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March 23, 2020

Re: LBNF Primary Beamline Radio-Activated Water (RAW) Preliminary Design Review

Karl Williams:

On February 19th and 20th, Lee Hammond, Marty Murphy, Adam Taylor and I listened to the LBNF Primary Beamline Radio-Activated Water RAW Preliminary Design Review presentations given by Karl Williams, David Hixson, Abhishek Deshpande, Raina Wang and Paul Kasley. Our panel was asked to perform a Preliminary Design Review on this system and all the relevant documentation that had been uploaded in the Dune DocDB database. We were given charge questions to address which we have done:

1. The preliminary design meets the requirements of the beamline components.

2. The design maturity presented for the Target Hall and Absorber Hall RAW systems is at a level appropriate for the Preliminary Design Phase, as guided by EDMS# 2173197LBNF /DUNE Review Plan. We encourage the design team to start work on the final design because of the risk of attrition of key members working on the project.

3. Yes, suitable engineering analyses have been performed and documented, and reviewed/peer reviewed and approved, where applicable.

   The Safety Factor usage should be passed on to the AE consultant so that they are not repeated multiples times in the final equipment capacities. The factor of safety for the different systems was not highlighted, but this is vital information.

4. Yes, the appropriate codes and standards adequately have been applied to the design. For the H + OH Mitigation system, any possible safety standards such as OSHA should be examined which may help provide safety guidance. This system is designed to remove diatomic H2 from the RAW in all Target Hall systems. The H2 is generated by interactions between proton beam and water molecules in the neutrino production process. Preliminary design is ongoing and lessons from NuMI/NOvA are still being learned and applied here. The three conceptual designs for removing H2 from the system are all viable with different strengths and weaknesses already identified. Further analysis of existing NuMI H2 gas production and mitigation and additional input from Radiation Physics will help in choosing the best option going forward.

5. The ES&H issues been identified and analyzed appropriately. However, it would be helpful if the radiation dose rates should be integrated within the design since this will affect the material selection and operational repairs. This may already be the case, and was simply not shown during the review, but this is key information which should be readily available. Are there any gates or fences to keep people from hanging out around the RAW room shield door?

6. Yes, overall the Fermilab Engineering Manual standards been applied to the design. The Review Panel was told that the appropriate Engineering Risk Assessments were completed in 2013, but these were not provided. It would be helpful for the ERA document numbers to be noted for easy reference and verification. Additionally, since so much time has past since the ERA(s) was completed, it would be useful to review them to ensure they are up to date. And each system may need an ERA, particularly the H + OH Mitigation system.

7. Potential design, manufacturing, and installation risks and challenges have been identified within the Neutrino Beamline components and been adequately planned to address these during the final design.

   The absorber Hall RAW System requires coordination due to a last-minute floor plan change. Confirm that all equipment fits within the new architectural round scheme. As shown in the presentation, the new floor plan does not appear to have enough floor space for the required equipment. The additional mezzanine space does not appear to be useful space due to height limitations. If the height of the mezzanine were increased, then this space may be used to

house some of the RAW system equipment. Consideration should be taken regarding removal of whatever equipment is located on the mezzanine. If large equipment is installed, the elevator should include a stop at the mezzanine level to make replacement and maintenance possible.

Consider installing monorails in the RAW room for pump and HX removal and installation. An operational concern for all systems in this building is accessibility. How accessible are the components for repair/replacement? How difficult is it to remove used RAW in 330G totes or barrels & iron DI casks? The Target Hall side of the facility seems well planned with wide access doors and clear access to the crane bay. In any event, there should be some mechanism to move large and heavy components with either a rail system or a motorized forklift. Are there any gates or fences to keep people from hanging out around the RAW room shield door?

The elevator should be a freight elevator capable of hauling any component or 330G tote full of RAW (~2700 lbs). I believe the best solution for water removal is to pump it to the surface for transfer to barrels or totes and should be strongly recommended for

8. The difficult design features and possible prototyping issues have been identified.

9. The level of integration with other LBNF beamline entities is appropriate for this stage of the work and the interfaces and collaborative design inputs are being managed appropriately. In addition, we encourage the design team to start work on the final design because of the risk of attrition of key members working on the project.

10. All LBNF RAW systems are currently undergoing estimation review through the Project Estimator. This includes the submission of sample packages to outside vendors for spot-checking of current values. The panel did a cursory check of the Cost and Schedule.

    The choice of pump for the Target Shield Pile Cooling RAW System is high cost and comes from Japan. This raises questions about service and accessibility of parts. Additional justification is needed for using these pumps rather than getting a different pump. Assuming the pump lifetime is indeed 30 years, then these pumps might be worth purchasing. More investigation/justification is needed.

Recent projects like g-2 or mu2e should be reviewed in terms of how their estimated design efforts compared to the actual design efforts. This information may provide guidance for this project in terms of making possible adjustments in their contingency.

In addition to the charge questions, we were asked to provide any other feedback which we thought was relevant.

Target Hall RAW System:
Preliminary design is ready for beam line components and the design is mature (>80%). The engineers have identified one problem - tubing size of Target Mount and Baffle – and are working on a solution. Operationally nothing in this presentation concerns us.

Horns A, B & C RAW System:
One concern is identifying "Plan-B" if the ejector pumps do not satisfy system cooling requirements. Prototyping is planned and will be useful and provide a good understanding of the injector pump's efficacy.

Target Shield Pile Cooling RAW System:
Design is well-planned and P&ID drawings are in good order. The choice of pump for the system is high cost and comes from Japan. This raises questions about service and accessibility of parts. Additional justification is needed for using these pumps rather than getting a different pump. Assuming the pump lifetime is indeed 30 years, then these pumps might be worth purchasing. More investigation/justification is needed.

If Mag Drive pumps are acceptable for the general RAW pumps, why can't those style of pumps also be used on the Target shield pile panels system? This could eliminate the need for specialty pumps.

Target Hall RAW Exchange Skid:
Exchange skid preliminary design is very mature (>80%). We do not see any operational problems.

Target Hall Intermediate Water System:

This system design is based off NuMI/NOvA designs and lessons learned. Preliminary design is well specified and sufficiently mature (>80%).

Target Hall Hydrogen Control System:
This system is designed to remove diatomic H2 from the RAW in all Target Hall systems. The H2 is generated by interactions between proton beam and water molecules in the neutrino production process. Preliminary design is ongoing and lessons from NuMI/NOvA are still being learned and applied here. The three conceptual designs for removing H2 from the system are all viable with different strengths and weaknesses already identified. Further analysis of existing NuMI H2 gas production and mitigation and additional input from Radiation Physics will help in choosing the best option going forward.

Absorber RAW/AH Exchange/AH Intermediate Cooling Systems:
The engineering specifications for these systems are well understood. Heat rejection, flow rates, etc. are not at issue. The challenge is that the Conventional Facility design is changing considerably; building geometry is changing from rectilinear to circular while maintaining the same floor surface area. This will present serious challenges in the floor layout of components.

This presents many challenges for systems that are deep underground. Chief among them is accessibility of components for repair and replacement. Regardless of future building & room designs components must be accessible for replacement – this includes thing like I-beams for hoists, plumbing to take used RAW water to the surface for remote disposal and other considerations for making a safe working environment. These items should be at the forefront of future P&ID and equipment layout designs.

If a burping system is to handle the target hall water quality, why is the method to handle the absorber hall still undecided? Is something different between the two systems that makes either system more/less desirable for the absorber hall instead of the target hall?
One issue that was raised was how/if the intermediate cooling system shall monitor the status of the air-cooled chillers.

Target Hall & Absorber Hall Controls
Controls design is naturally behind the system design. Control design direction presented during the panel demonstrates adequate knowledge of what will be required of the control system. The

P&ID for the Absorber Hall end of the project is very much in flux since the building design itself is being re-made. Their requirements for the system (e.g. heat rejection capacity) are well understood and layout and final design will follow once CF design is solidified.

We also suggest coordinating the flow/temp/press sensors with conventional facility piping. Are there any cross connections for alarming from AD PLCs to CF BAS?

On average the various RAW systems (Target, Horns, Chase Shielding, etc.) meet preliminary design requirements and are sufficiently mature – to about the 75% level. Target Hall system designs are mature and look reasonable. The wild cards are more on the Absorber Hall and controls end of the project.

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The system controls design is done to the extent that the controls requirements and specifications are well understood. However, the hardware and software specifications won't be made for several years at this point; doing so now would be needlessly premature.

We think the design team has done a great job with their presentations and their work thus far.

Regards,

Christine Ader

Review Panel Chair

Cc: Lee Hammond, Marty Murphy, and Adam Taylor