PRR-1 Decommissioning: Implementing Dismantling and Decontamination

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Introduction

- This presentation is based on the sections of the PRR-1 Decommissioning Plan dealing with dismantling and decontamination (D&D)
  - The PRR-1 Decommissioning Plan is Chapter 3 in the attached references
  - An overview of the PRR-1 Decommissioning Plan was presented in the R2D2P meeting in December 2007
  - The PRR-1 Decommissioning Plan is still in early development

- This presentation will concentrate on the physical implementation of D&D
  - The preparatory activities for D&D were described in the previous presentation
  - It is understood that each activity described here will undergo safety assessment (radiological and non-radiological), although it is not always explicitly mentioned
  - It is also understood that the regulator's authorization is necessary to perform these activities

- A recurring theme in the D&D activities that will be presented is that the PNRI will do activities that can be done with current or easily-obtainable additional resources, without waiting for the implementation of the entire decommissioning plan to be funded
  - Difficult to predict when full funding will come
  - Doing the already doable activities will preserve decommissioning momentum
  - PNRI will gain experience on D&D while waiting for full funding

Lightly Contaminated Areas

- The laboratories and related rooms in the East Wing are probably only lightly contaminated
  - Only light contamination is expected because the original radioisotope production equipment were removed in the 1990s and all heavy contamination was cleaned up
  - Remaining contamination expected to be residue on surfaces or near-surfaces of spills made during radioisotope processing and use

- Contamination can probably be removed by surface cleaning and perhaps light scabbling
- Decontamination of these lightly contaminated areas can be done with available resources
- The decontaminated areas will be sealed to prevent recontamination when other areas in the building undergo D&D

Contaminated Structures

- Reactor core box
  - The reactor core box is an aluminum structure containing the core grid and the core's coolant flow channels
    - The core box is suspended from the reactor bridge by a suspension frame which is not radioactive
    - The core box is not intensely radioactive (order of magnitude is 100 µSv at a meter distance); most radiation is believed to be from a few small stainless-steel bolts that attach the side panels

- The core box is already nearly empty
  - The fuel, reflector elements, and irradiation rigs that were installed in the core box were removed in the 1990s
  - Only the control elements and their shrouds, and the instrumentation neutron detectors remain

- The reactor core box will be detached, packaged, and moved to the Radioactive Waste Management Facility (RWMF) for storage in one piece.
  - The radioactivity of the core box is low enough to allow dismantling to be done manually

- A custom waste container will be designed and built
  - The container will be small - volume approximately 2 cubic meters
  - The container will be light - very little shielding is necessary
  - The container with core box inside can be handled by existing equipment - lifted by the building crane and carried by forklift to the RWMF
  - The basic container building material will be stainless steel sheets and angle bars, with strategically-placed lead sheets
  - The container will be designed to meet the acceptance criteria of the RWMF

- The core box will be detached from the suspension frame and packaged with the following steps:
  - Remove remaining contents of core box and set aside
  - Place open empty container on reactor pool floor
  - Move reactor bridge over container
  - Cut core box off from suspension frame at four corner posts and lower into container
  - Move reactor bridge away from container
  - Place previously set-aside contents of core box in container
  - Close container

- The dismantling procedure will be carefully designed and safety assessment will be done to assure worker radiation exposure is within limits

– With the reactor core box gone, the bridge and suspension frame can be dismantled without radiation protection, using ordinary techniques

– The dismantling of the core box, bridge and suspension frame can be done within the PNRI's available resources

- Thermal column
  - The thermal column is a graphite-filled irradiation facility that fills a large penetration in the bioshield
    - Made of a thick aluminum casing embedded in the concrete, which is completely filled with tightly-packed blocks of graphite
    - The end facing the reactor core has a lead layer incorporated within the casing
    - Has a wheeled shield door at the other end made of concrete with a face layer of boral

- The graphite will be removed as the first step in the dismantling of the thermal column
  - Most of the graphite blocks are too long to fit in standard 200-liter drums
  - Custom waste storage boxes designed to meet the acceptance criteria of the RWMF will be built
  - All of the graphite will fit in a few boxes about 2.5 meters long
  - The graphite blocks will be removed by hand and placed in the waste boxes by personnel wearing light protective clothing

- The filled waste boxes will be taken to the RWMF by forklift
- Removal of the graphite can be done within the PNRI's available resources

– The thermal column's casing and door will be left to be demolished later together with the bioshield

- Beam ports
  - The beam ports are horizontal penetrations of the bioshield made of 6-inch and 8-inch aluminum pipes embedded in the concrete
    - There is neutron-activated contamination of the pipes and probably some of the concrete beyond the pipe walls
    - The beam ports have detachable shutters and plugs made of metal and concrete at both ends, that also have some neutron activation

- The shutters and plugs will be removed as the first step in dismantling the beam ports
  - The smaller shutters and plugs will be placed in standard 200-liter drums
  - The plugs that are too large to fit in 200-liter drums will be set aside and broken up later at the same time as the bioshield
- Removing the shutters and plugs can be done within PNRI's current resources
- The aluminum pipes making up the rest of the beam ports will be demolished later together with the bioshield

- Reactor pool
  - Dismantling of the reactor pool (or reactor block, or bioshield) is the most complex part of decommissioning and will generate most of the waste
    - Beyond PNRI's current resources; will need special government funding to carry out

- It is expected that neutron activation above clearance level will be present in the lowest elevation of the reactor pool (at core level, or the first stage of concrete)
  - Based on experience in other reactors, unlikely to be more than about 60 cm deep on average, although deeper where there are large penetrations (beam ports and thermal column)
  - Extensive coring samples to be taken during the characterization survey will define the precise depth distribution
  - Sampling will also show whether the pool liner leak has spread the contamination deeper

- The entire pool will be dismantled even though only a fraction of the concrete is contaminated
  - Removing the large penetrations and reducing the wall thickness at the bottom will destabilize the pool
  - Dismantling of the entire pool, starting from the top, is therefore necessary for safety
  - Most of the concrete waste will be non-radioactive, not to be placed in the RWMF

- The pool dismantling sequence will be:
  - Obtain authorization from the regulator
    - Supported by written procedures and a safety assessment
  - Disconnect all electrical power, instrumentation and water connections to the pool

- Install scaffolding inside and around the pool
  - The pool is already dewatered
  - No significant radiation exposure to hamper work inside the pool, except at the first concrete stage (the lowest elevation), and even there the radiation level is not high
  - The lowest elevation inside the pool will be covered to prevent personnel access and stop rubble from falling there while the upper stages are being dismantled

- Dismantle the walkway platform around the top of the pool
  - Primarily made of steel, and could be broken up with cutting wheels and torches
  - Precautions should be taken against starting a fire
  - Special care should be taken to support heavy steel pieces while the platform is being cut up

- Dismantle the pool starting from the top (the fourth concrete stage) down to and including the second stage
  - Parts of the first stage that are below clearance level may also be removed if there is no danger of cutting through contaminated material
  - The dismantling technique could be one or a combination of the following, based on a study of the cost, waste handling, and personnel safety:
    - Using diamond-wire equipment, cut the concrete into rectangular blocks that could be safely lifted by the building crane (1 to 2 tons per block), or
    - Break the concrete into manageable pieces using expanding grout, or
    - Break the concrete into manageable pieces using manually-operated demolition equipment, or

- Use the same Brokk machine that will be used later (to demolish the contaminated part of the pool)

  - Dismantling will also deal with the embedded piping (up to 8-inch size)
  - The aluminum pool liner may be fully stripped before the concrete is broken up, or it could be cut up and removed simultaneously with the concrete

- The waste so far is not contaminated
  - Metal debris should be segregated and sold as scrap
  - Concrete rubble can be dumped as landfill into undeveloped (low and swampy) areas of the PNRI compound

- The next steps will deal with contaminated parts of the pool

- Clear and clean a work area around the pool, and apply a durable coating to the floor
  - Will prevent liquids used during dismantling from diffusing contamination below the floor
  - Floor drains will also be sealed

- Completely enclose what remains of the first stage of the pool and the cleared work area around it with a custom-designed and built dust-proof tent
  - The tent should have an internal air circulation system that will remove suspended dust and provide air conditioning (cooling), to make conditions inside the tent bearable when humans have to work inside it
  - There should also be a filtered air exhaust system (separate from the internal air circulation system) that will maintain a slight negative pressure inside the tent
  - Electrical power and lighting should be provided inside the tent

- The tent should be wide enough to enclose the area above the underfloor runs of the primary coolant piping going to the equipment room
- The tent opening serving as the entrance and exit should face the door to the reactor building's truck entrance ramp

- Prepare the truck entrance ramp as the waste package staging area
  - Apply a durable coating similar to the one applied around the pool to the floor and walls of the area
  - The staging area will be used for any waste repackaging, assay, and temporary storage of filled packages before their transport to the RWMF
  - Empty waste containers will also be prepared and temporarily stored in the staging area before being taken inside the tent and filled

- Dismantle the remaining first stage of the pool
  - A Brokk remotely-controlled demolition machine will be used to break concrete and cut metal into pieces that will fit inside waste containers
  - The Brokk machine will also be used to load the waste containers
  - An enclosed and air-conditioned control room for the Brokk operator will be set up outside the tent
  - The beam port outer plugs and the thermal column door will be broken with the Brokk machine and mixed with the other contaminated concrete
  - Dismantling will include excavation of the pool floor until the concrete meets clearance levels

- The aluminum pool liner, embedded primary coolant piping, the thermal column casing, and the beam ports will be broken and segregated from the concrete using the Brokk machine as these structures are encountered while demolishing the pool concrete
  - Exception: The lead shield at the front face of the thermal column casing will be cut out as a single piece, to be placed in a custom waste container and transported to the RWMF

- Excavate and remove the underfloor primary coolant piping
- After the dismantling of the reactor pool is completed, clean and decontaminate the Brokk machine
- Clean and decontaminate the tent and its interior, and disassemble and remove the tent
- Using a scabbler machine, remove a few centimeters off the floor of the work area (including the coating applied earlier) to assure the removal of all contamination

Contaminated Systems and Equipment

- Water purification systems
  - The reactor has two contaminated water purification systems
    - The clean-up system (part of the reactor's original equipment) that maintained the purity of the pool water
    - The portable deionizer connected to the temporary fuel storage tank in the reactor bay (both were installed after the reactor was shut down)
    - Both systems use ion-exchange resin in fully enclosed columns

- Nearly all contamination in these systems are expected to be trapped in the ion-exchange resin, with some possibly in internal deposits in the piping and valves
  - The characterization survey will reveal the actual amount and distribution of the contamination

- The D&D steps of the water purification systems are:
  - Cut and seal all piping connections to the vessel housing the ion-exchange column of the clean-up system
  - With the ion-exchange resin still inside, move the entire column to the RWMF
    - The removal of the ion-exchange resin from its vessel, the repackaging of the resin in waste storage containers, and the decontamination of the vessels are better done in the future at a prepared set-up at the RWMF than on-site
  - Do the same with the column of the water purification system of the fuel storage tank

- Dismantle the systems' piping
  - Cut the pipes that have deposits above clearance level into short lengths
  - Put the pipe and valves with contamination above clearance level into waste containers and move to the RWMF
  - Dispose of pipes and valves that have contamination below clearance level as ordinary scrap material
- Decontaminate the systems' storage tanks and pumps
  - May be disposed of as scrap or reusable equipment after decontamination

- Reactor cooling system
  - Nearly all of the reactor cooling system was dismantled and removed in the 1980s during the reactor's TRIGA conversion, and the replacement was never used significantly
    - The only remaining original components are the N-16 delay tank and the piping embedded in the reactor pool and under the floor of the reactor bay
  - It is believed that the characterization survey will confirm that the cooling system is not contaminated, except possibly for the N-16 delay tank and the embedded piping

- The embedded piping will be dismantled and removed together with the reactor pool
- The N-16 delay tank will be decontaminated, if necessary
  - If contamination exists, it will be as deposits in the wetted interior of the tank
  - The interior of the tank is accessible by opening a flanged manhole, and the interior is large enough to work within
- The cleared components of the reactor cooling system will be sold for re-use or as scrap

- Storage tanks
  - The PRR-1 has three large storage tanks, two in the original design and a tank built after shutdown for the temporary wet storage of fuel
  - One of the original tanks (the Drain Storage Tank) was dismantled and replaced in the 1990s during the reactor shutdown; the replacement was never used for reactor operations and could not be contaminated
  - The Retention Tank is full of demineralized water originally from the reactor pool
    - The water has been sampled and analyzed in the past and is not believed to be contaminated above clearance level

- The Fuel Storage Tank is full of demineralized water and contains the slightly-irradiated TRIGA fuel elements, the reactor's neutron sources, and a few small neutron-activated metal parts removed from the core box
  - The removal of the contents of this tank, except for the water, is described in the presentation on preparatory activities
  - Like the water in the Retention Tank, the water in the Fuel Storage Tank has been analyzed in the past and is not believed to be contaminated above clearance level

- If the characterization survey shows that any of the tanks contain contaminants in the water above clearance level, the portable deionizer of the Fuel Storage Tank will be used to lower the contamination below clearance level
- After obtaining authorization to do so, the demineralized water in the tanks will be disposed of by dumping into the storm drain outside the reactor building
- After drying, the tanks will be verified to be free of contamination; if any is found, the tanks will be decontaminated
- After being cleared, the tanks will be cut up and sold as scrap

- Sump pit and floor drains
  - All the floor drains in the reactor discharge into the concrete sump pit in the basement floor of the reactor building
  - The characterization survey will show whether there is any contamination above clearance level in the floor drains and the sump pit, and in the ground beneath them

- If there is contamination above clearance level, the following will be done using the Brokk machine that will also be used to demolish the reactor pool:
  - Excavate and remove the floor drains and its piping going to the sump pit
  - Excavate and remove the concrete from the sump pit until the remaining concrete is below clearance level
- The contaminated material will be packaged and moved to the RWMF

- Process equipment room and tank rooms
  - The process equipment rooms and tank rooms in the basement floor of the reactor building house the reactor's water systems
  - The characterization survey will identify patches of contamination above clearance level (if any) on the floor, walls and ceiling of these rooms
  - The contamination will be removed with a scabbler after the equipment and tanks in the rooms have been removed
  - The waste will be packaged and moved to the RWMF

- Reactor building ventilation system
  - Only a few parts of the reactor building ventilation system could be contaminated
    - Nearly all of the ventilation system was dismantled and replaced during the 1990s while the reactor was still under repair
    - The new ventilation system was never used
    - The only remaining original ventilation components are some of the ducts and a small blower that were re-integrated into the new ventilation system

- If the characterization survey shows that there is contamination above clearance level in the old ducts, the ducts will be decontaminated if it is practical to do so
  - If decontamination is not practical, the contaminated ducts will be cut into short sections, folded flat, packed in waste containers and taken to the RWMF
- The old blower will be decontaminated if it is contaminated above clearance level
- Cleared components of the ventilation system will be sold for re-use or as scrap

- Reactor bay
  - The reactor bay (or reactor hall) is the basement area around the reactor pool
  - Contamination is possible on the concrete floor and walls of the reactor bay from the use of the beam ports, which open into that area
    - A scabbler will be used to remove sufficient concrete from the floor and walls to meet clearance level requirements
  - The neutron spectrometers that were installed in the reactor bay were removed in the 1990s, but some shielding and metal parts remain. These will be packed into waste containers and moved to the RWMF.

- Contamination is also possible on the holes and niches on the walls of the reactor bay which were used during reactor operation to store the beam port plugs and irradiated material
  - The Brokk machine that will be used to demolish the reactor pool will also be used to break off this contaminated concrete
  - Care should be taken not to damage load-bearing elements of the wall

- SNIF
  - The Seed Neutron Irradiation Facility (SNIF) is a rig for the irradiation of a small amount of target material, usually plant seeds, with fast neutrons
    - The SNIF is basically a cylinder of aluminum-clad depleted uranium, with an inner cavity to hold the seeds
    - The SNIF has a funnel-like extension on top to guide the insertion of a sample into the cavity
    - The SNIF was floor-mounted inside the reactor pool on a pedestal near the core box
    - The SNIF was removed when the reactor pool was dewatered, and is now in the reactor bay

- The SNIF will be packaged and moved to the RWMF
  - The funnel and pedestal will be removed
    - If these parts do not have contamination above the clearance level, they may be disposed of as metal scrap; otherwise they will be cut up and packaged with the rest of the SNIF
  - The main body will be placed in a custom-built waste container and moved to the RWMF

Reactor Grounds

- Soil
  - It is not expected that there will be much soil contamination in the PRR-1, possibly none above clearance level
  - If the characterization survey finds any contamination, it would likely be on the following places:
    - On the surface
    - Around the septic tanks of the toilets
    - Around the underground waste water discharge pipe of the reactor sump
    - Beneath the sump pit under the reactor building basement floor

- Soil contamination that is accessible by direct excavation will be removed, placed in 200-liter drums, and taken to the RWMF
  - It is assumed that there will not be enough contaminated soil for their total volume to be a problem
- Soil under the basement floor could be exposed and removed with the Brokk machine
  - It is assumed that contamination will be confined to the small area under the sump pit and that destabilization of the reactor building foundation will not be a problem

- Surface and groundwater
  - It is believed that there is no water contamination above clearance level around the PRR-1
    - The environmental radioactivity in and around the PNRI compound has been measured many times
    - The characterization survey will provide confirmation

- Auxiliary external structures
  - The auxiliary structures in the reactor grounds include cooling towers, powerhouses and a fuel tank for diesel gensets, a storage tank for water from the city supply, and the office of the reactor staff
  - It is believed that none of the auxiliary structures is contaminated
  - The characterization survey will provide confirmation

Dismantling and Decontamination Schedule

- D&D should be performed in a prescribed order to ensure that resources are available, dependencies are met and the possibility of recontamination of cleaned areas and items is minimized

- The following will be the general order of activities, including preparatory activities described in the previous presentation:
  - Start working immediately on building the additional storage facilities in the RWMF (waste enclosures and the fuel storage vault)
    - Building physical infrastructure like these has a long lead time
  - Release the West Wing as soon as possible, ahead of the rest of the reactor
    - This will immediately make available the West Wing to other use

- Remove uncontaminated items from the reactor building as soon as a place to transfer them is available
  - It is desired that clutter be removed from the workplace as soon as possible
  - However, much of the material has some scrap value which will be lost if they are just dumped out of the building into the weather
  - A cleared West Wing may be able to serve as storage for uncontaminated materials

- Remove the Co-60 sources and all the other movable radiation sources from inside the reactor building
  - There is space for these in the RWMF without waiting for additional storage enclosures
- Move the fuel to the new storage vault in the RWMF
  - This will have to wait until the vault is ready, but some of the next items can be done with the fuel still inside the building
- Decontaminate the East Wing
- Decontaminate the process equipment room and tank rooms

- Remove the fuel storage tank
- Package and remove the core box
- Remove the bridge and suspension frame
- Remove the walkway platform around the top of the pool
- Remove the upper stages of the reactor pool (not contaminated)
- Remove the first stage of the reactor pool (contaminated)
- Decontaminate the reactor bay and truck entrance ramp
- Decontaminate the grounds (if necessary)