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Control of Occupational Exposure to Cosmic Radiation outside the Atmosphere

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INTRODUCTION

So far four Japanese have experienced travel to the outer space a total of five times. Participating in the international collaboration of construction of the space station International Space Station (ISS), the Japan Experiment Module (JEM), a major part of ISS, has been under construction in Japan and it is expected Japanese crew will stay on board for several months in the near future. The issue of radiation protection against cosmic rays for the crew in the space-ship has drawn the attention of people. Ordinary Japanese are rather sensitive to radiation exposure due to a recent criticality accident occurred in Tokai-mura and also due to the memories of atomic bombs dropped at Hiroshima and Nagasaki. Thus, the problem has been thrust on radiation protection scientists in Japan of how to harmonize the radiation protection systems used in ordinary radiation facilities and those to be used in the cases like this.

In this presentation, a summary of the recent report (1) on the controlling criteria of Japanese Cosmonauts made by NASDA (National Space Development Agency of Japan) is introduced and the comments of the authors are shown. Discussions are mainly focused on the subjects of philosophy and policy.

SUMMARY OF THE NASDA INTERIM REPORT

An interim report (1) of the Space Radiation Safety Working Group of the NASDA Advisory committee, Manned Space Support Committee, was released for public comments in March 1999. The summary of the interim report is as follows. (Authors are responsible for the Japanese – English translation.)

1. Status of the interim report

1) This is to make public the present status of discussing the issue of radiation dose limits of Japanese cosmonauts staying in the International Space Station (ISS) for extended periods.
2) This is an interim report based on the draft prepared by the radiological health division of NASDA and thought acceptable or tolerable by the Working Group from the standpoint of radiation disciplines.
3) This is to invite comments from Japanese people who are engaged or interested in space development and radiation protection.

2. Estimated cosmic radiation exposure to the crew of the ISS

1) Staying inside the vehicle in the normal cosmic radiation environment: 1 mSv/day (Total Body).
2) Staying inside the vehicle during solar particle events: several to several tens of times higher than normal depending on the magnitude of the solar flare (Total Body).
3) Extravehicular activities: several times higher than the dose rates inside the vehicle (Total Body).

3. Cosmic radiation effects on humans

3.1 Stochastic effects

Basic concept for setting career dose limits (Total Body)

a. to consider mainly ‘attributable lifetime cancer mortality’.
b. maximum allowable value of attributable lifetime cancer mortality for Japanese cosmonauts is 3 - 5%.
c. to set the dose limit so that the attributable lifetime cancer mortality equals nearly 3% assuming the most probable pattern of stay but never exceeding 5% even if cosmonauts stay in space every year within the dose limit.

Proposed career dose limits (Total Body: Effective Dose Equivalent)

(unit: Sv)

Age of initial exposure	27	30	35	40	45
Male	0. 6	0. 9	1. 0	1. 2	1. 2
Female	0. 6	0. 8	0. 9	1. 1	1. 1

3.1 Deterministic effects

Basic concept for setting tissue dose limits

a. to adopt threshold doses presented in the ICRP Publications in principle
b. to set tissue dose limits for probable effects to be expected during or after the space flight, comparing

the estimated doses with thresholds of organs and tissues

c. in case a unified dose limit unnecessarily limits cosmonauts' activities, it will be reasonable to show them a "reference level" instead of setting a dose limit and to make flight plans giving sufficient consideration to their own will

Proposed tissue dose limits (Dose Equivalent)

Tissue, Organ	Single short time (Sv)	One year (Sv/year)	Lifetime (Sv)
Testis	-	2	-
Lens of eye	0. 5	1	5
Bone marrow	-	0. 5	-
Skin	2	4	20

Proposed reference level

Testis/temporary infertility: Single short time 0.15 Sv, One year 0.4 Sv/year

4. Subjects to be discussed

The Subcommittee intends to discuss the following issues in order to establish a guideline for the cosmic radiation exposure control for Japanese cosmonauts to staying on ISS for extended periods

1) Radiation monitoring and dose estimation method
2) Radiation protection education and training of cosmonauts and how to obtain their consent
3) Health surveillance program to prevent radiation hazard

THE AUTHORS' COMMENTS ON THE REPORT: PROPOSED SCHEME TO ESTABLISH RADIATION PROTECTION SYSTEM AGAINST COSMIC RADIATION OUTSIDE THE ATMOSPHERE

In the NASDA report introduced above, the philosophy and policy of safety needed to design and construct a system of radiation protection are not clearly stated.

For a system of radiation protection, upon establishing a quantitative relation between cause and effect, science and technology of cause measurement (system of dosimetry) and philosophy of safety (system of dose limitation) are needed.

Following the traditional way of thinking for developing a new science or technology, it is desired the system be in harmony with other existing systems of radiation protection, since effects of radiation to matter including the human body are neither dependent on where radiation comes from nor the reason for the exposure. In fact, mathematics, science and technology have developed by the guiding principle of extending limits of applicability and unification of formulae or modification of concepts followed. Along this line of thinking, people yearn for a unified system of radiation protection applied to any kind of exposure.

However, the background of radiation protection as a science is quite specific in the points that the causality is stochastic, the relations between cause (dose) and effects are monotonously increasing functions, but not linearly proportional in general and even hold for a limited span of variables (dose), in the sense of mathematics, according to the limiting condition that we cannot die more than once.

Systems of radiation protection today used in many countries are based on the system created and recommended by ICRP, but their primary objects are limited to controllable radiation exposure whatever the version of the recommendation is, and the philosophy of safety seems poorly established. The issue under discussion is beyond the limit of applicability of the ICRP system of radiation protection.

Hence we would like to propose three fundamental principles upon which any system of radiation protection shall be designed.

Principle 1. Risk to an individual which is controllable or acceptable to himself/herself shall be controlled by the will of the individual and no universal risk limit shall be set.

Principle 2. It shall be guaranteed for those to whom Principle 1 applies necessary information on the risk be provided without any restriction.

Principle 3. Risk to individuals which is not controllable by themselves and risk to the population of a society shall be controlled by the society and the controlling criteria for them should be made by the will of the society.

We live our lives surrounded by so many risk sources and the risk factor of each source varies by time and place. It is very often neither rigorous nor practical to try to realize risk-free world of a source, since the risk of the residual exists always and the finance and man-power required increases as the risk decreases. Moreover, the acceptable level of risk associated with an action judged by the risk-benefit analysis varies by the sense of value of the individual concerned. We found the acceptable levels of radiation dose to an individual (spontaneous whole body exposure) spread so widely today (2).

Accordingly, we think it is not pertinent to make any dose limits, including the limit of career dose (3), to cosmonauts. Action levels in ICRP terminology will do for the project.

CONCLUSION

The present system of radiation protection developed by ICRP is not adequate enough for application to the issue of protecting cosmonauts against cosmic radiation in outer space. The necessity of philosophy and policy of safety is stressed to meet the issue, and three fundamental principles on risk control are proposed.

The gist of the recent interim report of NASDA treating radiation control system of Japanese cosmonauts is introduced with comments. The authors are against the idea of introducing special dose limits for cosmonauts.

REFERENCES

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