

Fukushima – INES scale rating

23 March 2011

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Aim and structure of the INES scale

In 1990 the International Nuclear and Radiological Event Scale (INES) was developed through international experts, summoned via the IAEA and the nuclear agency of the OECD (OECD / NEA). The aim of the INES scale is to provide prompt and consistent information covering the relevance of an event connected to radioactive material.

The INES scale covers eight levels:

level 7 major accident

level 6 serious accident

level 5 accident with wider consequences

level 4 accident with local consequences

level 3 serious incident

level 2 incident

level 1 anomaly

level 0 no safety significance

Chernobyl in 1986 was rated an INES 7 event, Three Mile Island in 1979 an INES 5 event.

The rating follows three main criteria areas: offsite radiological effects, onsite radiological effects, impairment of safety measures.

For accidents (level 4 – 7) the radiological effects outside the plant are primarily relevant.

Criteria for INES event rating

According to the INES handbook the radiological impacts outside a nuclear complex can be described through (a) the release of radioactive material into the atmosphere and (b) the radiation doses.

Following (a) will be applied. This is because releases can be estimated more precisely compared to received radiation doses. Besides this an INES rating of 6 is the maximum when based on radiation doses only.

For the rating the releases into the atmosphere are in J-131 equivalents. Specific factors for different nuclides are given to specify the J-131 equivalent. The factor for rare gases, for example, is 0, for Cs-137 it is 40 and for Pu-239 the factor is 10,000.

INES level 7 – more than a couple of 10,000 J-131 equivalents

INES level 6– some 1,000 to a couple of 10,000 TBq J-131 equivalents

INES level 5– some 100 to a couple of 1,000 TBq J-131 equivalents

INES level 4– some 10 to a couple of 100 TBq J-131 equivalents

The IAEA states it not being appropriate to use exact numbers to define ratings as early estimations are inevitably rough estimations only. To provide some orientation the IAEA suggests 50,000, 5,000 and 500 TBq.

Adaptability to a number of reactors

The handbook suggests the IAEA generally assuming that the INES scale of is applied to an event in one specific block of a nuclear power station. In general practical experience confirms this.

How to deal with a combination of events (like in Fukushima) remains open in the handbook.

As mentioned above, the aim of the INES scale is to provide prompt and consistent information covering the relevance of an event. Without doubt the overall release during an event is the most important part of information for the public. The overall release is relevant for air, ground, water, foodstuff contamination. Therefore it reflects the idea of the INES scale to take into account all events in a nuclear complex (like Fukushima Daiichi) where releases of a number of reactors overlap within a short time period, and rate them together. Additionally the course of events interlink through contamination, explosions, fires, direct radiation.

Beside this an individual rating can also be reasonable approach to add transparency to the course of events.

Fukushima releases to date

There have been estimations on releases from Fukushima Daiichi reactors, two are known to the author.

On 22.03.2011 the French Institut de Radioprotection et de Sûreté Nucléaire (IRSN) (www.irsn.fr) published an estimation covering reactors 1 – 3 and the time period between 12.03.2011 and 22.03.2011: 90,000 TBq J-131, 10,000 TBq Cs-137 (plus specification covering other nuclides).

On 22.03.2011 the Austrian Zentralanstalt für Meteorologie und Geodynamik (ZAMG) (www.zamg.ac.at) published estimations covering the total release of J-131 and Cs-137 in the first four days. This estimation has been specified on the 23.03.2011: 400,000 TBq J-131, 85,000 TBq Cs-137.

For J-131 the author did further estimations. Based on core inventory specifications and medium burn up (source: WNIH 2010) a J-131 inventory of 1,000,000 TBq for block 1 at the time of the shutdown due to the earthquake and for blocks 2 and 3 1,800,000 TBq each seems to be reasonable.

A release of 2.75% (equalling a non-filtered release during containment venting) results in an overall release of approx. 125,000 TBq J-131 (summing up the three blocks).

These numbers closely represent IRSN numbers and will be used as the base for further estimations. It is not to be assumed that this results in any kind of overestimation.

Radioactive decay is not taken into account by the author. It remains unclear whether it was taken into account by IRSN or ZAMG. Radioactive decay is – having the time period in mind – only relevant for J-131 (half life: eight days), not for Cs-137 (half life: 30 years).

Fukushima

The release of J-131 and Cs-137 alone (as stated through IRSN) corresponds to a 500,000 TBq J-131 equivalent.

Taken all Fukushima Daiichi reactors into consideration this is obviously an INES 7 event.

Each reactor considered individually results in more than 100.000 TBq per block (all releases divided by three and proportionally to the inventory) – three INES 7 events. If the release is not divided proportionally different ratings are possible.

As the Cs-137 release is the biggest share the above assessment remains unchanged, even when the radioactive decay is taken into consideration.