D0 DECOMISSIONING

Storage of depleted uranium modules inside D0 calorimeters after the termination of D0 experiment

D-ZERO ENGINEERING NOTE # 3823.000-EN-585

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PPD/MSD/D0 Operation

Depleted Uranium properties and hazards

Dzero liquid Argon calorimeters contain hadronic modules made of depleted uranium plates. After the termination of D0 detector's operation, liquid Argon will be transferred back to Argon storage Dewar, and all three calorimeters will be warmed up. At this point, there is no intention to disassemble the calorimeters. The depleted uranium modules will stay inside the cryostats.

Depleted uranium is a by-product of the uranium enrichment process. It is slightly radioactive, emits alpha, beta and gamma radiation. External radiation hazards are minimal. Alpha radiation has no external exposure hazards, as dead layers of skin stop it; beta radiation might have effects only when there is a direct contact with skin; and gamma rays are negligible - levels are extremely low.

Depleted uranium is a pyrophoric material. Small particles (such as shavings, powder etc.) may ignite with presence of Oxygen (air). Also, in presence of air and moisture it can oxidize. Depleted uranium can absorb moisture and keep oxidizing later, even after air and moisture are excluded. Uranium oxide can powder and flake off. This powder is also pyrographic. Uranium oxide may create health problems if inhaled. Since uranium oxide is water soluble, it may enter the bloodstream and cause toxic effects.

Hazards at D0

Since D0 calorimeters will stay assembled with no modules taken out, there is no radiation hazard – cryostat walls will provide shielding. There is no ignition source inside the calorimeter (high voltage will be disabled), so the fire hazard is minimal. The ODH classification of the DZero collision hall was class 0 (no hazard/no precautions necessary) when the calorimeters were full of liquid argon. After the stabilization period, all cryogenic fluids and essentially all sources of inerting gas will be removed. There will be no ODH concerns from the few gas lines that will continue to be in use.

The only hazard would be a formation of uranium oxide. The formation of the oxide and resulting powder would complicate the future de-commissioning of the calorimeters. The powder would need to be washed off the modules and collected in a controlled manner. The amount of oxide might be substantial – the total surface area of multiple plates is large.

Conclusions and solution

The oxidation of depleted uranium plates must be prevented after cryostats warm up. It will be achieved by backfilling the cryostats with dry inert gas and keeping it a slightly positive pressure. In our case, the storage gas will be Argon, since the cryostats will remain connected to the liquid argon storage dewar after the liquid is transferred. The control valves, PV-114-A , PV-214-A, PV-314-A, and monitoring system are already in place. Our intent is to maintain the calorimeter control system and calorimeter

instruments useable during the extended storage period. Local alarms and local monitoring of pressure, valve position, etc. will be possible. If a positive gas pressure is lost, an automated phone dialer program will notify someone. With respect to Tony Leveling's input (see appendix 1), we are not considering using gas Nitrogen as an inert gas media.

References:

1. US Armed Forces Radiology Resources Institute: *Health effects of depleted uranium fragments.*
2. Casarett and Doull's toxicology: *The basic science of poisons.*
3. Bill Cooper's experience with depleted uranium modules assembly.
4. Wikipedia

Appendix 1:

Thoughts on D0 calorimeters – email from Tony Leveling, January 2011

Kathy J Graden

From: Don Cossairt
Sent: Wednesday, January 12, 2011 10:03 AM
To: 'leveling@fnal.gov'
Cc: Kathy J Graden
Subject: RE: Thoughts on the D0 calorimeter

Tony,

Thanks much for this rather extensive list provided on such short notice.
We will surely find this useful.

Don

From: Tony Leveling [mailto:leveling@fnal.gov]
Sent: Wednesday, January 12, 2011 9:09 AM
To: Don Cossairt
Subject: Thoughts on the D0 calorimeter

Hi Don,
I'll give you my unfiltered thoughts on the calorimeter, in no particular order. Please use them if/as you see fit.

1. The detector is really a marvelous beast. I wonder if it could find another life for some other physics purpose in place at the D0 collision hall.
2. I would really want to know if and to what extent uranium oxide contamination is found in argon subsystems associated with the detector. The reason would be to get a clue about how uranium oxides might have migrated away from the detector plates and onto surrounding surfaces or settled into the bottom of the cryostat.
3. Parts of the detector were built at Brookhaven and other parts were built at Fermilab. I know that we took a great deal of care to clean uranium plates very thoroughly for the modules built at Fermilab. I also know that Brookhaven did a great deal less than we did to remove loose oxides before assembling their sections. They had little piles of oxides in their sections
4. After 20 + years of immersion in liquid argon one should wonder what condition the plates are in now. One would naturally imagine that the plates are well preserved while stored in liquid argon, but I would keep an open mind on that point.
5. We found some very unexpected behavior regarding corrosions rates. It turned out that plates stored in "dry" nitrogen would oxidize at a very high rate compared with plates stored in dry air. If the detector argon is allowed to boil away, attempts to inert the atmosphere of the detector with nitrogen gas would be a bad idea. Any trace of moisture in otherwise dry nitrogen will lead to accelerated corrosion rates. Dry air is a better way to store DU.
6. We have a much more highly qualified group of RCTs now than we did in those days. Some of the guys could probably actually manage the radiological side of the disassembly.
7. Could the modules be removed from the calorimeter, packaged, and shipped to Oak Ridge for disassembly and recycling the DU?
8. Should the DU be recycled or could it just be disposed of?
9. If we were going to do reclaim the DU here, I would start with a clean room environment. Epoxy painted floors for easy decontamination, single point entry/exit with step off pads and friskers or perhaps a portal monitor. A negative pressure ventilation system with HEPA filtration to prevent airborne activity migrating away. I would put supply air in the top and exhaust at the bottom to prevent airborne dust from settling out in upper structures of the facility. I recall that this occurred at IB4 but wasn't found until the DU processing facilities were removed from IB4.

10. The MFH DU was shipped to Fermilab in steel boxes. If these boxes still exist, they could be reused to repack the plates.
11. The DU plates for the MFH sections weigh 80 pounds each and are ¼" thick. In those days, we picked them up by hand. Perhaps a vacuum lift could be used to pick them up now, but the plates have many holes for spacers, etc, and so the fixture would need to be designed for considering the hole pattern.
12. We welded small wires to the edges of the plates to apply voltage (or was it ground?). These will be sharps that could cause cuts if care is not taken.
13. The plates also have SS button spacers to create the gap for detector boards. These buttons would probably need to be removed.
14. Of course you would have measureable alpha contamination in such a facility.
15. Surface wipes of DU plates could have contamination levels from < 0.5nCi/100cm^2 to 2 to 3 nCi/100 cm^2 depending on the quantity of loose oxides on the plates.
16. Kurt Krempetz was a mechanical engineer for the project at the time and would be a great resource regarding mechanical details of the detector especially regarding its disassembly.
17. The plates and detector boards were stacked up and then a thin SS jacket was welded around the stack for containment. There was a thicker end plate so that the modules could be installed horizontally. A significant lifting fixture was designed for this purpose and would be required for disassembly.
18. It would be a good idea to do internal dosimetry for people handling so much DU. Urinalysis was the primary method, although whole body counting was also used. I think the former is much simpler and would be sufficient.
19. Respirators might be necessary, depending on the amount of loose oxides present. Of course, it would be better to engineer a disassembly location with a simple ventilation system to have fresh air available in the worker breathing zone. We used some simple ventilation techniques for filing uranium plates (metal fume) and other machine work which readily controlled exposure.
20. Personal air monitors should probably be used when appropriate.
21. An AMS3 or similar full time monitor system connected to a remote readout and datalogging system would be very useful.
22. We had occasional air alarms at IB4, especially on long weekends when the air exchange rate was decreased due to door opening/closing. From ½ life determinations, I think the problem was always related to radon daughters. Such a monitor is a good early warning in the event DU is involved in a fire or some other extraordinary release event. Dropping DU plates or other forms of rough handling could generate airborne radioactivity.
23. The MFH SS skins and detector boards may be difficult or impossible to decon. These materials would probably need to be disposed of as radwaste. To reduce burial volume, a fair amount of cutting would be required.

I hope you find some of this useful.
Tony