

NOvA Module Factory Trip Report

Saint Paul, MN

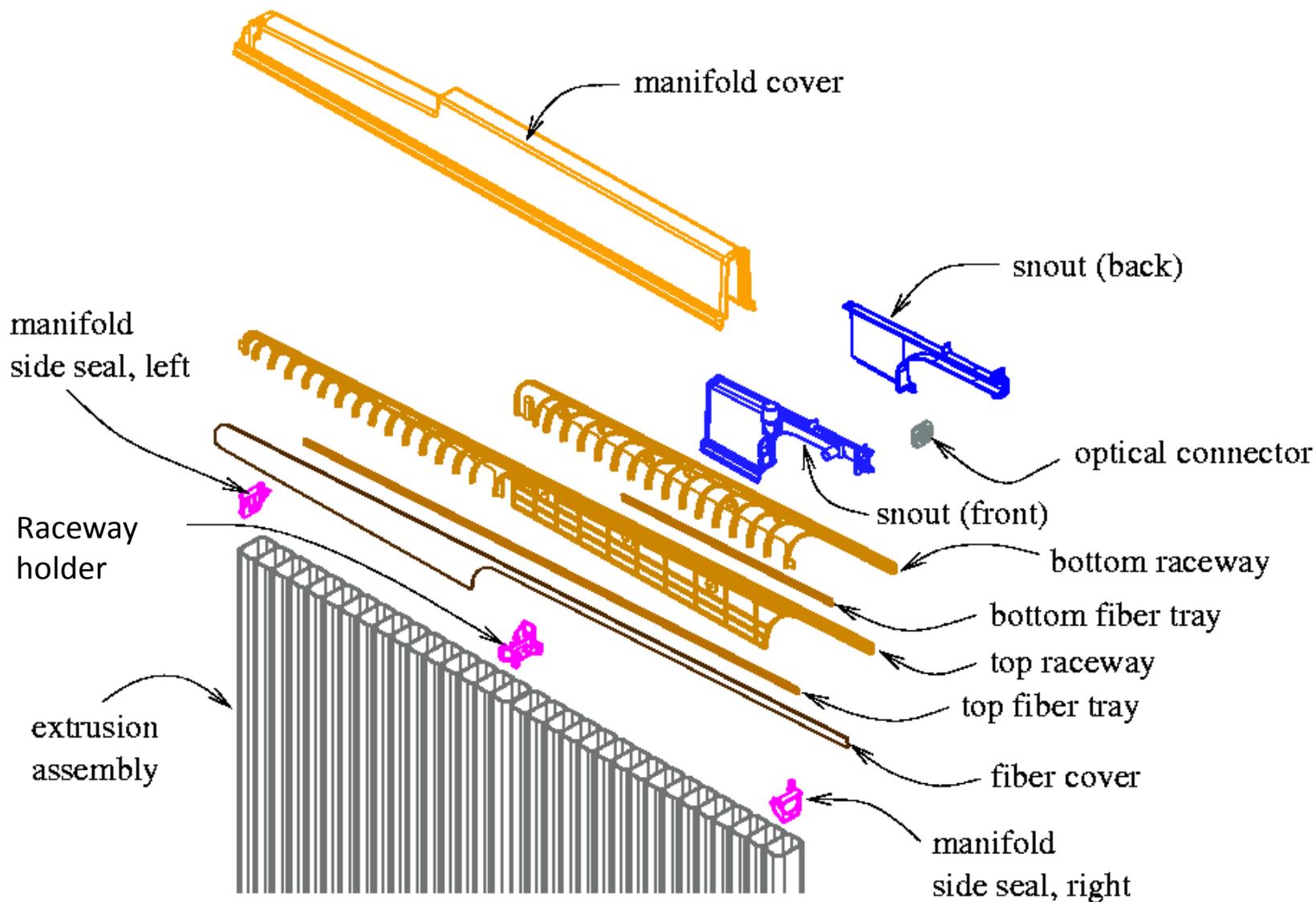
May 17-18, 2012

Eugene "JJ" Schmidt, PPD/QAR

Why did QA team go to module factory?

- At May 8 NOvA review, Ken Heller gave a talk on PVC module production. Ken is Principle Investigator and NOvA level 2 manager at the module factory which is run by the University of Minnesota in Saint Paul. (After completion, modules are trucked 300 miles to far detector site at Ash River in northern Minnesota.)
- The talk had a slide that was (perhaps unfortunately) titled "Module Shipping/Receiving Damage." The slide included statement, "Visual inspection of modules at Ash River by module factory personnel found damaged fiber: 5 modules (21%) in stack 1, and 6 modules (25%) in stack 2. All (were) good leaving factory."
- Reviewers (particularly DOE) found these numbers alarming and requested that Fermilab/NOvA management make sure problems were being addressed. Team of TJ Sarlina (NOvA QA), Halley Brown (NOvA QA audits, bookkeeping, etc), Joe Howell (independent Fermilab engineer), and "JJ" Schmidt (PPD QAR) were asked to visit factory for two days to assess the situation. No formal charge was given to the team. (This in my mind somewhat limited value of trip.)
- The spin of Ken's slide is unfortunate because the visual test applied at Ash River was not done at the factory so implication that problem occurred in shipping may be incorrect. In addition, it would have been less alarming to state percentage of fibers with problem ($1/32$ of number of modules if single fiber per module fails the visual inspection). That said, the requirement is that all modules have all fibers that pass final tests.

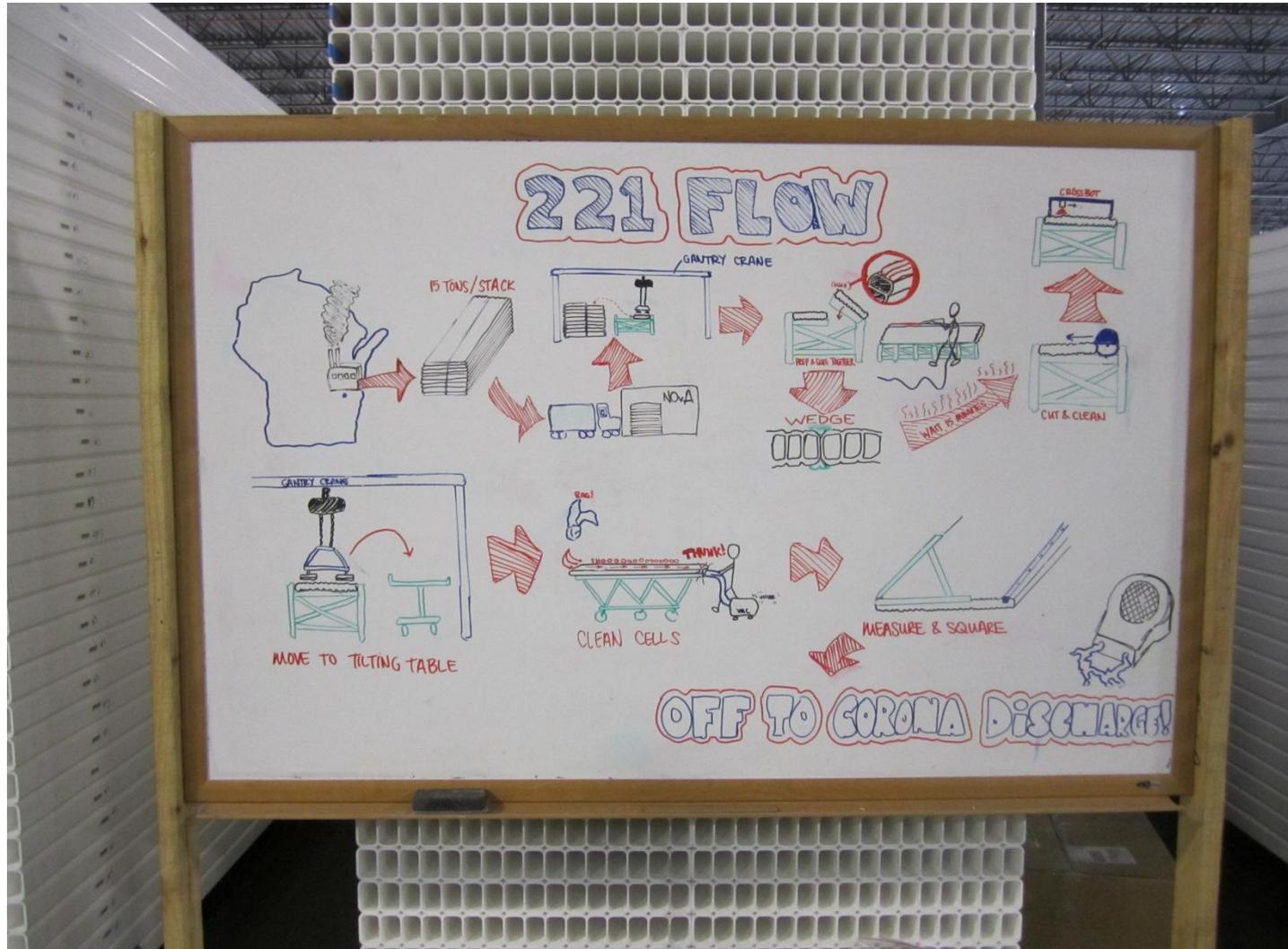
Manifold Parts (from Ken Heller review talk)



Factory Pictures



factory



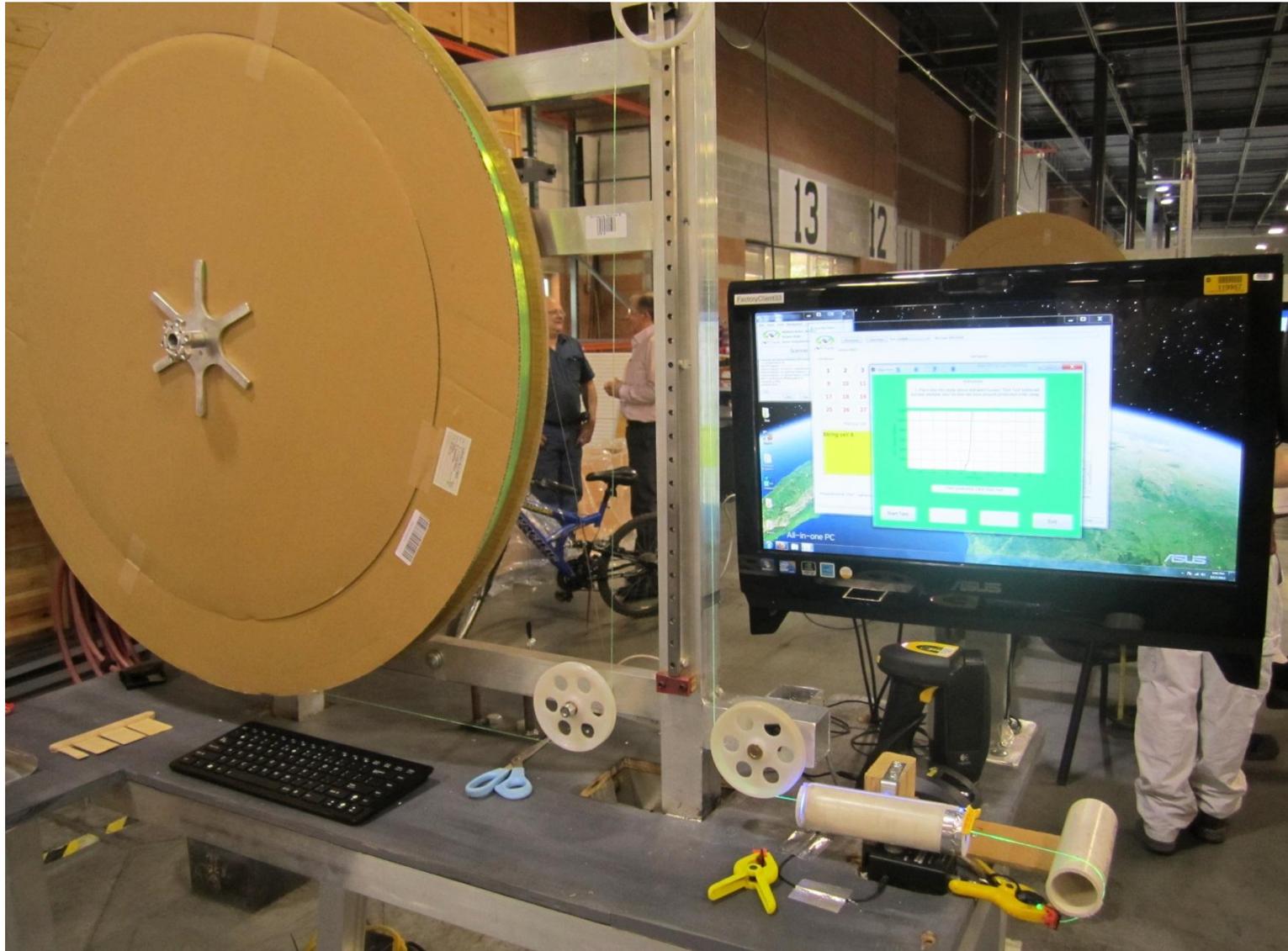
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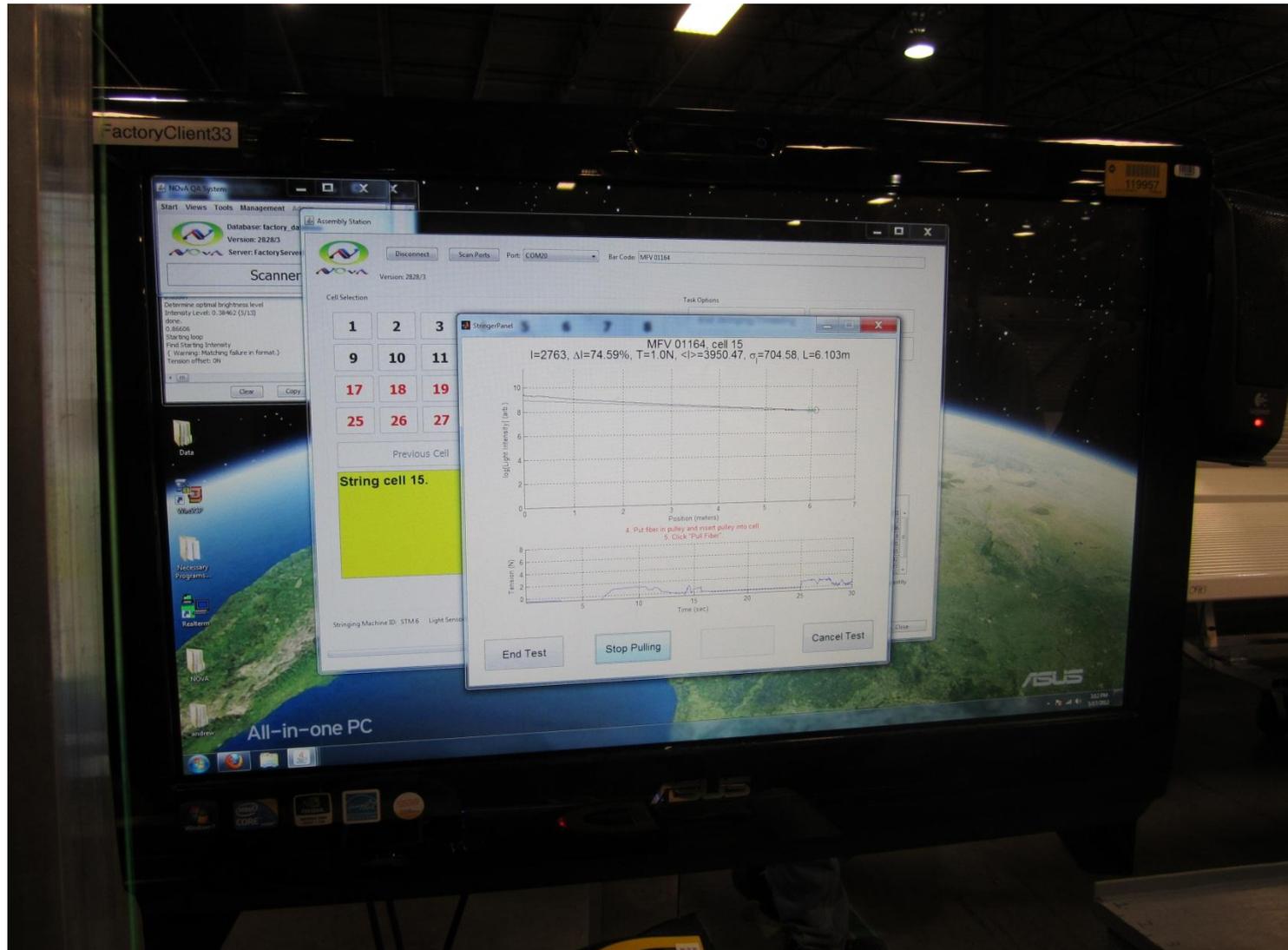
Pulling fiber loop



Pulling fiber



Optical test during pull



Dressing fibers into manifold



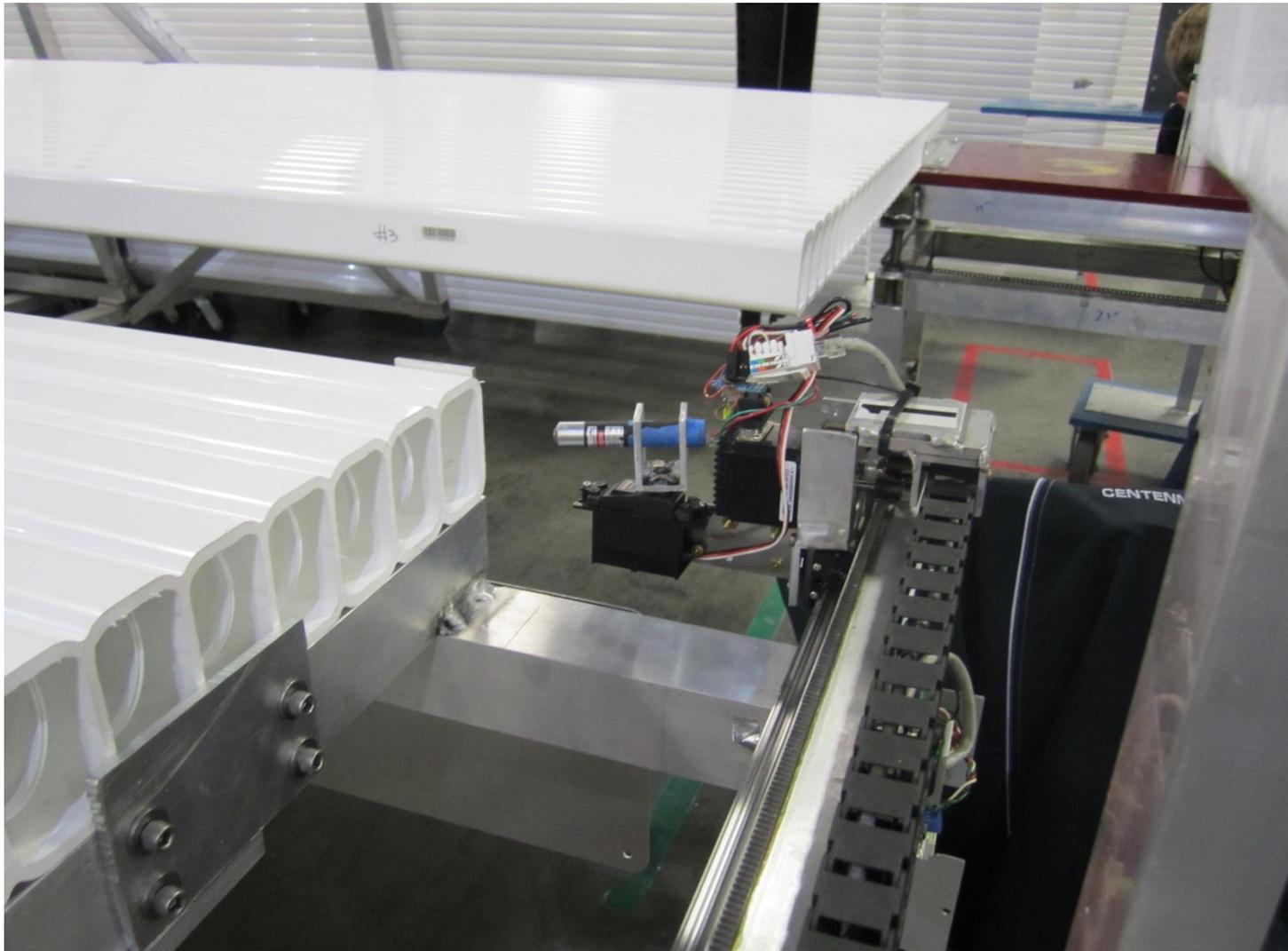
Dressing fibers into connector



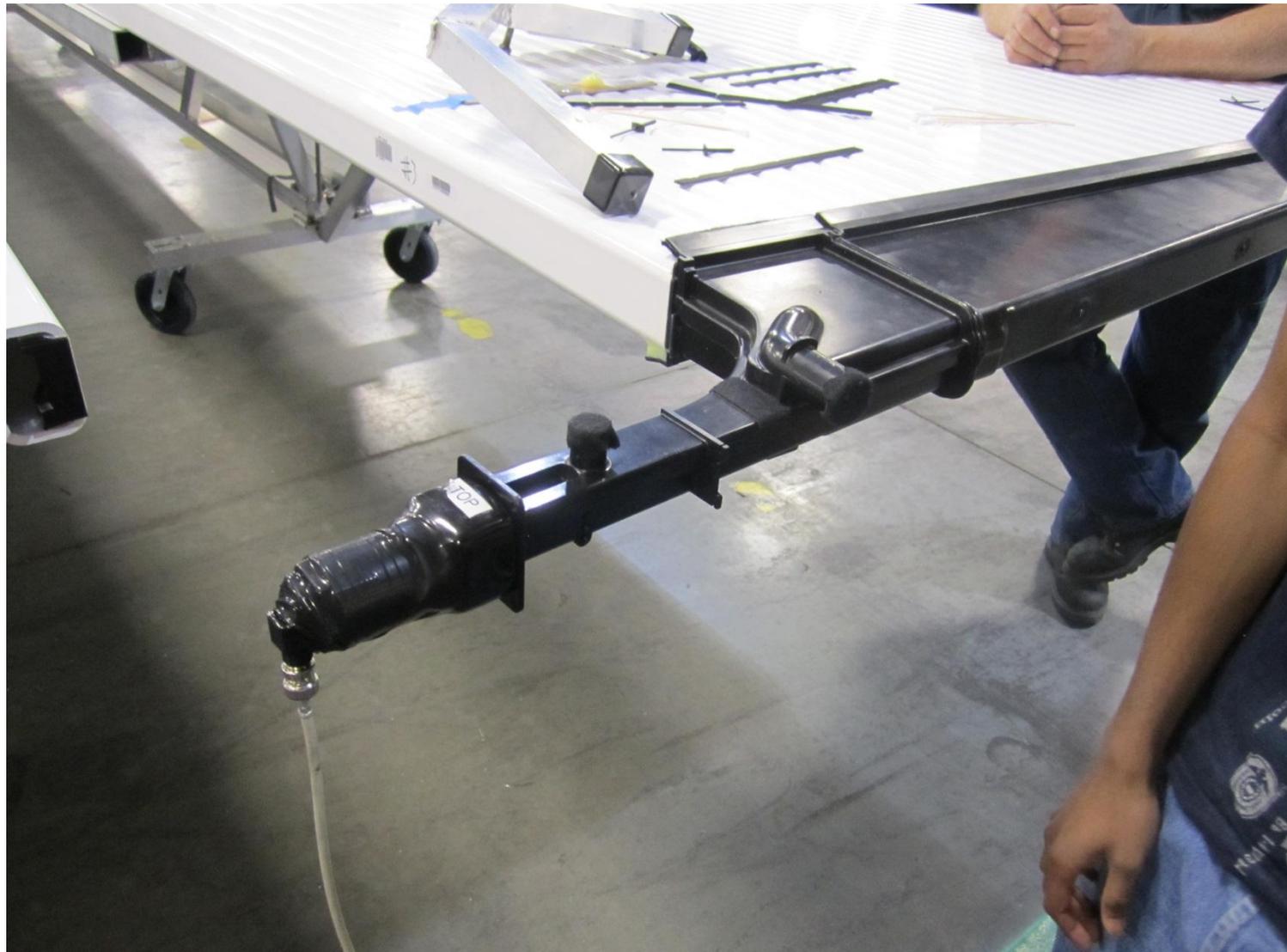
Dressing fibers into connector – layer 1



Laser-bot optical test – light source



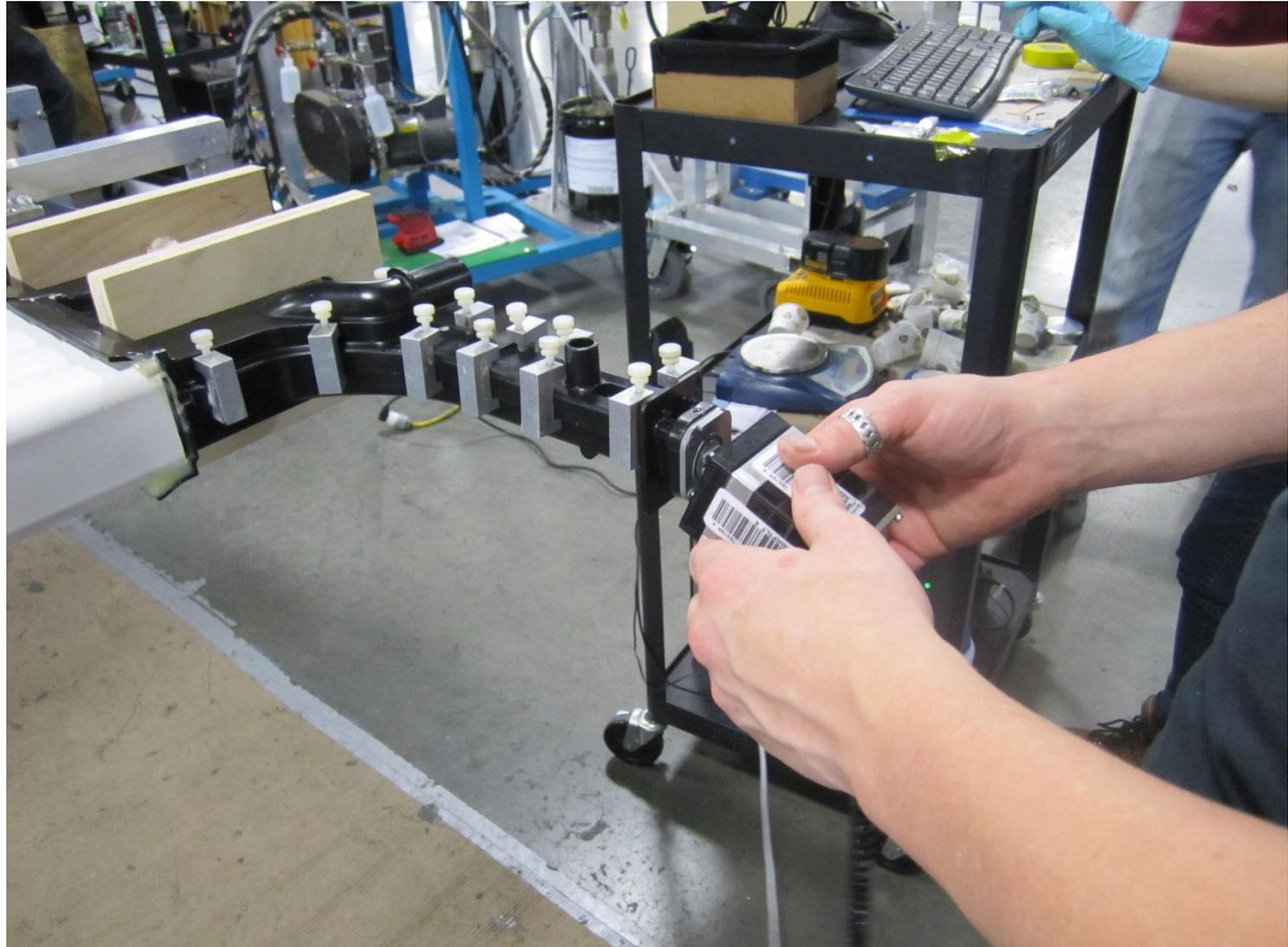
Laser-bot optical test - readout



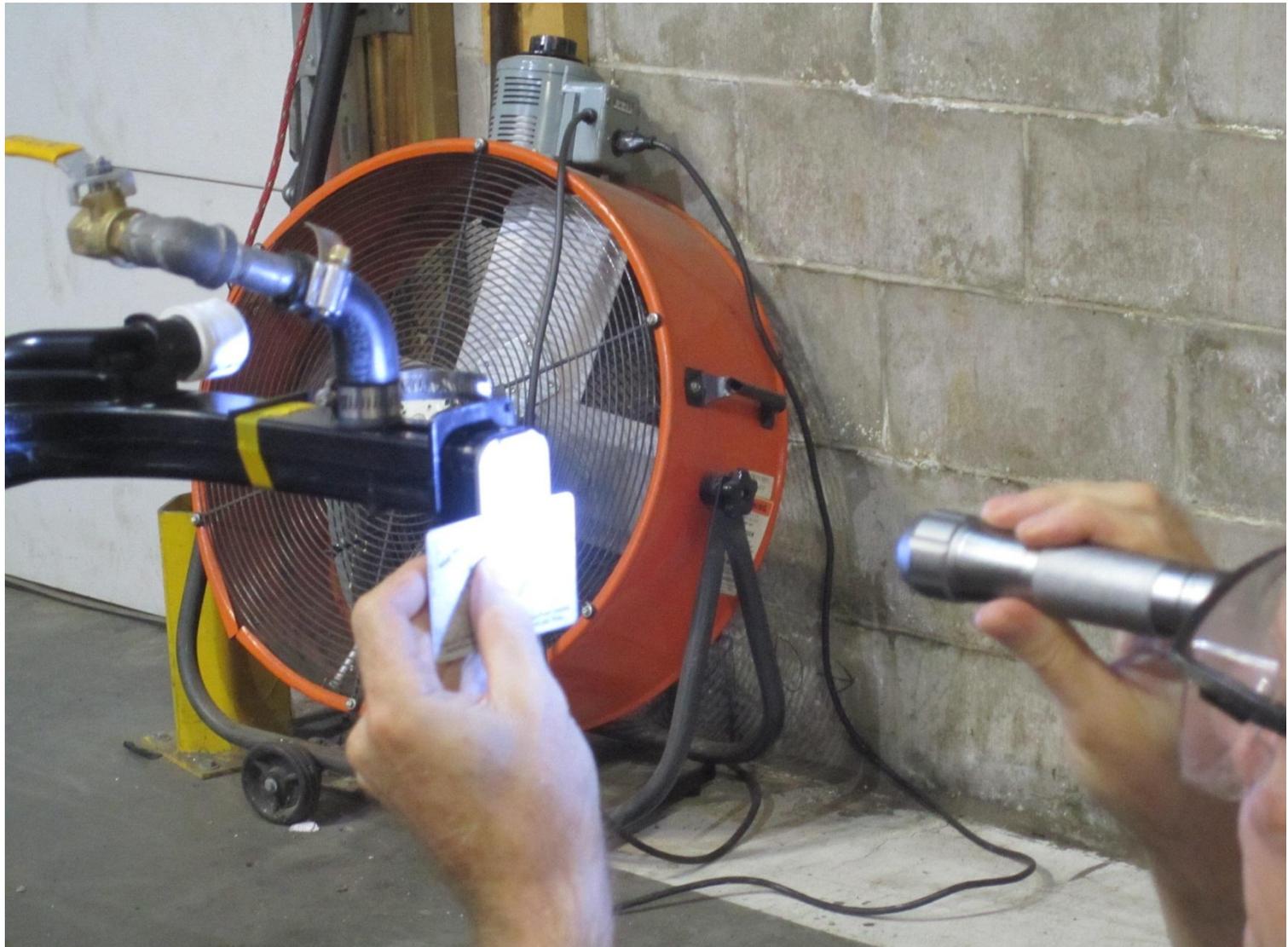
Fly cutting optical connector



MSU 32 channel optical transmission tester



“Credit Card” optical test



General Observations

- NOvA module production factory is pleasant place housed in a large warehouse. Warehouse was well lit, clean, air conditioned, and well organized with a staff that was engaged and appeared very attentive to detail. Line workers are students.
- Modules are conceptually simple but production involves many steps so there are ample opportunities for things to go wrong. Quality control is clearly important.
- Steps in production chain appeared to have good process control with discrete procedures and quality checks.
- Process involves electronically documenting completion of steps, id of person doing work, and results of tests or checks done.
- Data is available to track problems and potential problem sources in the production process although it appears staff is not yet in position to fully process data from the production chain and is not yet examining data for trends.

Optical Tests

- **Optical transmission during stringing:** Checks continuity and looks for major flaws in bulk fiber during stringing of the fiber loop.
- **Laser Robot (laser-bot) Test:** Tests light transmission in fiber just after dressing of fiber into optical connector. Test is qualitative since it is difficult to align the light source in reproducible way. All fibers are compared to best fiber for that module.
- **Michigan State Fiber Loop Transmission Test:** Quantitative optical transmission test of all fibers after fly cutting of optical connector. Injects red LED light in one end of fiber loop and reads out intensity at other end. Does all 32 channels at once and is difficult device since both ends of a fiber loop are contiguous in connector. This test was suppose to be “gold standard.”
- **Credit Card Test:** Simple visual test that looks for light (presumably) reflected back from flaw in fiber. Literally requires only a flashlight and a straight edge like a credit card.

Complicating Factors

- Card test was not part of production process and was initially only applied to modules after arrival at Ash River.
- Post production tests of completed modules at factories after the problem was discovered at Ash River indicated those modules also failed card test at similar level to the ones shipped to Ash River. i.e. Shipping not likely the problem.
- Some fibers that fail credit card test pass the MSU tester and might be useable for physics.
- Factory is in production, has skilled staff, and has finite storage space. Stopping production or shipping to Ash River would be potentially costly to NOvA. i.e. Problem/issue needed to be solved “on the fly” if possible.
- Weak collaboration/communication between module factory managers and MSU experts on the MSU FLT unit.

What was done (ongoing during our visit)

- Make educated guesses as to possible sources of problem and change production. In particular, fibers were spot glued into raceways. This had been part of process for NOvA test detector but was dropped to save time and money. NOvA has something like 11,000 modules so a few minutes per module is a real cost to experiment.
- Add the credit card test to both the production chain and as a requirement for a module to be deemed acceptable for Ash River.
- Put more emphasis on careful handling of fibers during stringing and production.
- Build some test modules and do destructive testing to learn possible sources of defects that cause fiber to fail card test. Note that it is extremely difficult if not impossible to do autopsy on failed modules. “Observing the system disturbs the system particularly if observing requires cutting system apart.”
- Note that team (at least JJ and Joe Howell) are not in any followup loop to track progress on problem. (Recall lack of charge....)
- Factory level 2 manager Ken Heller strongly believed existing factory staff would be able to isolate and correct problem without either help from other NOvA collaboration members or independent outside help.

Team Recommendations

- Do tests to verify that fibers are not failing during shipping. Tests should be done with modules completed with current production procedures (i.e. fibers glued in raceways and modules tested during production with card test).
- Provide detailed production and special test results to NOvA upper management to assess the situation. (Prior to our trip, it was clear that inconsistent information was being transmitted by different people associated with the factory.)
- Give factory staff 1-2 weeks to solve problem without outside intervention. If no solution in that time frame insist that larger group of collaborators (and possibly outside experts) be assembled to analyze production and special test data and make a structured plan to understand and correct problem.
- *Current status:* Recent project update status report by John Cooper indicates problem has been solved in sense that modules are no longer failing the card test. Shipping has been verified to not cause significant number of failures (if any). Source of problem is not completely understood. Data exist to show that gluing alone was not sufficient to eliminate card test failures so assumption is that more careful dressing of fibers was part of s

Current Status

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- Worth noting that above information in above bullet is known to me only because I poked around NOvA recent documentation.

QA Conclusions

- The team was not instrumental in solving problem. Our main contribution was likely “another set of independent eyes” that might have picked up something missed by people closely involved in production.
- JJ would be interested in feedback from OQBP/QARs on what NOvA might have done differently so that this issue did not occur at all or was caught and corrected earlier.
- Having a formal charge would have made it easier to get quantitative information from the factory.