COMPONENTS FOR SURFACE ANALYSIS

X-ray Source
XR-50

- High intensity
- Very low cross talk
- Highly efficient water cooling of anode and anode housing
The XR-50 is a new, high intensity twin anode X-ray source optimized for XPS experiments. The anode is made of silver to avoid any CuL\(\alpha\) breakthrough. The electron optical design of the anode, filament and source housing guarantees maximum X-ray intensity and very low cross-talk between the anode faces. A specially configured nose cone allows maximum access to the sample. The source housing may be pumped either via a series of integral direct pumping orifice or via DN38CF bypass differential pumping port with the direct pumping orifice sealed by a cylindrical sleeve. In addition to the anode the anode housing is very efficiently water-cooled in order to reduce the damage of the sample by thermal effects during operation. Even during longterm operation the sample temperature is not increased by more than 5\(^\circ\)C.

Controls

**POWER UNIT · PU-XR 50**
- Max. power 600W (15kV, 40mA)
- Display of anode voltage, emission, power, power limit, filament current
- Safety interlocks for water flow, vacuum and HT-protection
- Power unit to cooling controller interconnect cable
- Complete remote control by analog/digital interfaces
- 19\" (W) x 132 mm (H), 20 kg
- 230/115 V, 6/4 A, 50/60 Hz

**COOLING CONTROL · CCX 50**
- Display of flow rate/water pressure
- HT protection by closed metal cover
- Filter and water flow valve
- Interlock output for water flow
- Protected PTFE water pipes
- 5m flexible services conduit
- Option: Closed circuit water-cooling system
- 19\" (W) x 132 mm (H), 15 kg

SPECS GmbH – Surface Analysis and Computer Technology
Voltastraße 5
13355 Berlin
GERMANY
Tel: +49 (0)30 46 78 24-0
Fax: +49 (0)30 4 64 20 83
e-mail: support@specs.de
http://www.specs.de

Your Representative:

**Competence in Surface Analysis**
XR50

X-ray Source

Manual

1.1
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User Manual for the X-ray Source XR50.

SPECS order number for this manual: 7800132.
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- and “Initial Setup of the source” on page 23

For operation procedure please see section 4:
- “Normal Operation” on page 25
- “Switch-Off of X-Ray Source” on page 26

1.1 Application, Capability

The XR-50 is a new, high-intensity twin anode X-ray source optimized for XPS (ESCA) experiments in order to produce low energy X-ray quanta. Additionally the source can be used for excitation in Photoinduced Desorption Spectroscopy (PDS).

The standard XR-50 is equipped with a Mg/Al twin anode and designed with two filaments, and ensures continuous operation powers of Mg/Al 300/400 W. SPECS offers the capability of coating the anode on request with other elements or as a single anode for only Al or Mg operation.

The mounting flange is DN 38 CF (2 3/4” OD). The installation of an optional linear Z-shift allows the shaped nose cone of the XR-50 to be positioned very close to the sample during operation while being able to retract the source to provide space for other techniques or protecting the X-ray source window against contamination.

The slender design allows, if the XR-50 is used in a spherical or cylindrical analysis chamber, the arrangement of further analysis modules and excitation sources around a fixed sample.
The XR-50 module (with removed water supply and removed HV protection cover) can be baked up to 250°C allowing true UHV operation. „Quick Fit“ connectors are providing safe and rapid removing of water lines and HV cable.

The anode region of the XR-50 can be differentially pumped via a DN 38 CF (2 3/4” OD) flange, optionally. SPECS offers as an optional extra customized pumping facilities for a best fit to existing UHV equipment.

The power supplyXRC1000 and the cooling control unit CCX 50 for operating the XR-50 module are described in user manuals attached to these instructions.

The manual describes the installation of the X-ray source, the initial commissioning, the normal operation, and trouble shooting. The standard maintenance procedures for the X-ray source is described in Section 5.

1.2 Safety Hints

1.2.1 General

Attention!

Beware! Lethal high voltage up to 15 kV is applied to the X-ray source. Hazardous voltages are present, therefore only persons with the appropriate training are allowed to carry out the installation, adjustment and repair works.

All national, federal, state, and company or department internal regulations, restrictions, codes, and rules for protection against radiation sources have to be observed during installation and operation of the X-ray source at its site!

Consult your safety inspector in case of a primary installation and in case of any doubt. The users are responsible for a correct labelling of the source and its power supplies, and providing safety instructions in their mother language, if requested by the law!

Before any electric or electronic operations please consult „SPECS Safety Instructions“ and follow them strictly.
Some tests which might have to be carried out according to this manual are hazardous. These parts are indicated by a warning label:

!!Attention!!

The tests described in the following have to be performed at connectors of the electronics not plugged into the source. Hazardous voltages are present, therefore only persons with the appropriate training are allowed to do the job.

Make measurements only with special insulated tools released for voltages higher than 20 kV.

1.2.2 Special hints

1.2.2.1 HV protection

The XR-50 module needs high voltages up to 15 kV dangerous to life! You have to respect the following safety hints:

- Check whether your main voltage corresponds to the mains setting at the rear panel of the power supplies for the XR-50 (XRC1000 and CCX 50).
- Use only original cables, connectors, and flexible conduits from SPECS. Pay attention that all cables and water lines are without mechanical or electrical defects. In case of doubt the cable or the water line has to be replaced by an original SPECS part.
- Please connect the X-Ray source only with HF low impedance cable to the power supply ground. Large contact areas are important. A proper connection will protect the sensitive electronic units of your system and in your neighborhood.
- Never run the X-ray source without grounding cable or loosen ground connection!
- All shields for interlock, remote and other connections must be grounded with a proper HF performance, too!
- Operate the XR-50 only in case of a fully closed protection cover and properly fixed cable conduit for HV and water supply! Open slits and holes could be a danger for life and violating the regulations regarding X-ray protection!
- Do not operate the X-ray source unless your system pressure has come below $10^{-6}$ mbar!
- Do not operate the X-ray source without water cooling for anode. Cooling the housing jacket limits the temperature increase of an irradiated sample during continuous operation.
- Before switching on the power units the electrical and mechanical installation has to be completed. The interlocks for vacuum, water, and HV guard have to be correctly activated and tested for safe and proper functioning.
- Never short the HV guard and water interlock system!
Introduction and Safety Hints

- Never operate the power supplies with removed housing parts!
- Connect the XR-50 only when the power supplies have been turned off!
- After switching off the power units the operator has to wait in the minimum 3 minutes before opening any connections, the power supplies or the X-ray source protection cover.
- In case of wetting the XR-50 source by cooling water a complete drying of the module, the protection cover, the conduit, and the cables is strongly recommended. The usage of a fan could support the operation.
- Never run a wet XR-50 module or wet inner parts of the conduit!
- In case of operating the XR-50 with other equipment than delivered by SPECS, you may loosen your warranty. In case of doubt please contact the SPECS service department.

1.2.2.2 Soft X-ray radiation protection

Supplementary to the regulations, restrictions, codes, and rules for protection against radiation which have to be observed by the law at the operational site of the XR-50 SPECS recommend the following hints:

- Cover all window flanges additionally by X-ray protection lead glass or use window flanges with lead glass are useful but normally not necessary.
- All flanges of the chamber attached to the XR-50 have to be closed by blank flanges or compact UHV components made by stainless steel. If larger components of other materials (e.g. glass) are installed consult your safety inspector for suitable measures!
- Pregnant women should announce their situation to the superior or safety inspector!

Note:

Using acceleration voltage beneath 20kV the local dose performance of <0.1 µSv/h will not be obtained or exceeded anywhere at the source within a distance of 0.1m. Note that the source runs in vacuum only, i.e. if the plant itself is not passing the radiation, working with access trough a whole (open flange) is not possible. Normally stainless steel chambers and components as well as sight classes >1.5mm thickness (DN16CF windows) are not permeable for this kind of radiation because of the similar wall thickness like the source body.
2.1 Hardware Description

The complete X-ray source package consists of the X-ray source module XR-50, the power supplies XRC1000 and cooling unit CCX 50.

The mechanical parts of the X-ray source XR-50 are shown in figure 1 and are shortly described below:

- X-ray source main housing with bypass pumping port and cover support, 4-pin feedthrough for cathode assembly, and „Quick Fit“ connector flanges for the anode cooling and the water-cooled outer jacket. The mounting flange is DN 38 CF and so must be the gaskets.

Note: Cu gaskets for DN 35 CF are too tight! Use only Cu gaskets for DN 38 CF with min. 38 mm ID. The chamber flange inner diameter has to be 38.4 mm in minimum otherwise contact to water cooling lines will occur.

Note: Check inner diameter of the chamber flange where the XR-50 will be attached for primary installation! Estimate welding seams and mu-metal inlets, if exist!

- Rotatable X-ray source main chassis with source head, anode cage, bypass ring shutter, and fixing seats for the Cu made cooling tanks.
- Two opposite arranged cooling tanks.
- Cathode assembly with filament wire. (see figure 2).
- Anode, which is covered usual half with Al and half with Mg.
- Anode inner tube („water pipe“) with „Quick Fit“ connector flanges for water cooling of the anode and small Cu ring for sealing the anode water supply.
- Shaped Cu nose cone with X-ray source window made from alumina foil and a cross-talk protection rod.
- Ceramic flange for isolation of the X-ray source anode and „water pipe“ against ground.

The XR-50 module has a weight of about 10 kg.
2.2 Basic Principles

2.2.1 X-ray photon generation

If solid state material is bombarded by high energy electrons (> some keV) an ionization process of electron core levels occurs. If these vacancies are refilled by electrons from energetically higher levels characteristic X-ray radiation or Auger electrons will be generated. Besides these two processes also radiation with continuous frequency spectrum (Bremsstrahlung) will be produced by retarded electrons.

2.2.2 X-ray photon flow

The irradiated surface under regular anode to sample distance is of elliptical shape with an area of 1 to 2 cm² depends on sample distance.

Under the same conditions an unbiased sample current of approximately 0.8 nA per 1 W Mg Kα X-ray power is generated by irradiating a clean sputtered Ag target. If the photon yield is approximated to η = 1 a photon density of 5 x 10¹² s⁻¹ cm⁻² at 300 Watt can be calculated. A more realistic approximation based on a yield of 0.1 or 0.01 will change the mentioned value by the factors 10 and 100, resp.

2.3 General Information, Principle Setup

2.3.1 Twin anode

The main advantage of a twin or dual anode is that the simple alternative operation with two different excitation energies enables a rapid distinction of Auger electron lines from photoelectron structures in a X-ray source excited spectrum.

The most commonly employed anode materials in XPS are Al and Mg which are producing Kα,β radiation lines at energies of 1486.6 eV and 1253.6 eV, respectively. The natural line width is lower than 1 eV and sufficient to determine the binding energies of core levels within 0.2 eV.

In the Appendix excitation energies, relative intensities, and line widths of the main anode materials are referred (see table 1 on page 40). In Table 2 (page 40) of the Appendix the energy shifts and relative intensities of satellite lines regarding the main excitations are summarized.

Low energy X-ray excitation lines (Y Mα, Zr Mα) are attractive both for its energies at 132 eV and 151 eV, resp., and its natural line widths of 470 meV and 770 meV, resp. The radiation energies are intermediate between Al/Mg Kα and the quasi monochromatic UV excitations.
The anode and its water inner tube are interchangeable. Details of the procedure are described in section 5.5 and section 5.8.

The minimum distance between the center of the anode face and the sample is about 14 mm.

2.4 X-Ray Source Voltages and Currents

This document deals with different voltages, currents, and powers of the X-ray source. For a better understanding a block diagram is depicted below showing the source voltages and currents which are described below in details.

![Block diagram of principle operation](image)

**Figure 1**

2.4.1 Vacuum conditions

The design of the source fully meets the UHV requirements. The parts exposed to vacuum consist exclusively of high quality stainless steel, very pure copper, tungsten and alumina. The water-cooled outer jackets limits the temperature increase of an irradiated metallic sample during continuous operation to 3 K in comparison to ambient temperature.

During operation at max. power (400 W) a temperature increase at the X-ray source Cu head of max. 30 K was observed under regular cooling conditions. Therefore the efficient cooling will avoid intensive desorption from the walls.

The XR-50 could work satisfactorily in the pressure range below $1 \times 10^{-5}$ mbar. Nevertheless, better vacuum conditions in the $10^{-8}$ mbar range or better are strongly recommended to prevent contamination of the X-ray window and the volume around the anode behind. Good vacuum conditions will prevent oxidation of the filaments while in use, ensure a longer lifetime of anode and window, reduce the risk of sparkovers between the anode and grounded parts, and enables a longer availability of the X-ray source at full intensity.
2.4.2 Separate and Bypass pumping

The installation of a vacuum bypass or separate pumping system are a measure to ensure better vacuum conditions in the anode volume, especially during bakeout. Additional pumping facilities are strongly recommended if harmful or aggressive gas components are introduced in the main chamber or are decomposed.

The installation of a bypass or separate pumping will reduce aging effects of the anode and the Al window. The lowest level and the most simple solution for a bypass can be got by the installation of a flexible bellow connector between the XR-50 bypass flange and a suitable flange of the main chamber.

More comfortable bypass systems include either ion getter pumps or turbomolecular pumps, a valve which is remote-controlled for simultaneous venting and vacuum gauge for monitoring the pressure.

The bypass or separate line must be vented simultaneously together with the main chamber to avoid the damage of the Al-window (see section 2.4.3).

For the bypass ring shutter at the X-ray source main frame the following has to be considered:

- If no separate or bypass pumping the holes must be open!
- If separate or bypass pumping the holes must be closed!

2.4.3 Al window

The radiation aluminium window (standard thickness 2 μm) suppresses the Bremsstrahlung and prevents the input of stray electrons generated by the filament from entering the electron energy analyzer. Additionally the X-ray window works as a separation between the main chamber and anode volumes.

Note: Replace strong perforated X-ray windows because of stray electrons and enlarged portions of Bremsstrahlung.

A bore in the outer jacket of the source allows evacuation either together with the analysis chamber or separately via a DN 40 CF flange of a bypass system (see section 2.4.2).

The Al window can be destroyed if a larger pressure difference between the volumes before and after the window occurs. The bypass system must ensure by its construction or by automatic valves flanged to the main chamber that larger pressure differences (e.g. during regular or emergency venting processes) can be avoided.

Besides the anode degradation the contamination of the X-ray window from both side is the main reason for X-ray source intensity reduction. Therefore any dirty processes (e.g. sputtering, deposition, desorption) in the immediate vicinity of the Al window must be avoided in the chamber where the X-ray source is flanged on.
The retraction of the X-ray source from the sample during ion bombardment by a z-shift reduces the deposition rate at the Al-window in orders of magnitude.

The installation of a shutter just before the X-ray window and operated by remote control or by hand is an alternative tool for protection. Because of the space occupied by the shutter the X-ray source can not be arranged so close to the sample which results in a small intensity decrease.

The window can be contaminated as well from the inner side by deposition of anode and filament material or bypass line pump oil. In consequence of accidents (e.g. emergency venting, excessive O₂ inlet, turbomolecular pump breakdown) the material deposition or oil contamination can be enlarged.

Note: Any visible coloration of the Al X-ray window is a bad sign for thin films deposited which reduce X-ray intensity distinctly! Replace contaminated X-ray windows! Use z-retractor or shutter to protect the window during ion bombardment or other dirty processes in the chamber!

### 2.4.4 Bakeout procedure

With all cables and water pipes disconnected and with a removed protection cover the XR-50 can be baked up to 250 °C. In order to avoid temperature differences in the anode or the inner cooling tanks of the source it is recommended to remove (to blow out) all the water from the anode inner tube and the water-cooled outer jacket before the bakeout starts. This operation can prevent the formation of micro leakages.

SPECs recommends heating tents with IR radiators for the bakeout of the XR-50 and the chamber flanged on in order to ensure homogeneous temperature conditions without thermal gradients. The usage of heating straps and heating jackets is not supported by SPECs because thermal gradients enforce the redistribution of desorbed species from hot to colder inner surfaces.

Note: Homogeneous bakeout is essential for stable operation and long lifetime of anode and whole X-ray source.

### 2.4.5 Water-cooling

Note: SPECs recommends for protection of environment to utilize closed circulation water-cooling system.

SPECs supports for the XR-50 only the use of water as the cooling agent.

Full anode power dissipation of the X-ray source can only be obtained if the pressure of the cooling water is larger than 3.5 bar and the rate of the flow is about 2.5 - 3.5 l/min. The temperature should stay below 22 °C. Lower temperature than room temperature will force the water condensation and therefore flashover to ground inside the water conduit or the protection cover. Higher temperature results in overload, i.e. an evaporation of the anode material or worst case in a cracked anode with water injection into the vacuum chamber.
Normally the anode cooling and the outer jacket cooling will be performed serial (see figure 7, “Connection Diagram for X-Ray Source XR-50,” page 38). If the environment do not allow to get the cooling conditions of 2.5 -3.5 l/min a separate cooling of the outer jacket is possible. About 1 l/min in this line is enough to get the specified temperature limit of the source head.

2.4.5.1 Water resistance

During X-ray source operation the anode flange and the anode inner tube are contacted to Max. + 15 kV. The anode net power consists of X-ray radiation and heat dissipation. The anode gross power includes in addition the voltage drop via water inflow and reflow lines for the anode cooling. The water cooling box is grounded.

The difference between gross and net anode power will increase as much lower the water resistance or as much higher the water conductivity.

The difference between gross and net emission currents (so-called „water current“) should not exceed 10 mA. In other cases the cooling water in the closed circulation system must be replaced against deionized or distilled water after washing the pipes and the tank carefully from remains.

If otherwise the water resistance is too large (< 2 mA „water current“ at 15kV, e.g. application of clean, pure pipes and distilled water) sparks between anode and water line as well as enforced electrochemical attacks at the anode inner tube (especially at the „Quick Fit“ pipe connections) can occur. Under these circumstances a small amount of NaCl or the addition of tap water will reduce the resistivity and ensure stable conditions.

If the „water current“ exceeds the limit mentioned above for XR-50 users with tap water supply it is obvious that this type of cooling couldn’t be continued. The installation of a closed circulation system is indispensable.

Note: Water resistance is an important parameter for stable operation!

2.4.5.2 Circulation diagram

In figure 7, “Connection Diagram for X-Ray Source XR-50,” page 38 the arrangement of the water-cooling box CCX-50 and the water pipes is demonstrated. The water pipes have to be of sizes 3/4“ or 1/2“. Please note that a particle filter is added to the input line as standard!

If several consumers are attached to one circulator box or one water drain cock (e.g. turbomolecular pumps) the water flow rate, the heat transmission, and the water pressure have to be checked. The different water consumers have to be organized in a shunt arrangement. The conditions summarized in 2.3.1. and mentioned above have to be fulfilled for stable and sure operation under all different operational conditions and loads in the different lines.

Note: Take care that under all operational conditions the water flow rate, temperature, and water pressure are stable within the limits!
2.4.5.3 Water quality / Closed circulation system

If a closed circulation system is utilized some hints should be followed:

- SPECS recommend the use of deionized water for closed circulation systems to get correct water resistances.
- Follow strictly the instructions made by the manufacturer or supplier of the closed circulation system! Respect the safety instructions!
- Incorporate the control of the closed circulation water-cooling system into the X-ray source interlock system!
- Inspect sometimes the water level and quality to all appearances! Refill or replace water, if necessary!
- Wash and clean the box and the water lines, if too much water conductivity, resp. „water current“ was observed! Make some cleaning cycles with tap water before refilling deionized water!
- SPECS recommend the use of an anti-algeon agent to suppress proliferate biological activity. For the same reason the use of dark, non-transparent water pipes is advised.

2.4.5.4 Water Quality / Tap water

If tap water is utilized as the cooling agent some additional hints should be followed:

- Water polluted by suspended particles can not be utilized without particle filter.
- Water polluted by colored additions should not be used for cooling the XR-50 module.
- Salt water (also with lower concentration) cannot be utilized for reasons of reduced water resistance and increased electrochemical activity!

Note: Never utilize polluted or contaminated tap water for X-ray source module cooling! In case of doubt consult the local authority and water supplying company!

2.4.5.5 Contamination of Water pipes

The water pipes can be contaminated either on inner and outer walls. The main reason for contamination along the inner surfaces are particles and soluted chemical compounds deposited as sediments as well as biological origin. This process will be intensified if longer periods of X-ray source inactivity take place.

Please do not forget to add few drops of anti-algeon agent!

Note: If the X-ray source will taken out of operation for a longer period, remove the water hoses from the XR-50 module to avoid intensive sedimentation! Remove (Blow out) the water from the water pipes inside the module!

The water hoses could also be dirty at its outer walls depending from the purity level in the laboratory.
Under extreme situations the voltage drop which normally occur via the inflow and outflow anode water supply can be established alongside the sediments. Shorts to the grounded cover plate of the X-ray source could be developed. Parts of the plastic water hoses can be inflamed and melt.

Note: If such an very rare incident had occurred the total replacement of the water hoses within the conduit between XR-50 module and water cooling box is strongly recommended! Consult SPECS in case of such an incident! Replace the „Quick Fit“ connectors! Organize the restart of the water-cooling with very much care!

### 2.4.6 Use of a Z-retractor

The installation of a z-retractor between the XR-50 and the chamber flange offers the ability to move the whole source from its position for XPS into a parking position for other operations (e.g. ion bombardment, sample annealing, desorption, transfer, approach for other modules and methods).

The move of the XR-50 into the parking end position allows ion bombardment nearly without sputter deposition onto the Al-window. For delicate samples which could decompose or change their chemical bonding under X-ray radiation or electron bombardment (polymers, et. al.) a partial retraction of the X-ray source will reduce these damages.

The use of the z-retractor for avoiding thermal stress (as it is essential for some X-ray sources manufactured by other producers) is irrelevant for the XR-50. Because of the efficient cooling of Cu head and main frame thermal stress for the sample not occur also in case of long term operations.

### 2.4.7 Residual magnetic field

The XR-50 module head is manufactured mainly from Cu, Al, and other diamagnetic or nonmagnetic materials.

SPECS specify a residual magnetic field at the sample which is below 0.5 μT.

A very low level of magnetic fields in the volume between sample, electron energy analyzer, and X-ray source module is essential to get X-ray excited photoelectron lines of different kinetic energies from the same analyzer acceptance area.

### 2.4.8 Ghost lines and Cross talk

The XR-50 is equipped with Ag-tipped anodes coated usually with Al/Mg. Therefore Cu \( l_s \) breakdown structures which could complicate otherwise the XPS spectra interpretation are not expected if the Mg and Al thin films are exhausted regarding regular degradation.

The anodes are manufactured under carefully controlled conditions to guarantee an even and pure coating within the intended thickness. The UHV conditions during Al/Mg
deposition ensure very low oxygen contamination avoiding additional photoelectron structures and peak broadening.

Just behind the Al-window a small rod is arranged which reduces the Al/Mg cross contamination (so-called cross-talk) to values specified below 0.35%. The rod is oriented parallel to the groove at the anode top which is separating the two anode sides to each other. The distance between the rod and the anode is the most critical place for HV sparks inside the vacuum. Clean and dust free surfaces without sharp edges are recommended.

Figure 2 Cross talk spectra

2.5 X-Ray source

2.5.1 Anode
Anode: on positive high voltage
Anode material: Al, Mg, Al/Mg; other materials upon request
Anode base material: Ag-tipped
Anode voltage: + 15 kV Max., 0 to 40 mA (with respect to ground)
Power dissipation: 1 kW Max.
Continuous load: Al 400 W, Mg 300 W
Anode cooling: water, 3.5 to 5 bar, > 2.5 l/min, 15 ... 22 °C
Head cooling: water > 1 l/min, 15 ... 22 °C
Anode sample distance (regular) 15 mm

2.5.2 Cathode
Cathode: Tungsten (spiral)
Power consumption: Max. 30W
2.5.3 Operation Range

Working pressure: better 10^{-5} mbar (regular)
Bakeout temperature: 250 °C, without cable connections and protection cover

2.5.4 Setup

Vacuum pumping: via analysis chamber or via separate pumping line
Outer jacket: Cu pipes and Cu blocks, water-cooled
Anode: interchangeable on flange DN 38 CF
 Radiation window: Al, thickness about 1.7 -2 μm, pressure-proof to 1 mbar difference
Mounting flange: DN 38 CF, larger flanges upon request
Max. diameter: 37.8 mm
z-retraction (optional): 50/100 mm
Copper gaskets: DN 38 CF
Weight: 10 kg

2.5.5 Test Conditions and Results

UHV system with Quadrupol. Source was leak tested with He after a bakeout of 8h at 200°C.
Spherical Energy Analyzer: Mode B=const.
Cross Over for double anodes: less than 0.35%
Photo electron current (achieved): 280 nA (Ag, sputter-cleaned, 300 W Mg K_{\alpha}, for the used test system the photo electron current may be differ depending on sample distance
Residual magnetic field at below 0.5 μT
 sample position

2.5.6 XR-50 for X-ray Monochromator

The XR-50 can be altered for an use as a X-ray monochromator source (XR-50M with separate manual). Consult SPECS weather such a modification is intended.
2.6 Power Supply Units for Operation

SPECS specially designed for operation together with the XR-50 source module the power supplies XRC1000 and CCX 50. Some important information will be given in the next sentences.

Attention

Mind the safety hints given on page 2!!!
Beware! Lethal high voltage is applied to the water within the hoses during operation.

Warning: It will take 3 minutes before the turned off high voltage is reduced to about zero. So wait with patience at least 3 minutes before opening the protection cover and disconnecting any cables from the power supplies or the X-ray source.

2.6.1 Cooling Control Unit CCX 50

Size / Height: 19”, 3 chassis units (134 mm)
Depth: 360 mm chassis (+ 150 mm space for cable connections)
Weight: 14 kg (with conduit and HV-cover, unfilled)
HV limit: 15 kV
Flow rate measurement: mechanical flow meter, up to 5 l/min
Water pressure measurement: mechanical meter, up to 10 bar
Water Interlock: 5-pin DIN plug
Operating pressure: 3.5 to 5 bar
Power: no mains consumption

The water line consist of two PTFE hoses in a plastic covered, reinforced conduit. The Cooling Control Unit CCX 50 opens the water inlet valve, if the COOLING button of the X-ray power supply XRC1000 is pressed. The internal flow rate meter (visible from the front panel) has a set point value at 2.5 l/min and will enable the Operate function of the X-ray power supply via the interlock line.
2.6.2 Emission and High Voltage Supply XRC1000

(excerpt of the XRC1000 manual)

The new XRC 1000 supplies all voltages and currents needed for the operation of the source XR50. This power supply is also capable of powering other X-ray sources than the XR50.

The functions and controls of the XRC1000 can be divided into five main parts:

1. Front panel control
2. Rear panel control
3. Emission control
4. HV control
5. Remote control

The front panel provides a number of push-button, indicators, and displays allowing the user to control the power supply. On the rear panel a number of sockets and status indicators are provided for interlock control, filament supply, and high voltage supply.

The emission control supplies the filament current and regulates the emission current.

Two different anodes can be easily selected by push buttons.

The HV control supplies the anode voltage up to 15kV / 66mA. The high voltage output is short circuit and arc protected.

The optional remote control allows remote control via RS232 or CAN bus. This unit is also capable of ramping the high voltage automatically, e.g. after each backing out.

Figure 4 XRC1000 front view

Figure 5 XRC1000 rear view
**Size / Height:** 19” (W) x 132 mm (H, 3 chassis units) x 495 mm (T) +10 mm (plug)

**Depth:** 483 (+ 80 mm for cable plugs) x 33 x 57 mm

**Weight:** 18.5 kg

**High Voltage:** 0 - 15 kV, continuous

**Emission Current:** variable, standard up to 66mA

**Cathode Supply:** 0 - 8 A, 0 - 10 V

**Power:** 1000 W\(^1\)

**Mains:** 115 / 230 V, 50/60 Hz, Fuse: please check XRC 1000

**Interlock:** HV Guard, Vacuum, Water

**Optional**

Remote: Refer to the remote control manual

Soft start Variable ramp for voltage and emission current

---

\(^1\) The X-ray power is calculated by emission current \(I_E\) and high voltage. The total HV current \(I_{HV}\) consist of emission current \(I_E\) and Water current can be displayed separate. (see section 2.4.5.1, “Water resistance” on page 10)
Chapter 3

Installation of X-Ray Source & Supply Units

Refer to figure 6, “page 37 and figure 7,” page 38.

The X-ray source is supplied ex works for an application without separate or bypass pumping (see 2.2.3.).

If separate or bypass evacuation are required the bypass ring shutter figure 6, “page 37 must be rotated in such a way that the pumping holes of the volume around the anode become closed. The pumping port has to be connected to the separate or bypass system.

3.1 Test prior to Installation

Note: Prior to the installation of the XR-50 following checks are recommended:

1) Measure electrical resistance of both sides of the cathode (filament feedthrough flange, figure 6, “X-Ray Source XR-50,” page 37), nominal: < 0.5 Ohm.
   Please taking into account that two feedthrough pins are short circuit in the source. This two pins goes to the middle of the filament wire. Selecting a cathode means using one side of the circular shaped filament wire.
   Beware! For small resistances the measured value depends strongly on the type of the utilized measuring device and the applied measuring method.

2) Check whether cathode assembly has contact to the main source frame or not.

3) Check of the Al radiation window figure 8, “Source Head XR-50,” page 39 for any damage and the holder of the window for correct and tight fitting.

4) Check whether the anode flange and inner water tube have contact to the main source frame or not.
3.2 Installation of the source

No distinct fitting position for installation of the X-ray source is specified. However, the slender design allows the arrangement of further analysis modules around a positioned sample. Fit the source in accordance to the arrangement of other components.

If the XR-50 is mounted in a spherical chamber with the energy analyzer on top the feedthrough for the cathode supply should be aligned horizontally.

If bypass or separate pumping lines are planned to be installed further on the water connectors of the X-ray module chassis should be aligned on top.

If z-shift retractor is planned to be installed check space and best fitting position. Z-shifts supplied by SPECS are equipped with a DN 38 CF flange with a doubled bolt hole circle to guarantee best fitting orientation.

3.3 Water Connection

Usual connections as refer to figure 7, “Connection Diagram for X-Ray Source XR-50,” page 38.

Full anode power dissipation of the X-ray source can only be obtained if the pressure of the cooling water is between 3.5 and 5 bar and the flow rate is higher than 2.5 l/min (section 2.4.5).

1. Connect the Cooling Control Unit to the water supply. The water connection should be outfitted with a additional shut-off valve.

2. Inlet and outlet of the anode water cooling (plastic covered, reinforced conduit) should be carefully checked and connected to the anode inner tube pipe connections (shroud plug and socket) correspondingly according to the marks. Arrows at the water connectors of the anode water flange and of the hoses show the direction of the water flows out from the unit into the anode, and back from the anode into the cooling unit. *Normally the middle pipe connection at the anode inner tube flange means, water in' the anode.*

**Note:** Pay attention to the flow directions at the anode water flange. Mistakes can damage the anode thin films because of reduced cooling!

**Mind the safety hints given in „Exchange of the inner parts of the anode on page 34 and on page 2!!!**

3. The rate of water flow should not be set below 2.5 l/min. Maximum power can not be achieved at lower flow rate. Overload results in an evaporation of the anode material or worst case in a cracked anode with water injection into the vacuum chamber.

4. Connect the anode water reflow at the rear panel of the Cooling Control Unit to one of the water connectors of the XR-50 main housing.
The other water connector should be connected to the reflow flange of the closed circulation system or the water outlet.

**There is no privileged direction of the water flow in the XR-50 main housing.**

### 3.4 Electrical Connection

Usual connections as refer to figure 7, “Connection Diagram for X-Ray Source XR-50,” page 38.

The standard electrical supply for the X-ray source consists of two 19“-rack modules:

- the High voltage power & emission regulation unit XRC1000 (Section 2.6.2 ) and
- the Cooling Control Unit CCX 50 (Section 2.6.1 )

**Attention**

Mind the safety hints given on page 2!!!

**Warning:** It will take 3 minutes before all high voltages are absent. So wait at least 3 minutes before disconnecting any cables from the power supply or the X-ray SOURCE.

1. The high voltage unit has to be connected directly to the mains supply (115 / 230 V, 50/60 Hz).
2. The high voltage line between the cooling unit and further to the anode (cable no.7) is the most critical connection. A careful installation is necessary.
   - The high voltage connection between the Cooling Control Unit and the High Voltage Supply has to be fixed with traction reliefs on both sides.
   - Connect the X-Ray source with a HF low impedance cable to the power supply ground. Large contact areas are important. This connection will protect the sensitive electronic units of your system.
   - The connection from the cable no. 7 (HV to anode) to the banana plug has to be fixed with M2 screw.
   - The screen of the high voltage cable no. 7 (HV to anode) has to be connected with the back side of the cover plate of the source.
   - **A perfect screen of the high voltage cable protects your live, your additional electronic equipment and the XR-50 source.**
3. The safety interlock for the cooling water (Cooling Control Unit CCX 50), the safety HV-cover switch (of the X-ray source and the vacuum interlock have to be plugged into the respective sockets („WATER“, „HV-GUARD“ and „VACUUM“) at the rear panel of the X-ray power supply.
4. The water cooling unit has to be connected as referred figure 7, “Connection Diagram for X-Ray Source XR-50,” page 38.
Chapter 4

Operation of X-Ray Source

Attention

Mind the safety hints given on page 2!!!

For the initial commissioning and after each venting of the vacuum system or in a situation after bad vacuum conditions a careful setup of the X-ray source is recommended.

4.1 Initial Setup of the source

Note: Some steps described here result in pressure increases due to gas desorption. The pressure will decrease afterwards continuously. Each step should stay as long as the pressure is not longer decreasing, especially at higher voltages. A rapid increase of the high voltage can lead to violent plasma discharges and sparking, thus XR-50 source and electronics can be damaged.

4.1.1 Soft Start Option

If your supply dispose of a soft start ramp simply push the Ramp button. The Ramp push-button can only be used in conjunction with the optional remote interface. Upon pushing this button the high voltage and the emission current are ramped slowly for both anodes. This function is usually used to start up the source automatically after each bakeout. The LED is on if the ramp is in progress.

If spark-over or other failure occur, the ramp starting over 2 times and will stop, if the third ramp will not run, with a blinking Ramp lamp. Try it again and watch the display during the soft start to verify the failure.

The status after successful soft start is off.
For more details see also the user manual of the XRC1000 remote interface.
4.1.2 Manual Initial Setup

1. Check vacuum conditions, the chamber vacuum should be better than $10^{-7}$ mbar.
2. Set high voltage and emission current to zero (potentiometers named ‘Set’).
3. **Power** switch the supply on.
4. The interlock “**Water**” is blinking.
5. If any of the other interlock LEDs are unlighted check the appropriate connection, refer to the fault finding guide in the power supply manual.
6. Push the **Water** button. Now the cooling water circuit is switched on i.e. the valve for the water flow is opened. If all air bubbles in the cooling water hoses have disappeared after a few seconds the interlock cooling LED switches off.
7. Select the anode by pushing the button **Anode 1** or **Anode 2**.
8. Push **Standby**. This will set filament current to the standby current of about 1.5 A within few seconds.
9. Choose a small voltage (2 - 3 kV) and switch **HV on**. Increase slowly (1000V steps within few minutes) up to about 5 kV.
10. Switch anodes (respectively the cathodes) between the voltage steps!
11. Set the emission current to a small value (about 5mA) and start the Emission Regulation Circuit by pushing **Operate**.
12. You can watch filament current, filament voltage and power supplied to the anode in the power supply display by pressing the inscribed push-buttons.
13. Increase the high voltage and the emission current step by step (step width: 1000V, 5 mA) to 8kV as following:
   - After each step for the voltage increase the emission current after few minutes up to 10 mA and set back to 5 mA for the next high voltage step.
   - Monitor chamber pressure! (Note the hints above in front of this procedure!)
   - At 8kV you can go up to 20mA
14. Maintain a value of 8 kV 20 mA at least 1/2 h of operation.
15. Increase the high voltage and the emission current step by step (1000V, 5mA) to 12-14 kV, 100W
16. Wait at every step until the stable operation can be observed! Monitor the chamber pressure!
17. After few hours stable operation with low power (100W) the power could be increased slowly (50W / 5 min) to the desired value (depending on your desired working conditions, e.g. 12.5kV 20mA = 250W).

If stable operation of the X-ray source was observed over some hours before the procedure described here can be to abridged in case of a repetition. The high voltages
and the emission currents can be set with the velocities implemented by the power supply.

4.2 Normal Operation

1. Check vacuum, the vacuum should be better than 1 x 10⁻⁷ mbar.
2. Power on (switch left side at the front panel). The display comes up and the interlock lamps indicate the actual status. The lamp for the interlock Water is on.
3. If any of the other interlocks are enlightened check the appropriate connection, refer to the fault finding guide in section 5.1 in the power supply manual.
4. Push Water button. Now the cooling water circuit is switched on i.e. the valve for the water flow is opened. After a few seconds the interlock indicator lamp switches off.
5. Select the anode by pushing the button Anode 1 or Anode 2.
6. Push Standby (right side). This will set filament current to the standby current within few seconds. You may check this pressing I₁ button below the monitoring display.
7. Choose the desired voltage with Set potentiometer below the ‘Anode Voltage (kV)’ section and switch HV on (red button). Wait for the end of the voltage ramp.
8. Set the emission current to the desired value and start the emission regulation circuit by pushing the Operate button.
9. You can watch total current, power, filament current and filament voltage supplied to the anode in the power supply display by pressing the inscribed buttons section 3.2.2 in the power supply manual.
10. Wait until the system has become stable (monitoring the pressure)

In case the high voltage is automatically switched off due to an interrupt of water flow (e.g. air bubbles) or due to activation of vacuum safety control the above described procedure should be repeated to turn on the high voltage again.

Beware:

If in the „operate“ mode the I₁ is blinking, the „current limit“ is active, then the filament assembly is shorted or the preset high voltage is not sufficient to enable the chosen emission current. Check filament resistance! In the second case it is necessary to increase immediately the high voltage or decrease the emission current. Otherwise the life time of the filament would be shortened or cathode material could be evaporated onto the anode faces.

- Never short the interlock system for HV Guard and Cooling!
- Never operate the X-Ray source without cooling! The anode coatings will be evaporated immediately and the anode can be cracked.
4.3 Switch-Off of X-Ray Source

1. For turning off the power supply push the HV on button. HV will be switch off and the filament goes immediately in the Standby mode (The LED at this button is active).
2. Push Standby to switch off the filament (LED in this button is off).
3. Wait one minute then turn off the water circuit by pushing the Water button.
   The water cooling should not be continued, otherwise the anode will be cooled down and become the coldest surface of the analysis system. Intensive condensation of contaminants at the anode surface would be the unintended result.
4. Power will switch off the power supply.
5. Turn off the water support from (and to) the cooling unit. For a longer non-operational period it is recommended to remove the water supply and to effuse the water from the pipes.

Attention

Mind the safety hints given on page 2!!!
Warning: It will take 3 minutes before all high voltages are absent. So wait at least 3 minutes before disconnecting any cables from the power supply or the X-ray SOURCE.

4.4 Bakeout of X-Ray Source

For bakeout the system with the X-ray source it is necessary to remove all cables and water connections.

Attention

Mind the safety hints given on page 2!!!
Warning: It will take 3 minutes before all high voltages are absent. So wait at least 3 minutes before disconnecting any cables from the power supply or the X-ray SOURCE.

Refer to figure 7, “Connection Diagram for X-Ray Source XR-50,” page 38.

1. Loosen the grounding cables. Loosen the screws of the protection cover (back plate of the cover too).
2. Pull back the released tube of the protection cover.
3. Relieve connecting cables (HV) and water hoses.
4. Detach cooling water connection.
5. Place the protection cover (anode plug) outside the bakeout zone.
6. Remove filament supply (loosen the fixing screw first).
7. Prior to bakeout it is most important to remove the remaining water out of the anode and the main housing of the module.

The X-ray source can be baked up to 250°C.

After the bakeout the reassembling of the X-ray source should be carried out in reversed order.

4.5 Hints for Operation

Depending on the utilized anode material an operating voltage exists for the X-ray source at which the X-ray quantum yield is in its maximum for a certain fixed anode dissipation power. Therefore sample currents generated by 300 Watt (15 kV, 20 mA) and by 300 Watt (10 kV, 30 mA) will be distinct.

Additionally it is possible to determine the state of aging of the anode with the aid of the curves of X-ray quantum yield versus applied high voltage at constant anode dissipation power. The sensitivity achieved in ESCA depends on the sensitivity of the energy analyzer and the specific radiation density of the characteristic X-ray emitted from the sample surface.

The specific radiation intensity on the sample surface depends on the X-ray power as well as on the X-ray-anode-sample distance. The X-ray-anode-sample distance is determined essentially by the sample geometry. Additionally the specific radiation intensity depends on the applied high voltage in the X-ray source. This is reasonable because below the ionization energy (approx. 1500 eV for Al) no characteristic X-ray radiation can be emitted, even by using very high anode power. On the other end it is well-known that the ionization cross section decreases with increasing energy. It exists therefore between these two extrema an optimum, by applying a constant anode dissipation power. The maximum lies at 10-13 kV for Al and 13-17 kV for Mg anode. The yield curves show a flat region around the maximum. This effect is additionally stabilize the X-ray power. Normally an operation voltage of 12.5 kV is enough to get a optimum radiation for both anode materials.

Strong outgassing organic samples can lead to a contamination of the anode with carbon or other materials. The same effect will be caused by frequent operation of the analysis system under bad vacuum condition. This contamination layer reduces the X-ray intensity because the electrons for the excitation of the anode material must penetrate this layer first. This effect of intensity decrement is distinguishable from other influences, e.g. change of amplification of the multiplier, if the intensity yield curve is plotted versus applied high voltage at constant anode dissipation power. With a contaminated anode the maximum will be drifted towards higher energies. If the contamination is to strong then the maximum will even disappear within the working range of the X-ray source up to a high voltage of 15 kV.

The contamination of the anode caused directly by the sample will be eliminated because of the using of the Al radiation window.
The transmission of the Al window will be influenced by sputtering of the sample in front of the source as well as by the evaporation of tungsten from the filament during operation or because of fusing.
A 0.2 μm Tungsten layer on the window absorb the same intensity as 2.5 μm Aluminium. Each anode exchange or filament replacement should be normally associated with a window exchange.
SPECS offers a complete cleaning and testing of your X-ray source on request (Overhauling „XR-50“). This offer includes anode and filament replacement, anode inner tube replacement or refurbishment, if necessary, and a complete test with specification report.

Important Safety Information:

- **Note that products returned to SPECS for repair or maintenance must be free of harmful substances (e.g. radioactive, toxic, caustic or microbiological). Otherwise, the type of contamination has to be declared.**

### 5.1 Spare parts

Spare parts filament, anode, Al-radiation window, anode inner tube (water inlet part), hose connections, filter

Please contact SPECS (support@specs.de) for actual prices and delivery time.

### 5.2 Fault Finding

### 5.3 Power Supply Fault Finding Guide

Please check the power supply fault finding guide in the supply manual.
5.3.1 HV sparks

If HV sparks occur normally the power supply will switch off the HV and go to standby mode. At the beginning of the source operation and after venting or replacement of source parts some sparks may occur. Normally the abundance will go down.

Possible sources for HV sparks are:

- bad ground connections
- bad vacuum conditions
- water leakage inside the protection cover
- the protection cover itself (PTFE isolation)
- the HV cable or the HV supply
- the anode (especially the critical distance between anode and Al window rod which suppress the crosstalk). Overload, contaminations, dust particles or cooling problems perform the building of small spots with a crater shape and sharp edges. HV sparks force the building of such pits. This is accompanied in an evaporation of the anode material or in the worst case in a cracked anode with water injection into the vacuum chamber.
- the Al window (esp. crosstalk rod) shows sharp edges

Attention

Mind the safety hints given on page 2!!!
Warning: It will take 3 minutes before all high voltages are absent. So wait at least 3 minutes before disconnecting any cables from the power supply or the X-ray source.

If the frequency of sparks increases it is absolutely necessary to find out the reason. Please try to find out either the sparks are outside or inside the source (vacuum). Please contact SPECS prior to dangerous test procedures!

1. The sparks effect the pressure inside the vacuum chamber or not? Please consider that even in case of HV sparks outside the source module the vacuum reading at the controller can be influenced by electromagnetic pulse EMP, pretending a pressure increase.

2. Do the sparks depend on operate / standby and / or the absolute value of high voltage?

3. Do the PTFE shield inside the protection cover is not complete and / or shows HV traces and / or is dirty / wet?

4. Switch off the HV and check the HV cable isolation between line and screen. Disconnect the HV cable at the source (banana plug) and isolate this contact very proof.
WARNING!
HAZARDOUS VOLTAGE! DANGER FOR LIFE!

5. Sparks occur still in standby mode?
   (Do not perform operate, because the filament current will goes to I_M.
   This will decrease the filament life time.)

If sparks still occur:
   HV sparks are in the supply the protection cover or the HV cable!
   Separate the source by disconnecting step by step the supply line.

Reassemble the original configuration to avoid any dangerous situation.

5.4 X-ray Source Check

Note: Place the source which was removed from the main chamber on clean and
spacious table and use the water bypass tubes and the water inlet as support points.
Caution: If the anode and the water inlet flange are removed for maintenance the
source head will become the third support point because of a different weight-
distribution balance. Avoid damage of the filaments!

If the XR-50 is removed because of one of the Maintenance procedures described below,
the following source checks are recommended to avoid later troubles:

- Cathode OK? (resistance, check by appearance)
- Al radiation window OK? (holes, contamination either from sample or anode
  side) see also “Hints for Operation” on page 27
- If the Al window was damaged by pressure difference the lost Al foil must be
  found by all means otherwise electrical contact between the anode and the
  grounded XR-50 body can be occurred.
- Anode centering bush (Vespel) contaminated? Measure the resistance between
  anode and body.
  Anode still centered or misaligned? The Cu cathode cap (see figure 8,” page
  39) must be removed for this procedure.
- If damaged or malfunctioning parts are identified, replace or refurbish these
  components! Otherwise valuable experimental time will be lost!

5.5 Exchange of Anode

For exchanging the anode it is not necessary to remove the X-ray source from the
vacuum system.

Attention

Mind the safety hints given on section 1!!!
Warning: It will take 3 minutes before all high voltages are absent. So wait at least
3 minutes before disconnecting any cables from the power supply or the X-ray SOURCE.

Refer to figure 7,“ page 38 and figure 8 in section 6.1.

Remove all connections of the source (see “Bakeout of X-Ray Source” on page 26). It is necessary to remove the anode and water inlet flange from the X-ray source body (ceramic stay on body).

Following procedure must be carried out:

1. Remove the flange screws of the anode/water inlet.
2. Remove internal part (water inlet flange) of the anode.
3. Remove the anode. Note the Al / Mg direction!
4. Replace the used copper gasket with a new one.
5. Insert the new anode with Mg / Al sides as memorized.
6. Replace the used Cu water sealing ring
   (a new one is supplied together with every new anode; shape is not important, it is only a water sealing!).

Beware:
Fasten the screws until the slit between the flanges become invisible. If necessary apply slightly excessive torque to the screws.

7. Reassemble in reversed order.

Please see “Recommendations new anode and water inlet” on page 35, also.

5.6 Exchange of Cathode

For exchanging the cathode it is necessary to remove the X-ray source from the vacuum system.

Attention

Mind the safety hints given on page 1!!!
Warning: It will take 3 minutes before all high voltages are absent. So wait at least 3 minutes before disconnecting any cables from the power supply or the X-ray SOURCE.

Refer to figure 7, “Connection Diagram for X-Ray Source XR-50,” page 38 and figure 8, “Source Head XR-50,” page 39.

Remove all connections of the source (see “Bakeout of X-Ray Source” on page 26) and remove the X-ray source.

Following procedure must be carried out:
1. Check the height of the cap in respect to the copper head body.  
   (Slit size between this two parts.)
1. Loosen the cylindrical screws.
2. Carefully pull out the cathode cap without to cant the cathode cap.
3. Loosen the fixing screws of the cathode.
4. Pull the cathode out of the support pins.
5. Insert the new cathode on the supporting pins until the uppermost part of the filament not see the surface of the anode.  
   (Normally it is ok if the height of the new filament is like the old one.)
6. Fix the M2 screws.
7. Mount carefully the cathode cap onto the external cylinder of the X-ray source.  
   Height of the cap should be like checked above.

Important: The cathode cap must never touch the cathode. Connect Ohmmeter between the corresponding cathode pin and source body, then observe the electrical resistance while carrying out whole adjustment.

Eventually it would be recommendable to bent carefully the filament or at least the supporting pins to correct the position of the cathode.

8. Fix the cylindrical screws.

Please see “Test prior to Installation” on page 19, also. Adjustment of the $I_{\text{standby}}$ and $I_{\text{MAX}}$ filament current setting may be necessary (see “Emission and High Voltage Supply XRC1000” on page 16)

**5.7 Exchange of Aluminium Window**

For exchanging the window it is necessary to remove the X-ray source from the vacuum system.

**Attention**

Mind the safety hints given on page 1!!!  
Warning: It will take 3 minutes before all high voltages are absent. So wait at least 3 minutes before disconnecting any cables from the power supply or the X-ray SOURCE.

Remove all connections of the source (see "Bakeout of X-Ray Source" on page 26) and remove the X-ray source.

1. Remove the Al window by loosen the guard ring and pull out the window.
2. Insert carefully the Al window into the groove of the copper cooling cap and press the window ring slightly. Make sure that the Al window lies flatly on the cooling cap and not bent.
3. Fix the Al window with the guard ring. Cover the window during this process with a flat smooth part.
4. Insert the X-ray source.

Please see “Test prior to Installation” on page 19 and “Recommendations new anode and water inlet” on page 35, also.

5.8 Exchange of water inlet (anode inner tube)

The inner part of the anode (water inlet), which is support the water to the anode walls, is influenced by corrosion (see “Corrosion of the water inlet parts” on page 35. This effect is much stronger for deionized water. As long as the front surface of the connectors (shroud plug and socket) is still smooth there is no danger. If the surface shows deep craters the inner part should be changed.

**Warning**

*If the water connection are leaky, water with high voltage will drop into the source cover. The high voltage will be automatically switched off.

Mind the safety hints given on page 1!!!*

To exchange the inner part of the anode it is not necessary to remove the X-ray source from the vacuum system.

**Attention**

*Mind the safety hints given on section 1!!! Warning: It will take 3 minutes before all high voltages are absent. So wait at least 3 minutes before disconnecting any cables from the power supply or the X-ray source.*

Refer to figure 7, “Connection Diagram for X-Ray Source XR-50,” page 38.

Remove all connections of the source (see “Bakeout of X-Ray Source” on page 26).

Following procedure must be carried out:

1. Follow the procedure given in “Exchange of Anode” on page 31 item 1 up to „Replace the used copper gasket with a new one.“
2. Inspect the anode and insert the old one, if no strong damage is visible.
3. Replace the used Cu water sealing ring on the anode flange (a new one is supplied together with every new anode or water inlet part). Insert the water inlet part.
4. Fasten the screws until the slit between the flanges become invisible. If necessary apply slightly excessive torque to the screws.
5. Reassemble in reversed order.

Please see “Test prior to Installation” on page 19 and “Recommendations new anode and water inlet” on page 35, also.
5.9 Recommendations new anode and water inlet

Note: These recommendations should be followed up to prevent a rapid decrease of the anode performance.

5.9.1 Length of the water inlet part (anode inner tube)

The inner tube should never be installed enforcing mechanical pressure into the inner of the anode. The length of the inner tube should have to fit exactly to the anode. Otherwise the regular water flow will be reduced and the anode will degrade very fast. Simply blow trough at one of the connections is the best way to make a continuity check. The pressure to blow trough should be similar to fill a balloon.

5.9.2 Corrosion of the water inlet parts

The inner tube as well as the water pipe connections underlies because of its connection to + 15 kV anode voltage a normal process of electrochemical corrosion. Electrochemical corrosion at the water pipe connections causes step by step a decomposition of the „Quick Fit“ couplings. Please check the connections occasionally. Replace the anode inner tube and the „Quick Fit“ connectors if water leakages are observed. Sedimentation processes take place especially in the top of the tube. This sedimentation effect is accelerated after the X-ray source was taken out of operation for a longer period. The sediments should be removed mechanically to guarantee effective cooling of the anode.

5.9.3 Cooling with tap water

By cooling with tap water with low temperature (10 - 14 °C) the cooling effect on the main body of the x-ray source module can be felt. Lower temperature than room temperature will force the water condensation and therefore flashover to ground inside the water conduit or the protection cover. Higher temperature results in overload, i.e. an evaporation of the anode material or worst case in a cracked anode with water injection into the vacuum chamber.

5.9.4 Closed circulation water-cooling systems

Especially during high power operations (> 300 W) please check the cooling temperature which should be lower than 20 °C. Please note that blocked filters in the water line could reduce the water flow dramatically resulting in temperatures at the anode at which the anode material will be evaporated. Therefore it is strongly recommended to tune the water flow meter to a level with a flow rate higher than 2.5 l/min.
6.1 Pictures and Drawings

Figure 6  X-Ray Source XR-50
Figure 7 Connection Diagram for X-Ray Source XR-50
Figure 8  Source Head XR-50

Source Head Scheme
XR 50
6.2 Excitation energies of different anode materials

Excitation energies and line width of the main X-ray source anode materials

<table>
<thead>
<tr>
<th>Element and Line</th>
<th>Excitation Energy (in eV)</th>
<th>Linewidth (in meV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mg Kα1/2</td>
<td>1253.64</td>
<td>680</td>
</tr>
<tr>
<td>Al Kα1/2</td>
<td>1486.65</td>
<td>850</td>
</tr>
<tr>
<td>Zr Mβ</td>
<td>151.4</td>
<td>770</td>
</tr>
<tr>
<td>Y Mβ</td>
<td>132.3</td>
<td>470</td>
</tr>
<tr>
<td>Si Kα</td>
<td>1739.5</td>
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<td>Zr Lα</td>
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<td>Ag Lα</td>
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Ref.: D. Briggs and M.P.Seah, Practical Surface Science Analysis, Wiley, Chichester, p.50, p.128

Table 1: Main X-ray source radiation lines

6.3 Satellites of Mg and Al

Energy shifts and relative intensities of Kα satellites of Mg and Al

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<thead>
<tr>
<th>Line</th>
<th>Energy shift (in eV) Mg</th>
<th>relative Intensity (in %) Mg</th>
<th>Energy shift (in eV) Al</th>
<th>relative Intensity (in %) Al</th>
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Ref.: J.F. Moulder et. al., Handbook of X-ray Photoelectron Spectrosc., Physical Electronics, Inc., 1995, p. 18

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