Report

Scope of Radioactive Waste Management for Large Accelerator Facilities — From the Example of SLAC, Involving Environmental Restoration Project —

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An approach how and what to discuss the decommissioning of large accelerator facilities has been overviewed through a case study on Stanford Linear Accelerator Center (SLAC) in USA, which is also under discussion in Japan. SLAC has its own framework on radioactive waste management, however it is still involved in difficulties about the treatment of large amount of low-level radioactivated materials, such as shielding blocks or soil surrounding the underground accelerator. Introduction of disposition criterion of solid material was deferred by US regulatory authority. SLAC is also focusing on the environmental protection using Environmental Restoration Project due to United States Environmental Protection Agency (USEPA). Remedies for the circumstance water or land which are affected by the SLAC's past operations are started. Every kind of pollution including radioactive contaminations are targets of remedies. It means they address the inclusive management of various risks, such as chemical hazardous risk and radiological consequence risk. It is helpful for other accelerator facilities over the world which program decommissioning.

KEY WORDS: accelerator, decommissioning waste, treatment of radioactivated material, environmental restoration, stakeholder involvement, hazardous material, integrated safety.

I INTRODUCTION

There were two relevant studies on radioactive waste management presented in AOCRP (Asian and Oceanic Congress for Radiation Protection)-II by researchers from High Energy Accelerator Research Organization (KEK) in Japan and Stanford Linear Accelerator Center (SLAC) in USA. They are interested in the activation of materials generated from accelerators.^{1, 2)} Their main scope of both studies is the preparation of decommissioning of accelerator equipments. The treatment and/or disposal of the decommissioning waste of accelerator facilities are still unresolved both in Japan and USA.

We visited the SLAC on Jan. 2007 to see the real situation, and to discuss what they think and how they contend with the problem to be solved for decommissioning of accelerator facility. We discussed radiation safety and radioactive waste management with Dr. Sayed ROKNI, the Acting Associate Director of Environmental, Safety and Health Division, Dr. LIU, the Leader of Dosimetry and Radiological Environmental Protection Group, and other accelerator health physics experts in SLAC. We noticed that they had already started the effort

to reach an agreement with residents living in the vicinity on the treatment of wastes, including radioactive waste, from accelerator facilities.

This report presents several discussion points to forward the radioactive waste management in a large accelerator facility, based on the experience/opinion exchange with SLAC staffs.

II PROFILE OF SLAC

1. Profile of the laboratory

The SLAC is in San Mateo County of California, almost 60 miles south from San Francisco, surrounded by flat hills and fields. It is close to the Silicon Valley, the Mecca of semiconductor industry.

The SLAC is one of the famous quantum physics laboratories in the world. It was established in 1962. SLAC, in 1960's, was the leading laboratory of the quantum discovery. The quarks as discovered at SLAC are up, down and charm. Four researchers who belonged to SLAC received the Nobel Prizes. A report on the development of EGS4³⁾ was published from SLAC contributed with Dr. HIRAYAMA at KEK.

They have a 3 km length linear accelerator (Linac) and beam storage rings at SLAC shown in **Fig. 1**. The beams extracted from them are used in many kinds of researches. It is, now, on going to lengthen the 3 km-Linac to research photon science. They also targeted the field about astro-particle science with Electron Positron Linear Collider Project (, so-called ILC project).

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Fig. 1 Diagrammatic sketch of the SLAC Accelerator.

Fig. 2 SLAC radiation safety regulatory system.

2. Environment, Safety and Health Division

The Environment, Safety and Health (ES&H) Division conduct the achievement and maintenance of excellence in matters related to environment, safety, and health. The division consists of 25 members in 4 departments, which are Knowledge Management, Chemical and General Safety, Radiation Protection and Environmental Protection. The staffs are mainly involving in the management and quality control; factual field operations had been already outsourced. Many staffs are basically physics researchers or technicians. They are not only safety specialists but also good facility operators.

As stated by SLAC that their mission is “Discovery, Training, and Safety”, they enhanced their consciousness of importance of safety. DOE strengthens more and more the safety operation and research for any facility. The research institute is also focusing on the safety more than ever before. Under this recent background SLAC had stopped their accelerator operation for several months in 2006 after an electrical incident. DOE approved SLAC to re-start its operation at last both after SLAC had constructed appropriate measure to prevent any similar accident and after DOE had authorized it.

(1) Radiation Safety

The radiation safety system is based on the U.S. regulation as shown in Fig. 2. All of the documents on their system are open to the public on the SLAC web site.⁴⁾ Three bases of radiation control in SLAC are shielding, access control and containment.

The rules of SLAC are a little different from Japanese ones in some cases. The U. S. regulations have been developing independently, and they are a little different in detail from the radiation safety due to ICRP, which is basis of Japanese regulations. The comparison between US system and Japanese one might become a good chance to reconsider our standpoint for radiation safety.

Nowadays, SLAC is requested from DOE to introduce the concept of integrated safety. Integrated safety means combination of radiation safety and non-radiation safety. It will be balanced with risk. We believe this point of view is extremely important for all related facilities in the world.

(2) Radioactive Waste Management

They manage treatment of radioactive waste and other mixed waste in SLAC. “Mixed waste” is the concept used in USA, which is any hazardous waste that is also radioactive. Manual for radioactive waste is open to the public on the

SLAC web site⁴⁾. The responsibility for waste management in SLAC basically lies with generator of the waste. Radioactive Waste Management Group promotes their waste management training to every researcher.

The annual amount of radioactive waste in SLAC is almost 15,000 cubic feet (≈ 420 cubic meter). They categorize and distinct the produced waste and dispose of them at both DOE and commercial licensed waste disposal facility. They are facing the problem of fund to dispose of the waste. The cost of waste disposal to DOE is about \$450 per cubic yard ($\approx ¥62,000$ per cubic meter), \$250,000 ($\approx ¥30$ million) a year. Their fund is not enough to dispose of all of the waste at the same time. The remaining waste to wait the opportunity is piling up in an area of the laboratory.

They also manage the activated waste produced with the renovation or demolition of laboratories. They can evaluate the amount of activated waste by calculation, and they intend to apply the calculation to manage the radiation activated waste management. One of the biggest problems they are facing is the treatment of shielding blocks. They have 1,700 cubic feet (≈ 50 cubic meter) of shielding blocks some of which might be treated as a radioactive waste in a future. Other problem is the treatment of soil around the underground linear accelerator. They might be activated by the beam loss. They are strongly waiting for establishment of the process to manage (dispose, reuse, recycle or other way) the used shielding blocks or other materials with small amounts of residual radioactivity. Discussions about establishment of criterion for disposition of such solid materials at US regulatory authority was deferred in 2005.

III ENVIRONMENTAL RESTORATION PROJECT

1. Environmental Restoration Order

In 1970, United States Environmental Protection Agency (USEPA) was established. It has been working for a cleaner, healthier environment for the American public. They have concerned about all manner of environmental pollutions. Radioactive waste and even the radioactivated surrounding materials, such as soil or groundwater around underground accelerator tubes they would be still radioactivated insensibly, are also one of the objectives of USEPA’s activities, however they are the only fractions of all the USEPA interesting. They conduct not only the assessment and prevention of the product of pollution, they also evaluate the past pollution and request

recovery action to the related organizations.

In May 2005, Stanford University and DOE agreed with the order of the site cleanup requirements for SLAC from California Regional Water Quality Control Board, San Francisco Bay Region (Water Board).⁵⁾ The order follows the

instructions by USEPA, and many organizations, including DOE and their laboratories, agreed with similar orders. The contents of the orders for SLAC are shown in **Table 1**.

The order contains much and detail information, as mentioned ‘FINDINGS’, about circumstances of pollutions which

Table 1 Contents of the ORDER to SLAC by Water Board

FINDINGS	ORDERS
1. Purpose of Order	A. PROHIBITIONS
2. Site Location and Ownership	1 The discharge of wastes or hazardous substances in a manner that will degrade water quality or adversely beneficial uses of waters of the State is prohibited.
3. Adjacent Land Use	2 Further significant migration of wastes or hazardous substances through surface or subsurface transport to waters of the State is prohibited.
4. Site History	3 Activities associated with the subsurface investigation and cleanup that will cause significant adverse migration of wastes or hazardous substances are prohibited.
5. Named Dischargers	4 The storage, handling, treatment, or disposal of polluted soil or groundwater shall not create a nuisance as defined in California Water Code Section 13050 (m).
6. Regulatory Status	B. TASKS
Other Relevant Permits	1 Environmental Baseline Report (1/Feb/2006)
Stormwater, Sanitary Sewer/ Wastewater, Air, Hazardous Waste, Hazardous Waste Treatment Units	2 Proposed Land Use and Development Plan (1/Sep/2005)
7. Regional Topography	3 Public Participation Plan (PPP)(1/Feb/2006)
8. Regional Watershed	4 Remedial Investigation / Feasibility Study (RI/FS) Workplan and Implementation Schedule (60days from Approval of Task 1)
9. Surface Water	5 Remedial Investigation (RI) Report (IAW APPD Task 4)
10. Groundwater	6 Baseline Human Health and Ecological Risk Assessment (IAW APPD Task 4)
11. Stormwater	7 Feasibility Study(FS) Report (IAW APPD Task 4)
12. Ecological Concerns	8 Remedial Action Plan (RAP) (IAW APPD Task 4)
13. Remedial Investigations Performed to Date (for each relevant area)	9 Remedial Design (IAW APPD Task 4)
14. Remedial Actions Performed and Current Remedial Status (for each relevant area)	10 Implementation of the Final RAP (IAW APPD Task 4)
15. Additional Sites Requiring Investigation and Potential Remediation (for each relevant area)	11 Operation and Maintenance (O&M) (IAW APPD Task 4)
16. Basis for Cleanup Standards	12 Risk Management Plan (IAW APPD Task 4)
Basin Plan, State Board Resolution No. 68-16, No. 92-49, No. 88-63	13 Five-year Review Report (IAW APPD Task 4)
17. Groundwater Beneficial Use	14 Investigation, Remediation, and Closure Protocol for Newly Discovered Sites and for Land Use Changes (60days prior to Proposed Site Action(s))
18. Surface Water Beneficial Use	15 Proposed Curtailment or Closure (60days prior to Proposed Site Curtailment or Closure)
19. Basis for Groundwater Cleanup Standards	16 Implementation of Curtailment or Closure (60days after completion of Task15)
20. Basis for Soil Cleanup Standards	17 Evaluation of New Health Criteria (90days after requested by Executive Officer)
21. Preliminary Cleanup Goals	18 Evaluation of New Technical Information (90days after requested by Executive Officer)
Groundwater, Soil	19 Delayed Compliance
22. Potential for Modification of Cleanup Standards	C. PROVISIONS
23. Reuse or Disposal of Extracted Groundwater	1 Good O&M
24. Basis for California Water Code Section 13304 Order	2 Cost Recovery
25. Cost Recovery	3 Access to Site and Records
26. California Environmental Quality Act (CEQA)	4 Self-Monitoring Program
27. Notification	5 Contractor / Consultant Qualifications
28. Public Hearing	6 Lab Qualifications
	7 Electronic Reporting
	8 Document Distribution
	9 Reporting of Changed Owner or Operator
	10 Reporting of Hazardous Substance Release
	11 Periodic Order Review

will be caused by SLAC operation. FINDINGS includes purposes, site characteristics, regulatory status includes relevant permits, topologic/hydraulic/environmental conditions, remedial processes, remediation target, public involvement and other relevant information. They are regional, however national common requested information. The order represents four prohibitions and 19 tasks to SLAC. The tasks require SLAC to submit baseline reports, action plans, feasibility studies, reviews, and evaluations of their remediation works, and also of public participation. It is notable that tasks have COMPLIANCE DATE and SLAC must take action to comply with the orders before the approved date. All of the submissions from tasks are necessary to approve by or notify to the Executive Officer of Water Board.

Along with this order, SLAC started the Environmental Restoration Project overseen by Water Board. SLAC started to remedy the circumstances polluted with chemicals or radioactive materials with the promotion of the Environmental Protection Group. They submitted and approved some documents ordered by the tasks, and implement the submitted plans. They also submitted Public Participation Plan (PPP)⁶⁾ and approved by Water Board.

Water Board has published the Fact Sheet⁶⁾ to notify the progress of the project and the publication of relevant documents to the public. They also indicate the procedure to submit comments. It is along with the PPP⁶⁾, approved by Water Board. The documents about this project are open at the public library and the State's data management website. Both Water Board and the authorities of SLAC are the contact of public comments. The person, who has interesting to the contents of the fact sheet, can make a comment via any communication tools such as mail, telephone, fax or e-mail. The comment period is almost one month. SLAC and the Water Board work on this project in close coordination, maintaining the transparency to the public. It is one of the effective trials to constitute the stakeholder involvement.

Similar orders would be issued to every organization in USA as USEPA stated. They are working for their environmental restoration programs.

2. Discussion

The important point of the Environmental Restoration Order is that it is given from USEPA and Regional Water Board. It means that the treatment of radioactivated surrounding materials is equal to other hazardous materials, because USEPA concerns about every aspects to protect human health and the environment. All the hazardous materials are treated depending on their risk, such as chemical hazardous risk or radiological consequence risk. Radioactive material and non-radioactive material are treated on equal criterion of risk on hazard analysis.

Such a risk integrated environmental protection scheme would be better way to pursue the integrated safety of people and the environment from kinds of waste. It would be helpful and reasonable to promote general risk management. Even though, there will be some problems are still existing. The problem is the kind of risk. The risk with radioactive material has been analyzed epidemiologically, since the risk of chemi-

cal hazardous material is mainly on lethality and devoid of enough epidemiological knowledge. It might be not a right way to treat them in the same field. It is still uncertain that the comprehensive risk-based hazardous material control is workable. Careful consideration is necessary.

Same situation can occur also on the accelerator facilities in Japan. The risk based environmental protection action addressed with stakeholders will be more important for facility operation. The systems and experiences of USA will be helpful.

IV CONCLUSION

We visited SLAC and had an effective discussion with several health physics experts on the safety, especially on the radioactive waste management in accelerator facilities. SLAC is one of the good examples of large facilities in the world and tackling with difficult problem using their advanced techniques and knowledge.

The treatment of radioactivated materials concerned with accelerator facilities is under discussion in USA. This situation is similar in Japan. The feature of USA policy in radiation safety of accelerator facilities is integrated safety which is the combination of radiation safety and non-radiation safety with balance of their risk. They already started the risk based environmental protection action with stakeholders, which treat both chemical and radioactive pollution.

The systems and experiences of USA will be helpful for the related facilities in the world. The progress in USA must be carefully observed.

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