



# Information Related To The Fukushima Nuclear Accident

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Berthold Technologies

AMUG Meeting Las Vegas 5 May 2011



# Earthquake & Tsunami March 11, 2011



NISA and JNES Japan The 2011 off the Pacific coast of Tohoku Pacific Earthquake and the seismic damage to the NPPs <http://www.jnes.go.jp/english>, April 4, 2011

Alfred Klett May 5, 2011



# Nuclear Reactors near Epicenter

## Location of the Nuclear Installations



Onagawa  
 Unit1: 524 MW, 1984-  
 Unit2: 825 MW, 1995-  
 Unit3: 825 MW, 2002-

Fukushima I  
 Unit1: 460 MW, 1971-  
 Unit2: 784 MW, 1974-  
 Unit3: 784 MW, 1976-  
 Unit4: 784 MW, 1978-  
 Unit5: 784 MW, 1978-  
 Unit6: 1,100 MW, 1979-

Fukushima II  
 Unit1: 1,100 MW, 1982-  
 Unit2: 1,100 MW, 1984-  
 Unit3: 1,100 MW, 1985-  
 Unit4: 1,100 MW, 1987-

Tokai II (1,100 MW, 1978-)

NISA and JNES Japan  
 The 2011 off the Pacific coast of Tohoku Pacific Earthquake and the seismic damage to the NPPs  
[www.jnes.go.jp/english](http://www.jnes.go.jp/english)  
 April 4, 2011



# Satellite View Fukushima Dai-ichi NPP



Many structures facing the bay are destroyed

NISA and JNES Japan  
The 2011 off the Pacific coast of Tohoku Pacific Earthquake and the seismic damage to the NPPs  
[www.jnes.go.jp/english](http://www.jnes.go.jp/english)  
April 4, 2011

Source: Google Earth



## Released Activities

- ▶ Noble gases: Krypton, Xenon
- ▶ Volatile Elements: Tellurium, Caesium, Iodine
- ▶ Intermediate: Strontium, Ruthenium, Barium
- ▶ Refractory (including fuel particles): Zirconium, Molybdenum, Cerium, Neptunium, Plutonium, Curium



# Chernobyl Releases (UNSCEAR 2000)

Radionuclide	Halflife	Inventory PBq	Released PBq	Fraction
Kr-85	10.72 a	28	33	100,0%
Sr-89	50.5 d	3.960	115	2,9%
Sr-90	29.12 a	220	10	4,5%
Zr-95	64.0 d	5.850	196	3,4%
Mo-99	2.75 d	6.110	168	2,7%
Ru-103	39.3 d	3.770	168	4,5%
Ru-106	368 d	850	73	8,6%
Te-132	3.26 d	4.200	1.150	27,4%
I-131	8,04 d	3.200	1.760	55,0%
Xe-133	5,3 h	6.500	6.500	100,0%
Cs-134	2,0 y	150	54	36,0%
Cs-137	30,0 y	260	85	32,7%
Ba-140	12.7 d	6.070	240	4,0%
Ce-141	32.5 d	5.550	196	3,5%
Ce-144	284 d	3.920	116	3,0%
Np-239	2.36 d	58.100	945	1,6%
Pu-238	87.84 a	0,93	0,035	3,8%
Pu-239	24.065 a	0,96	0,03	3,1%
Pu-240	6537 a	1,5	0,042	2,8%
Pu-241	14.4 a	190	6	3,2%
Cm-242	163 d	31	0,9	2,9%
<b>Total</b>		<b>108.962</b>	<b>11.816</b>	<b>10,8%</b>



Alfred Klett May 5, 2011 remember: 1 PBq = 1 x 10<sup>15</sup> Bq



# Releases from Fukushima

**IRSN**

INSTITUT  
DE RADIOPROTECTION  
ET DE SÛRETÉ NUCLÉAIRE

22 March 2011

## *Information Report*

### **IRSN publishes assessment of radioactivity released by the Fukushima Daiichi Nuclear Power Plant (Fukushima I) through 22 March 2011**

To assess air contamination levels resulting from the accident affecting the FUKUSHIMA DAIICHI power plant, IRSN made a preliminary evaluation of the quantity of radioactivity that may have been released over the period from 12 to 22 March 2011 by the three damaged reactors. This assessment is designed to give a realistic order of magnitude for the releases consistent with an interpretation of information provided by Japanese authorities and the IAEA as well as the results of field measurements using reasonably conservative assumptions.



# IRSN Estimates Fukushima Releases

Radionuclides	Release [Bq]
Rare Gases	$2 \times 10^{18}$
Iodine	$2 \times 10^{17}$
Caesium	$3 \times 10^{16}$
Tellurium	$9 \times 10^{16}$

IRSN Estimated Releases 2011-03-22





# IRSN Estimates Fukushima Releases [Bq]

Nuclide	Activity	Nuclide	Activity	Nuclide	Activity	Nuclide	Activity
Kr-85	2E+16	I-131	9E+16	Cs-134	1E+16	Sb-128	1E+10
Kr-85m	1E+14	I-132	7E+16	Cs-136	6E+16	Te-127	5E+15
Kr-87	7E+11	I-133	2E+16	Cs-137	1E+16	Sb-128m	1E+13
Kr-88	5E+13	I-134	4E+11	Cs-138	3E+09	Sb-129	4E+13
Xe-133	2E+18	I-135	2E+15	Cs-134m	1E+12	Te-129m	7E+15
Xe-133m	2E+16	I-129	2E+09	Rb-88	5E+13	Sb-131	8E+05
Xe-135	2E+16	I-132m	2E+10	Rb-89	3E-02	Te-125m	1E+14
Xe-138	9E+01	I-128	4E+04	Te-133m	4E+10	Te-132	6E+16
Kr 83m	1E+13	I-130	5E+13	Te-134	6E+09	Te-127m	1E+15
Xe-131m	2E+16	Br-83	2E+12	Sb-130	1E-15	Te-131	5E+14
Xe-135m	6E+14	Br-84	7E+07	Sb-125	6E+14	Te-131m	2E+15
				Sb-128	1E+10	Te-133	7E+09



# Chernobyl vs. Fukushima Releases

Radionuclide	Chernobyl [PBq]	Fukushima [PBq]	Ratio
Kr-85	33	20	61%
Xe-133	6.500	2000	31%
I-131	1.760	90	5%
Te-132	1.150	60	5%
Cs-134	54	10	19%
Cs-137	85	10	12%



## Ministry of Health, Labour and Welfare

- ▶ MHLW set provisional regulatory standards for agricultural goods
- ▶ MHLW notified water suppliers on drinking water
  - ▶ refrain from drinking tap water with exceeding
    - ▶ 300 Bq/kg radioactive iodine
    - ▶ 200 Bq/kg radioactive caesium
  - ▶ in case radioactive iodine exceeds 100 Bq/kg, refrain from giving tap water to infants



# Ministry of Health, Labour and Welfare, Japan

## Limits on Food, Water, Milk, Vegetables, Rice, Meat, Egg, Fish

食安発0405第1号  
平成23年4月5日

各  $\left( \begin{array}{l} \text{都道府県知事} \\ \text{保健所設置市長} \\ \text{特別区長} \end{array} \right)$  殿

厚生労働省医薬食品局食品安全部長

魚介類中の放射性ヨウ素に関する暫定規制値の取扱いについて



# Ministry of Health, Labour and Welfare, Japan Limits on Food, Water, Milk, Vegetables, Rice, Meat, Egg, Fish

参考

核種	食品衛生法(昭和22年法律第233号)の規定に基づく食品中の放射性物質に関する暫定規制値 (Bq/kg)	
放射性ヨウ素 (混合核種の代表核種: <sup>131</sup> I)	飲料水 WATER	300
	牛乳・乳製品 注) MILK	
	野菜類 (根菜、芋類を除く) VEGETABLE	2,000
	魚介類 FISH	
放射性セシウム <sup>137</sup> Cs	飲料水 WATER	200
	牛乳・乳製品 MILK	
	野菜類 VEGETABLE	500
	穀類 RICE/WHEAT	
	肉・卵・魚・その他 MEAT, EGG, FISH	
ウラン URAN	乳幼児用食品 BABY FOOD	20
	飲料水 WATER	
	牛乳・乳製品 MILK	100
	野菜類 VEGETABLE	
	肉・卵・魚・その他 MEAT, EGG, FISH	
プルトニウム及び超ウラン元素のアルファ核種 ( <sup>238</sup> Pu, <sup>239</sup> Pu, <sup>240</sup> Pu, <sup>242</sup> Pu, <sup>241</sup> Am, <sup>242</sup> Cm, <sup>243</sup> Cm, <sup>244</sup> Cm 放射能濃度の合計)	乳幼児用食品 BABY FOOD	1
	飲料水 WATER	
	牛乳・乳製品 MILK	10
	野菜類 VEGETABLE	
	穀類 RICE	
	肉・卵・魚・その他 MEAT, EGG, FISH	

注) 100 Bq/kg を超えるものは、乳児用調製粉乳及び直接飲用に供する乳に使用しないよう指導すること。  
for children not to be used



Ministry of Health, Labour and Welfare, Japan  
Limits on Food, Water, Milk, Vegetables, Rice, Meat, Egg, Fish

Food	<sup>131</sup> I [Bq/kg]	Caesium [Bq/kg]	Uran [Bq/kg]	Pu, Am, Cm [Bq/kg]
Water	300	200	20	1
Milk	300	200	20	1
Vegetable	2000	500	100	10
Rice / Wheat		500		10
Baby Food			20	1
Meat, Egg, Fish	2000	500	100	10



# Limits European Directive 351/2011

Element	Food for babies and children [Bq/kg]	Milk and Milk Products [Bq/kg]	Other Food [Bq/kg]	Liquid Food Beverages [Bq/kg]
Strontium	75	125	750	125
Iodine	100 (earlier 150)	300 (earlier 500)	2000	300 (earlier 500)
Plutonium	1	1 (earlier 20)	10 (earlier 80)	1 (earlier 20)
Caesium	200 (earlier 400)	200 (earlier 1000)	500 (earlier 1250)	200 (earlier 1000)



## Limits for other materials than food

- ▶ IAEA SAFETY GUIDE No. RS-G-1.7 2004  
Application of the Concepts of Exclusion,  
Exemption and Clearance, 2004
- ▶ Limits for Activity Concentration for  
Radionuclides of Artificial Origin in Bulk
- ▶ Based on  $10\mu\text{Sv}$  concept
- ▶ Comparable to clearance levels





## Limits for other materials than food

<b>Nuclide</b>	<b>Activity concentration (Bq/g)</b>
$^{131}\text{I}$	10
$^{134}\text{Cs}$	0.1
$^{137}\text{Cs}$	0.1
$^{239}\text{Pu}$	0.1

IAEA Safety Guide RS-G-1.7, Vienna, 2004



# Main Measurement Focus

## ▶ Territorial

- ▶ Japan
- ▶ East Asia
- ▶ Europe, especially Germany

## ▶ Applications

- ▶ Activity measurements
  - ▶ food, water, beverages
  - ▶ many other materials for manufacturers in all type of industries (automotive, cosmetics, ....)
- ▶ Contamination measurement
- ▶ Dose rate measurement



# Food Activity Measurement





# LB 200 Becquerel-Monitor

- ▶ Scintillation Measurement System for Assessment of Gamma Activity in Foodstuffs, Liquids, Bulk Goods in Bq/l
- ▶ Features:
  - easy to operate even for unskilled users
  - small dimensions
  - sample volume 0.5 liter
  - $^{137}\text{Cs}$  detection limit 20 Bq/l
  - display of the statistical accuracy
  - power supply mains or batteries





# Contamination Monitor LB 124 SCINT

- ▶ Flat ZnS Scintillator
- ▶ Innovative Reflectorgeometry
- ▶ PMT light detection
- ▶ Simultaneous and separate measurement of alpha- and beta-radiation
- ▶ Good uniformity across sensitive area
- ▶ High efficiency and extremely low detection limits





# Nuclear Energy in Germany

- ▶ Decision German Government March 17, 2011
- ▶ German nuclear power plants to undergo safety review
- ▶ The events in Japan have shown that incidents can occur that exceed any of the scenarios hitherto taken into account. This gives rise to the need to analyse the situation unconditionally, taking the current events into account.
- ▶ Review to be carried out by the independent Reactor Safety Commission
- ▶ Furthermore, the seven oldest German nuclear power plants are to be taken off the grid for three months



# Fukushima Internet Information

ACRS	Advisory Committee on Reactor Safeguards, USA <a href="http://www.nrc.gov/about-nrc/regulatory/advisory/acrs.html">http://www.nrc.gov/about-nrc/regulatory/advisory/acrs.html</a>
BMU	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit / German Federal Ministry for Environment, Nature Protection and Reactor Safety <a href="http://www.bmu.de/allgemein/aktuell/160.php">http://www.bmu.de/allgemein/aktuell/160.php</a>
BfS	Bundesamt für Strahlenschutz / German Federal Office for Radiation Protection <a href="http://www.bfs.de/bfs">http://www.bfs.de/bfs</a>
CEA	Commissariat à l'Énergie Atomique (French government-funded technological research organization) <a href="http://www.cea.fr/english_portal">http://www.cea.fr/english_portal</a>
DWD	Deutscher Wetterdienst / German Weather Service <a href="http://www.dwd.de/">http://www.dwd.de/</a>
HPA	Health Protection Agency UK / Gesundheitsschutzbehörde Grossbritannien <a href="http://www.hpa.org.uk/">http://www.hpa.org.uk/</a>
GPR	Groupe permanent d'experts pour les réacteurs nucléaires (GPR), France <a href="http://www.asn.gouv.fr/presentation/quicontrole/orgcontrole.asp">http://www.asn.gouv.fr/presentation/quicontrole/orgcontrole.asp</a>
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) / Germany's central expert organisation in the field of nuclear safety <a href="http://www.grs.de/">http://www.grs.de/</a> & <a href="http://fukushima.grs.de/">http://fukushima.grs.de/</a>



# Fukushima Internet Information

IAEA	International Atomic Energy Agency / Internationale Atomenergiebehörde <a href="http://www.iaea.org">http://www.iaea.org</a>
IRSN	Institut de Radioprotection et de Sûreté Nucléaire / France <a href="http://www.irsn.fr/">http://www.irsn.fr/</a>
JNES	Japan Nuclear Energy Safety Organization (JNES) <a href="http://www.jnes.go.jp/english/index.html">http://www.jnes.go.jp/english/index.html</a>
KTA	Der Kerntechnische Ausschuss / German Nuclear Safety Standards <a href="http://www.kta-gs.de/">http://www.kta-gs.de/</a>
KNS	Eidgenössische Kommission für nukleare Sicherheit (KNS), Schweiz <a href="http://www.bfe.admin.ch/kns/">http://www.bfe.admin.ch/kns/</a>
METI	Ministry of Economy, Trade and Industry (METI), Japan <a href="http://www.meti.go.jp/english/index.html">http://www.meti.go.jp/english/index.html</a>
MHLW	Ministry of Health, Labour and Welfare (Japan) <a href="http://www.mhlw.go.jp/english/">http://www.mhlw.go.jp/english/</a>
NISA	Nuclear and Industrial Safety Agency, Japan <a href="http://www.enecho.meti.go.jp/english/">http://www.enecho.meti.go.jp/english/</a>
NIST	National Institute of Standards and Technology / Nationales Institut für Standards und Technologie <a href="http://www.nist.gov/index.html">http://www.nist.gov/index.html</a>
NPL	National Physical Laboratory / Nationales Physikalisches Labor <a href="http://www.npl.co.uk/">http://www.npl.co.uk/</a>





# Fukushima Internet Information

NRC	Nuclear Regulatory Commission / Behördliche Kernenergie Kommission <a href="http://www.nrc.gov/">http://www.nrc.gov/</a>
NSC	Nuclear Safety Commission, Japan <a href="http://nsc.jst.go.jp/index_english.htm">http://nsc.jst.go.jp/index_english.htm</a>
PTB	Physikalisch Technische Bundesanstalt / Physical Technical Federal Institute <a href="http://www.ptb.de/">http://www.ptb.de/</a>
SSK	Strahlenschutzkommission / German Commission on Radiological Protection <a href="http://www.ssk.de/en/index.htm">http://www.ssk.de/en/index.htm</a>
TEPCO	The Tokyo Electric Power Company, Inc. <a href="http://www.tepco.co.jp/en/index-e.html">http://www.tepco.co.jp/en/index-e.html</a>
WHO	World Health Organization <a href="http://www.who.int/en/">http://www.who.int/en/</a>



## References

- 1) Nuclear and Industrial Safety Agency (NISA) Japan Nuclear Energy Safety Organization (JNES) Japan - The 2011 off the Pacific coast of Tohoku Pacific Earthquake and the seismic damage to the NPPs, <http://www.jnes.go.jp/english>, 4th April, 2011
- 2) Institute De Radioprotection et de Sûreté Nucléaire IRSN Information Report IRSN publishes assessment of radioactivity released by the Fukushima Daiichi Nuclear Power Plant (Fukushima I) through 22 March 2011, IRSN Paris, France 22 March 2011
- 3) UNSCEAR United Nations Scientific Committee on the Effects of Atomic Radiation, Sources and Effects of Ionizing Radiation, Volume I: Sources, United Nations, New York, 2000
- 4) UNSCEAR United Nations Scientific Committee on the Effects of Atomic Radiation, Sources and Effects of Ionizing Radiation, Volume II: Effects, United Nations, New York, 2000



## References

- 5) Ministry of Health, Labour and Welfare Japan (MHLW) - Limits on Food, Water, Milk, Vegetables, Rice, Meat, Egg, Fish, April 2011
- 6) COMMISSION IMPLEMENTING REGULATION (EU) No 351/2011 of 11 April 2011 amending Regulation (EU) No 297/2011 imposing special conditions governing the import of feed and food originating in or consigned from Japan following the accident at the Fukushima nuclear powerstation Fukushima L 97/20 Official Journal of the European Union 12 April 2011
- 7) IAEA, One Decade After Chernobyl – Summing up the Consequences of the Accident, Proceedings of an International Conference held in Vienna April 8-12, 1996, Vienna, Austria, 1996
- 8) WHO World Health Organization, Health Effects of the Chernobyl Accident and Special Health Care Programmes, Report of the UN Chernobyl Forum Expert Group “Health”, Eds: B. Bennett, M. Repacholi, Z.Carr, Geneva, 2006



# Integrated Dose Received

