Changes in the Annual Dose Limits and Their Potential Impact on the IAEA Transport Regulations

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ABSTRACT

The International Commission on Radiological Protection (ICRP) has already recommended a change in the annual dose limit for members of the public, not yet incorporated by the International Atomic Energy Agency (IAEA), the World Health Organization (WHO) and the International Labour Organization (ILO) in the Basic Safety Standards for Radiation Protection. In addition, Information from different sources could imply a reduction of the annual dose limits for occupational exposures in the near future.

After a frief description of how the annual dose limits were employed in the IAEA Transport Regulations, both for the limitation or control of actual exposures and for taking safety decisions in relation with potential exposures (e.g., for requiring a Type B instead of a Type A package), this paper analyzes how changes in the annual dose limits could affect some parts of the IAEA Transport Regulations and discuss potential areas of conflict between design and operational aspects of the transport of radioactive materials as well as some difficulties associated with changes on requirements dealing with "protection" and "safety". Finally, the areas of interest for the new revision of the IAEA Transport Regulations are described in this context.

INTRODUCTION

The ICRP published its latest basic *Recommendations of the International Commission on Radiological Protection* in 1977. Later, the IAEA published a new edition of Safety Series No. 9, *Basic Safety Standards for Radiation Protection: 1982 Edition*, a publication jointly sponsored by the IAEA, the ILO and the WHO. As usual, the IAEA Safety Series No. 9 was based on the previous ICRP recommendations.

At present the ICRP recommendations are under review, while the Safety

Series No. 9 will be revised on 1990, and in both cases it is expected the introduction of some implicit or explicit changes in the values of the Annual Dose Limits (ADLs), in addition to modifications and refinements of radiation protection principles, concepts and basic procedures.

Among others, the following facts indicate a possible reduction of the ADLs:

- in 1985, the ICRP stated that, for stochastic effects, the main ADL applicable to individual members of the public should be 1 mSv (ICRP, *Statement from the 1985 Paris Meeting of the International Commission on Radiological Protection*); and
- the dose risk factors were revised and it can be expected a reduction of the ADLs for workers (ICRP, *Statement from the 1987 Como Meeting of the International Commission on Radiological Protection*).

Also, it is stressed that the concept of dose-upperbound as a source-related limit or constraint has gained increasing force during last years (IAEA, *Radiation Protection Glossary*, Safety Series No. 76, 1986; IAEA, *Principles for Limiting Releases of Radioactive Effluents to the Environment*, Safety Series No. 77, 1987; and IAEA, *Principles for the Exemption of Radiation Sources and Practices from Regulatory Control*, Safety Series No. 89, 1988). With reference to the most exposed individuals, this implies that only a fraction of the applicable ADL should be allocated to a given source of exposure, such as the transport of radioactive materials, and this aspect shall be considered in the next revision of the Agency's Transport Regulations.

THE USE OF ADLs IN THE AGENCY'S TRANSPORT REGULATIONS

In the Agency's Transport Regulations there are requirements aimed at the control of the exposure to ionizing radiation in normal conditions of transport as well as requirements intended to limiting the probability of occurrence of significant overexposures.

Examples of requirements aimed at limiting the exposure of members of the public and workers in routine transport are: the specification of maximum allowable radiation levels; the categorization of the packages; the limitations on the accumulation of packages either during in-transit storage or on vehicles; and the recommended values for deriving segregation distances.

It should be noted that, in general, there are not obvious correlations between the applicalbe ADL and the requirements intended to the control of the exposure in routine transport. For instance, a reduction of the dose rate around each package by increasing the shield thickness implies heavier packages and, perhaps, the individual doses associated to the handling will be increased while the individual doses of other workers and of members of the public will be decreased. Anyway, it is evident

that a significant reduction of the ADLs will force a revision of some transport requirements to assure that the primary limits of dose are not exceeded. Furthermore, if only a fraction of the ADLs is allocated to the exposure arising from the transport of radioactive materials (the concept of dose-upperbound or optimization constraint), it should be necessary to assure that this fraction is not exceeded, or to introduce changes in the Regulations.

In relation with potential exposures (e.g., transport accidents), reference is made to the Q System used to calculate the activity limits for Type A packages and, in consequence, to decide when a Type B package shall be requested or when an excepted package can be accepted (IAEA, *Explanatory Material for the IAEA Regulations for the Safe Transport of Radioactive Material*, 1985 Edition, Safety Series No. 7, 1987). In this case, the ratio between the individual doses expected in hypothetical accidents and the applicable ADL for workers was used to determine the level of safety to be applied for limiting the probability of occurrence of significant exposures in potential accidents by requesting the use of a given type of package. Therefore, in principle, a change in the ADLs will imply a revision of this area of the Agency's Transport Regulations. Furthermore, new information seems to demonstrate that the in-utero exposure during a defined period of pregnancy (between the 8th week and the 25th week after conception) could induce mental retardation (*Effect on Intelligence of Prenatal Exposure to Ionizing Radiation*, Schull and Otake, 1986; and UNSCEAR, *Genetic and Somatic Effects of Ionizing Radiation*, 1986). As a pregnant woman could be exposed in some transport accidents, this fact should be carefully considered, particularly if there is not evidence of threshold for this effect.

THE PRACTICAL CONSTRAINTS OF THE AGENCY'S TRANSPORT REGULATIONS

Some basic principles implicitly considered in the Agency's Transport Regulations are largely responsible for their wide national and international acceptability. These principles are practical constraints because if a change affects significantly one of them it will be difficult to reach international consensus for its introduction. The most significant of these practical constraints are as follows:

A. The level of safety is fundamentally specified by the type of package requested (Excepted, Industrial, Type A or Type B) and this level should be good enough, even considering the wide range of variation in the transport global safety due to the mode of transport used (road, rail, air, sea), the possible weather conditions during carriage, the quality of the vehicles or roads used, the frequency of shipments, etc. Although this principle does not preclude the introduction by a National Competent Authority of additional requirements dealing with the aspects indicated above, for instance on routine restrictions for some kind of shipments, these additional re-

quirements should not be necessary to grant a high level of safety.

B. Requirements related to one specific mode of transport should be limited as far as possible.

C. Special operational requirements during carriage and in-transit storage should be limited to few simple directions, mainly based on the information displayed on the package labels.

D. As far as possible, the packages should be handled, loaded or stored by conventional means without the need of specialized workers or unusual tools or devices.

POTENTIAL MODIFICATIONS OF THE AGENCY'S TRANSPORT REGULATIONS

In the above parts it was explained why can be expected a reduction of the ADLs, which kind of requirements of the Agency's Transport Regulations can be affected and which practical constraints should be considered when the introduction of changes or new requirements are discussed. The points presented hereon are intented to describe the areas of revision to be considered in next years.

Package Activity Limits and Potential Changes in the ADLs

The Q System takes into account various exposure models, mainly in-door accident scenarios, that allow to correlate the radioactive content of the package with the possible doses incurred by the assumed "most exposed" person. When the activity content of a given radionuclide is such as any of the dose values calculated equals the applicable ADL for workers, this activity content is taken as the activity limit in a Type A package for this radionuclide (IAEA, *Regulations for the Safe Transport of Radioactive Material, 1985 Edition*, Safety Series No. 6; and Safety Series No.7).

Although the use of the ratio between possible accidental doses and a given dose for deciding the applicable level of safety is not particular to transport, it is stressed that to take the ADLs for workers as reference values is somewhat arbitrary. In fact, any dose quite below the thresholds for non-stochastic effects could be used from a technical point of view. In this sense, it should be noted that the probability of occurrence of such doses is low and the event of having the same person exposed to more than one radiation transport accident during his life has such a low probability that can be generally disregarded.

Therefore, it is recommended not to change the present package activity limits only on the basis of a change in the ADLs but to review the reference values used in the Q System (and the exposure models when appropriate) to assure that both reference doses and intakes are quite below the thresholds for non-stochastic effects.

Routine Exposures and Potential Changes in the ADLs

In relation with the control of the exposure in accident-free transport

conditions, the following aspects should be considered: (a) exposure of workers to external radiation; (b) workers potential intakes because of non-fixed surface contamination; and (c) exposure of members of the public to external radiation. Although it is possible the intake of radioactive material by members of the public because of non-fixed surface contamination of the packages, this pathway seems not to be significant.

Workers (External Radiation and Potential Intakes)

Usually various sorts of workers are exposed to external radiation and potential intakes during transport operations. For instance, specialized workers are involved in the preparation of the packages and in the unloading operation when they arrive to the final destination. Non specialized workers are usually involved in handling. In-transit storage, administrative controls, transfers and the carriage itself. A reduction of the doses incurred by specialized workers can be obtained by changes in the handling procedures or by means of the use of special tools or devices, but the same cannot be applied to the case of non-specialized workers because it violates the practical constraints stated in points C. and D. above.

Assuming that the total activity to be transported per year is independent of the transport requirements, any change in the rules for package accumulation or for deriving segregation distances will only modify the frequency of shipments, probably without an effective reduction of the doses incurred by the most exposed workers. Therefore, if a dose reduction is needed, it seems that the only way available is a contraction of the allowable levels of radiation.

However, as it was already noted, the weight of each package will increase and it can be envisaged situations where the exposure time of the workers involved in handling operations and their doses could be increased. In addition, heavier Type A or Industrial packages could have a lower capacity to withstand an accident (the probability of potential doses could be augmented).

Fortunately, the information available indicates that the exposure of the workers is not high, with the exception of highly concentrated distribution systems (IAEA, *Assessment of the Radiological Impact of the Transport of Radioactive Materials*, IAEA-TECDOC-398, 1986). But if a change should be introduced, two possible solutions seems to be available:

(I) to eliminate the Category Yellow III for beta and low energy gamma emitters (or in any case where with a little shielding increase can be obtained a significant reduction of the dose rate); or

(II) to eliminate Category Yellow III for every light package (e.g., for packages weighting less than 20 kg).

In these cases, neither changes in the handling procedures nor modifications of the exposure times during handling are expected. Therefore, an individual dose reduction equivalent to the average reduction of the dose

rate can be anticipated.

In relation with potential intakes by workers, it is noted that only a few packages, usually of the re-use type, could have significant external surface contamination. Therefore, this area does not seem to be a practical problem. However, if something is done, it seems to be enough the introduction of an additional external label requesting the use of gloves for handling of the packages.

Members of the Public (External Radiation)

In routine transport, it seems that the doses incurred by the more exposed members of the public are not quite significant (IAEA-TECDOC-398, 1986). In addition, most of the doses (both individual and collective) came from the transport of radiopharmaceutical products (*Radiation Exposure Resulting from the Normal Transport of Radioactive Materials within the United Kingdom*, Gelder et al., NRPB-R155, 1984). Also in this case, changes in the requirements dealing with segregation or accumulation should have little effect in the doses of the most exposed persons and no effect (or probably an increase) on the colective doses.

Based on the same considerations as for workers, it seems that the reduction of the allowable levels of radiation could be the best solution for a reduction of the doses incurred by the members of the public. In this context, the above suggestion (I) or (II) can be effective ways to reduce the public doses.

Protection versus Safety

In dealing with the reduction of the doses incurred by workers and members of the public, it is always convenient to take into account the potential conflict between radiation protection (control of actual doses) and safety (probability of occurrence of potential accidents). High transport speeds, use of secondary roads, simplified ways of handling and the like are always attractive measures that can reduce the exposure of workers and members of the public, but that also usually imply a lower level of safety. Care should be taken in this area to avoid, both in an international and national level, the introduction of measures that can increase the potentiality of accidents.

CONCLUSIONS

Summarizing, the areas of revision of the Agency's Transport Regulations in the case of reduction of present ADLs as well as the extended use of the concept of dose-upperbound or optimization constraint will be the followings:

(i) the Q System (and the activity limits for Industrial, Type A and Type B packages);

(ii) the requirements dealing with radiation levels in routine conditions;

(iii) the requirements dealing with dose limitation in routine conditions, such as that related to accumulations of packages, segregation distances and the like; and

(iv) the requirements dealing with non-fixed surface contamination.

Although not discussed in this paper, another area that should deserve special attention during the revision of the Agency's Transport Regulations is the one between routine transport and transport accidents. In fact, is in this area where it seems most difficult to evaluate the impact of a reduction of the ADLs because the lack of information both in frequency and type of incidents or minor mishaps as well as on the doses consequence of such events.

Based on the Authors experience, the usual mishaps are: wrong address of the consignee; temporary missing packages; labelling mistakes; and, in quite a few cases, the shipment as "empty" of a package actually carrying a decayed radioactive source. Generally, cannot be anticipated the occurrence of significant doses, but it is noted that with present dose rate values of up to 2 mSv/h on the surface and up to 0.1 mSv/h at 1 meter from the package, if a white label is placed instead of a Yellow III one, then it appears difficult to assure that the applicable ADL will not be exceeded.

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