excillum

Operating manual

MetalJet D2+/C2

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Acknowledgement

Copyright notice

Contact information

The MetalJet D2+/C2 source described in this operating manual has been produced by Excillum Aktiebolag. Excillum may be contacted in several different ways.

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1 Introduction

1.1 Validity

This operating manual is for Excillum customers that describes the functionality of the MetalJet D2+/C2 source and provides the most important information for safe use of the unit. The description follows applicable EU guidelines. Up-to-date operating instructions may be obtained by contacting Excillum. See page ii for contact information.

1.2 Instructions and conventions

The safety instructions in this operating manual are the result of a risk assessment in accordance with SS-EN 12100:2010 (Safety of Machinery – General principles for design – Risk assessment and risk reduction).

In this document, the following hazard levels and information are considered:

DANGER
Immediate danger: Death or very severe injuries may occur.

WARNING/ATTENTION
Possible danger: Severe injuries may occur.

CAUTION
Possible danger: Medium to slight injuries may occur.

NOTE
Command or note: Command to perform an action or information about properties. If ignored, this may result in damage to the product.

Number	Symbol	Reference	Description
1		IEC 60417-5031 (2002-10)	Direct current
2		IEC 60417-5032 (2002-10)	Alternating current
3		IEC 60417-5033 (2002-10)	Both direct and alternating current
4		IEC 60417-5032-1 (2002-10)	Three-phase alternating current
5		IEC 60417-5017 (2006-08)	Earth (ground) TERMINAL
6		IEC 60417-5019 (2006-08)	PROTECTIVE CONDUCTOR TERMINAL
7		IEC 60417-5020 (2002-10)	Frame or chassis TERMINAL
8			Not used
9		IEC 60417-5007 (2009-02)	On (Power)
10		IEC 60417-5008 (2009-02)	Off (Power)
11		IEC 60417-5172 (2003-02)	Equipment protected throughout by DOUBLE INSULATION or REINFORCED INSULATION
12			Caution, possibility of electric shock
13		IEC 60417-5041 (2002-10)	Caution, hot surface
14		ISO 7000-0434B (2004-01)	Caution [a]
15		IEC 60417-5268 (2002-10)	In position of a bi-stable push control
16		IEC 60417-5269 (2002-10)	Out position of a bi-stable push control
17		ISO 361	Ionizing radiation

Figure 1-1 Signs that can be used on MetalJet E1+ source

1.3 Product information

1.3.1 Product identification

To correctly identify the product when communicating with Excillum, always provide the following information from the identification tag(s):

- Model number
- Article number
- Serial number
- Manufacturing year
- Anode alloy

The identification tag on each of the four sub-assembly units (see table below) is located on the backside, close to the electrical power connector.

The MetalJet article numbers are the following:

- MetalJet D2+: G-020-0047
- MetalJet C2: G-020-0080
- MetalJet D2+ SO: G-020-9030

The X-ray source consists of the following four sub-assembly units.

Sub-assembly unit	Article number
Electron gun/X-ray head	G-020-0046 (70kV), G-020-0048 (160kV)
Pump box	G-035-0230 (open pump box), G-035-0260 (closed pump box)
X-ray system controller	G-010-0069 (70kV), G-010-0098 (160kV)
X-ray high-voltage controller	G-010-0090 (70kV), G-010-0040 (160kV)

1.3.2 Design and function

The MetalJet D2+/C2 X-ray source is based on a metal-jet anode. It is not a stand-alone X-ray source, but a component in a complete X-ray system (for more information, see Section 2.1).

The MetalJet D2+/C2 source consists of a recirculating metal jet loop, an electron gun, as well as electronics modules for operation control. The electron gun generates an electron beam which strikes the metal-jet and produces X-rays. This X-ray source is suitable for use in any X-ray application where increased X-ray source brightness is desired. Increased source brightness can be used to decrease the exposure time or increase the resolution of the X-ray image.

1.3.2.1 X-ray system controller

The ethernet interfaces that are available on the X-ray system controller are 1 Gbps interfaces. For internal peripherals there is one ethernet port, six RS232 serial ports, and four USB ports. There is

one HDMI interface which is the recommended interface for an external screen. On the front there are two USB ports for a mouse, keyboard, and an on/off button for safe Linux shutdown which is the preferred way to shutdown X-ray system controller.

1.3.2.2 Liquid-metal circulation loop

The jet pump displaces liquid metal from the reservoir in the low-pressure flex-hose assembly to the high-pressure side. The pressure in the high-pressure tubing is stabilized by a pulsation dampener. When the liquid metal reaches the nozzle assembly, a metal-jet is ejected. This metal-jet is the target for the electron beam generated in the electron gun. After interaction with the electron beam, the metal-jet ends up in the reservoir in the low-pressure flex-hose assembly, and a closed circulation loop is completed.

1.3.2.3 Electron gun/X-ray head

A potential difference between the cathode and the plate with the anode hole generates an electric field. The cathode is heated to emit electrons into the electric field. When free electrons enter the electric field, they are accelerated towards the plate with the anode hole. The electron beam passes through the anode hole into the flight tube. The electron optics and the focusing lens manipulate the electron beam to focus it onto the metal-jet. X-rays are produced and emitted through the X-ray window when the electron beam strikes the metal-jet.

The electron gun/X-ray head consists of the following parts. See **Figure 1-2**. below:

1. High-pressure tube
2. Particle filter
3. Nozzle assembly
4. Lens cooling block
5. High-vacuum gauge
6. High-vacuum pump (turbopump)
7. Ventilation valve
8. Fore-vacuum hose
9. High-voltage cable connected to high-voltage feedthrough
10. Interconnecting cables
11. X-ray head PCB (cross connect board)
12. Electron optics
13. Exit window (not visible, it is underneath the shutter)
14. Flex-hose assembly
15. Jet brake
16. Upper cooling block
17. Shutter

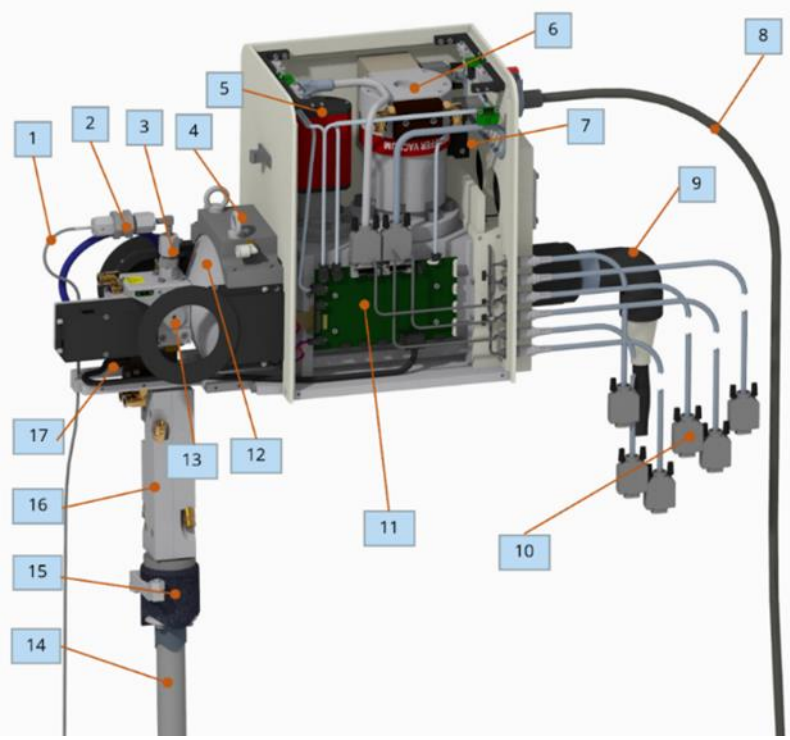


Figure 1-2. The main components of the electron gun/X-ray head.

The main components of the pump box are the following parts (see Figure 1-3.):

1. High-pressure tube
2. Upper cooling block
3. Jet brake
4. Flex-hose assembly
5. Fore-vacuum hose
6. Cooling water inlet
7. Cooling water outlet
8. Pulsation dampener
9. Diaphragm guard
10. Jet pump
11. Outlet check valve
12. Pump head
13. Inlet check valve
14. Liquid-metal filling valve
15. Filling valve adapter
16. Lower cooling block
17. Roughing pump
18. Heater fan
19. Pump box electronics

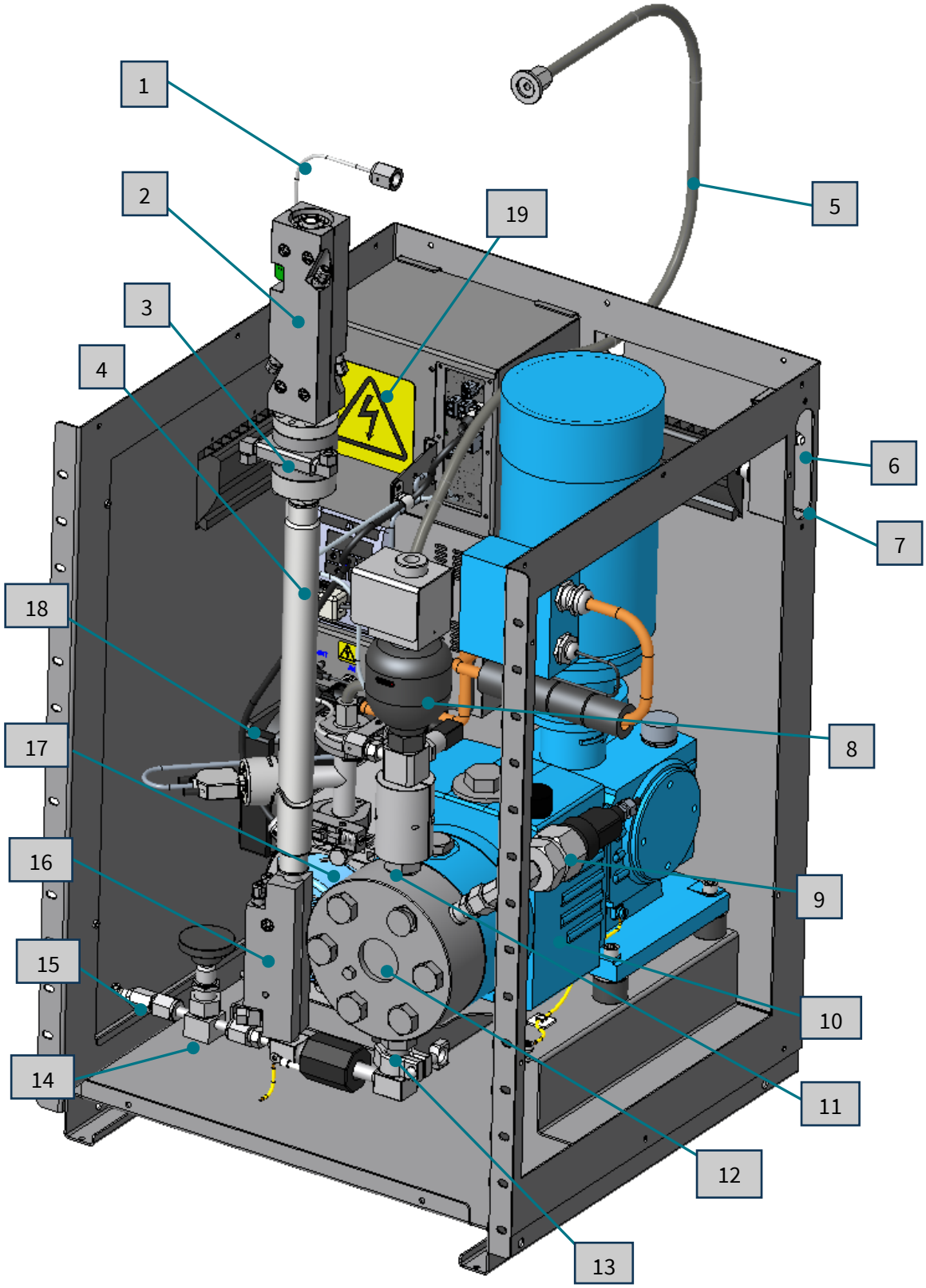


Figure 1-3. The main components inside the pump box.

1.3.3 X-ray output options

MetalJet D2+/C2 source can be configured to operate with the X-ray output either on the left-hand side (left-handed), the right-hand side (right-handed) or both sides (dual port). The definition of left and right is indicated in Figure 1-4. using a red arrow for the left-handed source and a green arrow for the right-handed source.

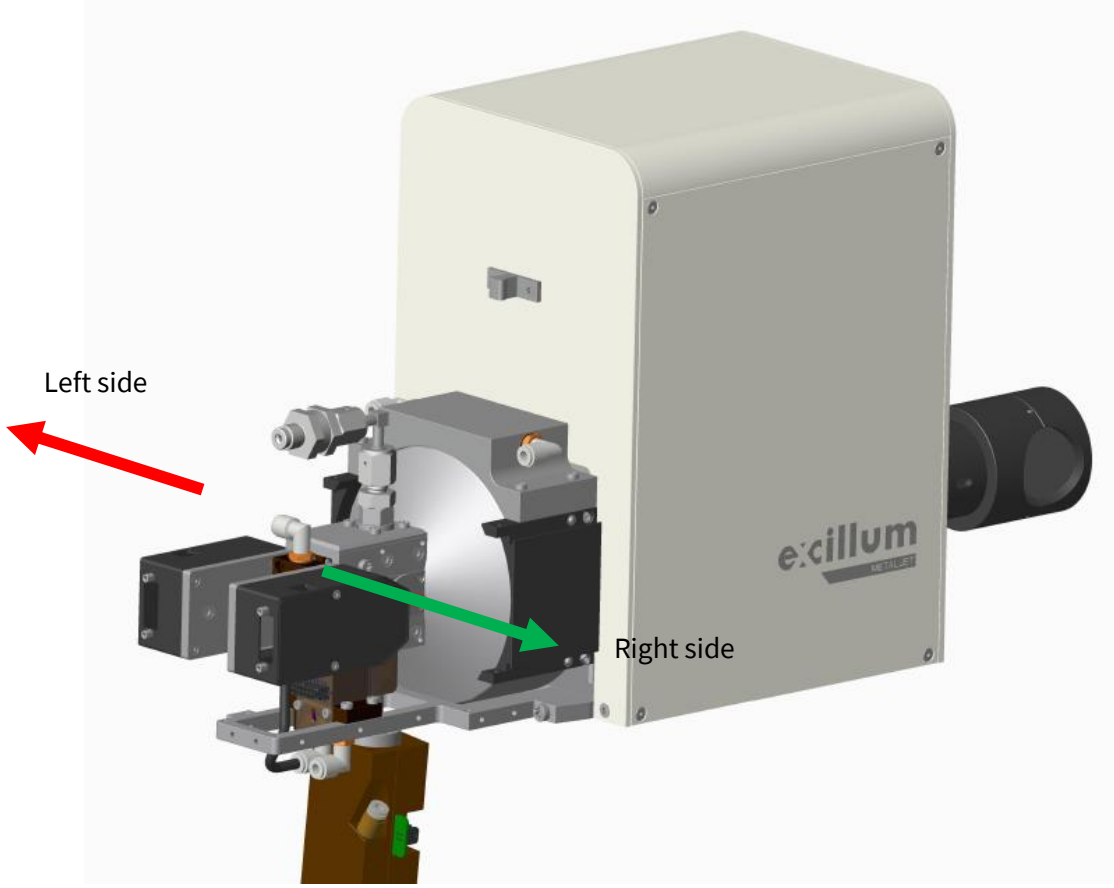


Figure 1-4. MetalJet D2+/C2 source configured with the X-ray output on both sides (dual port). The red arrow indicates output direction of a left-handed source and green arrow indicates output direction of a right-handed source.

The output direction can be reconfigured in field, but we highly recommend that the output direction is specified when placing the order.

The source can also be configured to operate either with or without an X-ray shutter. When operated without a shutter, it can be configured with a standard exit window or an exit window with an increased cone angle. The figures in Sections 1.3.3.1, 1.3.3.2 and 1.3.3.3 show minimum source-to-object distance, exit window diameter and X-ray emission cone angle for each of these configurations.

1.3.3.1 With X-ray shutter

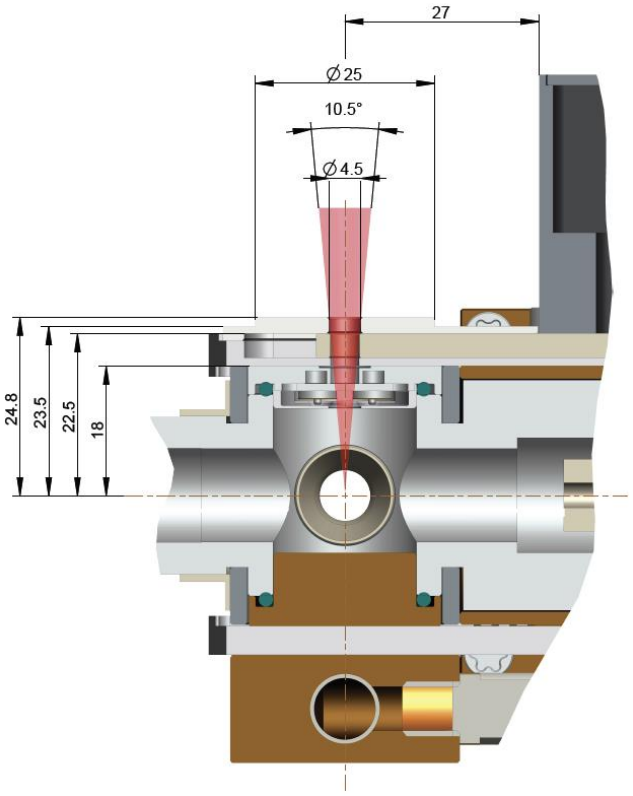


Figure 1-5. Schematic of the X-ray head with X-ray shutter mounted.

1.3.3.2 Without X-ray shutter using standard exit window

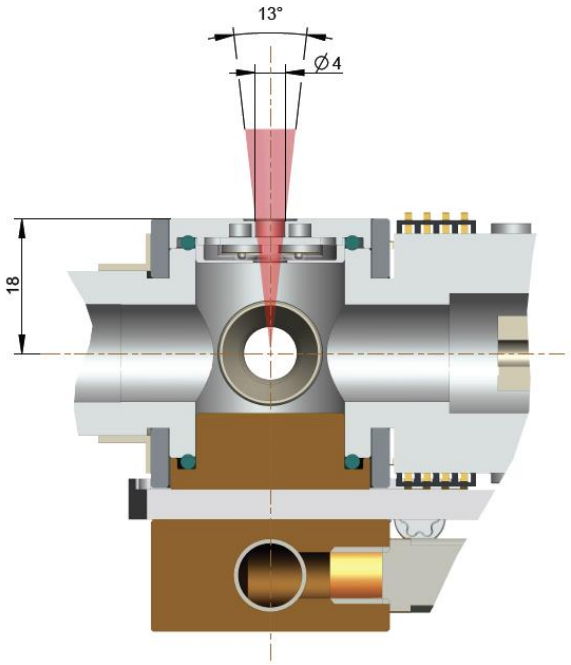


Figure 1-6. Schematic of the X-ray head without X-ray shutter using standard exit window.

1.3.3.3 Without X-ray shutter using increased cone angle exit window

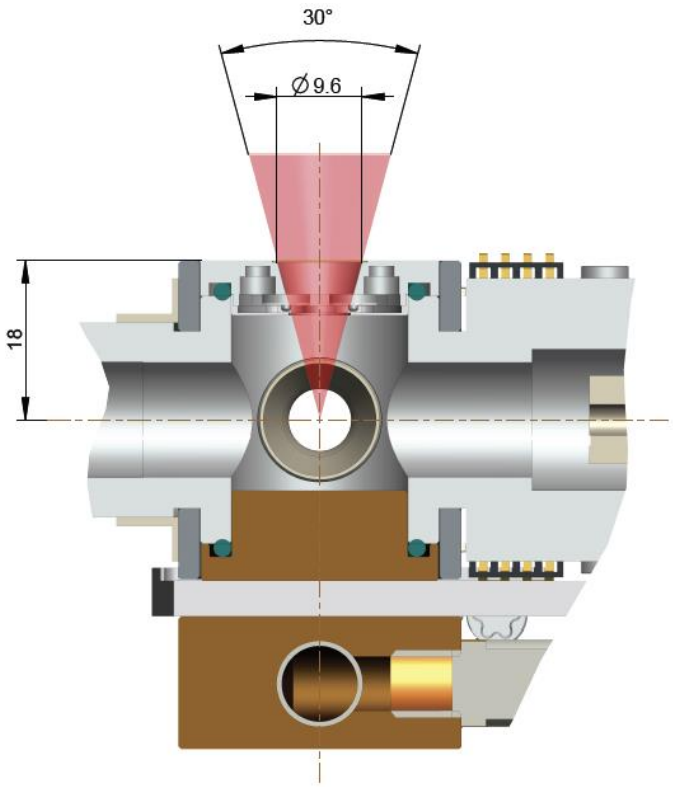


Figure 1-7. Schematic of the X-ray head without X-ray shutter using increased cone angle exit window.

2 Safety

2.1 Safety precautions

2.1.1 Qualified personnel

Installation work, commissioning and operation of the MetalJet D2+/C2 source must be done by qualified and skilled personnel. Installation work shall only be done by qualified personnel who are skilled in the following:

- Safety regulations
- X-ray radiation
- Accident prevention regulations
- Standards and approved rules of technique

The qualified personnel must have the ability to assess the assigned job, identify possible dangers and avoid them. The personnel must be authorized by the person in charge for security of the plant to carry out the necessary work and tasks. Personal protective equipment (at least gloves and eye protection) shall be used during work with the MetalJet D2+/C2 source.

2.1.2 Partly completed machinery

The MetalJet D2+/C2 source is considered partly completed machinery (as defined by the Machinery Directive 2006/42/EC) and is therefore intended to be incorporated into or assembled with other machinery or partly completed machinery to function properly. It is the responsibility of the machinery integrator to make sure that the final machinery meets all local safety regulations such as radiation protection and all other applicable regulations such as CE compliance, Machinery Directive, EMC Directive, etc.

NOTE

Partly completed machinery

Excillum is not responsible for the installation, use, or application of the MetalJet D2+/C2 source.

If the MetalJet D2+/C2 source is used in a manner not specified by Excillum, then protection built into the MetalJet D2+/C2 source may be impaired.

It is the sole responsibility of the machinery integrator that the final machinery including the MetalJet D2+/C2 is safe to use.

2.1.3 Operating manual

This operating manual contains important information regarding the workings, operation, maintenance, and safety of the MetalJet D2+/C2 source. All persons involved in operation or service must have thoroughly read and understood the operating manual beforehand.

ATTENTION

Operating manual must be read and understood

This operating manual contains necessary information to ensure safe operation of the MetalJet D2+/C2 source. Each person involved in the installation, operation or maintenance must have read and understood this operating manual.

Keep this manual handy and in a safe place for future reference. In case of this manual being lost or damaged, please contact Excillum for a replacement copy (see Page ii for contact information).

In case the MetalJet D2+/C2 source is moved to another location, make sure to bring the manual.

2.1.4 X-ray radiation

In its original design the MetalJet D2+/C2 70 kV source provides a high degree of protection from unnecessary radiation. Therefore, do not modify, remove, or otherwise change any part of the MetalJet D2+/C2 source unless this action has a written approval by Excillum in advance. However, no practical design can provide complete protection nor prevent operators from exposing themselves or others to unnecessary radiation. The MetalJet D2+/C2 160 kV has a lower degree of protection, therefore additional protection must be designed by the customer.

Personal radiation monitoring and protective devices are available. Operators are urged to use them to protect against unnecessary radiation exposure.

DANGER

X-ray radiation can be a health hazard

X-ray equipment may cause injury, or even death, if improperly used.

The MetalJet D2+/C2 apparatus is a source of X-ray radiation, which is harmful to the human body. To avoid health problems arising from exposure to X-rays, exercise the greatest possible caution when using this X-ray source.

This X-ray source may be operated by, or under supervision of, authorized and trained personnel only. All applicable local safety regulations must be strictly complied with.

2.1.5 Electricity and high voltage

Make sure electrical power is ramped down and then switched off, and other appropriate safety precautions are followed before maintenance or service work is performed.

The MetalJet D2+/C2 source contains a high voltage generator. Proper high voltage precautions and grounding techniques must be observed during installation and operation of the MetalJet D2+/C2 apparatus.

The electrical power must be ramped down before the high voltage source is switched off. The high-voltage decay time when power is shutdown can be significant.

Read the document “AN-05” also known as "No, You Touch It, HVPS output fall and discharge times explained” from Spellman which gives an estimation of the decay time.

https://www.spellmanhv.com/en/Technical-Resources/Application-Notes-HVPS/AN-05

In no event should the safety interlocks on the MetalJet D2+/C2 source be disconnected or bypassed.

DANGER

High voltage is potentially lethal

High voltage can cause electric shock or burn.

All sub-units of the MetalJet D2+/C2 source must be properly grounded before being energized. Use high voltage precautions.

Always ensure complete discharge of the high-voltage cable when removing it from the source by letting the circled metal connectors touch ground. See Figure 2-1.

Figure 2-1. Always ensure complete discharge of the high-voltage cable when removing it from the source by letting the circled metal connectors touch ground.

2.1.6 High pressure

The MetalJet D2+/C2 source has, unlike conventional X-ray source, a liquid metal jet anode. The metal-jet is generated by forcing a liquid metal through a small orifice. The pressure generated by the metal pump is 190 bar. Therefore, only properly trained service personnel should be permitted to service the diaphragm pump, or any part of the tubing system connected to the pump. Always use personal protective equipment (at least gloves and eye protection) at least during maintenance of source. Remember to inspect high pressure sling when service of high pressure sling has occurred or as a regular yearly maintenance check.

WARNING

High liquid-metal pressure

Under no circumstances should any kind of service, maintenance, tube connections, adjustments to the jet pump or the equipment shall be done while the MetalJet D2+/C2 source is in operation.

All Service, maintenance, equipment, adjustments of the jet pump and tubing connected to it, may only be performed by properly trained service personnel.

2.1.7 Heat

During operation of the MetalJet D2+/C2 source, the surfaces of the X-ray head, focus lens, vacuum pumps, and the low-pressure tubing may become hot. Depending on the operating and ambient

conditions these surfaces may reach temperatures above 50 °C (122 °F). Use suitable finger guards if necessary.

CAUTION

Hot surfaces

The X-ray head, focus lens, vacuum pumps, and the low-pressure tubing may become hot during operation of the MetalJet D2+/C2 source.

2.1.8 Magnetic fields

The electron gun/X-ray head of the MetalJet D2+/C2 source is sensitive to external magnetic fields which may cause severe loss of X-ray output performance, since the electron beam may be affected.

The MetalJet D2+/C2 source may also be sensitive to ferromagnetic materials (and other materials with a high relative magnetic permeability) when close to the electron gun/X-ray head. This may affect the magnetic fields generated by the electron optics and the focusing lens and thus cause a severe loss of X-ray output performance.

Materials with a high relative permeability and external magnetic fields to the MetalJet D2+/C2 source may be damaged and in need of service to exchange parts and recalibrate settings.

Permanent magnets, energized electro-magnets, or ferromagnetic materials must not be placed close to the MetalJet D2+/C2 source.

CAUTION

External magnetic fields and ferromagnetic materials

The MetalJet D2+/C2 source may experience loss of performance as well as damage if exposed to external magnetic fields or ferromagnetic materials close to the electron gun/X-ray head.

2.1.9 Poisoning hazard

The X-ray exit window of the MetalJet D2+/C2 source consists of beryllium foil. Beryllium metal is highly toxic. Do not touch or otherwise handle the foil. Take care to read and follow the instructions below.

WARNING

Poisoning hazard – Beryllium window

Fumes or dust from beryllium and its compounds can be hazardous if inhaled! Corrosion of the beryllium may occur during use. Beryllium must not be cut, machined, or handled in any way.

The beryllium foil of the X-ray source is fragile and brittle. When installing, replacing, or working around the X-ray source and detector assemblies, proceed with great caution.

DO NOT touch the beryllium foil and DO NOT expose the beryllium window to corrosive substances such as acid, acid vapor, water, water vapor, or other substances.

In case of an implosion of the X-ray tube, you could get hurt by beryllium fragments. You must wear safety goggles and gloves when cleaning the instrument after such an incident.

Disposal of beryllium must comply with all applicable national, state, local laws and regulations.

1. If breakage of a beryllium window occurs, proceed as follows:
   Avoid touching, inhaling, or ingesting the particles and do not allow the particles to come in contact with your skin or clothing.
2. Gather all broken pieces and particles immediately using a pair of tweezers or the sticky side of masking tape.
3. Handle the beryllium pieces as you would a poison. Place them in a sealed, unbreakable container labeled “CAUTION: BERYLLIUM - POISON,” and contact the proper authorities for transport and disposal guidelines.

If the beryllium particles have come in contact with skin, remove them as described above and wash the affected area thoroughly with soap and water.

If the beryllium particles have come in contact with clothes, remove and discard the particles carefully as described above. Wash the clothing thoroughly. Check for beryllium particles on the skin as described above.

2.1.10 Corrosion

Liquid gallium and gallium alloys are highly corrosive towards many metals. Aluminum is especially reactive with gallium, and it is very important to avoid having any aluminum parts in contact with gallium or gallium alloys. There are also many other rather common metals that are quite reactive with liquid gallium, e.g., gold, silver, tin, lead, zinc, and copper. These materials may get stained by the gallium even if they are in contact only for a moment.

NOTE

Gallium is corrosive: Gallium has a rather high corrosion rate when in contact with many different metals. Among the materials with the lowest corrosion resistance to gallium are aluminum, gold, silver, zinc, and alloys containing large fractions of these materials. There may, however, be exceptions from this rule. Contact Excillum for information regarding a specific material.

2.2 Proper use

The MetalJet D2+/C2 apparatus is an X-ray source and may only be used as such.

Only use accessories and spare parts mentioned in this operating manual or with written approval from Excillum.

Any guarantees, warranties and the manufacturer's Declaration of Incorporation become invalid if the MetalJet D2+/C2 source is modified without authorization from Excillum.

Installation, operation, and maintenance regulations must be complied with.

2.3 Improper use

Improper use will cause all claims for liability and guarantees to be forfeited. Improper use is deemed to be all use for purposes deviating from those mentioned in Section 2.1.10 above, especially but not limited to:

- Using accessories or spare parts not mentioned in this operating manual without authorization from Excillum.
- Pumping other liquids, gases, slurries, or similar in the metal jet loop than what is stated in the confirmation of the purchase order.
    - If permitted liquids (or similar) are not stated in the confirmation of the purchase order, a written approval from Excillum must be acquired before exchanging liquids (or similar).
- Operating the MetalJet D2+/C2 source in potentially explosive areas.
- Operating the MetalJet D2+/C2 source with removed covers or disconnected or bypassed interlocks.
- Performing maintenance or service on the MetalJet D2+/C2 source while it is energized.
- Connection to units which have touchable and voltage carrying parts.
- Connection to units which are not suitable for this purpose according to their operating instructions.

DANGER

Immediate danger: Improper use of the MetalJet can cause injury or death.

2.4 Handling of allium-based alloy

Gallium-based alloys are used in the jet system of the MetalJet source to generate a liquid-jet anode. One of the key benefits of these alloys for this type of application is their low melting point, which is usually around or below normal room temperature.

This section contains information about the most important characteristics of these alloys. Section 2.4.1 covers information about personal safety and instructions about how to clean surfaces as well as yourself in case of contamination. Section 2.1.12 covers the corrosive properties of gallium-based alloys and provides rules and guidelines on how to handle gallium-based alloys to prevent costly and potentially dangerous mistakes.

2.4.1 Safety

According to the material safety data sheet (MSDS), gallium-based alloys do not pose any significant risk if the normal rules of industrial hygiene are observed. These alloys do not constitute any fire or explosion risk. Please read and follow the instructions of the material safety data sheet for the alloy used in your MetalJet system. These are appended to this manual.

However, some characteristics of gallium-based alloys need special attention and special equipment to avoid problems.

- Do not ingest the alloy.
- Wear protective clothes in case of splashing risk or other possible risk of body contact with the alloy.
- Wear protective eyewear in case of possible eye contact through splashing.
- Wear gloves always when handling gallium-based alloys.
- Use MetalJet cleaner to remove droplets and puddles of gallium-based alloy.
- Use lint-free tissue paper together with isopropanol when cleaning the interior of the X-ray source.
- Use spillage protection sheets to minimize impact of spillage.
- Use isopropanol to clean gallium spillage from surfaces inside the X-ray source.
- Use water and soap solution to remove gallium spillage from the floor or a table surface.
- Use a Scotch-Brite sponge instead of tissue paper if the surface is somewhat porous.

2.4.1.1 Personal safety

If some gallium-based alloy contacts the skin, wash off using normal soap and water.

Always wash hands properly after work and before breaks.

Gallium reacts with common jewelry metals such as gold and silver. To avoid damage, remove precious items before handling gallium-based alloys.

CAUTION

Risk of slipping: Gallium-based spillage on the floor is slippery. In case of spilling, clean up immediately. See Section 2.4.2 below.

2.4.1.2 Plan your work

Before performing maintenance or service that may cause some gallium-based alloy spillage, always plan your work in detail before starting. Always use proper protection gear.

2.4.2 Cleaning

In case of spilled ExAlloy, the spillage should be cleaned immediately. Cleaning up spilled gallium-based alloys is a two-step process:

1. Remove droplets and puddles of liquid metal using the provided MetalJet cleaner, see Figure 2-2, or sweep up as much as possible of the spilled alloy and feed it into a plastic container for recycling (see Section 2.1.13).
2. Remove remaining stains using tissue paper or a Scotch-Brite sponge, and a soap-and-water solution or isopropanol. If the spillage occurs on a surface part of the vacuum system, we recommend to use lint-free tissue and isopropanol.

3. DANGER

Disconnect electricity before cleaning: All parts to be cleaned, or close to those parts being cleaned, must be properly disconnected and de-energized before cleaning may begin. High voltage is potentially lethal.

During installation and service spillage may occur. Under normal conditions there should not be any leaks from the MetalJet source causing spillage of liquid metal. If liquid metal is leaking from any part of the system, immediately contact Excillum.

Figure 2-2. The MetalJet cleaner is a very effective tool for cleaning up liquid metal spillage.

3 Transport and storage

3.1 Transport

- The MetalJet D2+/C2 source should only be transported in an upright position.
- The MetalJet D2+/C2 source may be considered as dangerous goods when being transported. Contact Excillum for more information.
- Information regarding the overall dimensions and weight may be found in Section 11.
- Only remove the protection caps from the connections on the turbopump, roughing pump, jet-exit port, low-pressure flex-hose assembly, and high-pressure tubing immediately before assembly.

3.1.1 Lifting

If possible, use the permanent lifting loops and a lifting device to lift the pump box. See Figure 3-1. If a device is not available, use the three lifting handles on the side to lift the open pump box. The pump box must be lifted by at least two persons using correct lifting technique to avoid personal injuries as well as damage to the pump box.

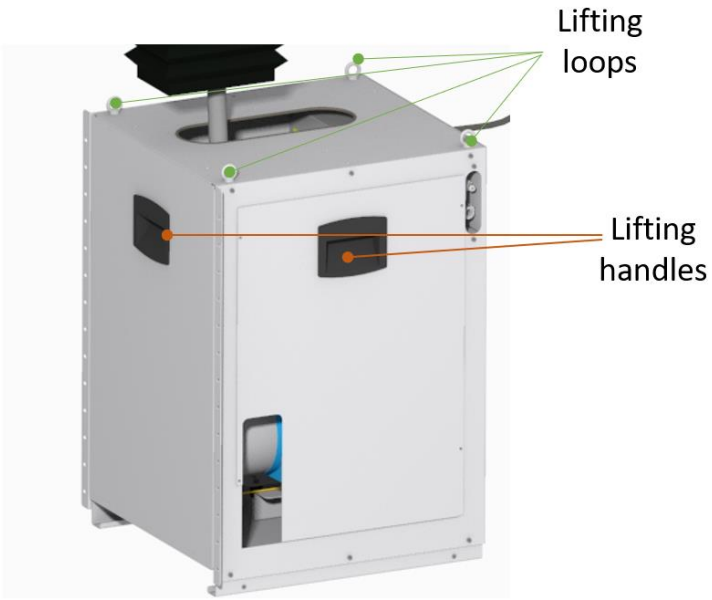


Figure 3-1. Use the three lifting handles when moving the pump box. The third handle is on the far side of the pump box (not shown in the image).

If possible, use the permanent lifting loops and a lifting device to lift the electron gun/X-ray head. If not, the electron gun/X-ray head must be lifted by at least two persons using correct lifting technique to avoid personal injuries as well as damage to the electron gun/X-ray head.
Each controller box is not heavy and special lifting technic is not required. However, the 160 kV High Voltage generator is very heavy and must be lifted by at least two persons.

Pay special attention to the jet-exit port and cooling-water connections when putting the electron gun/X-ray head down. It sticks out below the base plate and may be damaged if not positioned slightly outside the edge of a table. See Figure 3-2.

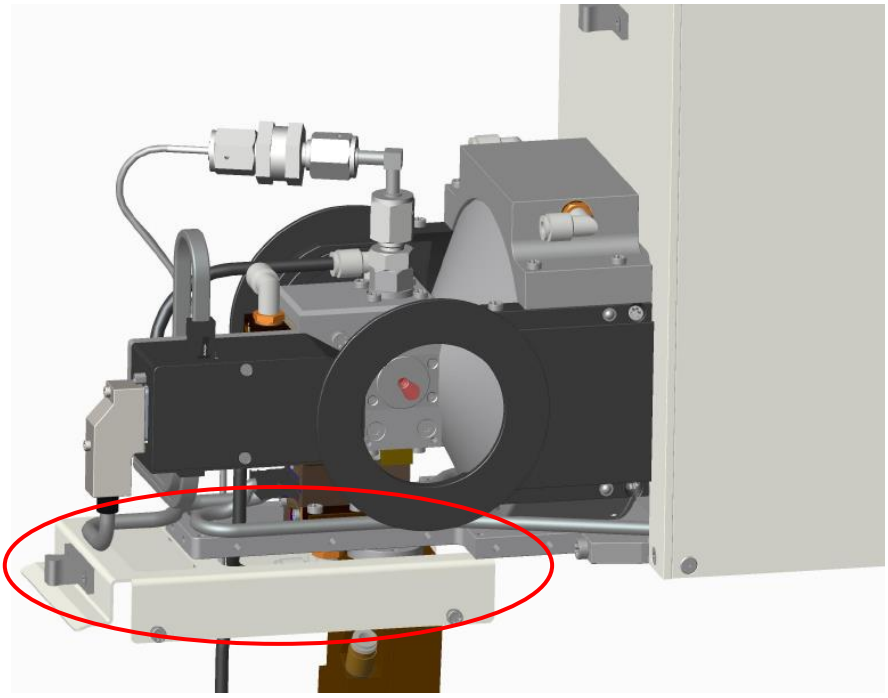


Figure 3-2. Pay special attention to the cooling-water connections and the jet-exit port when placing the electron gun/X-ray head on a table. It may become damaged unless positioned slightly outside the edge of the table.

CAUTION
Lifting of equipment Never attempt to lift the pump box or the electron gun/X-ray head alone. You may injure yourself and/or the equipment.

3.2 Storage

- The MetalJet D2+/C2 source should only be stored in an upright position.
- Check that all openings on the MetalJet D2+/C2 source are properly closed to prevent dust, dirt, or other contaminants from entering the source during storage.
- Store the MetalJet D2+/C2 source in the temperature range 20-40 °C (68-104 °F).
- Store the MetalJet D2+/C2 source in a dry place.

If it cannot be stored in a dry environment it, (as a whole unit or divided into its sub-assembly units) must be airproof shrink-wrapped in a plastic bag together with some bags of desiccant.

4 Installation

4.1 Initial Installation Checklist

This checklist is intended as a hands-on assistance before and during installation of the Excillum MetalJet D2+/C2 source to minimize potential complications.

It is highly recommended that at least steps 1-6 are performed by the customer prior to on-site installation and training by Excillum staff to save time. Should you feel uncertain about how to perform any of these steps below, please contact Excillum support for advice.

1. Read the Operating Manual thoroughly, especially the sections regarding the installation requirements that you as a customer are responsible for:
    a. Mechanical mounting of the source
    b. Ambient specifications (temperature and humidity), not exposed to airflow from air condition or airflow from ventilation
    c. Cooling water (unless included in your specification)
    d. Electrical requirements on mains supply
    e. Electrical requirements of shutter driver (if included in your specification)
    f. Electrical requirements of the safety interlock system.
2. If you have included installation assistance and source training from Excillum, we urge you to send us the details of your installation (as detailed above) well ahead of the installation visit so that we may review it to make sure any issues are sorted out beforehand.
3. When you receive the MetalJet D2+/C2 source, unpack it and make sure there are no transport damages and that everything looks ok.
4. Without removing any of the liquid metal loop transport seals mechanically, install the pump box, source head and the two electronics control racks in their intended positions. Make sure that the liquid loop appears to be able to mate once transport seals are removed (see Section 4.4.3.2).
5. Install the chiller and the optional controller in their intended positions.
6. Verify that the relative positions of different components are such that the provided cables can reach between them with ease.
7. Produce and connect appropriate grounding cables according to the instructions in Section 4.4.3.10 to the protective earth (PE) terminals of the source head, pump box and two electronics rack modules.
8. Remove the transport seals and connect the liquid-metal loop properly (see Sections 4.4.3.2 and Section 4.4.3.4).
9. Remove the transport seals and connect the vacuum hose to the roughing pump as well as the electron gun (see Section 4.4.3.5).
10. Remove the transport seals and connect the water chiller to the pump box. Also connect the loose ends of the cooling-water hoses. See Section 4.4.3.3.

11. Remove the transport seals and connect the high voltage cable to the electron gun as well as to the high-voltage power supply (See Section 4.4.3.8 [70 kV] or 4.4.3.9 [160 kV]).
12. Plug in all interconnecting cables (See Section 4.4.3.7).
13. Connect mains power to the pump box, and the two electronics rack modules.

4.2 Unpacking

Make sure to look for possible transportation damage to the container before unpacking. In case of transportation damage, immediately notify the carrier and contact Excillum.
Check the material received against the packing list. Report any discrepancies immediately.
Inspect the electron gun/X-ray head, the pump box, the X-ray system controller, and the X-ray high-voltage controller for possible shipping damage.
Do not bend cables too sharply. The minimum bend radius for high-voltage cables is 0.5 m.

4.3 Waste / Recycle

It is strongly advised, that when cleaning after installing the X-ray source, the personnel performing the installation pay attention to the environment. Primarily, recycle all waste materials that can be recycled and sort waste so that it can be disposed according to local regulations.
Recycle or dispose of all packing in accordance with local recycling regulations.

4.4 Setting up the MetalJet D2+/C2 source

NOTE
Internal surfaces of the MetalJet D2+/C2 source is clean upon delivery Surfaces exposed to vacuum, and high-voltage insulator ends on the cables should never be handled with bare hands. Use clean room gloves to keep parts free from fingerprints and other contaminants when setting up the MetalJet D2+/C2 source.

4.4.1 Exterior Cleaning

The exterior of the source shall be clean with a dry cloth to remove dust, dirt or grease. If it is hard to remove some dirt, then lightly moist the cloth with some water.

4.4.2 Mounting of sub-assembly units

The electron gun/X-ray head and the pump box are designed to be semi-rigidly connected to each other by the supply high-pressure tubing and the return low-pressure flex-hose assembly of the metal jet loop. See Figure 4-1. In addition, 8 mm outer diameter flexible hoses for cooling water supply and return run from the opening in the pump box towards the X-ray head. The design allows for smaller adjustments of the X-ray head relative to the pump box. Figure 4-1. through Figure 4-3. shows the relative placement of the X-ray head and the pump box for the standard configuration of the MetalJet D2+/C2 source. Remember to proper mount all sub-assembly units before use.

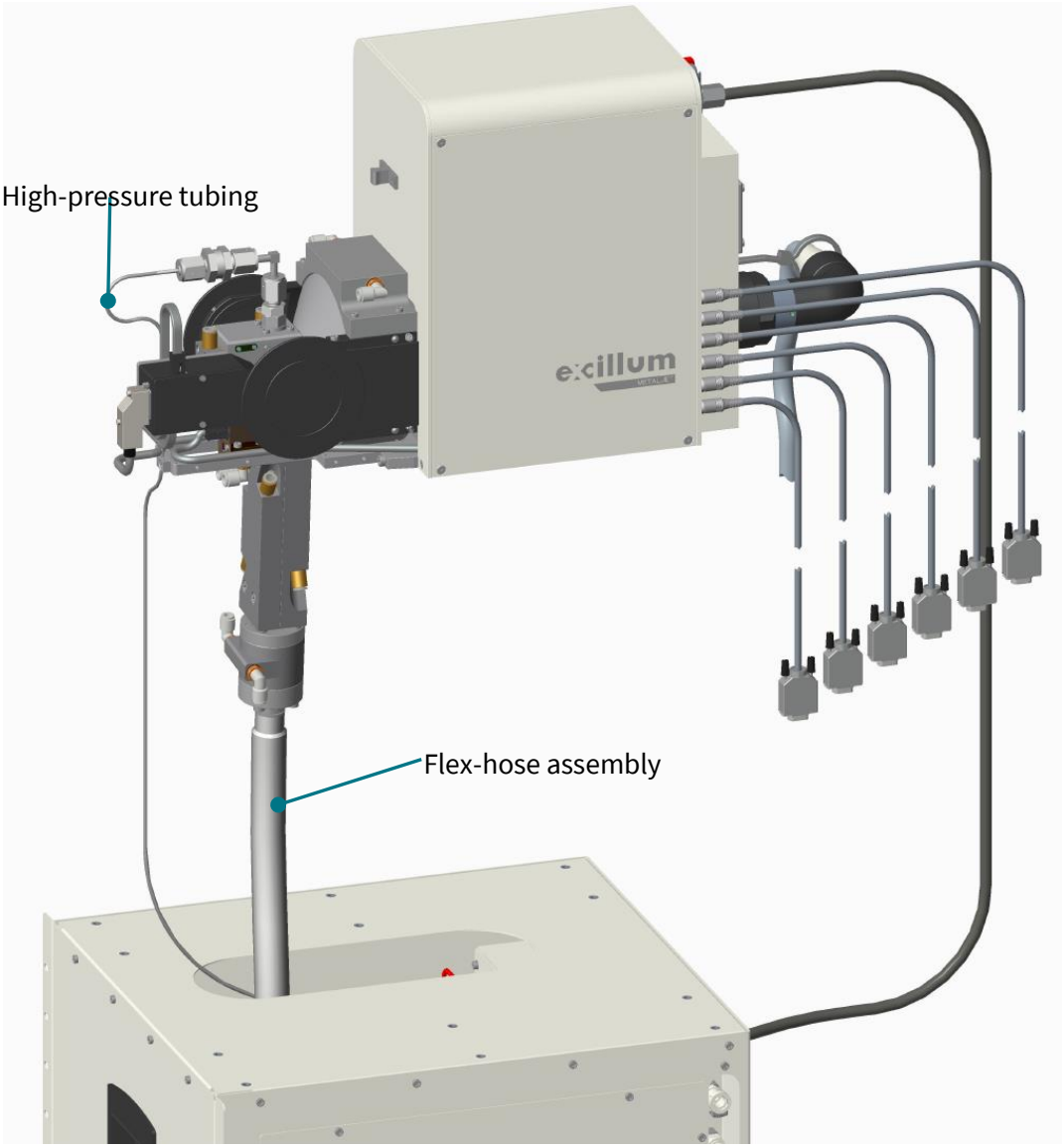


Figure 4-1. The X-ray head is semi-rigidly connected to the pump box by the supply high-pressure tubing and the return bellow for the metal-jet loop. In addition, 8 mm outer diameter flexible hoses for cooling water supply and return run from the opening in the pump box towards the X-ray head.

In order not to over-stretch or over-compress the metal-jet loop components during these adjustments, there are limitations to their vertical positions in relation to each other. See Figure 4-3. for a source with 60 cm sling. In Table 4-1 different slings present what expected height of the source is expected, numbers in parenthesis indicate height difference when sling is nominal length.

Nominal Sling Length [cm]	Pump box > X-ray Head [cm]	Floor > X-ray Window [cm]
60	40-55 (50)	115-130 (125)
75	55-70 (65)	130-145 (140)

90	70-85 (80)	145-160 (155)

Table 4-1. Slings and height differences

In addition, it is also important that the jet-exit port (see Section 4.4.3.2) is placed straight above the hole in the pump box lid. See Figure 4-2. and Figure 4-3.

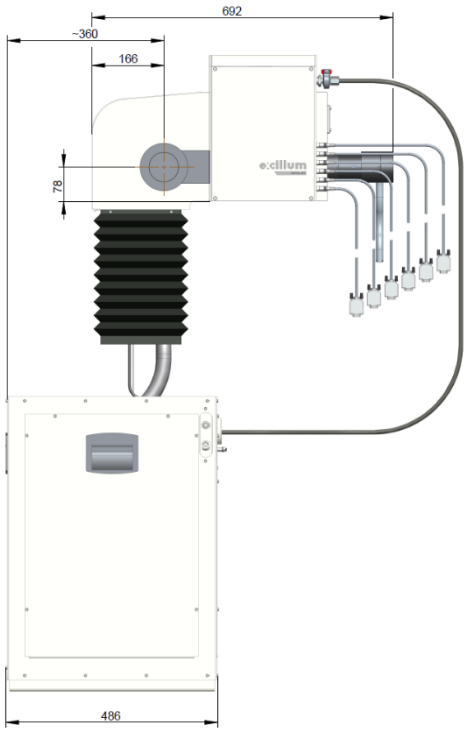


Figure 4-2. The jet-exit port should be placed straight above the rectangular hole in the pump box lid.

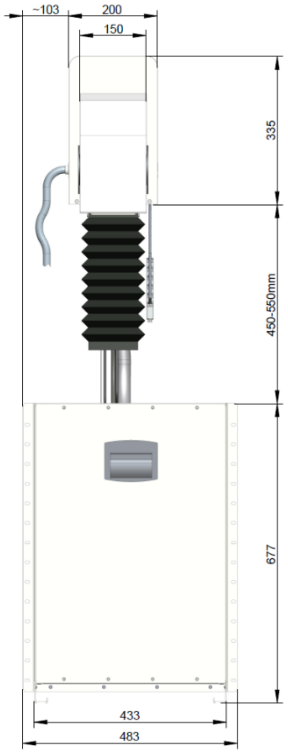


Figure 4-3. The jet-exit port should be placed straight above the hole in the pump box lid, distance in figure between pump box lid to lower end of front cover is for a 60 cm sling**.**

The electron gun/X-ray head and the pump box must be properly fastened to avoid dangerous situations where personnel may get injured, or equipment may get damaged. It is strongly suggested to avoid the use of aluminum for the structure holding the X-ray head due to its reactivity towards the alloys.

The electron gun/X-ray head should be properly fastened using the six M6-threaded holes underneath the base plate. See Figure 4-5. Mount the base plate onto a support with dimensions smaller than the base plate to avoid that the side covers take up the weight of the X-ray head. The center-of-gravity for the X-ray head is indicated in Figure 4-4.
The pump box can either be rack mounted or positioned directly on the floor. It is important that it is leveled. Use the side brackets on the front of the pump box to attach the pump box to a 19” rack, see Figure 4-6., or to fasten it relative to the floor. Note that the 19” rack must in turn also be stable in its relative position to the electron gun/X-ray head. In case the pump box is on wheels, it is very important to lock the wheels to avoid any unwanted movement.

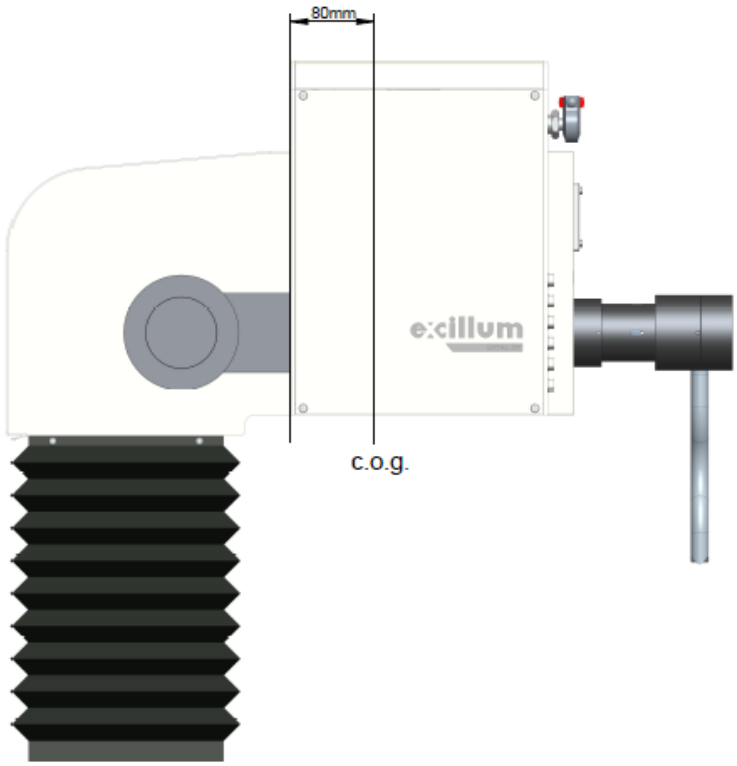


Figure 4-4. Location of center-of-gravity for the X-ray head.

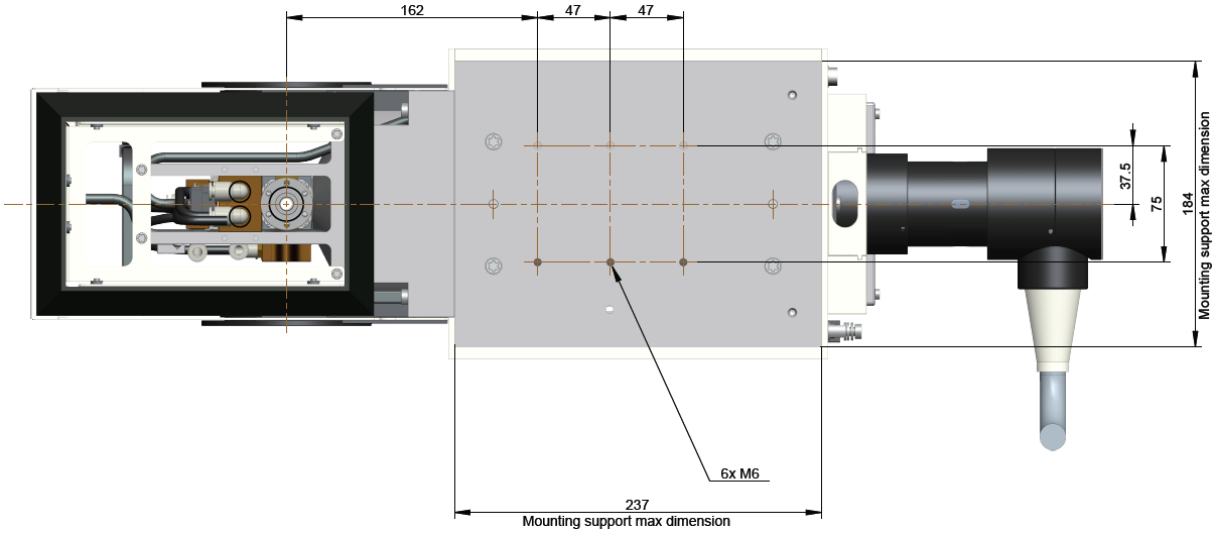


Figure 4-5. The six M6-threaded holes are spaced according to this image (the electron gun/X-ray head seen from below).

Mount the X-ray system controller and the X-ray high-voltage controller properly into a 19” rack located close to the electron gun/X-ray head and the pump box.

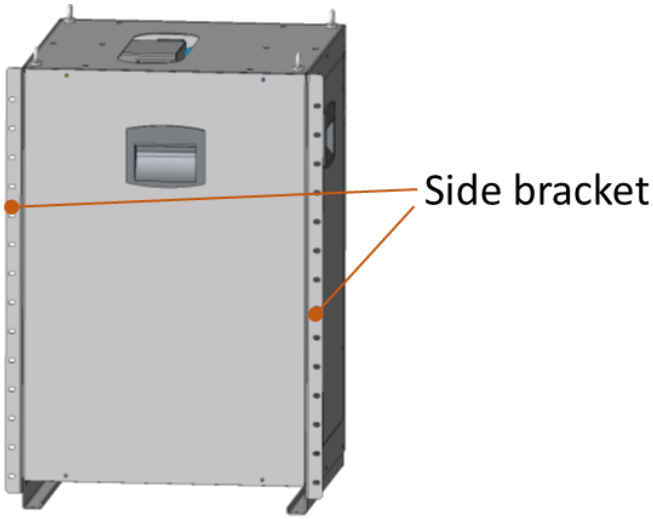


Figure 4-6. Use the side brackets on the front of the pump box to attach the pump box to a 19” rack.

4.4.3 Connecting tubing and cables

4.4.3.1 Tighten inlet and outlet check valve housings

Temperature cycling during transportation may reduce the preload of the sealing surfaces inside the check valve housings, which may cause liquid metal leaks.

1. Tighten the inlet and outlet check valve housings to 50 Nm on the metal-jet pump, circled in red in Figure 4-7., using an open ended wrench.

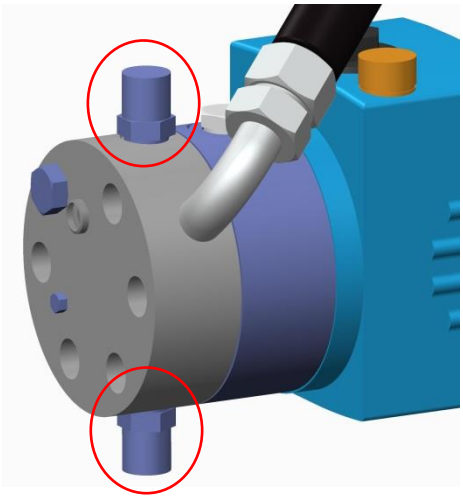


Figure 4-7. Tighten the inlet and outlet check valve housings slightly, circled in red, using an open ended wrench

4.4.3.2 Flex-hose assembly and jet-exit port

1. Remove transportation seals from the flex-hose assembly and jet-exit port before connecting these to each other. Store the transportation seals for future sealing purposes. **NOTE:** Be careful not to scratch the sealing surfaces during assembly.
2. Connect the top end of the flex-hose assembly to the jet-exit port using a 14x3 mm Viton O-ring and six M4x12 screws. See Figure 4-8.

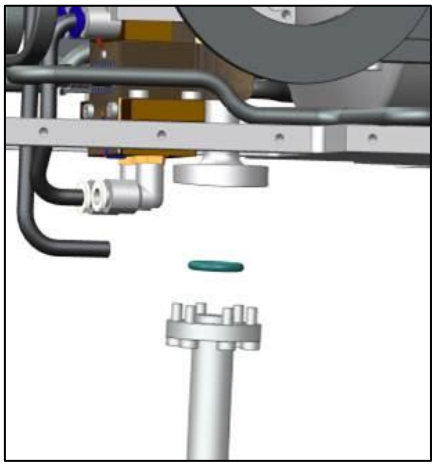


Figure 4-8. Connect the top end of the flex-hose assembly to the jet exit port using a 14x3 mm Viton O-ring and six M4x12 screws. Be careful not to scratch the sealing surfaces during assembly.

3. Attach the upper cooling block around the straight section of the flex-hose assembly using the four M6-screws and a Torx-30 screwdriver with the interlock connector facing forward. See Figure 4-9.

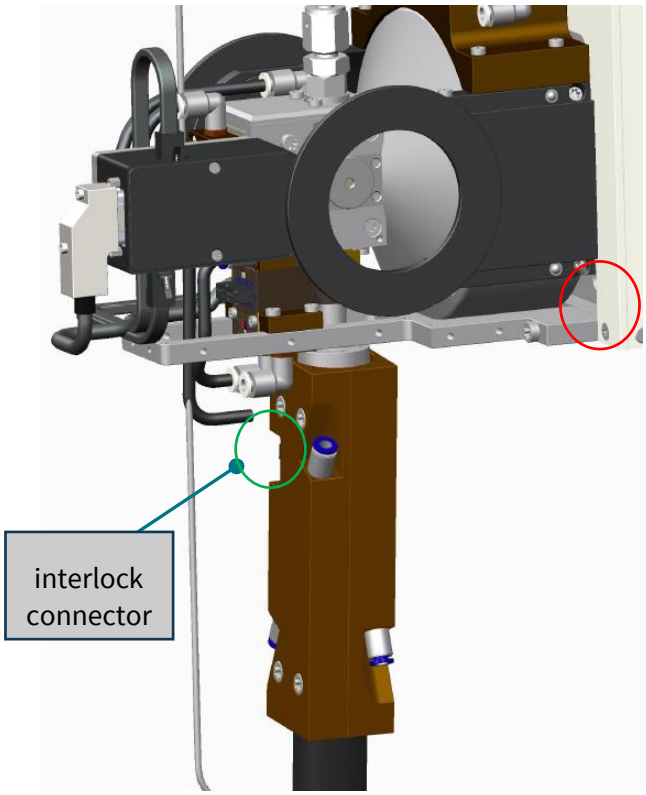


Figure 4-9. Upper cooling block held in position with four M6-screws around the straight section of the flex-hose assembly.

4. Locate the interlock cable coming out from the opening, circled red in Figure 4-9. and connect it to the interlock connector of the upper cooling block circle in green.
   Note: The upper cooling block is part of the radiation shielding design and as such it must be connected to the head interlock circuit.

4.4.3.3 Cooling water supply and return

The hose that supplies the turbopump inside the X-ray head with cooling water is routed from the pump box along the flex-hose assembly into the X-ray head through the opening, circled red in Figure 4-9. The return hose is connected to the lens. Both supply and return hoses are plugged and stored inside the pump box during shipping. The labels attached to the hoses indicate which hose connects to the turbopump and to the upper cooling block respectively.

The routing of the cooling water hoses depends on whether the source is configured left-handed, right-handed or dual port. However, the cooling water should be routed to provide cooling to the subassemblies in the order outlined by Figure 4-10.

1. Pump box inlet
2. Turbopump cooling block
3. Lens cooling block
4. Electron dump cooling block
5. Blank window cooling block (when present)
6. Target chamber cooling (when present)
7. Upper cooling block
8. Jet brake cooling block
9. Lower cooling block
10. Pump box outlet

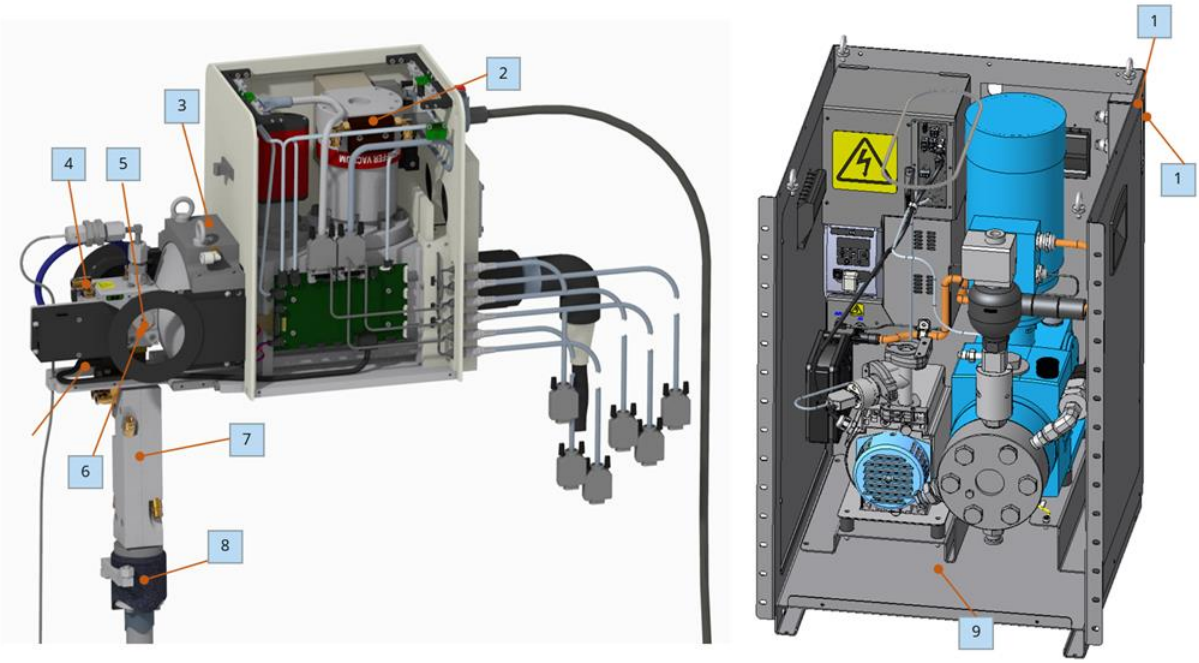


Figure 4-10. Cooling water flow direction through source subassemblies.

Follow the instructions below to connect the supply hose for the turbopump and the return hose from the upper cooling block.

1. Remove the right-hand cover of the X-ray head using a 2 mm Allen wrench to expose the turbopump cooling block. Then route the supply hose through the opening indicated in Figure 4-9. and connect the water hose to the turbopump cooling block and make sure that it is properly connected.
   Note: Leave the cover off until the pump motor has been started to ensure that there are no leaks.

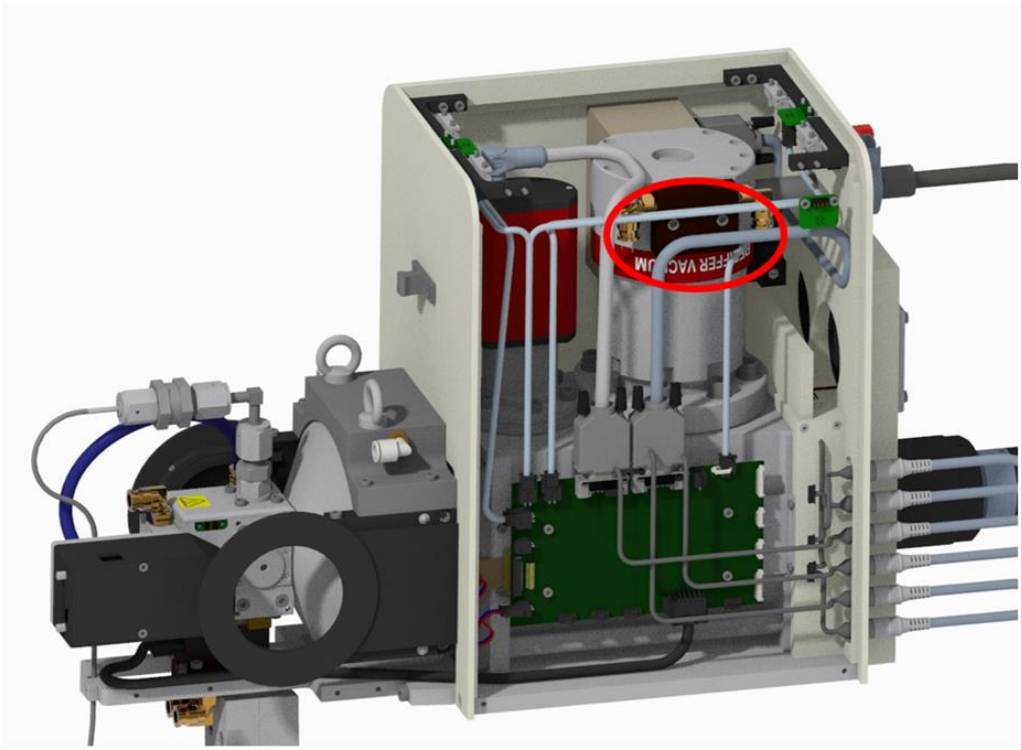


Figure 4-11. X-ray head with right hand cover removed. Turbo pump cooling block circled in red.

2. Connect the return hose to the fitting on the upper cooling block circled in green. See Figure 4-12.

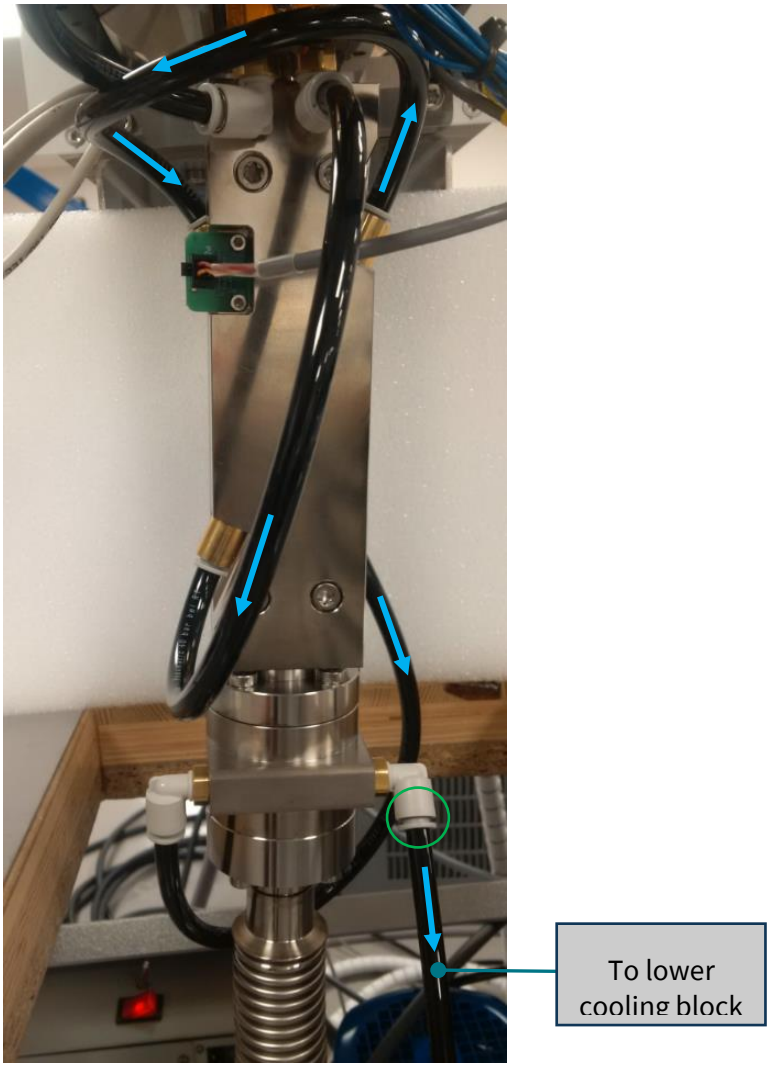


Figure 4-12. Upper cooling block with water hoses connected and flow direction indicated with blue arrows.

4.4.3.4 High-pressure tubing and nozzle assembly

1. Carefully remove transportation seals from the high-pressure tubing and the particle filter before connecting one to each other.
   NOTE: Some pressure can build up inside the high-pressure tubing due to temperature and air pressure cycling possibly causing liquid metal spillage. Open the VCR cap inside a plastic bag to avoid spillage.
2. Connect the port on the high-pressure tubing to the particle filter using an unplated stainless steel VCR gasket. See Figure 4-13.
   a. Snap the VCR gasket with its retainer onto the end of the assembly.
   b. Screw on and tighten the nut on the high-pressure tubing using your fingers only.
   c. Use wrenches to tighten the nut relative the particle filter another 45°.

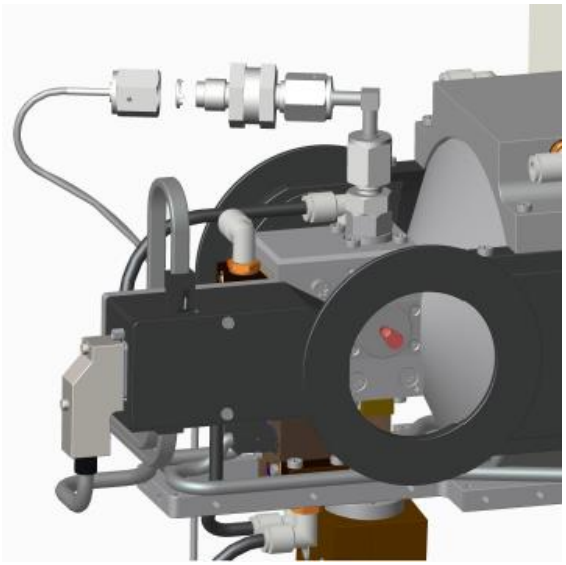


Figure 4-13. Connect the port on the high-pressure tubing to the nozzle assembly using an unplated stainless steel VCR gasket. Pay careful attention to the assembly instructions in the text above.

4.4.3.5 Vacuum hose

Connect the vacuum hose to the KF16 ports on the turbopump on the electron gun and the roughing pump in the pump box using KF16 O-rings and stainless steel KF16 clamps, see Figure 4-14.

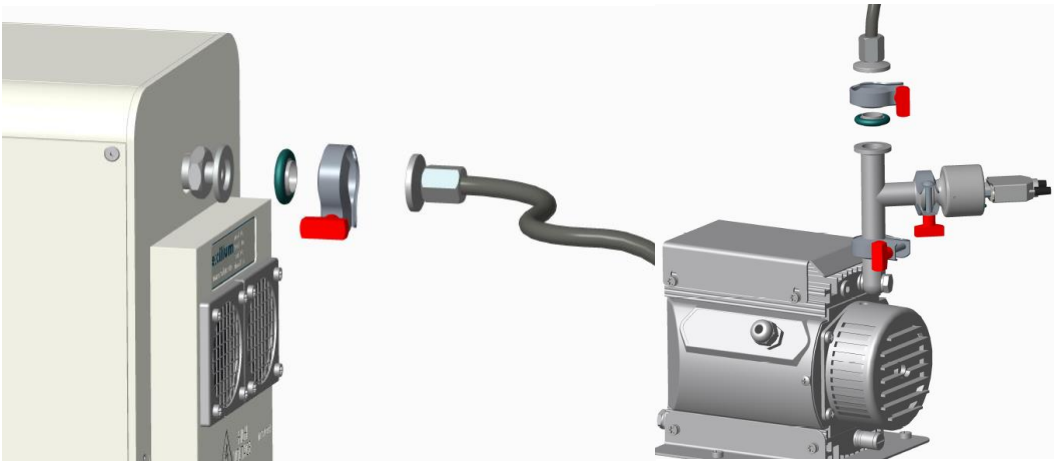


Figure 4-14. Connect the vacuum hose to the KF16 ports on the two vacuum pumps.

4.4.3.6 Cooling water

MetalJet D2+/C2 source is supplied with a water cooling solution which is fully integrated into the control software. To avoid damage to the source due to overheating, the water flow and water reservoir fill levels are continuously monitored. Full software integration of the water cooling system is a requirement for MetalJet D2+/C2 source.

Note: Customer supplied water cooling solutions can only be supported if flow rate and fill level can be communicated to the control software by either RS232 or USB. In addition, the water temperature must be compatible with the melting point of the alloy used. Contact Excillum for further information about water chiller requirements if an external water cooling solution is preferred or required.

MetalJet D2+/C2 source could be delivered with a standalone chiller. The document “Installation and Maintenance Manual Air Cooled Thermo Con for Rack Mount”, assembled by SMC, contains detailed installation instructions for this chiller.

1. Follow appropriate installation instructions to ensure proper installation of the water cooling solution delivered with the MetalJet D2+/C2 source.
2. Before starting the circulation of cooling water, verify that all water hoses are properly connected.
3. When starting the cooling water circulation, verify that all water hose connections are free from leaks. Be prepared to turn off water circulation as soon as there is an indication of a water leak.

4.4.3.7 Interconnecting cables

1. Connect all interconnecting cables between X-ray head, X-ray system controller, X-ray high-voltage controller and pump box according to Table 4-2 below. Refer to Section 4.4.3.8 and Figure 4-15. Regarding connector locations for MetalJet D2+/C2 70 kV source and Section 4.4.3.9 and Figure 4-15. Also Figure 4-21. for MetalJet D2+/C2 160 kV source.
   Note: The cables connecting the X-ray head to the X-ray system controller and the X-ray high-voltage controller has a standard length of 5 m, but they can also be supplied in a 10 m version.

Cable part number	Port 1	Port 2
E-009-0037 (5 m) E-009-0236 (10 m)	DP (X-ray system controller) #1	DP (X-ray head)
E-009-0151 (5 m) E-009-0234 (10 m)	B1 (X-ray system controller) #4	B1(X-ray head)
E-009-0153 (5 m) E-009-0233 (10 m)	B2 (X-ray system controller) #5	B2(X-ray head)
E-009-0036 (5 m) E-009-0238 (10 m)	U3 (X-ray system controller) #7	U3 (X-ray head)
E-009-0079 (5 m) E-009-0237 (10 m)	U5 (X-ray system controller) #6	U5 (X-ray head)
E-009-0038 (5 m) E-009-0235 (10 m)	SN (X-ray high-voltage controller)	SN (X-ray head)
E-009-0100 (1.5 m)	D-HV (X-ray system controller) #2	D-HV (X-ray high-voltage controller)
E-009-0101 (1.5 m)	A-HV (X-ray system controller) #3	A-HV (X-ray high-voltage controller)
E-009-0102 (3.3 m)	A-PB (pump box)	A-PB (X-ray high-voltage controller)
E-009-0103 (3.3 m)	D-PB (pump box)	D-PB (X-ray high-voltage controller)

Table 4-2. List of interconnecting cables to be connected during installation.

2. Connect the source to the local network using the ethernet port in the back of the X-ray system controller. See Figure 4-15. X-ray system controller seen from behind.

   Note: Monitor, keyboard and mouse can also be connected to the X-ray system controller. However, normally the source is accessed over TCP/IP using the VNC server running on the X-ray system controller.

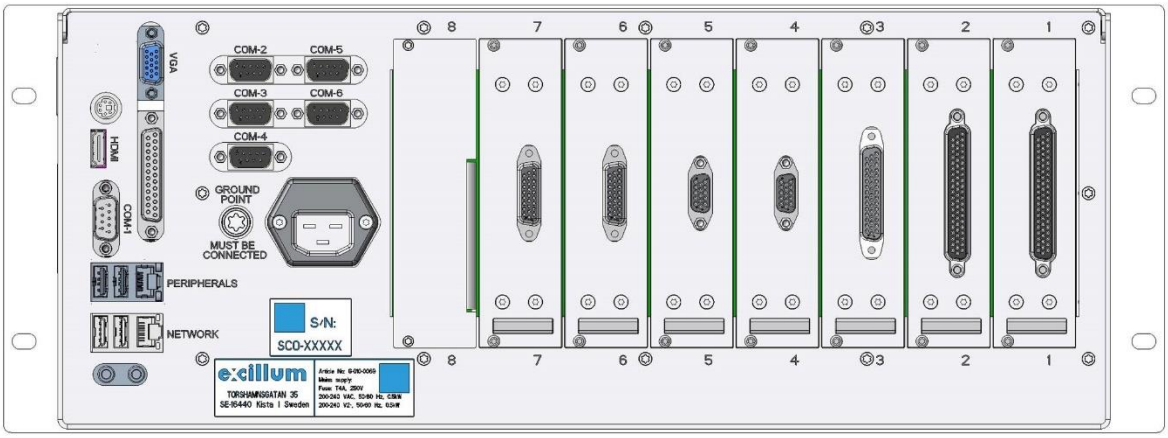


Figure 4-15. X-ray system controller seen from behind.

For a MetalJet D2+/C2 the modules in Figure 4-15. are in order as in Table 4-3.

X-ray System Controller Slot	Modules MetalJet D2+/C2 70 kV	Modules MetalJet D2+/C2 160 kV
1	DP	DP
2	D-HV	D-HV
3	A-HV	A-HV
4	B1	B1
5	B2	B2
6	U5	U5
7	U3	U5
8	Empty	Empty

Table 4-3. List of modules in X-ray System Controller

Figure 4-16. X-ray head from behind showing connectors to X-ray system controller and X-ray high-voltage controller (left side).

4.4.3.8 MetalJet D2+/C2 70 kV

The high-voltage generator is external in MetalJet D2+/C2 70 kV source and connect to the X-ray high-voltage controller. See Figure 4-17.

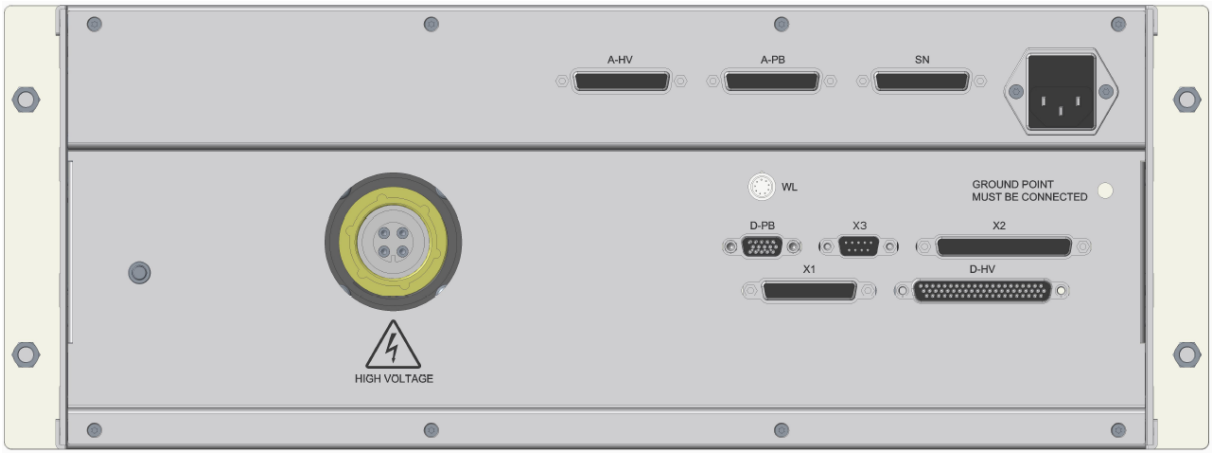


Figure 4-17. X-ray high-voltage controller seen from behind.

1. Connect the high-voltage cable to the electron gun (Figure 4-18).

a. Remove the transportation cover and wipe the tapered end of the insulator on the connector of the high-voltage cable with a minor amount of isopropanol and lint-free tissue paper.

b. Gently insert the tapered end into the high-voltage connector on the electron gun carefully not to scrape the insulator. Avoid excessive twisting or force when inserting cable.

c. Tighten the eight M6x20 screws in a star-shaped pattern until fully screwed in.

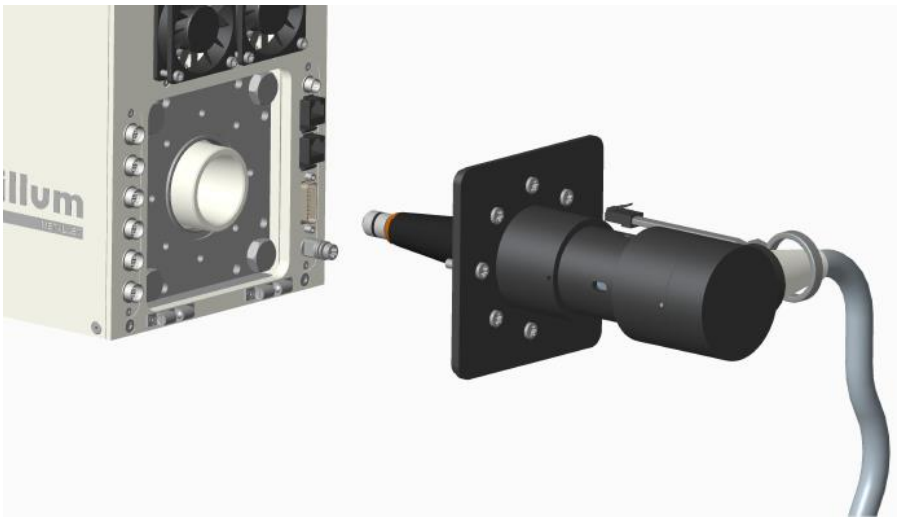


Figure 4-18. Connect the tapered end of the high voltage cable to the electron gun according to the instructions above.

2. Connect the cable labeled “E-009-0065 RC” to the RJ45 socket labeled “Pull wire”.
Note: The purpose of the pull wire is to prevent users from removing the high-voltage cable without removing the pull wire. Presence of the pull wire can be detected by an external safety system.

Figure 4-19. X-ray head from behind (right side) showing the connectors for the safety system interface.

3. Remove transportation cover and connect the high-voltage cable to the X-ray high-voltage controller (Figure 4-20).

a. Insert the ribbed contact into the receptacle socket on the back of the X-ray high-voltage controller. Attention: the key mates with the bottom of the receptacle.
   i) If the friction when inserting the ribbed contact is too high; put a small amount of silicone oil (part number M-00476) on the ribbed contact and smear it out properly.
b. Hand-tighten the ring nut.
c. Tighten the grub screw.

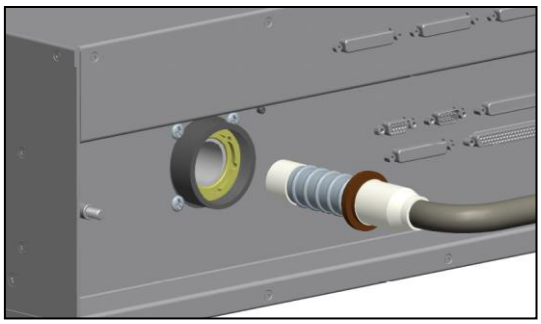


Figure 4-20. Connect the ribbed contact of the high voltage cable to the rear of the X-ray high-voltage controller unit.

DANGER

High voltage is potentially lethal

All sub-assembly units must be properly grounded, and all cables must be securely attached before turning on the MetalJet D2+/C2 source.

Ensure that all interlocks are connected before energizing the MetalJet D2+/C2 source.

Do not disconnect or bypass any interlocks.

NOTE

Separate high-voltage cable

During installation it is preferred to separate high-voltage cable from other cables. Ensure that high-voltage cable is separate from other cable after each modification of source such as after service.

4.4.3.9 MetalJet D2+/C2 160 kV

The high-voltage generator is external in MetalJet D2+/C2 160 kV source and connect to the X-ray high-voltage controller. See Figure 4-21.

Figure 4-21. X-ray high-voltage controller seen from behind.

1. Connect all interconnecting cables between X-ray high-voltage controller and the high-voltage generator according to Table 4-4 below.

Cable part number	Port 1	Port 2
C-0007 (1 m)	9-Pin D-sub GENERATOR CONTROL (X-ray high-voltage controller)	RS-232 (high-voltage generator)
E-009-0189 (1 m)	15-Pin D-sub GENERATOR CONTROL (X-ray high-voltage controller)	JB1 (high-voltage generator)
C-00006 (1 m)	GENERATOR SUPPLY (X-ray system controller)	J2 (high-voltage generator)

Table 4-4. Interconnecting cables between X-ray high-voltage controller and high-voltage generator.

2. Connect the high-voltage cable to the electron gun (Figure 4-22).
   a. Remove the transportation cover and wipe the tapered end of the insulator on the connector of the high-voltage cable with a minor amount of isopropanol and lint-free tissue paper.
   b. Gently insert the tapered end into the high-voltage connector on the electron gun, being careful not to scrape the insulator. Avoid excessive twisting or force when inserting cable.
   c. Tighten the eight M6x20 screws in a star-shaped pattern until fully screwed in.

Figure 4-22. Connect the tapered end of the high voltage cable to the electron gun according to the instructions above.

3. Connect the cable labeled “E-009-0065 RC” to the RJ45 socket labeled “Pull wire”.
   Note: The purpose of the pull wire is to prevent users from removing the high-voltage cable without removing the pull wire. Presence of the pull wire can be detected by an external safety system.

Figure 4-23. X-ray head from behind (right side) showing the connectors for the safety system interface.

4. Remove transportation cover and connect the high-voltage cable to the X-ray high-voltage controller (Figure 4-24.).
   1) Insert the high-voltage contact into the receptacle socket in the back of the high-voltage generator.
   2) Tighten the four screws to holding the connector flange in position and check for correct HV cable compression by visual inspection on the side of the cable assembly.

Figure 4-24. Connect the ribbed contact of the high voltage cable to the rear of the X-ray high-voltage controller unit.

3) The two first rings should be visible but not the third one. See Figure 4-25. below. Adjust if necessary by removing the four screws and rotating the cable flange.

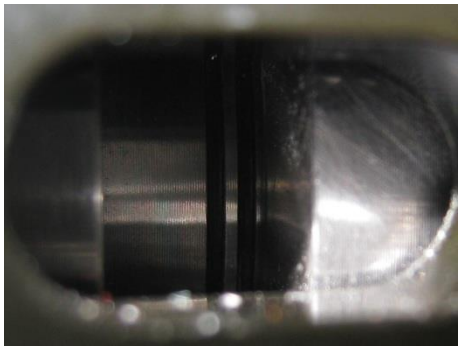


Figure 4-25. Two rings should be visible when the cable compression is correctly adjusted.

DANGER

High voltage is potentially lethal

All sub-assembly units must be properly grounded, and all cables must be securely attached before turning on the MetalJet D2+/C2 source.

Ensure that all interlocks are connected before energizing the MetalJet D2+/C2 source.

Do not disconnect or bypass any interlocks.

NOTE

Separate high-voltage cable

During installation it is preferred to separate high-voltage cable from other cables. Ensure that high-voltage cable is separate from other cable after each modification of source such as after service.

4.4.3.10 Mains supply

1. Connect appropriate grounding cables to the protective earth (PE) terminals of the four modules to a common system PE terminal. See Figure 4-26. or Figure 4-27. The terminals

are located close to the Mains supply terminals. The PE terminals are located at the back of each module. The uninterrupted power supply (UPS) offered with MetalJet D2+/C2 source in Figure 4-26. or Figure 4-27 is optional. Follow installation instructions from the UPS supplier if a UPS has been purchased together with the source. It is mandatory to connect the common system PE terminal to the Mains inlet PE terminal (dashed red line).

DANGER

Immediate danger: Connect secondary ground to building ground according to Figure 4-26. or Figure 4-27.

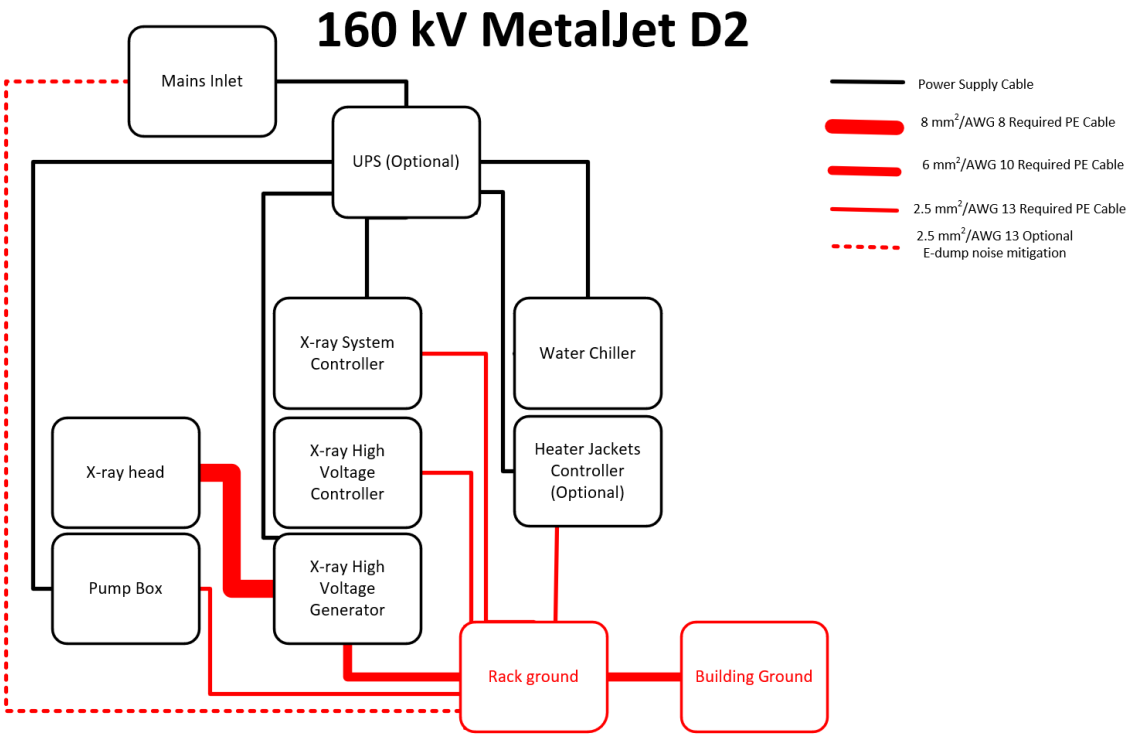


Figure 4-26. Schematic showing how to connect the protective earth terminals of the sub-modules to the system ground terminal on 160 kV MetalJet D2.

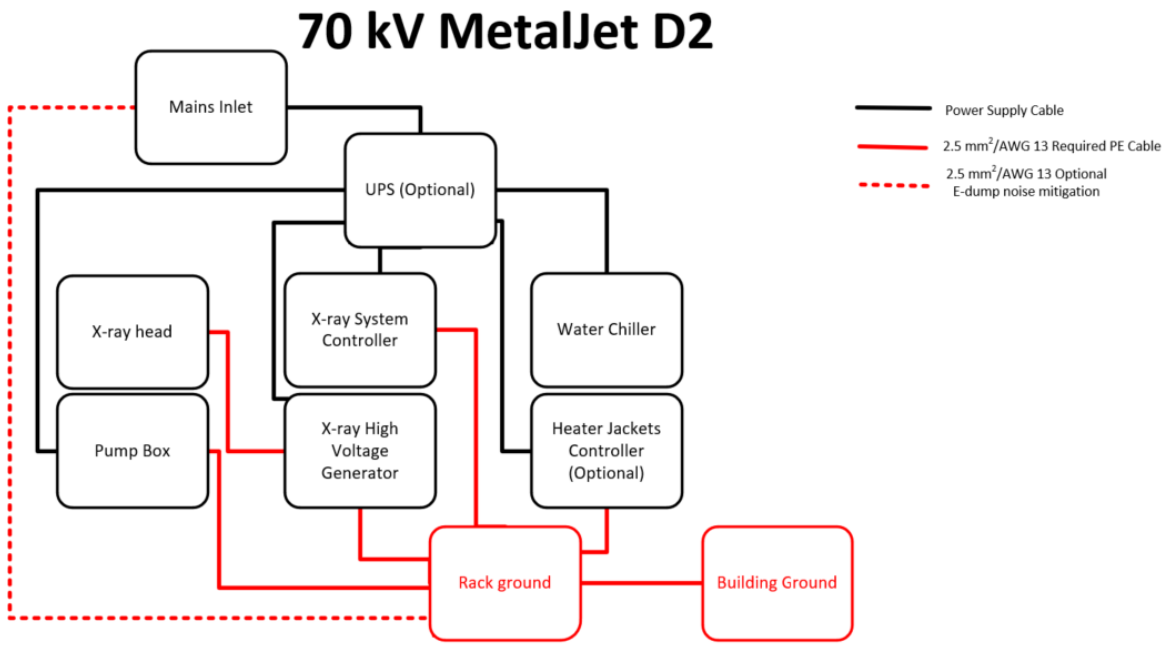


Figure 4-27. Schematic showing how to connect the protective earth terminals of the sub-modules to the system ground terminal on 70 kV MetalJet D2.

Table 4-5 summarize which sub-modules that are rack mounted and indicates space requirements within the rack.

Sub-assembly unit	MetalJet D2+/C2 70 kV	MetalJet D2+/C2 160 kV
Heater jacket controller	Optional, see Heater jackets operating manual	
X-ray system controller	4U 19” rack mounted	
X-ray high-voltage controller	4U 19” rack mounted integrated high-voltage generator	2U 19” rack mounted
High-voltage generator	-	4U 19” rack mounted
Water chiller	See water chiller manual	

Table 4-5. Rack mounted sub-modules for MetalJet D2+/C2 70 kV and 160 kV sources.

2. Connect electrical mains cables to the rear of the X-ray high-voltage controller, X-ray system controller, pump box and the water chiller. Mains cables are not included except when a UPS is purchased together with the source. Verify that all electrical mains cables connected to each sub-assembly are connected to a residual-current circuit breaker and that the supply voltage is within the technical data in Section 11.

WARNING

Residual current devices must be used

For safety reasons, the power cables must be plugged into sockets equipped with residual current devices.

NOTE

Disconnecting device must be used in final installation

The installation must incorporate a disconnecting device, which disconnects all current-carrying conductors.

4.5 Safety system

The MetalJet D2+/C2 is not equipped with a built-in safety system but provides the signals necessary to implement one. All safety related signals are dual and separated so that an external safety system can be built in a “fail safe” manner. It is based on two safety relays that control the mains supply to the high voltage generator which can only be activated by an external signal. The MetalJet D2+/C2 source has the possibility to inhibit the circuitry controlling the relays, but not the ability to activate them. This means that to generate X-rays, a safety system needs to be implemented by the customer.

The customer is supplied with a safety system interface with the MetalJet D2+/C2 source through the high voltage controller and the electron gun. Section 4.5.1 and 4.5.2 below explain the purpose and functionality coupled to the various connectors.

Excillum document “P-029-0002 - Customer safety system example” is appended to this operating manual. It shows a system level diagram of how a rudimentary but not complete customer safety system can be implemented.

DANGER

The 160 kV source must be run inside a radiation shielding cabinet

X-ray radiation can be a health hazard. The 160 kV source is not radiation shielded, therefore it must be run inside a radiation shielding cabinet.

The shutter **does not** provide radiation shielding for 160 kV radiation.

4.5.1 High voltage controller

The high voltage controller has a 44-pin male high density D-sub connector labeled **X1**. It gives access to the safety relays and high voltage monitor outputs. The safety relays should only be activated when the customer’s safety requirements are fulfilled. It is the responsibility of the customer to decide what safety level is required.

In addition to controlling the mains supply to the high voltage generator, it also provides the customer with safety relay status feedback and the possibility to route other signals through the safety relays. Furthermore, it provides analog monitor signals of the high voltage. High voltage monitors outputs that range from 0.6 V to 3.93 V for 0 kV to V_{max} kV, where V_{max} is max rating for the high-voltage generator. Values outside these indicate a malfunction. **Note** that the high voltage monitor output is not a fully qualified safety signal according to ISO 13849-1.

4.5.1.1 Safety system interface 70 kV

Excillum document “P-029-0000 - High voltage controller safety system interface” is appended to this operating manual and shows a detailed schematic of the X1 connector pin-outs for a 70 kV system.

4.5.1.2 Safety system interface 160 kV

DANGER

The 160 kV source must be run inside a radiation shielding cabinet

X-ray radiation can be a health hazard. The 160 kV source is not radiation shielded, therefore it must be run inside a radiation shielding cabinet.

The shutter **does not** provide radiation shielding for 160 kV radiation.

Excillum document “P-029-0007 - High voltage controller safety system interface X1 160 kV” is appended to this operating manual and shows a detailed schematic of the X1 connector pin-outs for a 160 kV system.

4.5.2 Electron gun

The safety system related connectors of the electron gun are in the back of the electron gun. See Figure 4-28.

Figure 4-28. X-ray head from behind (right side) showing the connectors for the safety system interface.

Excillum document “P-029-0001 - Electron gun safety system interface” is appended to this operating manual. It shows a detailed schematic for the connectors described below. If you have any question regarding the implementation of your safety system, please contact support@excillum.com.

Interlock is a HR10A-7P-4S from HIROSE which gives access to the two loops that will be closed when all radiation shielding covers including the shutter and the upper cooling block are mounted.

DANGER

The 160 kV source must be run inside a radiation shielding cabinet

X-ray radiation can be a health hazard. The 160 kV source is not radiation shielded, therefore it must be run inside a radiation shielding cabinet.

The shutter **does not** provide radiation shielding for 160 kV radiation

Shutter is a 26-pin male high-density D-sub connector (DB26HD). It is used to control the shutter and to detect the state of the shutter. It can also be used to detect the state of the pull wire, see below, and to drive optional warning lamps that connect to the RJ45 socket labeled “Display.”

Figure 4-29 Hubmagnet HM207-F 24VDC 4%ED

The shutter actuator contains a 24V solenoid (Hubmagnet HM 207-F 24VDC 4%ED), and a flyback diode mounted internally to handle inductive voltage spikes from supply power changes. The shutter needs to be driven by a “pull in and hold circuit.” A pull-in current source of 1.5 A for 0.5 s and then a hold current of 0.5 A is needed for the shutter to be opened. To obtain that we strongly recommend a regulated constant current drive circuit with a current level switch controlled by a timer. Using a pulse-width modulation drive design for the shutter is not recommended.

If the shutter driver current is turned off, the shutter will automatically close.

The three optical sensors (OPB960N51) are typically driven with separate current limited DC frequency signals. Each light emitting diode emits pulses of invisible infrared light when energized by the light curtain’s timing and logic circuit. The purpose of using different frequencies is to eliminate potential crosstalk. Sensor side logic should then be built to remove the added frequency signal to get the actual state of the sensor.

Note: The shutter has in total three opto switches (labelled OPB960N51), where only one is equipped with a resistance. For the implementation of your safety system remember to add external resistors for the other two opto switches.

Note: The shutter that Excillum supplies only includes the actuator and sensors and does NOT include any drivers or adaption logic.

DANGER

The 160 kV source must be run inside a radiation shielding cabinet

X-ray radiation can be a health hazard. The 160 kV source is not radiation shielded, therefore it must be run inside a radiation shielding cabinet.

The shutter **does not** provide radiation shielding for 160 kV radiation.

Pull wire is a female RJ45 connector that connects to the pull wire that is strapped to the high-voltage cable and can be used to control the mains supply to the high voltage generator. The purpose is to make it impossible to remove the high-voltage cable without disconnecting the pull wire. Presence of the pull wire is detected from the 26-pin high-density D-sub connector labeled “Shutter”.

Display is a female RJ45 connector that can be used to connect a small warning display. We suggest a small moveable display that can be placed close to the MetalJet D2+/C2 source somewhere where it is clearly visible by the user of the source.

4.6 Operating conditions

The MetalJet D2+/C2 source may only deliver optimum performance if the following operating conditions are respected.

4.6.1 Ambient conditions

- See technical data in Section 11
- The MetalJet D2+/C2 should not be placed in a space where it may be exposed to direct sunlight, atmospheric agents (rain, snow, ice, etc.), dust or aggressive gases.
- Do not install or use the MetalJet D2+/C2 in explosive environments or those with a high fire risk.
- Do not install or use the MetalJet D2+/C2 in an area were ambient temperature changes or in an area with different ambient temperature for different parts of the MetalJet D2+/C2.
- If metal-jet pump need to be started please check that pump box and metal-jet sling is warm before enter ready state. If source is stuck in state heatup then the source is needed to be heated during a period before metal-jet pump can be started.

4.6.2 Ventilation

Do not block the air intakes of the source head, pump box and two electronics rack modules.

4.6.3 Cooling water

See technical data in Section 11

4.7 System integration

This section gives recommendations regarding system integration and accessibility of system components to allow maintenance and service to the MetalJet D2+/C2 source. It also explains how to integrate the system controller in the system IT infrastructure.

4.7.1 Source accessibility

Easy access to the source simplifies regular maintenance and service and should be considered during the source design phase. Servicing the jet pump benefit from easy access to the pump box from all four sides. However, in cases where this is not possible access from the front should be prioritized. See Figure 4-30.

Figure 4-30. Easy access to the pump box simplifies regular maintenance and service to the source and should be considered during the source design phase.

During cathode replacement, the high-voltage cable and the high-voltage flange need to be removed. See Figure 4-31. If possible, provide access to both front and back by removable radiation shielding covers.

Figure 4-31. Allow for enough clearance to remove the high voltage cable and high voltage flange during cathode replacement.

Replacing the nozzle, the exit window and performing service to the electron dump require access to the front of the X-ray head from different directions. See red arrows

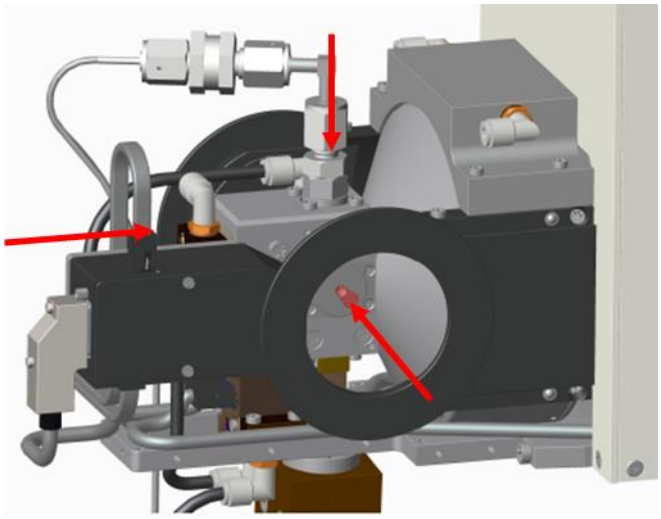


Figure 4-32. The shutter must be removed to access the exit window which eventually will need to be replaced.

4.7.2 Network connectivity

The X-ray system controller should be connected to a local network. See Figure 4-33. A router with a DNS server is preferred, but a switch can also be used if the X-ray system controller is configured to use a static IP address. The X-ray system controller runs a VNC server and a SFTP server that can be used to control the machine remotely and access files stored on the system controller.

In most cases, connecting a monitor, keyboard and a mouse directly to the X-ray system controller is only necessary during installation if network settings need to be changed.

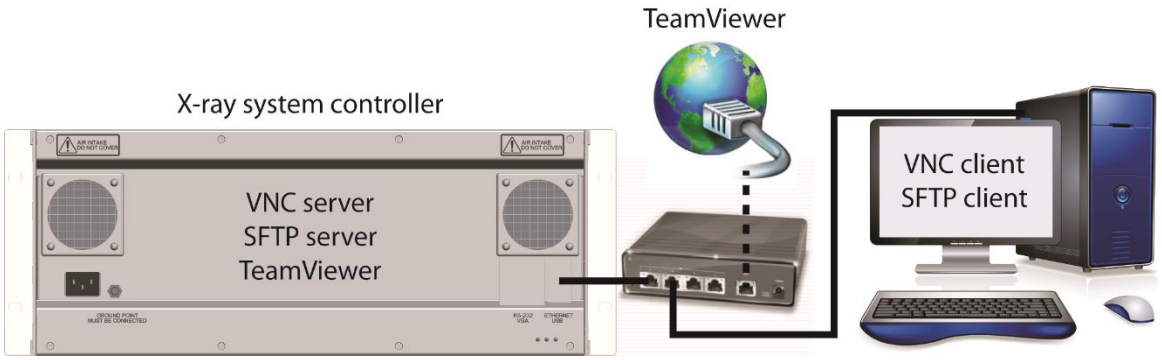


Figure 4-33. Suggested network architecture and capabilities of the X-ray system controller.

We recommend using TightVNC combined with FileZilla or MobaXterm to remote connect to the X-ray system controller desktop as well as transferring files to and from the system. The user name is “jxs” and the password is “jxs4944.” The three applications can be downloaded for free from the internet.

5 Operation

This chapter opens with some introductory notes on the operation of the MetalJet D2+/C2 source. The rest of the chapter covers standard operation using the software that is delivered with the source: The cores application X-ray Control Software (XCS) consists of a controller software and a user interface, Human-Machine Interface (HMI) or Graphical User Interface (GUI). All operations of the source can be carried out using HMI/GUI.

The instructions and screenshots assume that XCS 3.5.X is installed, including a custom desktop for the Debian that the X-ray system controller is running. However, most of the instructions are valid also for older versions of the XCS.

Service or maintenance shall only be conducted by service trained personnel wearing personal protective equipment (at least gloves and eye protection).

Up-to-date operating instructions may be obtained by contacting Excillum.

Before using the MetalJet D2+/C2 source after a service or maintenance occurrence the source shall be checked, and proper action shall take place to avoid damage or accidents. Depends on what have been done during last maintenance some items could be thoroughly or flashy.

- Inspection of source at least include high pressure sling
- Inspect sub-assembly such as fan filters, cabling and other items
- Check proper vacuum levels
- Check proper jet pressure
- Check high-voltage generation (conditioning, cathodebake and heatertune)
- Perform alignment or check alignment
- Perform parametrization or check parametrization
- Check calibration

5.1 Introductory notes on source operation

5.1.1 Starting the jet pump

CAUTION
Possible danger: It is suggested that the operator/engineer is standing at a safe distance or not directly in front of an open pump box when starting the jet pump. High pressure jet could inflict injury in case of catastrophic failure.

When the jet pump in a MetalJet D2+/C2 source has been turned off for some time, and the jet system has been subjected to temperatures close to or below the freezing point of the alloy used, there is a risk of freezing. This may happen during storage or transport, or even in heavily airconditioned laboratories.

Before starting the jet pump in the MetalJet D2+/C2 source it is therefore important to ensure that the alloy inside the entire jet system has been liquefied. The source has a HeatUp task which protects against freeze ExAlloy and secures that it is heated before starting the jet pump. If the source has been running the jet pump and then unpowered for a short time the HeatUp task will remember that it was warm previously. It is also possible to override the warmup time.

NOTE
Warranty void if warmup time have been overridden If Exalloy was not liquefied, the warranty will not cover the damage of the source.

MetalJet D2+/C2 sources may be operated using three different anode alloys: **ExAlloy-G1**, **ExAlloy-I1**, **ExAlloy-I2**

If a source containing **ExAlloy-G1** has been stored in particularly cold environment, then the alloy might take more than the standard HeatUp to warm up. In this case, please contact Excillum Support to have further instruction.

They have different compositions, which are tailored for different applications. Contact Excillum for further information about which alloy to choose for a specific application. The physical properties of the alloys are also different.

Refer to the MetalJet D2+/C2 service manual, Section **Start jet pump,** for instructions on how to prepare the source for starting the jet pump.

5.1.2 Leave MetalJet D2+/C2 source in On or Ready

It is strongly recommended that the MetalJet D2+/C2 source is always in either the “On” state or in the “Ready” state (see chapter 5.4.1) where vacuum is maintained, and the metal jet is running. In this state, the jet operation is very stable and reliable for long durations. When the jet is stopped, a nozzle exchange can be required to achieve stable operation (see Section 6.2.4).

5.1.3 Expected time between service

The main degradation factor for a MetalJet D2+/C2 source is cathode aging caused by various processes such as *e.g.* thermally induced evaporation of the LaB_6 crystal surface. See section 6.3.1 for further information on cathode aging.

5.1.4 Electron beam power vs. spot size

The MetalJet D2+/C2 source is in principle capable of focusing 300 W of power into a sub ~5 µm spot. Such a high anode power loading will however generate significant amounts of metal vapor that can damage the source in various ways. The maximum power for a given spot size and shape is therefore limited by software. It is important that the spot size is accurately calibrated. The spot size is regularly calibrated (see Section 5.9.1) to avoid too high of power loading. It is important to not override this calibration.

NOTE
It is important to not override the calibrated spot size To avoid too high of power loading of the anode.

5.2 Starting the MetalJet D2+/C2 source

The decision process when starting the MetalJet D2+/C2 source is illustrated by a flowchart in Figure 5-1. below. Contact Excillum by sending an email to support@excillum.com in situations not covered by this flowchart.

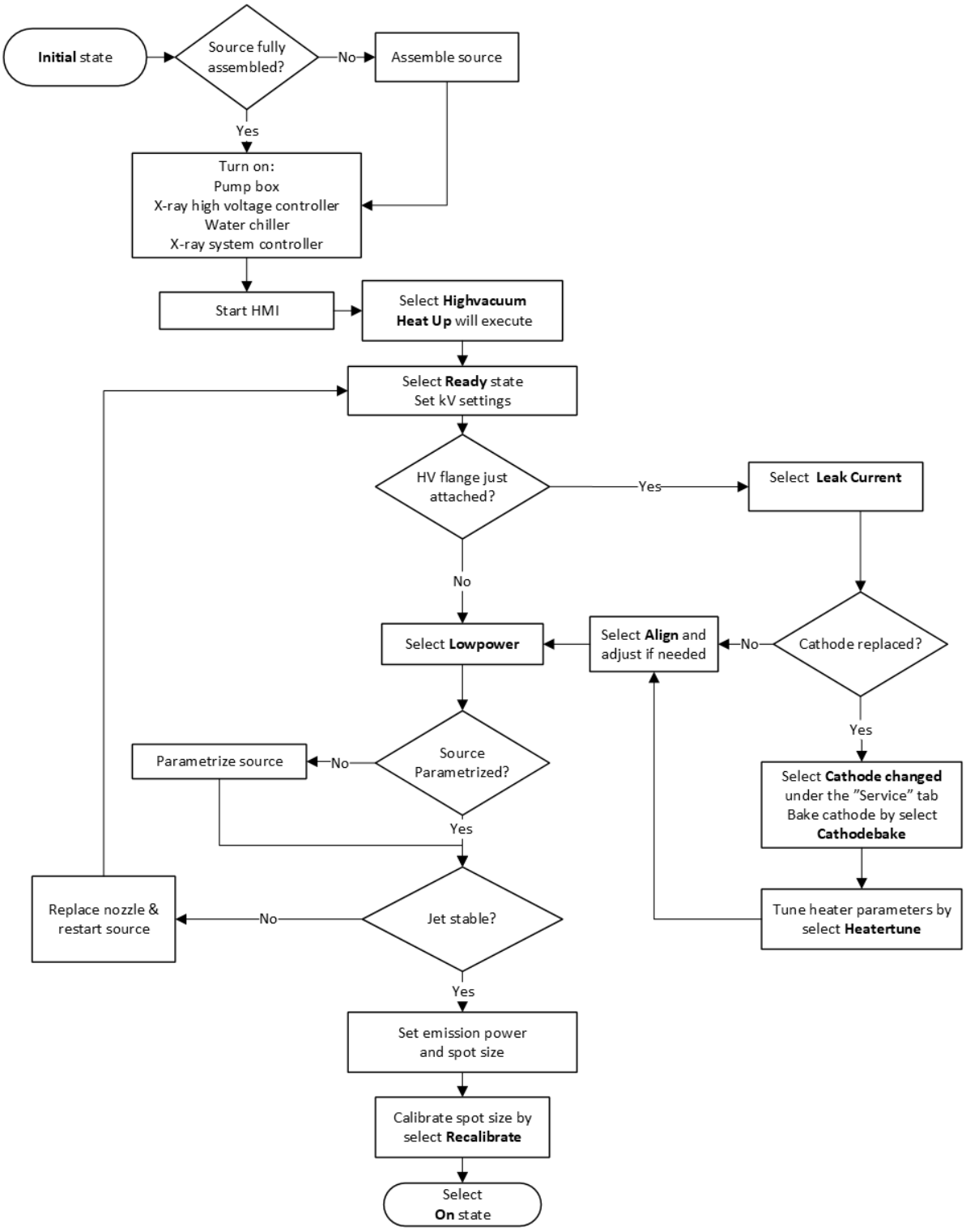


Figure 5-1. Flowchart showing the decision process when starting the MetalJet D2+/C2 source.

5.2.1 Starting the Metaljet after service

The purpose of this section is to clarify which parts of this Chapter are to be performed after a service of the Metaljet. Different cases can be distinguished:

If during service the cathode has been exchanged, it is required to run Align and Parametrization as described in the following Sections.
If during service the nozzle has been changed, it is required to run Parametrization as described in Section 5.8, but not to run Align. Please not that realigning the source will result in a possible modification of the position of the beam requiring a re-alignment of the optics of the platform, if any.
If no cathode or nozzle has been exchanged or removed during service, only focus (Section 5.8.2) needs to be performed.

5.2.2 Capabilities of the software

The XCS software and its corresponding HMI application can control all parameters in the source. The main functions of the software are:

- Performing parametrization (Section 5.8).
- Turning X-ray generation on and off (Sections 5.10.1 and 5.10.3).
- Changing emission power and spot size (Section 5.10.2).
- Perform source service actions covered by the service manual.

5.3 Starting the software and GUI

The software is started by the following sequence:

1. Turn on the pump box, the X-ray high-voltage controller and the water chiller.
2. Turn on the X-ray system controller and wait until the desktop is shown. See Figure 5-2.
3. The X-ray system controller starts the XCS control software automatically and the source state is indicated in the lower left corner.
4. Click on the desktop and select “Source user interface” to bring up the GUI for user control of the MetalJet D2+/C2 source, as seen in Figure 5-3.

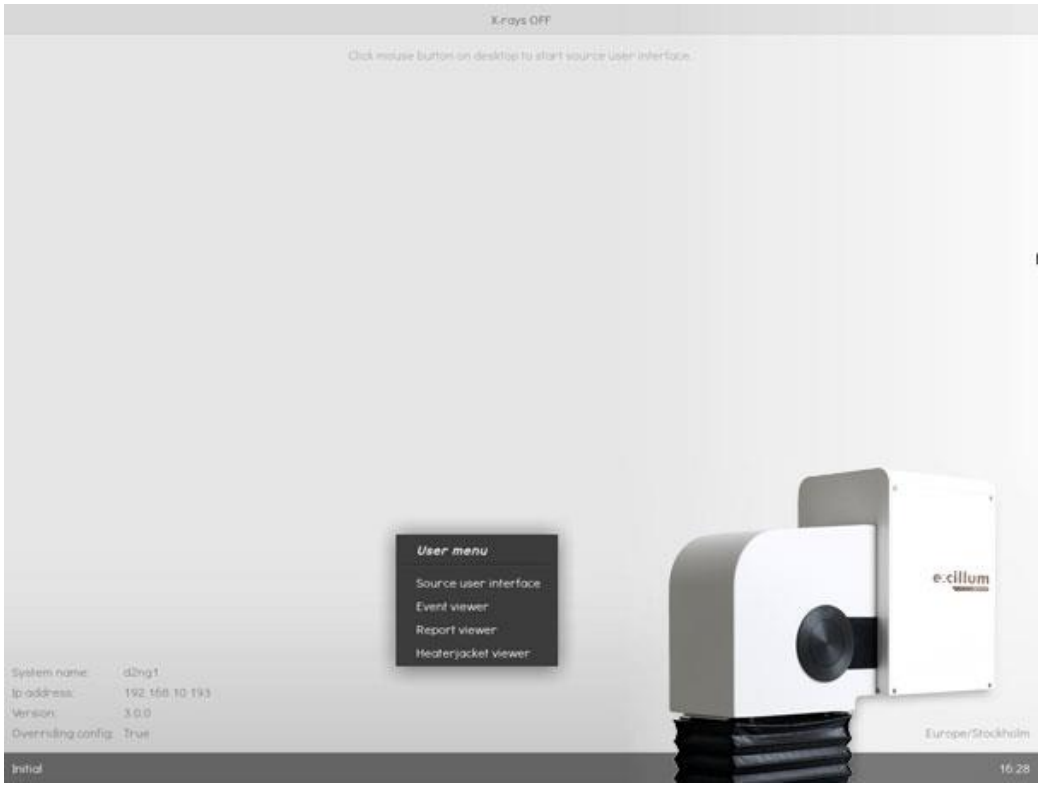


Figure 5-2. XCS desktop for the MetalJet D2+/C2 source.

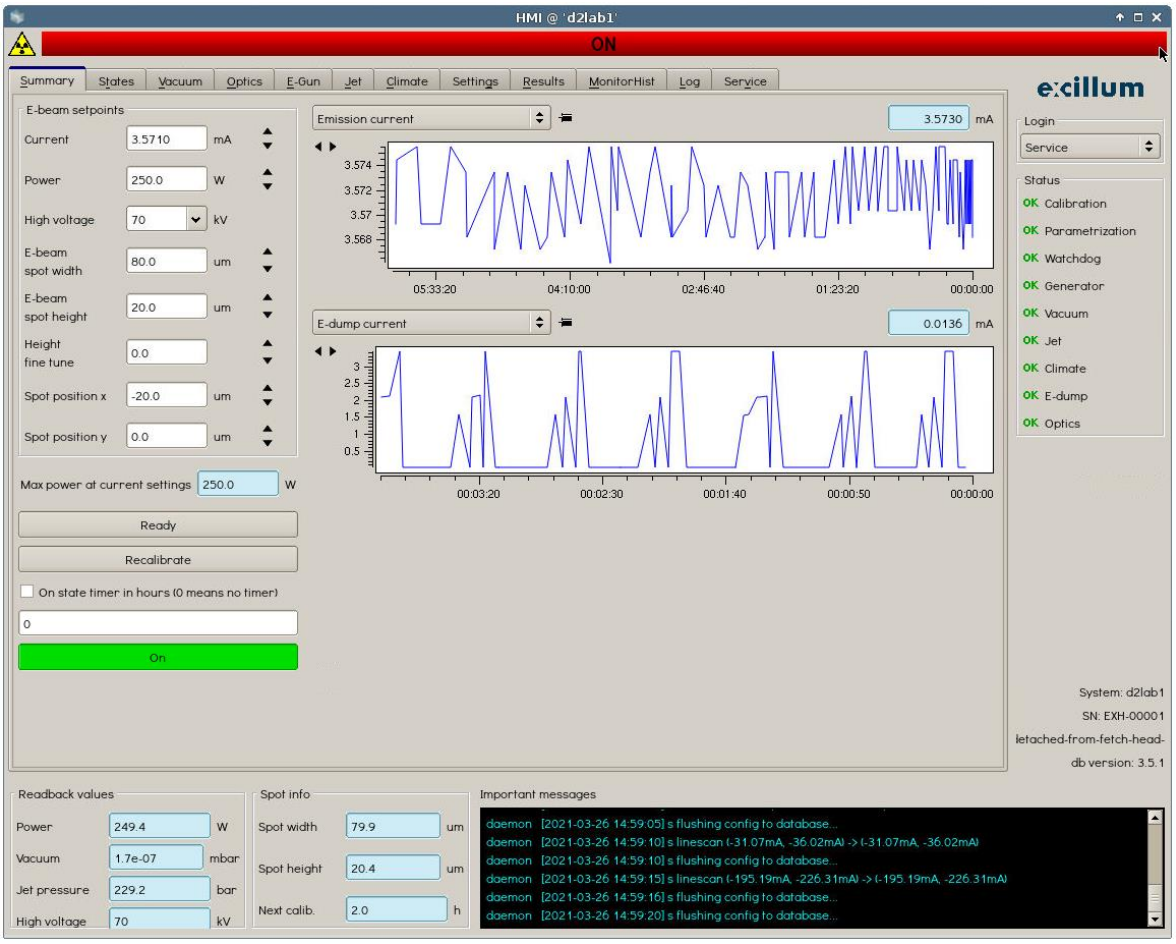


Figure 5-3. The “Summary” tab is the start view of the GUI for control of the MetalJet D2+ source. For a MetalJet C2 source spot width and spot height are replaced with spot diameter.

5.3.1 GUI layout

The GUI has eleven tabs, each controlling specific parts of the MetalJet D2+/C2 source. In each tab certain functions of the source may be controlled.

Tab	Functions
Summary	Summary of source settings and source status
States	State machine controls
Vacuum	Vacuum pumps and ventilation valve
Optics	Electron-beam control optics
E-gun	Electron gun
Jet	Jet pump and exit window

Climate	Temperature control of source
Settings	Configuration database
Results	Parametrization images and history
MonitorHist	Graphs of different source parameters
Log	State reports, error and warning messages
Service	Service actions and troubleshooting tools

There are also a few static regions to the right and at the bottom, which are always visible independently of which tab is currently shown. See Figure 5-3. above. These are:

- **Login**. Indicates current user level
- **Status**. Gives a source status overview. Exclamation marks indicate problems. Detailed information is displayed when hovering over the exclamation mark.
- **Readback values**. Shows current readings from electron gun power, vacuum levels and jet pump pressure.
- **Spot info.** Displays spot size calibration information from last calibration.
- **Important messages.** Shows a subset of important messages from XCS, also shown in the "Log" tab.

5.4 The states of the software

The software essentially works as a linear state machine. All normal operation of the source is carried out by requesting a state change. The state machine will move through and execute every state that is needed to reach the desired state. This is done from the "States" tab. See Figure 5-4. below.

5.4.1 Standard states

The following **standard** states exist:

- **Initial**. This is an undefined state that the machine starts in when the XCS control software is started. There are no rules regarding what hardware is on or off in this state, as it depends on the way in which the source was previously shut down.
- **High vacuum**. This is usually an intermediate state when going to the "Ready" state. It means the vacuum pumps are operating and that the source has reached a good enough vacuum to turn on the liquid-metal-jet system.
- **HeatUp** This is a state when the source is requiring to be warm before change state. More information in the climate tab in the GUI.
- **Ready**. This is the standby state of the machine. It means that the exit window is on, the liquid-metal-jet is operating at the correct pressure, and that the vacuum is good enough to turn on X-ray generation.

- **On**. In this state, the source generates X-rays at the requested power, while the liquid-metal-jet is running, and the source maintains a good vacuum. This is the standard state of operation.
- **Recalibrate**. Due to the dynamic properties of the cathode, the source must be recalibrated regularly. This is done automatically when entering the “On” state, but can also be done explicitly by using this state. The source will return to the “On” state after recalibration.
- **Vent**. The vacuum pumps, liquid-metal-jet, and X-ray generator are turned off. Moreover, the vacuum venting valve is opened, effectively bringing the source to atmospheric pressure.

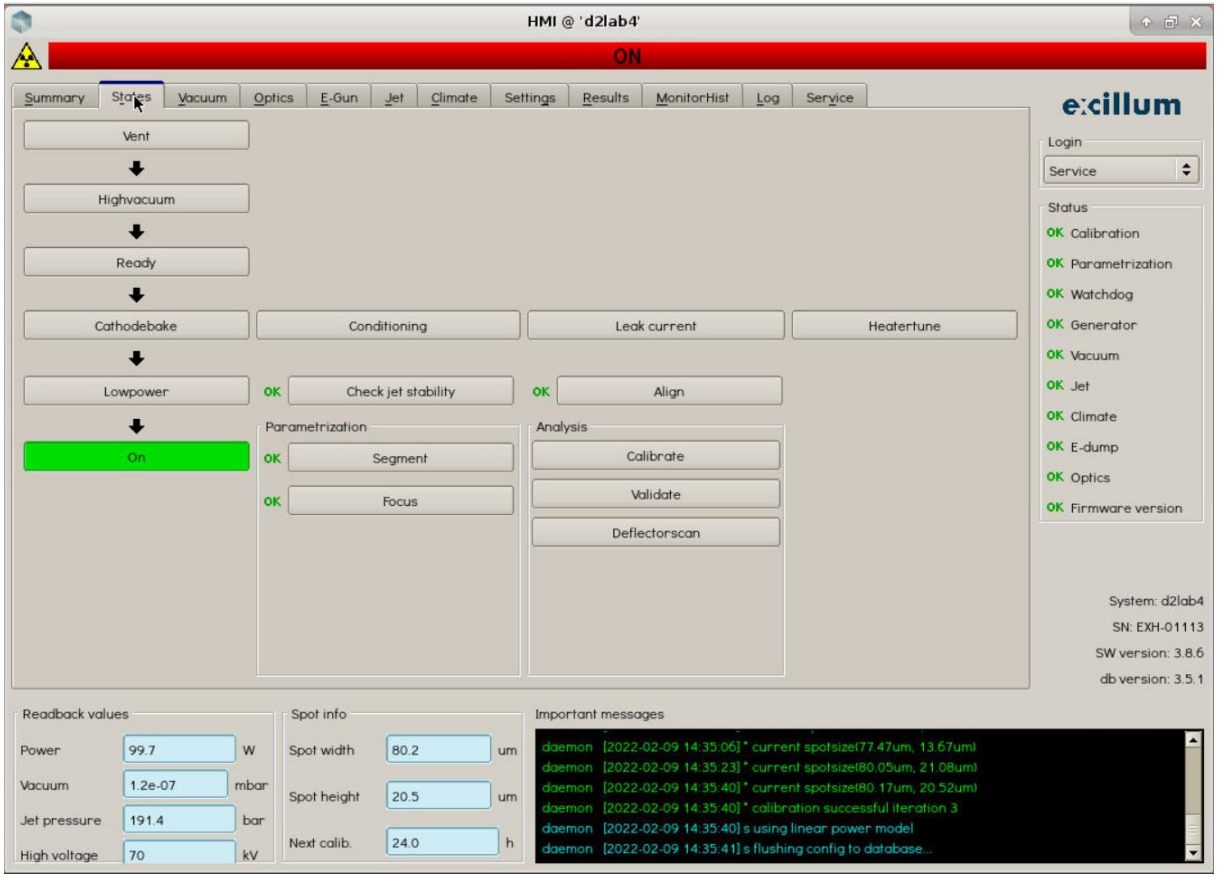


Figure 5-4. The “States” tab from which regular operation of the MetalJet D2+/C2 source is carried out through state requests from this tab.

5.4.2 Advanced states

In addition, the following **advanced** states can be selected by the user:

- **Cathodebake**. Heats the cathode without enabling high voltage. The purpose is to remove oxides from the cathode surface before normal operation to ensure smoothest possible startup. This routine is automatically performed before going to “lowpower” if the source has been vented.
- **Heatertune**. When a new cathode is installed, this state should run to automatically create a look-up table with cathode heater currents and the corresponding electron-beam

emission current. That table is a necessary reference for the electron-beam emission current regulation loop to generate a stable output from the electron gun.

- **Conditioning**. Ramps the high voltage without heating the cathode. This conditions the HV components to avoid arcing of electron gun during normal operation. This routine should be running after each cathode replacement.
- **Leak current**. It is used to calculate the leak current. The leak current is automatically set after this state is run. This state also generates a graph in the *Reports* tab.
- **Lowpower**. This is the parent state of the parametrization procedure. It is like the “On” state in which that it turns on X-ray generation, but at a lower power suitable for parametrization purposes. Before being able to enter the “On” state a complete parametrization must be performed. See Section 5.8 regarding the parametrization procedure.
- **Align.** The electron beam shall be aligned to the optical axis of the column. The align is performed at 30 kV. See Section 5.7.
- **Check jet stability.** This state checks the stability of the jet and the e-beam system. If instabilities are detected, the system will print out warnings in the logs suggesting the possible reasons and appropriate actions.
- **Segment**, **Focus**. These states are sub-states of the parametrization procedure. See Section 5.8 for more details.
- **Calibrate**. Measures the spot size and adjusts the electron beam optics to match the spot size settings.
- **Validate**. Measures the spot size without making any changes.
- **Deflectorscan**. Performs a raster scan of the deflector x- and y-coils.

5.4.3 State indicators

There are three types of indicators in the GUI that show the state of the source, and if it is in the progress of changing state.

1) **Requested state – dark gray button.** To request a state change, simply click the desired state button. The clicked button will shift to a darker shade of gray to indicate that the GUI has registered the click.

2) **Change of state in progress – yellow button.** A yellow state button indicates which state the source is currently trying to reach. This is also indicated at the top of the GUI, which shows the name of the state followed by three dots.

3) **Reached state – green button.** A green state button indicates that the source has reached the requested state.

5.5 User levels

There are three different user levels in the GUI. They are used to control which features are accessible to the user. The three user levels are:

- **User**. The standard login level, in which the user can access the “Summary” and “States” tabs. This allows control of source settings and source states, but not most hardware control parameters.
- **Admin**. Most hardware control parameters can be modified.
- **Service**. All hardware parameters can be modified. It also gives access to the “Service” tab.

The default user level is “user.” Certain operations of the source do, however, require that the user is logged in at a higher level than the default level. Changing the user level is done in the upper right corner using the drop-down list under the Excillum logotype. See Figure 5-4. above. The default password is “jxs4944”.

NOTE
During normal operation it is recommended to always use the “user” level.

NOTE
The default username and password are commonly used and should be taken into consideration. Option is to change the username and/or password and keep the information tight.

5.6 Error messages

When an error occurs, it will be displayed in the “Important messages” region in the bottom right corner along with other important server messages. It can also be reviewed under the “Log” tab. See Figure 5-5.

The scroll bar can be used to view older server entries.

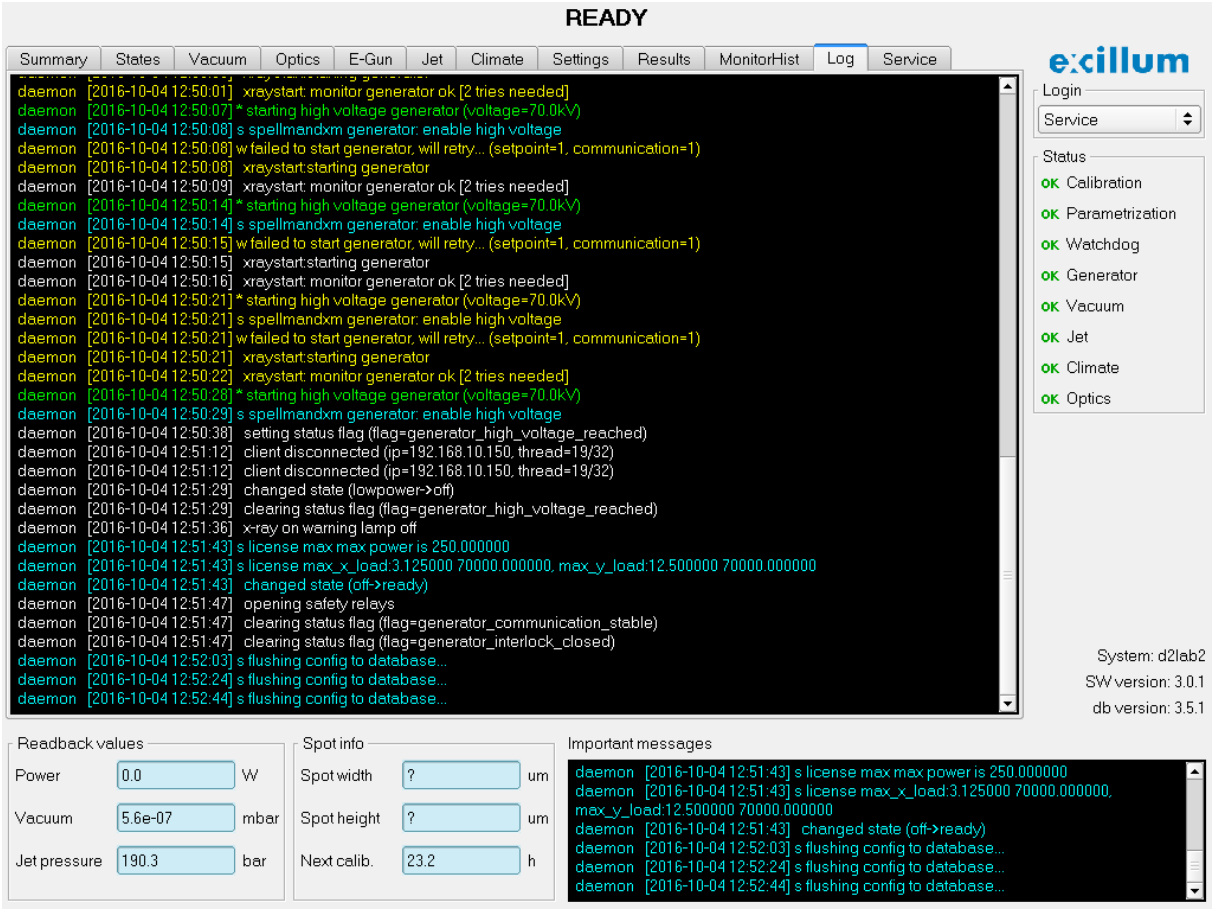


Figure 5-5. The “Log” tab. Errors, warnings, and other relevant information regarding the operation of the MetalJet D2+/C2 source may be found here.

5.7 Align electron beam to optical axis

The next step is to align the electron beam to the optical axis of the column. This is done automatically at 30 kV by the “Align” step.

1. Click the **Align** button.
   - This initiates a routine that sweeps the current of the alignment coils at the same time as it changes the focus lens current between two preset values.
   - The routine will repeat itself until it finds the alignment coil currents that result in the smallest shift in electron-beam position between the two focus lens currents.
   - In addition, it aims at centering the electron-beam dump aperture.
2. Wait for the green button to indicate that the “Align” state is reached.
3. Go to the “Results” tab, select “Align” under last images and inspect the image. If the source is ok, the image of the electron-dump should be a circle free from metal debris. See Figure 5-6 (left image).

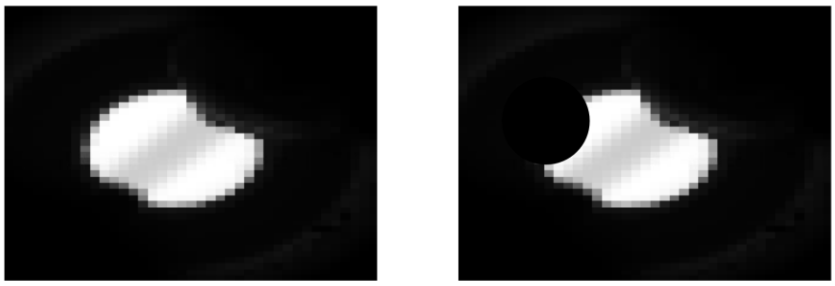


Figure 5-6. Align of clean (left) and contaminated (right) electron-beam dump aperture.

4. If the alignment algorithm finishes without errors, proceed to Section 5.8. The **Align** button will turn green if no errors occur.
5. If the mechanical alignment accuracy of the HV feedthrough is insufficient, this step may fail and the HV feedthrough must be mechanically aligned. Refer to the service manual under **Align HV feedthrough** for instructions.
   NOTE: The spot size calibration accuracy is negatively affected by deflection aberrations if high currents are required in the alignment coils. Aligning the HV feedthrough aim at minimizing the amount of current that is required.
6. If the electron-beam dump aperture is contaminated, see Figure 5-6 (right image), the liquid-metal debris must be removed before proceeding. Refer to the service manual under **Remove liquid-metal debris from electron-beam dump aperture** for instructions.

5.8 Parametrization

The first time the MetalJet D2+/C2 source is set up, or when the cathode or the electron optics have been physically modified or adjusted, the source needs to be parametrized. The parametrization routine consists of several steps and needs to be repeated independently for each acceleration voltage:

- Determine jet size and position
- Characterize focus lens and verify jet stability

After the parametrization is completed, it is possible to set the electron-beam power, spot size and position in relation to the liquid-metal-jet.

5.8.1 Determine jet size and position

The next step is to determine the size and position of the liquid-metal-jet.

1. Click the **Segment** button.
   - The electron beam will repeatedly sweep across the liquid-metal-jet to determine the rough position and geometry of the jet.
2. Wait for the green button to indicate that the “Segment” state is reached.
3. Go to the “Results” tab, select “Segment” in the images list and inspect the image. If the source is ok, the image of the jet should be fairly sharp, straight, and centered in the aperture. See Figure 5-7.

4. An unstable jet can be seen in the “Segment” image in the “Results” tab after having reached the “Segment” state. Excillum’s recommendation with regards to jet stability is to attempt restarting nozzles not only when the jet pump has been stopped with the source kept under vacuum but also after having vented the source. When restarting nozzles after venting we recommend attempting two extra restarts without venting if the jet is not stable before replacing nozzle, and filter. Wait 3-5 minutes after stopping the jet pump before attempting to restart again and pay attention to vacuum spikes in the vacuum graphs to reside after having stopped the jet pump before restarting again. Refer to Section 6.2.4 for further instructions.

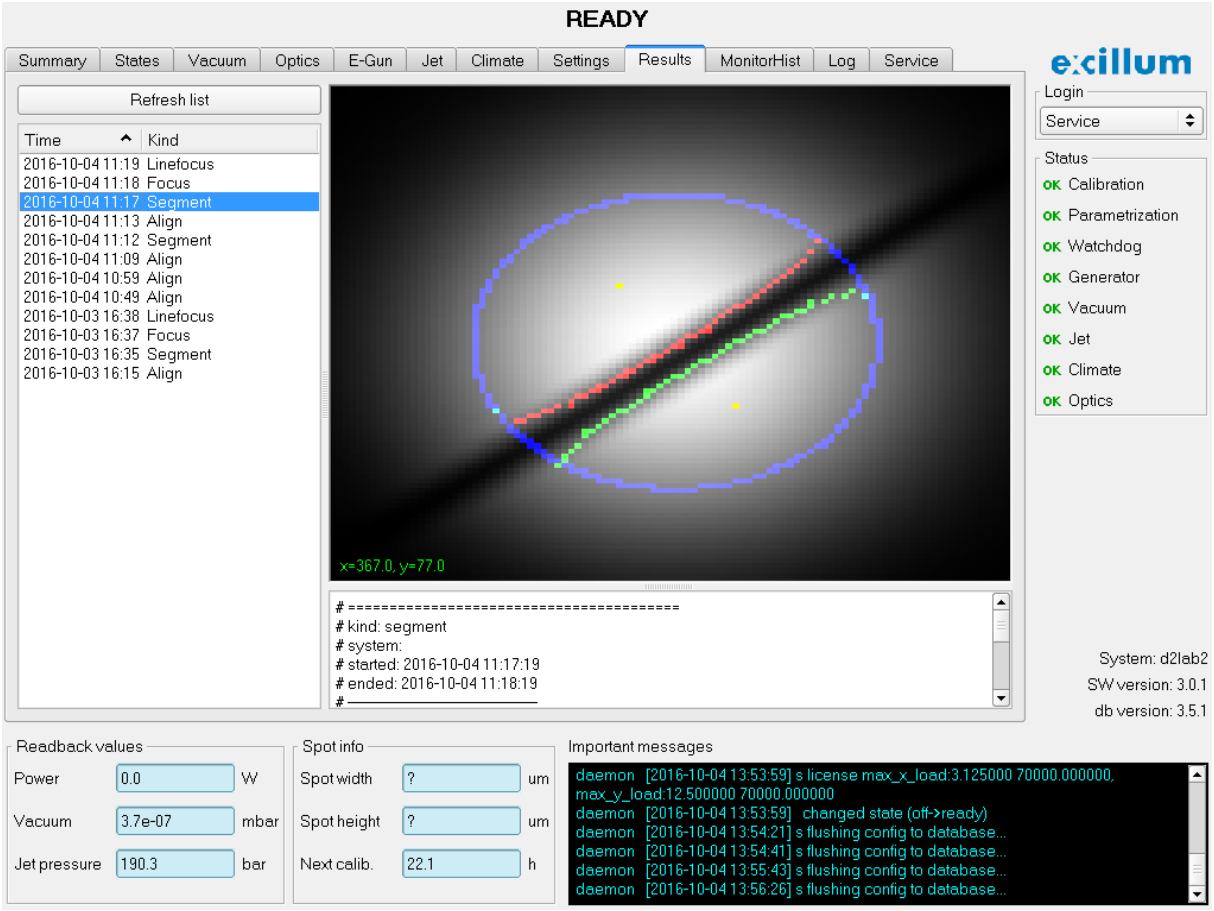


Figure 5-7. A sharp image of the jet goes straight through the aperture. This indicates that the determination of the size and position of the jet is performed correctly.

5.8.2 Characterize focus lens and verify jet stability

The next step is to map up electron-beam spot sizes for different focus lens settings, and to verify the liquid-metal-jet stability.

1. Go to the “States” tab and click the **Focus** button.
   - The electron beam will be swept across the liquid-metal-jet multiple times, each time with a new focus lens setting to calibrate the focus lens.
2. Wait for the green button to indicate that the “Focus” state is reached.
3. Go to the “Results” tab, select “Focus” in the last images list and inspect the image.

- The x-axis represents a horizontal position sweep and the y-axis represents different focus lens settings.
- If the liquid-metal-jet is stable, the image resembles an hourglass shape with gradual transition from black to white in the edges.

4. The software automatically checks the status of the jet stability, then changes the color of the “confirm stability jet” button in the “Service” tab if the jet is stable.
   In case the software does not confirm jet stability automatically, the customer has the option to analyze the image in Figure 5-8 and determine if the jet is stable enough. The following procedure is then executed:
   - If the image shows an hourglass shape with smooth edges, similar to Figure 5-8., go to the “Service” tab and confirm that the jet is stable by pushing the “Confirm jet stability” button.
     NOTE: If the focus image is not well centered, the focus routine should be run again. This will improve the spot size accuracy.
   - If the transition in the edges is not smooth, it is a strong indication that the jet is unstable. In that case the nozzle needs to be replaced, and the parametrization routine must start over from Section 5.8.1. Refer to Section 6.2.4 for further instructions.

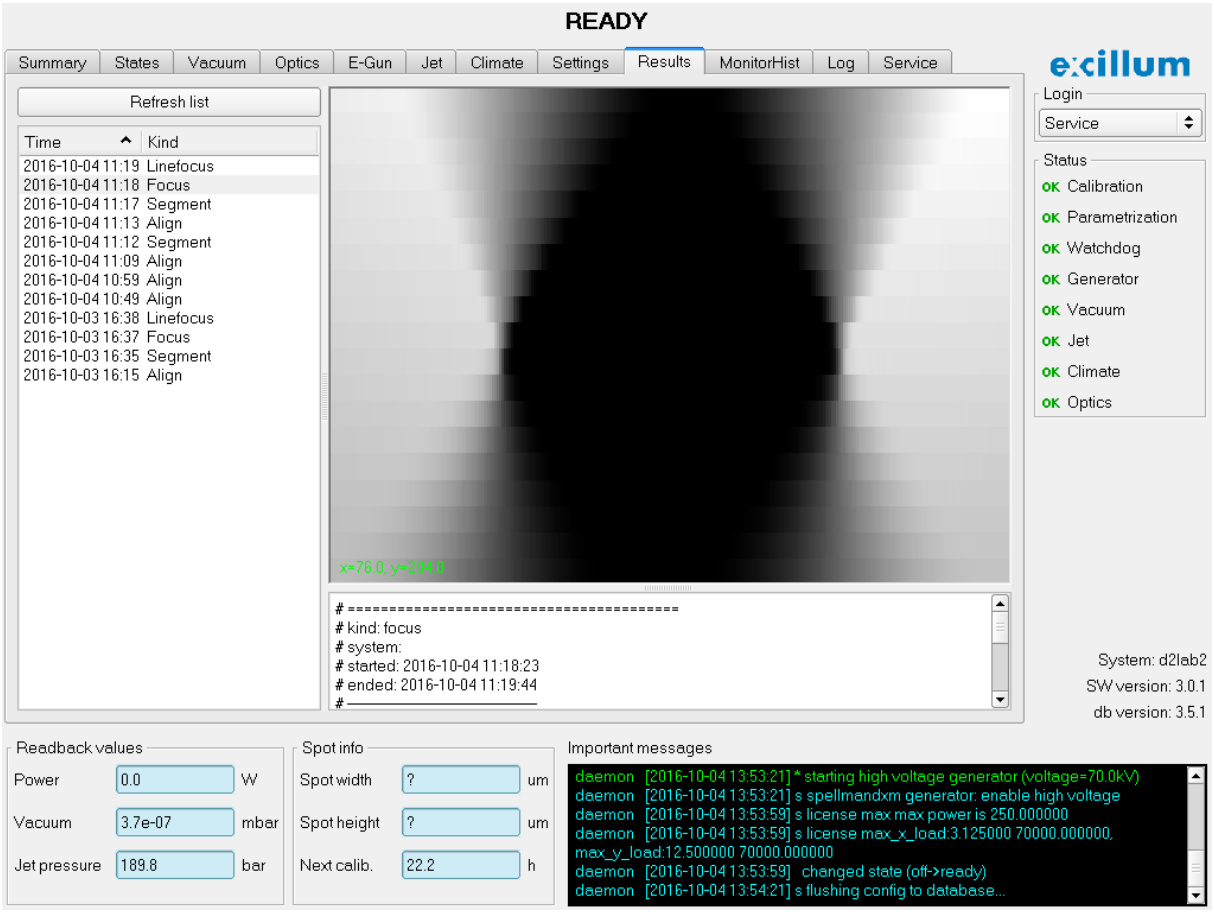


Figure 5-8. The image shows a straight hourglass shape with gradual transition from black to white in the edges. This indicates that the source is well aligned, and that the liquid-metal-jet is stable.

5.9 Set emission power and spot size

The focus lens has some hysteresis, which may affect the electron-beam spot size setting negatively when the spot size value is changed, especially when making big changes to the spot size. To avoid this potential problem, the focus lens should be adjusted for the focus lens hysteresis effect after every change of electron-beam spot size. The calibration routine measures the spot size by sweeping the electron beam. It then adjusts the focus lens and iterates until the measured electron spot size is within tolerance.

1. Go to the “Summary” tab and set “Power,” “High voltage,” “Spot width” and “Spot height” in the “Setpoints” region.
   Note: The “High voltage” settings can only be changed in the “Ready” state.
   Note: The “Spot info” region will say “? Um”. This will be the case until the spot has been calibrated (see below).
   Note: “Height fine tune” enables source to live height adjustment. “Height fine tune” adjusts the currents in the focus and stigmator coils in a way that modifies the height of the beam. Spot height + Height fine tune = Output. Negative value decreases the height. Only available when measurement feedback exists. What is measured can be adjusted manually to better match expected value. “Height fine tune” is not available for MetalJet C2.

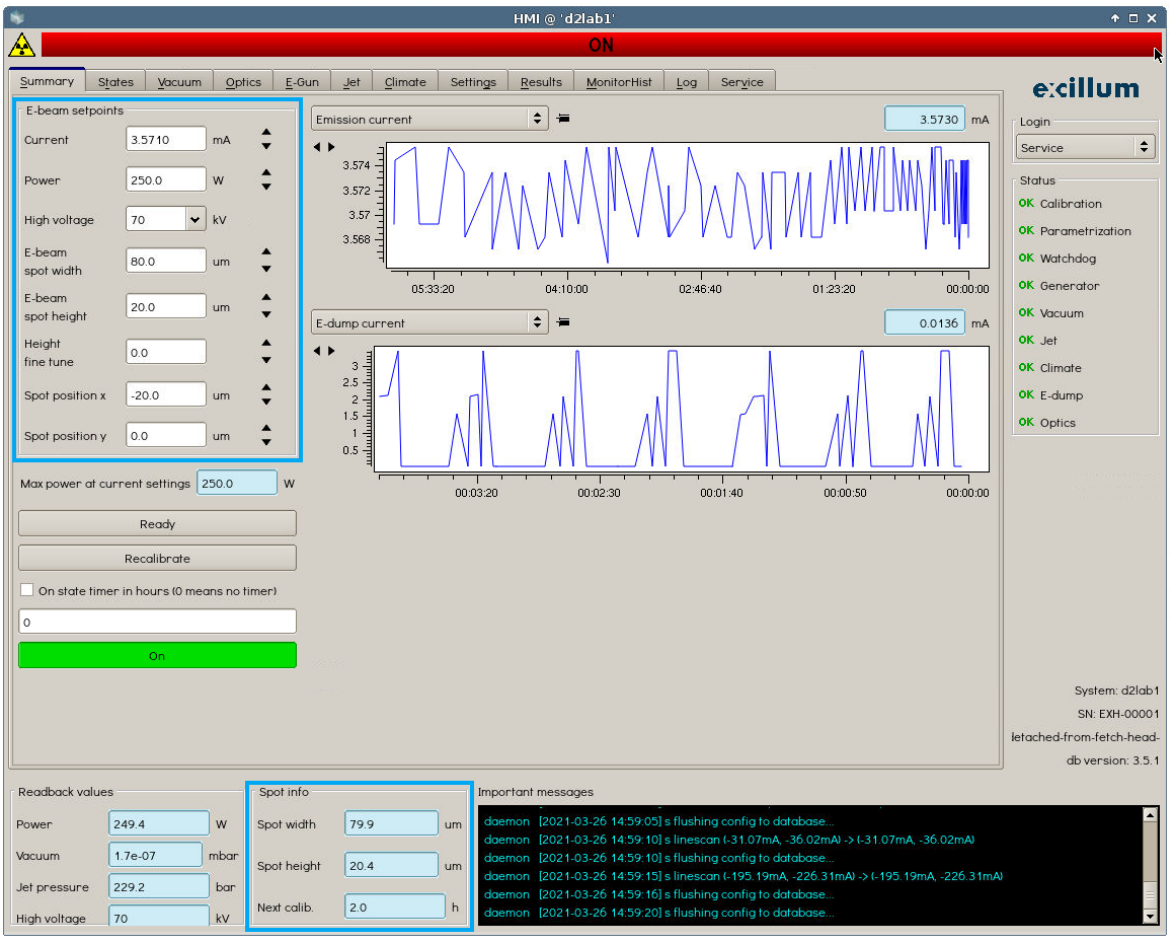


Figure 5-9. The “Setpoints” and “Spot info” regions of the “Summary” tab are highlighted with a blue frame. For a MetalJet C2 source the spot width and spot height are replaced with spot diameter, and Height fine tune is not available.

2. Click the **Recalibrate** button for the new set point settings to take effect.
   - The high voltage will be enabled unless this is already done.
   - The emission power will now be increased to the requested power.
   - The source will then use an iterative algorithm to find the correct focus coil settings.
3. After the recalibration routine has finished the machine will go to the “On” state.
4. The actual spot size is now measured and displayed in the “Spot info” region of the “Summary” tab. If the deviation between requested spot size and actual spot size is too great, the source will warn you and you will not be allowed to enter the “On” state. This usually indicates a hardware error.

5.9.1 Recalibrate spot size

Due to the dynamic properties of the cathode, the source must be recalibrated regularly. This is done automatically when entering the “On” state and periodically every 24 hours, but it can also be done explicitly by clicking the “Recalibrate” button. The source will return to the “On” state after recalibration.

5.9.2 Validate spot size

The actual electron beam spot size can be verified at any given time by clicking the **validate** button. The validation routine only measures the spot size without making changes to the focus lens coils.

5.10 Normal operation

This mode of operation requires that a full parametrization (see Section 5.8) at the correct high voltage setting has been performed and that the source is in the “Ready” state. There may be some transient emission instabilities when ramping up power. This is due to changes in the surface chemistry as oxides evaporate from the cathode. This effect may be amplified when the source has been run at low power for a long time during the parametrization routine.

5.10.1 Turning on X-ray generation

1. Go to the “Summary” tab and follow the instructions in Section 5.9 to change the emission power and spot size.
2. Click the **On** button and wait for the green button to indicate that the source has reached the “On” state and the emission current is stable.

5.10.2 Change emission power and spot size

1. Go to the “Summary” tab and follow the instructions in Section 5.9 to change the emission power and spot size.
2. Click the **Recalibrate** button and wait for the green button to indicate that the source has reached the “On” state and the emission current is stable.

5.10.3 Turning off X-ray generation

It is strongly recommended to put the MetalJet D2+/C2 source in standby when not using the source. The standby state is called “Ready” and means that the vacuum pumps and the metal-jet pump are running, but the high voltage is not activated.

1. Go to the “Summary” tab and click the **Ready** button.
    - This will turn off the X-ray generation and high voltage and put the source in a standby state.

5.10.4 Turning off the MetalJet D2+/C2 source

If the source is not going to be used for a long time (more than two months), it may be completely turned off.

1. Go to the “States” tab and click the **Vent** button.

   This will turn off the X-ray generation, high voltage, liquid-metal-jet pump, turbo vacuum pump, and roughing pump. Then the venting valve will open.
2. Push the green on/off button on X-ray system controller.
3. Turn off all sub-assemblies such as X-ray high-voltage controller, pump box and X-ray system controller units using their switches on the front of the boxes.
4. Store the MetalJet D2+/C2 source in accordance with the storage instructions in Section 3.2.

5.11 Source Settings

The source settings menu can be accessed by right clicking on the gray banner in the bottom of the screen and selecting “Settings” see Figure 5-10. This menu can be used to change network settings as well as the time zone and keyboard layout. If the system time on the XCM is changed by a large time frame, either by manual terminal commands or by sync to an NTP server, it is necessary to reboot the XCM controller. If not, there is a risk of getting frozen monitor values. For hostname the maximal number of chars is 15.

Note: The menu “Runmode” should only be used by trained service technicians.

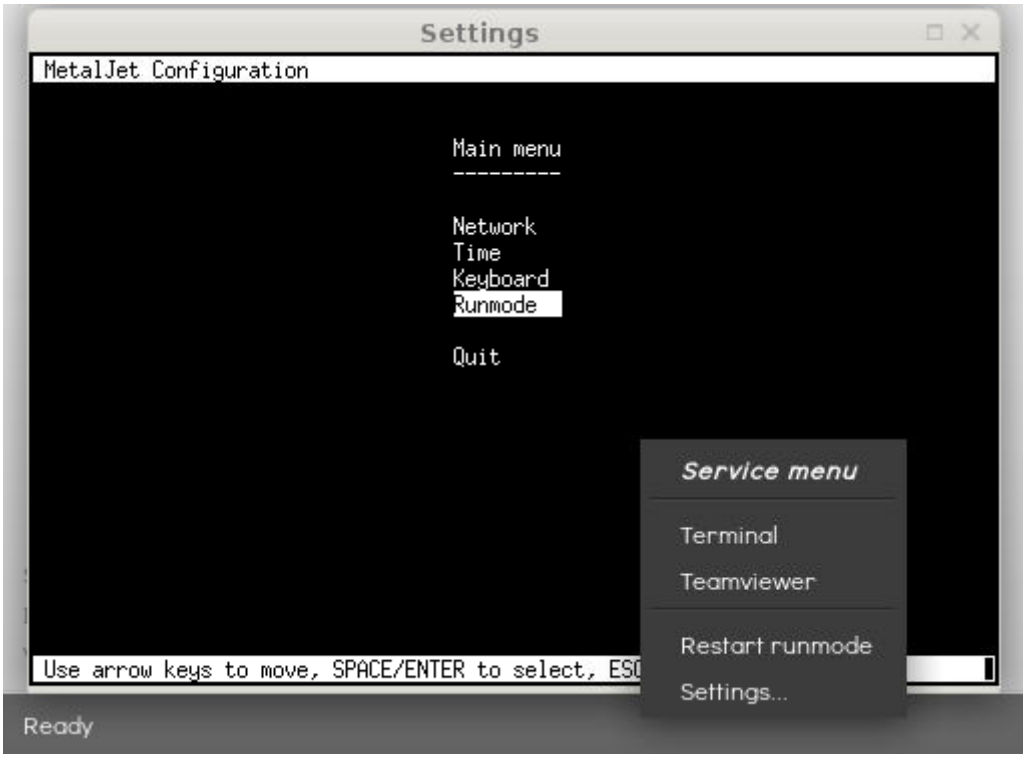


Figure 5-10. Access the source settings menu by right clicking the gray banner in the bottom of the screen.

5.12 Software API

Controlling the XCS over TCP/IP from customer written software is simple. The XCS acts as a TCP server listening on port 4944. All commands are sent in clear-text and follow a request – reply pattern. Commands end with an end-line.

Contact Excillum for a detailed description of the XCS API.

6 Maintenance and service

This chapter describes all source components that require maintenance and service. It explains what drive service and give recommendations on when to perform service for individual components.

NOTE
Disclaimer of liability Excillum accepts no liability for personal injury, material damage, loss or operating malfunctions due to improperly performed maintenance.

Table 6-1 summarizes which sources and components that will require maintenance and service for the MetalJet D2+/C2 source to function normally. Each component is described in more detail in the sections indicated below.

The **Excillum recommendation** minimize scheduled service, but assume that unexpected shutdowns, that does not damage the source further are acceptable. Other customers may wish to

perform preemptive maintenance based on third party **Manufacturer information** to minimize nonscheduled down time.

Component	Section	Service when[1]
Vacuum system	6.1	
Roughing pump	6.1.1	Rough pump pressure is insufficient
Turbopump	6.1.2	Vacuum pressure is insufficient
Jet system	6.2	
Jet pump lubricants	6.2.1	Inspect for leaks every 6 months. Replace lubricants with a 2-year interval
Jet pump diaphragm **Error! Reference source not found.**	6.2.2	Diaphragm breaks
Jet pump check valves	6.2.3	Jet system troubleshooting efforts indicate check valve malfunction.
Nozzle assembly	6.2.4	Nozzle fails to produce a stable jet.
Exit window	6.2.5	Exit window fails or application requirements demand it.
Liquid metal spillage	6.2.6	When spillage occurs
Electron gun	6.3	
Cathode assembly	6.3.1	Service interval driven by application spot size requirements.
Climate system	6.4	
Cooling water	6.4.1	No inspection necessary if water cooler is system integrated. Periodic inspection if water cooler is not system integrated.

Table 6-1. Summary of systems and components that will require maintenance and service. Detailed information can be found, and when to perform service.

[1] This is the summary recommendation by Excillum, but the complete referenced section should be read prior to deciding on service intervals.

6.1 Vacuum system

6.1.1 Roughing pump

Background: Over time, the diaphragms inside the pump wear out and cause the base pressure of the pump to increase. This eventually limits the turbopump performance resulting in poor vacuum levels. Pump service involves replacing the diaphragms and occasionally replacing bearings. Excillum offers roughing pump service through a replacement program.

Excillum recommendation: Roughing pump performance is monitored by a vacuum sensor which detects and signal through software when pump performance becomes inadequate.

Excillum suggests that service is driven by pump performance unless preemptive maintenance is required by customer.

Manufacturer information: Manufacturer gives no information on preemptive service interval but claim normal lifetimes excess of 10,000 hours for diaphragms and valves. Bearings have a typical durability of 40,000 hours. Motor capacitors have a typical durability in the range of 10,000 to 40,000 h depending strongly on operating conditions including ambient temperature, humidity and load.

Service instructions: Service manual under Section **Replace roughing pump**.

6.1.2 Turbopump

Background: The bearing of the turbopump rotor is lubricated by a filtered circulating fluid reservoir. Both the bearing and the fluid reservoir eventually need to be replaced for the pump to function properly. Excillum offers turbopump service through a replacement program.

Excillum recommendation: Turbopump performance is monitored internally by the pump to shut it down in case current draw or temperature thresholds are exceeded.

We therefore suggest service is driven by when the turbopump repeatedly shuts down due to high temperature or high current draw. This is especially the case when troubleshooting efforts have ruled out other sources of failure, such as insufficient cooling water, and or vacuum leaks. Preemptive maintenance should be performed if required by customer.

Manufacturer information: Manufacturer recommends changing the operating fluid reservoir at least every four years and to change the turbopump bearing at least every four years.

Service instructions: Service manual under Section **Replace turbopump**.

6.2 Jet system

6.2.1 Jet pump lubricants

Background: The jet pump uses two types of oil to lubricate moving parts. Over time, wear debris from the moving parts inside the pump are accumulated and the lubricants eventually need to be replaced.

Excillum recommendation: Excillum have extended experience with letting these pumps run without replacing the lubricants for several years without performance degradation or oil leakage. However, wear debris in the lubricants can create damage to the internals which then leads to a shorter lifetime of the pump.

We therefore recommend scheduling a drive unit and hydraulic oil replacement at least every two years or when replacing the pump diaphragm unless preemptive maintenance is required by customer. This should typically be performed when other service is required.

In addition, inspection for oil leaks inside pump box is recommended with a six month interval. Report any oil spillage to Excillum and remove spillage.

Manufacturer information: Manufacturer recommends to

check the hydraulic oil level monthly and the drive unit oil level weekly.
change hydraulic oil depending on the degree of soiling, minimum once a year.
change drive unit oil after 8800 operating hours (one year) or every two years at the latest.

Service instructions: Service manual under Section **Replace pump lubricants**.

6.2.2 Jet pump diaphragm

Background: The jet pump is a diaphragm pump which is a positive displacement pump. It utilizes a sandwich diaphragm construction with two diaphragms lying on top of each other. The space between the two diaphragms are pressure less in normal operation. Only if a diaphragm is damaged does the fluid penetrate the diaphragm space, leading to an increase in pressure. This increase in pressure in the diaphragm space is used to indicate diaphragm damage. The diaphragm will eventually break due to material fatigue and will need to be replaced.

Excillum recommendation: Excillum has extended experience with letting the pump diaphragm run until it fails. Diaphragm failure is detected by the diaphragm guard and is handled by our software. Furthermore, it does not damage the MetalJet D2+/C2 source. Several systems have been running four years without diaphragm failure.

We therefore suggest that service is driven by diaphragm failure unless preemptive maintenance is required by customer.

Manufacturer information: Manufacturer recommends replacing the diaphragm once a year (together with the lubricant exchange).

Service instructions: Service manual under Section **Replace pump diaphragm**.

6.2.3 Jet pump check valves

Background: The jet pump, which is a positive displacement pump, first traps a fixed amount of liquid from the inlet reservoir. Then forces (displaces) the trapped volume into the discharge pipe. The displaced volume is constant for each cycle of operation. The inlet and the outlet of the jet pump are fitted with dual check valves that enable unidirectional flow of the liquid.

For the jet pump to be able to produce a stable jet pressure, it is vital that the check valves work properly and that the alloy fill level is above a certain minimum level. Specifically, this means that the balls inside the valves must be able to move freely inside the ball guides to alternately seal tightly against the seat, and easily release from the seat to allow liquid metal to stream past the ball.

The sealing surfaces of the check valves eventually wear out but can be prematurely damaged by foreign particles in the metal loop. Regardless of whether the damaged seal is in the inlet or outlet check valve it will effectively reduce the displaced volume in each stroke, causing the pump frequency to go up without being able to maintain the desired jet pressure.

Excillum recommendation: We suggest that service is driven by when the jet pump shows symptoms of check valve wear and troubleshooting efforts indicate check valve malfunction. See Section 8. Excillum's experience is that the check valve on the inlet side wears out more frequently than the one on the outlet side. We therefore recommend that only the inlet check valve is replaced initially. Preemptive maintenance should be performed if required by customer.

Manufacturer information: Manufacturer does not provide any information on expected lifetime of check valves.

Service instructions: Service manual under Section **Replace inlet check valve** and Section **Replace outlet check valve**.

6.2.4 Nozzle assembly

Background: Nozzles rarely fail during normal operation. However, during jet start and stop, there is a small risk that a previously used nozzle fails to produce a stable jet. If there is any indication of an unstable jet in the "Focus" image in the "Results" tab after having reached the "Focus" state (see Section 5.8.2), the nozzle assembly should be exchanged for a new one.

Excillum recommendation: Excillum's recommendation with regards to jet stability is to attempt restarting nozzles not only when the jet pump has been stopped with the source kept under vacuum but also after having vented the source. When restarting nozzles after venting we recommend attempting two extra restarts without venting if the jet is not stable before replacing the nozzle and filter. Wait 3-5 minutes after stopping the jet pump before attempting to restart again and pay attention to vacuum spikes in the vacuum graphs to reside after having stopped the jet pump before restarting again. See Section 5.8.2.

If a new nozzle fails, this is a strong indication of a more serious contamination of the liquid metal loop itself.

Manufacturer information: Follow recommendation above.

Service instructions: Service manual under Section **Replace nozzle assembly**.

6.2.5 Exit window

Background: The exit window consists of a beryllium window and a heated carbon foil. The assembly is designed to protect the beryllium vacuum window from being contaminated by depositions of liquid-metal vapor or droplets. Protection is provided by passing an electrical current through a thin carbon foil, heating the carbon foil to several hundred degrees.

The exit windows are heated 10 minutes every 24 h to ensure that any debris is evaporated from the carbon foil. We've found that cycled operating of the exit window using these time constants extend the lifetime of the windows while ensuring that the metal vapor buildup is negligible. When exit windows are heated the X-ray spot may shift in position.

Any liquid-metal vapor or droplets ending up on the hot carbon foil is immediately evaporated and the X-ray exit window is kept clean.

During normal operation of the exit window, the current through the carbon foil is 1.5 A and the applied voltage is about 4 V (±0.5 V).

The two most common failure modes are

1. Current is 1.5 A, but the voltage is only about 1 V or even lower.

2. Current is about zero and the voltage is significantly higher than 4 V.

Failure mode #1 indicates that the exit window is contaminated by liquid metal in such a way that the carbon foil is not electrically isolated from the steel cover anymore.

Failure mode #2 indicates that the carbon foil is damaged in such a way that the electrical resistance has increased significantly.

The functionality of the exit window cannot be guaranteed in either of the two failure modes, and the solution is to replace the faulty exit window with a new one.

Excillum recommendation: The lifetime of the window has so far been limited by incidents related to jet instabilities or by customer requirements on beryllium window homogeneity. We therefore suggest that service is entirely driven by exit window failure or application requirements.

Manufacturer information: Follow recommendation above. **Service instructions:** Service manual under Section **Replace exit window**.

6.2.6 Liquid metal spillage

Background: During installation and service, spillage may occur. Under normal conditions there should not be any leaks from the MetalJet D2+/C2 source causing spillage of liquid metal.

If liquid metal is leaking from any part of the system, immediately contact Excillum support.

Excillum recommendation: Droplets and puddles of liquid metal should be removed using the MetalJet D2+/C2 cleaner. The remaining stains are easily cleaned using a soap-and-water solution and some lint-free tissue paper, or a Scotch Brite sponge to remove tougher stains. PPE should be used and at least some eye protection and gloves. Please read and follow the instructions of the material safety data sheet for the alloy used in your MetalJet D2+/C2 source. These are appended to this operation manual.

DANGER
Disconnect electricity before cleaning All parts to be cleaned, or close to those parts being cleaned, must be properly disconnected and de-energized before cleaning may begin. High voltage is potentially lethal.

6.3 Electron gun

6.3.1 Cathode assembly

Background: The electron emitter of the MetalJet D2+/C2 source consists of a LaB_6 crystal that is heated to extract electrons. The temperatures that these cathodes operate under cause the material to evaporate at a slow rate. The rate of material loss is typically influenced by the vacuum level and the operating power.

Beam dynamics: When the surface of the cathode evaporates, it changes the optical characteristics of the emitted beam. This can be recorded as a change in the minimum achievable e-beam focal spot size. With a C200 cathode the typical behavior is that the minimum spot size achievable initially increase towards ~20 µm and then decline again prior to finally continuously

increase. The spot shape will gradually distort from an ideal shape which eventually will degrade the performance of an application and motivate a change of the cathode. The cathode may also at some point no longer be able to emit enough electron beam current to maintain the desired X-ray power. The source operating point and the specifics of the application will determine when either of these points are reached.

Periodic spot size calibration: Periodically, running calibrate to compensate for effects of the beam dynamics due to cathode aging is recommended. It keeps the source at specs and avoids overloading the jet target. Based on beam dynamics observations, we have set the required calibration interval to 24 hours. Calibration can be initiated externally by sending commands to the server software. Another option is to set up the server to calibrate at a time every day/night that avoid interrupting experiments.

The accuracy of the calibration routine is controlled by calibrate.max_allowed_deviation_um in the database. The repeatability between two successive calibrations is better than ±0.5 µm and the default setting of the parameter is currently 1.0 µm.

Lifetime: The useful lifetime of the cathodes used in the MetalJet D2+/C2 sources is determined by when the achievable spot shape no longer supports the application or not enough e-beam power can be generated, as described above. The source can still be operated with stability beyond this time, but a continuous performance loss will continue unless a different source setting in terms of power and spot shape can compensate.

As a reference, with an 80x20 μm^2 e-beam spot size at 250 W and 70 kV acceleration voltage it is estimated that the source, depending on the loss in performance the application can tolerate, can operate for a full year with a C200 cathode when operated under good vacuum conditions.

Excillum recommendation: Service interval driven by application spot-size and power requirements as described above.

Manufacturer information: Follow recommendation above. **Service instructions:** Service manual under Section **Replace cathode assembly**.

6.4 Climate system

6.4.1 Cooling water

Background: The MetalJet D2+/C2 source requires cooling water to maintain the correct operation temperature for the turbopump and the jet system. It comes with the option of using an Excillum supplied water cooler which is integrated into our software or an independent water cooler.

Excillum strongly recommends the integrated solution for increased temperature stability and ease of use.

Excillum recommendation: MetalJet D2+/C2 sources equipped with the integrated Excillum supplied water cooler automatically monitor flow rates and detect when the water reservoir needs to be refilled. Therefore, no inspection interval is necessary when water cooling is provided by Excillum.

Customers using external water coolers should ensure sufficient water flow by inspecting water levels periodically based on manufacturer recommendations.

Manufacturer information: Follow recommendation above. **Service instructions:** See document “Installation and Maintenance Manual Air Cooled Thermo Con for Rack Mount” by SMC.

7 Shutdown

7.1 Shutting down for shorter periods

If the MetalJet D2+/C2 source is not going to be used for a shorter period of time (less than two months), it is preferred to leave it in the “ready” state, i.e. with the vacuum pumps and jet pump running, but with the high voltage generator turned off (see Section 5.10.3).

7.2 Shutting down for longer periods

If the source is not going to be used for a longer period (more than two months), it may be completely turned off (see Section 5.10.4). Follow the instructions in Section 3.2 about how to store it.

If the source cannot be stored in a dry environment (as a whole unit or divided into its sub-assembly units), it must be air-tight shrink-wrapped in a plastic bag together with some bags of desiccant.

7.3 Restarting after longer shutdown

- Visually inspect all sub-assembly units. If there is evidence of rust on any of the parts of the source, then do not take it into operation before having consulted Excillum (send an email to support@excillum.com).
- Depending on how long the source has been taken out of operation the O-rings may have to be replaced. Contact Excillum for advice.
- Inspect and, if necessary, exchange the drive unit lubricant in the jet pump. Follow the maintenance instructions in Section 6.2.1.
- Inspect and, if necessary, exchange the hydraulic oil in the jet pump. Follow the maintenance instructions in Sections 6.2.1.
- Install and commission the source in accordance with the installation and operating instructions of Sections 4 and 5.

7.4 Disposal

Products or parts (mechanical and electrical components, operating fluids, etc.) may cause environmental burden. Safely dispose of the materials according to the locally applicable regulations. In addition, please take care that all oil and grease is disposed according to the ordinance of waste oils.

Before recycling the individual materials must be separated. Most important components are cast iron, steel, aluminum, copper, gallium-based liquid metal alloy, Beryllium and plastics. Electronic components like printed circuit boards must be recycled separately.

WARNING

Poisoning hazard – Beryllium window

Fumes or dust from beryllium and its compounds can be hazardous if inhaled! Corrosion of the beryllium may occur during use. Beryllium must not be cut, machined, or handled in any way.

The beryllium foil of the X-ray source is fragile and brittle. When installing, replacing, or working around the X-ray source and the detector assemblies, proceed with great caution.

DO NOT touch the beryllium foil and DO NOT expose the beryllium window to corrosive substances such as acid, acid vapor, water, water vapor, or other substances.

In case of an implosion of the X-ray tube, you could get hurt by beryllium fragments. You must wear safety goggles and gloves when cleaning the instrument after such an incident.

Disposal of beryllium must comply with all applicable national, state, and local laws and regulations.

If breakage of a beryllium window occurs, proceed as follows:

1. Avoid touching, breathing or swallowing the particles and do not allow the particles to meet your skin or clothing.
2. Gather all broken pieces and particles immediately using a pair of tweezers or the sticky side of masking tape.
3. Handle the beryllium pieces as you would a poison. Place them in a sealed, unbreakable container labeled “CAUTION: BERYLLIUM - POISON,” and contact the proper authorities for transport and disposal guidelines.

If the beryllium particles have come in contact with skin, remove them as described above and wash the affected area thoroughly.

If the beryllium particles have come in contact with clothes, remove and discard the particles carefully as described above. Wash the clothing thoroughly. Check for beryllium particles on the skin as described above.

8 Malfunction and troubleshooting

In case of MetalJet D2+/C2 source malfunction, you will find possible causes and instructions for repair in the following table. If there is no reference to a specific section in this operating manual or the service manual in the “remedy” column, please contact Excillum for further instructions.

Additional and more detailed information regarding the jet pump, roughing pump, turbopump, fore-vacuum gauge, and high-vacuum gauge may be found in their respective operating manual.

Problem/Symptom	Possible cause	Remedy
High voltage generator shuts down repeatedly due to arcing	Contaminated high-voltage connectors	Contact Excillum support to remove and clean connectors with isopropanol
	Metal debris contamination of high voltage chamber	Follow service manual instructions to *Clean interior of HV chamber*
	Faulty high-voltage cable	Contact Excillum support.
No electron-beam emission	Cathode assembly short circuit caused by liquid-metal debris	Follow service manual instructions to *Remove & attach HV feedthrough* and inspect cathode assembly for metal debris
Fluctuations of electron-beam power emission	Oxide layer on cathode	Evaporate oxide layer from cathode using the *Cathode bake* button in the GUI
Low photon flux in relation to electron-beam power	Electron beam hits metal-jet in non-optimal position	Adjust electron-beam position relative to metal-jet
	Exit window out of order and contaminated	Check exit window heating current and voltage – if not 1.5 A and about 4 V, follow service manual instructions to *Replace exit window*
	Large leakage current in electron caused by either Contamination of high voltage feedthrough, metal	Immediately contact Excillum support

	electrodes and vacuum chamber Faulty high-voltage cable Faulty high-voltage power supply unit	
X-ray flux fluctuates violently	Jet is unstable	Follow service manual instructions to *Replace nozzle assembly*
X-ray spot size very large (>50 µm) in the horizontal direction	Jet is unstable	Follow service manual instructions to *Replace nozzle assembly*

Problem/Symptom	Possible cause	Remedy
Alignment procedure does not converge No electron-dump signal	HV feedthrough insufficiently aligned	Follow service manual instructions to *Align HV feedthrough*
	Electron-dump aperture contaminated by liquid-metal debris	Follow service manual instructions to *Remove liquid-metal debris from electron-beam dump aperture*
	No electron-dump signal due to short circuit by liquid-metal debris or improper mounting	Follow service manual instructions to *Remove liquid-metal debris from electron-beam dump aperture*
Heating current to exit window reaches set value, but the voltage value is about zero	Exit window short circuited	Follow service manual instructions to *Replace exit window*
Jet pressure fluctuates violently between almost zero and <200 bar	Pulsation dampener broken	Follow service manual instructions to *Replace pulsation dampener*

Jet pressure fluctuates more slowly (and possibly irregularly) and with smaller amplitude than above	Check valves not tight due to dirt, wear, or damage	Knock on inlet check valve housing to remove dirt – if jet pressure does not stabilize, follow service manual instructions to *Replace inlet check valve*
Jet pressure does not reach set value	Not enough liquid metal in source	Follow service manual to troubleshoot the jet system
	Check valves not tight due to dirt, wear, or damage	
Jet pressure close to zero with pump frequency at 50 Hz	Ball in inlet check valve stuck in seat	Follow service manual to troubleshoot the jet system
	Not enough liquid metal in source	
	Air is trapped inside pump head	
Roughing pump does not reach below 3 mbar	Water condensation inside roughing pump	Follow service manual instructions to *Introduce ballast load*
	Roughing pump due for service	Follow service manual instructions to *Replace roughing pump*
Turbopump does not attain the final rotation speed (1500 Hz) within the specified run-up time	Fore-vacuum pressure too high	See remedy for the above problem
	Vacuum leak in the source	Locate leak and seal it
	Turbopump due for service	Follow service manual instructions to *Replace turbopump*

9 Customer support

Excillum strives at offering first-class customer support. We will provide our customers with fast and reliable advice on the most cost-effective and quickest solution. Most replacement parts can be shipped immediately.

To ensure a fast and smooth servicing process, contact Excillum by sending an email to support@excillum.com with the following information:

- Company name, contact person, contact information (e-mail, phone, and street address).
- Model number, article number, serial number, and manufacturing year of the sub-assembly unit in need of service.
- Description of the problem (more details will lead to correct decisions faster)

9.1 Source log files

The X-ray control software continuously logs valuable information. This information is sometimes requested by Excillum during support cases. It can easily be downloaded using any SFTP client that connects remotely to the machine. Refer to Section 4.7.2 for network connectivity arrangements.

The folder /home/jxs/ contains files and folders that may be requested during support cases. Table 9-1 list the most important files and folders including a description of the contents.

File / Folder	Description
events.log	Today's log file with all source events (also shown in the log tab)
monitors.log	Today's read back values for all monitored source values with 5 s intervals
logs/	events.log and monitors.log files older than one day
reports/	Images and text reports acquired during source parametrization
archive/	Compressed archives (zip) containing copies of config.backup, events.log, monitors.log, setpoints.backup from the dates indicated by the filename.
.xcs/	Database holding present configuration and parametrization

Table 9-1. The most important files and folders including a description in /home/jxs/.

If a problem has occurred the same day, it is often enough to send events.log and monitors.log as well as the reports from that day. Problems that have occurred in the past can often be diagnosed by sending the relevant files from the day the problem occurred.

9.2 Remote support

Remote support using TeamViewer requires that the X-ray system controller itself or a computer, which can connect to the X-ray system controller using VNC, is connected to internet. TeamViewer comes preinstalled on the X-ray system controller, but it can be downloaded for free from www.teamviewer.com. When TeamViewer is started an ID number and a password is shown which can be used to invite Excillum support to assist with troubleshooting.

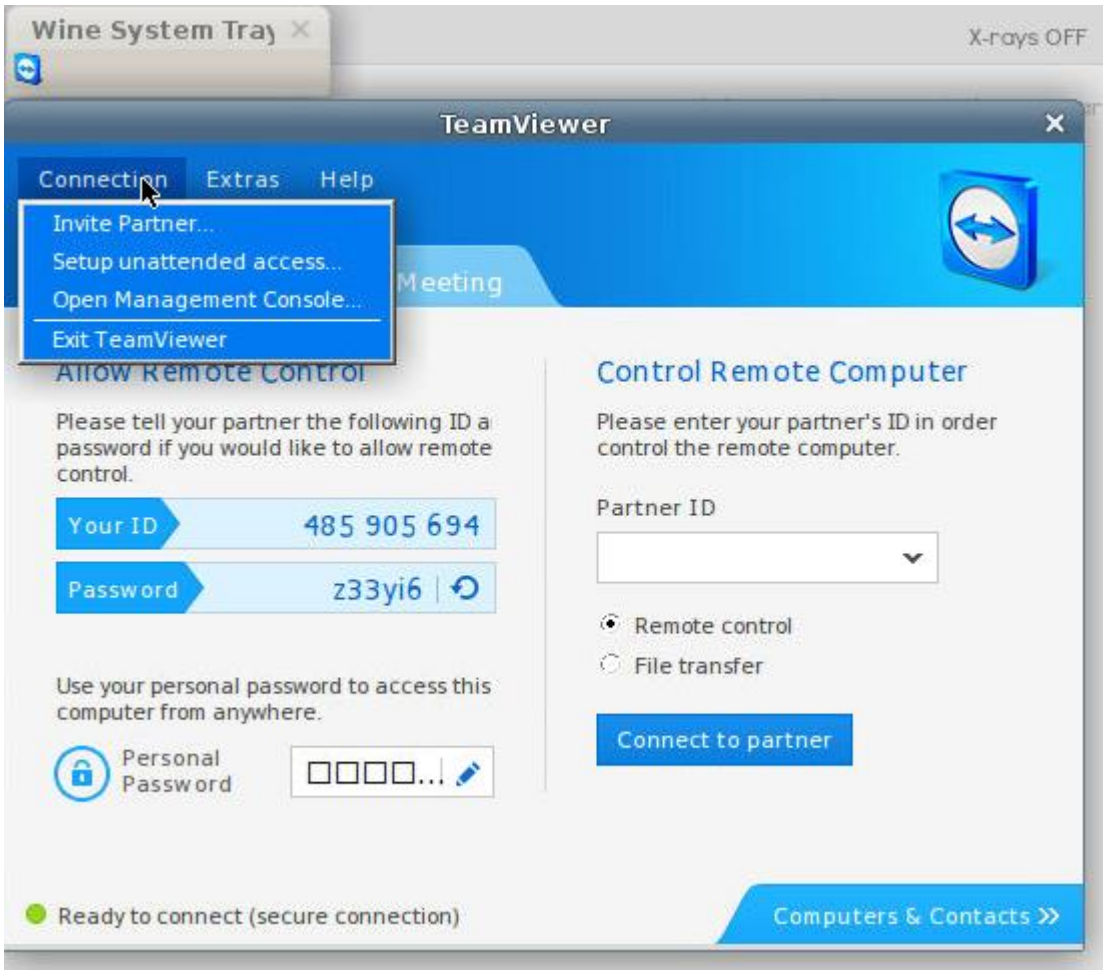


Figure 9-1. TeamViewer started on the X-ray system controller.

After the support session has finished and TeamViewer has been closed by selecting Connection->Exit TeamViewer, the ability to remotely connect is disabled.

10 Transportation

10.1 Dangerous Goods

The X-ray sources is considered dangerous goods when being transported as well as the spare parts, alloy and the pulse damper.

If the X-ray source or the spare parts - alloy or pulse damper, will be transported to another location after Excillum has sent it to the customer, the customer is solely responsible for making a correct transport, fulfilling all requirements and aspects of transporting dangerous goods

11 Technical data

Parameter	Value
Electron gun/X-ray head	
Max acceleration voltage & beam current	70/160 kV & 4.28 mA
Max electron-beam power	250 W
Min X-ray focal spot size	10 µm
Jet alloy (target material)	ExAlloy-G1 / ExAlloy-I1 / ExAlloy-I2
Max X-ray leakage at full power	0.6 µSv/h
X-ray window material	Beryllium
Focus to object distance (FOD)	24.8 mm (with shutter), 18 mm (without shutter)
Cooling method	Water cooling
Weight (excluding cables and liquid metal loop)	~61 kg
Closed pump box (G-035-0260)	
Mains supply	200-240 VAC, 50/60 Hz, 0.5 kW 200-240 V 2~, 50/60 Hz, 0.5 kW
Supply connector	Panel mount mains inlet for IEC 60320-C-13 cable
Fuse	T 10 A H, 250 V
Dimensions	15.3U 19” rack mounted, 48 cm deep
Weight	92 kg

Open pump box (G-035-0230)	
Mains supply	200-240 VAC, 50/60 Hz, 0.6 kW, class 1 200-240 V 2~, 50/60 Hz, 0.6 kW, class 1
Supply connector	Panel mount mains inlet for IEC 60320-C-13 cable
Fuse	T 10 A H, 250 V
Dimensions	15.3U 19” rack mounted, 48 cm deep 602 x 500 x 955 mm
Weight	105 kg
X-ray system controller	
Mains supply	200-240 VAC, 50/60 Hz, 0.5 kW 200-240 V 2~, 50/60 Hz, 0.5 kW
Supply connector	Panel mount mains inlet for IEC 60320-C-13 cable
Fuse	T 4 A L, 250 V
Dimensions	4U, 19” rack mounted, 40 cm deep
Weight	12.2 kg
X ray high-voltage controller	
Max acceleration voltage & beam current	70 kV / 4.28 mA
Mains supply	200-240 VAC, 50/60 Hz, 0.5 kW 200-240 V 2~, 50/60 Hz, 0.5 kW
Supply connector	Panel mount mains inlet for IEC 60320-C-13 cable

Fuse	M 3.15 A, 250 V
Dimensions	4U, 19” rack mounted, 40 cm deep
Weight	12.6 kg
Heater jackets controller	
Main supply	200-240 VAC, 50/60 Hz, 0.6 kW 200-240 V 2~, 50/60 Hz, 0.6 kW
Supply connector	Panel mount mains inlet for IEC 60320-C-13 cable
Fuse	T 4 A L, 250 V
Dimensions	2U, 19” rack mounted, 25 cm deep
Weight	5.3 kg

Parameter	Value
Cooling water specification	
Water specification	Nalco
Min pump flow rate capacity	0.7 l/min
Min pump pressure capacity	2 bar
Typical water flow rate	3 l/min at ΔP = 2 bar
Water temperature	Alloy dependent, for ExAlloy G1 30 ± 0.2 °C (86 ± 0.4 °F)
Water connection	3/8” hose barb
Cooling capacity	300 W minimum
Weight and dimensions	Approx 20-25 kg

	4U, 19” rack mounted, 40 cm deep
Environmental operating conditions	
Installation location	Weather protected (indoors)
Installation altitude	2000 m max. (up to 20% reduction in cooling above 1000 m)
Temperature	Any temperature in the range 15-30 °C (59-86 °F), but preferably stable within ±0.5 °C (±0.9 °F)
Pollution Degree	2
Relative humidity of air	Max 85% (no condensation)
Overvoltage category	II
Mains supply voltage fluctuations	Up to ±10% of the nominal voltage
Storage conditions	
Room temperature	20-40 °C (68-104 °F)
Relative humidity of air	Max 85% (no condensation)

CUSTOMER SAFETY SYSTEM EXAMPLE FOR SHIELDED SETUP WITH SHUTTER

DISPLAY

8P8C "RJ45"

SMALL WARNING DISPLAY

SHUTTER OPEN

X-RAY ON

SHUTTER

MALE 26 HD D-SUB

INTERLOCK

HR10-7R-4P(73)

CUSTOMER SAFETY CONTROLLER
+24V, USE 1 AMP FUSE

Safety relay supply lines

SHUTTER DRIVER,
SHUTTER CONTROL,
CUSTOMER SPECIFIC
LOGIC

X1

MALE 44 HD D-SUB

SAFETY RELAY
MONITOR LOGIC

HIGH VOLTAGE MONITOR

X-RAY WARNING LAMP

1 Route +24V through pullwire. This will split up +24V into two separate lines.

2 Route the two +24V individually through the cover interlock circuit.

3 Monitor shutter state. Break safety relay supply lines if in invalid state. For example that the customers enclosure doors are open simultaniously as the shutter is open.

It is also suggested that this stage also drives a warning lampa attached to the head through the DISPLAY connector.

This warning lamp can be placed in the vicinity of the samples or setup inside the enclosure.

4 Monitor safety relay feedbacks. Break safety relay supply lines if in wrong state.

5 Monitor high voltage feedback. Break safety relay supply lines if above valid voltages. Valid voltages are between 0.6V and 3.93V. Break if above 4.1V.

NOTE: These signals are not ISO 13849-1 compliant

6 Warning lamps. On when the high voltage generator has mains supply.

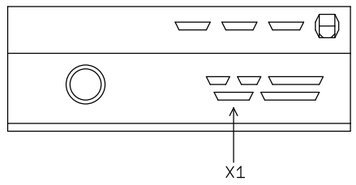
Description:				Project:
Rev:	Date:	Name:	Approved:	eXcillum
2	2015-09-01	R TERFELT		
3	2015-09-01	R TERFELT		Filename: P-029-0002 R04
4	2022-05-18	R Pettersson		Sheet:

2022-05-18 11:56

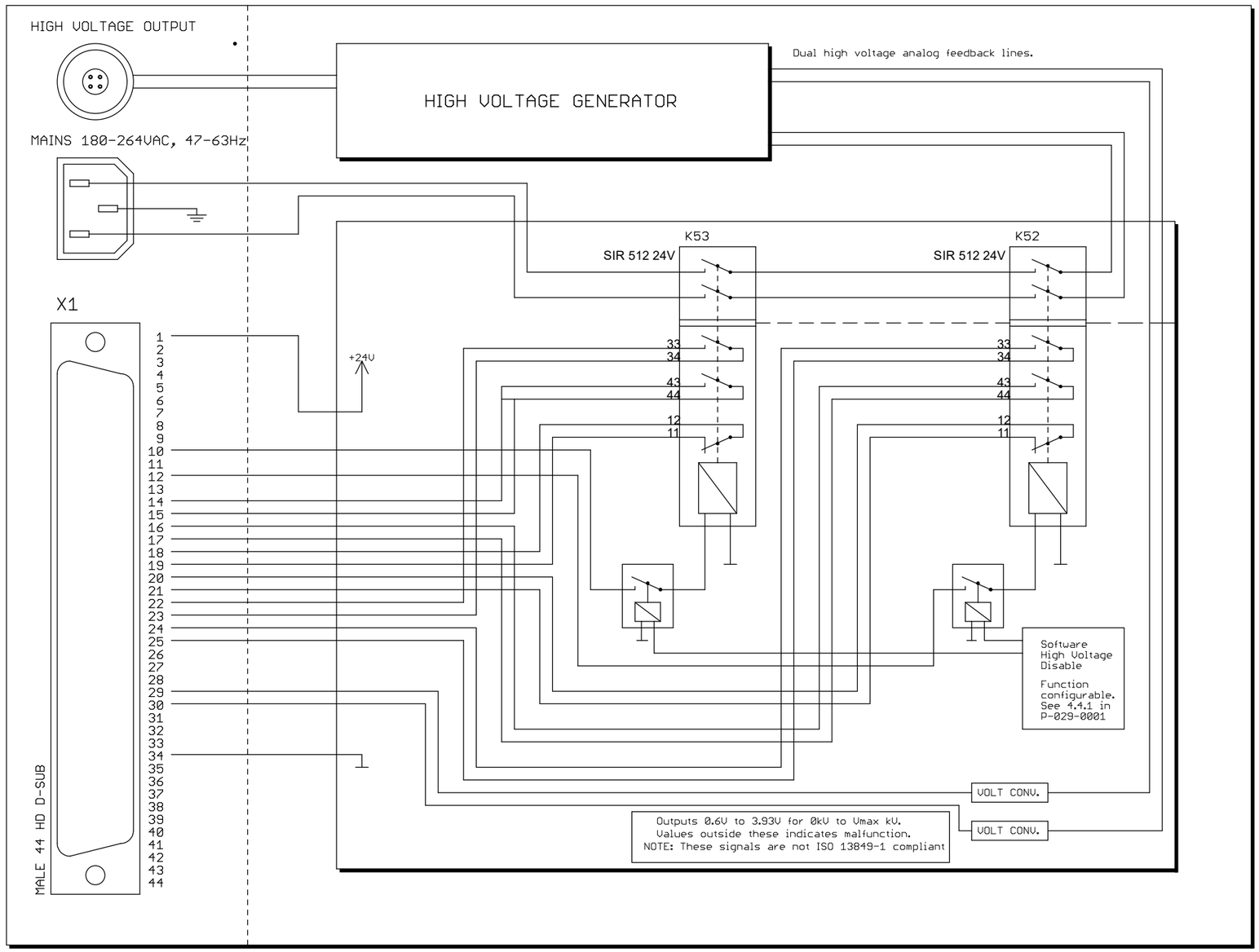
Excillum AB Finlandsgatan 14 164 74 Kista Sweden

HIGH VOLTAGE CONTROLLER SAFETY SYSTEM INTERFACE X1

X-ray High Voltage Controller



HIGH VOLTAGE BOX



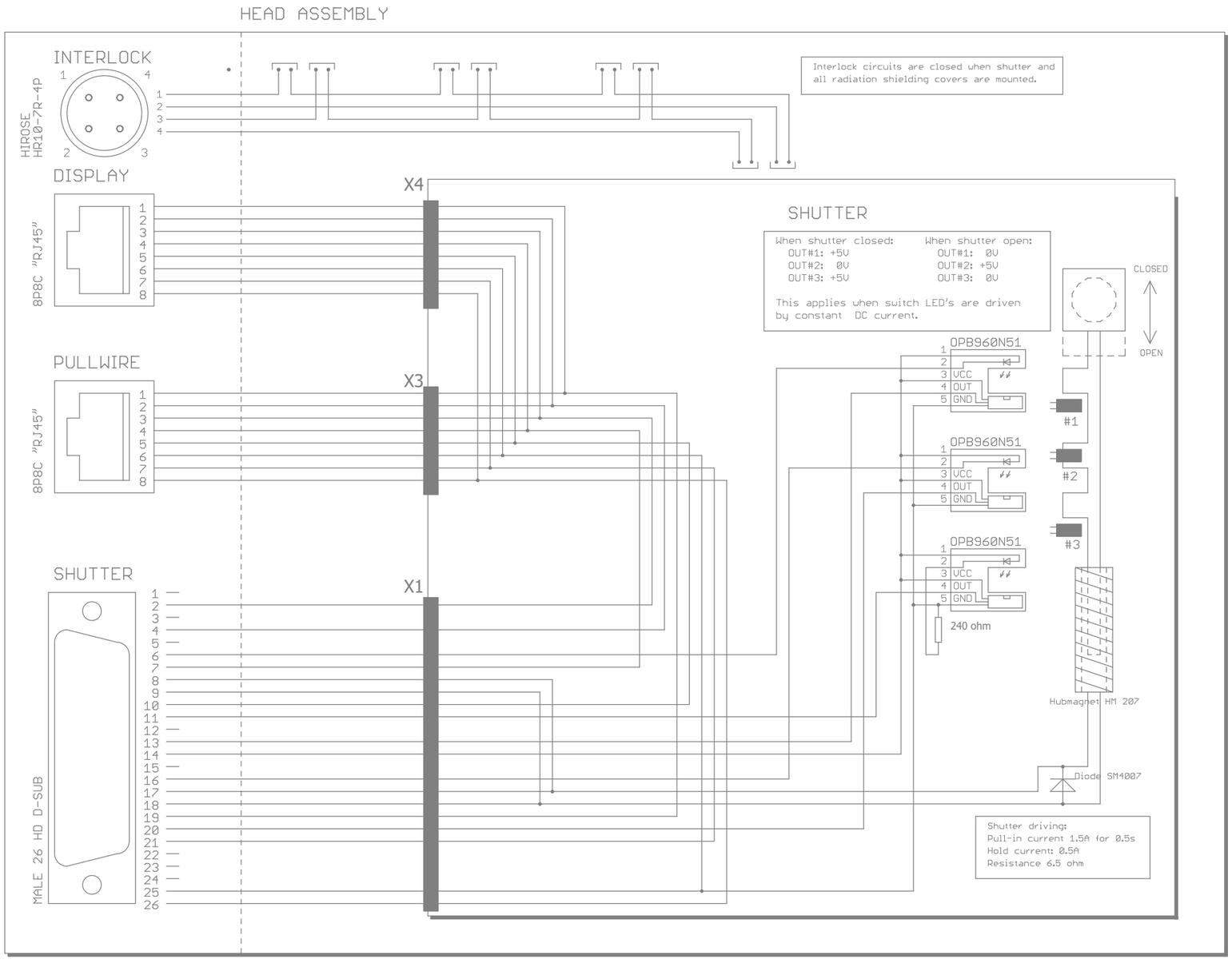
1	IN	SUPPLY +24V (MAX 0.5A)
2		DO NOT CONNECT
3		DO NOT CONNECT
4		DO NOT CONNECT
5		DO NOT CONNECT
6		DO NOT CONNECT
7		DO NOT CONNECT
8		DO NOT CONNECT
9		DO NOT CONNECT
10	IN	RELAY K53 CONTROL (+24V,32mA,760ohm)
11		DO NOT CONNECT
12	IN	RELAY K52 CONTROL (+24V,32mA,760ohm)
13		DO NOT CONNECT
14		K53 NO 43
15		K53 NO 44
16		K52 NO 43
17		K52 NO 44
18		K53 NC 12
19		K53 NC 11
20		K52 NC 12
21		K52 NC 11
22		K53 NO 33
23		K53 NO 34
24		K52 NO 33
25		K52 NO 34
26		DO NOT CONNECT
27		DO NOT CONNECT
28		DO NOT CONNECT
29	OUT	HIGH VOLTAGE MONITOR #1 (ANALOG 0.6V-3.93V)
30	OUT	HIGH VOLTAGE MONITOR #2 (ANALOG 0.6V-3.93V)
31		DO NOT CONNECT
32		DO NOT CONNECT
33		DO NOT CONNECT
34	IN	GROUND SUPPLY 0V
35		DO NOT CONNECT
36		DO NOT CONNECT
37		DO NOT CONNECT
38		DO NOT CONNECT
39		DO NOT CONNECT
40		DO NOT CONNECT
41		DO NOT CONNECT
42		DO NOT CONNECT
43		DO NOT CONNECT
44		DO NOT CONNECT

Excillum AB Finlandsgatan 14 164 74 Kista Sweden

2019-11-01 15:10:37

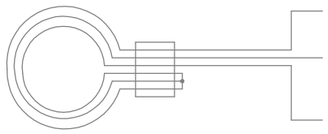
Description: HV CONTROLLER SAFETY INTERFACE				Project:
Rev:	Date:	Name:	Approved:	eXcillum
6	2015-10-22	R. Terfelt		
7	2019-11-01	R. Terfelt		
				Filename: P-029-0000 R07.sch — Sheet:

ELECTRON GUN SAFETY SYSTEM INTERFACE



NOTE! EXAMPLE/SUGGESTED USE OF DISPLAY CONNECTOR

1		NOT CONNECTED
2		SHUTTER OPEN DISPLAY LINE 1
3		X-RAYS ON DISPLAY LINE 1
4		NOT CONNECTED
5		X-RAYS ON DISPLAY LINE 2
6		GROUND
7		SHUTTER OPEN DISPLAY LINE 2
8		NOT CONNECTED



1		DO NOT CONNECT
2		DISPLAY PIN 3 (X-RAYS ON DISPLAY LINE 1)
3		DO NOT CONNECT
4		DISPLAY PIN 2 (SHUTTER OPEN DISPLAY LINE 1)
5		DO NOT CONNECT
6	IN	OPTO SWITCH #1 CATHODE
7		PULLWIRE PIN 4
8	IN	SHUTTER COIL +
9	IN	SHUTTER COIL -
10		DISPLAY PIN 5 (X-RAYS ON DISPLAY LINE 2)
11	OUT	SHUTTER OPEN (NOTE: +5V WHEN SHUTTER CLOSED)
12		DO NOT CONNECT
13	OUT	OPTO SWITCH #1 OUTPUT
14	IN	OPTO SWITCHES SUPPLY +5V
15		DO NOT CONNECT
16	IN	OPTO SWITCH #2 CATHODE
17	IN	SHUTTER COIL +
18	IN	SHUTTER COIL -
19		PULLWIRE PIN 1
20	OUT	OPTO SWITCH #2 OUTPUT
21		DISPLAY PIN 7 (SHUTTER OPEN DISPLAY LINE 2)
22		DO NOT CONNECT
23		DO NOT CONNECT
24		DO NOT CONNECT
25	IN	GROUND 0V
26		PULLWIRE PIN 8

eXcillum AB, Finlandsgatan 14, 164 74 Kista, Sweden

2019-02-04 16:29

Description:				Project:
ELECTRON GUN SAFETY INTERAFACE				
Rev:	Date:	Name:	Approved:	eXcillum
3	2016-04-21	R. TERFELT		
4	2019-01-01	R. TERFELT		
				Filename: P-029-0001 R04.sch
				Sheet:

SAFETY DATA SHEET

1. Identification

Product identifier **Beryllium Solid**

Other means of identification

SDS number M10

CAS number 7440-41-7

Synonyms Metallic Beryllium, Glucinium, I220H, IF-1®, S200F, S200FH, S200FC, SR200, S65, PS-200®, PF10, PF-60®, O-30, O-30H, I-70, I-70H, UHP Beryllium, .9999 Beryllium, B-26D, Be, IS-50M®

Manufacturer/Importer/Supplier/Distributor information

Manufacturer

Company name Materion Brush Inc.

Address 6070 Parkland Boulevard
Mayfield Heights, OH 44124
United States

Telephone 1.800.862.4118

Website www.materion.com

E-mail ehs@materion.com

Contact person Theodore Knudson

Emergency phone number 1.800.862.4118

2. Hazard(s) identification

Physical hazards Not classified.

Health hazards

Carcinogenicity	Category 1
Specific target organ toxicity, repeated exposure	Category 1 (Respiratory system)

Environmental hazards Not classified.

OSHA defined hazards Not classified.

Label elements

Signal word Danger

Hazard statement May cause cancer by inhalation. Causes damage to organs (respiratory system) through prolonged or repeated exposure by inhalation.

Precautionary statement

Prevention Obtain special instructions before use. Do not handle until all safety precautions have been read and understood. Minimize dust generation and accumulation. Do not breathe dust/fume. Wash thoroughly after handling. Do not eat, drink or smoke when using this product. Contaminated work clothing must not be allowed out of the workplace. Wear protective gloves/protective clothing/eye protection/face protection. In case of inadequate ventilation wear respiratory protection.

Response If on skin: Wash with plenty of water. If inhaled: Remove person to fresh air and keep comfortable for breathing. If exposed or concerned: Get medical advice/attention. If skin irritation or rash occurs: Get medical advice/attention. If experiencing respiratory symptoms: Call a poison center/doctor. Wash contaminated clothing before reuse.

Storage Store locked up.

Disposal Dispose of contents/container in accordance with local/regional/national/international regulations.

Hazard(s) not otherwise classified (HNOC)	None known.
Supplemental information	Exposure to the elements listed in Section 3 by inhalation, ingestion, and skin contact can occur when melting, casting, dross handling, pickling, chemical cleaning, heat treating, abrasive cutting, welding, grinding, sanding, polishing, milling, crushing, or otherwise heating or abrading the surface of this material in a manner which generates particulate. For further information, please contact the Product Stewardship Department at +1.800.862.4118.

3. Composition/information on ingredients

Substances

Chemical name	Common name and synonyms	CAS number	%
Beryllium	Metallic Beryllium, Glucinium, I220H, IF-1®, S200F, S200FH, S200FC, SR200, S65, PS-200®, PF10, PF-60®, O-30, O-30H, I-70, I-70H, UHP Beryllium, .9999 Beryllium, B-26D, Be, IS-50M®	7440-41-7	100

4. First-aid measures

Inhalation	If symptoms develop move victim to fresh air. For breathing difficulties, oxygen may be necessary. Breathing difficulty caused by inhalation of particulate requires immediate removal to fresh air. If breathing has stopped, perform artificial respiration and obtain medical help.
Skin contact	Take off contaminated clothing and wash before reuse. Thoroughly wash skin cuts or wounds to remove all particulate debris from the wound. Seek medical attention for wounds that cannot be thoroughly cleansed. Treat skin cuts and wounds with standard first aid practices such as cleansing, disinfecting and covering to prevent wound infection and contamination before continuing work. Obtain medical help for persistent irritation. Material accidentally implanted or lodged under the skin must be removed.
Eye contact	Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention if symptoms persist.
Ingestion	If swallowed, seek medical advice immediately and show this container or label. Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person.
Most important symptoms/effects, acute and delayed	May cause allergic skin reaction. Prolonged exposure may cause chronic effects.
Indication of immediate medical attention and special treatment needed	Treatment of Chronic Beryllium Disease: There is no known treatment which will cure chronic beryllium disease. Prednisone or other corticosteroids are the most specific treatment currently available. They are directed at suppressing the immunological reaction and can be effective in diminishing signs and symptoms of chronic beryllium disease. In cases where steroid therapy has had only partial or minimal effectiveness, other immunosuppressive agents, such as cyclophosphamide, cyclosporine, or methotrexate, have been used. In view of the potential side effects of all the immunosuppressive medications, including steroids such as prednisone, they should be used only under the direct care of a physician. Other treatment, such as oxygen, inhaled steroids or bronchodilators, may be prescribed by some physicians and can be effective in selected cases. In general, treatment is reserved for cases with significant symptoms and/or significant loss of lung function. The decision about when and with what medication to treat is a judgment situation for individual physicians. In their 2014 official statement on the Diagnosis and Management of Beryllium Sensitivity and Chronic Beryllium Disease, the American Thoracic Society states that “it seems prudent for workers with BeS to avoid all future occupational exposure to beryllium.”
General information	If exposed or concerned: get medical attention/advice. Get medical attention if symptoms occur. Wash contaminated clothing before reuse. As supplied, there is no immediate medical risk with beryllium products in article form. First aid measures provided are related to particulate containing beryllium.

5. Fire-fighting measures

Suitable extinguishing media The product is non-combustible. Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.

Unsuitable extinguishing media Do not use water to extinguish fires around operations involving molten metal due to the potential for steam explosions.

Specific hazards arising from the chemical Not applicable.

Special protective equipment and precautions for firefighters Firefighters should wear full protective clothing including self contained breathing apparatus. Wear suitable protective equipment.

Fire fighting equipment/instructions Move containers from fire area if you can do so without risk. Water runoff can cause environmental damage.

Specific methods Pressure-demand self-contained breathing apparatus must be worn by firefighters or any other persons potentially exposed to the particulate released during or after a fire.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures In solid form this material poses no special clean-up problems. Wear appropriate protective equipment and clothing during clean-up.

Methods and materials for containment and cleaning up Clean up in accordance with all applicable regulations.

Environmental precautions Avoid release to the environment. In the event of a spill or accidental release, notify relevant authorities in accordance with all applicable regulations. Prevent further leakage or spillage if safe to do so. Avoid discharge into drains, water courses or onto the ground.

7. Handling and storage

Precautions for safe handling Obtain special instructions before use. Do not handle until all safety precautions have been read and understood. Minimize dust generation and accumulation. Do not breathe dust/fume. Wear protective gloves/protective clothing/eye protection/face protection. Wear respiratory protection. Wash thoroughly after handling. When using, do not eat, drink or smoke. Contaminated work clothing must not be allowed out of the workplace.

Conditions for safe storage, including any incompatibilities Keep locked-up. Avoid contact with acids and alkalies. Avoid contact with oxidizing agents.

8. Exposure controls/personal protection

Occupational exposure limits

US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Material	Type	Value
Beryllium (CAS 7440-41-7)	STEL	0.002 mg/m3
	TWA	0.0002 mg/m3

US. ACGIH Threshold Limit Values

Material	Type	Value	Form
Beryllium (CAS 7440-41-7)	TWA	0.00005 mg/m3 (as beryllium)	Inhalable fraction.

US. NIOSH: Pocket Guide to Chemical Hazards

Material	Type	Value
Beryllium (CAS 7440-41-7)	Ceiling	0.0005 mg/m3 (as beryllium)

US. California Code of Regulations, Title 8, Section 5155. Airborne Contaminants

Material	Type	Value
Beryllium (CAS 7440-41-7)	Ceiling	0.025 mg/m3 0.025 mg/m3 (as beryllium)

US. California Code of Regulations, Title 8, Section 5155. Airborne Contaminants

Material	Type	Value
	PEL	0.0002 (as beryllium) 0.0002 mg/m3

Biological limit values

No biological exposure limits noted for the ingredient(s).

Exposure guidelines

Based on joint research conducted with the National Institute for Occupational Safety and Health (NIOSH), Materion adopted an 8 element Beryllium Worker Protection Model (BWPM) which includes the use of a recommended exposure guideline (REG) for airborne beryllium of 0.2 µg/m3 as a time-weighted average (TWA) limit for an 8-hour work day. Subsequent NIOSH studies have shown that the BWPM has reduced but not eliminated the risk of beryllium sensitization and chronic beryllium disease (CBD) in workers. Information on the BWPM can be found at www.berylliumsafety.com or by contacting Materion at +1 800.862.4118. In January 2017, OSHA issued a comprehensive occupational health standard for beryllium which includes a Permissible Exposure Limit (PEL) of 0.2 µg/m3 as an 8-hour TWA. In its evaluation, OSHA concluded that "despite the reduction in risk expected with the new PEL, the risks of CBD and cancer to workers with average exposure levels of 0.2 µg/m3 are still clearly significant." (Preamble to Final Rule, Occupational Exposure to Beryllium, Docket #OSHA-H005C-2006-0870, at 316.) Therefore, Materion recommends that beryllium users not only comply with the OSHA Beryllium Standard and carefully apply all elements of the BWPM, but reduce airborne exposures to the lowest feasible level.

The American Conference of Governmental Industrial Hygienists (ACGIH®) is a scientific body that has developed guidelines for all listed substances. In its development documents, the ACGIH® states that "Threshold Limit Values and Biological Exposure Indices represent conditions under which ACGIH® believes that nearly all workers may be repeatedly exposed without adverse health effects. They are not fine lines between safe and dangerous exposures, nor are they a relative index of toxicology."

Specific genetic factors have been identified and shown to increase an individual's susceptibility to CBD. Medical testing is available to detect those genetic factors in individuals.

Appropriate engineering controls

Ensure adequate ventilation, especially in confined areas.
Good general ventilation (typically 10 air changes per hour) should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level.

Whenever possible, the use of local exhaust ventilation or other engineering controls is the preferred method of controlling exposure to airborne particulate. Where utilized, exhaust inlets to the ventilation system must be positioned as close as possible to the source of airborne generation. Avoid disruption of the airflow in the area of a local exhaust inlet by equipment such as a man-cooling fan. Check ventilation equipment regularly to ensure it is functioning properly. Provide training on the use and operation of ventilation to all users. Use qualified professionals to design and install ventilation systems.

Control parameters

VENTILATION: Good general ventilation (typically 10 air changes per hour) should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level.

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WET METHODS: Machining operations are usually performed under a liquid lubricant/coolant flood which assists in reducing airborne particulate. However, the cycling through of machine coolant containing finely divided particulate in suspension can result in the concentration building to a point where the particulate may become airborne during use. Certain processes such as sanding and grinding may require complete hooded containment and local exhaust ventilation. Prevent coolant from splashing onto floor areas, external structures or operators' clothing. Utilize a coolant filtering system to remove particulate from the coolant.

WORK PRACTICES: Develop work practices and procedures that prevent particulate from coming in contact with worker skin, hair, or personal clothing. If work practices and/or procedures are ineffective in controlling airborne exposure or visual particulate from deposition on skin, hair, or clothing, provide appropriate cleaning/washing facilities. Procedures should be written that clearly communicate the facility's requirements for protective clothing and personal hygiene. These clothing and personal hygiene requirements help keep particulate from being spread to non-production areas or from being taken home by the worker. Never use compressed air to clean work clothing or other surfaces.

Fabrication processes may leave a residue of particulate on the surface of parts, products or equipment that could result in employee exposure during subsequent material handling activities. As necessary, clean loose particulate from parts between processing steps. As a standard hygiene practice, wash hands before eating or smoking.

HOUSEKEEPING: Use vacuum and wet cleaning methods for particulate removal from surfaces. Be certain to de-energize electrical systems, as necessary, before beginning wet cleaning. Use vacuum cleaners with high efficiency particulate air (HEPA). Do not use compressed air, brooms, or conventional vacuum cleaners to remove particulate from surfaces as this activity can result in elevated exposures to airborne particulate. Follow the manufacturer's instructions when performing maintenance on HEPA filtered vacuums used to clean hazardous materials.

Individual protection measures, such as personal protective equipment

Eye/face protection

Wear approved safety glasses, goggles, face shield and/or welder's helmet when risk of eye injury is present, particularly during operations that generate dust, mist or fume.

Skin protection

Hand protection

Wear gloves to prevent contact with particulate or solutions. Wear gloves to prevent metal cuts and skin abrasions during handling.

Other

Protective overgarments or work clothing must be worn by persons who may become contaminated with particulate during activities. Skin contact with this material may cause, in some sensitive individuals, an allergic dermal response. Particulate that becomes lodged under the skin has the potential to induce sensitization and skin lesions.

Respiratory protection	When airborne exposures exceed or have the potential to exceed the occupational exposure limits, approved respirators must be used as specified by an Industrial Hygienist or other qualified professional. Respirator users must be medically evaluated to determine if they are physically capable of wearing a respirator. Quantitative and/or qualitative fit testing and respirator training must be satisfactorily completed by all personnel prior to respirator use. Users of tight fitting respirators must be clean shaven on those areas of the face where the respirator seal contacts the face. Use pressure-demand airline respirators when performing jobs with high potential exposures such as changing filters in a baghouse air cleaning device.
Thermal hazards	Not applicable.
General hygiene considerations	Handle in accordance with good industrial hygiene and safety practice.

9. Physical and chemical properties

Appearance	
Physical state	Solid.
Form	Various shapes.
Color	Grey
Odor	None.
Odor threshold	Not applicable.
pH	Not applicable
Melting point/freezing point	2348.6 °F (1287 °C)
Initial boiling point and boiling range	5378 °F (2970 °C)
Flash point	Not applicable
Evaporation rate	Not applicable.
Flammability (solid, gas)	Not available.
Upper/lower flammability or explosive limits	
Explosive limit - lower (%)	Not applicable.
Explosive limit - upper (%)	Not applicable.
Vapor pressure	6.67 hPa estimated
Vapor density	Not applicable
Relative density	Not applicable.
Solubility(ies)	
Solubility (water)	Not applicable.
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not applicable.
Decomposition temperature	Not applicable.
Viscosity	Not applicable.
Other information	
Density	1.85 g/cm3 2 estimated
Molecular formula	Be
Molecular weight	9.01 g/mol
Specific gravity	1.85 estimated

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport.
Chemical stability	Material is stable under normal conditions.
Possibility of hazardous reactions	Hazardous polymerization does not occur.
Conditions to avoid	Avoid dust formation. Contact with acids. Contact with alkalis.

Incompatible materials	Strong acids, alkalies and oxidizing agents.
Hazardous decomposition products	No hazardous decomposition products are known.

11. Toxicological information

Information on likely routes of exposure

Inhalation	May cause damage to organs (respiratory system) through prolonged or repeated exposure.
Skin contact	Not likely, due to the form of the product.
Eye contact	Not likely, due to the form of the product.
Ingestion	Not likely, due to the form of the product.
Symptoms related to the physical, chemical and toxicological characteristics	Respiratory disorder.

Information on toxicological effects

Acute toxicity	Based on available data, the classification criteria are not met.
Skin corrosion/irritation	Not likely, due to the form of the product.
Serious eye damage/eye irritation	Not likely, due to the form of the product.

Respiratory or skin sensitization

Respiratory sensitization	May cause damage to organs (respiratory system) through prolonged or repeated exposure.
Skin sensitization	Not a skin sensitizer.
Germ cell mutagenicity	Due to lack of data the classification is not possible.
Carcinogenicity	Cancer hazard.

IARC Monographs. Overall Evaluation of Carcinogenicity

Beryllium (CAS 7440-41-7)	1 Carcinogenic to humans.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not regulated.

US. National Toxicology Program (NTP) Report on Carcinogens

Beryllium (CAS 7440-41-7)	Known To Be Human Carcinogen.

Reproductive toxicity	Not classified.
Specific target organ toxicity - single exposure	Not classified.
Specific target organ toxicity - repeated exposure	May cause damage to organs (respiratory system) through prolonged or repeated exposure by inhalation.
Aspiration hazard	Due to lack of data the classification is not possible.
Chronic effects	Hazardous by OSHA criteria. May cause damage to organs through prolonged or repeated exposure.
Further information	Symptoms may be delayed.

12. Ecological information

Ecotoxicity	No ecotoxicity data noted for the ingredient(s).
Persistence and degradability	No data is available on the degradability of this product.
Bioaccumulative potential	Not available.
Mobility in soil	Not available.
Other adverse effects	Not available.

13. Disposal considerations

Disposal instructions Material should be recycled if possible. Disposal recommendations are based on material as supplied. Disposal must be in accordance with current applicable laws and regulations, and material characteristics at time of disposal. When this product as supplied is to be discarded as waste, it does not meet the definition of a RCRA waste under 40 CFR 261.

Waste from residues / unused products Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions).

Contaminated packaging Empty containers should be taken to an approved waste handling site for recycling or disposal. Since emptied containers may retain product residue, follow label warnings even after container is emptied.

14. Transport information

DOT

Not regulated as dangerous goods.

IATA

Not regulated as dangerous goods.

IMDG

Not regulated as dangerous goods.

15. Regulatory information

US federal regulations All components are on the U.S. EPA TSCA Inventory List.
This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

CERCLA Hazardous Substance List (40 CFR 302.4)

Beryllium (CAS 7440-41-7) Listed.

SARA 304 Emergency release notification

Not regulated.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not regulated.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories Immediate Hazard - Yes
Delayed Hazard - Yes
Fire Hazard - Yes
Pressure Hazard - No
Reactivity Hazard - No

SARA 302 Extremely hazardous substance

Not listed.

SARA 311/312 Hazardous chemical Yes

SARA 313 (TRI reporting)

Chemical name	CAS number	% by wt.
Beryllium	7440-41-7	100

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Beryllium (CAS 7440-41-7)

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Clean Water Act (CWA) Section 112(r) (40 CFR 68.130) Priority pollutant
Toxic pollutant

Safe Drinking Water Act (SDWA)	0.004 mg/l 0.004 mg/l
US state regulations	WARNING: This product contains a chemical known to the State of California to cause cancer.

US - California Proposition 65 - CRT: Listed date/Carcinogenic substance

Beryllium (CAS 7440-41-7) Listed: October 1, 1987

US. California. Candidate Chemicals List. Safer Consumer Products Regulations (Cal. Code Regs, tit. 22, 69502.3, subd. (a))

Beryllium (CAS 7440-41-7)

16. Other information, including date of preparation or last revision

Issue date	05-28-2015
Revision date	10-13-2017
Version #	06
Further information	Transportation Emergency Call Chemtrec at: Domestic: 800.424.9300 International: 703.527.3887
Disclaimer	This document has been prepared using data from sources considered to be technically reliable and the information is believed to be correct. Materion makes no warranties, expressed or implied, as to the accuracy of the information contained herein. Materion cannot anticipate all conditions under which this information and its products may be used and the actual conditions of use are beyond its control. The user is responsible to evaluate all available information when using this product for any particular use and to comply with all Federal, State, Provincial and Local laws, statutes and regulations.
Other information	Revised information in Section 2. Revised information in Section 11.

SECTION 1: DESIGNATION OF THE SUBSTANCE OR THE MIXTURE AND THE COMPANY

1.1. Product identifier

Trade name	GALLIUM
REACH registration	01-2120762811-54-0005
CAS No.	7440-55-3
EC No.	231-163-8

1.2. Relevant identified uses of the substance or mixture and uses advised against

Identified uses Base metals and alloys, production of fine chemicals, production of bulk chemicals, electronics and semiconductor industry

Inadvisable uses No specific uses are identified that are advised against.

1.3. Details of the supplier providing the safety data sheet

Supplier
Geratherm Medical AG
Fahrenheitstrasse 1
99331 Geratal
Germany
TEL: +49(0)36205/98-0
FAX: +49(0)36205/98-115

1.4. Emergency number

+49(0)700 24112112 (GMR)
Giftnotruf Erfurt: 0361/730 730

SECTION 2: POSSIBLE HAZARDS

2.1. Classification of the substance or mixture

Regulation (EC) No. 1272/2008
Hazard categories:
Corrosive to metals: Met. corr. 1
Hazard warnings:
May be corrosive to metals.

2.2. Labelling elements

Regulation (EC) No. 1272/2008
Signal word: Caution
Pictograms:

Hazard warnings
H290 May be corrosive to metals.
Safety instructions

P234 Keep only in the original container.
P390 Collect spilled quantities to avoid material damage.
P406 Store in corrosion resistant container with corrosion resistant lining.

2.3. Other hazards

Irritations of the skin, eyes and mucous membranes may occur.
Dust and dust powders may be subject to classifications and precautions other than those given in this safety data sheet.

The product does not meet the PBT or vPvB criteria according to Annex XIII of the REACH Regulation.

SECTION 3: COMPOSITION/INFORMATION ON COMPONENTS

3.1. Substances

Chemical formula: Ga
Molar mass: 69.723 g/mol

CAS no.	Designation			Percentage
	EC No.	Index No.	REACH No.	
	GHS classification			
7440-55-3	Gallium			100 %
	231-163-8		01-2120762811-54-0005	
	Met. Corr. 1; H290			

Text of H and EUH statements: see section 16.

SECTION 4: FIRST AID MEASURES

4.1. Description of first aid measures

General information
First aider: Pay attention to self-protection!
Consult a doctor if symptoms occur or persist.
After inhalation
Inhalation is not a potential exposure.
Remove affected persons from the danger zone. Allow the person to breathe freely in the fresh air.
After skin contact
In case of contact with skin, wash immediately with plenty of water and soap. If skin irritation occurs, seek medical advice.
After eye contact
Eye contact is unlikely in its present form.
Seek medical attention immediately. In case of contact with eyes, rinse immediately with plenty of running water for 10 to 15 minutes with eyelids open. Remove contact lenses. Protect unharmed eye.

After swallowing
Seek medical attention immediately. Rinse mouth thoroughly with water. Move affected person to fresh air and allow them to relax. Drink plenty of water in small sips (dilution effect). DO NOT induce vomiting. Remove affected persons from the danger zone and lay them down. Never instil anything through the mouth of an unconscious person. Bring a vomiting person lying on his back into a stable lateral position.

4.2. Important acute and delayed symptoms and effects

Irritations of the skin, eyes and mucous membranes may occur.

4.3. Information on immediate medical help or special treatment

Symptomatic treatment

SECTION 5: MEASURES TO FIGHT FIRES

5.1. Extinguishing agents

Suitable extinguishing agents
The product is not flammable. Adjust extinguishing measures to the environment.
Water spray jet. Extinguishing powder. Foam.
Unsuitable extinguishing agents
None known

5.2. Special hazards arising from the substance or mixture

Dangerous combustion gases can be produced during combustion.

5.3. Instructions for fire fighting

In case of fire, use self-contained breathing apparatus and flame retardant clothing if necessary.
Cool endangered containers with water spray jet. Collect contaminated extinguishing water separately.

SECTION 6: MEASUREMENTS IN THE EVENT OF ACCIDENTAL RELEASE

6.1. Personal precautions, protective equipment and emergency procedures

Ensure adequate ventilation. Avoid contact with eyes and skin.
Wear personal protective equipment.

6.2. Environmental precautions

Do not allow to enter drains or watercourses. Do not allow to reach the subsoil/soil.
In the event of leakage or accidental release, notify the competent authorities in accordance with all applicable regulations.

6.3. Methods and materials for retention and cleaning

Collect mechanically and dispose of in suitable containers. Treat the collected material in accordance with the 'Disposal' section.

6.4. Reference to other sections

For personal precautions: see section 8
For safe handling: see section 7
For disposal: see section 13

SECTION 7: HANDLING AND STORAGE

7.1. Protective measures for safe handling

Instructions for safe handling
Avoid contact with eyes and skin.
Ensure adequate ventilation/suction at the workplace. Wear personal protective equipment.
Do not eat, drink or smoke during use. Wash hands before breaks and at the end of work.

Further information on handling
Check electrical installation regularly due to increased risk of corrosion.

7.2. Conditions for safe storage, including any incompatibilities

Requirements for storerooms and containers
Store in corrosion resistant container with corrosion resistant lining. Store only in the original container in a cool, well-ventilated place. Recommended storage temperature: <20 °C.
Keep container tightly closed. Store in a dry place.
Information on storage in a common storage facility
Unsuitable materials: Metals (in particular aluminium). Metal structures must be protected since gallium corrodes and dissolves most metals.
Further information on storage conditions
Keep away from food, drinks and animal feed.

Storage class according to TRGS [Technical Rule for Hazardous Substances] 510: 13 (non-flammable solids that cannot be assigned to any of the aforementioned storage classes)

7.3. Specific end uses

Industrial use
Base metals and alloys

SECTION 8: LIMITATION AND MONITORING OF EXPOSURE/PERSONAL PROTECTIVE EQUIPMENT

8.1. Parameters to be monitored

Additional information on limit values
No exposure limit values are currently available.

8.2. Limitation and monitoring of exposure

Protection and hygiene measures
Do not eat, drink, smoke or snuff at the workplace. Change contaminated clothing. Wash hands before breaks and at the end of work.

Eye/face protection
Use safety goggles with side protection.

Hand protection
Wear suitable protective gloves. Suitable material: NR (natural rubber, natural latex).
Chemical protective gloves must be selected specifically for the workplace depending on the concentration and quantity of hazardous substances.

Body protection
Protective workwear

Breathing protection
In case of dust formation: If technical suction or ventilation measures are not possible or insufficient, respiratory protection must be worn.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

9.1. Information on the basic physical and chemical properties

State of matter:	solid (massive)
Colour:	light grey / silver
Odour:	odourless
pH value:	No data available

State changes

Melting point:	29.8 °C
Initial boiling point and boiling range:	2200 °C
Sublimation temperature:	No data available
Softening point:	No data available
Flash point:	No data available

Flammability

Solid:	No data available

Explosion hazards
No data available.

Lower explosive limit:	No data available
Upper explosive limit:	No data available
Ignition temperature:	No data available

Self-ignition temperature

Solid:	No data available
Decomposition temperature	No data available

Oxidising properties
No data available

Vapour pressure:	No data available
Density (at 20 °C):	5.91 g/cm^3
Bulk density:	No data available
Water solubility:	No data available

Solubility in other solvents
No data available

Partition coefficient:	No data available
Dyn. viscosity:	No data available
Evaporation rate:	No data available

9.2. Other information

No data available

SECTION 10: STABILITY AND REACTIVITY

10.1. Reactivity
No hazardous reactivity under normal environmental conditions.

10.2. Chemical stability
The product is stable under normal environmental conditions.

10.3. Possibility of dangerous reactions
The substance may react dangerously with: Aluminium alloys; hydrogen chloride; halogens; alkalis; oxidising agents; acids
Danger of explosion if in contact with: Hydrogen peroxide / hydrochloric acid

10.4. Conditions to be avoided
None known

10.5. Incompatible materials
Unsuitable materials: Metals (in particular aluminium). Metal structures must be protected since gallium corrodes and dissolves most metals.

10.6. Hazardous decomposition products
Thermal decomposition can produce gases and vapours that are harmful to health.

SECTION 11: TOXICOLOGICAL INFORMATION

11.1. Information on toxicological effects

Acute toxicity
On the basis of the available data, the classification criteria are not met.

Irritant and corrosive effect
On the basis of the available data, the classification criteria are not met.

Sensitising effects
On the basis of the available data, the classification criteria are not met.

Carcinogenity, mutagenicity and toxicity for reproduction
On the basis of the available data, the classification criteria are not met.

Specific target organ toxicity in case of single exposure
On the basis of the available data, the classification criteria are not met.

Specific target organ toxicity in case of repeated exposure
On the basis of the available data, the classification criteria are not met.

Danger of aspiration
On the basis of the available data, the classification criteria are not met.

SECTION 12: ENVIRONMENTAL INFORMATION

12.1. Toxicity
No data available

12.2. Persistence and degradability
The product is not biodegradable.

12.3. Bioaccumulation potential
No bioaccumulation potential suspected.

12.4. Mobility in the ground
No data available.

12.5. Results of PBT and vPvB assessment
The product does not meet the PBT or vPvB criteria according to Annex XIII of the REACH Regulation.

12.6. Other adverse effects
No data available.

SECTION 13: INFORMATION ON DISPOSAL

13.1. Waste treatment process

Recommendation
Consider possible recovery or recycling processes. Disposal in accordance with official regulations. The assignment of the waste code numbers/waste identification is to be carried out in accordance with AVV [Waste Catalogue Regulation] specific to the industry and the process.

Disposal of uncleaned packaging and recommended cleaning agents
Contaminated packaging shall be treated in the same way as the substance.
Non-contaminated and cleaned packaging can be recycled.

SECTION 14: TRANSPORT INFORMATION

Land transport (ADR/RID)

14.1. UN number:	UN 2803
14.2. Proper UN shipping name:	GALLIUM
14.3. Transport hazard classes	8
14.4. Packaging group	III
Hazard label:	8

Classification code:	C10
Limited quantity (LQ):	5 kg
Exempted quantity:	E0
Transport category:	3
Hazard number:	80
Tunnel restriction code:	E

Inland waterways transport (ADN)

14.1. UN number:	UN 2803
14.2. Proper UN shipping name:	GALLIUM
14.3. Transport hazard classes	8
14.4. Packaging group	III
Hazard label:	8

Geratherm Medical AG

Classification code:	C10
Limited quantity (LQ):	5 kg
Exempted quantity:	E0

Maritime transport (IMDG)

14.1. UN number:	UN 2803
14.2. Proper UN shipping name:	GALLIUM
14.3. Transport hazard classes	8
14.4. Packaging group	III
Hazard label:	8

Special regulations: -
Limited quantity (LQ): 5 kg
Exempted quantity: E0
EmS: F-A, S-B

Air transport (ICAO-TI/IATA-DGR)

14.1. UN number: UN 2803
14.2. Proper UN shipping name: GALLIUM
14.3. Transport hazard classes 8
14.4. Packaging group III
Hazard label: 8

Special regulations: A69 A804
Limited Quantity (LQ) for passenger: Forbidden
Passenger LQ: Forbidden
Exempted quantity: E0

IATA Packaging instruction for passenger: 867
IATA-Maximum quantity for passenger: 20 kg
IATA packing instruction for cargo: 867
IATA maximum quantity for cargo: 20 kg

14.5. Environmental hazards

DANGEROUS TO THE ENVIRONMENT: no

14.6. Special precautions for the user

No special precautions are known.

14.7. Transport in bulk in accordance with Annex II to the MARPOL Convention and the IBC Code

Not applicable

SECTION 15: LEGISLATION

15.1. Safety, health and environmental protection regulations/legislation specific to the substance or mixture

EU regulations
Information on the SEVESO III Directive 2012/18/EU: Not subject to the SEVESO III Directive

Additional information

Regulation (EC) No. 648/2004 on detergents: not applicable
Regulation (EC) No. 1005/2009 on substances that deplete the ozone layer: not applicable
Regulation (EC) No. 850/2004 on persistent organic pollutants: not applicable
Regulation (EC) No. 689/2008 of the European Parliament and of the Council concerning the export and import of dangerous chemicals: This mixture does not contain any chemicals subject to the export notification procedure (Annex I).
The mixture contains the following substances of very high concern (SVHC) that are included in the candidate list under REACH Article 59: none
The mixture contains the following substances of very high concern (SVHC) subject to authorisation under REACH, Annex XIV: none

National regulations

Employment restrictions:
Observe employment restrictions for young people (§ 22 JArbSchG). Observe employment restrictions for expectant and nursing mothers (§§ 11 and 12 MuSchG). Observe employment restrictions for women of childbearing age.

Water hazard class:
1 - slightly water-hazardous

Status: Classification of mixtures according to Annex 1, No. 5 AwSV

Additional information
The national legal regulations must also be observed!

15.2. Chemical safety assessment
A chemical safety assessment has been carried out for this substance.

SECTION 16: OTHER INFORMATION

The information is based on the current state of our knowledge and serves to describe the product with regard to the safety precautions to be taken. They do not represent an assurance of the properties of the product described.
The safety data sheet was created on the basis of information from upstream suppliers.

Amendments
Version 1 first creation: 22.07.2018
Version 1.01: adaption REACH 13.12.2019

16.1 Abbreviations / acronyms

ADR: Accord euroéen sur le transport des marchandises dangereuses par Route
(European Agreement concerning the International Carriage of Dangerous Goods by Road)
BImSchV: German Federal Immission Protection Ordinance
CAS: Chemical Abstract Service
DIN: Standard of the German Institute for Standardization
EC: Effective Concentration
EC: European Community
EN: European Standard

IATA: International Air Transport Association
IBC code: International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk
ICAO: International Civil Aviation Organisation
IMDG: International Maritime Code for Dangerous Goods
ISO: Standard of the International Standards Organization
CLP: Classification Labelling Packaging
IUCLID: International Uniform ChemicaL Information Database
lC: Lethal Concentration
LD: Lethal dose
logKow: Distribution coefficient between octanol and water
MARPOL: Maritime Pollution Convention = Convention for the Prevention of Pollution from Ships
OECD: Organisation for Economic Co-Operation and Development
PBT: Persistent, bioaccumulative, toxic
RID: Regulation concerning the International Carriage of Dangerous Goods by Rail
TRGS: Technical rules for hazardous substances
UN: United Nations
VOC: Volatile Organic Compounds
vPvB: very persistent and very bioaccumulative
VwVwS: Administrative Regulation for Substances Hazardous to Water
WGK: Water hazard class
GHS: Globally Harmonised System of Classification and Labelling of Chemicals
EINECS: European Inventory of Existing Commercial Chemical Substances
DNEL: Derived No Effect Level
PNEC: Predicted No Effect Concentration
TLV: Threshold Limiting Value
STOT: Specific Target Organ Toxicity

The information given in this safety data sheet is intended to describe the product with regard to the necessary safety precautions. It does not serve to guarantee certain properties and is based on the current state of our knowledge.

SECTION 1: DESIGNATION OF THE SUBSTANCE OR THE MIXTURE AND THE COMPANY

1.1. Product identifier

Trade name EXALLOY-G1

1.2. Relevant identified uses of the substance or mixture and uses advised against

Identified uses Base metals and alloys, production of fine chemicals, production of bulk chemicals, electronics and semiconductor industry

Inadvisable uses No specific uses are identified that are advised against.

1.3. Details of the supplier providing the safety data sheet

Supplier
Geratherm Medical AG
Fahrenheitstrasse 1
99331 Geratal
Germany
TEL: +49(0)36205/98-0
FAX: +49(0)36205/98-115

1.4. Emergency number

+49(0)700 24112112
Giftnotruf Erfurt: 0361/730 730

SECTION 2: POSSIBLE HAZARDS

2.1. Classification of the substance or mixture

Regulation (EC) No. 1272/2008
Hazard categories:
Corrosive to metals: Met. corr. 1
Hazard warnings:
May be corrosive to metals.

2.2. Labelling elements

Regulation (EC) No. 1272/2008
Signal word: Caution
Pictograms:

Hazard warnings
H290 May be corrosive to metals.
H315 Causes skin irritation

Safety instructions
P302 IF ON SKIN:
P353 Rinse skin with water [or shower]
P406 Store in corrosion resistant container with corrosion resistant lining.

2.3. Other hazards

Irritations of the skin, eyes and mucous membranes may occur.
Dust and dust powders may be subject to classifications and precautions other than those given in this safety data sheet.

The product does not meet the PBT or vPvB criteria according to Annex XIII of the REACH Regulation.

SECTION 3: COMPOSITION/INFORMATION ON COMPONENTS

3.1. Substances

This product is an alloy.

Chemical formula:	Ga	In
Molar mass:	69,723 g/mol	114,82

CAS no.	Designation		
	EC No.	Index No.	REACH No.
	GHS classification		
7440-55-3	Gallium		
	231-163-8		05-2114306905-50-0000 (Pre-registration no.)
	Met. Corr. 1; H290		
7440-74-6	Indium		
	231-180		05-2114306912-55-0000

Text of H and EUH statements: see section 16.

SECTION 4: FIRST AID MEASURES

4.1. Description of first aid measures

General information
First aider: Pay attention to self-protection!
Consult a doctor if symptoms occur or persist.
After inhalation
Inhalation is not a potential exposure.
Remove affected persons from the danger zone. Allow the person to breathe freely in the fresh air.
After skin contact
In case of contact with skin, wash immediately with plenty of water and soap. If skin irritation occurs, seek medical advice.
After eye contact
Eye contact is unlikely in its present form.
Seek medical attention immediately. In case of contact with eyes, rinse immediately with plenty of running water for 10 to 15 minutes with eyelids open. Remove contact lenses. Protect unharmed eye.

After swallowing
Seek medical attention immediately. Rinse mouth thoroughly with water. Move affected person to fresh air and allow them to relax. Drink plenty of water in small sips (dilution effect). DO NOT induce vomiting. Remove affected persons from the danger zone and lay them down. Never instil anything through the mouth of an unconscious person. Bring a vomiting person lying on his back into a stable lateral position.

4.2. Important acute and delayed symptoms and effects

Irritations of the skin, eyes and mucous membranes may occur.

4.3. Information on immediate medical help or special treatment

Symptomatic treatment

SECTION 5: MEASURES TO FIGHT FIRES

5.1. Extinguishing agents

Suitable extinguishing agents
The product is not flammable. Adjust extinguishing measures to the environment.
Water spray jet. Extinguishing powder. Foam.
Unsuitable extinguishing agents
None known

5.2. Special hazards arising from the substance or mixture

Dangerous combustion gases can be produced during combustion.

5.3. Instructions for fire fighting

In case of fire, use self-contained breathing apparatus and flame retardant clothing if necessary.
Cool endangered containers with water spray jet. Collect contaminated extinguishing water separately.

SECTION 6: MEASUREMENTS IN THE EVENT OF ACCIDENTAL RELEASE

6.1. Personal precautions, protective equipment and emergency procedures

Note possible danger of slipping due to leaked / spilled product.
Avoid contact with eyes and skin.
Wear personal protective equipment.

6.2. Environmental precautions

Do not allow to enter drains or watercourses. Do not allow to reach the subsoil/soil.
In the event of leakage or accidental release, notify the competent authorities in accordance with all applicable regulations.

6.3. Methods and materials for retention and cleaning

Pick up larger quantities with a syringe or sweep them up and bring them to recovery in plastic containers (no aluminium containers). Remove product residues with a soap solution. Avoid dust formation.

6.4. Reference to other sections

For personal precautions: see section 8
For safe handling: see section 7
For disposal: see section 13

SECTION 7: HANDLING AND STORAGE

7.1. Protective measures for safe handling

Instructions for safe handling
Avoid contact with eyes and skin.
Wear personal protective equipment.
Do not eat, drink or smoke during use. Wash hands before breaks and at the end of work.

7.2. Conditions for safe storage, including any incompatibilities

Requirements for storerooms and containers
Store in a corrosion-resistant container. Dry storage
Advice on storage compatibility: unsuitable working materials - metals (especially aluminium)

Further information on safe handling
Avoid spilling. Avoid unnecessary chemical contact.
Handling unpacked EXALLOY-G1 can change its quality and purity. Geratherm is not liable for changes and product quality resulting from processing.

7.3. Specific end uses

Hg substitute, lubricant, reflection medium, electrically conductive medium

SECTION 8: LIMITATION AND MONITORING OF EXPOSURE/PERSONAL PROTECTIVE EQUIPMENT

8.1. Parameters to be monitored

Additional information on limit values
No exposure limit values are currently available.

8.2. Limitation and monitoring of exposure

Protection and hygiene measures
Do not eat, drink, smoke or snuff at the workplace. Change contaminated clothing. Wash hands before breaks and at the end of work.

Eye/face protection
Use safety goggles with side protection.

Hand protection
Wear suitable protective gloves. Suitable material: NR (natural rubber, natural latex).
Chemical protective gloves must be selected specifically for the workplace depending on the concentration and quantity of hazardous substances.

Body protection
Protective workwear

Breathing protection
In the event of an accident, if oxide smoke occurs, use breathing protection P3.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

9.1. Information on the basic physical and chemical properties

Appearance

Physical state:	liquid
Colour:	Silver
Odour:	odourless
pH value:	No data available

Security-relevant data

Explosion hazard:	No
Vapor pressure:	<10 (-8) torr
Density:	6.1 g / cm3
Expiry time:	not applicable
Water solubility:	> 800 g / l
pH value:	n.a.
Boiling point / range:	> 1300 ° C
Flash point:	n.a.
Ignition temperature:	n.a.

SECTION 10: STABILITY AND REACTIVITY

10.1. Reactivity
No hazardous reactivity under normal environmental conditions.

10.2. Chemical stability
The product is stable under normal environmental conditions.

10.3. Possibility of dangerous reactions
Product can react dangerously with halogens (chlorine, bromine), hydrogen peroxide / hydrogen chloride, aluminium.
Dangerous reactions with strong acids and oxidizing agents.

10.4. Conditions to be avoided
With aluminium and with subsequent water addition exothermic!

10.5. Incompatible materials
Unsuitable working materials: metals (especially aluminium)
The product alloys superficial metals such as copper, tin, lead, zinc, gold and silver jewellery, especially light metals are superficially alloyed, especially if they are free of oxides.
If necessary, the product must be checked for reactions with materials and chemical substances in the specific application.

10.6. Hazardous decomposition products
Thermal decomposition can produce gases and vapours that are harmful to health.

SECTION 11: TOXICOLOGICAL INFORMATION

11.1. Information on toxicological effects

Acute toxicity
On the basis of the available data, the classification criteria are not met.

Irritant and corrosive effect
On the basis of the available data, the classification criteria are not met.

Sensitising effects
On the basis of the available data, the classification criteria are not met.

Carcinogenity, mutagenicity and toxicity for reproduction
On the basis of the available data, the classification criteria are not met.

Specific target organ toxicity in case of single exposure
On the basis of the available data, the classification criteria are not met.

Specific target organ toxicity in case of repeated exposure
On the basis of the available data, the classification criteria are not met.

Danger of aspiration
On the basis of the available data, the classification criteria are not met.

SECTION 12: ENVIRONMENTAL INFORMATION

12.1. Toxicity
No data available

12.2. Persistence and degradability
The product is not biodegradable.

12.3. Bioaccumulation potential
No bioaccumulation potential suspected.

12.4. Mobility in the ground
No data available.

12.5. Results of PBT and vPvB assessment
The product does not meet the PBT or vPvB criteria according to Annex XIII of the REACH Regulation.

12.6. Other adverse effects
No data available.

SECTION 13: INFORMATION ON DISPOSAL

13.1. Waste treatment process

Recommendation
Proper use or recycling are preferable to disposal.
Disposal according to the locally applicable laws and regulations for waste disposal (official information obligation).

Dispose of uncleaned packaging and recommended cleaning agents
Contaminated packaging should be treated like the substance.
Uncontaminated and cleaned packaging can be recycled.

SECTION 14: TRANSPORT INFORMATION

Land transport (ADR/RID)
Transport information
14.1 ID No.: UN 1760
14.2 proper shipping name: Corrosive liquid, n.o.s. (composition contains ca.95 % gallium)
14.3 transport hazard class: 8, hazard label: 8

14.4 packing group: III
14.5 environmental hazards: no environmental hazards
14.6 special precautions
for user: avoid contact with aluminium and precious metals (gold and silver jewellery)
14.7 transport in bulk: not provided
The instructions and restrictions of IATA, IMDG-code and ADR must be followed.

The current regulations according to IATA, IMDG code and ADR apply.

More information:
The transport regulations are quoted according to international regulations and in the form used in Germany. Possible deviations in other countries are not taken into account.

SECTION 15: LEGISLATION

15.1. Safety, health and environmental protection regulations/legislation specific to the substance or mixture

EU regulations
Information on the SEVESO III Directive 2012/18/EU: Not subject to the SEVESO III Directive

Additional information

Regulation (EC) No. 648/2004 on detergents: not applicable
Regulation (EC) No. 1005/2009 on substances that deplete the ozone layer: not applicable
Regulation (EC) No. 850/2004 on persistent organic pollutants: not applicable
Regulation (EC) No. 689/2008 of the European Parliament and of the Council concerning the export and import of dangerous chemicals: This mixture does not contain any chemicals subject to the export notification procedure (Annex I).
The mixture contains the following substances of very high concern (SVHC) that are included in the candidate list under REACH Article 59: none

National regulations

Employment restrictions:
Observe employment restrictions for young people (§ 22 JArbSchG). Observe employment restrictions for expectant and nursing mothers (§§ 11 and 12 MuSchG). Observe employment restrictions for women of childbearing age.

Water hazard class:
1 - slightly water-hazardous

Status: Classification of mixtures according to Annex 1, No. 5 AwSV

Additional information
The national legal regulations must also be observed!

15.2. Chemical safety assessment
A chemical safety assessment has been carried out for this substance.

SECTION 16: OTHER INFORMATION

The information is based on the current state of our knowledge and serves to describe the product with regard to the safety precautions to be taken. They do not represent an assurance of the properties of the product described.
The safety data sheet was created on the basis of information from upstream suppliers.

Amendments
Version 1 first creation: 11.10.2012
Version 1.01. 23.08.2018
Version adaptation REACH Reg. 07.01.2020

Changes compared to the last version
Adaptation to Regulation (EC) No 1272
change of address

References and data sources
Regulations
REACH Regulation (EC) No. 1907/2006, as last amended by Regulation (EU) 2018/675
CLP Regulation (EC) No. 1272/2008, as last amended by Regulation (EU) 2018/669
Internet
List of hazard statements that were not fully written out in sections 2 to 15
Health and environmental hazards: calculation method

training advice
No training is required for activities with this hazardous substance

16.1 Abbreviations / acronyms

ADR: Accord euroéen sur le transport des marchandises dangereuses par Route
(European Agreement concerning the International Carriage of Dangerous Goods by Road)
BlmSchV: German Federal Immission Protection Ordinance
CAS: Chemical Abstract Service
DIN: Standard of the German Institute for Standardization
EC: Effective Concentration
EC: European Community
EN: European Standard
IATA: International Air Transport Association
IBC code: International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk
ICAO: International Civil Aviation Organisation
IMDG: International Maritime Code for Dangerous Goods
ISO: Standard of the International Standards Organization
CLP: Classification Labelling Packaging
IUCLID: International Uniform ChemicaL Information Database
lC: Lethal Concentration
LD: Lethal dose
logKow: Distribution coefficient between octanol and water
MARPOL: Maritime Pollution Convention = Convention for the Prevention of Pollution from Ships
OECD: Organisation for Economic Co-Operation and Development
PBT: Persistent, bioaccumulative, toxic
RID: Regulation concerning the International Carriage of Dangerous Goods by Rail
TRGS: Technical rules for hazardous substances
UN: United Nations
VOC: Volatile Organic Compounds
vPvB: very persistent and very bioaccumulative
VwVwS: Administrative Regulation for Substances Hazardous to Water
WGK: Water hazard class
GHS: Globally Harmonised System of Classification and Labelling of Chemicals
EINECS: European Inventory of Existing Commercial Chemical Substances
DNEL: Derived No Effect Level
PNEC: Predicted No Effect Concentration
TLV: Threshold Limiting Value
STOT: Specific Target Organ Toxicity

The information given in this safety data sheet is intended to describe the product with regard to the necessary safety precautions. It does not serve to guarantee certain properties and is based on the current state of our knowledge.

SECTION 1: DESIGNATION OF THE SUBSTANCE OR THE MIXTURE AND THE COMPANY

1.1. Product identifier

Trade name EXALLOY-I1
REACH registration 01-2120762811-54-0005

1.2. Relevant identified uses of the substance or mixture and uses advised against

Identified uses Base metals and alloys, production of fine chemicals, production of bulk chemicals, electronics and semiconductor industry

Inadvisable uses No specific uses are identified that are advised against.

1.3. Details of the supplier providing the safety data sheet

Supplier
Geratherm Medical AG
Fahrenheitstrasse 1
99331 Geratal
Germany
TEL: +49(0)36205/98-0
FAX: +49(0)36205/98-115

1.4. Emergency number

+49(0)700 24112112
Giftnotruf Erfurt: 0361/730 730

SECTION 2: POSSIBLE HAZARDS

2.1. Classification of the substance or mixture

Regulation (EC) No. 1272/2008
Hazard categories:
Corrosive to metals: Met. corr. 1
Hazard warnings:
May be corrosive to metals.

2.2. Labelling elements

Regulation (EC) No. 1272/2008
Signal word: Caution
Pictograms:

Hazard warnings
H290 May be corrosive to metals.
H315 Causes skin irritation

Safety instructions
P302 IF ON SKIN:
P353 Rinse skin with water [or shower]
P406 Store in corrosion resistant container with corrosion resistant lining.

2.3. Other hazards

Irritations of the skin, eyes and mucous membranes may occur.
Dust and dust powders may be subject to classifications and precautions other than those given in this safety data sheet.

The product does not meet the PBT or vPvB criteria according to Annex XIII of the REACH Regulation.

SECTION 3: COMPOSITION/INFORMATION ON COMPONENTS

3.1. Substances

This product is an alloy.

Chemical formula:	Ga	In	Sn
Molar mass:	69,723 g/mol	114,82	118,71

CAS no.	Designation		
	EC No.	Index No.	REACH No.
	GHS classification		
7440-55-3	Gallium		
	231-163-8		05-2114306905-50-0000 (Pre-registration no.)
	Met. Corr. 1; H290		
7440-74-6	Indium		
	231-180		05-2114306912-55-0000
7440-31-5	Tin		
	231-141-8		05-2114306920-58-0000

Text of H and EUH statements: see section 16.

SECTION 4: FIRST AID MEASURES

4.1. Description of first aid measures

General information
First aider: Pay attention to self-protection!
Consult a doctor if symptoms occur or persist.
After inhalation
Inhalation is not a potential exposure.
Remove affected persons from the danger zone. Allow the person to breathe freely in the fresh air.
After skin contact
In case of contact with skin, wash immediately with plenty of water and soap. If skin irritation occurs, seek medical advice.

After eye contact
Eye contact is unlikely in its present form.
Seek medical attention immediately. In case of contact with eyes, rinse immediately with plenty of running water for 10 to 15 minutes with eyelids open. Remove contact lenses. Protect unharmed eye.
After swallowing
Seek medical attention immediately. Rinse mouth thoroughly with water. Move affected person to fresh air and allow them to relax. Drink plenty of water in small sips (dilution effect). DO NOT induce vomiting. Remove affected persons from the danger zone and lay them down. Never instil anything through the mouth of an unconscious person. Bring a vomiting person lying on his back into a stable lateral position.

4.2. Important acute and delayed symptoms and effects

Irritations of the skin, eyes and mucous membranes may occur.

4.3. Information on immediate medical help or special treatment

Symptomatic treatment

SECTION 5: MEASURES TO FIGHT FIRES

5.1. Extinguishing agents

Suitable extinguishing agents
The product is not flammable. Adjust extinguishing measures to the environment.
Water spray jet. Extinguishing powder. Foam.
Unsuitable extinguishing agents
None known

5.2. Special hazards arising from the substance or mixture

Dangerous combustion gases can be produced during combustion.

5.3. Instructions for fire fighting

In case of fire, use self-contained breathing apparatus and flame retardant clothing if necessary.
Cool endangered containers with water spray jet. Collect contaminated extinguishing water separately.

SECTION 6: MEASUREMENTS IN THE EVENT OF ACCIDENTAL RELEASE

6.1. Personal precautions, protective equipment and emergency procedures

Note possible danger of slipping due to leaked / spilled product.
Avoid contact with eyes and skin.
Wear personal protective equipment.

6.2. Environmental precautions

Do not allow to enter drains or watercourses. Do not allow to reach the subsoil/soil.
In the event of leakage or accidental release, notify the competent authorities in accordance with all applicable regulations.

6.3. Methods and materials for retention and cleaning

Pick up larger quantities with a syringe or sweep them up and bring them to recovery in plastic containers (no aluminium containers). Remove product residues with a soap solution. Avoid dust formation.

6.4. Reference to other sections

For personal precautions: see section 8
For safe handling: see section 7
For disposal: see section 13

SECTION 7: HANDLING AND STORAGE

7.1. Protective measures for safe handling

Instructions for safe handling
Avoid contact with eyes and skin.
Wear personal protective equipment.
Do not eat, drink or smoke during use. Wash hands before breaks and at the end of work.

7.2. Conditions for safe storage, including any incompatibilities

Requirements for storerooms and containers
Store in a corrosion-resistant container. Dry storage
Advice on storage compatibility: unsuitable working materials - metals (especially aluminium)

Further information on safe handling
Avoid spilling. Avoid unnecessary chemical contact.
Handling unpacked EXALLOY-I1 can change its quality and purity. Geratherm is not liable for changes and product quality resulting from processing.

7.3. Specific end uses

Hg substitute, lubricant, reflection medium, electrically conductive medium

SECTION 8: LIMITATION AND MONITORING OF EXPOSURE/PERSONAL PROTECTIVE EQUIPMENT

8.1. Parameters to be monitored

Additional information on limit values
No exposure limit values are currently available.

8.2. Limitation and monitoring of exposure

Protection and hygiene measures
Do not eat, drink, smoke or snuff at the workplace. Change contaminated clothing. Wash hands before breaks and at the end of work.

Eye/face protection
Use safety goggles with side protection.

Hand protection
Wear suitable protective gloves. Suitable material: NR (natural rubber, natural latex).
Chemical protective gloves must be selected specifically for the workplace depending on the concentration and quantity of hazardous substances.

Body protection
Protective workwear

Breathing protection
In the event of an accident, if oxide smoke occurs, use breathing protection P3.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

9.1. Information on the basic physical and chemical properties

Appearance

Physical state:	liquid
Colour:	Silver
Odour:	odourless
pH value:	No data available

Security-relevant data

Explosion hazard:	No
Vapor pressure:	<10 (-8) torr
Density:	6.44 g / cm3
Expiry time:	not applicable
Water solubility:	> 800 g / l
pH value:	n.a.
Boiling point / range:	> 1300 ° C
Flash point:	n.a.
Ignition temperature:	n.a.

SECTION 10: STABILITY AND REACTIVITY

10.1. Reactivity
No hazardous reactivity under normal environmental conditions.

10.2. Chemical stability
The product is stable under normal environmental conditions.

10.3. Possibility of dangerous reactions
Product can react dangerously with halogens (chlorine, bromine), hydrogen peroxide / hydrogen chloride, aluminium.
Dangerous reactions with strong acids and oxidizing agents.

10.4. Conditions to be avoided
With aluminium and with subsequent water addition exothermic!

10.5. Incompatible materials
Unsuitable working materials: metals (especially aluminium)
The product alloys superficial metals such as copper, tin, lead, zinc, gold and silver jewellery, especially light metals are superficially alloyed, especially if they are free of oxides.
If necessary, the product must be checked for reactions with materials and chemical substances in the specific application.

10.6. Hazardous decomposition products
Thermal decomposition can produce gases and vapours that are harmful to health.

SECTION 11: TOXICOLOGICAL INFORMATION

11.1. Information on toxicological effects

Acute toxicity
On the basis of the available data, the classification criteria are not met.

Irritant and corrosive effect
On the basis of the available data, the classification criteria are not met.

Sensitising effects
On the basis of the available data, the classification criteria are not met.

Carcinogenity, mutagenicity and toxicity for reproduction
On the basis of the available data, the classification criteria are not met.

Specific target organ toxicity in case of single exposure
On the basis of the available data, the classification criteria are not met.

Specific target organ toxicity in case of repeated exposure
On the basis of the available data, the classification criteria are not met.

Danger of aspiration
On the basis of the available data, the classification criteria are not met.

SECTION 12: ENVIRONMENTAL INFORMATION

12.1. Toxicity
No data available

12.2. Persistence and degradability
The product is not biodegradable.

12.3. Bioaccumulation potential
No bioaccumulation potential suspected.

12.4. Mobility in the ground
No data available.

12.5. Results of PBT and vPvB assessment
The product does not meet the PBT or vPvB criteria according to Annex XIII of the REACH Regulation.

12.6. Other adverse effects
No data available.

SECTION 13: INFORMATION ON DISPOSAL

13.1. Waste treatment process

Recommendation
Proper use or recycling are preferable to disposal.
Disposal according to the locally applicable laws and regulations for waste disposal (official information obligation).

Dispose of uncleaned packaging and recommended cleaning agents
Contaminated packaging should be treated like the substance.
Uncontaminated and cleaned packaging can be recycled.

SECTION 14: TRANSPORT INFORMATION

Land transport (ADR/RID)
Transport information
14.1 ID No.: UN 1760
14.2 proper shipping name: Corrosive liquid, n.o.s. (composition contains ca.70 % gallium)
14.3 transport hazard class: 8, hazard label: 8

14.4 packing group: III
14.5 environmental hazards: no environmental hazards
14.6 special precautions
for user: avoid contact with aluminium and precious metals (gold and silver jewellery)
14.7 transport in bulk: not provided
The instructions and restrictions of IATA, IMDG-code and ADR must be followed.

More information:
The transport regulations are quoted according to international regulations and in the form used in Germany. Possible deviations in other countries are not taken into account.

SECTION 15: LEGISLATION

15.1. Safety, health and environmental protection regulations/legislation specific to the substance or mixture

EU regulations
Information on the SEVESO III Directive 2012/18/EU: Not subject to the SEVESO III Directive

Additional information

Regulation (EC) No. 648/2004 on detergents: not applicable
Regulation (EC) No. 1005/2009 on substances that deplete the ozone layer: not applicable
Regulation (EC) No. 850/2004 on persistent organic pollutants: not applicable
Regulation (EC) No. 689/2008 of the European Parliament and of the Council concerning the export and import of dangerous chemicals: This mixture does not contain any chemicals subject to the export notification procedure (Annex I).
The mixture contains the following substances of very high concern (SVHC) that are included in the candidate list under REACH Article 59: none

National regulations

Employment restrictions:
Observe employment restrictions for young people (§ 22 JArbSchG). Observe employment restrictions for expectant and nursing mothers (§§ 11 and 12 MuSchG). Observe employment restrictions for women of childbearing age.

Water hazard class:
1 - slightly water-hazardous

Status: Classification of mixtures according to Annex 1, No. 5 AwSV

Additional information
The national legal regulations must also be observed!

15.2. Chemical safety assessment
A chemical safety assessment has been carried out for this substance.

SECTION 16: OTHER INFORMATION

The information is based on the current state of our knowledge and serves to describe the product with regard to the safety precautions to be taken. They do not represent an assurance of the properties of the product described.
The safety data sheet was created on the basis of information from upstream suppliers.

Amendments

Version 1 first creation:	18.10.1996	
Version 1.01	02.01.2002	
Version 1.02	04.05.2004	
Version 1.03	14.09.2006	
Version 1.04	09.07.2013	
Version 1.05	14.06.2016	
Version 1.06	10.01.2018	
Version 1.07	12.11.2019	
Version 1.08	07.01.2020	adaptation REACH Reg.

Changes compared to the last version
Adaptation to Regulation (EC) No 1272
change of address

References and data sources
Regulations
REACH Regulation (EC) No. 1907/2006, as last amended by Regulation (EU) 2018/675
CLP Regulation (EC) No. 1272/2008, as last amended by Regulation (EU) 2018/669
Internet
List of hazard statements that were not fully written out in sections 2 to 15
Health and environmental hazards: calculation method
training advice
No training is required for activities with this hazardous substance

16.1 Abbreviations / acronyms

ADR: Accord euroéen sur le transport des marchandises dangereuses par Route
(European Agreement concerning the International Carriage of Dangerous Goods by Road)
BlmSchV: German Federal Immission Protection Ordinance
CAS: Chemical Abstract Service
DIN: Standard of the German Institute for Standardization
EC: Effective Concentration
EC: European Community
EN: European Standard
IATA: International Air Transport Association
IBC code: International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk
ICAO: International Civil Aviation Organisation
IMDG: International Maritime Code for Dangerous Goods
ISO: Standard of the International Standards Organization
CLP: Classification Labelling Packaging
IUCLID: International Uniform ChemicaL Information Database
lC: Lethal Concentration
LD: Lethal dose
logKow: Distribution coefficient between octanol and water
MARPOL: Maritime Pollution Convention = Convention for the Prevention of Pollution from Ships
OECD: Organisation for Economic Co-Operation and Development
PBT: Persistent, bioaccumulative, toxic
RID: Regulation concerning the International Carriage of Dangerous Goods by Rail
TRGS: Technical rules for hazardous substances
UN: United Nations
VOC: Volatile Organic Compounds
vPvB: very persistent and very bioaccumulative
VwVwS: Administrative Regulation for Substances Hazardous to Water
WGK: Water hazard class
GHS: Globally Harmonised System of Classification and Labelling of Chemicals
EINECS: European Inventory of Existing Commercial Chemical Substances
DNEL: Derived No Effect Level
PNEC: Predicted No Effect Concentration
TLV: Threshold Limiting Value
STOT: Specific Target Organ Toxicity

The information given in this safety data sheet is intended to describe the product with regard to the necessary safety precautions. It does not serve to guarantee certain properties and is based on the current state of our knowledge.

SECTION 1: DESIGNATION OF THE SUBSTANCE OR THE MIXTURE AND THE COMPANY

1.1. Product identifier

Trade name EXALLOY-I2

1.2. Relevant identified uses of the substance or mixture and uses advised against

Identified uses Base metals and alloys, production of fine chemicals, production of bulk chemicals, electronics and semiconductor industry

Inadvisable uses No specific uses are identified that are advised against.

1.3. Details of the supplier providing the safety data sheet

Supplier
Geratherm Medical AG
Fahrenheitstrasse 1
99331 Geratal
Germany
TEL: +49(0)36205/98-0
FAX: +49(0)36205/98-115

1.4. Emergency number

+49(0)700 24112112
Giftnotruf Erfurt: 0361/730 730

SECTION 2: POSSIBLE HAZARDS

2.1. Classification of the substance or mixture

Regulation (EC) No. 1272/2008
Hazard categories:
Corrosive to metals: Met. corr. 1
Hazard warnings:
May be corrosive to metals.

2.2. Labelling elements

Regulation (EC) No. 1272/2008
Signal word: Caution
Pictograms:

Hazard warnings
H290 May be corrosive to metals.
H315 Causes skin irritation

Safety instructions
P302 IF ON SKIN:
P353 Rinse skin with water [or shower]
P406 Store in corrosion resistant container with corrosion resistant lining.

2.3. Other hazards

Irritations of the skin, eyes and mucous membranes may occur.
Dust and dust powders may be subject to classifications and precautions other than those given in this safety data sheet.

The product does not meet the PBT or vPvB criteria according to Annex XIII of the REACH Regulation.

SECTION 3: COMPOSITION/INFORMATION ON COMPONENTS

3.1. Substances

This product is an alloy.

Chemical formula:	Ga	In	Sn
Molar mass:	69,723 g/mol	114,82	118,71

CAS no.	Designation		
	EC No.	Index No.	REACH No.
	GHS classification		
7440-55-3	Gallium		
	231-163-8		05-2114306905-50-0000 (Pre-registration no.)
	Met. Corr. 1; H290		
7440-74-6	Indium		
	231-180		05-2114306912-55-0000
7440-31-5	Tin		
	231-141-8		05-2114306920-58-0000

Text of H and EUH statements: see section 16.

SECTION 4: FIRST AID MEASURES

4.1. Description of first aid measures

General information
First aider: Pay attention to self-protection!
Consult a doctor if symptoms occur or persist.
After inhalation
Inhalation is not a potential exposure.
Remove affected persons from the danger zone. Allow the person to breathe freely in the fresh air.
After skin contact
In case of contact with skin, wash immediately with plenty of water and soap. If skin irritation occurs, seek medical advice.

After eye contact
Eye contact is unlikely in its present form.
Seek medical attention immediately. In case of contact with eyes, rinse immediately with plenty of running water for 10 to 15 minutes with eyelids open. Remove contact lenses. Protect unharmed eye.
After swallowing
Seek medical attention immediately. Rinse mouth thoroughly with water. Move affected person to fresh air and allow them to relax. Drink plenty of water in small sips (dilution effect). DO NOT induce vomiting. Remove affected persons from the danger zone and lay them down. Never instil anything through the mouth of an unconscious person. Bring a vomiting person lying on his back into a stable lateral position.

4.2. Important acute and delayed symptoms and effects

Irritations of the skin, eyes and mucous membranes may occur.

4.3. Information on immediate medical help or special treatment

Symptomatic treatment

SECTION 5: MEASURES TO FIGHT FIRES

5.1. Extinguishing agents

Suitable extinguishing agents
The product is not flammable. Adjust extinguishing measures to the environment.
Water spray jet. Extinguishing powder. Foam.
Unsuitable extinguishing agents
None known

5.2. Special hazards arising from the substance or mixture

Dangerous combustion gases can be produced during combustion.

5.3. Instructions for fire fighting

In case of fire, use self-contained breathing apparatus and flame retardant clothing if necessary.
Cool endangered containers with water spray jet. Collect contaminated extinguishing water separately.

SECTION 6: MEASUREMENTS IN THE EVENT OF ACCIDENTAL RELEASE

6.1. Personal precautions, protective equipment and emergency procedures

Note possible danger of slipping due to leaked / spilled product.
Avoid contact with eyes and skin.
Wear personal protective equipment.

6.2. Environmental precautions

Do not allow to enter drains or watercourses. Do not allow to reach the subsoil/soil.
In the event of leakage or accidental release, notify the competent authorities in accordance with all applicable regulations.

6.3. Methods and materials for retention and cleaning

Pick up larger quantities with a syringe or sweep them up and bring them to recovery in plastic containers (no aluminium containers). Remove product residues with a soap solution. Avoid dust formation.

6.4. Reference to other sections

For personal precautions: see section 8
For safe handling: see section 7
For disposal: see section 13

SECTION 7: HANDLING AND STORAGE

7.1. Protective measures for safe handling

Instructions for safe handling
Avoid contact with eyes and skin.
Wear personal protective equipment.
Do not eat, drink or smoke during use. Wash hands before breaks and at the end of work.

7.2. Conditions for safe storage, including any incompatibilities

Requirements for storerooms and containers
Store in a corrosion-resistant container. Dry storage
Advice on storage compatibility: unsuitable working materials - metals (especially aluminium)

Further information on safe handling
Avoid spilling. Avoid unnecessary chemical contact.
Handling unpacked EXALLOY-I2 can change its quality and purity. Geratherm is not liable for changes and product quality resulting from processing.

7.3. Specific end uses

Hg substitute, lubricant, reflection medium, electrically conductive medium

SECTION 8: LIMITATION AND MONITORING OF EXPOSURE/PERSONAL PROTECTIVE EQUIPMENT

8.1. Parameters to be monitored

Additional information on limit values
No exposure limit values are currently available.

8.2. Limitation and monitoring of exposure

Protection and hygiene measures
Do not eat, drink, smoke or snuff at the workplace. Change contaminated clothing. Wash hands before breaks and at the end of work.

Eye/face protection
Use safety goggles with side protection.

Hand protection
Wear suitable protective gloves. Suitable material: NR (natural rubber, natural latex).
Chemical protective gloves must be selected specifically for the workplace depending on the concentration and quantity of hazardous substances.

Body protection
Protective workwear

Breathing protection
In the event of an accident, if oxide smoke occurs, use breathing protection P3.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

9.1. Information on the basic physical and chemical properties

Appearance

Physical state:	liquid
Colour:	Silver
Odour:	odourless
pH value:	No data available

Security-relevant data

Explosion hazard:	No
Vapor pressure:	<10 (-8) torr
Density:	6.4 g / cm3
Expiry time:	not applicable
Water solubility:	> 800 g / l
pH value:	n.a.
Boiling point / range:	> 1300 ° C
Flash point:	n.a.
Ignition temperature:	n.a.

SECTION 10: STABILITY AND REACTIVITY

10.1. Reactivity
No hazardous reactivity under normal environmental conditions.

10.2. Chemical stability
The product is stable under normal environmental conditions.

10.3. Possibility of dangerous reactions
Product can react dangerously with halogens (chlorine, bromine), hydrogen peroxide / hydrogen chloride, aluminium.
Dangerous reactions with strong acids and oxidizing agents.

10.4. Conditions to be avoided
With aluminium and with subsequent water addition exothermic!

10.5. Incompatible materials
Unsuitable working materials: metals (especially aluminium)
The product alloys superficial metals such as copper, tin, lead, zinc, gold and silver jewellery, especially light metals are superficially alloyed, especially if they are free of oxides.
If necessary, the product must be checked for reactions with materials and chemical substances in the specific application.

10.6. Hazardous decomposition products
Thermal decomposition can produce gases and vapours that are harmful to health.

SECTION 11: TOXICOLOGICAL INFORMATION

11.1. Information on toxicological effects

Acute toxicity
On the basis of the available data, the classification criteria are not met.

Irritant and corrosive effect
On the basis of the available data, the classification criteria are not met.

Sensitising effects
On the basis of the available data, the classification criteria are not met.

Carcinogenity, mutagenicity and toxicity for reproduction
On the basis of the available data, the classification criteria are not met.

Specific target organ toxicity in case of single exposure
On the basis of the available data, the classification criteria are not met.

Specific target organ toxicity in case of repeated exposure
On the basis of the available data, the classification criteria are not met.

Danger of aspiration
On the basis of the available data, the classification criteria are not met.

SECTION 12: ENVIRONMENTAL INFORMATION

12.1. Toxicity
No data available

12.2. Persistence and degradability
The product is not biodegradable.

12.3. Bioaccumulation potential
No bioaccumulation potential suspected.

12.4. Mobility in the ground
No data available.

12.5. Results of PBT and vPvB assessment
The product does not meet the PBT or vPvB criteria according to Annex XIII of the REACH Regulation.

12.6. Other adverse effects
No data available.

SECTION 13: INFORMATION ON DISPOSAL

13.1. Waste treatment process

Recommendation
Proper use or recycling are preferable to disposal.
Disposal according to the locally applicable laws and regulations for waste disposal (official information obligation).

Dispose of uncleaned packaging and recommended cleaning agents
Contaminated packaging should be treated like the substance.
Uncontaminated and cleaned packaging can be recycled.

SECTION 14: TRANSPORT INFORMATION

Land transport (ADR/RID)
Transport information
14.1 ID No.: UN 1760
14.2 proper shipping name: Corrosive liquid, n.o.s. (composition contains ca.47 % gallium)
14.3 transport hazard class: 8, hazard label: 8

14.4 packing group: III
14.5 environmental hazards: no environmental hazards
14.6 special precautions
for user: avoid contact with aluminium and precious metals (gold and silver jewellery)
14.7 transport in bulk: not provided
The instructions and restrictions of IATA, IMDG-code and ADR must be followed.

The current regulations according to IATA, IMDG code and ADR apply.

More information:
The transport regulations are quoted according to international regulations and in the form used in Germany. Possible deviations in other countries are not taken into account.

SECTION 15: LEGISLATION

15.1. Safety, health and environmental protection regulations/legislation specific to the substance or mixture

EU regulations
Information on the SEVESO III Directive 2012/18/EU: Not subject to the SEVESO III Directive

Additional information

Regulation (EC) No. 648/2004 on detergents: not applicable
Regulation (EC) No. 1005/2009 on substances that deplete the ozone layer: not applicable
Regulation (EC) No. 850/2004 on persistent organic pollutants: not applicable
Regulation (EC) No. 689/2008 of the European Parliament and of the Council concerning the export and import of dangerous chemicals: This mixture does not contain any chemicals subject to the export notification procedure (Annex I).
The mixture contains the following substances of very high concern (SVHC) that are included in the candidate list under REACH Article 59: none

National regulations

Employment restrictions:
Observe employment restrictions for young people (§ 22 JArbSchG). Observe employment restrictions for expectant and nursing mothers (§§ 11 and 12 MuSchG). Observe employment restrictions for women of childbearing age.

Water hazard class:
1 - slightly water-hazardous

Status: Classification of mixtures according to Annex 1, No. 5 AwSV

Additional information
The national legal regulations must also be observed!

15.2. Chemical safety assessment
A chemical safety assessment has been carried out for this substance.

SECTION 16: OTHER INFORMATION

The information is based on the current state of our knowledge and serves to describe the product with regard to the safety precautions to be taken. They do not represent an assurance of the properties of the product described.
The safety data sheet was created on the basis of information from upstream suppliers.

Amendments
Version 1 first creation:
Version 1.01 09.07.2013
Version 1.02 14.06.2016
Version 1.03 10.01.2018
Version 1.04 12.11.2019
Version 1.05 07.01.2020 adaptation REACH Reg.

Changes compared to the last version
Adaptation to Regulation (EC) No 1272
change of address

References and data sources
Regulations
REACH Regulation (EC) No. 1907/2006, as last amended by Regulation (EU) 2018/675
CLP Regulation (EC) No. 1272/2008, as last amended by Regulation (EU) 2018/669

Internet
List of hazard statements that were not fully written out in sections 2 to 15
Health and environmental hazards: calculation method
training advice
No training is required for activities with this hazardous substance

16.1 Abbreviations / acronyms

ADR: Accord euroéen sur le transport des marchandises dangereuses par Route
(European Agreement concerning the International Carriage of Dangerous Goods by Road)
BImSchV: German Federal Immission Protection Ordinance
CAS: Chemical Abstract Service
DIN: Standard of the German Institute for Standardization
EC: Effective Concentration
EC: European Community
EN: European Standard
IATA: International Air Transport Association
IBC code: International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk
ICAO: International Civil Aviation Organisation
IMDG: International Maritime Code for Dangerous Goods
ISO: Standard of the International Standards Organization
CLP: Classification Labelling Packaging
IUCLID: International Uniform ChemicaL Information Database
lC: Lethal Concentration
LD: Lethal dose
logKow: Distribution coefficient between octanol and water
MARPOL: Maritime Pollution Convention = Convention for the Prevention of Pollution from Ships
OECD: Organisation for Economic Co-Operation and Development
PBT: Persistent, bioaccumulative, toxic
RID: Regulation concerning the International Carriage of Dangerous Goods by Rail
TRGS: Technical rules for hazardous substances
UN: United Nations
VOC: Volatile Organic Compounds
vPvB: very persistent and very bioaccumulative
VwVwS: Administrative Regulation for Substances Hazardous to Water
WGK: Water hazard class
GHS: Globally Harmonised System of Classification and Labelling of Chemicals
EINECS: European Inventory of Existing Commercial Chemical Substances
DNEL: Derived No Effect Level
PNEC: Predicted No Effect Concentration
TLV: Threshold Limiting Value
STOT: Specific Target Organ Toxicity

The information given in this safety data sheet is intended to describe the product with regard to the necessary safety precautions. It does not serve to guarantee certain properties and is based on the current state of our knowledge.

SECTION 1: DESIGNATION OF THE SUBSTANCE OR THE MIXTURE AND THE COMPANY

1.1. Product identifier

Trade name EXALLOY-I3

1.2. Relevant identified uses of the substance or mixture and uses advised against

Identified uses Base metals and alloys, production of fine chemicals, production of bulk chemicals, electronics and semiconductor industry

Inadvisable uses No specific uses are identified that are advised against.

1.3. Details of the supplier providing the safety data sheet

Supplier
Geratherm Medical AG
Fahrenheitstrasse 1
99331 Geratal
Germany
TEL: +49(0)36205/98-0
FAX: +49(0)36205/98-115

1.4. Emergency number

+49(0)700 24112112
Giftnotruf Erfurt: 0361/730 730

SECTION 2: POSSIBLE HAZARDS

2.1. Classification of the substance or mixture

Regulation (EC) No. 1272/2008
Hazard categories:
Corrosive to metals: Met. corr. 1
Hazard warnings:
May be corrosive to metals.

2.2. Labelling elements

Regulation (EC) No. 1272/2008
Signal word: Caution
Pictograms:

Hazard warnings
H290 May be corrosive to metals.
H315 Causes skin irritation

Safety instructions

P302 IF ON SKIN:
P353 Rinse skin with water [or shower]
P406 Store in corrosion resistant container with corrosion resistant lining.

2.3. Other hazards

Irritations of the skin, eyes and mucous membranes may occur.
Dust and dust powders may be subject to classifications and precautions other than those given in this safety data sheet.

The product does not meet the PBT or vPvB criteria according to Annex XIII of the REACH Regulation.

SECTION 3: COMPOSITION/INFORMATION ON COMPONENTS

3.1. Substances

This product is an alloy.

Chemical formula:	Ga	In
Molar mass:	69,723 g/mol	114,82

CAS no.	Designation		
	EC No.	Index No.	REACH No.
	GHS classification		
7440-55-3	Gallium		
	231-163-8		05-2114306905-50-0000 (Pre-registration no.)
	Met. Corr. 1; H290		
7440-74-6	Indium		
	231-180		05-2114306912-55-0000

Text of H and EUH statements: see section 16.

SECTION 4: FIRST AID MEASURES

4.1. Description of first aid measures

General information
First aider: Pay attention to self-protection!
Consult a doctor if symptoms occur or persist.
After inhalation
Inhalation is not a potential exposure.
Remove affected persons from the danger zone. Allow the person to breathe freely in the fresh air.
After skin contact
In case of contact with skin, wash immediately with plenty of water and soap. If skin irritation occurs, seek medical advice.
After eye contact
Eye contact is unlikely in its present form.
Seek medical attention immediately. In case of contact with eyes, rinse immediately with plenty of running water for 10 to 15 minutes with eyelids open. Remove contact lenses. Protect unharmed eye.

After swallowing
Seek medical attention immediately. Rinse mouth thoroughly with water. Move affected person to fresh air and allow them to relax. Drink plenty of water in small sips (dilution effect). DO NOT induce vomiting. Remove affected persons from the danger zone and lay them down. Never instil anything through the mouth of an unconscious person. Bring a vomiting person lying on his back into a stable lateral position.

4.2. Important acute and delayed symptoms and effects

Irritations of the skin, eyes and mucous membranes may occur.

4.3. Information on immediate medical help or special treatment

Symptomatic treatment

SECTION 5: MEASURES TO FIGHT FIRES

5.1. Extinguishing agents

Suitable extinguishing agents
The product is not flammable. Adjust extinguishing measures to the environment.
Water spray jet. Extinguishing powder. Foam.
Unsuitable extinguishing agents
None known

5.2. Special hazards arising from the substance or mixture

Dangerous combustion gases can be produced during combustion.

5.3. Instructions for fire fighting

In case of fire, use self-contained breathing apparatus and flame retardant clothing if necessary.
Cool endangered containers with water spray jet. Collect contaminated extinguishing water separately.

SECTION 6: MEASUREMENTS IN THE EVENT OF ACCIDENTAL RELEASE

6.1. Personal precautions, protective equipment and emergency procedures

Note possible danger of slipping due to leaked / spilled product.
Avoid contact with eyes and skin.
Wear personal protective equipment.

6.2. Environmental precautions

Do not allow to enter drains or watercourses. Do not allow to reach the subsoil/soil.
In the event of leakage or accidental release, notify the competent authorities in accordance with all applicable regulations.

6.3. Methods and materials for retention and cleaning

Pick up larger quantities with a syringe or sweep them up and bring them to recovery in plastic containers (no aluminium containers). Remove product residues with a soap solution. Avoid dust formation.

6.4. Reference to other sections

For personal precautions: see section 8
For safe handling: see section 7
For disposal: see section 13

SECTION 7: HANDLING AND STORAGE

7.1. Protective measures for safe handling

Instructions for safe handling
Avoid contact with eyes and skin.
Wear personal protective equipment.
Do not eat, drink or smoke during use. Wash hands before breaks and at the end of work.

7.2. Conditions for safe storage, including any incompatibilities

Requirements for storerooms and containers
Store in a corrosion-resistant container. Dry storage
Advice on storage compatibility: unsuitable working materials - metals (especially aluminium)

Further information on safe handling
Avoid spilling. Avoid unnecessary chemical contact.
Handling unpacked EXALLOY-I3 can change its quality and purity. Geratherm is not liable for changes and product quality resulting from processing.

7.3. Specific end uses

Hg substitute, lubricant, reflection medium, electrically conductive medium

SECTION 8: LIMITATION AND MONITORING OF EXPOSURE/PERSONAL PROTECTIVE EQUIPMENT

8.1. Parameters to be monitored

Additional information on limit values
No exposure limit values are currently available.

8.2. Limitation and monitoring of exposure

Protection and hygiene measures
Do not eat, drink, smoke or snuff at the workplace. Change contaminated clothing. Wash hands before breaks and at the end of work.

Eye/face protection
Use safety goggles with side protection.

Hand protection
Wear suitable protective gloves. Suitable material: NR (natural rubber, natural latex).
Chemical protective gloves must be selected specifically for the workplace depending on the concentration and quantity of hazardous substances.

Body protection
Protective workwear

Breathing protection
In the event of an accident, if oxide smoke occurs, use breathing protection P3.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

9.1. Information on the basic physical and chemical properties

Appearance

Physical state:	liquid
Colour:	Silver
Odour:	odourless
pH value:	No data available

Security-relevant data

Explosion hazard:	No
Vapor pressure:	<10 (-8) torr
Density:	6.44 g / cm3
Expiry time:	not applicable
Water solubility:	> 800 g / l
pH value:	n.a.
Boiling point / range:	> 1300 ° C
Flash point:	n.a.
Ignition temperature:	n.a.

SECTION 10: STABILITY AND REACTIVITY

10.1. Reactivity
No hazardous reactivity under normal environmental conditions.

10.2. Chemical stability
The product is stable under normal environmental conditions.

10.3. Possibility of dangerous reactions
Product can react dangerously with halogens (chlorine, bromine), hydrogen peroxide / hydrogen chloride, aluminium.
Dangerous reactions with strong acids and oxidizing agents.

10.4. Conditions to be avoided
With aluminium and with subsequent water addition exothermic!

10.5. Incompatible materials
Unsuitable working materials: metals (especially aluminium)
The product alloys superficial metals such as copper, tin, lead, zinc, gold and silver jewellery, especially light metals are superficially alloyed, especially if they are free of oxides.
If necessary, the product must be checked for reactions with materials and chemical substances in the specific application.

10.6. Hazardous decomposition products
Thermal decomposition can produce gases and vapours that are harmful to health.

SECTION 11: TOXICOLOGICAL INFORMATION

11.1. Information on toxicological effects

Acute toxicity
On the basis of the available data, the classification criteria are not met.

Irritant and corrosive effect
On the basis of the available data, the classification criteria are not met.

Sensitising effects
On the basis of the available data, the classification criteria are not met.

Carcinogenity, mutagenicity and toxicity for reproduction
On the basis of the available data, the classification criteria are not met.

Specific target organ toxicity in case of single exposure
On the basis of the available data, the classification criteria are not met.

Specific target organ toxicity in case of repeated exposure
On the basis of the available data, the classification criteria are not met.

Danger of aspiration
On the basis of the available data, the classification criteria are not met.

SECTION 12: ENVIRONMENTAL INFORMATION

12.1. Toxicity
No data available

12.2. Persistence and degradability
The product is not biodegradable.

12.3. Bioaccumulation potential
No bioaccumulation potential suspected.

12.4. Mobility in the ground
No data available.

12.5. Results of PBT and vPvB assessment
The product does not meet the PBT or vPvB criteria according to Annex XIII of the REACH Regulation.

12.6. Other adverse effects
No data available.

SECTION 13: INFORMATION ON DISPOSAL

13.1. Waste treatment process

Recommendation
Proper use or recycling are preferable to disposal.
Disposal according to the locally applicable laws and regulations for waste disposal (official information obligation).

Dispose of uncleaned packaging and recommended cleaning agents
Contaminated packaging should be treated like the substance.
Uncontaminated and cleaned packaging can be recycled.

SECTION 14: TRANSPORT INFORMATION

Land transport (ADR/RID)
Transport information
14.1 ID No.: UN 1760
14.2 proper shipping name: Corrosive liquid, n.o.s. (composition contains ca.75 % gallium)
14.3 transport hazard class: 8, hazard label: 8

14.4 packing group: III
14.5 environmental hazards: no environmental hazards
14.6 special precautions
for user: avoid contact with aluminium and precious metals (gold and silver jewellery)
14.7 transport in bulk: not provided
The instructions and restrictions of IATA, IMDG-code and ADR must be followed.

The current regulations according to IATA, IMDG code and ADR apply.

More information:
The transport regulations are quoted according to international regulations and in the form used in Germany. Possible deviations in other countries are not taken into account.

SECTION 15: LEGISLATION

15.1. Safety, health and environmental protection regulations/legislation specific to the substance or mixture

EU regulations
Information on the SEVESO III Directive 2012/18/EU: Not subject to the SEVESO III Directive

Additional information

Regulation (EC) No. 648/2004 on detergents: not applicable
Regulation (EC) No. 1005/2009 on substances that deplete the ozone layer: not applicable
Regulation (EC) No. 850/2004 on persistent organic pollutants: not applicable
Regulation (EC) No. 689/2008 of the European Parliament and of the Council concerning the export and import of dangerous chemicals: This mixture does not contain any chemicals subject to the export notification procedure (Annex I).
The mixture contains the following substances of very high concern (SVHC) that are included in the candidate list under REACH Article 59: none

National regulations

Employment restrictions:
Observe employment restrictions for young people (§ 22 JArbSchG). Observe employment restrictions for expectant and nursing mothers (§§ 11 and 12 MuSchG). Observe employment restrictions for women of childbearing age.

Water hazard class:
1 - slightly water-hazardous

Status: Classification of mixtures according to Annex 1, No. 5 AwSV

Additional information
The national legal regulations must also be observed!

15.2. Chemical safety assessment
A chemical safety assessment has been carried out for this substance.

SECTION 16: OTHER INFORMATION

The information is based on the current state of our knowledge and serves to describe the product with regard to the safety precautions to be taken. They do not represent an assurance of the properties of the product described.
The safety data sheet was created on the basis of information from upstream suppliers.

Amendments
Version 1 first creation: 23.08.2018
Version adaptation REACH Reg. 07.01.2020

Changes compared to the last version
Adaptation to Regulation (EC) No 1272
change of address

References and data sources
Regulations
REACH Regulation (EC) No. 1907/2006, as last amended by Regulation (EU) 2018/675
CLP Regulation (EC) No. 1272/2008, as last amended by Regulation (EU) 2018/669
Internet
List of hazard statements that were not fully written out in sections 2 to 15
Health and environmental hazards: calculation method
training advice
No training is required for activities with this hazardous substance

16.1 Abbreviations / acronyms

ADR: Accord euroéen sur le transport des marchandises dangereuses par Route
(European Agreement concerning the International Carriage of Dangerous Goods by Road)
BlmSchV: German Federal Immission Protection Ordinance
CAS: Chemical Abstract Service
DIN: Standard of the German Institute for Standardization
EC: Effective Concentration
EC: European Community
EN: European Standard
IATA: International Air Transport Association
IBC code: International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk
ICAO: International Civil Aviation Organisation
IMDG: International Maritime Code for Dangerous Goods
ISO: Standard of the International Standards Organization
CLP: Classification Labelling Packaging
IUCLID: International Uniform ChemicaL Information Database
lC: Lethal Concentration
LD: Lethal dose
logKow: Distribution coefficient between octanol and water
MARPOL: Maritime Pollution Convention = Convention for the Prevention of Pollution from Ships
OECD: Organisation for Economic Co-Operation and Development
PBT: Persistent, bioaccumulative, toxic
RID: Regulation concerning the International Carriage of Dangerous Goods by Rail
TRGS: Technical rules for hazardous substances
UN: United Nations
VOC: Volatile Organic Compounds
vPvB: very persistent and very bioaccumulative
VwVwS: Administrative Regulation for Substances Hazardous to Water
WGK: Water hazard class
GHS: Globally Harmonised System of Classification and Labelling of Chemicals
EINECS: European Inventory of Existing Commercial Chemical Substances
DNEL: Derived No Effect Level
PNEC: Predicted No Effect Concentration
TLV: Threshold Limiting Value
STOT: Specific Target Organ Toxicity

The information given in this safety data sheet is intended to describe the product with regard to the necessary safety precautions. It does not serve to guarantee certain properties and is based on the current state of our knowledge.

NALCO
An Ecolab Company

SAFETY DATA SHEET

460-TFS200, Treated Water,CCLS

SECTION 1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	460-TFS200, Treated Water,CCLS
Other means of identification	:	Not applicable.
Restrictions on use	:	Refer to available product literature or ask your local Sales Representative for restrictions on use and dose limits.
Company	:	Nalco Company 1601 W. Diehl Road Naperville, Illinois 60563-1198 USA TEL: (630)305-1000
Emergency telephone number	:	(800) 424-9300 (24 Hours) CHEMTREC
Issuing date	:	08/06/2014

SECTION 2. HAZARDS IDENTIFICATION

Emergency Overview

CAUTION
May cause irritation with prolonged contact.
Do not get in eyes, on skin, on clothing. Do not take internally. Use with adequate ventilation. In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. After contact with skin, wash immediately with plenty of water. Use a mild soap if available.
Wear suitable protective clothing.
Not flammable or combustible.

Potential Health Effects

Eyes	:	Health injuries are not known or expected under normal use.
Skin	:	Health injuries are not known or expected under normal use.
Ingestion	:	Health injuries are not known or expected under normal use.
Inhalation	:	Health injuries are not known or expected under normal use.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

No hazardous ingredients

SECTION 4. FIRST AID MEASURES

In case of eye contact	:	Rinse with plenty of water. Get medical attention if symptoms occur.
In case of skin contact	:	Wash off with soap and plenty of water. Get medical attention if symptoms occur.
If swallowed	:	Rinse mouth. Get medical attention if symptoms occur.
If inhaled	:	Get medical attention if symptoms occur.

Protection of first-aiders	:	In event of emergency assess the danger before taking action. Do not put yourself at risk of injury. If in doubt, contact emergency responders.Use personal protective equipment as required.
Notes to physician	:	No specific measures identified.

See toxicological information (Section 11)

SECTION 5. FIREFIGHTING MEASURES

Suitable extinguishing media	:	Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.
Unsuitable extinguishing media	:	None known.
Specific hazards during firefighting	:	Not flammable or combustible.
Hazardous combustion products	:	Carbon oxides nitrogen oxides (NOx)
Special protective equipment for firefighters	:	Use personal protective equipment.
Specific extinguishing methods	:	Fire residues and contaminated fire extinguishing water must be disposed of in accordance with local regulations.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures	:	Refer to protective measures listed in sections 7 and 8.
Environmental precautions	:	No special environmental precautions required.
Methods and materials for containment and cleaning up	:	Stop leak if safe to do so. Contain spillage, and then collect with non-combustible absorbent material, (e.g. sand, earth, diatomaceous earth, vermiculite) and place in container for disposal according to local / national regulations (see section 13). Flush away traces with water. For large spills, dike spilled material or otherwise contain material to ensure runoff does not reach a waterway.

SECTION 7. HANDLING AND STORAGE

Advice on safe handling	:	For personal protection see section 8. Wash hands after handling.
Conditions for safe storage	:	Keep out of reach of children. Keep container tightly closed. Store in suitable labeled containers.
Suitable material	:	Keep in properly labelled containers.
Unsuitable material	:	not determined

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Contains no substances with occupational exposure limit values.

Engineering measures	:	Good general ventilation should be sufficient to control worker exposure to airborne contaminants.

Personal protective equipment

Eye protection	:	Safety glasses
Hand protection	:	Wear protective gloves. Gloves should be discarded and replaced if there is any indication of degradation or chemical breakthrough.
Skin protection	:	Wear suitable protective clothing.
Respiratory protection	:	No personal respiratory protective equipment normally required.
Hygiene measures	:	Wash hands before breaks and immediately after handling the product.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	:	Liquid
Colour	:	Clear
Odour	:	no data available
Flash point	:	does not flash
pH	:	no data available
Odour Threshold	:	no data available
Melting point/freezing point	:	no data available
Initial boiling point and boiling range	:	no data available
Evaporation rate	:	no data available
Flammability (solid, gas)	:	no data available
Upper explosion limit	:	no data available
Lower explosion limit	:	no data available
Vapour pressure	:	no data available
Relative vapour density	:	no data available
Relative density	:	1.0 (25 °C)
Density	:	no data available
Water solubility	:	completely soluble
Solubility in other solvents	:	no data available
Partition coefficient: n-octanol/water	:	no data available
Auto-ignition temperature	:	no data available
Thermal decomposition	:	Carbon oxides nitrogen oxides (NOx)
Viscosity, dynamic	:	no data available

Viscosity, kinematic	:	no data available
VOC	:	no data available

SECTION 10. STABILITY AND REACTIVITY

Chemical stability	:	Stable under normal conditions.
Possibility of hazardous reactions	:	No dangerous reaction known under conditions of normal use.
Conditions to avoid	:	Extremes of temperature None known.
Incompatible materials	:	None known
Hazardous decomposition products	:	Oxides of carbon Oxides of nitrogen

SECTION 11. TOXICOLOGICAL INFORMATION

Information on likely routes of exposure	:	Inhalation, Eye contact, Skin contact

Potential Health Effects

Eyes	:	Health injuries are not known or expected under normal use.
Skin	:	Health injuries are not known or expected under normal use.
Ingestion	:	Health injuries are not known or expected under normal use.
Inhalation	:	Health injuries are not known or expected under normal use.
Chronic Exposure	:	Health injuries are not known or expected under normal use.

Experience with human exposure

Eye contact	:	No symptoms known or expected.
Skin contact	:	No symptoms known or expected.
Ingestion	:	No symptoms known or expected.
Inhalation	:	No symptoms known or expected.

Toxicity

Product

Acute oral toxicity	:	Acute toxicity estimate > 5,000 mg/kg
Acute inhalation toxicity	:	no data available
Acute dermal toxicity	:	no data available
Skin corrosion/irritation	:	no data available

Serious eye damage/eye irritation	: no data available
Respiratory or skin sensitization	: no data available
Carcinogenicity	: no data available
Reproductive effects	: no data available
Germ cell mutagenicity	: no data available
Teratogenicity	: no data available
STOT - single exposure	: no data available
STOT - repeated exposure	: no data available
Aspiration toxicity	: no data available

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity

Environmental Effects	: This product has no known ecotoxicological effects.

Product

Toxicity to fish	: no data available
Toxicity to daphnia and other aquatic invertebrates	: no data available
Toxicity to algae	: no data available

Persistence and degradability

no data available

Mobility

no data available

Bioaccumulative potential

no data available

Other information

no data available

SECTION 13. DISPOSAL CONSIDERATIONS

If this product becomes a waste, it is not a hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA) 40 CFR 261, since it does not have the characteristics of Subpart C, nor is it listed under Subpart D.

Disposal methods	: Where possible recycling is preferred to disposal or incineration. If recycling is not practicable, dispose of in compliance with local regulations. Dispose of wastes in an approved waste disposal facility.
Disposal considerations	: Dispose of as unused product. Empty containers should be taken to an approved waste handling site for recycling or disposal. Do not re-use empty containers.

SECTION 14. TRANSPORT INFORMATION

The shipper/consignor/sender is responsible to ensure that the packaging, labeling, and markings are in compliance with the selected mode of transport.

Land transport (DOT)

Proper shipping name	: PRODUCT IS NOT REGULATED DURING TRANSPORTATION

Air transport (IATA)

Proper shipping name	: PRODUCT IS NOT REGULATED DURING TRANSPORTATION

Sea Transport (IMDG/IMO)

Proper shipping name	: PRODUCT IS NOT REGULATED DURING TRANSPORTATION

SECTION 15. REGULATORY INFORMATION

EPCRA - Emergency Planning and Community Right-to-Know Act

CERCLA Reportable Quantity

This material does not contain any components with a CERCLA RQ.

SARA 304 Extremely Hazardous Substances Reportable Quantity

This material does not contain any components with a section 304 EHS RQ.

SARA 311/312 Hazards	: No SARA Hazards
SARA 302	: SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.
SARA 313	: SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

California Prop 65

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

INTERNATIONAL CHEMICAL CONTROL LAWS :

TOXIC SUBSTANCES CONTROL ACT (TSCA)
The substances in this preparation are included on or exempted from the TSCA 8(b) Inventory (40 CFR 710)

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA)
The substance(s) in this preparation are included in or exempted from the Domestic Substance List (DSL).

AUSTRALIA
All substances in this product comply with the National Industrial Chemicals Notification & Assessment Scheme (NICNAS).

CHINA
All substances in this product comply with the Provisions on the Environmental Administration of New Chemical Substances and are listed on or exempt from the Inventory of Existing Chemical Substances China (IECSC).

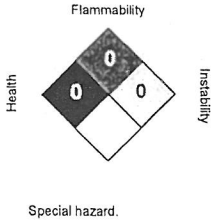
JAPAN
All substances in this product comply with the Law Regulating the Manufacture and Importation Of Chemical Substances and are listed on the Existing and New Chemical Substances list (ENCS).

KOREA
All substances in this product comply with the Toxic Chemical Control Law (TCCL) and are listed on the Existing Chemicals List (ECL)

PHILIPPINES
All substances in this product comply with the Republic Act 6969 (RA 6969) and are listed on the Philippines Inventory of Chemicals & Chemical Substances (PICCS).

SECTION 16. OTHER INFORMATION

NFPA:



HMIS III:

HEALTH	0
FLAMMABILITY	0
PHYSICAL HAZARD	0

0 = not significant, 1 =Slight,
2 = Moderate, 3 = High
4 = Extreme, * = Chronic

Revision Date : 08/06/2014
Version Number : 1.1
Prepared By : Regulatory Affairs

REVISED INFORMATION: Significant changes to regulatory or health information for this revision is indicated by a bar in the left-hand margin of the SDS.

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific

SAFETY DATA SHEET

460-TFS200, Treated Water,CCLS

material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.
For additional copies of an MSDS visit www.nalco.com and request access.

WACKER

Safety Data Sheet (1907/2006/EC)

Material: 60002712 **WACKER® AK 350 SILICONE FLUID**

Version: 2.10 (GB) Date of print: 18.05.2018 Date of last alteration: 06.09.2017

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product identifier

Commercial product name: **WACKER® AK 350 SILICONE FLUID**

1.2 Relevant identified uses of the substance or mixture and uses advised against

Use of substance / preparation:
Industrial.
Intermediate chemical

This product is a polymer, which is exempted from registration according to (EC) regulation 1907/2006, article 2.

1.3 Details of the supplier of the safety data sheet

Manufacturer/distributor:	Wacker Chemie AG	
Street/POB-No.:	Hanns-Seidel-Platz 4	
State/postal code/city:	D 81737 München	
Telephone:	+49 89 6279-0	
Telefax:	+49 89 6279-1770	
Information about the Safety Data Sheet:	Telephone	+49 8677 83-4888
	Telefax	+49 8677 886-9722
	eMail	WLCP-MSDS@wacker.com

1.4 Emergency telephone number

Emergency Information (German):	**Plant fire brigade**	**+49 8677 83-2222**
Emergency Information (internat.):	**National Response Center**	**+49 621 60-43333**

SECTION 2: Hazards identification

2.1 Classification of the substance or mixture

Classification according to Regulation (EC) No. 1272/2008:

Not a hazardous substance or mixture.

2.2 Label elements

Labelling according to Regulation (EC) No. 1272/2008:

No labeling according to GHS required.

2.3 Other hazards

No data available.

SECTION 3: Composition/information on ingredients

3.1 Substances

3.1.1 Chemical characteristics

Polydimethylsiloxane

3.1.2 Hazardous ingredients

This material does not contain any ingredients above the permitted limit(s).

3.2 Mixtures

not applicable

SECTION 4: First aid measures

4.1 Description of first aid measures

General information:
In case of accident or if you feel unwell seek medical advice (show label or SDS where possible).

After contact with the eyes:
Rinse immediately with plenty of water. Seek medical advice in case of continuous irritation.

After contact with the skin:
Wipe off excess material with cloth or paper. Wash with plenty of water or water and soap. In the event of a visible skin change or other complaints, seek medical advice (show label or SDS where possible).

After inhalation:
Provide fresh air.

After swallowing:
Give several small portions of water to drink. Do not induce vomiting.

4.2 Most important symptoms and effects, both acute and delayed

Any relevant information can be found in other parts of this section.

4.3 Indication of any immediate medical attention and special treatment needed

Further toxicology information in section 11 must be observed.

SECTION 5: Firefighting measures

5.1 Extinguishing media

Suitable extinguishing media:
water mist , extinguishing powder , alcohol-resistant foam , carbon dioxide , sand .

Extinguishing media which must not be used for safety reasons:
water jet .

5.2 Special hazards arising from the substance or mixture

Risk of hazardous gasses or fumes in the event of fire. Exposure to combustion products may be a health hazard! Hazardous combustion products: carbon oxides , silicon oxides , incompletely burnt hydrocarbons , toxic and very toxic fumes .

5.3 Advice for firefighters

Special protective equipment for fire fighting:
Use respiratory protection independent of recirculated air. Keep unprotected persons away.

SECTION 6: Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures

If material is released indicate risk of slipping. Do not walk through spilled material.

6.2 Environmental precautions

Prevent material from entering surface waters, drains or sewers and soil. Contain any fluid that runs out using suitable material (e.g. earth). Close leak if possible without risk.

6.3 Methods and material for containment and cleaning up

Take up mechanically and dispose of according to local/state/federal regulations. For small amounts: Absorb with a liquid binding material such as diatomaceous earth and dispose of according to local/state/federal regulations. Contain larger amounts and pump up into suitable containers. Clean any slippery coating that remains using a detergent / soap solution or another biodegradable cleaner. Apply sand or other inert granular material to improve traction.

6.4 Reference to other sections

Relevant information in other sections has to be considered. This applies in particular for information given on personal protective equipment (section 8) and on disposal (section 13).

SECTION 7: Handling and storage

7.1 Precautions for safe handling

General information:

No special protective measures required.

Precautions for safe handling:
Spilled substance increases risk of slipping. Liquid silicone based materials have lubricating properties that can substantially reduce or eliminate traction and may pose a slip hazard. Please use warning labels on consumer products where traction is essential for safety.

Precautions against fire and explosion:
Observe the general rules for fire prevention.

7.2 Conditions for safe storage, including any incompatibilities

Conditions for storage rooms and vessels:
none known

Advice for storage of incompatible materials:
not applicable

Further information for storage:
Keep container tightly closed. Store in a dry and cool place.

7.3 Specific end use(s)

No data available.

SECTION 8: Exposure controls/personal protection

8.1 Control parameters

Maximum airborne concentrations at the workplace:

CAS No.	Material	Type	mg/m^3	ppm	Dust fract.	Fibre/m^3
	Aerosol - inhalable fraction		10,0			

-

The aerosol limit specified is a recommendation should aerosol be formed during processing.

8.2 Exposure controls

8.2.1 Exposure in the work place limited and controlled

General protection and hygiene measures:
Observe standard industrial hygiene practices for the handling of chemical substances. Do not eat or drink when handling.

Personal protection equipment:

Respiratory protection

not required .

Eye protection

Recommendation: protective goggles .

Hand protection

Recommendation: Protective gloves made of butyl rubber , Protective gloves made of nitrile rubber .

8.2.2 Exposure to the environment limited and controlled

Prevent material from entering surface waters and soil.

SECTION 9: Physical and chemical properties

9.1 Information on basic physical and chemical properties

Property:	Value:	Method:
Appearance		
Physical state / form	liquid	
Colour	colourless	
Odour		
Odour	odourless	
Odour limit		
Odour limit :	no data available	
pH-Value		
pH-Value	approx. 7	
Melting point/freezing point		
Melting point / melting range	-50 - -35 °C	
Initial boiling point and boiling range		
Boiling point / boiling range	not determinable	(EU-GL.A.2)
Flash point		
Flash point	260 °C	(ISO 2719)
Flash point	> 300 °C	(ISO 2592)
Evaporation rate		
Evaporation rate	no data available	
Upper/lower flammability or explosive limits		
Lower explosion limit (LEL)	not applicable	
Upper explosion limit (UEL)	not applicable	
Vapour pressure		
Vapour pressure	not applicable	
Solubility(ies)		
Water solubility / miscibility	virtually insoluble at 20 °C	
Vapour density		
Relative gas/vapour density	No data known.	
Relative Density		
Relative Density	approx. 0,97 (25 °C) (Water / 4 °C = 1,00)	(DIN 51757)
Density	approx. 0,97 g/cm³ (25 °C)	(DIN 51757)
Partition coefficient: n-octanol/water		
Partition coefficient: n-octanol/water	No data known.	
Auto-ignition temperature		
Ignition temperature	410 °C	(EN 14522)
Decomposition temperature		
Thermal decomposition	Decomposition begins at > 250 °C	
Viscosity		
Viscosity (dynamic)	324 - 356 mPa.s at 25 °C	(DIN 53019)
Viscosity (kinematic)	approx. 350 mm²/s at 25 °C	(DIN 53019)
Molecular mass		
Molecular mass	no data available	

9.2 Other information

No data available.

SECTION 10: Stability and reactivity

10.1 – 10.3 Reactivity; Chemical stability; Possibility of hazardous reactions

If stored and handled in accordance with standard industrial practices no hazardous reactions are known.

Relevant information can possibly be found in other parts of this section.

10.4 Conditions to avoid

none known

10.5 Incompatible materials

none known

10.6 Hazardous decomposition products

If stored and handled properly: none known . Measurements have shown the formation of small amounts of formaldehyde at temperatures above about 150 °C (302 °F) through oxidation.

SECTION 11: Toxicological information

11.1 Information on toxicological effects

11.1.1 Acute toxicity

Product details:

Route of exposure	Result/Effect	Species/Test system	Source
oral	LD_{50}: > 5000 mg/kg Neither mortality nor clinical signs of toxicity were observed with the given dose.	rat	literature (Polydimethylsiloxane)
dermal	LD_{50}: > 2008 mg/kg Neither mortality nor clinical signs of toxicity were observed with the given dose.	rat	literature (Polydimethylsiloxane)

11.1.2 Skin corrosion/irritation

Product details:

Result/Effect	Species/Test system	Source
not irritating	rabbit	literature (Polydimethylsiloxane)

11.1.3 Serious eye damage / eye irritation

Product details:

Result/Effect	Species/Test system	Source
not irritating	rabbit	literature (Polydimethylsiloxane)

11.1.4 Respiratory or skin sensitization

Product details:

Route of exposure	Result/Effect	Species/Test system	Source
dermal	not sensitizing	guinea-pig; Magnusson-Kligman	literature (Polydimethylsiloxane) OECD 406

11.1.5 Germ cell mutagenicity

Assessment:

Based on known data a significant mutagenic potential may be excluded.

Product details:

Result/Effect	Species/Test system	Source
negative	mutation assay (in vitro) bacterial cells	literature (Polydimethylsiloxane) OECD 471

11.1.6 Carcinogenicity

Assessment:

Animal tests have not revealed any carcinogenic effects.

Product details:

Result/Effect	Species/Test system	Source
NOAEL: >= 1000 mg/kg NOAEL= NOAEL (carcinogenic effects)	carcinogenicity study rat (F344) oral (feed) 2 a	literature (Polydimethylsiloxane)

11.1.7 Reproductive toxicity

Assessment:

Animal tests have shown no indications of possibility of damage to embryo and impairment of fertility.

Product details:

Result/Effect (Examinations of developmental toxicity and teratogenicity)	Species/Test system	Source
NOAEL (developmental): >= 1000 mg/kg NOAEL (maternal): >= 1000 mg/kg Symptoms/Effect: Nothing abnormal detected.	Developmental Toxicity Study rabbit oral (gavage) ; day 6 - 19 of gestation	literature (Polydimethylsiloxane)

11.1.8 Specific target organ toxicity (single exposure)

Assessment:

For this endpoint no toxicological test data is available for the whole product.

11.1.9 Specific target organ toxicity (repeated exposure)

Assessment:

For this endpoint no toxicological test data is available for the whole product.

Product details:

Result/Effect	Species/Test system	Source
NOAEL: >= 1000 mg/kg NOAEL = NOAEL (systemic effects)	chronic study rat oral (feed) 1 a Follow-up observation period: 1 a	literature (Polydimethylsiloxane)

11.1.10 Aspiration hazard

Assessment:

For this endpoint no toxicological test data is available for the whole product.

11.1.11 Further toxicological information

Human patch test: Product displays good compatibility with the skin.

SECTION 12: Ecological information

12.1 Toxicity

Assessment:

Based on available data no effects on aquatic organisms that are relevant for classification must be expected for the product up to its limits of water solubility. According to current knowledge adverse effects on water purification plants are not expected.

Product details:

Result/Effect	Species/Test system	Source
> 1000 mg/l (nominal) effect level > maximum achievable concentration	static (water-accommodated fraction) Fish (96 h)	literature
EC_{50}: > 0,0001 mg/l (measured) effect level > maximum achievable concentration	static (water-accommodated fraction) Daphnia magna (48 h)	literature
IC_{50} (growth rate): > 100000 mg/l (nominal)	static (water-accommodated fraction) Marine alga (skeleonema costatum) (72 h)	literature
NOEC: > 10000 mg/kg	feeding study rainbow trout (Oncorhynchus mykiss) (28 d)	literature
NOEC (mortality, growth, reproduction): > 500 mg/kg The exposure to treated sediment did not result in effects.	exposure via sediment Daphnia magna (21 d)	literature

12.2 Persistence and degradability

Assessment:

Silicone content: biologically not degradable. Elimination by adsorption to activated sludge. Polydimethylsiloxanes are degradable to a certain extent in abiotic processes.

12.3 Bioaccumulative potential

Assessment:

Polymer component: Bioaccumulation is not expected to occur.

12.4 Mobility in soil

Assessment:

Polymer component: insoluble in water. Adsorbs on soil.

12.5 Results of PBT and vPvB assessment

This substance/mixture contains no components considered to be either persistent, bioaccumulative and toxic (PBT), or very persistent and very bioaccumulative (vPvB) at levels of 0.1% or higher.

12.6 Other adverse effects

none known

SECTION 13: Disposal considerations

13.1 Waste treatment methods

13.1.1 Material

Recommendation:
Material that cannot be used or chemically reprocessed should be disposed of at an approved facility in accordance with any applicable governmental regulations.

13.1.2 Uncleaned packaging

Recommendation:
Completely discharge containers (no tear drops, no powder rest, scraped carefully). Containers may be recycled or re-used. Observe local/state/federal regulations.

13.1.3 Waste Disposal Legislation Ref.No.(EC)

It is not possible to determine a waste code for this product in accordance with the European Waste Catalogue (EWC) since it is only possible to classify it according to how it is used by the customer. The waste code is to be determined within the EU in liaison with the waste-disposal operator.

SECTION 14: Transport information

14.1 – 14.4 UN number; UN proper shipping name; Transport hazard class(es); Packing group

Road ADR:
Valuation .....: Not regulated for transport

Railway RID:
Valuation .....: Not regulated for transport

Transport by sea IMDG-Code:
Valuation .....: Not regulated for transport

Air transport ICAO-TI/IATA-DGR:
Valuation .....: Not regulated for transport

14.5 Environmental hazards

Hazardous to the environment: no

14.6 Special precautions for user

Relevant information in other sections has to be considered.

14.7 Transport in bulk according to Annex II of MARPOL and the IBC Code

Bulk transport in tankers is not intended.

SECTION 15: Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

National and local regulations must be observed.

For information on labelling please refer to section 2 of this document.

Relevant regulations:
SI 2002/1689: CHIP Regulations 2002
SI 2002/2677: COSHH Regulations 2002
SI 1999/3242: Management of Health & Safety at Work Regulations 1999
Health & Safety at Work Act 1974
SI 1993/1643: Environmental Protection Act 1993 & Subsidiary Regulations.
Other national and local measures relating to the workplace, pollution control, environmental protection and waste control.

Other specifications, restrictions and prohibitions:

Regulation (EC) No 649/2012 of the European Parliament and the Council concerning the export and import of dangerous chemicals: Not applicable

15.2 Chemical safety assessment

A chemical safety assessment according to (EC) regulation 1907/2006 (REACH) has not been carried out for this product.

15.3 Details of international registration status

Relevant information about individual substance inventories, where available, is given below.

South Korea (Republic of Korea) ..... : **ECL** (Existing Chemicals List):
This product is listed in, or complies with, the substance inventory.

Japan ..... : **ENCS** (Handbook of Existing and New Chemical Substances):
This product is listed in, or complies with, the substance inventory.

Australia ..... : **AICS** (Australian Inventory of Chemical Substances):
This product is listed in, or complies with, the substance inventory.

People's Republic of China ..... : **IECSC** (Inventory of Existing Chemical Substances in China):
This product is listed in, or complies with, the substance inventory.

Canada ..... : **DSL** (Domestic Substance List):
This product is listed in, or complies with, the substance inventory.

Philippines..... : **PICCS** (Philippine Inventory of Chemicals and Chemical Substances):
This product is listed in, or complies with, the substance inventory.

United States of America (USA)..... :	**TSCA** (Toxic Substance Control Act Chemical Substance Inventory): This product is listed in, or complies with, the substance inventory.
Taiwan (Republic of China)..... :	**TCSI** (Taiwan Chemical Substance Inventory): This product is listed in, or complies with, the substance inventory. General note: Taiwan REACH requires a phase 1 registration for TCSI-listed or TCSI-compliant substances if imports to Taiwan or manufacturing in Taiwan exceed the trigger quantity of 100 kg/a (for mixtures to be calculated per each ingredient). It is the duty of the importing/manufacturing legal entity to take care of this obligation.
European Economic Area (EEA)..... :	**REACH** (Regulation (EC) No 1907/2006): General note: the registration obligations for substances imported into the EEA or manufactured within the EEA by the supplier mentioned in section 1 are fulfilled by the said supplier. The registration obligations for substances imported into the EEA by customers or other downstream users must be fulfilled by the latter.

SECTION 16: Other information

16.1 Material

The details in this document are based on the state of our knowledge at the time of revision. They do not constitute an assurance of the described product properties in terms of statutory warranty requirements.

The providing of this document to a recipient does not relieve the recipient of his or her responsibility toward compliance with all laws and stipulations applicable to the product. This applies in particular to the further sale or distribution of the product or substances or items containing the product, in other jurisdictions and with regard to the protection of third-party intellectual property rights. If the described product is processed or mixed with other substances or materials, the details stated in this document cannot be conferred to the resultant new product unless this has been expressly mentioned. If the product is repackaged, the recipient is obligated to additionally provide the required safety-related information.

All deliveries are subject to the WACKER SILICONES Health Care Policy, which is available at www.wacker.com.

16.2 Further information:

Commas appearing in numerical data denote a decimal point. Vertical lines in the left-hand margin indicate changes compared with the previous version. This version supersedes all previous versions.

- End of Safety Data Sheet -

SAFETY DATA SHEET

According to regulation (EC) n° 1907/2006 Annex II

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product identifier:

Product name: BLUESIL PASTE 4 **Product No.:** PRCO90000167

1.2 Relevant identified uses of the substance or mixture and uses advised against:

Identified uses: Lubricant.

Uses advised against: None known.

1.3 Details of the supplier of the safety data sheet:

Manufacturer:

Elkem Siliconi Italia Srl
via Archimede, 602
I-21042 Caronno Pertusella

Telephone: +39 (02) 964 141
Fax: +39 (02) 96450209

E-mail: fds.sil@elkem.com

Supplier:

Elkem Silicones Scandinavia AS
Drammensveien 169
NO-0277 Oslo

Telephone: +47 947 92 814

1.4 Emergency telephone number: CHEMTREC Sweden (24h) : +(46)-852503403 / National Poison Centre : 112 – ask for Poisons Information

SECTION 2: Hazards identification

2.1 Classification of the substance or mixture

The product has not been classified as hazardous according to the legislation in force.

Classification according to Regulation (EC) No 1272/2008 as amended.

Not classified

2.2 Label Elements

Supplemental label information

EUH210: Safety data sheet available on request.

Hazard summary

Physical Hazards: No specific recommendations.

Health Hazards

Inhalation: No specific symptoms noted.

Eye contact: No specific symptoms noted.

Skin Contact: No specific symptoms noted.

Ingestion: No specific symptoms noted.

Other Health Effects: No other information noted.

Environmental Hazards: Not regarded as dangerous for the environment.

2.3 Other hazards No data available.

SECTION 3: Composition/information on ingredients

3.2 Mixtures

General information: Mixture of Polyorganosiloxanes, fillers.

Chemical name	Concentration	CAS-No.	EC No.	REACH Registration No.	M-Factor:	Notes
Boric acid	0,3 - <1%	10043-35-3	233-139-2	No data available.	No data available.	

* All concentrations are percent by weight unless ingredient is a gas. Gas concentrations are in percent by volume.
# This substance has workplace exposure limit(s).

Classification

Chemical name	Classification	Notes
Boric acid	Repr. 1B H360FD**;**	No data available.

CLP: Regulation No. 1272/2008.

The full text for all H-statements is displayed in section 16.

SECTION 4: First aid measures

General: Get medical attention if symptoms occur. Contaminated clothing to be placed in closed container until disposal or decontamination.

4.1 Description of first aid measures

Inhalation: Not relevant.

Skin Contact: Remove contaminated clothing and shoes. Wash contact areas with soap and water.

Eye contact: In the event of contact with the eyes, rinse thoroughly with clean water. Continue to rinse for at least 15 minutes.

Ingestion: Do not induce vomiting. Rinse mouth thoroughly.

4.2 Most important symptoms and effects, both acute and delayed: None known.

4.3 Indication of any immediate medical attention and special treatment needed

Hazards: No specific recommendations.

Treatment: No specific recommendations.

SECTION 5: Firefighting measures

General Fire Hazards:	No specific recommendations.
5.1 Extinguishing media **Suitable extinguishing media:**	Extinguish with foam, carbon dioxide or dry powder. Water spray.
Unsuitable extinguishing media:	None known.
5.2 Special hazards arising from the substance or mixture:	None known. For further information, refer to section 10: "Stability and Reactivity".
5.3 Advice for firefighters **Special fire fighting procedures:**	Water spray should be used to cool containers.
Special protective equipment for fire-fighters:	Self-contained breathing apparatus and full protective clothing must be worn in case of fire.

SECTION 6: Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures:

6.1.1 For non-emergency personnel:	Use personal protective equipment. See Section 8 of the SDS for Personal Protective Equipment.
6.1.2 For emergency responders:	No data available.
6.2 Environmental Precautions:	Collect spillage. Do not discharge into drains, water courses or onto the ground.
6.3 Methods and material for containment and cleaning up:	Containers with collected spillage must be properly labelled with correct contents and hazard symbol. Container must be kept tightly closed. Absorb with sand or other inert absorbent. To clean the floor and all objects contaminated by this material, use an appropriate solvent.(cf. : § 9) Flush area with plenty of water. Incinerate in suitable combustion chamber.
6.4 Reference to other sections:	Caution: Contaminated surfaces may be slippery. For waste disposal, see Section 13 of the SDS.

SECTION 7: Handling and storage

7.1 Precautions for safe handling:	No specific precautions.
7.2 Conditions for safe storage, including any incompatibilities:	No special storage precautions noted. Material is stable under normal conditions. Avoid contact with oxidizing agents. Use container made of: Plastic lined steel drum. Suitable plastic material.
7.3 Specific end use(s):	No specific recommendations.

SECTION 8: Exposure controls/personal protection

8.1 Control Parameters
Occupational Exposure Limits

None of the components have assigned exposure limits.

8.2 Exposure controls

Appropriate Engineering Controls: No specific recommendations.

Individual protection measures, such as personal protective equipment

General information: No specific precautions.

Eye/face protection: Safety Glasses

Skin protection

Hand Protection: Material: Nitrile.
Material: Polyvinyl chloride (PVC).
Material: Rubber or plastic.

Other: No skin protection is ordinarily required under normal conditions of use. In accordance with good industrial hygiene practices, precautions should be taken to avoid skin contact.

Respiratory Protection: No specific precautions.

Hygiene measures: Provide eyewash station and safety shower.

Environmental Controls: No data available.

SECTION 9: Physical and chemical properties

9.1 Information on basic physical and chemical properties

Appearance	
Physical state:	Solid
Form:	Viscous paste
Color:	White
Odor:	Faint
Odor Threshold:	No data available.
pH:	Not applicable.
Melting Point:	No data available.
Boiling Point:	No data available.
Flash Point:	225 °C (Closed cup according to method ASTM D56.)
Evaporation Rate:	No data available.
Flammability (solid, gas):	No data available.
Flammability Limit - Upper (%):	No data available.
Flammability Limit - Lower (%):	No data available.
Vapor pressure:	< 0,1 hPa (20 °C)
Vapor density (air=1):	No data available.
Density:	Approximate 1,01 kg/dm3 (20 °C)
Solubility(ies)	
Solubility in Water:	Practically Insoluble
Solubility (other):	Acetone: Insoluble Alcohol: Insoluble Diethylether: Dispersible Aliphatic hydrocarbons: Dispersible Aromatic hydrocarbons: Dispersible Chlorinated solvents: Dispersible
Partition coefficient (n-octanol/water):	No data available.
Autoignition Temperature:	> 400 °C

Decomposition Temperature:	No data available.
Viscosity:	No data available.
Explosive properties:	No data available.
Oxidizing properties:	According to the data on the components Not considered as oxidizing. (evaluation by structure-activity relationship)

9.2 Other information: No data available.

SECTION 10: Stability and reactivity

10.1 Reactivity:	No other information noted.
10.2 Chemical Stability:	Stable.
10.3 Possibility of hazardous reactions:	No data available.
10.4 Conditions to avoid:	No other information noted.
10.5 Incompatible Materials:	Strong oxidizing agents.
10.6 Hazardous Decomposition Products:	Thermal decomposition or combustion may liberate carbon oxides and other toxic gases or vapors.

SECTION 11: Toxicological information

Information on likely routes of exposure

Inhalation:	No data available.
Ingestion:	No data available.
Skin Contact:	No data available.
Eye contact:	No data available.

11.1 Information on toxicological effects:

Acute toxicity:

Oral:

Product:	Not classified for acute toxicity based on available data.

Dermal:

Product:	Not classified for acute toxicity based on available data.

Inhalation:

Product:	Composition/information on ingredients
Specified substance(s):	
boric acid	LC 50 (Rat, Female, Male, 4 h): > 2,03 mg/l AerosolLC 50 (Rat, Female, Male, 4 h): > 2,12 mg/l Dust

Repeated dose toxicity:

Product:	No data available.

Specified substance(s):

boric acid	NOAEL (Rat(Female, Male), Oral): 17,5 mg/kg LOAEL (Rat(Female, Male), Oral): 58,5 mg/kg NOAEL (Rat(Female, Male), Inhalation): 0,47 mg/l Aerosol NOAEL (Dog(Female), Inhalation): >= 0,057 mg/l Aerosol

Skin Corrosion/Irritation:

Product:	No data available.
Specified substance(s):	
boric acid	According to a standardised method. (Rabbit) : Occluded (Dermal)

Serious Eye Damage/Eye Irritation:

Product:	Composition/information on ingredients
Specified substance(s):	
boric acid	OECD 405 (Rabbit) : Slightly irritating.

Respiratory or Skin Sensitization:

Product:	Composition/information on ingredients
Specified substance(s):	
boric acid	OECD 406 (Guinea Pig) : Not a skin sensitizer.

Germ Cell Mutagenicity:

In vitro:

Product:	Composition/information on ingredients
Specified substance(s):	
boric acid	Bacteria (OECD 471): No mutagenic effects.

In vivo:

Product:	No data available.
Specified substance(s):	
boric acid	(OECD 474)No mutagenic effects.

Carcinogenicity:

Product:	No data available.

Reproductive toxicity:

Product:	Composition/information on ingredients
Specified substance(s):	
boric acid	May damage fertility. May damage the unborn child.

Reproductive toxicity (Fertility):

Product:	Composition/information on ingredients
Specified substance(s):	
boric acid	Rat (Ingestion): NOAEL (parent): 17,5 mg/kg NOAEL (F1):17,5 mg/kg NOAEL (F2): 17,5 mg/kg

Developmental toxicity (Teratogenicity):

Product:	Composition/information on ingredients
Specified substance(s):	
boric acid	Rat (Ingestion): NOAEL (terato): 9,6 mg/kg NOAEL (mater): 13,3 mg/kg Method: OECD 414

Specific Target Organ Toxicity - Single Exposure:
Product: No data available.

Specific Target Organ Toxicity - Repeated Exposure:
Product: No data available.

Aspiration Hazard:
Product: No data available.

SECTION 12: Ecological information

12.1 Toxicity:

Acute toxicity:

Fish:
Product: No effects expected (assessment based on ingredients).

Aquatic Invertebrates:
Product: No effects expected (assessment based on ingredients).

Chronic Toxicity:

Fish:
Product: No effects expected (assessment based on ingredients).

Aquatic Invertebrates:
Product: No effects expected (assessment based on ingredients).

Toxicity to Aquatic Plants:
Product: No effects expected (assessment based on ingredients).

12.2 Persistence and Degradability:

Biodegradation:
Product: Not applicable.

BOD/COD Ratio:
Product: No data available.

12.3 Bioaccumulative potential:

Product: Composition/information on ingredients
Specified substance(s):

boric acid	Chinook salmon (Oncorhynchus tshawytscha), Bioconcentration Factor (BCF): < 0,1 (Measured)

12.4 Mobility in soil: No data available.

12.5 Results of PBT and vPvB assessment: None Reported

12.6 Other adverse effects: None known.

SECTION 13: Disposal considerations

13.1 Waste treatment methods:

General information: The user's attention is drawn to the possible existence of local regulations regarding disposal.

Disposal methods

Disposal instructions: Dispose of waste at an appropriate treatment and disposal facility in accordance with applicable laws and regulations, and product characteristics at time of disposal. Incinerate.

Contaminated Packaging: Contaminated packages should be as empty as possible. Dispose of waste at an appropriate treatment and disposal facility in accordance with applicable laws and regulations, and product characteristics at time of disposal. Recycle following cleaning or dispose of at an authorised site.

SECTION 14: Transport information

This material is not subject to transport regulations.

Other information: No special precautions.

14.7 Transport in bulk according to Annex II of MARPOL and the IBC Code: Not applicable..

SECTION 15: Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture:

Regulation (EC) No. 1907/2006, REACH Annex XIV Substances subject to authorisation, as amended:
none

15.2 Chemical safety assessment: No Chemical Safety Assessment has been carried out.

Inventory Status:

Australia AICS:	On or in compliance with the inventory.
Canada DSL Inventory List:	On or in compliance with the inventory.
EINECS, ELINCS or NLP:	On or in compliance with the inventory.
Japan (ENCS) List:	On or in compliance with the inventory.
China Inv. Existing Chemical Substances:	On or in compliance with the inventory.
Korea Existing Chemicals Inv. (KECI):	On or in compliance with the inventory.
Philippines PICCS:	On or in compliance with the inventory.
US TSCA Inventory:	On or in compliance with the inventory.
New Zealand Inventory of Chemicals:	On or in compliance with the inventory.

SECTION 16: Other information

Revision Information: Not relevant.

References

PBT	PBT: persistent, bioaccumulative and toxic substance.
vPvB	vPvB: very persistent and very bioaccumulative substance.

Key abbreviations or acronyms used:
No data available.

Key literature references and sources for data: No data available.

Wording of the H-statements in section 2 and 3

H360FD	May damage fertility. May damage the unborn child.

Training information: No data available.

Issue Date: 14.12.2017
SDS No.:
Disclaimer: The information given is based on data available for the material, the components of the material, and similar materials. The information is believed to be correct. It is given in good faith. This information should be used to make an independent determination of the methods to safeguard workers and the environment.

SAFETY DATA SHEET

According to Regulation (EC) No. 1907/2006 (REACH) Article 31, Annex II as amended.

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product identifier

Product name: RENOLIN PG 220

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses: Lubricant
Uses advised against: No uses advised against identified.

1.3 Details of the supplier of the safety data sheet

Manufacturer / Supplier	FUCHS LUBRICANTS SWEDEN AB Box 194 149 22 Nynäshamn SE
Telephone:	+46 8 128 25 000
Contact Person:	HSE Advisor
Telephone:	+46 8 128 25 000
E-mail:	HSEASC@fuchs-oil.com

1.4 Emergency telephone number: +46 20 996 000

SECTION 2: Hazards identification

2.1 Classification of the substance or mixture

The product has not been classified as hazardous, but needs to be labelled according to regulation (EU) 1272/2008 (CLP).

Hazard summary
Physical Hazards: No data available.

2.2 Label Elements

EUH210: Safety data sheet available on request.

2.3 Other hazards: By handling of mineral oil products and chemical products no particular hazard is known when normal precautions (item 7) and personal protective equipment (item 8) are kept. The product may not be released into the environment without control.

SECTION 3: Composition/information on ingredients

3.2 Mixtures

General information: Mixture of synthetic base oils with additives.

Chemical name	Identifier	Concentration *	REACH Registration No.	Notes
Amine aromatic , alkylated	Confidential	1,00 - <5,00%	Confidential	
Phenol derivative	Confidential	1,00 - <5,00%	Confidential	

* All concentrations are percent by weight unless ingredient is a gas. Gas concentrations are in percent by volume.
PBT: persistent, bioaccumulative and toxic substance.
vPvB: very persistent and very bioaccumulative substance.

Classification

Chemical name	Identifier	Classification	
Amine aromatic , alkylated	Confidential	CLP:	Aquatic Chronic 3;H412
Phenol derivative	Confidential	CLP:	Aquatic Chronic 4;H413

CLP: Regulation No. 1272/2008.

For the wording of the listed hazard statements refer to section 16.

SECTION 4: First aid measures

General: Instantly remove any clothing soiled by the product.

4.1 Description of first aid measures

Inhalation: Supply fresh air; consult doctor in case of symptoms.

Eye contact: Promptly wash eyes with plenty of water while lifting the eye lids.

Skin Contact: Wash with soap and water.

Ingestion: Rinse mouth thoroughly.

4.2 Most important symptoms and effects, both acute and delayed: May cause skin and eye irritation.

4.3 Indication of any immediate medical attention and special treatment needed Get medical attention if symptoms occur.

SECTION 5: Firefighting measures

5.1 Extinguishing media

Suitable extinguishing media: CO_2, fire extinguishing powder or fog like water spraying. Extinguish larger fires with alcohol resistant foam or spray water with suitable surfactant added

Unsuitable extinguishing media: Water with a full water jet.

5.2 Special hazards arising from the substance or mixture: During fire, gases hazardous to health may be formed.

5.3 Advice for firefighters

Special fire fighting procedures: Move container from fire area if it can be done without risk. Dispose of fire debris and contaminated fire fighting water inaccordance with official regulations. Collect contaminated fire fighting water separately. It must not enter drains.

Special protective equipment for fire-fighters: Self-contained breathing apparatus and full protective clothing must be worn in case of fire.

SECTION 6: Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures: In case of spills, beware of slippery floors and surfaces.

6.2 Environmental Precautions: Prevent from spreading (e.g. by binding or oil barriers). Avoid release to the environment. Environmental manager must be informed of all major spillages. Prevent further leakage or spillage if safe to do so. Do not allow to enter drainage system, surface or ground water.

6.3 Methods and material for containment and cleaning up: Absorb with liquid-binding material (sand, diatomite, acidbinders, universal binders, sawdust). Dispose of the material collected according to regulations. Stop the flow of material, if this is without risk.

6.4 Reference to other sections: See Section 8 of the SDS for Personal Protective Equipment. See Section 7 for information on safe handling See Section 13 for information on disposal.

SECTION 7: Handling and storage:

7.1 Precautions for safe handling: Prevent formation of aerosols. Do not eat, drink or smoke when working with the product. Take usual precautions when handling mineral oil products or chemical products. Observe good industrial hygiene practices. Provide adequate ventilation.

7.2 Conditions for safe storage, including any incompatibilities: Local regulations concerning handling and storage of waterpolluting products have to be followed.

7.3 Specific end use(s): No data available.

SECTION 8: Exposure controls/personal protection

8.1 Control Parameters

Occupational Exposure Limits

None of the components have assigned exposure limits.

8.2 Exposure controls

Appropriate engineering controls: Provide adequate ventilation. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level.

Individual protection measures, such as personal protective equipment

General information: Wash hands before breaks and after work. Use personal protective equipment as required. Personal protection equipment should be chosen according to the CEN standards and in discussion with the supplier of the personal protective equipment. The usual precautionary measures should be adhered to inhandling the chemicals or the mineral oil products.

Eye/face protection: Safety glasses (EN 166) recommended during refilling.

Skin protection

Hand Protection: Material: Nitrile-butadiene rubber (NBR).
Min. Breakthrough time: >= 480 min
Recommended thickness of the material: >= 0,38 mm

Avoid long-term and repeated skin contact. Suitable gloves can be recommended by the glove supplier. Use skin protection cream for preventive skin protection. Protective gloves, where permitted in acc. to safety directions. The exact break through time has to be found out by the manufacturer of the protective gloves and has to be observed.

Other: Do not carry cleaning cloths impregnated with the product in trouser pockets. Wear suitable protective clothing.

Respiratory Protection: Ensure good ventilation/exhaustion at the workplace. Avoid breathing vapour/ aerosol.

Thermal hazards: Not known.

Hygiene measures: Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing to remove contaminants. Discard contaminated footwear that cannot be cleaned.

Environmental Controls: No data available.

SECTION 9: Physical and chemical properties

9.1 Information on basic physical and chemical properties

Appearance	
Physical state:	liquid
Form:	liquid
Color:	Pale yellow
Odor:	Characteristic
Odor Threshold:	Not applicable for mixtures
pH:	not applicable
Freezing point:	Not applicable for mixtures

Boiling Point:	Value not relevant for classification
Flash Point:	240 °C
Evaporation Rate:	Not applicable for mixtures
Flammability (solid, gas):	Value not relevant for classification
Flammability Limit - Upper (%)–:	Not applicable for mixtures
Flammability Limit - Lower (%)–:	Not applicable for mixtures
Vapor pressure:	Not applicable for mixtures
Vapor density (air=1):	Not applicable for mixtures
Density:	1,07 g/ml (15,00 °C)
Solubility(ies)	
Solubility in Water:	partly soluble
Solubility (other):	No data available.
Partition coefficient (n-octanol/water):	Not applicable for mixtures
Autoignition Temperature:	Value not relevant for classification
Decomposition Temperature:	Value not relevant for classification
Kinematic viscosity:	220 mm2/s (40 °C)
Explosive properties:	Value not relevant for classification
Oxidizing properties:	Value not relevant for classification
9.2 Other information	No data available.

SECTION 10: Stability and reactivity

10.1 Reactivity:	Stable under normal use conditions.
10.2 Chemical Stability:	Stable under normal use conditions.
10.3 Possibility of hazardous reactions:	Stable under normal use conditions.
10.4 Conditions to avoid:	Stable under normal use conditions.
10.5 Incompatible Materials:	Strong oxidizing substances. Strong acids. Strong bases.
10.6 Hazardous Decomposition Products:	Thermal decomposition or combustion may liberate carbon oxides and other toxic gases or vapors.

SECTION 11: Toxicological information

11.1 Information on toxicological effects

Acute toxicity

Oral

Product:

Not classified for acute toxicity based on available data.

Specified substance(s)

Phenol derivative	LD 50 (Rat): > 5.000 mg/kg

Dermal
Product:
Not classified for acute toxicity based on available data.

Inhalation
Product: ATEmix: 456,67 mg/l
Dusts, mists and fumes

Skin Corrosion/Irritation:
Product: Based on available data, the classification criteria are not met.
Specified substance(s)
Amine aromatic , alkylated — OECD 404 (Rabbit):
Not irritant.

Serious Eye Damage/Eye Irritation:
Product: Based on available data, the classification criteria are not met.
Specified substance(s)
Amine aromatic , alkylated — OECD 405 (Rabbit):
Not irritant.

Respiratory or Skin Sensitization:
Product: Skin sensitizer: Based on available data, the classification criteria are not met.
Respiratory sensitizer: Based on available data, the classification criteria are not met.

Specified substance(s)
Amine aromatic , alkylated — No sensitizing effect (guinea pig); OECD 406

Phenol derivative — (Guinea Pig)
Not a skin sensitizer.

Germ Cell Mutagenicity
Product: Based on available data, the classification criteria are not met.

Carcinogenicity
Product: Based on available data, the classification criteria are not met.

Reproductive toxicity
Product: Based on available data, the classification criteria are not met.

Specific Target Organ Toxicity - Single Exposure
Product: Based on available data, the classification criteria are not met.

Specific Target Organ Toxicity - Repeated Exposure
Product: Based on available data, the classification criteria are not met.

Aspiration Hazard
Product: Based on available data, the classification criteria are not met.

Other adverse effects: No data available.

SECTION 12: Ecological information

12.1 Toxicity

Acute toxicity

Product: Based on available data, the classification criteria are not met.

Fish

Specified substance(s)

Phenol derivative	LC 50 (Fish, 96 h): > 101 mg/l (OECD 203)

Aquatic Invertebrates

Specified substance(s)

Amine aromatic , alkylated	EC 50 (Water Flea, 48 h): 51 mg/l
Phenol derivative	EC 50 (Water Flea, 24 h): > 101 mg/l (OECD 202)

Chronic ToxicityProduct: Based on available data, the classification criteria are not met.

Toxicity to Aquatic Plants

Specified substance(s)

Phenol derivative	EC 50 (Alga, 72 h): > 101 mg/l (OECD 201)

12.2 Persistence and Degradability

Biodegradation

Product: Not applicable for mixtures

Specified substance(s)

Phenol derivative	The product is slightly biodegradable.

12.3 Bioaccumulative potential

Product: Not applicable for mixtures

12.4 Mobility in soil:

Product: Not applicable for mixtures

12.5 Results of PBT and vPvB assessment:

The product does not contain any substances fulfilling the PBT/vPvB criteria.

12.6 Other adverse effects:

No data available.

SECTION 13: Disposal considerations

13.1 Waste treatment methods

General information: Dispose in accordance with all applicable regulations.

Disposal methods: Do not empty into drains; dispose of this material and its container in a safe way. When storing used products, ensure that the waste categories and mixing instructions are observed.

European Waste Codes

13 02 06*: synthetic engine, gear and lubricating oils

SECTION 14: Transport information

ADR/RID

14.1 UN Number:	–
14.2 UN Proper Shipping Name:	–
14.3 Transport Hazard Class(es)	
Class:	Non-dangerous goods
Label(s):	–
Hazard No. (ADR):	–
Tunnel restriction code:	–
14.4 Packing Group:	–
14.5 Environmental hazards:	–
14.6 Special precautions for user:	–

ADN

14.1 UN Number:	–
14.2 UN Proper Shipping Name:	–
14.3 Transport Hazard Class(es)	
Class:	Non-dangerous goods
Label(s):	–
14.3 Packing Group:	–
14.5 Environmental hazards:	–
14.6 Special precautions for user:	–

IMDG

14.1 UN Number:	–
14.2 UN Proper Shipping Name:	–
14.3 Transport Hazard Class(es)	
Class:	Non-dangerous goods
Label(s):	–
EmS No.:	–
14.3 Packing Group:	–
14.5 Environmental hazards:	–
14.6 Special precautions for user:	–

IATA

14.1 UN Number:	–
14.2 Proper Shipping Name:	–
14.3 Transport Hazard Class(es):	
Class:	Non-dangerous goods
Label(s):	–
14.4 Packing Group:	–
14.5 Environmental hazards:	–
14.6 Special precautions for user:	–

14.7 Transport in bulk according to Annex II of MARPOL and the IBC Code: Not applicable.

SECTION 15: Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture:

EU Regulations

Regulation (EC) No. 2037/2000 Substances that deplete the ozone layer: none

Regulation (EC) No. 850/2004 on persistent organic pollutants: none

15.2 Chemical safety assessment: No Chemical Safety Assessment has been carried out.

SECTION 16: Other information

Revision Information: Vertical lines in the margin indicate an amendment.

Wording of the H-statements in section 2 and 3

H412	Harmful to aquatic life with long lasting effects.
H413	May cause long lasting harmful effects to aquatic life.

Other information: The classification complies with the current EU lists; however, it has been supplemented with expert literature information and information provided by/about our company. It was derived from the test data and/or the application of the conventional method.

Revision Date: 14.02.2018

Disclaimer: The data contained in this safety data sheet are based on our current knowledge and experience and are given to the best of our knowledge and belief. It characterizes the product only with regard to safety requirements for handling, transport and disposal. The data do not describe the product's properties (tech. product specification). Neither should any agreed property nor the suitability of the product for any specific technical application be deduced from the data contained in this safety data sheet. Modifications on this document are not allowed. The data are not transferable to other products. In the case of mixing the product with other products or in the case of processing, the data in this safety data sheet are not necessarily valid for the new-made material. It is the responsibility of the recipient of the product to observe federal, state and local law. Please contact us to obtain up-to-date safety data sheets. This document was issued electronically and has no signature.

SAFETY DATA SHEET

According to Regulation (EC) No. 1907/2006 (REACH) Article 31, Annex II as amended.

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product identifier

Product name: HYDRAWAY HVXA 22

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses: Lubricant
Uses advised against: No uses advised against identified.

1.3 Details of the supplier of the safety data sheet

Manufacturer / Supplier	FUCHS LUBRICANTS SWEDEN AB Box 194 149 22 Nynäshamn SE
Telephone:	+46 8 128 25 000
Contact Person:	HSE Advisor
Telephone:	+46 8 128 25 000
E-mail:	HSEASC@fuchs-oil.com

1.4 Emergency telephone number: +46 20 996 000

SECTION 2: Hazards identification

2.1 Classification of the substance or mixture

The product has been classified and labelled as hazardous according to regulation (EU) 1272/2008 (CLP).

Classification according to Regulation (EC) No 1272/2008 as amended.

Health Hazards

Aspiration Hazard	Category 1	H304: May be fatal if swallowed and enters airways.

Hazard summary

Physical Hazards: No data available.

Health Hazards

Ingestion: If ingested, material may be aspirated into the lungs and cause chemical pneumonitis. Treat appropriately.

2.2 Label Elements

Contains: Base oil, low viscous

Signal Words: Danger

Hazard Statement(s): H304: May be fatal if swallowed and enters airways.

Precautionary Statements

Response: P301+P310: IF SWALLOWED: Immediately call a POISON CENTER/doctor.
P331: Do NOT induce vomiting.

2.3 Other hazards: By handling of mineral oil products and chemical products no particular hazard is known when normal precautions (item 7) and personal protective equipment (item 8) are kept. The product may not be released into the environment without control.

SECTION 3: Composition/information on ingredients

3.2 Mixtures

General information: Mixture containing severely refined base oils and additives.

Chemical name	Identifier	Concentration *	REACH Registration No.	Notes
Base oil, low viscous	EINECS: 265-157-1	50,00 - <100,00%	01-2119484627-25	
Base oil, low viscous	EINECS: 276-737-9	20,00 - <50,00%	01-2119474878-16	
Phenolic antioxidant agent	EINECS: 204-884-0	0,10 - <0,25%	01-2119490822-33	

* All concentrations are percent by weight unless ingredient is a gas. Gas concentrations are in percent by volume.
PBT: persistent, bioaccumulative and toxic substance.
vPvB: very persistent and very bioaccumulative substance.

Classification

Chemical name	Identifier	Classification	
Base oil, low viscous	EINECS: 265-157-1	CLP:	Asp. Tox. 1;H304
Base oil, low viscous	EINECS: 276-737-9	CLP:	Asp. Tox. 1;H304
Phenolic antioxidant agent	EINECS: 204-884-0	CLP:	Aquatic Acute 1;H400, Aquatic Chronic 1;H410, Skin Irrit. 2;H315

CLP: Regulation No. 1272/2008.

For the wording of the listed hazard statements refer to section 16.

Please note that the mineral oils and petroleum distillates used in our products are severely refined and have a DMSO extract < 3% as measured by method IP 346 and are not classified as carcinogenic according to Note L of Annex VI of Regulation EC 1272/2008."

SECTION 4: First aid measures

General:	Instantly remove any clothing soiled by the product.

4.1 Description of first aid measures

Inhalation:	Supply fresh air; consult doctor in case of symptoms.
Eye contact:	Promptly wash eyes with plenty of water while lifting the eye lids.
Skin Contact:	Wash with soap and water.
Ingestion:	Call a physician or poison control center immediately. Rinse mouth. Never give liquid to an unconscious person. If vomiting occurs, keep head low so that stomach content doesn't get into the lungs. Do NOT induce vomiting.
4.2 Most important symptoms and effects, both acute and delayed:	If ingested, material may be aspirated into the lungs and cause chemical pneumonitis. Treat appropriately.
4.3 Indication of any immediate medical attention and special treatment needed	Get medical attention if symptoms occur.

SECTION 5: Firefighting measures

5.1 Extinguishing media

Suitable extinguishing media:	CO2, fire extinguishing powder or fog like water spraying. Extinguish larger fires with alcohol resistant foam or spray water with suitable surfactant added
Unsuitable extinguishing media:	Water with a full water jet.
5.2 Special hazards arising from the substance or mixture:	During fire, gases hazardous to health may be formed.

5.3 Advice for firefighters

Special fire fighting procedures:	Move container from fire area if it can be done without risk. Dispose of fire debris and contaminated fire fighting water inaccordance with official regulations. Collect contaminated fire fighting water separately. It must not enter drains.
Special protective equipment for fire-fighters:	Self-contained breathing apparatus and full protective clothing must be worn in case of fire.

SECTION 6: Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures:	In case of spills, beware of slippery floors and surfaces.

6.2 Environmental Precautions: Prevent from spreading (e.g. by binding or oil barriers). Avoid release to the environment. Environmental manager must be informed of all major spillages. Prevent further leakage or spillage if safe to do so. Do not allow to enter drainage system, surface or ground water.

6.3 Methods and material for containment and cleaning up: Absorb with liquid-binding material (sand, diatomite, acidbinders, universal binders, sawdust). Dispose of the material collected according to regulations. Stop the flow of material, if this is without risk.

6.4 Reference to other sections: See Section 8 of the SDS for Personal Protective Equipment. See Section 7 for information on safe handling See Section 13 for information on disposal.

SECTION 7: Handling and storage:

7.1 Precautions for safe handling: Prevent formation of aerosols. Do not eat, drink or smoke when working with the product. Take usual precautions when handling mineral oil products or chemical products. Observe good industrial hygiene practices. Provide adequate ventilation.

7.2 Conditions for safe storage, including any incompatibilities: Store locked up. Local regulations concerning handling and storage of waterpolluting products have to be followed. Do not heat up to temperatures close to the flash point.

7.3 Specific end use(s): Not applicable

SECTION 8: Exposure controls/personal protection

8.1 Control Parameters

Occupational Exposure Limits

Chemical name	Type	Exposure Limit Values	Source
Base oil, low viscous - Mist.	NGV	1 mg/m3	Sweden. Occupational Exposure Limit Values (2007)
Base oil, low viscous - Mist.	KTV	3 mg/m3	Sweden. Occupational Exposure Limit Values (2007)

8.2 Exposure controls

Appropriate engineering controls: Provide adequate ventilation. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level.

Individual protection measures, such as personal protective equipment

General information: Wash hands before breaks and after work. Use personal protective equipment as required. Personal protection equipment should be chosen according to the CEN standards and in discussion with the supplier of the personal protective equipment. The usual precautionary measures should be adhered to inhandling the chemicals or the mineral oil products.

Eye/face protection:	Safety glasses (EN 166) recommended during refilling.
Skin protection	
Hand Protection:	Material: Nitrile-butadiene rubber (NBR). Min. Breakthrough time: >= 480 min Recommended thickness of the material: >= 0,38 mm Avoid long-term and repeated skin contact. Suitable gloves can be recommended by the glove supplier. Use skin protection cream for preventive skin protection. Protective gloves, where permitted in acc. to safety directions. The exact break through time has to be found out by the manufacturer of the protective gloves and has to be observed.
Other:	Do not carry cleaning cloths impregnated with the product in trouser pockets. Wear suitable protective clothing.
Respiratory Protection:	Ensure good ventilation/exhaustion at the workplace. Avoid breathing vapour/ aerosol.
Thermal hazards:	Not known.
Hygiene measures:	Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing to remove contaminants. Discard contaminated footwear that cannot be cleaned.
Environmental Controls:	No data available.

SECTION 9: Physical and chemical properties

9.1 Information on basic physical and chemical properties

Appearance	
Physical state:	liquid
Form:	liquid
Color:	Yellow
Odor:	Characteristic
Odor Threshold:	Not applicable for mixtures
pH:	Not applicable Not applicable Not applicable
Freezing point:	-45 °C
Boiling Point:	Value not relevant for classification
Flash Point:	192 °C (DIN EN ISO 2592)
Evaporation Rate:	Not applicable for mixtures
Flammability (solid, gas):	Value not relevant for classification
Flammability Limit - Upper (%)–:	Not applicable for mixtures
Flammability Limit - Lower (%)–:	Not applicable for mixtures
Vapor pressure:	Not applicable for mixtures
Vapor density (air=1):	Not applicable for mixtures
Density:	0,86 g/cm3 (15 °C) (DIN EN ISO 12185)
Solubility(ies)	
Solubility in Water:	Insoluble in water

Solubility (other):	No data available.
Partition coefficient (n-octanol/water):	Not applicable for mixtures
Autoignition Temperature:	Value not relevant for classification
Decomposition Temperature:	Value not relevant for classification
Kinematic viscosity:	20,3 mm2/s (40 °C, DIN EN ISO 3104)
Explosive properties:	Value not relevant for classification
Oxidizing properties:	Value not relevant for classification
9.2 Other information	No data available.

SECTION 10: Stability and reactivity

10.1 Reactivity:	Stable under normal use conditions.
10.2 Chemical Stability:	Stable under normal use conditions.
10.3 Possibility of hazardous reactions:	Stable under normal use conditions.
10.4 Conditions to avoid:	Stable under normal use conditions.
10.5 Incompatible Materials:	Strong oxidizing substances. Strong acids. Strong bases.
10.6 Hazardous Decomposition Products:	Thermal decomposition or combustion may liberate carbon oxides and other toxic gases or vapors.

SECTION 11: Toxicological information

11.1 Information on toxicological effects

Acute toxicity

Oral

Product:

Not classified for acute toxicity based on available data.

Specified substance(s)

Base oil, low viscous	LD 50 (Rat): > 5.000 mg/kg (OECD 423)
Base oil, low viscous	LD 50 (Rat): > 5.001 mg/kg (OECD 401)
Phenolic antioxidant agent	LD 50 (Rat): > 5.001 mg/kg

Dermal

Product:

Not classified for acute toxicity based on available data.

Specified substance(s)

Base oil, low viscous	LD 50 (Rabbit): > 5.000 mg/kg (OECD 402)
Phenolic antioxidant agent	LD 50 (Rabbit): > 10.000 mg/kg

Inhalation
Product:
Not classified for acute toxicity based on available data.

Specified substance(s)

Base oil, low viscous	LC 50 (Rat, 4 h): > 5,53 mg/l Dusts, mists and fumes

Skin Corrosion/Irritation:
Product: Based on available data, the classification criteria are not met.

Serious Eye Damage/Eye Irritation:
Product: Based on available data, the classification criteria are not met.

Respiratory or Skin Sensitization:
Product: Skin sensitizer: Based on available data, the classification criteria are not met.
Respiratory sensitizer: Based on available data, the classification criteria are not met.

Germ Cell Mutagenicity
Product: Based on available data, the classification criteria are not met.

Carcinogenicity
Product: Based on available data, the classification criteria are not met.

Reproductive toxicity
Product: Based on available data, the classification criteria are not met.

Specific Target Organ Toxicity - Single Exposure
Product: Based on available data, the classification criteria are not met.

Specific Target Organ Toxicity - Repeated Exposure
Product: Based on available data, the classification criteria are not met.

Aspiration Hazard
Product: May be fatal if swallowed and enters airways.

Other adverse effects: No data available.

SECTION 12: Ecological information

12.1 Toxicity

Acute toxicity
Product: Based on available data, the classification criteria are not met.

Fish
Specified substance(s)

Base oil, low viscous	LC 50 (Fish, 96 h): > 101 mg/l (OECD 203)
Base oil, low viscous	LC 50 (Fish, 96 h): > 100 mg/l (OECD 203)
Phenolic antioxidant	LC 50 (Fish, 96 h): 0,11 mg/l

agent

Aquatic Invertebrates
Specified substance(s)

Base oil, low viscous	EC 50 (Water Flea, 48 h): > 10.000 mg/l (OECD 202)
Phenolic antioxidant agent	EC 50 (Water Flea, 48 h): 0,45 mg/l

Chronic ToxicityProduct: Based on available data, the classification criteria are not met.

Aquatic Invertebrates
Specified substance(s)

Base oil, low viscous	NOEC (Water Flea, 21 d): 10 mg/l (OECD 211)

Toxicity to Aquatic Plants
Specified substance(s)

Base oil, low viscous	EC 50 (Alga, 72 h): > 101 mg/l
Base oil, low viscous	NOEC (Alga, 72 h): > 100 mg/l (OECD 201)
Phenolic antioxidant agent	EC 50 (Alga, 72 h): 3,6 mg/l

12.2 Persistence and Degradability

Biodegradation
Product: Not applicable for mixtures

12.3 Bioaccumulative potential
Product: Not applicable for mixtures

12.4 Mobility in soil:
Product: Not applicable for mixtures

12.5 Results of PBT and vPvB assessment: The product does not contain any substances fulfilling the PBT/vPvB criteria.

12.6 Other adverse effects: No data available.

SECTION 13: Disposal considerations

13.1 Waste treatment methods

General information: Dispose in accordance with all applicable regulations.

Disposal methods: Discharge, treatment, or disposal may be subject to national, state, or local laws.

European Waste Codes

13 01 10*: mineral based non-chlorinated hydraulic oils

SECTION 14: Transport information

ADR/RID

14.1 UN Number:	–
14.2 UN Proper Shipping Name:	–
14.3 Transport Hazard Class(es)	
Class:	Non-dangerous goods
Label(s):	–
Hazard No. (ADR):	–
Tunnel restriction code:	–
14.4 Packing Group:	–
14.5 Environmental hazards:	–
14.6 Special precautions for user:	–

ADN

14.1 UN Number:	–
14.2 UN Proper Shipping Name:	–
14.3 Transport Hazard Class(es)	
Class:	Non-dangerous goods
Label(s):	–
14.3 Packing Group:	–
14.5 Environmental hazards:	–
14.6 Special precautions for user:	–

IMDG

14.1 UN Number:	–
14.2 UN Proper Shipping Name:	–
14.3 Transport Hazard Class(es)	
Class:	Non-dangerous goods
Label(s):	–
EmS No.:	–
14.3 Packing Group:	–
14.5 Environmental hazards:	–
14.6 Special precautions for user:	–

IATA

14.1 UN Number:	–
14.2 Proper Shipping Name:	–
14.3 Transport Hazard Class(es):	
Class:	Non-dangerous goods
Label(s):	–
14.4 Packing Group:	–
14.5 Environmental hazards:	–
14.6 Special precautions for user:	–

14.7 Transport in bulk according to Annex II of MARPOL and the IBC Code: Not applicable.

SECTION 15: Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture:

EU Regulations

Regulation (EC) No. 2037/2000 Substances that deplete the ozone layer: none

Regulation (EC) No. 850/2004 on persistent organic pollutants: none

15.2 Chemical safety assessment: No Chemical Safety Assessment has been carried out.

SECTION 16: Other information

Revision Information: Vertical lines in the margin indicate an amendment.

Wording of the H-statements in section 2 and 3

H304	May be fatal if swallowed and enters airways.
H315	Causes skin irritation.
H400	Very toxic to aquatic life.
H410	Very toxic to aquatic life with long lasting effects.

Other information: The classification complies with the current EU lists; however, it has been supplemented with expert literature information and information provided by/about our company. It was derived from the test data and/or the application of the conventional method.

Revision Date: 23.05.2018

Disclaimer: The data contained in this safety data sheet are based on our current knowledge and experience and are given to the best of our knowledge and belief. It characterizes the product only with regard to safety requirements for handling, transport and disposal. The data do not describe the product's properties (tech. product specification). Neither should any agreed property nor the suitability of the product for any specific technical application be deduced from the data contained in this safety data sheet. Modifications on this document are not allowed. The data are not transferable to other products. In the case of mixing the product with other products or in the case of processing, the data in this safety data sheet are not necessarily valid for the new-made material. It is the responsibility of the recipient of the product to observe federal, state and local law. Please contact us to obtain up-to-date safety data sheets. This document was issued electronically and has no signature.