Section Four

ALARA Activities at DOE

4

ALARA Activities at DOE

This section on ALARA activities is a vehicle to document successes and to point all DOE sites to those programs whose managers have confronted radiation protection issues and used innovative techniques to solve problems common to most DOE sites. DOE program and site offices and contractors who are interested in benchmarks of success and continuous improvement in the context of Integrated Safety Management and quality are encouraged to provide input to be included in future reports.

4.1. ALARA Activities at the Fermi National Accelerator Laboratory

At the Fermi National Accelerator Laboratory (Fermilab), a policy consistent with integrated safety management (ISM) and in accordance with 10 CFR Part 835 requirements is to conduct activities in such a manner that worker and public safety, and protection of the environment are given the highest priority. Fermilab is committed, in all its activities, to maintain any safety, health, or environmental risks associated with ionizing radiation or radioactive materials at levels that are As Low As Reasonably Achievable (ALARA). Likewise, Fermilab management supports related work planning and review activities in support of Fermilab's ALARA program.

During CY2009, the primary activities at Fermilab that resulted in occupational radiation exposures were associated with a summer shutdown to perform maintenance activities of the Fermilab accelerator. Nearly all dose to personnel was due to exposures to items activated by the accelerated beams. Many shutdown maintenance activities were necessary as the Fermilab accelerator complex was challenged to meet the scientific objectives of the Tevatron Run II Collider Program while simultaneously operating the proton beam needed for the Neutrinos at the Main Injector (NuMI), Booster Neutrino (MiniBooNE), and SciBar Booster Neutrino (SciBooNE) experiments. Fermilab safely accomplished various essential accelerator repairs, maintenance activities, and upgrades as a result of the shutdown in the summer of 2009. Much of this work involved component replacement and repairs in the Linear Accelerator (LINAC), Booster, Main Injector, Antiproton, and NuMI Experimental Hall. The success in maintaining and controlling radiation doses to personnel is achieved only through the many laudable efforts of personnel lab-wide and in particular Accelerator Division personnel who work with AD ES&H Department staff to plan and coordinate shutdown work while implementing ALARA measures on a task-by-task basis.

The following activities highlight Fermilab's continued commitment to keeping exposures ALARA.

4.1.1. Reduced Accelerator Beam Intensity Prior to Shutdown and at Start-Up

Two weeks prior to the 2009 Shutdown, beam intensity to all accelerators was reduced by approximately 50 percent in order to reduce radiation exposures to shutdown personnel in all accelerator beam areas. The estimated dose savings for this pre-shutdown action is 10,000 person-mrem. After the summer shutdown was concluded, accelerator operations started the accelerator up at lowered beam intensity. This lowered beam intensity ensured that personnel would not be exposed to unnecessary radiation exposure due to radio-activation from initial beam tuning and new corrector magnet realignment work. The estimated dose savings from this post-shutdown action was 500 person-mrem.

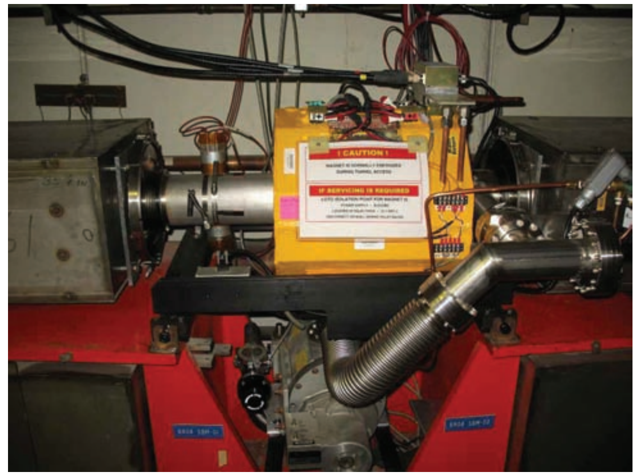
4.1.2. Expertise in Leak Checking a Vacuum Leak Saves Radiation Dose

The Booster is the first circular accelerator, or synchrotron, in the chain of accelerators at Fermilab. It consists of a series of magnets arranged around a 75-meter radius circle. It takes 400 MeV negative hydrogen ions from the LINAC and strips the electrons off, which leaves only the proton. The Booster accelerates protons to 8 GeV. In March, 2009, workers repairing a vacuum leak in the Booster beam line adjusted the steps needed to complete their work and were able to forego unnecessary steps in the ALARA plan based on their experience in identifying vacuum leaks. Area exposure rates were 300 mR/hr. Temporary shielding was used which reduced the exposure rate to 150 mR/hr upstream and 100 mR/hr downstream. Workers were able to skip a longer time consuming vacuum leak check of the entire vacuum sector based on their judgment that it was only necessary to leak check the immediate area known as "Short 6." The job overall was completed faster than the predicted times. The dose estimate was 397 person-mrem and the workers were able to complete the work with an actual dose of only 233 person-mrem. This efficient work resulted in a dose savings of approximately 164 person-mrem.

4.1.3 Implemented Cool-Off Time and Worker Experience Saves Dose in Replacement of Booster Corrector Magnet

Corrector magnets (see Exhibit 4.1) in the Booster are also called "bend," "trim," or "dipole" magnets. The function of corrector magnets is to bend the proton beam in either a horizontal or vertical direction. Fermilab upgraded Booster corrector magnets over two shutdown periods. The second phase of the corrector magnet replacement occurred during the 2009 summer shutdown. The order of the corrector magnet replacement was determined by vacuum sector and exposure rates in those sectors. The corrector magnets with lowest exposure rates were replaced first. Because exposure rates were relative low compared to other sectors, the first sector corrector magnet replacement was utilized for training all personnel who were temporarily loaned to Accelerator Division from other Divisions/Sections/Centers. The area exposure rate at Booster location Long 6 was 500 mR/hr at one foot. The combination of a four week cool-off period and the use of temporary shielding in the form of steel plates resulted in a reduced exposure rate of 400 mR/hr at one foot. The collective dose estimate for replacement of Long 6 corrector magnet was 1,640 person-mrem. The actual dose received to workers was only 287 person-mrem. The most significant factor resulting in such a significant dose reduction was performing the Long 6 corrector magnet replacement last. After changing out the twelve other corrector magnets before working on Long 6, workers were very adept and efficient in corrector magnet replacement. Therefore, the actual time spent replacing corrector Long 6 was significantly lower than estimated in the ALARA plan. Through the use of shielding, cool-off, and especially worker experience resulting in less time spent on the job, about 1,353 person-mrem was saved.

Exhibit 4-1:
Booster Corrector Magnet.



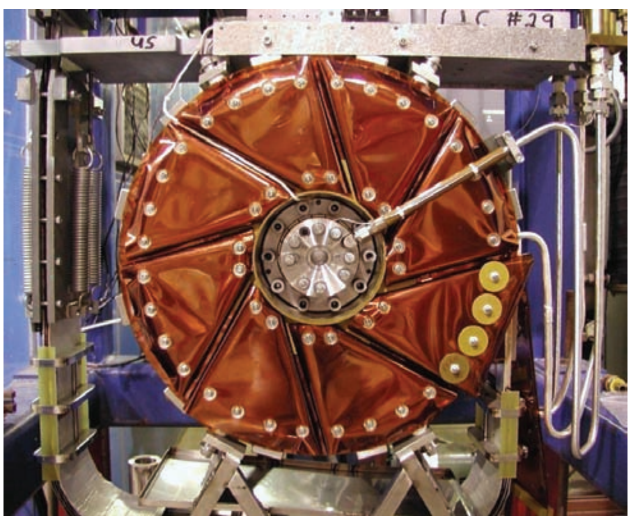
4.1.4 Main Injector Upgrades

The Main Injector is a circular ring seven times the circumference of the Booster. It accelerates 8 GeV protons from the Booster to either 120 GeV or 150 GeV, depending on their destination. New penetrations were drilled into the Main Injector tunnel. These new penetrations will serve to connect power to new kicker magnets for the Recycler ring which will be installed in a future shutdown. A kicker magnet is an extremely fast magnet that is used to divert the particle beam from one machine to another. The Recycler is a storage ring constructed mainly of permanent magnets located in the Main Injector above the Main Injector magnets. The Recycler Ring stores antiprotons and then supplies them to the Tevatron for particle beam stores. During planning for the project, the foresight concerning the magnitude of the radiation exposures that would be encountered led to the purchase of a large number of lead blankets. The purchase of these lead blankets was incorporated into the project budget. These blankets were placed over quadrupole magnets in the Main Injector to reduce the area exposure rates. Before the lead blankets were placed, the highest exposure rate was 200 mR/hr at one foot. After the lead blankets were in place, the exposure rates dropped to 20 mR/hr and as low as 5 mR/hr in some areas. To catch water and sediment from core drilling, pans were mounted to the ceiling of the tunnel. The dose estimate for this job was 1,736 person-mrem and the actual dose received was 787 person-mrem. The reason the actual dose was much less than the estimate was due to the fact that the workers finished the task in much less time than anticipated. Also, the effective use of lead blankets attenuated local hot spots in the surrounding magnets.

4.1.5 Lithium Lens Replacement and Antiproton Target Module Work

At Fermilab, antiprotons are produced by sending 120 GeV protons from the Main Injector to strike a nickel target in the antiproton source. It takes 100,000 to 1,000,000 protons to make one antiproton. A lithium lens focuses the newly created antiprotons into a beam. Prior to replacement, the used lithium lens (see Exhibit 4.2) measured approximately 120 R/hr at one foot. The new lithium lens was replaced and power striplines were attached in both the alcove and the lower vault seamlessly. The workers were efficient

Exhibit 4-2: Lithium Lens.



and quite knowledgeable of the task. It was decided to replace and relocate the air pressure monitor on the target module during this same task. This work added 5 person-mrem to the job. The collective dose estimate was 137 person-mrem and the actual dose received was 141 person-mrem.

4.1.6 Lithium Lens and Transformer Assembly Repair

A water leak and a broken tie rod were discovered in the antiproton lithium lens and transformer assembly. Exposure rates in the area were about 50 R/hr on contact with the transformer assembly. Four shielding coffins were used to create a rifle slot so that workers could work behind the coffins and use the rifle slot to access the lens and transformer assembly. The shielding coffins reduced the exposure rate to about 5 R/hr at the front edge of the rifle slot. Contamination from the lithium lens components was a also concern, so herculite drop cloths, personnel protective equipment, and bagging and wrapping tools successfully prevented the spread of contamination. The dose estimate for the work was 58 person-mrem and the actual dose received was 55 person-mrem. The repair of the lithium lens and transformer assembly went smoothly and according to the ALARA plan.

4.1.7 Neutrinos at the Main Injector (NuMI) Horn Power Stripline Improvements

The purpose of NuMI (see Exhibit 4.3) is to send neutrinos to a near detector located at Fermilab and to another far detector located 450 miles away at the Soudan Underground Mine State Park in Tower-Soudan, Minnesota for the Main Injector Neutrino Oscillation Search (MINOS) Experiment. The MINOS Experiment is a long-baseline neutrino experiment designed to observe the phenomena of neutrino oscillations, an effect which is related to neutrino mass. The Fermilab NuMI beamline uses protons from the Main Injector to produce an intense beam of neutrinos. The NuMI horn is a focusing device. The NuMI horn steers neutrinos to the MINOS Experiment near and far detectors. One of the two NuMI horns indicated a power stripline failure/fracture. This failure was the result of using steel washers on the power stripline restraint bolts. After a few years, the steel washers failed due to corrosion. Additionally,

Exhibit 4-3: NuMI Power Stripline and Holder.

the washer fastener lost its clamp load which lead to large unrestrained deflections of the power stripline layer. The deflections due to magnetic forces caused a fracture of the outer power stripline conductor just under the remote clamp. As a result of this failure, all new spare NuMI horns use inconel washers instead of titanium. Inconel is a nickel-based alloy made from chromium and iron that is highly corrosion resistant. The use of inconel washers will prevent future repairs due the NuMI horns. Assuming a failure rate of once per year, these improvements are anticipated to save a collective dose of approximately 900 person-mrem per year.

4.1.8 Neutrinos at the Main Injector (NuMI) Target Replacement

The Fermilab NuMI beamline uses protons from the Main Injector to produce an intense beam of neutrinos which are utilized by the Main Injector Neutrino Oscillation Search (MINOS) Experiment. The 8 GeV protons are sent to a beryllium target (see Exhibit 4.4) to produce pions. Pions are charged particles that can be controlled and eventually decay into neutrinos. In August of 2009, the NuMI beryllium target was removed from the NuMI target chase and replaced with a new target. NuMI target replacement work was delayed until the end of the summer 2009 shutdown to allow for maximum reduction in general area exposure rates. The general area exposure rate in the NuMI chase was about 10 mR/hr. The highest exposure rate measured at one foot from the used target was about 11 R/hr. Due to the high exposure rate, the used beryllium target was moved into the hot cell area and lead blankets were added to the top of the work cell to lower exposure rates. The lead blankets reduced the general area exposure rate to approximately 5 mR/hr. The used target was removed (see Exhibit 4.5) and moved into the NuMI morgue which was specially built for storage of used targets. The new beryllium target was attached and was placed in the target chase area. The workers were experienced and no problems occurred during removal of the old target and replacement of the new target. The collective dose estimate was 362 person-mrem and the actual dose received was 271 person-mrem.

Exhibit 4-4:
NuMI Target.

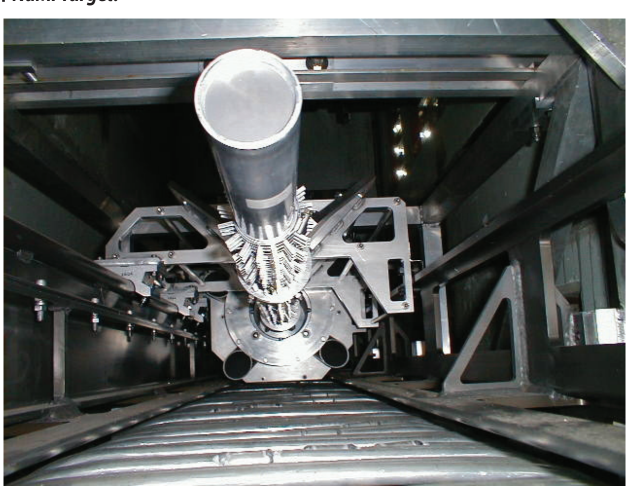


Exhibit 4-5:
NuMI Target Module Being Removed from Chase.

4.1.9 Neutrinos at the Main Injector (NuMI) Horn Jig Leveling Foot Improvement

A NuMI horn ground faulted because a jig leveling foot vibrated loose. Even though the leveling foot was fastened with a nut and a locking jam nut, it came loose and horn repairs were required due to the ground fault. To prevent this situation in the future, the NuMI horn hardware components were secured with safety wire, pins, locknuts, dynamic fasteners, belts, and suspenders. Assuming a previous horn jig leveling foot failure rate of one time per year, a collective dose of about 500 person-mrem will be saved as a result of these enhancements.

4.2. ALARA Activities at the Savannah River Site

4.2.1. Preparations for TRU Waste Resizing

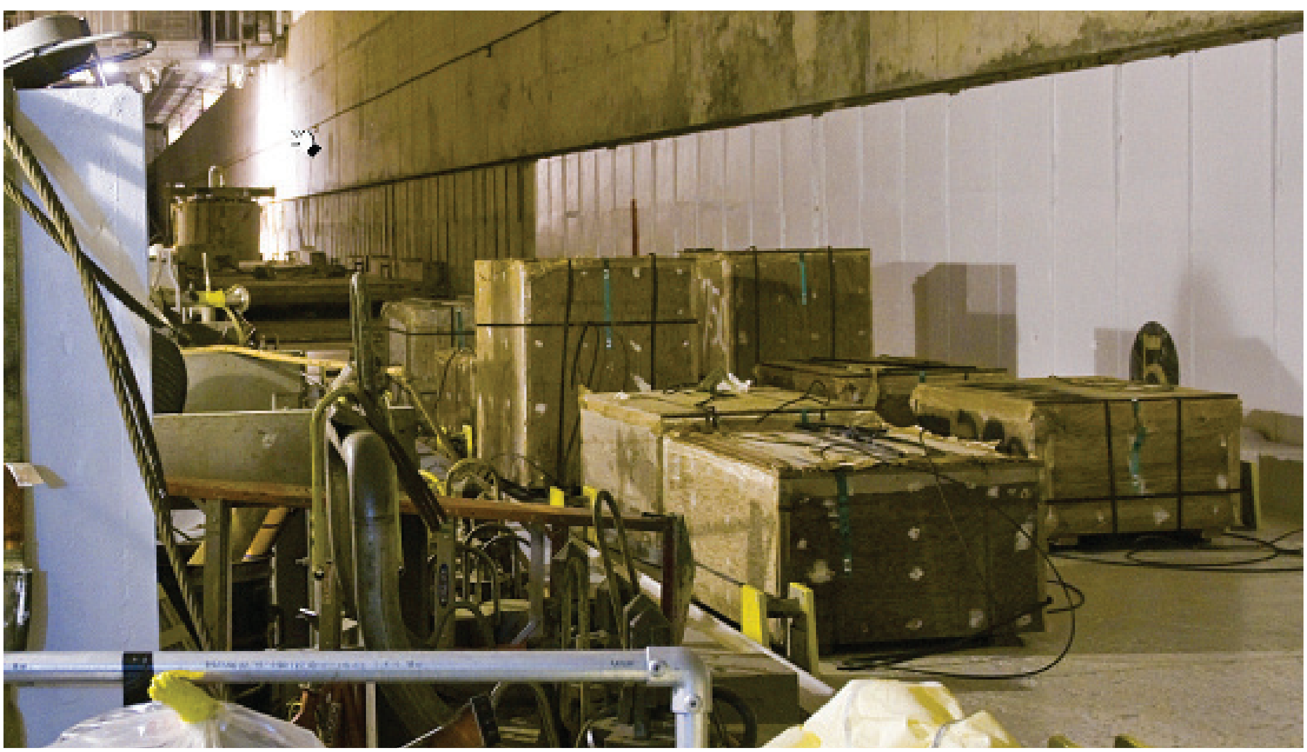
4.2.1.1. Project Description

H-Canyon is resizing TRU waste into WIPP compliant standard large boxes (SLB) or standard waste boxes (SWB) for disposal or into non-compliant containers. In preparation for commencing the TRU waste resizing campaign, H-Canyon Operations has significantly reduced the radiological source term within the Warm Shop, Section 4/5 cell cover and the Truck Well. Construction has performed extensive decontamination of these areas to prepare the surfaces for painting. Section 4/5 cell cover, the Truck Well and Warm Shop are freshly painted and prepared for staging and handling of the TRU waste containers (see Exhibit 4-6). In addition to the source term reduction, the Warm Shop area has been enhanced both radiological and operational to safely support the resizing effort. An additional airlock (see Exhibit 4-7) within the Warm Shop has been constructed to improve the transition between the airborne area and the non-airborne contamination area. Real time air monitoring has been added in the Warm Shop and the Warm Gang Valve Corridor airlock. Lastly, a scoop/ventilation duct is used during the opening and resizing of the waste that is directed into the canyon exhaust.

Operational improvements include the addition of a demister for fire control, updated emergency lighting, handrails in section 3 and a barrel ladder.

Exhibit 4-7:
Additional airlock in the warm shop.

Exhibit 4-6:
Staged waste containers in Section 4/5 cell covers.



Techniques used during the evolution include but are not limited to misting the interior of the container with ETGS, invisible blue, the use of a scoop during the opening and resizing evolution and communication equipment.

4.2.1.2. Radiological Concerns

The initial concern during the resizing operation is accessing the equipment within the wooden box. Contamination levels and airborne particles are unknowns. The wooden lids are methodically pried off the wooden box with the use of a crow bar while maintaining the scoop duct at the opening. Other unknowns like: Is the equipment packaging compromised? Is there unexpected waste in the crate?

Another concern is the unknown levels of contamination during the resizing operation of the piece of equipment. The scoop duct, canyon ventilation and the misting provides an engineering level of control during these evolutions.

The equipment chosen for the resizing by the team is a slower cutting tool to reduce the cutting dust and the safety concerns when compared to faster/quicker cutting tools.

Total collective dose for the project:
Estimated dose for the campaigned for 25 TRU waste boxes was 3500 mrem. Radiological work permit recorded exposure to date is 313 mrem.

Effect on dose rates, airborne and/or surface contamination:
N/A

Information on how the process implemented ALARA techniques in an innovative or unique manner:
N/A

Project staff involved:
Operations, Radiological Protection Dept., Construction, Engineering

Approximate cost of the ALARA effort:
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Impact on work processes, in person-hours if possible:
N/A

4.2.2. IAEA Material Consolidation

4.2.2.1 Mission Statement

To reduce risks by safely managing, storing and processing nuclear material.

4.2.2.2. Project Description

On August 17, 2009 DOE requested that we place 446 additional 9975containers under the IAEA Surveillance Program. The amount of time required for completing the phases of the operation and the number of personnel required were developed and documented by a cross functional team. This work included removing the 9975 containers from pallets and replacing them back on pallets, assaying 240 containers and replacing RFTIDs on 111 pallets. A detailed 17 phase plan was developed to estimate exposure for the job and reviewed with the operations FLM to ensure that the time line and hours assigned to each phase of the plan was correct. The Site ALARA Coordinator also toured K Area Material Storage and reviewed the work plan to assist in identification of additional ALARA improvement items. The general area dose rates in KAMS were from 10 mrem/hr. to 23 mrem/hr. A High Radiation Area in KAMS had a maximum dose rate of 280 mrem/hr. When the exposure estimate was completed the total dose estimate for the planned work was 17.4 rem.

Phase 1, to consolidate the material in the Stack Area under IAEA control, was initiated on 8/24/09, one week after the official DOE request was received. Each work group had involvement in the preplanning. Thanks to all of the work groups taking ownership in the development, preparation and completion of this work activity unnecessary personnel exposure was saved. Also all material movement/handling was performed without injury and ahead of schedule. This success story exemplifies the “team work” mind set shared by work groups that support K Area Complex. People working together to improve processes and procedures saves exposure and expense which demonstrates good stewardship to our customer.

4.2.2.3. Radiological Concerns

The radiological concern was the large amount of radioactive material, stacked 3 pallets high, with only narrow pathways to use to retrieve and replace material. Constant diligence to the ALARA principles of time and distance were critical in reducing exposure. Our initial ALARA initiatives were as follows:

- Preparation of banding material prior to banding drums to the pallets
- Segregation of high dose drums
- Completing paperwork outside of the Radiation Area
- Use of an A-Frame with a hoist to move drums from pallet to floor
- Use of a drum hand truck to move drums
- Movement of drums to low dose area to inspect, segregate and survey
- Separation and identification of KIS and MOX feed drums to prevent future handling
- Workers moving to low dose areas when not working with drums

Total collective dose for the project

Pre-job collective dose estimate	17.4 person-rem
Actual collective dose measured	2.468 person-rem

Effect on dose rates, airborne and/or surface contamination:
When the work was complete the highest individual dose received per EPD readings was .123 rem. The dose received for the entire job per EPD readings was 2.468 rem. 14.932 rem was saved due to continuing diligence to ALARA principles. The following are improvements identified as contributing to dose reduction.

- Requested and received approval to terminate Four Person Security Rule (3727 mrem saved)
- IAEA personnel stayed in the Crane Wash Area (2 mrem/hr) The dose estimate for IAEA personnel and his escorts was based on the assumption that they would be in a 20 mrem / hr field 50% of the time. (2576 mrem saved)
- IAEA spent 75% of their time in the No Dose Area (Computer Room) (1477 mrem saved)
- Low Dose Area (Crane Wash Area) was estimated to increase to 5 mrem/hr when material was moved to that location. Never increased above 2 mrem/hr. (708 mrem saved)
- Did not perform phase 10 which was to locate 10 drums not needed for IAEA that are needed for FY10 KIS Feed and relocate from Crane Wash area to 910B. (480 mrem saved)
- Most experienced fork truck drivers were used during work in High Radiation Area. Reduced time in High Radiation Area by half. (200 mrem saved)
- Completed work one and a half weeks ahead of schedule. (5764 mrem saved)

Information on how the process implemented ALARA techniques in an innovative or unique manner:
N/A

Project staff involved:
Operations, Radiological Protection Dept., Engineering, IAEA

Approximate cost of the ALARA effort:
N/A

Impact on work processes, in person-hours if possible:
N/A

4.2.3. Disposition of Process Water Deionizers

4.2.3.1. Mission Statement

To reduce risks by safely managing, storing and processing nuclear material.

4.2.3.2. Project Description

Nuclear Materials Storage Project/K-area Complex originally had in inventory a total of 16 Process Water Deionizers (PWDIs) requiring disposition as waste to the E Area Intermediate Level Vault (ILV). In 2008 the first eight (8) PWDIs, categorized as low dose deionizers were dispositioned successfully utilizing a variety of methods. In 2009, the next four (4) PWDIs, categorized as high dose, were successfully dispositioned. A team of personnel consisting of Waste Management, Engineering, Radiological

Protection Dept., Rigging, Maintenance and Operations, employed various tools and techniques to safely and with minimal exposure, vent, package, and transfer these deionizers to the ILV.

In addition to the disposition of four high dose PWDIs in 2009, dose rate surveys were required to determine the category of the last remaining four PWDIs located in a remote cell. Due to no available radiological data on these legacy items, remote monitoring was set up in the Trailer Space using RO-7 instrumentation. The PWDIs were remotely handled with the Purification Cell Crane and brought from the cell to the detectors for initial dose readings. Radiological Protection Inspectors (RPIs) were able to obtain rates from outside of the posted ARA/HRA/CA. Once categorized, the low dose remained in the Trailer Space for further survey and processing and the high dose deionizer (1) was relocated back into the cell to be processed at a later date.

Nuclear Materials Storage Project/KAC has successfully dispositioned a total of 12 of the 16 Process Water Deionizers. The work was accomplished with minimal exposure and risk to the workers involved due to the use of remote monitoring, remote activities performed by a crane operator and careful job preplanning. An experienced crane operator was able to perform maintenance activities such as venting and removal/installation of Hanford connectors while working in a clean area and due to remote handling and monitoring no entry was required to obtain initial dose rates on the last four deionizers.

Through teamwork and dedication, the work groups involved have made a successful project even better. The Process Water Deionizer disposition has continued to be accomplished safely, without a contamination event and ahead of schedule.

4.2.3.2. Radiological Concerns

Due to the high dose rates on 4 of the deionizers and unknown dose rates on the last 4 deionizers that were located in a remote cell, the following ALARA initiatives were executed:

- observation of similar work being performed in R-area and P-area.
- verification of proper ventilation
- preparation of work area
- remote handling of PWDIs by experienced crane operator
- remote performance of maintenance activities (removal/re-installation of Hanford Connectors)
- use of remote dose rate instruments and remote Kanne monitoring
- use of concrete culverts during packaging/transfer
- dedicated team of workers

Total collective dose for the project

Pre-job collective dose estimate	900 person-mrem
Actual collective dose measured	196 person-mrem

Effect on dose rates, airborne and/or surface contamination:
Time spent in the ARA/HRA/CA was reduced by 80% by using remote handling methods and survey techniques. Also deionizers were placed in concrete culverts for shielding during transportation. PPE was minimized due to remote venting and remote Kanne monitoring of the line break. A negative pressure respirator was worn for entry in lieu of a plastic suit which would have been needed if a mechanic had been required to manually perform the line break.

Information on how the process implemented ALARA techniques in an innovative or unique manner:
N/A

Project staff involved:
Waste Management, Maintenance, Operations, Rigging, Radiological Protection Dept.

Approximate cost of the ALARA effort:
N/A

Impact on work processes, in person-hours if possible:
N/A