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Application Status of Operational Intervention Levels for Prompt Decision-Making of Public Protective Actions in Nuclear or Radiological Emergencies

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1. Introduction

The IAEA has issued comprehensive safety requirements and guides concerning emergency preparedness and response (EPR) to be applied in nuclear or radiological emergencies [1-4]. In such situations, prompt and effective decision-making regarding public protective actions is paramount. Emergency action levels (EALs) and operational intervention levels (OILs) are predetermined values by nuclear licensees and emergency response organizations, respectively, derived from generic criteria (GC) to facilitate this process. In particular, OILs can be immediately and directly utilized, without further assessment, to determine appropriate protective actions based on environmental measurements such as ambient dose rates or activity concentrations.

In 1997, the IAEA provided OILs in TECDOC-955 [2]. In Korea, emergency response organizations have applied these OIL values in their emergency response manuals. However, since Fukushima NPP accident in 2011, new default OILs have been developed in recent safety guides and technical reports issued by the IAEA [3-4]. While some countries have adopted these new OILs, others have developed their own OILs considering national GC or lessons learned from past nuclear accidents [5-7]. This study investigates the recently applied OILs in three countries (Canada, Australia and Japan) and reviews the application plan for the new OILs to enhance the effectiveness of response to nuclear or radiological emergencies.

2. Methods and Results

2.1 OILs provided by IAEA

Table 1 presents default OIL values provided by the IAEA. In IAEA TECDOC-955 [2], OIL1 to OIL9 were provided. OIL1 and OIL2 denote ambient dose rates while passing the radioactive plume. OIL1 is utilized for decision-making of evacuation, whereas OIL2 is employed for taking thyroid blocking agents (e.g. Potassium Iodide). OIL3 to OIL5 are ambient dose rates resulting from ground deposition. OIL3 and OIL4 are utilized for decisions on evacuation and relocation, respectively, while OIL5 is indicative of restrictions of food consumption. OIL6 and OIL7 represent surface contamination (Bq/m^2) of I-131 and Cs-137 resulting from ground deposition, respectively. OIL8 and OIL9 are activity concentration (Bq/kg) of general foods, water or milk of I-131 and Cs-137, respectively. OIL6 to OIL9 are utilized for decisions on restrictions of food consumption with marker isotopes, I-131 and Cs-137.

New default OILs ranging from OIL1 to OIL6 were introduced in IAEA GSG-2 [3]. OIL1 to OIL3, reflecting environmental measurements (dose rates and surface contaminations) from ground deposition, are utilized for decisions regarding evacuation, relocation and food control, respectively. OIL4 values represent measurements from the skin or clothing. OIL5 values are gross alpha and beta activities from foodstuffs. If OIL5 values are exceeded, OIL6, activity concentrations of foods dependent on the radionuclides, is utilized for restricting food consumption. These OIL values are applicable not only in nuclear accidents but also in radiological accidents.

Table 1. Default OIL values provided by IAEA

No.	TECDOC-955 (1997) [2]	GSG-2 (2011) [3]	EPR-NPP-OILs (2017) [4]
OIL1	(P) 1 mSv/h	(G) 1 mSv/h (γ) (G) 2,000 cps (β) (G) 50 cps (α)	(G) 1 mSv/h
OIL2	(P) 0.1 mSv/h	(G) 0.1 mSv/h (γ) (G) 200 cps (β) (G) 10 cps (α)	(G) 0.1 mSv/h (first 10 days) (G) 25 μSv/h (after 10 days)
OIL3	(G) 1 mSv/h	(G) 1 μSv/h (γ) (G) 20 cps (β) (G) 2 cps (α)	(G) 1 μSv/h
OIL4	(G) 0.2 mSv/h	(S) 1 μSv/h (γ) (S) 1,000 cps (β) (S) 50 cps (α)	(S) 1 μSv/h (γ) (S) 1,000 cps (β)
OIL5	(G) 1 μSv/h	(F) 100 Bq/kg (gross β) (F) 5 Bq/kg (gross α)	N.A.
OIL6	(G) 2~10 kBq/m^2 (I-131)	(F) radionuclide-dependent	N.A.
OIL7	(G) 2~10 kBq/m^2 (Cs-137)	N.A.	(F) 1 kBq/kg (I-131) (F) 0.2 kBq/kg (Cs-137)
OIL8	(F) 0.1~1 kBq/kg (I-131)	N.A.	(T) 0.5 μSv/h
OIL9	(F) 0.2~0.3 kBq/kg (Cs-137)	N.A.	N.A.

(P): Plume monitoring, (G): Ground monitoring, (F) Food monitoring, (S): Skin monitoring, (T): Thyroid monitoring, N.A.: Not Applicable

Furthermore, the IAEA has published EPR technical report series. Among these reports, the EPR-NPP-OILs introduced new default OILs tailored for responding to reactor accidents [4]. OIL2 is subdivided into two ambient dose rate values according to time elapsed after reactor shutdown. OIL7, instead of OIL5 and OIL6, was designated for food control in this report. OIL8 was newly provided for thyroid monitoring in this version.

2.2 OILs applied in Canada, Australia and Japan

Table 2 summarizes the OIL values applied in three countries: Canada, Australia and Japan. Health Canada, responsible for public health services in Canada, has provided OIL values from their technical document [5]. OIL1 to OIL4 align with the IAEA EPR-NPP-OILs. However, OIL5 and OIL6 values in Canada are lower than those provided by IAEA GSG-2. In addition, Health Canada did not apply OIL7 and OIL8.

ARPANSA (Australian Radiation Protection and Nuclear Safety Agency) has issued radiation protection series including OILs [6]. OIL1 and OIL2 in Australia are lower than those provided by IAEA and Health Canada. Notably, plume monitoring is still applied in OIL1, contrary to recent IAEA reports. However, other OILs are similar with values provided by IAEA GSG-2 and EPR-NPP-OILs.

In Japan, NRA (Nuclear Regulation Authority) has published an EPR guide addressing EALs and OILs [7]. The NRA's OIL values are mainly determined from the experience of the Fukushima NPP accident. The EPR guide utilizes a screening level for restricting food consumption instead of OIL3 even though the concept of this value is corresponding to the OIL3. Overall, Japanese OIL values are lower than those of IAEA and the other two countries.

Table 2. OIL values applied in Canada, Australia and Japan

No.	Health Canada (2018) [5]	ARPANSA (2019) [6]	NRA EPR Guide (2019) [7]
OIL1	(G) 1 mSv/h	(P)(G) 0.5 mSv/h (for evacuation) (P)(G) 0.1 mSv/h (for sheltering)	(G) 0.5 mSv/h
OIL2	(G) 0.1 mSv/h (first 10 days) (G) 25 μSv/h (after 10 days)	(G) 50 μSv/h (first 7 days) (G) 10 μSv/h (after 7 days)	(G) 20 μSv/h
OIL3	(G) 1 μSv/h	(G) 1 μSv/h	(G) 0.5 μSv/h
OIL4	(S) 1 μSv/h	(S) 1 μSv/h (γ) (S) 1,000 cps (β)	(S) 40,000 cpm (first 1 month) (S) 13,000 cpm (after 1 month)
OIL5	(F) 10~30 Bq/kg (gross β) (F) 1~3 Bq/kg (gross α)	(F) 100 Bq/kg (gross β) (F) 5 Bq/kg (gross α)	N.A.
OIL6	(F) radionuclide-dependent	(F) radionuclide-dependent	(F) radionuclide-dependent
OIL7	N.A.	(F) 100 Bq/kg (I-131 or Cs-137)	N.A.
OIL8	N.A.	(T) 0.5 μSv/h	N.A.

(P): Plume monitoring, (G): Ground monitoring, (F) Food monitoring, (S): Skin monitoring, (T): Thyroid monitoring, N.A.: Not Applicable

2.3 Application plan of OILs in Korea

Emergency response organizations in Korea have applied OILs provided by IAEA TECDOC-955. Conversely, other countries have updated their OIL values based on recent IAEA reports and technical reviews from past nuclear accidents. Plume monitoring has been excluded in the recent IAEA reports since it is difficult to promptly conduct environmental measurements in a timely manner. In addition, there is a great variation of measurements depending on time and location during a radioactive release. Consequently, OILs for plume monitoring should be eliminated from the previous version. OILs using ambient dose rates should follow the recent IAEA methodology for their derivation, considering national GC. However, further study is necessary to determine OILs for food and thyroid monitoring, taking account of specific accident scenarios. Particularly, OIL8 for thyroid monitoring following intake of radioiodine, which predominantly contributes to thyroid exposure after reactor accidents, has a significant variation depending on age group and time following intake.

3. Conclusions

In this study, OILs applied in Canada, Australia and Japan were investigated through comparison with relevant IAEA reports. It was observed that these countries have applied updated OIL values based on the recent IAEA reports and technical reviews for effective protective measures. The findings of this study underline the need for revision of OILs in Korea to harmonize with the recent international standards after thorough consideration of Korean EPR framework.

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