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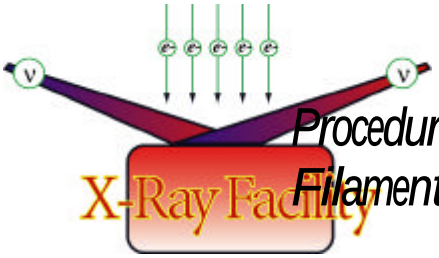
X-Ray Facility Hardware Manual

Filament Change



Procedure for changing burnt X-Ray Generator Filament and replacing it with a new filament

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August 05, 2001
Photos courtesy of Rigaku/MSC

Filament Change

*Procedure for changing burnt x-ray filament and replacing it with a new filament**

Introduction

During the regular use of the x-ray generator (Rigaku generator is only covered in this write-up) the filament that produces the electrons burns out and needs to be replaced. The useful life of a typical x-ray filament is approximately one thousand hours of operation (assuming continuous generator operation this means filament needs to be changed once in forty days). The symptoms of a burnt out filament are one or combination of the following:

- Alarm at the x-ray generator with a lit red LED next to FC
- Needle at the filament current meter shows no measurable value
- Hour meter does not change value even after several minutes of generator operation
- No diffraction pattern after eight to ten minutes of exposure
- Absence of water ring and/or absence of beam stop shadow in diffraction pattern.

This notes describes how to remove the burnt filament and replace it with a new one. Due to the fact, we have to break and regenerate high vacuum, the whole procedure can take eight to ten hours.

Removal of burnt filament

1. Switch the x-ray generator off, close the chilled water supply to the Haskris water chiller[1], however, maintain the water circulation to the generator and wait for ½ hour.
2. Shut the rotating anode (RA) off, if it is not already off, and shut down the vacuum pumps. Switch off the main powers at the gray breaker box on the wall, switch off the Haskris water chiller, and wait for another ½ hour.
3. Using the special tool (flat steel plate with a wedge[2]), open the vacuum release valve[3] (see Figure 1) underneath the front covers to the anode chamber and let in air slowly. Once the anode chamber is equilibrated with

[1] Haskris water chiller is located beside the generator and connected to the building chilled water supply.
[2] For a picture of the special tool, consult magnetic seal replacement procedure Figure 1.
[3] Vacuum release valve has a knurled circular head with a '-' slot in the middle.

outside pressure, tighten the vacuum release valve back to the original position (hand tight).

Figure 1 *Vacuum release knob located beneath the rotating anode chamber*

4. Using a Phillips screwdriver carefully remove the four screws (see Figure 2) found on the front vacuum cover assembly of the x-ray generator head, ensuring that the removal of the screws proceed uniformly.

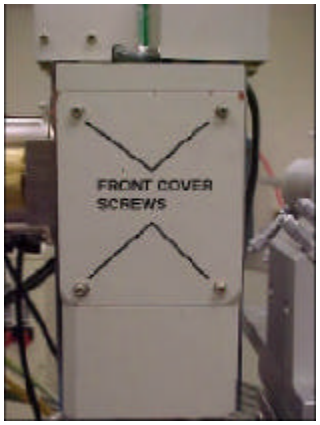

Figure 2 *Front vacuum cover assembly with screws highlighted*

5. Remove the front vacuum cover and its 'o'-ring making sure NOT to touch the interiors of the cover or the chamber. Place the cover and the 'o'-ring aside. Now you can see the interior of the anode chamber (see Figure 3).

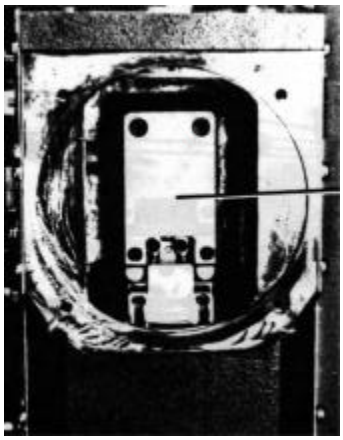

Figure 3 *Cathode assembly & anode chamber upon removal of front vacuum cover plate*

6. Now place a long lint-free Kimwipes ® EX-L[4] inside the space made available with the removal of front cover. The idea behind the Kimwipes is to protect any screws, shims, and such falling into the vacuum chamber located directly underneath the cathode assembly while one is removing the burnt filament (see Figure 4). So, stretch the wipe underneath the cathode assembly and let part of it hang outside the chamber. Essentially all operations are done above the wipe and anything falls will be caught by the wipe.

Figure 4 *Cathode assembly with Kim Wipes placed beneath the assembly*

7. Visible in front will be the back of the cathode assembly (it may be VP3 cathode, i.e., 0.3 x 3.0 mm^2 fine focus cathode). The terminal cover-plate[5] protecting the filament terminals is located directly beneath the cathode assembly. Carefully undo few turns of the two Phillips screws holding the plate, with out completely removing the screws.

[4] Long Kimwipes are better due to their extra width.
[5] Terminal cover plate is very thin silvery plate with two oval-shaped slots at the bottom corners.

8. The terminal cover plate should automatically slip down revealing behind it the two terminal posts for the cathode (see Figure 5). Now tighten the Phillips screws back with the terminal cover plate down.

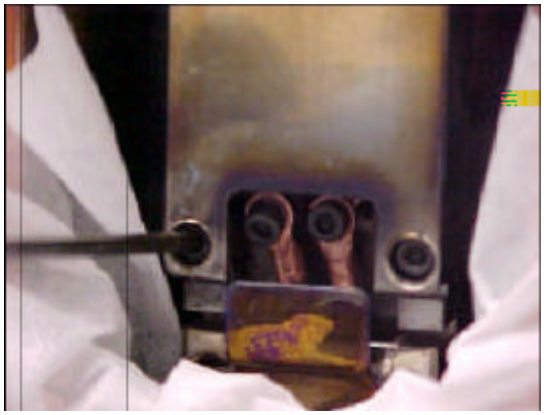

Figure 5 *High voltage wires visible after terminal cover plate has been moved down*

9. Using a metric hex wrench undo the two hex heads holding the high voltage wires to the bottom legs of the cathode assembly. These are captured-screws and can't be removed. Remove the wires away from the legs of the cathode.
10. Using one gloved hand, hold the cathode assembly with an electronics-lab glove [6](made of white nylon). Now with the other hand, unscrew the hex heads at the bottom corners of the cathode assembly. Once the screws are completely undone, you can remove the whole cathode assembly away from the chamber retaining the two hex screws (captured-screws[7]). This should reveal the rotating anode, filament terminal and cathode holding screws.
11. Place the cathode assembly on a clean Kimwipes sheet with the Wehnelt window facing up. Careful examination will reveal that the filament is broken. Most of the time filament breaks at the middle. This breakage is accompanied by bend in the filament as well. (See Figure 6 for the frontal & backside view of the VP3 cathode assembly).

[6] It is essential that fingerprints or oily residues not left anywhere inside the vacuum chamber.
[7] Terminals hold the captured-screws and they do not come off once undone.

Figure 6 *a) Frontal view of Rigaku VP3 cathode assembly and Wehnelt window is at the top center; b) back side view of the same assembly*

12. Now turn the cathode such as way that the hex heads are facing up on a clean Kimwipes sheet. Now undo the two Phillips screws found on the top corners of the cathode assembly completely.
13. The back cover of the cathode should now come off completely, revealing inside the burnt filament (see Figure 7).

Figure 7 *a) Removing the back cover reveals the filament. b) Removing the screws to remove burnt filament*

14. The filament itself is held to the Wehnelt window (i.e., the front of the cathode assembly) with two more hex screws[8]. Removing the two hex screws will release the filament from the cathode assembly. Now carefully store the hex screws. The removed filament will look similar to one of those shown in Figure 8 below except for the missing filament.

[8] The filament is spot welded on the top of two metal posts. The metal posts are secured to a ceramic base.

15. Using very fine Emery polishing paper clean the inside and Wehnelt window[9] of the cathode assembly taking care not to create big scratches.

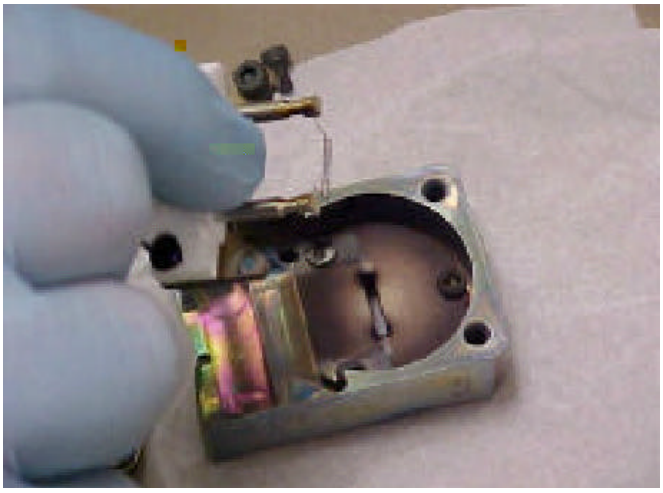

Figure 8 *Replacing a new x-ray filament in side the cathode assembly*

This completes the removal of the burnt filament. Now we will proceed to installation of a new filament in the next section.

[9] Wehnelt window seen in Figure 6a determines the focus even if the filament is the same.

Installing new filament

16. Select the appropriate filament. For example, VP3 cathode can take Rigaku Cat # CN 4892V2 if one requires 0.3 x 0.3 mm^2 fine focus at 6° take off angle or VP5 cathode can take Rigaku Cat # CN 4892V1 if one requires 0.5 x 1.0 mm^2 fine focus at 6° take off angle. Some of the new fine focus and line focus filaments are shown below in Figure 9.

Figure 9 *New Rigaku filaments:* CN4892V2 *fine focus (0.3 x 3.0 mm^2)* CN4892V1 *fine focus (0.5 x 1.0 mm^2) &* CN4892X2 *line focus (0.2 x 0.2 mm^2).*

17. Place the filament inside the cathode assembly. Place the hex screws in place and engage them slightly.
18. Observe under an optical microscope and align the filament appropriately making sure that it is not bent. The filament should not be too close to the windows either.
19. When the optimal position is reached, tighten the hex screws fully.
20. Place the back cover of the cathode assembly and hand-tighten it using the two Phillips screws.
21. Holding the cathode assembly with an electronics-lab glove place it back in the chamber and engage the two hex screws at the bottom corners of the cathode to the holes inside the chamber.
22. A small guiding pin[10] found inside the chamber will help you position the cathode in the appropriate place.
23. After ensuring that the cathode is placed evenly, hand-tighten it fully.

[10] The guiding pin is located between two cathode terminals in side the vacuum chamber.

24. Carefully place the captured-screws attached to the high voltage wires back to their respective legs at the bottom of the cathode and tighten them one by one. While tightening, make sure they do not come in contact either with themselves or with the walls of the cathode assembly[11].
25. Carefully release the Phillips screws holding the cover plate and at the same time move the plate upward to hide the high voltage terminals behind the plate.
26. Once the plate covers the terminals completely, fully engage the two Phillips screws.
27. Place the vacuum chamber cover back in place making sure that the 'O'-ring is still in place and tighten the cover evenly.
28. Ensure the vacuum release valve is hand-tight. Due to minor differences in the placement and tension of various screws the exact position of the new filament is has changed. Therefore, complete beam optimization procedure should be done following the successful installation of new filament.
29. First, switch the vacuum control from AUTO to MANUAL. Flipping the vacuum controller panel switch to MANUAL mode can do this. See Figure 10 below for the location of the switch.

Figure 10 *Vacuum controller panel*

30. Start only the rotary pump by flipping the RP switch to ON position. Run the pump several hours (~6-8 h) to ensure degassing and removal of adsorbed gases and moisture.

[11] Holding the terminal with a self-locking tweezers will be helpful

31. Then start the turbo molecular pump (TMP) by flipping the switch to ON position. Run this pump together with RP pump for few (~2-3 h) hours. Then switch on the ion gauge (IG).
32. Monitor the vacuum with the digital multi meter. When the vacuum is better than 0.200 V, switch on the TARGET motor. Due to degassing of adsorbed gases in the magnetic seal, there will be some degradation in vacuum but soon it will recover.
33. Now you are ready to start the x-rays. This completes the procedure for new filament replacement.
34. Now proceed to monochromator adjustment procedure.

Conclusion

If one follows this note, it is relatively easy to replace the burnt filament. As noted in the beginning, steps 30 to 32 make take several hours. At times, it may require you go back and forth between steps 30 and 32 few times for uninterrupted generator operation. Please send your suggestions and comments to Soma.

**Photos courtesy of Rigaku/MSC*