Special Issue

Handbook on Nuclear Power

Basic Information about Radiation and Nuclear Power

Ibaraki Prefecture

2022 Edition

Introduction

This handbook provides basic information about radiation and nuclear power as well as measures for nuclear safety and nuclear disaster prevention in an easy-to-understand manner.

The handbook is intended to help citizens of Ibaraki Prefecture to deepen their understanding of radiation and nuclear power and take actions based on accurate information in the event of a nuclear emergency.

Table of Contents

*Abbreviations in this handbook

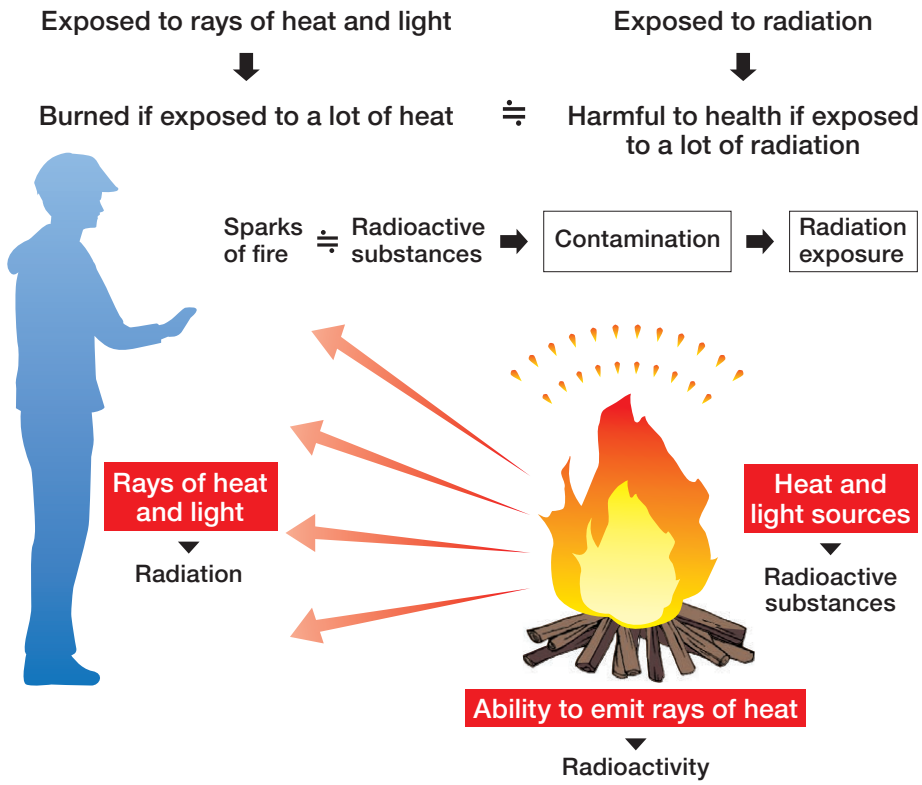
NRDA: National Research and Development Agency
IURIC: Inter-University Research Institute Corporation
NUC: National University Corporation
PIIA: Public Interest Incorporated Association
PIIF: Public Interest Incorporated Foundation
IAA: Independent Administrative Agency

What Is Radiation?

Radiation is the flux of particles with high energy levels. These particles are emitted from radioactive substances and travel in the same way as light.

Radiation has high energy levels and is very similar to light in terms of its properties, but it is not visible to the naked eye. If you were to be hit with radiation, you would not feel anything. However, radiation passes through substances and damages the DNA (genes) in your body. The specific properties of radiation differ by the type of radiation (See page 4).

Difference between radiation and radioactive substances: If compared to a bonfire



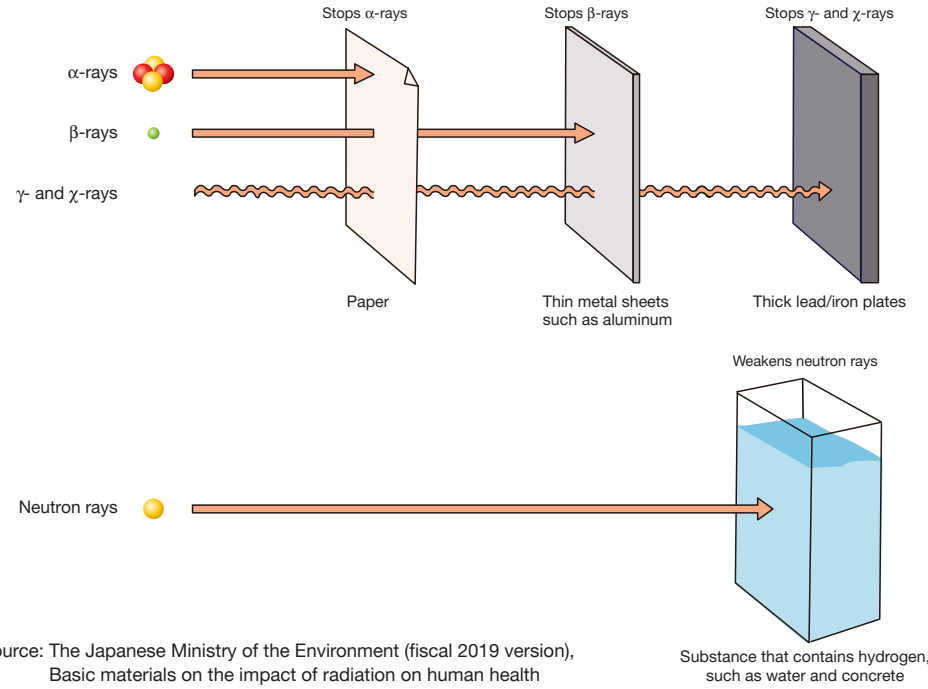
Types and Characteristics of Radiation

There are various types of radiation, all of which can penetrate materials but the penetration power differs by type.

There are several types of radiation: alpha (α)-rays, beta (β)-rays and gamma (γ)-rays[1] as well as neutron rays composed of free neutrons.

The radiation that has been posing problems after the nuclear accident at the Fukushima Daiichi Nuclear Power Station is mostly gamma (γ) radiation emitted from radioactive cesium[2].

Types of Radiation and Their Penetration Power



Source: The Japanese Ministry of the Environment (fiscal 2019 version), Basic materials on the impact of radiation on human health

Types of Radiation and Their Penetration Power

Type	Essence	Penetration power
Alpha (α)-rays	Particle composed of two protons and two neutrons (Helium nucleus)	Very small. Stopped by a sheet of paper or the stratum corneum (outermost layer of epidermis). Can travel only about 4 cm after being released into the air.
Beta (β)-rays	Electron	Small. Stopped by an aluminum or plastic sheet with a thickness of several millimeters and 1 cm, respectively. Can travel about 5 m after being released into the air.
Gamma (γ)-rays X (χ)-rays	Electromagnetic wave (Photon)	Large. Stopped by lead, iron and other high-density substances.
Neutron (η)-rays	Neutron	Very large and can penetrate even iron and lead. Stopped by thick concrete or water and other substances that have a high hydrogen content.

Note 1: The strength of radiation depends on the energy of each traveling particle and on how many particles are traveling.
Note 2: Cesium is an element discovered by two German chemists. The atomic number is 55, and the element symbol is Cs.

What Are Radioactive Substances?

Substances that emit radiation.

Radioactive substances are substances that exist in nature. They are contained in radon and radium in hot springs as well as in animals and plants[3]. There are also artificial radioactive substances generated due to past nuclear tests.

Because radioactive substances have unstable nuclei[4], they decay at a certain rate, emitting radiation. The ability to emit radiation is called **radioactivity**.

Many radioactive substances emit radiation and change into other substances that will not emit radiation, so their radioactivity will decrease with the passage of time.

Typical Radioactive Substances

Natural substances:	Uranium-238, Radium-226, Radon-222, Potassium-40, Carbon-14, etc.
Artificial substances:	Cesium-137, Iodine-131, Strontium-90, Plutonium-239, etc.

Physical Half-life

The time required for an amount of a radioactive substance to decrease by half is called the half-life.
The physical half-life refers to the length of time required for the radioactivity to reduce to half its initial value.

Physical Half-life by Nuclide (Examples)

Nuclide	Half-life
Radon-222	3.8 days
Iodine-131	8.0 days
Cobalt-60	5.3 years
Tritium	12.3 years
Strontium-90	28.8 years
Cesium-134	2.1 years
Cesium-137	30.1 years
Radium-226	1,600 years

Nuclide	Half-life
Plutonium-239	24,000 years
Uranium-238	4.5 billion years
Potassium-40	1.25 billion years
Carbon-14	5,700 years
Rubidium-87	49.2 billion years
Lead-210	22.2 years
Poronium-210	138.4 days

Source: *Radioisotope Pocket Data Book* 11th Edition (2011), Japan Radioisotope Association

Note 3: For example, potassium-40 enters the body through food.
Note 4: The nucleus is in the center of an atom and is composed of protons and neutrons. The nucleus “decays” by changing into a different type of nucleus.

Becquerel: Unit of Radioactivity

The becquerel is a unit used to measure the rate of decay of radiation-emitting radioactive substances within a certain period.

In other words, the becquerel (Bq) is used to indicate the radioactivity[5] of a radioactive substance. According to the scientific definition, in a radioactive substance measuring one becquerel, the average rate of decay of unstable nuclei is one per second. While the becquerel is not strictly a unit of measurement of the amount of a radioactive substance, because radioactivity is proportional to the amount, the becquerel is used to indicate the amount of a radioactive substance. The term becquerel is more frequently used in conjunction with another unit than by itself.

For example, for food and water, the becquerel is used with the unit of the kilogram (Bq/kg) to show the amount of a radioactive substance contained in one kilogram of food or water (See page 19).

Example) 100 Bq/kg of radioactive cesium in food
→100 becquerels of radioactive cesium contained in one kilogram of food

Unit of Radiation and Radioactivity

0.001 sieverts (Sv) = 1 millisievert (mSv) = 1,000 microsieverts (μSv)

	Unit	Symbol	Explanation
Unit for radiation	Gray	Gy	The amount of radiation energy absorbed by a substance/human body exposed to radiation is measured in grays (Gy).
	Sievert	Sv	The level of impact of radiation on the human body is measured in sieverts (Sv).
Unit of radioactivity (ability of a radioactive substance to emit radiation)	Becquerel	Bq	This unit shows how many nuclei decay per second.

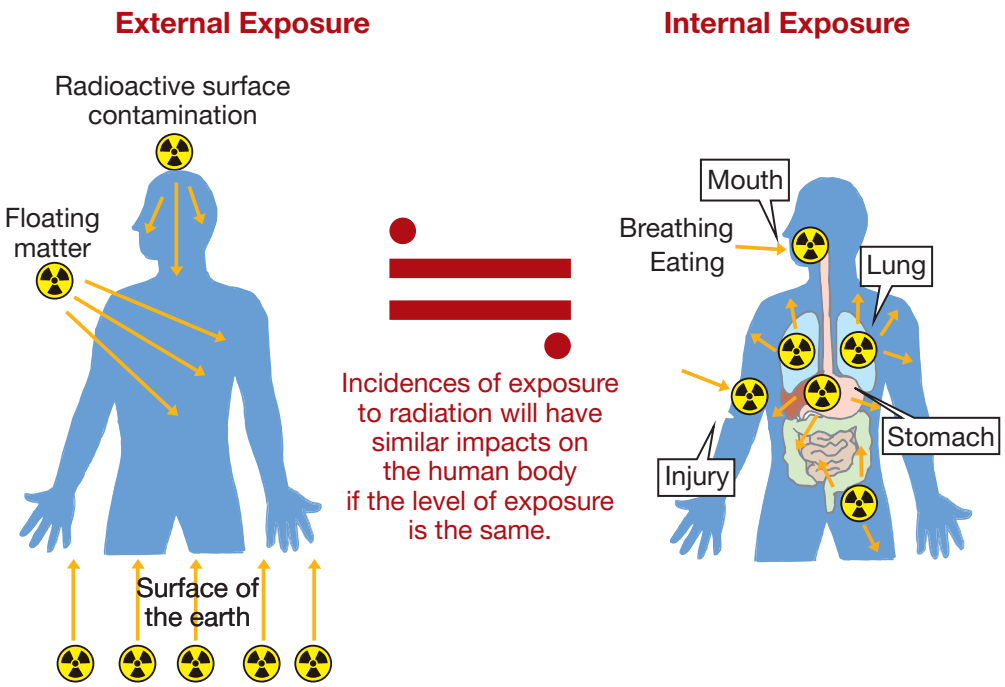
Note 5: It could be measured also in weight or in volume, but is measured in the becquerel by focusing on the rate of decay caused by the emission of radiation.

Sievert: Unit Used to Indicate the Level of Radiation Exposure

The sievert is a unit used to indicate the level of damage that could be sustained by human beings due to exposure to radiation.

In other words, the sievert (Sv) is a unit used to indicate how radiation impacts human beings exposed to it. It could be interpreted that the damage that was (or might have been) sustained by the exposed person is proportional to the level of exposure to radiation that is indicated numerically using the unit of the sievert, which is used for both external and internal exposures.

Regardless of the cause of exposure, if the number indicated in sieverts is the same, the damage inflicted to the human body is considered to be equal[6].



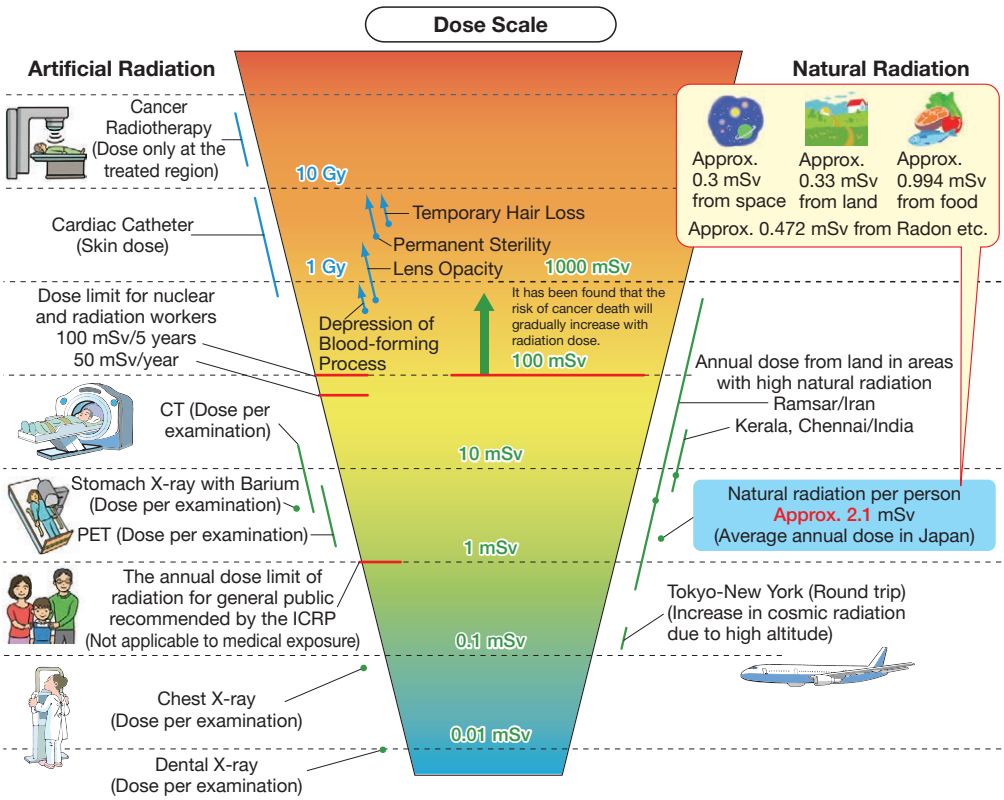
Note 6: Strictly speaking, the sievert is used as a unit for each of the four different dose categories: “equivalent dose” and “1 cm dose equivalent” used for human tissue; and “effective dose” and “committed effective dose” used for the full body, but the damage-based idea is applied commonly to all of the categories.

Radiation and Health

The upper radiation exposure limit of one millisievert/year (1 mSv/year) set for the general public does not represent a numerical border between safety and danger.

As shown in the following figure, there are two types of radiation: artificial radiation used for medical treatment, and natural radiation from the earth and space. In a normal environment with no nuclear accidents, the upper annual radiation exposure limit is set at 1 mSv, excluding exposure to medical and natural radiation. However, this limit of 1 mSv, which was set by the International Commission on Radiological Protection (ICRP)[7], does not represent a numerical border between safety and danger. Rather, it indicates a social norm (**rough standard**).

Radiation Exposure in Living Environment[8]



Source: Created by the National Institute of Radiological Sciences, NRDA National Institutes for Quantum and Radiological Science and Technology based on: *Dose Scale* posted on its website; UNSCEAR 2008 Report; ICRP 2007 recommendations; medical exposure guidelines of the Japan Association of Radiological Technologists; and on the document on environmental radiation created by the Nuclear Safety Research Association (Created May 2013; Revised May 2018) <Natural Radiation> Source: United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) Report 2008 and the report made by the Nuclear Safety Research Association on Japanese population dose from natural radiation (third edition, 2020)

Note 7: The International Commission on Radiological Protection (ICRP) makes recommendations for radiological protection from the standpoint of an expert. Although it is not a public organization, the recommendations made by the ICRP are referred to as de facto international standards and provide the foundation for radiation-related criteria and laws also in Japan.

Note 8: For the units of measurement of radiation dose, refer to page 6.

What's the Amount and Duration of Radiation Exposure that Affects the Body?

For the exposure dose of 100 mSv or more, it has been revealed that the risk of cancer death gradually increases in accordance with an increase in the dose[9].

The effects of radiation on the human body are divided into "somatic effects" and "genetic effects," and somatic effects are divided into **"acute effects"** (appearance of symptoms a few days after exposure) and **"late effects"** (onset of a disease several years to several decades after exposure). Genetic effects refer to the impacts given to the offspring of a person exposed to radiation. The causal relationship between radiation and genetic effects on the human body has not yet been proven in a specific manner (though relevant research has progressed).

Relationship between the Level of Exposure and Impact on Health

The impact on human health is categorized into acute effects and late effects according to the timing of impairment, and these effects have the following features.

Acute effects

Symptoms appear a few days to a few months after exposure to radiation.

1. Symptoms will not appear unless the level of exposure reaches a certain threshold.

1,000 mSv or more

Temporary hair loss, skin disorders

2. Fatal level of exposure (if without any medical treatment)

Roughly 4,000 mSv (full body)

Half of all people with this exposure dose will die within several months after the exposure.

Late effects

Onset of a disease (such as cancer or cataracts) a long time after being exposed to radiation.

1. It is revealed that the carcinogenic rate increases according to the level of exposure in a group of people who were exposed to a level exceeding several hundred millisieverts.

2. It is clarified that for a level of exposure that exceeds 100 mSv, the cancer death risk gradually increases as the exposure dose rises.

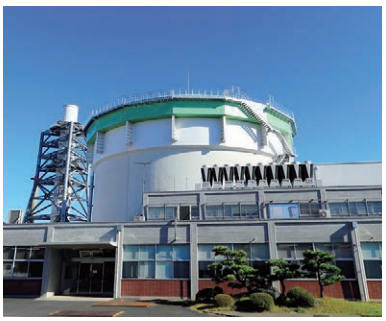
3. It is revealed that being exposed to a lower level of radiation for a longer period will have a smaller impact on your health than being exposed to the same level within a short period.

Note 9: If all members of a group of people whose average lifetime cancer death rate is about 30% are exposed to extra radiation of 10 mSv and 100 mSv, the death rate will increase to 30.05% and 30.5%, respectively.

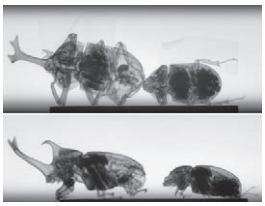
Applications of Radiation and Nuclear Power Promoted in Ibaraki Prefecture

Ibaraki Prefecture is home to important R&D centers aimed at promoting the use of radiation and nuclear power in a variety of fields, such as medical treatment, agriculture, and industry.

Field of Nuclear Energy



JRR-3



Neutron radiographic image of beetles

Tokai Nuclear Science Research Institute (Tokai Village)

NRDA Japan Atomic Energy Agency

This institute conducts R&D to promote base technologies and safety for nuclear energy and to use quantum beams from research reactors and accelerators for a range of applications in relation to elementary particles, substances, and materials.

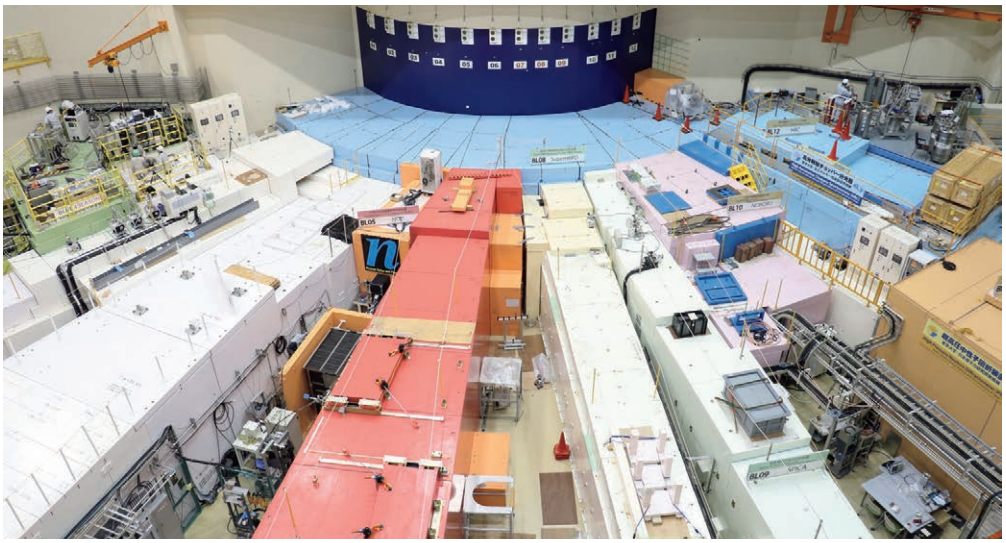
High Temperature Engineering Test Reactor (HTTR)

Oarai Research and Development Institute (Oarai Town)

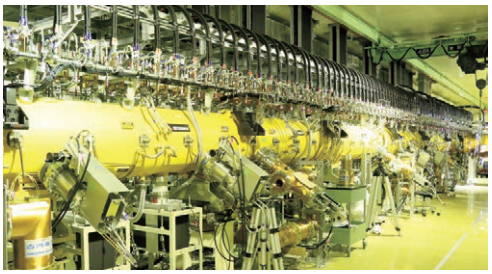
NRDA Japan Atomic Energy Agency

Based on its long experience and development technologies for new types of reactors, this center utilizes the different types of test reactors and related research facilities to conduct R&D for high-temperature gas-cooled reactors and technologies to use the heat supplied from the reactors; for fast reactor cycle technologies; and for higher safety of light water reactors.

Field of Advanced Science



Materials and Life Science Experimental Facility



Linac

Japan Proton Accelerator Research Complex (J-PARC) (Tokai Village)

NRDA Japan Atomic Energy Agency/ IURIC High Energy Accelerator Research Organization

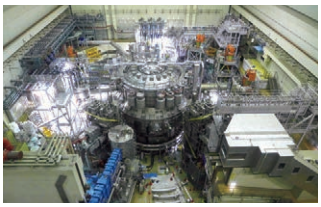
This international institute conducts advanced research in a variety of fields by using proton accelerators with the world's top-level beam intensity.

IURIC High Energy Accelerator Research Organization (KEK) (Tsukuba City)

This institute uses electrons and X-rays to research the origins of space and the sources of matter and life.

Field of Nuclear Fusion

JT-60 experiment building



JT-60SA superconducting tokamak experiment equipment

Naka Fusion Institute (Naka City)

NRDA National Institutes for Quantum Science and Technology

This institute comprehensively conducts R&D into nuclear fusion for the practical use of energy generated from nuclear fusion[1]. (Image shared by: QST)

Field of Medical Treatment

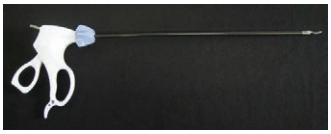
Proton Medical Use Research Center

Proton Medical Research Center (Tsukuba City)

NUC University of Tsukuba Hospital

Proton therapy is a new radioactive therapy for cancer, and only a few university hospitals in Japan have proton therapy facilities. The center is also equipped with a facility necessary for Boron Neutron Capture Therapy (BNCT), a next-generation cancer therapy, and is pressing forward with clinical research for the therapy.

Tokai Center of Japan Irradiation Service Co., Ltd.



Surgical forceps

Vacuum blood-collecting tubes

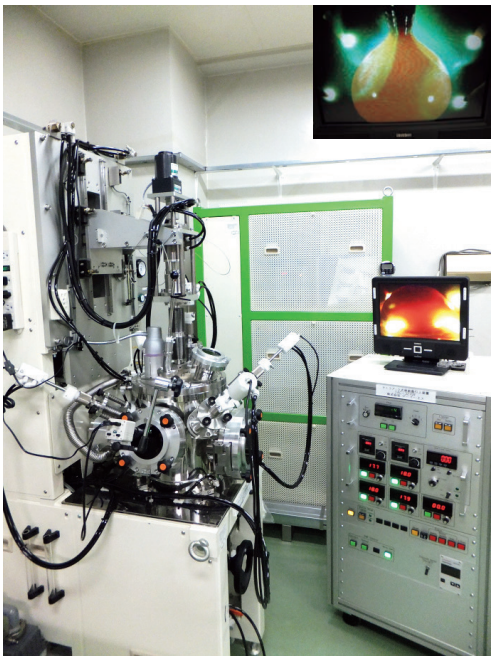
Tokai Center (Tokai Village)

Japan Irradiation Service Co., Ltd.

The company sterilizes unused medical equipment and containers by way of irradiation.

Note 1: The nuclei of elements with a small mass, such as hydrogen, heavy hydrogen, and tritium, collide and change into the nuclei of helium and others, thereby producing enormous amounts of energy. This nuclear fusion is the source of solar energy.

Field of Basic Research and Education



Tetra arc furnace

Advanced materials analysis equipment

International Research Center for Nuclear Materials Science (Oarai Town)

Institute for Materials Research, NUC Tohoku University

This institute hosts guest researchers and engages in human resources development as a nationwide open center for research into advanced nuclear materials and the creation of new substances based on the use of actinide elements and others.

Field of Agriculture

©National Agriculture and Food Research Organization

Gold Nijisseiki pears

Institute of Radiation Breeding (Hitachiomiya City)

Institute of Crop Science NRDA National Agriculture and Food Research Organization

By irradiating seeds, the division induces mutations at a higher frequency than would occur naturally with an eye to developing new crop strains.

Map of Major Nuclear Power Research, Utilization and Learning Facilities in Ibaraki Prefecture

Nuclear power research/ utilization facilities

1. Nuclear Science Research Institute, NRDA Japan Atomic Energy Agency
2. Oarai Research and Development Institute, NRDA Japan Atomic Energy Agency
3. Japan Proton Accelerator Research Complex (J-PARC), NRDA Japan Atomic Energy Agency/IURIC High Energy Accelerator Research Organization
4. IURIC High Energy Accelerator Research Organization (KEK)
5. Naka Fusion Institute, Fusion Energy Directorate, NRDA National Institutes for Quantum Science and Technology
6. Proton Beam Medical Research Center, NUC University of Tsukuba Hospital
7. Tokai Center, Japan Irradiation Service Co., Ltd.
8. International Research Center for Nuclear Materials Science, Institute for Materials Research, NUC Tohoku University
9. Radiation Breeding Division, Institute of Crop Science, NRDA National Agriculture and Food Research Organization

Learning facilities

10. Ibaraki Science Museum of Atomic Energy, PIIA Ibaraki Atomic Energy Council
11. Tokai Visitor Center, The Japan Atomic Power Company
12. Oarai Wakuwaku Science Museum, NRDA Japan Atomic Energy Agency
13. Tsukuba Expo Center, PIIF Tsukuba Expo '85 Memorial Foundation

The Accident at the Fukushima Daiichi Nuclear Power Station

The Fukushima Daiichi Nuclear Power Station belonging to Tokyo Electric Power Holdings, all station blackout occurred due to the strong vibrations and tsunami caused by the Great East Japan Earthquake.

As a result of losing the most important function such as cooling the nuclear reactors, the fuel rods of Units 1 to 3 melted, causing hydrogen explosions and the release of radioactive substances into the environment.

Outline of the Accident

Occurrence of the earthquake (with the seismic intensity of upper 6)

- The reactors in operation stopped automatically.
- External power was lost due to the collapse of the power transmission towers and others.

Tsunami (with the run-up height of 14 to 15 m)

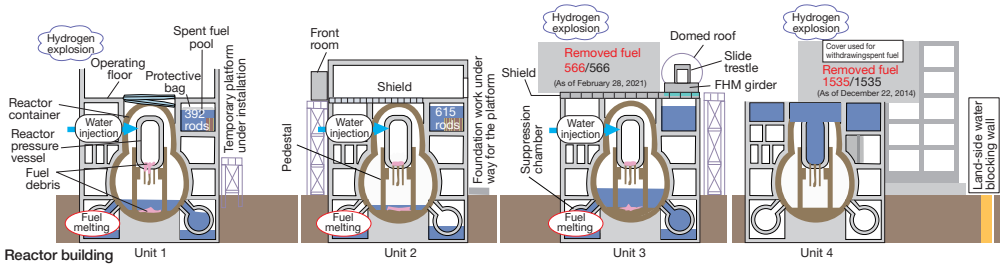
- Although the emergency diesel power generator was activated, the generator and the switchboard were flooded by the tsunami.

Complete loss of power

- The loss of the reactor cooling function caused the melting of the nuclear fuel, and the delay of the vent operation[Note] caused hydrogen explosions, which damaged the reactor buildings and others.

Note: Operation that releases the reactor container pressure into the atmosphere

Present Situation of the Major Reactors Damaged by the Accident



	Unit 1	Unit 2	Unit 3	Unit 4
When the earthquake occurred	In operation			Suspended for regular inspection
Damage to the buildings, etc.	Mar. 12, 2011 Damaged due to hydrogen explosion (estimated)	Unclear of the damage caused to the pressure suppression chamber, etc.	Mar. 14, 2011 Damaged due to hydrogen explosion (estimated)	Mar. 15, 2011 Damaged due to hydrogen explosion (estimated)
Status of the core	Core meltdown		Feb. 28, 2021 Completion of the removal of fuel from the spent fuel pool	Dec. 22, 2014 Completion of the removal of fuel from the spent fuel pool
Cooling of the core	Being cooled by the circulation-type water injection cooling equipment			
Temperature at the bottom of the reactor pressure vessel (As of Dec. 21, 2022)	17.1°C–18.3°C	26.2°C–27.4°C	21.4°C–21.6°C	—
Date of decommission	April 19, 2012	April 19, 2012	April 19, 2012	April 19, 2012

(References) Materials prepared for the 109th round meeting on decommissioning and the treatment of contaminated water held on Dec. 22, 2022 by the team in charge and the secretariat, Agency for Natural Resources and Energy
Progress status report (outline report) on the Mid-and-long-term Roadmap toward the Decommissioning of Fukushima Daiichi Nuclear Power Station Units 1-4 made by Tokyo Electric Power Holdings, Incorporated
Parameters related to the plants at Fukushima Daiichi Nuclear Power Station

Enhancement of Regulatory Standards for Nuclear Power Plants

In order to ensure the safety of nuclear power plants, the national government has set new regulatory standards and checks for conformity to the new standards.

The new regulatory standards set by the national government(the Nuclear Regulation Authority) are stricter than the old standards regarding the provisions to prevent severe accidents and newly include standards to measure against a severe accident or terrorism.
Major provisions newly added or enhanced in the new regulatory standards are as follows:

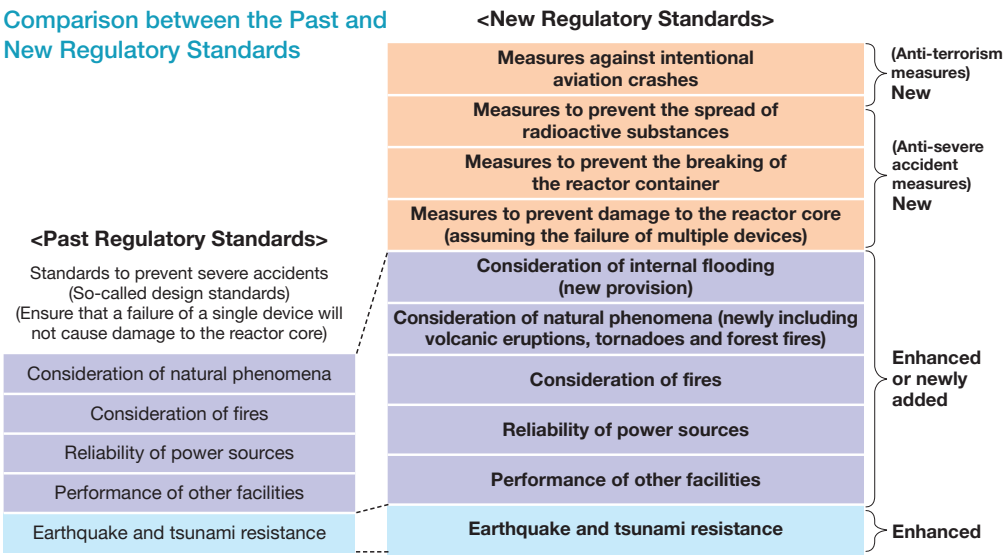
<Anti-severe Accident Measures>

- Establishment of an emergency response facility equipped with a seismic isolation function
- Deployment of a power supply vehicle, mobile large-capacity pump vehicle, and others to cool the reactors in case of an accident
- Measures against terrorism, such as airplane crashes

<Revision of the Design Standards>

- Prohibition of the installation of a reactor building on an active fault
- Assumption of the largest-scale tsunami as a benchmark
- Safety measures against earthquakes, tsunamis, volcanic eruptions and forest fires

Comparison between the Past and New Regulatory Standards



Source: *New Regulatory Requirements for Light-Water Nuclear Power Plants* announced by the Nuclear Regulation Authority (Updated in February 2016)

Nuclear safety policy of Ibaraki

Although the nuclear safety regulations are governed by the national government from a legal point of view, the prefecture itself also has safety policies to protect the communities and the environment.

【Nuclear Safety Agreement】

Ibaraki prefectural government, the municipalities with nuclear facilities, and the neighboring municipalities have the nuclear safety agreement, called Agreement for ensuring the safety and the environment preservation of the areas surrounding nuclear facilities, with the operators of nuclear facilities in Tokai and Oarai (17 facilities as of April 1st 2022).

Based on the agreement, the prefectural government monitors the operating status of the facilities.

<Main contents of the Nuclear Safety Agreement>

- The operators of the nuclear facilities must give top priority to ensuring the safety of the neighboring communities.
- The operators of nuclear facilities need to obtain approval from the prefectural government and the host municipalities before planning to establish new facilities, extending existing facilities, and decommissioning their facilities.
- The prefectural government and host municipalities can directly (without national government intervention) demand that the operators of the facilities implement necessary safety measures such as suspending the operation and improving operation methods and equipment.
- The operators of the nuclear facilities must not exceed the allowable limits of radioactive concentration in exhaust air and wastewater as well as the amount of release regulated by the prefectural government.
- The prefecture government, the host municipalities, and the neighboring municipalities can carry out on-site inspections any time.

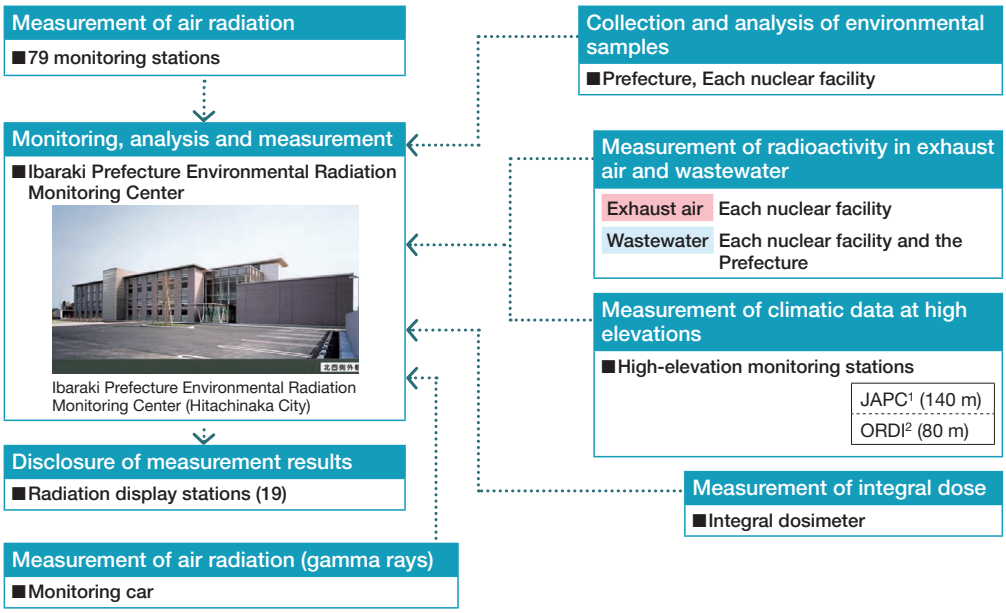
Under What System Is the Prefecture Monitoring Radiation?

In order to check the impact of radiation and radioactivity, there are 79 monitoring stations in Ibaraki. These stations are on 24-hour alert for abnormalities in the surrounding environment.

<Major measurement and monitoring activities>

- Collect and analyze environmental samples such as rainwater, airborne dust, soil, vegetables, milk, seawater and fish.
- Measure the radioactivity of the exhaust air and wastewater released from the nuclear facilities.
- Collect climatic data at high elevations.(80 to 140 meters above the ground.)
- Measure radiation across the Prefecture by a monitoring car.
- Measure the accumulated dose(Total amount of radiation during a certain period.) at about 90 locations in the Prefecture.
- Measure the air dose rate 24 hours a day at 79 radiation monitoring stations across the Prefecture.
- Conduct monitoring, measurement and analysis at the Ibaraki Prefecture Environmental Radiation Monitoring Center.
- Disclose the measurement results in real time at 19 display stations in the Prefecture and on the Internet.

Measurement and Monitoring System Implemented in Normal Times



Note 1: The Japan Atomic Power Co.,Ltd
Note 2: Oarai Research and Development Institute, Japan Atomic Energy Agency

Confirmation of the Safety Standard Values for Food

The safety standard value for radioactive substances in food that we regularly consume: 100 becquerels/kg

Standard values of radioactive materials in food is at a level where one can safely continue to eat them forever. These safety standard values are categorized in 4 food groups: (general food, infant food, milk, and drinking water).
The standard value of general food is the value (1 millisievert of additional radioactive material from food per year) that is internationally considered safe regardless of age and sex, while also taking individual eating habits into consideration. These values are as follows.

Standards Set for Radioactive Cesium

Food category	Standard value (Unit: becquerels/kg)
General food	100
Food for infants	50
Milk	50
Drinking water	10

Standard values for food for infants and milk

Giving consideration to children who may be highly sensitive to radiation, the standard values are set at 50 becquerels/kg for food for infants and milk, which is half the value set for general food.

Standard value for drinking water

Everyone drinks water, for which there is no substitute. Accordingly, the standard value is set at 10 becquerels/kg, in reference to the standards published by the World Health Organization (WHO).

Limits on the intake of food and drink

If any food or drink is revealed as a result of emergency environmental monitoring to be radioactively contaminated at a level higher than the threshold, limits will be imposed on the intake of the food or drink by residents and its shipment will be banned.

Are Agricultural Products and Seafood Produced in Ibaraki Prefecture Safe?

Agricultural products and seafood produced in Ibaraki Prefecture are tested for their radioactive safety based on the method indicated by the national government so that products that meet the radioactive safety standards will be distributed to consumers.

Ibaraki prefectural goverment conducts 1,500 inspections per year. Aside from some wild vegetables, mushrooms, fish and shellfish, most of them are drastically below the designated standard value and are checked for their level of safety.

You can check the latest information about the radioactive safety of local agricultural products and seafood, including the test results and limits on shipments at the following website of the Prefecture:

"Information about the monitoring results of agricultural products and seafood produced in Ibaraki Prefecture" (Website where you can search for test results)
http://www.ibaraki-rdtest.jp/

Number of Agricultural and Marine Products Tested for Radioactive Substances

	No. of items	No. of samples	Major items
Grains 	10	4,399	Rice (brown rice), wheat varieties, unpolished buckwheat, peanuts, soybeans, etc.
Vegetables 	51	1,783	Spinaches, parsleys, green onions, *mizuna* leaves, tomatoes, strawberries, sweet potatoes, etc.
Fruits 	12	282	Plums, pears, blueberries, grapes, apples, chestnuts, etc.
Special forest products	79	3,774	Mushrooms, wild mushrooms, bamboo shoots, Ostrich ferns, etc.
Livestock products 	6	245,622	Raw milk, beef (including beef tested for mad cow disease), pork, eggs, and horsemeat
Seafood 	194	20,822	Young sardines, anchovies, flatfish, *yamatoshijimi* clams, *ayu* fish, etc.
Tea	3	372	Fresh tea leaves, crude tea, drinking tea
Processed agricultural products	1	44	Dried sweet potatoes
Processed marine products	20	33	Dried young sardines, dried Japanese pond smelts, steamed octopuses, etc.
Total	376	277,131	

(March 18, 2011 to November 30, 2022)

What about disaster prevention measures in case of accidents?①

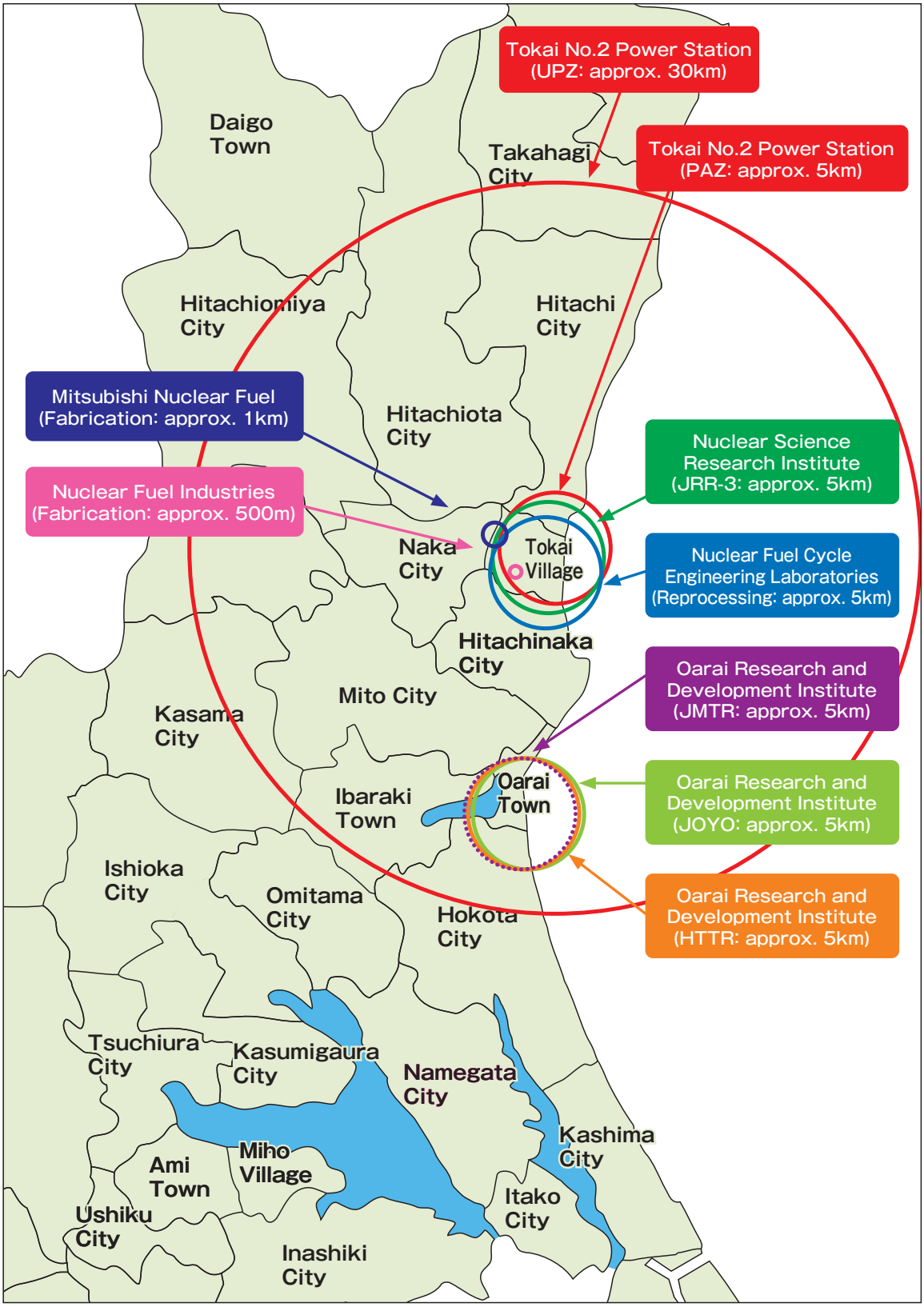
In the event of the worst case scenario, measures including the “Regional Evacuation Planning” and the “Indoor Sheltering and Evacuation Guidance Planning” continue to be developed.

Every nuclear facility continues to develop plans for regional zones where nuclear-power disaster countermeasures will be implemented in a prioritized manner.(off-site emergency zones)

Area	Facility location	Off-site emergency zones		
		Nuclear facilities	Emergency zones and area sizes	Host and related municipalities
Tokai/Naka Area	The Japan Atomic Power Co.,Ltd Tokai No.2 Power Station	Nuclear power reactor facility	(PAZ) about 5km (UPZ) about 30km	Tokai Village Mito City Hitachi City Hitachiota City Takahagi City Kasama City Hitachinaka City Hitachiomiya City Naka City Hokota City Ibaraki Town Oarai Town Shirosato Town Daigo Town
	Japan Atomic Energy Agency Nuclear Science Research Institute	Research and test reactor facility(JRR-3)	(UPZ) about 5km	Tokai Village Hitachi City Hitachinaka City
	Japan Atomic Energy Agency Nuclear Fuel Cycle Engineering Laboratories	Reprocessing facility	(UPZ) about 5km	Tokai Village Hitachi City Hitachinaka City
	Nuclear Fuel Industries,Ltd. Tokai Works	Fabrication facility	(UPZ) about 500m	Tokai Village
	Mitsubishi Nuclear Fuel Co.,Ltd.	Fabrication facility	(UPZ) about 1km	Tokai Village Naka City
Oarai/Hokota Area	Japan Atomic Energy Agency Oarai Research and Development Institute	Research and test reactor facility(HTTR) Research and test reactor facility(JOYO) Research and test reactor facility(JMTR)	(UPZ) about 5km	Oarai Town Hokota City Mito City Ibaraki Town

Off-site emergency zones of the Nuclear Power Station	Division	Area
	PAZ (Precautionary Action Zone)	about 5km
	UPZ (Urgent Protective Action Planning Zone)	about 5~30km

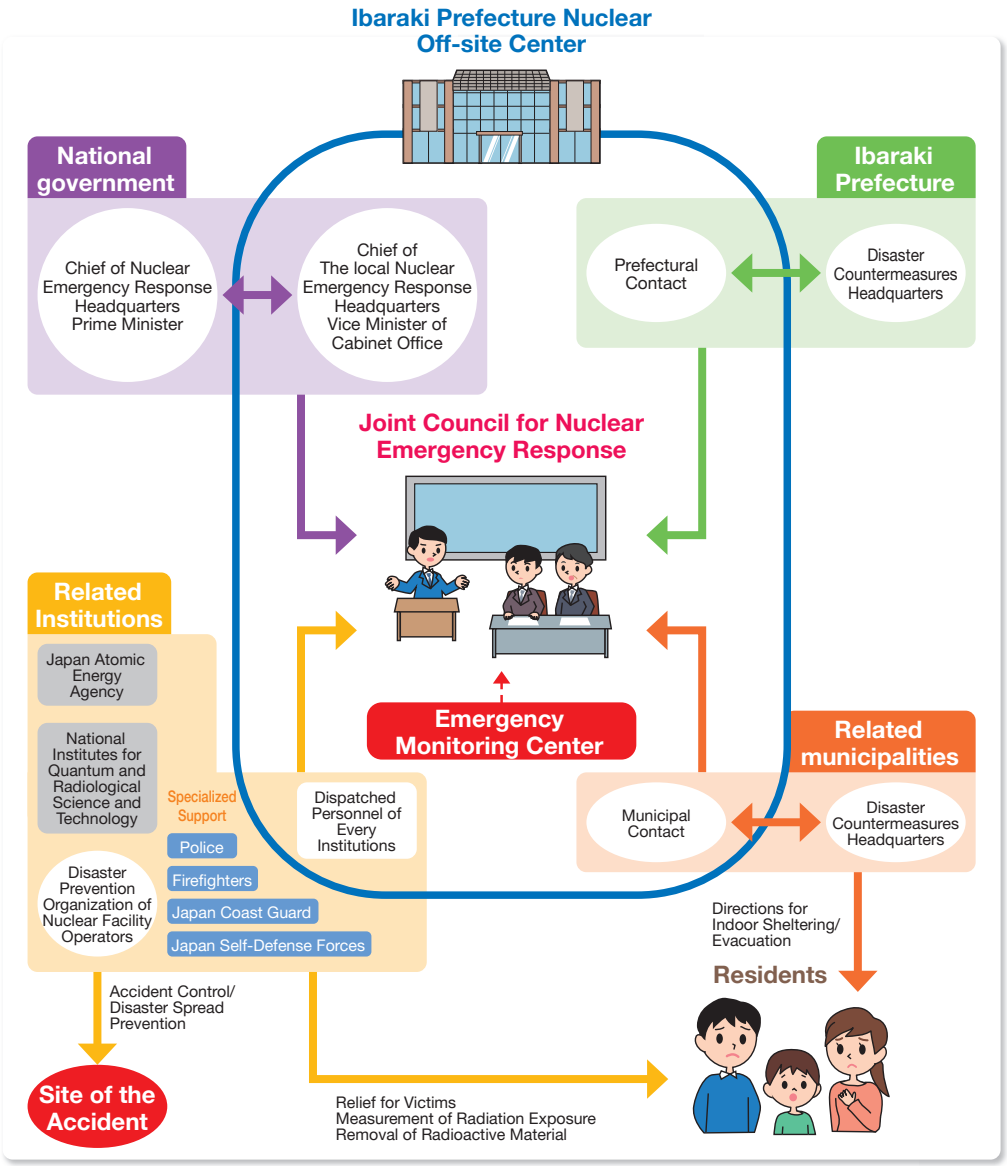
Area of off-site emergency zone



What about disaster prevention measures in case of accidents?②

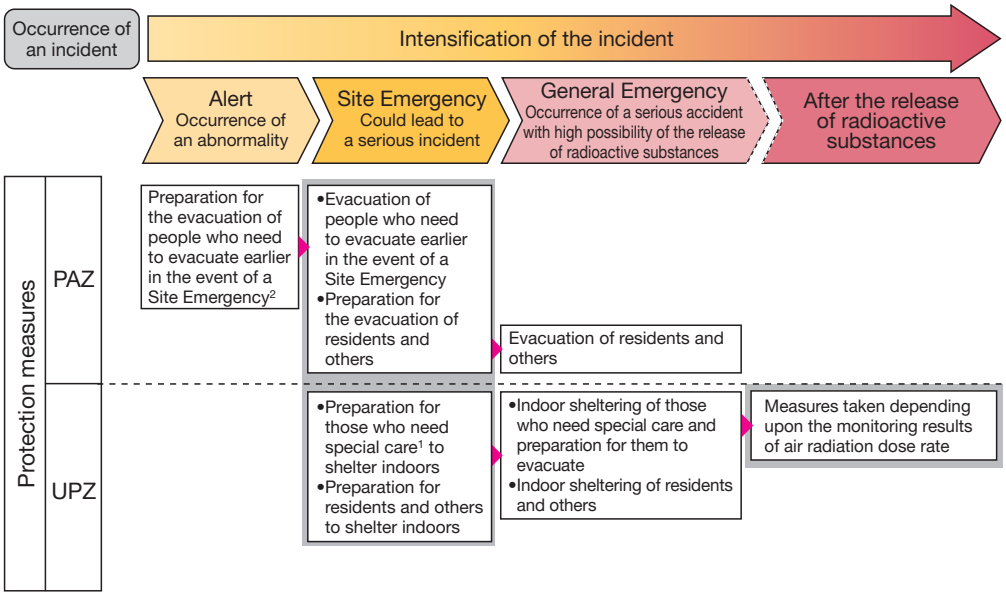
In the event of the worst case scenario, the national government, prefectural government, municipal governments and related institutions will establish a disaster prevention structure, collect information and broadcast it to residents.

In order to share information between related parties, to consolidate intentions, and to implement emergency countermeasures in a quick and accurate manner, the national government and municipal governments are organized in the “Joint Council for Nuclear Emergency Response”.

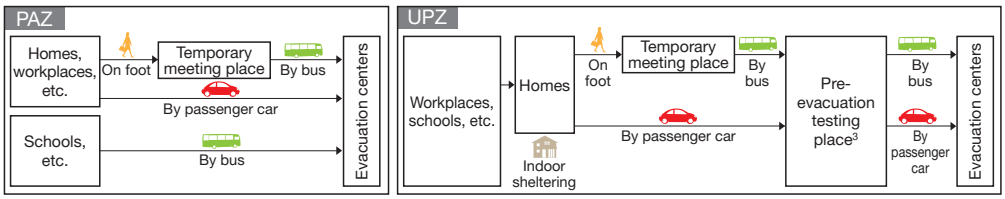


[Flow of Evacuation in the Event of an Emergency]
In Preparation for Emergencies

- Protective measures will be taken step by step to deal with the incident as the situation intensifies.
- Citizens living in the PAZ (see page 21~22), which is nearer to the nuclear site, will start evacuation first. Citizens living in the UPZ (See page 21~22), which surrounds the PAZ, will first seek shelter indoors and wait for further instruction or notice of evacuation depending upon the monitoring results of the air radiation dose rate.
- Measures for those who need special care[1] will be started earlier than other measures.



Evacuation Methods



Note 1: Refer to the elderly, people with disabilities, infants and others who need special care, including pregnant and lactating women as well as parents and guardians of infants.
Note 2: Among people living in the PAZ who need special care for evacuation, those who need more time than usual: pregnant and lactating women, infants and those who need to evacuate with infants, and those who are told not to take stable iodine by doctors.
Note 3: The test is conducted to check for radioactive contamination of evacuees before they leave the UPZ. (▶ P.32)

[Protective Measures to Be Taken in the UPZ after the Release of Radioactive Substances]

In Preparation for Emergencies

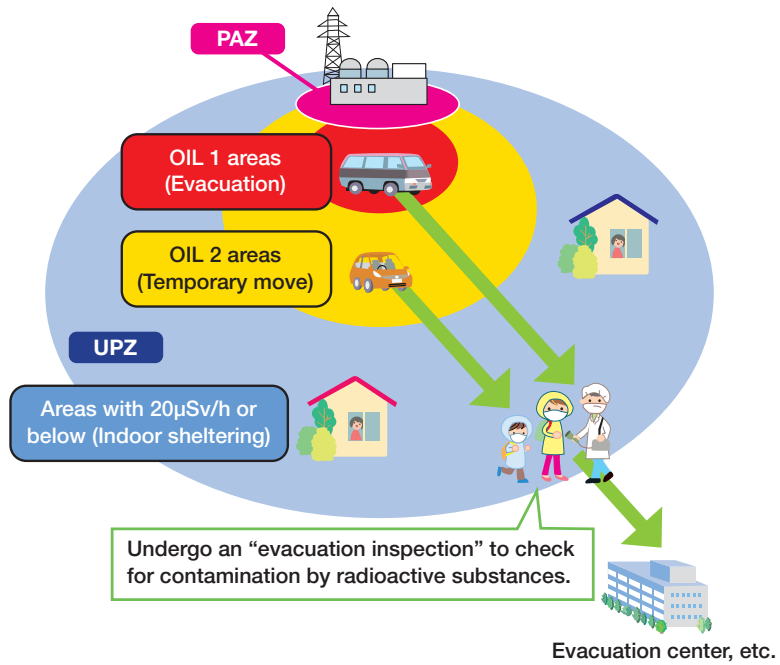
- In the event of General Emergency (see page 24), citizens living in the UPZ (see pages 21~22) will seek shelter indoors, in principle.
- However, after the release of radioactive substances, citizens living in the areas where the emergency radiation monitoring results have exceeded the predefined operational intervention levels (OIL) will temporarily move to other locations or evacuate according to the instructions given by the local government and other authorities.

Operational Intervention Level (OIL)

Used as the criteria to decide which protective measures should be implemented after the release of radioactive substances. Citizens living in areas that exceed the criteria set as "OIL 1" and "OIL 2 "will evacuate and temporarily move to other locations, respectively.

Criteria	Rate of air radiation dose	Protective measures
OIL 1	More than 500μSv/h	Evacuate*4 within one day
OIL 2	More than 20μSv/h	Temporarily move to other locations*5 within about a week
—	20μSv/h or below	Continue to stay indoors

*μSv/h: Microsieverts per hour

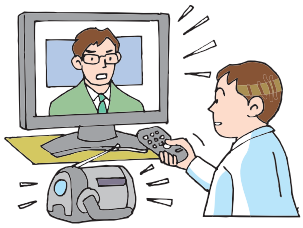


Note 4: Means to evacuate immediately from the areas that have or will probably have a high rate of air radiation dose to reduce radiation exposure.

Note 5: Means to leave within a certain period (about a week) from the areas to avoid radiation exposure that would be caused by continuing to live there, although the areas have a lower rate of air radiation dose compared with the areas from which residents need to be evacuated.

[Information Collection]
In Preparation for Emergencies

In the event of an accident at a nuclear facility, the Prefecture and relevant municipalities will provide citizens with necessary information. Please take actions calmly based on the information provided.

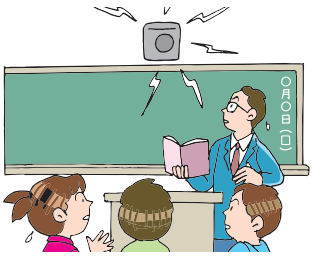


Turn on the radio/TV immediately to obtain accurate information.

[Details to be confirmed]

1. What kind of incident occurred in which nuclear facility and when
2. The current situation at the facility and future outlook
3. Measures implemented by the emergency response headquarters, and others

Information will be provided through all possible means, including wireless communication by local governments, emergency alert emails, the Internet, and public announcement cars.

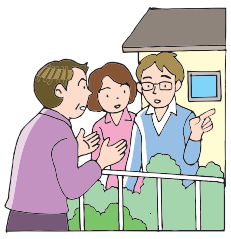


The emergency response headquarters will inform local schools of the accident and those on school grounds are required to follow the school's instructions.

Do not take actions on your own. Wait for new information inside a building.

Do not act on rumors and be wary of those spreading false information.

Refrain from making inquiries by phone as this will hinder disaster control activities.



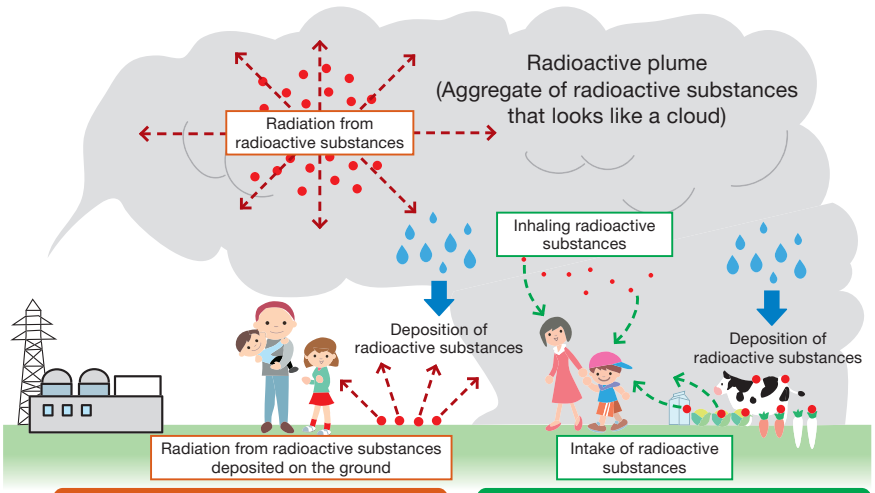
Exchange information with neighbors for confirmation.

[Effect of Indoor Sheltering]
In Preparation for Emergencies

In the event that a radioactive plume is passing over the area due to a nuclear disaster, you can reduce your radiation exposure by staying indoors rather than going outdoors for evacuation.

●By staying indoors in a building that is airtight and provides a shielding effect, you can avoid or significantly reduce the influence of radiation.

Illustrative image of a nuclear disaster (after the release of radioactive substances)



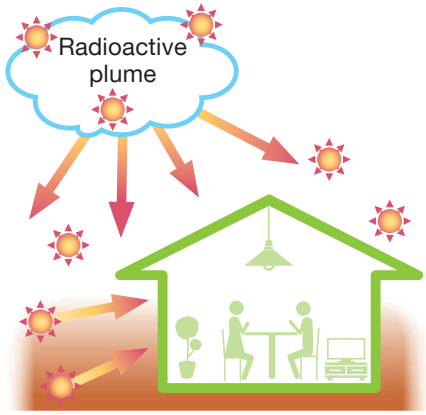
External exposure to radiation

Exposure to radiation from outside the body, for example from radioactive substances floating in the air and deposited on the ground

Internal exposure to radiation

Exposure to radiation from inside the body, for example from radioactive substances that you have inhaled by breathing or that have entered your body through food.

Effect of indoor sheltering



●Airtight buildings prevent radioactive substances from entering the buildings, thereby reducing internal exposure to radiation caused by the inhaling of radioactive substances.

●Due to the shielding effect provided by buildings, you can also reduce external exposure to radiation caused by radioactive substances existing outdoors.

Effect of indoor sheltering	Internal exposure due to inhaling of radioactive substances	External exposure due to radiation (gamma rays and others) from outdoors	
		Gamm rays emitted from nuclides deposited in the surrounding environment	Gamm rays emitted from radioactive plumes
Wooden buildings	Down **75**%	Down **60**%	Down **10**%
Concrete buildings	Down **95**%	Down **80**%	Down **40**%

Source: Estimates made by the Nuclear Regulation Authority about the exposure dose and effect of protective measures taken in case of emergency.

[Indoor Shelter]
In Preparation for Emergencies

If an order to evacuate to an indoor shelter is given, please stay indoors and shut all doors and windows to minimize the level of your exposure to radiation.

*You can usually continue using air conditioners for home use, except for those that take air from outside the building for recirculation of the air inside.

[Evacuation]
In Preparation for Emergencies

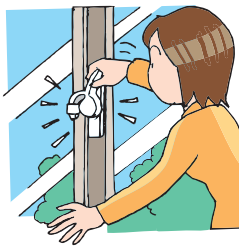
**Your municipality will give an evacuation order when necessary.
In such case, please listen to the details, including evacuation methods, the targeted areas and where to evacuate, and calmly take actions.**

Turn off the power breaker and turn off the gas at the main valve.

[Details to be confirmed]

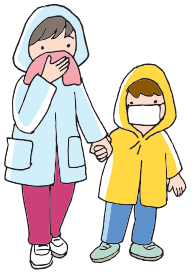
1. Targeted areas from which you need to evacuate
2. Destination evacuation center, or when and where to gather for evacuation
3. Transportation means and others

Communicate with neighbors and help each other to evacuate.



Be sure to lock all your windows and doors before evacuating.

Keep what you take with you to a minimum, but do not forget to bring valuables, medicines, and others.



To prevent internal exposure to radiation, cover your skin with a mask, a cap, a raincoat, etc.

Before evacuating by car, check the destination, route, and location of the place where you need to go to undergo a radiation dose screening test before leaving the area. For safety, wear a mask, shut the car windows and set the air conditioner to interior mode. (In preparation for emergencies, please regularly check your car's fuel gauge.)

[Administration of Stable Iodine]
In Preparation for Emergencies

Take stable iodine by following the instructions given by the emergency response headquarters.

If radioactive iodine, which may be released immediately after an accident at a nuclear facility, enters your body, it may concentrate in the thyroid gland and cause thyroid cancer. By taking stable iodine in advance, you may reduce the risk of developing this cancer. However, stable iodine is not a cure-all and is not an effective remedy for external exposure or if you consume food and drinks contaminated by radioactive substances other than radioactive iodine.

Stable iodine will be distributed beforehand to residents in the PAZ (See page 21~22), who will be asked to evacuate immediately after the outbreak of a nuclear accident, in principle. To people living in UPZ (See page 21~22), who will seek an indoor shelter if radioactive substances are released and then evacuate or temporarily move to other locations depending upon the rate of air radiation dose and other factors, the Prefecture and municipalities will distribute stable iodine as necessary.

The stable iodine distributed beforehand needs to be replaced upon reaching its expiration date (Tablets expire 5 years after the date of manufacture, jelly expires 3 years after the date of manufacture). Children younger than three years old will take stable iodine in the form of jelly while those aged three years or older will take stable iodine tablets (or stable liquid iodine if intake of a tablet is difficult).

Stable iodine tablet

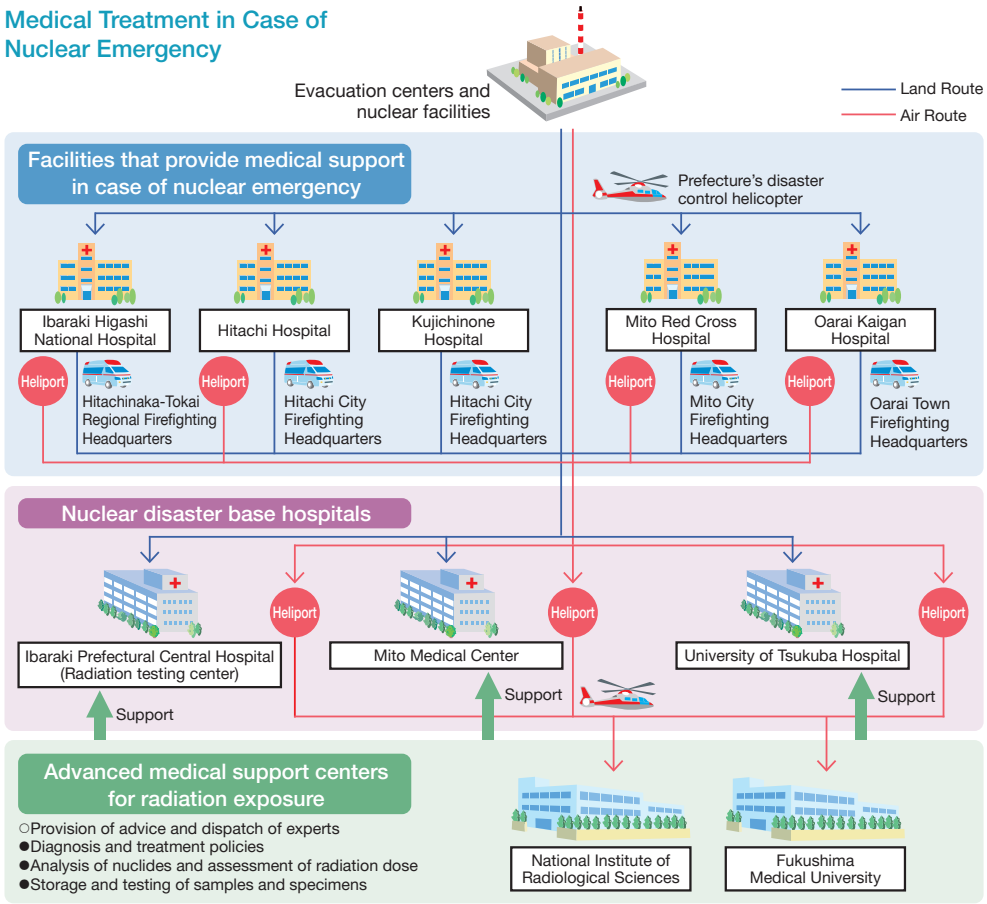
Stable iodine jelly

[Emergency Medical Service]
In Preparation for Emergencies

In the event of an emergency, an urgent medical system will be organized by medical facilities in the prefecture and provide medical care.

- First aid medical diagnosis, measurement of the level of contamination by radioactive substances (screening), and simple decontamination will be conducted at the nuclear facility where the incident occurred and at the urgently established first aid medical station.
- Those who are feeling sick or injured can receive medical advice and first-aid treatment promptly.
- Also, victims will be sent to local facilities that provide medical support in the event of a nuclear emergency or to the nuclear disaster base hospitals (Mito Medical Center of IAA National Hospital Organization, Ibaraki Prefectural Central Hospital, and NUC University of Tsukuba Hospital) for treatment.
- Furthermore, those who need special treatment will be transported to the Fukushima Medical University (Fukushima City, Fukushima Prefecture) or the National Institute of Radiological Sciences (Chiba City, Chiba Prefecture) of the National Institutes for Quantum and Radiological Science and Technology.

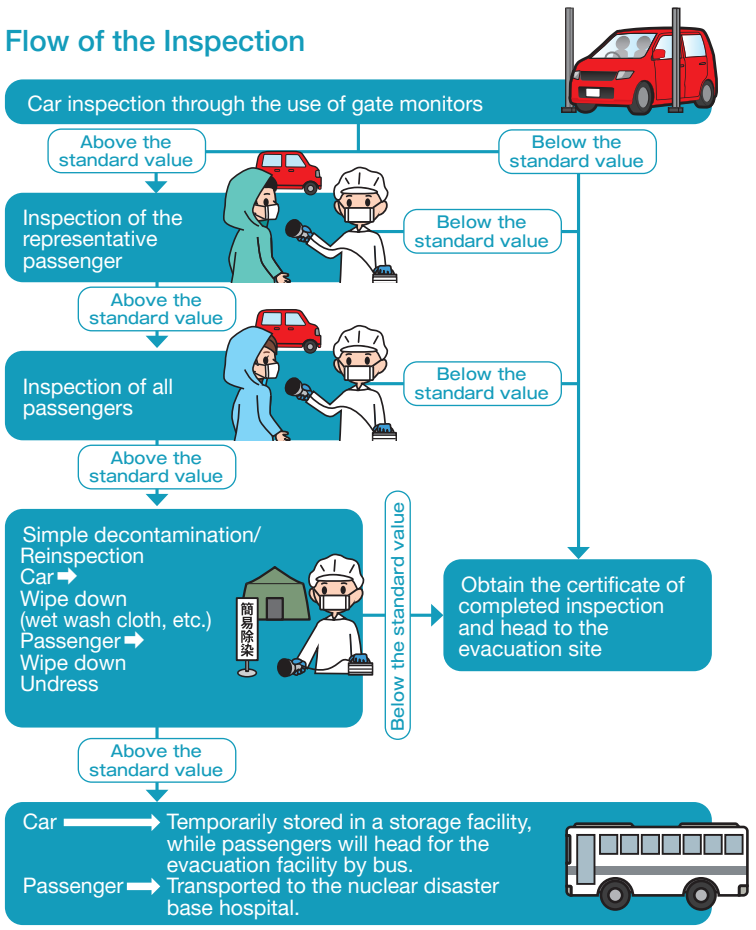
Medical Treatment in Case of Nuclear Emergency



[Evacuation Inspection]
In Preparation for Emergencies

The “Evacuation Inspection” is an inspection conducted on evacuation routes to see if radioactive materials are stuck on either the clothes, cars, or other items of residents evacuating out of the UPZ.
In order to ensure the safety and security of receptions at evacuation sites, and to prevent the spread of contamination, you must go through this inspection and make your way to the evacuation site after receiving the “Certificate of Completed Inspection”.

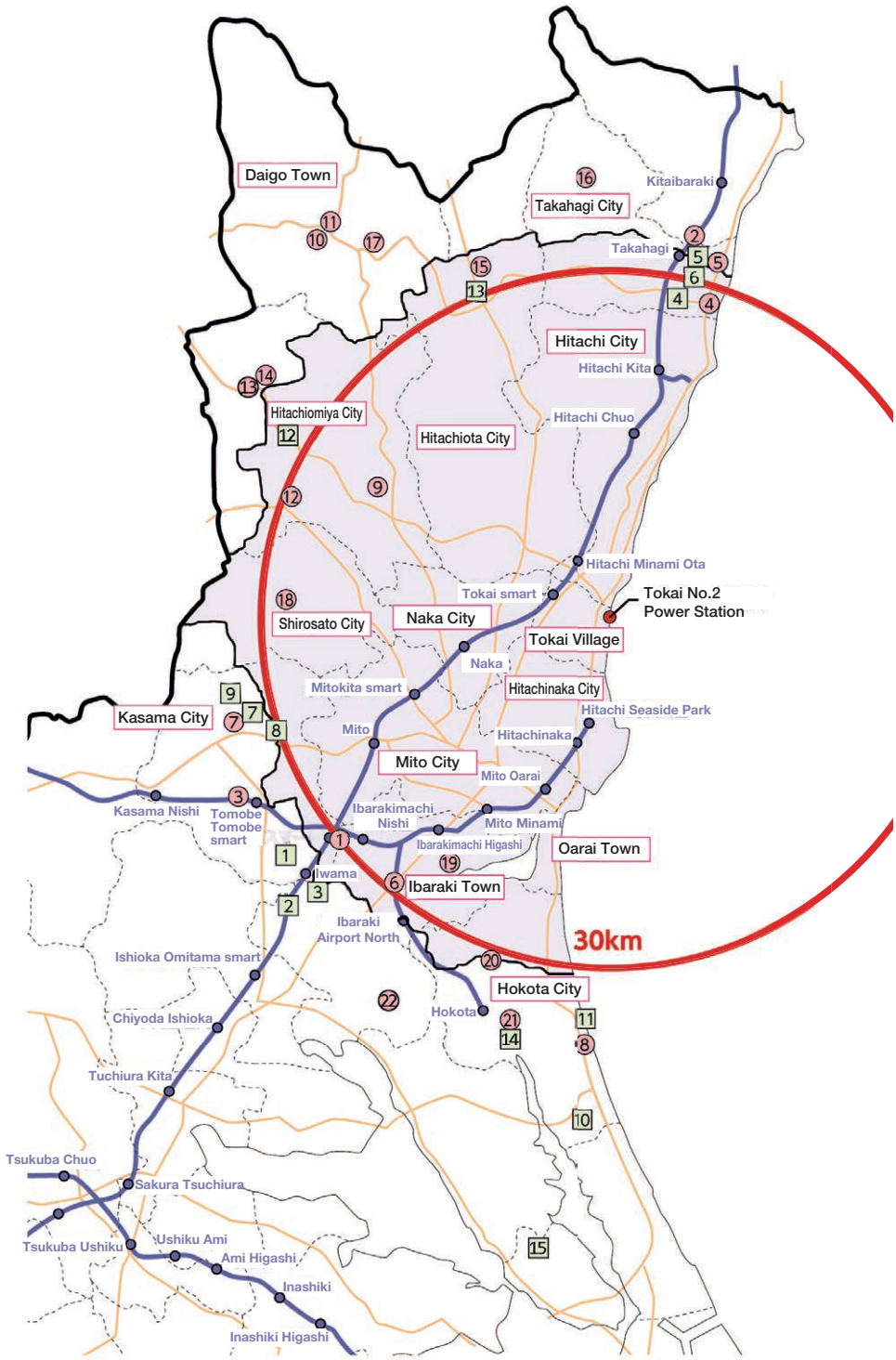
Flow of the Inspection



Car inspection by using a gate monitoring system

residents inspection

[List of Evacuation Inspection Points]
In Preparations for Emergencies



Inspection locations (as of April 28, 2022)

①	Tomobe Service Area on the Joban Expressway
1	Kasama City Iwama Marine Center
2	Minori Parking Area on the Joban Expressway
3	Ibaraki Agricultural Institute
②	Nakago Service Area on the Joban Expressway
4	Takahagi Baseball Stadium
5	Takahagi City Recycling Center
6	Sun Sports Land Takahagi
③	Kasama Parking Area on the Kita-Kanto Expressway
7	Kasama High School
8	East parking area of the Crafthills Kasama
9	Kasama City Multi-Purpose Park
④	Takahagi Junior High School
⑤	Takahagi Seisho High School
⑥	Ibaraki Higashi High School
⑦	Old Kasama City Hall
⑧	Kashimanada Seaside Park
10	Hokota City Taiyo Sports Ground
11	Parking area of the *Otake Coast*

⑨	Omiya Sports Park
⑩	Daigo Government Building
⑪	Daigo Town Central Public Hall
⑫	Hitachiomiya City Gozenyama Branch
⑬	Michinoeki Miwa
12	Product Center Kazaguruma
⑭	Hitachiomiya City Miwa Branch
⑮	Satomi Fureai-kan
13	Satomi Cultural Center
⑯	Takahagi You Field (Old Kimida Elementary and Junior High School)
⑰	Second parking area of the Fukuroda Falls
⑱	Shirosato Environmental Center/ Product Center Yamazakura
⑲	Fire Academy
⑳	Hokota Agricultural High School
㉑	Hokota Government Building
14	Hokota Daiichi High School
㉒	soranoeki SOL LA LA
15	Suigo Kenmin-no-Mori

Main inspection locations　Sub inspection locations

*Citizens living in the areas that have exceeded the predefined rates of air radiation dose will be given instructions on protective measures, including temporary move to other locations.
*Discussions are underway to specify the inspection points for each area.

<List of Contacts for Inquiries>

●About nuclear power:	The Prefecture's Nuclear Energy Safety Management Division ☎029-301-2922 (8:30 a.m. to 5:15 p.m. on weekdays)
●About the safety of food:	The Prefecture's Public Health Division ☎029-301-3424 (8:30 a.m. to 5:15 p.m. on weekdays)
●About the safety of drinking water:	The Prefecture's Water Policy Division ☎029-301-3431 (8:30 a.m. to 5:15 p.m. on weekdays)
●About the safety of agricultural products:	The Prefecture's Agriculture Technology Division ☎029-301-3936 (8:30 a.m. to 5:15 p.m. on weekdays)
●About the health effects of exposure to radiation:	The Prefecture's Infectious Disease Countermeasures Division ☎029-301-5134 (8:30 a.m. to 5:15 p.m. on weekdays) National Institute of Radiological Sciences, NRDA National Institutes for Quantum and Radiological Science and Technology hibakusoudan@qst.go.jp
●About stable iodine:	The Prefecture's Pharmaceutical Division ☎029-301-3384 (8:30 a.m. to 5:15 p.m. on weekdays)

Ibaraki
Prefecture

Handbook on Nuclear Power

Basic Information about Radiation and Nuclear Power

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