



Memo

To: Salman Tariq
From: Ryan Schultz
CC: Kris Anderson, Patrick Hurh, Curtis Baffes, Mike McGee
Date: 02/20/2013
Re: FESHM Chapter 5033.1 Engineering Note Review

Subject: Review of the NuMI Beam Line Beryllium Vacuum Window engineering note

The NuMI Beam Line Beryllium Vacuum Window engineering note falls within and needs to comply with FESHM Chapter 5033.1. Joel Misek originally designed and wrote the engineering note for this window in 2004. Even though the window will be in an *unmanned area*, the note is written to and complies with the more conservative *manned area* criteria (SF of 2) of FESHM 5033.1.

It is important to first understand the failure of the original window. After 7 years and $7e7$ pulses, the window developed a small $10e-8$ permeation vacuum leak in the outer braze area most likely due to corrosion from the humid and nitric acid environment. In looking at pictures one can see the greenish copper oxide on most of the outer braze area. But the pin hole leak can be seen on the outer diameter with a whitish corrosion surrounding it. This suggests that the failure was more likely corrosion-driven and not beam-induced fatigue. Although it should be noted that a greenish corrosion was also present in the center of the window, but this is not where the window failed.

The written note assesses fatigue using published data, and a Goodman Diagram method to extrapolate published data to relevant values of stress magnitude and stress reversal coefficient. This method is appropriate, but limitations in the available starting data will always introduce a significant level of uncertainty. The note then plots the single NuMI operation data point on the Goodman diagram, and has suggested that over time we try to add other operation data points for comparison. This is a good approach, and goes a long way towards substantiating the analysis.

The note is an improvement over the original note from Misek, utilizing the now common FEA analysis and more recent fatigue analysis. But given the failure mechanism the concern is not fatigue, even at 700 kW according to the analysis. The concern is primarily corrosion and reducing the stresses in the outer braze region. To this end the most important factor is manufacturing the window in such a way as to reduce the stresses in the outer region by adding 0.020" pre-curvature and also preventing corrosion by encapsulating the braze joint in gold. If manufactured correctly, these two improvements will substantially improve the reliability going forward.

Ryan Schultz