Report of the Production Readiness Review of the DUNE Single Phase Cathode Plane Assembly

February 23, 2017

DEEP UNDERGROUND NEUTRINO EXPERIMENT

1.0 PURPOSE/ SCOPE

The purpose of this review is to ensure there is a fabrication process in place and documented. The fabrication process should include the fabrication steps taken to complete the component and the define the quality control inspections and tests that will be performed to ensure the component meets its design and intended function.

The scope of the review included a review of the applicable documentation that had been uploaded to an Indico site and Docdb. The documentation reviewed is listed at the end of this report in Attachment A. These documents were reviewed by the Project Electrical and Mechanical Engineers, the Project ESH Manager, the Project QA Manager and the DUNE-US Project Manager. Comments and questions were provided to the QA Manager for discussion with the DUNE Single Phase Cathode Plane Assembly (CPA) Team. The QA Manager and DUNE-US Project Manager held the review and discussion at Argonne National Lab on February 23, 2017.

2.0 Comments

The DUNE Single Phase Cathode Plane Assembly Team at Argonne National Lab are very experienced and very knowledgeable. The Team has produced the prototype CPA used in the Ash River Trial Assembly. The majority of the required documentation for production readiness has been completed. The drawings, CPA Manufacturing Procedure, CPA Production QC Checklists, Shipping Plan, QC Plan have been uploaded into Docdb. Handling, Storage and Packaging procedures are to be developed.

The CPA will be fabricated in accordance with the approved Fabrication procedure and assembly drawings. The CPA Manufacturing Procedures at Argonne National Laboratory for ProtoDUNE/SP should be revised since the drawings referenced in the procedure do not show the detail required for assembly. The QC Plan for the CPA does not meet the template that is being used for the DUNE Project. The DUNE QA Manager will assist with the development of this QC Plan.

A preliminary CPA Hazard Analysis has been developed. In addition, a formal Hazard Analysis has been completed for the assembly procedure for the Upper Modules of the CPA detector. The WPC (Work Planning and Control Review Package for the Assembly of Upper Modules has been drafted. The Hazard Analysis and WPC Review Packages need to be completed for the assembly of the other modules and complete assembly. The documents reviewed were satisfactory. The assembly team have integrated the ANL ESH policies and procedures into their work planning including oversight by the Physics Division ESH Coordinator. The information on the FR4 material regarding the ability to meet the CERN requirements for no halogens or fire rating has been submitted to CERN. These requirements were approved by CERN on February 25, 2017.

Three recommendations from the CPA Design Review applied to the Fabrication of the CPA. The status of these recommendation was updated during this review. The results are as follows:

Recommendation:

Make sure to get approval for the fabrication drawings and the Interface Control Documents.

Update:

Drawings were available during this review. Undetermined how final versions will be identified or whether as-builts will be prepared. They are located in DUNE docdb#1488.

Recommendation:

Subject electrical design of FC/CPA to an internal peer review.

Update:

CPA team agreed to the peer review during this review.

Recommendation:

Take into account the time needed for CERN HSE validation (average 14 working days) in the planning and submit a calculation well in advance to be able to have the validation before the PRR and before production is launched. Ask asap for an official derogation from CERN HSE for the materials that are not compliant with the CERN Safety Rules.

Update:

(2/8/17) Document was submitted to CERN HSE during the first week of January. It was revised & resubmitted based on initial comments. Still awaiting final approval. (2/23/17) Discussed at PRR. Still awaiting approval. Approval was received on February 25, 2017.

There are a number of recommendations that have resulted from this review. These are detailed below. A written response to the recommendations is requested within two weeks of the receipt of this report. The recommendations do not affect the ability of the CPA Team to go into full production. The Review Team recommends the CPA Team to begin production.

3.0 Recommendations

- 3.1 Complete the Hazard Analysis and WPC Review Packages for the remaining modules and panel assembly.
- 3.2 Review the crimped wire connections and splices used during construction and verify that all applicable QC checks have been documented. This should include the inspections required for the High Voltage Cables. Develop QC Checklists for any newly identified QC checks.
- 3.3 There should be a rated contact pressure for the ring terminals used in the HV connections. This contact pressure should be maintained during cold cycling. It is recommended these be tested to ensure the contact pressure holds to spec after at least a couple of cold cycles.
- 3.4 Review the materials and the thermal coefficients to verify that they are satisfactory.
- 3.5 Dimensions are in dual units (Metric and English) for the assembly drawings. It is recommended that dual units be placed on all the drawings.
- 3.6 Through lessons learned on other projects, it has been noted that Lar is an excellent lubricant causing fasteners to loosen over time. It is recommended that the team look into using lock washers with the nut and bolt fasteners being utilized.

3.7 There is a concern that during fabrication and also reassembly at CERN that the fasteners may strip the threads in the polymeric materials. A torque value should be provided for the installation of the fasteners and a procedure be provided with the shipment to CERN on what should be done if stripping does occur during reassembly.

3.8 The tolerances called out on the drawings are +/-0.02 for two places. This appears to be over specified as a very tight tolerance. This tolerance should be reviewed to verify if it is required and can be met during fabrication. If it is not required, a greater tolerance should be developed to avoid nonconformance to the drawings.

3.9 The CPA Manufacturing Procedure shows the resistive panel being slid into the into the grooves of the side bars and intermediate bar. To reduce the chance of damage to the coating from the slide action, the procedure should be revised having the frame being built around the resistive panel.

3.10 Electrical testing of the components has been performed at Brookhaven National Lab. A vertical test for the High Voltage cables should be performed.

3.11 Several drawings call out the material to be G10, however the design paper refers to FRP or FR-4. The drawings should align with the design paper terminology for consistency.

3.12 Part DUNE-1-4 is called a Lifting Fixture. If this a removable lifting fixture it should be related to documented stress calculations to show it is structurally sound for CERN HSE.

3.13 The drawing for Part DUNE-1-4 shows the material to Aluminum. The specific alloy of aluminum should be called out on the drawing.

3.14 Paragraph 2.1 of the CPA Manufacturing Procedure lists a dimensional inspection and a visual inspection for scratches. The QC Checklist should document the results of the visual inspection.

3.15 Paragraph 2.4 of the CPA Manufacturing Procedure states mount the HV cable across the top of the module. The drawing referenced (DUNE-1-1) does not show the cable. DUNE-1-5 and DUNE-1-6 show several HV cables. The procedure should reference the correct drawing showing the HV Cable installation and reference which cable gets mounted across the top of the module.

3.16 Paragraph 2.4 of the CPA Manufacturing Procedure states mount the resistive board on the panel. The referenced drawing (DUNE-1-1) does not show the resistive board. The procedure should reference the correct drawing showing Resistive Board installation.

3.17 Paragraph 2.4 of the CPA Manufacturing Procedure states mount the Field Shaping Strip (FSS) on the panel. The referenced drawing (DUNE-1-1) does not show the FSS. The Procedure and drawing does not show that there are 7 resistive boards to be installed. Procedure and drawing does not show that there are 7 FSS to be installed. The procedure and drawing do not show when and where does the PROFILE TO FIELD SHAPING STRIP WIRE (DUNE-1-37) get installed. The procedure should be updated to instruct where and how these items are installed.

3.18 Paragraph 2.4 of the CPA Manufacturing Procedure states mount the HV tabs (DUNE-1-1-A) that are used for connecting resistive panels between module together. There is only one tab (Top Center Tab) shown on the drawing and it has its own step. The procedure should be revised to show the installation of the HV Tabs.

3.19 For Paragraph 2.5 of the CPA Manufacturing Procedure, the comments about the HV cable, resistive board and FSS above applies to this Middle Module also.

3.20 For Paragraph 2.6 of the CPA Manufacturing Procedure, the comments about the resistive board, FSS and HV tabs apply to this Lower Module also.

3.21 The CPA Manufacturing Procedure should have procedure title and revision on every page and page numbers.

3.22 CPA Production QC Checklist for the Field Shaping Strips should have a column for the visual inspection detailed in the procedure.

3.23 CPA Manufacturing Procedure references a visual and dimensional inspection for the FR4 material. There should be a QC Checklist developed for this inspection.

3.24 After each inspection table in the QC Checklists, there should a space to complete the name of the person performing the inspection and the date of the inspection.

3.25 Where electrical checks are being performed the QC Checklist should contain a space to fill in the serial number of the digital meter used and the calibration due date.

3.26 The handling, storage and packaging procedures need to be completed.

4.0 CPA Production Readiness Review Team

Name	Title
Kevin Fahey	LBNF/DUNE QA Manager
Michael Andrews	LBNF /DUNE ESH Manager
Theresa Shaw	DUNE Project Electrical Engineer
Jack Fowler	DUNE Project Mechanical Engineer
Jolie Macier	DUNE-US Project Manager

5.0 Argonne National Lab CPA Team

Name
Victor Guarino
Steve Magill
Ken Wood
Frank Skrzecz
Rich Talaga

6.0 Summary

The Review Team recommends the CPA Team to begin production. The recommendations do not affect the ability of the CPA Team to go into full production. A written response to the recommendations is requested within two weeks of the receipt of this report. The response should be sent to Kevin Fahey at Kfahey@fnal.gov. If there any questions or a need for more information, contact Kevin Fahey at 630-840-2693.

Attachment A

CPA Production Readiness Review Documentation

- CPA Hazard Analysis
- CPA WCD Review Package Task #1
- Hazard analysis Task 1
- CPA Manufacturing Procedures, Rev. 1
- CPA Quality Control Plan
- CPA QC Checklists
- CPA Design Review Recommendations
- ProtoDUNE CPA Shipping Plan
- Fabrication Drawings in Docdb 1488
- Parts List – Fabrication Responsibilities