



Regulatory status and current issues for optimization of occupational radiation protection for commercial aircrew in Republic of Korea

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1. Background and Goal of the present work

- With much economic development around the world, the commercial air transport business is expanding for international trade and travel.
- Accordingly, the flight time at high altitudes of commercial aircrew is increasing, and the exposure dose of cosmic radiation tends to increase.
- In recent UNSCEAR and national survey reports such as the United States and Korea, the average dose of cosmic radiation of flight crews is about 2 mSv/y, which is higher than that of occupational radiation of other radiation workers.
- Hence, optimization of cosmic radiation protection for commercial aircrews is emerging as an important issue globally.
- In this background, 'regulatory status and current issues for the optimization of occupational radiation protection of Korean commercial aircrew' are reviewed in this study.
- Since cosmic radiation-related research has been mainly conducted from the perspective of space/astronomical physics and cosmic meteorology, this study is mainly focused on the perspective and role of the government and regulatory authorities in charge of radiological safety regulation for flight crew members.

2. Current status of international and domestic standards for the optimization of radiation protection for aircrews

2.1. International Standards

- IAEA safety standards related to the protection of cosmic radiation due to the performance of duties of aircrew members are the GSR Part 3 requirements(2014) and the GSG-7 guides(2018).
- The IAEA GSR Part 3 classify and manage cosmic radiation exposure of aircrews as existing exposure situations, and related requirements are presented in chapter 5, 5.30. - 5.32. paragraphs.
- In particular, the requirements related to "optimization" of cosmic radiation protection for aircrews can be summarized into the following factors.

 - ① Selection of crew members in need of safety management
 - ② Set reference level of dose
 - ③ Establishment of evaluation methodology for cosmic radiation dose
 - ④ Evaluation and recording, provision of information of dose to aircrews
 - ⑤ Selection and implementation of optimization options after comparison between evaluation value and reference level.

2.2. Domestic Regulatory Standards

- The Act for the protection of cosmic radiation protection for Korean aircrews is the 'Act on Protective Action Guidelines against Radiation in the Natural Environment', which was enacted in 2012 and has been revised several times.
- In this law, cosmic radiation is defined as 'radiation incident from the sun or universe into the Earth's atmosphere', and Article 18 presents the safety management requirements for cosmic radiation.
- Meanwhile, the government ministries for the implementation of these requirements are divided into the Nuclear Safety and Security Commission (NSSC) and the Ministry of Land, Infrastructure and Transport (MOLIT).
- Pursuant to Article 8 of the Act, NSSC shall prepare the 'Safety guidelines', and distribute it to the general public as well as stakeholders such as air transportation business operators and MOLIT.
- Pursuant to Article 18 of the Act, MOLIT shall prescribe and publicly notify detailed matters necessary for safety control of cosmic radiations, including the procedure and method for the investigation and analysis.
- The regulatory requirements related to "optimization" of cosmic radiation protection for aircrews are summarized based on the factors extracted from the IAEA safety standards as table 1.

Table 1. Korean regulatory requirements on optimization of cosmic radiation protection for the factors from IAEA standards

Factor	Korean regulatory requirements on optimization of cosmic radiation protection
①	Flight attendants on international air routes operated by air transport operators
②	Reference level of dose : 6 mSv/y (1 mSv for pregnant woman during pregnancy)
③	Evaluation by computer program or measurements considering the flight route, altitude, latitude and longitude, flight time of crew members, and the effect of solar activity.
④	Investigation, analysis, and record of cosmic radiation exposure of crew members by flight route, annual dose, and report to regulatory authorities (MOLIT) annually
⑤	Take each of the following measures if it is expected that the reference level will be exceeded. 1) Limit the number of boarding international flight, 2) Change of boarding international air route

3. Domestic regulatory activities and current issues

3.1. Domestic Regulatory Activities

- Pursuant to Article 23 of the Act, regulatory authorities conduct annual investigation and analysis of the actual state of safety management of air transport operators, and publish annual report.
- In this study, the latest three-year (2019-2021) reports, containing information of investigation from 2018 to 2020, were analysed.
- Based on the "optimization" factors of cosmic radiation protection, they are summarized as shown in table 2.

Table 2. Summary of survey results on safety management of cosmic radiation by Korean air transportation business operators(2018-2020)

Factor	2020	2019	2018
①	# of aircrews : 21,685	# of aircrews : 23,251	# of aircrews : 22,484
②	All operators apply 6 mSv/y (2 mSv for pregnant woman during pregnancy)		
③	All operators evaluates radiation dose by computer program (CARI-6, CARI-6M, NAIRAS)		
④	Average dose : 0.89mSv Maximum dose : 4.89mSv	Average dose : 2.12mSv Maximum dose : 5.46mSv	Average dose : 2.09mSv Maximum dose : 5.65mSv
⑤	No person exceeding the ref. level, Change of duties such as flight suspension immediately upon confirmation of pregnant crew		

3.2. Domestic Issues and Responses

- In Republic of Korea, the outbreak of leukemia and claims for industrial accidents by a former aircrew of a Korean airline in 2018 were widely reported in the media.
- It became a big social issue and the problems and responses in safety management were discussed at the National Assembly and government.
- These can be broadly divided into technical issues such as underestimation of solar cosmic radiation, regulatory agency issues such as dual government departments in charge, and safety management issues such as retention period of crew exposure records.
- Recent responses for each problem raised have been implemented as table 3.

Table 3. Recent issues and responses to cosmic radiation exposure of aircrews in Republic of Korea

Issues (related factor)	Problems	Responses
Dose Evaluation (③)	Reliability of exposure dose evaluation programs (deviation between programs, etc.)	Research on improvement of regulatory validation systems led by NSSC (Ex. [1])
Regulatory Agency (①~⑤)	Dual government departments in charge of safety management (NSSC and MOLIT)	Revision of the Act('22.6.10.) to unify NSSC through cooperation with National Assembly
Safety Management (②, ④)	retention period of crew exposure records (5yrs), dose standards of pregnant (2mSv)	Extension of storage period (30yrs after retirement), reduction of dose standards for pregnant crews (1mSv)

4. Conclusions

- In this study, the current status and issues of regulations in Korea related to the optimization of the cosmic radiation protection for aircrews were overviewed.
- It is considered that Korean regulatory standards and activities are established and operated to comply with the IAEA safety standards.
- However, it is necessary to continuously improve the regulatory standards and technology for optimization of radiation protection in response to domestic issues and public concerns, and it is actively in progress led by NSSC.
- Also, if international exchanges and cooperation on national governments' verification and authorization systems on evaluation and measurement method, data become more active, it is expected that the optimization of radiation protection for aircrew is more strengthened globally.

5. References

- [1] G. Y. Han, J. Y. Kim, A Study on the Selection Schemes of the Appropriate Computer Programs for Evaluating Cosmic Radiation Exposure at Commercial Aircraft Altitude, Proceedings of IRPA15(15th International Congress of the International Radiation Protection Association), 2021.

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