Summary of the Report from the Working Group for The External Expert Panel on the Radioactive Material Leak Accident at the Hadron Experimental Facility of J-PARC

July 29, 2013

At around 11:55 on May 23, 2013, the electromagnets for slow extraction of proton beams from the 50-GeV synchrotron (MR) malfunctioned, and then an intense peaked beam beyond a designed value was delivered to the gold target in the Hadron experimental hall (HD hall). Part of the gold target was damaged and the radioactive material dispersed from the gold target. It leaked into the environment outside of the radiation controlled area of the Hadron Experimental Facility (HD facility) due to a series of incidents beyond expectations and a failure in grabbing ongoing situations properly. The working group investigated and analyzed causes of the accident and matters of the safety management system. We considered preventive measures against recurrence of similar accidents and examined the soundness of the facilities other than the HD facility in J-PARC.

The accident of the radioactive material leakage occurred through the following five stages.

1) Due to the malfunction of electromagnets, intense peaked proton beam exceeded a designed value was delivered to the gold target.
2) The target was instantaneously heated up to a very high temperature and was partially damaged, causing vaporization of gold and dispersion of radioactive material in gold.
3) The radioactive material leaked into the primary beamline room because the target container was not hermetically sealed.
4) Since airtightness of the primary beamline room was not sufficient, the radioactive material leaked into the HD hall and workers were exposed to radiation.
5) Due to operation of ventilation fans in the HD hall, the radioactive material was released into the environment outside of the radiation controlled area of the HD facility.

Thirty-four out of 102 people who entered the HD hall at the time of the accident, were internally exposed to radiation. They had a whole-body counter measurement, and the maximum amount of their radiation doses was 1.7 mSv. Medical examination confirmed the absence of any adverse effects due to the radiation exposure. The total amount of radioactive material released into the HD hall was estimated with a simulation based on actual data of the airborne sample that had been collected at HD hall and readings of the area monitors in the HD hall, being found to be ~20 billion Bq (2×10^{10} Bq). The radiation dose of the site boundary at the location closest to the HD facility was estimated below 0.29 μSv as reported in the first statutory report and it has little effect on the environment.

Based on the analysis of this accident, here we summarized preventive measures against recurrence of similar accidents from standpoints of “the prevention of the radioactive material leakage”, “the prevention of radioactive exposure” and “ensuring soundness of the facilities”. The frameworks for the measures are as follows: 1) preventive measures against the malfunction of electromagnets, 2) ensuring of air-tightness, 3) management of exhaust ventilation, and 4) reinforcement of monitoring radioactivity, etc. It is very important to decrease a frequency of a malfunction of the power supply system. However, we found that it is impossible to completely eliminate a malfunction through an examination of a various preventive measures. Essentials of the preventive measure against the radioactive material leakage are reinforcement of airtightness of the target container and exhaustion of the air through filters from a stack after checking concentration of radioactive material. Correspondence of envisioned case studies of severe accidents was examined and then we confirmed that it would be able to prevent recurrence of the leakage accident of radioactive material at the HD facility. Direct observation of the target has not yet been conducted.

Although the incidents could have been almost figured out based on simulations, direct observation of the target and the circumstances is required to draw a final conclusion. Direct observation, however, is not an essential in considering the preventive measures against recurrence of similar accidents.

In addition to the preventive measures against the hardware aspect, the safety management system was also verified. Inadequacy of safety management system of the J-PARC Center led to delay in reporting and incorrect judgments, and they could not prevent the radioactive material leakage and radiation exposure, which should be able to prevent under appropriate conditions. The impletion is summarized in the following two points: 1) inadequacy of the safety management system to respond to emergency situations and 2) inadequacy of the review system from the aspect of radiation safety. Regarding the safety management system, the following matters will be particularly improved: (a) clarification of a hierarchy for officers in charge, of which Director of the J-PARC Center is a top and has the highest responsibility; (b) arrangement of their authorities and a chain of commands; (c) establishment of a new “alert status” to collect necessary information and to respond to an incident at a stage when any indication of an abnormality is observed; and (d) enforce the clarification of the criteria for judgments and the revision of operation manuals. This new system will be established with incorporating users. Regarding the inadequacy of the radiation safety review system, the measures to enforce functions of a committee where discusses radiation safety issues has been proposed. The measures include new appointments of committee members to provide an opportunity for intensive and fruitful discussions. To maintain and improve individual safety awareness, it is very important to provide continuous safety education and training. In this accident, there were many users who recognized increases in radiation readings but did not leave the HD hall. Therefore, it is important to provide a safer experimental environment to users through conducting more efficient safety education and training.

J-PARC consists of, besides the HD facility, the Materials and Life Science Experimental Facility (MLF), the Neutrino Experimental Facility and the Accelerator Facility. These facilities were examined on their validity of a classification of radiation controlled areas and safety management equipment, and the safety of instruments and devices. As a result, it turned out that the classification of radiation controlled areas and the radiation control were conducted adequately and also it was confirmed that the instruments and devices were highly safe at the three facilities above.

Table1: Correspondence table of incidents and preventive measures

Incidents	Preventive measures
Damage to the target	• Prevent abnormal beam extraction by improving the operation condition of EQ magnet power supply system • Improve monitors for target temperature • Retract the target off the beam orbit during accelerator studies
Leakage of radioactive material	• Make the target container air-tight and install radiation monitors • Reinforce airtightness in the primary beamline room and implement monitoring function • Exhaust the air through filters from a stack, after checking concentration of radioactive material
Lack of sharing radiation monitoring information	• Unify radiation safety management equipment • Improve interlock system

Table 2: Issues and measures from the viewpoints of safety management and procedures to be carried out in emergency situations

Issues	Measures
Organizational setup for responding to incidents was incomplete.	• Introduce three levels of status in response to incidents: "the normal status", "the alert status", and "the emergency status". A uniquely identified commander to conduct information collection and sharing, reporting, actions in incident site, and evacuation conduct.
Organizational setup for safety review was insufficient.	• Internal Radiation Safety Committee will be reorganized into J-PARC Radiation Safety Review Committee.
Periodical reviews of education /training and safety standards were insufficient.	• Continual education and training including users • Bidirectional education processes and exercises for radiation-related accidents • Periodical reviews of the criteria and procedures, etc. to prevent stereotypical responses