Development of Fuel Debris Retrieval Technology at IRID

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Outline of IRID

1. Name
   International Research Institute for Nuclear Decommissioning (IRID)

2. Establishment
   August 1, 2013: Establishment of IRID was approved by the Minister of Economy

2. Location of Headquarters
   5F 3Toyo Kaiji Building, 23-1 Nishi-shinbashi 2-chome, Minato-ku
   Tokyo 105-0003, Japan
   TEL: +81 3 6435 8601 (representative)
   website: http://www.irid.or.jp/en

3. Membership (18)
   Research Institutes: Japan Atomic Energy Agency (JAEA),
   National Institute of Advanced Industrial Science and Technology
   Manufacturers, etc.: TOSHIBA Corporation, Hitachi-GE Nuclear Energy, Ltd.,
   Mitsubishi Heavy Industries, Ltd., ATOX Co., Ltd.
   Electric Utilities, etc.: Hokkaido Electric Power Co., Inc., Tohoku Electric Power Co., Inc.,
   Tokyo Electric Power Co., Inc., Chubu Electric Power Co., Inc.,
   Hokuriku Electric Power Company, Kansai Electric Power Co., Inc.,
   Kyushu Electric Power Co., Inc., The Japan Atomic Power Company,
   Electric Power Development Co., Ltd., Japan Nuclear Fuel Limited
IRID gathers knowledge and ideas from around the world for the purpose of R&D in the area of nuclear decommissioning under the integrated management system.

**R&D projects:**
- Fuel Removal from spent fuel pool
- Preparation for fuel debris retrieval
- Treatment and disposal of radioactive waste

**R&D for Decommissioning**

**Promotion of Collaboration on Decommissioning with Domestic and International Parties**

**Development of Human Resource for R&D**
IRID focuses on a current urgent challenge—R&D for decommissioning of the Fukushima Daiichi NPS—with a view to strengthening the foundation of nuclear decommissioning technologies.

Role of IRID

- **Tokyo Electric Power Co. (D&D Company)**
  - Decommissioning of Fukushima Daiichi NPS
  - Provision of R&D results
  - R&D needs

- **IRID**
  - R&D implementation

- **Nuclear Regulatory Authority**
  - Approval of safety regulations and implementation plans

- **Government (METI)**
  - Establishment of Mid-and-long Term Roadmap (Including R&D programs)
  - Advice, supervision, guidance
  - Report on progress status
  - Entrusting of important issues

- **NDF**
  - Strategy planning of important issues
  - R&D planning
  - Report
  - Support as needed

- **Fund for technical development**
  - (Management office: Mitsubishi Research Institute)
  - Grant
  - Application for grant
  - Funding

Report, application

Approval of safety regulations and implementation plans
IRID’s R&D Projects

R&D for Fuel Removal from Spent Fuel Pool
- Evaluation of Long-term Structural Integrity of Fuel Assemblies Removed from the Spent Fuel Pool

Decontamination/Dose Reduction
- <Securing of work environment>
  - Remotely Operated Decontamination Equipment
  - Reliability Evaluation of Remotely-operated Decontamination Equipment

Debris Retrieval
- <Securing of stable condition>
  - PCV/RPV Integrity Evaluation
  - Criticality Control in Fuel Debris Retrieval
- <Fuel debris retrieval>
  - Upgrading of Retrieval Method for Fuel Debris & Reactor Internals

Repair and Water Leakage
- Stoppage of PCV
  - Repair and Water Stoppage Technology of PCV
  - Full-Scale Test

Investigation/Analysis in the Reactor
- Investigation Inside PCV
- Investigation Inside RPV
- Detection of Fuel Debris
- Accident Progression Analysis
- Identifying Properties of Fuel Debris

Radioactive Waste Treatment/Disposal
- Collecting, Transferring and Storing of Fuel Debris
- Fundamental Retrieval Technology for Fuel Debris & Reactor Internals

Solid Waste Treatment and Disposal
Development of Technology for Remotely Operated Decontamination
support to reduce the work exposure in the investigations and the decommissioning works
Development of Inspection/Investigation Equipment

Device for Investigation of the S/C upper part
Investigation of leakage from the S/C upper structures

Device for Investigation of the joint part between the vent tube and the D/W
Investigation of water leakage at the bottom part of the vent pipe, using a camera

Device for Investigation of the S/C lower part
Investigation of the existence of a hole with a diameter of 30 mm or more in a submerged part

Device capable of underwater swimming and floor travelling
Investigation of areas penetrating walls underwater and in muddy water

VT-ROV

Telerunner

Gengo ROV

Trydiver

Reflection from a pipe
Reflection from a tracer

Tracer

Sonar

http://www.irid.or.jp/en/
Development of Technology for Remotely Operated Decontamination

**Composition of an air dose**

Air doses in the reactor building (example)

**Contamination forms**

Loose, fixed and permeated contamination forms are combined.

- Loose contamination
- Fixed contamination
- Surface coating (Epoxy)
- Concrete (Permeated contamination)

**Approaches to decontamination areas**

For low places (the floor, the lower surfaces of walls)

- Extension
- Revolving arm

For upper floors

- Compressor cart
- Decontamination unit cart
- Work cart

Decontamination device for contamination forms

- High pressure water jet
- Dry ice blast
- Blast(suction)

Air doses in the reactor building (example)
Development of remote decontamination technology: Examples of tie-ups with universities

- Operating a robot using only data from a normal robot-mounted camera makes it difficult to understand the robot’s surroundings, and operations are not easy.
- Avoiding interferences when using a multi-jointed manipulator in confined spaces is difficult and requires complex operations.

**Examples of technical issues**

**Understanding the vicinity 1**
“Tokyo Uni. Yamashita Lab”
- Revised images from multiple robot-mounted cameras, and images looking down at the robot from above (quasi-overhead view) facilitate understanding the condition of the environment
- Development of techniques to allow Changes in camera type, attachment position and direction to be handled flexibly, and easily adjust the amount of image correction

**Understanding the vicinity 2**
“Tsukuba Uni. Tsubouchi Lab”
- Development of a system that maps 3D measurement data to the robot surroundings, thus facilitating judgements.
- Considering applicability to robots, development of a system that appropriately selects still or moving images of the required definition to enable flexible responses even when signal speed is low.

**Improved Operability**
“Kobe Uni. Yokokohji Lab”
- While manipulators with multi degrees of freedom can avoid obstacles and have advantages in confined areas, they are also difficult to operate.
- As operability should be made less complex, the development of an easy to use interface that allows instinctive self-motion commands

* : Movements which change the entire shape of the manipulator while the tip of its claw and base are fixed in position

- Quasi-overhead images taken from Super Giraffe
- Quasi-overhead images taken from MEISTeR
- 3D mapping screen (currently under development) of data taken with Super Giraffe
- Image showing understanding of surrounding environment using 3D sensor data and camera images
- Tip of claw is fixed in position
- Example of self-motion movements of manipulator with 9 degrees of freedom
Development of Technology to Repair the PCV
Set up of the basic configuration of the debris removal works and reduction of the additional RI release risk
Development of Technology to Repair the PCV

Areas that need to be studied for repair in order to submerge fuel debris in the PCV with water or to form a PCV boundary

Water stoppage technology for leakage from the sealing section
Water stoppage technology for leakage from the pipe bellows
The inside of the small chamber

Water stoppage technology involving injection of sealing material into the vent pipe
Vent pipes, quenchers and strainers
Water stoppage technology for leakage from the vacuum break line (Unit 1)

Construction of boundaries for PCV connector pipes
Pipes installed in the torus room which are the D/W connector pipes

Study on the circulation cooling system

Technology to stop water leakage from clearances in the reactor building

Technology for strengthening the suppression chamber support columns

D/W shell repair technology

Target areas for Development of Repair and Water Leakage Stoppage Technology
Check of water leakages

Expansion joint on main steam piping

The protective cover of the expansion joint on the vacuum breaker line

Sand cushion drain pipe

Water leakage points

Method to repair openings outside the D/W

Injection of non-cement based material

Protective cover

Method to repair narrow spaces outside the D/W

Injection

Method to repair PCV lower part

Basic test of a water stoppage method in which the vent pipe is filled up with water stoppage material.
Development of Technology to Repair the PCV

Stopping water leakage from the vent pipes

**Repairing materials**
used for vent pipe expansion flattery and the measure against degradation of areas water leak blockage part

**Sub inflatable sealing bag**

Installation of an inflatable sealing bag

Possible water leakage to S/C connection system

**Possible minor water leakage**

Possible water leakage from the vent pipe

**Inflatable sealing bag**
Balloon

**Water stoppage material**
Mainly grout.

S/C (suppression chamber) cross-section

Stopping water leakage from the downcomer

**Guide pipe**
suppresses a water flow amount at the time of junction (welding) to S/C, grout injection and construction

**Stoppage of water leakage from the vacuum breaker**

**Stoppage of water leakage from the downcomer**
Mainly grout

**Stoppage of water leakage from the quencher**

**Stoppage of water leakage from the downcomer and vacuum breaker**

**Stoppage of water leakage from the strainer**

**Stoppage of water leakage from the vent pipes**

**Repairing materials**

**Stoppage of water leakage from the downcomer**

**Sub inflatable sealing bag**

**Installation of an inflatable sealing bag**

**Possible water leakage to S/C connection system**

**Possible minor water leakage**

**Possible water leakage from the vent pipe**

**Inflatable sealing bag**

**Balloon**

**Water stoppage material**
Mainly grout.
Mock-up Test

Facilities for the development and validation of remotely-operated devices and equipment

Equipment for Investigation of the S/C lower part

It is necessary to prepare an environment to repeatedly test and verify devices and equipment and avoid checking the applicability of the devices and equipment on site in a trial-and-error manner.

Method to repair the PCV lower part

Full-scale test for repair and water leakage stoppage technology for leakage points inside the PCV

1/1(1/8) Sector Suppression Chamber Mock up

JAEA, Naraha Remote Technology Development Center Test building

Interior of the torus room

Interior of the S/C
Probe for fuel debris

Investigation inside the PCV
Investigation inside the RPV
Muon technique
Identification and Analysis of Conditions inside the Reactor
Severe Accident Progression Analysis Technology
Investigation inside the PCV

Development of robots to investigate inside the PCV

- A linear shape that allows the robot to go through a guide pipe with a diameter of about 100 mm and stable movement in the PCV
- Use of robots under severe environments (high radiation dose, darkness, steamy atmosphere, etc.), and collection of "image", "temperature" and "dose rate" data

Shape-changing robot

In going through a pipe

Dosimeter

In moving on a plane surface

The robot goes into the PCV through a 115 mm-diameter penetration.

Scorpion robot

Camera & lighting

Crawler

Requirements for radiation resistance

- 100 Gy/h
- Cumulative 1 KGy

The robot goes into the inside of the pedestal from the CRD* rail.

[Unit 1] X-100B Penetration (115 mm in diameter)

[Unit 2] X-6 penetration

CRD rail

Self-righting mechanism

CRD: function to drive control rods

Camera & lighting

Crawler

Camera

Thermometer

Camera

Dosimeter

Crawler

Camera
Internal inspection of reactor containment vessel (PCV)

**Expectations for internal inspection of PCV**

1. **Location of fuel debris**
   - Consideration of access, unloading route, cutting method, basic data required for design

2. **Fuel debris distribution, composition (properties)**
   - Data required for decision on technical framework to enable risk management and keep reactor safe
   - Data required for design that maintains environment and allows provision of cutting so that work proceeds steadily

3. **Damage and other conditions**
   - Required data to enable water to be shut-off and allow continuation of removal work that employs water
   - Required data to allow debris removal to be completed smoothly, and retain the pressure vessel with certainty

**Investigation Steps**

- **Survey of CRD rail condition (A1)**
  Performed Aug 2013

- **Survey of condition of pedestal inner platform / lower CRD / slot opening (A2)**

- **Survey of area under platform (A2)**

- **Survey for deciding fuel debris removal method (A3)**

**Issues in A2: Steps up to survey of inner PCV**
- Decrease dose around penetration
- Make a hole in penetration hatch (Φ115mm)
- Secure access route to platform

**Issues in A3: Steps up to survey of inner PCV**
- Opening the hatch
- Avoiding/removing penetration inclusions
- Avoiding/removing suspended tools on CRD rail
  ※Judgement will be made depending on the result of A2 survey

Unit 2: Proposed access route to inside containment vessel and pedestal (below pressure vessel)
Investigation inside the PCV

**Future plan**

① Development of shielding, isolation and boring device for the X6 penetration of unit #2, Pedestal platform investigation

② Investigation of fuel debris below the pedestal platform of unit #2

③ Investigation of PCV lower floor of unit #1 to utilize video camera and dose rate meter from the upper floor

④ Investigation of inside the pedestal of unit #3 by underwater ROV
Investigation inside the Reactor Pressure Vessel (RPV)

**Purpose of investigation inside the RPV**

Obtain data on the locations of fuel debris inside the RPV, the damaged condition of reactor internals, temperature and dose inside the RPV, etc.

- Study methods to access, investigate and sample investigation targets

**Study of access methods**

- Access to drill the upper part
- Access to system piping
- Access after the reactor is opened

The following is considered:

- Doses and the installability of shield
- Accessibility of investigation equipment
- Observability

Device to drill the RPV head

Feederwater A system

Jet pump instrumentation

Reactor core spray

- Access to system piping
  - Electromotive travelling device
  - Jet pump instrumentation
  - Reactor core spray

- Access after the reactor is opened
  - Hydraulc type travelling device

- Traveling
- Grabbing
- Bifurcation

Horizontal and vertical
Elbow and deformed pipes
Position and posture holding
Passage of T-shaped bifurcation
Directional control
Visualization Technology

3D imaging of the situation inside the reactor building

- 3D laser scanner
  - Data of 40,000,000 points per 10 minutes

(A horizontal plane)

(A upper surface)

A route for lowering devices from the ceiling (the floor surface on the first floor) was found.

Visualization of air dose

- Gamma camera
- Camera
- Collimator
- Shutter

Hot spots exist in pipes.

Visualization of fuel debris in the RPV
Development of Technology for Detection of Fuel Debris in the Reactor

Simulation (90 days)

- Muon detector
- XY detection unit

Gamma ray detector

Data of 40,000,000 points per 10 minutes

- Muon detector
- XY detection unit
Detectors were installed at the north and north-west corners of Unit 1 reactor building (late January, 2015)

- Measured from February through May
- Detectors installed in the front of the reactor building were shielded by 10 cm thick iron plates
Estimation of Fuel Debris Location Based on Comparison between Design Image and Measurement (Detector 1)

- Measured data, though it does not clearly indicate, shows that equipment, etc. are detected at locations where they are supposed to exist based on the design documents.
- The boundaries of the PCV and the RPV in the image acquired from measurement matches those in the image drawn from design data.
- High density material (fuel) is not detected at the area where the reactor core was originally located.
Identification and Analysis of Conditions inside the Reactor

Severe Accident Progression Analysis Code

**MAAP** (Modular Accident Analysis Program)
- "Simplified model" using test result-based correlation formula allows high speed calculation
- Can perform parametric analysis of phenomenon of large uncertainty

**SAMPSON** (Severe Accident analysis code with Mechanistic, Parallelized Simulations Oriented towards Nuclear fields)
- Uses theoretical models and "mechanistic model" with sophisticated descriptions of physical and chemical phenomena
- Multidimensional analysis of space distribution-related phenomena is possible

MAAP Schematic model of reactor pressure vessel interior

- Heat Transfer to Isolation Condenser
- Steam Dryers
- RPV Heat Loss to Drywell
- Steam Separators
- Core Sprays
- Safety Injection
- Loss through Break
- Zr/H2O Reaction
- Heat Transfer to Water in Core
- Leakage from CRD
- Provided by EPRI
- Stream & H2 Production from Core
- Release through Safety/Relief Valves
- Main Steam Flow
- Flow to HPCI/RCIC
- Heat Transfer to Gas in Primary System
- Main Feed Water Flow
- Fission Products Decay
- Core Heatup & Melt Progression
- Heat Transfer to Heat Sinks
- RPV Heat Loss to Pedestal
- Fluid Loss through RPV Penetration
- Heat Transfer from Debris in Lower Plenum

Event description/analysis
- Initial event
- Estimate of plant status (temp, press, PCV, RPV, water lev.)
- PCV leak / RPV damage location & area
- Assessment of PCV leak condition
- Assessment of RPV damage condition
- Location & amount of debris
- Debris temperature
- Analysis of core concrete reaction
- Re-criticality
- FP amount in PCV & RPV
- Prediction of water feed amount, pressure & temperature
- H2 density (upper limit)
  - Prediction of amount of N2 supplied pressure & temperature
  - Prediction of N2 & H2 densities

TEPCO: Remote visualization of actual plant status

Understanding reactor internal status using severe accident analysis code
- Improvement of Analysis Codes & Accident analysis using actual data
  - MAAP / SAMPSON
- Individual event assessment through thermal flow analysis
- International Cooperation: OECD/NEA benchmark analysis (BSAF)

JAEA: Mock-up Test (Seawater heat transfer test, etc.)

Relation between analysis item & analysis code

- Severe accident analysis code MAAP, SAMPSON
- Simple heat transfer flow calculated: Energy balance, Thermal conduction, Radiation, Convection
- Transient Analysis Code TRACG, etc.
- Universal heat flow analysis code

"Overview of improvements in assessing conditions inside the reactor through technical progress in accident development analysis" The Institute of Applied Energy 22/10/2012
Severe accident development analysis technology

Melted Core - Concrete Interaction (MCCI) Assessment
Example of MCCI assessment performed on the Unit 1 actual sump system with eroded concrete convection flow/spread model added to the DSA module which has a high generality in the SAMPSON codes

Eroded concrete convection flow/spread model
Addition of convection flow/spread of eroded concrete to debris

- Model: Cross-section of concrete floor

Validation through OECD/MCCI CCI-2 Test Results:
Final surface form of debris predicted within an accuracy of 13%

Unit 1 actual sump system measured results
Analysis carried out until 12 hours after RPV damage
### Severe accident development analysis technology

#### Summary of overall analysis & assessment results of fuel debris distribution

Fuel debris assessment from severe accident development analysis codes and other survey results

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit 1</th>
<th>Unit 2</th>
<th>Unit 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accident development analysis</strong></td>
<td>Most fuel debris transferred to PCV side</td>
<td>Fuel debris distribution greatly depends on amount of water pumped in by firefighters</td>
<td>Most fuel debris transferred to PCV side</td>
</tr>
<tr>
<td><strong>Assessment of heat balance methods</strong></td>
<td>Few heat sources inside RPV</td>
<td>Constant rate in both RPV and PCV</td>
<td>Constant rate in both RPV and PCV</td>
</tr>
<tr>
<td><strong>Myon Measurement</strong></td>
<td>Almost no high density material (fuel) in reactor core</td>
<td>Almost no large pieces of fuel debris in reactor core</td>
<td>Not measured</td>
</tr>
<tr>
<td><strong>Internal Inspection of PCV</strong></td>
<td>No large scale damage to PCV wall in confirmed scope</td>
<td>No large scale damage to external area surrounding lower part of RPV</td>
<td>No damage to internal PCV structure in confirmed scope</td>
</tr>
<tr>
<td><strong>Overall Assessment</strong></td>
<td>Most fuel debris transferred to PCV side</td>
<td>Constant rate in both RPV and PCV</td>
<td>Most fuel debris transferred to PCV side</td>
</tr>
</tbody>
</table>
Development of Fuel Debris Retrieval

Fuel Debris Characterization
Collection, Transfer and Storage of Fuel Debris
Structural Integrity Evaluation
Assessment of Seismic Resistance
Fuel Debris Retrieval Method
Fuel Debris Characterization

**Generation of mock debris**

- Estimate of oxidization, metals produced
  → Thermodynamic equilibrium calculated
  (fuel distribution, oxygen density, temperature inside reactor)

**Oxidation:** (U, Zr) O₂
**Metals:** Zr(O), Fe₂ (Zr, U)

**Understanding distinctive reactions at Fukushima Daiichi**

- Boron-generated reaction products
  Boride derived from B₄C control material is remarkably hard, and may burden cutting tools

- High temperature reaction with concrete (MCCI *)
  *Molten Core Concrete Interaction
  Product composition varies with concrete composition, melting temperature, time
  Multiple layers of oxidized material between eroded concrete surfaces

- High temperature reaction with seawater sodium

**Investigation of physical properties required for extraction & sampling of fuel debris**

- **Physical Features**
  (shape, size, density/porosity, hardness, elasticity, fracture toughness)

- **Thermal Features**
  (specific heat, thermal conductivity, melting point)

- **Comparison with TMI-2 debris**
  Hardness of mock debris is almost identical to TMI-2

**Estimate of distribution of hardness for each chemical system of debris**

- (boride, oxide, metal)

**Types of extraction tools**

- **Cutting**
  - Principle: Impact
  - Principle: Shear
  - Principle: Fusing

- **Collection**
  - Principle: Pick & place
  - Principle: Suction
  - Principle: Grind & compress

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*Image of actual debris*
Collection, Transfer and Storage of Fuel Debris

Fukushima Daiichi Issues

- High degree of burn-up and concentration
  ⇒ radiation, large disintegration, high reactivity
- Generation of concrete-related melt product expected
  ⇒ Concerns of hydrogen emission via radioactive breakdown of water in concrete
- Seawater injection, melting of instrument cables
  ⇒ Effects of sodium in fuel debris, introduction of multiple impurities
Development of Technology for Criticality Control in Fuel Debris Retrieval

Objectives of criticality control technology development

It is believed that currently the fuel debris is not in state of criticality, but alongside future work to retrieve fuel debris, criticality control methods and monitoring will be developed to prevent any re-criticality occurring even with changes to fuel shape and amount of water included.

Technical development point

PCV interior
- Changes to fuel debris shape
- Changes to amount of water included (water level) due to submersion
  - Small risk of exposure, but important to monitor conditions over a relatively wide area
  - Development of re-criticality occurrence detection methods
  - Prevent re-criticality from occurring
  - Development of neutron-absorbing material to prevent criticality

PCV exterior
- Powder produced when cutting fuel debris has a risk of escaping and collecting in waste water treatment/cooling equipment
  - Need to preemptively prevent exposure of equipment maintenance workers
  - Development of sub-criticality monitoring Technologies
Structural Integrity Evaluation

Residual life assessment outline flow

Need a means to maintain reactor structural integrity for a long time until the fuel debris is retrieved from reactor core
- Effect of high temperature during fuel melt
- Effect of corrosion due to inclusion of seawater and foreign particles
- Effect of equipment damage due to hydrogen explosion
- Effect of debris retrieval method
- Effect of further earthquakes

Model Creation
- Water level
- Basic ground motion Ss
- Damage to equipment
- Influence of corrosion

Assessment Conditions
- Allowable values
- Corrosion wall thinning (test data)
- High-temperature strength degradation (test data)

Example of soundness assessment point

Anticipated plant condition
- Submerged
- Water stopped (grout fixed)

Increased anticipated long-term corrosion wastage

Building behavior analysis (Building damage simulation) → Building-equipment coordination behavior analysis → Organizing loading conditions → Equipment strength assessment → Low margin equipment listed up

Residual life assessment outline flow

Example of soundness assessment point

PCV Stabilizer
PCV penetration
D/W shell
S/C shell
Reacto shield wall
RPV Pedestal
Vent pipe
Column support

Long-term corrosion test
Comparison of corrosion control measures
Methods of Fuel Debris Retrieval

Selection options for method of fuel debris retrieval

- a. Submersion – top entry method
- b. Partial submersion – top entry method
- c. Partial submersion – side entry method

Diagram below taken from NDF “Technical Strategic Plan 2015”

System Concept, Investigation of Method Feasibility

- Radioactive dust treatment system
- Criticality control system
- Fuel debris retrieval device
- Internal gas management system (negative pressure control)
- Circulation, feed water, cooling system
- Purification System

Techniques required for method feasibility study

- ✔ Techniques to prevent contamination spread during retrieval of large structure
- ✔ Techniques to prevent contamination spread during retrieval of fuel debris from inside RPV
- ✔ Techniques to access fuel debris
- ✔ Techniques to retrieve fuel debris through remote operations
- ✔ Techniques for cutting, collecting, monitoring, and measuring during fuel debris retrieval

Points to consider regarding fuel debris retrieval equipment

- ✔ Equipment resistance to radiation & maintainability
- ✔ Improved efficiency in fuel debris retrieval method
- ✔ Compatibility with storage cans and other equipment
- ✔ Equipment to collect radioactive dust from around device

Reference:
Guidelines for solicitation of entities to implement with subsidies “Subsidy to Project of Decommissioning and Contaminated Water Management (Project of Upgrading Approach and System for Retrieval of Fuel Debris and Internal Structures)” and “Subsidy to Project of Decommissioning and Contaminated Water Management (Project of Development of Fundamental Technologies for Retrieval of Fuel Debris and Internal Structures)” in the FY2014 Supplementary

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Summary

1. Development of Fuel Debris Removal Technology
   - Project of Fuel Debris Retrieval Method Development
   - Projects to support fuel debris retrieval development
     • decontamination, investigations, accident analysis, repair and water leakage stopping, structural integrity evaluation, criticality control
     • collection, transfer and storage, waste management

2. Key technologies
   - Challenges in the extremely high dose environment
     • radiation shielding, mitigation of RI release
     • remote control technology
     • visualization technology
   - Established reliable technology and flexibility of introduction of new technique

3. To ensure the safety: Nuclear safety is the maximum value
   - Introduction of debris handling experiences, performance and lessons learned from overseas countries
   - Design to support the risk management in the site
   - Establishment of safety design plan and dialogue with the regulator
   - Verification by examinations and mock up tests
   - Enough trainings