



**Fermilab**

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Tuesday, August 19, 2003

Dr. Roger Dixon  
Head, Beams Division  
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Dear Roger:

I believe that yesterday's review of the vacuum work for the upcoming Recycler shutdown went very well. The committee was an excellent one, well matched to the task, and engaged with the issues. The presentations were well organized and to the point. Sergei's presentation of his measurements and analysis of the emittance growth was quite elegant and convinced all of the committee members that the lifetime and emittance growth problems are due to scattering off residual gas. I have attached the specific conclusions presented at the closeout, with the addition of a few items that were forgotten by me at that time.

In spite of the excellent analyses and presentations, the committee does not understand the discrepancies between the beam-based measurements of the residual gas pressure and the vacuum instrumentation-based measurements of the residual gas pressure and composition. There have been two possible explanations forwarded to me (so far) that may inspire further study.

Nevertheless, the committee felt confident in making the following recommendations:

1. You should proceed with the shutdown based on the present plan, as described, including the instrument and other upgrades that require opening the beam pipe, and especially including the bake out of the entire ring.
2. The plan and resource-loaded schedule for the shutdown work seems reasonable as far as we could absorb it in a few hours. Certainly, the most obvious issues were covered. It is a plan assuming success, however, and there is very little time or resource contingency inserted for difficulties encountered except switching to longer and more work shifts. Because of the tight schedule, the committee makes the following recommendations:
  - a. You should make every attempt to populate the technical team with people who are well trained in vacuum work and familiar with the Recycler. In particular, the committee felt strongly that you should use as much as possible the technicians who were involved in the previous Recycler shutdowns and vacuum work. The schedule is predicated on this assumption. Little time was allowed for training.
  - b. You should consider bringing in portable power, additional distribution equipment and possibly more personnel in order to bake more of the ring simultaneously, which

may create more time contingency. More power would also permit baking the beam-tube appendages (ion pumps, RGAs, etc.) at higher temperature, which was recommended.

- c. There was some concern voiced by the vacuum side of the committee that leak finding and repair might be underestimated. Anderson expressed the opinion that they do not find all of the leaks, which raised some eyebrows. More time might be allotted to this activity, and perhaps more training.
3. There are a few beam-based experiments that might be performed that could shine some light on the issues. They might help determine whether there is an electron/ion trapping issue. None of these are certain to help, but they might. They are described in the notes.
4. There are a few offline experiments that might prove useful in understanding the measurements and that could prove useful during the shutdown and in the following months. Again, none of these are guaranteed to help, but they might. These are also described in the notes.
5. There are a few specifics of technique and procedures used during the shutdown and in the handling of vacuum components that the committee felt could be improved. Most of these changes are in the spirit of bringing Fermilab practices into compliance with best vacuum practices. That these were found in a short review suggests that there may be more such non-standard practices.

It was noted, for example, that there is not a standard vacuum lab with vapor degreasing apparatus; that vacuum components are often cleaned with alcohol or acetone after high-temperature degassing; that gauge calibration is not done in house. It was also noted that the firing of the sublimation pumps is not optimized and that the nitrogen purge is not as water-free as it might be. Some details are listed in the accompanying notes.
6. It was the opinion of most of the committee that more intense and sophisticated modeling could and should be done to help design and understand the vacuum system. Nagaitsev indicated that this work was being encouraged.

Overall, committee felt that the Fermilab team is doing a very good job planning the Recycler work, and that the work is well focused on the major issues, and well designed to improve the vacuum. The discrepancies among the measurements are not understood. They will be, in time, and they may prove to be very interesting.

The members of the committee all expressed the hope that this short review and report will prove useful to the Recycler and to Fermilab.

Sincerely,

Peter Limon  
For the Review Committee

Encl: Concluding notes  
Transparencies from the presentations

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