The 6th International Forum on the Decommissioning of the Fukushima Daiichi Nuclear Power Station @ Iwaki Performing Arts Center (Alios)

Current Status and Challenges of Analysis for Decommissioning Work

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Masumi Ishikawa

Director
Tokyo Electric Power Company Holdings, Inc.

TEPCO

Contents

TEPCO

1. Objective of Analysis

Perform the following analyses to ensure the safety of Fukushima Daiichi and proceed with decommissioning work strategically and steadily.

- **On-site/off-site monitoring**
  - Comprehending radiological impact on the surrounding environment
  - Keeping informed of on-site contamination & radiation control for workers, etc.
- **Decommissioning work planning, facility design, and safety assessment/verification**
  - Characterization of unknown substances, including fuel debris, and study of retrieval policies and methods
  - Confirmation of design conditions (including optimization) & performance retention
  - Various studies for waste processing/disposal
- **Accident investigation**

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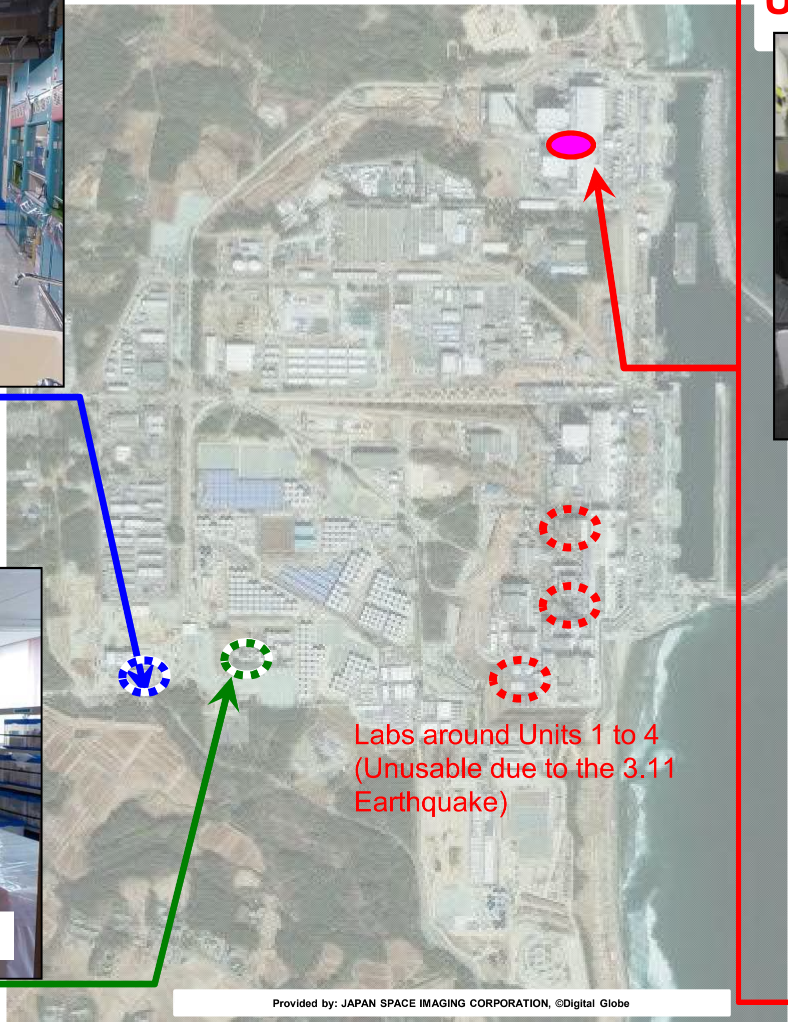
2-1. Current Status of Analysis - Analysis Facilities [1] -

Analyses are performed mainly at two locations (Unit 5/6 lab and chemical analysis building).

Chemical analysis building

Analysis room + Measurement room: 1000 m^2



Unit 5/6 lab

As of 2022

Analysis room + Measurement room: 850 m^2

Cleanup, decontamination, and expansion work

Immediately after the 3.11 Earthquake

Environmental management building

Limited work due to transfer of functions to other labs.

Analysis room + Measurement room: 480 m^2

2-1. Current Status of Analysis - Analysis Facilities [2] -

Chemical analysis building

- Analysis target: **Samples with low concentration**
  - Environmental samples (seawater, etc.)
  - Groundwater bypass and sub-drain purified water
  - Filters for air discharge control
  - ALPS treated water, etc.
- Handling equipment: 35 hoods

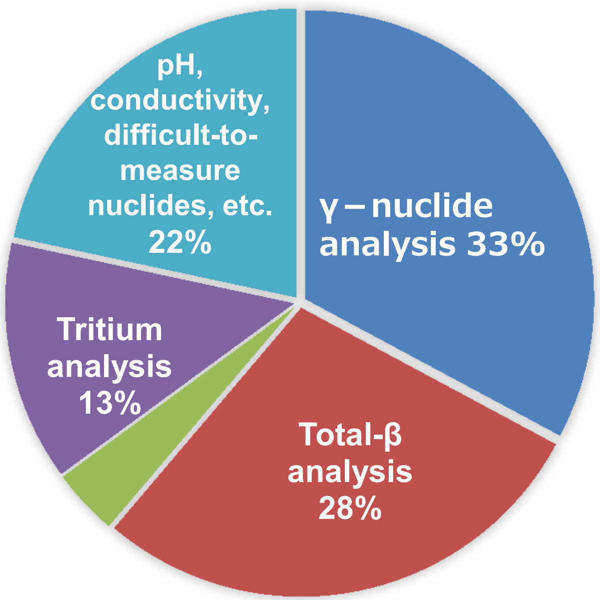
Unit 5/6 lab

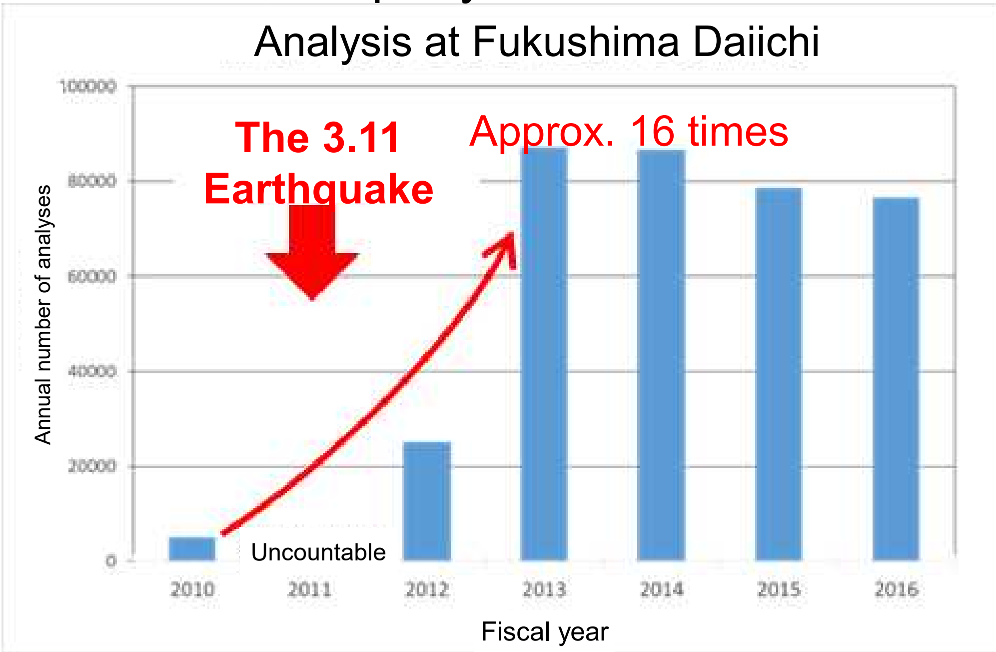
- Analysis target: **Samples with medium and low concentration**
  - Stagnant water in Units 1 to 4
  - System water from contaminated water treatment facilities
  - Spent fuel pool water, etc.
- Handling equipment:
  1 shielded glove-box, 5 glove-boxes, 26 hoods

2-2. Current Status of Analysis - Analysis Equipment and Number of Analysts

Measuring device	Main applications	Unit 5/6 lab		Chemical analysis building	
		Number of devices	Analysts	Number of devices	Analysts
Ge semiconductor detector	γ-nuclides (Cs-134, 137, etc.)	8	Approx. 60	13	Approx. 30
Automatic α-measuring device	Total-α concentration	4		3	
α spectrometer	α-nuclides (qualitative analysis only)	1		2	
Low back gas flow counter	Total-β concentration/Sr-90	4		5	
β-nuclide analyzer	Sr-90	5		2	
Liquid scintillation counter	Tritium/C-14, etc.	3		11	
ICP-MS	I-129/Tc-99, etc.	2		2	

- Analysis volume has increased by **about 16 times** since before the 3.11 Earthquake to **about 80,000 a year**.
- The number of samples analyzed is about 30,000 per year.



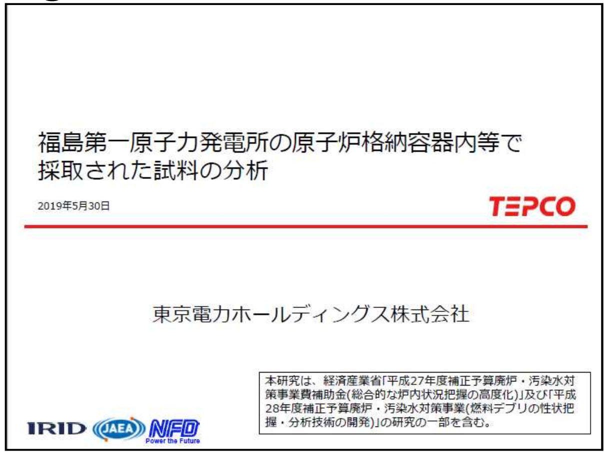


About 5,000/year before the 3.11 Earthquake

=> All analysis results are available on TEPCO's website.

https://www.tepco.co.jp/decommission/data/

We have conducted detailed analyses of samples collected from inside the primary containment vessels (PCVs) of Units 1 to 3 in collaboration with the “Project of Decommissioning and Contaminated Water Management” promoted by the national government.

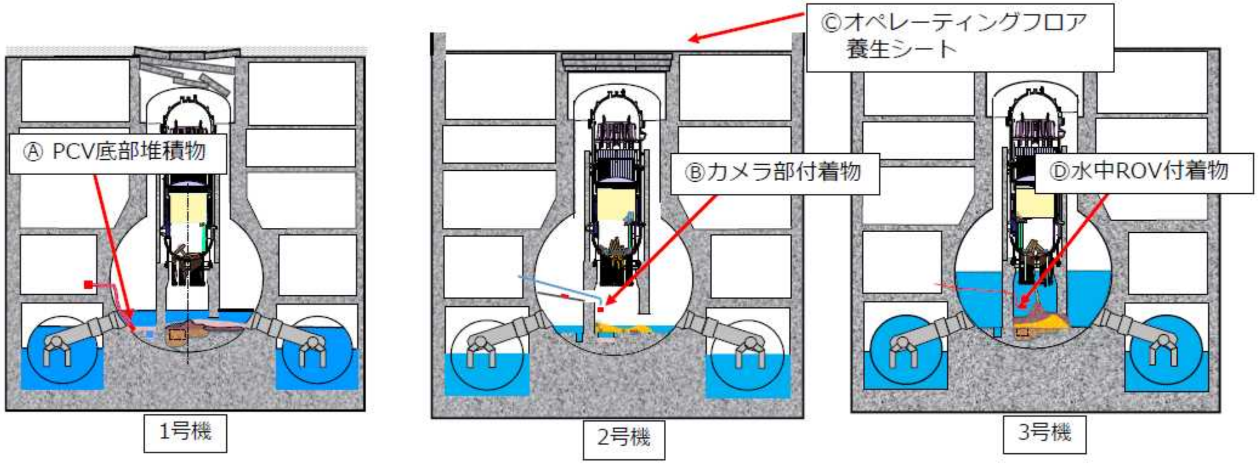

福島第一原子力発電所の原子炉格納容器内等で
採取された試料の分析

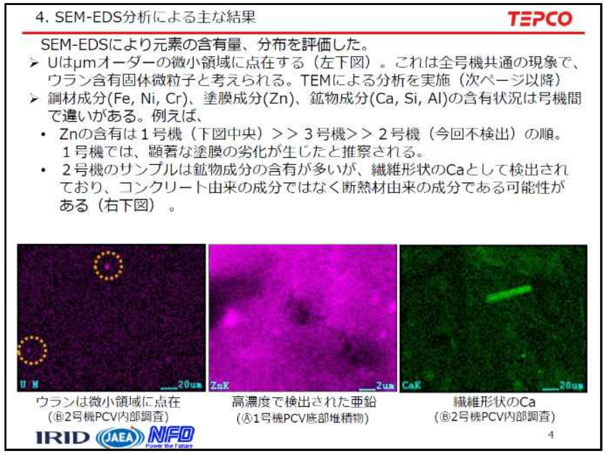
2019年5月30日

TEPCO

東京電力ホールディングス株式会社

本研究は、経済産業省「平成27年度補正予算廃炉・汚染水対策事業費補助金(総合的な炉内状況把握の高度化)」及び「平成28年度補正予算廃炉・汚染水対策事業(燃料デブリの性状把握・分析技術の開発)」の研究の一部を含む。




4. SEM-EDS分析による主な結果

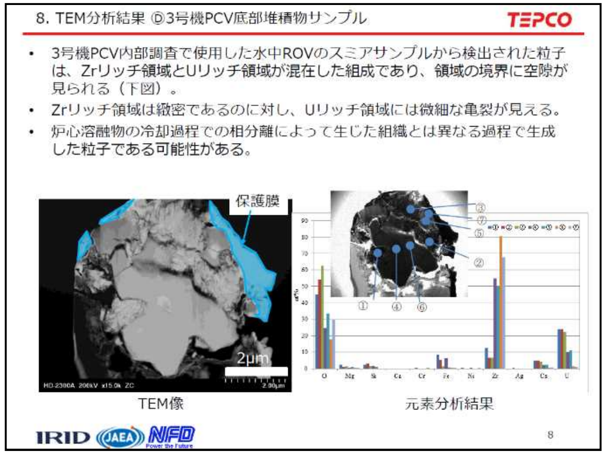
SEM-EDSにより元素の含有量、分布を評価した。

- Uはμmオーダーの微小領域に点在する（左下図）。これは全号機共通の現象で、ウラン含有固体微粒子と考えられる。TEMによる分析を実施（次ページ以降）
- 鋼材成分(Fe, Ni, Cr)、塗膜成分(Zn)、鉱物成分(Ca, Si, Al)の含有状況は号機間で違いがある。例えば、
  - Znの含有は１号機（下図中央）＞＞３号機＞＞２号機（今回不検出）の順。１号機では、顕著な塗膜の劣化が生じたと推察される。
  - ２号機のサンプルは鉱物成分の含有が多いが、繊維形状のCaとして検出されており、コンクリート由来の成分ではなく断熱材由来の成分である可能性がある（右下図）。

ウランは微小領域に点在（Ⓑ2号機PCV内部調査）

高濃度で検出された亜鉛（Ⓐ1号機PCV底部堆積物）

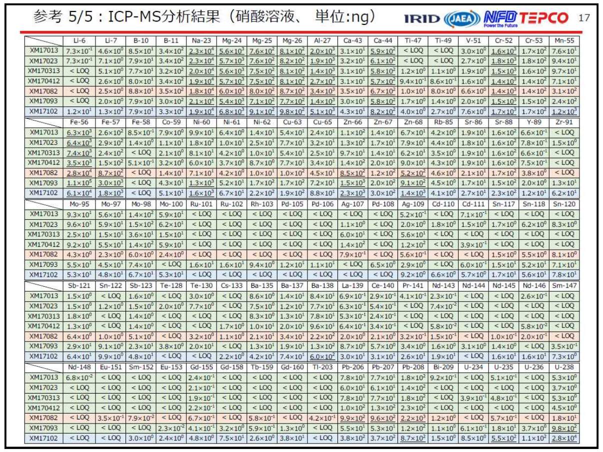
繊維形状のCa（Ⓑ2号機PCV内部調査）


8. TEM分析結果 Ⓓ3号機PCV底部堆積物サンプル

- 3号機PCV内部調査で使用した水中ROVのスミアサンプルから検出された粒子は、Zrリッチ領域とUリッチ領域が混在した組成であり、領域の境界に空隙が見られる（下図）。
- Zrリッチ領域は緻密であるのに対し、Uリッチ領域には微細な亀裂が見える。
- 炉心溶融物の冷却過程での相分離によって生じた組織とは異なる過程で生成した粒子である可能性がある。

TEM像

元素分析結果

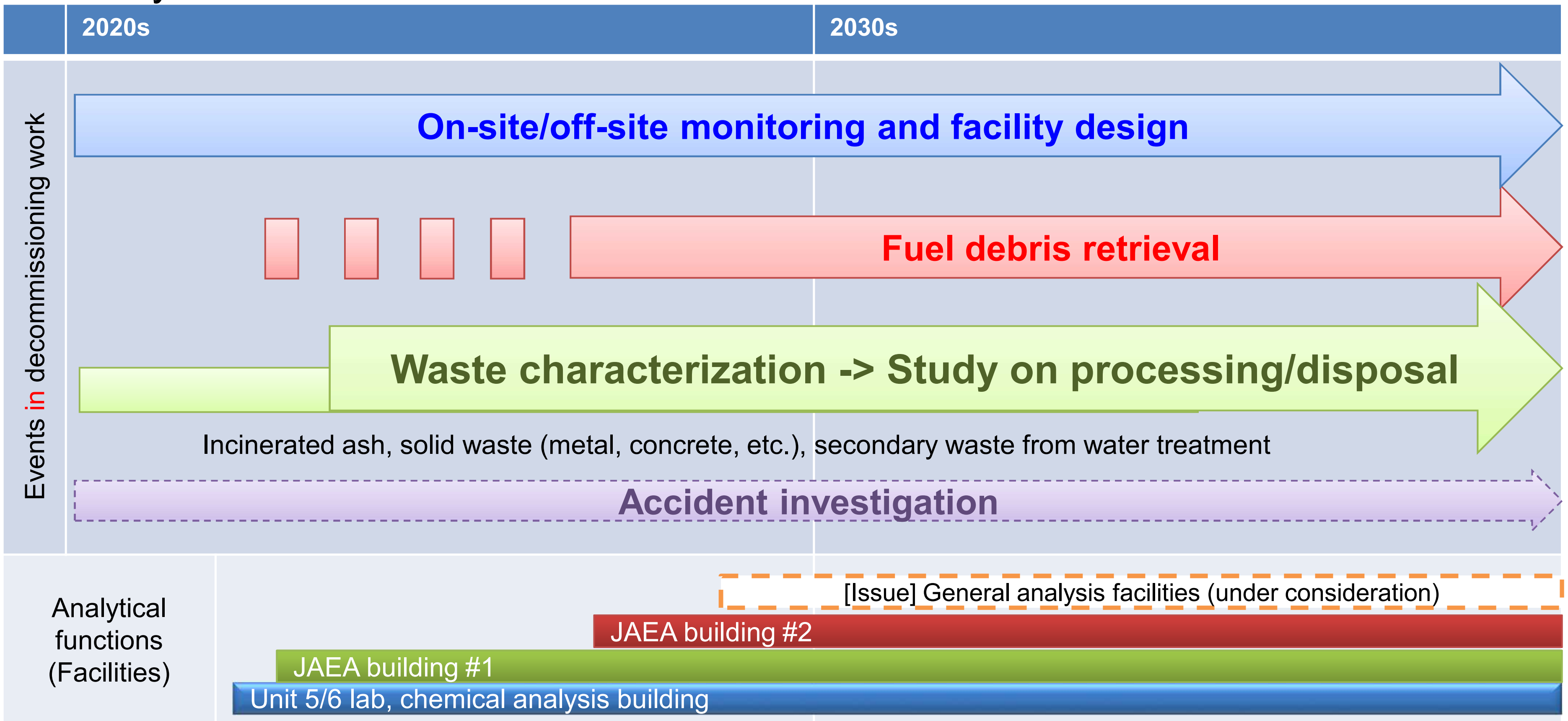

参考 5/5：ICP-MS分析結果（硝酸溶液、単位:ng）

<Results of SEM-EDS>　<Results of TEM>　<Results of ICP-MS>

Source: “Analysis of samples collected from inside the primary containment vessels (PCVs) and other locations in the Fukushima Daiichi NPS (May 30, 2019)”

3-1. Future Prospects - Important Events from an Analytical Perspective -

- Full-scale analysis of "waste characterization" and "fuel debris retrieval" is expected to begin in the mid-2020s.
- In the initial stage, research and development by JAEA will play a central role in the analysis, but in the future, TEPCO will aim to be capable of performing the analyses on a routine basis.



3-2. Future Prospects - Division of Roles between TEPCO and JAEA

- Division of analytical roles between TEPCO and JAEA
  - Analysis for research and technical development: JAEA
  - Analysis for facility management, etc.: TEPCO
- However, depending on the status of the decommissioning work, each facility will take a coordinated and flexible approach so that necessary analysis and monitoring can be performed.

<Key roles of each institute>

JAEA building #1

- ○ Research and technical development on waste processing/disposal
- ○ Development of analytical methods, etc.

JAEA building #2

- ○ Research and technical development on fuel debris
- ○ Development of analytical methods, etc.

Existing off-site analysis facilities

- ○ Research and technical development on processing/disposal
- ○ Development of analytical methods, etc.

TEPCO's general analysis facilities

- ○ On-site monitoring and troubleshooting
- ○ Design and progress management for decommissioning work such as fuel debris retrieval
- ○ Data expansion for waste processing/disposal
- ○ Accident investigation, etc.

NDF

- ○ Review of leading research programs
- ○ Review of rational management tactics based on research results, etc.

Since we have mainly conducted simple analyses such as γ-ray nuclide analyses of liquid samples, we have almost no experience in analyzing solid samples such as waste and fuel debris, for which pre-treatment techniques are complicated. In addition, there are no facilities or cells for handling highly radioactive samples such as fuel debris.

■ Challenges

- **Securing analytical techniques and human resources**
  - Securing analytical technicians who are capable of establishing analytical procedures.
  - Establishing analytical procedures for samples with no previous experience, such as in fuel debris, and securing analysts.
- **Development of analytical facilities**
  - Developing equipment and facilities to handle highly radioactive samples such as fuel debris.

4-2. Approach to Challenges - Securing Human Resources [1]

■ Approach

It largely depends on experience and takes time to develop human resources.

➢ Securing analytical technicians:
- Cultivate through **personnel exchanges (temporary transfer) with external analytical institutions, etc.**
- Mid-career employment

➢ Securing analysts:
- Training for analysts (to be considered)
- **Reduce the number of analysts required <- Simplify, accelerate, and automate analysis tasks**

Organizational illustration	Functional elements	Assumed headcount	
Analysis evaluator	• Understand the decommissioning process • Understand information necessary for decommissioning work and reflect the analysis results in decommissioning work	Several	
Analytical technician	• Understand analysis results and principles • Establish/refine procedures • Improve measuring instruments/systems	Several	Insufficient
Analysis manager	• Analytical data management • Quality control • Outsource management	More than ten	
Analyst	• Understand procedures • System/device operation skills • Knowledge of radiation protection/control	About 100	

4-2. Approach to Challenges - Securing Human Resources [2]

■ Expectations for analytical technicians

- Capable of **quantifying the amount of radioactivity** for each nuclide and **analyzing** the physical and chemical **properties** of the radioactive materials contained in **unidentified samples**.
- Capable of **establishing, optimizing, and verifying procedures** for physical pretreatment (e.g., severing, crushing, polishing) and chemical pretreatment (e.g., dissolution, separation) based on an understanding of measurement techniques and according to the properties of the samples to be analyzed.
- **Capable of explaining** the results obtained **in an easy-to-understand manner based on standards and hands-on experience.** Capable of examining and explaining the mechanism that allows the results obtained to occur from on-site conditions and making proposals for each area of work.

■ Elements required for human resources

- Measurement-related: Understand the principles and implications of equipment output
- Pretreatment-related: **Knowledge of physics and chemistry, experience with chemical reactions**, handling skills in operating tools
- Explanation-related: Knowledge of laws and regulations, knowledge of historical analysis data

4-3. Approach to Issues - Development of Analysis Facilities -

■ Analysis target

On-site/off-site monitoring samples, fuel debris, waste samples, system facility samples, bioassay samples, clearance samples, samples for accident investigation, etc.

■ Main analytical systems

Concrete cells, iron cells, glove boxes, measuring instruments, etc.

■ Status

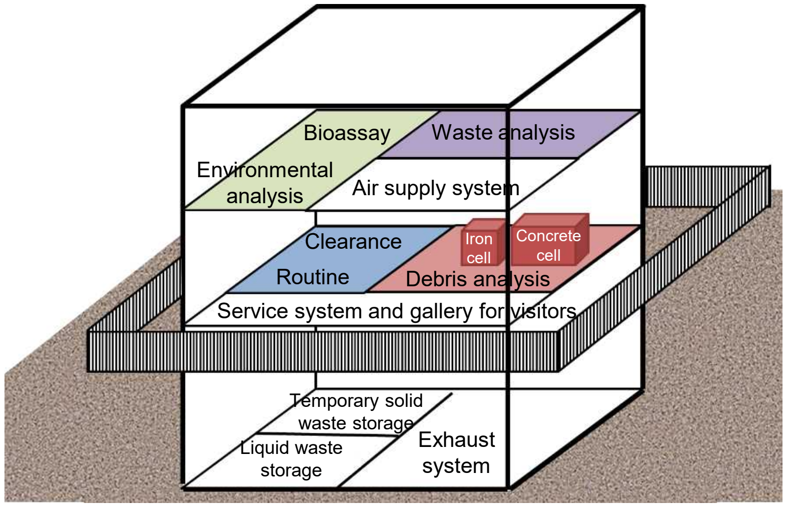
Conceptual study

↓ Examine facility size and feasibility

Current status ▶ Fundamental design

↓
- Summarize concepts to ensure safety
- System design policy/basic specifications
- Consider automation of routine analyses

Detailed design and construction



<Schematic drawing of general analysis facilities>