Answers to CPA PRR Reviewer Questions

Mechanical:

Regarding EDMS 3086538, the connection configuration schematics are helpful to show detail which is difficult to see on the 2D drawings (nice work). Do you think there is enough detail on this document for the assemblers? It took me a bit of time to sort out where each connection config appears on an assembly drawing. Have you considered if the connection schematic is an appropriate place to list the torque specs for each type and size of fastener? Or is that covered elsewhere?

>> Each type of connection is labeled which indicates its location. This doc is meant to be a reference and is posted on the wall of the clean room. The detailed instructions for the connections are contained in the iPad app step-by-step. Each procedure includes the order of screw, washers, nuts etc. and the torque requirement. These pictures are just meant to illustrate the connections in case a worker wants to confirm what the procedure says.

Do you want to add a similar detail for the Z shape brackets that go between the cathode frame and FC profiles?

>> No, we are replacing all Z brackets with clip brackets.

There is a 90 deg angle profile with three Z shape brackets (assembly DFD-20-A116) and three ¼-20 screws to mount it to the cathode frame. I only see two tapped holes in the frame member, however. Can you address the third fastener (which doesn’t have a mating hole) before releasing the drawings?

>> Ok.

Speaking of, within CPA frame members, there are several blind tapped holes (e.g. DFD-20-A402). Are those trapped volumes acceptable? I am operating under the guidance that trapped volumes must be (or should be?) vented for DUNE. However, this requirement has been passed to me word of mouth, and I am not sure of a formal document that specifies this. Has this been asked and addressed in previous reviews?

>> These features have been used in 2 ProtoDUNEs, no ill effects have been seen with very high purity of LAr obtained in ProtoDUNE-2. Scaling to FD-HD, the detector material vs LAr volume ratio remains roughly the same therefore we do not expect any impact to the FD. Another way to look at this is to calculate the total mass of air in these trapped holes, which is estimated to be of the order of 10g in the FD-HD, to the 17kton of LAr mass inside the cryostat. This contamination from oxygen is at the order of 100 ppt level before purification, far better than the commercial grade LAr we are filling the cryostat with.

Requesting you review each of the frame member connections (what I call a bridle joint) where there are inside corners with a radius. I see mating parts with sharp 90 outside corners. The area that caught my attention are the upper corners of DFD-20-G100 where DFD-20-A402 meets DFD-20-A404. In other places I see a chamfer on the outside corner. This makes me think a few other places need a chamfer. Without this, holes won’t line up, assembly will be time consuming and result in parts being sent for rework.

>> We will check to make sure that radii and chamfers match and provide adequate clearance.

Further, I see different size inside corner radii across parts (20-B502 with R.13 vs 20-B404 with R0.6 vs 20-A402 with no radius specified). Was that intentional or do you want to clean that up?

>> Will make these correct and consistent.

Balloons on assembly drawings. I’m seeing some assembly drawings that are missing balloons. This makes it difficult to find where items listed in the BOM are located. For example, on DFD-20-G100 there are no balloons for item numbers 8, 11, 20, 34, 39 and 41 so it is challenging to find where each belongs.

>> We will review.

Manhong had two drawing notes to pass along for the resistive panel PRR. Did you want to address those? See <https://edms.cern.ch/ui/file/3014657/1/FD1_HVS_CPAResistivePanels_PRR_Report_v1.a_docx_cpdf.pdf>

>> These have been addressed.

There are two FSS parts (DFD-20-A109 and DFD-20-A302) that do not indicate if the Kapton resistive coating is single sided (all others indicate coating on one side). Is that okay?

>> The current drawings indicate the coating side.

Electrical:

There is no formal approval of the Grounding and Shielding plan for the HVS system and the HVS consortium has not submitted one for review. Does the HVS consortia consider this document complete and are they ready to submit for formal approval?

>> The HVS plan has not yet been approved – this is not part of this CPA production review.

The document FD1\_CPA\_Interconnects\_04102024.pdf was reviewed as part of the Electrical safety review. The document DUNE-SP-HVS-connections-interior.pdf seems to be an older version of the above. The HV drift cable is documented in FD1-HD-HV\_delivery\_exterior documents dated 08/22. Is some clean-up required in this EDMS folder so that same material is not covered in two documents with different dates/authors?

>> These documents were older documents of the FD1 HV system. For this review, a new document of the CPA wiring and connections was created and reviewed as part of the Electrical Safety Analysis review. This document is EDMS #3138025 v.2 “DUNE FD1-HD CPA Interior Electrical Cabling and Wiring Connections”. The link to the older documents has been detached from this PRR review document list.

Trying to match hardware stack-up shown in EDMS 3086538 with hardware stack-up in EDMS 2633164 DFD\_CPA\_071123.pdf and cannot do it. The hardware stack-up described in EDMS 3086538 does not seem to be detailed in the same way in EDMS 2633164 DFD\_CPA\_071123.pdf. One example is for the profile jumper, page DFD-20-A120 of wiring diagram. Which is correct?

>> Connections are described in complete detail in the iPad app and docs 3094498 and the Interconnect document in 2380734 v.5. We identified the assembly drawings with parts lists and indicator balloons that don’t match the procedures and are in the process of updating all drawings so that the parts list and balloons are consistent with the procedures.

On page DFD-20-A042, it shows that cable insulation is exposed at connection points. Is this a problem?

>> This drawing is obsolete - not used for DUNE and not in the final release of the CPA drawing package.

On page DFD-20-A021, wire shows severe bend at one end. Is this truly the way installation is planned?

>> It’s an ~90 degree bend which in practice assumes a larger radius than is shown in the drawing.

Can a “Readme.txt” file be added to this EDMS entry with information on the file format? Other than the PDF and Gerber files, I cannot open anything?

>> Guess you are referencing doc 2144465 v.3? The original charge asked for pdf and gerber files only. In this case, original KiCad design files are included for reference.

Compliance Office:

In EDMS 3078038, the table indicated that ANL is involved in producing profiles? Is this just for bending for the corners?

>> This is EDMS 3078039. Profiles provided by CERN. This doc says ANL will bend the 8 corner profiles (they stay at ANL for production of the end Panels) and will inspect the other profiles, sending ~1/2 of the Top/Bottom profiles to W&M.

Also, in EDMS 3078038, what is meant by Prep/checklist in the table?

>> Again, EDMS 3078039. Prep means some handling needs to be done before using in production. For FR4 frames, hanger bars and AR rods, cleaning in ultrasonic bath is done. For the FSS, edge treatment is done. All parts have a checklist that results in pass/fail of the part.

Also, in EDMS 3078038 under QC data storage, what does local mean? Is this just to indicate that the data will be stored locally temporarily until it can be moved into the hardware DB?

>> EDMS 3078039. Where the data is stored – local means on the iPad (and in an email), HWDB means data is uploaded to the Hardware Database.

Also, in EDMS 3078038, can you call out the fraction of spares for each component. We note that the numbers in this table do not always match exactly with those in EDMS 2952719.

>> EDMS 3078039. Both docs now consistent.

Any design changes occurring after the PRR will need to be approved by the Technical Board and FDC Executive Board. Can you please update EDMS 3078041 to make this clear.

>> Doc 3078041 has been revised and updated

Technical Coordination:

With respect to scope, what about all the other little parts like the PEEK light diffuser holders (I believe they are installed at the factories), pins that tie the CPA panels together (used during installation), spare electrical connections between panels, and assembly tools to be used underground. Is that all supplied by ANL?

>> PEEK diffusers are produced by SDSMT as part of the Photon Detector Consortium and they are installed at SURF, not at the factories in CPA production. Alignment pins are included in the Basis of Estimate (BOE) and are obtained from a vendor. Spare connections are included in the BOE file. All tools needed are supplied in a toolbox sent to SURF along with spare parts. After production at the factories is complete, all tools and spare parts will be sent to SURF (in a spare CPA crate). See Doc 3078043.

Is the weekly schedule based on ANL pre-production? Are there any assumptions or extrapolations from the pre-production or is everything based on real data?

>> This is based on real data from ProtoDUNE-SP, ProtoDUNE-2 and various components supplied to Ash River for installation trials. The production schedule for CPA Panels has been consistent from the first prototype (ProtoDUNE-SP).

It is mentioned in the document (EDMS 3078042) that a similar production plan to the one described for ANL will be followed at the College of William and Mary to produce and ship 48 CPA Panels in up to 30 weeks. Is this confirmed by W&M? What does similar mean in this context? Are there any details? What are the plans for W&M pre-production?

>> Yes – this is the plan developed by both factories. “Similar” means using the exact same equipment and procedures, but of course, in a not exact copy, but similar clean room configuration. W&M has 2 production tables and 2 CPA templates in hand and will setup as soon as the clean room area becomes available there. Both factories have a required tools list. W&M will practice Panel production on their tables and templates as was done at ANL They will follow the production procedures and checklists in the iPad app the same as ANL.

Have you evaluated the difference in cost between shipments of 2 crates every two weeks and 4 crates every four weeks? Is there any other impact of this choice beyond cost?

>> We will aim for shipment of 4 crates every 4 weeks from each factory on a single flatbed truck. Shipping costs are determined by number of trips (driver and truck trip time), so fewer trips would result in less shipping costs. We are able to store 2 full crates while we are filling 2 more for 2 weeks. However, if the 4 crates are not removed as soon as the final 2 crates are filled, production would be delayed until the 4 crates are removed. Shipping 2 crates every 2 weeks allows us to keep production going even if a shipment is delayed by up to 2 weeks.

What is behind the optimization for assuming 4 hours/day for each of the workers? Some clarification would be helpful.

>> One of the expert workers at ANL has different daily hours than the others, so we can overlap with him 4 hours per day. Also, use of students and postdocs for production half of their time allows them to pursue thesis work and physics analysis also at half time. Both factories can complete production and shipping by working 4 hours per day for an estimated 6-7 months (includes holidays, vacations, absents, etc.)

How many iPads will be available at each factory?

>> Each factory has 2 iPads which will end up at SURF for CPA assembly and installation.

Do your risks cover the potential loss of experienced personnel during production? Is the funding for your experienced workers secure? What level of training for new workers is needed? Is it foreseen to build contingency into the schedule for the learning curve of new workers? How is it planned to transfer the expertise of the current team to new workers?

>> We plan to have 5 trained and experienced workers available at each factory with 4 needed each day. We have held 1 training session so far for new personnel at ANL and from W&M. We plan to hold additional training sessions at both ANL and W&M before production starts. We have enough spare parts to train workers to produce 1 CPA Panel at each factory. We can hold training sessions as often as we need to train new workers and to refresh everyone before production. See 3078042.

Should there be risks for problems in the component supply chain or for complete shipments getting lost?

>> We have reliable experience with our colleagues and with multiple vendors for each of our components. Our production schedule allows for at least 5-6 months of lead time for procurement of components from colleagues and vendors. In all cases, QC of parts is ongoing throughout this time period – any problems with supply and/or part quality can be addressed without incurring significant delays. See 3078045.

What kind of visual inspection is being performed at each step during the shipment process ? Are these only to assess the integrity of the shipping frame?

>> Only visual inspection of the crate at the Rapid City warehouse is done (no crates are opened). We have tried this shipping configuration in a shipment to Ash River for installation trials. If significant damage is seen to the crate after shipping, it can be opened to determine if any of the contents has been affected. If there is damage to the contents, the factory can be notified and replacements can be produced. Lead time for a new crate is ~2 weeks. See 3078045.

Is the shipping frame opened prior to arrival underground ? Is it safe to assume that this would only be done in the case of potential damage to shipping frame?

>> No, not opened unless it appears that the contents might be damaged (hole in the side of the crate). See 3078045.

What type of documents are received from the commercial vendors and institutional partners to verify that the required QC has been performed?

>> A compliance statement is included with invoices from vendors. We have required QC at vendors for some parts with very good results for ProtoDUNE-2, for example. Doc 3078040 includes this.

We assume that Steve Magill currently holds the ultimate responsibility for ensuring the CPA production effort. What is the succession plan if Steve was to leave the effort before its completion.

>> Aleena Rafique, ANL Assistant Physicist is being trained to take over from Steve Magill during the production process and will continue as coordinator of CPA operations through assembly and installation at SURF.

Review Office:

From the FD1 HV PDR recommendations tracking spreadsheet (EDMS 2399708), it appears that recommendations 9 (testing installation procedure at Ash River) and 10 (updating interface documents with TC, cryo, and CALCI) are still listed as “For Future”. I think these might be complete and closed, and the spreadsheet has just not been updated. Can you confirm and update the spreadsheet? If these really are still open, when does the team anticipate them being closed?

>> These recommendations have been marked as closed in EDMS 2399708?

From the FDR (review-066), recommendation #4 (camera system grounding details is still listed as “For Future” in the recommendations tracking spreadsheet (and on SharePoint site). I don’t think this precludes moving to production for the HVS, but it would be good to have an anticipated date by which this will be resolved. The comment in SharePoint is that “we have made arrangements with the grounding team to review the camera system after they complete their ongoing review of the ProtoDUNE configurations.” What is the anticipated date of this grounding review? Is there any danger that this review might highlight something that would necessitate modifications to CPA modules?

>> The camera system will be part of the HV distribution system PRR which is planned for spring 2025 after NP02 commissioning. We anticipate the camera system is reviewed by the electrical review team in early 2025 after we have addressed lessons learned from NP02 early results. There is no dependency of the CPA system on the camera system since they are very far away from each due to their 180kV potential difference.

Also, from the FDR (review-066), recommendation #5 (consistency of part numbers across subsystems) is still listed as “For Future” in the recommendations tracking spreadsheet and on SharePoint site. The comments from the owner indicate some misunderstanding of the recommendation. It was a general statement about using the same part numbers across different subsystems, and we gave two examples of inconsistency. The comments from the owner focus on one example and indicate that they will provide a list of cables that don’t meet low smoke requirements. It is hard to understand the status of our recommendation here – have the part numbers been made consistent in HVS and CE documentation, or is there some other assurance that the parts HVS will use are indeed the same parts that CE is expecting (and vice versa)? When does the team expect this interface issue be resolved?

>> Thank you for pointing out our misunderstanding. Regarding the cables, other than the interconnect wires and HV bus that are included in this PRR, we have only the cathode HV cables in our scope. The rest of the cables serving the HVS are from CE. We will ensure our documentation correctly references the part numbers used by CE.

Project ES&H:

Project Quality Assurance:

Are the acceptance criteria documented in the checklists and/or in the component incoming inspection procedures?

>> The instructions for the QC tests and acceptance evaluation are in the checklists on the iPad app.

In EDMS 3078040 (Plan for Commercial Vendor QC Documentation) QC requirements such as “Check of tongue and groove” seem to lack the details needed to perform the QC check? Are the specific QC inspection criteria shown in the iPad?

>> The inspection criteria are the same at the vendor and at the factories when we receive the parts. For example, we supplied Atlas Fibre with an aluminum template block for them to check the size of the frame tongues and the hole locations – the same template we use when we receive the parts.