# The Communication of Information Such as Evacuation Orders at the Time of a Nuclear Power Station Accident

## —Recommendations for responses by the national government and electric power utilities to the "Information Disaster"—

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Takashi HATANAKA,[1] Sumito YOSHIDA,[2] Mayo OJINO,[3] Masami ISHII[4]


## Abstract

This research was carried out from the perspective that the damage to the people of Fukushima and others from the Fukushima Daiichi Nuclear Power Station (NPS) accident was an "information disaster." It evaluated the critical problems raised by and actual condition analysis on the process of events in the Fukushima Daiichi NPS disaster and responses of the governments and others, notification of the occurrence of the accident and evacuation order by the national and local governments and the evacuation of residents, and guidance for distribution and intake of stable iodine tablets. The research aimed to provide a basis for the implementation of effective distribution and intake of stable iodine tablets and responses to the "information disaster" in the nuclear power disaster.

On March 15 at the time that the most radioactive substances were dispersed, even when the average wind speed at the site area was 1.6 m/s, the radioactive substances had reached the outer boundary of Urgent Protective action planning Zone (UPZ, the region with a radius of 30 km) within about five hours. Because of this, every second counted in the provision of information about the accident and the issuance of evacuation orders. This study evaluated the actual condition of information provision by the national government and others from the perspective of this awareness of the importance of time.

On the basis of the results of this kind of consideration, we come to the following recommendations: The Nuclear Emergency Response Guidelines and the system for communication of information to medical providers should be revised. The national government should make preparations for the effective advance distribution and intake of stable iodine tablets.


**Key words** Information disaster, Fukushima Daiichi, SCRAM, TEPCO, Venting, Evacuation order

## Problems and the Actual Conditions of Evacuation Orders and Order to Take Iodine Tablets in the Fukushima Daiichi Nuclear Power Station (NPS) Accident

### Problems in the response of the national government and other bodies to the main events in the Fukushima Daiichi NPS

**Table 1** summarizes the timeline of the main events in the Fukushima Daiichi NPS accident and actions of the national government such as the evacuation orders.[1-3] This table shows the date and time of the responses of the national government and others to the events which occurred as well as the elapsed time from the time of the emergency shutdown (SCRAM) of the reactor subsequent to the Great East Japan Earthquake (**Table 1** and other similar tables are

[1] Chief Senior Researcher, Japan Medical Association Research Institute, Tokyo, Japan (hatanaka@jmari.med.or.jp); [2] Senior Researcher, Japan Medical Association Research Institute, Tokyo, Japan; [3] Researcher, Japan Medical Association Research Institute, Tokyo, Japan; [4] Executive Board Member, Japan Medical Association, Tokyo, Japan.

**Table 1 Chronology of main events and evacuation orders in the Fukushima Daiichi NPS Accident**[1-3]

| Date | Time | Main events and evacuation orders | Elapsed time (hours:min) |
|---|---|---|---|
| 3.11 | **14:46** | **Great East Japan Earthquake (SCRAM—Automatic shutdown of reactor)** | **0** |
| | ca. 15:37 | Largest tsunami hits | 0:51 |
| | 15:42 | TEPCO/Notification of special situation occurrence at Fukushima Daiichi NPS based on Article 10 of Nuclear Emergency Act (all AC power sources are lost) | 0:56 |
| | 16:45 | TEPCO/Notification of special situation occurrence at Fukushima Daiichi NPS based on Article 15 of Nuclear Emergency Act (Emergency core cooling system fails) | 1:59 |
| | 18:33 | TEPCO/Notification of special situation occurrence at Fukushima Daini NPS based on Article 10 of Nuclear Emergency Act | 3:47 |
| | **19:03** | **Government/Declaration of Nuclear Emergency** | **4:17** |
| | 20:50 | Evacuation Order related to Fukushima Daiichi NPS issued by Governor of Fukushima Prefecture<br>Evacuation of residents within radius of 2 km from NPS | 6:04 |
| | 21:23 | Evacuation Order related to Fukushima Daiichi NPS issued by Chief of Nuclear Emergency Response Headquarters (NERHQ)<br>Evacuation of residents within radius of 3 km from NPS<br>Shelter in place for residents from radius of 3 km to radius of 10 km from NPS | 6:37 |
| 3.12 | 5:44 | Evacuation of residents within 10 km of NPS | 14:58 |
| | 7:45 | Evacuation Order related to Fukushima Daini NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 3 km from NPS<br>Shelter in place for residents from radius of 3 km to radius of 10 km from NPS | 16:59 |
| | **14:30** | **Venting at Unit 1** | **23:44** |
| | **15:36** | **Explosion of Unit 1 reactor building** | **24:50** |
| | 17:39 | Evacuation Order related to Fukushima Daini NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 10 km from NPS | 1 day 2:53 |
| | ca. 18:00 | Safety relief (SR) valve (containment vessel pressure relief valve) opened at Unit 2 | 1 day 3:14 |
| | 18:25 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within 20 km of NPS | 1 day 3:39 |
| 3.13 | **9:20** | **Venting at Unit 3** | **1 day 18:34** |
| 3.14 | **11:01** | **Explosion of Unit 3 reactor building** | **2 days 20:15** |
| | **18:06** | **Venting at Unit 2** | **3 days 3:20** |
| 3.15 | **6:12** | **Explosion of Unit 4 reactor building** | **3 days 15:26** |
| | **6:12** | **Serious damage to Unit 2 pressure suppression chamber** | **3 days 15:26** |
| | 11:00 | Residents between 20 km radius and 30 km radius from NPS shelter in place | 3 days 20:14 |
| 3.25 | | Recommendation for voluntary evacuation of residents within 20 km radius and 30 km radius from NPS | 14 days |
| 4.21 | 11:00 | Order to establish a Restricted Area within 20 km radius from NPS in accordance with the Disaster Countermeasures Basic Act | 40 days |
| | 11:00 | Evacuation Order, etc. related to Fukushima Daini NPS issued by NERHQ Chief<br>Evacuation zone changed from within 10 km radius of NPS to within 8 km radius of NPS | 40 days |
| 4.22 | 9:44 | Evacuation Order, etc. related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Lifted order to shelter in place between 20 km radius and 30 km radius from NPS, established planned evacuation zone and emergency evacuation zone (removing Iwaki City) | 41 days |

Note: Items shaded gray are related to Fukushima Daini NPS.

in the same format).

Because of the large-scale earthquake at 14:46 on March 11, and the arrival of the largest tsunami at about 15:37, all AC power supply was lost at 15:42. As a result of this, Tokyo Electric Power Company (TEPCO) notified the national government of occurrence of a specific incident under Article 10 of the "Act on Special Measures

Concerning Nuclear Emergency Preparedness" (hereinafter, "Nuclear Emergency Act"). About one hour later, at 16:45, the emergency core coolant system cooling water injection function was lost and the national government was notified under Article 15 of the Nuclear Emergency Act.

At 19:03, two hours and 18 minutes (hereinafter: T+2:18) after receiving this notification, the national government issued a "Declaration of Nuclear Emergency" under Article 15. After this declaration, significant events occurred and TEPCO emergency responses were carried out (**Table 1**).

**Problem 1: Delay in the issuance of the declaration of nuclear emergency**

The time interval was not even one hour between the notification under Article 10 of the occurrence of a situation as a result of the station blackout (SBO) (Article 10 notification) at 15:42 on March 11, and the notification under Article 15 of the occurrence of a situation due to the emergency core coolant system cooling water injection function loss (Article 15 notification).

In the newly revised "Nuclear Emergency Response Guidelines,"[4] the response to an emergency situation on the facility premises equivalent to an Article 10 notification and the response to a general emergency situation equivalent to an Article 15 notification are stipulated separately, but from looking at the Fukushima Daiichi NPS accident, both of these should be responded to in an integrated manner.

In addition, at 16:45 on March 11, notification was made of a special situation based on Article 15, Section 1 of the Act. Regardless of the fact that it is stipulated in Article 15, Section 2, two hours and 18 minutes passed until the declaration was issued (four hours and 17 minutes after the earthquake struck) (**Table 1**).

**Problem 2: Insufficient contents of the declaration of nuclear emergency and Chief Cabinet Secretary press announcement**

Because in the content of the declaration of nuclear emergency, the specific details of the notification, etc. are left out, the imminent state of the reactor ends up not being communicated at all. As a result, the information communicated to residents in the region and citizens throughout the country was essentially that since there was no problem with the reactor, they should just remain calm and wait. In other words, there was no communication at all that conveyed the fact that the situation was one in which "all reaction cooling functions had been lost, and that the injection of water by the emergency core cooling system was not functioning," which was the most significant situation for local governments involved.

In addition, in the Chief Cabinet Secretary press announcement concerning the declaration held on March 11, the urgency of the reactor situation was not communicated at all, and the specific details ended up being omitted. In particular, the notification that the situation was such that "all water supply functions to the reactor had been lost, and that water injection to the reactor by all of the emergency core cooling system was not functioning," had not been publicly announced at all.

On the contrary, the information conveyed to the public, that "there is at this time no problem with the reactors themselves," was different from the contents of the notification.

**Problem 3: Delay in the evacuation orders for within the 3 km zone and for within the 10 km zone**

After the Article 15 notification was made at 16:45 on March 11 (T+1:59), nearly five hours elapsed before the evacuation order for residents within a 3-km radius of the NPS was issued at 21:23 on March 11. In addition, the evacuation order for residents within a 10-km radius of the NPS was issued after an interval of about thirteen hours at 5:44 on March 12 (**Table 2**).

Although the Article 15 notification should have been a report of extremely severe conditions for residents, preparations for evacuation were greatly delayed by the time required for the procedures of the government to actually communicate information to residents and the insufficiency of awareness about the emergency conditions (**Table 1**).

**Problem 4: Delay in resident evacuation within a 10-km radius**

Subsequent to the issuance of the declaration of nuclear emergency, the government issued an evacuation order for residents within a radius of 3 km from the NPS and an order to shelter in place for residents between a radius of 3 km and a radius of 10 km from the NPS. However, quite a lot of time passed before the government announced the evacuation order for residents within a radius of 10 km from the NPS as an additional measure at 5:44 on the next morning,

**Table 2 Venting at Unit 1 of Fukushima Daiichi NPS and chronological response**[1]

| Date | Time | Chronology leading up to Unit 1 venting operation | Elapsed time (hours:min) |
|---|---|---|---|
| 3.11 | **14:46** | **Great East Japan Earthquake (SCRAM—Automatic shutdown of reactor)** | **0** |
| | ca. 15:37 | Largest tsunami hits | 0:51 |
| | 15:42 | TEPCO/Notification of special situation occurrence at Fukushima Daiichi NPS based on Article 15 of Nuclear Emergency Act (all AC power sources are lost) | 0:56 |
| | 16:36 | Confirmation of vent opening procedures begins in central control room of Fukushima Daiichi NPS | 1:50 |
| | 16:45 | TEPCO/Notification of special situation occurrence at Fukushima Daiichi NPS based on Article 15 of Nuclear Emergency Act (Emergency core cooling system fails) | 1:59 |
| | **19:03** | **Government/Declaration of Nuclear Emergency** | **4:17** |
| | 20:50 | Evacuation Order related to Fukushima Daiichi NPS issued by Governor of Fukushima Prefecture<br>Evacuation of residents within radius of 2 km from NPS | 6:04 |
| | 21:23 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 3 km from NPS<br>Shelter in place for residents from radius of 3 km to radius of 10 km from NPS | 6:37 |
| 3.12 | 0:06 | Site Superintendent Yoshida orders preparations for Unit 1 containment vessel vent operation | 9:20 |
| | 3:06 | Joint press conference held by Kaieda, Minister of Economics, Trade and Industry (METI Minister Kaieda), Nobuaki Terasaka, Director-General of the Nuclear and Industry Safety Commission (NISA Director-General Terasaka), and TEPCO Managing Director Akio Komori announcing vent operations to begin at about 3:30 | 12:20 |
| | 3:30 | Venting at Unit 1 not possible | 12:44 |
| | 5:44 | Evacuation of residents within 10 km of NPS | 14:58 |
| | 6:50 | METI orders TEPCO to open vents based on the Law on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (Law No.166, 1957, hereinafter "Nuclear Reactor Regulation Law") | 16:04 |
| | 8:37 | TEPCO gave notice to Fukushima Prefecture that vent operation would take place at about 9:00 after confirming the evacuation status of residents | 17:51 |
| | 9:00 | Venting operation at Unit 1 not possible | 18:00 |
| | 14:30 | Venting at Unit 1 | 23:44 |
| | **15:36** | **Explosion of Unit 1 reactor building** | **24:50** |
| | 18:25 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within 20 km of NPS | 1 day 3:39 |

Note: Items shaded gray are related to evacuation orders.

March 12 (T + 14:58) (**Table 2**).

In the eyes of residents living between the zones with a radius of 3 km and 10 km of the NPS, if the evacuation order had been issued the previous day at 21:23, just over eight hours could have been effectively used to prepare for evacuation, and this time ended up being spent unproductively (**Table 2**).

## Timing of venting, hydrogen explosion of the building, and resident evacuation

At the Fukushima Daiichi NPS of TEPCO, venting the containment vessel was considered from the beginning. That is, two hours after the SCRAM on March 11, at 16:36 (T + 1:50), confirmation of the procedure for conducting the venting had already begun in the Fukushima Daiichi NPS Central Control Room (**Table 2**).

After that, at 0:06 on March 11 (T + 9:20), Site Superintendent Masao Yoshida gave the order to prepare for venting the Unit 1 containment vessel, and subsequently Minister of Economics, Trade and Industry Banri Kaieda ("METI Minister Kaieda") and Nobuaki Terasaka, Director-General of the Nuclear and Industrial Safety Agency (NISA) held a joint press conference and announced that the venting operation would be carried out at about 3:30 (T + 12:44). However, even at 3:30, the venting operation could not be carried out, and the vents were opened

only at 14:30 (T+23:44) (**Table 2**).

**Problem 5: Time of venting at Unit 1 (T+23:44)**

Meanwhile, at 5:44 on March 12, an evacuation order was issued for residents within a radius of 10 km from the NPS. However, if the venting had been implemented as planned at 3:30, it would have been extremely dangerous for many residents, who would have been exposed to radiation only two hours after venting.

It is questionable whether the initial plan for venting was to be done in such a way as to coordinate with the evacuation order for residents within a 10-km radius.

**Problem 6: Evacuation order for residents within a 20-km radius two hours after the hydrogen explosion (T+27:39)**

As the National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission (NAIIC) pointed out, at 13:45 on March 12 (T+22:59), "there is a passage in a memorandum on the proceedings prepared by the intelligence team of the Kashiwazaki-Kariwa NPS, saying, 'We are concerned about hydrogen at 1F-1 (Unit 1 of the Fukushima Daiichi NPS).'"[1]

However, there are no signs that TEPCO considered the risk of a hydrogen explosion until the actual hydrogen explosion at Unit 1 (**Table 3**).

Amidst this, even though the Unit 1 vents were opened at 14:30 (T+23:44), the Unit 1 reactor building exploded at 15:36 (T+24:50). But the order of the national government at 18:25 (T+27:39) was for residents to evacuate within a radius of 20 km of the NPS.

There was no doubt that the order from the national government to residents within a radius of 20 km, because it was the first one, and furthermore was an order coming just three hours after the reactor building of Unit 1 had exploded, not only caused confusion for the residents but also left them exposed to radiation.

### Problems in the information provision to residents and citizens which avoided the condition of the core and fuel at Fukushima Daiichi NPS

**Problem 7: Problems in the expressions used in information provided by the NISA**

From March 12, information began to be provided by NISA concerning the condition of the core and fuel at Unit 1, but according to the NAIIC report,[2] there was a dramatic change in the content of the expressions around the time when the Unit 1 vents were opened and the reactor building exploded.

Before the Unit 1 vents were opened at 14:30 on March 12 (T+23:44), the condition of the core and fuel used the expressions "core meltdown" and "fuel meltdown" (**Table 4**).

But after the Unit 1 reactor building explosion at 15:36 on March 12 (T+24:50), there was a change of personnel in charge of communication, and the expressions related to the condition of the fuel also changed to avoid the terms "core meltdown" and "fuel meltdown" and the words used were "core damage" and "cladding damage" (**Table 4**).

These kinds of expressions were found to be a handicap for residents, citizens and others to correctly understand the situation of the fuel inside of the reactor, which is a "black box" environment.

## Actions by the National Government and Local Governments Such as the Notification of Incident Occurrence and Evacuation Orders

### Problems in the communication from the national government to local governments

**Problem 8: Decision making and information communication led by the Prime Minister's Office instead of existing nuclear disaster prevention organizations**

Previously, when a declaration of a nuclear emergency situation was issued, responses would be carried out by designated administrative structure, but for a variety of reasons such as the collapse of the communications and transportation networks, delays in assembling personnel, the loss of function of the Local Nuclear Emergency Response Headquarters (Local NERHQ or "Off-site Center"), the administrative structure as a whole was unable to respond.

Then, in the case of the accident this time, against the backdrop of these various factors, decisions and communications about matters such as the declaration of nuclear emergency, evacuation orders, and mandatory evacuation zones were made largely by the some of the members of the Nuclear Emergency Response Headquarters (NERHQ) with the Prime Minister at the center, on the fifth floor of the Prime Minister's Office. As a result, the NISA could not perform its duties at that time.

**Table 3 Chronology of responses to hydrogen explosion of Unit 1 reactor building**[1,3]

| Date | Time | Chronological responses to the hydrogen explosion | Elapsed time (hours:min) |
|---|---|---|---|
| 3.11 | **14:46** | **Great East Japan Earthquake (SCRAM—Automatic shutdown of reactor)** | **0** |
| | ca. 15:37 | Largest tsunami hits | 0:51 |
| | 15:42 | TEPCO/Notification of special situation occurrence at Fukushima Daiichi NPS based on Article 10 of Nuclear Emergency Act (all AC power sources are lost) | 0:56 |
| | 16:45 | TEPCO/Notification of special situation occurrence at Fukushima Daiichi NPS based on Article 15 of Nuclear Emergency Act (Emergency core cooling system fails) | 1:59 |
| | **19:03** | **Government/Declaration of Nuclear Emergency** | **4:17** |
| | 20:50 | Evacuation Order related to Fukushima Daiichi NPS issued by Governor of Fukushima Prefecture<br>Evacuation of residents within radius of 2 km from NPS | 6:04 |
| | 21:23 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 3 km from NPS<br>Shelter in place for residents from radius of 3 km to radius of 10 km from NPS | 6:37 |
| 3.12 | 5:44 | Evacuation of residents within 10 km of NPS | 14:58 |
| | 13:45 | There is a passage in a memorandum on the proceedings prepared by the intelligence team of the Kashiwazaki-Kariwa NPS, saying, 'We are concerned about hydrogen at 1F-1 (Unit 1 of the Fukushima Daiichi NPS).' However, there are no signs that TEPCO considered the risk of a hydrogen explosion until the actual hydrogen explosion at Unit 1. | 22:59 |
| | **14:30** | **Venting at Unit 1** | **23:44** |
| | **15:36** | **Explosion of Unit 1 reactor building** | **24:50** |
| | 18:25 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within 20 km of NPS | 1 day 3:39 |
| 3.13 | **9:20** | **Venting at Unit 3** | **1 day 18:34** |
| | 9:42 | There was concern that there was a possibility that a hydrogen explosion similar to that of Unit 1 could occur for Unit 3 as well. Request by Site Superintendent Yoshida to TEPCO headquarters to consider actions to prevent a hydrogen explosion: "Although it is not completely certain that hydrogen was the cause of yesterday's explosion, what is extremely important is that we take action to prevent an explosion like in Unit 1. I would like to draw on the experience of others including TEPCO HQ." | 1 day 18:56 |
| | 10:43 | Order issued from NISA to consider actions such as opening the blowout panel for Unit 3 as well because an explosion similar to that of Unit 1 was considered possible. | 1 day 19:57 |
| 3.14 | 5:54 | Warning issued from Site Superintendent Yoshida that the D/W pressure in Unit 3 is increasing and possibility of explosion similar to that of Unit 1 is increasing. | 2 days 15:08 |
| | 6:48 | Possibility of Unit 3 hydrogen explosion increases, and the situation is such that work in yard becomes difficult | 2 days 16:02 |
| | **11:01** | **Explosion of Unit 3 reactor building** | **2 days 20:15** |
| | **18:06** | **Venting at Unit 2** | **3 days 3:20** |
| 3.15 | **6:12** | **Explosion of Unit 4 reactor building** | **3 days 15:26** |
| | **6:12** | **Serious damage to Unit 2 pressure suppression chamber** | **3 days 15:26** |
| | 11:00 | Residents shelter in place between a radius of 20 km and a 30 km from NPS | 3 days 20:14 |

Note: Items shaded gray are related to evacuation orders.

It has been found that the inadequate and late response to the accident may have been because of the fact that responses and other matters could not be carried out within the administrative structure originally foreseen, and that instead the lead was taken by some members of the NERHQ with the Prime Minister at the center, on the fifth floor of the Prime Minister's Office.

**Problem 9: Notification by telephone to the local governments at the site and no notification to the local governments in the surrounding area concerning the occurrence of the accident**

There are two towns, Okuma and Futaba at the

**Table 4 Provision of information by NISA related to the condition of the core and fuel of Fukushima Daiichi NPS**[1,3]

| Date | Time | Provision of information of the condition of the core and fuel | Elapsed time (hours:min) |
|---|---|---|---|
| 3.11 | **14:46** | **Great East Japan Earthquake (SCRAM—Automatic shutdown of reactor)** | **0** |
| | ca. 15:37 | Largest tsunami hits | 0:51 |
| | 15:42 | TEPCO/Notification of special situation occurrence at Fukushima Daiichi NPS based on Article 10 of Nuclear Emergency Act (all AC power sources are lost) | 0:56 |
| | 16:45 | TEPCO/Notification of special situation occurrence at Fukushima Daiichi NPS based on Article 15 of Nuclear Emergency Act (Emergency core cooling system fails) | 1:59 |
| | **19:03** | **Government/Declaration of Nuclear Emergency** | **4:17** |
| | 20:50 | Evacuation Order related to Fukushima Daiichi NPS issued by Governor of Fukushima Prefecture<br>Evacuation of residents within radius of 2 km from NPS | 6:04 |
| | 21:23 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 3 km from NPS<br>Shelter in place for residents from radius of 3 km to radius of 10 km from NPS | 6:37 |
| 3.12 | 5:44 | Evacuation of residents within 10 km of NPS | 14:58 |
| | 9:45 | It was found that part of the cladding **had begun to melt**. It was not possible to rule out the chance that some of the fuel had begun to melt. | 18:59 |
| | 13:00 | It was probably too soon to determine whether a **fuel meltdown** was occurring at Unit 1. | 22:14 |
| | 14:00 | There was a possibility of a core meltdown. Was the **core meltdown** already in progress? | 23:14 |
| | **14:30** | **Venting at Unit 1** | **23:44** |
| | **15:36** | **Explosion of Unit 1 reactor building** | **24:50** |
| | 18:25 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within 20 km of NPS | 1 day 3:39 |
| | 21:30 | (in response to a question about meltdown in Unit 1) We are not aware of the degree to which it is occurring. We believe that it is highly likely that there is **core damage** but we do not know precisely. At this point it is probably the case that a meltdown is not in progress. | 1 day 6:44 |
| 3.13 | 5:30 | (in response to a question about core meltdown in Unit 1) It should be kept in mind that the possibility cannot be ruled out. | 1 day 14:44 |
| | **9:20** | **Venting at Unit 3** | **1 day 18:34** |
| | 17:15 | About half of the fuel in Unit 3 was out of the water, and it was suspected that **the fuel rods had been damaged**. | 2 days 2:29 |
| 3.14 | 9:15 | (in response to a question about Unit 3 core meltdown) It is not at the meltdown stage. For part of the fuel, the proper expression is that there is **damage to the external cladding**. | 2 days 18:29 |
| | **11:01** | **Explosion of Unit 3 reactor building** | **2 days 20:15** |
| | 16:45 | (in response to a question about Unit 3 core meltdown) It is true that there is at least **damage to the core** of Unit 3. We do not really know whether it has reached a meltdown. | 3 days 1:59 |
| | **18:06** | **Venting at Unit 2** | **3 days 3:20** |
| | 21:45 | High possibility of Unit 2 **core damage** | 3 days 6:59 |
| 3.15 | **6:12** | **Explosion of Unit 4 reactor building** | **3 days 15:26** |
| | **6:12** | **Serious damage to Unit 2 pressure suppression chamber** | **3 days 15:26** |
| | 11:00 | Residents shelter in place between a radius of 20 km and a 30 km from NPS | 3 days 20:14 |

Note: Items shaded gray are related to evacuation orders.

site of the Fukushima Daiichi NPS within the zone 3 km from the NPS. In the surrounding area, four towns are within the zone 10 km; two cities, five towns and two villages are within the zone 20 km, and three cities, six towns and three villages are in the zone 30 km from the NPS.

The local governments at the site, Okuma and Futaba, received a communication from TEPCO concerning the Article 10 and Article 15 notifications, by telephone. Although the timing was about the same as the reports from TEPCO to the national government, since all of these were telephone communications, it could not be confirmed whether the proposed notifications were appropriately detailed including the severe status in which all of the water supply functions to the reactor had been lost, and all feed-water injection capability from the emergency core cooling system had also been lost (**Table 5**).

An even larger problem was the communication to the local governments in the surrounding areas.

Of the local governments in the surrounding area, within the 20 km zone are the towns of Namie, Tomioka, Naraha and Hirono; the villages of Kawauchi and Katsurao, and the cities of Minamisoma and Tamura. Among these, at least Namie town, Minamisoma and Tamura cities, and Katsurao village either became aware of the accident through media reports, or became aware when they received requests from the local governments at the site to accept evacuees (**Table 5**).

This time, the evacuation order from the national government was limited to the local governments within the 20 km zone. On the other hand, evacuation planned by the local governments themselves, evacuation by advisory orders for voluntary evacuation or voluntary evacuation of residents took place even in surrounding areas in the 30 km region. It was a big problem that at the time of the occurrence of the accident, the local governments in this region had not received any notice from the national government or anyone else.

**Problem 10: Notification to the local governments at the site and no notification to the local governments in the surrounding area about the evacuation order**

The evacuation order was issued in stages according to the distance of the zones from the Fukushima Daiichi NPS (**Table 6**).

Concerning the evacuation order for residents in the 3 km zone of March 11 at 21:23 (T + 6:37), Futaba town received a communication from the national government but Okuma town became aware of it from media reports.

Concerning the evacuation order for residents in the 10 km zone of March 12 at 5:44 (T + 14:58), notice was received at 6:29 in Futaba town by fax from the national government, and at about 6:00 in Okuma town by a telephone from the Prime Minister aide Goshi Hosono. However, Naraha town became aware of it from media reports, the towns of Tomioka and Okuma became aware of it through the Disaster Prevention Radio System. All of these local governments are within the 10 km zone of the Fukushima Daiichi NPS.

Notice of the evacuation order for residents within the 20 km zone on March 12 at 18:25 (T + 27:39) was sent from Fukushima Prefectural Government to Tamura City, but for the rest, the towns of Namie and Hirono, Minamisoma City, and the villages of Kawauchi and Katsurao, they either received no communication or became aware of it from media reports.

Then, on March 25 (T + 14 days), residents between a radius of 20 km and 30 km from the NPS were requested by the national government to evacuate voluntarily. In this way, information from the national government concerning evacuation orders was not carried out appropriately, and it became a situation which depended on media reports. A deep feeling of distrust about the information provision aspect of the evacuation orders remains, and will be a large problem on the occasion of future occurrences of nuclear accidents.

Because of this, the situation was such that Kawauchi village mayor Yuko Endo complained that at the time of the Fukushima Daiichi nuclear disaster "he spent the time as if paralyzed with fear. This disaster was in a sense an 'information disaster.'"[5]

## Problems with the evacuation order to residents from the local governments

**Problem 11: Evacuation order without any scientific data or other information necessary for evacuation**

From 6:12 in the morning of March 15 (T + 3 days 15:26) until March 16, an exceptional increase in the radiation emission level near the main gate of the NPS was observed. As a result,

**Table 5 Communication of information from national government to local governments concerning the occurrence of the Fukushima Daiichi NPS accident**[1]

| Date | Time | Communication of information concerning the occurrence of the ccident | | Elapsed time (hours:min) |
|---|---|---|---|---|
| 3.11 | **14:46** | **Great East Japan Earthquake (SCRAM—Automatic shutdown of reactor)** | | **0** |
| | ca. 15:37 | Largest tsunami hits | | 0:51 |
| | 15:42 | TEPCO/Notification of special situation occurrence at Fukushima Daiichi NPS based on Article 10 of Nuclear Emergency Act (all AC power sources are lost) | | 0:56 |
| | | after 16:00 | Okuma (in zone 3 km from Fukushima Daiichi NPS): Article 10 notification by telephone | ca. 1:14 |
| | | ca. 16:36 | Futaba (in zone 3 km from Daiichi NPS): Article 15 notification by telephone | ca. 1:50 |
| | 16:45 | | TEPCO/Notification of special situation occurrence at Fukushima Daiichi NPS based on Article 15 of Nuclear Emergency Act (Emergency core cooling system fails) | 1:59 |
| | | ca. 17:00 | Okuma (in zone 3 km from Daiichi NPS): Article 15 notification by telephone | ca. 2:14 |
| | | ca. 17:00 | Hirono (in zone 10 km from Daiichi NPS): Learned of Fukushima Daiichi NPS Accident from media reports | ca. 2:14 |
| | 18:33 | TEPCO/Notification of special situation occurrence at Fukushima Daini NPS based on Article 10 | | 3:47 |
| | **19:03** | **Government/Declaration of Nuclear Emergency** | | **4:17** |
| | 20:50 | Evacuation Order related to Fukushima Daiichi NPS issued by Governor of Fukushima Prefecture<br>Evacuation of residents within radius of 2 km from NPS | | 6:04 |
| | 21:23 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 3 km from NPS<br>Shelter in place for residents from radius of 3 km to radius of 10 km from NPS | | 6:37 |
| | | ca. 22:30 | Naraha (in zone 3 km from Daiichi NPS): Explanation of situation by two TEPCO employees from Fukushima Daini NPS | ca. 7:44 |
| | | — | Tomioka (in zone 3 km from Daiichi NPS): Received Article 10 and Article 15 notifications concerning Fukushima Daini NPS | — |
| | | — | Hirono (in zone 10 km from Daiichi NPS): Received Article 10 and Article 15 notifications | — |
| | | — | Namie (in zone 5 km from Daiichi NPS): Learned of accident from media reports | — |
| | | — | Tamura (in zone 20 km from Daiichi NPS): Learned of accident from media reports | — |
| | | — | Minamisoma (in zone 20 km from Daiichi NPS): No communication concerning occurrence of accident | — |
| | | — | Katsurao (in zone 20 km from Daiichi NPS): Learned of accident from media reports | — |
| | | — | Iitate (in zone 30 km from Daiichi NPS): Learned of accident from media reports | — |
| 3.12 | **0:00** | **Local NERHQ (Off-site Center) loses all electrical power. All functionality subsequently lost, except for satellite telephones.** | | **9:14** |
| | **4:00** | **All nuclear safety inspectors at Fukushima NPS withdrawn from the Off-site Center.** | | **13:14** |
| | 5:44 | Evacuation of residents within 10 km of NPS | | 14:58 |
| | | Morning | Kawauchi (in zone 20 km from Daiichi NPS): Learned of accident when mayor of Tomioka requested to accept evacuees | — |
| | **15:36** | **Explosion of Unit 1 reactor building** | | **24:50** |
| | 18:25 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within 20 km of NPS | | 1 day 3:39 |
| | | — | Kawamata (in zone 50 km from Daiichi NPS): Learned of accident when mayors of Futaba and Namie requested to accept evacuees | — |
| 3.13 | | ca. 10:00 | Kawauchi (in zone 20 km from Daiichi NPS): Received explanation of situation from Site Supervisor of Daini NPS | ca. 1 day 19:14 |
| 3.15 | **—** | **Local NERHQ (Off-site Center) moves to Fukushima Prefectural Office Building** | | **4 days** |
| 3.25 | — | Residents within the zone between a 20 km radius and 30 km radius of NPS recommended to evacuate voluntarily | | 14 days |

Note: Items shaded gray are related to evacuation orders.

**Table 6 Evacuation orders, etc. to residents from each local government**[1,3]

| Date | Time | Evacuation orders, etc. to residents from each local government | Elapsed time (hours:min) |
|---|---|---|---|
| 3.11 | **14:46** | **Great East Japan Earthquake (SCRAM—Automatic shutdown of reactor)** | **0** |
| | ca. 15:37 | Largest tsunami hits | 0:51 |
| | 15:42 | TEPCO/Notification of special situation occurrence at Fukushima Daiichi NPS based on Article 10 of Nuclear Emergency Act (all AC power sources are lost) | 0:56 |
| | 16:45 | TEPCO/Notification of special situation occurrence at Fukushima Daiichi NPS based on Article 15 of Nuclear Emergency Act (Emergency core cooling system fails) | 1:59 |
| | **19:03** | **Government/Declaration of Nuclear Emergency** | **4:17** |
| | 20:50 | Evacuation Order related to Fukushima Daiichi NPS issued by Governor of Fukushima Prefecture<br>Evacuation of residents within radius of 2 km from NPS | 6:04 |
| | 21:23 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 3 km from NPS<br>Shelter in place for residents from radius of 3 km to radius of 10 km from NPS | 6:37 |
| | 0:30 | Okuma (in zone 3 km from Fukushima Daiichi NPS): Evacuation to Tamura, Koriyama, Miharu, Ono | 9:44 |
| | 0:30 | Futaba (in zone 3 km from Fukushima Daiichi NPS): Evacuation to Kawamata | 9:44 |
| 3.12 | 5:44 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within 10 km of NPS | 14:58 |
| | 6:00 | Namie (in zone 10 km from Fukushima Daiichi NPS: Ordered evacuation on its own initiative to outside the 10 km zone | 15:14 |
| | ca. 6:21 | Okuma: evacuation order for all citizens | 15:35 |
| | 7:30 | Futaba: evacuation order for all citizens | 16:44 |
| | 7:45 | Evacuation Order related to Fukushima Daini NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 3 km from NPS<br>Shelter in place for residents from radius of 3 km to radius of 10 km from NPS | 16:59 |
| | 8:30 | Naraha: evacuation order for all citizens (evacuation to Iwaki) | 17:44 |
| | 11:00 | Namie: Ordered evacuation on its own initiative to outside the 20 km zone (evacuation to Tsushima district of Namie, in a northwesterly direction from Fukushima Daiichi NPS) | 20:14 |
| | Morning | Tomioka: Ordered evacuation of all residents on its own initiative (6,000 people evacuated to Kawauchi) | — |
| | **14:30** | **Venting at Unit 1** | **23:44** |
| | **15:36** | **Explosion of Unit 1 reactor building** | **24:50** |
| | 18:25 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within 20 km of NPS | 1 day 3:39 |
| | Evening | Hirono: Appeal for voluntary evacuation to outside of the town (all residents evacuated to Ono) | |
| | — | Tamura: Ordered on its own initiative the evacuation of citizens in the Miyakoji district (all residents within the Miyakoji district evacuated to the Funabiki district) | — |
| | — | Katsurao: Evacuation order for residents within the 20 km zone | — |
| 3.13 | **9:20** | **Venting at Unit 3** | **1 day 18:34** |
| | 6:30 | Minamisoma: Evacuation order for all residents within the 20 km zone (evacuation to Fukushima City, Niigata Prefecture, Gunma Prefecture, etc.) | — |
| | 11:00 | Hirono: Evacuation order for all residents | 1 day 20:14 |
| | — | Kawauchi: Evacuation order for all residents within the 20 km zone (evacuation to Kawauchi Elementary School) | — |
| 3.14 | 9:15 | Katsurao: Evacuation order on its own initiative for all residents (to Fukushima City) | 2 days 18:29 |
| | **11:01** | **Explosion of Unit 3 reactor building** | **2 days 20:15** |
| | **18:06** | **Venting at Unit 2** | **3 days 3:20** |
| 3.15 | **6:12** | **Explosion of Unit 4 reactor building** | **3 days 15:26** |
| | **6:12** | **Serious damage to Unit 2 pressure suppression chamber** | **3 days 15:26** |
| | 11:00 | Residents shelter in place between radius of 20 km and 30 km from NPS | 3 days 20:14 |
| | — | Kawauchi: Voluntary evacuation recommendation | — |
| | — | Kawamata: Planned evacuation of residents of Yamakiya district begins | — |
| | — | Iitate: Planned evacuation begins (evacuation of 500 residents from areas of high radioactivity to Kanuma, from March 19-20) | — |
| | — | Kawauchi: Ordered evacuation of all residents on its own initiative | — |
| 3.25 | — | Residents within the zone between 20 km radius and 30 km radius of NPS recommended to evacuate voluntarily | 14 days |

Note: Items shaded gray are related to evacuation orders by the national government.

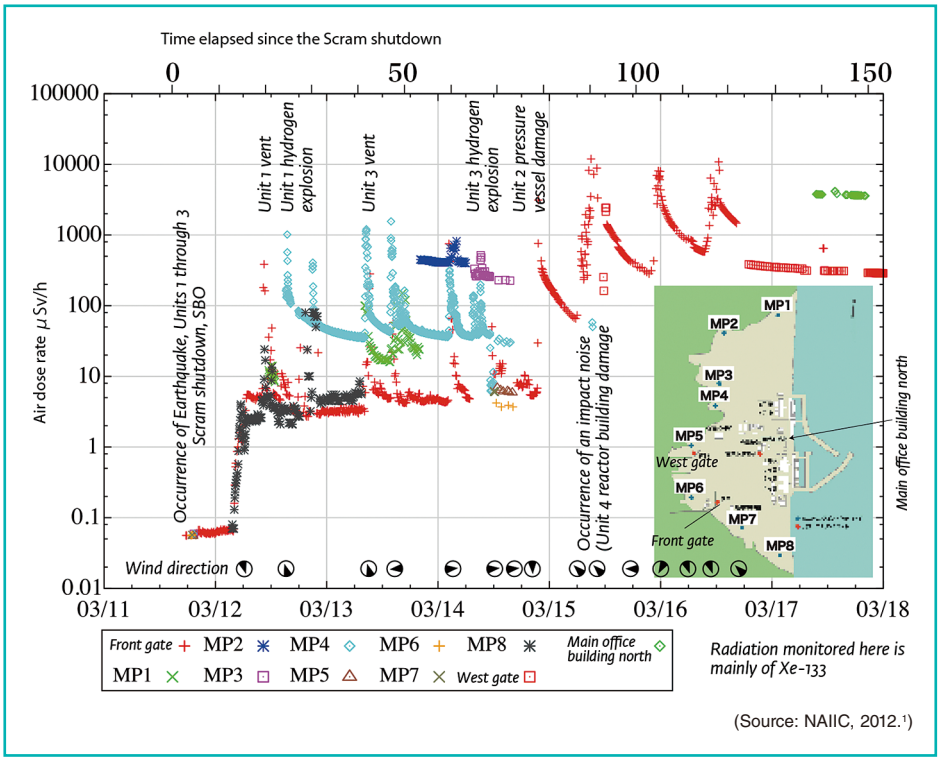


**Fig. 1 Radiation dosage measured by a monitoring car in the Fukushima Daiichi plant**

at 11:00 on March 15 (T + 3 days 20:14), an order was issued to "Shelter in place in the 20-30 km Zone." Here the problem was that only an evacuation order was issued, and there was no order of the direction of evacuation based on scientific data (**Fig. 1, Table 6**).

In other words, this time when the evacuation order was issued, the System for Prediction of Environmental Emergency Dose Information (SPEEDI) was not used.

At the time, the direction in which many residents of the villages of Namie and Futaba evacuated was in the direction of the Tsushima branch office of the Namie village office to the west-northwest to northwest (after noon on March 15, in east-southeast and southeast winds). As a result of this, they ended up evacuating in the direction that the radioactive substances were flowing.

This SPEEDI information, even though information about the emission source was not available, is able to obtain a calculation result for the direction of dispersion by estimating the unit volume emission (emission of 1 Bq/h of radioactive substances). The Ministry of Education, Culture, Sports, Science and Technology of the national government has a great responsibility for its operation and management.

**Problem 12: Evacuation in a northwesterly direction from Fukushima Daiichi NPS**

From March 11 to March 12 and March 15, evacuation was implemented when each local government issued evacuation orders for its residents from late in the night of March 12 through March 16 after receiving evacuation orders from the national government for each zone from 3 km to 30 km. Of the residents who evacuated, there were problems with the residents of the towns of Namie and Futaba having evacuated in east-southeast to southeast winds on March 15 when the explosion in the Unit 4 reactor building and the large-scale damage to the Unit 2 pressure suppression chamber occurred at 6:12 (T + 3 days 15:26) (**Table 6, Fig. 1**).

Due to the occurrence of these events, and readings of 400 mSv/h near Unit 3 as well as

readings of 100 mSv/h near Unit 4 at 10:22 (T + 3 days 19:36), the volume of radioactive emissions from near the main gate on March 15 increased sharply and reached nearly 12 mSv/h at one point (**Fig. 1**).

Because the wind direction after noon was the east-southeast or southeast (with wind blowing in the direction of the west-northwest and northwest), the possibility of radiation exposure was pointed out for the residents of the towns of Namie and Futaba who had already evacuated.

**Problem 13: Residents in the surrounding area forced to evacuate from after noon on March 12 until March 18 at a time when high levels of radiation were anticipated**

The radiation levels on site at the Fukushima Daiichi NPS from March 12 to March 18 exceed 500 μSv/h just after noon at MP4 (monitoring point name from **Fig. 1**, hereafter the same), reached 1,015 μSv/h at 15:29, and the radiation level continued to rise after that as well.[1,3,6] (**Fig. 1, Table 7**).

After this condition continued until March 13, on March 14 levels at the Main Gate monitoring point reached 3,130 μSv/h at 21:37, and at MP6 at 22:23 levels reached 3,200 μSv/h. Next, at 6:12 on March 15 (T + 3 days 15:26), after the Unit 4 reactor building explosion and the large-scale damage to the Unit 2 pressure suppression chamber occurred, at 9:00 the Main Gate recorded a peak of 11,930 μSv/h, and at MP6 at 10:15 a peak of 8,837 μSv/h was measured.

Furthermore, at 10:22, 400 mSv/h was measured near Unit 3,100 mSv/h near Unit 4. These radiation levels were values on site at Fukushima Daiichi NPS, but the fact that these radioactive substance were dispersed by the wind outside the site area to as far as the 30 km zone was anticipated sufficiently by such facts as the cumulative radiation level results from the Tsushima branch office of the Namie village.

The evacuation of residents in the surrounding areas was implemented after noon on March 12 and the time of stay at the evacuation centers was to be at least until March 16. It can be said that the evacuation of the residents of the surrounding areas was forced at a time when high radiation levels were anticipated. Since the average wind speed on March 15 was 1.6 m/s (meters/second), in the five hours from about 10:00 to 15:00 that the southeast wind was blowing, calculations show that radioactive substances were transported as far as 28.8 km.

1.6 m/s × 60 seconds × 60 minutes × 5 hours = 28.8 km

## Residents' Availability of information about the accident and the evacuation orders as well as problems of the actions of residents in the evacuation

**Problem 14: Only just over 30% of the residents were aware of the occurrence of the NPS accident at the stage of the evacuation order for residents in the 10 km zone on March 12.**

The declaration of nuclear emergency was issued on March 11 at 19:30 (T + 4:17), but about ten hours later at the stage when the evacuation order for residents in the 10 km zone at 5:44 (T + 14:58), only just over 30% of the residents were in the broadest sense aware of the occurrence of the NPS accident (**Fig. 2**).

The reason that has been put forward for this is the fact that in the 10 km zone (the towns of Futaba, Okuma, Tomioka and Naraha), the local government was the information source about the accident for only about 30-40% of the residents, while TV, radio and the Internet were the information source for over 30% of the residents, and family and neighbors were the information source for most of the remainder. In addition, when the zone was expanded to 20 km, there was a tendency for the local government to be the information source for an even smaller number of residents, while TV, radio and the Internet became even more prevalent (**Fig. 3**).

In other words, accurate information about the accident should have been made known by the local government, but since they had not been informed by the local government, residents variously used TV, radio and the Internet or their families and neighbors for gathering information, and it was found that due to this there were few residents who had knowledge of the occurrence of the accident.

**Problem 15: There was a large gap in awareness of the evacuation order among the residents in the 20 km zone on March 13.**

The evacuation order from the national government for residents in the 20 km zone was issued on March 12 at 18:25 (T + 27:39), but one day later at the end of the day on March 13, there was a large gap in the percentage of residents in the 20 km zone with awareness of this evacuation order from over 10% to over 90%, depend-

**Table 7 Status of leaks of radioactive substances at Fukushima Daiichi NPS site area**[1,3,6]

| Date | Time | Value measured at monitoring posts in NPS site area (μSv/h) | | | Elapsed time (hours:min) |
|---|---|---|---|---|---|
| | | Main gate | MP4 | MP6 | |
| 3.11 | **14:46** | **Great East Japan Earthquake (SCRAM—Automatic shutdown of reactor)** | | | **0** |
| | 15:12 | **normal** | **normal** | **normal** | |
| | ca. 15:37 | Largest tsunami hits | | | 0:51 |
| | **19:03** | **Government/Declaration of Nuclear Emergency** | | | 4:17 |
| | 20:50 | Evacuation Order related to Fukushima Daiichi NPS issued by Governor of Fukushima Prefecture<br>Evacuation of residents within radius of 2 km from NPS | | | 6:04 |
| | 21:23 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 3 km from NPS<br>Shelter in place for residents from radius of 3 km to radius of 10 km from NPS | | | 6:37 |
| 3.12 | 0:30 | Okuma (2 km zone): Evacuation action for residents within 3 km zone | | | 9:44 |
| | 0:30 | Futaba (2 km zone): Evacuation action for residents within 3 km zone | | | 9:44 |
| | 5:44 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 10 km from NPS | | | 14:58 |
| | 6:00 | Namie (5 km zone): Evacuation order on its own initiative for residents within 10 km zone | | | 15:14 |
| | ca. 6:21 | Okuma (2 km zone): Evacuation order for all residents | | | 15:35 |
| | 7:30 | Futaba (2 km zone): Evacuation order for all residents | | | 16:44 |
| | 7:45 | Evacuation Order related to Fukushima Daini NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 3 km from NPS<br>Shelter in place for residents from radius of 3 km to radius of 10 km from NPS | | | 16:59 |
| | 8:30 | Naraha (3 km zone): Evacuation order for all residents | | | 17:44 |
| | 11:00 | Namie (5 km zone): Evacuation order on its own initiative to outside the 20 km zone | | | 20:14 |
| | Morning | Tomioka (3 km zone): Evacuation order on its own initiative for all residents | | | — |
| | **14:30** | **Venting at Unit 1** | | | **23:44** |
| | 15:29 | — | **1,015** | — | 24:43 |
| | **15:36** | **Explosion of Unit 1 reactor building** | | | 24:50 |
| | 18:25 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within 20 km of NPS | | | 1 day 3:39 |
| | Night | Hirono (10 km zone): Appeal to residents to evacuate voluntarily outside of the town | | | — |
| | — | Tamura (20 km zone): Evacuation order on its own initiative for entire Miyakoji district | | | — |
| | — | Katsurao (20 km zone): Evacuation order for all residents within the 20 km zone | | | — |
| 3.13 | 8:33 | — | **1,204** | — | 1 day 17:47 |
| | **9:20** | **Venting at Unit 3** | | | **1 day 18:34** |
| | 11:00 | Hirono (10 km zone): Evacuation order for all residents | | | 1 day 20:14 |
| | 13:52 | — | **1,558** | — | 1 day 23:06 |
| | — | Kawauchi (20 km zone): Evacuation order for all residents within 20 km zone | | | |
| 3.14 | 2:20 | — | — | **751** | 2 days 11:34 |
| | 3:30 | **433** | — | — | 2 days 12:44 |
| | 9:15 | Katsurao (20 km zone): Evacuation order on its own initiative for all residents | | | 2 days 18:29 |
| | **11:01** | **Explosion of Unit 3 reactor building** | | | **2 days 20:15** |
| | **18:06** | **Venting at Unit 2** | | | **3 days 3:20** |
| | 21:37 | **3,130** | — | — | 3 days 6:51 |
| | 22:23 | — | — | **3,200** | 3 days 7:37 |
| 3.15 | **6:12** | **Explosion of Unit 4 reactor building** | | | **3 days 15:26** |
| | **6:12** | **Severe damage to Unit 2 pressure suppression chamber** | | | **3 days 15:26** |
| | 8:31 | **8,217** | — | — | 3 days 17:45 |
| | 9:00 | **11,930** | — | — | 3 days 18:14 |
| | 10:15 | — | — | **8,837** | 3 days 19:29 |
| | 10:22 | **400 mSv/h in area around Unit 3**<br>**100 mSv/h in area around Unit 4** | | | 3 days 19:36 |
| | 11:00 | Residents within zone between 20 km radius and 30 km radius shelter in place | | | 3 days 20:14 |
| | 23:30 | **8,080** | — | — | 4 days 8:44 |
| | — | Kawauchi (20 km zone): Recommendation for voluntary evacuation | | | — |
| | — | Kawamata (50 km zone): Planned evacuation begins of residents in Yamakiya district | | | — |
| | — | Iitate (30 km zone): Planned evacuation begins | | | — |
| 3.16 | 6:40 | **400 mSv/h in the west area of Unit 3**<br>**100 mSv/h in the west area of Unit 4** | | | 3 days 19:36 |
| | 8:47 | **150 mSv/h in area around Unit 2**<br>**300 mSv/h in area between Units 2 and 3**<br>**400 mSv/h in area around Unit 3** | | | 3 days 19:36 |
| | 10:40 | **10,000** | — | — | 4 days 19:54 |
| | 12:30 | **10,851** | — | — | 4 days 21:44 |
| | — | Kawauchi (20 km zone): Evacuation order on its own initiative for all residents | | | — |

Note 1: Values for each monitoring post are displayed at the time when they exceeded 400 μSV/h and afterwards at the time when these values exceeded earlier values shown.
Note 2: Items shaded gray are related to the evacuation orders by the national government.
Note 3: Items in parentheses are evacuation order distances to whichever is closer, Fukushima Daiichi NPS or Fukushima Daini NPS.

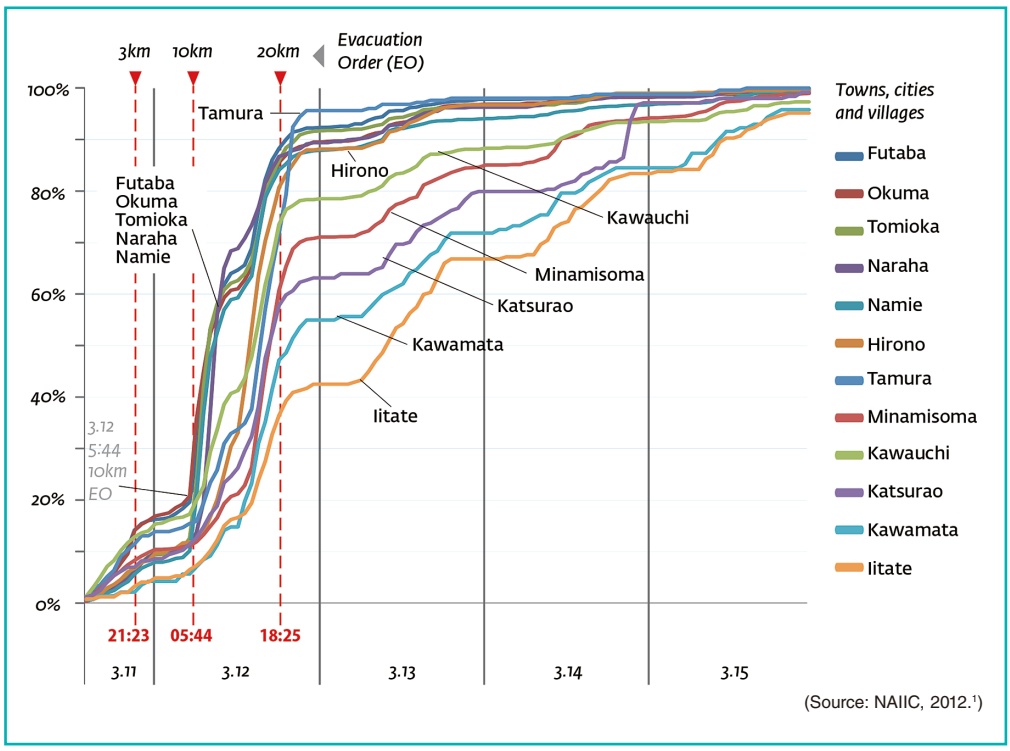


**Fig. 2 Percentage of residents who were aware that the accident had occurred (100 percent: evacuated residents)**

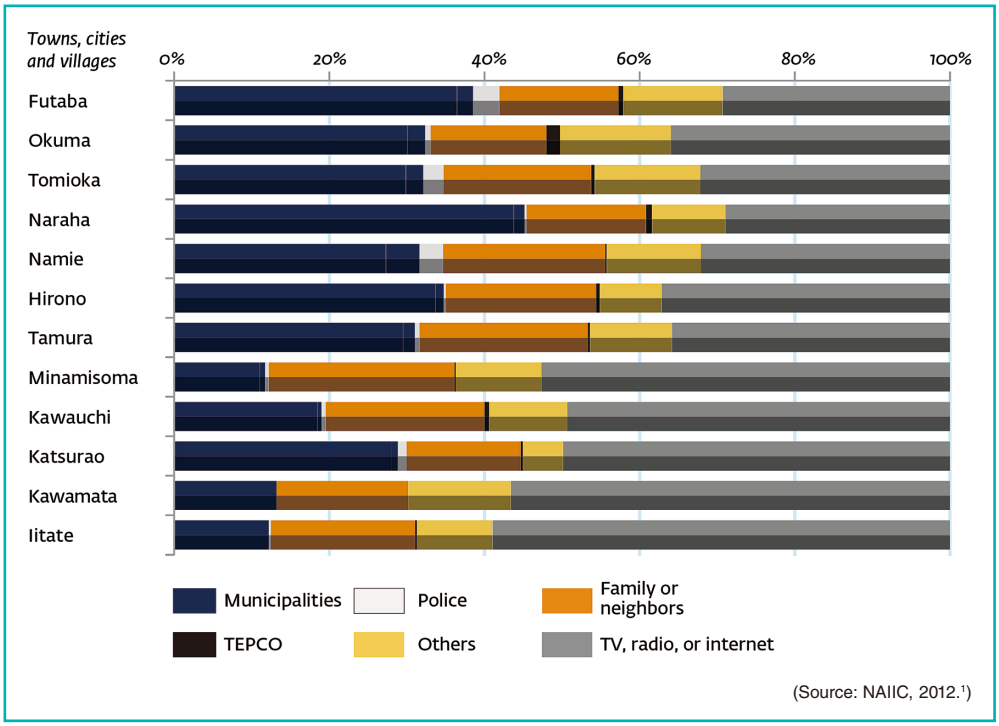


**Fig. 3 Source(s) of information concerning the accident**

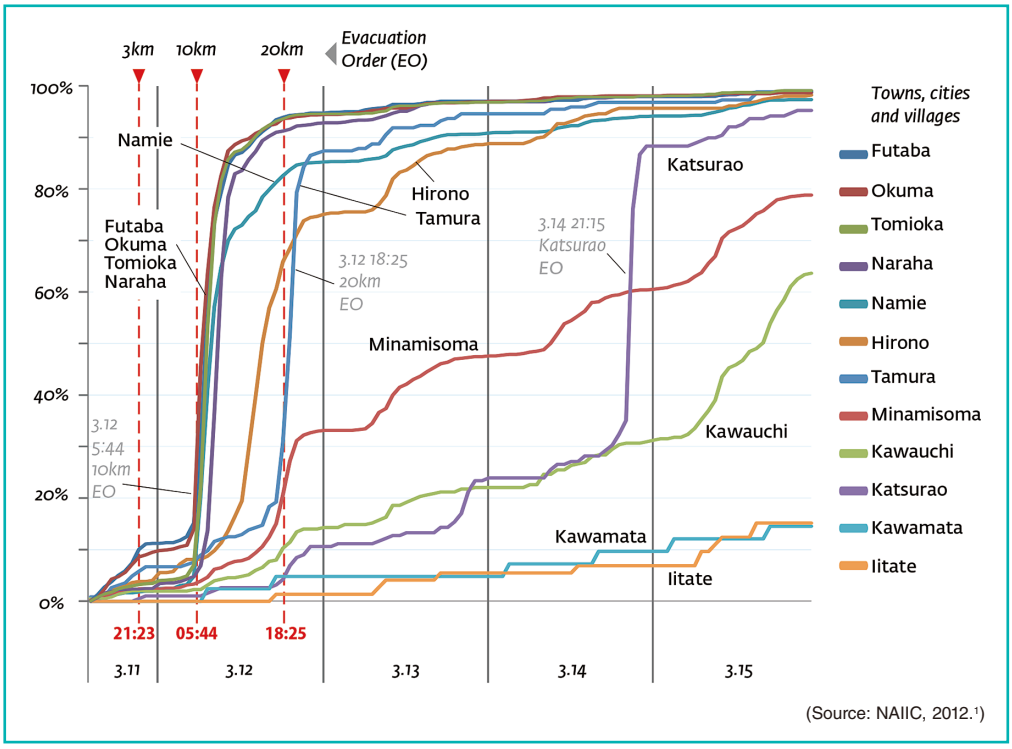


**Fig. 4 Percentage of residents who had knowledge of the respective evacuation orders (100 percent: Residents who were evacuated)**

ing on the municipality (**Fig. 4**).

The municipalities with a high percentage of evacuation of residents ordered to evacuate the 20 km zone were mostly at the site of Fukushima Daiichi and Daini NPS such as the towns of Futaba, Okuma, Tomioka and Naraha. The municipalities with the next highest percentage of evacuation were in the surrounding areas: the towns of Namie and Hirono and Tamura City. By contrast, the lowest were those further than 10 km from Fukushima Daiichi NPS: Minamisoma City and the villages of Kawauchi and Katsurao. The Katsurao village had the lowest percentage of evacuation, just over 10%.

Local governments as the source of information about the evacuation, with the exception of a few municipalities, rose to 50-60%, much higher than for awareness about the occurrence of the accident, but since in fact the share of residents who had knowledge of the evacuation order was low, how to inform residents as a whole was a problem. On the other hand, in most municipalities, TV, radio and the Internet was the information source about the evacuation order for only about 10-20% of the residents, which showed the limits of TV, radio and the Internet as an information source.

**Problem 16: There was a large gap in the percentage of residents ordered to evacuate the 20 km zone who actually evacuated on March 13.** The evacuation order from the national government ordering the evacuation of residents in the 20 km zone was issued on March 12 at 18:25 (T + 27:39), but one day later at the end of the day on March 13, there was a wide range in the proportion of residents in the 20 km zone who had actually evacuated, from over 20% to over 90%, depending on the locality (**Fig. 5**).

The municipalities with a high percentage of evacuation of residents ordered to evacuate the 20 km zone were mostly at the site of Fukushima Daiichi and Daini NPS such as the towns of Futaba, Okuma, Tomioka and Naraha with large numbers of residents. The municipalities with the next highest percentage of evacuation were in the surrounding areas: the towns of Namie and

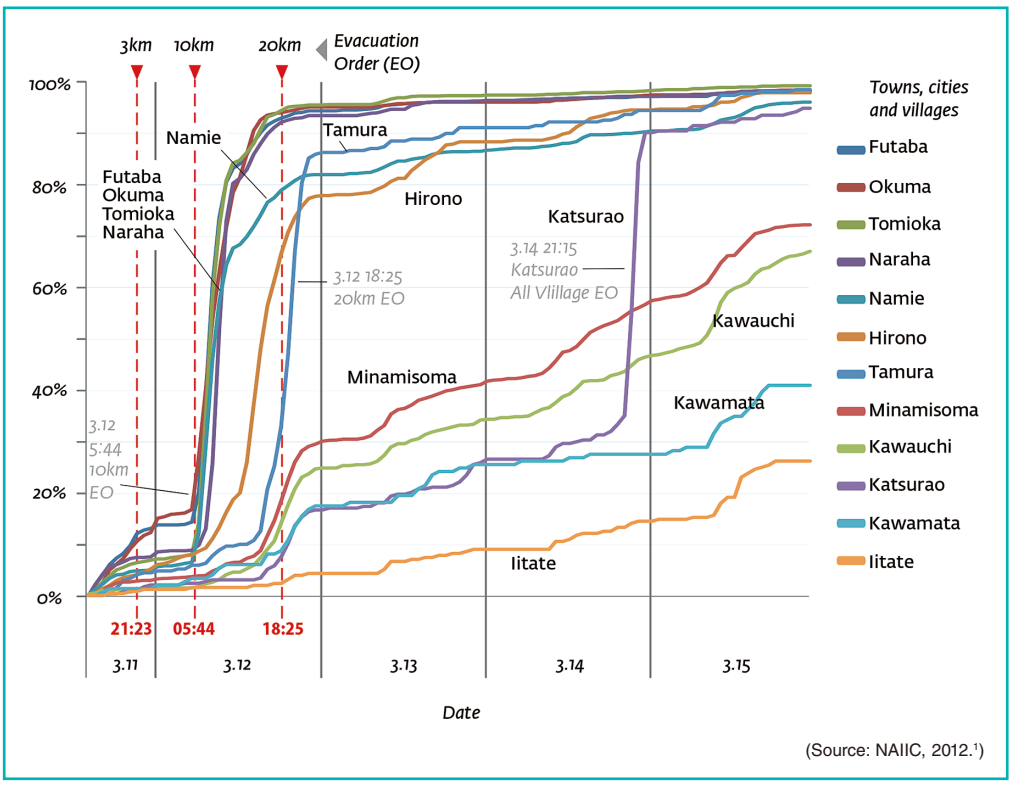


**Fig. 5 Percentage of evacuated residents**

Hirono and Tamura City. By contrast, the lowest were those further than 10 km from Fukushima Daiichi NPS: Minamisoma City, and the villages of Kawauchi and Katsurao.

It was found that as one of the reasons that the municipality had the highest evacuation percentages was the high degree of communication of information from the local governments and the high level of urgency of the residents themselves about suffering damage.

**Problem 17: High numbers of residents evacuated voluntarily in areas further from the NPS.**

Other than in the municipalities at the site, the percentage of residents evacuating based on their own judgment among the residents ordered to evacuate from the 20 km zone was relatively high in the region at some distance from the NPS, in Kawauchi village and Minamisoma City (there had also been an order for the planned evacuation of Kawauchi village), at over 40% to just under 60%. By contrast, the percentage was much lower, from over 10% to just under 20% in the municipalities at the site, the towns of Futaba, Okuma, Tomioka and Naraha.

This phenomenon should be considered sufficiently at the time of deliberations of the time required for evacuation and related matters in preparation for future nuclear accidents.

## Problems with the evacuation of hospitals

**Problem 18: Public hospitals with easy access to information evacuated at the same time as residents, while the evacuation of private sector hospitals could be later than that of the residents**

Of the hospitals within the 20 km zone from Fukushima Daiichi and Daini NPS, two were public hospitals (Oono Prefectural Hospital, Minamisoma Odaka Municipal Hospital) and five were private hospitals. Of these, the two public hospitals evacuated at about the same time as the residents: Oono Prefectural Hospital on the morning of March 12, and Minamisoma Odaka Municipal Hospital evacuated on March 13. On the other hand, other than the JA-related Futaba Kosei Hospital, evacuation was later than for the residents, and they evacuated from the

evening of March 13 through March 15 (**Table 8**).

Of the five hospitals, Odaka Akasaka Hospital requested assistance from the Odaka ward office on March 12 and 13 but received none, and on March 14, police who visited the hospital provided a bus in the evening. Furthermore, Futaba Hospital did not receive any support for severely ill patients from the town, and from March 12, requests for assistance from firefighters, police and the Self Defense Forces (SDF), but the bus for the transport of severely ill patients and SDF vehicles arrived on March 14 and 15.

**Problem 19: The main reason for the deaths of the severely ill patients was the long time for transportation.**

Of the severely ill patients in Futaba Hospital, three patients died in the bus during transport, eleven more died after arrival the next day at their destination (Iwaki City) and by the end of March a total of 40 people had died. The number of patients who died was dramatically higher than at other hospitals (**Table 8**).

The length of the travel time was found to be one of the reasons for this.

The bus of severely ill patients from Futaba Hospital departed at 10:30 on March 14 (T+2 days 19:44), first went to Minamisoma Soso Health Center at 14:00, and after than stopped in Fukushima City, arriving finally at a high school in Iwaki City at 20:00. This travel time totaled nine and one half hours.

It was found that as a response for the future, planned designation in advance is necessary to secure nearer hospitals able to admit the severely ill patients from hospitals that must be evacuated on the occasion of a nuclear accident.

## Problems in the Order for Distribution and Intake of Stable Iodine Tablets

**Problem 20: Order for distribution and intake of stable iodine tablets after dispersion of radioactive substances from venting and reactor building explosion**

When the intake of stable iodine tablets is done before internal exposure to radioactive substances, it has an effectiveness of 100%. But after this accident, four local governments (the towns of Tomioka, Futaba, Okuma and Miharu) issued intake orders, but all of these were issued after considerable period of time had passed since the aerial dispersion of radioactive substances as a result of venting operation at Unit 1 on March 12 at 14:30 (T+23:44) and the explosion of the reactor building at 15:36 (T+24:50) on the same day (**Table 9**).

More specifically, the intake order of Tomioka (21,000 tables distributed) lasted from the evening of the day of venting at Unit 1 until the next day (March 13), in Futaba (intake by at least 845 people) the order was on the day after venting at Unit 1, in Okuma (intake by 340 people who had evacuated to Miharu) the order was on the second day after venting at Unit 1 (March 15), and in Miharu (intake by 7,520 people) and Okuma the order was on the second day after venting at Unit 1.

All residents of Tomioka, Futaba, and Okuma had been ordered to evacuate no later than the morning of March 12 and had already moved away from the Daiichi NPS. However, because of the fact that the intake order was issued after a considerable time had passed after the dispersion of radioactive substances, the dispersion of the radioactive plume had reached 30 km in the five hours, as shown in the previous calculation, much doubts remained about its effectiveness.

**Problem 21: Tablets were distributed but there was no intake order.**

There were some local governments which had taken the positive step to distribute stable iodine tablets, which are highly effective as a protective measure against thyroid cancer due to radioactive substances, but did not issue an intake order (**Table 9**).

More specifically, tablets were distributed to individuals in Iwaki City (the morning of March 16, 152,500 people, 257,700 tablets) and in Naraha town (the morning of March 15, 3,000 people) but the intake order was not issued for reasons such as because there was no information about the level of airborne radiation, the timing of when to take them was not known, or they had waited for orders from the Fukushima Prefectural Government.

Furthermore, it was determined that residents who had evacuated to Tsushima district in Namie village had been exposed to the radioactive plume, but stable iodine tablets were distributed on March 13 and 14 in the evacuation center to the 8,000 people who had evacuated to Tsushima district. However, there was no order issued for the intake of these tablets.

**Table 8 Timing of evacuation and means of transportation of seven hospitals within the 20 km zone around Fukushima Daiichi NPS[1]**

| Date | Time | Timing of evacuation and access to transportation of the seven hospitals within the 20 km zone | Elapsed time (hours:min) |
|---|---|---|---|
| 3.11 | **14:46** | **Great East Japan Earthquake (SCRAM—Automatic shutdown of reactor)** | **0** |
| | ca. 15:37 | Largest tsunami hits | 0:51 |
| | **19:03** | **Government/Declaration of Nuclear Emergency** | **4:17** |
| | 20:50 | Evacuation Order related to Fukushima Daiichi NPS issued by Governor of Fukushima Prefecture<br>Evacuation of residents within radius of 2 km from NPS | 6:04 |
| | 21:23 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 3 km from NPS<br>Shelter in place for residents from radius of 3 km to radius of 10 km from NPS | 6:37 |
| 3.12 | 5:44 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within 10 km of NPS | 14:58 |
| | 7:45 | Evacuation Order related to Fukushima Daini NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 3 km from NPS<br>Shelter in place for residents from radius of 3 km to radius of 10 km from NPS | 16:59 |
| | Morning | Oono Prefectural Hospital: 35 inpatients in departments including Internal Medicine and Gastroenterology evacuated at about the same time as other residents. Seriously ill patients were evacuated by ambulance (no patients died by the end of March). | — |
| | **14:30** | **Venting at Unit 1** | **23:44** |
| | **15:36** | **Explosion of Unit 1 reactor building** | **24:50** |
| | 18:25 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within 20 km of NPS | 1 day 3:39 |
| | Evening until morning of 3.13 | Futaba Kosei Hospital in the 5 km zone: 136 inpatients in departments including Internal Medicine, Obstetrics and Gynecology, and Pediatric Medicine evacuated at about the same time as the other residents. Seriously ill patients were evacuated by SDF helicopter (4 patients died by the end of March). | — |
| 3.13 | **9:20** | **Venting at Unit 3** | **1 day 18:34** |
| | — | Minamisoma Odaka Municipal Hospital in the 20 km zone: 68 inpatients in departments including Internal Medicine, Surgery, Ophthalmology and Radiology were evacuated at about the same time as the other residents. Seriously ill patients were evacuated by ambulance and microbus (no patients died by the end of March). | — |
| | Evening until morning of 3.14 | Imamura Hospital, within 10 km zone: 96 inpatients in departments including Internal Medicine and Cardiovascular Medicine evacuated later than other residents. Seriously ill patients evacuated by SDF helicopter (3 patients died by the end of March). | — |
| | 10:30 | Futaba Hospital, within 5 km zone: 339 inpatients in departments including Psychiatric Medicine and Internal Medicine evacuated later than other residents. Seriously ill patients were evacuated by SDF vehicles and busses (40 patients died by the end of March). | — |
| 3.14 | **11:01** | **Explosion of Unit 3 reactor building** | **2 days 20:15** |
| | **18:06** | **Venting at Unit 2** | **3 days 3:20** |
| | Evening | Odaka Akasaka Hospital, within 20 km zone: 104 inpatients in departments including Psychiatric Medicine, Internal Medicine and Clinical Medicine evacuated later than other residents. Seriously ill patients were evacuated by and busses (no patients died by the end of March). | — |
| | Evening | Nishi Hospital, within 10 km zone: 75 inpatients in Internal Medicine and other departments, most of whom were undergoing dialysis treatment, were evacuated later than other residents. Seriously ill patients were evacuated by SDF helicopter and police vehicles (3 patients died by the end of March). | — |
| 3.15 | **6:12** | **Explosion of Unit 4 reactor building** | **3 days 15:26** |
| | **6:12** | **Serious damage to Unit 2 pressure suppression chamber** | **3 days 15:26** |
| | 11:00 | Residents between 20 km radius and 30 km radius from NPS shelter in place | 3 days 20:14 |

Note: Items shaded gray are related to evacuation orders issued by the national government.

**Table 9 Status of local governments that distributed and ordered intake of stable iodine tablets**[1]

| Date | Time | Status of local governments that distributed and ordered intake of stable iodine tablets | Elapsed time (hours:min) |
|---|---|---|---|
| 3.11 | **14:46** | **Great East Japan Earthquake (SCRAM—Automatic shutdown of reactor)** | **0** |
| | ca. 15:37 | Largest tsunami hits | 0:51 |
| | **19:03** | **Government/Declaration of Nuclear Emergency** | **4:17** |
| | 20:50 | Evacuation Order related to Fukushima Daiichi NPS issued by Governor of Fukushima Prefecture<br>Evacuation of residents within radius of 2 km from NPS | 6:04 |
| | 21:23 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 3 km from NPS<br>Shelter in place for residents from radius of 3 km to radius of 10 km from NPS | 6:37 |
| 3.12 | 0:30 | Okuma (2 km zone): Evacuation action for residents within 3 km zone | 9:44 |
| | 0:30 | Futaba (2 km zone): Evacuation action for residents within 3 km zone | 9:44 |
| | 5:44 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 10 km from NPS | 14:58 |
| | 6:00 | Namie (5 km zone): Evacuation order for residents within 10 km zone | 15:14 |
| | ca. 6:21 | Okuma (2 km zone): Evacuation order for all residents | 15:35 |
| | 7:30 | Futaba (2 km zone): Evacuation order for all residents | 16:44 |
| | 7:45 | Evacuation Order related to Fukushima Daini NPS issued by NERHQ Chief<br>Evacuation of residents within radius of 3 km from NPS<br>Shelter in place for residents from radius of 3 km to radius of 10 km from NPS | 16:59 |
| | 8:30 | Naraha (3 km zone): Evacuation order for all residents | 17:44 |
| | 11:00 | Namie (5 km zone): Evacuation order on its own initiative to outside the 10 km zone | 20:14 |
| | Morning | Tomioka (3 km zone): Evacuation order on its own initiative for all residents | — |
| | **14:30** | **Venting at Unit 1** | **23:44** |
| | **15:36** | **Explosion of Unit 1 reactor building** | **24:50** |
| | 18:25 | Evacuation Order related to Fukushima Daiichi NPS issued by NERHQ Chief<br>Evacuation of residents within 20 km of NPS | 1 day 3:39 |
| | **Night** | **● Tomioka: Iodine tablet intake order (21,000 tablets distributed)** | **—** |
| 3.13 | **9:20** | **Venting at Unit 3** | **1 day 18:34** |
| | | **● Futaba: Iodine tablet intake order for residents who had evacuated to Kawamata (intake by 845 people)** | **—** |
| | **3.13-14** | **Namie: Distribution only of iodine tablets at Tsushima District evacuation center, intake waited for order from Prefectural Government (8,000 people)** | **—** |
| 3.14 | **11:01** | **Explosion of Unit 3 reactor building** | **2 days 20:15** |
| | **18:06** | **Unit 2 vent operation** | **3 days 3:20** |
| 3.15 | **6:12** | **Explosion of Unit 4 reactor building** | **3 days 15:26** |
| | **6:12** | **Severe damage to Unit 2 pressure suppression chamber** | **3 days 15:26** |
| | 11:00 | Residents within zone between 20 km radius and 30 km radius shelter in place | 3 days 20:14 |
| | **13:00-18:00** | **● Miharu: Intake order for iodine tablets (7,250 people)** | **—** |
| | **Afternoon** | **Naraha: Distribution only of iodine tablets to individuals who had evacuated to Iwaki City, intake waited for order from Prefectural Government (3,000 people)** | **—** |
| | **—** | **● Okuma: Intake order for iodine tablets for residents who had evacuated to Miharu (340 people)** | **—** |
| 3.16 | 10:35 | Order from NERHQ Chief to Fukushima Prefecture Governor<br>Intake of stable iodine tablets to all residents remaining in the evacuation zone (20 km radius) at the time of the emergency. (At the point in time when the order was issued, evacuation had already been completed, so there were no residents who took stable iodine tablets based on this order) | 4 days 19:49 |
| | **Afternoon** | **Iwaki: Iodine tablets only distributed to individuals, intake waited for order from Prefectural Government (152,000 people, 257,000 tablets)** | **—** |

Note 1: **● indicates that an intake order was issued, local governments without this mark only distributed.**
Note 2: Items shaded gray are related to the evacuation orders by the national government.
Note 3: Items in parentheses are evacuation order distances to whichever is closer, Fukushima Daiichi NPS or Fukushima Daini NPS.

As described above, the distribution without an intake order produced the problem that the valuable stable iodine tablets ended up being wasted.

**Problem 22: The failure of the intake order for stable iodine tablets issued by the national government**

The local governments which issued their own intake orders ended their intake orders from March 13 to March 15. But after these ended, on March 16 at 10:35 (T + 4 days 19:49), there was an order from the NERHQ of national government to the Governor of Fukushima Prefecture for the intake of stable iodine tablets at the time of evacuation to all people still in the evacuation zone (within a 20 km radius)[7] (**Table 9**).

There was a significant problem: at the time of this order, because the evacuation had already been completed, there were no residents who took stable iodine tablets on the basis of this order,[7] and the intake order for stable iodine tablets issued by the national government ended up as a failure.

**Problem 23: The order of the Japan Society of Obstetrics and Gynecology to administer potassium iodine tablets to pregnant and nursing women was ignored.**

The Japan Society of Obstetrics and Gynecology, a public interest corporation, published on its web site on March 15 the document, "The Administration of Potassium Iodide Tablets (for Prevention of Developing Thyroid Cancer) to Pregnant and Nursing Women at the Time of Radiation Exposure due to the Fukushima Nuclear Accident."[8]

The main points of the document are the two following points, but there is a problem that the national government and many scientific societies have ignored them.

1. Even when it is unclear whether there has been radiation exposure, if pregnant women and nursing mothers are under 40 years old, they should be instructed to take two 50 mg tablets of potassium iodide (100 mg).
2. Pregnant women should be preferentially evacuated from land where there is a risk.

## Problems in the Nuclear Emergency Response Guidelines from the Perspective of the Actual Conditions and Problems Related to the Evacuation Orders and Iodine Tablet Intake Orders in the Fukushima Daiichi NPS Accident

### The Basic concept of the Nuclear Emergency Response Guidelines

**Problem 24: The guidelines lack constructive responses to the "closed-door" nature of nuclear emergencies that hinder the provision of information to residents**

It is clearly stated that "Disaster preparedness plans shall be formulated from the perspective of the residents" as a basic concept of the Nuclear Emergency Response Guidelines[4] among its "Objectives and Purposes," and this perspective should be reflected in the specific details of the Guidelines. However, five special characteristics of nuclear emergencies are listed in the guidelines, and the most important "closed-door" nature of nuclear emergencies is overlooked.

Even in tsunami emergencies in which it is comparatively easier for residents to obtain information than in nuclear emergencies, drastic changes in policies are being considered because of the enormous damage that was caused this time. By contrast, on the occasion of the Fukushima Daiichi NPS accident, information about the accident at the NPS and evacuation was withheld to the extent that residents were almost entirely ignored, which produced a problem that can be called an 'information disaster'[9] (**Table 10**).

Because of this, even more than in tsunami emergencies, we need to stand in the position of citizens and residents affected by the disaster, and provide information about the NPS accident in real time, so that residents in each region can take immediate actions including evacuation and the intake of stable iodine tablets.

**Problem 25: The responsibility of securing the safety of residents and citizens, specific divisions of roles and actions should be clearly stated as the responsibility of the nuclear power operator.**

It is clearly stated in the Guidelines, Chapter 1 Nuclear Emergencies, (1) Nuclear Emergencies and the Responsibilities of the Nuclear Power Operator, that "the nuclear power operator must recognize the fact that it has the primary responsibility for the convergence of events such as an accident that are the cause of the emergency,

**Table 10 Comparison of the special characteristics of the damage caused by the tsunami disaster and the nuclear accident in the Great East Japan Earthquake**

| Provision to residents of information | Occurrence of the Great East Japan Earthquake (Northeast Japan Pacific Ocean Earthquake) | |
|---|---|---|
| | Large scale tsunami disaster (visible disaster) | Nuclear accident such as core meltdown (invisible disaster in a black box) |
| Information about **the location** of the disaster | Location of epicenter of earthquake was **provided quickly** to residents by earthquake and tsunami information provision system. | Details of the accident at Fukushima Daiichi and Daini NPS were either announced by the government or, until the hydrogen explosion, **not clearly communicated for several days**. |
| Information about **the scale and details** of the disaster | The magnitude of the earthquake was **provided quickly** to residents. | Information was **provided only slowly** by the government.<br>Accident was classified as Level 7 only **after about one month** after its occurrence. |
| | There were **almost no factors that blocked communication** in the process of information provision such as meetings. | There were **a high number of factors that blocked communication** in the process of information provision such as meetings. |
| Information **necessary for evacuation** | There were some minor errors concerning the scale of the tsunami but it was **provided quickly** to residents. | Accurate information about radiation level values were **basically not provided to residents** in the area surrounding the NPS. |
| | The direction of evacuation relative to the tsunami was generally away from the ocean, and this was **generally known** to the residents. | The volume of inhaled aerial radiation and direction of dispersion from SPEEDI were **basically not provided** to residents in the area surrounding the NPS. |
| | The methods of evacuation relative to the tsunami was generally going up to higher ground, and this was **generally known** to the residents. | **Almost none** of the residents in the area surrounding the NPS knew about the methods of evacuation from radioactive substances. |

(Source: Hatanaka T. JMAJ, 2012.[9])

and also has a large responsibility for actions in a nuclear emergency," but it should also clearly state specifically how roles are divided in which response areas in practice, and how these responses are to be made.

Furthermore, the responsibility to secure the safety of residents of the surrounding areas or more expansively of all citizens is not clearly stated as the responsibility of the nuclear power operator, and the Guidelines should state this clearly.

Specifically, whether in the case of a site area emergency or a general emergency, the Guidelines should state clearly that along with communication with local governments, the preparation of preventive protective actions, and the implementation of evacuation within the Urgent Protective action planning Zone (UPZ) in which urgent protective actions had been prepared (within 30 km). The Guidelines should also state clearly specific responses such as a duty to notify local governments of Article 15 notifications, a duty to assist evacuation of evacuees from a site area emergency, and a duty to compensate receiving hospitals.

## Staged responses to urgent situations in the Guidelines

**Problem 26: For NPS accidents due to large-scale earthquakes, site area emergencies and general emergencies should be responded in an integrated manner.**

In the Guidelines, protective actions for residents are listed in three categories as the basic concept for implementation of protective actions in an urgent situation. What is a problem is that the Guidelines try to separate the responses by dividing protective actions for residents and

**Table 11 Basic concept for implementation of protective actions in emergencies**[10]

| Category | Alert | Site area emergency | General emergency |
|---|---|---|---|
| | At the time, there is no emergency that has or threatens to have an impact on the general public due to radiation. However, since there is an unusual incident at the NPS facility, at this stage it is necessary to begin information collection and protective actions such as preparation for emergency monitoring and preparation for evacuation of persons at the site area who require evacuation in an emergency* | Because an incident has occurred at the NPS facility which may possibly have an impact on the general public due to radiation, at this stage it is necessary to begin preparation for the main protective actions such as the evacuation of areas surrounding the NPS planned for emergencies. | Because an incident has occurred at the NPS facility which is highly likely to have an impact on the general public due to radiation, at this stage it is necessary to implement rapid protective actions in order to avoid a definite effect and to minimize the risk of stochastic effect. |
| **Accident situation** | | | |
| • Effect of radiation on the general public (listed in the Nuclear Emergency Response Guidelines) | None (not an emergency) | Almost none (possible) | Yes (high possibility) |
| **Main countermeasures** | | | |
| • Emergency monitoring | Preparations | Implementation | (Implementation) |
| • Prophylactic evacuation of persons requiring evacuation* | Preparations | Implementation | (Implementation) |
| • Protective actions for residents and others | | Preparations | Implementation |
| **Laws and statutes** | | | |
| • Act on Special Measures Concerning Nuclear Emergency Preparedness | — | Article 10 (Notification event) | Article 15 (Nuclear emergency) |

* Persons requiring evacuation: people who need more time than usual when evacuation is carried out, and people who require support during an emergency so that the health risk from carrying out evacuation is not increased (sick or injured people, inpatients, elderly, disabled, foreign citizens, infants and small children, pregnant women and other persons who require support during an emergency), people to whom stable iodine tablets were not distributed in advance, and among the people for whom intake of stable iodine tablets is contraindicated, those for whom it is necessary to implement protective actions such as early evacuation during a site area emergency.

others into the categories of site area emergency (Article 10 situations under the Nuclear Emergency Act) and general emergency (Article 15 situations under the Nuclear Emergency Act)[10] (**Table 11**).

For site area emergencies, the impact of radiation on the general public is stated to be nearly zero (although there is a possibility), and other than the implementation of preventive evacuation, the protective actions for citizens and others stop at the preparation stage. On the other hand, for general emergencies, it is stated that there is an impact of radiation on the general public, and protective actions for citizens and other are implemented.

But in the Fukushima Daiichi NPS accident, there was only one hour of time difference between the site area emergency and general emergency. In the event that another disaster similar to the Great East Japan Earthquake occurs, this kind of division only invites confusion, and if a site area emergency occurs, actions should also be taken to prepare for a general emergency (**Table 1**).

## The flow of emergency information communication in the Guidelines

**Problem 27: In any kind of emergency, local governments and the general public should be notified immediately of NPS accidents and the status of the emergency.**

**Figure 6** shows the degree of emergency, sequence of communication from the nuclear power operator to the national government, local governments and the general public and others about the occurrence of an emergency and the status of the facility accident for each type of emergency stated in the Guidelines. Here, it is a problem that the concept for protective actions for residents and others is divided into the categories of "alert," "site area emergency" and "general emergency." There are also problems in that the scope of local governments that are to be the targets of communication by the nuclear power operator and the national government is not clearly stated, and in that there is no need for the nuclear power operator to inform local governments and the general public and others immediately at the "alert" stage (**Fig. 6**).

There were many local governments which were not notified of the occurrence of the Fukushima Daiichi NPS accident by the national government or by the nuclear power operator, and as a result of this, residents were of course also not notified by local governments, and this caused many residents to be unaware of the occurrence of the accident. On the other hand, the national government ended up ordering residents between the 20 km radius and the 30 km radius to shelter in place (T + 3 days 20:14) and voluntary evacuation (T + 14 days).

In any kind of emergency, local governments, the general public, and others should be notified immediately of the status of the NPS.

**Problem 28: In the event of a large-scale earthquake, in any kind of emergency, local governments, the general public, and others within a 30 km zone should be notified of the status of the NPS.**

After the SCRAM occurred at the Fukushima Daiichi NPS, the notification of a site area emergency came 56 minutes later, and the notification of a general emergency came one hour and 56 minutes later from TEPCO to the national government. The towns of Okuma and Futaba were notified by TEPCO in a telephone communication, and the neighboring Hirono town became aware of the occurrence of the accident from media reports (**Table 5**).

Local governments within the 30 km zone including Namie town, the cities of Tamura and Minamisoma, and the villages of Katsurao and Iitate became aware of the accident from media reports, and Kawauchi village learned of the occurrence of the accident when requested the next morning to receive evacuees from the towns of Tomioka, Futaba and Namie (**Table 5**).

In the event of a large-scale earthquake, the flow of information communication for emergencies in the Guidelines should be modified. Specifically in the event of a large-scale earthquake, in the case of an alert, site area emergency, general emergency or any kind of emergency, the nuclear power operator should in principle notify immediately local governments, the general public and others within a zone of at least 30 km about the details of the emergency (**Fig. 7**).

**Problem 29: Local governments should not limit distribution of stable iodine tablets to the PAZ but should also distribute them in the UPZ and PPA.**

In the Guidelines, standards for intake and distribution of stable iodine tablets are established separately for each of the nuclear emergency response key zones. In the Precautionary Action Zone (PAZ, within 5 km), in peacetime it is clearly stated that advance distribution shall be carried out, but in the UPZ (within 30 km) and the Plume Protection planning Area (PPA, beyond 30 km), advance distribution is not clearly stated, and some abstract preparation of a distribution system and stockpiling is to take place (**Table 12**).

More specifically, for PAZ, at the point in time when it becomes a general emergency, because the NERHQ or local government immediately orders evacuation and the intake of stable iodine tablets, they are to be taken in principle by following this order. However, people who are unable to take stable iodine tablets, or people who are at a greater risk of health effects from exposure of the thyroid gland to radiation from radioactive iodine, such as infants and small children, and their guardians, are to evacuate preferentially during the site area emergency, a stage at which the intake of stable iodine tablets is not necessary.

On the other hand, the response in UPZ and PPA is to be that after it becomes a general emergency, depending on factors such as the sta-

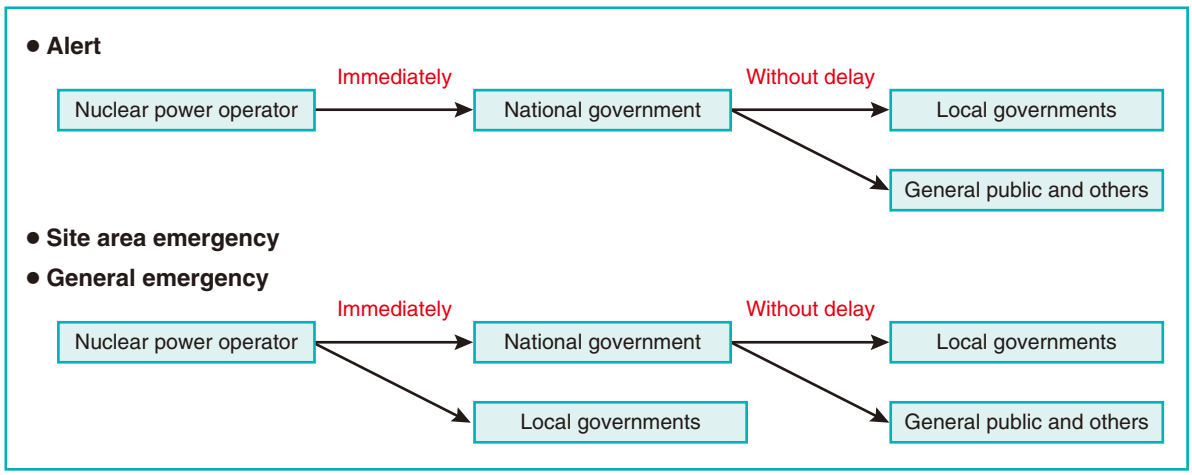


**Fig. 6 Flow of emergency information communication in the Guidelines**[4]

This figure is created based on the Guidelines' Section 2: Measures prior to nuclear emergencies, (2) Basic concept of implementation of protective actions in an emergency, 2) Concept for protective actions in initial response stage of an emergency.

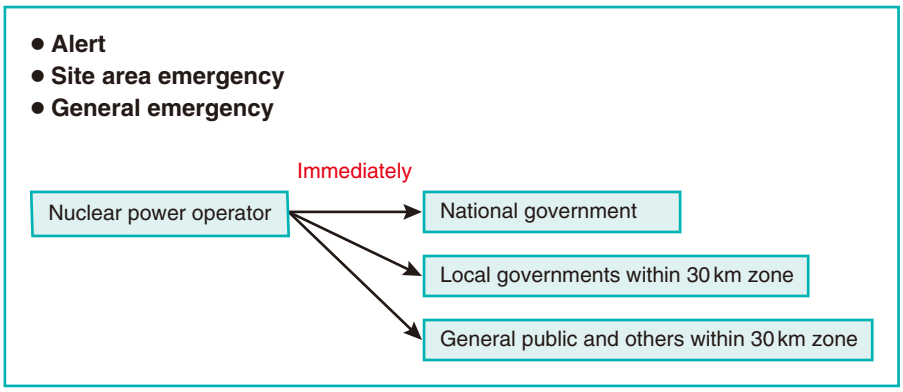


**Fig. 7 Proposed modifications for the flow of emergency information communication in the event of large-scale earthquake**

tus of the NPS and the level of airborne radiation, the Nuclear Regulation Authority (NRA) determines the necessity of the distribution and intake of stable iodine tablets, along with evacuation or sheltering in place, and because the NERHQ or local government orders it, they are to be taken in principle by following this order.

On the occasion of the Fukushima Daiichi NPS accident, orders for evacuation within 3 km and orders to shelter in place between 3 km and 10 km, zones in which there were municipalities at the site, were issued simultaneously six hours and 37 minutes after the SCRAM. Then, on the day after the SCRAM, fourteen hours and 58 minutes later, the evacuation order for the 10 km zone was issued, and there was only eight hours and 21 minutes between them (**Table 1**).

In this way, because the evacuation orders of municipalities belonging to PAZ and UPZ were issued without setting any time, there is a high possibility that the different standards set for distribution of stable iodine tablets in PAZ and UPZ will end up not matching the actual conditions of the accident. Because of this, local governments should not limit advance distribution of stable iodine tablets to PAZ but should also distribute them in UPZ and PPA.

Furthermore, the order for intake of stable

**Table 12 Key zones for nuclear emergency response**[4]

| Category | PAZ<br>Precautionary Action Zone<br>(Zone for preparation of preventive protective actions) | UPZ<br>Urgent Protective Action Planning Zone<br>(Zone for preparation of protective actions for an emergency) | PPA<br>Plume Protection Planning Area<br>(Zone for implementation of protective actions for the purpose of avoiding radiation exposure from the plume) |
|---|---|---|---|
| Objective of establishment of zone | Zone for preparation of preventive protective actions at a stage prior to the release of radioactive substances into the environment, in order to prevent definite effects from radiation exposure even in the case of a rapidly developing accident, in support of Emergency Action Level (EAL) and for such purposes as implementation of immediate evacuation. | This is a zone that prepares protective actions in the time of an emergency based on EAL and Operational Intervention Level (OIL) in order to contain the risk of an effective impact at a minimal level. | Even outside the UPZ, it is anticipated that impacts such as radiation exposure of the thyroid gland due to the inhalation of radioactive iodine when the plume passes through. In other words, even though it is outside the 30 km boundary of the UPZ, there will be cases in which protective measures are necessary, primarily in the area surrounding the UPZ. |
| Boundary of zone | About 5 km radius from NPS facility | About a 30 km radius from NPS facility | Outside the boundary of the UPZ |

iodine tablets in PAZ, UPZ and PPA is to be an order issued by the NERHQ or local government. However, on the occasion of the Fukushima Daiichi NPS accident, notification to local governments of the occurrence of the accident and the evacuation orders were not reliably communicated even to the local governments at the site of the NPS, and almost every other local government did not become aware of it from the national or prefectural government or the nuclear power operator (**Tables 5, 6**).

Because of this, strengthening the means of notifications and communication is a matter of course, the fail-safe concept should be introduced, and specific response methods should be listed, taking into consideration the condition that the orders from the NERHQ or local government do not arrive.

## Recommendations: Revisions in the Investigation of the Fukushima Daiichi NPS Accident and Reflection in the Nuclear Emergency Response Guidelines

### The Nuclear Emergency Response Guidelines

**Constructive measures to avoid an 'information disaster'**

On the occasion of the Fukushima Daiichi NPS accident, specific information about the accident at the NPS and information necessary for evacuation was withheld from residents to the extent that residents were almost entirely ignored, which produced a problem that can be called an 'information disaster.' Because of this, the Guidelines should stand in the position of citizens and residents affected by the disaster, and provide information about the NPS accident in real time, without fear of failure, so that residents in each region can immediately take evacuation actions including the intake of stable iodine tablets based on this information.

**State clearly the specific roles and tasks of nuclear power operators in the 30 km zone**

Damage to residents due to the release of radioactive substances on the occasion of an accident is the responsibility of the nuclear power operator. In the Guidelines the nuclear power operator should be responsible for communication with local governments, the preparation of preventive protective actions, and the implementation of evacuation at least within UPZ. The Guidelines should also state clearly specific responses such as a duty to notify local governments of Article 15 notifications, a duty to assist evacuation of evacuees from a site area emergency, and a duty to compensate receiving hospitals.

**An integrated response to site area emergencies and general emergencies in NPS accidents due to events such as large-scale earthquakes**

The Guidelines try to separate the responses by

dividing protective actions for residents and others into the categories of site area emergency (Article 10 situations) and general emergency (Article 15 situations). But in the Fukushima Daiichi NPS accident, there was only one hour of time difference between the site area emergency and general emergency. In the event that another disaster such as a large-scale earthquake similar to the Great East Japan Earthquake occurs, the actions to respond to a site area emergency should be the same as a general emergency.

**In the event of a large-scale earthquake, information about the emergency should be provided to all local governments, the general public and others within the 30 km zone in any type of emergency.**

When the large-scale earthquake occurred, the flow of communication to the national government, local governments and general public and others, and the degree of emergency stated in the Guidelines did not function and should be altered. More specifically, on the occasion of the large-scale earthquake, in the event of any type of emergency—alert, site area emergency, or general emergency—the nuclear power operator should provide information about the details of the emergency, in principle immediately, to all local governments, the general public, and others within at least the 30 km zone.

**Advance distribution of stable iodine tablets should not be limited to PAZ but distribution should also be in UPZ and PPA.**

Local governments should not limit distribution of stable iodine tablets to PAZ and should extend to UPZ and PPA.

Concerning the order for intake of stable iodine tablets as well, strengthening the means of notifications and communication is a matter of course, the fail-safe concept should be introduced, and specific response methods for intake orders should be listed, taking into consideration the condition that the orders from the NERHQ or local government do not arrive.

## Revision of the system for information communication to medical care providers

Medical providers are in a position to play an important role in protecting the lives and health of residents by such actions as providing explanations of the protective actions and the effects on the health of residents who evacuated, medical treatment for emergency patients with contamination, evacuation of hospital inpatients, and decisions about sheltering in place. The paths of communication appropriate for each community should be deliberated from the perspective of an adequate system for collecting information about radiation, the expansion of the scope of communication, the distance from NPS, human networks in peacetime, and the continuity of communication of natural disaster information. In the future, an effective system of information communication should be constructed by conducting disaster drills.

## Preparation by the national government of an infrastructure for the effective distribution and intake of stable iodine tablets

**The national government should prepare an infrastructure for advance distribution to residents in UPZ and PPA.**

In the future, it is anticipated that along with the establishment of an expanded evacuation planning area which includes not only PAZ, but also UPZ and PPA, methods will be considered for advance distribution of stable iodine tablets. If this is the case, smooth advance distribution by local governments will be difficult under the present system.

It is necessary that as quickly as possible, the national government should hold discussions about and make preparations for a system for advance distribution on a scale targeting tens or hundreds of thousands of residents.

**The national government should establish a setting in which the opinions of medical professionals concerning the advance distribution and intake can be heard broadly.**

Not only in the region where nuclear power stations are located, it is vital for physicians and medical associations to provide input to local governments with scientific medical knowledge about the timing of intake and distribution of stable iodine tablets, in order to minimize the risks of radiation exposure to residents based on understanding the accident situation and risk assessment. Therefore, it is necessary for the national government to establish a setting in which the opinions of medical professionals can be heard broadly concerning advance distribution and intake.

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