

**TO: M. JAWORSKI, M. SMITH, S. GERHARDT**

**FROM: M.L. REINKE**

**SUBJECT: IMPACT OF SMALL GAPS IN CENTERSTACK TILES**

### Recommendation

The gaps in the FY16 NSTX-U CSAS tiles may be useful as a confirmation of acceptable gaps between PFCs during the Recovery. To confirm this, an activity to clean and inspect observed discoloration/coatings is recommended.

### Background

The present version of the PFC SRD [1] is somewhat ambiguous about the ability to field 'gaps' between tiles. In section 3.3-c,d it presently (rev0) says:

“PFCs design should ensure that there is no large line-of sight from the plasma to the centerstack casing, centerstack bellows, or outer vacuum vessel in the “polar regions” or PF-1c reentrant housing; included in this is the requirement that graphite armor be present in continuous form from the outboard divertor to the secondary passive plates as per Fig. 3.3.1. Here, “large gaps” do not preclude nominally small tile-to-tile gaps.”

“d: Regions on the casing and divertors not protected from direct lines of sight shall be minimized. Any gap wider than 1 mm must be evaluated and approved during the design review process.”

There is presently no reference to any evaluation process that will allow gaps larger than 1 mm (0.040”) to be approved and there exists chits to be closed from the PDR about tile-to-tile gaps. Any gap that is sufficient width and depth that would lead to direct plasma contact for steep, but achievable, impact angles will not be acceptable, but narrow, deep gaps are not expected to lead to a power exhaust problem. For example, if the radiative heat flux normal to the surface is  $q_{\text{RAD}} \sim 1 \text{ MW/m}^2$ , an estimate for the heat flux at the bottom of the surface that is  $d=1 \text{ cm}$  deep and  $w=2 \text{ mm}$  wide would be  $q_{\text{SURF}} \sim q_{\text{RAD}} * w / 2\pi d \sim 31 \text{ kW/m}^2$ .

Narrow gaps still allow for material to be deposited on the centerstack. This includes dust as well as coatings from boronization or lithium evaporation. The later was not deployed in FY16 NSTX-U operations, but boronization was heavily utilized. It is proposed to use an inspection of NSTX-U post FY16 operations to confirm that boronization coatings on the centerstack from small tile gaps do not pose a risk, allowing these gaps to be used as an upper limit to confirm acceptability for the PFCs fielded during the Recovery Project.

### Observations

Post run inspection of the surface below the CSAS revealed a series of markings between the two tile rows on the CSAS, as shown in Figure 1 (image courtesy of M. Mardenfeld).

The location of the discoloration occurs near the gaps between the CSAS tiles, motivating an inspection of possible gaps in the FY16 PFCs. Figure 2 and Figure 3 show investigations of the CAD model, where line of sight through the PFCs is revealed as red. A normal incidence view (Figure 2) reveals a pair of gaps near the corners, while for even a steep incident view, approximated by Figure 3, this line of sight is eliminated.

This suggests a normal incidence deposition and excludes a direct plasma interaction. Further visual inspection of the centerstack demonstrated that the alternating pattern of gaps, e.g. top/bottom and left/right justified, as evident in Figure 2, is manifested on the centerstack, shown in Figure 4. Additional inspection of Figure 4 indicates the possibility of a slight smearing of this discoloration suggesting that it is a coating that could be easily removed.

#### Proposed Work

To gain insight into the impact of these coatings, it is recommended that the Recovery project, either via the PFC or Vacuum Vessel and Internal Hardware WBS teams, develop an inspection and cleaning procedure. The goal is to document the before and after, as well as any specific methods necessary to clean these surfaces as well as any indication of permanent surface damage. This would allow these gaps to act as a method of confirming acceptable sizes to underlying vacuum vessel/centerstack surfaces for PFCs, helping to improve Section 3.3-c,d of the PFC System Requirements Document [1].

### **References**

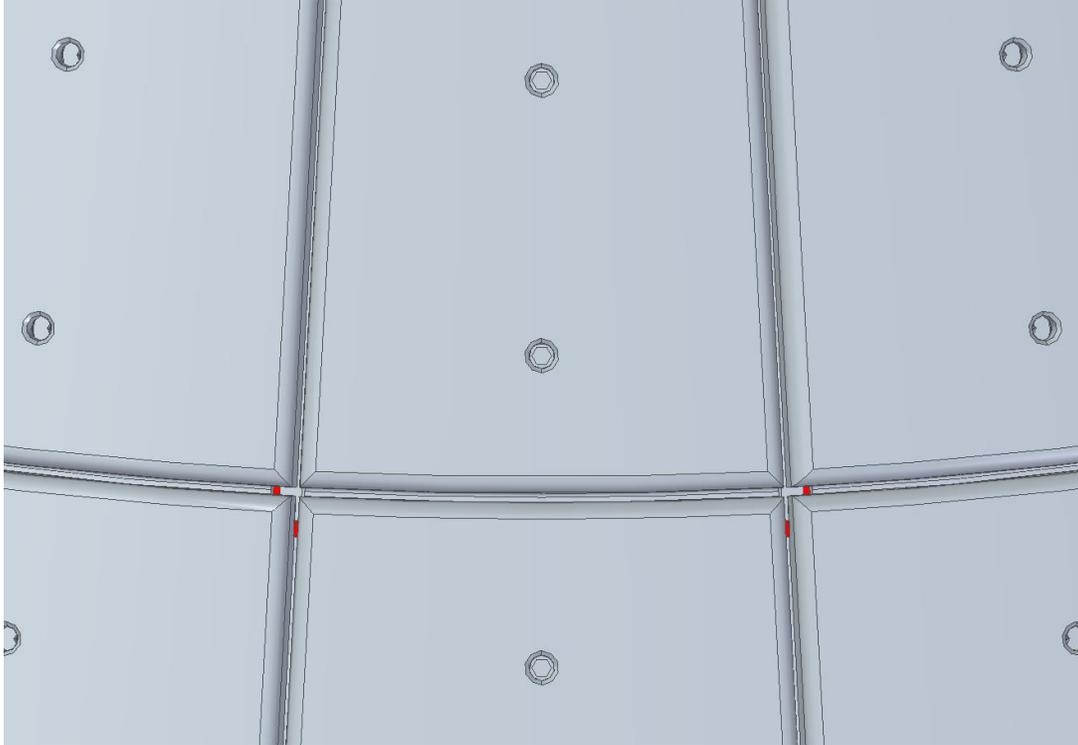
[1] NSTX-U-RQMT-SRD-003-00 available at this [link](#)

### **Record of Changes**

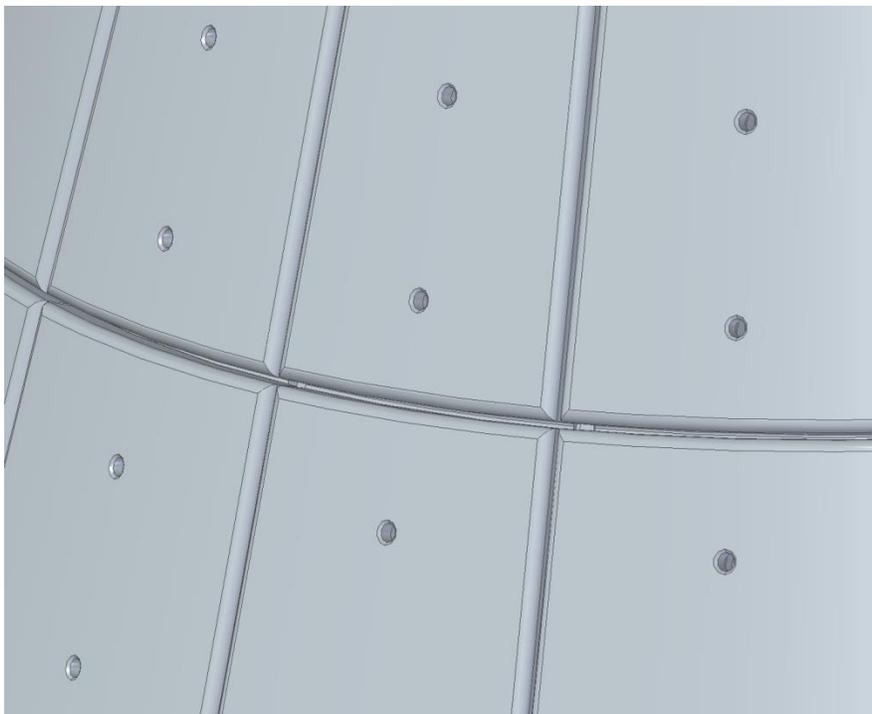
<b>Rev.</b>	<b>Date</b>	<b>Description of Changes</b>
0	1/24/18	Initial draft release to M. Jaworski for comment
1	2/7/18	Release to PFCR-WG website and Recovery Project



Figure 1: Picture (Jan 2018) of lower mounting surface for lower CSAS PFCs, highlighting deposit.



**Figure 3: CAD of CSAS tiles with the gaps between tiles revealed by the red regions that would allow access via normal incidence. These gaps become hidden when viewed at an angle as from heat/particle flux from the plasma.**



**Figure 2: CAD of CSAS tiles viewed from angle showing the lack of access to the centerstack surface by the absence of the red as shown in Figure 2.**



**Figure 4: A wider view of the centerstack mounting surface for the lower CSAS (January 2018). The repeating pattern of gaps that is evident in Figure 2 is seen on the centerstack.**