

Operation and service manual ESS Scanner Magnets on Girder

DF project no. 502446

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1 Contents

1	Contents.....	2
2	Read this first	3
2.1	About this document	3
2.2	Intended Use of Equipment	3
2.3	Requirements	3
2.4	Reference documents (See Appendix)	3
2.5	Acronyms and Abbreviations	3
2.6	Note Conventions.....	3
2.7	Safety Precautions	4
3	Magnet data	6
3.1	Operating data	6
3.2	General	6
4	Installation Instructions	7
4.1	General	7
4.2	Installation of girder	10
4.3	Installation of the magnets.....	11
4.4	Vacuum chamber installation	11
4.5	Termination filter installation	17
4.6	Power and safety interlock connection.....	17
4.7	Coil Replacement	18
5	Preventive Maintenance	18
5.1	Preventive Maintenance Checklist	18
5.2	Every 12 Months.....	18
6	Troubleshooting	19
6.1	Troubleshooting Checklist.....	20
6.2	Checking coils or filters with a thermal imaging camera	22
6.3	Measuring flow in individual circuits	23
7	Deinstallation and disposal Instructions	23
7.1	Local laws	23
7.2	General	23
7.3	Deinstallation	23
7.4	Perform section 4.2 Installation of girder	24
7.5	Overview of a typical magnet.....	24
8	Appendix	26
8.1	Checklists	26
8.2	Risk Analysis for installation and maintenance	29
8.3	List of protective measures.....	33
8.4	Drawings	33

2 Read this first

2.1 About this document

This document is intended for service engineers responsible for the installation, maintenance and repair of the magnets supplied by Danfysik A/S. External cabling, cooling hoses and power supplies are outside the scope of this manual. Regular preventive maintenance is necessary to ensure a high uptime of the installed equipment.

2.2 Intended Use of Equipment

The supplied magnets are to be installed in a particle accelerator built according to industrial standards. Their primary function is to control the beam in a particle accelerator.

The magnets are controlled from an external power supply that provides the current for the magnet to control the beam. All magnets provide interlock signals to the power supply in the event of overheating.

The magnets are designed as fixed equipment and must be permanently connected. They must be installed in an enclosed operating area.

Only skilled personnel are allowed to install and only instructed personnel are allowed operate the equipment.

Should the magnets fail to control the beam, the accelerator system must be able to detect and shut down the accelerator in a safe manner.

2.3 Requirements

2.3.1 Qualifications

The installation, service and maintenance of equipment described in this manual may only be performed by qualified personnel.

In this context, "qualified" signifies that the technician has been trained and has had practical experience in the required routines so that he/she is capable of performing service work on the system.

2.3.2 Personnel

Certain maintenance procedures may require the assistance of two people. Where relevant this will be indicated in the instructions.

2.4 Reference documents (See Appendix)

- Main assembly drawing, 7103033532
- Magnet assembly drawing, 7103033504
- Main schematics, 8200093700

2.5 Acronyms and Abbreviations

ACS	Accelerator Control System
BOM	Bill of Materials
DF	Danfysik A/S
MPS	Magnet Power Supply
NO	Normally Open contact

2.6 Note Conventions

WARNING	A <i>warning</i> label indicates potential risk of injury or loss of life to personnel if safety guidelines and instructions are ignored or circumvented.
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CAUTION

A *caution* label indicates potential damage to equipment if the necessary precautions are not heeded.

NOTE

A *note* label provides practical information that can be helpful in various maintenance situations.

2.7 Safety Precautions

Installation of these magnets presupposes that they will be installed in an enclosed operating area clearly marked as such (signs, restricted access etc.)
Only use certified lifting equipment (e.g. H-beam and round slings).

WARNING

Failure to observe the warnings specified in this document may lead to serious injury or loss of life. The guidelines contained in this document must be strictly followed.

WARNING

Risk of accident and injury! Switch off the system main power before starting any service and/or maintenance activities.

2.7.1 Radiation Hazards

WARNING

Risk of radioactive contamination!

Parts located in the radiation-controlled area might be activated.

Contact the local radiation officer for authorization prior to access, removing parts or bringing parts out of the controlled area.

WARNING

Risk of exposure to radiation!

Staying inside the accelerator area during operation might result in exposure to radiation.

Always comply with your location's safety and security regulations.

2.7.2 Electrical Hazards

WARNING	Risk of electric shock! If high voltages are present, utmost caution must be taken when measuring or working inside the cabinets or near magnets.
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2.7.3 Electric and Magnetic Field Hazards

WARNING	Magnetic fields present. Risk of accident and injury! Electric and magnetic fields can damage or interfere with active implants. Risk of death or severe injury to staff working in this area! With an active or magnetic implant, avoid working in this area during operation.
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WARNING	Magnetic fields present. Risk of accident and injury! Switch off the system main power before starting any service and/or maintenance activities. However for troubleshooting of a faulty magnet, it will often be necessary to power up the magnet. The working area must be restricted by signs and barricades. Only trained personnel are allowed to operate the power supplies.
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2.7.4 Environmental Hazards

CAUTION	Environmental Protection Hazardous materials must be properly disposed of by an authorized waste management company. Risk of environmental pollution! Dispose of hazardous materials in accordance with local regulations.
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3 Magnet data

3.1 Operating data

Item	Value	Unit
Magnet No.	16653, 16654	
Nominal Field	0.018	T
Nominal Strength	0.0054	Tm
Nominal Current	332	A
Maximum Voltage	427	V
Inductance	7.8	μ H
Resistance @ 40 kHz	9	m Ω
Magnet Aperture HxV	120x100	mm
Free Aperture HxV	107x100	mm
Total weight	30	kg
Manufacturing year	2017	

3.2 General

NOTE

To identify the magnet type, look at the Danfysik A/S product information label attached to the side of the magnet.



Figure 1: Product information label (example)

The purpose for all magnets is to control the beam.

An electromagnet consists primarily of pole shoes, coils, and return yokes. A current is supplied to the serial-connected coils, and a current in a conductor always generates a magnetic field. The proton or ion beam is always deflected when it passes near a magnetic field.

The structure of a magnet yoke defines the magnetic field by the gap between the pole shoes. The yoke provides a path for the circuit of magnetic flux (the flow of a magnetic field).

4 Installation Instructions

4.1 General

WARNING

Radiation Area!

The magnets will be installed in an enclosed operating area with restricted access. Warning signs should therefore be visible on doors and near the entrance area.

Certain basic conditions are necessary to ensure safe and responsible installation of the equipment:

- The place of installation must be a weather protected area (against rain, wind and dust, etc.)
- The installation area must be kept free from dirt and dust particles.
- The installation area must allow an operating temperature of 15 - 30°C, with a relative humidity of 0 - 70%.

- Access ways to must be kept clear.
- Warning signs and barricades must be in place to prevent unauthorized access to the working area

4.1.1 Tools and Auxiliary Materials

- Ordinary assembly tools
- Forklift
- Crane
- Pallet jacks
- Protective equipment according to local regulations, for instance hard hats, safety glasses, and/or goggles, safety shoes with toecap protection

4.1.2 Truck unload and ground transport

All Danfysik A/S collies can be unloaded from the truck using a fork lift.

WARNING

Centre of gravity for each section may be different from centre line.
Fork lift must have full grip under the package before lifting or moving.

4.1.3 Unpacking and Installation

WARNING

Risk of injury from fall!

Safety shoes must be worn at all times during installation of the magnets.

4.1.4 Instructions for Unpacking

Before unpacking check the shock tester and the tilt tester (if installed) located outside the crate. If any of the testers indicate stress during transport, carefully inspect the crate outside and the product inside, and report to Danfysik A/S.

The package is opened by taking off the top plate and then the side plates. Take off the top plate first by unscrewing the screws on top plate. Note that there may be more screws than shown in Figure 2.

After removal of the top plate, the side plate can be removed. Be careful that nothing hits the equipment. The magnet is lifted out of the crate using a crane.



Figure 2: Transport crate (example)

4.1.5 Storage environment requirements

Do not store the magnets in places where they are exposed to large temperature ranges and resulting moisture. The storage area must be frost free and with a relative humidity less than 80%.

4.2 Installation of girder

Tools: Lifting device, adjustable spanner

- Lift the two columns 8103033528 in place according to dwg 7103033532 using an appropriate crane. M24 eye bolts should be used.
- Secure the columns to the floor using the $\varnothing 28$ mm holes in the columns.
- On one column:
 - Mount 1 link arm 7103033529 on the column for transverse alignment according to dwg 7103033532
 - Mount 1 M36 x 200 in hole the center of the column top plate. Adjust the height to app. 85 mm.
- On the other column:
 - Mount 1 link arm 7103033529 on the column for transverse alignment according to dwg 7103033532
 - Mount 1 link arm 7103033529 on the column for longitudinal alignment according to dwg 7103033532
 - Mount 2 M36 x 200 in the outermost holes in the column top plate. Adjust the height to app. 85 mm.
- Lift the girder 7103033526 in place on the two columns using an appropriate crane. The scanner magnets are installed when delivered. M24 eye bolts should be used for lifting.
- Connect the link arms from the columns to the girder.
- Final alignment can be done using the link arms and the M36 support rods.

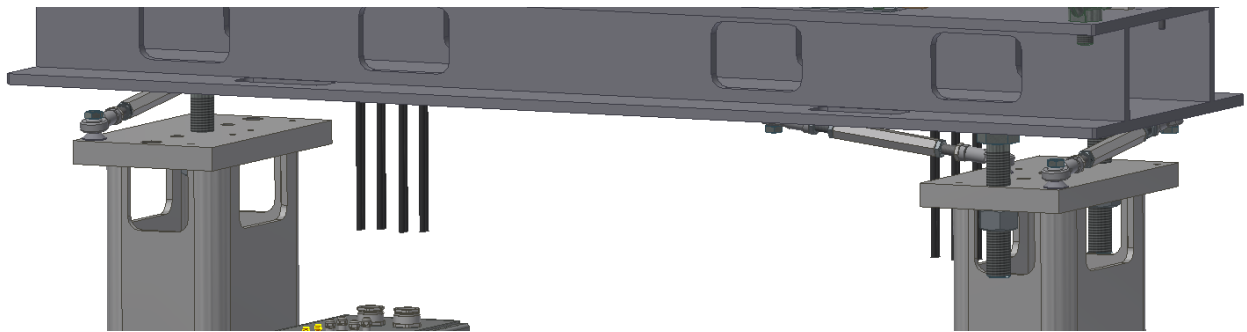


Figure 3: Girder placed on the columns

4.3 Installation of the magnets

CAUTION

The ferrite return yoke is fragile. Avoid shocks and stresses. Care should be taken that lifting eyes in the alu housing will not damage the ferrites.

Tools: Lifting device, hex keys 5-14, adjustable spanner

- Lift the magnet in place using an appropriate crane. M12 eye bolts should be used.
- Secure the magnet to the girder using the M8 x 30 bolts.
- Install protective covers over the magnet coil terminals using the M8 x 20 bolts.

4.4 Vacuum chamber installation

CAUTION

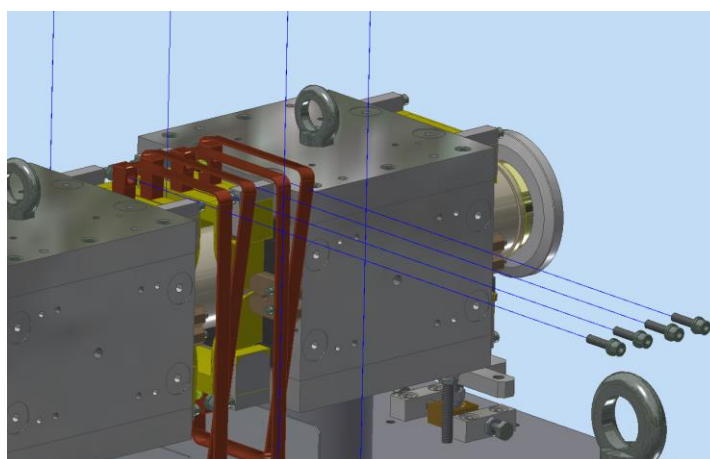
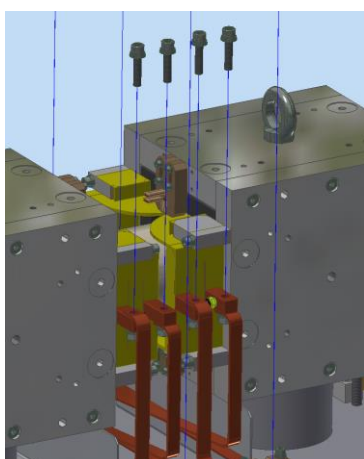
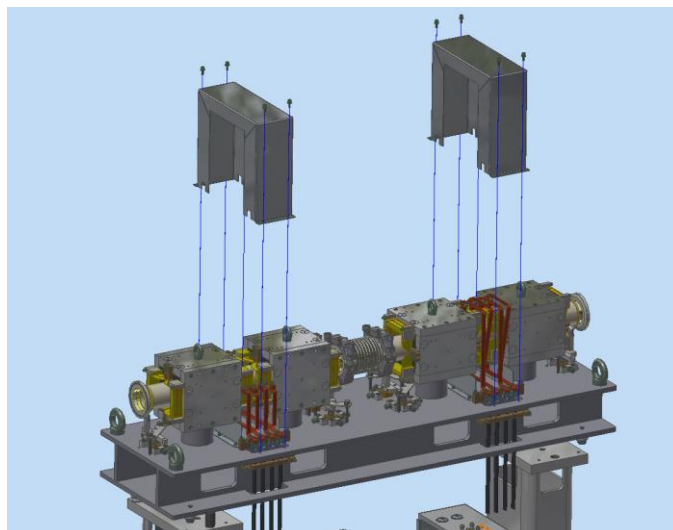
The chamber is fragile. Avoid shocks and stresses.

CAUTION

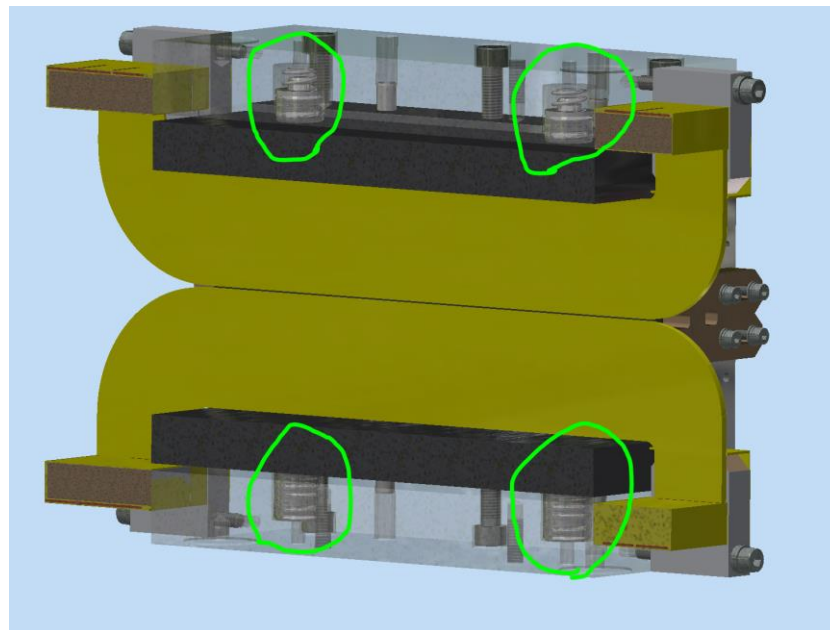
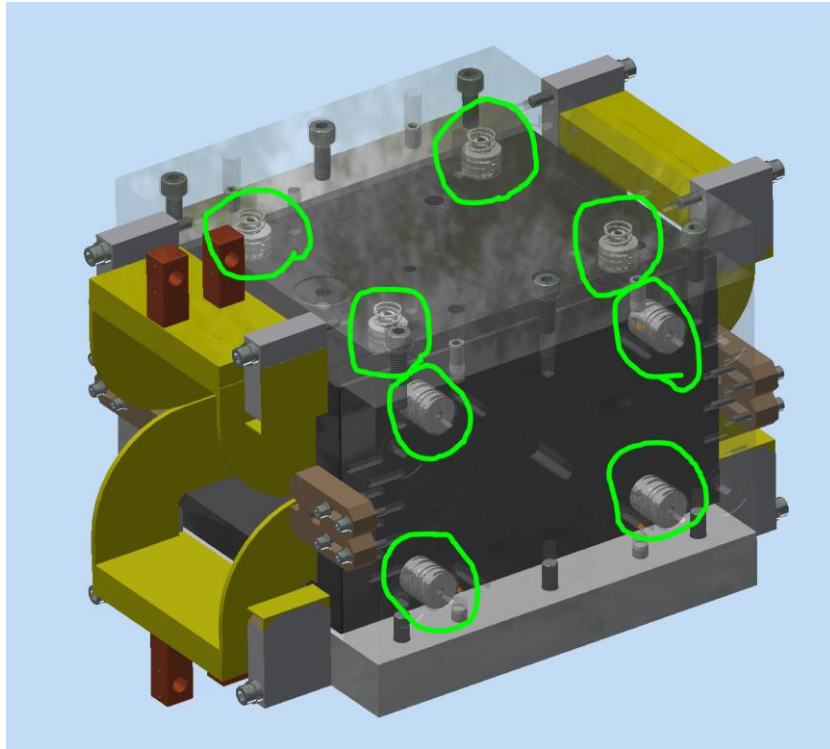
The ferrite return yoke is fragile. Avoid shocks and stresses. Care should be taken that lifting eyes in the alu housing will not damage the ferrites.

Tools: Lifting device, hex keys 5-14, adjustable spanner

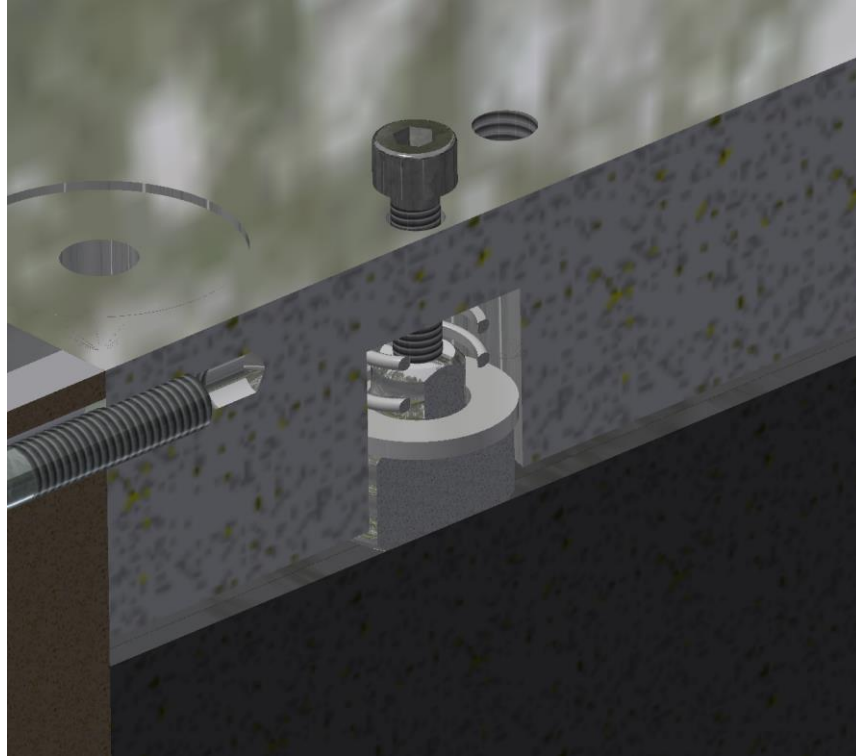
- Remove protective covers and busbars and then disconnect the klixons and B-dot sensors from the electrical connection terminal.



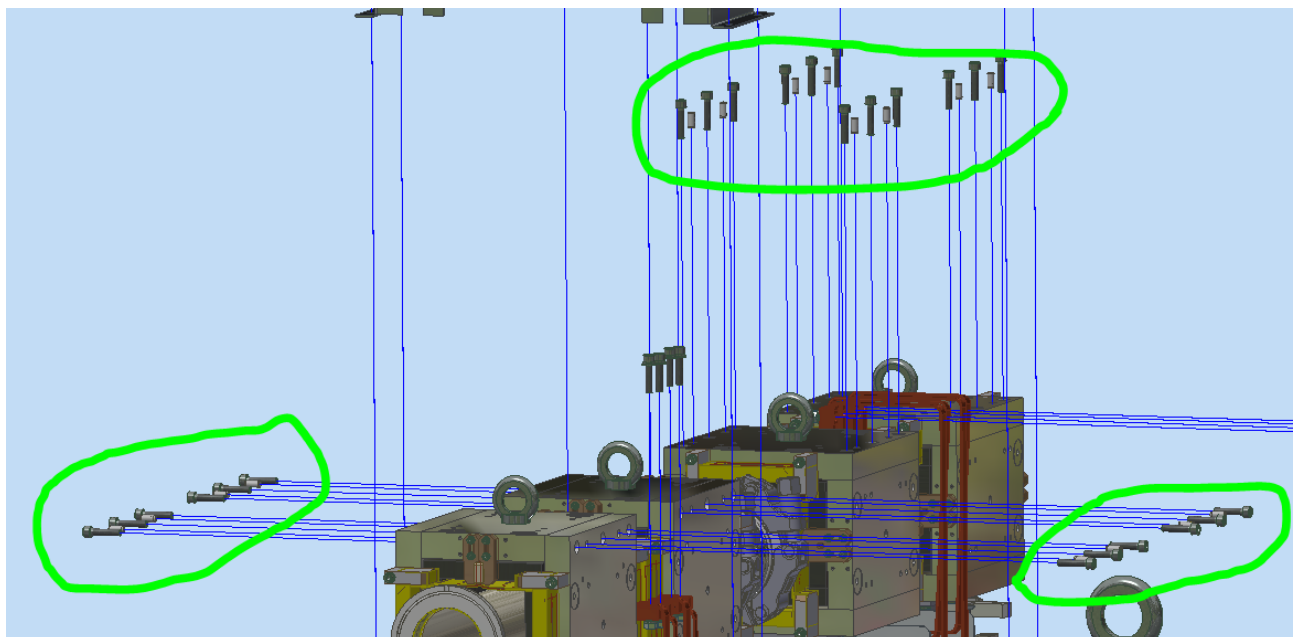
- Release the coil from the aluminum housing.
Note that ferrite plates are suspended inside the aluminum housing in between 16 bushes (each magnet) 8 of which is fixed and others are adjustable by spring. If on one side the fixed bushes are placed (for example on the bottom side), adjustable bushes are placed on the opposite side (top side).



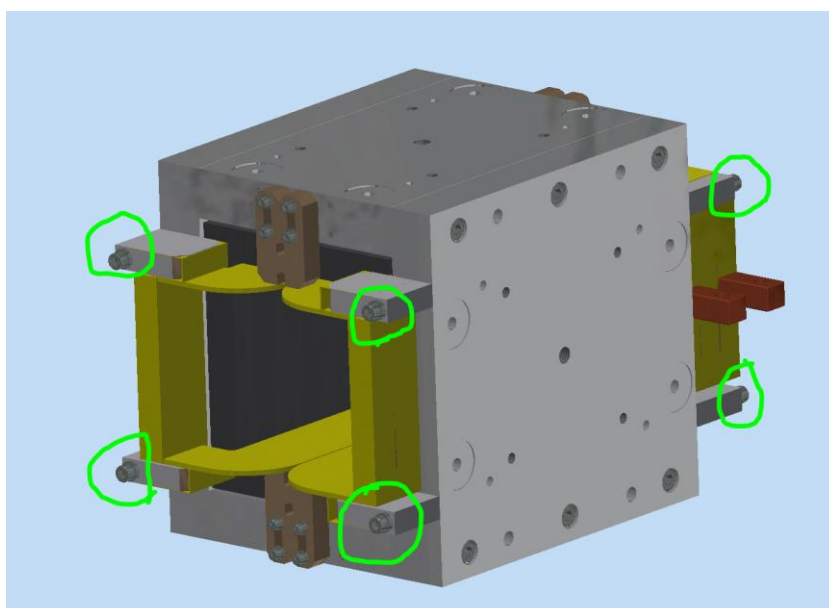
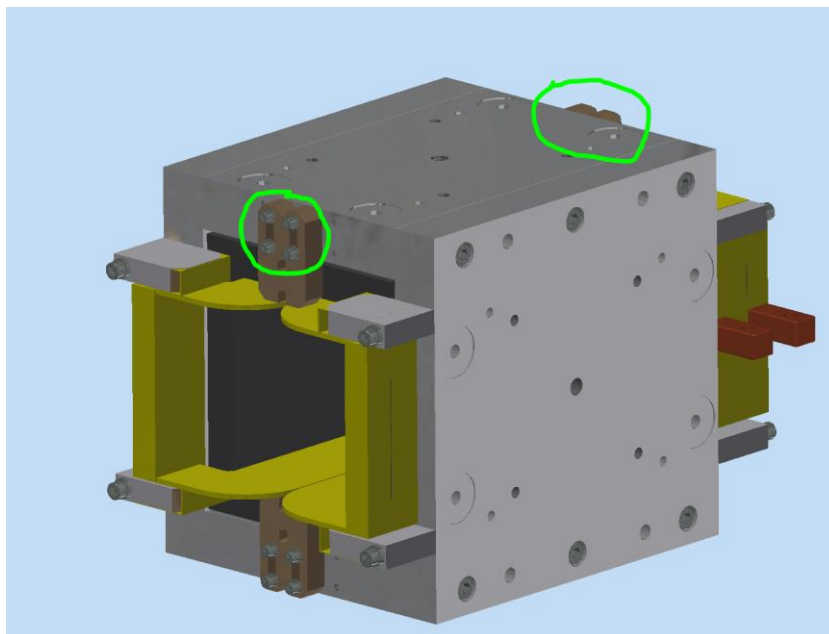
Tighten M5 screws inside the threaded holes of adjustable bushes to keep them in place and relax the ferrites.



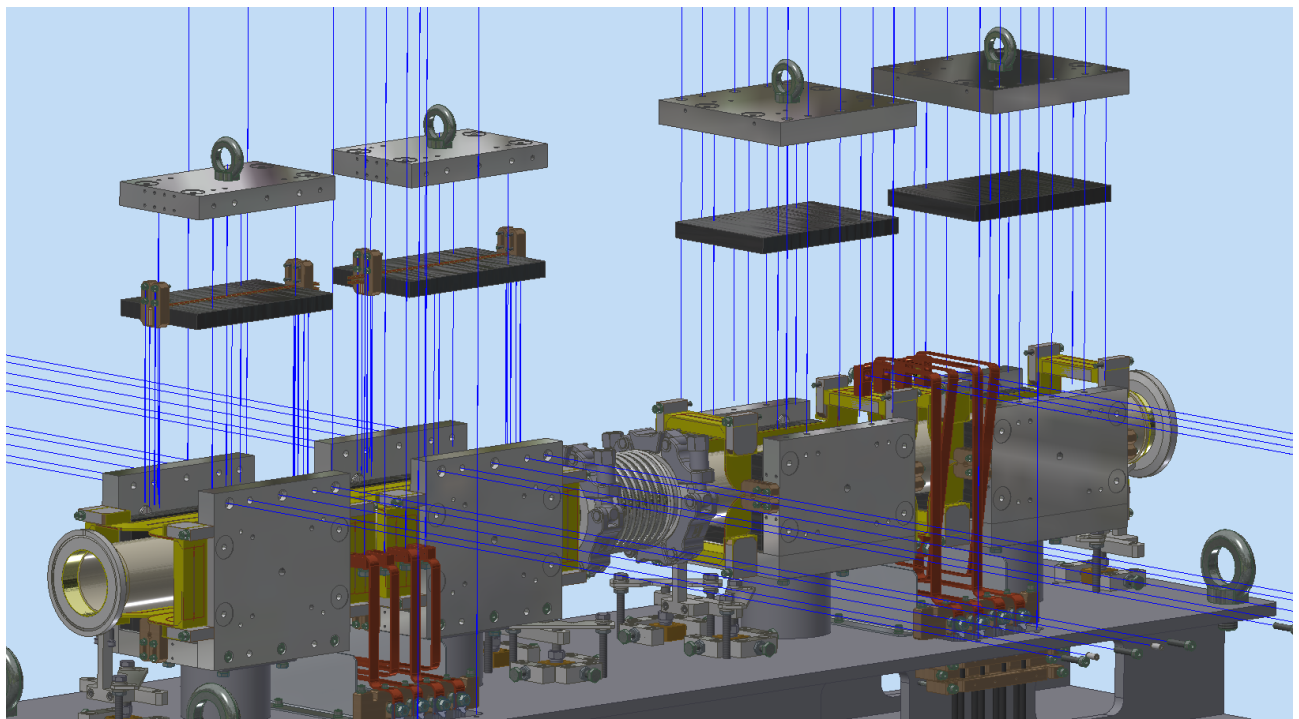
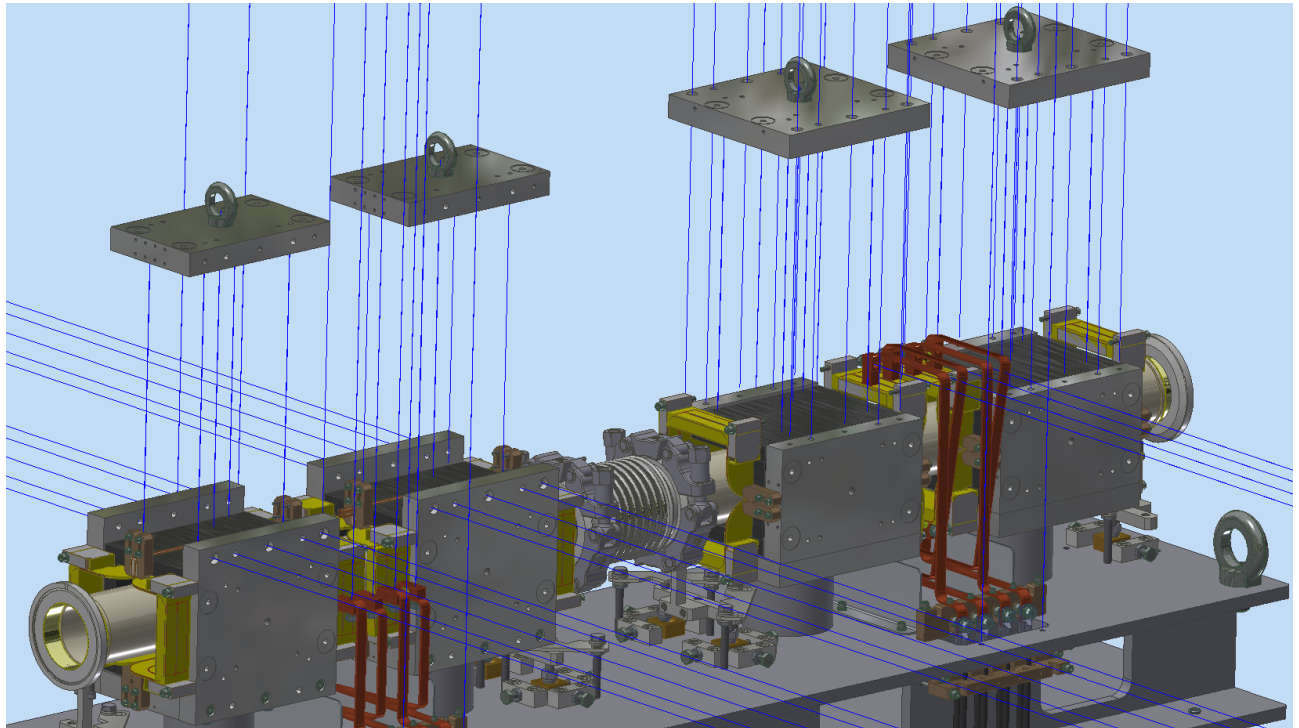
- Remove the screws and pins that are between top plate of the aluminum housing and side plates. To avoid falling parts, keep at least two screws in place until it is time to remove the side plates. Also note that there are two types of magnets which are assembled vertically and horizontally.



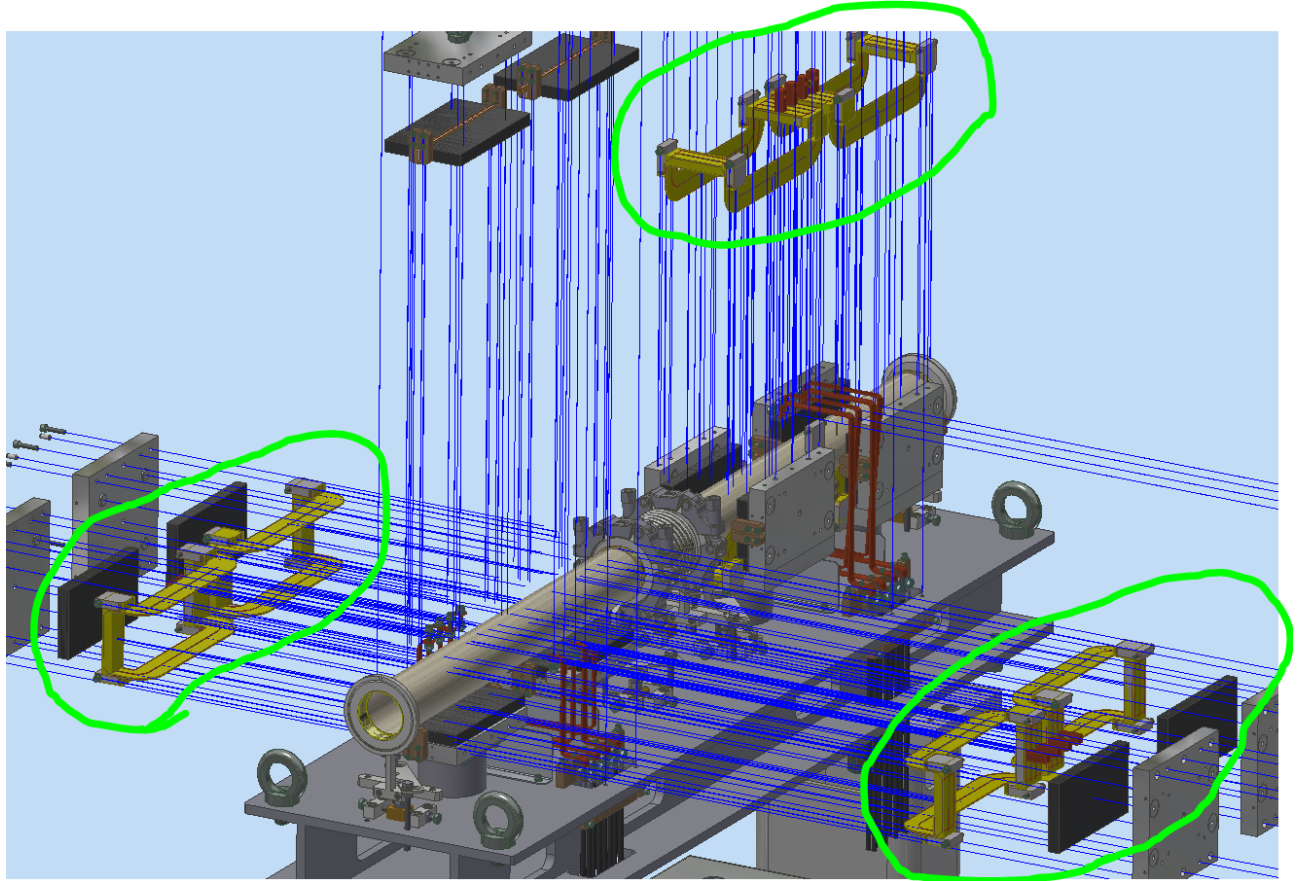
- Remove the screws that hold the B-dot sensors and coils (on both sides).



- First remove the top plate and then carefully remove the top ferrites. Take special attention when removing the ferrites to prevent chipping the ferrites.



- Now remove the coils, side aluminum plates and side ferrites carefully. Take special attention when removing the ferrites to prevent chipping the ferrites.



Now both vacuum chambers are accessible. To replace only one of the chambers, it is possible to follow the disassembling instruction only for those two magnets around the mentioned vacuum chamber.

Reassemble the magnets by following the instruction in reverse order.

4.5 Termination filter installation

Tools: Hex keys 5-14, adjustable spanner

- Mount the termination filter on the girder column
- To connect cooling water to the magnet, attach appropriate cooling water hoses to the cooling circuit

4.6 Power and safety interlock connection

Tools: Adjustable spanner

- Connect interlock wiring to control crate according to schematic 8200093700
- Connect load cable between output converter and termination filter according to schematic 8200093700. See also Figure 4.
- Remove cover from magnet terminals.
- Connect cable between termination filter and magnet terminal connection block according to schematic 8200093700. See also Figure 4.

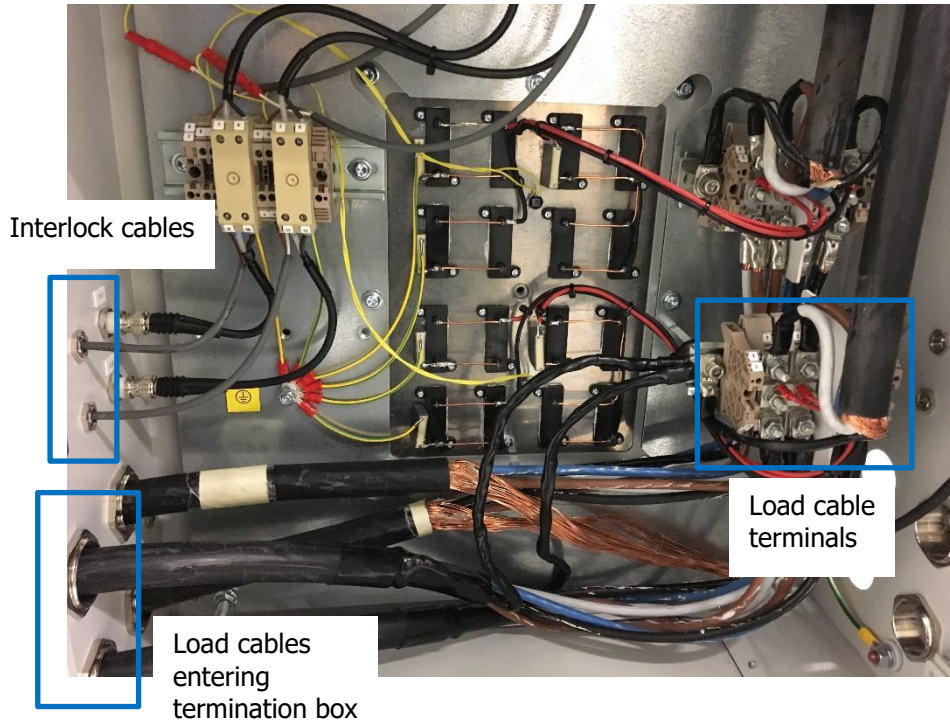


Figure 4: Inside view of the termination filter box

4.7 Coil Replacement

The replacement of coils may require fitting of the new coil and should be done under workshop conditions, preferably at Danfysik.

5 Preventive Maintenance

Before attempting any work on the accelerator equipment, make sure you are familiar with the safety procedures outlined in section 2, Read this first.

Ensure that power to the magnet has been turned off. Local regulations will provide instructions how this will be ensured.

Please notice that power will have to be turned on when performing the infrared test. Special care must be taken.

5.1 Preventive Maintenance Checklist

Use the Preventive Maintenance Check List in section 8.1.2 as a guide when carrying out preventive maintenance.

Tools: vacuum cleaner, hex keys 5-14, adjustable spanner, an infrared camera or infrared thermometer gun

5.2 Every 12 Months

5.2.1 Visual and Mechanical Inspection

Please refer to section 2, Read this first, before proceeding with any inspection.

- Check the magnet for excessive accumulation of dirt and dust.

- If necessary, clean dirty or dusty parts.
- Check for signs of corrosion on manifolds, fittings, brackets and alignment surfaces.
- Check for leaks when water cooling is on.
 - If necessary, tighten the clamps.
- Inspect electrical connections for degradation and tightness.
- Check electrical connections and coil termination for dust and debris.
- Check the coil for wear at all clamping points.
- Check that the thermostats are not loose.
- Check that all warning signs are legible and in place.

5.2.2 Infrared Test

WARNING

Perform this test under full load conditions. This test may only be carried out by trained personnel. Respect the minimum working distance at all times.

- Perform a test with an infrared camera or infrared thermometer gun
 - Conduct an infrared test on cables, coils, and termination filters for hot spots that may indicate overload conditions or loose connections.
 - If necessary, tighten electrical connections as indicated by the infrared scan.

NOTE

Some training and experience is necessary to interpret the results of the infrared scan.

Infrared scanning is an excellent tool for troubleshooting the complete electrical system, especially the serious problems that can result from poor contacts, improper connections, blown fuses, overloading or any other higher than normal temperature situations. The best time to make a thermographic survey is under full load conditions. Infrared inspections are extremely beneficial in reducing electrical failures by identifying potentially dangerous conditions, such as loose or dirty connections, overloaded or imbalanced circuits, or improperly installed equipment.

5.2.3 Water Hoses

WARNING

Risk of burns and scalds!

Damaged or worn cooling water hoses can cause water leakage.

The water cooling system of the termination filter is vital for continuous functioning of the system. If the filter overheats, thermostats will initiate a shutdown.

- Check water hose connections for leakages.
- Check water hose connections for signs of corrosion.
- Check water hoses for signs of wear.
- Check that all hoses are secured properly.

5.2.4 Cleaning

- Vacuum clean electrical connections.
In dusty or dirty environments the maintenance points listed should be performed more frequently. Dust particles on insulation become conductive when combined with moisture. This can lead to degradation of insulation, electric discharges and short-circuiting. Please notice that dust particles could be contaminated.

6 Troubleshooting

There are basically two types of faults that will initiate a check of the magnet, these are:

- Auto-generated error messages reported by the Accelerator Control System (ACS) such as:
 - Coil temperature above accepted level
 - Cooling water flow below accepted level
- Error messages reported by accelerator physicists indicating that a given magnet is not performing as required (or not conforming to specifications).

6.1 Troubleshooting Checklist

Symptom	Check	Probable Cause	Action
No magnetic field	Power supply	Cabling and connections	Check voltage at magnet connection terminal (compare with preset value from power supply).
		Power supply failure	Check power supply output voltage Please refer to MPS service documentation for details.
	Coils and connections	Short circuit in termination of coils	Check busbar and connections for visible short circuit. Testing with an insulation tester and a thermal imaging camera can help locate a short circuit.
Magnetic field not as required	Mechanical alignment	Collision - magnet support has moved during service or repair work on components nearby.	Re-align the magnet against system specifications, consult second line support or installation documentation.
		Failure in support structure	Repair/replace support and realign. Refer to installation documentation.
	Power supply	Cabling and connections	Check voltage at magnet.
		Power supply failure	Check power supply output Please refer to MPS service documentation for details.
	Coils and connections	Short circuit in coils	For coils connected in series: check voltage over each coil if possible.

Symptom	Check	Probable Cause	Action
		Short circuit in termination of coils	Check busbar and connections for visible short circuit. Testing with an insulation tester and a thermal imaging camera can help locate a short circuit.
Water spillage observed	Connection from water board	Unions and/or fittings loose or damaged	Check tightening torque and replace any damaged parts. Please refer to water board service documentation for details.
	Connection to termination filter	Unions and/or fittings loose or damaged	Check tightening torque or replace damaged parts.
Temperature error	Cooling water	Temperature of cooling water too hot when entering magnet	Check temperature of cooling water at inlet to magnet (must not exceed 30°C) Please refer to your cooling water documentation for corrective action.
		Water flow not adequate	Check water flow and pressure drop. Please refer to your cooling water documentation for corrective action.
	Thermo switch	Thermo switch malfunctioning	Check temperature with thermal imaging camera. Replace switch if temperature is not above 70°C
	Coil and connections	Short circuit in coils	For coils connected in series: check voltage over each coil if possible.
		Short circuit in termination of coils	Check busbar and connections for visible short circuit. Testing with an insulation tester and a thermal imaging camera can help locate a short circuit.
	Power supply	Power supply failure/faulty settings	Check power supply output Please refer to MPS service documentation for details.

Symptom	Check	Probable Cause	Action
Water flow error	Cooling water pressure	Inlet pressure below set point	Check pressure at inlet. Please refer to your cooling water documentation for corrective action.
	Magnet cooling system, coil/hose/manifold	Cooling system contaminated/clogged	Check coils with thermal imaging camera - this might reveal which section is clogged (raised temperature in section).
			Disconnect hoses and check each cooling circuit. Measure flow and compare all circuits.
			Check hoses and manifold for contamination.
			Note - flooding circuits in the reverse direction might remove any contamination.

If the above guide does not lead to detection and relief of a faulty magnet, then consult second line support:

Danfysik A/S
Gregersensvej 8
DK-2630 Taastrup
Denmark

Tel.: +45 7220 2403
Email: service@danfysik.dk

6.2 Checking coils or filters with a thermal imaging camera

Possible problems can be detected by monitoring a coil or filter with a thermal imaging camera. A local increase in temperature often indicates a poor electrical connection, a short circuit or poor cooling.

The thermal picture below shows an inadequate cooling of a termination filter.

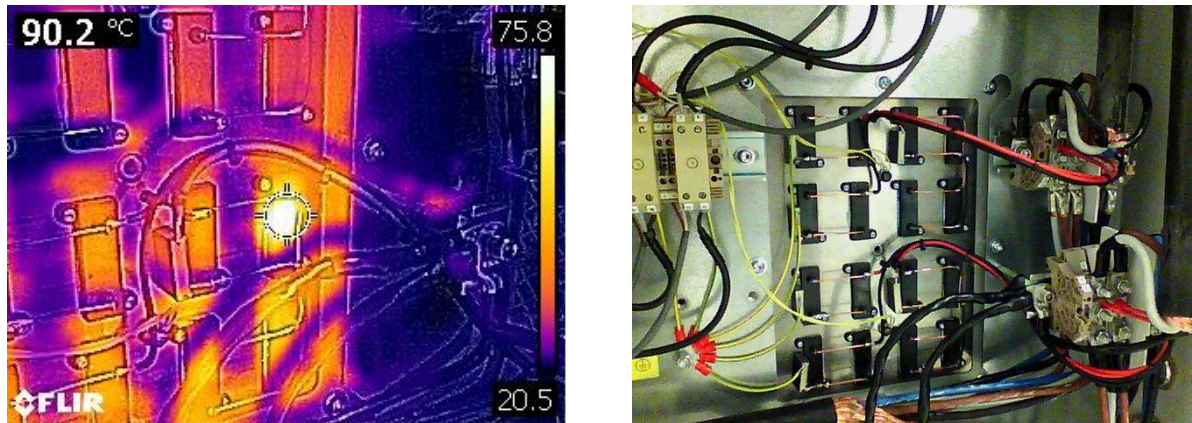


Figure 5: Thermal imaging of the inside of a termination filter.

6.3 Measuring flow in individual circuits

The water flow in all cooling circuits should be identical. In order to determine this, the flow must be measured for each circuit.

Follow this procedure:

- Turn off the water supply.
- Disconnect the first cooling hoses from the outlet manifold.
- Block the open manifold connection and direct the free end of the hose into a suitable container.
- Turn on the water supply and record the volume that bleeds over a fixed time (e.g. 10 s).
- Turn off the water supply again and repeat the procedure for all circuits.
- After the test make sure to assemble everything as before.

7 Deinstallation and disposal Instructions

This chapter describes how to deinstall the magnets and how to dispose of the individual components of the magnets.

Before attempting any work on the accelerator equipment, make sure you are familiar with the safety procedures outlined in section 2, Read this first.

7.1 Local laws

Accelerator Magnets must be disposed of according to local laws. If there is a contradiction between the local laws and instructions in this document, the local laws should be adhered to.

7.2 General

Accelerator magnets consist mainly of electronic components that can be disposed of and recycled in accordance with current WEEE and RoHS standards. All components must be disposed of according to local regulations.

This disposal information is relevant when disposing of the system after disassembly and when replacing defective parts during operation. Defective parts should be recycled if they cannot be repaired.

7.3 Deinstallation

- Ensure that all power has been turned off and that power cables have been disconnected before commencing any work on the magnets. Refer to documentation for magnet power supplies for power off procedures.

- Turn off water supply and remove the outlet hose for emptying water into your sewage/drainage system. Connect compressed air to the inlet hose (max. 10bar) and wait until the water stops coming out of the outlet hose.

7.4 Perform section 4.2 Installation of girder

Tools: Lifting device, adjustable spanner

- Lift the two columns 8103033528 in place according to dwg 7103033532 using an appropriate crane. M24 eye bolts should be used.
- Secure the columns to the floor using the $\varnothing 28$ mm holes in the columns.
- On one column:
 - Mount 1 link arm 7103033529 on the column for transverse alignment according to dwg 7103033532
 - Mount 1 M36 x 200 in hole the center of the column top plate. Adjust the height to app. 85 mm.
- On the other column:
 - Mount 1 link arm 7103033529 on the column for transverse alignment according to dwg 7103033532
 - Mount 1 link arm 7103033529 on the column for longitudinal alignment according to dwg 7103033532
 - Mount 2 M36 x 200 in the outermost holes in the column top plate. Adjust the height to app. 85 mm.
- Lift the girder 7103033526 in place on the two columns using an appropriate crane. The scanner magnets are installed when delivered. M24 eye bolts should be used for lifting.
- Connect the link arms from the columns to the girder.
- Final alignment can be done using the link arms and the M36 support rods.

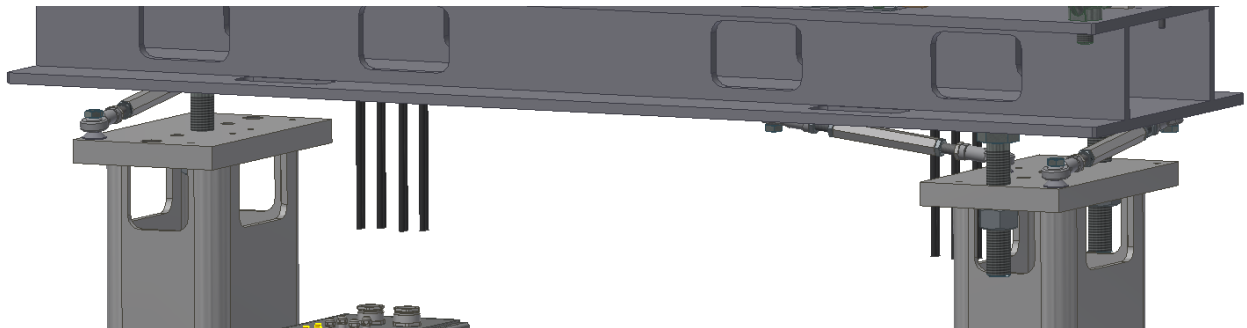


Figure 3: Girder placed on the columns

- Installation of the magnets in reverse order to deinstall the magnets.

WARNING

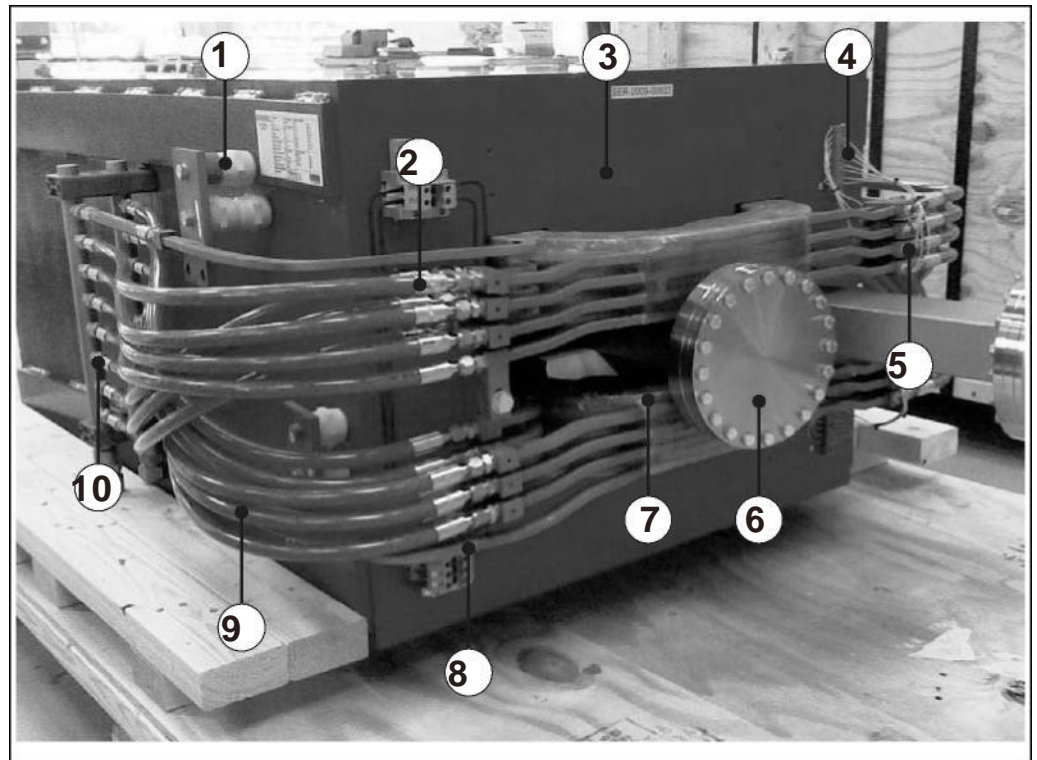
Metal exposed to high levels of radiation can still be activated. Follow the precautions and procedures laid down by your safety and environmental authorities.

7.5 Overview of a typical magnet

When disposing of a fully mechanically disassembled magnet, its parts can be divided into two groups:

- The yokes, covers and all loose parts such as water manifolds, hose fittings, nuts, bolts etc. are all considered non-toxic parts.
 - The yokes and all other metal parts can be disposed as "Regular metal waste".

- Covers, rubber pads, manifold brackets and hoses can be disposed as "Regular combustible waste". Cables, connectors, and thermos switches must be disposed as "Electronic waste".
- Coils are considered toxic due to epoxy which surrounds the coils and therefore have to be handled accordingly as hazardous material waste. They must be delivered to an authorized department which can dispose of the material according to local environmental laws.



1. Connector (electronic waste)
2. Water fittings (metal waste)
3. Yoke (metal waste)
4. Thermo switch connect (electronic waste)
5. Thermo switch (electronic waste)
6. Vacuum chamber (ceramic waste)
7. Coil (electronic waste)
8. Connector (electronic waste)
9. Hoses (polymer waste)
10. Manifold (metal waste)

8 Appendix

8.1 Checklists

8.1.1 Installation Checklist

Device Name:		S/N:	
Inspection person:		Date	
Test Step	Description	Accept Criteria	Result
Inspection after unpacking			
	Check transport crate for visual damage	No visual damage	
	Inspection of Tilt Tester	Indicator not red	
	Inspection of Shock Tester	Indicator not red	
	Visual inspection	No visual damage	
Inspection after installation			
	Check that magnet is mounted on support girder with the appropriate bolts	Torque:	
	Check that vacuum chamber is mounted on support girder with the appropriate bolts	Torque:	
	Check that the screen is mounted over the coil terminals	Present	
	Visual inspection for collisions with other parts	No collisions	
	Grounding wire connected to magnet is connected.	Torque:	
	Power supply cables are connected, 2pcs: Cable name 1:		
	Cable name 2:		
	Thermo switch cables are connected, 2pcs Cable name 1:		
	Cable name 2:		

Remarks:

8.1.2 Preventive Maintenance Checklist, referring to section 5, Preventive Maintenance

Device Name:		S/N:	
Inspection person:		Date	
Test Step	Description	Accept Criteria	Result
Visual check			
	Visual and Mechanical Inspection	Everything according to section 5.2.1	
Infrared test			
	Infrared test	Everything according to section 5.2.2	
Water hoses check			
	Check water hoses	Everything according to section 5.2.3	
Label check			
	Type plate on magnet	Present and visible	
Cleaning			
	Perform cleaning	Cleaning performed	
Remarks:			

8.2 Risk Analysis for installation and maintenance

Generic Hazard	Description	Applicable		Comments
		Yes	No	
IEC 60204-11:2000				
	Failures or faults in electrical equipment resulting in the possibility of electric shock or electrical fire;	Yes		Supplied voltage 427 V Supplied current 340 A Low duty cycle (power)
	Failures or faults in control circuits (or components and devices associated with those circuits) resulting in the malfunction of the machine		No	No control electronics included in magnet
	Disturbances or disruptions in power sources as well as failures or faults in the power circuits resulting in the malfunctioning of the machine		No	No control electronics included in magnet
	Loss of continuity of circuits that depend upon sliding or rolling contacts, resulting in a failure of a safety function.		No	
	Electrical disturbances (e.g. electromagnetic, electrostatic or radio interference) either from outside the electrical equipment or internally generated		No	
	Stored energy (either electrical or mechanical)		No	
	Audible noise at levels that cause health problems to persons.		No	
IEC 60204-1:2006				
	Surface temperatures		No	
IEC 61010-1:2010				
	Protection against electrical shock - Accessible parts - Voltage levels - Single Fault conditions: • Loss of protective impedance • Continuous operation • Capacitor S/C • Main Transformer S/C • Main Transformer overload • Output S/C • Loss of Cooling • Loss of insulation between circuits and parts • Interlock malfunction	Yes		Supplied voltage 640 V Supplied current 340 A Low duty cycle (power)
	Protection against mechanical hazards: - Static tests - Dynamic tests	Yes		Static only
	Protection against spread of fire		No	
	Equipment temperature limits and resistance to heat		No	

	Protection against hazards from fluids		No	
	Protection against radiation - ionizing radiation - accelerated electrons - ultraviolet radiation - microwave radiation - sonic and ultrasonic pressure - laser sources		No	
	Protection against liberated gases, explosions and implosions		No	

ID	Life cycle	Intended use or reasonably foreseeable misuse	User Group	Hazard Identification	Risk Estimation Before mitigation		Risk Evaluation	Mitigation No	Mitigation	Residual Risk		Risk Evaluation
1	Installation	Handling of heavy magnet	Installation Personnel	Risk of injury from fall	2	B	1	1	personal Safety measures applies e.g. Safety shoes to be worn during installation	1	B	1
								2	User manual to state minimum safety measures	1	A	1
2	Installation		Installation Personnel, Trained Operator	Risk of injury due to burrs and sharp edges	1	C	1	1	All edges rounded	1	B	1
3	Installation	Magnet receive high current from power supply - Connection box open	Installation Personnel	Risk of electrical burns - during installation	2	A	1	1	Power supply not to be energized before completion of magnet installation	2	A	1
4	Installation	damage of vacuum chamber - incorrect installation of magnet	Installation Personnel	Risk of damaging chamber due to wrong handling at installation.	1	C	1	1	Service manual to provide sequence for installation	1	C	1
5	Installation	damage to magnet - incorrect installation of magnet	Installation Personnel	Risk of damaging magnet due to wrong handling at installation	1	C	1	1	Service manual to provide sequence for installation	1	C	1
6	Operation	Magnet receive high current from power supply - Connection box open	Trained Operator	Risk of electrical burns - during commissioning	2	A	1	1	No user parts inside connection boxes	2	A	1
								2	Trained personnel	2	A	1
7	Operation	No water cooling or inadequate water cooling on termination filter	Installation Personnel, Trained operator	Risk of overheating termination filter.	1	A	1	1	Thermal switch mounted in each termination filter. Power must shut down if activated	1	A	1
								3	Service Manual to provide installation check list	1	A	1
8	Operation	Magnet receive high power from power supply - normal use	Trained Operator	Damage of equipment due to fire. Caused by bad connection.	2	B	1	1	Use of flame retardend materials , halogen free materials wherever possible.	1	B	1

							2	Installation manual to provide installation and maintenance check lists	1	A	1	
9	Operation			Injury due to inhalation of smoke	3	C	2	1	Use of flame retardend materials , halogen free materials wherever possible.	1	B	1
10	Operation	Magnet receive high power from power supply - Overcurrent from defect power supply.	Trained Operator	Injury due to inhalation of smoke	3	C	2	1	Use of flame retardend materials , halogen free materials wherever possible.	1	B	1
11	Operation	Magnet handling particle beam. - Beam loss into the magnet	Trained Operator	Risk of activating magnet causing radiological hazzard for environment and personal, degeneration of materials	3	D	3	1	Uses of radiation resistand materials. User responsible to install RP survillance and special maintainance/decom missoning procedures , design to quickly exchange the magnet and restriction of access to area	2	B	1
								2	service manual to state risk of activated parts.	2	A	1
12	Maintenance	Magnet receive high voltage from power supply - Connection box open	Installation Personnel	Risk of electrical shock - during installation	4	C	3	1	PCO not be energized before completion of magnet installation	2	B	1
								2	Warning must be added to user manual	2	A	1
13	Maintenance	Magnet receive high voltage from power supply - Connection box open	Trained Operator	Risk of electrical shock - during commissioning	4	C	3	1	No user parts inside connection boxes	3	B	2
								2	Trained personnel	3	A	1
								3	High voltage marking on connection box	3	A	1
14	Maintenance	Magnet handling particle beam. - Beam loss into the magnet	Trained Operator	Risk of activating magnet causing radiological hazzard for environment and personal, degeneration of materials	3	D	3	1	Uses of radiation resistand materials. User responsible to install RP survillance and special maintainance/decom missoning procedures , design to quickly exchange the magnet and restriction of access to area	2	B	1
								2	service manual to state risk of activated parts.	2	A	1
15	Deinstallation	Handling of heavy girder components	Installation Personnel	Risk of injury from fall	2	B	1	1	personal Safety measures applies e.g. Safety shoes to be worn during installation	1	B	1
								2	User manual to state minimum safety measures	1	A	1

16	Deinstallation	Magnet handling particle beam. - Beam loss into the magnet	Trained Operator	Risk of activating magnet causing radiological hazard for environment and personal, degeneration of materials	3	D	3	1	uses of radiation resistand materials, User responsible to install RP surveillance and special maintainance/decom missoning procedures.	2	B	1
								2	service manual to state risk of activated parts.	2	A	1

Risk Assessment Procedure according to IEC 61010-1 : 2010

This Risk analysis covers risks that can cause the component to become harmful in a way that affects personal safety, damage of equipment and or danger to the environment.

Normal use and reasonable foreseeable misuse is considered.

The analysis only covers hazards on the component itself. Consequenses in a specific application, due to loss of function in normal operation or due to misuse, is not considered. These hazards and their consequences must be addressed and solved in a system risk analysis by the system designer.

Severity of harm

Severity Group	People	Equipment / Facility	Environment
4 - Catastrophic	One or more fatalities	System or facility loss	Chemical release with acute or public health impact
3 - Severe	Disabling	Major subsystem loss or facility damage	Chemical release with temporary environmental or public health impact
2 - Moderate	Medical treatment or restricted work activity	Minor subsystem loss or facility damage	Chemical release triggering external reporting requirements
1 - Minor	First aid only	Non-serious equipment or facility damage	Chemical release requiring only routine clean-up without reporting

Probability of harm

Likelihood	Expected rate of occurrence
E - Frequent	More than five times a year
D - Likely	More than once per year, but not more than five times a year
C - Possible	More than once in five years, but not more than one a year
B - Rare	More than once in ten years, but not more than one in five years
A - Unlikely	No more than once in ten years

Risk Category

Severity of Harm	E - Frequent	D	C - Possible	B	A
4 - Catastrophic	3	3	3	2	2
3 - Severe	3	3	2	2	1
2 - Moderate	3	2	1	1	1
1 - Minor	2	1	1	1	1
Key	Category		Description		
1	Broadly acceptable		This fulfils the requirement for TOLERABLE RISK		
2	As low as reasonably practicable		This does not automatically fulfil the requirement for TOLERABLE RISK. If possible these risks should be reduced further to Key 1. If not possible, then the instructions should contain a description of the risk so that the safety responsible can take appropriate steps		
3	Intolerable		This contains risks that are not TOLERABLE RISK		

8.3 List of protective measures

- Thermoswitches
- Connection box with cover
- Insulation of coil and conductors

8.4 Drawings

- Main assembly drawing, 7103033504