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ABSTRACT:

University of California Project to Reduce the Risk of High Activity Sources through the Cesium Irradiator Replacement Project (CIRP)

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The Cesium Irradiator Replacement Project (CIRP) project was established by the National Nuclear Security Administration (NNSA) Office of Radiological Security (ORS) in 2014. Under this program, ORS seeks to reduce the risk posed by high activity radiological sources by encouraging sites to transition from using Cobalt-60 (Co-60) and Cesium-137 (Cs-137) irradiators with non-radioisotopic technologies, and in particular, x-ray and electron beam irradiators.

In late 2016, the University of California Office of the President (UCOP) and the State of California became aware of CIRP and held a series of meetings with researchers and clinicians, and a Working Group was formed to study the possibility of replacing cesium and cobalt-based irradiators with x-ray irradiators. After meeting and researching the options, UCOP and the State of California determined that participating in the CIRP Project would indeed be advantageous for the UC system as it would decrease the level of potential risks and increase the options for researchers.

Through support from the CIRP project, UC has purchased 26 X-Ray Irradiators or Linacs to replace the Cs-137 and Co-60 irradiators slated for removal. To date, UC has had 21 Cs-137 and Co-60 irradiators removed from around the UC system under the auspices of the Offsite Source Recovery Program (OSRP); this equates to almost half of all the irradiators on the ten UC campuses. Another 19 removals are pending. Device recoveries have slowed over that last two years because of an event at the University of Washington Harborview Medical Center, which resulted in a pause in recoveries as well as COVID travel restrictions that have impacted the ability for contractors to be on site. Device recoveries are beginning to slowly resume, and UC anticipates the remainder of its devices will be recovered over the next few years.

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University of California Project To Reduce The Risk of High Activity Sources Through the Cesium Irradiator Replacement Project (CIRP)

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The Cesium Irradiator Replacement Project (CIRP) was established in 2014 by the United States National Nuclear Security Administration (NNSA) Office of Radiological Security (ORS). Under this program, ORS seeks to reduce the risk of high activity radiological sources by encouraging sites to transition from radioisotopic Cobalt 60 (Co-60) and Cesium 137 (Cs-137) irradiators to non-radioisotopic technologies, and in particular X-Ray and Electron Beam Irradiators.

We will discuss the following concepts and approaches:

- Isotopic Irradiators, their uses and inherent risks
- CIRP Program goals and processes
- University of California and State of California embracing CIRP Program
- Non-radioisotopic or alternate technology: X-Ray Irradiators
- Status of the CIRP program at the University of California
- Gamma Irradiator removals

Isotopic Irradiators, their Uses and Inherent Risks

Radioisotopic Irradiators are self-shielded devices that contain large sources of radioactive materials, the most common for blood and research irradiator being either Co-60 or Cs-137. These irradiators are used in both our clinical and research facilities at the University of California. The most common clinical use for Co-60, with a half-life of 5 years, is as the treatment component of a gamma knife for brain tumors. Cs-137, with a half-life of over 30 years, is the active component in a Blood Irradiator. Blood irradiation is necessary prior to transfusion, primarily in patients that are very young, very old or those with compromised immune systems to prevent a fatal condition known as Transfusion Associated Graft versus Host Disease (TA-GVHD). In the research setting, the most commonly used irradiator contains Cs-137, which is used in cancer research, cell or marrow ablations, sterilizing teeth for the dental school, insect irradiation and exposing cells or small animals to radiation. The activity in these irradiators range from hundreds of millicuries to thousands of Curies and even at the smaller ranges could result in a catastrophic release of radioactive materials to surrounding areas.

The security and access to radioisotopic irradiators was not considered an issue until the early 2000, after the Twin Tower Attacks of September 11, 2001 in New York City. In retrospect, the event is viewed as a 'failure of the imagination'. It was after this event that there was a sea change in the approach of unsecured radioactive sources. The number of sources being used at unsecured facilities prompted a new look at security. Multiple activities were launched to focus on securing certain high activity sources. The goal was to study and design a nationwide and more protected approach to these irradiators. The concern was that if a source was used in a radiological dispersal device (RDD), also referred to as a 'dirty bomb', the University of California Office of the President (UCOP) determined that the human cost and the potential for the campuses and surrounding cities to become uninhabitable was not acceptable.

In 2013, the U.S. Nuclear Regulatory Commission (NRC) published 10 CFR Part 37 with detailed and extensive security plans to assure the protection of large radioactive sources. Since that time, multiple revisions have been released to increase the levels of protection. The University of California, like all facilities that possess the higher activity sources, developed their individual plans demonstrating their adherence to the most recent requirements.

There are extensive security steps prior to an individual gaining access to these machines. These steps include Federal Bureau of Investigation (FBI) fingerprints, seven years of background checks, and education verification. To gain admittance to a room housing a gamma-based irradiator at the University of California (UC), staff must use their UC ID badge, a personalized identification number (PIN) and a biometric identifier (iris scan). Another security step required is a semi-annual check of all the alarms and the radiation and motion detectors. This requires Radiation Safety staff to physically set off the alarms at each location and the Increased Controls manager to verify the triggering of the alarms in police dispatch. The open nature of research in a university setting and tests and treatments in a medical center setting makes it difficult to maintain security of these irradiators. The consequences of the theft or loss of any of these sources could be devastating.

In terms of the current national threat levels, the University of California is aware that several campuses exist in the top ten terrorist targets in the country. In addition, the intelligence community is convinced the production of a radioactive dispersal device (RDD) is not IF but WHEN.

CIRP Program Goals and Processes

ORS works to prevent the use of high activity radiological materials from being used in acts of terrorism. ORS uses the following strategies to enhance radiological security not only domestically but also globally:

- PROTECT large radioactive sources being used daily for vital medical, research and commercial purposes
- REMOVE AND DISPOSE of disused radioactive sources
- REDUCE the domestic and global reliance on high activity radioactive sources by encouraging the adoption and the development of non-radioisotopic alternative technology

The Office of Radiological Security (ORS) has been working with domestic users of gamma-based irradiators to educate the community about the non-radioisotopic options to the security burdened radioisotopic irradiators. The Cesium Irradiator Replacement Project (CIRP) provides an incentive to those using blood and research irradiators to make the transition from gamma to X-Ray Irradiators when feasible.

Qualified users would receive

- Removal and disposal of the Cs-137 or Co-60 irradiator, resulting in a savings of $100,000 to $300,000 for each removal process
- A financial incentive to assist in the purchase a non-radioisotopic alternative device, such as an X-Ray Irradiator which equals 50% of the cost of the new irradiator or $135,000, whichever is less. The higher the number of gamma irradiators that are removed and replaced, the higher the incentive payment.

By enrolling in CIRP, the facility would benefit in the following ways:

- Equipment reliability
- Ease of use and training
- Established operational protocols with accurate radiation delivered doses
- Minimize related security expenses
- Release from potential liability
- Mitigation of security risks
- Consistent energy with decay calculations no longer necessary

<u>University of California and State of California Embracing CIRP</u>

In late 2016, the University of California Office of the President (UCOP) and the State of California became aware of CIRP. A series of meetings with University, State, and Federal Officials were arranged to discuss the far-reaching implications of CIRP and to determine if the project would not only benefit the University and the State but might also perform a higher purpose by protecting the citizenry of the State. It became clear that the 'Remove, Reduce and Replace' concept of CIRP was not only in the monetary interest of the State and University, but also followed the basic mission and philosophy of UCOP by providing a public service to the people of California.

Once UCOP and the State of California were in agreement to further study the CIRP program, the additional part of UCOP's mission to serve society as a center of higher learning and provide its researchers and clinicians with state of the art scientific equipment would require meetings with involved staff. A Working Group of researchers, scientists, Principal Investigators, Radiation Safety Officers and UCOP Representatives was formed to study the ramifications of transitioning from irradiators with large radiation sources to X-Ray irradiators that would not have the extensive security concerns. After months of research, meetings, and collaboration with other entities, it was agreed that participating in CIRP would be the best course of action and indeed be advantageous to the UC System by decreasing the level of potential risks and increase options for researchers

X-Ray Irradiators

X-Ray Irradiators are the most common non-radioisotopic or 'alternate technology' to replace the radioisotopic Irradiators. X-Ray Irradiators do not have the level of security required by the Cesium or Cobalt Irradiators and users do not have to pass through the rigid security clearances before gaining access, therefore making them less burdensome to use and maintain.

Cs-137 Irradiators have a single photon energy of 662 keV, much higher than the current maximum X-Ray Irradiator energy produced. The initial concern of the transition to X-Ray Irradiators is that this lower energy may not produce the same results. After extensive research, published literature shows that the energy produced in the most common X-Ray Irradiator is equivalent to the Cs-137 Irradiator energy and is actually more biologically effective to achieve the same biological endpoint for ablation and tumor cell destruction. The higher energy of the Cs-137 supplies needless radiation dose for this application. Regarding irradiation of cells and tissue cultures, the X-Ray Irradiator supplies sufficient energy to produce the same results as the Cs-137 Irradiator. In terms of Blood Irradiation, the Food and Drug Administration (FDA) has approved the use of X-Ray Irradiation. The systems available not only achieve the level of exposure required, 25 Greys, the throughput is often six times that of the Cs-137 irradiator and the need to periodically recalculate the time for exposure related to decay of Cs-137 is not necessary. Specific types of irradiation to small animals may not show an equivalency so this application is continued to be studied. One of the agreements with researchers was to allow comparison between Cesium irradiation and X-Ray Irradiators before the removal was completed.

With partial funding from CIRP, the University of California has purchased 26 X-Ray Irradiators or Linacs (Linear Accelerators) to replace the removed Cs-137 Irradiators. At this time, 25 X-Ray Irradiators have been installed on the UC campuses. All Blood Irradiators at the University of California Medical Centers have been replaced with X-Ray Irradiator technology.

Status of the CIRP Program at the University of California

When UC first started this transition process in 2018, the UC Campuses possessed 47 Cs-137 or Co-60 irradiators. These irradiators comprised almost half of all the irradiators in the state. To date, the University of California has successfully removed 21 irradiators under the auspices of the Offsite Source Recovery Program (OSRP) and also funded by ORS at little or no cost to the state.

Some of the irradiators were under-utilized and the removal was inevitable. As the cost of a single removal could exceed $300,000, the CIRP program was invaluable in supplying most of the funding for this process. Other irradiators are used on a daily basis, and UC has partially supported these researchers to perform comparison studies with the newly installed X-Ray Irradiators and the Cs-137 irradiators.

Gamma Irradiator Removals

The removal process is a careful and involved dance between each UC campus, the Radiation Safety Officer and team, the UCOP Center of Excellence (COE) CIRP Lead, the UC Campus Police Department, Local Law Enforcement (LLE), Local Federal Bureau of Investigation (FBI) teams and the FBI Weapons of Mass Destruction (WMD) Coordinator, State and Local Homeland Security Teams, State Radiological Health Branch (RHB) and the National Labs involved in the removal. As the University of California San Francisco possessed the majority of the irradiators to be removed, a checklist was designed to assure all steps and notifications were completed. As of this time, the checklist is 22 pages long and in the UCOP mission, a generic checklist could be shared with other entities, planning a removal.

An additional 19 removals are planned from the UC Campuses. When this program was started in early 2018, the original plan was to complete the removals by mid 2021. However, other issues arose to delay that plan. In May of 2019, a removal incident occurred at the University of Washington, Harborview Medical Center that brought removals to a grinding halt. During the removal of a large Cs- 137 source, a procedure resulted in the inadvertent release of radioactive materials. This incident necessitated a hard stop to all similar removals and the need to design and produce a shipping container that could accommodate these larger irradiator removals, without a source transfer in the field. In addition to this incident, in March 2020, travel restrictions instituted as a result of the COVID-19 pandemic resulted in bans from entering campuses, restricted airline travel, constrained hotel options and limitations to crossing state lines or country borders. It wasn’t until January 2021 that UC could remove a cesium irradiator with stringent precautions in place and a designation that these removals were considered essential work as determined by the University. There is still an issue and delay in removing the larger cesium irradiators. Even though a cask has been designed and cleared to perform such removals, there are only two casks in the country that can accommodate such a procedure. At this point, the University of California is awaiting clearances and equipment to once again proceed with these removals.

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