NuMI Air Handling Review

R, Stanek July 30, 2003

The NuMI air handling system provides cooling for the walls of the target pile (which has implications for the stability of the component support system) and to some extent the components within the pile. The review of this system revealed a well thought through design approach that has a thorough and detailed analysis supporting it. The understanding based on material presented is that this air handling/cooling system while important in the overall calibration of the experiment is not a system, which if it had operational difficulties, would keep the experiment from running. The caveat to this statement might involve the radiation effects of either a no flow or leaky flow condition. It was also stated that after the system is operational but before beam is established, there will be an opportunity to take measurements and make adjustments on the fixed restrictions in order to fine tune airflows.

Issues that might need further attention include:

1) **QC checks**
There was some discussion about verification of the analysis that calculates airflows and heat transfer in the target pile. Some reviewers suggested using an independent FEA to check the accuracy of the analysis. The feasibility of this approach should be investigated. However, it may be that what is needed in order to check the flow rate calculations is to use CFD (Computational Fluid Dynamics) code to provide an answer. There is some question as to whether this is available. However, certain parts of the analysis such as the heat transfer (conduction and convection) involving the walls and components that was done with I-Deas simulation could be checked independently using ANSYS. The flow calculations might be examined using a simple sensitivity analysis (see below).

2) **Instrumentation**
I agree with all of the comments already presented that recommend that instrumentation be installed with some level of redundancy to assure that information concerning the operation of the air system is always available. Installing additional instrumentation is much easier now than retrofitting something in the future. Temperature and flow measurements in key areas should be measured with some level of redundancy.

3) **Refill of drain traps**
The floor drains offer an escape path for air that must be blocked in order to deliver the required airflow. The water in the drain traps will eventually evaporate and create a "hole" in the system. During the review, some ideas were presented that suggested a system design that kept the traps filled. A final design should be developed that eliminates this concern and includes a way to verify a no leakage condition.

4) **Safety margin**
It is important to clearly understand the contingency being incorporated into the design of the system and its components. There seemed to be some confusion as to what the exact "design load" should be and how to incorporate a safety margin into the equipment. Do not rely on the contractor to provide additional capacity based on

standard components or industry standards. The specification for the equipment should have an attached summary document that states the nominal, maximum and minimum design loads. The contingency should be appropriate for this type of industrial application and be able to handle variations in the heat load.

5) **Sensitivity analysis**

The airflow distribution in the system was calculated using closed-form pressure drop formulations (well established formulas) augmented in a spreadsheet format for ease of calculation and modification. The complexity, scope and just sheer number of inter-related formulas call for some sort of quality control check. One way to approach this issue would be to perform a sensitivity analysis on any fundamental number that is taken from empirical data or has a range of possible values. A suggestion might be to look at parameters such as friction coefficients, roughness factors or coefficients of discharge as well as fluid properties that depend on the state of the air such as density and viscosity and vary these numbers throughout the whole range of reasonable values. For those parameters that require a certain degree of judgment in order to choose a correct value (such as roughness factor) a contingency of approximately 50 to 100 percent should be added, depending upon the initial magnitude of the range of values. The results of the spreadsheet driven analysis will then show how sensitive the answer is to variations in these parameters. This should strengthen confidence in the analysis methodology.

6) **FMEA/What If analysis**

The P&ID presented in the review should be analyzed using an FMEA and What If Analysis approach to look for areas of single point failure that can cripple or disable the system. The result of this analysis may prove useful in specifying additional instrumentation, control strategies and system redundancy requirements.

7) Equipment redundancy

Look for opportunities to create full or semi redundant capabilities in the system by optimizing the selection of components. An example of this might be to examine the feasibility of multiple fans in place of a single unit.

8) Unit turndown

I cannot recall this being specifically addressed in the review, but it is important to design into the system the capability to run at all required levels of cooling in an efficient manner. This may require the use of variable speed controls/motors or multiple fans/motors that could be turned down.