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**Pictures of a Good and a Failed Main Injector Bellows**

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**Introduction**

In preparation for the 2004 Facility Shutdown, a survey for high radiation areas was conducted in the Main Injector. An unexpected pattern of localized high radiation was observed in the vacuum minitubes upstream of many defocusing quadrupoles in regular lattice cells. Since these high radiation areas were a few inches downstream of the standard Main Injector bellows assembly, a concern was raised as to the integrity of the bellows assembly including the rf beam shield. If the rf beam shield (finger stock) was out of place (popped fingers), then it could potentially intercept beam in such a way as to create a localized hot spot downstream.

The vacuum installation employs assemblies of the bellows with finger stock installed. It consists of beam pipe sections to which the bellows are welded and stainless steel finger gasket material which is held in contact with the beam pipe using a spring. A .pdf view of this assembly is available as Drawing No. [9502.000-MB-305780 Rev B](#) ~~-----~~ [FIND CHANGED URL -BDNEW IS GONE](#). These assemblies are clamped in place before welding to the beam pipe. Successful completion of this procedure results in a bellows which has been installed with only small stresses and no opportunity for the rf beam shield to be disturbed.

On the occasion of a mishap during installation, it is possible to have a portion of beam pipe clamped or welded to the assembly and then have some failure in the clamping and/or welding operation result in a large torque on the bellows which could permit the the rf beam shield to escape from its design position and be lodged such that it impinges on the beam aperture.

If the installation failure results in an overextension of the bellows assembly, it is possible for one or a few of the fingers to be released into the beam aperture and remain after the force which overextended the bellows is removed.

Kieth Dillow provided the author with an unused bellows assembly for examination. He also had an assembly which had been damaged by an incident which caused a large torque to release all of the upper fingers. After a portion of beam pipe had been clamped to the assembly, a failure occurred.

In the following section we show pictures of these two assemblies. We concluded that the condition of the bellows with rf beam shield displaced and trapped out of place would be visible upon inspection in the tunnel without opening the beam pipe. An incident which releases a few fingers will create less of an effect on the bellows assembly and, while it may still be visible, it has a greater chance of being undetectable by external inspection.

An incident which releases many rf fingers is almost sure to be observed by the installation crew. An incident which releases only a few fingers is still likely to be observed. We are confident that such events would have been reported and corrected. We conclude that it is unlikely that rf beam shield displacements are responsible for the observed hot spots.

We comment that if single fingers have been release at some location, previous experience with the Main Ring suggests that a careful horizontal aperture scan would be likely to identify this by localized losses which are more apparent on one edge of the vertical aperture.

A discussion of the Main Injector radiation issues circa 2004 is available as [Old link Beams-doc-1382](#) or [Beams-doc-1382](#).

**Photos**

**Unused Bellows Assembly Pictures**

Picture	Picture
	<p>Main Injector Bellows Assembly</p>



Main Injector Bellows Assembly



Main Injector Bellows Assembly

**Damaged Bellows Assembly Pictures**

Picture	Comments
	<p>Main Injector Bellows Assembly</p>
	<p>Main Injector Bellows Assembly</p>



Main Injector Bellows Assembly



Main Injector Bellows Assembly