

# Regarding the Injection of Nitrogen into the Primary Containment Vessel (PCV) at Unit 3 of Fukushima Dai-ichi Nuclear Power Station, Tokyo Electric Power Co. Inc.

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Nuclear and Industrial Safety Agency

## 1. Background

In addition to injecting nitrogen at Units 1 and 2 of the Fukushima Dai-ichi Nuclear Power Station (NPS), Tokyo Electric Power Co., Inc. (TEPCO) is planning to inject nitrogen at Unit 3 as well for the purpose of preventing a hydrogen explosion inside the Primary Containment Vessel (PCV).

For this reason, the Nuclear and Industrial Safety Agency (NISA) requested TEPCO to submit a report regarding the necessity and safety of implementing the injection of nitrogen into the PCV, pursuant to the provisions of Article 67 paragraph 1 of the Act on the Regulation of Nuclear Source Materials, Nuclear Fuel Materials and Reactors.

## 2. Evaluation by NISA

NISA made the following confirmations and evaluations based on the report submitted by TEPCO.

### (1) Necessity for the injection of nitrogen

The pressure of the PCV at Unit 3 is the same as that at Unit 2, which is almost equivalent to atmospheric pressure, and so, there is significant leakage from the PCV. As a result, the hydrogen arising from the radiation decomposition of the water mixed with the large quantity of steam arising from the heating up of the injected water by the decay heat is leaking out from the PCV. At this time, the possibility for a hydrogen explosion to occur inside the PCV is extremely low.

On the other hand, at the stage after the cooling of the reactor has progressed, the quantity of steam will be reduced and the mixing of the hydrogen arising from the radiation decomposition of the water will not proceed, such that it can be perceived that hydrogen may accumulate inside the PCV. From this perspective, by supplying nitrogen, the hydrogen

concentration could be sufficiently lowered to prevent it reaching the limit where an explosion is possible.

NISA, also, has determined that a hydrogen explosion could be prevented by supplying the appropriate quantity of nitrogen with respect to hydrogen quantity arising from the radiation decomposition of the water, which will render it possible to control the increase of hydrogen concentration even at the stage after the cooling of the reactor.

(2) Safety for the injection of nitrogen

(a) Implementation procedures and effect of preventing a potential hydrogen combustion

- The hydrogen quantity arising from the radiation decomposition of the water inside the PCV was assessed and it was determined that the necessary nitrogen volume injected was 14Nm<sup>3</sup>/h to ensure the hydrogen concentration does not reach the minimum concentration that could lead to an explosion.
- The equipment has the required discharge pressure to inject the nitrogen into the PCV and it has the function to inject sufficiently pure nitrogen (having purity higher than 99%).
- Hypothetically, if the concentration of nitrogen falls for any reason, the system can automatically discontinue supplying the nitrogen.

Furthermore, NISA confirmed that there were specific procedures in place for monitoring the pressure and for careful opening operations of the injection valve, such that the steam inside the PCV would not condense. In addition, NISA also confirmed that sufficiently pure nitrogen (having purity higher than 99%) could be injected.

(b) Impact on the surrounding environment by the conceivable radioactive materials that can be pushed out from the PCV by the injection of nitrogen

On the surfaces of the Reactor Pressure Vessel (RPV) and the PCV, the radioactive materials transforming from their liquid phase, etc. to their gaseous phase inside the PCV, are examined and the quantity remains unchanged before and after the injection of nitrogen with the temperature conditions and other relevant factors. Therefore, NISA confirmed that there is no additional discharge of radioactive materials accompanying the increase in gas leaking from the PCV due to the effect of

impeding the condensation of the steam from the water on the walls of the PCV and the injected nitrogen itself. In addition, NISA confirmed that TEPCO, as a precaution, is planning to reinforce its monitoring of the impact on the environment due to the injection of nitrogen.

Moreover, regarding the effect on the leakage of injected water into the reactor building due to the injection of nitrogen, since the operation of the contaminated water treatment system was started, NISA confirmed that this would not become problematic.

(c) Hypothetically, if sudden hydrogen combustion occurred inside the PCV, the impact on the surrounding environment by the conceivable radioactive materials

As a precaution, TEPCO also evaluated the environmental impact in the event of the occurrence of sudden hydrogen combustion, in a hypothetical situation. According to the Severe Accident Analysis Codes, NISA confirmed that, after an accident, notwithstanding the significant leakage of the PCV, taking an extremely conservative analysis presuming an inconceivable leakage of radioactive materials from the gaseous phase inside the PCV, even if all these radioactive materials were pushed out of the PCV to the outside due to sudden hydrogen combustion, the assessment at the site boundaries would be around  $6 \times 10^{-1}$  mSv, which is less than the public dose limit of 1mSv.

(d) Radiation exposure management of workers when building the connection of the nitrogen injection device to the PCV

For the actual connection of the provisional line for the injection of nitrogen, NISA confirmed that TEPCO has selected locations in the areas where the dose is as low as possible, based on the dose measurement results by surveys conducted using robots, and the like; as well, NISA also confirmed that measures were being implemented such as collection of dust by vacuum cleaners, shielding by iron sheets, and the like, in order to reduce the doses in these areas. Furthermore, NISA confirmed that radiation exposure management was being conducted by confirming that waiting places and work flow lines were accessible and that improvements to accessibility by aerial work vehicles attaching shielding bodies as well as time management were being performed.

Based on the above, NISA determined that TEPCO's implementation of the emergency measures pursuant to Article 64 paragraph 1 of the Nuclear Regulation Act was a valid assessment by TEPCO and NISA concluded that TEPCO actions were necessary measures to avoid the risk.

### 3. Future Action

As to the injection of nitrogen, Nuclear Safety Inspectors will confirm as necessary whether the injection of nitrogen is appropriately implemented as indicated in the details of TEPCO's report.

### Injection line to the PCV of Unit 3

