Enforcement of the New Regulatory Requirements for Commercial Nuclear Power Reactors

July 8, 2013
Nuclear Regulation Authority

A severe accident at TEPCO's Fukushima Daiichi Nuclear Power Station, triggered by the devastating natural events of March 2011, taught Japan and the world many important lessons on nuclear safety issues. The learning process has by no means ended and the future will no doubt unlock many more lessons to be learned.

One of the centerpiece actions taken in Japan post-Fukushima to improve its nuclear safety management and regulation is the creation of a new nuclear regulatory body, the Nuclear Regulation Authority (NRA). Following its inauguration on September 19, 2012, the NRA carried out a complete review of safety guidelines and regulatory requirements with the aim of formulating a set of new regulations to protect people and the environment. On July 8, 2013, the new regulatory requirements for commercial power reactors got into force.

Based on a concept of "Defense-in-Depth", essential importance was placed on the third and fourth layers of defense and the prevention of simultaneous loss of all safety functions due to common causes. In this regard, the previous assumptions on the impact of earthquakes, tsunamis and other external events such as volcanic eruptions, tornadoes and forest fires were re-evaluated, and countermeasures for nuclear safety against these external events were decided to be enhanced. Furthermore, it is required to take countermeasures against internal fires and internal flooding, and to enhance the reliability of on-site and off-site power sources to deal with the possibility of station blackout (SBOs). In addition to the above-described enhancement of countermeasures established at design basis, countermeasures for severe accident response against core damage, containment vessel damage and a diffusion of radioactive materials, enhanced measures for water injection into spent fuel pools, countermeasures against malicious airplane crash, and an installation of emergency response building are also required.

The new regulatory requirements were developed taking into account the lessons-learnt from the accident at Fukushima Daiichi Nuclear Power Station that were identified in the reports of the National Diet's Nuclear Accident Investigation Commission, the Government's Nuclear Accident Investigation Committee and the Independent Investigation Commission on the Fukushima Daiichi nuclear accident, considering the harsh natural conditions unique to Japan, and in line with the consistency with the safety standards and guidelines of the International Atomic Energy Agency (IAEA). So-called "safety myth" had critically impeded efforts for nuclear safety in Japan before the accident at Fukushima Daiichi nuclear accident, however, more stringent regulations have been developed with an underlying assumption that severe accidents could occur at any moment.

In the sense of "Back-fit", the new regulations are applied to the existing nuclear power stations, however, a five-year deferment period from the time of enforcement of the new regulations is given to a realization of some safety measures including filter vents for pressurized water reactors (PWR) and control rooms for the time of emergency.

Nuclear power reactors, that are generally limited to 40 years of operation life-time, will be given one-time legal permission to extend it to another 20 years. Under the revised Reactor Regulation Act, operators applying for such an extension are required to implement special inspections to assess whether their facilities meet or not the latest technical standards and properly maintain or not their operation from the viewpoints of any expected wear/tear and deterioration of facilities and equipment in the 20-year time period.

In the situation that the NRA has been tackling on the on-going serious conditions at Fukushima Daiichi Nuclear Power Station, the new regulatory requirements and regulations were developed with strict time constraints. Therefore, they will be necessary to be constantly reviewed with new findings and scientific technologies that are acknowledged in Japan and overseas with continuous efforts to enhance nuclear safety. Although restoring trust in Japan's nuclear safety regulations after the accident at Fukushima Daiichi Nuclear Power Station will be extremely difficult, "Safety Culture" in which safety is paramount should be fostered among operators, other industry sectors and the NRA. The NRA hopes that the new regulatory requirements and regulations will become both the guidepost and the foundation to improve "Safety Culture" in Japan.

Attachment:

New Regulatory Requirements for Light-Water Nuclear Power Plants – Outline –

New Regulatory Requirements for Light-Water Nuclear Power Plants – Outline –

August 2013

Nuclear Regulation Authority

Safety Regulation Problems before the Fukushima Daiichi Nuclear Accident

- Major safety regulation problems before the Fukushima Daiichi Nuclear Accident
  - ✓ Regulatory requirements did not cover ‘severe accidents’ and there were few preventive activities in place
  - ✓ No legal framework in place to retroactively apply new requirements to existing nuclear power plants, which hindered continuous safety improvements.

○ <u>Countermeasures against severe accidents including external events were left purely to the discretion of operators. (National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission (NAIIC))</u>

○ <u>No legal framework to retroactively apply new regulatory requirements to existing nuclear power plants (so-called “back-fitting” system). (NAIIC)</u>

○ Japanese regulators made little effort to either introduce the latest foreign technology or improve safety procedures dealing with uncertain risks. (NAIIC)

○ Comprehensive risk assessment covering not only earthquakes and tsunamis but also fires, volcanic eruptions, and slope failures that may trigger accidents, had not been conducted. (Investigation Committee on the Accident at the Fukushima Nuclear Power Stations of Tokyo Electric Power Company)

○ An integrated legal system is preferable to avoid confusion caused by multiple laws and the involvement of multiple government agencies. (NAIIC)

New Regulatory Requirements and Legal Amendments (Promulgated in June 2012)

- Based on lessons learned from Fukushima, laws were amended in June 2012,adding the environment in addition to the general public as major safety targets, expanding coverage to include severe accidents and introducing a provision that new requirements can be applied retroactively to existing nuclear facilities.
- Amendments shall be enforced within 10 months after the date on which the Nuclear Regulation Authority was established (by July 18, 2013).

○Addition to the objectives of the Act

- Assume large-scale natural disasters, terrorist attacks and other criminal acts will occur in the future.
- Protect the lives, health, and property of the public, preserve the environment and contribute to national security

○ New safety regulation emphasizing major accidents

- <u>Measures against severe accidents must be included in safety operations</u> and new regulations
- Require nuclear operators to conduct periodic and comprehensive safety assessments and file the results to the regulator and public to ensure continuous safety improvement.

○ Shift to a new regulatory system incorporating the latest knowledge is reflected even in existing nuclear facilities

- <u>Introduce a "back-fitting" system authorizing enforcement of the latest regulatory requirements on already licensed facilities</u>

○ Integration of nuclear safety regulations

- Integrate power plant safety regulations contained in the Electricity Business Act (periodic inspections) into the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (the Reactor Regulation Act)
- Delete provisions on the planned use of nuclear energy from objectives and permission criteria in the Reactor Regulation Act and clarify that nuclear safety is paramount.

Schedule for Preparing New Regulatory Requirements

- New Regulatory Requirements (NRA Ordinance) were discussed during preparatory work to enforce the Amended Act which become effective in July 2013.
- Discussions at the meetings were open and public comments were solicited twice.

Hearing from experts at the NRA Commission meetings

Open discussions at the Study Team on New Regulatory Requirements

Comparison with international standards

Hearing from the operators subject to the regulation

Compilation of draft outlines

Hearing from specialists

Solicitation of Public Comments (from Feb. 7 to Feb. 28, 2013)

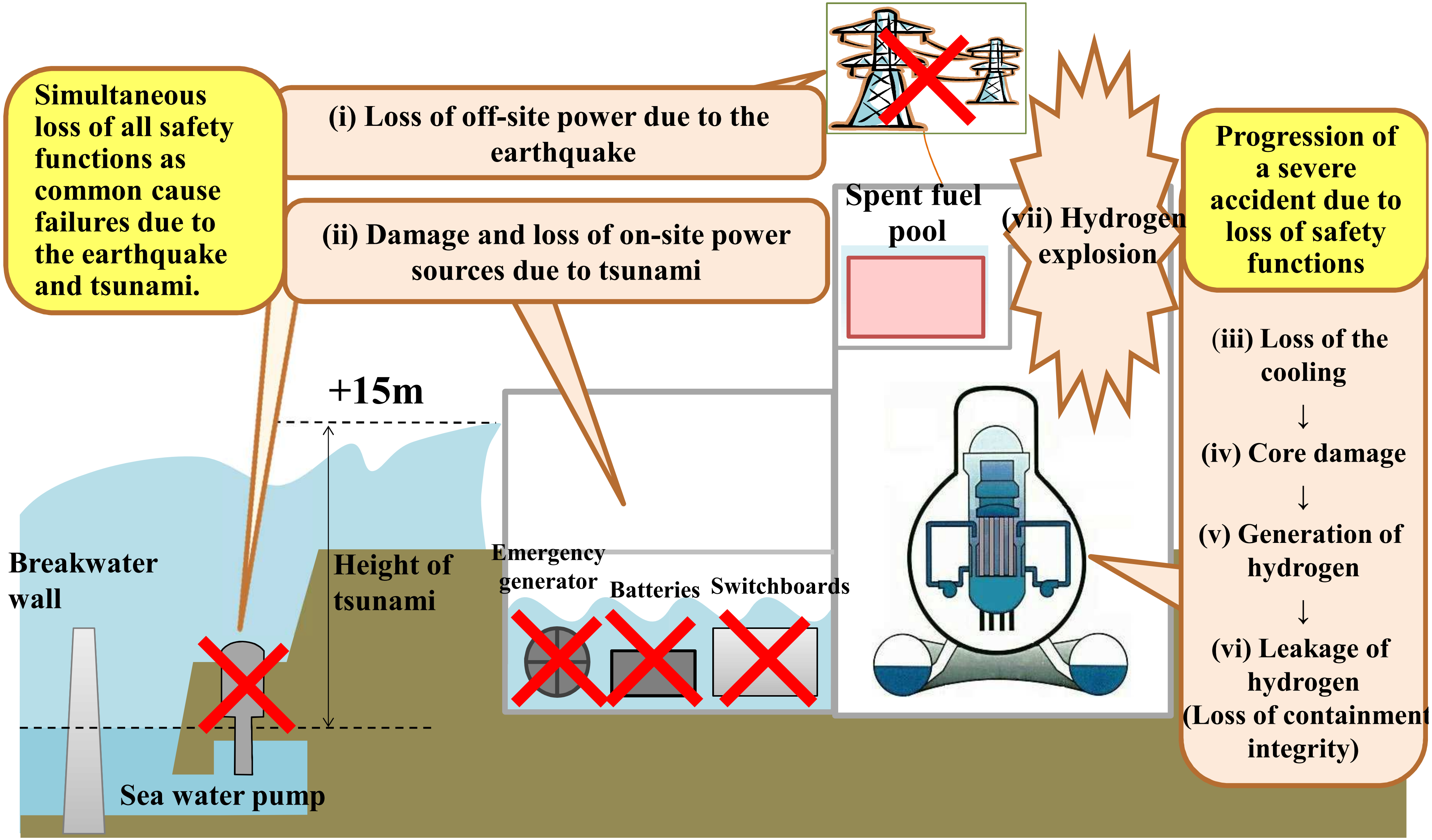
Preparation of the draft Ordinance

Solicitation of Public Comments (from Apr. 11 to May 10, 2013)

Enforcement (on July 8)

Lessons Learned from the Fukushima-Daiichi Nuclear Power Station Accident

- All safety functions were lost simultaneously due to the earthquake and tsunami.
- The initial impact spread and the crisis eventually developed into a 'severe accident.'



Basic Policies in Preparing New Requirements

- Based on the concept of defense in depth, the design basis for and, counter measures against, natural phenomena are significantly enhanced in order to prevent simultaneous loss of safety functions due to common causes.
- In addition, countermeasures against events other than natural phenomena such as fires, which may cause simultaneous loss of safety functions due to common causes, are also enhanced.

(i) Emphasis on Defense-in-Depth

Prepare multi-layered protective measures and, for achieve specific objectives in each layer independent of other layers

(ii) Significantly enhance design basis and strengthen protective measures against natural phenomena which may lead to common cause failure

Strict evaluation of earthquakes, tsunamis, volcanic eruptions, tornadoes and forest fires: countermeasures against tsunami inundation and due consideration to ensure diversity and independence

(iii) Enhance countermeasures against events other than natural phenomena that may trigger common cause failures

Strict and thorough measures for fire protection, countermeasures against internal flooding, reinforcement of power supply systems to prevent power failure

(iv) Performance-based requirements in regulatory requirements

Operators select concrete measures to comply with requirements and the characteristics of their facilities.

Basic Policies against Severe Accidents and Terrorism

- Require measures to prevent the spread of severe accidents.
- Measures against intentional aircraft crashes , as the Act requires postulation of terrorist attacks.

(i) Prepare multi-layered protective measures, including prevention of core damage, maintenance of containment integrity, controlled release by venting, and suppression of radioactive materials dispersion

(ii) Use mobile equipment as in the United States and enhance reliability by permanent equipment

(iii) Enhance protective measures in spent fuel pools

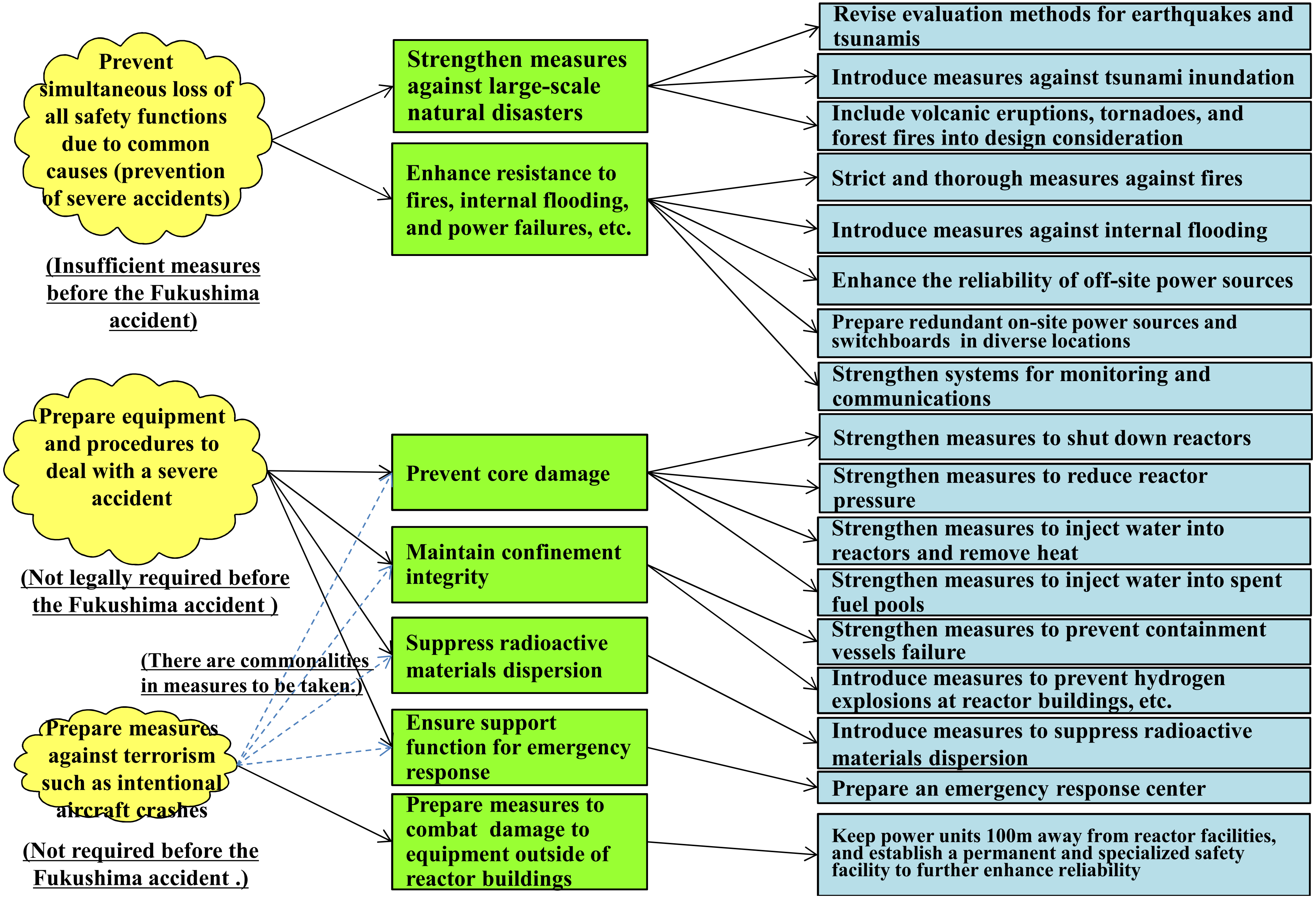
(iv) Improve command communication and instrumentation. Strengthen emergency response center , communication system, and instrumentation, facility systems including spent fuel pools

(v) Prepare procedure manuals, ensure the presence of essential personnel, and provide training to integrate equipment (hardware) and on-site work (software) functions

(vi) Disperse mobile equipment and connection points of them to combat intentional aircraft crashes, and introduce "a specialized safety facility" as a backup to enhance reliability

New Regulatory Policies and Major Requirements

➢ **Establish measures to prevent loss of safety functions due to common causes and spread of severe accidents**



Comparison between Previous and New Regulatory Requirements

➢ **The New Regulatory Requirements tighten measures to prevent or deal with severe accidents and acts of terrorism**

＜Previous Regulatory Requirements＞

Design basis to prevent severe accidents (Confirm that a single failure would not lead to core damage)

- Consideration of natural phenomena
- Fire protection
- Reliability of power supply
- Function of other SSCs*
- Seismic/tsunami resistance

* SSC: Structure, Systems and Components

＜New Regulatory Requirements＞

- Response to intentional aircraft crashes
- Measures to suppress radioactive materials dispersion
- Measures to prevent containment vessel failure
- Measures to prevent core damage (postulate multiple failures)
- Consideration of internal flooding (newly introduced)
- Consideration of natural phenomena in addition to earthquakes and tsunamis-- volcanic eruptions, tornadoes and forest fires
- Fire protection
- Reliability of power supply
- Function of other SSCs
- Seismic/tsunami resistance

Newly introduced (measures against terrorism)

Newly introduced (measures against severe accidents)

Reinforced or newly introduced

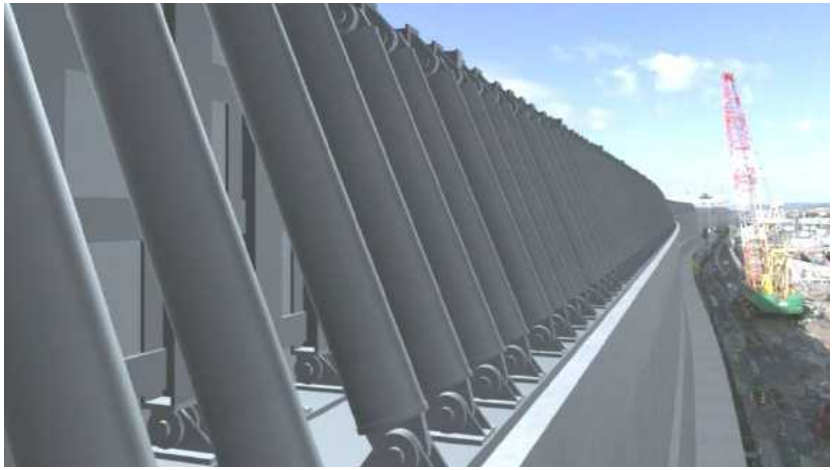
Reinforced

Significant Enhancement of Measures against Tsunamis

- The Standards define a "Design Basis Tsunami" as one which exceeds the largest ever recorded. The Standards require protective measures such as seawalls to combat such a phenomena.
- The Standards require SSCs for tsunami protective measures to be classified as Class S, the highest seismic safety classification applicable to RPV, to ensure that they continue to prevent inundations even during earthquakes.

＜Examples of multi-layered protective measures against tsunamis＞

○Installation of a seawall to prevent site inundation



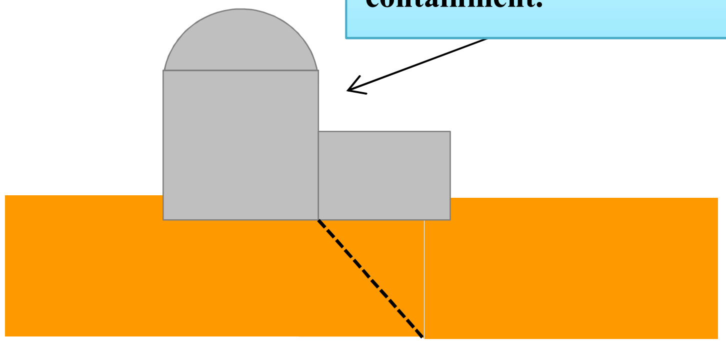
○Installation of water-tight doors to prevent the flooding of buildings

Clarification of the Standards concerning displacement and ground deformation in addition to those for seismic ground motion

- **The Standards require construction of S-class buildings and structures on ground surfaces without an outcrop(*) of a capable fault, etc. preventing a risk of fault displacement damaging the buildings and equipment therein.**

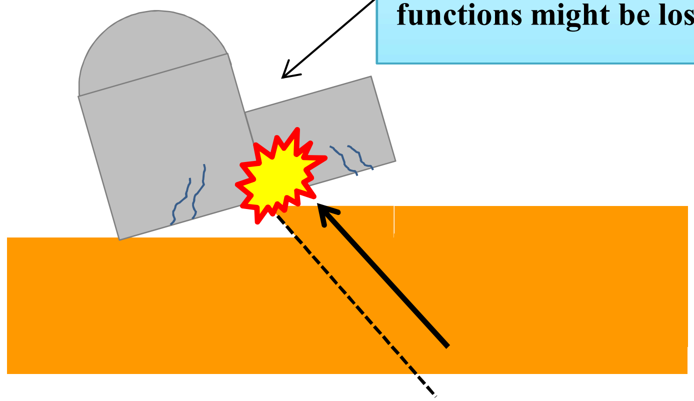
(*) An outcrop means a place where a fault (or other geological structure) is directly exposed without being covered by surface soil. Outcrops that appear as a result of excavation are included, as well.

Facilities that are important to safety with functions such as shutdown, cooling and containment.



Fault displacement or other movements

There is a risk that a reactor building and equipment inside are damaged and that their fundamental safety functions might be lost.



It is difficult to predict the level of displacement or deformation, or the ground upheaval.

Clarification of Standards for Determining Capable Faults

- **Faults with the potential to have activities in the future are recognized if activities after the late Pleistocene epoch (approx. 120,000 to 130,000 years ago or later) cannot be denied (Case 1).**
- **Fault activities are evaluated as far back as the middle Pleistocene epoch (approx. 400,000 years ago or more recently) if it is deemed necessary (Case 2).**

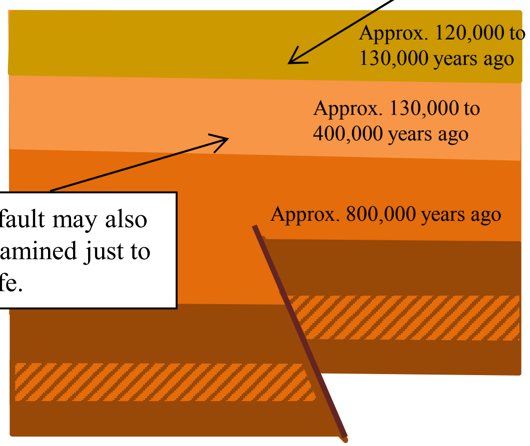
Case (1)

When there are geological layers or geomorphic surfaces of approx. 120,000 to 130,000 years old as clearly shown by evidence

If it is confirmed that the geological layers or geomorphic surfaces of approx. 120,000 to 130,000 years old show no displacement or deformation due to fault activities, the fault existing in lower layers can be judged unlikely to be capable.

In order to make the judgment clearer, it is important to check the lower geological layers or geomorphic surfaces of approx. 130,000 to 400,000 years old just to be safe to confirm that they show no displacement or deformation due to fault activities either.

When no displacement or deformation is observed, there is no possibility that the fault is capable.



This fault may also be examined just to be safe.

Approximately 120,000 to 130,000 years ago?

During this era, the climate was moderate and the sea level was higher than present. Marine terraces formed during this era are present all over Japan. Therefore, the geological layers of this era can be found relatively easily and are used as the indicator to judge fault activities.

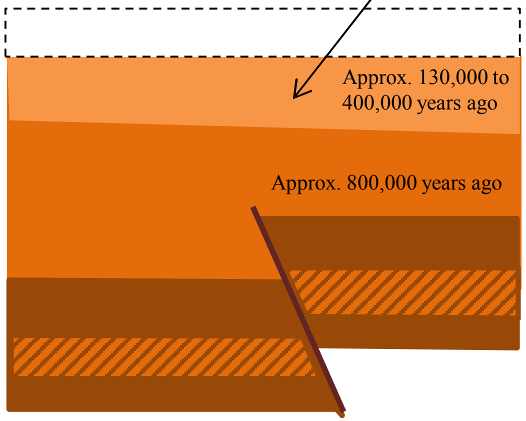
Case (2)

When there are no geological layers or geomorphic surfaces of approx. 120,000 to 130,000 years old, or when fault activities during this era cannot be clearly judged

If it is confirmed that there is no displacement or deformation due to fault activities by comprehensive considerations on geological formation, geological conditions, geological structures, stress field and other geological settings as far back as approximately 400,000 years ago, the fault existing in lower layers can be judged unlikely to be capable.

In this case, geological layers or geomorphic surfaces for the judgment may be in any period between approximately 130,000 and 400,000 years ago.

When no displacement or deformation is observed, there is no possibility the fault is capable.

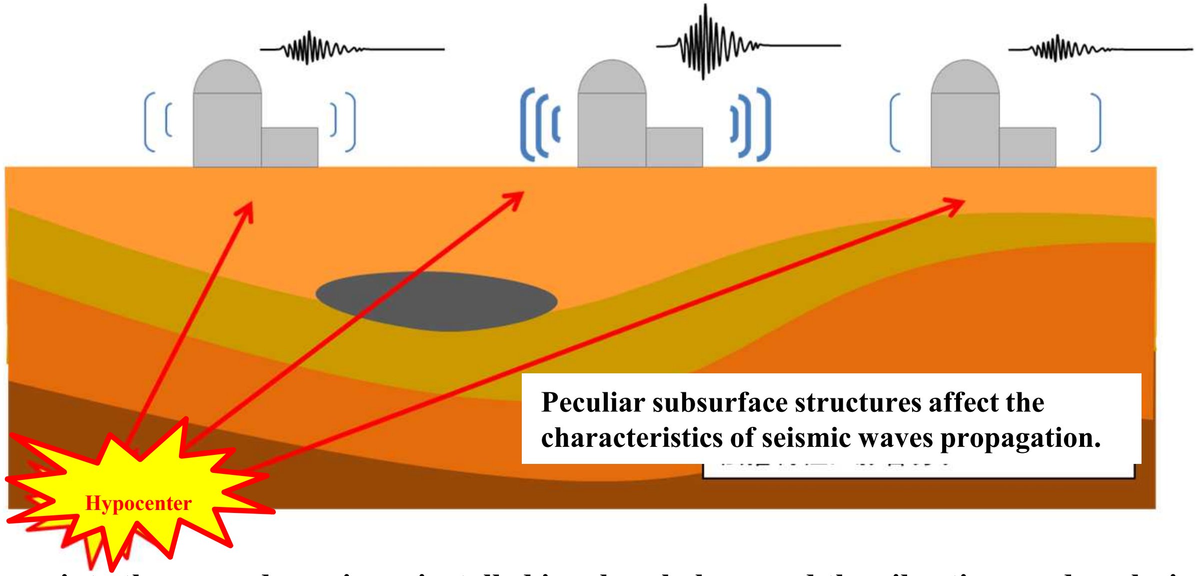


Approximately 400,000 years ago?

According to the long-term evaluation method for active faults (provisional version) compiled by the national government's Headquarters for Earthquake Research Promotion, almost the same crustal movements have been continuing in active faults from approximately 400,000 years ago to date and it is highly likely that the same movements will continue into the future as well.

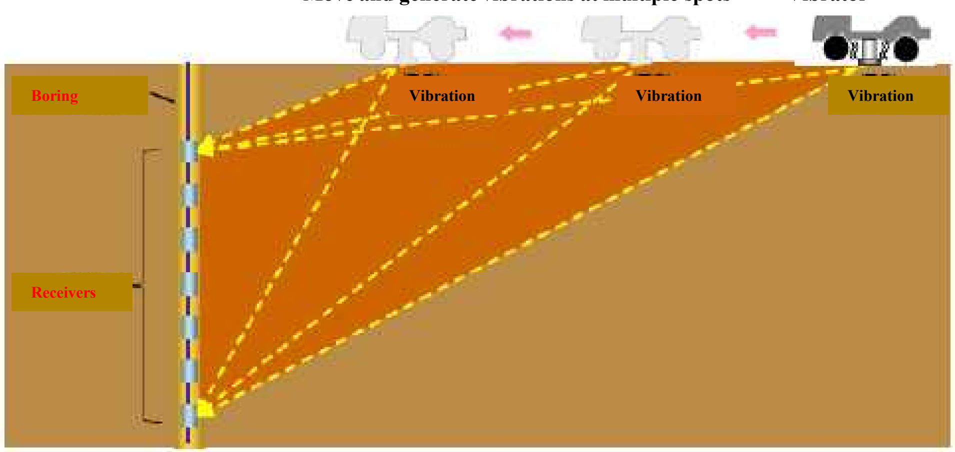
Determination of More Accurate Design Basis Seismic Ground Motions

➢ **Because seismic ground motions may be amplified due to the subsurface structures beneath NPS sites, the Standards require three-dimensional evaluations of the subsurface structure**



＜An example of a subsurface structure survey＞

As a vehicular vibrator generates waves into the ground, receivers installed in a borehole record the vibrations and analysis can plot the subsurface structure.

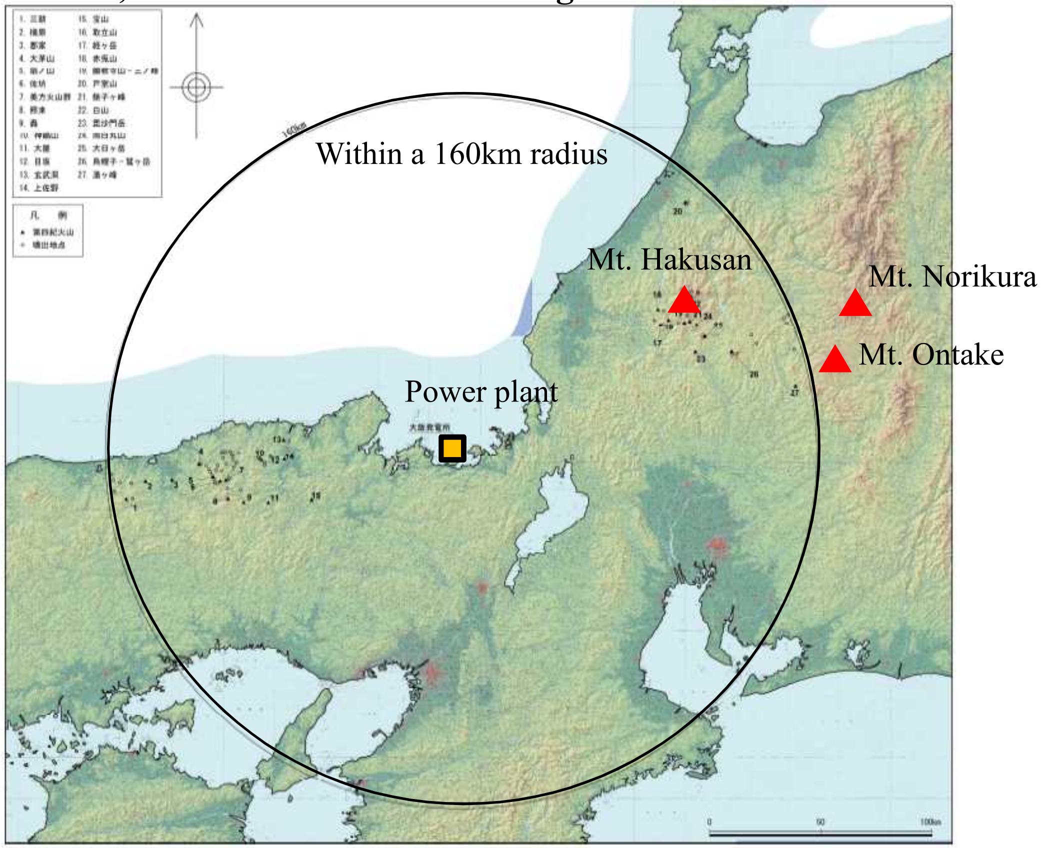


Vibrator

Expansion of the Design Considerations to other Natural Phenomena and Enhancement of Countermeasures against them

- **To prevent simultaneous loss of all safety functions due to a common cause, design basis and protective measures against volcanic eruptions, tornadoes and forest fires have been significantly enhanced.**

(An example of volcanic eruptions)
The standards require the survey of volcanoes within a 160km radius of nuclear power plants to assess the possibility and effect of pyroclastic flows and volcanic ashes reaching a facility. The standards require protective measures in advance, commensurate with the degree of hazard.



Measures to Prevent Common Cause Failures due to Events other than Natural Phenomena (1)

➢ **Significantly strengthen measures against power failure which may trigger simultaneous loss of all safety functions due to common causes other than natural phenomena**

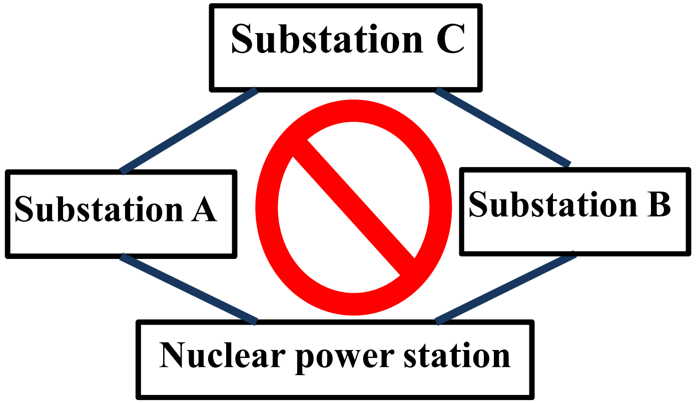
Comparison between the Pre-existing and New Regulatory Requirements for power sources

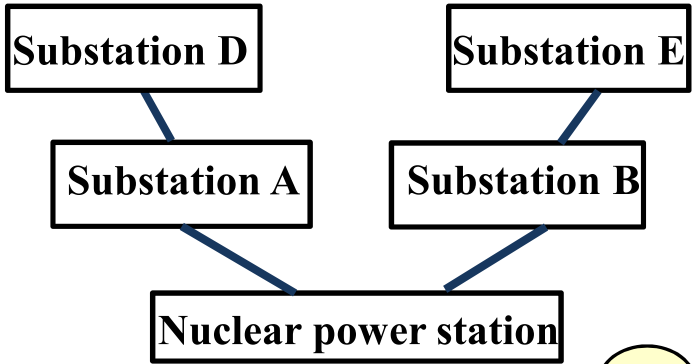
	Pre-existing Regulatory Requirements	New Regulatory Requirements
Off-site power	Two circuits (independence was not required)	Two circuits (independence is required)
On-site AC power source	Two permanently installed units (emergency diesel generators)	In addition to those set forth in the left column, another permanently installed unit and two more mobile units , and storage of fuel for seven days
On-site DC power source	One permanently installed system with a capacity for 30 minutes	Increase of the capacity of the system set forth in the left column to 24 hours duration and addition of one mobile system and one permanently installed system, both with 24 hours duration

*Additionally, require that switchboards and other equipment will not lose their operational capabilities because of common causes

Place mobile units on a hill (mobile AC power source)

Reinforcement of off-site power systems (connect to two or more substations located in different places through two or more transmission lines)

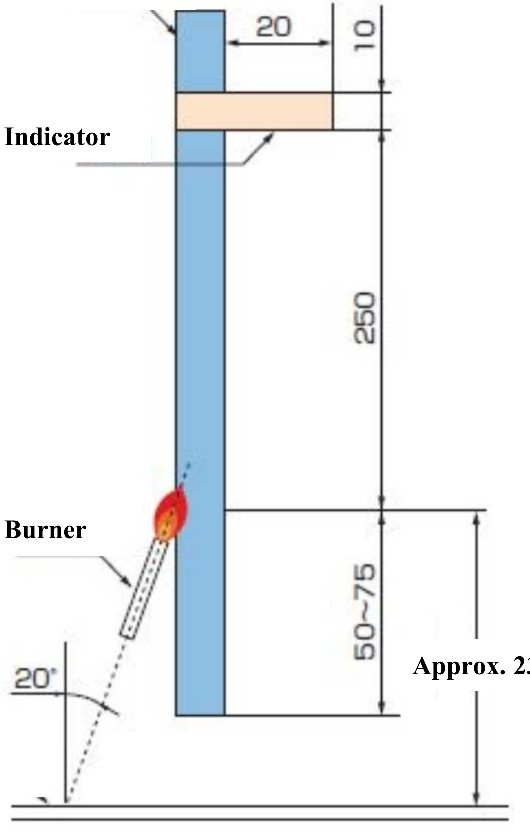




Measures to Prevent Common Cause Failures due to Events other than Natural Phenomena (2)

- Strengthen measures for fire protection and internal flooding as events other than natural phenomena which trigger simultaneous loss of all safety functions due to common causes

(Example of measures for fire protection)
Require the use non-combustible materials for cables installed in SSCs with safety functions and whose non-combustibility are confirmed by verification tests



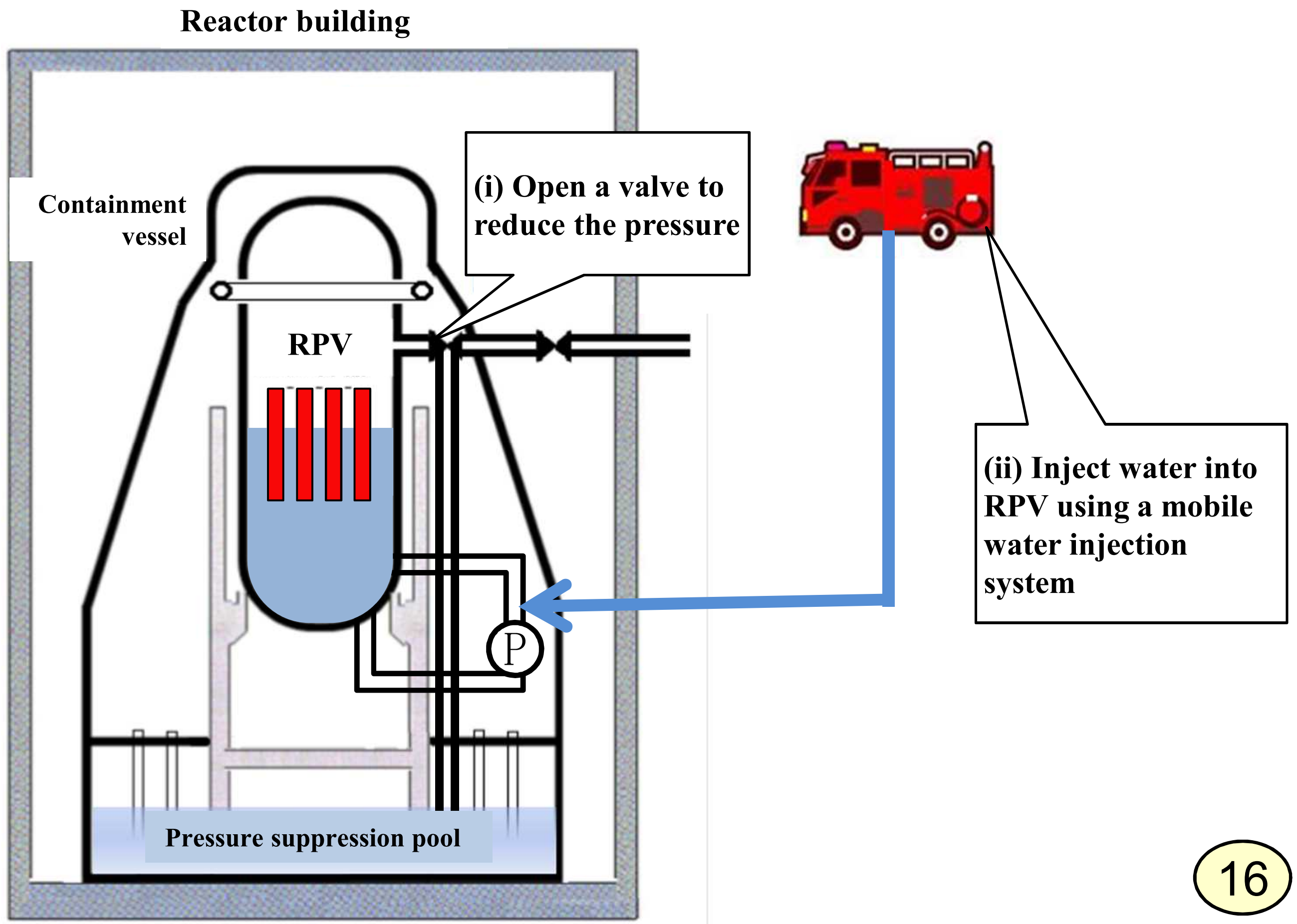
Example of verification test for self-extinguishing performance (UL vertical flame test)

Measures to Prevent Core Damage

- **Require measures to prevent core damage even in the event of loss of safety functions due to common cause**

(Example 1) In the event of power failure, open a safety-relief valve by using mobile power sources to reduce the pressure inside the RPV until water can be injected using a mobile water injection system or other devices (BWR)

(Example 2) After reducing the pressure inside the RPV, inject water into the RPV using a mobile water injection system

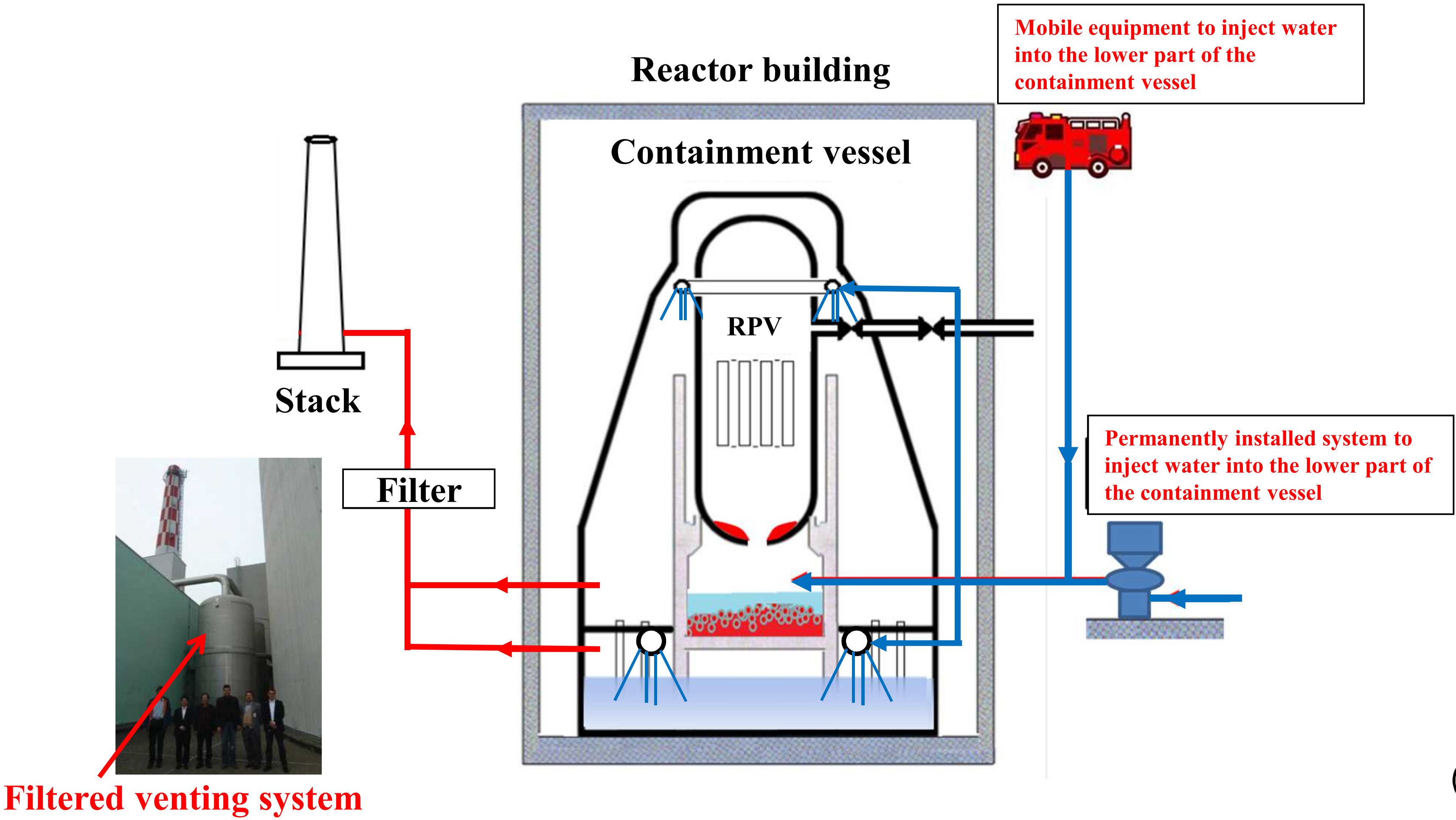


Measures to Prevent Containment Vessel Failure

- **Require measures to prevent containment vessel failure in the event of core damage**

(Example 1) Install a filtered venting system to reduce the pressure and temperature inside the containment vessel and to reduce radioactive materials while exhausting (BWR)

(Example 2) Prepare a system (mobile pumps, hoses, etc.) to inject water into the lower part of the containment vessel to cool down the core to prevent containment vessel failure due to a molten core



Measures to Suppress Radioactive Materials Dispersion outside the Facility

- **Require measures to suppress radioactive materials dispersion in the event of containment vessel failure**

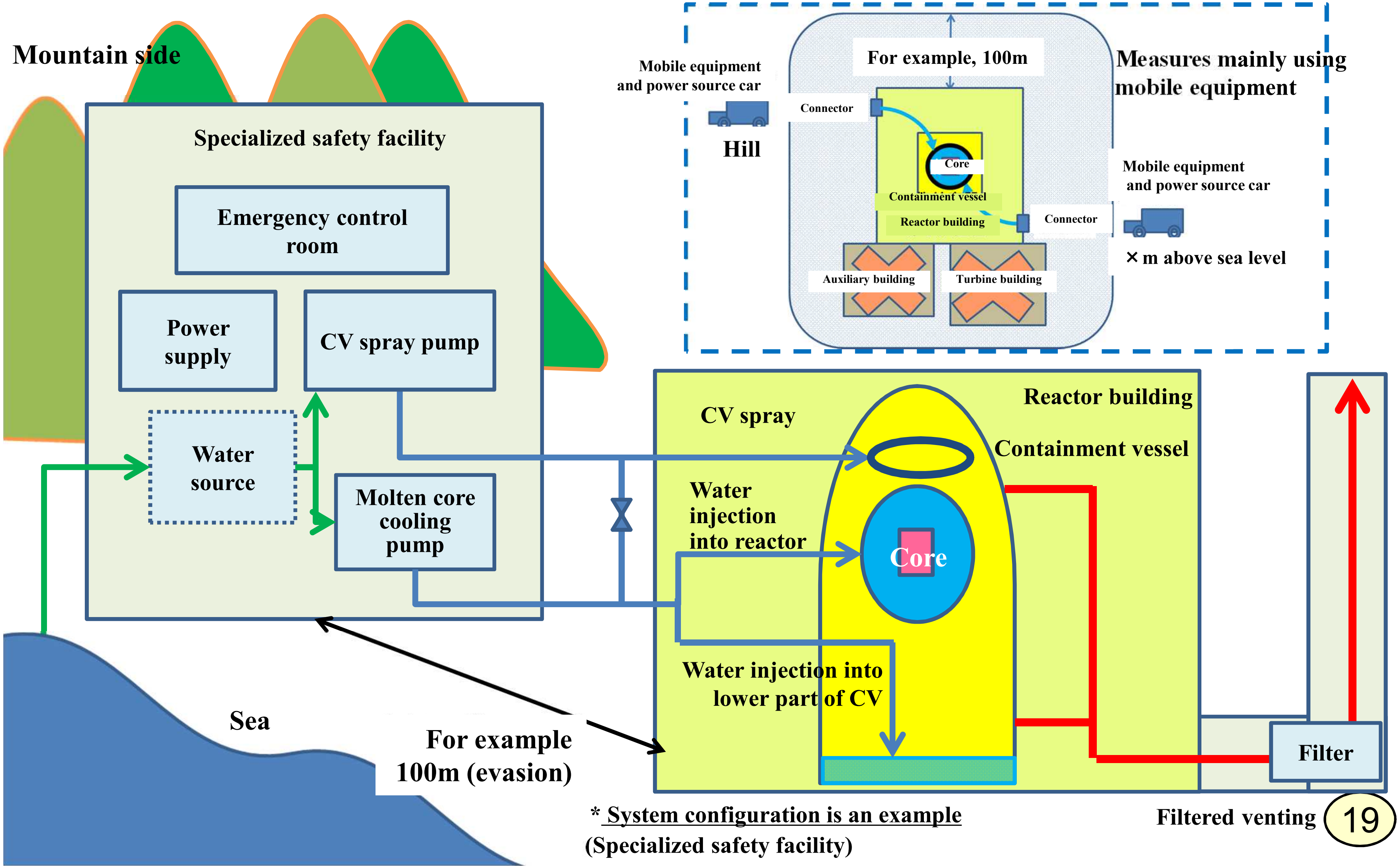
Deployment of outdoor water spray Equipment to douse the reactor building and prevent a Plume of radioactive materials contaminating the atmosphere

water-spraying training with a large scale bubble water cannon system

Photo: from the FY2011 White Paper on Fire and Disaster Management
http://www.fdma.go.jp/html/hakusho/h23/h23/html/2-1-3b-3_2.html

Measures against Intentional Aircraft Crashes, etc

- Measures against intentional aircraft crashes using mainly mobile equipment located at multiple sites as well as the installation of permanent backup facilities designated as "specialized safety facility"



* System configuration is an example (Specialized safety facility)

Timeline for the enforcement of the New Regulatory Requirements

- All necessary equipment and procedures required based on the lessons learned from Fukushima-Daiichi accident must be ready when the New Regulatory Requirements go into force in July 2013.
- The requirements on backup facilities aimed to improve reliability shall be conformed within five years.

	All necessary functions must be prepared by July 2013, when new regulations are enforced.	Back-up facilities improving reliability will be ready within a five year period
Reinforced activities to prevent severe accidents	・Stricter assessment of earthquakes and tsunamis ・Measures against tsunamis (seawalls) ・Measures for fire protection ・Preparation and placement of redundant power source systems in diverse locations	
Newly introduced functions to respond to severe accidents *Including measures against intentional aircraft crashes and other terrorist attacks	・Prevention of core damage (equipment and procedures for reducing pressure and injecting water) ・Confinement function of CVs (filtered venting for BWR, etc.) ・Emergency response center ・Deployment of mobile power units and water injection pumps at least 100m away from reactor building	・Backup facilities - Permanent power units and water injection pumps at least 100m away from reactor building and installation of a permanent emergency control room therefor (a specialized safety facility) - Permanent DC power source (the third system)

Schedule for the Enforcement of the Amended Reactor Regulation Act

- **The revised Reactor Regulation Act shall be effective on July 8, 2013.**
- **After the New Regulatory Requirements come into effect, the NRA will start reviews of applications submitted by electric utilities.**

June 19
The New Regulatory Requirements were determined

June 21
Cabinet decision on enforcement date

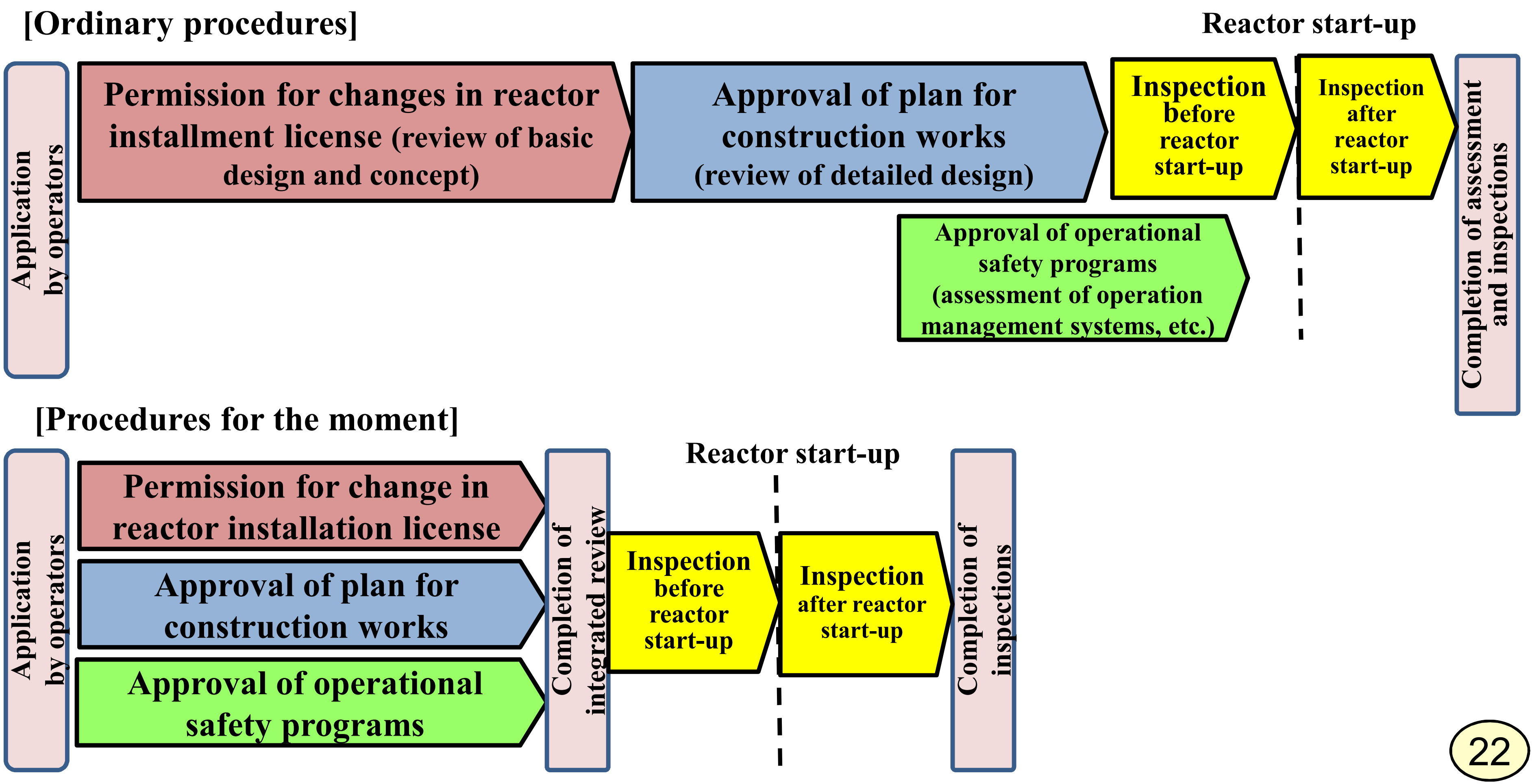
July 8
The Amended Reactor Regulation Act is enforced
(start to apply New Regulatory Requirements)

July 18
Legal deadline for enforcing the amended Act

Begin reviews on conformity to the New Regulatory Requirements upon receiving application by electric utilities

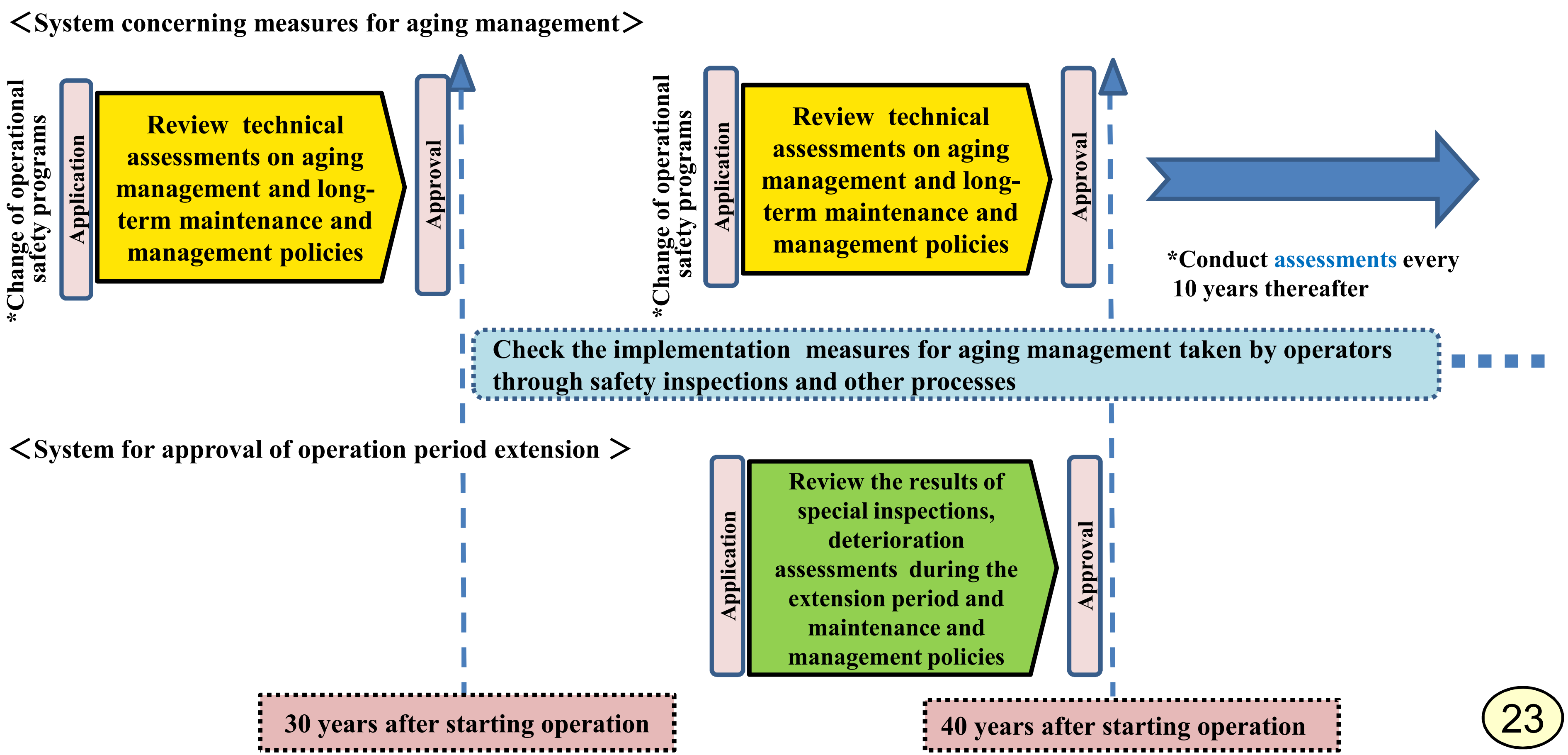
Outline on Reviews and Inspections process once the New Regulatory Requirements come into force

- Ordinarily, applications reviews for a "reactor installment license", "plan for construction works" and "operational safety programs" are conducted sequentially.
- Henceforth, applications for all three will be filed simultaneously by operators and their reviews will proceed in parallel so that the effectiveness of both hardware and software can be reviewed in an integrated manner.



Measures for Aging management and Approval of Operational Extension Periods

- **Measures for aging management:** A system under which, every 10 years, reactors that have been operating for more than 30 years are required to conduct aging assessments of SSCs and to establish long-term maintenance and management policies, which are subject to an approval of operational safety programs
- **Approval of operational extension period:** A system under which operational periods of power reactors are limited to 40 operational years. Operators may extend the life of the reactor one more time if they receive approval before its normal expiration date. The extension period will be decided on an individual basis extension but shall not exceed 20 years



Approval of Operational Extension Periods

- Criteria for approving operational extension periods are that the facilities conform to the latest technical standards and maintain that condition during the extension period, while factoring in expected deterioration
- When filing an extension application operators are required to conduct the following, after which the NRA will decide the facility's readiness

(i) Special inspection on deterioration-related events
(ii) Technical assessment on the expected deterioration during an extension period
(iii) Establishment of maintenance and management policies for the extension period

<Basic concept concerning special inspections>

Detailed inspection particularly of items which earlier inspections excluded or only partially examined, excluding those to be dealt with in ordinary maintenance activities

<Example of equipment and its portion subject to special inspection (Examples of PWR)>

Equipment to be inspected	Portion to be inspected and its current inspection methods	Special inspection
Reactor vessel	Ultrasonic Test (UT) only to weld	Ultrasonic Test (UT) of base metal and weld (100% of core region)
Reactor containment vessel (steel liner)	Leakage rate test	Visual inspection of coating condition
Concrete structures	Visual inspection and non-destructive inspection	Check the strength, neutralization, chloride penetration, etc. with collected core samples

Safety Goals

- **The now-defunct Nuclear Safety Commission did not make final decision on safety goals that is aimed to achieve through regulation, different from other foreign countries.**
- **The NRA held discussions and finally agreed on the safety goals in April 2013.**

(i) The discussions were based on the results of the deliberation(*) by the Special Committee on Safety Goals of the now-defunct Nuclear Safety Commission.

* Core damage frequency: approximately 10^{-4}/year
Containment failure frequency: approximately 10^{-5}/year ,etc.

(ii) Incorporating the impact of environmental contamination by radioactive materials, **the frequency of an accident that causes discharging Cs-137 over 100TBq should be reduced to not exceed one in a million reactor years** (excluding accidents by terrorist attacks, etc.)

(iii) Safety goals should be **applied to all power reactors without exception**.

(iv) Safety goals are paramount **in the NRA's administration of nuclear regulations**

(v) The NRA is dedicated to continuous discussions on strengthening safety goals **in the nuclear industry**.