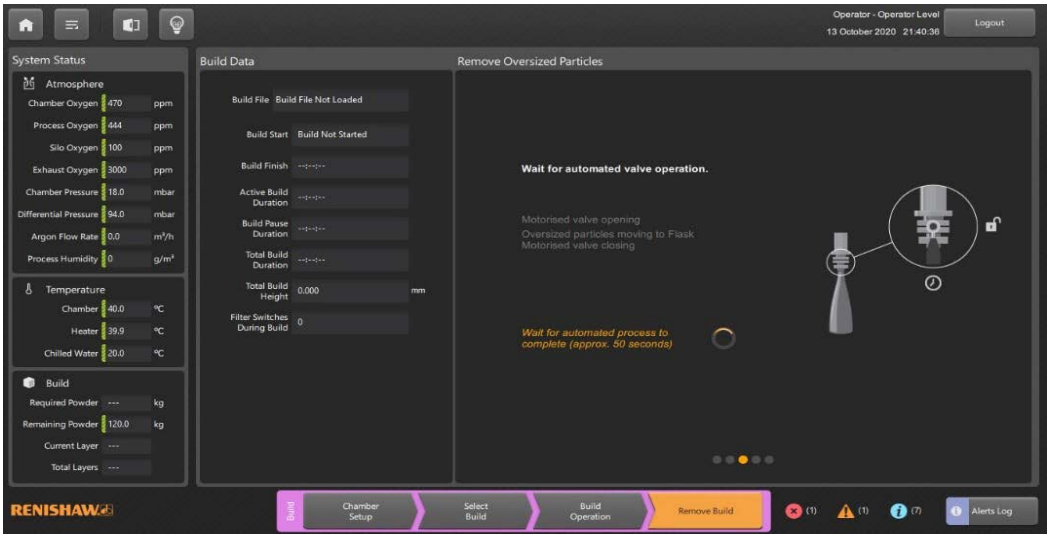


Figure 219 "Wait for automated valve operation" dialog box

11. When the transfer of oversized particles is complete, a dialog box will display (Figure 220). On the powder flask, close the manual isolation valve. The handle will be at 90° to the pipework. On the dialog box (Figure 220), confirm that the isolation valve has been moved to the closed position.

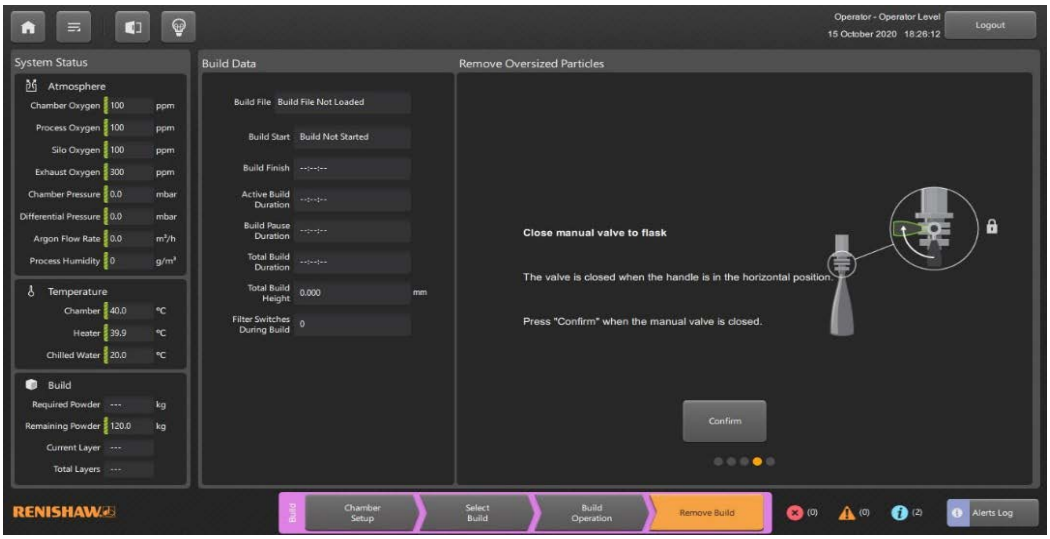


Figure 220 "Close manual valve to flask" dialog box

PB-015-02 – Remove

1. The “Remove flask of oversized particles from motorised valve” dialog box will be displayed (Figure 221). Grip the neck of the oversized particle collection flask. Remove the quick-release clamp securing the oversized particle collection flask isolation valve KF flange to the system outlet KF flange. Separate the oversized particle collection flask from the RenAM 500 / RenAM 500 Ultra. Remove the centring ring. Refit the blanking plate to the oversized particle outlet and secure with a quick-release clamp.

2. On the “Remove flask of oversized particles from motorised valve” dialog box (Figure 221), select Confirm to confirm that the flask has been removed. This will return you to the System Controls page. The removal of oversized particles is now complete.

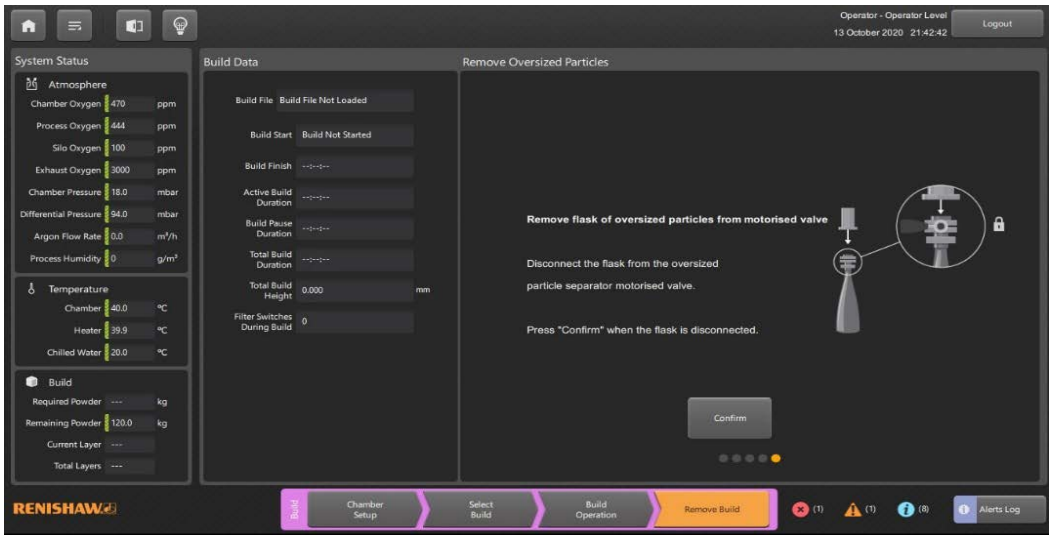


Figure 221 "Remove flask of oversized particles from motorised valve" dialog box

PB-015-03 – Empty

Dispose of the contents of the oversized particle collection flask in accordance with the local rules for the disposal of metal waste products.

NOTE: It may be possible to reuse the contents of the oversized particle collection flask. The material may need to be tested, sieved, examined, etc before it can be reused; this is up to the discretion, processes and procedures of the end user and their organisation.

8.3.17 PB-016 – Lens protection system – Inspect

CAUTION: The lens protection system is made from fused silica, and has an optical coating that will scratch if handled incorrectly.

CAUTION: Do not touch the surface of the lens protection system.

CAUTION: The lens protection system needs to be completely clear, removing all nanoparticles and leaving no smudges that can affect laser beam coupling efficiency and focus.

Regularly inspect the condition of the lens protection system. Over time the lens protection system window will require cleaning, will degrade and will require replacement in order to maintain AM system performance and part quality. Care and attention when inspecting and cleaning will significantly improve the life of the lens protection system window. Inspecting and cleaning the lens protection system window is the recommended method to ensure maximum life.

1. Open the top door.
2. Ensure that the build chamber has been emptied of metal powder and thoroughly cleaned in accordance with task “PB-005 – Build chamber – Clean”.
3. Using a torch, inspect the surface of the lens protection window (Figure 222) for dust, particles, metal powder, condensate or streaks.

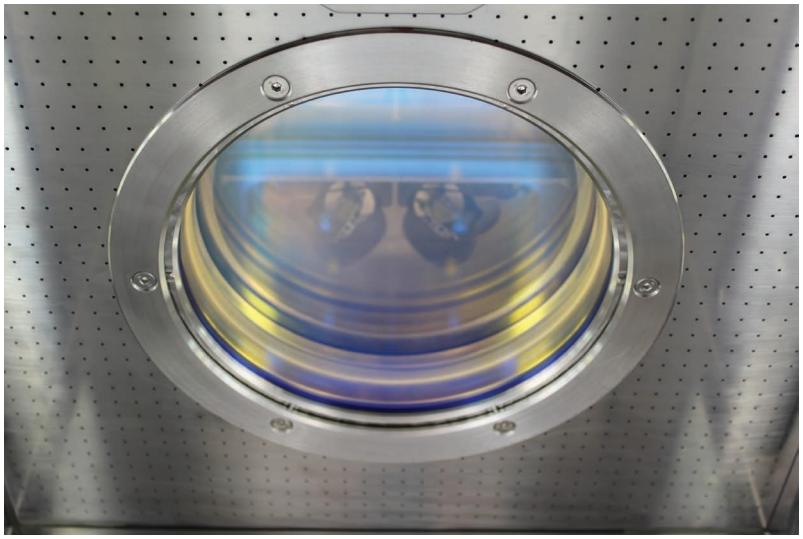


Figure 222 Lens protection system assembly

4. If dust, particles, metal powder, condensate or streaks are found, clean the lens protection window. For more information, see section 10.19, “PM-035 – Lens protection window – Clean”.

8.3.18 PB-017 – Cyclone filter particle collection flask – Remove and empty

The cyclone filter particle collection flask collects oversized particles from the gas flow system that do not meet the physical criteria for use within the RenAM 500 series system.

The cyclone filter particle collection flask should be emptied from the RenAM 500 series after every build.

The cyclone filter collection flask is located in the rear right cupboard behind the door.

WARNING: Ensure you are wearing the correct PPE: ESD safety footwear, eye protection, full face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

PB-017-01 – Remove

1. Open the rear right cupboard door.
2. On the RenAM 500 series cyclone filter outlet, close the isolation valve (Figure 223).
3. On the cyclone filter particle collection flask, close the isolation valve (Figure 223).

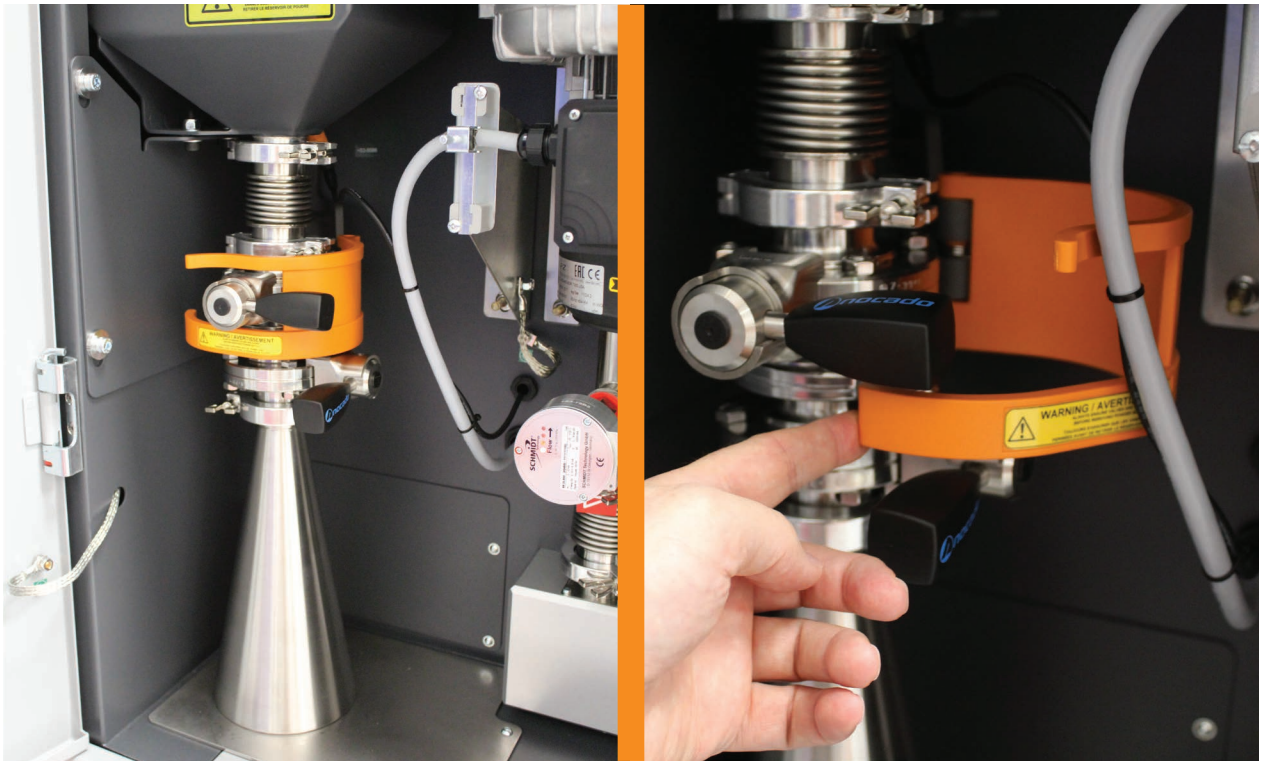


Figure 223 Isolation valves in the closed position (left-hand) and cyclone filter particle collection flask – isolation valve's plastic cover (right-hand)

4. Grip the neck of the cyclone filter particle collection flask. Open the plastic cover (Figure 223) and remove the quick-release clamp securing the cyclone filter particle collection flask isolation valve to the cyclone filter outlet isolation valve.

5. Separate the cyclone filter particle collection flask from the RenAM 500 series. Remove the centring ring. Refit the blanking plate to the cyclone filter particle outlet and secure with a quick-release clamp.

6. The cover is spring-loaded and self-closes.

PB-017-02 – Empty

Dispose of the contents of the cyclone filter particle collection flask in accordance with the local rules for the disposal of metal waste products.

WARNING: Do not add the contents of the cyclone filter particle collection flask back into the load/feed hopper. It may be possible to reuse the contents of the cyclone filter particle collection flask, but the material will need to be sieved, tested and examined before it can be reused. You must satisfy yourself that the material meets the material specification for the RenAM 500 series system before it can be reused; this is the responsibility of the end user and their organisation.

8.3.19 PB-018 – Overflow flask – Remove and empty (RenAM 500 Flex only)

The overflow flasks are located in the front left cupboard behind the door.

WARNING: Ensure you are wearing the correct PPE: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

WARNING: Always ensure both the overflow flask isolation valve and the overflow pipe isolation valve are closed before removing the quick-release clamp. Failure to do so while the machine is running could potentially result in powder spillage into the atmosphere.

NOTE: If the front overflow flask requires emptying mid-build, it is recommended that the rear flask is removed, emptied and replaced at the same time due to limited access to the rear flask while the front flask is fitted.

NOTE: It should be possible to reuse the contents of the overflow flask once material has been sieved. However, the material may need to be tested, examined, etc before it can be reused; this is up to the discretion, processes and procedures of the end user and their organisation.

PB-018-01 – Remove (1.7 L (103 in³) flask)

1. Open the front left cupboard door.
2. On the RenAM 500 Flex overflow pipe, close the isolation valve (Figure 224).
3. On the overflow flask, close the isolation valve (Figure 224)

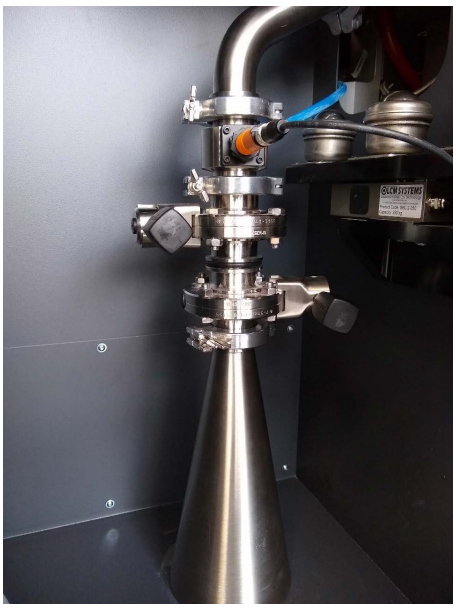


Figure 224 Isolation valves in the closed position on the overflow pipe and overflow flask

4. Grip the neck of the overflow flask. Remove the quick-release clamp securing the overflow flask

isolation valve to the overflow pipe isolation valve.

5. Separate the overflow flask from the RenAM 500 Flex. Remove the centring ring.
6. Lift the flask from the powder cabinet, gripping the neck and bottom of the flask.
7. Repeat for the rear overflow flask.
8. Transport the flasks to the sieve location and sieve in accordance with the powder recovery system operating instructions in section 7.7, “Powder recovery system (sieve) (recommended for RenAM 500 and RenAM 500 Ultra) (mandatory for RenAM 500 Flex)”.

PB-018-02 – Remove (10 L flask)

WARNING: 10 L (610 in³) overflow flasks (A-6810-6040) full of powder can weigh in excess of 60 kg (132.7 lb). Attempting to lift these flasks manually may result in injury. Always use the Renishaw universal lifter to move these flasks when they contain powder. For specific lifter instructions, refer to the universal lifter user guide.

1. Open the front left cupboard door.
2. On the RenAM 500 Flex overflow pipe, close the isolation valves (Figure 225).
3. On the overflow flasks, close the isolation valve (Figure 225).



Figure 225 Isolation valves in the closed position on the overflow pipe and 10 L (610 in³) overflow flask

4. Remove the quick-release clamp securing the overflow flask isolation valve to the overflow pipe isolation valve.

5. Separate the overflow flask from the RenAM 500 Flex. Remove the centring ring.

6. Manoeuvre the universal lifter so that the cut-outs in the arm align with the bosses on the flask (Figure 226).



Figure 226 Universal lifter aligned with 10 L (610 in³) flask

7. Raise the lifter until it engages with the boss on the flask. Check that both sides are engaged correctly.

8. Raise the lifter until the flask is just clear of the floor (Figure 227), then move the lifter back until it is clear of the cabinet.



Figure 227 Flask lifted clear of the floor

9. Move the lifter to the desired location and lower the lifter until it is completely disengaged from the flask.

10. Check that the rear flask isolation valve and overflow pipe isolation valve are both in the closed position

11. Remove the quick-release clamp securing the overflow flask isolation valve to the overflow pipe isolation valve.

12. Separate the overflow flask from the RenAM 500 Flex. Remove the centring ring.

13. Wrap a 2 m (6.56 ft) sling around the back of the flask, then pull the flask towards the front of the cabinet (Figure 228).

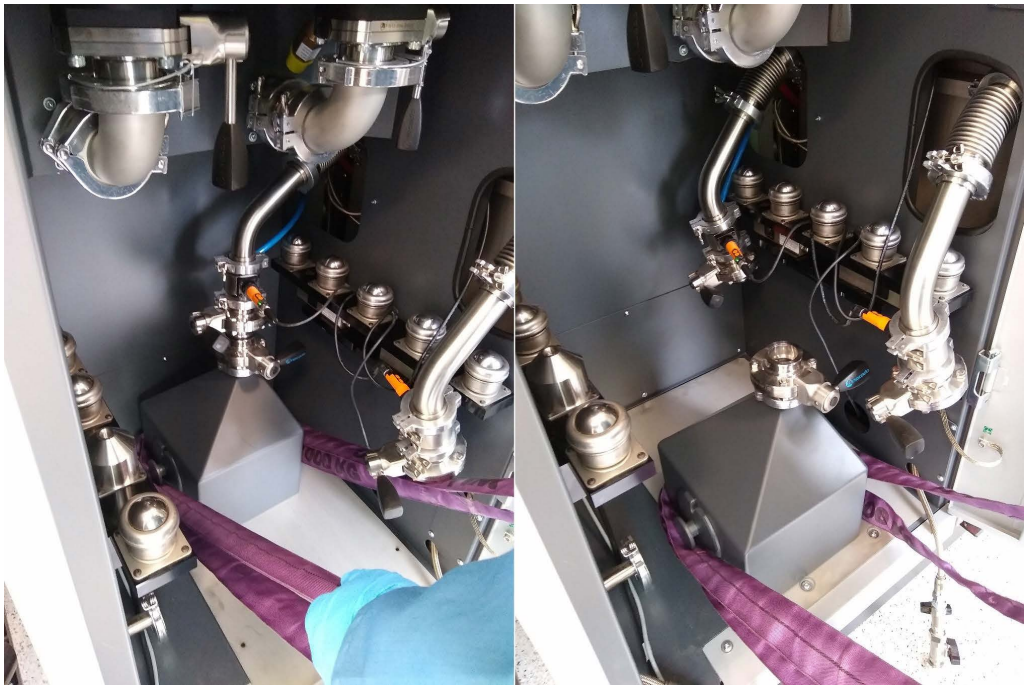


Figure 228 Use sling to remove flask

14. Remove the sling then use the universal lifter to the remove the flask using the same method as the front flask.

8.4 Occasional tasks

The following table lists all the operation tasks that are occasionally required to be carried out on the RenAM 500 series system.

Task number	Task title	User level
OT-001	Chiller fluid level – Top up	Operator
OT-002	Argon gas cylinder – Replace	Operator
OT-003	Powder flask – Fill	Operator
OT-005	Large SafeChange filter assembly – Remove	Operator
OT-006	Large SafeChange filter element – Remove	Operator
OT-007	Large SafeChange filter element – Refit	Operator
OT-008	Large SafeChange filter assembly – Refit	Operator
OT-009	Chiller fluid – Remove	Operator
OT-010	RenAM 500 series system – Build recovery	Operator
OT-011	Feed hopper – Remove (RenAM 500 Flex only)	Technician
OT-012	Feed hopper – Refit (RenAM 500 Flex only)	Technician
OT-013	Powder loading arm – Adjust (RenAM 500 Flex only)	Operator
OT-014	10 L flask – Decant powder	Operator

8.4.1 OT-001 – Chiller fluid level – Top up

1. On the front of the chiller, unscrew the filler cap, circled (Figure 229).



Figure 229 SMC Pneumatics chiller coolant filler

2. Top-up the chiller to the H mark using pre-mixed Nalco chiller fluid (part no. P-HX04-0003) (Figure 230).

CAUTION: Do not fill above the H mark on the sight glass.

CAUTION: Do not use water or any other liquid in place of pre-mixed Nalco chiller fluid.

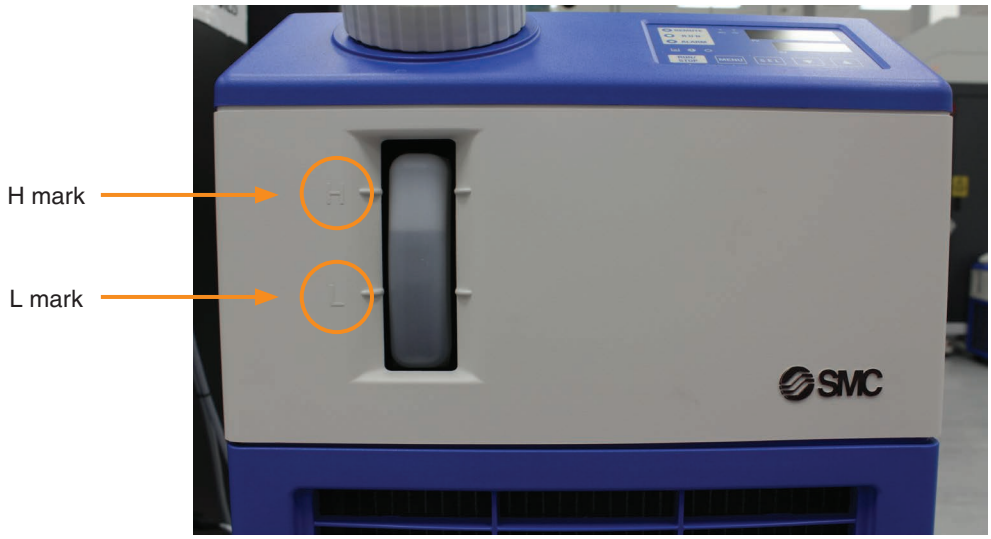


Figure 230 SMC Pneumatics chiller – L and H marks

8.4.2 OT-002 – Argon gas cylinder – Replace

Only people trained, competent and certified to fit compressed gas regulators and handle gas bottles should connect a RenAM 500 series to an argon bottle. Renishaw recommends using an appropriately certified local body to train, assess and certify people.

WARNING: Argon gas cylinders can be heavy. Ensure gas cylinders are correctly secured to prevent them falling over. Use suitable equipment and processes to move cylinders. Consider contacting your argon gas supplier for equipment, information and advice on handling gas cylinders. Take suitable precautions when handling pressurised gas cylinders.

A minimum argon gas pressure of approximately 50 bar (725 psi) is recommended at the start of a build. If the argon supply is depleted, the build process will pause and an alarm will sound. If the argon pressure is below 50 bar (725 psi) at the start of a build, consider replenishing the gas supply.

The following text describes a typical gas cylinder available in the UK. The size and type of gas cylinder and gas regulator may be different in the geographic area where your RenAM 500 series system is located.

1. Close the argon gas cylinder valve by rotating it clockwise.
2. Detach the regulator from the gas valve using a 1 1/8 inch (approximately 29 mm) or adjustable spanner.
3. Remove the empty gas cylinder and store it securely by chaining it in the designated storage location.
4. Install a full gas cylinder in the designated location near the system and secure it appropriately.
5. Attach the regulator to the cylinder valve using a 1 1/8 inch (approximately 29 mm) or adjustable spanner.

   WARNING: Never use oil or grease, sealing compounds or tapes on the gas cylinder connections.

6. Open the argon gas valve by unscrewing the valve completely (anticlockwise), then back off by screwing clockwise half a turn.
7. Regulate the supply pressure to between 3.5 bar (50 psi) and 7 bar (101 psi). Clockwise on the regulator valve will increase the pressure. Listen for any leaks coming from the gas supply and rectify as necessary.

   CAUTION: Do not exceed 10 bar (145 psi) gas supply pressure to the RenAM 500 series system, as this will cause the RenAM 500 series system to stop due to a gas overpressure alarm.

NOTE: Argon gas can be supplied in a cylinder, bank or Cryospeed (liquid). The choice of method to use is up to the end user.

8.4.3 OT-003 – Powder flask – Fill

This task describes the safe transfer of metal powder from a supplier's container to a powder flask. It requires the use of a powder adaptor funnel.

WARNING: Ensure you are wearing the correct PPE: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

NOTE: Renishaw recommends that full-length clothing is made from non-static-generating fabric such as cotton (avoid wool and synthetic fabrics). Avoid turn-ups or pockets that may trap powder. Refer to NFPA 484 for details.

WARNING: Do not load powder directly from the supplier's container into the RenAM 500 series – powder must first be decanted into a powder flask.

WARNING: Do not attempt to fill the RenAM 500 series while the system is under vacuum.

WARNING: When using titanium powder, the silica desiccant bag must be removed from the supplier container to prevent it being transferred into a powder flask.

1. Take a powder adaptor funnel, ensure it is clean and dry, fit a centring ring and an isolation valve and secure with a quick-release clamp. Ensure the isolation valve is closed.
2. Remove the lid of the supplier powder bottle.

   WARNING: The supplier powder bottle is now open and it must be connected with care to avoid any spillage of metal powder. The time spent with the powder bottle open should be kept as short as possible.
3. If the metal powder being transferred is titanium, remove the silica desiccant bag.
4. Screw the powder adaptor funnel on to the top of the supplier powder bottle.
5. Take a powder flask, fit a centring ring and an isolation valve and secure with a quick-release clamp. Ensure the isolation valve is closed.
6. With the bottom of the supplier powder bottle placed on a horizontal surface, fit a centring ring to the KF40 flange of the isolation valve. Rotate the powder flask through 180° and secure the KF40 flanges of the two isolation valves together with a quick-release clamp.

   WARNING: The supplier powder bottle full of metal powder, isolation valves and powder flask weigh approximately 15 kg (33 lb).

7. Rotate the connected powder flask and bottle so that the supplier powder bottle is uppermost. Open both isolation valves and allow the metal powder to flow from the supplier powder bottle into the powder flask below.

8. Tap the powder flask to determine when it is full (hollow sound when empty).

9. When the powder flask is full, close the isolation valve on the powder flask.

10. Rotate the powder bottle and flask through 180° so that the powder flask is uppermost. Allow any remaining metal powder in the coupling to drop back into the supplier powder bottle. Close the isolation valve on the supplier powder bottle.

11. Remove the quick-release clamp securing the two isolation valve KF flanges and separate the powder bottle and flask.

12. The powder is now ready to be loaded into the RenAM 500 series system.

8.4.4 OT-005 – Large SafeChange™ filter assembly – Remove

WARNING: Ensure you are wearing the correct PPE: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

WARNING: Do not close the large SafeChange filter isolation valves if the RenAMP software indicates that a filter is in use.

WARNING: Do not remove either of the large SafeChange filters if the RenAMP software indicates that a filter is in use.

CAUTION: This procedure does not apply to RenAM 500 series systems equipped with the external Long-Life Filter system. For more information, see section 7.10, “Long-Life Filter (optional)”.

The large SafeChange filter assemblies each weigh approximately 15 kg (33 lb) when dry. There are two large SafeChange filter assemblies fitted to the RenAM 500 series system.

Ensure that the oversized particle collection flask is not fitted to the system, as it is not possible to remove the large SafeChange filters assemblies with it in place. If fitted, remove in accordance with task “PB-015 – Oversized particle collection flask – Refit, remove and empty (RenAM 500 and RenAM 500 Ultra only)”.

1. On the touch screen control panel, from the Home screen select Chamber Setup. From Chamber Setup in the Filters pane identify which large SafeChange filter is to be replaced.

   NOTE: From the front of the RenAM 500 series system, with the filter access door open, filter 1 is on the left-hand side and filter 2 is on the right-hand side.

2. The Filters pane (Figure 231) enables you to set whether the large SafeChange filters are Present or Absent. Before either filter is removed, set the appropriate toggle switch to Absent.



Figure 231 Large SafeChange filter Present and Absent toggle switches

3. There are two isolation valves on each large SafeChange filter assembly, one on the system outlet (upper) and one on the filter outlet (lower) (Figure 232). Check both isolation valves are in the isolated position. If they are not, move them to the isolated position, with the handles at 90° to the system pipework.

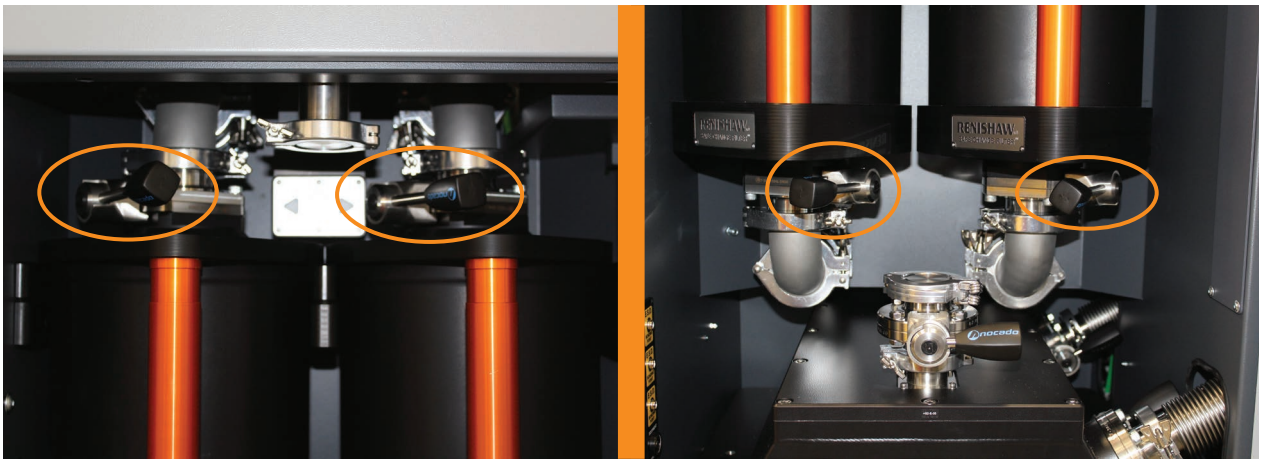


Figure 232 Large SafeChange filter upper isolation valves in isolated position (left). Large SafeChange filter lower isolation valves in isolated position (right)

4. At the top of the large safe filter assembly, above the isolation valve is the upper quick-release clamp. The upper quick-release clamp secures the KF50 flanges of the system outlet and upper isolation valve together. On the upper quick-release clamp, open the latch, remove the two collars of the clamp and disengage the two KF50 flanges. Remove the centring ring and store it with the quick-release clamp until required during refit.

5. At the bottom of the large SafeChange filter assembly, between the isolation valve and the system pipework, is the lower quick-release clamp. Open the latch on the lower quick-release clamp and remove the two collars of the quick-release clamp from the lower KF50 flange connection. Remove the centring ring from the KF50 flanges and store it with the quick-release clamp until required during refit.

WARNING: The dirty large SafeChange filter element contains fine particulate which must be neutralised by soaking in water.

WARNING: Failure to fully submerge the dirty filter element in water before disassembly may result in fire.

6. The dirty filter element contains fine particulate, which must be neutralised by soaking in water. The dirty large SafeChange filter assembly must be filled with water before removing the dirty filter element. This procedure must be followed regardless of the material type being processed.

WARNING: The large SafeChange filter assembly weighs approximately 15 kg (33 lb) when dry. Use suitable lifting equipment as necessary.

7. Grip the handle with the right hand, support the weight of the dirty large SafeChange filter assembly at the base with the left hand, and carefully slide it off the bracket and out of the AM system. Keep the dirty filter assembly upright, do not rotate it and keep it in the same orientation as it was in the AM system. Renishaw recommends that this task is risk assessed in accordance with the user's local rules before it is carried out.

8. In the same orientation as it was removed from the machine, place the large SafeChange filter assembly on a secure surface or bracket that prevents the filter from falling over or being dropped. Renishaw recommends using a Renishaw universal lifter (Renishaw part no. A-6810-3500) fitted with the universal lifting attachment or a Renishaw SafeChange filter wall bracket (Renishaw part no. A-6521-2109) (Figure 233).



Figure 233 Renishaw universal lifter, shown here with a substrate lifting plate (left) and SafeChange filter wall bracket (right)

9. If using the Renishaw universal lifter, move the large SafeChange filter assembly to a suitable location with water tap and hose pipe fitting.

10. Filling the large SafeChange filter assembly with water will increase its weight to approximately 30 kg (66 lb). Do not attempt to lift or move the filter during the passivation process or when it is full of water, even if you are using the Renishaw universal lifter.

11. Place a clean centring ring on the KF50 flanges of the dirty large SafeChange filter assembly upper isolation valve.

12. Locate and obtain a KF50 quick-release clamp.

13. Place the passivation tank (Figure 234) on top of the dirty large SafeChange filter assembly, align the two KF50 flanges and hold in place.

NOTE: This task may be easier to carry out with two people.



Figure 234 Passivation tank with KF50 flange

14. Secure the two KF50 flanges with a quick-release clamp.

15. Ensure the passivation tank and large SafeChange filter assembly are secured against movement, as the centre of gravity is above the support equipment.

16. Using a hosepipe (Figure 235), fill the passivation tank to the top with water, above the minimum fill level marker, up to the underside of the metal upper ring (Figure 235).

WARNING: Immediately clean up any water spillages and mop the area clean and dry after use.



Figure 235 Fill passivation tank with hosepipe (left) and passivation tank full (right)

17. Place a bucket or suitable receptacle such as a dirty filter disposal drum underneath the dirty large SafeChange filter assembly. This is to capture dirty water flowing from the SafeChange filter assembly.

18. On the dirty large SafeChange filter assembly (Figure 236), fully open the upper isolation valve and allow water to flow into the dirty filter assembly.

    WARNING: There is a risk of hydrogen being generated. Do not close the upper isolation valve after soaking the filter in water.

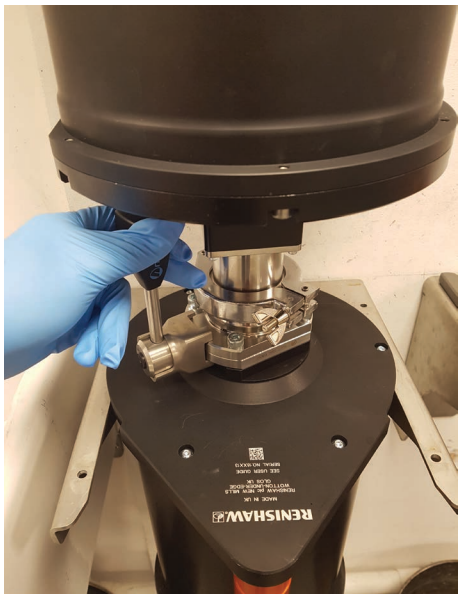


Figure 236 Open the upper isolation valve

19. Start a timer and wait 20 minutes to allow the water to drain into the dirty large SafeChange filter assembly and for the dirty filter to passivate.

    WARNING: Failure to wait 20 minutes could result in the filter not being fully soaked in water.

    WARNING: Do not leave the filter unattended whilst it is soaking.

    NOTE: When the water level in the funnel stops dropping, it means the filter element is fully soaked.

20. Check the water level. If the water level is still in the tank, continue to step 21. If the water level has fallen below the passivation tank, fill it to approximately one-third full and repeat from step 19.

21. Ensure a bucket or suitable receptacle such as a dirty filter disposal drum is under the isolation valve. Fully open the lower isolation valve.

22. Allow water to fully drain (Figure 237) into a bucket or suitable receptacle.



Figure 237 Draining dirty filter water into a suitable receptacle (dirty filter disposal drum shown here)

23. Check inside the passivation tank for signs of any particulate. Use a hose to wash away any that is present (Figure 238).

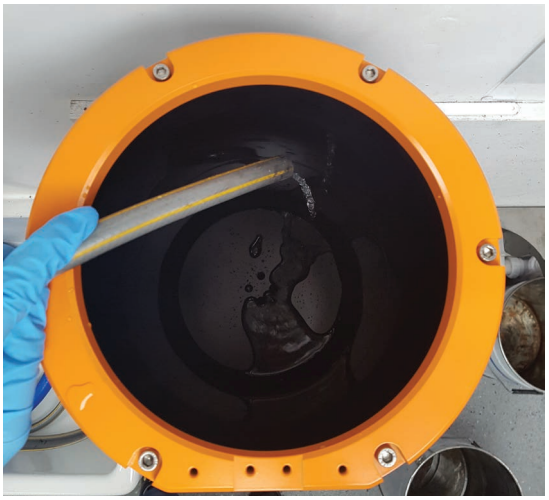


Figure 238 Wash away particulate from passivation tank with hosepipe

24. Release the quick-release clamp securing the two KF50 flanges of the passivation tank and large SafeChange filter assembly and separate the two.

25. Clean the passivation tank inside and out using Class 3 IPA and a disposable cloth, and wipe dry. Store the passivation tank in a suitable location.

26. Fully close the large SafeChange filter assembly lower isolation valve.

WARNING: Do not close the upper isolation valve.

27. Rotate the SafeChange filter assembly through 180° and empty any leftover water into the bucket or suitable receptacle through the open upper isolation valve.

28. Ensure the contaminated water is disposed of by suitably licensed waste contractors in accordance with the applicable local legislation.

    WARNING: Immediately clean up any water spillages and mop the area clean and dry after use.

29. Place the SafeChange filter assembly back on the suitable support equipment.

8.4.5 OT-006 – Large SafeChange™ filter element – Remove

WARNING: Ensure you are wearing the correct PPE: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

CAUTION: This procedure does not apply to RenAM 500 series systems equipped with the external Long-Life Filter system. For more information, see section 7.10, “Long-Life Filter (optional)”.

1. The large SafeChange filter assembly must be disassembled after removal from the RenAM 500 series system and soaked in water for at least 20 minutes.

   WARNING: The large SafeChange filter element contains fine particulate which must be neutralised by soaking with water.

   WARNING: Do not close the upper isolation valve after soaking.

2. Locate the filter dirty disposal drum and open it (Figure 239).



Figure 239 Dirty filter disposal drum

3. If the drum is empty, fill it with enough water to fully submerge the filter element.

   NOTE: If processing aluminium, add a 5% solution of Hydra-Sol-MAG additive (Part no. P-LU08-0006) to the water. For information about Hydra-Sol-MAG additive, refer to the safety data sheet.

4. Place the large SafeChange filter assembly on a suitable workbench or support bracket. Using a 5 mm (0.19 in) hexagon key, remove the six M6 bolts securing the access cover of the large SafeChange filter assembly (Figure 240).

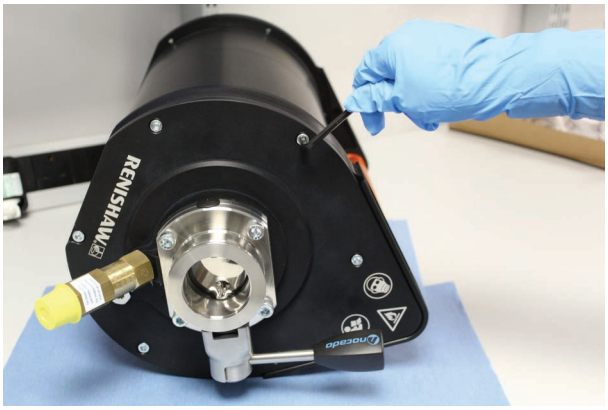


Figure 240 Removing the access cover

5. Lift the access cover off the large SafeChange filter assembly (Figure 241). Due to the close fit between the access cover and the filter, the filter may be attached to the access cover; separate as necessary. Remove the used filter element and filter support plate. Remove the filter support plate from the used filter (Figure 241) and retain the plate for cleaning.

   WARNING: The filter element will be wet and dirty when it is removed from the SafeChange filter assembly.

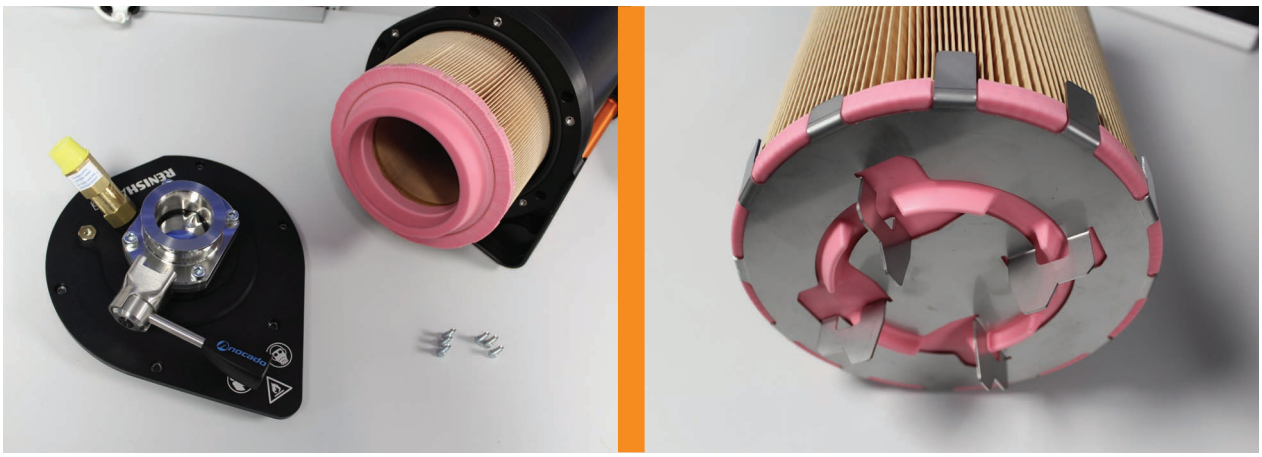


Figure 241 Removing the filter (left-hand), filter and filter support plate (right-hand)

6. Dispose of the wet dirty filter element in the filter disposal drum and ensure it is fully submerged (Figure 242).



Figure 242 Dispose of the dirty filter in the filter disposal drum

7. Refit the lid to the drum and ensure that the drum remains ventilated. The lid must be ventilated so that any generated gas can vent to the atmosphere.

8. When the drum becomes full, ensure the contaminated water and filters are disposed of by suitably licensed waste contractors in accordance with the applicable local legislation.

9. Wipe the filter chamber, access cover and filter support plate inside and out with Class 3 IPA and a disposable cloth to remove any residue.

10. To reduce system downtime, Renishaw recommends that spare large SafeChange filter assemblies are kept in a state ready to be installed in the RenAM 500 series system when required.

11. After cleaning the filter chamber, access cover and filter support plate, they will need to dry before they can be reassembled and reused. Drying time will depend upon ambient humidity and temperature. It is important that moisture is not introduced into the RenAM 500 series system. Recommended drying times (following a dry wipe) is four hours.

    WARNING: Ensure the pressure relief valve is free from contamination such as nanoparticles and metal powder. Clean as necessary using IPA. Consider contacting Renishaw to arrange for a replacement if the pressure relief valve (part no. A-6521-5225) is heavily contaminated.

12. Check the access cover O-ring seal. Ensure it is fitted correctly. Ensure there are no signs of damage or deformation that will affect its ability to seal. Replace the O-ring as necessary (Figure 243).

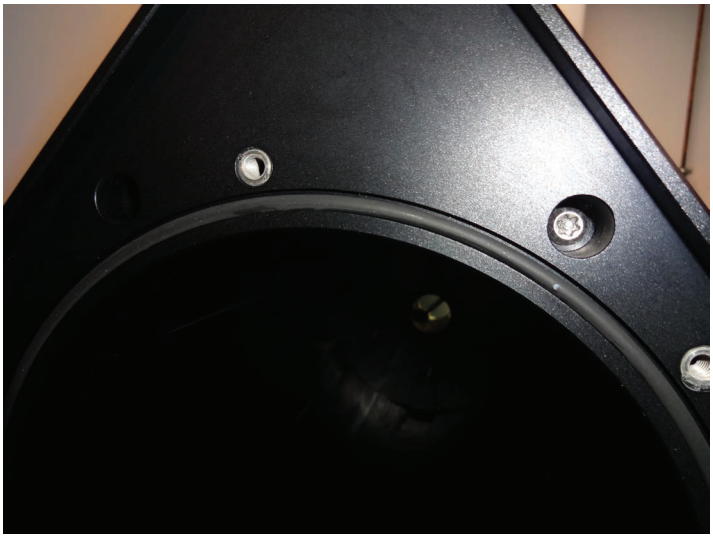


Figure 243 Filter chamber O-ring seal

8.4.6 OT-007 – Large SafeChange™ filter element – Refit

CAUTION: Never refit a used filter.

CAUTION: This procedure does not apply to RenAM 500 series systems equipped with the external Long-Life Filter system. For more information, see section 7.10, “Long-Life Filter (optional)”.

1. Once the filter chamber is fully dry, fit a filter support plate to the filter and install them into the filter chamber as follows.

2. Open the filter kit packaging (part no. A-5778-6000) and remove a filter element.

NOTE: Filters are supplied in sealed plastic bags dried to a specification of 0.5 g/m³ (0.0134844 oz/yard³) of water. Opening the sealed plastic bag and leaving the filter exposed to atmospheric air for 10 minutes will negate the benefits of drying it. To gain the benefits from a dried filter, Renishaw recommends opening the filter plastic bag and immediately installing in the filter chamber.

3. Fit a filter support plate to the closed end of the filter (Figure 244).

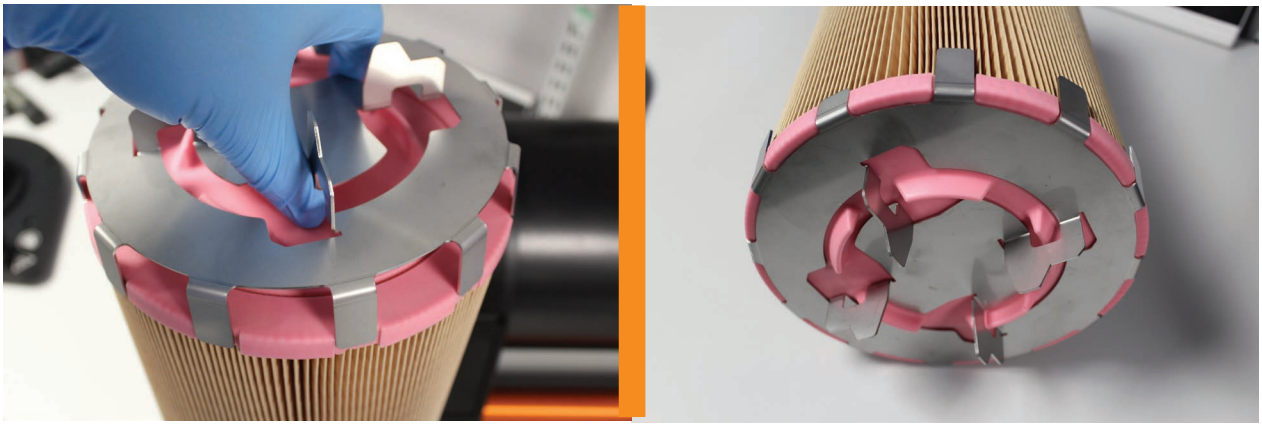


Figure 244 Fit a filter support plate to the filter

4. Fit the filter element and filter support plate into the filter chamber (Figure 245).

CAUTION: Ensure that the open end of the filter element is at the open end of the filter chamber.



Figure 245 Open end of filter element

5. Ensure the filter element and support plate are centred in the filter chamber.

6. Check the access cover O-ring seal. Make sure it is fitted correctly in the groove surrounding the filter chamber opening. Make sure there are no signs of damage or deformation that will affect its ability to seal. Replace the O-ring as necessary (Figure 246).

WARNING: Make sure the O-ring is fitted correctly before refitting the access chamber. If the O-ring is not fitted correctly, oxygen may enter the system and compromise the inert state of the large SafeChange filter, which may result in a thermal event.



Figure 246 Filter chamber O-ring seal

7. Refit the access cover to the filter chamber. When refitting the access cover on to the filter chamber, place the access cover on one side of the filter chamber and angle the access cover down to complete the sealing of the cover onto the chamber.

8. Refit the six M6 bolts securing the access cover to the filter chamber. Torque tighten the bolts to 20 Nm (14.75 lbf/ft) in a diagonal sequence, using a 5 mm (0.19 in) hexagon key and a suitable torque wrench.

9. On the large SafeChange filter assembly ensure the upper and lower isolation valves are closed – the handles will be at 90° to the direction of gas flow. This prevents the filter from being exposed to atmospheric air and absorbing moisture.

8.4.7 OT-008 – Large SafeChange™ filter assembly – Refit

WARNING: The large SafeChange filter assembly weighs approximately 15 kg (33 lb) when dry.

WARNING: Make sure the filter element has been replaced in accordance with task “OT-007 – Large SafeChange™ filter element – Refit” before installing the large SafeChange filter assembly into the RenAM 500 series system.

NOTE: Ensure that the oversized particle collection flask is not fitted to the system as it will not be possible to refit the large SafeChange filter assemblies. If fitted, remove in accordance with task “PB-015 – Oversized particle collection flask – Refit, remove and empty (RenAM 500 and RenAM 500 Ultra only)”.

NOTE: Install the large SafeChange filter assembly with the handles positioned wide apart to facilitate the installation of oversize particle collection flask between the handles.

CAUTION: This procedure does not apply to RenAM 500 series systems equipped with the external Long-Life Filter system. For more information, see section 7.10, “Long-Life Filter (optional)”.

1. Once the filter element has been replaced, install the large SafeChange filter assembly into the RenAM 500 series system.

2. Grip the large SafeChange filter assembly handle with the right hand and support the weight at the base with the left hand.

3. Lift the large SafeChange filter assembly on to the support bracket in the RenAM 500 series system, and slide it fully home (Figure 247).



Figure 247 Large SafeChange filters installed

4. Obtain the two quick-release clamps and two centring rings removed previously.

5. Check the two centring ring seals are free from damage and deformation. Replace the seals as necessary.

6. Fit a centring ring seal to the large SafeChange filter upper isolation valve KF flange.

WARNING: Make sure the centring ring seals are fitted correctly and free of damage. If the seal is not fitted correctly, oxygen may enter the system and compromise the inert state of the large SafeChange filter, which may result in a thermal event.

7. Align the system outlet pipe KF flange with the large SafeChange filter upper KF flange.

8. Fit the quick-release clamp collars over the two KF50 flanges. Close the quick-release clamp collars and ensure they are fully secure. Fit and close the latch to fully secure the quick-release clamp.

9. Fit a centring ring seal to the system recirculation pipe KF flange.

WARNING: Make sure the centring ring seals are fitted correctly and free of damage. If the seal is not fitted correctly, oxygen may enter the system and compromise the inert state of the large SafeChange filter, which may result in a thermal event.

10. Align the system recirculation pipe KF flange with the large SafeChange filter lower isolation valve KF flange.

11. Fit the quick-release clamp collars over the two KF50 flanges. Close the quick-release clamp collars and ensure they are fully secure. Fit and close the latch to fully secure the quick-release clamp.

12. Operate the two isolation valves on the large SafeChange filters and move them to the open position, with the handle in line with the system pipework.

13. On the touch screen control panel, from the ‘Home’ screen select “Chamber setup”. From “Chamber Setup” in the “Filters” pane identify which large SafeChange filter has been replaced.

NOTE: From the front of the RenAM 500 series system, with the filter access door open, filter 1 is on the left-hand side and filter 2 is on the right-hand side.

14. The Filters pane (Figure 248) enables you to set the whether the large SafeChange filters are Present or Absent. After a filter has been replaced, set the appropriate toggle switch to Present.

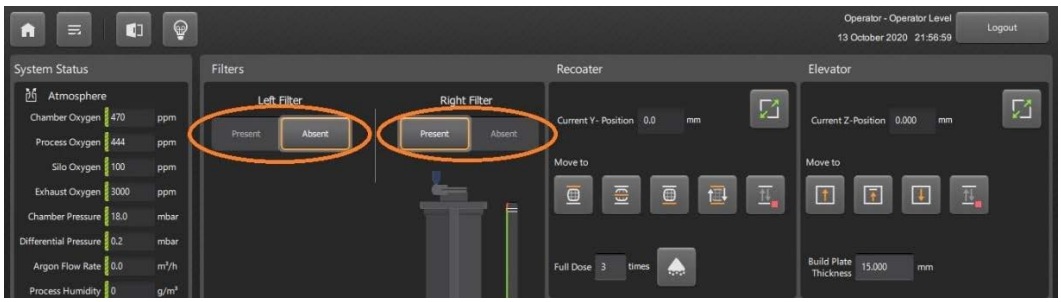


Figure 248 Large SafeChange filter Present and Absent toggle switches

15. The large SafeChange filter is now ready for use.

8.4.8 OT-009 – Chiller fluid – Remove

1. Ensure the over-full chiller is powered down and electrically isolated.

2. At the rear of the chiller is a drain plug (Figure 249).



Figure 249 Chiller drain plug

3. Place a suitable tray under the drain plug.

NOTE: The SMC Pneumatics model HRSH090-AF-40 chiller contains approximately 18 L (0.63 cu/ft) of chiller fluid. The total system capacity is approximately 20 L (0.7 cu/ft), depending upon hose length.

4. Open the drain plug and drain off enough chiller fluid to reduce the level below the H mark but above the L mark (Figure 250).

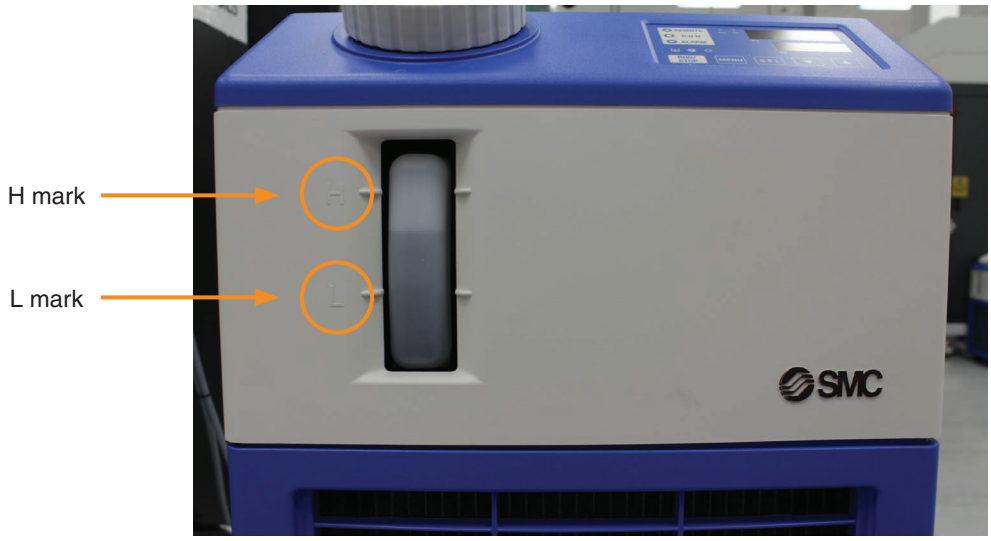


Figure 250 L and H marks on front of SMC Pneumatics chiller

5. Close the drain plug.

6. Dispose of any drained-off fluid in accordance with applicable local legislation and rules.

8.4.9 OT-010 – RenAM 500 series system – Build recovery

It is sometimes possible to restart a build if a build has halted.

If a build layer has completed and the build stops, identify the layer number where the build stopped, reload the build and recommence the build on the next layer by navigating to the layer and pressing the play button.

8.4.10 OT-011 – Feed hopper – Remove (RenAM 500 Flex only)

NOTE: Ensure that the front and rear overflow flasks are fitted to the system prior to commencing this task. If not fitted, install in accordance with task “AB-023 – Overflow flasks – Fit (RenAM 500 Flex only)”.

WARNING: Ensure you are wearing the correct PPE: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

On occasion, it may be required to remove the feed hopper from the RenAM 500 Flex system without performing a full material change, such as for hopper cleaning, or when changing to an alternative size hopper.

1. Check that the Silo High Level Sensor is turned off on the Sensor Status screen (Figure 251). If the Silo High Level Sensor is on, use powder dosing to move powder out of the silo until the sensor reads “OFF”.

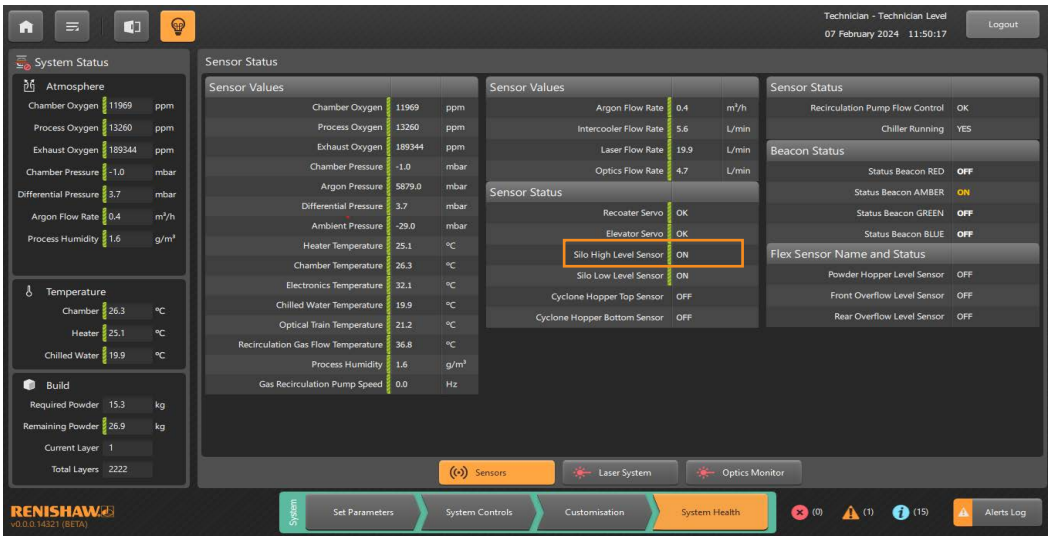


Figure 251 Silo High Level Sensor

2. Ensure the fitted feed hopper is completely empty of powder.
3. Turn off the machine PC according to task “PB-009 – RenAM 500 series system – Shut down”.
4. Isolate the machine from the power supply using the main isolation switch.
5. Remove the rear floor skirt panel from the machine.

6. Disconnect the balance line (Figure 252) at the hopper and insert a 10 mm (0.39 in) blanking plug into the hopper connector.

7. Disconnect/unscrew the cable from the feed hopper capacitive sensor (Figure 252), then unscrew and remove the sensor from the hopper.

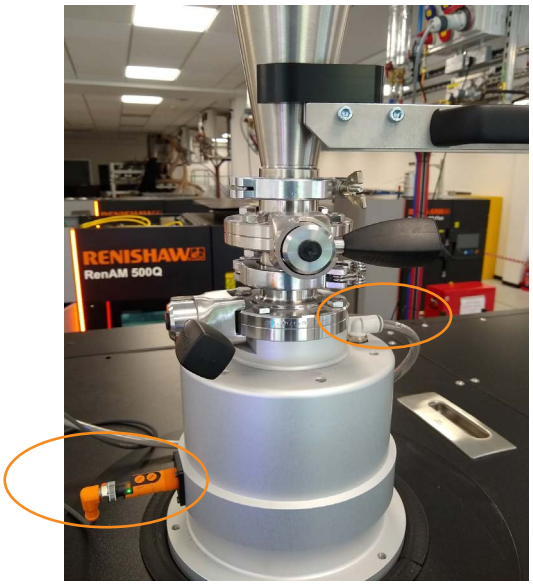


Figure 252 Feed hopper capacitive sensor (left) and balance line (right)

8. Open the rear middle door of the machine.

9. Close the feed hopper flow isolation valve (Figure 253).

10. Open the feed hopper flow valve interlock (not shown), then remove the KF40 quick-release swing clamp (Figure 253).



Figure 253 Feed hopper flow isolation valve and swing clamp

11. Remove the two M8 thumbscrews below the feed hopper support bracket that retain the hopper (Figure 254).

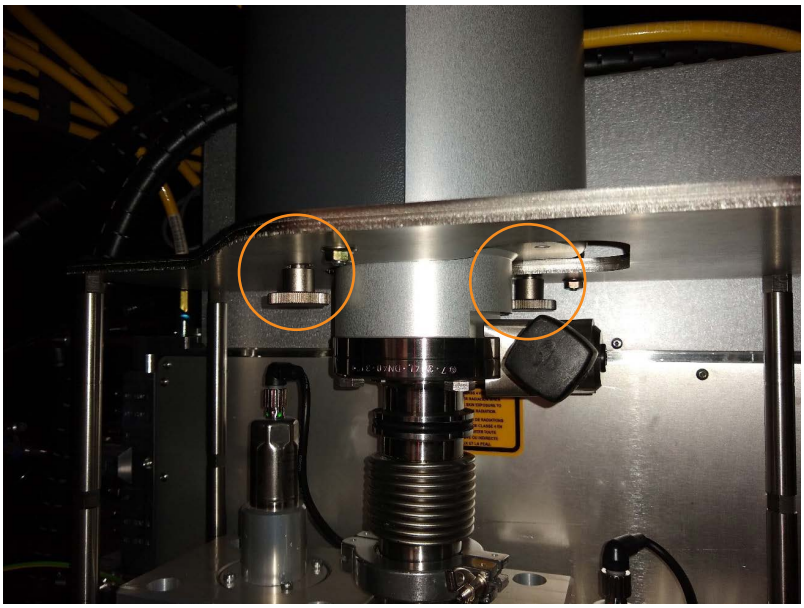


Figure 254 Feed hopper retaining thumbscrews

12. Fit the universal lifting attachment to the universal lifter in the orientation shown in Figure 255.



Figure 255 Universal lifter

13. Ensure the security bolt between the universal lifting attachment and universal lifter is fitted and tightened.

WARNING: Do not operate the universal lifter with the universal lifting attachment without the security bolt installed, as doing so increases the risk of the load dropping from the lifter and causing injury.

14. Raise the lifter mast so that the attachment forks are clear of the top of the RenAM 500 Flex machine.

15. Manoeuvre the universal lifter to the rear of the chamber, with the forks aligned around either side of the feed hopper.

16. Push the lifter forwards until the end stops of the lifting attachment are clear of the hopper lifting points (Figure 256).

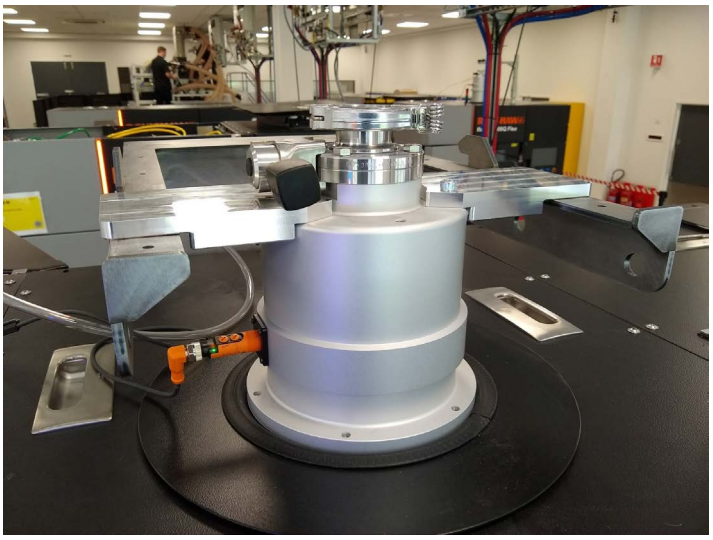


Figure 256 Universal lifting attachment in correct position

17. Carefully raise the lifter mast until the bottom of the hopper is clear of the roof panel of the RenAM 500 Flex machine (Figure 257).

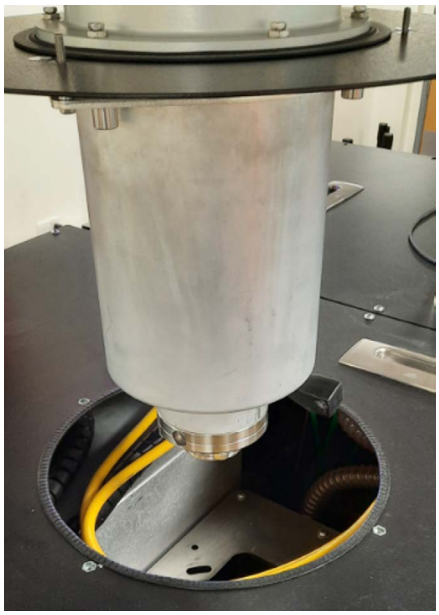


Figure 257 Feed hopper clear of roof panel

NOTE: While raising and lowering the lifter, ensure the carriage plate does not catch on any cables or earth braids.

18. Manoeuvre the lifter until the lifting attachment forks are clear of the RenAM 500 Flex machine.

19. Lower the lifter mast to a safe height.

20. Remove the hopper skirt by undoing the captive screws under the hopper and slowly sliding the skirt downwards off the hopper (Figure 258).

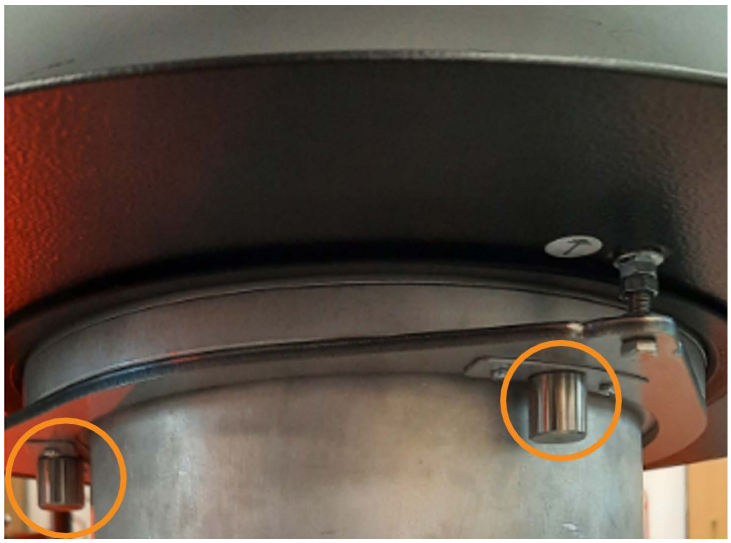


Figure 258 Hopper skirt captive screws

WARNING: Be careful to not lift or twist the hopper while removing the hopper skirt. Lifting or twisting the hopper increases the risk of the hopper detaching from the lifter attachment forks and dropping from the lifter, causing potential injury.

21. Remove the top half of the hopper skirt from the underplate by removing the wing nuts and lifting the top half off the screws.

22. Screw the wing nuts back onto the underplate to prevent losing them.

23. Manoeuvre the lifter to the desired location to store the hopper.

24. Manually lift the hopper from the lifting attachment to the desired storage location.

25. Look inside the bellows on the silo and make sure they are free of powder within the corrugations.

26. Inspect the roof panel and the area underneath the hopper for any powder spillages and clean with the ATEX vacuum cleaner and IPA wipes.

WARNING: When placing the feed hopper on a surface, ensure that it is prevented from rolling on the surface to avoid any accidental dropping that could result in drop injury or damage.

8.4.11 OT-012 – Feed hopper – Refit (RenAM 500 Flex only)

WARNING: Ensure you are wearing the correct PPE: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

CAUTION: Make sure the hopper is empty and clean of residual powder before installing onto the machine. Installing a hopper still containing powder onto the RenAM 500 Flex may result in an inaccurate measurement of powder mass if taring is required. If the hopper contains residual powder, this will not be measured within the system after taring is complete.

1. Check that the Silo High Level Sensor is turned off on the Sensor Status screen (Figure 251). If the Silo High Level Sensor is on, use powder dosing to move powder out of the silo until the sensor reads “OFF”.
2. Look inside the bellows on the silo and make sure they are free of powder within the corrugations.
3. Ensure there is a centring seal on top of the bellows on the silo in the rear-centre cabinet.
4. Place the feed hopper on the forks of the universal lifter, oriented so that during installation the lower valve is on the same side of the machine as the filter and powder cabinet.
5. Remove the wing nuts from the underplate. Ensure the flange on the nut below is facing upwards (Figure 259).



Figure 259 Underplate wing nuts

WARNING: Be careful to not lift or twist the hopper while installing the hopper skirt. Lifting or twisting the hopper increases the risk of the hopper detaching from the lifter attachment forks and dropping from the lifter, causing potential injury.

6. Slide the hopper skirt onto the hopper (Figure 260).



Figure 260 Hopper skirt on hopper

7. Slide the underplate onto the hopper and make sure the screws from the underplate protrude through the hopper skirt (Figure 261). The orientation of the underplate is not important.

NOTE: Do not assemble the wing nuts at this point.



Figure 261 Underplate screws protruding through hopper skirt

8. Tighten the captive screws to secure the underplate to the hopper (Figure 262).

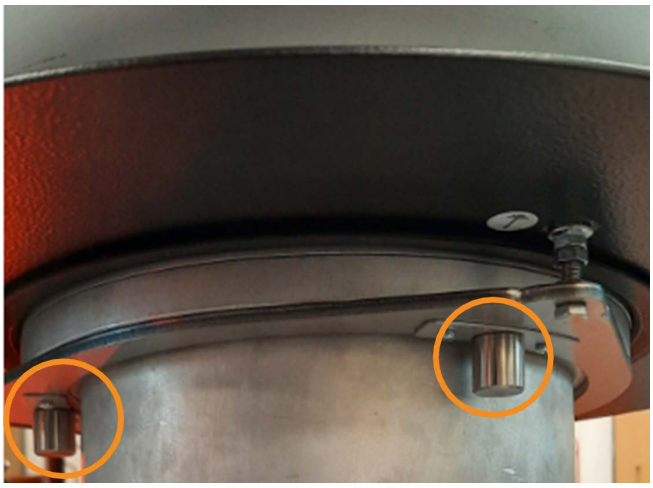


Figure 262 Underplate captive screws

WARNING: Failure to securely tighten the captive screws to the hopper may result in limited earthing of the hopper skirt, potentially causing static to build up. Ensure all captive screws are tight enough to secure the hopper skirt with no movement.

9. Manoeuvre the lifter to the rear of the machine.

10. Raise the lifter mast until the base of the hopper clears the roof panel.

11. Align the hopper with the aperture in the roof panel (Figure 263).

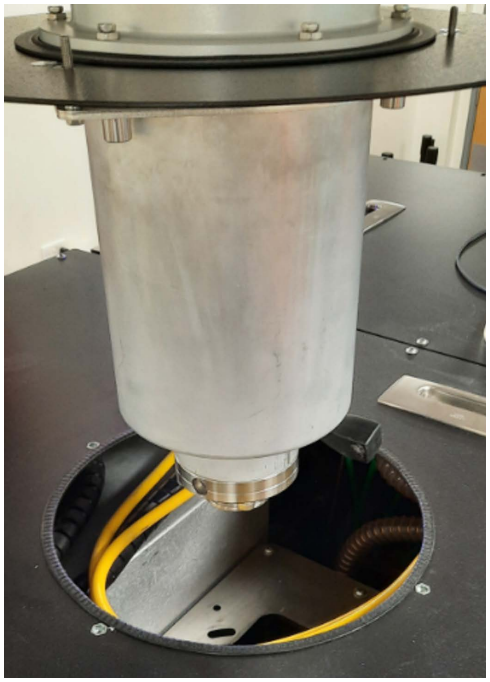


Figure 263 Hopper aligned over roof aperture

12. Carefully lower the lifter, ensuring the hopper does not get caught on the hopper cowling or support bracket.

13. Once the feed hopper is seated on the support bracket, lower the lifting mast so the end-stops clear the lifting points on the hopper and pull the lifter back away from the machine, ensuring the lifter does not catch on any cables or earth braids.

14. Ensure the hopper is seated squarely on the bellows and centring seal and install the two feed hopper retaining thumbscrews (Figure 264).

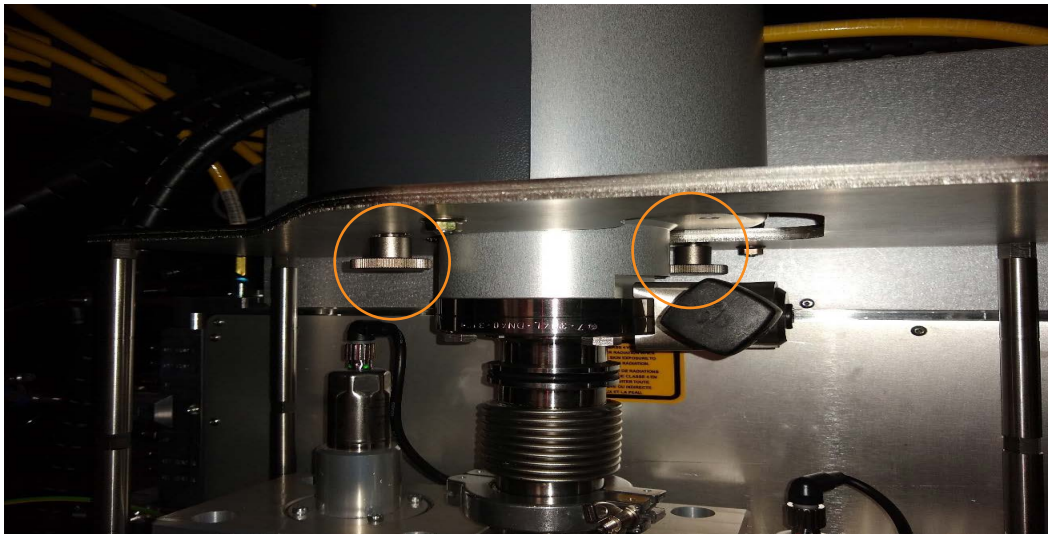


Figure 264 Feed hopper retaining thumbscrews

15. Hold open the interlock and install the KF40 quick-release swing clamp (Figure 265).

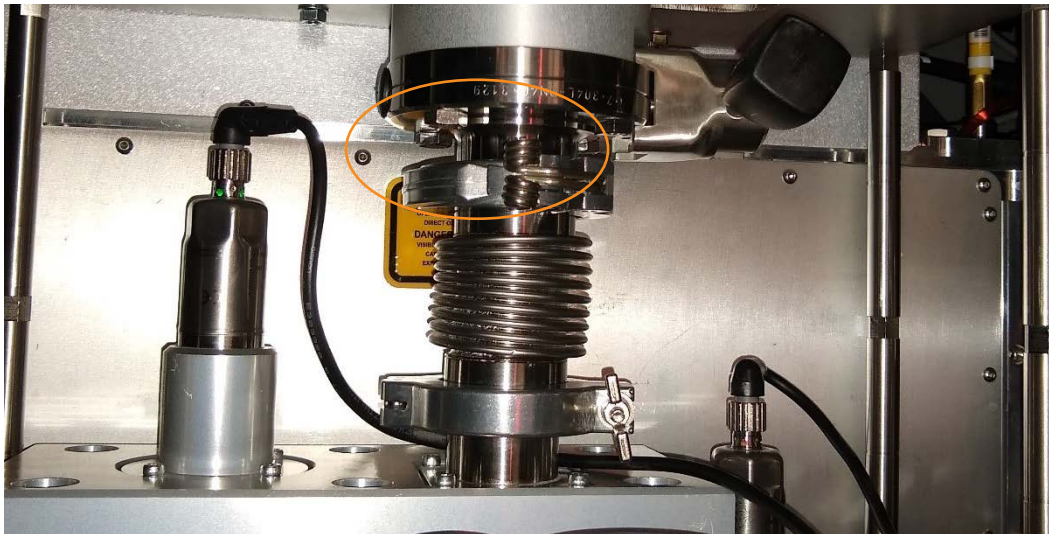


Figure 265 Feed hopper quick-release swing clamp installed

16. Open the feed hopper flow isolation valve.

17. Screw the feed hopper capacitive sensor into the pocket on the feed hopper, then screw the cable connector to the sensor (Figure 266).

18. Remove the 10 mm (0.39 in) blanking plug from the balance line connector, then fit the balance line, ensuring it is pushed fully into the connector (Figure 266).

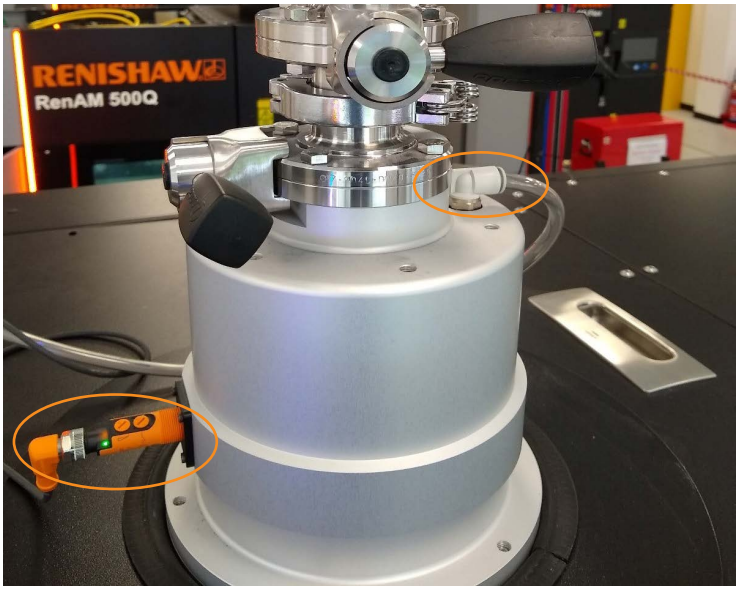


Figure 266 Feed hopper capacitive sensor and balance line installed

19. Measure the gap between the hopper skirt and roof panel at a point near each protruding screw. The gap should measure between 5 mm and 12 mm (0.19 in and 0.47 in) (Figure 267). If the gap criterion is not met, follow steps a. to f. given below.

NOTE: If the hopper skirt is in contact with the roof panel, the 'Remaining Powder' value shown within RenAMP will be inaccurate.



Figure 267 Gap between hopper skirt and roof panel

a. Lift the hopper skirt above the underplate screws to access the nuts below.

b. Loosen both the flanged nut and nut below on the underplate screw closest to the measurement point that fell outside the gap criterion.

c. Use a ruler to set the height of the top face of the bottom nut to the machine roof panel (Figure 268).

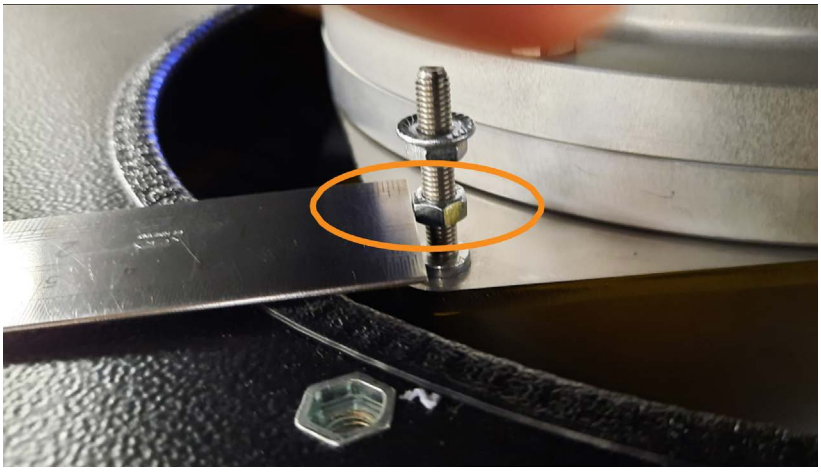


Figure 268 Positioning of bottom nut on underplate screw

d. Tighten the flanged nut against the bottom nut (Figure 269).



Figure 269 Tightened flange nut

e. Place the hopper skirt back onto the underplate screws. Make sure the skirt is sitting flush with each of the three flange nuts.

f. Re-measure the gap between the hopper skirt and roof panel at a point near each protruding screw. If the gap is below 5 mm (0.19 in), increase the height of the bottom nut of the nearest screw accordingly. If the gap is above 12 mm (0.47 in), decrease the height of the bottom nut. Adjust until the gap criterion is met.

20. Install and hand-tighten the underplate wing nuts on each protruding screw (Figure 270).

WARNING: If the wing nuts are not securely tightened, there is a risk of no earth path for the hopper skirt.



Figure 270 Underplate wing nuts installed

21. Repeat step 17 to ensure the gap between the hopper skirt and roof panel remains within specification.

22. Close the rear-centre cabinet door then refit the rear skirt to the machine.

23. Make sure the selected hopper size in RenAMP matches the newly installed hopper and select Auto Tare (Figure 271).

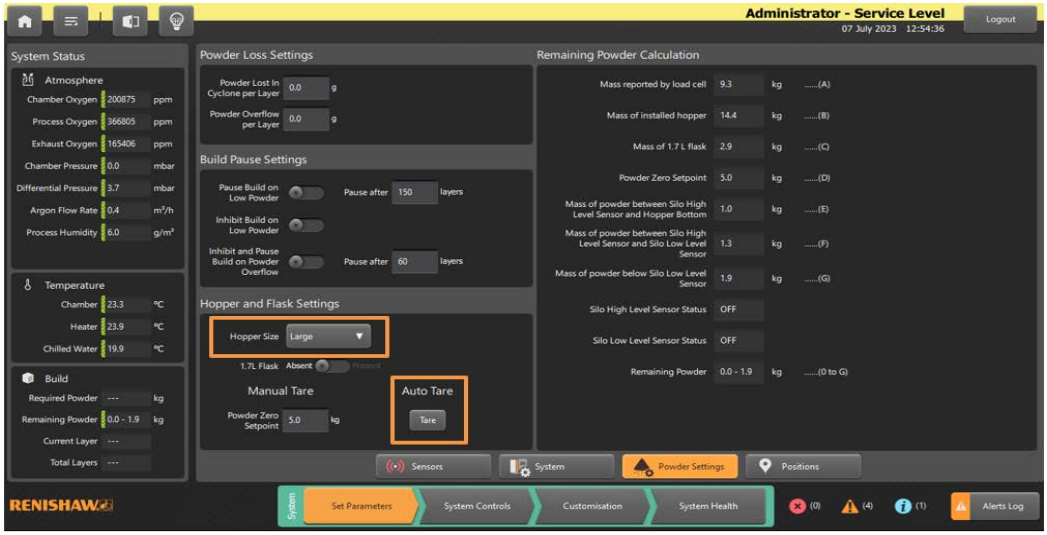


Figure 271 Hopper size selection and Auto Tare

8.4.12 OT-013 – Powder loading arm – Adjust (RenAM 500 Flex only)

WARNING: Ensure you are wearing the correct PPE: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

If a new, or different sized, feed hopper is fitted to the machine, the powder arm may require adjustment to ensure the flask correctly engages with the feed hopper for powder loading. The powder loading arm is adjustable for height, docking position and reach.

OT-013-01 – Height adjustment

1. Remove the quick-release swing clamp, blanking cap and centring from both KF40 flanges on the powder flask and hopper inlet.

2. Fit an empty powder flask into the claw of the arm and attempt to rotate it until the flask is positioned in line and above the hopper inlet.

3. Measure the gap between the bottom of the flask KF fitting and the top surface of the hopper fitting (Figure 272). The gap should be between 4 mm and 6.5 mm (0.15 in and 0.25 in). If it is outside this range, continue with the steps below; otherwise no adjustment is required.

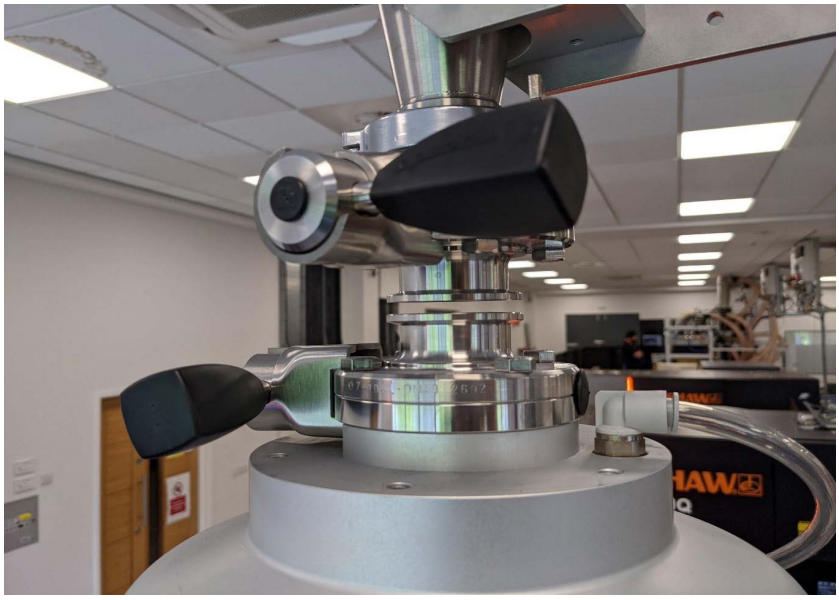


Figure 272 Gap between feed hopper and flask

4. To adjust the arm height, loosen the M10 × 60 cap screw (Figure 273) and carefully move the horizontal section up or down. Re-tighten and repeat step 2. Continue to repeat steps 2 to 4 until the gap is within range.

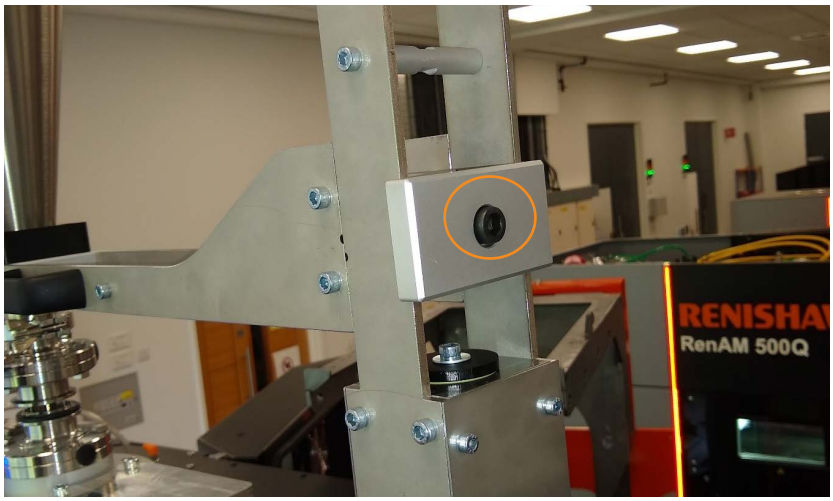


Figure 273 Height adjustment screw

OT-013-02 – Docking position adjustment

1. Place a centring seal in the hopper inlet KF fitting and fit a full flask to the arm. Rotate the arm until the flask is directly above the hopper inlet.

2. The arm should move down to close the gap between the feed hopper and the flask. Depending on the powder load, a small amount of downward force may be required to overcome the in-built spring. If the arm does not move down at the correct rotation position, move on to step 3. If it does, no adjustment is necessary.

3. Loosen the wheel guide block by slackening the three M6 × 14 button head screws on the arm base (Figure 274). Rotate as required so the wheels can drop into the slots at the required rotational angle for the flask to dock with the hopper inlet. Re-tighten the three screws once the correct position has been determined.

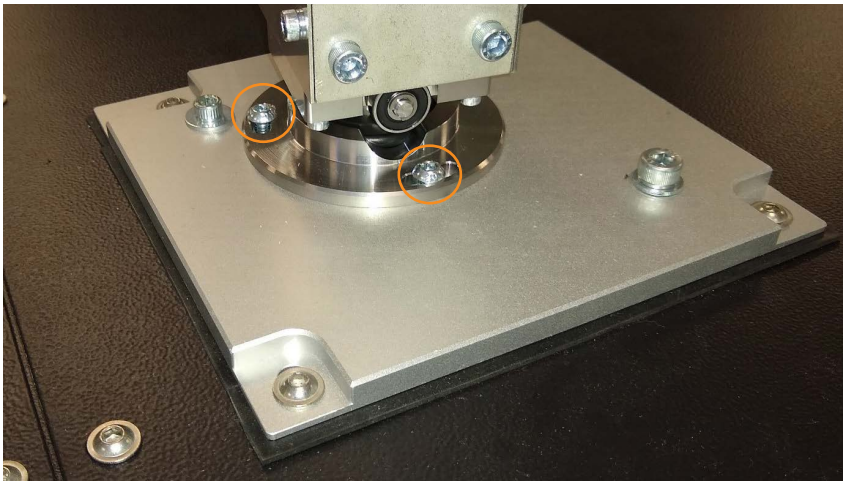


Figure 274 Docking position adjustment screws

OT-013-03 – Reach adjustment

1. Place a centring seal in the hopper inlet KF fitting and fit a full flask to the arm. Rotate the arm until the flask is directly above the hopper inlet.

2. Check that the bottle is positioned correctly over the centring seal on the top of the feed hopper. If the arm is not at the correct reach position, move on to step 3. If it does, no adjustment is necessary.

3. Loosen the two screws on the arm claw (Figure 275) and move the claw in or out in its slots until the two KF flanges on the flask and hopper are correctly aligned. Once the correct position is found, re-tighten the two screws to a torque of 5 Nm.

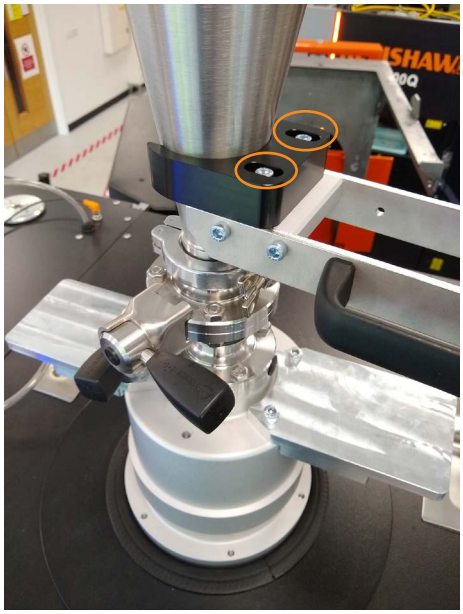


Figure 275 Reach adjustment screws

8.4.13 OT-014 – 10 L (610 in³) flask – Decant powder

Before loading overflow powder contained in a 10 L (610 in³) flask into the powder recovery system, it should first be transferred into 1.7 L (103 in³) flasks. This ensures the powder recovery system is not overloaded which can cause it to fail to properly process material.

WARNING: Ensure you are wearing the correct PPE: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

1. Ensure the 10 L (610 in³) flask is in a suitable location for picking up by the universal lifter.
2. Manoeuvre the universal lifter so that the cut-outs in the arm align with the bosses on the flask (Figure 276).



Figure 276 Universal lifter aligned with 10 L (610 in³) flask

3. Raise the lifter until it engages with the boss on the flask. Check that both sides are engaged correctly.

4. Raise the lifter until the flask is at an appropriate working height, approximately 1 m (3.28 ft) from the floor (Figure 277).



Figure 277 Correct working height for powder decanting

5. Fit an empty 1.7 L (103 in³) flask to the isolation valve on top of the flask using a centring seal and quick-release clamp (Figure 278).



Figure 278 10 L (610 in³) flask with 1.7 L (103 in³) flask attached above

6. Holding the 1.7 L (103 in³) flask securely with one hand, release the locking pin with the other (Figure 279) and rotate the flask 180°, with the upper 1.7 L (103 in³) flask initially moving away from the lifter, until the 1.7 L (103 in³) flask is on the bottom. The locking pin will automatically re-engage, securing the two flasks to prevent further rotation.



Figure 279 10 L (610 in³) flask with locking pin (circled) before rotation

7. Open the isolation valves on both flasks (Figure 280) to allow powder to start flowing into the 1.7 L (103 in³) flask.



Figure 280 Isolation valves in the open position

8. Once the bottle is full, close the isolation valve on the 10 L (610 in³) flask (Figure 281).



Figure 281 10 L (610 in³) flask isolation valve in closed position

9. Tap the flask and the valves several times with a rubber mallet to remove any powder between the valves, then close the isolation valve on the 1.7 L (103 in³) flask (Figure 282).



Figure 282 Isolation valves in the closed position

10. Gripping the 1.7 L (103 in³) flask securely with one hand, remove the quick-release swing clamp and centring ring to remove the 1.7 L (103 in³) flask ready for sieving.

11. Attach an empty 1.7 L (103 in³) flask with a centring ring and quick-release swing clamp and repeat the process from step 7 until the 10 L (610 in³) flask is empty.

12. Release the locking pin, rotate the 10 L (610 in³) flask 180°, then transport and deposit the 10 L (610 in³) flask at the desired location.

8.5 Technician level tasks

The following table lists all the technician level tasks that can be carried out before a build is started on a RenAM 500 series system.

Task number	Task title	User level
TT-001	Change date and time	Technician
TT-002	Pause build on low powder level	Technician
TT-003	Pause build on powder overflow (RenAM 500 Flex only)	Technician
TT-004	Add/update material information	Technician
TT-005	Auto-tune heater plate	Technician

8.5.1 TT-001 – Change date and time

1. From the RenAMP home screen, select ‘Set Parameters’.

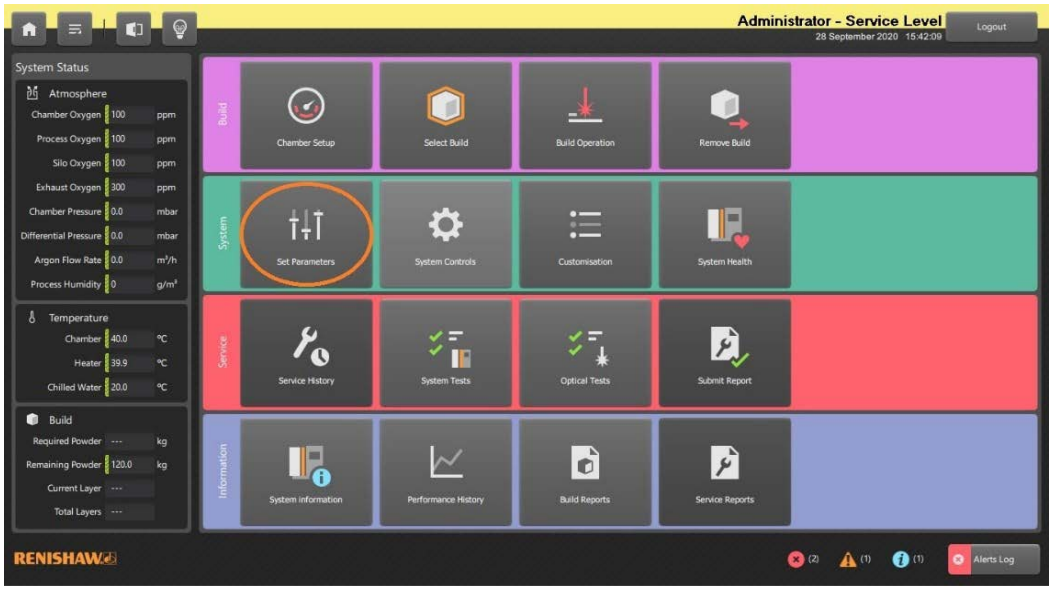


Figure 283 Home screen with Set Parameters circled

2. Select the ‘System’ tab from the ‘Set Parameters’ screen to view the ‘User Settings’ pane.

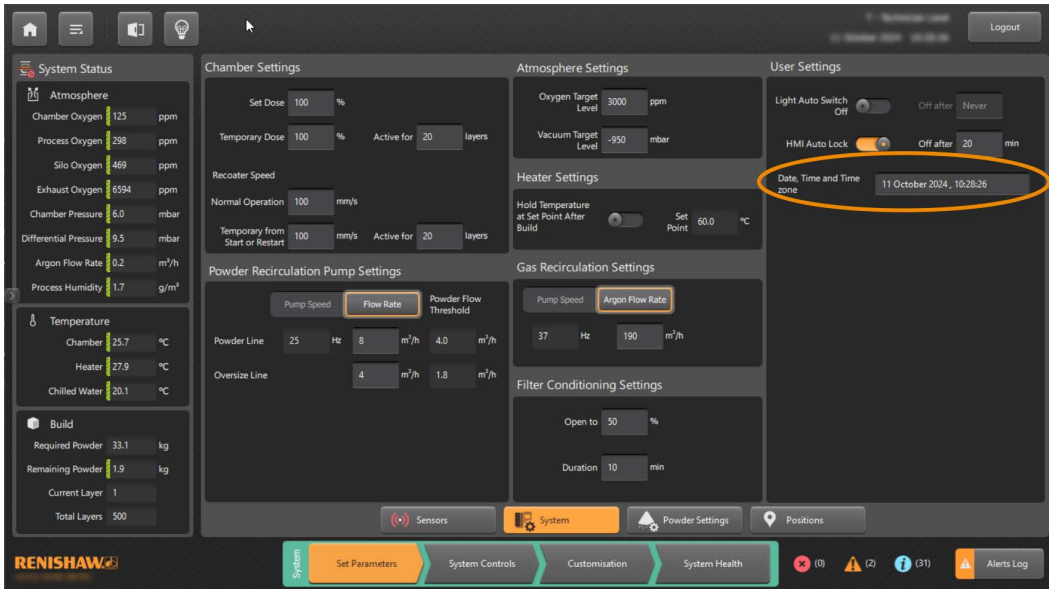


Figure 284 User Settings pane with Date and Time on Systems screen

3. Click the ‘Date and Time zone’ field to open a dialog box containing options to update date, time and time zone.

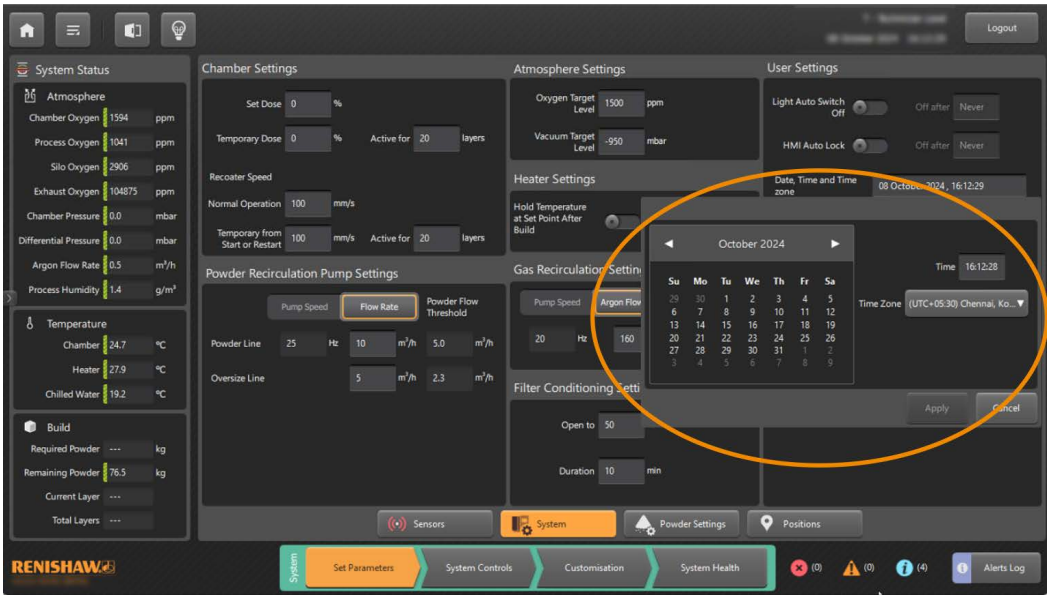


Figure 285 User Settings pane

4. The date can be selected from the calendar. To change the time, use the ‘Time’ text field.

5. Enter the time using the on-screen keypad and click the return button.

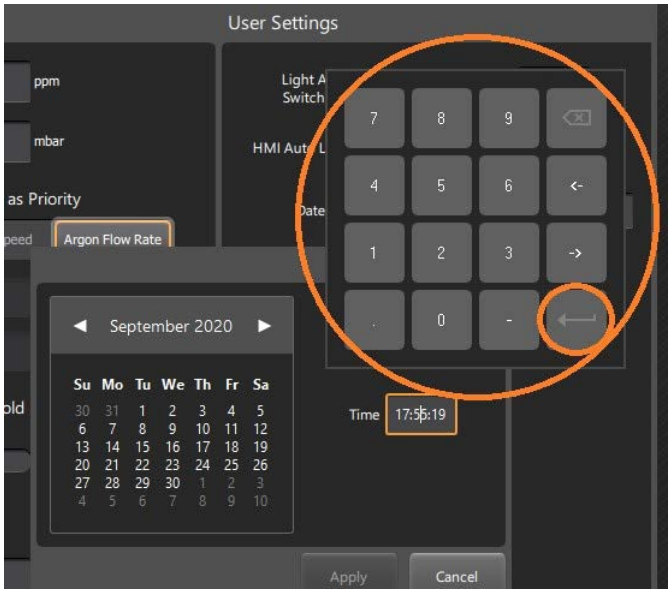


Figure 286 On-screen keypad for updating time

6. Select the required ‘Time zone’ from the drop-down list.

7. If you change the date or time, a warning message is displayed.

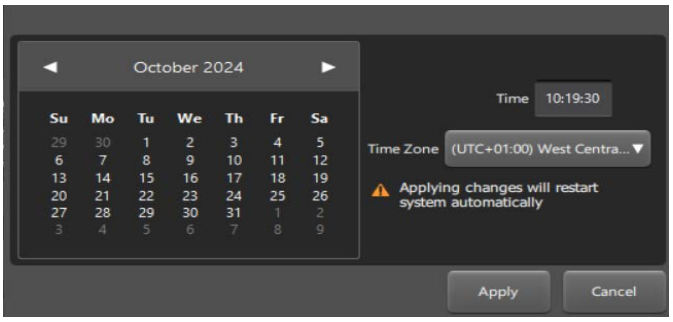


Figure 287 Warning message before updating the date or time

8. If you select 'Apply', the system performs an immediate restart and then shows the new date and time. Select 'Cancel' to close the dialog box without implementing the changes.

8.5.2 TT-002 – Pause build on low powder level

RenAMP provides the option to configure the behaviour of the machine when the powder is below the silo low level sensor. These settings allow the user to:

- Inhibit or allow a build to start when there is low powder in the system
- Pause or continue a build if powder level drops below the silo low level sensor during a build

When the powder silo is detected as having low powder by the silo low-level sensor, there is still some powder below the sensor with which some layers would get completed. The intent of these settings is to use this extra powder to complete a set number of layers after low powder is detected, which will delay the pause activation until those layers are completed. This delay gives the operator a chance to refill the powder in the hopper (Flex machine), or for the powder recirculation process to complete (non-Flex machine) before the build is paused.

The default number of layers to delay the pause by is 40 layers after the ‘Silo Empty’ alert is displayed on RenAMP, but the user can enter their own unique number of layers if needed. The build will continue during these layers, but an information alert will be shown on screen after every layer, indicating how many layers are left until the build is paused (highlighted on Figure 288). The layer count before pause can also be seen on the Build Operation screen under Auto Chamber Preparation (highlighted on Figure 288), and in the Alert Logs screen (circled on Figure 289).

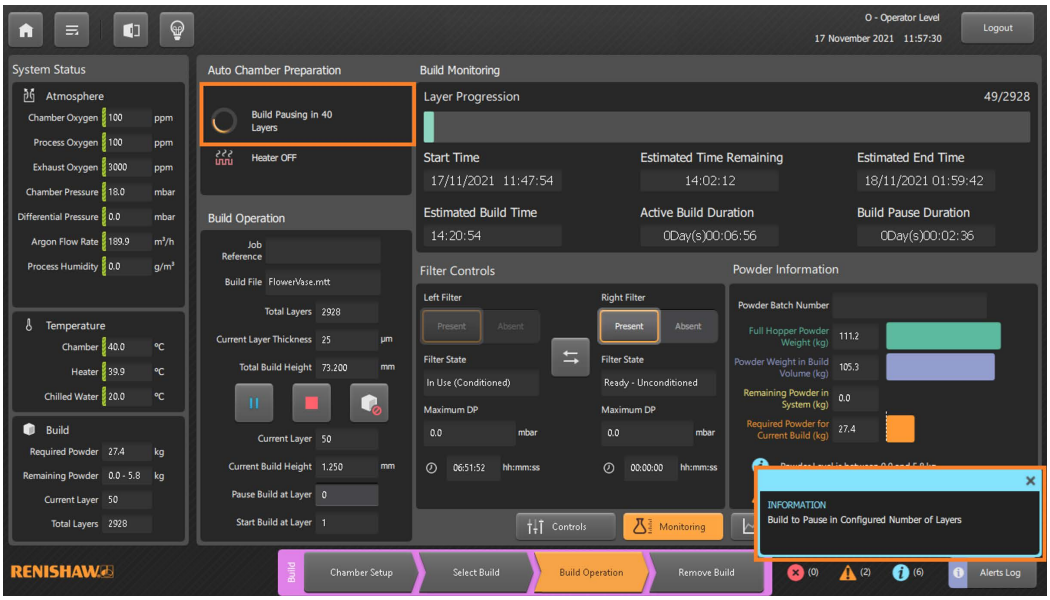


Figure 288 Build Operations with Build Pausing indication highlighted

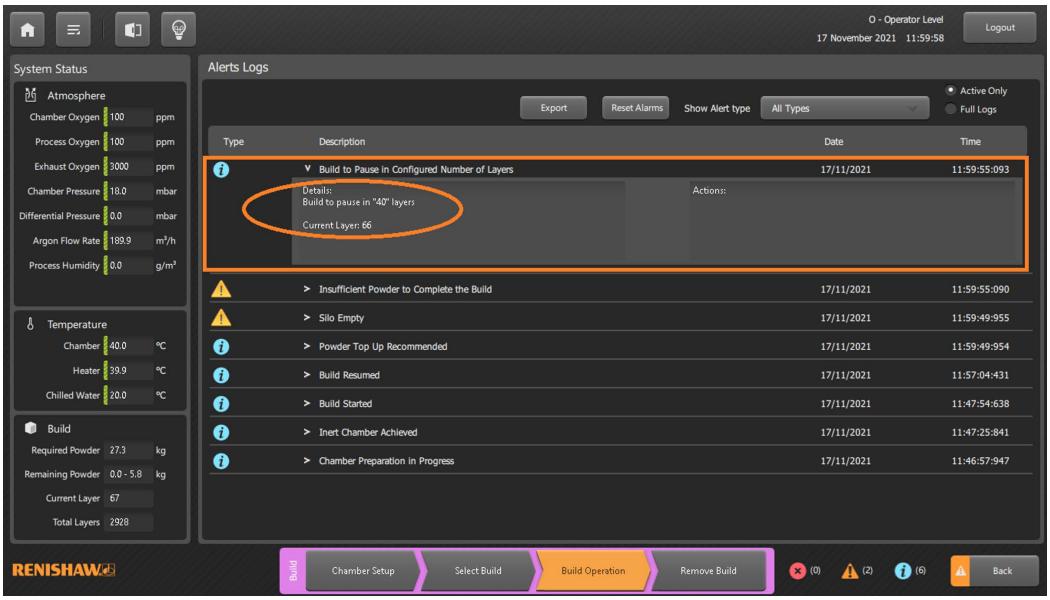


Figure 289 Alert Logs page with “Build to pause in n layers” alert displayed

When the pause delay layers are complete, the machine will perform the following pause function, depending on whether the machine is a Flex model or not:

Machine model	Description of pause function
RenAM 500 and RenAM 500 Ultra	On completion of the set number of pause delay layers following the “silo empty” alert, the machine first moves to an “auto paused” state. If the powder recirculation process or a user refills the silo while the machine is in the “auto paused” state, the build will resume automatically. The machine will stay in an “auto paused” state for 30 minutes, after which it will move to a “paused” state. Any corrective action taken after the build moves to a “paused” state will need to be followed by a manual resume by clicking the Build Play button on RenAMP.
RenAM 500 Flex	On completion of the set number of pause delay layers following the “silo empty” alert, the Flex machine moves directly to a paused state. Any corrective action taken when the build is in a “paused” state will need to be followed by a manual resume by clicking the Build Play button on RenAMP.

NOTE: Any build pause, including a manual pause by the operator, pauses the build only after the completion of the layer currently being built.

To configure any of the settings detailed above:

1. From the Home screen (Figure 290), select Set Parameters (circled). This will open the Set Parameters screen (Figure 291).

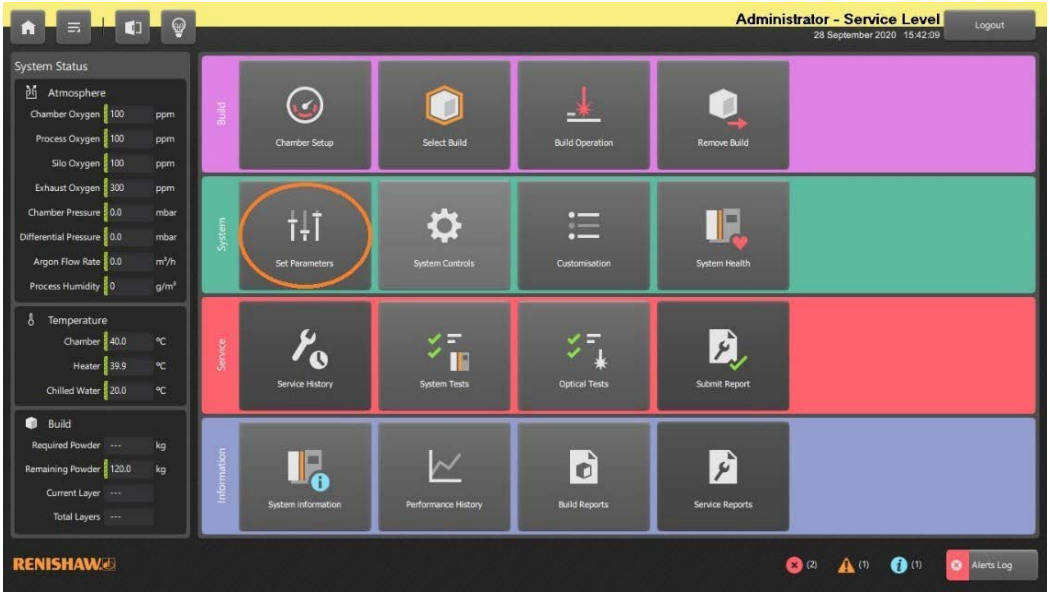


Figure 290 Home screen with Set Parameters circled

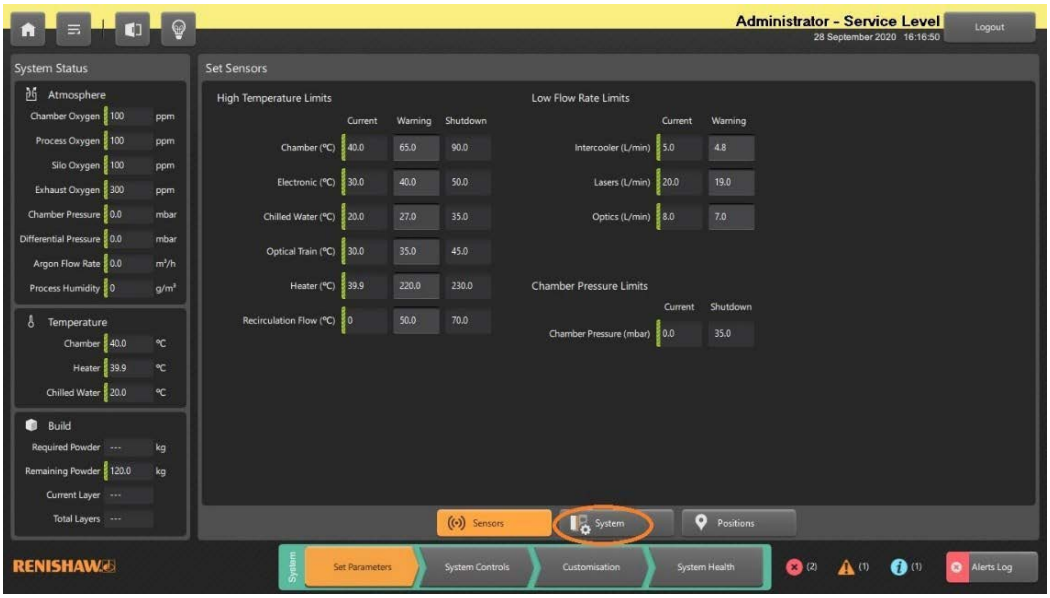


Figure 291 Set Parameters screen and System button

2. The Set Parameters screen (Figure 292) contains three buttons. Select the System button (circled), which will open the System screen. The System screen contains the Build Pause Settings pane (highlighted).

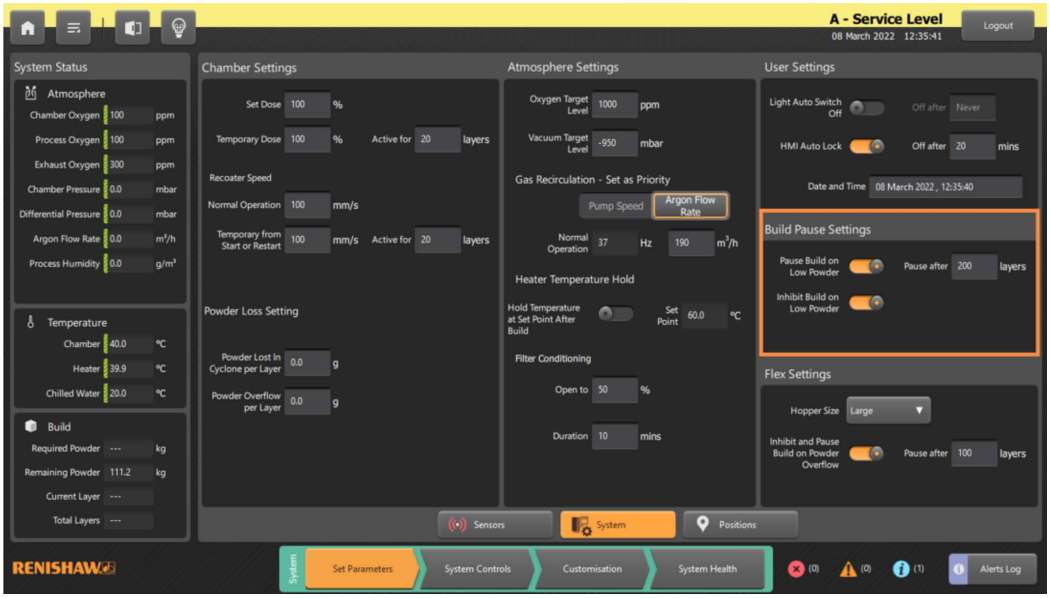


Figure 292 Build Pause Settings on the System screen

3. Configure the build pause settings as required.

Setting	Explanation
Pause Build on Low Powder	Enabling this setting will allow the machine to pause the build as soon as powder goes below the silo low level sensor.
Pause after n layers	A number, n, can be entered into the “Pause after n layers” box to the right of the “Pause Build on Low Powder” switch (Figure 292). Entering a number will make the machine alert the user when any of the overflow flasks are full, then pause the build after n layers have been completed after the alert. The recommended value for n is 40.
Inhibit Build on Low Powder	Enabling this setting will not allow the build to start if powder is below the silo low level sensor.

8.5.3 TT-003 – Pause build on powder overflow

RenAMP provides the option to configure the behaviour of the machine when one or both of the overflow flasks are full (applicable to RenAM 500 Flex machines only). These settings allow the user to:

- Inhibit or allow a build to start when one or both of the overflow flasks are full.
- Pause or continue a build if one or both of the overflow flasks become full during a build

When an overflow flask is detected as being full, there is still some space left in the overflow flask in which some powder can fit, meaning a limited number of extra layers can be completed before the overflow flask needs to be emptied. If the user chooses to configure the machine to complete a set number of extra layers after a full overflow flask is detected, the pause activation will be delayed until the extra layers are finished. This delay gives the operator a chance to empty the full overflow flask before the build is paused.

The machine can be configured to continue dosing powder for a set number of layers after a full overflow flask is detected, with the default number being 40 layers. After these layers are completed, the machine will enter a “paused” state, and the operator will have to manually resume the build by clicking the “Build Play” button on RenAMP. Refer to task “TT-002 – Pause build on low powder level” for further details, as the behaviour of the machine after a full overflow flask is detected is the same as when there is low powder in the silo.

To configure any of the settings detailed above:

1. From the Home screen (Figure 293), select Set Parameters (circled). This will open the Set Parameters screen (Figure 294).

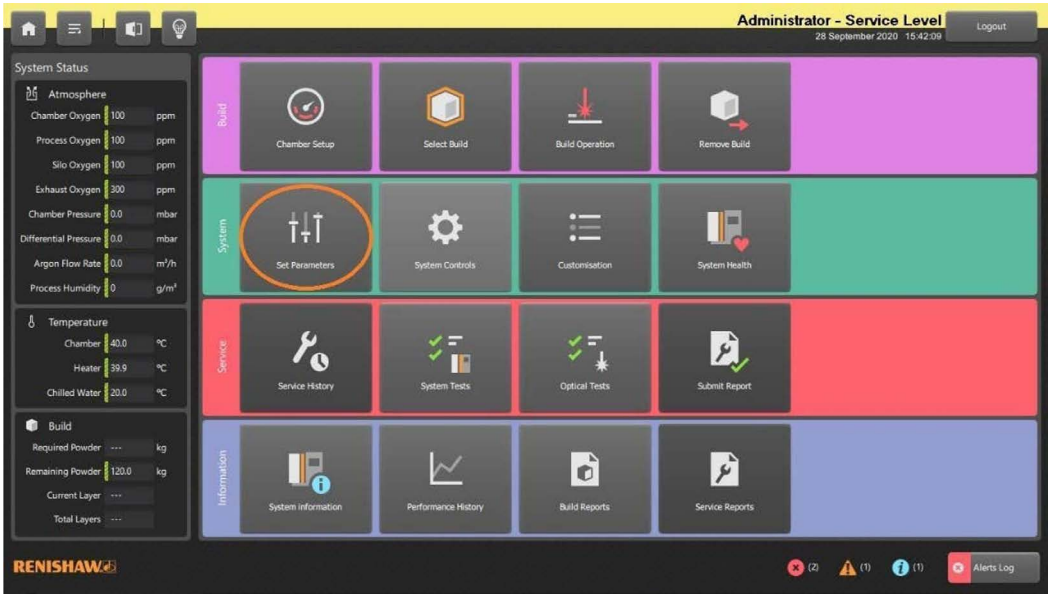


Figure 293 Home screen with Set Parameters circled

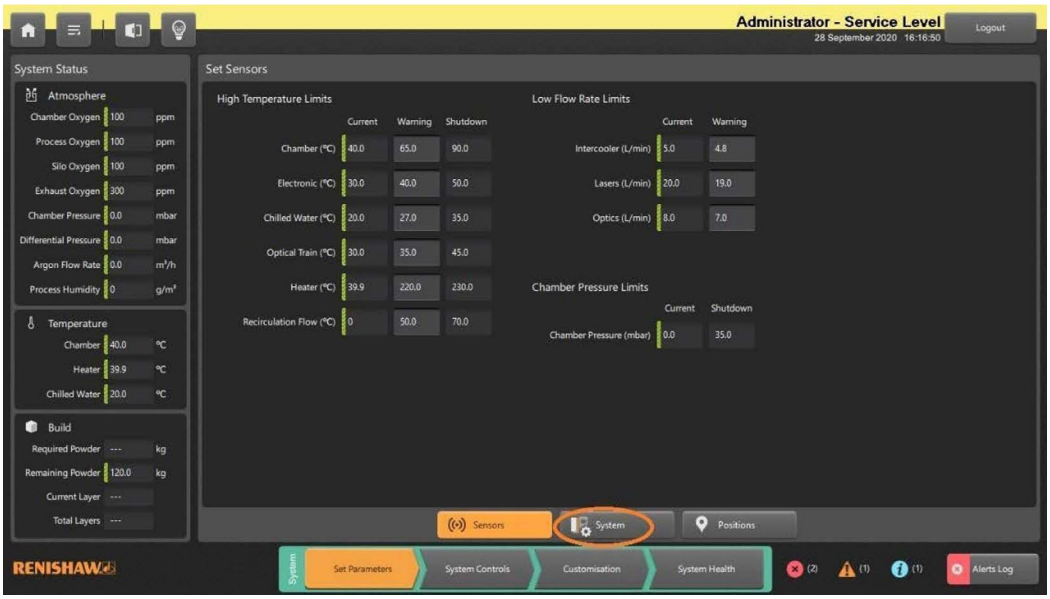


Figure 294 Set Parameters screen and System button

2. The Set Parameters screen (Figure 294) contains three buttons. Select the System button (circled), which will open the System screen (Figure 295). The System screen contains the Flex Settings pane (highlighted).

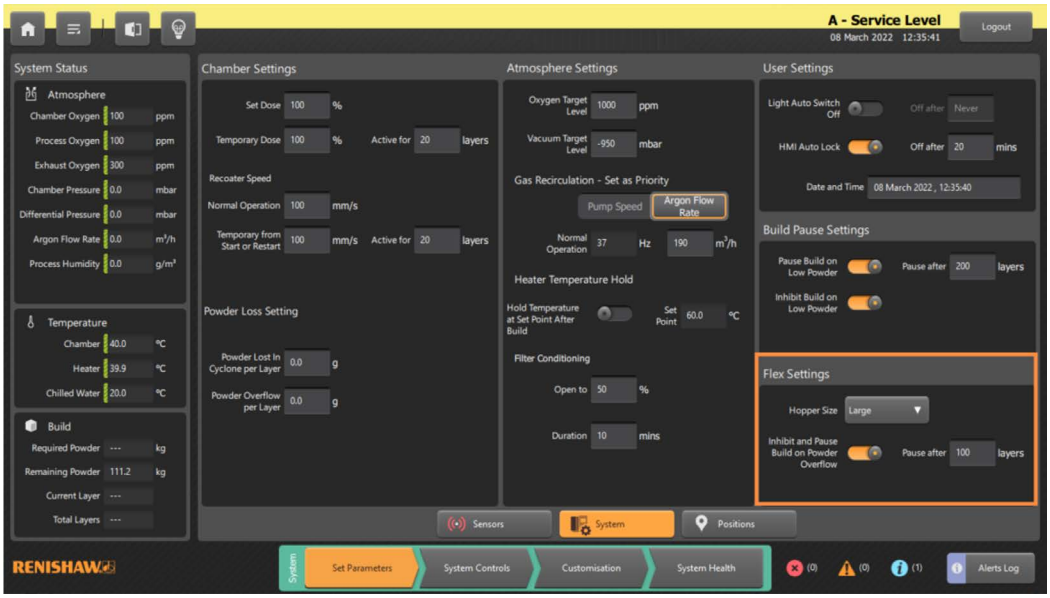


Figure 295 Build Pause settings and Flex settings

3. Configure the Flex settings as required.

Setting	Explanation
Inhibit and pause build on powder overflow	Enabling this setting will allow the machine to pause a running build if any of the overflow flasks are full. It will also not allow a build to start if any of the overflow flasks are full.
Pause after n layers	A number, n, can be entered into the “Pause after n layers” box to the right of the “Inhibit and Pause Build on Powder Overflow” switch (Figure 292). Entering a number will make the machine alert the user when any of the overflow flasks are full, then pause the build after n layers have been completed after the alert. The recommended value for n is 0.

4. The correct hopper size needs to be chosen from the drop-down list, based on the size of hopper used on the machine. Refer to section 6.17, “Feed hopper (RenAM 500 Flex only)”, for details on feed hopper size for the Flex machines. This setting should never change unless there is a change in the hopper size on the machine.



Figure 296 Hopper size setting based on hopper capacity

8.5.4 TT-004 – Add/update material information

RenAMP allows you to add or update materials information. If the user wants to run builds with a different powder material, then the correct material needs to be selected using RenAMP.

RenAMP allows you to:

- Add/update material with its density.
- Configure filter switch differential pressure for respective materials.

1. From the Home screen (Figure 297), select System Controls (circled). This will open the System Controls screen (Figure 298).

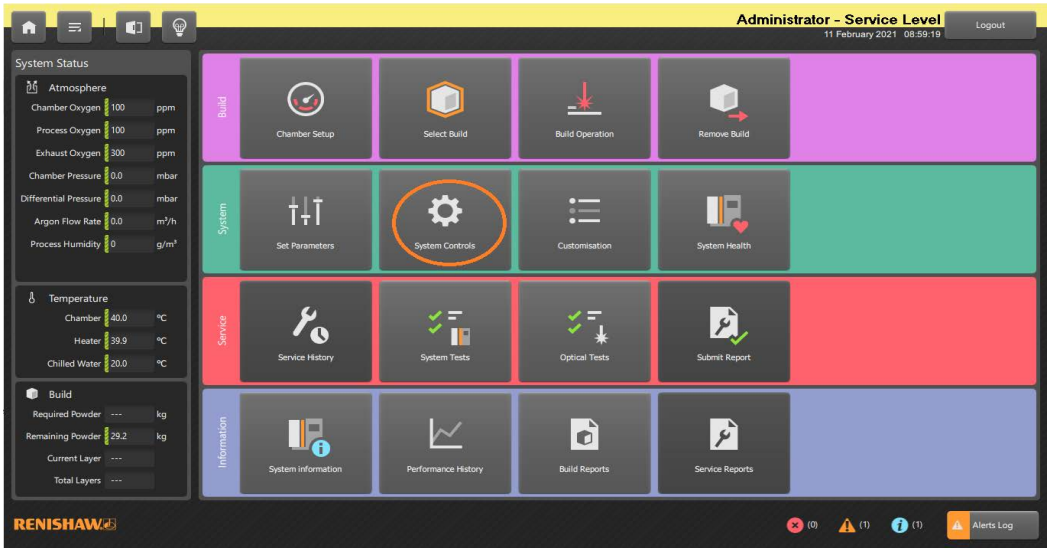


Figure 297 Home screen with System Controls circled

2. The System Controls screen (Figure 298) contains two buttons. Select the Recirculation button (circled). It will open the Recirculation screen.

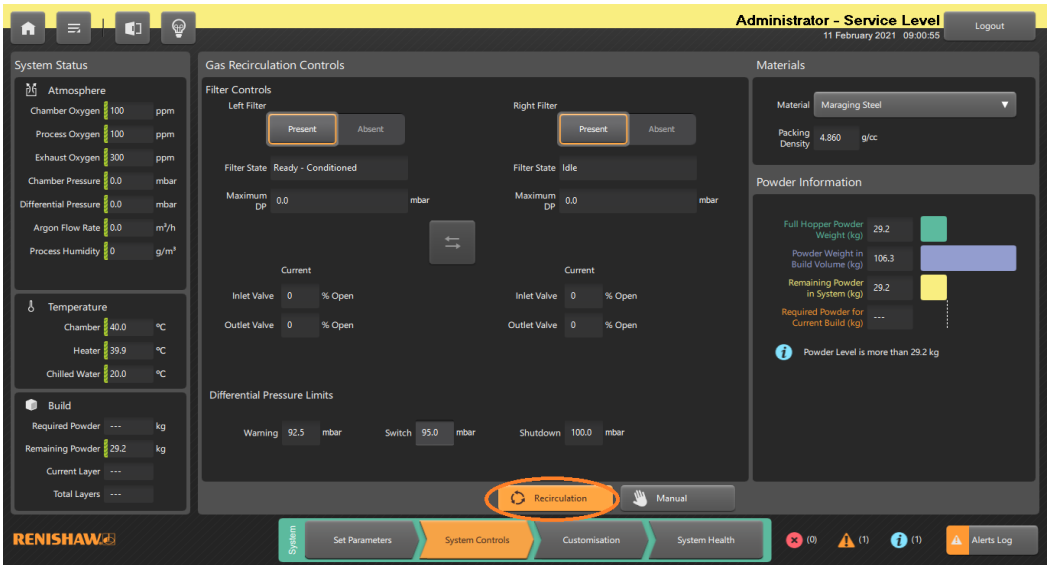


Figure 298 System Controls screen with Recirculation button

3. The Recirculation screen (Figure 299) contains the Materials pane as highlighted.

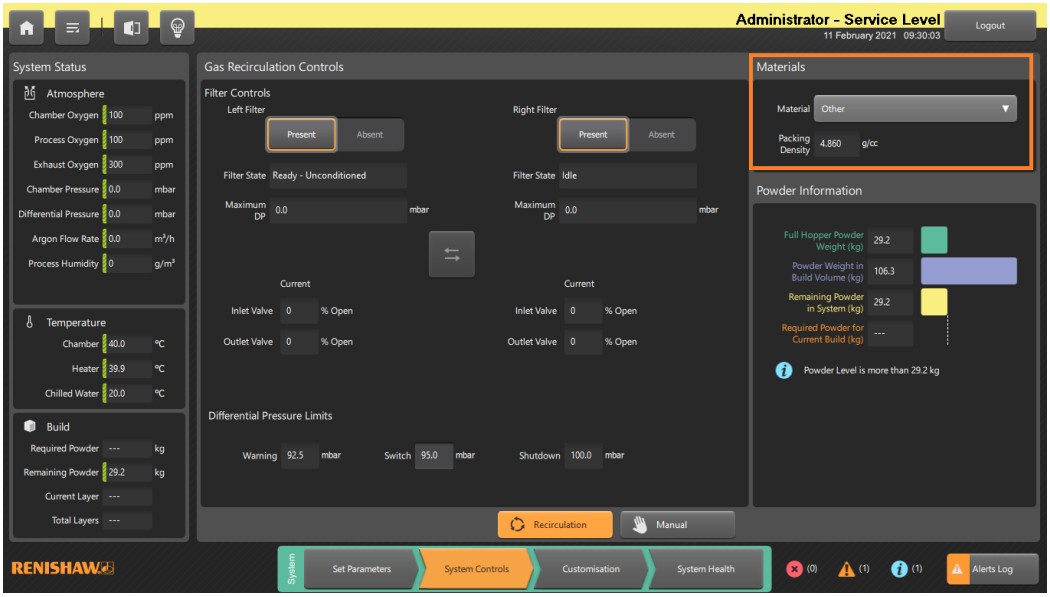


Figure 299 Recirculation screen with Materials pane

TT-004-01 – Change material

The material currently in use can be changed by selecting from the list of available materials (as highlighted in Figure 300).

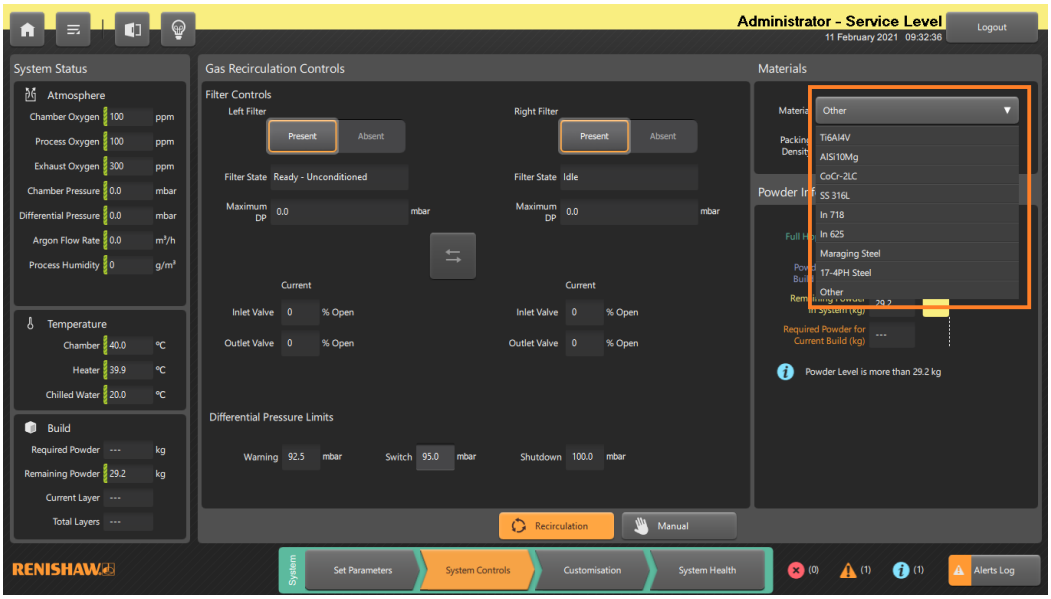


Figure 300 Drop-down list of materials available

TT-004-02 – Adding a new material

1. Select Other from the Materials drop-down list (Figure 301).

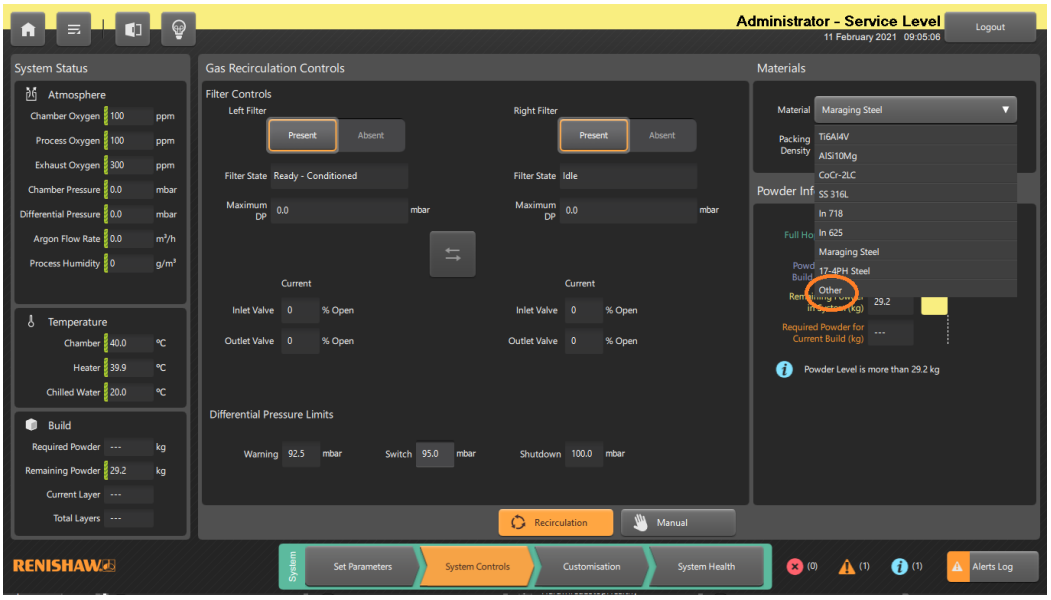


Figure 301 Other material

2. Add a suitable material name and density in the Other Material dialog box (circled) in Figure 302.

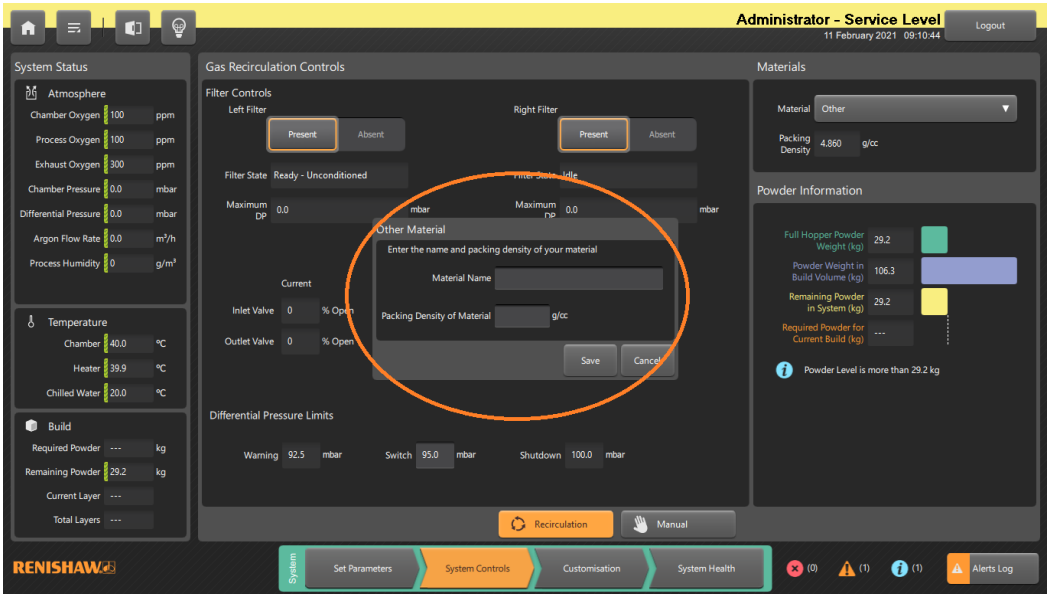


Figure 302 Other Material dialog box

3. Each material has filter switch and warning limits associated with it. Differential Pressure Limits are highlighted in Figure 303.

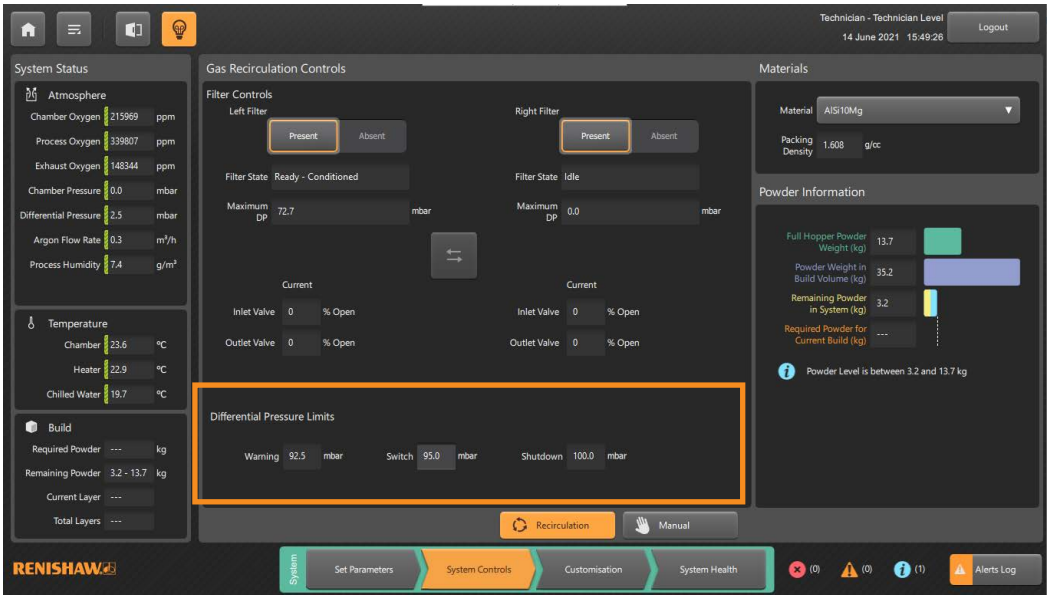


Figure 303 Differential Pressure Limits pane

Differential Pressure Limit	Explanation
Warning	An alert will be displayed as soon the filter differential pressure reaches this limit.
Switch	The filter will be switched if the differential pressure reaches this limit, with a condition that the other filter should be marked present and is clean. In there is not a clean filter present, the switch will not happen.
Shutdown	If the filter switch did not happen (due to filter marked absent or not clean) then the build will pause at this differential pressure limit.

4. Configure the settings as desired in the Switch input box circled in Figure 304.

NOTE: Renishaw recommends entering a lower ‘Switch’ value when using reactive materials, such as Ti6Al4V, to minimize the risk of thermal events during the filter passivation process.

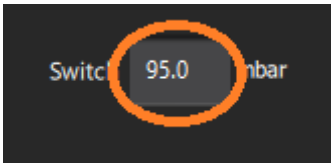


Figure 304 Switch input box

8.5.5 TT-005 – Auto tune heater plate

The following procedure outlines the automatic temperature-tuning process for the heater plate (heater auto-tune), which should be performed after its installation.

WARNING: Do not use the RenAM 500 series system once you have started the automatic temperature-tuning process of the heater plate. This process might take up to 4 hours to complete.

CAUTION: To prevent damage to the heater element within the heater plate, it is recommended to perform heater auto-tune after the following tasks:

- Setting up the machine for the first time.
- Changing standard substrate thickness (for example, replacing a 15 mm (0.59 in) build plate with a 34 mm (1.33 in)).

1. Install the build plate to the heater plate. For more information, see “AB-008 – Build plate – Install”.
2. Press the blue ‘Reset’ button to reset the machine.
3. From the RenAMP home screen, select ‘Chamber Setup’ and click the maximise button on the ‘Elevator’ pane.
4. In the expanded view of the ‘Elevator’ pane, use the ‘Elevator Controls’ to lower the elevator position by 20 mm (0.78 in). To achieve this, type 20 mm (0.78 in) in the ‘Move by’ field and click the ‘Elevator down’ button.

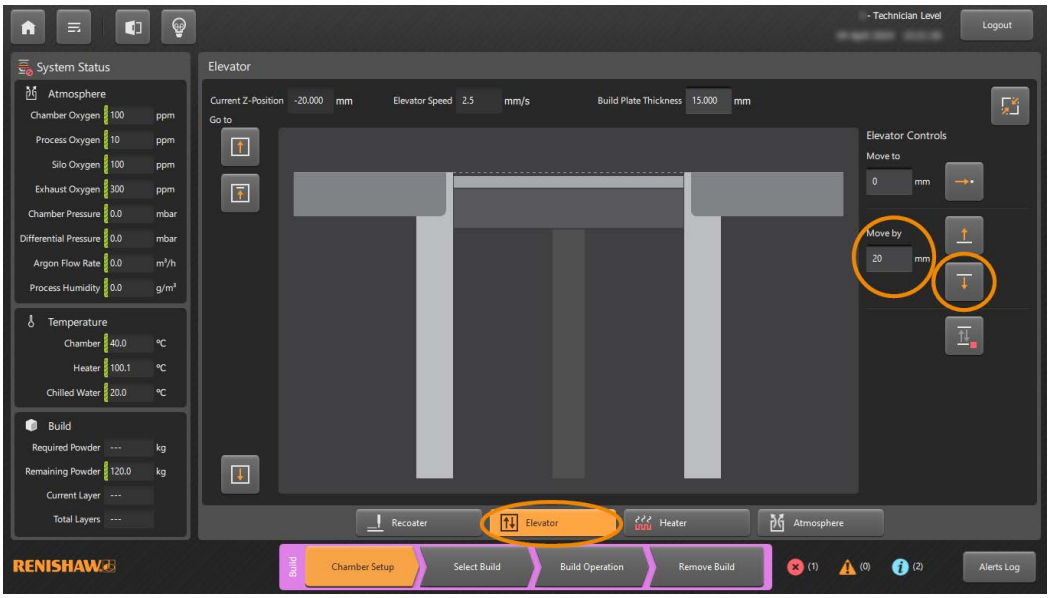


Figure 305 Elevator configuration

5. Select the ‘Heater’ tab at the bottom of the screen and set the ‘Heater Target Temperature’ to 100 °C (212 °F).

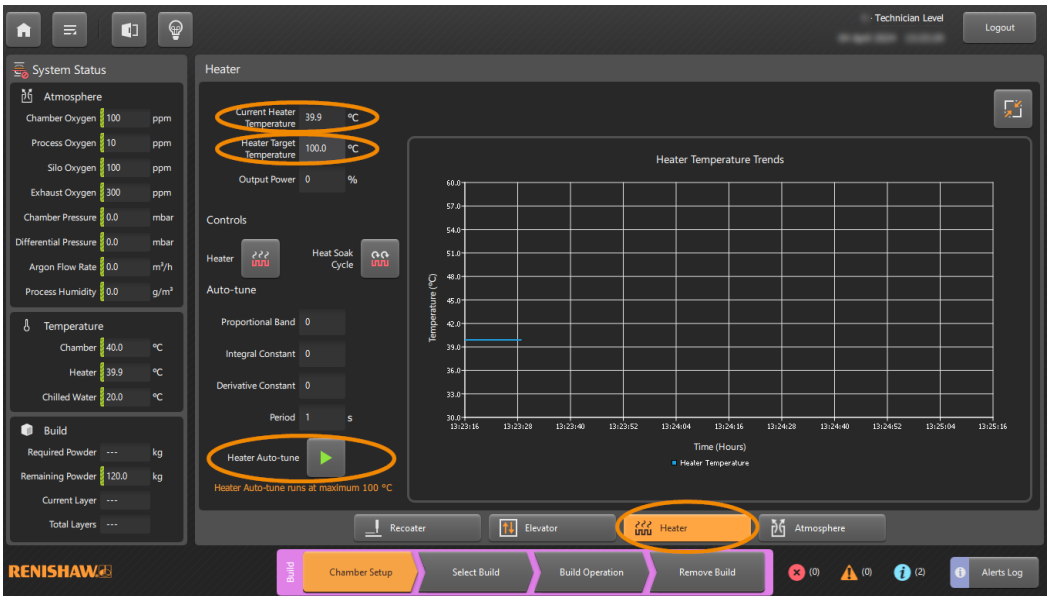


Figure 306 Heater configuration

6. Click the ‘Heater Auto-tune’ button to start the process.

NOTE: The system does not allow you to start the auto-tune process if the ‘Current Heater Temperature’ is more than 40 °C (104 °F). Please ensure that the ‘Current Heater Temperature’ is below 40 °C (104 °F).

---

7. Click the ‘Alert log’ button at the bottom right corner of the RenAMP to check the status of the initiated heater auto-tune process.

NOTE: The ‘Alert Logs’ page displays the information as ‘Heater Auto Tuning Completed’ after successfully completing the auto tuning process.

8.6 Optical tests

WARNING: It is not recommended to perform an optical test when the chamber or heater temperature exceeds 30 °C (86 °F). This may affect test results, damage the test equipment, or cause injury to the operator.

The optical tests are a collection of procedures which allow users to measure and calibrate some key laser machine characteristics including focus, power and scanfield (X, Y position). These tests provide the user with more input and control over the calibration history of their machines, with traceability and the ability to roll back. The following table lists the optical tests that can be carried out on a RenAM 500 series system.

Optical test	Test title	User level
TT-005	Laser power measurement test	Technician
ST-001	Laser power recalibration	Service
TT-006	Laser focus measurement test	Technician
ST-002	Laser focus recalibration	Service
TT-007	Laser scanfield measurement test	Technician
ST-003	Laser scanfield recalibration	Service
TT-008	Custom laser power and focus	Technician

This section also includes “ST-004 – Calibration management tasks”, which covers some of the tasks common across the three recalibration processes carried out with Service user level.

Use of the equipment for all three tests will require placing the equipment into the machine chamber and firing the IR laser at them in an inert atmosphere. Renishaw does not deem it safe to allow the lasers to be fired while not in an inert atmosphere. Before starting any of the optical tests, it is mandatory that the chamber is prepared properly so that the laser can be fired.

NOTE: This section provides information about the user interfaces available in RenAMP, the equipment needed and the operating procedure to be followed for conducting the optical tests.

8.6.1 TT-005 – Laser power measurement test

TT-005-01 – Overview

WARNING: It is not recommended to perform an optical test when the chamber or heater temperature exceeds 30 °C. This may affect test results, damage the test equipment, or cause injury to the operator.

To confirm the correct laser power is being delivered into the build, it is necessary to measure the output power using a power meter. Directly firing the laser into the device at five power values over the laser's operating range gives the user confidence of its accuracy and stability. The five powers used in Renishaw's OSV laser power measurement process are: 100 W, 200 W, 300 W, 400 W and 500 W.

The RenAMP laser power test can be run for all lasers in the system individually or all together (applicable only for RenAM 500Q). With either method, the user must interrogate the results after the measurement test has been performed. For the individual lasers, the test sequence is as shown in Table 1. For the combined All Lasers option (applicable only for RenAM 500Q), the process runs all Laser 1 powers again in the test sequence seen in Table 1, then Laser 2, Laser 3 and finally Laser 4.

Test sequence	Laser powers (W)
Exposure 1	100
Exposure 2	200
Exposure 3	300
Exposure 4	400
Exposure 5	500

Table 1 Laser power test sequence

TT-005-02 – Pre-requisites

1. **Machine software and firmware:**
    - The machine must be upgraded to Machine Software Suite (MSS) 1.6 or newer.
    - The machine must have an upgraded V5 quad controller (Renishaw part no. A-6170-0012-04 or newer).
    - The user will need the following RenAMP logins:
        - Technician: for optical test access.
        - Service: for optical test and calibration access.

2. Equipment required:

Part number	Part name / description
7Z02798 / P-EU01-0063	Ophir Ariel power meter (referred to from now on as the Ariel)
M-6813-0011	Customer ML commissioning plate – part of the OSV kit (Renishaw part no. A-6813-0001) or power and focus kit (Renishaw part no. A-6813-0002).
A-6813-3003	Ophir Ariel tooling assembly – part of the OSV kit (Renishaw part no. A-6813-0001) or power and focus kit (Renishaw part no. A-6813-0002).

NOTE: The Ariel must be calibrated by Ophir. Refer to the setting section on the Ariel for the next recommended maintenance and calibration. Calibration periods are at least every 18 months. Contact your local Ophir sales team to organise calibration when required.

3. Ophir Ariel manual

Before beginning the test, refer to the Ophir Ariel user manual, which can be found here:

MKS Ophir - The Ariel User Manual (ophiropt.com)

CAUTION: The diffuser (protective window) on the top of the Ariel must be kept free of contamination, as this can affect power readings. Low levels of contamination on the diffuser can be carefully removed with alcohol, once the Ariel has cooled, or blown off with compressed air. In the case of heavy, non-removable contamination or damage, the diffuser must be replaced with a new one – this can be purchased through your local Ophir representative – and the unit must be sent back for calibration with the new diffuser.

WARNING: Contamination and fingerprints on the diffuser can lead to damage, shattering or splintering during measuring operation.

- Do not touch the diffuser glass.
- Regularly check the condition of the diffuser and exchange it in case of pollution.
- Refer to the Ophir Ariel user manual, Wavelength options.
- Only operate the device with a clean diffuser.

4. Ariel configuration

The Ariel must be set up as follows:

- The diffuser must be attached, not the window, as shown in Figure 307.

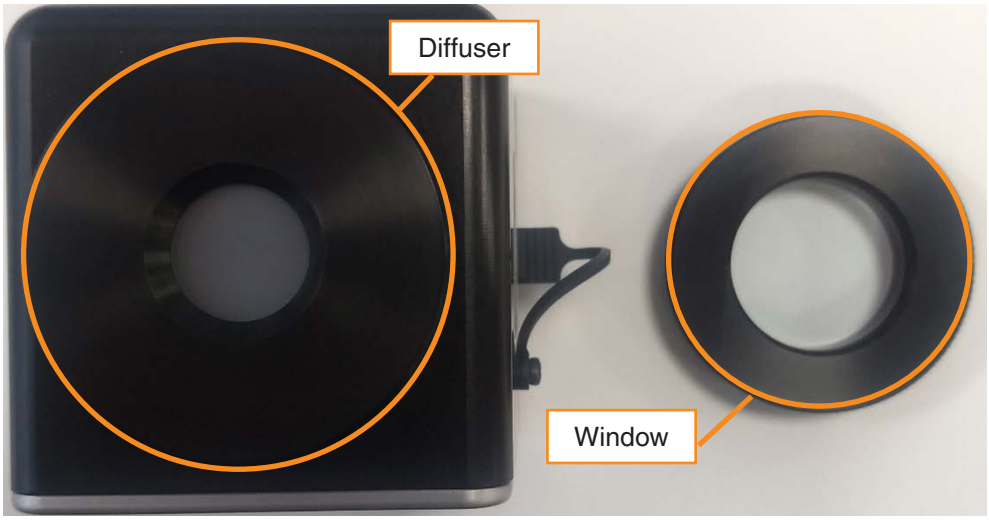


Figure 307 Ariel apertures – diffuser and window

- The Ariel must be in Pulsed Measurement mode and NIRD mode, and set to 500J as shown in Figure 308.
  - Use the middle button on the home screen to cycle to the 500J setting.
  - Use the right-hand button on the home screen to cycle to Pulsed Measurement mode.
  - To select NIRD mode, click the left-hand button to open the menu, use the middle button to toggle to Diff/λ, then click the right-hand button to select it. Use the middle button to toggle to NIRD and click the right-hand button to select it. See Figure 309.

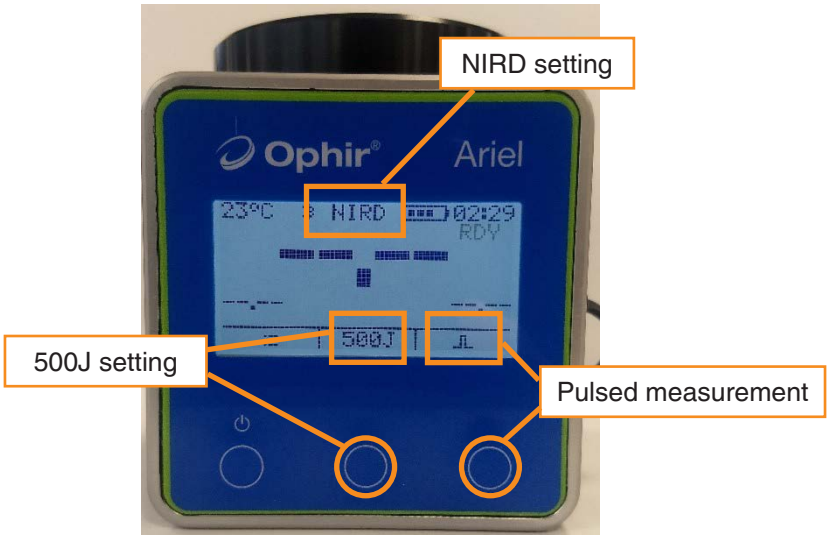


Figure 308 Ariel home/measurement screen



Figure 309 Diff/λ NIRD setting

5. Ariel damage

If the Ariel sustains damage, contact Ophir for replacement parts and recalibration.

This is particularly relevant for the diffuser. If the diffuser is damaged, it must be replaced to protect the Ariel. The standard Ariel window must not be used.

TT-005-03 – Pass/Fail criteria

For Renishaw's OSV laser power calibration, the following criteria must be met for all laser channels:

Allowable power deviation from each measured point	
Powers ≥ 100 W	≤ 6%

Table 2 Laser power pass/fail criteria

TT-005-04 – Machine preparation and hardware set-up

This section details the set-up required to perform the power measurement checks.

1. Log in to the machine with Technician level credentials.

   WARNING: The power test is a measurement process and should not be run if the chamber/heater plate temperature is above 30° C (86 °F).

2. Check that the chamber / heater plate temperature of the machine is below 30 °C (86 °F). If it is not, wait until it is to continue the set-up. The temperatures can be found on the left-hand side of the RenAMP Home screen (Figure 313).

   NOTE: If the set-up is continued while the temperature is above this, the commissioning plate and the Ariel may absorb excess heat and give poor results during measurement.

3. Clean the chamber thoroughly, including the gas inlet and outlet, removing all residual powder, as described in task “PB-005 – Build chamber – Clean”. There is a risk that powder will be blown onto the equipment if this is not done.

4. Mount the customer commissioning plate (Renishaw part no. M-6813-0011) onto the heater top plate as with a standard build plate and secure using the four M5 bolts as shown in Figure 310. Ensure that the engraved “FRONT” is at the front of the chamber.

   WARNING: Follow local procedure for handling of build substrates when handling the commissioning plate.

5. Ensure that the Ariel power meter is set up correctly before placing it inside the chamber.

   The Ariel should be powered on and have sufficient charge to complete the testing.

   The diffuser must be attached, and the Ariel must be in Pulsed Measurement mode, NIRD mode and set to 500 J. See “Ariel configuration”.

6. Mount the power meter stand assembly (Renishaw part no. A-6813-3003) in the centre location (location indicated in Figure 310 and shown mounted in Figure 311).



Figure 310 Commissioning plate with locations for power meter stand indicated



Figure 311 Power meter stand fitted in central position

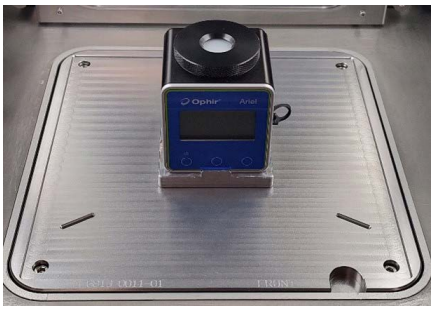


Figure 312 Ariel in the central position with cover removed seated on the tooling

7. Place the Ariel onto the stand, ensuring the screen faces the front of the chamber and the window cover has been removed (Figure 312).

8. Close the machine door.

9. From the Home screen, select Optical Tests (circled). This will take the user to the Optical Tests section.

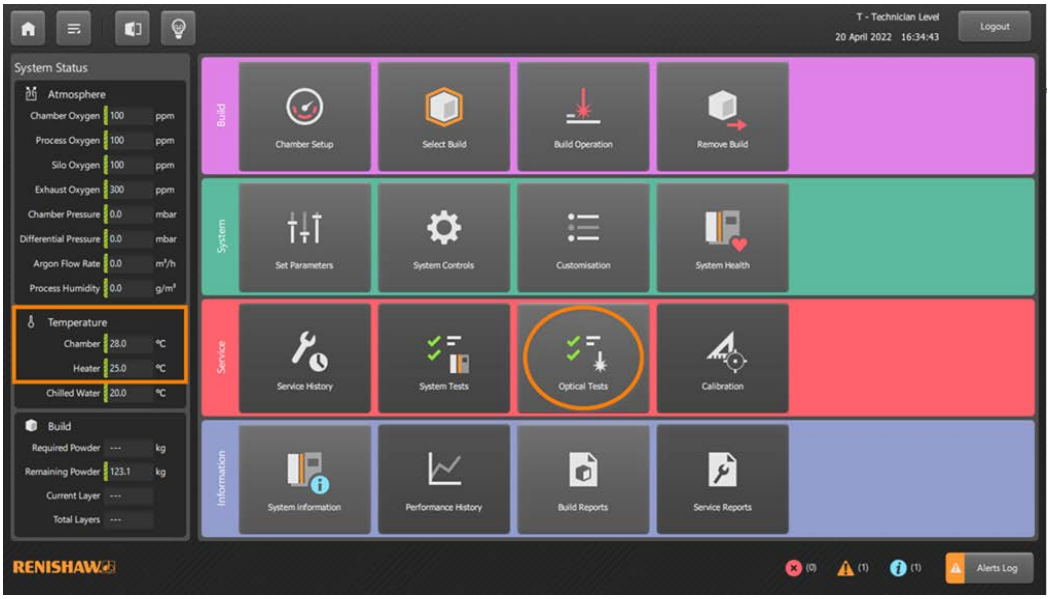


Figure 313 RenAMP Optical Tests page selection

10. If the page does not open on the Laser Power page, navigate to it by clicking the Laser Power button at the bottom of the screen as shown in Figure 314.

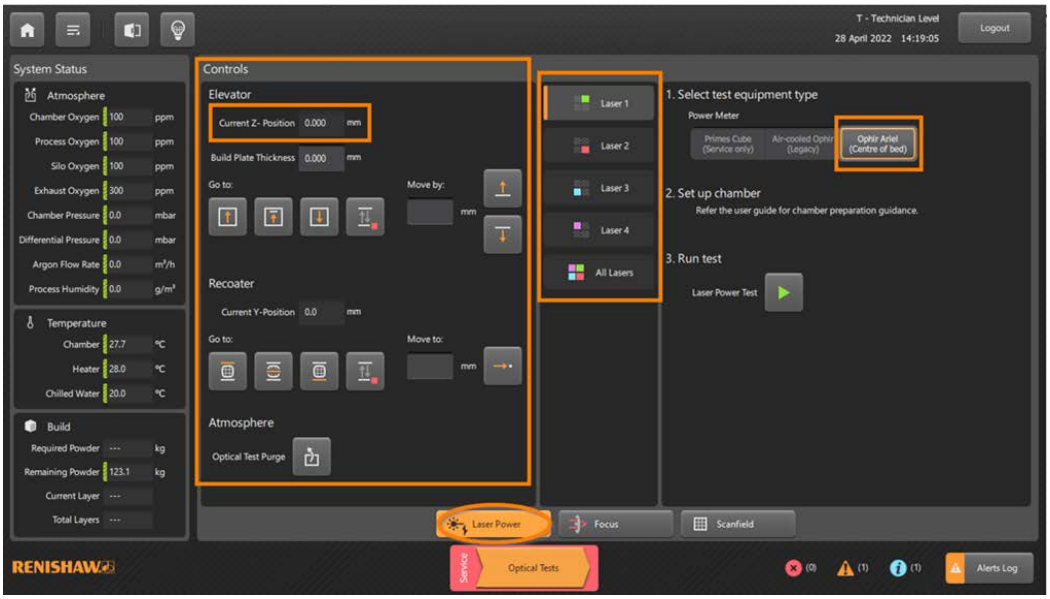


Figure 314 RenAMP Laser Power Test page selection, Laser 1 Ophir Ariel (Centre of bed) selected

11. The Ariel (Centre of bed) power meter option should be selected.

WARNING: The other two power meter options are for legacy service power meters and should only be used by Renishaw service personnel. Usage of these power meters may give incorrect results.

12. Lower the elevator by 15 mm (49 in) from the absolute top position using the Elevator Move by controls. The Controls section (highlighted in Figure 314) is used for elevator movements and for preparing the chamber for testing.

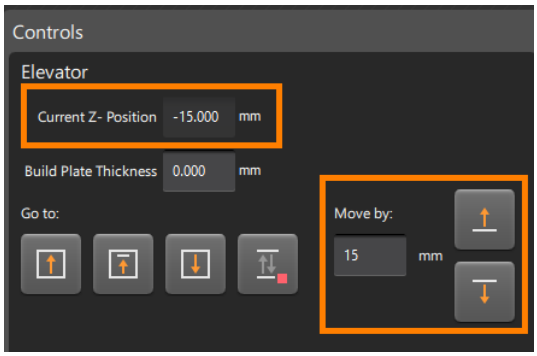


Figure 315 Optical test elevator controls

CAUTION: The top surface of the plate should now be at the approximate height of the recoater blade.

13. Click the Optical Test Purge button as seen in Figure 316. This will inert the chamber without a vacuum. Optical test processes, like part builds, can only be run in an inert atmosphere. Purging will take approximately 20 minutes.

WARNING: Creating a vacuum on the Ariel may damage the equipment.

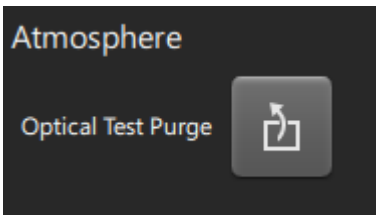


Figure 316 Optical Test Purge button

While purging, the Optical Test Purge button will appear as shown in Figure 317.

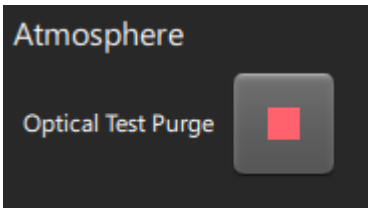


Figure 317 Optical Test Purge button while purging

The mechanical set-up is now complete, and the Ariel is installed in the machine ready to start the measurement test.

TT-005-05 – Laser power measurement test

The power checks can only be completed once the chamber is purged with argon. To run the measurement check, the following procedure should be followed:

1. Ensure the machine has finished purging – the chamber/process oxygen levels will be below 10 000 ppm and the Optical Test Purge button will once again appear as shown in Figure 316.

2. Ensure the Ophir Ariel (Centre of bed) power meter is selected on the Laser Power RenAMP screen.

3. Ensure that the Ariel absorber temperature is below 35 °C (95 °F) (shown on the Ariel screen or visible via the Android app). The Ariel can withstand multiple cycles of the process before it heats up significantly.

   WARNING: Monitor the temperature on the screen of the Ariel. If the absorber temperature goes above 60 °C (140 °F), activate the emergency stop. Monitoring the Ariel temperature can be done via Bluetooth with the Android StarViewer app.

4. The Ariel power measurement process allows for two measurement options: each Laser individually or All Lasers (applicable only for RenAM 500Q).

   These options can be seen in Figure 318, which shows the All Lasers option highlighted and selected. Selection is signified by the orange bar on the left and the grey rather than black box.



Figure 318 Power measurement laser selection options – All Lasers option selected (applicable only for RenAM 500Q)

The sequence of all options is discussed in task “TT-005-01 – Overview” and can be seen in Table 1.

For RenAM 500Q machines, it is recommended to run the All Lasers power test rather than the individual laser options. On starting the test, this will fire five laser pulses in 30 second intervals for each laser. This takes approximately 10 minutes. The process will run all Laser 1 power values, then Laser 2, Laser 3 and finally Laser 4.

For RenAM 500S machines, the Laser 4 power test will be the only available option. On starting the test, this will fire five laser pulses in 30 second intervals. This takes approximately 2.5 minutes.

For RenAM 500D machines, the Laser 1 and Laser 4 power test will be the only available option. On starting the test, this will fire five laser pulses in 30 second intervals for Laser 1 and then Laser 4.

NOTE: Do not use the Primes Cube (Service Only) or Air Cooled Ophir (Legacy) power test options – these are for service and legacy power meters.

5. Select the Run Laser Power Test button, as shown in Figure 319, to fire the Laser Power optical test.

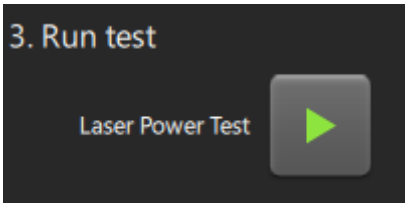


Figure 319 Laser Power Test button before the start of the test and after test completion

While the test is running, a Stop button will be displayed instead of a Play button, as shown in Figure 320. If for any reason the user needs to stop the test, this button or the Emergency Stop may be pushed.

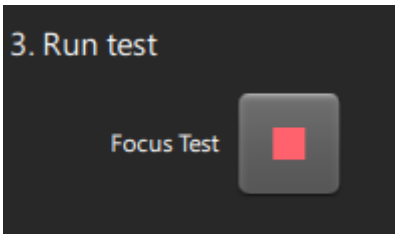


Figure 320 Laser Power Test button during the test

NOTE: If the “User Action Request Failed” information pop-up appears, check the machine is in a reset and inert state. If this error persists, request help from Renishaw Service.

WARNING: Incorrect positioning of test equipment and/or not following the procedure may cause irreversible damage to the Ariel. Equipment may become hot enough to cause injury. Press the Emergency Stop button and allow tooling to cool before attempting to proceed.

6. The test may take a little while to start firing. When it does, the ready ‘RDY’ status will change to ‘INT’ (initialising). Once the power meter has processed the exposure, it will display a power reading. This sequence will happen for every laser exposure.

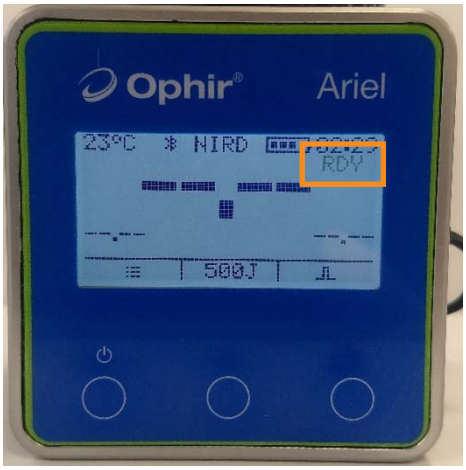


Figure 321 Power meter displaying the RDY status and no measurement reading

7. Record the results. This can be done in a variety of ways:

   a. Look through the chamber window, read the powers from the Ariel's display and write down the values.

   b. Connect to the Ariel via Bluetooth with the Android StarViewer app and write down the values.

   c. Wait until the test is complete and look at the results in the Ariel's logs. How to do this is detailed in step 12.

   Results could be recorded in a table similar to Table 3.

Demand power	Laser 1 (W)	Laser 2 (W)	Laser 3 (W)	Laser 4 (W)
100				
200				
300				
400				
500				

Table 3 Example table for recording laser power results

8. When the Stop button returns to a Play button, the test has finished.

9. If the machine is a RenAM 500Q and the user has fired a single laser rather than the All Lasers option but wants to measure the power of multiple lasers, repeat steps 4 to 8, changing lasers until all lasers have been measured.

   NOTE: It may be necessary to wait for the absorber to cool to below 35 °C (95 °F) between tests. This is an unlikely occurrence because of the Ariel's thermal management.

10. Open the chamber door.

    WARNING: Before handling tooling after running a test, be aware that it may be hot – under normal operation it should not be.

11. Remove the power meter from the chamber.

    NOTE: Wear nitrile gloves when removing equipment to prevent contact with residual powder.

12. To check the power values or record them for the first time from the Ariel logs, the following should be done:

    a. Press the power/menu button on the left-hand side of the Ariel to display the menu.

    b. Select the log by clicking the right-hand button.

    c. Click the right-hand button again to select the log list – this will show the last six measured values.

    d. To cycle to the next six values, click the middle button again. Repeat until all values needed are recorded.

    NOTE: To look at an individual reading more closely, click the right-hand button once on the log list.

Reading 1 is the most recent reading (500 W for the last laser fired) – there will be five readings per laser. Cycle through the readings until the first 100 W reading of the session is reached.

For RenAM 500Q, if the All Lasers file were fired, reading 1 will be 500 W for Laser 4, reading 6 will be 500 W for Laser 3, reading 11 will be 500 W for Laser 2 and reading 16 will be 500 W for Laser 1.



Figure 322 Example Ophir Ariel data

TT-005-06 – Analysis of laser power data

1. The user should have laser power values for each tested laser recorded from the Ariel. Analyse the data for each laser individually against the laser power specification – see Table 4.

Target power (W)	Minimum value (W)	Maximum value (W)
100	94	106
200	188	212
300	282	318
400	376	424
500	470	530

Table 4 Laser minimum and maximum power specifications

2. If the result is a pass, no further testing is required for that laser. If all lasers are in specification, the user should continue to task “TT-005-08 – Next steps”. Otherwise continue.

3. If results are out of specification for a laser, then that laser will need recalibration. Continue to Section “ST-001 – Laser power recalibration”.

NOTE: The most likely cause for loss of laser power is optical cleanliness. If the optical module chamber window appears dirty, it should be cleaned and the measurements retaken. For more information, see section 10.19, “PM-035 – Lens protection window – Clean”.

NOTE: If just the higher powers (500 W) are out of specification, it may point towards the laser reaching end-of-life conditions. If this is still an issue after recalibration, contact Renishaw Service.

TT-005-07 – Remove test equipment

1. Open the chamber.

   NOTE: Wear nitrile gloves when removing equipment to prevent contact with residual powder.

   WARNING: Before handling tooling after running a test, be aware that it may be hot. This is unlikely under normal conditions, as the Ariel has good thermal management.

2. Remove the Ariel and wipe with IPA to remove any residual powder. Put the window cover back on and store in the padded case provided.

3. Remove Ariel tooling and the commissioning plate and wipe down with IPA to remove any residual powder.

4. Put the equipment back into the OSV protective case.

TT-005-08 – Next steps

The power measurement testing is now complete and the machine is known to have in-specification power calibration. The user has a choice as to how to continue:

- Continue with the next optical test (see “TT-006 – Laser focus measurement test”).
- Finish optical testing here and continue using the machine for normal operation.

8.6.2 ST-001 – Laser power recalibration

ST-001-01 – Recalibration process

This section documents how to apply a change to the power calibration.

1. To create and apply a power measurement file, the user must be a trained Service level user. If not already logged in at Service level, log out and log in again at Service level.

   NOTE: If not a Service level user, contact a Service level user to continue.

2. Move to the Calibration tab, using the button at the bottom of the screen as seen in Figure 323.

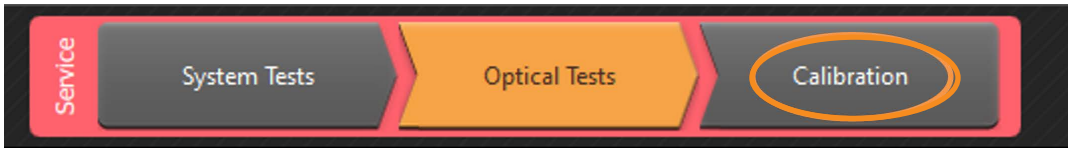


Figure 323 Optical Test page to Calibration page

3. To create a new measurement file containing power offsets for the lasers requiring alteration, click the '+' button on the Measurement page as seen in Figure 324.

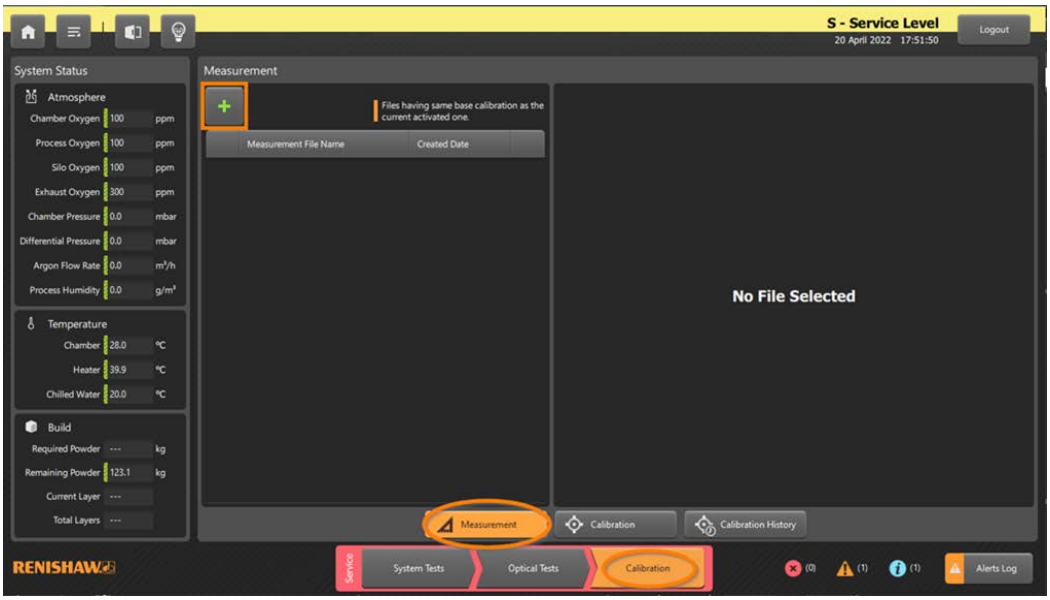


Figure 324 Calibration page, Measurement tab

This will open the Measurement file creation page on the Power tab.

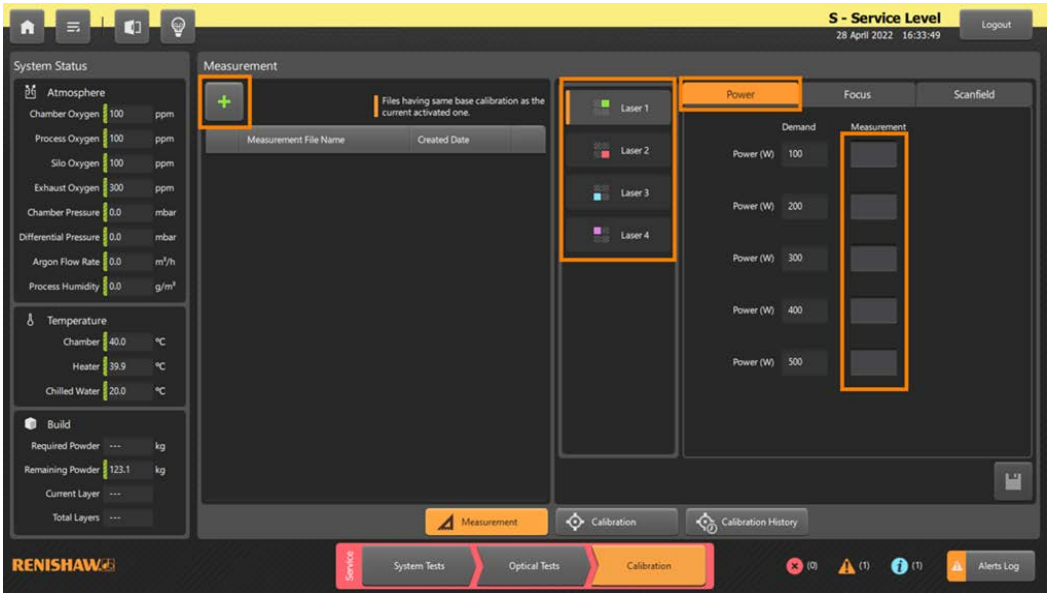


Figure 325 Measurement file creation page, Power tab

4. Navigate to the laser that needs updating and fill all five Measurement boxes with the measured laser powers for that laser, as highlighted in Figure 325.

If all measurements are in specification, then a measurement file for that laser does not need to be saved.

If a measurement is 10% out of specification, a notification will appear (see Figure 326). This is to ensure the user has not made an error in recording the value. Measurements should not frequently have an error of more than 10%.

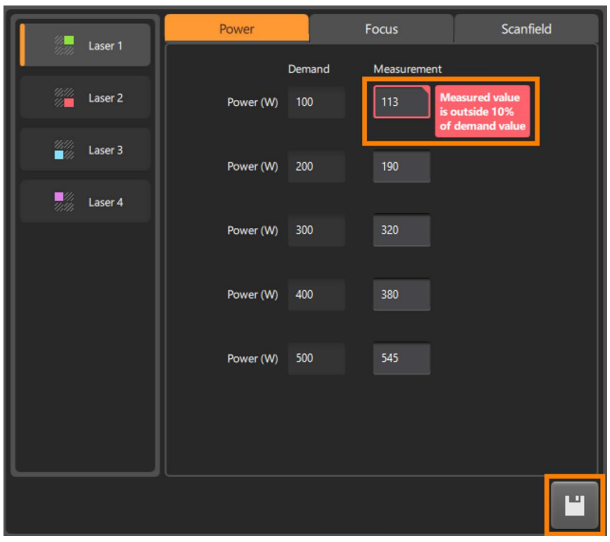


Figure 326 Valid measurement file – power measurement notifications/error messages

RenAMP will allow a measurement file with an error of more than 10%, but will not allow an error that is more than 20% to be saved (see Figure 327 – note the disabled Save button). An error this large is an unlikely occurrence, but may point towards an issue in the optical system. If found, contact Renishaw Service.

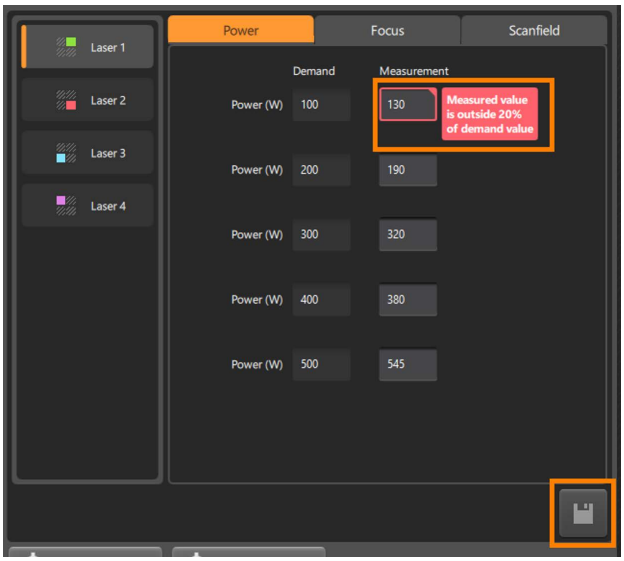


Figure 327 Invalid measurement file – power measurement notifications/error messages

5. If multiple lasers need an offset adjustment, repeat step 4 until all lasers have been set.

6. Click the Save button in the bottom right of the screen to create a measurement file. The Save button will be enabled if the user has given valid entries in all the required fields (see Figure 328).



Figure 328 Enabled Save button

7. The Save File dialog box will appear. The user can change the File Name and Description, if required, by clicking in the boxes using the on-screen keyboard that pops up on HMI. Special characters /, \, “, :, *, ?, <, >, | in the file name should be avoided. The default name format is “Measurement_Date_Time”. It is recommended to add the measurement type, for example “Power”, to the name.

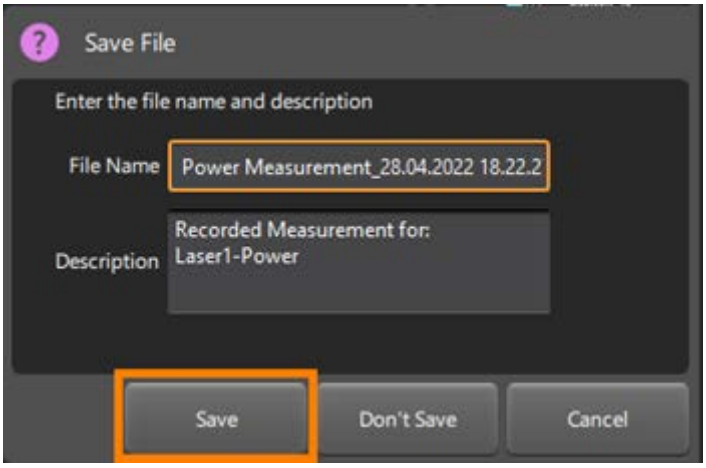


Figure 329 Save File dialog box

8. To continue, click the Save button as shown in Figure 329.

   This will create the new measurement file which is easily identifiable using the File Name and/or Created Data column (highlighted in Figure 330).

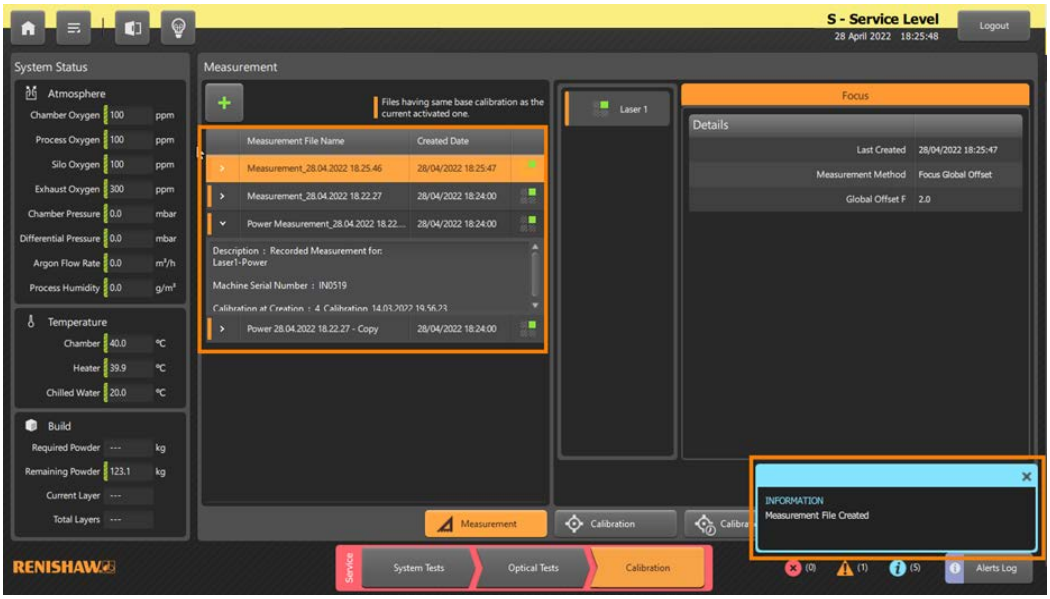


Figure 330 Measurement page with newly created measurement file

NOTE: The coloured boxes next to the measurement file indicate which lasers have a change to their calibration state.

An information pop-up will tell the user that the file was created; this can also be viewed in the alert logs.

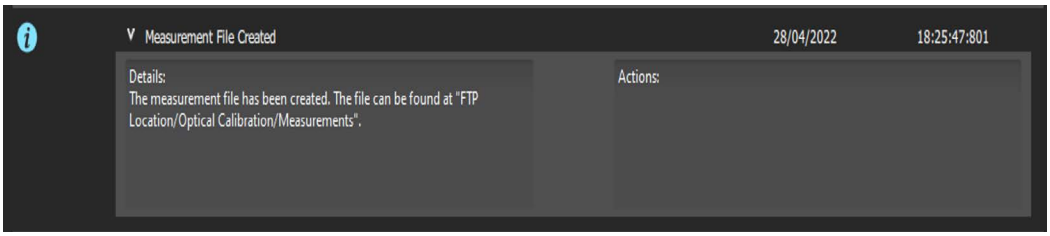


Figure 331 Alert log – measurement file created

9. The top line highlighted in orange on the Measurement screen is the new measurement file that has been created as shown in Figure 332. If the new measurement file is not highlighted orange, select it and then click the Create Calibration button at the bottom right to create a calibration file, highlighted by the orange box.

   NOTE: It is important to ensure the correct measurement file is selected to make the correct calibration file.

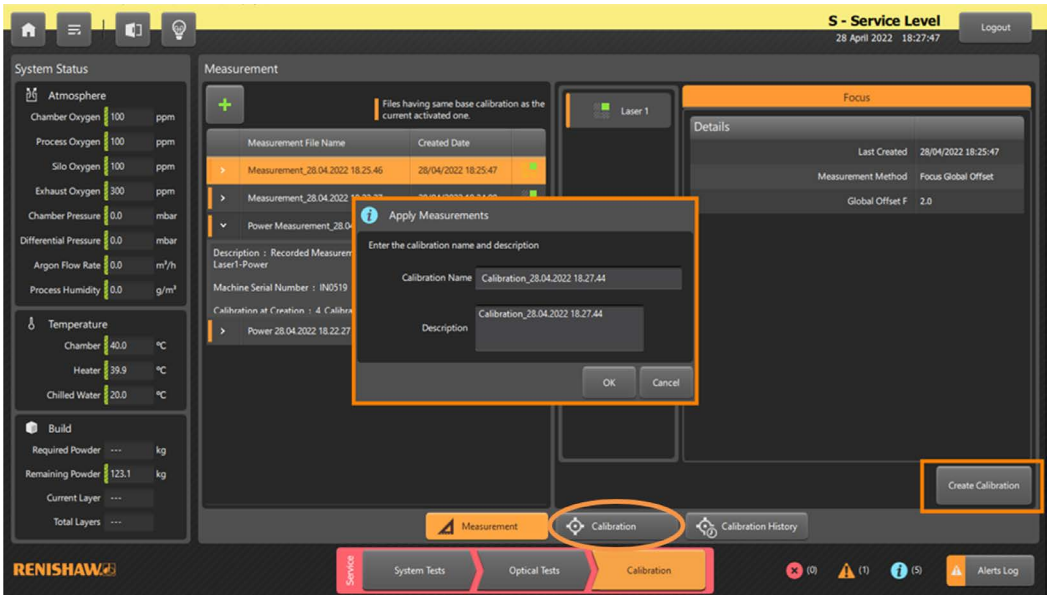


Figure 332 Measurement page – Create calibration – Apply measurement dialog box

10. The Apply Measurements dialog box will appear. The user can change the Calibration Name and Description by clicking in the boxes and using the on-screen keyboard that pops up on HMI. It is recommended to add the calibration type, for example “Power”, to the name.

11. Click the OK button as shown in Figure 332 to complete the calibration creation.

    An information pop-up will appear stating ‘New Calibration State Created’. As with the creation of a measurement file, this can be viewed in the alert logs if required.

12. Move to the Calibration screen by clicking the button at the middle of the screen highlighted by the orange circle in Figure 332.

13. The line highlighted in dull orange with the orange bar at its left end is the current machine calibration.

    The top line of the table is the most recently created calibration file – the calibration containing the user's new power measurements. To make this calibration the active calibration, click it to highlight it orange and then click the Activate button, indicated by the orange rectangle below.

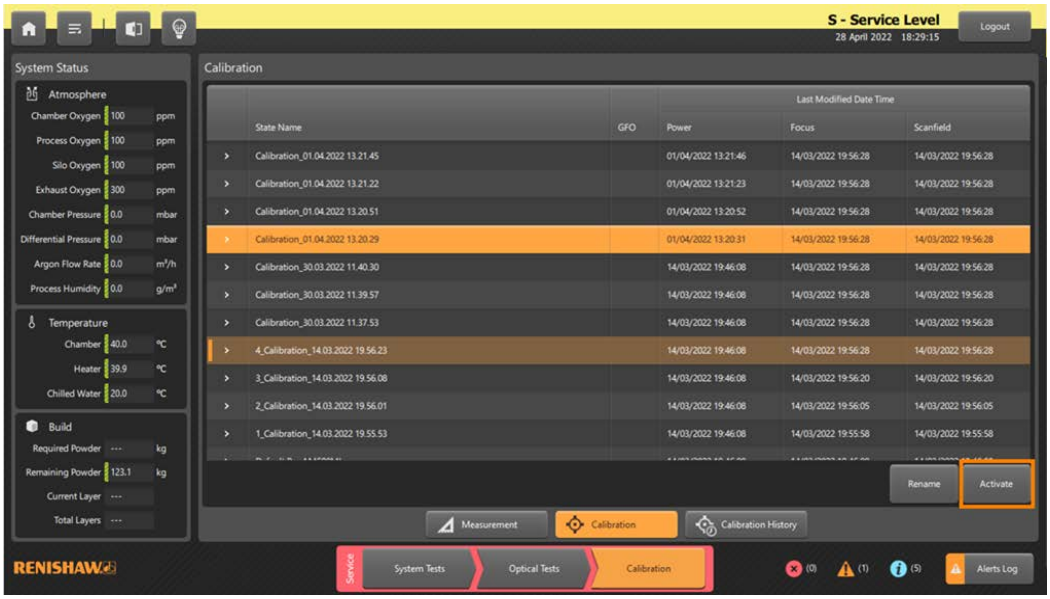


Figure 333 Calibration screen

14. The user will be prompted to accept or reject the changes to the calibration by clicking Yes or No. Click Yes to active it.

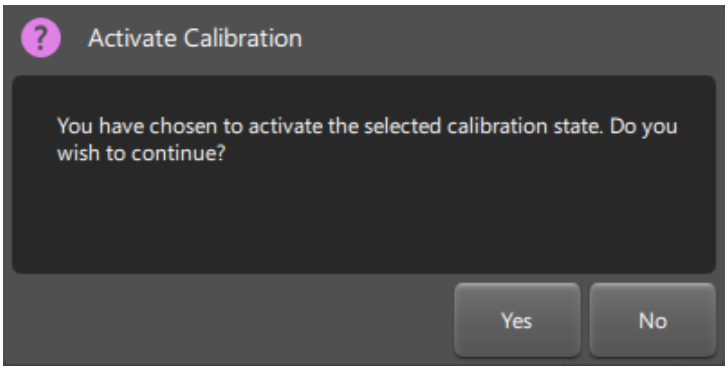


Figure 334 Activate calibration pop-up

15. The new calibration is now active, as shown in Figure 335. This is indicated by the change in the line that is highlighted in dull orange. It can also be seen in an information pop-up in the bottom right of the screen initially after application, and can be checked in the alerts log in the bottom right.

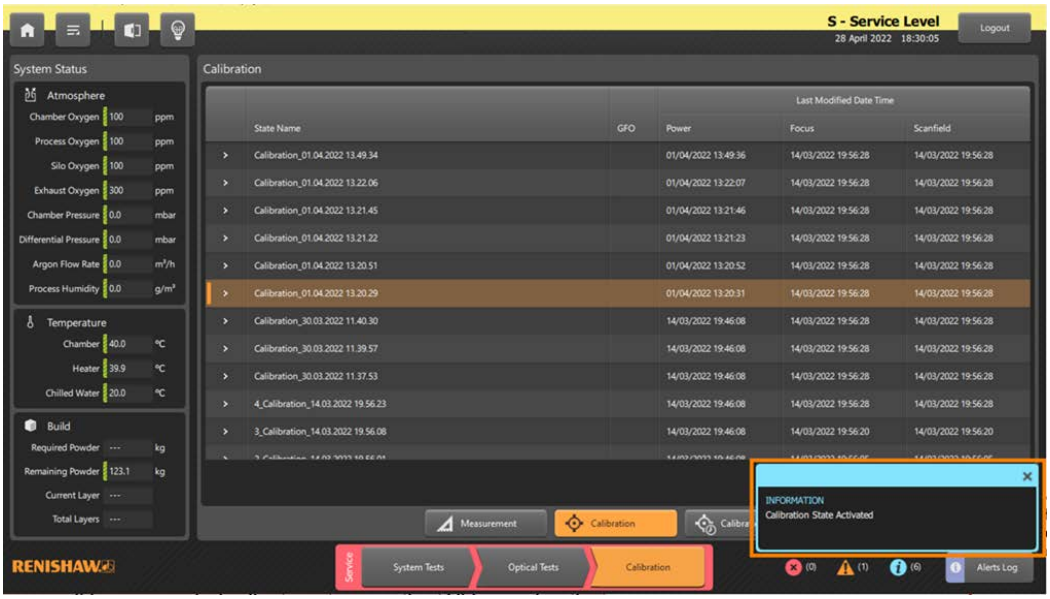


Figure 335 New active calibration

16. To check the calibration is now in specification, re-run the power measurement test.

    a. Put the Ariel back into the machine, close the door and purge the chamber.

    b. Re-start the procedure from task “TT-005-05 – Laser power measurement test”. It is only necessary to re-test lasers that needed adjustment. For Laser 1 use the Laser 1 tab, for Laser 2 use the Laser 2 tab etc. If all lasers needed adjustment, re-run the All Lasers option (applicable only for RenAM 500Q).

    c. If it is still incorrect, contact Renishaw Service for support.

NOTE: It may be necessary to wait for the absorber to cool below 35 °C (95 °F) between tests. This is an unlikely occurrence because of the Ariel’s thermal management.

8.6.3 TT-006 – Laser focus measurement test

TT-006-01 – Overview

WARNING: It is not recommended to perform an optical test when the chamber or heater temperature exceeds 30 °C (86 °F). This may affect test results, damage the test equipment, or cause injury to the operator.

The focus test is a visual assessment of the beam waist position in the Z direction and is used to ensure the minimum spot size is focused on the recoater plane (the powder bed).

The Renishaw optical system has the ability to move around a nominal focus position; this movement allows the system to be in focus everywhere across the powder bed. This position indicates a Global Focus Offset (GFO) of zero. The system has some built-in redundancy to allow it to have an offset applied if this 'zero' position does not align with the minimum spot size on the recoater plane.

The method used to find the focus height is to etch a series of equi-spaced lines onto the surface of a marking (black anodised aluminium) plate whilst changing the focal length of the optical system. The etched lines allow the lighter colour of the aluminium to show through; where the lines are thinnest –around the beam waist – the plate appears darker. This dark area is used to "see" the focus (see Figure 348).

TT-006-02 – Pre-requisites

1. **Machine software and firmware:**
    - MSS 1.6 or newer.
    - Quad controller (Renishaw part no. A-6170-0012-04 or newer).
    - The user will need the following RenAMP logins:
        - Technician: for optical test access.
        - Service: for optical test and calibration access.
2. **Machine optical state:**
    - The machine should be in a good state of optical commissioning having a valid power map. Tasks "TT-005 – Laser power measurement test" and "ST-001 – Laser power recalibration" can be used to verify this.
3. **Equipment required:**

Part number	Part name / description
M-6813-0011	Customer ML commissioning plate – part of the OSV kit (Renishaw part no. A-6813-0001) or power and focus kit (Renishaw part no. A-6813-0002).
M-6521-0600	Marking plate kit, pack of 8 (Renishaw part no. A-6813-2003) – also part of the OSV kit (Renishaw part no. A-6813-0001) or power and focus kit (Renishaw part no. A-6813-0002).

TT-006-03 – Pass/fail criteria

The RenAM 500 series laser focus process is not sensitive to small focus errors. For the process to be within specification, the following criteria must be met:

Specification	Limit
Maximum Global Focus Offset (GFO) – the variation in the centre of the build area (see position 5 on Figure 349)	≤ ±4 mm (0.15 in)
Variation of residual error across nine positions around the build area – the maximum offset seen, minus the minimum offset (see Figure 349)	≤ 2 mm (0.07 in)

TT-006-04 – Machine preparation and hardware set-up

This section details the set-up required to perform the focus checks.

1. Log in to the machine with Technician level credentials.

   WARNING: The focus test is a measurement process and should not be run if the heater or chamber temperature is above 30 °C (86 °F).

2. Check the chamber/heater plate temperature of the machine is below 30 °C (86 °F). If it is not, wait until it is to continue the set-up. The temperatures can be found on the left-hand side of the RenAMP “Home” screen (see Figure 338).

   NOTE: If the set-up is continued while the temperature is higher than this, then the commissioning plate and the marking plate may absorb excess heat and give poor results during measurement.

3. Clean the chamber thoroughly, including the gas inlet and outlet, removing all residual powder (see task “PB-005 – Build chamber – Clean”. There is a risk that powder will be blown onto the equipment if this is not done.

4. While cleaning the chamber, also ensure the recoater blade is clean and free from powder.

   a. Use steps 4 to 5 of task “PB-003 – Build chamber metal powder – Remove” to remove the recoater assembly and clean it using the ATEX vacuum cleaner.

   b. Use Class 3 IPA and a disposable cloth to wipe down the recoater blade as described in step 8 of task “PB-005 – Build chamber – Clean”.

   c. Follow steps 5 to 6 of task “AB-010 – Recoater assembly – Install” to re-attach the recoater assembly.

5. Mount the customer commissioning plate (Renishaw part no. M-6813-0011) onto the heater top plate as with a standard build plate and secure it using the four M5 bolts as shown in Figure 336. Ensure that the engraved “FRONT” is at the front of the chamber.

   WARNING: Follow local procedure for handling of build substrates when handling the commissioning plate.

6. Place a marking plate (Renishaw part no. M-6521-0600), contained in the marking plate kit and the optical test kit, into the recess of the customer commissioning plate so that it sits level with the top face.



Figure 336 Customer commissioning plate

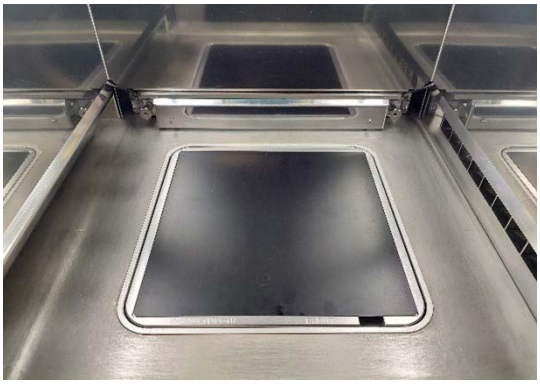


Figure 337 Marking plate on the commissioning plate

7. Close the chamber door.

8. From the Home screen, select Optical Tests (circled in Figure 338 below). This will take the user to the Optical Tests page (Figure 339).

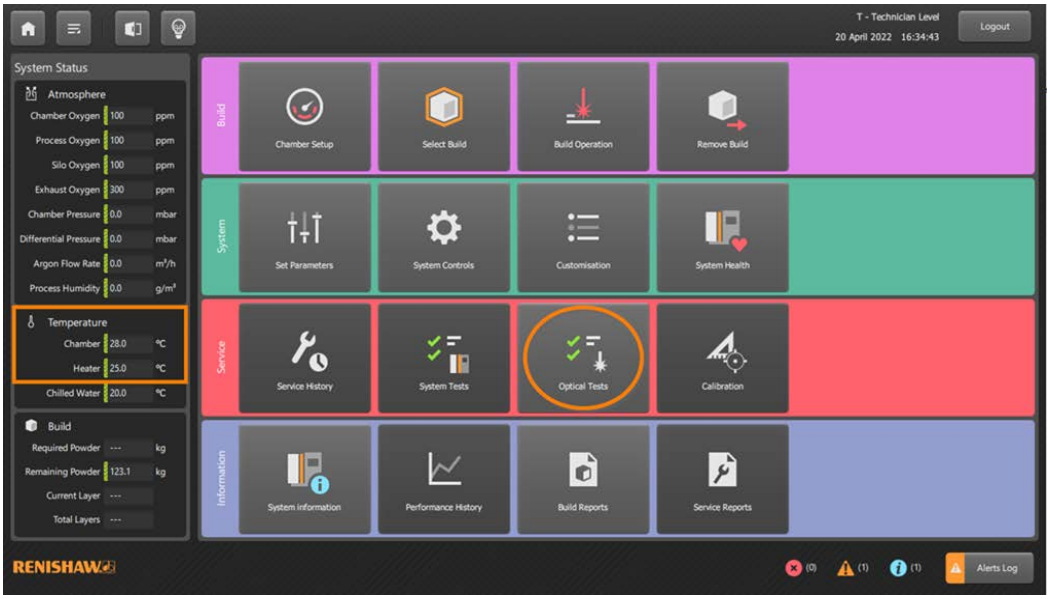


Figure 338 RenAMP Optical Tests page selection

9. Go to the Focus test page by clicking the Focus button (circled in Figure 339). The Controls section (highlighted) is used for elevator and recoater movements and for preparing the chamber for the test.

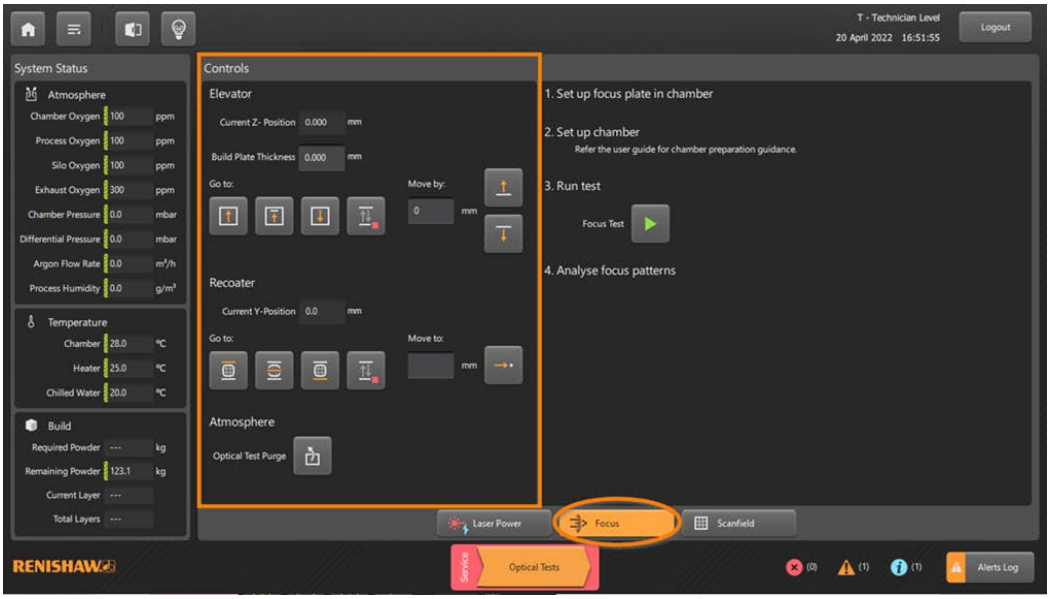


Figure 339 RenAMP Focus test page selection

10. Lower the elevator by 16 mm (0.62 in) from top position, using the Elevator Move by controls.



Figure 340 Optical Test Elevator controls

11. Move the recoater to the centre position using the RenAMP Recoater Centre button.

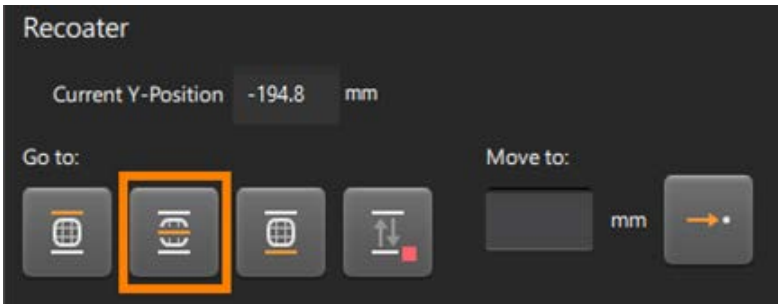


Figure 341 Optical Test Recoater controls – Centre button highlighted

The top surface of the marking plate should now be at the approximate height of the recoater.

WARNING: When moving the elevator up, care must be taken to not crash the elevator into the recoater. If this is done, the recoater may need recalibration or repairing by Renishaw Service.

12. Raise the elevator in 0.1 mm (0.003 in) increments using the RenAMP elevator Move by controls, so the recoater and anodised marking plate are just touching. The chamber door must be closed to make these movements.

    a. Open the chamber door between moves to check the position.

    b. Move/slide the marking plate laterally back and forth in its commissioning plate pocket.

    c. When the recoater and marking plate are just touching, resistance will be felt when trying to move it.

    d. Be careful to ensure the commissioning and marking plate do not crash into the recoater.

    e. At this point do not move the plate further up.

13. Edit the Build Plate Thickness and make it equal to the Current Z-Position, ensuring the Build Plate Thickness is a positive number. See Figure 342.

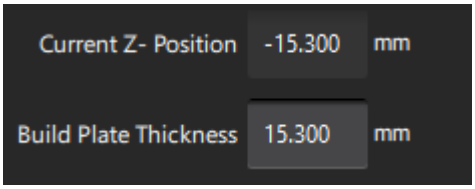


Figure 342 Example Build Plate Thickness equal to the current Z-position

This will prevent the heater plate accidentally being moved up into the recoater.

14. If the door is open, close it.

15. Lower the elevator by 2 mm (0.07 in) using the elevator Move by controls. This is to ensure the recoater is clear of the plates before moving it.

WARNING: When moving the recoater, it is advised to move the elevator down by 2 mm (0.07 in) prior to the recoater move, to avoid collision. The elevator can then be raised by 2 mm (0.07 in) again after movement.

16. Move the recoater to the back position using the RenAMP recoater Back button.

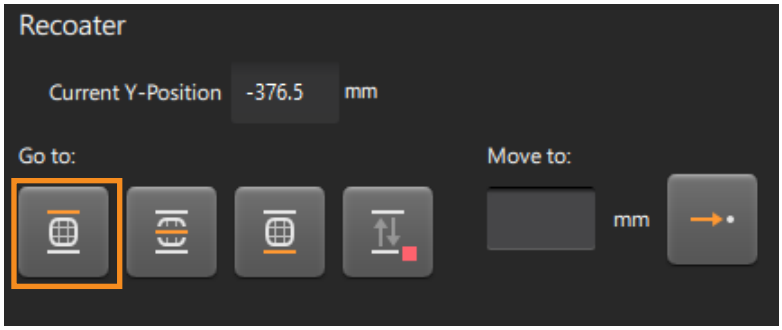


Figure 343 Optical Test Recoater controls – Back button highlighted

17. Raise the elevator by 2 mm (0.07 in), using the elevator Move by controls.

18. Check there is no powder or contamination on the marking plate. If there is, open the door and clean the top surface of the plate using a lint-free cloth and IPA, then reclose the door.

19. Reset the machine, if needed, by clicking the blue Reset button.

20. Click the Optical Test Purge button as seen in Figure 344. Optical test processes, like part builds, can only be run in an inert atmosphere. Purging will take approximately 20 minutes.

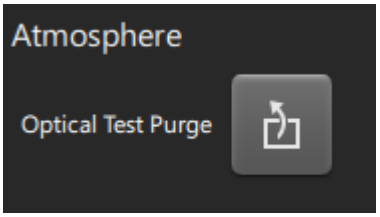


Figure 344 Optical Test Purge button

21. While purging, the Optical Test button will appear as shown in Figure 345.

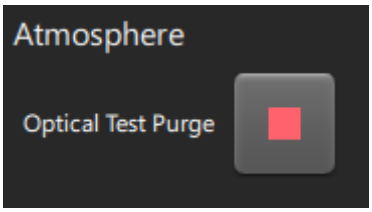


Figure 345 Optical Test Purge button while purging

The mechanical set-up is now complete and the focus marking plate is installed in the machine, ready to start the measurement test.

TT-006-05 – Focus measurement test

The focus test can only be completed once the chamber is purged with argon. To run the measurement test, the following procedure should be followed:

1. Ensure the machine has finished purging – the chamber/process oxygen levels will be below 10 000 ppm (this can be checked from the System Status tab as shown in Figure 338) and the Optical Test Purge button will once again appear as shown in Figure 344.

2. Select the Run Focus Test button, as shown in Figure 346, to fire the focus optical test.

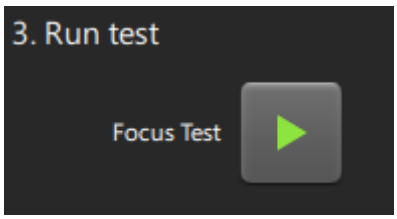


Figure 346 Run Focus Test button

While the test is running, a Stop button will be displayed instead of a Play button, as shown in Figure 347. If for any reason the user needs to stop the test, push this button or the E-Stop.

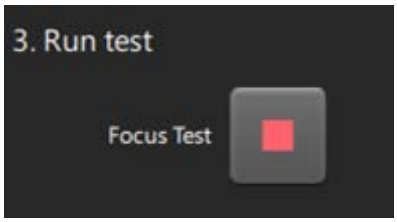


Figure 347 Stop Focus Test button

3. When the Stop button changes back to a Play button, this indicates that the test has finished. An alert appears stating “Focus Test Complete”.

   NOTE: If a message ‘User Action Request Failed’ appears, then check the machine is in a reset and inert state. If this error persists, request help from Renishaw Service.

   On completion, the marking plate should appear as shown in Figure 348.

   WARNING: There may be smoke or debris visible in the chamber. Allow this to clear before opening the door. Otherwise, a mask or respirator is recommended when removing the plate. For more information, see section 3.4.8, “Personal protective equipment (PPE)”.

4. Open the chamber door.

   WARNING: Before handling tooling after running a test, be aware that it may be hot – under normal operation it should not be.

5. Remove the plate for analysis.

   NOTE: Wear nitrile gloves when removing equipment to prevent contact with residual powder or debris. Clean the marking plate before inspection.

TT-006-06 – Analysis of focus plate

1. After firing the focus test, the marked plate should appear similar to the example shown in Figure 348. The number notation in the centre of the plate aids with plate orientation, and helps the user to identify which mark is made by which laser. The laser assignment for the patterns across the test plate is shown in Figure 349.

   The centre marks to the side of the arrays (circled for Laser 4) show where the ‘0’ focus position should be. This user wants the thinnest line in the array (or the centre of the dark patch) to be in line with this point.

   NOTE: For a RenAM 500S machine, all laser markings will be made by Laser 4, while for a RenAM 500D machine, the markings will be made by Lasers 1 and 4.

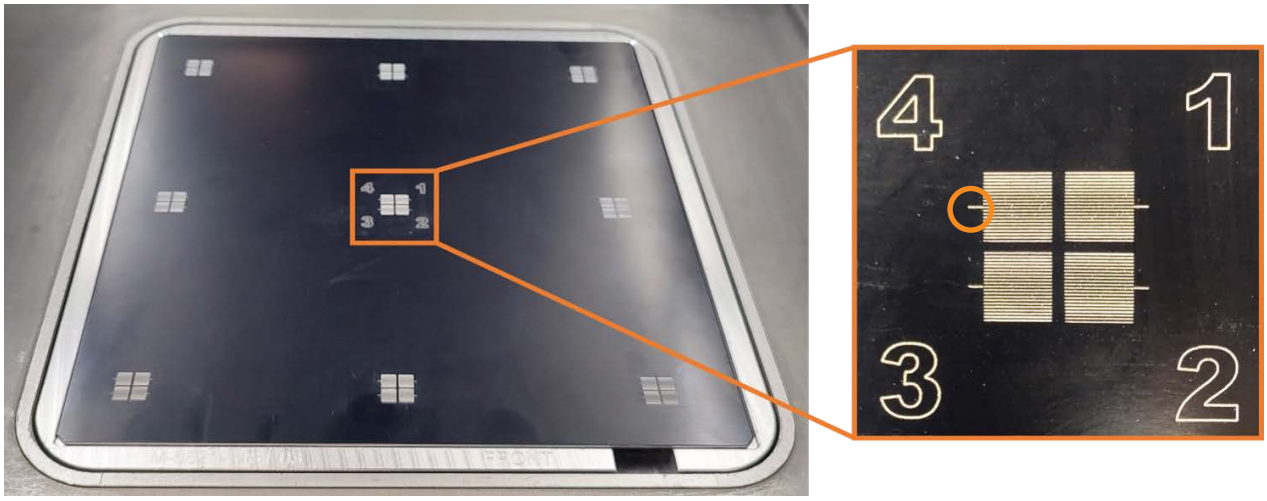


Figure 348 Marking plate after firing a focus test

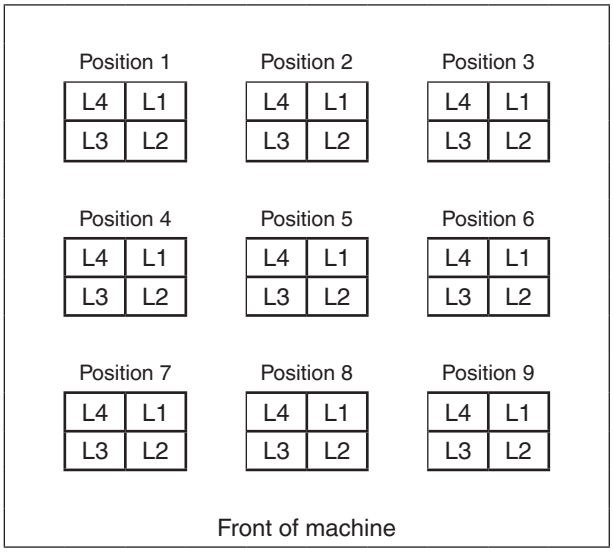


Figure 349 Laser assignment and marking positions

2. Considering the markings made by each laser separately, visually assess the fringe pattern in only the centre of the exposure plate (Position 5 in Figure 349) to determine if a focus offset needs to be applied to the Global Focus Offset (GFO).

   - Determine the direction of focus offsets, using the central side marking and Table 5.
   - Determine the magnitude of any focus offsets by checking which line is in the centre of the dark area and counting how far from nominal centre this is (one line represents 1 mm (0.03 in) in Z).

Pattern seen	Plate shows dark area	Correction required
	Forward of centre	Negative
	Behind centre	Positive
	Centred	Zero

Table 5 Guide to interpreting direction of focus offset

3. Take a note of the focus offset value, if any is seen, for each laser.

   An example offset of 2 mm (0.07 in) behind centre can be seen on Laser 2 in Figure 348. This would require an offset of +2 mm (0.07 in) to correct it.

   If any marking indicates a GFO of more than ±4 mm, contact Renishaw Service for advice on how to continue. This is an unlikely occurrence, but may point towards an issue in the optical system, if found. The current GFO for each laser can be seen while creating a measurement file or viewing the drop-down box on the active calibration file. This requires Service level access and is explained further in task “ST-002 – Laser focus recalibration”.

NOTE: It is up to the user to interpret the patterns using the guide above and record the focus offsets.

4. Now consider the rest of the patterns for each laser around the plate, determining the maximum and minimum for the laser in question. If the variation is more than 2 mm (0.07 in), contact Renishaw Service for advice on how to continue. This is an unlikely occurrence, but may point towards an issue in the optical system, if found.

5. If no offset is required in step 3 or 4, the laser focus has been verified as within specification. In this case, proceed to task “TT-006-07 – Removal of test equipment”. Otherwise continue.

6. If the measurement requires an offset resulting in a GFO of ≤ ±4 mm (0.15 in), a measurement file will need to be created. Proceed to task “ST-002 – Laser focus recalibration”.

TT-006-07 – Removal of test equipment

This section documents how to remove the test equipment from the machine.

1. Navigate back to the Focus Optical Test page.

2. Check the recoater is at its back position and ensure the commissioning plate and elevator are safe to move up.

3. Ensure the chamber door is closed.

4. Move the elevator to its top position using the Elevator Go to: Top button.



Figure 350 Elevator Go to: Top button

5. Open the chamber door.

6. Unbolt the four M5 bolts securing the customer commissioning plate.

7. Remove the commissioning plate from the chamber.

   WARNING: Follow local procedure for handling of build substrates when handling the commissioning plate.

8. Clean the plate with IPA if there is any residual powder or debris on it.

9. Return the plate to its packaging.

TT-006-08 – Next steps

Focus testing is complete; the machine is known to have focus calibration within specification. The user has a choice as to how to continue:

- Continue with the next optical test (see task “TT-007 – Laser scanfield measurement test”).
- Finish optical testing here and continue using the machine for normal operation.

8.6.4 ST-002 – Laser focus recalibration

ST-002-01 – Recalibration process

This section documents how to apply a change to the focus calibration.

1. To create and apply a focus measurement file, the user must be a trained Service level user. If not already logged in at Service level, log out and log in again at Service level.

   NOTE: If not a Service level user, contact a Service level user to continue.

2. Move to the Calibration tab, using the button at the bottom of the screen as shown in Figure 351.



Figure 351 Optical Tests page to Calibration page

3. To create a new measurement file containing focus offsets for the lasers requiring alteration, click the '+' button on the Measurement page as shown in Figure 352.

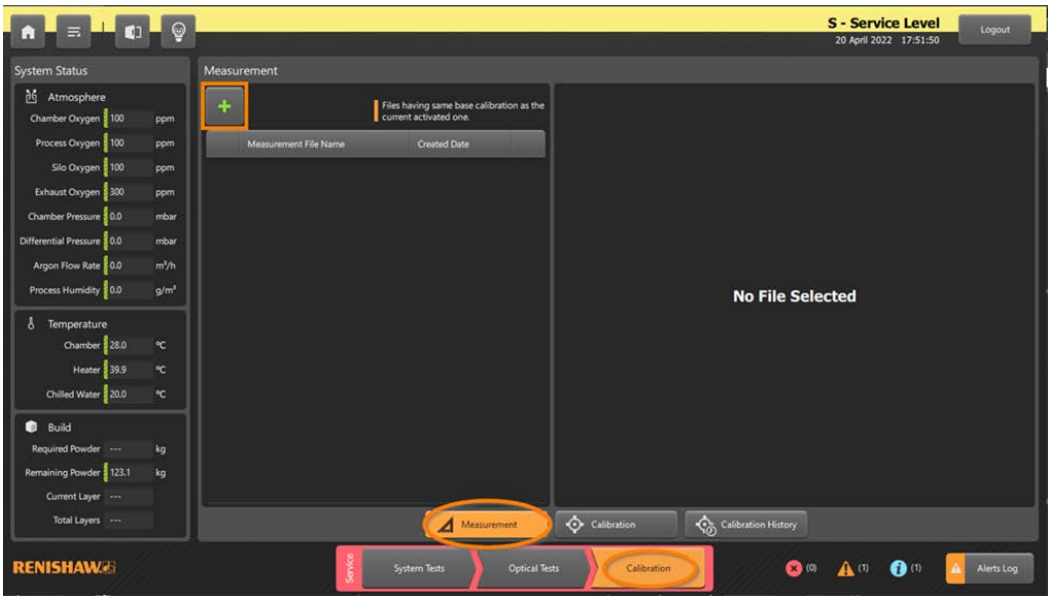


Figure 352 Calibration page, Measurement tab

This will open the Measurement creation tab on the Power tab.

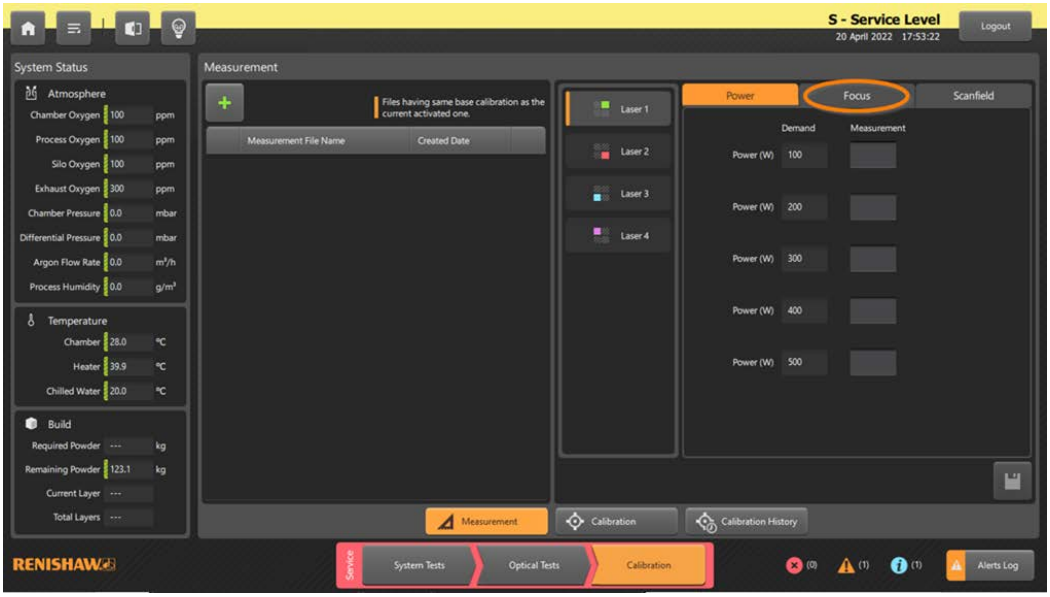


Figure 353 Calibration page, Measurement Creation Power tab

4. Click the Focus tab as shown in Figure 353 to change from the Power tab as seen in Figure 354.

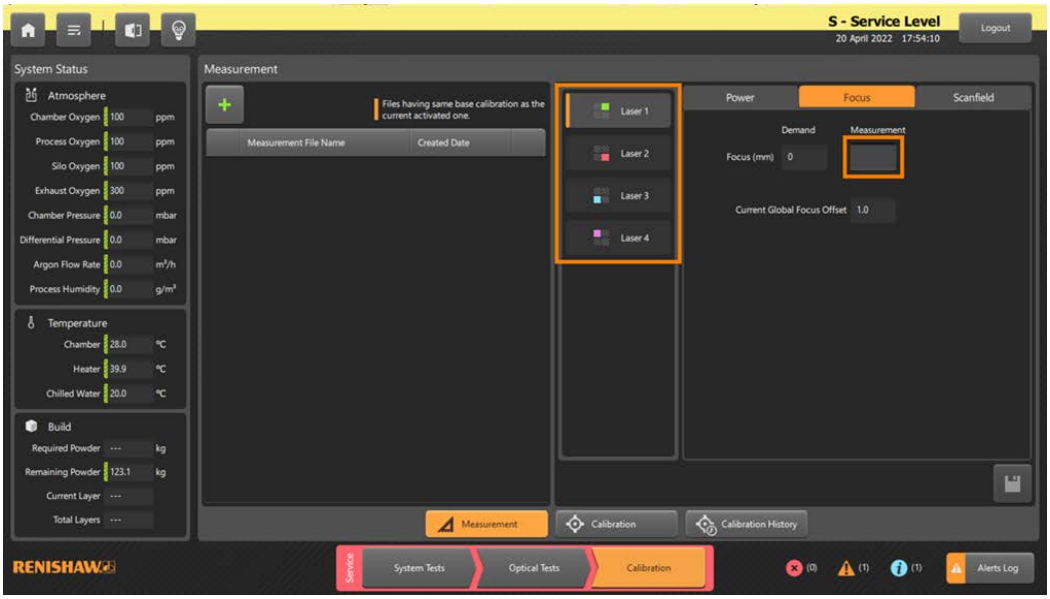


Figure 354 Calibration page, Measurement Creation Focus tab

5. Navigate to the laser that needs updating and enter the offset required in the Measurement box. The sign required is given in Table 1. The read-only Demand field indicates that zero is the nominal focus position on the bed for each laser, as the user is aiming to have the laser's minimum focus width positioned on the powder plane.

The Current Global Focus Offset indicates the total offset for each laser from the nominal position and can be viewed on this screen.

NOTE: RenAMP will not allow a GFO of more than ±4 mm (0.15 in) (see Figure 355). If any marking indicates a GFO of more than ±4 mm (0.15 in), contact Renishaw Service for advice on how to continue.

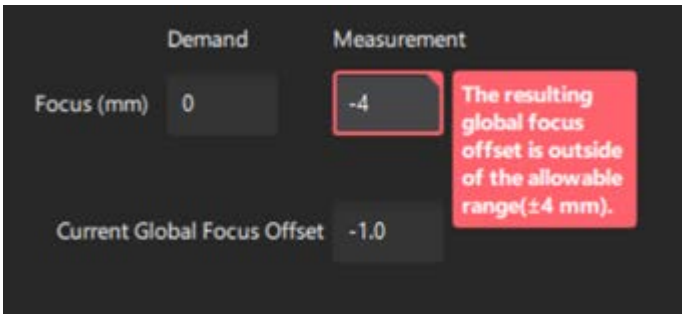


Figure 355 Global Focus Offset (GFO) allowable range error message

6. If multiple lasers need an offset adjustment, repeat step 5 until all lasers have been set.

7. Click the Save button (see Figure 356) in the bottom right of the screen to create a measurement file.

NOTE: The Save button will be enabled if the adjustments are valid, otherwise the button is disabled.



Figure 356 Enabled Save button

8. The Save File dialog box will appear. The user can change the File Name and Description, if required, by clicking in the boxes using the on-screen keyboard that pops up on HMI. Special characters /, \, “, :, *, ?, <, >, | in the file name should be avoided. The default name format is “Measurement_Date_Time”. It is recommended to add the measurement type, for example “Focus”, to the name.

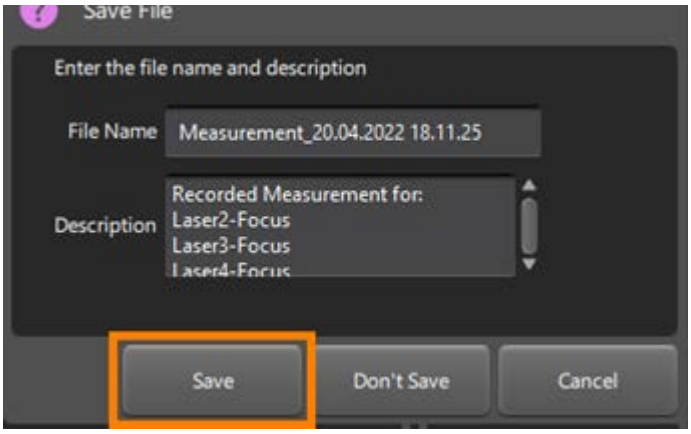


Figure 357 Save File dialog box

9. To continue, click the Save button as shown in Figure 357.

   This will create the new measurement file and is easily identifiable using the File Name and/or Created Date Columns (highlighted in Figure 358).

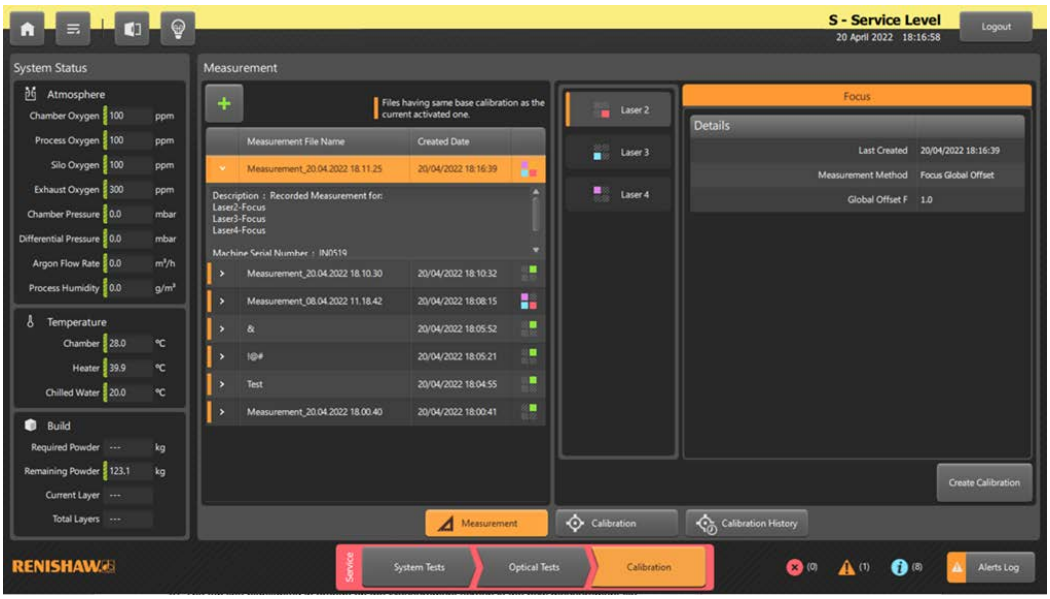


Figure 358 Measurement page with newly created measurement file

NOTE: The coloured boxes next to the measurement file indicate which lasers have a change to their calibration state.

An information pop-up will tell the user the file was created; this can also be viewed in the alert log.

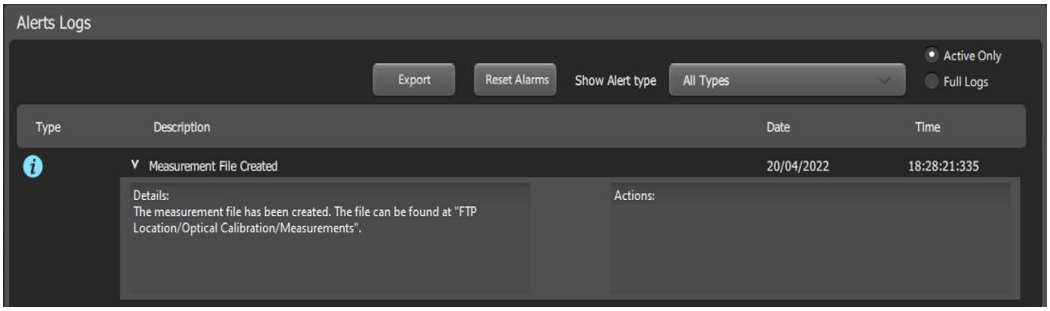


Figure 359 Alert log – measurement file created

10. The top line highlighted in orange on the Measurement screen is the new measurement file created as shown in Figure 360. If the new measurement file is not highlighted in orange, select it and then click the Create Calibration button at the bottom right, highlighted by the orange box, to create a calibration file.

NOTE: It is important to ensure the correct measurement file is selected to make the correct calibration file.

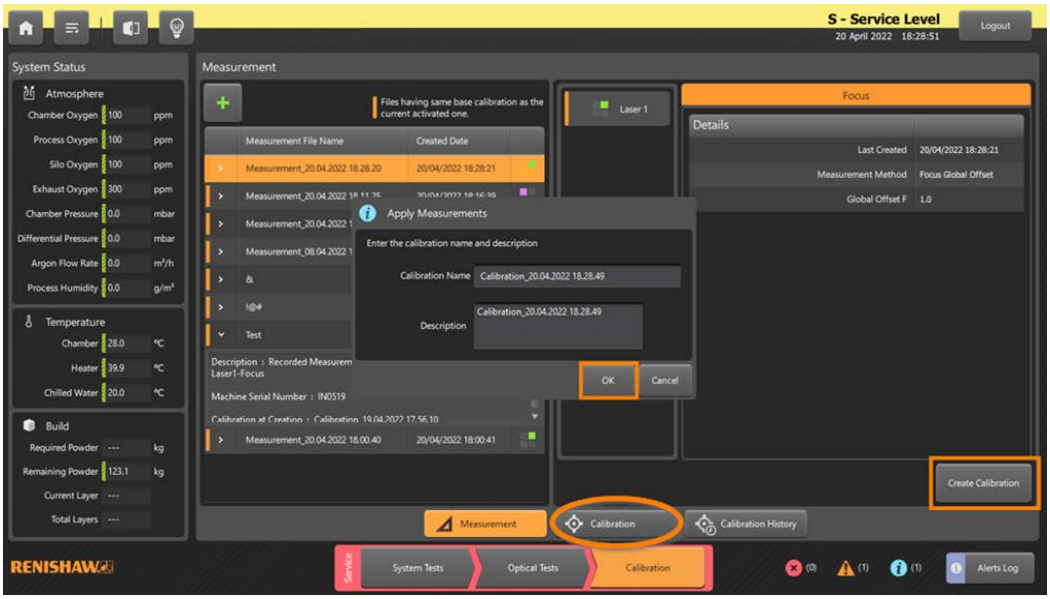


Figure 360 Measurement page Create calibration Apply Measurements dialog box

11. The Apply Measurements dialog box will appear. The user can change the Calibration Name and Description, if required, by clicking in the boxes using the on-screen keyboard that pops up on HMI. Special characters /, \, “, :, *, ?, <, >, | in the Calibration name should be avoided. The default name format is “Calibration_Date_Time”. It is recommended to add the calibration type, for example “Focus”, to the name.

12. Click the OK button as shown in Figure 360 to complete the calibration creation.

    An information pop-up will appear stating “New Calibration State Created”. As with the creation of a measurement file, this can also be viewed in the alert log.

13. Move to the Calibration screen by clicking the button at the middle of the screen highlighted by the orange circle in Figure 360.

14. The line highlighted in dull orange with the orange bar at its left end is the current machine calibration.

    The top line of the table is the most recently created calibration file – the calibration containing the user's new focus offsets. To make this calibration the active calibration, click it to highlight it orange and then click the Activate button, indicated by the orange rectangle below.

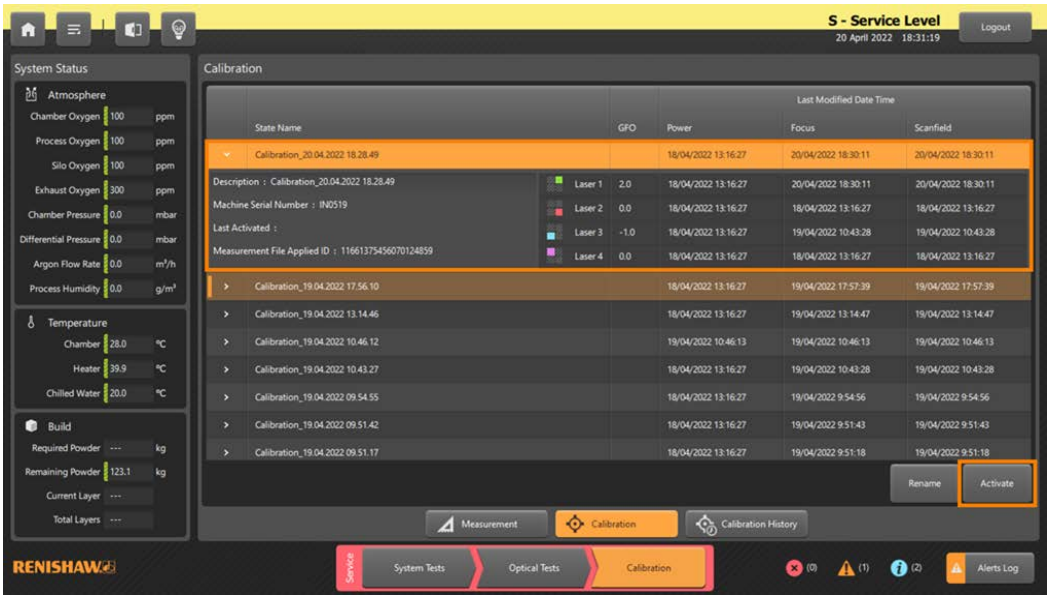


Figure 361 Calibration screen

15. The user will be prompted to accept or reject the changes to the calibration by clicking Yes or No. Click Yes to active it.

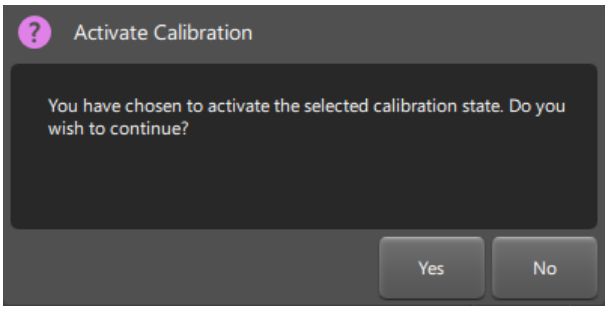


Figure 362 Activate Calibration pop-up

16. The new calibration is now active as shown in Figure 363. This is indicated by the change in the line that is highlighted in dull orange. It can also be seen in an information pop-up in the bottom right of the screen initially after application, or this alert can be checked in the alerts log in the bottom right.

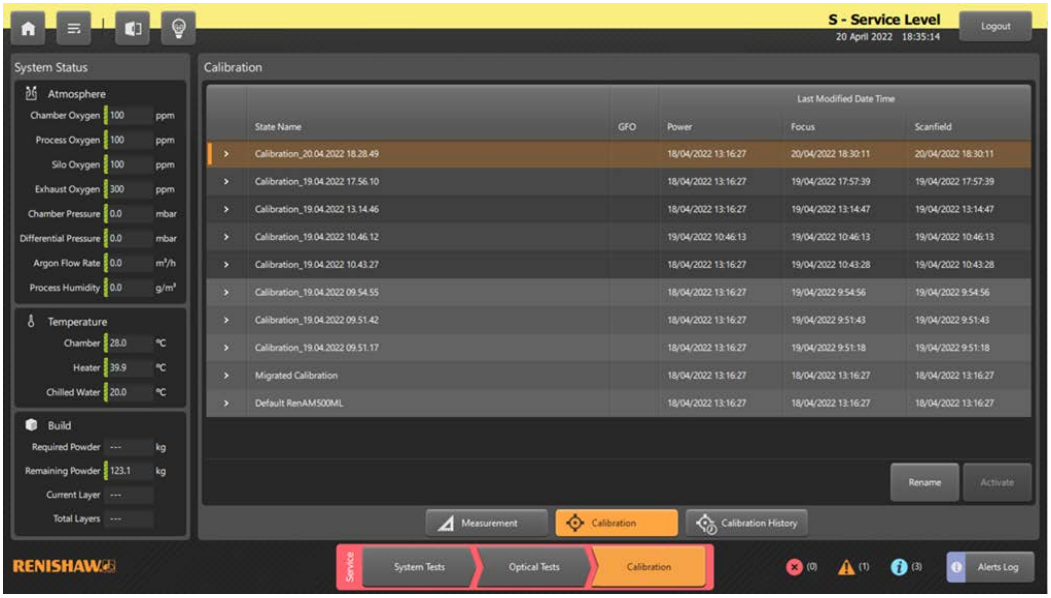


Figure 363 New active calibration

17. To check the calibration is now within specification, re-run the focus test. To do this, put a new marking plate into the machine, close the door and purge the chamber. Then re-start the procedure from task “TT-006-05 – Focus measurement test”. If the user has applied the right correction, the focal position for all lasers should be in the centre of the marked pattern. If it is still incorrect, another change can be applied or Renishaw Service can be contacted for support.

8.6.5 TT-007 – Laser scanfield measurement test

TT-007-01 – Overview

WARNING: It is not recommended to perform an optical test when the chamber or heater temperature exceeds 30 °C (86 °F. This may affect test results, damage the test equipment, or cause injury to the operator.

The sphere array process is designed to verify the X,Y positional accuracy of the laser(s) in the RenAM 500 series and can be used to recalibrate the system, if required.

The sphere array process replaces the Mylar process for machine scanfield which was performed by Renishaw Service during the optical commissioning procedure. The sphere array is made up of 169 metal spheres, placed at a pitch of 19.5 mm (0.76 in).

This task will focus on testing positional accuracy and calibrating a machine's X,Y positional error.

CAUTION: It should be noted that the build plane in the AM system is dictated by the recoater blade. If the recoater assembly or blade is changed, the build plane may change. To accommodate for this, the scanfield may need updating.

TT-007-02 – Pre-requisites

1. **Machine software and firmware:**
    - The machine should have been upgraded to MSS 1.6 or newer.
        - This must include the required "Laser back reflection" AMPM channels for analysis.
    - The machine should have been upgraded to a quad controller (Renishaw part no. A-6170-0012-04 or newer).
    - The user will need the following RenAMP logins:
        - Technician: for optical test access
        - Service: for optical test and calibration access

2. Machine hardware:

- Heater top plate assembly Z-axis (Renishaw part no. A-6521-2131-04 or newer), with the kinematic grooves as shown in Figure 364.

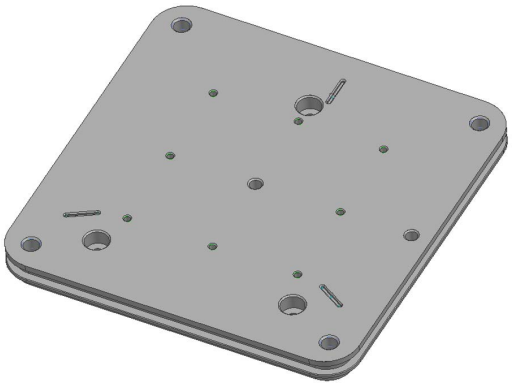


Figure 364 Top plate

3. Machine optical state:

- The machine should be in a good state of optical commissioning:
  - Valid power map
  - Valid focus calibration
  - X,Y position should have been previously calibrated by a Renishaw engineer, otherwise the mtt files used may not hit the metal spheres. If the scanfield is out of specification, this can be noticed during the focus test – the patterns for each laser will not be a set distance apart compared to the others.

CAUTION: Firing onto the metal spheres with a laser that is not in power or focus specification can result in irreversible damage to the spheres. Sufficient damage will render the sphere array plate unusable.

4. Equipment required

Part number	Part name / description
A-6780-0032	19.5 mm (0.76 in) pitch 12 mm (0.47 in) calibration artefact (sphere array plate) – part of the OSV kit (Renishaw part no. A-6813-0001)
–	CMM file – see “Putting an artefact serial no. CMM file onto a machine” for further details
P-TL04-0045	100 µm feeler gauge – part of the OSV kit (Renishaw part no. A-6813-0001)
–	2 mm (0.07 in) hexagon key set (for adjusting sphere array plate flatness)

NOTES:

The artefact must not be stored in a hot environment. Check task “TT-007-04 – Machine preparation and hardware set-up” for further details.

The artefact must be stored in its case when not in use for its protection.

The plate should be handled carefully and should not be dropped, as it may result in human injury. It is also highly likely that the metrology of the plate will change, resulting in poor calibration results.

The spheres on the artefact must be cleaned before use. Check task “TT-007-04 – Machine preparation and hardware set-up” for further details.

The sphere array artefact (Renishaw part no. A-6813-0004) is supplied with a UKAS calibration certificate which confirms that the accompanying CMM file is a true representation of the physical geometry at the time of initial supply.

The calibration state of the sphere array should remain valid so long as the geometry of the artefact remains unchanged. Depending on usage of the artefact it is recommended that users request recalibration of their sphere array every 12 to 18 months. Recalibration includes inspection and repair, re-measuring of the artefact (UKAS accredited CMM), and on-machine functional test. Sphere array recalibration ensures that the RenAM 500 machine laser position can be accurately calibrated using a traceable, certified artefact.

To request recalibration of the sphere array artefact please contact your local Renishaw customer service centre. Recalibration can take up to 8 weeks; if you require access to a sphere array plate during this time it is recommended to purchase another sphere array artefact.

5. Test definition files and mtt files

Test definitions are used in the scanfield process to allow different test parameters to be used. The test definition contains all the parameters associated with the test. This includes the laser scanning strategy in the form of an mtt file which is called into use during the procedure.

Only one mtt is required for the scanfield process. The test definition files are automatically updated based on the number of lasers installed on the machines. The mtt fires a 1 mm (0.03 in) fine resolution patch over all 169 metal spheres in both X and Y directions.

The mtt files have one layer and are 35 W, defocused 5 mm below the bed (+5 mm (0.19 in) in Renishaw QuantAM notation). Figure 365 shows the laser strategy of the multi-laser mtt files.

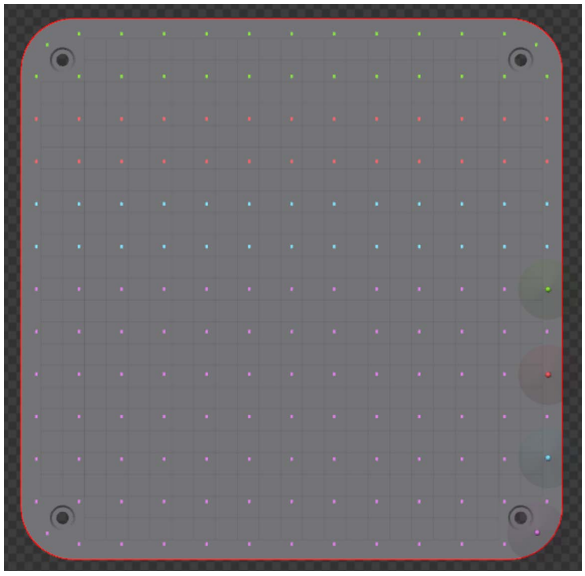


Figure 365 QuantAM screenshot of the multi-laser mtt. Each sphere is scanned by all four lasers, in both horizontal and vertical directions.

The correct test definitions and mtt files will be on each machine variant by default, depending to the MSS version.

TT-007-03 – Pass/fail criteria

For the scanfield test to achieve a pass, the results for each sphere scan must be within a radial tolerance of the sphere's known position. The two tolerances used in the test are the radial root mean square (RMS) error and the radial maximum error. These criteria can be found in the results table displayed in RenAMP on the Scanfield page within the Optical Tests section. Refer to task "TT-007-04 – Machine preparation and hardware set-up" for instructions on how to access this page.

TT-007-04 – Machine preparation and hardware set-up

The hardware set-up for the sphere array scanfield involves adjusting the flatness of the plate so that it matches the recoater (wiper) blade plane. To do this, the top of the fixed pins (marked by the orange circles in Figure 366) are aligned to the bottom of the recoater blade by modifying the Z-axis height and using the adjuster screws (marked by the blue circles). The more accurately this step is done, the better the scanfield will be. This section details the set-up required.

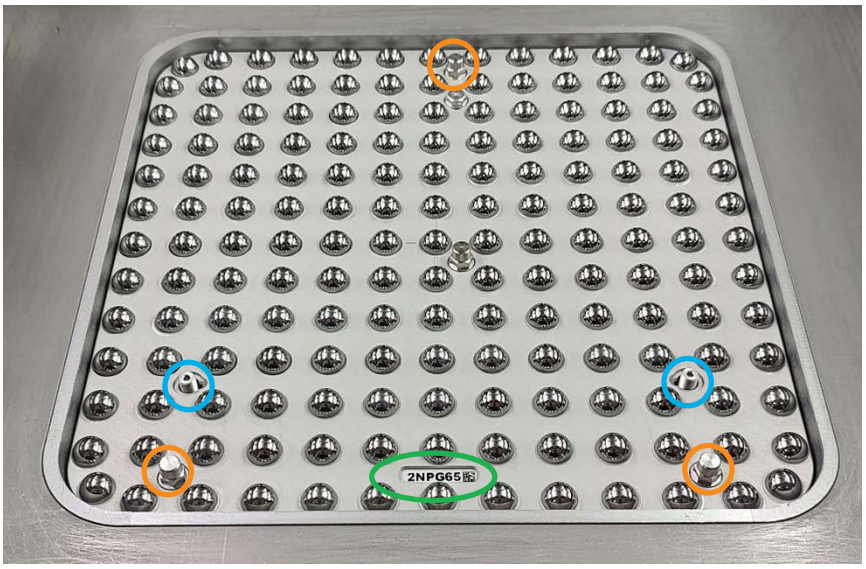


Figure 366 Sphere array with fixed pins, adjuster screws and serial number locations marked

WARNING: Firing onto the metal spheres when not set up correctly in Z can result in irreversible damage to the spheres.

1. Login to RenAMP using Technician level credentials.

   CAUTION: The sphere array plate is a calibrated artefact with a CMM file taken at approximately 20.5 °C (68.9 °F). This measurement process should not be run if the chamber/heater plate temperature is above 30 °C (86 °F). Ideally, it should be run as close to 20.5 °C (68.9 °F) as possible.

2. Check the chamber / heater plate temperature of the machine is below 30 °C (86 °F). If it is not, wait until it is to continue the set-up. If the set-up is continued while the temperature is above this, the sphere array plate may absorb excess heat and give poor results during measurement. The temperatures can be found on the left-hand side of any RenAMP screen and can be seen highlighted in Figure 367.

3. Navigate to the Optical Test page.

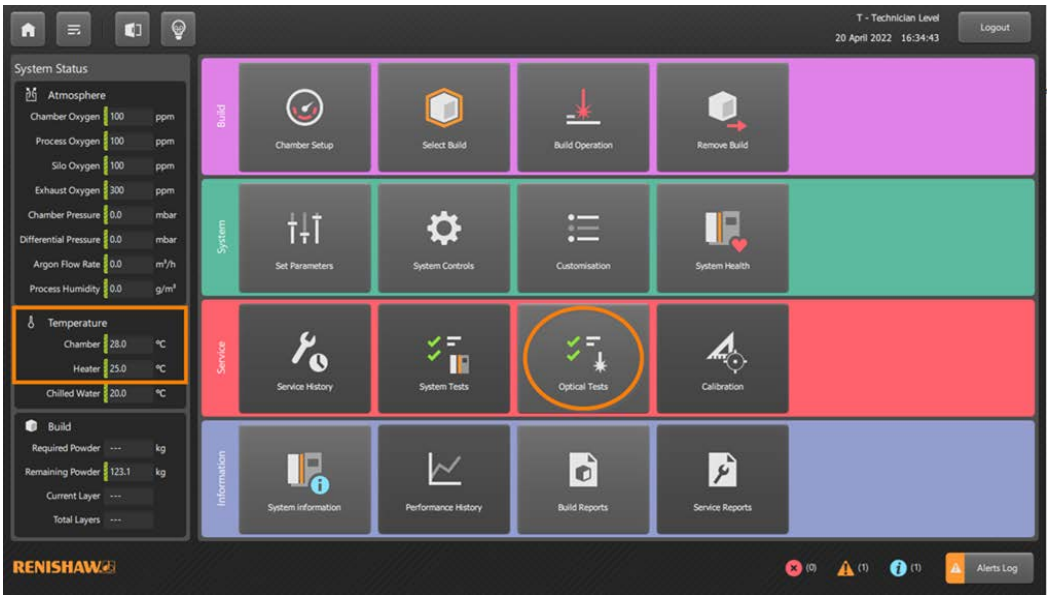


Figure 367 RenAMP Optical Test page selection

4. Navigate to the Scanfield Test page:

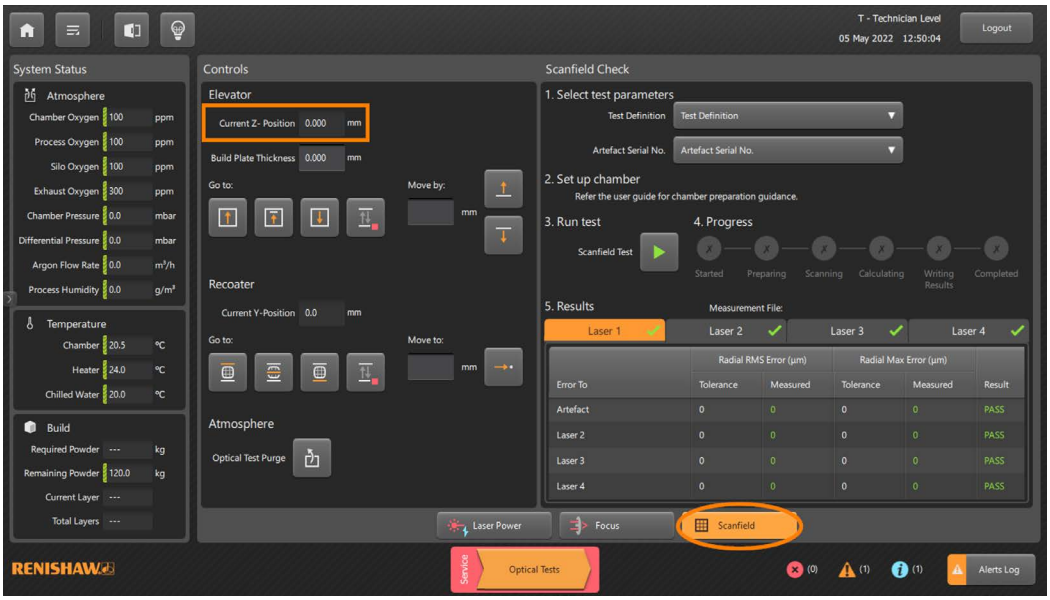


Figure 368 RenAMP Scanfield Test page selection

5. Clean the chamber thoroughly, including the gas inlet and outlet – removing all residual powder – as described in task “PB-005 – Build chamber – Clean” . There is a risk that powder will be blown onto the equipment if this is not done.

   If any powder gets onto the spheres, they may get damaged and report a bad signal when the laser fires over them.

6. While cleaning the chamber, also ensure the recoater blade is clean and free from powder.

a. Follow steps 4 to 5 of task “PB-003 – Build chamber metal powder – Remove” to remove the recoater assembly and clean it using the ATEX vacuum cleaner.

b. Use Class 3 IPA and a disposable cloth to wipe down the recoater blade as described in step 8 of task “PB-005 – Build chamber – Clean”.

c. Follow steps 5 to 6 of task “AB-010 – Recoater assembly – Install” to re-attach the recoater assembly.

7. With a clean chamber, install the sphere array plate (Renishaw part no. A-6780-0032) into the build volume, so that it sits in the kinematic grooves on the top of the heater plate.

8. Close the chamber door.

CAUTION: Care should be taken moving the elevator. Driving the elevator into the recoater will damage the recoater.

9. Lower the Z axis by 30.5 mm (1.20 in), using the Elevator Move by controls so that the top of the sphere array plate pins are below the recoater level (the pins should be approximately 2 mm to 3 mm (0.078 in to 0.11 in) below the recoater plane). Check this visually.

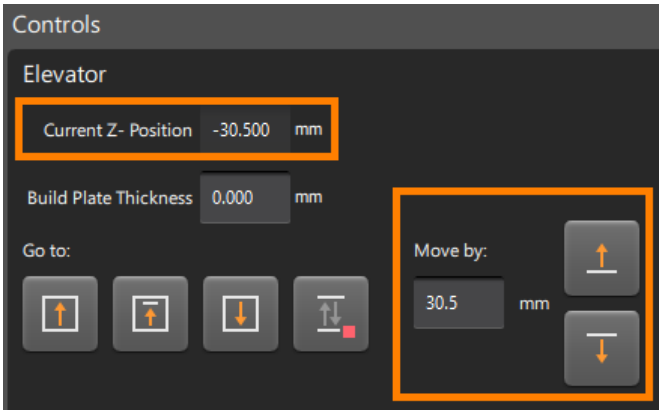


Figure 369 Optical Test elevator controls

10. Move the recoater to –283 mm (11.14 in), using the RenAMP recoater Move to controls – this is the location of the rear pin on the plate.

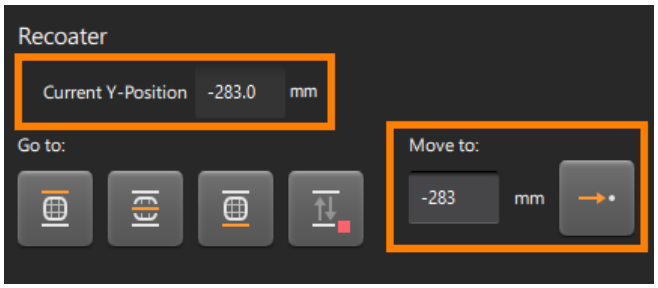


Figure 370 Optical Test Recoater controls

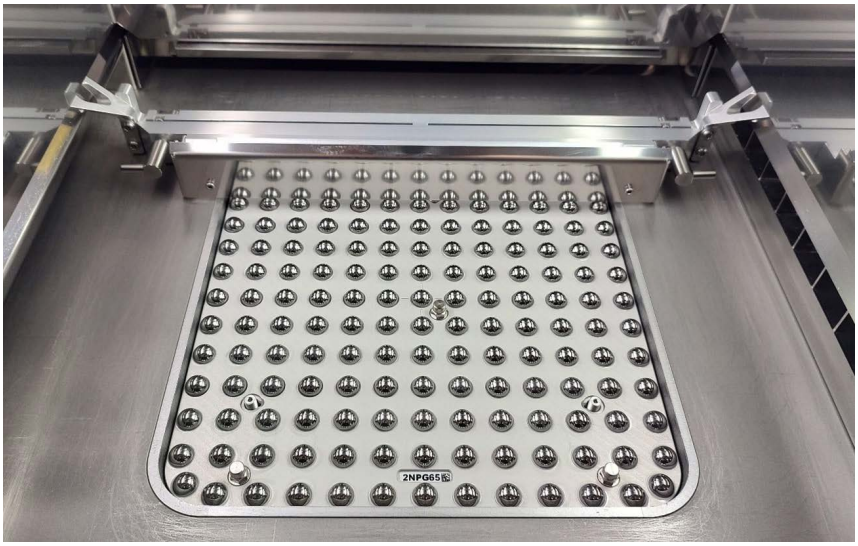


Figure 371 Recoater position set above the rear pin

CAUTION: Care must be taken when moving the elevator up to not crash the plate into the recoater. If this is done, the recoater may need recalibration or repairing by Renishaw Service.

11. Raise the elevator incrementally so that the recoater and a pin are almost touching, using the RenAMP Elevator Move by controls. The chamber door must be open and closed between elevator moves. The user must be careful to ensure the plate or plate pins do not crash into the recoater.

    When the door is closed, move the elevator up by 0.1 mm (0.003 in) steps so as not to crash the pin into the recoater. Use 100 µm and 150 µm feeler gauges as a go-nogo gauge until you are satisfied the pins are approximately 100 µm (0.1 mm (0.003 in)) away from the recoater.



Figure 372 RenAMP Elevator Move by controls

    The recoater calibration position is not necessarily the same on all machines; it may be necessary to move the recoater forwards or backwards so the recoater is in the middle of the pin, using the Move to controls. If this is being done, make sure the recoater and pin are not touching.

12. If the door is open, close it.

13. Lower the elevator by 2 mm (0.07 in), using the Elevator Move by controls. This is to ensure the recoater is clear of the pins before moving it.

    CAUTION: Whenever moving the recoater over the spheres, it is advised to move the elevator down by 2 mm prior to the recoater move, to avoid collision. The elevator can then be raised by 2 mm (0.07 in) again.

14. Move the recoater forward to –68.5 mm (the pitch between the front and back pins) using the RenAMP Recoater Move by controls. If the recoater position for the back pin was found to not be –283 mm (–11.14 in), this position will be incorrect. Take the back recoater position and add 214.5 mm (8.44 in) to it (this is the pitch between the front and back pins on the sphere array plate).

15. If this is the first use of the plate, ensure the front of the plate is lower than the rear of the plate by turning the sphere array plate adjuster screws anticlockwise. If it is not, the plate should be sufficiently level to continue.

16. Raise the elevator by 2 mm (0.07 in), using the elevator Move by controls. Care must be taken, as this may compress the recoater blade slightly if the front of the plate is higher than the rear. The recoater calibration position is not necessarily the same on all machines – it may be necessary to move the recoater forwards or backwards so that the recoater is in the middle of the pin, using the Move to controls. If this is done, make sure the recoater and pin are not touching.

17. Use the sphere array plate adjuster screws and 100 µm and 150 µm feeler gauges as a go-nogo gauge until the pins are approximately 100 µm (0.1 mm) away from the recoater. Use a 2 mm (0.07 in) allen key (as shown in Figure 373) to turn the adjuster pins – clockwise raises the plate, anticlockwise lowers it.

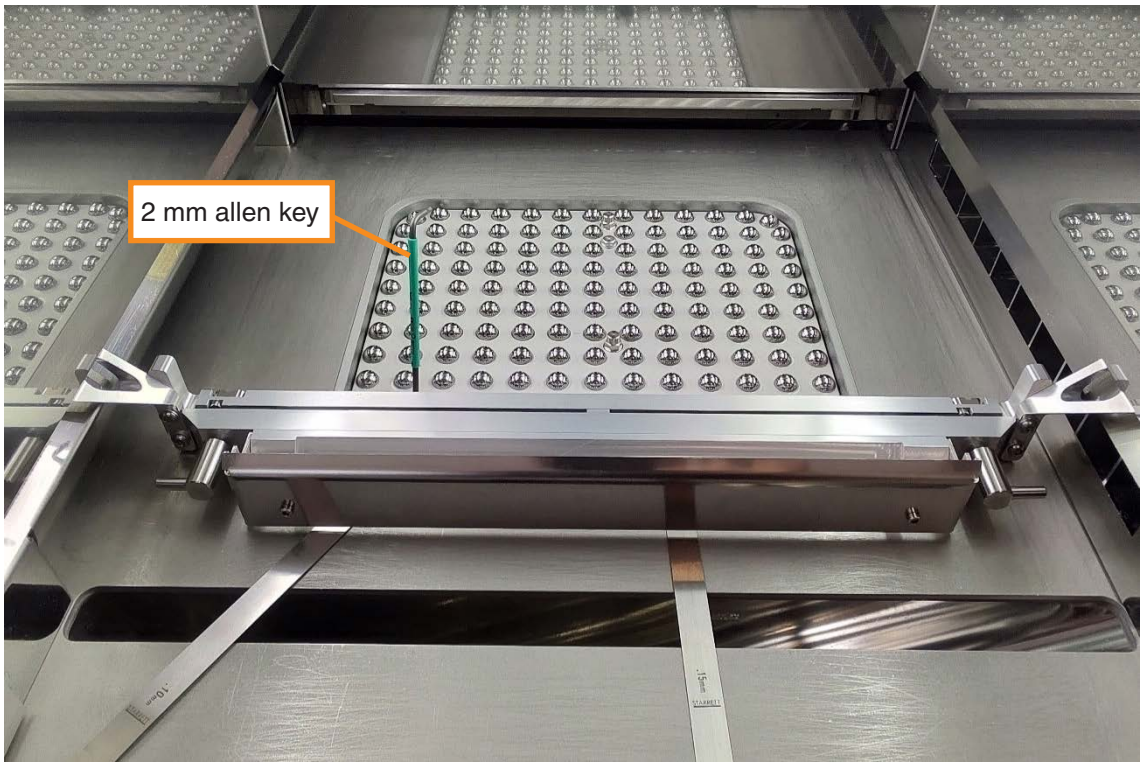


Figure 373 Recoater over the front pins, 2 mm allen key in place to adjust the left adjuster pin and 100 µm and 150 µm feeler gauge testing the distance between the pins and the recoater blade

18. Lower the elevator by 2 mm (0.07 in), using the Elevator Move by controls.

19. Move the recoater back to –283 mm (–11.14 in) using the Recoater Move to controls. This is to check the plate is parallel to the recoater plane.

20. Raise the elevator by 2 mm (0.07 in), using the Elevator Move by controls. Care must be taken, as this may compress the recoater blade slightly if the front of the plate is higher than the rear.

21. Use the feeler gauges to check the recoater and rear pin are still approximately 100 µm apart. If they are not, repeat steps 13 to 24 until you are satisfied that the plate and recoater are parallel.

22. Lower the elevator by 2 mm (0.07 in), using the Elevator Move by controls.

23. Move the recoater to the rear of the machine chamber using the Send recoater to rear of chamber button as shown in Figure 374.

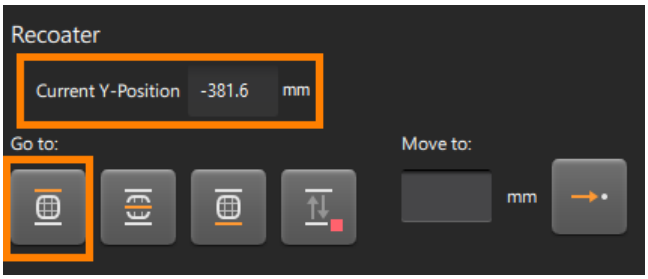


Figure 374 Wiper/recoater rear of chamber position

24. Raise the elevator by 2.1 mm (0.08 in) (the width of the shim used plus the distance moved down). This places the top of the pin on the same plane as the recoater blade.

25. Edit the Build Plate Thickness and make it equal to the Current Z-Position, but ensuring the Build Plate Thickness is a positive number and not a negative number like the Current Z-Position. See Figure 375 below for an example. This sets the build plate thickness to the Z axis position where the top of the pin is touching the recoater plane. This is so the elevator can be moved, and the position is still remembered.



Figure 375 Build Plate Thickness

26. Raise the elevator by a further 8 mm (0.31 in), using the elevator Move by controls (highlighted in Figure 376). This sets the centre of the metal spheres on the same plane as the recoater blade.

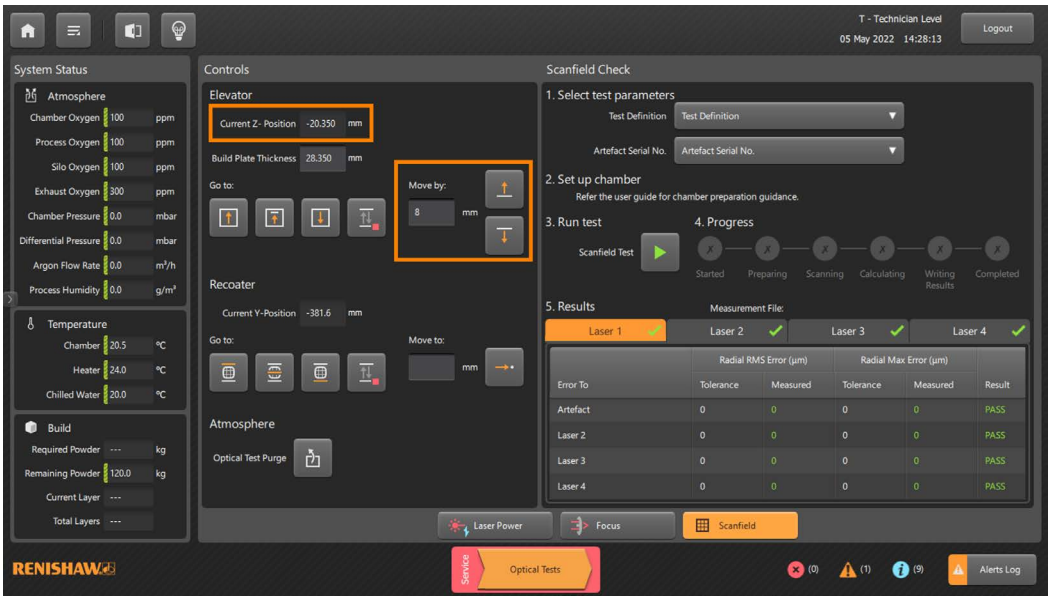


Figure 376 Scanfield Test page with the current Z position 8 mm higher than the build plate thickness

CAUTION: If the metal spheres are not at the correct Z height, it is possible to burn them, making them unusable.

The sphere array is now set up for scanfield, with the equator of the spheres on the recoater plane (as can be seen in Figure 377).

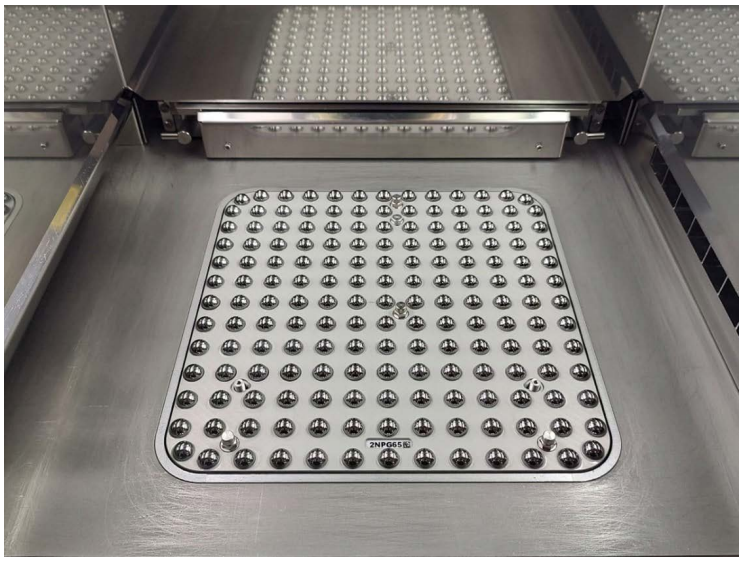


Figure 377 Completely set up sphere array

27. Clean the top surface of the metal spheres using a lint-free cloth and IPA.

CAUTION: If the metal spheres are not clean, from contamination, it is possible to burn them, making them unusable.

28. Close the chamber door.

29. Reset the machine (click the blue button).

30. Click the Optical Test Purge button as seen in Figure 378. Optical test processes, like part builds, can only be run in an inert atmosphere. Purging will take approximately 20 minutes.

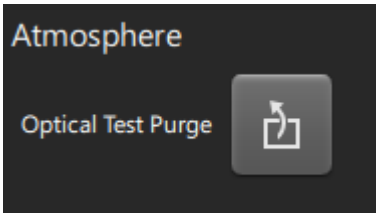


Figure 378 Optical Test Purge button

While purging, the Optical Test button will appear as shown in Figure 379.

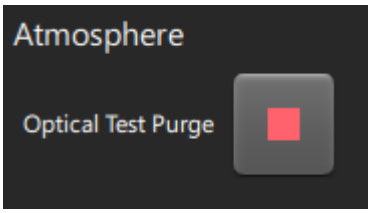


Figure 379 Optical Test Purge button while purging

The mechanical set-up is now complete, and the sphere array is installed into the machine.

NOTE: Any error between the recoater plane and the centre plane of the spheres will impart an error into the scanfield data later, so it is important to complete the set-up correctly.

TT-007-05 – Scanfield measurement test

Scanfield can only be completed once the chamber is purged with argon. To run the scanfield measurement test, the following procedure should be followed:

1. Select the customer test definition from the Test Definition drop-down menu.

   The 1 mm test definition files use a 1 mm patch to find the location of each metal sphere on the sphere array plate and, from that, calculate any error in the X,Y calibration of the machine.

   WARNING: Do NOT use the "…2 mm (0.07 in)…_(Service only)" test definition, as it is for initial machine set-up and has a lower resolution.

2. Select the artefact serial number from the drop-down menu. This is located on the edge of the plate facing closest to the chamber door and is highlighted in the green circle in Figure 366.

   NOTE: The correct serial number for the plate in use must be used so that the correct CMM file for the plate is used when calculating the test results. If the correct plate serial number is not visible, the file must be added to the machine and RenAMP restarted – see "ST-003-02 – Putting an artefact serial no. CMM file onto a machine".

3. Select the Run Scanfield Test button, as seen in Figure 380, to fire the scanfield optical test.

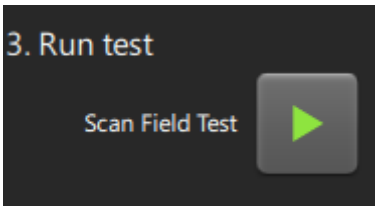


Figure 380 Scanfield Test button

The test will indicate its progress through the progress bar, shown in Figure 381. Once completed, all stations will show a green tick if successful, or a red cross if unsuccessful.

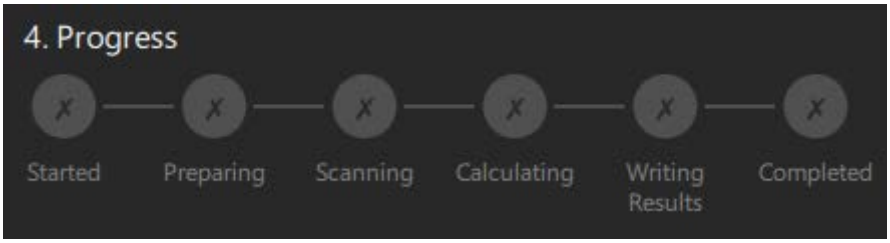


Figure 381 Scanfield test page progress bar

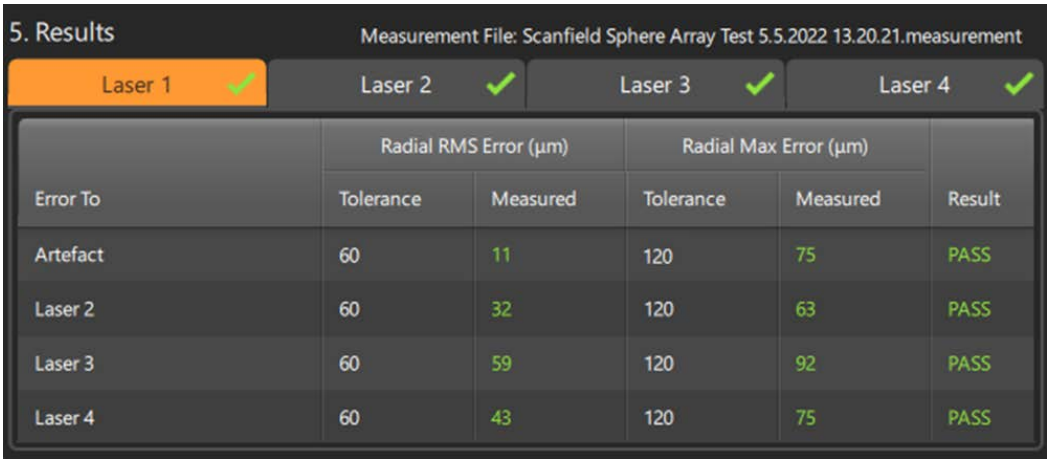
If the test was run successfully, the results table will be populated and a measurement file will be created.

4. Check the Results tab. The laser table shows:

   - Results for all the lasers present (based of the number installed lasers).
   - The relative error of the selected laser to the test artefact.
   - The laser-to-laser error, showing the deviation of the laser beam positions to one another (only present on a RenAM 500Q and 500D).

   An in specification result is indicated by green text, ticks and a PASS in the result column.

   An out of specification result is indicated by red text, crosses and a FAIL in the result column.



	Radial RMS Error (µm)		Radial Max Error (µm)		
Error To	Tolerance	Measured	Tolerance	Measured	Result
Artefact	60	11	120	75	PASS
Laser 2	60	32	120	63	PASS
Laser 3	60	59	120	92	PASS
Laser 4	60	43	120	75	PASS

Figure 382 Optical test scanfield results table

5. When all lasers and laser-to-laser pairings have passed and are in specification, the scanfield check is complete and the machine is deemed well-calibrated and is fit for use. The test artefact can be removed (see task “TT-007-06 – Removal of test equipment”) and the machine can continue to be used for normal operation.

6. If any value in the results table has failed, the laser(s) will need recalibration – continue to task “ST-003-01 – Recalibration process”.

TT-007-06 – Removal of test equipment

This task documents how to remove the test equipment from the machine.

1. Navigate back to the Scanfield Optical Test page.

2. Look through the chamber window and check the recoater is at its back position and ensure the sphere array plate and elevator are safe to move up.

3. Move the elevator to top position using the Elevator Go to: Top button



Figure 383 Elevator Go to: Top button

4. Open the chamber door.

5. Inspect the plate for damage or burn marks on the metal spheres. If any damage is found, photograph it and contact Renishaw Service.

6. Put the plate back into its protective bag and case.

TT-007-07 – Next steps

The optical testing is now complete. The machine is known to have in specification X,Y laser position calibration and thus can be used for normal operation.

8.6.6 ST-003 – Laser scanfield recalibration

ST-003-01 – Recalibration process

This task documents how to apply a change to the X,Y calibration.

1. To apply the measurement file, the user must be a skilled Service level user. If not already logged in at Service level, log out and log in again at Service level.

   NOTE: If not a Service level user, contact a Service level user to continue.

2. Move to the Calibration tab, using the button at the bottom of the screen as shown in Figure 384.



Figure 384 Optical Tests page to Calibration page

3. The top line highlighted in orange on the Measurement page is the new measurement file created from the scanfield test as seen in Figure 385. Click the Create Calibration button at the bottom right, indicated by the orange box, to create a calibration file.

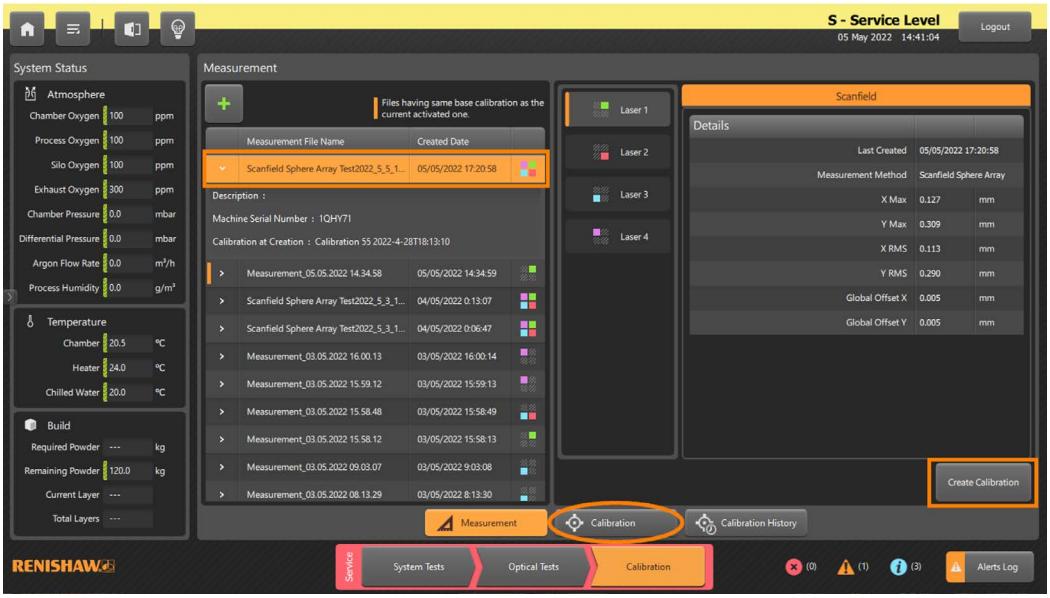


Figure 385 Measurement page showing the scanfield measurement file created

4. The Apply Measurement dialog box will appear. There is the option to change the calibration name and description by clicking in the boxes. When done, click the OK button as shown in Figure 386.

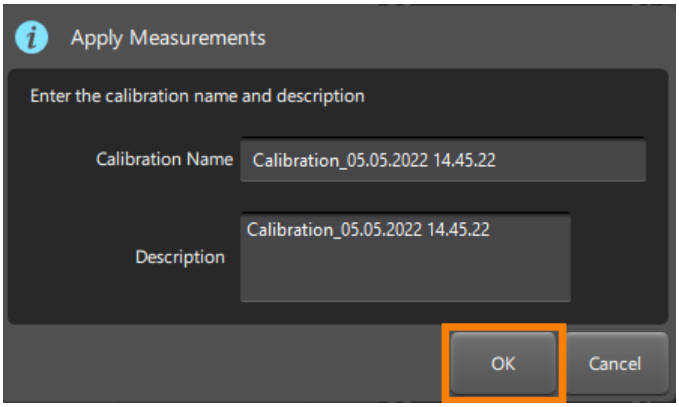


Figure 386 Measurement page Create calibration / Apply Measurements dialog box

5. Move to the Calibration screen by clicking the button in the middle of the screen highlighted by the orange circle in Figure 385.

   The line highlighted in dull orange with the orange bar on the left end is the current machine calibration.

   The top line of the table is the most recently created calibration file – the scanfield calibration. To make this calibration the active calibration, click the Activate button, indicated by the orange rectangle below.

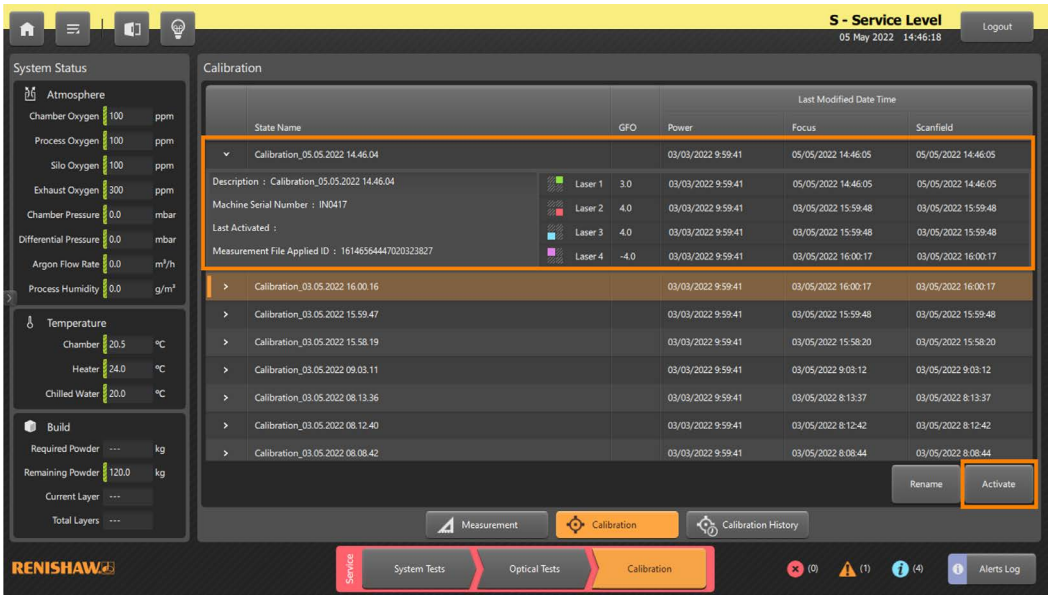


Figure 387 Calibration screen

6. The user will be prompted to accept or reject the changes to the calibration by clicking Yes or No. Click Yes to activate it.

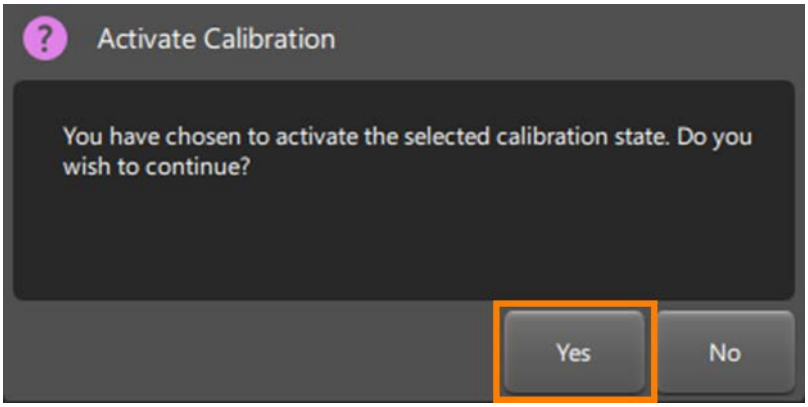


Figure 388 Activate Calibration pop-up

7. The new calibration is now active, as seen in Figure 389. This is indicated by the line that is highlighted in dull orange changing. It is also indicated by an information pop-up that appears at the bottom right of the screen initially after application. This alert can also be checked in the alerts log in the bottom right.

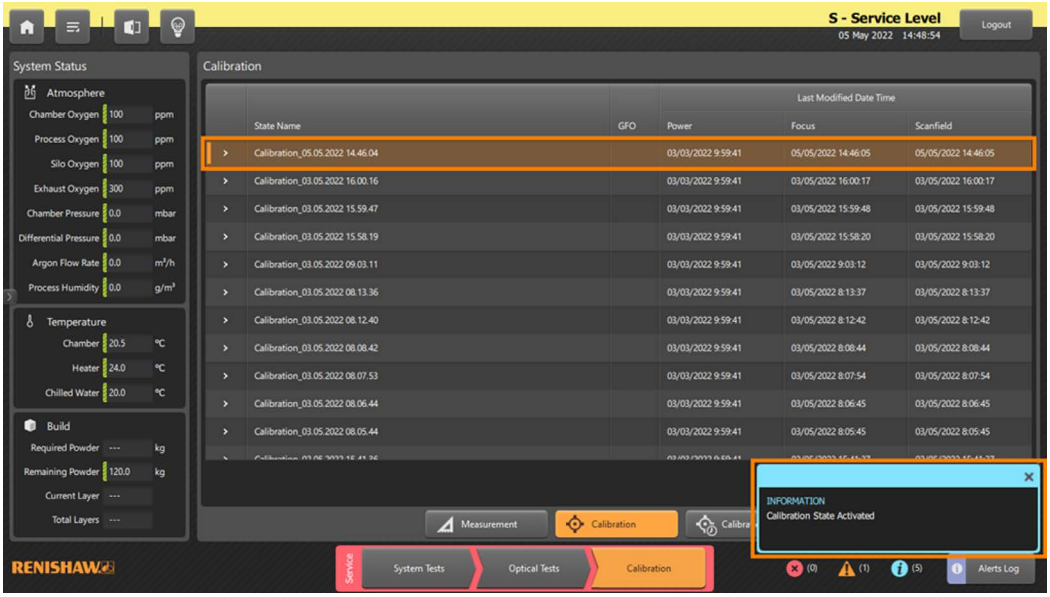


Figure 389 New active calibration

8. To check the calibration is now in specification, re-run task “TT-007-05 – Scanfield measurement test”.

ST-003-02 – Putting an artefact serial no. CMM file onto a machine

Each sphere array calibration artefact (Renishaw part no. A-6780-0032) used in the scanfield measurement checks and calibration process has its own CMM file associated with it; this individual file is identified via the plate serial number. This means that every plate used on a particular machine will need to have its CMM file uploaded to said machine.

This CMM file allows for the positions of all metal spheres on the plates to be known, and any associated errors are subtracted during calibration.

To transfer these files onto the machine:

1. Navigate to **https://renishawplc.sharepoint.com/sites/Ext-AMPD/Calibration**
2. Log in using the login credentials provided by Renishaw.
3. Download the CMM file for the sphere array calibration artefact to be tested on the machine. The CMM file name will contain the same serial number found on the artefact.
4. Transfer the file(s) onto the machine using the standard FTP or SMB method (see task “AB-016 – Build file – Transfer”).
5. Place the file into the following location:

   D:\AMresources\Optical Calibration\Calibration Artefact CMM Files
6. RenAMP must be restarted in order to detect the new file(s). Restart RenAMP using the PC controls as described in task “PB-009 – RenAM 500 series system – Shut down”, selecting Restart rather than Shutdown.

Once this process is complete, the artefact serial number will be selectable on the Optical Test Scanfield page.

8.6.7 ST-004 – Calibration management tasks

This section describes tasks related to the management of existing calibration states. Calibration states are created by applying measurement files to the active calibration, as has been covered in the previous sections.

ST-004-01 – Activating an existing calibration state

This section describes how to activate an existing calibration.

1. Navigate to the Calibration screen (refer to Figure 390). A table of all calibrations present on the system will be displayed in the order they are created, with the most recent at the top of the list. The currently activated calibration is highlighted in dull orange.

2. Select the calibration to activate by clicking on it in the table. It will be highlighted orange as shown in Figure 390.

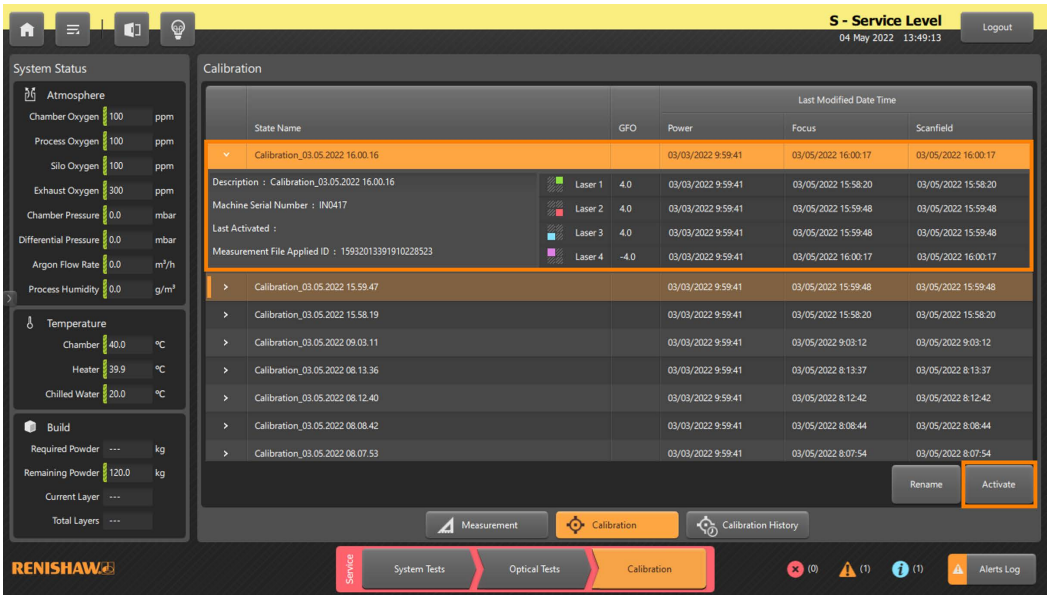


Figure 390 Calibration screen – Selected calibration state

3. Click the Activate button at the bottom right of the table.

4. The selected Calibration state will be activated and the Activate button for that calibration state will be disabled as shown in Figure 392.

5. The user will be prompted to accept or reject the changes to the calibration by clicking Yes or No (see Figure 391). Click Yes to active it.

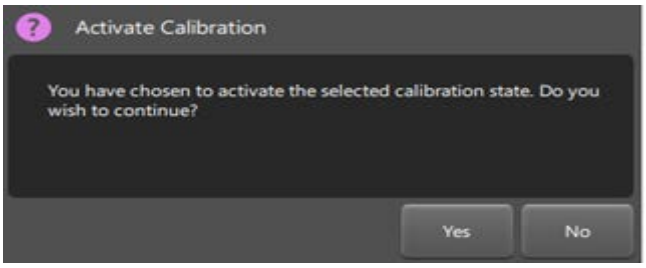


Figure 391 Activate Calibration dialog box

6. The activated state will be visible in orange as shown in Figure 392.

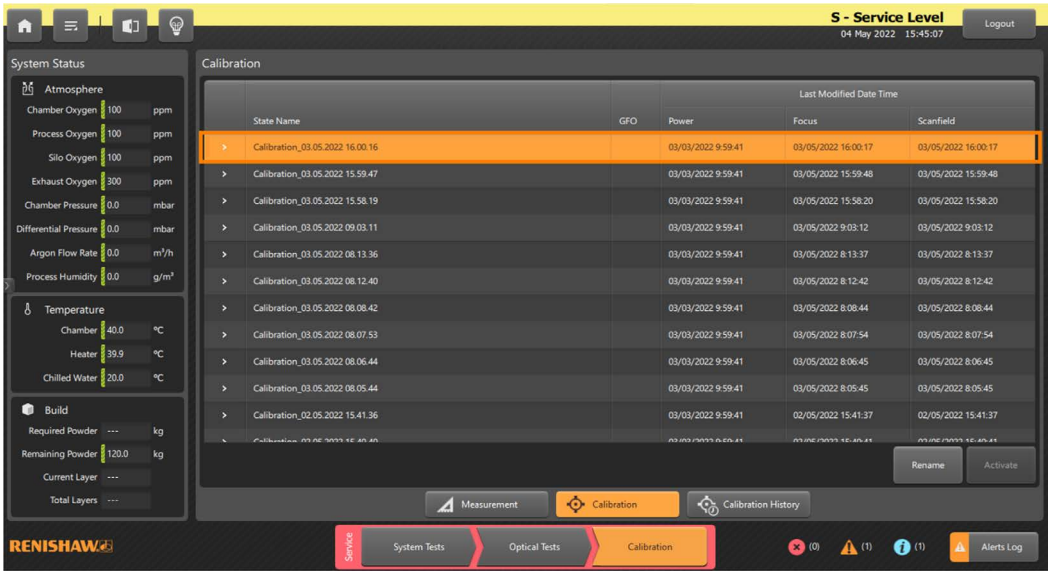


Figure 392 Activated Calibration state

ST-004-02 – Rolling back

It may be desirable to roll back to a previously activated calibration, in the case of a newly created calibration producing poor results or some other, similar situation.

1. Navigate to the Calibration History screen (see Figure 393). A table of calibration activation events will be displayed in order of when the activation occurred, with the most recent at the top.

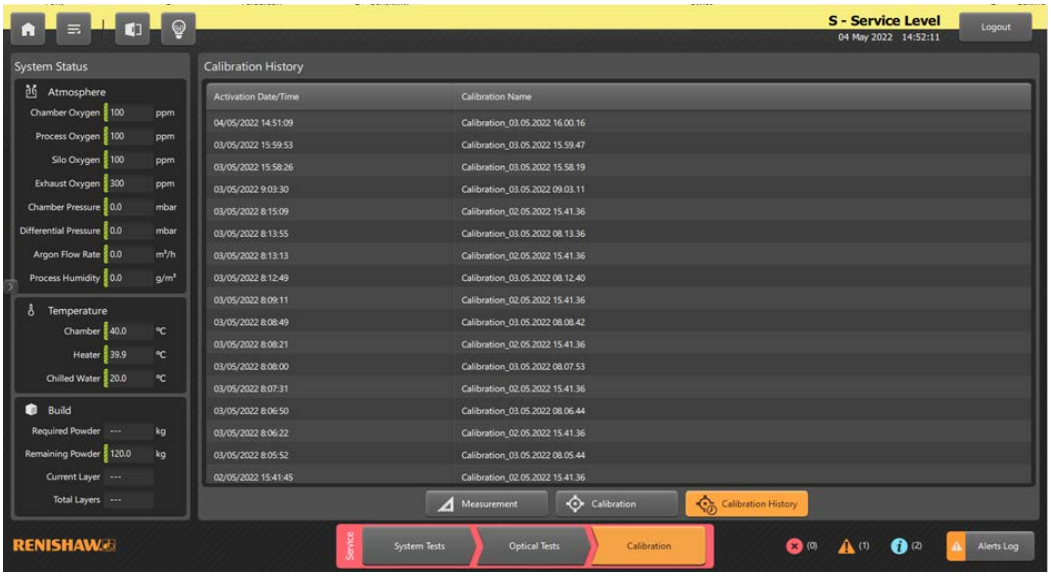


Figure 393 Calibration History screen

2. Use this table to find the calibration which was active at the time the system was last known to be in a good state.

3. Follow the steps in the task “ST-004-01 – Activating an existing calibration state” to activate this calibration.

ST-004-03 – Rename calibration

This section describes how to rename a calibration for easier reference. Note that although most areas of the software will display the modified name, the underlying name of the calibration is not altered and so the original name will appear in some areas such as within measurement files.

1. Navigate to the Calibration screen.

2. Select the calibration to rename.

3. Click the Rename button to the bottom-right of the table.

4. A dialog box will appear, requesting the new name. Enter the new name and click OK (see Figure 394).

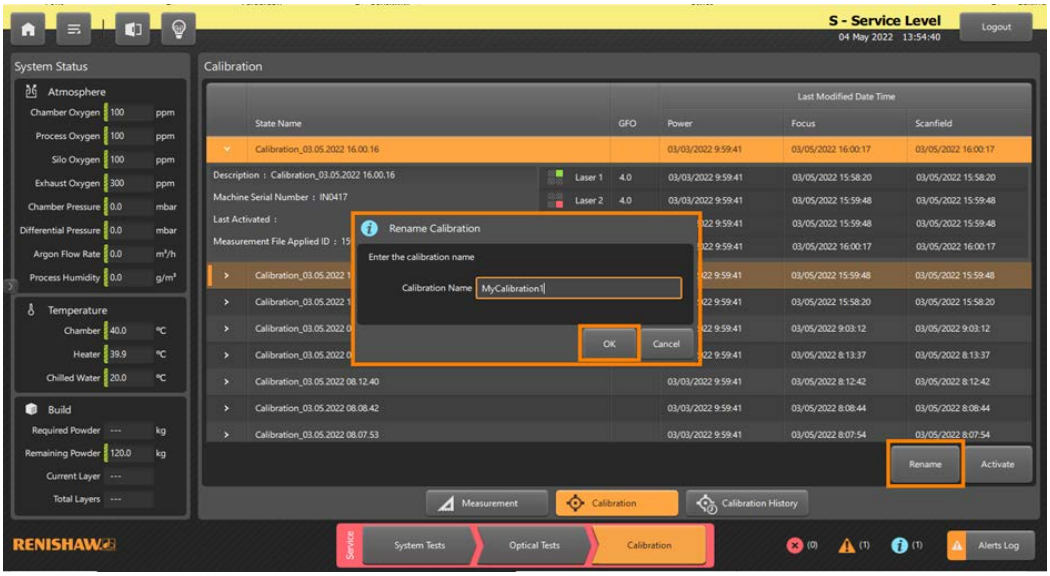


Figure 394 Rename Calibration dialog box

5. The changed name will reflect in the Calibration tab as highlighted in Figure 395.

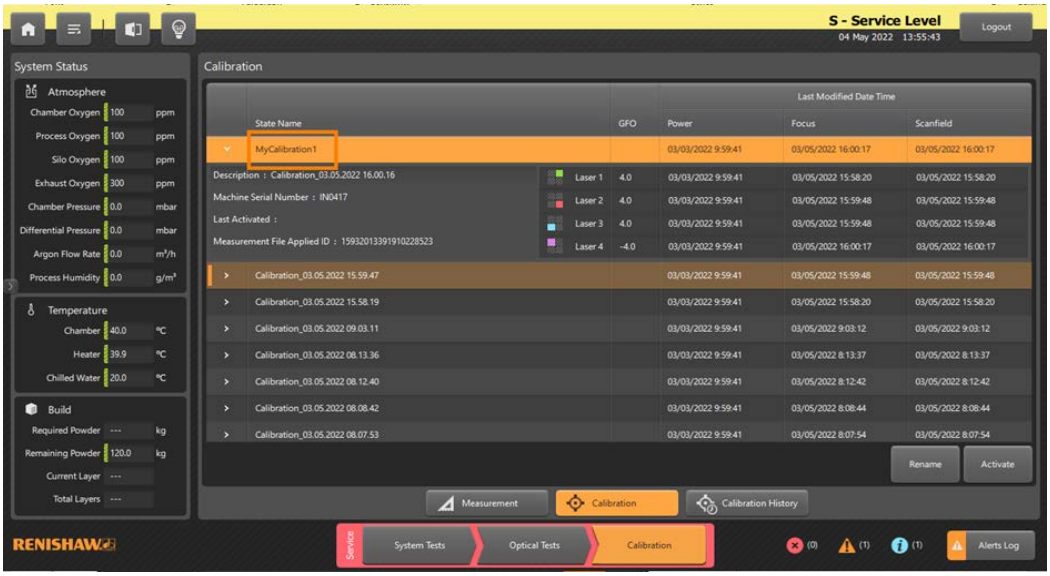


Figure 395 Renamed calibration

8.6.8 TT-008 – Custom laser power and focus

The RenAM 500 series machine allows you to execute laser power and laser focus tests using custom mtt files. This feature enables you to scan and complete the first layer of your custom build file with the configured power or focus settings, all without requiring any movement of the recoater. This functionality is particularly useful for visually verifying the laser parameters to ensure optimal performance and quality of the initial layer, which is critical for the success of the build.

CAUTION: Any power values or focus values executed in the custom test must not be applied for laser calibration. Failure to adhere to this guideline may result in inaccurate calibrations, potentially compromising the quality and safety of the laser operations.

Follow the steps below to execute a custom laser power and focus test:

1. Transfer the custom mtt build file to the RenAM 500 series system using the standard FTP or SMB method. For more information see section 8.8, “Transferring files”.

   NOTE: For custom laser power test, transfer the custom mtt build file to the system folder: **D:\AMResources\lasercalibration\Custom_power_tests**.

   NOTE: For custom laser focus test, transfer the custom mtt build file to the system folder: **D:\AMResources\lasercalibration\Custom_focus_tests**.

2. Restart RenAMP and login using Technician level credentials.

3. From the RenAMP home screen, select ‘Optical Tests’.

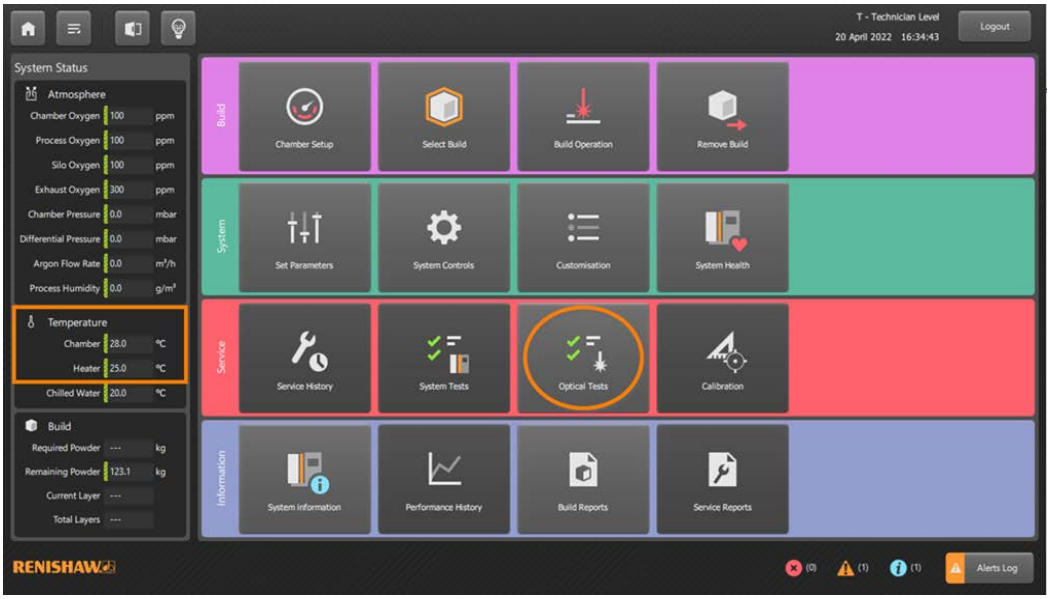


Figure 396 RenAMP Optical Tests page selection

4. Select the ‘Laser Power’ tab to perform a custom power test, or select the ‘Focus’ tab to perform a laser focus test.

5. From the ‘Control’ pane of the selected test, click ‘Custom’.

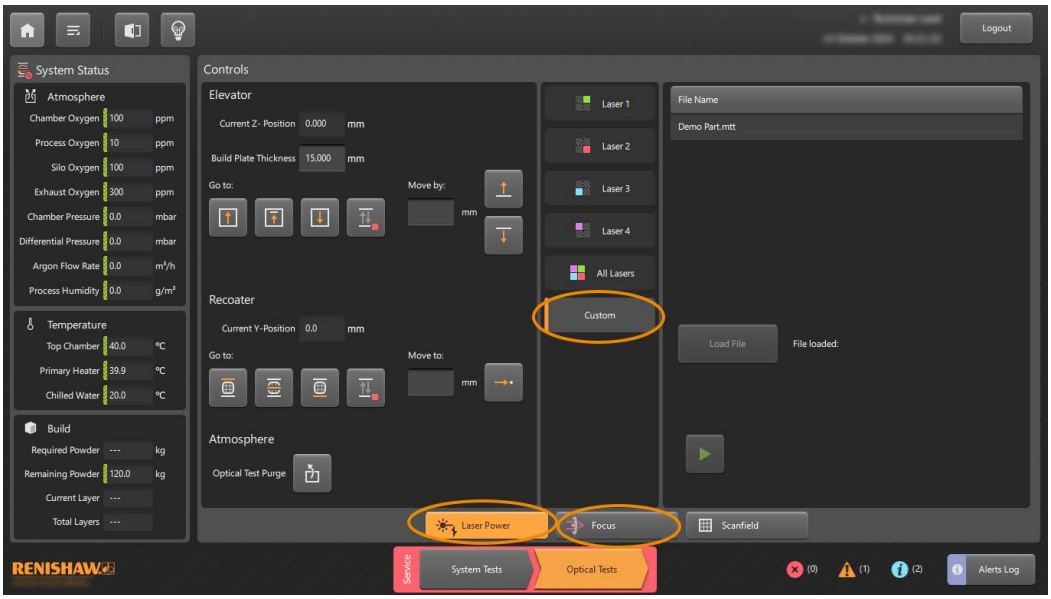


Figure 397 RenAMP Optical Tests page selection

6. All the custom mtt build files transferred to the system folder are displayed.

NOTE: For custom laser power test, the system displays the custom mtt build file available in the system folder: **D:\AMResources\lasercalibration\Custom_power_tests**.

NOTE: For custom laser focus test, the system displays the custom mtt build file available in the system folder: **D:\AMResources\lasercalibration\Custom_focus_tests**.

7. Select the required custom build file and click ‘Load File’.

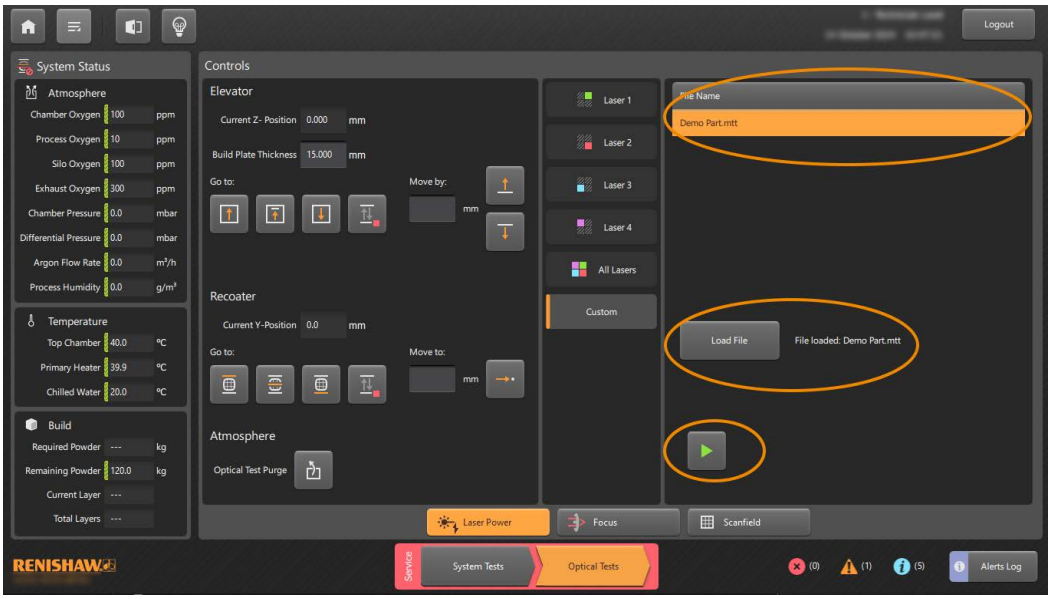


Figure 398 RenAMP Optical Tests page selection

8. Once the file is loaded, click the ‘Run’ button.

8.7 Network settings

The following table lists all the network settings tasks that can be performed on a RenAM 500 series system.

Task number	Task title	User level
ST-005	Network configuration – WAN1 / WAN 2	Service
TT-009	File transfer settings	Technician

8.7.1 ST-005 – Network configuration – WAN or Ethernet

NOTE: The latest RenAM 500 series machines no longer use a router for network connection. Instead, they are equipped with Ethernet ports directly on the main computer.

RenAMP allows service level users to configure the WAN or Ethernet ports on the RenAM 500 series so the machine can be connected to an external or local network. Refer to section 6.9, “Network topology”, for more information on network configuration.

NOTE: If your machine is equipped with a router, it must be running firmware version 5.6 or later.

1. From the RenAMP home screen, select ‘Customisation’.

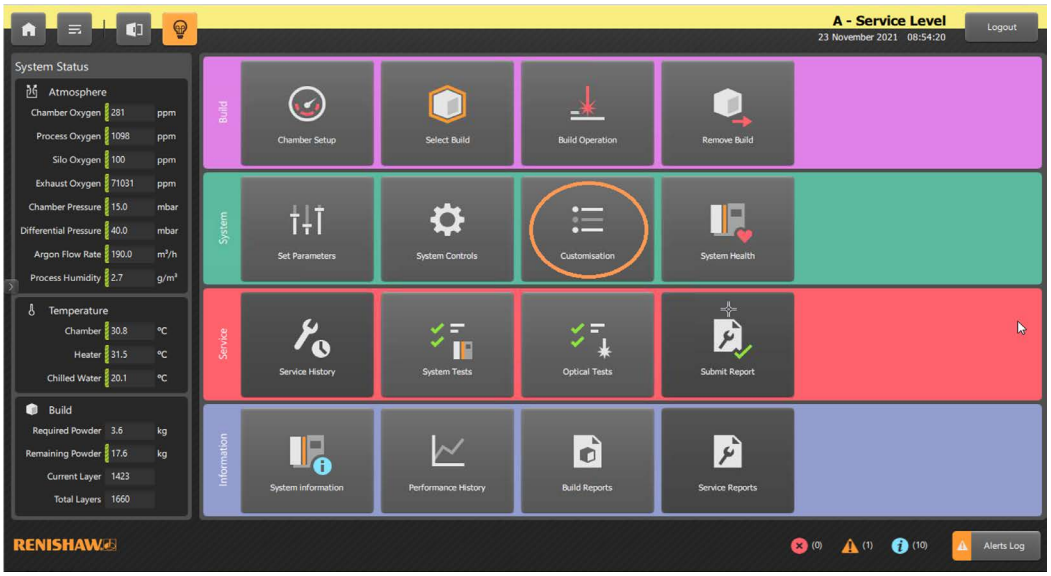


Figure 399 Home screen with Customisation circled

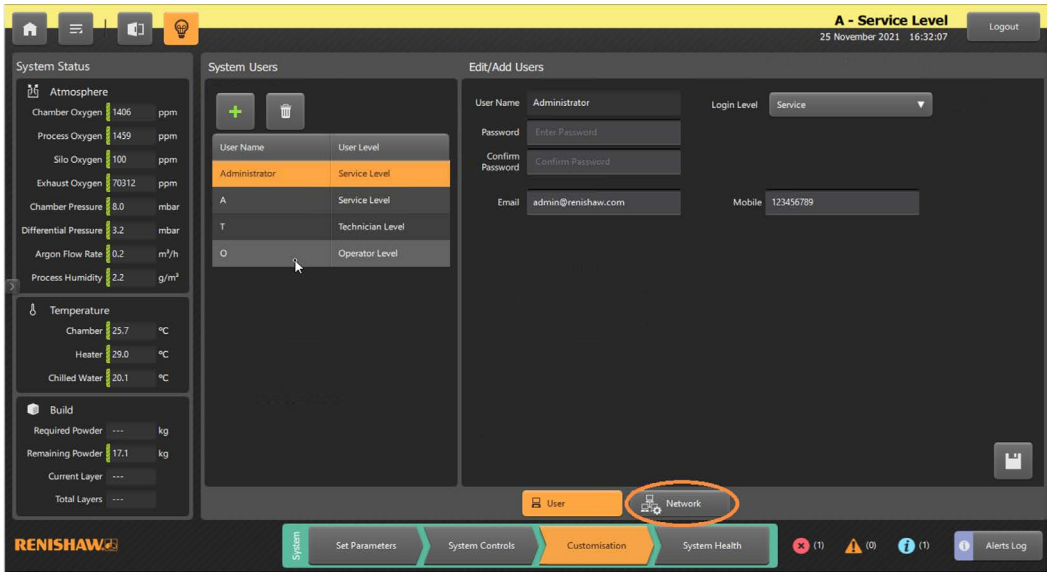


Figure 400 Customisation screen with Network circled

2. From the Customisation screen, select the ‘Network’ tab.

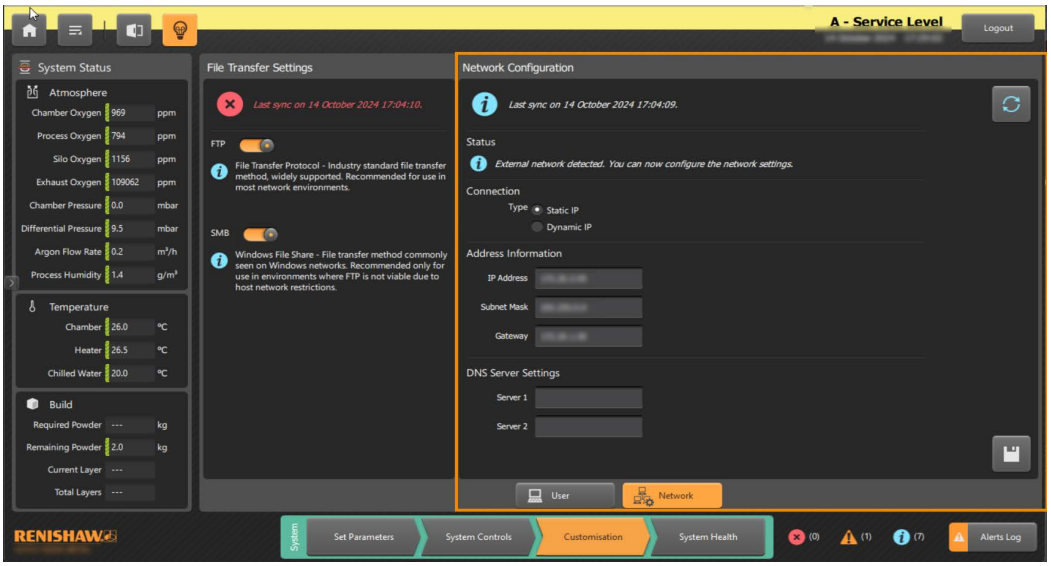


Figure 401 Network screen with Network Configuration highlighted

3. The ‘Network Configuration’ pane displays the network settings currently applied to the machine.

4. Use the ‘Refresh’ button to update the values displayed in the user interface to be in sync with the connected network. If the router or Ethernet port is not available for configuration, check for a loose cable connection between the router or Ethernet port and the switch and then click the refresh button.

NOTE: It is advised not to change the network setting during an ongoing build, as services such as InfiniAM Central, Renishaw Central, Data Transfer Service or any VPN connection to the machine would get disrupted.

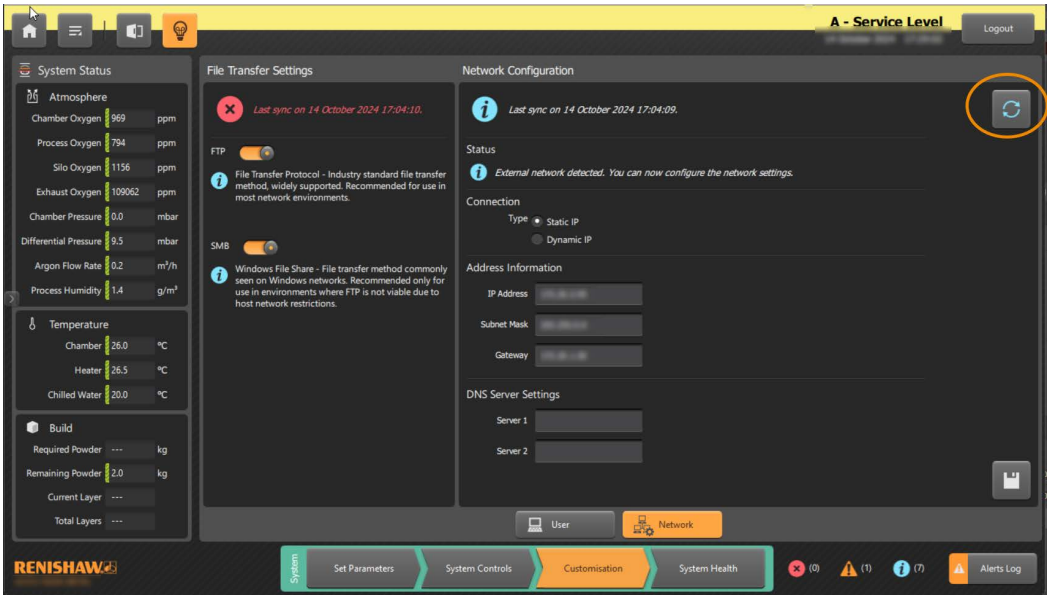


Figure 402 Location of the Refresh button

5. Use the radio buttons under the ‘Connection’ sub-menu to select either ‘Static IP’ or ‘Dynamic IP’ connection type for the WAN port or Ethernet port. Selecting a static Internet Protocol (IP) address will allow the user to edit the address information, whereas selecting the dynamic IP address will blank out the address information as it will be controlled by the connected network.

6. If Static IP is selected, enter the IP address, subnet mask and gateway for your network into the text field under ‘Address Information’.

   NOTE: Contact your network administrator before configuring the IP address, subnet mask and gateway information.

7. Under ‘DNS Server Settings’, enter the IP addresses for Server 1 and Server 2. The DNS server settings are required for the functioning of InfiniAM Central and Renishaw Central services. The addresses provided for Server 1 and Server 2 are respectively the primary and secondary servers which the services would use for resolving the domain names to IP addresses.

   NOTE: If both the server addresses are kept empty, the software does not mark it as an error. However, this is not recommended, as it may cause issues if any domain name is being used for InfiniAM Central and Renishaw Central. If DNS server settings are used, it is important that at least the ‘Server 1’ address is provided. If the ‘Server 1’ and ‘Server 2’ addresses are the same, or only the ‘Server 2’ address is provided, the software will display an error message.

   NOTE: Contact your network administrator before configuring the DNS server settings.

8. After changing the settings displayed in the ‘Network Configuration’ pane using steps 3 to 6, click the ‘Save’ button to save and apply the settings to the machine. If the DNS server settings have been changed, the PC in the RenAM 500 series will need to be restarted to bring the changes into effect.

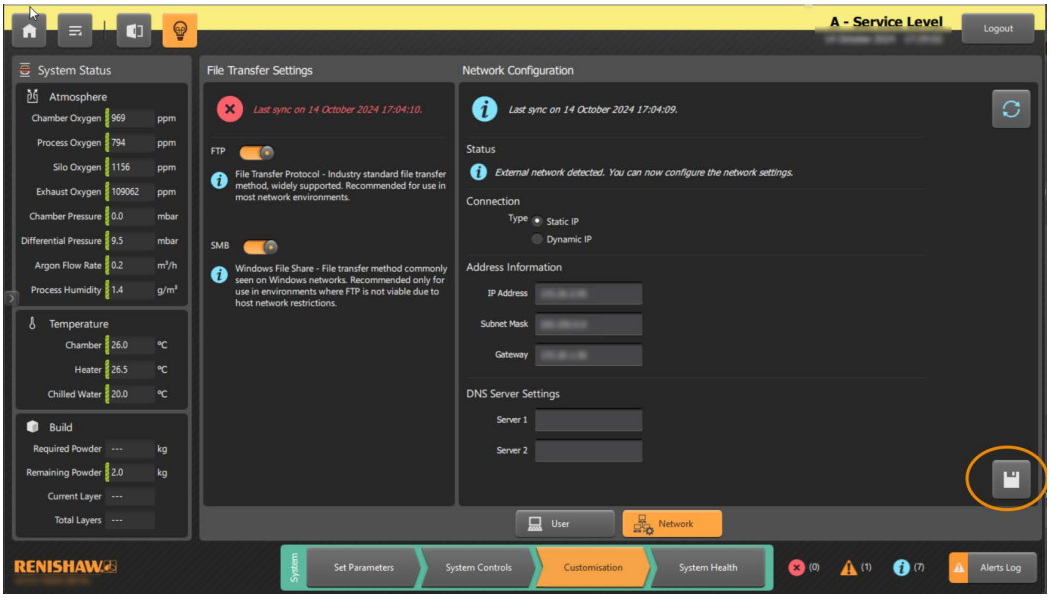


Figure 403 Location of the Save button

8.7.2 TT-009 – File transfer settings

The file transfer settings allow the user to set the mode used to transfer build files to the RenAM 500 series. The available options are File Transfer Protocol (FTP) or Server Message Block (SMB) (also known as Windows file share). For the procedure for transferring a build file from an external computer to the RenAM 500 series, and for more information regarding file transfer settings, refer to task “AB-016 – Build file – Transfer”.

NOTE: These settings can only be adjusted by a technician-level or service-level user.

1. From the RenAMP home screen, select ‘Customisation’.

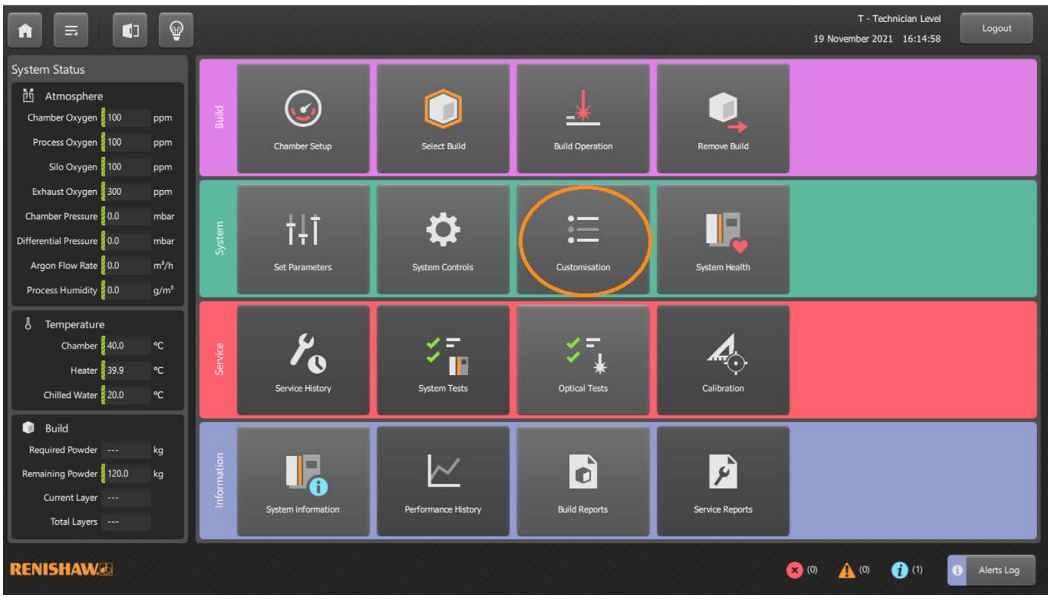


Figure 404 Home screen with Customisation circled

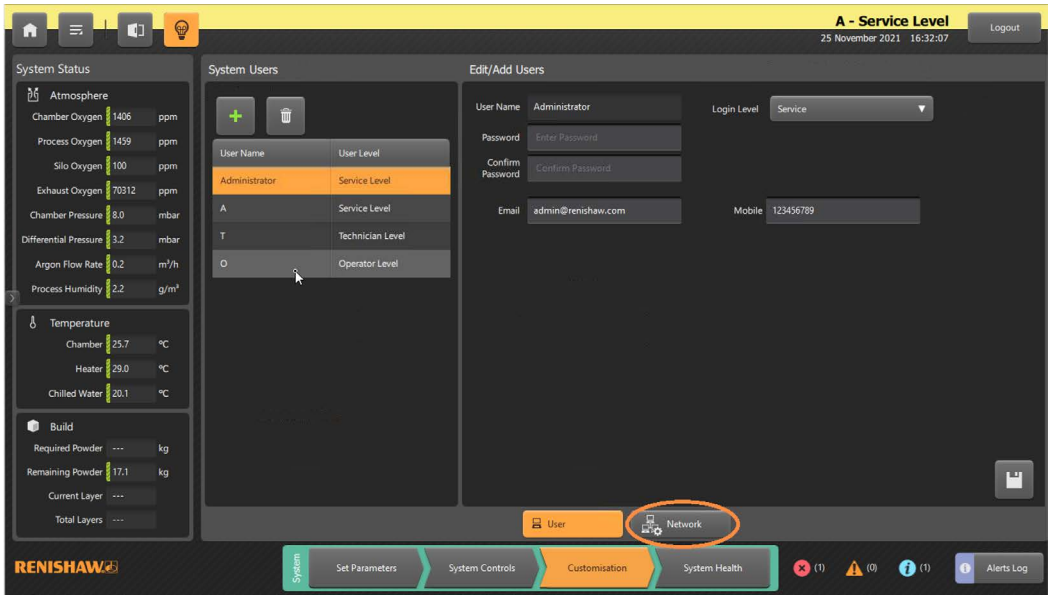


Figure 405 Customisation screen and Network button

2. From the Customisation screen, select the ‘Network’ tab.

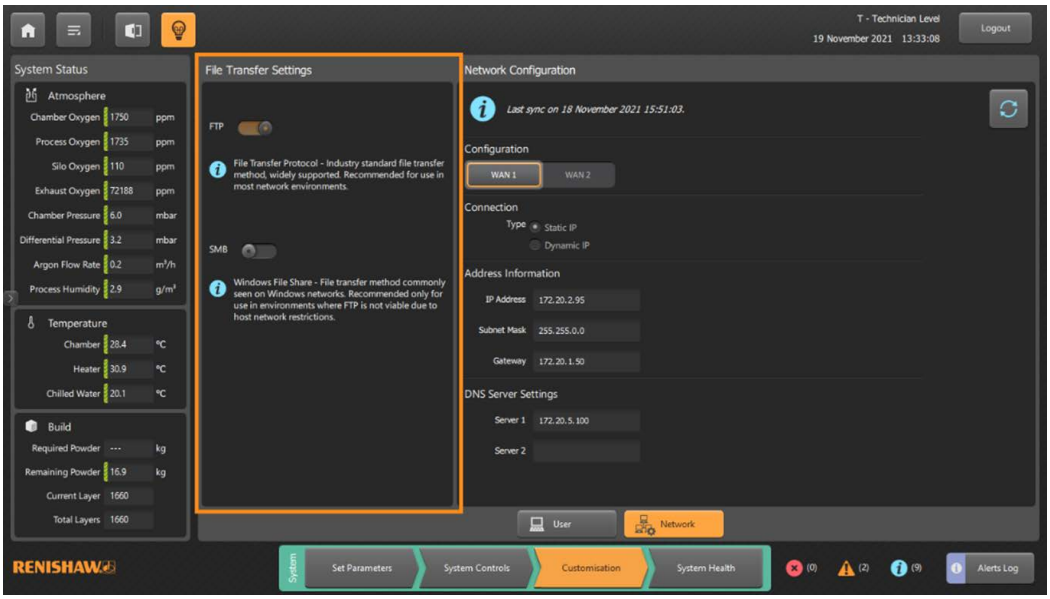


Figure 406 Network screen with File Transfer Settings highlighted

3. The Network screen contains the File Transfer Settings pane. Click the FTP or SMB toggle switches to enable or disable the ability to use FTP or SMB respectively to transfer build files to the machine.

NOTE: FTP is enabled by default, however either one or both the options can be enabled using the toggle switches.

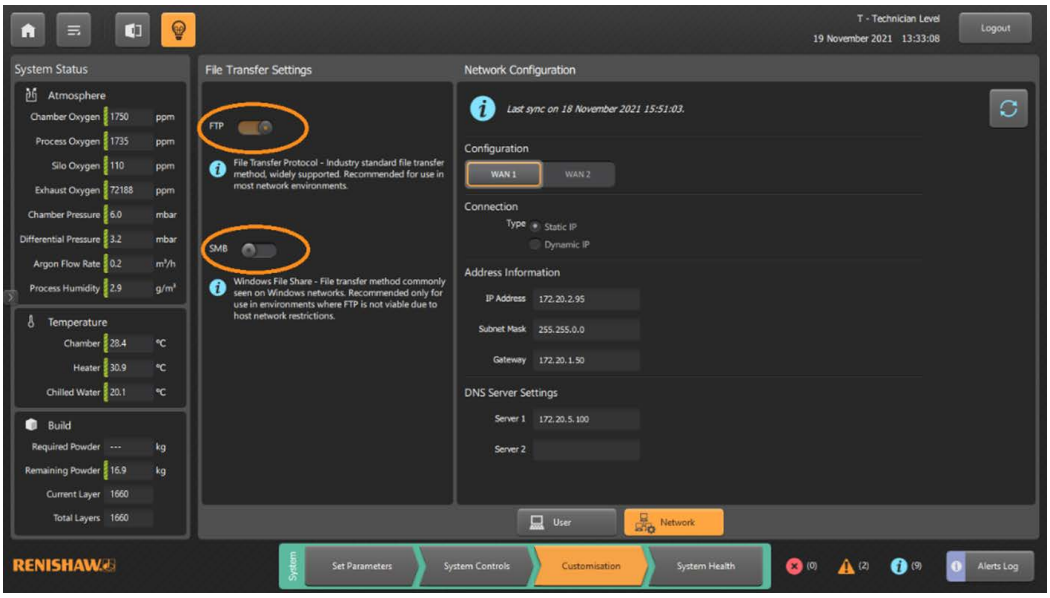


Figure 407 FTP and SMB toggle switches in the File Transfer Settings pane

8.8 Transferring files

Files can be transferred from an external computer to a RenAM 500 series system and vice versa using two protocols: File Transfer Protocol (FTP) and Server Message Block (SMB), also known as Windows file share. FTP is a file transfer method commonly used by clients such as FileZilla and Windows File Explorer, while SMB is a protocol often employed by Microsoft Windows File Explorer. Ensure that the necessary file transfer settings are enabled to initiate file transfer. To enable or disable FTP or SMB file transfer capabilities using RenAMP, refer to section 8.7.2, “TT-009 – File transfer settings”.

NOTE: A Renishaw service engineer will install and configure the build file transfer services when the RenAM 500 series system is installed and commissioned.

You can use the following methods to transfer files from an external computer to a RenAM 500 series system and vice versa.

8.8.1 Transferring files using FTP via Files Transfer Client

To transfer files using FTP via the file transfer clients perform the following steps:

1. Access the FTP file transfer client on your PC. To do this follow the set-up instructions supplied by the file transfer client.

NOTE: The file transfer client must be configured to use active mode when transferring files using FTP.

2. Connect to the required RenAM 500 series system using the IP address and the login credentials.
3. After successfully establishing the remote connection, access hard drive D:\ of the RenAM 500 series system.
4. Transfer the required files between the local PC and RenAM 500 series system.

NOTE: If the file transfer fails when using FTP clients, it is recommended to use Secure File Transfer Protocol (SFTP), also known as Secure Shell (SSH) FTP. Alternatively, SMB can be used for file transfer.

8.8.2 Transferring files using FTP via Windows File Explorer

To transfer files using FTP using Windows File Explorer, follow the instructions given below:

1. In Control Panel, navigate to ‘Internet Options’ > ‘Advanced’ tab and make sure that the ‘Enable FTP folder view’ checkbox is checked.
2. Open the Windows File Explorer.
3. In the address bar of Windows File Explorer, type ftp:// followed by the IP address of the required RenAM 500 series machine. For example, if the IP address is 198.168.1.1, type ftp://192.168.1.1. To find the IP address assigned to your RenAM 500 series machine, see section 8.7.1, “ST-005 – Network configuration – WAN or Ethernet”.
4. In the login dialog box, enter the credentials and click ‘Log On’.
5. After successfully establishing the remote connection, access the drive D:\ of the RenAM 500 series system.
6. Transfer files between the local PC and RenAM 500 series system.

8.8.3 Transferring files using SMB via Windows File Explorer

To transfer files via SMB using Windows File Explorer, do the following steps:

1. Open the Windows File Explorer.
2. In the address bar of Windows File Explorer, type the IP address of the required RenAM 500 series machine. For example, if the IP address is 198.168.1.1, type //192.168.1.1.
3. In the Windows Security dialog box, enter the credentials and click ‘OK’.
4. After successfully establishing the remote connection, access hard drive D:\ of the RenAM 500 series system.
5. Transfer files between the local PC and RenAM 500 series system.

9. Preventative maintenance schedule

The aim of this chapter is to provide a list of the preventative maintenance tasks that should be carried out to keep your RenAM 500 series system functioning correctly. Renishaw recommends that the RenAM 500 series is maintained in accordance with the following maintenance schedule to ensure the reliability and availability of your RenAM 500 series system.

It is important that the RenAM 500 series is maintained so that its performance does not deteriorate to the extent that it puts people at risk or adversely impacts on any applicable warranty.

WARNING: The safety integrity level (SIL) rated oxygen sensors must be replaced/exchanged at 12-month intervals to maintain their SIL rating. This is normally carried out by a service engineer on a service visit.

Operator preventative maintenance tasks are listed in this chapter. They are prefixed with “PM” followed by a number, for example “PM-001”.

This chapter also contains preventative maintenance checklists.

9.1 Personal protective equipment (PPE)

WARNING: Before starting any maintenance task, ensure you are wearing the correct PPE: ESD safety footwear, eye protection, full-face respirator (to EN143 type P3 + A1), protective gloves and full-length clothing.

NOTE: Renishaw recommends that full-length clothing is made from non-static-generating fabric such as cotton (avoid wool and synthetic fabrics). Avoid turn-ups or pockets that may trap powder. Refer to NFPA 484 for details.

9.2 Definitions of maintenance

The definitions of maintenance tasks is as follows:

- Inspect – determine the general condition of the component, that is, conformity to required specification. Check for things such as damage, wear, cracks, splits, leaks, scoring, distortion, looseness, corrosion and breaks
- Clean – remove all dirt and deposits
- Check – determine a particular nominated condition, for example, completeness of task, security, position or function
- Calibrate – restore the performance of an object or system to a defined state with a known tolerance using tools, equipment and a specification
- Replace – remove and discard the original part and provide a new specified part in its place

- Lubricate – apply the correct amount of a suitable lubricant to enable the smooth movement of a component or assembly
- Function test – prove the function of a system by carrying out a simple test
- Test – prove the correct operation and performance of a system by specified trial

9.3 RenAM 500 series preventative maintenance schedule

The method statements for all operator preventative maintenance tasks are contained in Chapter 11, “Preventative maintenance tasks”.

Equipment	Maintenance activity	Frequency	Skill level	Task number
RenAM 500 series system	Inspect	1 week	Operator	PM-001
RenAM 500 series system	Clean	1 week	Operator	PM-002
RenAM 500 series safety devices	Check	1 week	Operator	PM-003
RenAM 500 series system hoses and coolant system	Check	1 week	Operator	PM-004
Process room	Clean	1 week	Operator	PM-005
Build chamber viewing window	Inspect	1 week	Operator	PM-006
Top and bottom door seals	Check	1 week	Operator	PM-007
Safety signs and laser safety labels	Inspect	1 week	Operator	PM-008
User guide	Check	1 week	Operator	PM-009
Powder flasks and large SafeChange filters	Check	1 week	Operator	PM-010
Chiller settings	Check	1 week	Operator	PM-011
Vacuum pump oil level	Check	1 week	Operator	PM-012
Elevator position encoder and reading strip	Clean	1 month	Operator	PM-013
Vacuum pump gas ballast valve filter	Check	1 month	Operator	PM-015
Metal powder safety	Check	6 months	Operator	PM-023
Inert gas supply safety	Check	1 week	Operator	PM-024
Build chamber lights	Check	6 months	Operator	PM-028
Build chamber	Clean	1 month	Operator	PM-030
Lens protection window	Clean	1 week	Operator	PM-035
Elevator position encoder brush	Replace	6 months	Operator	PM-036
Top rear of chamber (RenAM 500 Flex only)	Clean	6 months	Technician	PM-037
Powder loading arm (RenAM 500 Flex only)	Inspect	6 months	Operator	PM-038
Feed hopper lifting brackets (RenAM 500 Flex only)	Inspect	6 months	Operator	PM-039

9.4 Ancillary equipment preventative maintenance schedule

Equipment	Maintenance activity
SMC Pneumatics HRSH090-AF-40 chiller	Maintain in accordance with manufacturer's instructions **www.smcpneumatics.com**
Ruwac NA7 ATEX vacuum cleaner	Maintain in accordance with manufacturer's instructions **www.ruwac.de**
Nabertherm N41/H furnace	Maintain in accordance with manufacturer's instructions **www.nabertherm.com**
Guyson Euroblast 4AM bead blaster	Maintain in accordance with manufacturer's instructions **www.guyson.co.uk**
Guyson C400 dust extractor	Maintain in accordance with manufacturer's instructions **www.guyson.co.uk**
Renishaw powder recovery system	Maintain in accordance with the Renishaw powder recovery system User guide (Renishaw part no. H-5800-4613)
Load hopper trolley	Maintain in accordance with the Renishaw load hopper trolley User guide (Renishaw part no. H-5800-4481)
Renishaw universal lifter	Maintain in accordance with the Renishaw universal lifter User guide

9.5 Preventative maintenance records

It is essential that records are made and kept of any and all maintenance that is carried out on your RenAM 500 series system. Good maintenance record keeping is essential to ensure that any modifications, repairs, system configuration modifications, etc, are known about. This can help with future upgrades, fault-finding, repairs, etc.

9.6 Preventative maintenance checklists

9.6.1 Weekly tasks

Equipment	Maintenance activity	Skill level	Task number	Completed Y/N?
RenAM 500 series system	Inspect	Operator	PM-001	
RenAM 500 series system	Clean	Operator	PM-002	
RenAM 500 series safety devices	Check	Operator	PM-003	
RenAM 500 series system hoses and coolant system	Check	Operator	PM-004	
Process room	Clean	Operator	PM-005	
Build chamber viewing window	Inspect	Operator	PM-006	
Top and bottom door seals	Check	Operator	PM-007	
Safety signs and laser safety labels	Inspect	Operator	PM-008	
User guide	Check	Operator	PM-009	
Powder flasks and large SafeChange filters	Check	Operator	PM-010	
Chiller settings	Check	Operator	PM-011	
Vacuum pump oil level	Check	Operator	PM-012	
Inert gas supply safety	Check	Operator	PM-024	
Lens protection window	Clean	Operator	PM-035	

9.6.2 Monthly tasks

Equipment	Maintenance activity	Skill level	Task number	Completed Y/N?
Elevator position encoder and reading strip	Clean	Operator	PM-013	
Vacuum pump gas ballast valve filter	Check	Operator	PM-015	
Build chamber	Clean	Operator	PM-030	

9.6.3 Six-monthly tasks

Equipment	Maintenance activity	Skill level	Task number	Completed Y/N?
Metal powder safety	Check	Operator	PM-023	
Build chamber lights	Check	Operator	PM-028	
Elevator position encoder brush	Replace	Operator	PM-036	
Top rear of chamber (RenAM 500 Flex only)	Clean	Technician	PM-037	
Powder loading arm (RenAM 500 Flex only)	Inspect	Operator	PM-038	
Feed hopper lifting brackets (RenAM 500 Flex only)	Inspect	Operator	PM-039	

10. Preventative maintenance tasks

The aim of this chapter is to describe, in the form of a method statement, the preventative maintenance tasks that must be carried out on the RenAM 500 series system.

The list of preventative maintenance tasks and the frequency at which they must be carried out is contained in Chapter 10, “Preventative maintenance schedule”.

Preventative maintenance tasks are listed and numbered by skill type. Operator preventative maintenance tasks are prefixed with “PM” followed by a number, for example “PM-001”. Operator preventative maintenance tasks can be carried out by a trained operator, technician or service engineer.

WARNING: The safety integrity level (SIL) rated oxygen sensors must be replaced/exchanged at 12-month intervals to maintain their SIL rating. This is normally carried out by a service engineer on a service visit.

10.1 PM-001 – RenAM 500 series system – Inspect

1. Ensure the RenAM 500 series is powered down.
2. Inspect the exterior of the RenAM 500 series system.
3. Ensure there are no fluid leaks from the RenAM 500 series or chiller. Clean up any fluid leaks.
4. Ensure all doors are closed, they fit correctly, the locks function correctly and they are free from damage or defect.
5. Ensure the system controls and displays are free from damage or defect.
6. Ensure there are no obvious signs of damage or defect to the RenAM 500 series system.
7. Check that the area around the RenAM 500 series is tidy and free of obstructions and that emergency exits are clear.
8. For advice on repairs or to schedule a repair visit, contact Renishaw AMPD Service (see section 12, “Customer support”).
9. Record the completion of the maintenance task in the maintenance records.

10.2 PM-002 – RenAM 500 series system – Clean

1. Ensure the RenAM 500 series is powered down.
2. Using a damp cloth and non-abrasive mild detergent, wipe down the exterior of the RenAM 500 series system and remove all traces of dirt.

   NOTE: Do not use excessive amounts of mild detergent. Do not apply detergent to power cables, the touch screen control panel, the interior of the electrical enclosure or any other electrical equipment.

3. Using a screen cleaning wipe, clean the touch screen control panel and remove any dirt.
4. For advice on repairs or to schedule a repair visit, contact Renishaw AMPD Service (see section 12, “Customer support”).
5. Record the completion of the maintenance task in the maintenance records.

10.3 PM-003 – RenAM 500 series safety devices – Check

1. Ensure the RenAM 500 series system is powered up and in an operational condition, but is not building parts.
2. On the touch screen control panel, select Open Door. The Unlock Top Door button will appear on the touch screen control panel.
3. Select the Unlock Top Door button, press the blue Reset button and open the top door.
4. Ensure a “Door open” alert appears on-screen and then disappears.
5. Check the Alerts log and ensure the “Door open” alert is present.
6. After 30 minutes, on the System Status Atmosphere pane, check that the Chamber Pressure is zero. Check that the Chamber Oxygen, Process Oxygen, Silo Oxygen and Exhaust Oxygen levels are greater than 170 000 ppm.
7. Ensure the RenAM 500 series system is powered up and in an operational condition, but is not building parts.
8. Using a glovebox door key, open the glovebox door.
9. Ensure a “Glovebox door open” alert appears on-screen and then disappears.
10. Check the Alerts log and ensure the “Glovebox door open” alert is present.
11. Ensure the RenAM 500 series system is powered up, in an operational condition but is not building parts.
12. Operate an Emergency stop on the system.
13. Ensure an “Emergency stop activated” alert appears on-screen and then disappears.
14. Check the Alerts log and ensure the “Emergency stop activated” alert is present.

15. Reset the Emergency stop.

16. Ensure the RenAM 500 series system is returned to the state it was in before the task started.

17. For advice on repairs or to schedule a repair visit, contact Renishaw AMPD Service (see section 12, “Customer support”).

18. Record the completion of the maintenance task in the maintenance records.

10.4 PM-004 – RenAM 500 series system hoses and coolant system – Check

PM-004-01 – System hoses – Check

1. Ensure the RenAM 500 series is powered down.

2. Open the front left-hand and rear right-hand cupboard doors.

3. Examine the system hoses and pipework for leaks and signs of leakage.

4. Ensure there are no nanoparticle deposits.

5. Ensure there are no metal powder deposits.

6. Clean any leaks or deposits.

7. Close and secure the front left-hand and rear right-hand cupboard doors

PM-004-02 – Coolant system – Check

1. Inspect all cooling pipes and connections to and from the RenAM 500 series system.

2. Ensure there are no leaks or drips from any of the pipes and connections.

3. Ensure the pipes and connections are free of damage and deformation.

4. Check the chiller fluid level is between the L and H marks. Top up the fluid level as necessary in accordance with section 8.4.1, “OT-001 – Chiller fluid level – Top up”.

PM-004-03 – Post completion

1. For advice on repairs or to schedule a repair visit, contact Renishaw AM Service (see section 12, “Customer support”).

2. Record the completion of the maintenance task in the maintenance records.

10.5 PM-005 – Process room – Clean

WARNING: Before starting this task, ensure you are wearing the correct PPE for working with metal powder: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

NOTE: Renishaw recommends that full-length clothing is made from non-static-generating fabric such as cotton (avoid wool and synthetic fabrics). Avoid turn-ups or pockets that may trap powder. Refer to NFPA 484 for details.

1. Clean the process room where the RenAM 500 series is located and remove all traces of metal powder.
2. Deposits of powder should be cleaned up by gentle sweeping using a non-synthetic non-static-generating brush into a metal receptacle (anti-static dustpan and brush).
3. Use an ATEX rated vacuum cleaner to clean any difficult to reach parts of the process room.

   WARNING: Always operate and maintain the ATEX vacuum cleaner in accordance with the manufacturer's instructions. Refer to the manufacturer's website **www.ruwac.de** for details.
4. Dispose of any powder in accordance with local rules and procedures.
5. Check that the process room is clean and free from any metal powder. Check that the process room is tidy. Ensure all access and egress points, especially emergency exits, are clear and free of obstructions.
6. For advice on repairs or to schedule a repair visit, contact Renishaw AM Service (see section 12, "Customer support").
7. Record the completion of the maintenance task in the maintenance records.

10.6 PM-006 – Build chamber viewing window – Inspect

1. Open the top door and inspect the inside of the build chamber viewing window.
2. Ensure the window is clean, free of scratches, cracks, damage or defects.
3. If the window is dirty, clean it with IPA and a disposable cloth.
4. For advice on repairs or to schedule a repair visit, contact Renishaw AM Service (see section 12, "Customer support").
5. Record the completion of the maintenance task in the maintenance records.

10.7 PM-007 – Top and bottom door seals – Check

WARNING: Before starting this task, ensure you are wearing the correct PPE for working with metal powder: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

1. Check the top and bottom door seals and ensure there is no powder trapped in the seals.
2. Remove any trapped powder with the ATEX vacuum cleaner. The ATEX vacuum cleaner must be operated in accordance with the instructions supplied by the equipment manufacturer. Wipe down the seal with IPA and a disposable cloth.
3. Check the top and bottom seals are free from damage and deformation.
4. Report any damaged or deformed seals.
5. For advice on repairs or to schedule a repair visit, contact Renishaw AM Service (see section 12.1, “Contact details”).
6. Record the completion of the maintenance task in the maintenance records.

10.8 PM-008 – Safety signs and laser safety labels – Inspect

1. Inspect the safety signs in the process room.
2. Ensure the safety signs are present, clean and legible. If a sign is dirty, clean it with a suitable cleaning product. If a sign is missing or illegible, replace it with a new sign. See section 3.1.2, “Safety signs and laser safety labels” for details of the signs and their location on the RenAM 500 series system.
3. Inspect the laser safety labels fitted to the RenAM 500 series.
4. Ensure the laser safety labels are present, clean and legible. If a label is dirty, clean it with a suitable cleaning product. If a label is missing or illegible, replace it with a new label. See section 3.1.2, “Safety signs and laser safety labels”, for details of the labels and their location on the RenAM 500 series system.
5. For advice on repairs or to schedule a repair visit, contact Renishaw AM Service (see section 12, “Customer support”).
6. Record the completion of the maintenance task in the maintenance records.

10.9 PM-009 – User guide – Check

1. Check there is a copy of the RenAM 500 series additive manufacturing system user guide (Renishaw part no. H-5800-3693) present near the RenAM 500 series system.

2. Check that it is in good condition and the pages are legible.

3. If the user guide is missing, damaged or illegible, contact Renishaw for a replacement. For more information, see section 12.1, “Contact details”.

4. For advice on repairs or to schedule a repair visit, contact Renishaw AM Service. For more information, see section 12, “Customer support”.

5. Record the completion of the maintenance task in the maintenance records.

10.10 PM-010 – Powder flasks and large SafeChange™ filters – Check

WARNING: Before starting this task, ensure you are wearing the correct PPE for working with metal powder: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

PM-010-01 – Powder flasks

1. Check the powder flasks, oversized particle flasks, cyclone filter particle collection flasks, overflow flasks (RenAM 500 Flex only), KF flange isolation valves and KF flange quick-release clamps used on your RenAM 500 series for damage, defects and operation.

2. Ensure the powder flasks, oversized particle flasks, overflow flasks (RenAM 500 Flex only) and cyclone filter particle collection flasks are free of damage and defect. Consider replacing any damaged or defective flasks.

3. Ensure isolation valves operate smoothly and latch in the open and closed positions. As far as is practical, check that valves seal in the closed position and that there are no gaps between the edge of the butterfly valve and the internal surface of the valve.

4. Ensure quick-release clamps are free from damage or defect and operate correctly. Consider replacing any damaged, defective or non-operational clamps.

5. Ensure the filter support plates are present, and free from damage and defect.

PM-010-02 – Large SafeChange™ filters

CAUTION: This procedure does not apply to RenAM 500 series systems equipped with the external Long-Life Filter system. For more information, see section 7.10, “Long-Life Filter (optional)”.

1. The RenAM 500 series is fitted with two large SafeChange filters. There are two isolation valves on each large SafeChange filter assembly, one on the system outlet (upper) and one on the filter outlet (lower).
2. With the large SafeChange filter removed from the RenAM 500 series system, inspect the isolation valves.
3. Ensure the handles are present, the handle locking mechanism works correctly and the valve operates smoothly through 90° of operation.
4. Listen for a grinding noise coming from the isolation valve; this indicates the presence of metal powder in the valve.
5. If required, remove the valve from the large SafeChange filter, repair or rectify as necessary, and refit the valve. More seriously defective valves may need to be removed, discarded and replaced with new valves.

PM-010-03 – Post completion

1. For advice on repairs or to schedule a repair visit, contact Renishaw AM Service (see section 12, “Customer support”).
2. Record the completion of the maintenance task in the maintenance records.

10.11 PM-011 – Chiller settings – Check

1. If the chiller is powered up and running, proceed to step 5. If it is not, continue to step 2.
2. Ensure that the SMC Pneumatics model HRSH090-AF-40 chiller mains power lead is connected to a suitable power supply.
3. On the rear of the chiller, operate the miniature circuit breaker (MCB) and move it to the On position – up.
4. On the chiller front control panel, press the Run/Stop button once to switch on the pump. The Run light will illuminate.
5. The SV (Set Value) temperature should display 20 °C (68 °F). If the SV temperature is not 20 °C (68°F), use the up and down keys and set the temperature to 20 °C (68 °F).
6. The PV temperature should display at 20 °C (68 °F). If the displayed temperature is not 20 °C (68 °F), refer to the SMC chiller operation manual for information about the action to take.
7. For advice on repairs or to schedule a repair visit, contact Renishaw AM Service (see section 12, “Customer support”).
8. Record the completion of the maintenance task in the maintenance records.

10.12 PM-012 – Vacuum pump oil level – Check

1. Open the rear door.
2. On the vacuum pump, check the oil level.
3. Ensure the oil level is between the MIN and MAX marks on the sight gauge.
4. If the oil level is below the MIN mark on the sight gauge, top up with oil (type LVO120) until the oil level is between the MIN and MAX mark.
5. For advice on repairs or to schedule a repair visit, contact Renishaw AM Service (see section 12, “Customer support”).
6. Record the completion of the maintenance task in the maintenance records.

10.13 PM-013 – Elevator position encoder and reading strip – Clean

This task outlines the procedure for inspecting and cleaning the position encoder and reading strip of the elevator. It ensures that the encoder and the reading strip are thoroughly cleaned and free from any potential contaminants that could affect its performance.

The following materials and equipment are required:

a. IPA Cleaning fluid or IPA wipes

b. Lint-free disposable cloth

c. The following PPE:


Wear eye protection


Wear respirator


Wear protective gloves


Wear protective clothing


Wear protective footwear

General safety advice

CAUTION: Always make sure that your hands and gloves are clean. You must change your gloves after you handle or touch any parts, materials, or bodies that could potentially contaminate the clean surface. Contaminants (such as oils, greases, fibres, dust, adhesives, fingerprints etc.) on the surface of your gloves could transfer to clean surfaces. This becomes particularly important when you use solvents and cleaning fluids, as they could potentially dissolve the contaminants and transfer them to clean surfaces when they evaporate.

CAUTION: All cleaning materials must be kept clean and stored in appropriate packaging in a clean environment.

Procedure

1. Clean the build chamber. For more information, see section 8.3.7, “PB-005 – Build chamber – Clean”.
2. Clean the lower chamber. For more information, see section 8.3.8, “PB-007 – Lower chamber – Clean”.
3. Log into RenAMP software using the operator touch screen control panel. For more information, see section 8.1.8, “AB-006 – RenAM 500 series system – Log in”
4. Click ‘Chamber Setup’ from the RenAMP home screen.
5. Click ‘Send Recoater to Rear of Chamber’ button from the maximised view of the ‘Recoater’ pane.
6. From the ‘Elevator’ pane, and click ‘Send Elevator to Bottom Position’ button to lower the elevator to its lowest position.

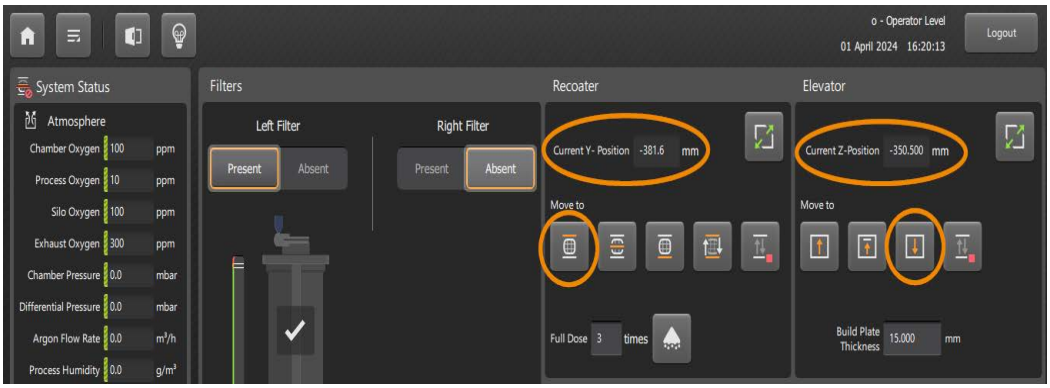


Figure 408 Configuring recoater and elevator position

7. Open the top and bottom doors using RenAMP and press the blue ‘Reset’ button on the machine.



Figure 409 Unlocking top door

8. Locate the encoder in the bottom chamber and check the colour of the encoder state LED for the following indication.

Colour of encoder state LED	Indication
Blue	Optimal
Green	Acceptable
Amber	Warning encoder head is dirty or slightly out of position
Red	Encoder is very dirty or out of position

9. Clean the encoder strip with IPA and a clean lint-free cloth (or IPA wipes) until there are no visible signs of dirt or deposits.

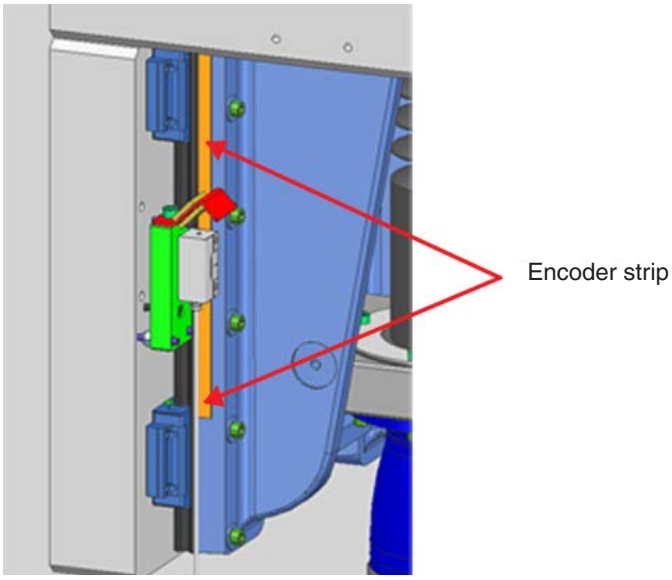


Figure 410 Encoder strip location

10. Apply IPA to another lint-free cloth, then slowly insert it between the encoder readhead and the encoder strip to clean the strip area.

NOTE: When you place a lint-free cloth or IPA wipes between the encoder readhead and encoder strip, the encoder light might turn red. Once you remove the tissue or cloth, the encoder light should change from red to blue or green.

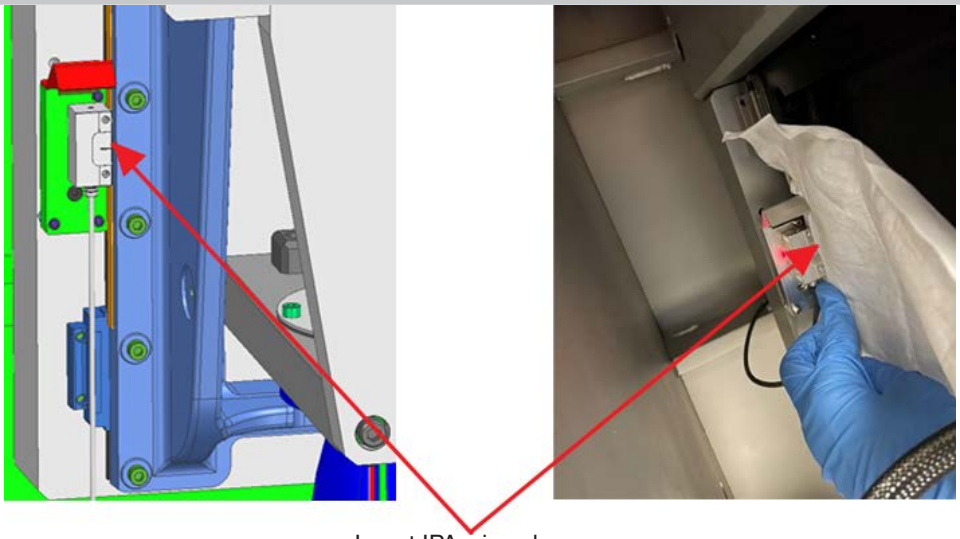


Figure 411 Cleaning the encoder strip

11. As the encoder breaks contact with the strip while cleaning the area between the encoder readhead and the encoder strip, the machine triggers three alerts: Elevator Servo Alarm, Elevator Servo Error, and Z-Axis Drive Error 51.

NOTE: Power cycle the machine to reset the above error messages.

12. Power down the machine. For more information, see section 8.3.11, “PB-010 – RenAM 500 series system – Power down”.

13. Keep the machine switched off for 5 minutes and then power it up. For more information, see section 8.1.7, “AB-005 – RenAM 500 series system – Power up”.

14. Make sure that the encoder state LED displays either a blue or green colour.

15. Close the top and bottom doors and press the blue ‘Reset’ button on the machine.

16. From the RenAMP home screen, click the ‘Chamber Setup’, then select the ‘Send elevator to top position’ button in the ‘Elevator’ pane to drive the elevator to its top position.

NOTE: Power cycle the machine to reset the error messages.

10.14 PM-015 – Vacuum pump gas ballast valve filter – Check

1. Check the cleanliness of the gas ballast valve filter.
2. If the filter is dirty, it is no longer functioning correctly and must be replaced.
3. For advice on repairs or to schedule a repair visit, contact Renishaw AMPD Service (see section 12, “Customer support”).
4. Record the completion of the maintenance task in the maintenance records.

10.15 PM-023 – Metal powder safety – Check

WARNING: Before starting this task, ensure you are wearing the correct PPE for working with metal powder: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

1. Check the metal powder storage areas, powder handling areas and process room, ensuring there are no accumulations of powder.
2. Pay particular attention to difficult to reach areas including around light fittings, ceiling tiles, underneath the RenAM 500 series system, trunking, ducting, flooring, furniture, etc.
3. Accumulations of powder should be cleaned up by gentle sweeping using a non-synthetic non-static-generating brush into a metal receptacle (anti-static dustpan and brush).
4. Use an ATEX rated vacuum cleaner to clean any difficult to reach parts.

   WARNING: Always operate and maintain the ATEX vacuum cleaner in accordance with the manufacturer’s instructions. Refer to the manufacturer’s website **www.ruwac.de** for details.
5. Dispose of any collected powder in accordance with local rules and procedures.
6. Check that metal powder is being stored correctly in line with applicable safety data sheets, the metal powder supplier’s recommendations, applicable local rules and legislation.
7. For advice on repairs or to schedule a repair visit, contact Renishaw AMPD Service (see section 12, “Customer support”).
8. Record the completion of the maintenance task in the maintenance records.

10.16 PM-024 – Inert gas supply safety – Check

1. Check the argon gas supply and gas hoses and pipework that supply the RenAM 500 series with argon.
2. Ensure all hoses and pipework are free of damage and deformation.
3. Turn on the gas supply to the RenAM 500 series and listen for leaks from the hoses and pipework. Pay particular attention to joints and connections.
4. If using bottled gas, check that the gas bottle is securely fastened and cannot fall over.
5. Ensure all hoses and pipework are clear of walkways and do not cause an obstruction. Relocate any hoses and pipework causing an obstruction.
6. For advice on repairs or to schedule a repair visit, contact Renishaw AM Service (see section 12, “Customer support”).
7. Record the completion of the maintenance task in the maintenance records.

10.17 PM-028 – Build chamber lights – Check

1. Power up the RenAM 500 series system.
2. Ensure the LED lights in the left-hand and right-hand sides of the build chamber are all illuminated.
3. Look through the build chamber viewing window, and ensure the LED lights are bright enough to illuminate the build chamber.

   WARNING: Do not stare at the LED light assembly, as it may be harmful to the eyes.

4. Clean the glass window over the lights, if necessary, using IPA and a disposable cloth.
5. For advice on repairs or to schedule a repair visit, contact Renishaw AMPD Service (see section 12, “Customer support”).
6. Record the completion of the maintenance task in the maintenance records.

10.18 PM-030 – Build chamber – Clean

WARNING: Before starting this task, ensure you are wearing the correct PPE for working with metal powder: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

1. In accordance with the maintenance schedule, the build chamber requires additional cleaning to that carried out in section 8.3.7, “PB-005 – Build chamber – Clean” after a build has completed. The additional cleaning is specified below.
2. Using the touch screen control panel, move the recoater to its mid-position.
3. Open the top door.
4. Using a hexagon key, remove the lens protection window and camera windows.
5. The build chamber liner is secured by four screws – two at the top and two at the bottom on the front of the liner. Remove the four screws and set them aside for reuse.

   WARNING: Do not operate the RenAM 500 series system with the build chamber liner removed.

6. Remove the build chamber liner by sliding it forwards and out.
7. Inspect the area behind the build chamber liner for any loose powder or condensate.
8. If no loose powder or condensate is found, proceed to step 11.

   NOTE: If no metal powder, condensate or dirt is found when carrying out this task, consider reducing the frequency at which this task is carried out.

9. If loose powder or condensate is present, using an ATEX vacuum cleaner and suitable attachments, clean the area behind the build chamber liner and the drive mechanism, paying particular attention to the drive belts.
10. Clean the inside and outside of the build chamber liner using a disposable cloth and IPA.
11. Using a disposable cloth and IPA, clean the drive belts, pulleys, guide rails and arms.
12. Using the ATEX vacuum cleaner and a non-static-generating long-handled brush, clean any loose powder from the manifolds.
13. Refit the build chamber liner and secure with four screws.
14. Refit the lens protection window and camera windows, and secure with the screws removed during disassembly. Torque tighten the lens protection window and camera window fasteners to 1.8 Nm (1.3 lb/ft).
15. Close the top door.

16. On the touch screen control panel, from the Home page select Chamber setup. From Chamber Setup, select the Elevator maximise button. From the maximised view of the Elevator pane, select Send elevator to bottom position.

17. Open the top door.

18. Using an ATEX vacuum cleaner, clean any loose powder from inside the build volume, paying particular attention to the gap around the edge of the elevator.

19. Using IPA and a clean disposable cloth, wipe down the inside of the build volume to remove all traces of metal powder, dirt or condensate.

20. Close the top door.

21. On the touch screen control panel, from the Home page select Chamber Setup. From Chamber setup, select the Elevator maximise button. From the maximised view of the Elevator pane, select Send elevator to top position.

22. For advice on repairs or to schedule a repair visit, contact Renishaw AMPD Service (see section 12, “Customer support”).

23. Record the completion of the maintenance task in the maintenance records.

10.19 PM-035 – Lens protection window – Clean

This task gives the procedure for inspecting and removing both light and heavy dirt from the lens protection window to prevent a reduction in laser power.

NOTE: Regularly inspect the lens protection assembly. Over time, the lens protection assembly will need cleaning, may degrade, and will require replacement to maintain system performance and part quality. Carefully inspecting and cleaning the lens protection assembly will significantly enhance the lifespan of the window. We recommend inspecting and cleaning the lens protection assembly to ensure maximum longevity.

The following equipment is required:

a. Cleaning kit (A-6521-4150)

- Nitrile gloves.
- Plastic tweezers.
- Sticky swabs.
- Manual blower.
- Lens tissue – small
- Lens tissue – large
- IPA cleaning wipes (for general machine cleaning only).

b. LED torch for inspection (Typically 800 lumens or above)


Wear eye protection


Wear respirator


Wear protective gloves


Wear protective clothing


Wear protective footwear

General safety advice

WARNING: The light from the LED torch is very bright. Avoid staring at the direct or reflected light during the optics inspection to prevent temporary or permanent visual impairment.

CAUTION: The lens protection window is made from fused silica and has an optical coating. It is prone to scratches if not handled properly.

CAUTION: The surface of the window must not be touched unless it is to be cleaned according to the defined procedure detailed within this task.

CAUTION: Renishaw recommends that you clean the lens protection system while it is installed on the RenAM 500 machine because removing the lens protection assembly exposes the system optics to the environment.

CAUTION: Always make sure that your hands and gloves are clean. You must change your gloves after you handle or touch any parts, materials, or bodies that could potentially contaminate them. Contaminants (such as oils, greases, fibres, dust, adhesives, fingerprints etc.) on the surface of your gloves could transfer to clean surfaces. This becomes particularly important when you use solvents and cleaning fluids, as they could potentially dissolve the contaminants and transfer them to clean surfaces when they evaporate.

CAUTION: All cleaning materials must be kept clean and stored in appropriate packaging in a clean environment.

Job set-up

1. Remove the metal powder from the build chamber. For more information, see section 8.3.5, “PB-003 – Build chamber metal powder – Remove”.

2. Clean the build chamber. For more information, see section 10.18, “PM-030 – Build chamber – Clean”.

PM-035-01 – Lens protection window – Inspect

Examine the lens protection window for signs of scratches, cracks, dust, contamination, smudges, metallic particles, or any signs of burning before cleaning it, following the steps given below.

1. Switch off the chamber lights.

2. Hold the LED torch and point it at an angle towards the lens protection window.

NOTE: When inspected with a high-power torch, very fine curved lines may be seen in a clean lens protection window. These lines result from the manufacturing process of the glass window (specifically, polishing) and are considered normal and acceptable.

3. Visually examine the lens protection window for signs of scratches, cracks, dust, contamination, smudges, or metallic particles, or any signs of burning.

CAUTION: The lens protection window must be free from contamination such as oils, greases, films, condensate, fingerprints, and smudges. Additionally, it should be free from metallic particles and any mechanical damage, including prominent scratches and digs. These contaminants can adversely affect laser beam coupling efficiency and focus.

4. Replace the lens protection window, if it is damaged, such as being cracked, scratched, or showing signs of burning.

5. If the lens protection window shows signs of dust, contamination, smudges, or metallic particles, clean it as described in the following steps.

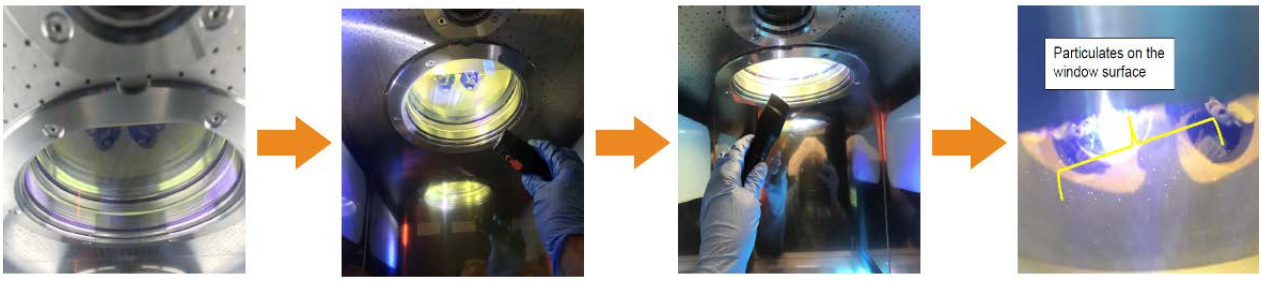


Figure 412 Inspecting lens protection window

PM-035-02 – Lens protection window – First stage cleaning

The first stage of cleaning is to remove any loose metallic particles using a manual blower or compressed gas.

1. Locate the position of the loose particles on the lens protection window using the LED torch.
2. Remove the loose particles using the manual blower.

   NOTE: Make sure that you keep the nozzle of the manual blower at least 50 mm (1.96 in) away from the surface of the lens protection window.

   CAUTION: Use the compressed gas only on the surface of the lens protection window. Do not use it to remove particulate contamination from the general chamber area.
3. If it is not possible to remove the particulate contamination with the manual blower, then use clean compressed gas. The compressed gas must be dry, clean and of high purity.
4. Repeat the procedure until all the loose particles on the lens protection window are removed.



Figure 413 Lens protection window – First stage cleaning

PM-035-03 – Lens protection window – Second stage cleaning

The second stage of cleaning intends to remove any metallic particles using a sticky swab.

1. Locate the position of the metallic particles on the lens protection window using the LED torch.

   NOTE: An LED torch can be a useful tool for identifying metallic particles. Metal particles will shine and reflect light when you use the torch.

2. Open the plastic case containing the sticky swabs.

3. Use a clean plastic tweezer to hold the lower end of a clean sticky swab and remove it from the plastic container.

   NOTE: Make sure to keep the gel tip of the sticky swab clean, in the air, and prevent it from touching any surface other than the lens protection window where it will be used for cleaning.

4. Hold the sticky swab vertically and position the gel tip directly over the metallic particle located on the lens protection window.

   CAUTION: Avoid applying too much pressure, rotating, or bending the swab stick, as it could potentially damage the surface of the lens protection window.

5. Apply light vertical pressure to push the gel tip onto the metallic particle.

6. Lower the sticky swab in a vertical orientation and inspect the gel tip to see if it has trapped the metallic particle.

7. Dispose of the sticky swab, which has trapped the metallic particle on its gel tip, without touching the lens protection window.

8. If additional metallic particulate contamination is present on the surface of the lens protection window, repeat steps 1 to 7 and remove it using a new sticky swab.

9. Repeat the inspection procedure specified in section , “PM-035-01 – Lens protection window – Inspect” to ensure that all loose and heavy metallic particles are removed from the surface of the lens protection window.

   CAUTION: Always make sure that the lens protection window surface is free of metallic particles before you attempt to wipe it.

10. If metallic particulates are still present, repeat the inspection and cleaning processes before continuing with the following cleaning steps.

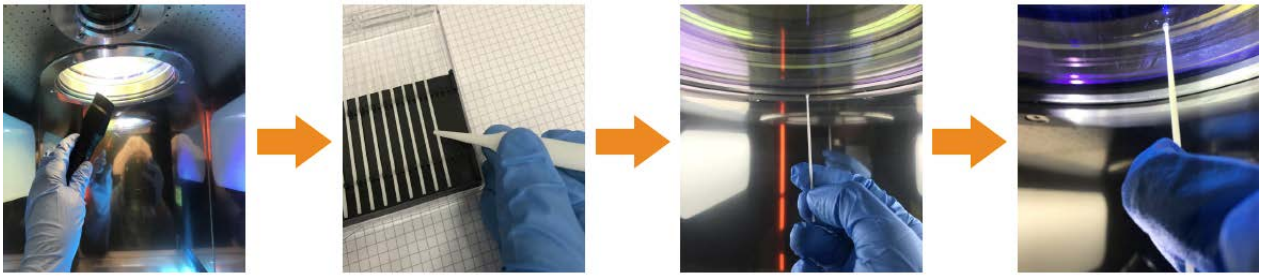


Figure 414 Lens protection window – Second stage cleaning

PM-035-04 – Lens protection window – Third stage cleaning

The third stage of cleaning removes surface residues, smears, films of contamination, etc.

CAUTION: The lens tissues described in the following section are packaged in a clean cardboard box sealed with adhesive tape. Dust from the cardboard and adhesive from the sealing tape may contaminate the gloves. In turn, the contaminated gloves could cause contamination of the lens protection window during the next stage of cleaning. It is important to use a new pair of gloves once the lens tissue package is opened. Alternatively, you can put on a new set of gloves over the first one.

CAUTION: You must only use the lens tissue specified in this task to wipe the surface of the lens protection window.

NOTE: Make sure that the lens tissues are clean and open the cardboard box containing the lens tissue only during the cleaning process. Close the box when it is not in use.

1. Take a large lens tissue and fold it across the long edge for six times until it measures approximately 40 mm × 25 mm (1.57 in × 0.98 in).

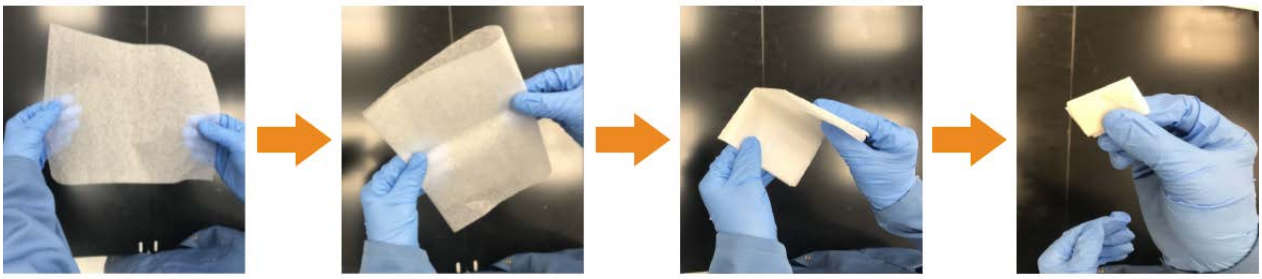


Figure 415 Folding the large lens tissue

2. Hold the bottom half of the folded lens tissue between your thumb and index finger.
3. Place the folded edge of the lens tissue against the interface edge between the lens protection window and the metal support.
4. Apply light pressure to the lens tissue and wipe around the edge of the glass-to-metal interface.

   NOTE: Ensure that the surface of the glove does not touch the lens protection window.

5. Remove the lens tissue and check for any signs of contamination.
6. Take a large new lens tissue and repeat steps 1 to 5 until the lens tissue appears visibly clean.

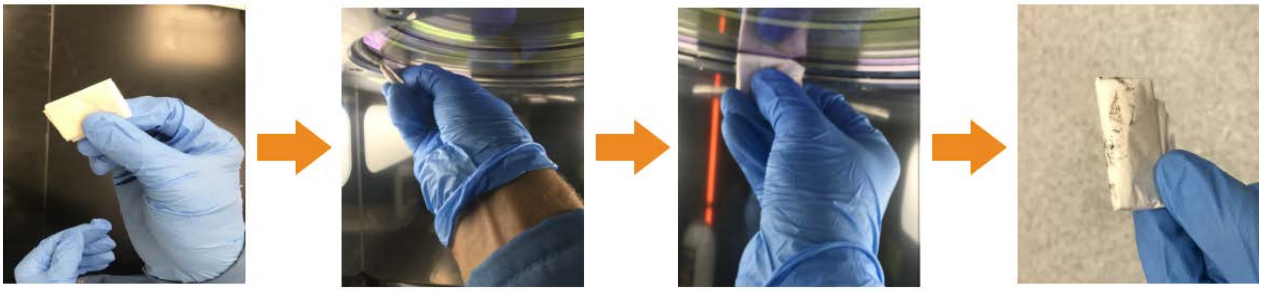


Figure 416 Cleaning the edge between the lens protection window and the metal support

PM-035-05 – Lens protection window – Fourth stage cleaning

The fourth stage of cleaning involves cleaning the lens protection window in a radial manner.

CAUTION: The lens tissues described in the following section are packaged in a clean cardboard box sealed with adhesive tape. Dust from the cardboard and adhesive from the sealing tape may contaminate the gloves. In turn, the contaminated gloves could cause contamination of the lens protection window during the next stage of cleaning. It is important to use a new pair of gloves once the lens tissues are opened. Alternatively, you can put on a new set of gloves over the first one.

NOTE: You must only use the lens tissue specified in this task to wipe the surface of the lens protection window.

1. Take a large lens tissue and fold it across the long edge for six times until it measures approximately 40 mm × 25 mm (1.57 in × 0.98 in).

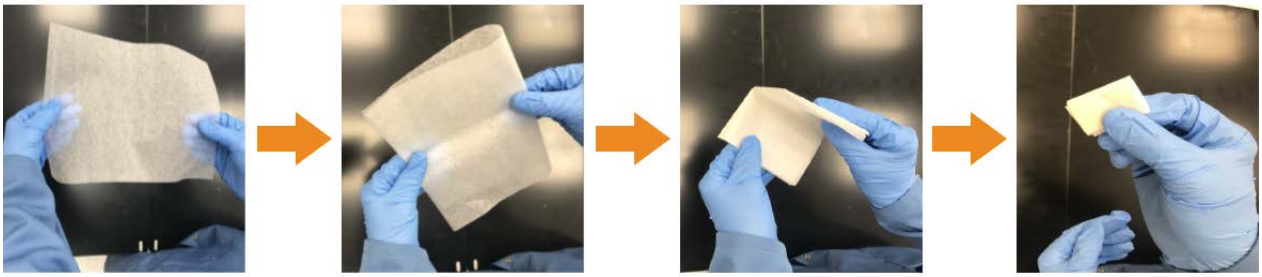


Figure 417 Folding the large lens tissue

2. Hold the bottom half of the folded lens tissue between your thumb and index finger.
3. Place the folded edge of the lens tissue against the centre of the lens protection window.
4. Apply light pressure to the lens tissue, and slowly wipe from the centre to the outside edge of the lens protection window.

   NOTE: Ensure that the surface of the glove does not touch the lens protection window.

5. Remove the lens tissue from the lens protection window, then turn the tissue inside out to expose a clean section.
6. Fold the lens tissue and hold it as described in step 1 and 2.
7. Place the folded edge of the lens tissue against the centre of the lens protection window.
8. Apply light pressure to the lens tissue, and slowly wipe from the centre to the outer edge of the lens protection window, focusing on the area adjacent to the previously cleaned section.
9. Discard the lens tissue and repeat steps 1 to 8 until the entire lens protection window surface has been wiped.

NOTE: The LED torch must be used during the cleaning to identify the areas have not been wiped.

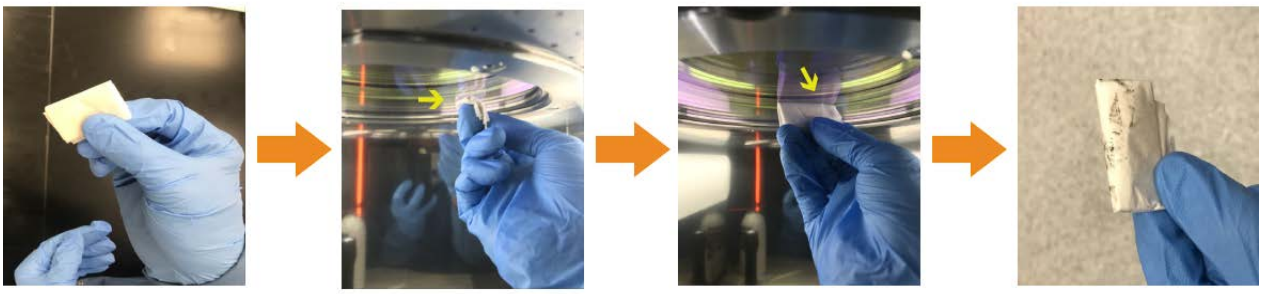


Figure 418 Cleaning the lens protection window in radial manner

M-035-05 – Lens protection window – Fifth stage cleaning

In the third cleaning step, the lens protection window is cleaned in a circular motion manner.

CAUTION: The lens tissues described in the following section are packaged in a clean cardboard box sealed with adhesive tape. Dust from the cardboard and adhesive from the sealing tape may contaminate the gloves. In turn, the contaminated gloves could cause contamination of the lens protection window during the next stage of cleaning. It is important to use a new pair of gloves once the lens tissues are opened. Alternatively, you can put on a new set of gloves over the first one.

NOTE: You must only use the lens tissue specified in this task to wipe the surface of the lens protection window.

1. Take a large lens tissue and fold it across the long edge for six times until it measures approximately 40 mm × 25 mm (1.57 in × 0.98 in).

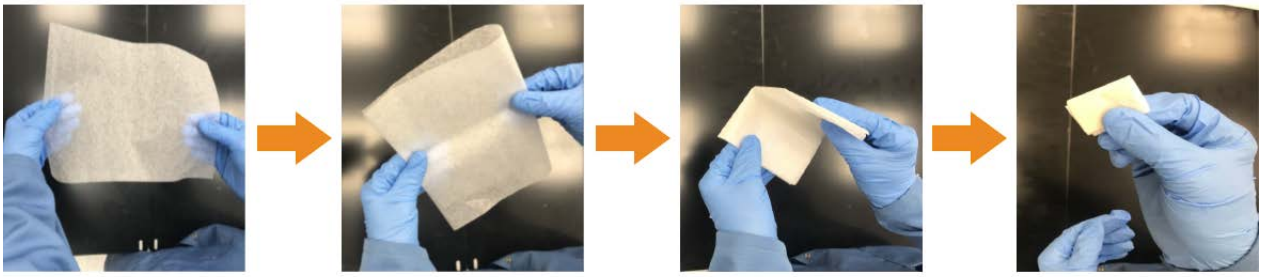


Figure 419 Folding the large lens tissue

2. Hold the bottom half of the folded lens tissue between your thumb and index finger.
3. Place the folded edge of the lens tissue against the centre of the lens protection window.
4. Apply light pressure to the lens tissue, then slowly wipe in a circular motion from the centre to the outer edge of the lens protection window.

   NOTE: Ensure that the surface of the glove does not touch the lens protection window.

5. Remove the lens tissue from the lens protection window, then turn the lens tissue inside out to expose a clean section.
6. Fold the lens tissue and hold it as described in steps 1 and 2.
7. Apply light pressure to the lens tissue, then slowly wipe in a circular motion from the centre to the outer edge of the lens protection window.

   NOTE: Ensure that the surface of the glove does not touch the lens protection window.

8. Discard the lens tissue.

NOTE: When you inspect the used lens tissue, it may look clean. However, you may have wiped and adsorbed the contamination onto the lens tissue's surface. Therefore, do not reuse the lens tissue, even if it looks clean.

9. Inspect the surface of the lens protection window for areas that have not been wiped clean using a high-power LED torch.

10. Repeat steps 1 to 9 until the lens protection window is visibly clean.

NOTE: When inspected with a high-power torch, very fine curved lines may be seen in a clean lens protection window. These lines result from the manufacturing process of the glass window (specifically, polishing) and are considered normal and acceptable.

11. Replace the lens protection window, if it is damaged, such as being cracked, scratched, or showing signs of burning.

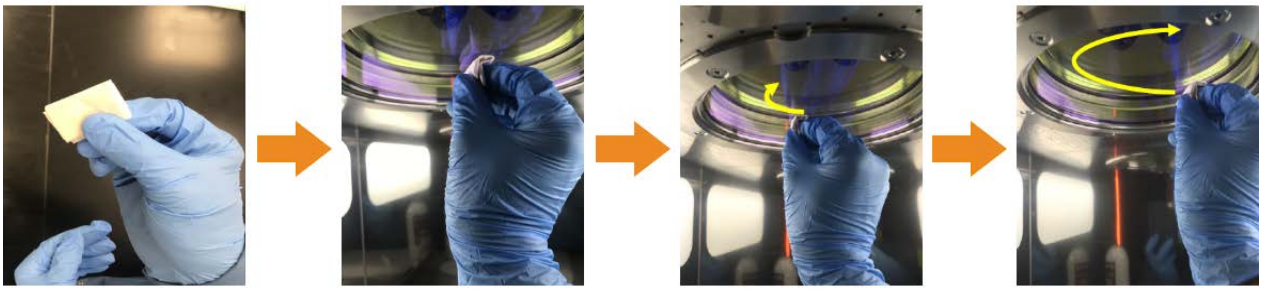


Figure 420 Cleaning the lens protection window in circular manner

PM-035-06 – Lens protection window – Examples of surface contamination

NOTE: In the following images of the lens protection window, some of the images were captured when the window was viewed in a Renishaw illuminated inspection jig. This highlights the entire surface of the window. The same defects will be detected using a high-power LED torch, however, the illuminated area will be smaller and the entire window will need to be scanned with the torch to allow inspection of the whole window.

Contamination – residues

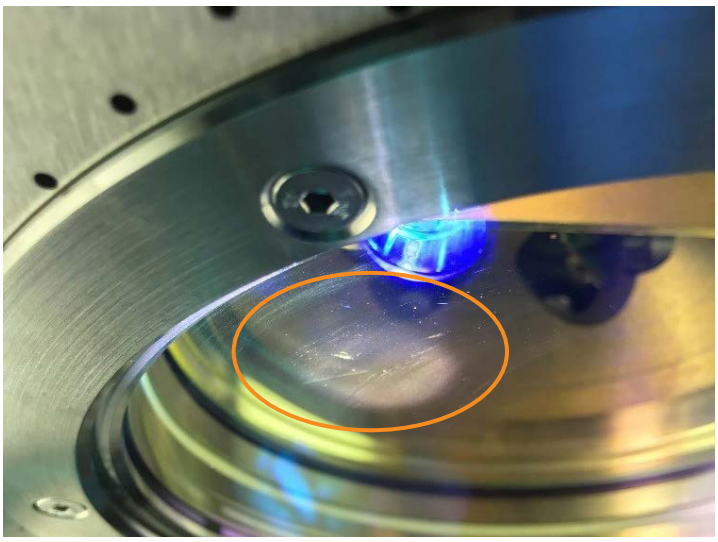


Figure 421 Condition of chamber window prior to cleaning – general surface residue and smearing visible

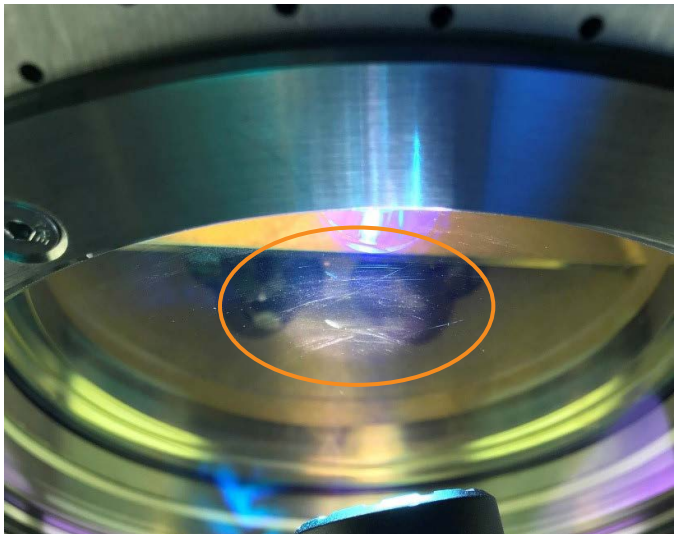


Figure 422 Condition of chamber window prior to cleaning – general surface residue and smearing visible



Figure 423 Condition of chamber window prior to cleaning – general surface residue and smearing visible

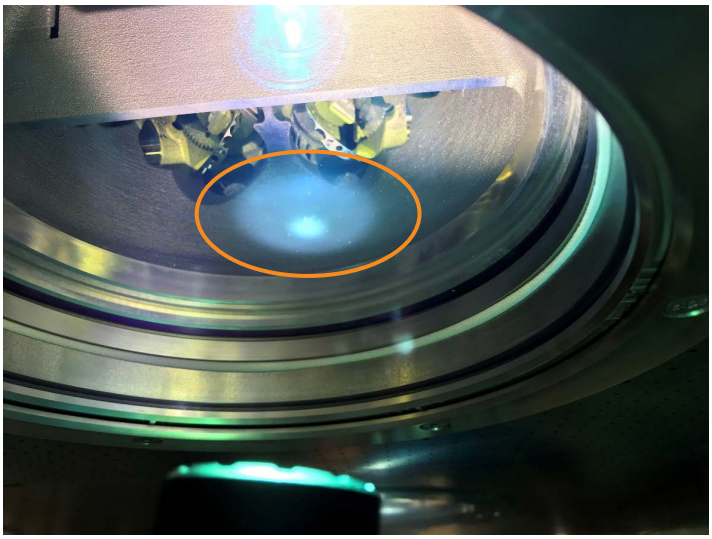


Figure 424 Dense spot of residue and a haze of contamination is uniformly spread over the window

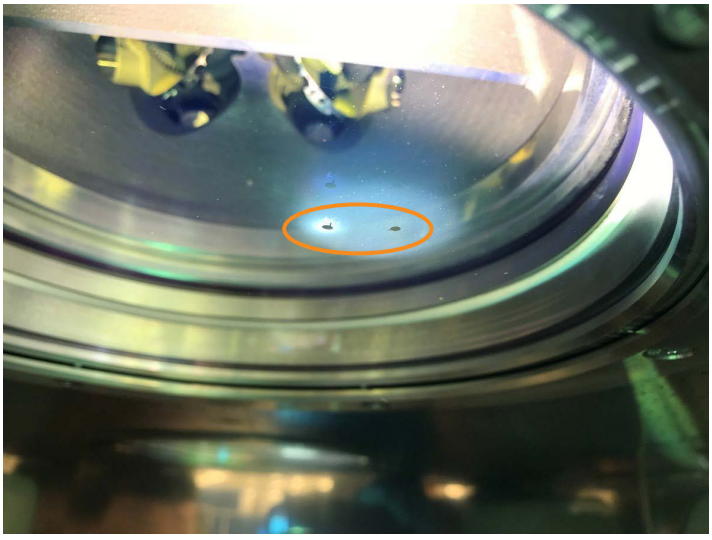


Figure 425 Residue wiped with a gel stick



Figure 426 Residue across the entire surface of the window

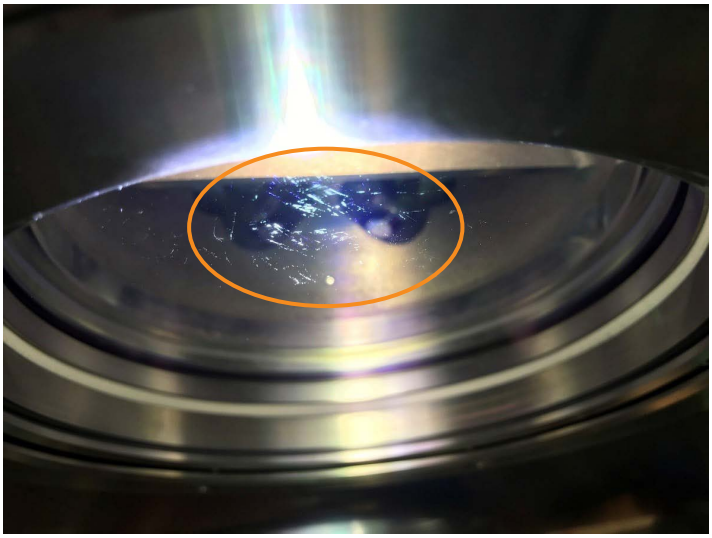


Figure 427 Contamination on the window surface – appears to be due to wiping

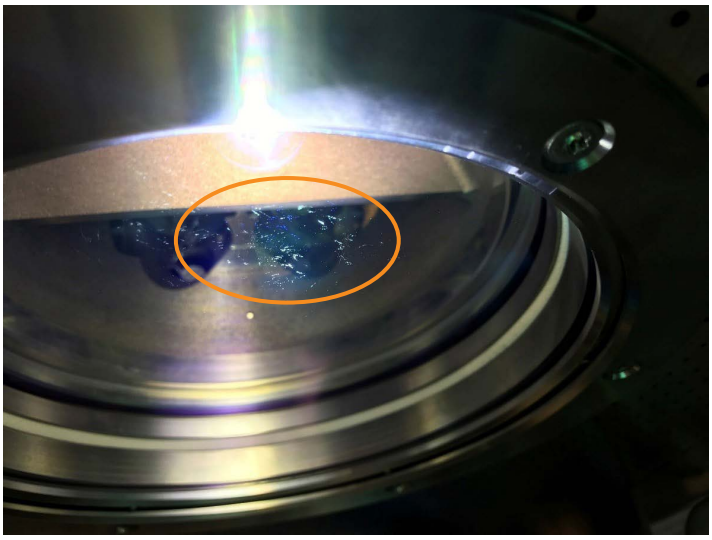


Figure 428 Contamination on the window surface – appears to be due to wiping

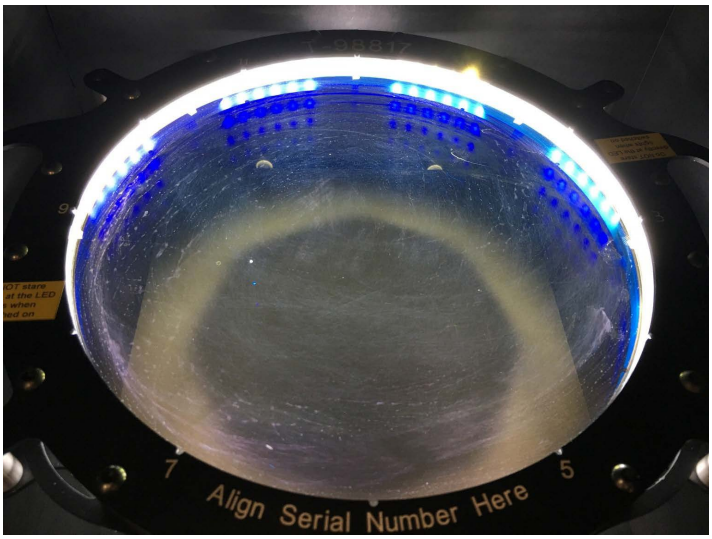


Figure 429 Residue across the entire surface of the window – appears to be due to wiping with a contaminated cloth



Figure 430 Smears across the centre of the window

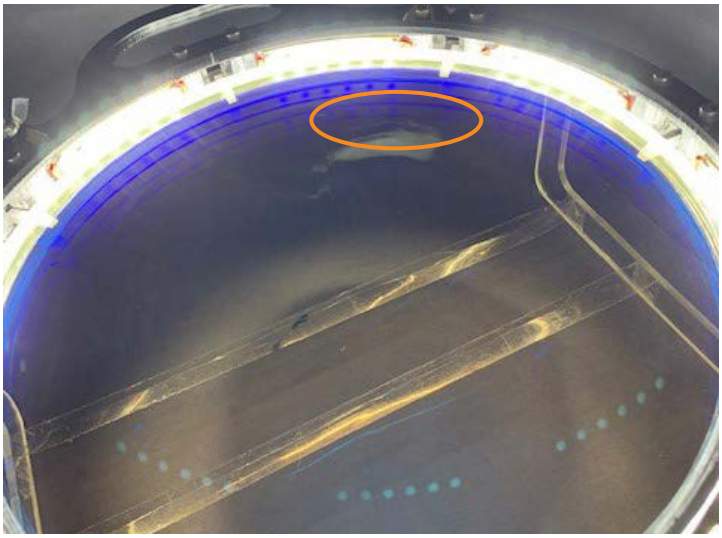


Figure 431 Residue at the edge of the window

Contamination – fingerprints and general contamination

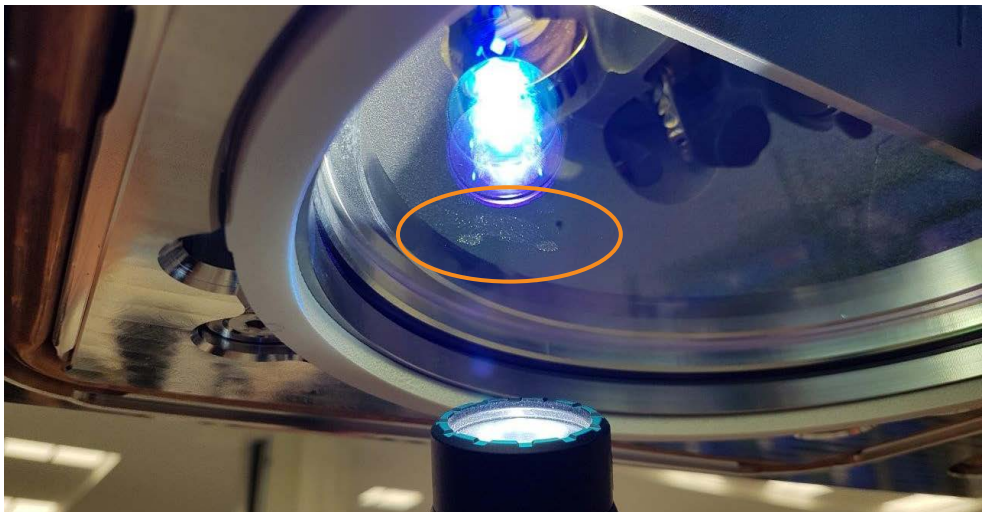


Figure 432 Fingerprints on the surface of the window

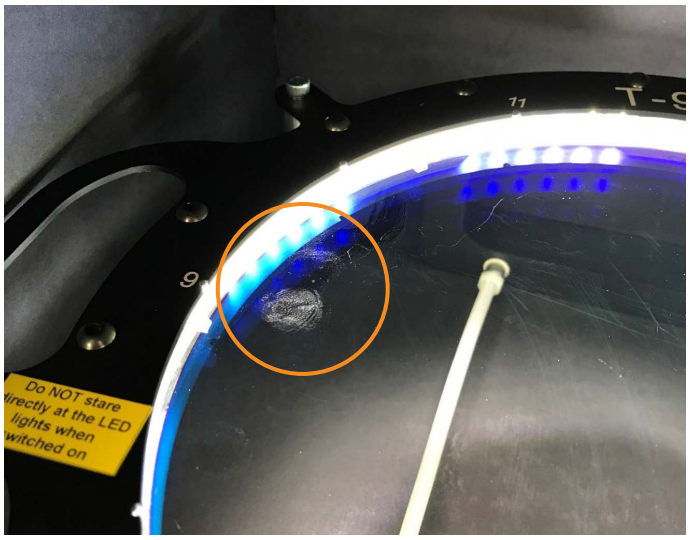


Figure 433 Fingerprints on the surface of the window

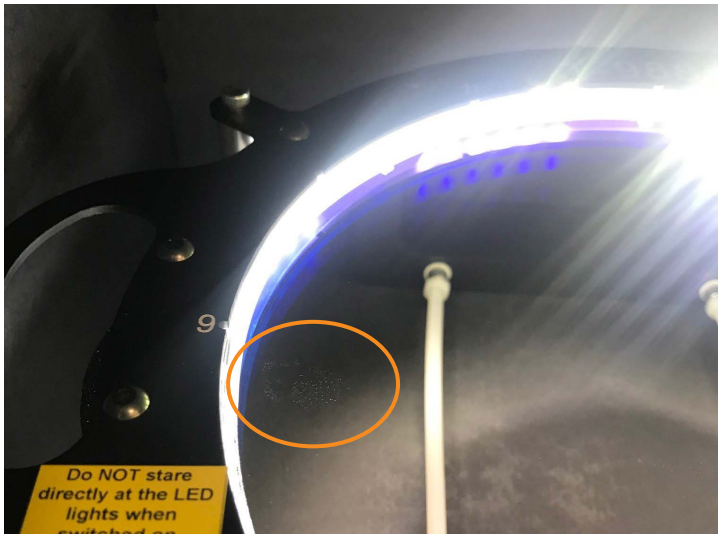


Figure 434 General light contamination on the surface of the window

Mechanical damage – digs and scratches



Figure 435 Multiple surface scratches

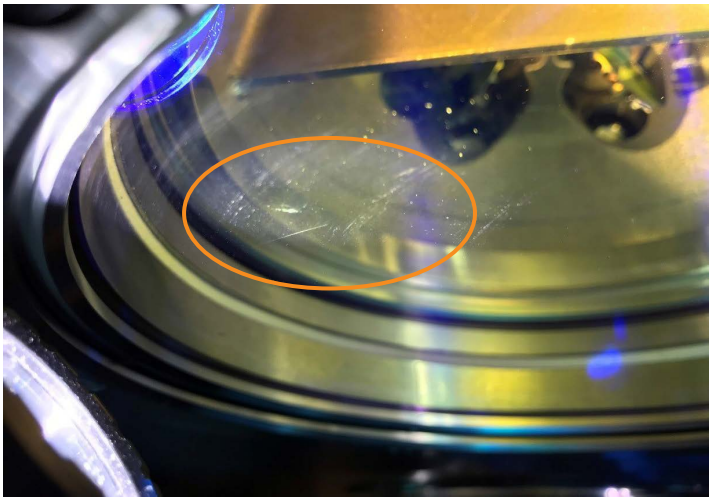


Figure 436 Condition of lens protection window prior to cleaning – surface contamination and possible mechanical damage to the window

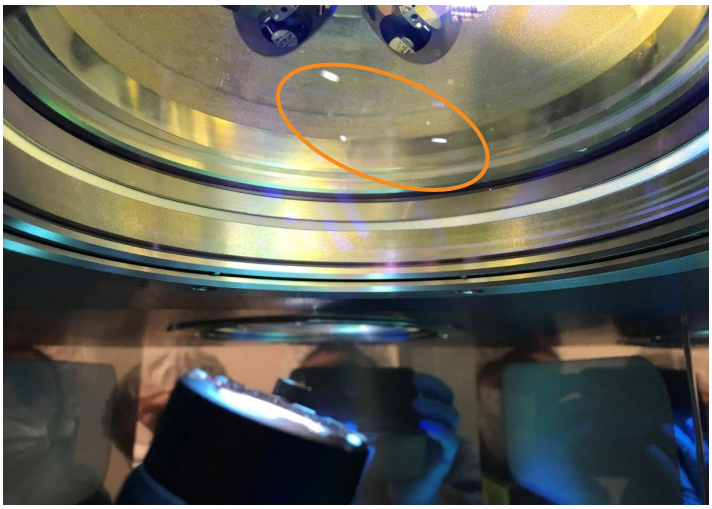


Figure 437 Condition of lens protection window after cleaning – mechanical damage is visible on the surface of the window

Dust and particles

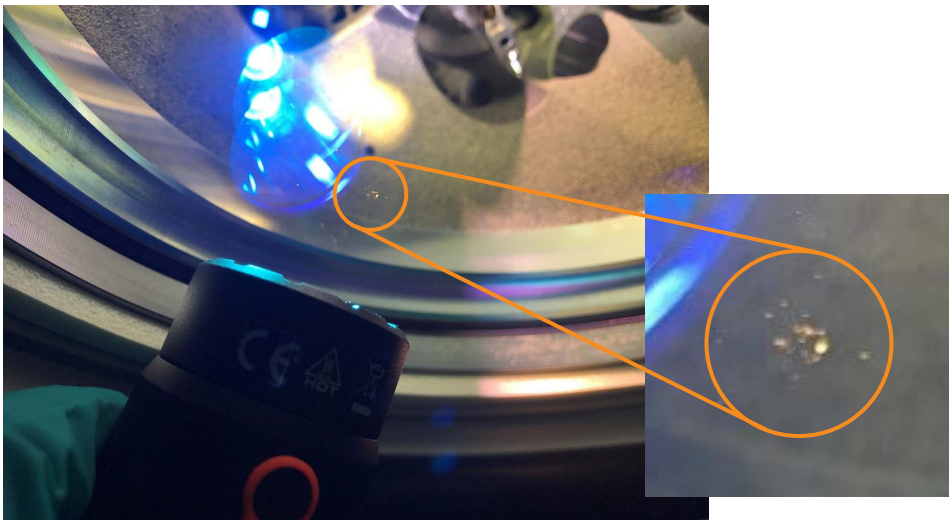


Figure 438 Small cluster of particles on the window surface



Figure 439 Excessive amount of dust and particles on the surface of the window



Figure 440 Excessive amount of dust and particles on the surface of the window

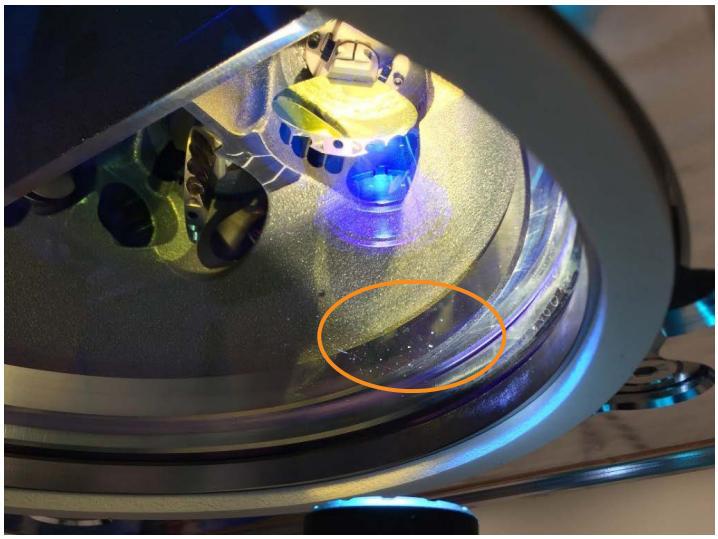


Figure 441 Larger particles and potentially metallic due to the shape and colour

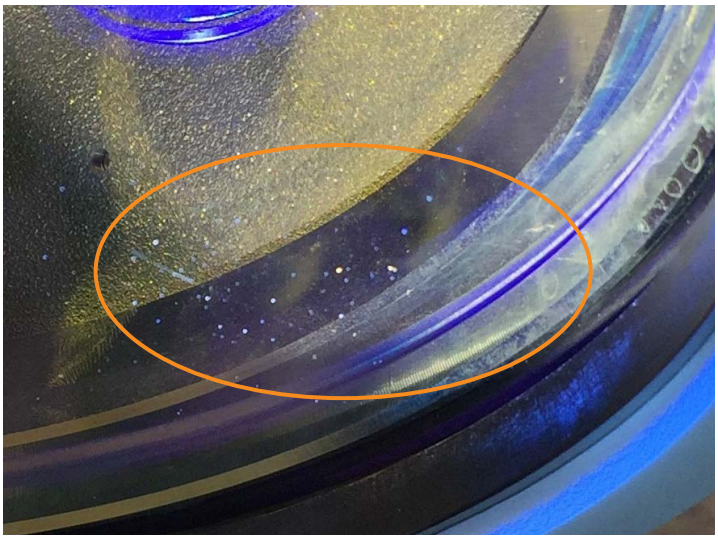


Figure 442 Larger particles and potentially metallic due to the shape and colour

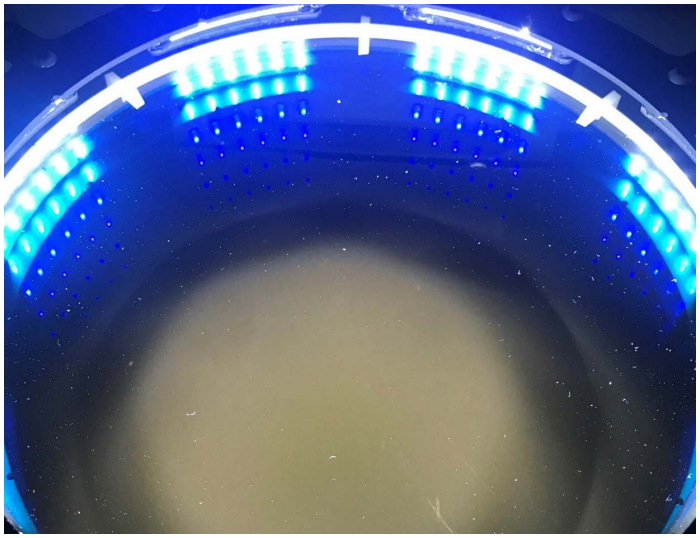


Figure 443 A small amount of fine dust will almost always be observed on the window surface when inspected with a high-power LED torch



Figure 444 A small amount of fine dust will almost always be observed on the window surface when inspected with a high-power LED torch



Figure 445 A small amount of fine dust will almost always be observed on the window surface when inspected with a high-power LED torch

PM-035-07 – Lens protection window – Post completion

Once complete, there should be no visible dirt, debris, dust or other contamination remaining on the lens protection window.

Record the completion of the maintenance task in the maintenance records.

10.20 PM-036 – Elevator position encoder brush – Replace

WARNING: Before starting this task, ensure you are wearing the correct PPE for working with metal powder: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

1. Open the lower door as follows. Select the Open Door button (Figure 446). Select the Unlock Top Door button and press the blue Reset button. The door will release and can be opened by pulling the door handle firmly towards you. Now open the bottom door by pulling its handle towards you.

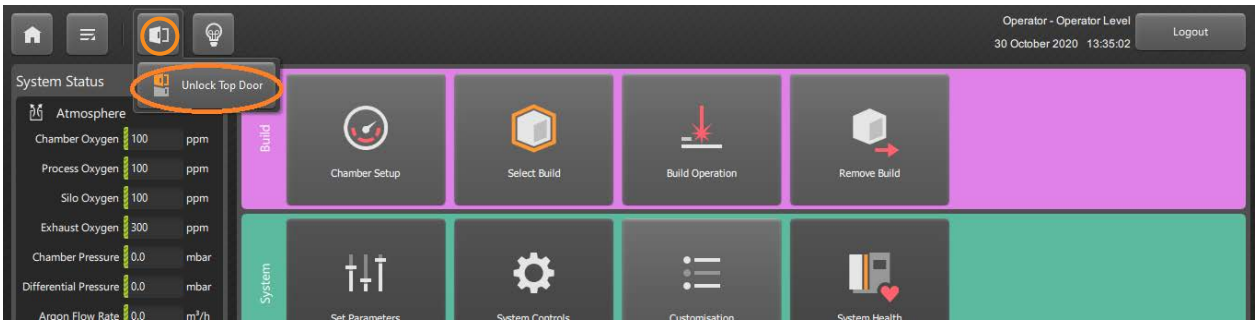


Figure 446 Open door button and Unlock Top Door button

2. If there is any metal powder present in the lower chamber, clean it up in accordance with the instructions in section 8.3.5, “PB-003 – Build chamber metal powder – Remove”. Pay particular attention to the encoder, brush and encoder hat.

3. Locate the encoder assembly on the Z axis (Figure 447).



Figure 447 Encoder on Z axis

4. Using a hexagon key, remove the M5 screw securing the hat and brush assembly to the encoder readhead bracket. The screw is located at the back of the encoder assembly (Figure 448) and may not be immediately visible.

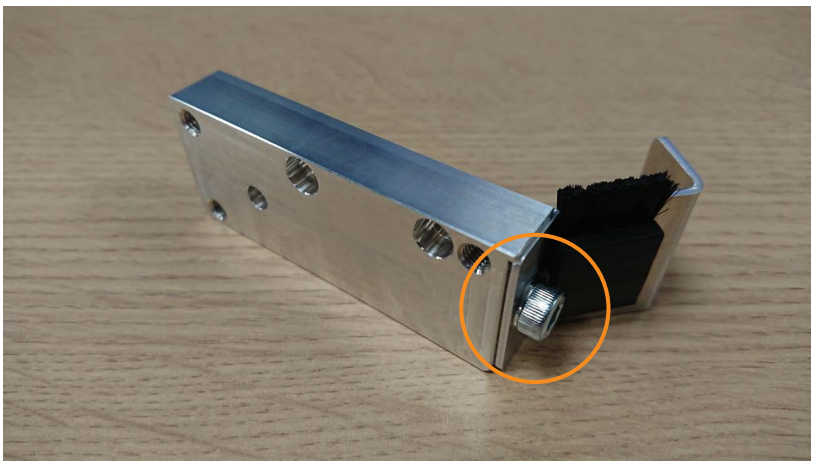


Figure 448 Encoder hat and brush assembly

5. Remove the brush assembly from the metal hat and dispose of it in accordance with the applicable local legislation for contaminated parts.

6. Fit the new brush assembly to the hat, and secure to the encoder readhead bracket with the M5 screw removed previously. Do not overtighten the M5 screw.

7. For advice on repairs or to schedule a repair visit, contact Renishaw AM Service (see section 12, “Customer support”).

8. Record the completion of the maintenance task in the maintenance records.

10.21 PM-037 – Top rear of chamber – Clean (RenAM 500 Flex only)

WARNING: Before starting this task, ensure you are wearing the correct PPE for working with metal powder: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

CAUTION: Behind the rear centre door are numerous items critical to the operation of the RenAM 500 Flex system. Take great care when working in this area not to remove, damage or otherwise displace any elements of the machine unless specifically instructed to.

1. Ensure the RenAM 500 Flex is powered down.
2. Isolate the machine's electrical supply by turning the main isolating switch to the Off position (Figure 449, right).

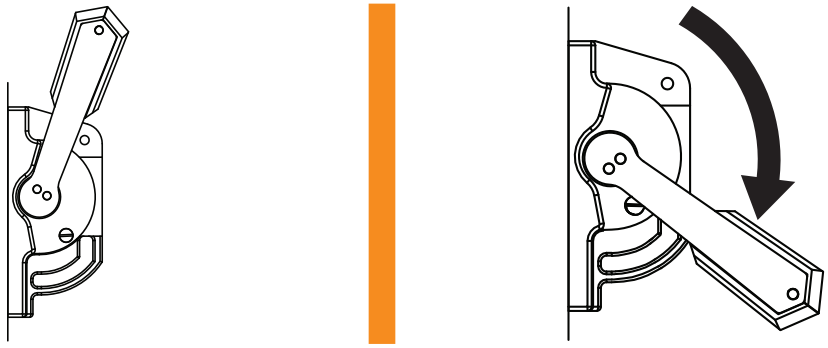


Figure 449 Equipment main isolation switch – On left and Off right

WARNING: Do not open the rear door to the machine without first ensuring that the electrical supply to the machine has been isolated, and the isolation switch is in the off position.

3. Open the rear centre door.
4. Using suitable mobile safety steps, use an ATEX vacuum cleaner to remove any powder from the area around the silo on top of the chamber.
5. Use an IPA wipe, or a cloth and liquid IPA solution, to wipe the area around the silo on the top of the chamber.
6. Close the rear centre door, ensuring the security latches are turned to the locked position.
7. For advice on repairs or to schedule a repair visit, contact Renishaw AM Service (see section 12, "Customer support").
8. Record the completion of the maintenance task in the maintenance records.

10.22 PM-038 – Powder loading arm – Inspect (RenAM 500 Flex only)

WARNING: Before starting this task, ensure you are wearing the correct PPE for working with metal powder: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

WARNING: The powder loading arm and/or its fasteners must be replaced if they show signs of bending, cracking or other mechanical defects. Do not attempt to load powder using an arm with damaged components.

1. Position the working platform at the front of the RenAM 500 Flex machine.
2. Inspect all visible components of the powder loading arm for signs of bending, cracking, or other mechanical defects.
3. Inspect all visible fasteners for signs of bending, cracking, necking or other mechanical defects.
4. Ensure all visible fasteners are correctly tightened and there are no loose components.
5. Rotate the powder arm and ensure that bearings are smooth running. Check that the arm can be raised and lowered on the bearing track as expected.
6. For advice on repairs or to schedule a repair visit, contact Renishaw AM Service (see section 12, “Customer support”).
7. Record the completion of the maintenance task in the maintenance records.

10.23 PM-039 – Feed hopper lifting brackets – Inspect (RenAM 500 Flex only)

WARNING: Before starting this task, ensure you are wearing the correct PPE for working with metal powder: ESD safety footwear, eye protection, full-face respirator (to EN143 Type P3 + A1), protective gloves and full-length clothing.

WARNING: The feed hopper lifting brackets and/or its fasteners must be replaced if they show signs of bending, cracking or other mechanical defects. Do not attempt to lift a feed hopper with damaged components.

1. Position the working platform at the front of the RenAM 500 Flex machine.
2. Inspect the machined feed hopper brackets (Figure 450) for signs of bending, cracking, or other mechanical defects.



Figure 450 Inspect the machined feed hopper brackets

3. Inspect all visible fasteners between the brackets and the feed hopper for signs of bending, cracking, necking or other mechanical defects.
4. Ensure all visible fasteners are correctly tightened and there are no loose components.
5. For advice on repairs or to schedule a repair visit, contact Renishaw AM Service (see section 12, “Customer support”).
6. Record the completion of the maintenance task in the maintenance records.

11. Consumables and spare parts

The aim of this chapter is to provide a list of the consumables parts for the RenAM 500 series system. The consumable parts are those which are replaced on a regular basis, such as the recoater blade and large SafeChange filters which are replaced after every build.

Many of these products are available to purchase on the online store via **www.renishaw.com/shop**.

NOTE: Renishaw software licences are also available to purchase via the online store.

11.1 Consumable parts – substrates

Part number	Description
A-5771-0001	248 × 248 × 15 mild steel substrate box of 3
A-5771-0003	248 × 248 × 15 mild steel substrate individually boxed
A-5771-0004	248 × 248 × 15 stainless steel substrate box of 3
A-5771-0005	248 × 248 × 15 stainless steel substrate individually boxed
A-5771-0008	248 × 248 × 15 aluminium substrate box of 3
A-5771-0009	248 × 248 × 15 aluminium substrate individually boxed
A-6521-6500	246 × 246 × 34 stainless steel substrate individually boxed
A-6521-6502	248 × 248 × 34 stainless steel step substrate individually boxed
A-6521-6506	246 × 246 × 34 mild steel substrate individually boxed
A-6521-6508	246 × 246 × 34 aluminium substrate individually boxed
A-6521-6509	248 × 248 × 34 aluminium step substrate individually boxed
A-6521-6510	246 × 246 × 34 titanium substrate individually boxed
A-6521-6512	248 × 248 × 34 mild steel step substrate individually boxed
A-6521-6514	246 × 246 × 15 titanium substrate individually boxed
A-6521-6515	246 × 246 × 15 titanium substrate box of 3
A-6521-6517	248 × 248 × 34 titanium step substrate individually boxed

11.2 Consumable parts – metal powder

Part number	Description
A-5771-0400	Maraging steel (1.2709) powder – 10 kg (22 lb)
A-5771-0402	INCONEL® 625 powder – 10 kg (22 lb)
A-5771-0403	Aluminium AlSi10Mg powder – 4 kg (8.8 lb)
A-5771-0404	Cobalt chrome powder – 10 kg (22 lb)
A-5771-0405	INCONEL® 718 powder – 10 kg (22 lb)
A-5771-0406	Titanium Ti6Al4V Grade 23 powder (subject to export control regulations) – 2.5 kg (5.5 lb)
A-5771-0407	Stainless steel 316L (1.4404) powder – 10 kg (22 lb)
A-5771-0408	Stainless steel 17-4PH (1.4542) powder – 10 kg (22 lb)

11.3 Consumable parts – other

Part number	Description
A-5771-0025	Recoater blade – 10 m (32.8 ft)
A-5778-6000	SafeChange filter insert kit (6 filter inserts, large)
A-6521-4150	Optical lens cleaning kit
A-6521-5286	Oversize powder filter kit
A-6810-6060	Flex material change consumable kit
P-AD99-0032	Vacuum additive – Defoamer – 1 L (61 in^3)
P-AD99-0105	Large lens tissue
P-HX04-0003	Nalco chiller additive – pre-mixed 22.75 L (5 gallons)
P-LU08-0004	Vacuum or storage drum additive – Hydra-Sol-MAG – 1 L (61 in^3)
P-WI02-0002	Lens cleaning tissues (25 pack)
P-LU01-0026	White mineral oil – 20L (4.4 gallons) (Long-Life Filter only)
(Customer-sourced)	212 L barrel, 610 mm (24.0 in) diameter × 800 mm (31.5 in) height (UN 1A2/Y1.5/150 or UN 1A2/X240/S certified)

11.4 Spare parts

Renishaw stocks a vast range of spare parts and can make recommendations on which critical spares to keep in stock to maximise the running time of your AM system.

Renishaw has a global network of skilled staff, trained and equipped to provide you with technical assistance remotely or directly at your site. We have a global network of highly skilled engineers who are available to support all aspects of your AM system. Choose a Renishaw service and support option for peace of mind.

To access the full catalogue of spare parts or to arrange a service visit, contact your local Renishaw office). For more information, see section 12, “Customer support”.

Part number	Description
A-5771-1135	Filter end support
A-5774-0346	Powder decanting adaptor kit
A-5778-3185	Glove box door fastener tool
A-6135-0185	RBV plate and seal spares kit
A-6252-0570	Powder flask 1.7 L (103 in^3)
A-6252-0696	Powder flask 0.85 L (51.9 in^3)
A-6521-0625	Sieve mesh frame kit (63 µm)
A-6521-0626	Sieve mesh frame kit (80 µm)
A-6521-0627	Sieve mesh frame kit (95 µm)
A-6521-4062	Z-axis seal sales kit
A-6521-5224	Large SafeChange filter kit
A-6810-6040	Powder flask 10 L (610 in^3)
P-0PTA-0121	Manual blower
P-TL50-0117	Chamber door glove

12. Customer support

If you experience an issue with your system or software, or if you need advice, contact Renishaw.

12.1 Contact details

Contact details for Renishaw are below:

Phone number:		+44 (0) 1453 524524 Hours of work: Monday to Friday 08:00 to 1700 hr (UTC and DST)
Email:	**For quotes and orders related to consumables, parts, and contracts**	**ampd.sales@renishaw.com**
	For scheduled maintenance visits, machine breakdowns or any machine operating queries	**am.support@renishaw.com**
	For any guidance or issues related to build file preparation, general machine operation, machine training, post build testing and analysis	**am_applications@renishaw.com**
	For any QuantAM licence issues or queries	**quantam.support@renishaw.com**
Service address:		Renishaw plc New Mills Wotton-under-Edge Gloucestershire GL12 8JR United Kingdom

1. System type	
2. System serial number	

Please quote the details above.

The system serial number plate can be found on the rear of the system.

Additional support can be sought by contacting your local Renishaw office. See:

www.renishaw.com/contact

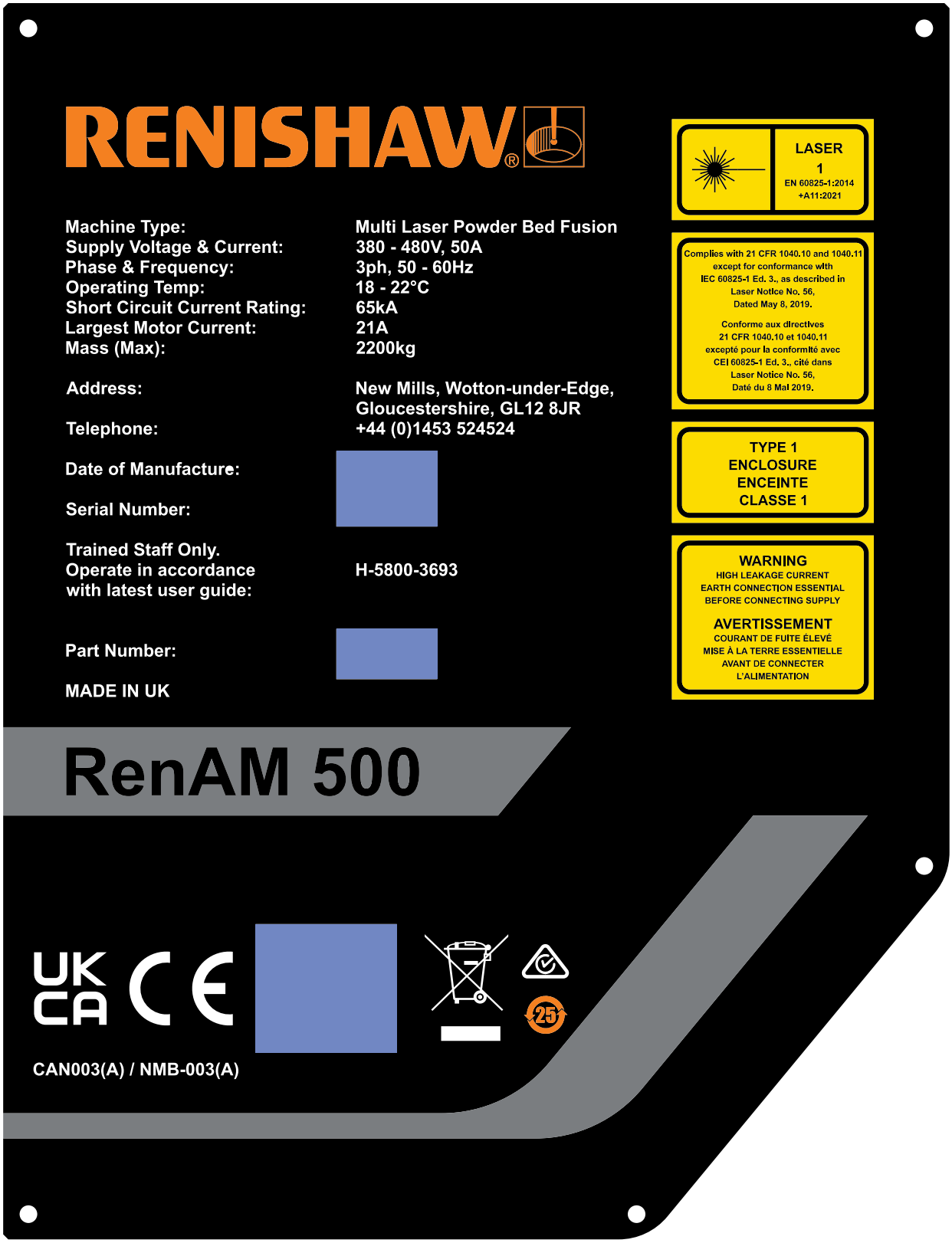


Figure 451 System build information

13. Glossary

13.1 Definitions

The following definitions are used throughout this guide:

Term	Definition
Client or end user	The organisation responsible for purchasing or using the equipment.
Supervisor	An individual who is ultimately responsible for ensuring the safe operation and maintenance of the equipment.
Trained operator	An individual working for the customer or end user who is competent to operate, maintain and clean the equipment safely. This is because they have been formally trained and assessed in the individual tasks required.
Technician	An operator who is trained to change material parameters, fault-find and change material types.
Service engineer	A Renishaw Service engineer or Renishaw trained person who is qualified and experienced to the highest level in repairing the RenAM 500 series system.
Equipment	The scope of supply from Renishaw that the client has purchased.
Ancillary equipment	Any item which is required for manufacture that is not included in the scope of supply.
Manufacture or manufacturing	Any process where the equipment is commissioned, trialled, operated, maintained or cleaned.
Must	Tasks, actions or activities that are essential for the safe operation of the system.
Should	Tasks, actions or activities that are recommended for the safe operation of the system.

13.2 Abbreviations

The following abbreviations are used throughout this guide:

Term	Definition
AM	Additive Manufacturing
AMPM	Additive Manufacturing Process Monitoring
ANSI	American National Standards Institute
ATEX	ATmosphères EXplosives (explosive atmospheres)
BDO	Beam Delivery Optic
BSP	British Standard Pipe (thread type)
COSHH	Control of Substances Hazardous to Health
DSEAR	Dangerous Substances and Explosive Atmospheres Regulations
EMC	Electro-Magnetic Compatibility
ESD	Electrostatic Discharge
FSE	Field Service Engineer
FTP	File Transfer Protocol
GFO	Global Focus Offset
HMI	Human Machine Interface
IEC	International Electrotechnical Commission

Term	Definition
IP	Internet Protocol
IPA	Isopropanol
LED	Light Emitting Diode
LPBF	Laser Powder Bed Fusion
MCB	Miniature Circuit Breaker
MIE	Minimum Ignition Energy
MSS	Machine Software Suite
NFPA	National Fire Protection Association
OSV	Optical System Verification
PC	Personal Computer
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment
PPM	Parts Per Million
PV	Present Value
RenAM 500 series	Renishaw's multiple-laser digital AM machine platform. This term refers to all the following models: RenAM 500S Flex RenAM 500D Flex RenAM 500Q Flex RenAM 500S RenAM 500D RenAM 500Q RenAM 500S Ultra RenAM 500D Ultra RenAM 500Q Ultra
RenAM 500 Flex	This term refers to models within the RenAM 500 series with a flexible total-loss powder management system, such as: RenAM 500S Flex RenAM 500D Flex RenAM 500Q Flex This does not include the RenAM 500 or RenAM 500 Ultra models.
RenAM 500	This term refers to models within the RenAM 500 series with on-board powder filtration and recirculation, but without TEMPUS technology, LaserVIEW and MeltVIEW hardware installed as standard, such as: RenAM 500S RenAM 500D RenAM 500Q This term does not include the RenAM 500 Flex or RenAM 500 Ultra models.
RenAM 500 Ultra	This term refers to models within the RenAM 500 series with on-board powder filtration and recirculation, with TEMPUS technology and LaserVIEW and MeltVIEW hardware installed as standard, such as: RenAM 500S Ultra RenAM 500D Ultra RenAM 500Q Ultra This term does not include the RenAM 500 Flex or RenAM 500 models.

Term	Definition
SIL	Safety Integrity Level
SMB	Server Message Block
UPS	Uninterruptable Power Supply
WAN	Wide Area Network

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