Contamination at Plutonium Fuel Research Facility of Oarai Research and Development Center

July 21, 2017

Japan Atomic Energy Agency

【Table of contents】

・Outline and events in chronological order ・・・ 1
・Outline of Plutonium Fuel Research Facility and contents of work ・・・ 4
・Schedule of response to contamination accident at PFRF (As of July 21) ・・・ 5
・Situation of radiation and contamination at the work site and contamination/exposure of the workers ・・・ 6
・situation of report concerning report required by the law ・・・ 7
・Impact on the environment ・・・ 8
・Measures taken after the accident ・・・ 9
・Exposure evaluation of workers ・・・10
・Investigation result of contents of the storage container ・・・12
・Investigation situation of radiation control information ・・・15
・Outline of the investigation into causes (examination situation) ・・・16
・Probable factors leading to the burst of the resin bags and measured to be taken ・・・17
・Probable factors leading to the intake of radioactive material ・・・18
・ Analysis of the causes ・・・19
・Measures to prevent recurrence, and dissemination of information throughout the organization ・・・24
・Conclusion ・・・26

Outline and events in chronological order

Outline

Around 11:25, June 6, 2017 (Tue), in Room No. 108 of Plutonium Fuel Research Facility (PFRF) (controlled area), resin bags ruptured and contamination occurred when five workers were inspecting a storage container containing plutonium and uranium with a hood.

Background

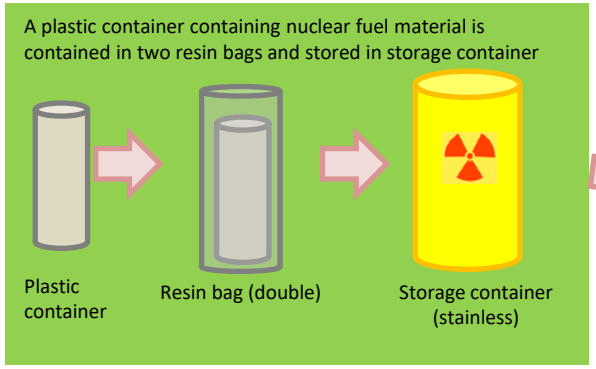
PFRF was constructed in FY 1974 for the research on advanced fuel etc. of fast reactors, and the policy to decommission the facility was issued in FY 2013.
Check of the empty capacity etc. of existing storage containers (80 units) started in February 2017 as part of efforts to improve the management condition of nuclear fuel materials.
The accident occurred while checking the 31st container.

Events in chronological order

June 6, Tue

- 11:15 Accident occurred.
- 11:37 All the five workers' contamination was confirmed
- 11:54 The facility manager ordered setting a greenhouse (GH).
- 12:43 Preparation of GH materials completed.
- 13:15 GH construction workers entered and started setting GH.
- 13:45 Additional construction workers entered.
- 14:29 GH setting completed.
- 14:30 The workers started leaving Room No. 108.

GH



The storage container was uncovered to check the storage situation in a hood.

Events in chronological order

- 14:44 Contamination check of the workers started.
  - Nasal cavity contamination of three workers was confirmed.(up to 24Bq(α ray))
- 16:27 Room No. 108 was designated as entry restriction area.
- 18:52 Decontamination of all the five workers completed.
- 18:55 Exit of the five workers from the restriction area completed.
- 19:05 The five workers left for Nuclear Fuel Cycle Engineering Laboratories.
- 19:41 The workers arrived at Nuclear Fuel Cycle Engineering Laboratories.
- 19:59 Measurement with lung monitor started.
- 22:05 Injection of chelating agent (medical agent prompting egestion of radioactive materials from body used in order to reduce the internal exposure dose) to the workers started.
- 23:33 Measurement of the five workers with lung monitor completed.
  - Maximum confirmed levels are Pu-239 22,000Bq, Am-241 220Bq

June 7, Wed

- 01:05 Injection of chelating agent to the workers completed.
- 01:42 The five workers arrived at Oarai Research and Development Center

Events in chronological order(2)

Events in chronological order

June 7 (Wed)
The five workers were admitted into the National Institute of Radiological Science (NIRS).
The judgement that reporting of the accident is required by the law was made.
Contamination check of Room No. 108 was performed.
・At maximum 55Bq/cm^2(α ray) was confirmed.

June 8 (Thu) – Jun 12 (Mon)
Lung monitor measurement was conducted at NIRS.
Care is provided appropriately to the workers and their families

June 13 (Tue)
The five workers were discharged NIRS.
Interview with the workers was conducted giving consideration to the physical and mental burden.

June 14 (Wed)
The SD card was taken from the camera having shot the work situation.

June 15 (Thu)
The industrial doctor interviewed with the five workers.

June 18 (Sun)
The five workers were admitted into NIRS (second time).

June 19 (Mon)
Report was submitted to nuclear regulation authority (NRA) in accordance with the Article 62-31 of the Nuclear Reactor etc. Regulation Law.

June 21 (wed), 23 (Fri), 28 (Wed)*1, 30 (Fri)*2
On-site inspection of NRA based on the paragraph 1, Article 68 of Nuclear Reactor etc. Regulation Law.
＊1：Supplemental interview conducted at the Secretariat of NRA
＊2：including the interview with the workers

June 23 (Fri)
Report was submitted in response to the request from Ibaraki Prefecture.

June 26 (Mon)
The five workers were discharged NIRS.
The industrial doctor interviewed with the five workers.

June 28 (Wed)
Three workers were interviewed by Mito Labor Standards Inspection Office and Ibaraki Prefectural Police Department, and then provided care by a health nurse.

Events in chronological order

June 30 (Fri)
The doctor of NIRC in charge of the five workers examined them.
After interview by the Secretariat of NRA, the five workers were provided care by a health nurse.

July 3 (Mon)
The three workers were admitted into NIRS (third time).

July 4 (Tue)
Restoration of the accident site started.
・Route to the hood was secured.
After interview by Mito Labor Standards Inspection Office and Ibaraki Prefectural Police Department, the two workers who were not included in the interview held on June 28 were provided care by a health nurse.

July 5 (Wed)
The result of on-site inspection was reported at NRA by the Secretariat of NRA.
Restoration of the accident site was continued.
・Clearance in GH
A health nurse interviewed with the three workers who were admitted into NIRS.

July 6 (Thu)
Restoration of the accident site was continued.
・Fixation of the lid of the storage container with tape and installation of overturn prevention instrument.
・Transport of metal containers storing recovered particles and curing sheets.

July 7 (Fri)
The three workers were discharged NIRS.
A health nurse provided care to them.
Slight contamination was confirmed at the corridor of PFRF (Work was temporarily suspended).

Events in chronological order(3)

Events in chronological order

July 10 (Mon)
NIRS released the result of the dose evaluation.
July 11 (Tue)
Three workers were interviewed by Mito Labor Standards Inspection Office, and then provided care by a health nurse.
Restoration of the accident site was continued.
・Decontamination of the corridor of PFRF was conducted by wiping off.
July 13 (Thu)
Two workers who were not included in the interview on July 11 were interviewed by Mito Labor Standards Inspection Office, and then provided care by a health nurse.
The industrial doctor interviewed with the three workers.
Restoration of the accident site was continued.
・Clearance in GH
Transport of smear filter paper etc. started (PFRF → Fuel Monitoring Facility (FMF))
July 14 (Fri)
The doctor of NIRS in charge of the workers examined the three workers.
Restoration of the accident sited was continued.
・Replacement of GH (carrying in materials, contamination check of the existing GH)
July 18 (Tue)
・Replacement of GH (contamination check of the existing GH, dismantlement of the existing GH)
July 19 (Wed)
Restoration of the accident site was continued.
・ Replacement of GH (setting a new GH)
・ Preparation for moving out the storage container

Events in chronological order

July 20 (Thu)
Restoration of the accident site was continued.
・ Replacement of GH (setting a new GH)
・Moving out the storage container (the hood in Room No. 108 → the glove box in Room No. 101)
The doctor of NIRS in charge of the workers examined the three workers.
July 21 (Fri)
Report (second report) was submitted to NRA based on the Article 62-3 of Nuclear Reactor etc. Regulation Law.

Outline of Plutonium Fuel Research Facility and contents of work

Outline of PFRF

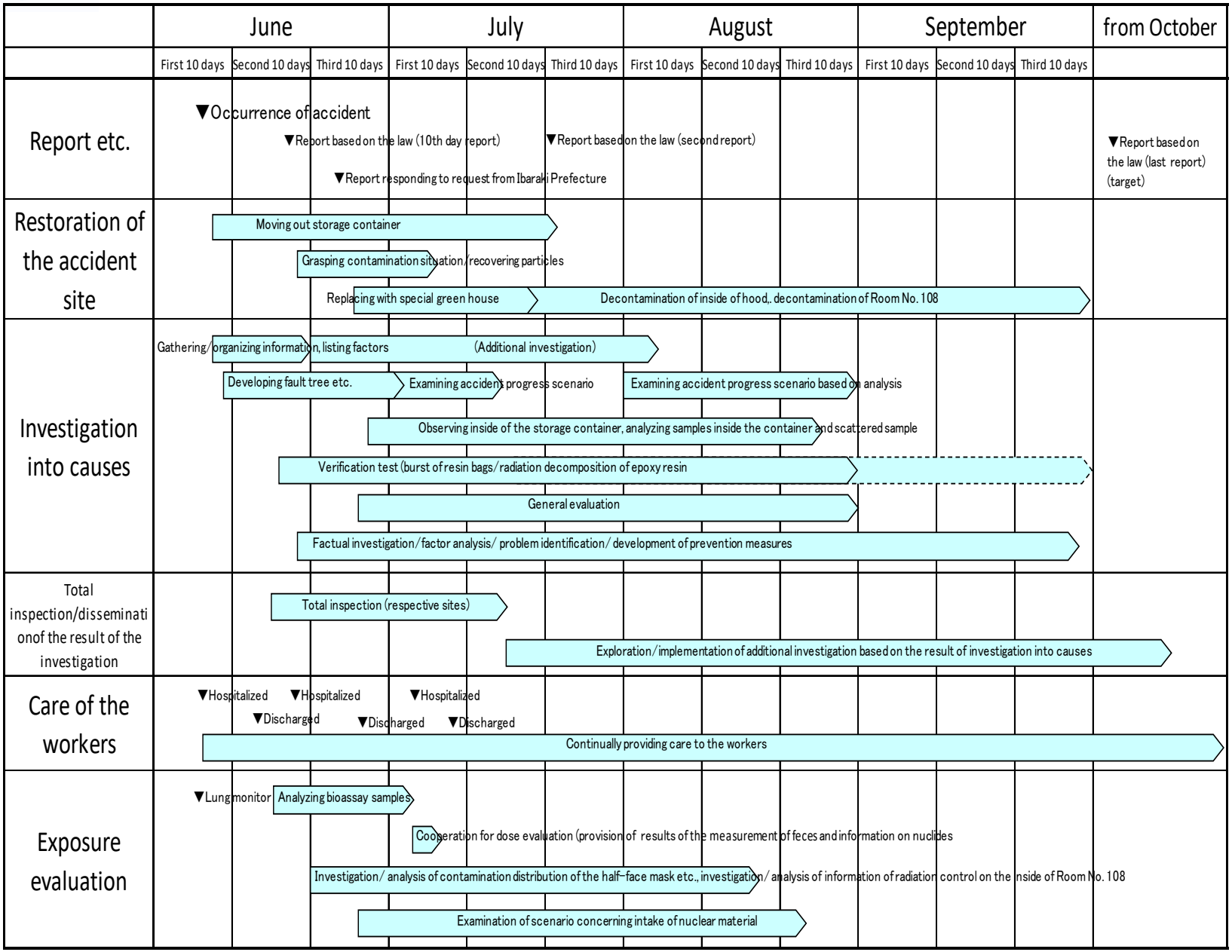
- PFRF was constructed with the purpose of conducting R&D on advanced fuel etc. for fast reactors and completed in 1974.
- Experiment using plutonium started in 1977.
- fabrication and research on physical property of new fuels such as uranium-plutonium mixed oxide fuel, nitride fuel, long-lived minor actinide nuclear transmutation fuel and metallic fuel for fast reactors, fabrication of fuel pins for irradiation test aiming for verification of fuel soundness and research concerning dry type separation using electrolysis of molten salt were conducted in this facility.
- R&D ended in 2015. In accordance with the policy for decommissioning issued in FY 2013, nuclear fuel materials used for experiment was being processed for stabilization and the decommissioning plan was being examined.

Facility outline:
Two-story building, fire-resistive construction with reinforced concrete,
1518 m^2 of total floor space (controlled area is 570 m^2)
Main equipment:
Main facility
glove box: 36 units, argon circulation generator: 4 units, hood 4: units

Outline of work

- In February 2017, correction of the below situation was ordered by NRA.
  - Nuclear fuel materials used in the past R&D were stored for a long period of time at a use facility of application for a use license, instead of a storage facility, under the excuse of being in use.
- In response to this order, work was planned to process these stored nuclear fuel materials etc. for stabilization, and store them additionally in 80 storage containers in the storage.
- In the storage container, the material is contained in a container and sealed in double resign bags. The purpose of the work is to open the storage container with the hood in Room No. 108 and check if there is a vacant space inside.
- The work started in February 2017, and have been completed for 30 of 80 storage containers, which contained items of which chemical form and physical property were clear. The accident occurred during opening work of the 31st storage container, which contained materials used experiment with various chemical compounds.

Schedule of response to contamination accident at PFRF（As of July 21）



Situation of radiation and contamination at the work site

- There was no change in the indication values of the monitoring posts and ventilation dust monitor of PFRF before and after the accident.
- With regard to the concentration of radioactive materials in the air of the accident site, the indication value of the Pu dust monitor No. 2 inside the room (Room No. 108) at the time of the occurrence of the accident was within the normal fluctuation range
- The indication value of the Pu dust monitor No.2 rose to 5×10^{-8}Bq/cm^3 (average concentration of a week) at 13:55, June 6, 2017, but there was no rise of the value after that. This value is lower by one digit than the level of Pu-239 designated by the law (7×10^{-7}Bq/cm^3). Later, as a result of replacing dust filter Pu dust monitor, it was confirmed that the indication value dropped to the normal fluctuation range. Since then, the indication value is within the normal fluctuation range.
- With regard to the surface concentration of Room No. 108, as a result of the measurement of the floor on June 7, 2017, contamination at the levels up to 55Bq/cm^2(α ray) and 3.1Bq/cm^2(β(γ) ray)were confirmed at 18:55. The maximum dose equivalent rate was 2μSv/h.
- It was confirmed that there was no contamination at the corridor to Room No. 108 and outside of the emergency exit of the room.
- Particles assumed to have scattered from the storage container were confirmed on the floor in front of the hood（H-1).

Exposure of the workers (Refer to p. 10 for detailed information)

- As a result of the physical contamination test conducted in the green house, contamination was confirmed on the special cloths of the five workers (more than 322Bq/cm^2（α ray））and on the skin of the four workers, and among three of the four workers, contamination in nasal cavity (up to 24Bq(α ray))was confirmed.
- The workers with skin contamination underwent decontamination in the shower room, and left the controlled area after confirming that the level is lowered than the detection limit (0.013Bq/cm^2(α ray)). When the decontamination for the first worker started, the flow of the shower water decreased in one or two minutes. The decontamination was restarted by bringing the industrial water with a hose from the machine room of the fuel research building.
- Three of the five workers wore individual dosimeters, and their values were 2μSv, 3μSv, and 60μSv.
- As a result of transporting the five workers to Nuclear Fuel Cycle Engineering Laboratories and conducting lung monitoring, the levels were evaluated as 22,000Bq and 220Bq with regard to Pu-239 and Am-241, and accordingly injection of chelate agent（Ca-DTPA）was administered.
- The five workers were transported to NIRS on June 7, 2017, and medical treatment including lung monitoring were administered.

Situation of report concerning report required by the law

- 13:00, June 7, 2017, the accident was judged as an accident for which reporting is required by Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors

  【Reason for the judgement】
  - As the measurement results showed the levels up to 22,000Bq and 220Bq with regard to Pu-239 and Am-241 due to the lung monitoring of the five workers conducted at Nuclear Fuel Cycle Engineering Laboratories, the levels of exposure exceed, or it is possible to exceed, the standards of reporting in the event of unplanned exposure of radiation workers entering controlled areas, which is 5mSv.
  - Judging from the contamination situation of the five workers, the surface concentration of the floor of Room No. 108 etc. exceeds, or it is possible to exceed, the standards for designating restriction area provided in the operational safety program（α nuclide：4Bq/cm^2）.

- The above matters were reported to the Secretariat of NRA at 13:27.

Report based on the law (the first report) was submitted to NRA on June 19.

Impact on the environment

- At the time of the occurrence of the accident, the ventilation system of PFRF continued operation to maintain the normal negative pressure in the controlled area, and values indicated by the monitoring posts and the ventilation dust monitor of PRFR were within the normal fluctuation range. Therefore, there is no impact on the environment caused by this accident.

- Operation of the ventilation system of PFRF continues after the occurrence of the accident, and the normal negative pressure outside the controlled area is maintained. The indication values of the monitoring posts, the ventilation dust monitor of PRFR and Pu dust monitor shift within the normal fluctuation range. Therefore, there is no impact on the outside of the facility.

Measures taken after the accident

Restoration of the accident site

(1) Measures for securing safety

- Cleaned the floor with wipe to prevent the expansion/scattering of contamination due to walk of workers, and secured routes to the hood.
- Fix the lid of the storage container in the hood with packing tape, and installed overturn prevention device to the storage container.
- Carried the storage container out of Room No. 108, carried it in Room No. 101, and put it in the glove box in the room.

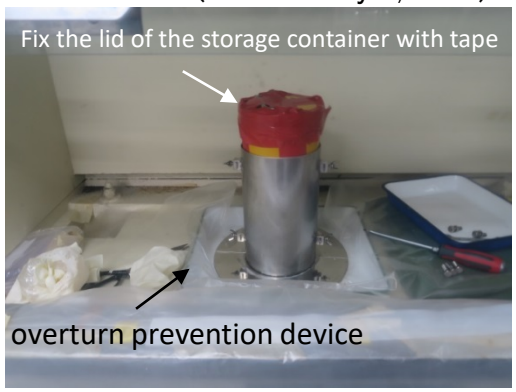
(2) Measures for the full-scale restoration of the accident site

- Replaced the makeshift greenhouse which was set immediately after the accident with the one added reinforcement from the standpoint of contamination control.
- Contamination test/decontamination of the hood and Room No. 108 will be carried out.

(shot on June 20, 2017)

Replaced greenhouse

(shot on July 6, 2017)

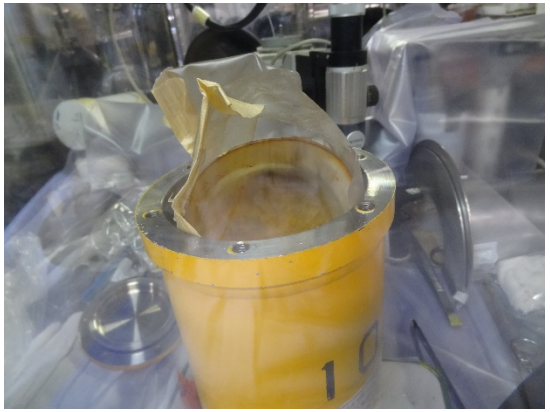


Storage of storage container in the hood

(shot on June 20, 2017)

Storage of the storage container after putting it in a glove box

(shot on June 20, 2017)



Storage container
(Confirmed after being put in a glove box)

Exposure evaluation of workers (1)

Evaluation result concerning external exposure

(1)Evaluation of effective dose due to external exposure

- Measurement by OSL（optically stimulated luminescence）dosimeter
  - Worker A,B,C,D： Lower then the lower detection limit (0.1mSv)
  - Worker E： Evaluation is not possible due to the contamination which adhered to the surface of the dosimeter.
- Measurement by electronic personal dosimeter（EPD）(Three of the five workers wore the dosimeters)
  - Worker B：2μSv, Worker D：3μSv, Worker E：60μSv
- Based on the above result, the exposure levels of the five workers were evaluated as lower than the record level (0.1mSv).

(2)Evaluation of skin exposure dose by body surface contamination

- As contamination was confirmed of the special cloths of all the workers and of the skin of the four workers, skin exposure dose due to such contamination was evaluated under conservative presumption.
- From the occurrence of the accident to the exit from the controlled area
  - It is presumed that skin exposure continued for the longest possible period of time (7.67 hours) which is between the occurrence of the accident and exit of all the workers after completing decontamination, with radiation of contamination density at 1,000Bq/cm^2（in the case of the surface of the OSL dosimeter with the highest contamination density）directly adhering to the skin.
  - Result of evaluation： at maximum 83μSv
- From the exit from the controlled area to the completion decontamination at NIRS
  - It is presumed that the skin contamination at the time of hospitalization into NIRS (at maximum 140cpm, equivalent 0.44Bq/cm^2) continued from the time of the exit from the controlled area to the time when the contamination information was released (about 22 hours).
  - Evaluation result： at maximum 0.11μSv
- Based on the above result, with regard to all the five workers, contamination was evaluated as lower than the record level (0.1mSv).

Exposure evaluation of workers (2)

Evaluation result concerning internal exposure

(1) Measurement/evaluation of internal exposure dose

- The workers were hospitalized into NIRS for examination of internal exposure and treatment.
- JAEA cooperated with NIRC for measurement/evaluation of internal exposure dose carried out as part of examination and treatment.
- NIRS examined in detail the result of bioassay test etc. and released the effective dose (committed effective dose) due to internal exposure as below.

Effective dose	Number of people
100 mSv and higher and lower than 200 mSv	1
10 mSv and higher and lower than 50 mSv	2
Lower than 10 mSv	2

(2) Planned measures

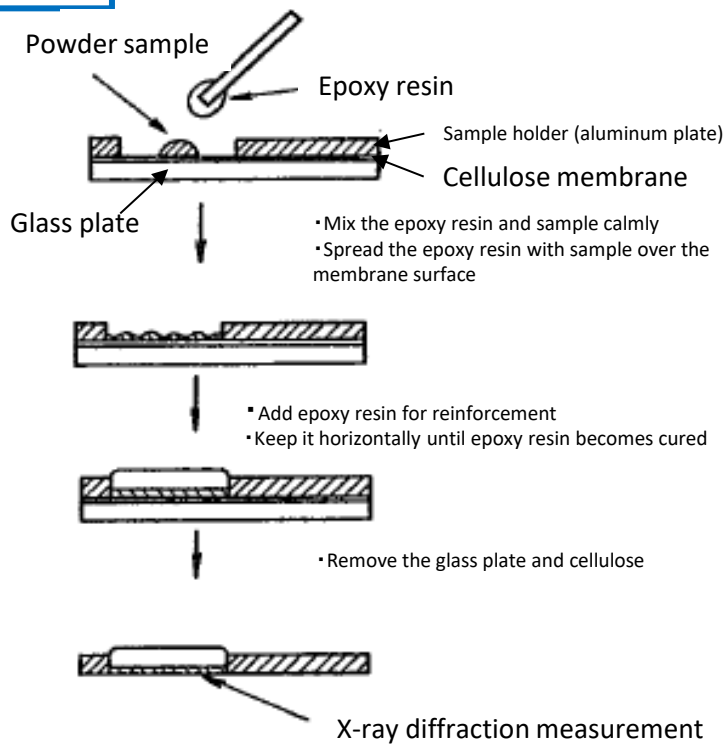
- JAEA will obtain the information following appropriate procedures in accordance with the handling of medical information of NIRC, and report/record the exposure dose based on the laws and regulations.
- Pu-239 and Am-241 were detected by lung monitor measurement carried out on the day of the accident (June 6), but Pu-239 was not detected by NIRS measurement conducted the following day. This difference considered to be attributable to the Pu-239 etc. adhered to skin that influenced on the measurement of JAEA. The relation between the value of the lung monitor measurement and contamination adhered to skin will be cleared.

Investigation result of contents of the storage container (1)

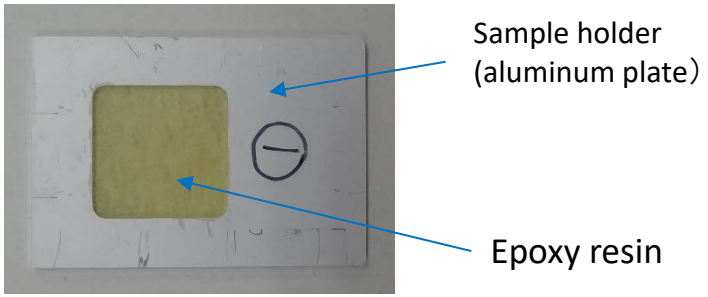
Investigation result of contents of the storage container

According to the result of inspection of the accounting record note, documents such as PFRF's monthly report, technical report, and inspection record, and interview with the staff (including retired staff), the following facts have become clear.

- Nuclear materials in the storage container are natural uranium (U) and plutonium (Pu), and with regard to Pu, different isotopic compositions are mixed.
- The nuclear materials in the storage container are gathering of the samples used for X-ray diffraction measurement.
- As characteristics of epoxy samples for X-ray diffraction measurement used at PFRF, method to mix the powder of nuclear fuel material and epoxy adhesive (mixture of main agent and curing agent) and fix it to aluminum sample holder was used. In the sample holder, the size of the square part of the solid material is 20×20mm with the depth of 1.5 mm. Per unit of this solid material, 0.1～0.2g of nuclear material powder and 0.7～1.0g of epoxy resin are included.



Sample preparation flow

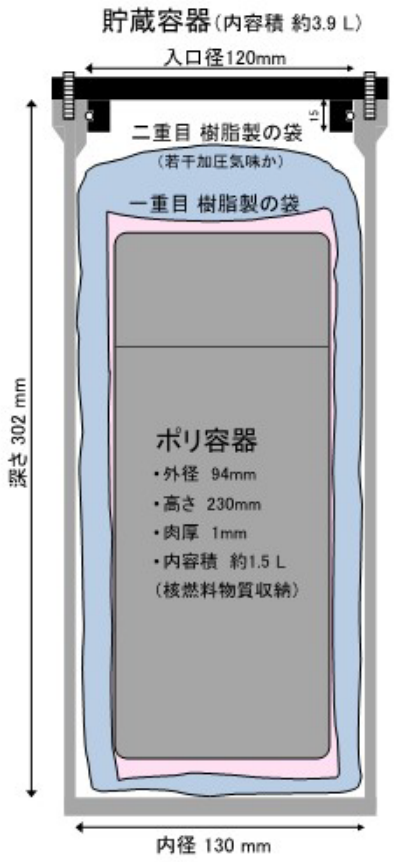


X-ray diffraction sample

Investigation result of contents of the storage container (2)

Investigation result of contents of the storage container

- As the container to contain the material inside the storage container, a relatively large polyester container stocked in PFRF was used.
- After the storage in this storage container started in October 1991, in August 1996, the lid of the storage container was opened, and the existence of the record of the inside state was confirmed on July 14, 2017. In the record, there was description that the bottom of the polyester container was broken, the resin bag was inflated, and there was no abnormality after changing the wrapping.



Storage container

貯 蔵 容 器 梱 包 更 新 の 記 録

核燃料物質貯蔵容器No. 1010　　平成 8年 7月19日

現状		更新後	
バッチ番号	W410	バッチ番号	W410
化学形	M化合物	化学形	M化合物
物理形	スクラップ	物理形	スクラップ
総重量	[redacted] g	総重量	[redacted] g
Pu・^{235}U 重量	[redacted] g	Pu・^{235}U 重量	[redacted] g
核分裂性物質量	[redacted] g	核分裂性物質量	[redacted] g
NU・Th 重量	[redacted] g	NU・Th 重量	[redacted] g
国籍	F、Q C、Q、U (U)	国籍	F、Q C、Q、U (U)
備考		備考	
梱包状態 内容器：ポリエチレン容器		梱包状態 内容器：ポリエチレン容器	
内容器内の状態 1. X線回折用試料		内容器内の状態 1. X線回折用試料	
梱包材劣化状況 ポリエチレン容器底部が変色、破損 内容器ビニルパックが膨張		梱包材劣化状況 異常なし。	

Record of inspection of July 1996 when it is presumed to have checked the inside of the storage container and changed the inside container and resin bag.

Investigation result of contents of the storage container (3)

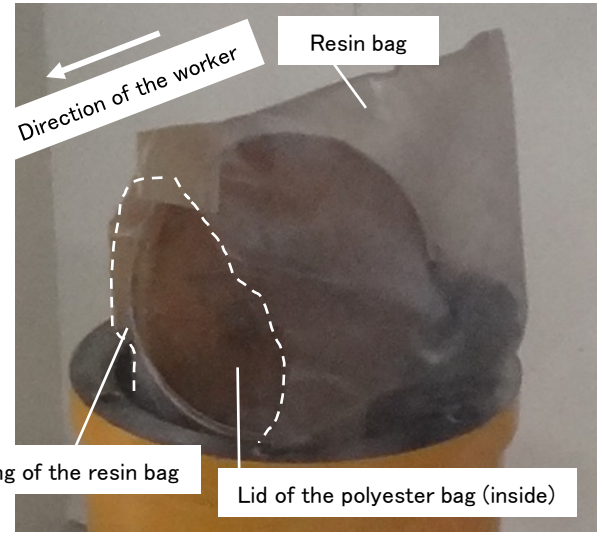
Investigation result of the situation at the time of the burst

(1) Interview result

- The lid was rising up while the six bolt of the storage container were being loosened one by one. After six bolts were removed, there was a hiss of the inside gas coming out when lessening remaining two bolts. The sample of smear was collected from the space between the container and lid and confirmed there was no contamination.
- Holding the handle of the lid, a worker loosened the two bolts one by one, and when the two bolt were removed from the container the lid floated with a sound of burst. The sound the workers heard was one bang.
- Seeing the material scattered over the curing sheet after the burst, the worker “thought it was solidified with something.”

(2) Photo of the storage container taken by a worker

- The resin bag comes out from the top edge of the storage container, and opening of the bag is made along the side of the bag in a way to split in the vertical direction. The opening made by the burst faces the direction of the worker, and it is correspond with the statement of the worker.
- The cylindrical material seen in the bag is a lid of the polyester container, which is according to the worker upside down. The side visible is the inside of the lid.
- Black material is visible inside the bag, right to the lid. Nuclear fuel material inside the polyester container is likely to have come out at the time of the burst.



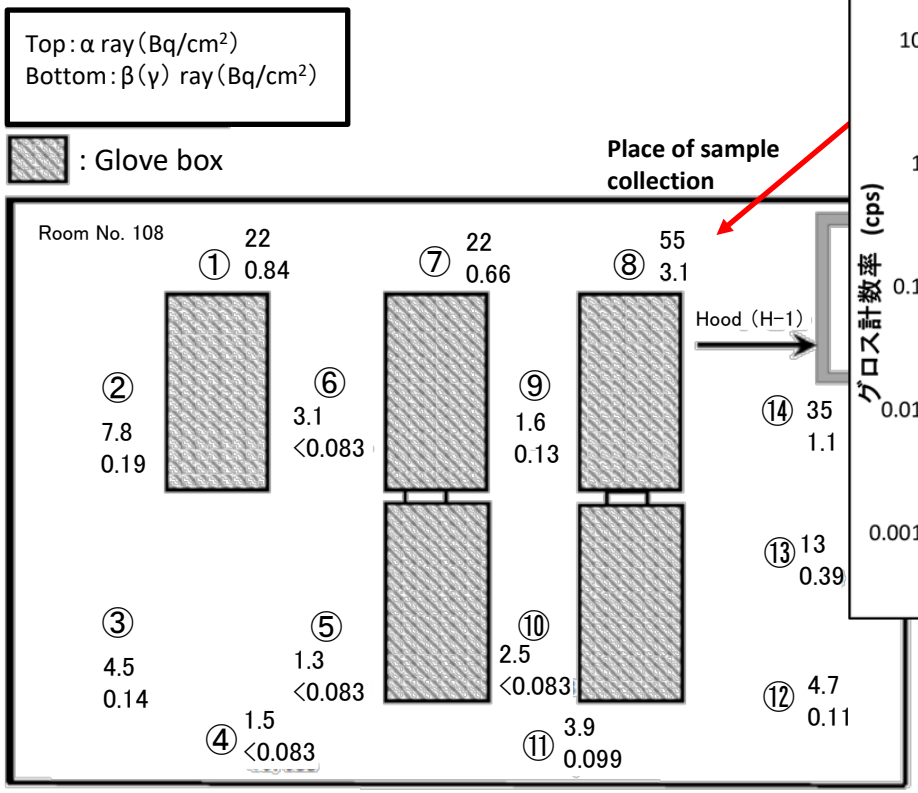
Enlarged photo taken by the worker at the time of the burst of the resin bag

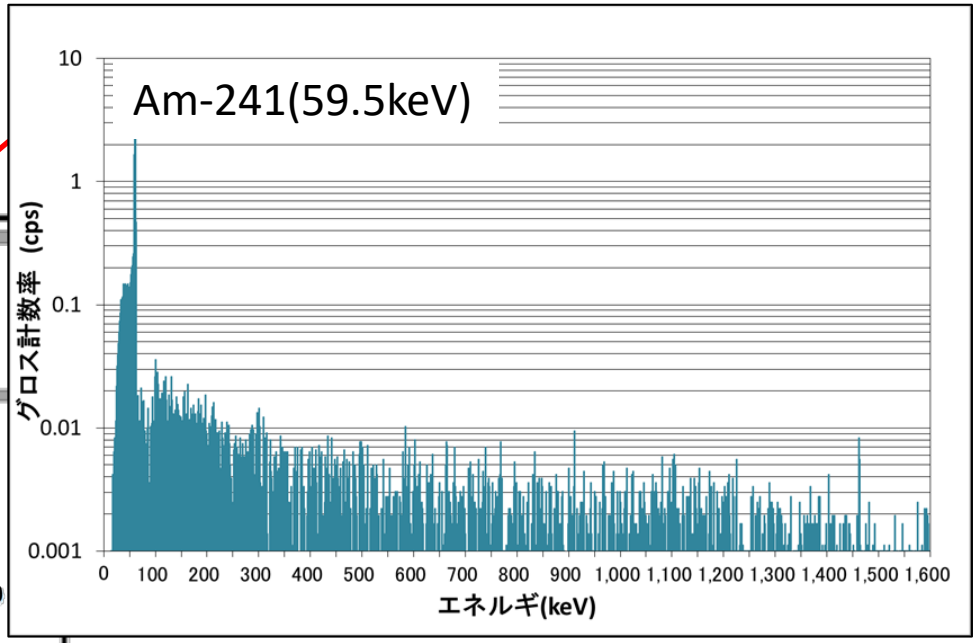
(The side of the bag was partially damaged in a way to split in the vertical direction)

Investigation situation of radiation control information etc.

Situation understanding of radioactive material taken in by the workers

- In order to understand the characteristics of the radioactive materials taken in by the workers such as nuclide composition and particle diameter distribution, radioactive nuclide analysis is carried out with regard to the filter of the Pu dust monitor No.2 recovered on June 6 by replacement and the smear filter used for the contamination test of Room No. 108 conducted June 7.
- With regard to these samples such as the filter, while radionuclide analysis is continued, particle diameter distribution will be cleared by the method of radiation image analysis etc. investigation/analysis will be moved forward with concerning the radiation situation of Room No. 108 and contamination situation of the workers' half faced masks.

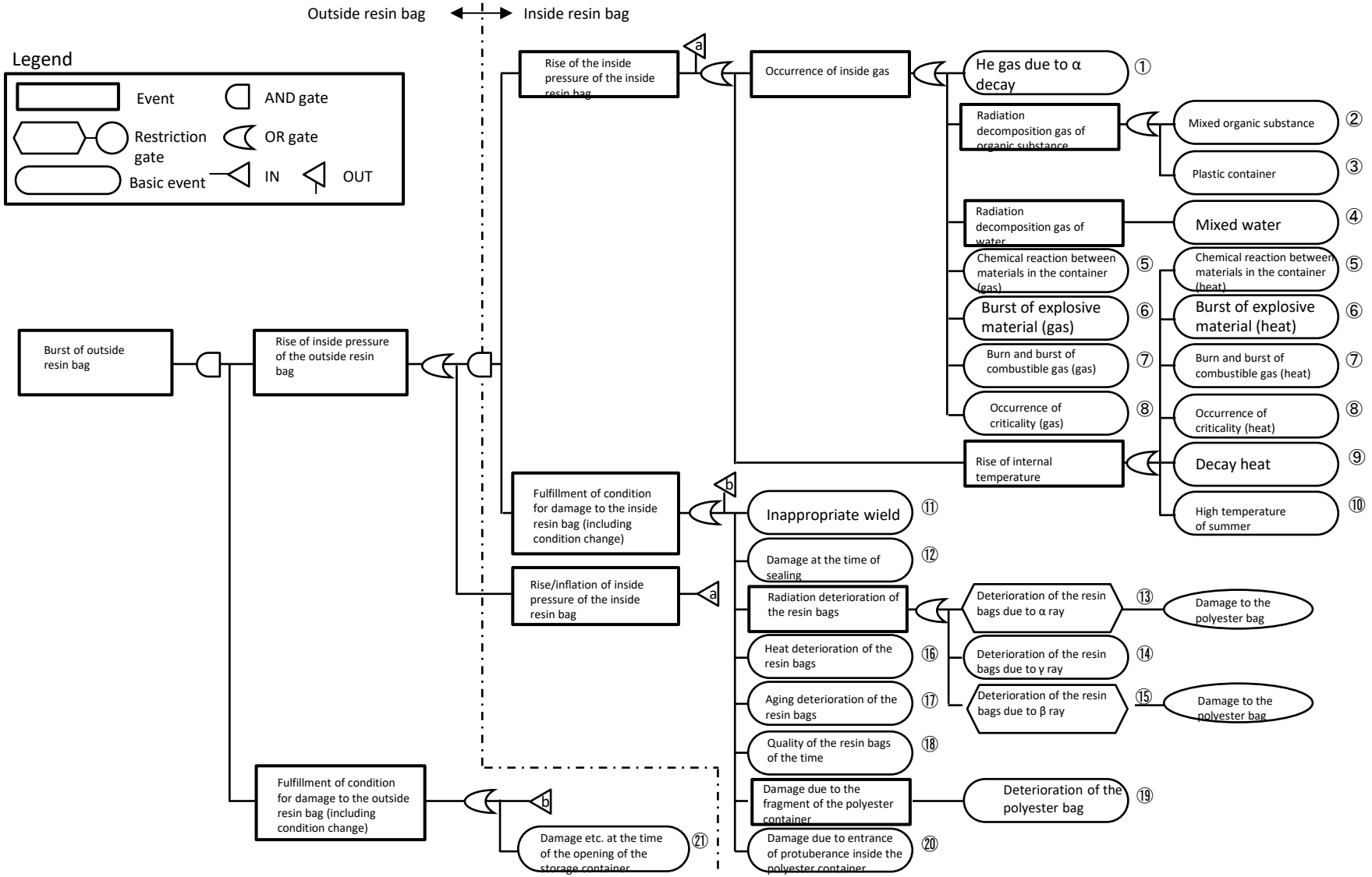




Example of the energy spectrum of smear sample by Ge semiconductor detector

Outline of the investigation into causes (examination situation)

There may be change in this chart depending on the result of the planned analysis etc. of the contents.



①～⑧: Factors relating to “internal gas occurrence”, ⑤～⑩: Factors relating to “internal temperature increase”, ⑪～㉑: Factors relating to “fulfillment of condition for damage to the inside resin bag (including condition change”

Probable factors leading to the burst of the resin bags and measures to be taken

Probable causes

- Due to fault tree analysis, cause for the burst of the resin bags was presumed to be the combination of three basic factors: mixed organic substance, polyester container and mixed water.
- Due to the above three factors or one factor, gas was generated, and during the 21 years of period, the inside pressure increase exceeded the inside pressure increase causing burst of the resin bags, but the bags did not burst due to the binding force of the storage container. Due to the opening of the lid of the storage container, the binding power was lost and the balance between the inside and outside pressure of the resin bags was lost, and the parts that were not fixed by the container, lid, etc. were presumed to have split open under the influence of the decrease of intensity and flexibility of the resin bags attributable to irradiation.

Current measures to be taken

- Remove epoxy resin etc. that generate a large amount of gas by heat process of samples before storage.
- Store powder type nuclear material in metallic containers.
- With regard to nuclear fuel materials stored in polyester containers, estimate in advance the period of time causing inflation and change in color, and take measures in appropriate interval such as visual inspection and replacement.

Probable factors leading to the intake of radioactive material

Investigation of probable causes (factor events) and measures to be taken

- Based on the information such as situation of the accident occurrence, possible factor events leading to the intake of radioactive material were identified and laid out as below. At this moment, possible factors were widely picked out.
- Probable factor events will be identified based on the radiation situation in the Room No. 108 and the green house, result of investigation and analysis of workers' half-face masks etc. and interview with concerned people (workers, staff of Facility Radiation Protection Section, etc.)

Occasion for radiation exposure	Factor event
When resin bags burst	・Dispersal If nuclear material associated with the break of the bags, density of radioactive material in the air of the work site rose precipitously, and part of it penetrated the filtering material of the half-face mask, and workers inhaled contaminated air. ・Reflexive movement of the face resulting from hearing the burst etc. lessened the adhesiveness of the surface of the half-face mask to the face (hereinafter "adhesiveness of the half-face mask"), and workers inhaled contaminated air.
When waiting in Room No. 108	・Adhesiveness of the half-face mask lowered when they communicate each other, talk to outside people on the phone and report orally, and workers inhaled contaminated air. ・Adhesiveness of the half-face mask lowered due to perspiration from long wearing of half-face mask, condensation of vapor in the intake gas, etc., and workers inhaled contaminated air. ・Contamination of the head (hair and the part of the face outside of the half-face mask) due to contact with the materials scattered at the time of the burst or contaminated air entered inside the half-face mask with sweat and was ingested orally.
When undressing in the greenhouse and decontaminating in the shower room	・When the workers change the half-face masks to the ones not contaminated (short period of time when they did not wear half-face masks), they inhaled contaminated gas in the greenhouse. ・During decontamination with running water, water having decontaminated hair and face came around the mouth and was orally ingested. ・During decontamination of nasal cavity, part of decontamination came to the oral cavity by mistake and was orally ingested.

Analysis of the causes (1)

Formation of the team for investigation into the causes

- Based on the result of the factor analysis of the resin bags' burst and exposure evaluation, direct factors, relating to work management including safety management, of the occurrence of the incident are being analyzed. For this, the "Team for Investigation into the Causes of the Contamination Accident of PFRF" was established under the Quality Assurance Promotion Committee of Oarai Research and Development Center in accordance with the Article 4 of the Rules of the Quality Assurance Promotion Committee (subcommittee).

Selection of events for analysis

- In addition to the information gathered so far, items for analysis were picked up based on relating documents (from both inside and outside of the country), records, interviews, etc.

(1) Encapsulation and storage of nuclear fuel material in the container, and safekeeping (until the time of starting correction work)
(2) Planning and implementing stages of the correction work and accident response

Investigation into the causes (2)

(1) Encapsulation and storage of nuclear fuel material in the container, and safekeeping (1/2)

- **Description of "necessity of great attention to rise in the gas pressure due to radiation decomposition" as a condition for storage of the Radiation Safety Manual Guide in 1989**

  ⇒In the Radiation Safety Manual Guide used in 1989, above description is included. Through fact investigation such as interviewing the concerned people of the time about their recognition of the description and the procedures for storage, problems will be identified.

- **Matters relating to storage method and recording concerning the storage of nuclear fuel material in the storage container in 1991**

  ⇒Through fact investigation such as checking the contents to see if the selection of the inside container (polyester container) was appropriate and surveying if the condition for storage of the Radiation Safety Manual Guide was considered, problems will be identified.

- **The fact that breakage at the bottom of the inside container (polyester container) and inflation of the resin bags were confirmed in the inspection of the storage container causing the accident in 1996.**

  ⇒Existence of the record of the inspection held in 1996 of the storage container causing the accident was confirmed. In it there was description that the damaged polyester container and resin bags were changed to new ones. Through fact investigation including clarifying, with regard to the confirmation of the damage that occurred within about five years, if the information on the fact was turned over and the situation was improved, problems will be identified.

Investigation into the causes (3)

(1) Encapsulation and storage of nuclear fuel material in the container, and safekeeping (2/2)

- **Matters relating to the incorporation of technical information on plutonium storage written in the IAEA Safety Report (1998) and DOE-STD (1994 and 2012)**

  ⇒ Through fact investigation on whether or not information in the report on plutonium storage compiled by the IAEA and DOE was applied to the management of PFRF, problems will be identified.

- **Matters relating to the handling of the information concerning the inflation on the resin bags encapsulating nuclear fuel material in the Plutonium Fuel No. 1 Development Room of Nuclear Fuel Cycle Engineering Laboratories which was explained to the Secretariat of NRA on January 26 and February 9, 2017.**

  ⇒Management of nuclear fuel material in Nuclear Fuel Cycle Engineering Laboratories was explained to the Secretariat of NRA on January 26 and February 9, 2017, and in it, “inflation of resin bags” in the Plutonium Fuel No. 1 Development Room was mentioned. Through fact investigation on whether or not this information was reflected to the work plan concerning checking storage container in PFRF, problems will be identified.

Investigation into the causes (4)

(2) Planning and implementing stages of the correction work and accident response (1/2)

- **Matters relating to creation of work plans for inspection etc. of nuclear duel material whose storage situation is not clear (including predictability of resin bags' burst)**

  ⇒Work plans are formulated based on the work process in the stage to plan the correction work, and during the formulation, various checks are conducted to identify risks of the work. Through fact investigation including clarifying how in this work planning "nuclear fuel material whose storage situation is not clear" was identified and included in the work plan, problems will be identified.

- **Matters relating to continuing work after the lid rose when bolts of the lid of the storage container were loosened**

  ⇒Rise of the lid during opening the lid of the storage container was confirmed. Through fact investigation on the state of work implementation and recognition of the workers, problems will be identified.

Investigation into the causes (5)

(2) Planning and implementing stages of the correction work and accident response (2/2)

- **Matters relating to the time required for the workers' exit from the occurrence of the accident (about three hours)**

  ⇒Between the occurrence of the accident and starting of the workers' exit, there were checking of situation of work and building of a greenhouse for exit. Through checking again the situation up to the exit in line with the emergency procedures, problems will be identified.

- **Matters relating to the management of accident response material and equipment (shower for decontamination etc.) of PFRF**

  ⇒After the occurrence of the accident, setting of a greenhouse and decontamination of the body using shower for decontamination were implemented. Through fact investigation on whether or not the accident response material and equipment was appropriately maintained and managed, problems will be identified.

Measures to prevent recurrence, and dissemination of information throughout the organization (1)

Total inspection of storage, handling work, etc. of nuclear fuel material

(Contents of implementation)

(1) On-site check of the storage container of nuclear fuel material etc.
Soundness of the storage container of nuclear fuel material etc. was checked visually etc.

(2) Total inspection concerning storage and handling of nuclear fuel material
Aiming for dissemination of information for preventing recurrence, investigation and inspection concerning storage and handling work of nuclear fuel material.

(Result)

Inspection item	Result
(1) On-site check of storage containers of nuclear fuel material etc.	With regard to storage containers, visual check of soundness was conducted from the perspective of distortion, fall, leakage of contents, etc. With regard to items for which visual check is not possible, based on the latest inspection result, structure of the container, etc., safe storage was confirmed.
(2) ①Situation responding to the order to suspend similar work	It was confirmed that the order was circulated to work sites of each R&D center, and the relevant work is not performed.
(2) ②Investigation on handling work and emergency response	Check of contents of storage containers etc., check about if there are manuals for emergency response were conducted. As a result, it was confirmed that there are manuals in the relevant departments/sections. Investigation and taking measures in more details based on the analysis of the causes will be conducted, as necessary.

Measures to prevent recurrence, and dissemination of information throughout the organization (2)

Total inspection of storage, handling work, etc. of nuclear fuel material

Inspection item	Result
(2)③Management situation of storage containers etc.	Through investigation on nuclide of nuclear fuel material, occurrence of mixture of organic substance, storage situation inside the storage containers etc. such as resin bags and encapsulation of containers, situation of storage was understood. As the cases similar to that of PFRF, there were 349 units, which account for 2.5 percent of the total, which Pu is encapsulated in, are suspected that organic substances were mixed in or are encapsulated in resin bags or containers (including suspicious ones), and have not been inspected with regard to the inside of the storage containers etc. **(Below table).**

Investigation item	Unit2
① Number of inspected storage containers etc.	13,878
② Number of storage containers including plutonium among ①	3,539
③ Number of storage containers that are suspected that organic substances were mixed in or are encapsulated in resin bags or containers among ②	2,280
④ Number of storage containers that have not been inspected among ③	349

In accordance with the causes that became clear along with the progress of the investigation and analysis of the causes, recurrence prevention measures will be developed and dissemination of information throughout the organization will be implemented as appropriate.

Note) The Alpha Gamma Facility and PFRF of Oarai R&D Center were excluded from this total inspection for focusing on restoration work of accident site.

Conclusion

- As the second report the following matters are reported: the probable causes of resin bags' burst were narrowed down; with regard to exposure evaluation of the workers, evaluation result of effective dose of external and internal exposure was obtained; with regard to restoration of the accident site, the storage container in the hood (H-1) was put in a glove box
- Following action
  - Determine the causes of resin bags' burst (around the end of August)
  - Obtain necessary information according to appropriate procedures, and report/record the exposure level of radiation workers based on laws and regulations such as Nuclear Reactor etc. Regulation Act
  - Clarify the major factors that caused the accident, and formulate the measures (around the end of September)
  - Complete the restoration of the accident site (around the end of September)
  - Submit the report required by the laws and regulations (final report) (around the end of September)