Study on the Protection Planning Actions and Response to Nuclear or Radiological Emergency

Perez, Clarice F.A.[a], Sahyun, Adelia[b,c], Freitas, Kenia A.M.[d]

[a]Centro Tecnológico da Marinha em São Paulo, - CTMSP, São Paulo, SP, Brasil.
[b]Atomo – Radioproteção e Segurança Nuclear S/C Ltda, São Paulo, SP, Brasil.
[c]Instituto de Pesquisas Energéticas e Nucleares – IPEN-CNEN/SP, São Paulo/SP, Brasil.
[d]Navele Empreendimentos Ltda, Rio de Janeiro, RJ, Brasil.

Abstract. Nuclear or Radiological emergencies can have as a consequence the rise of Deterministic effects, in the population involved, and/or Stochastic effects due to their doses. In these situations, protective actions need to be done in order to keep the doses in the affected population below the levels of deterministic effects and protective actions that might reduce the risk of stochastic effects should be adopted, minimizing the doses to reasonably achievable levels. This work presents a comparative study between the publication of IAEA Safety Series 109 and the document of the International Atomic Energy Agency GSG-2 "Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency" regarding the effective dose value system to be used as a basis to trigger protection actions in the Planning and Response to Nuclear or Radiological Emergencies that can reduce the risk of stochastic effects.

KEYWORDS: GILS; Response Actions to Exhibitions Emergency Situations.

1 INTRODUCTION

In this work we compared the publications IAEA Safety Series nº109[1] and IAEA GSG-2 "Criteria for Use in Preparedness and Response for Nuclear or Radiological Emergency"[2] with regard to the effective dose values system to be used as a basis to trigger protection actions in the Planning and response to Nuclear or Radiological Emergencies that can reduce the risk of stochastic effects.

2 APPROACH GSG-2 "CRITERIA FOR USE IN PREPAREDNESS AND RESPONSE FOR A NUCLEAR OR RADIOLOGICAL EMERGENCY"[2]

The recommendations presented in the document address health consequences due to external exposure and internal exposure of specific target organs, for which the generic criteria were developed. This use of generic criteria meets the need for a common term for the system of values that would be used as the basis for the implementation of protective actions and other response actions. Table 1 provides a set of generic criteria expressed in terms of the dose that has been projected or the dose that has been received. The set of generic criteria expressed in terms of the projected dose is compatible with reference levels within a range of 20–100 mSv. According to this publication, taking protective actions at this level of dose will allow the occurrence of all deterministic effects to be avoided and the risk of stochastic effects to be reduced to acceptable levels. If a protective action is implemented effectively, the majority of the projected dose can be averted. The concept of averted dose is therefore useful for the assessment of the efficiency of individual protective actions or their combination.

Table 1: Generic Standards for Protection Actions and Response Exhibition on Emergency Situations to Reduce the Risk of Stochastic Effects

	Generic Criteria	Examples of protective actions and other response actions
Projected dose that exceeds the following generic criteria: Take urgent protective actions and other response actions		
$H_{Thyroid}$	50 mSv in the first 7 days	Iodine thyroid blocking
E H_{Fetus}	100 mSv in the first 7 days 100 mSv in the first 7 days	Sheltering; evacuation; decontamination; restriction of consumption of food, milk and water; contamination control; public reassurance
Projected dose that exceeds the following generic criteria: Take protective actions and other response actions early in the response		
E H_{Fetus}	100 mSv per annum 100 mSv for the full period of in utero development	Temporary relocation; decontamination; replacement of food, milk and water; public reassurance
Dose that has been received and that exceeds the following generic criteria: Take longer term medical actions to detect and to effectively treat radiation induced health effects		
E	100 mSv in a month	Screening based on equivalent doses to specific radiosensitive organs (as a basis for medical follow-up); counseling
H_{Fetus}	100 mSv for the full period of in utero development	Counselling to allow informed decisions to bemade in individual circumstances

Note: H_T — equivalent dose in an organ or tissue T; E — effective dose.

3 APPROACH THE IAEA SAFETY SERIES 109[1]

According to the document the intervention in nuclear or radiological emergencies should be based on the Generic Intervention Level System (GILs) and Generic Action Levels (GALs) adopted in order to guide the implementation of the various protection measures proposed for avoid or reduce the population's exposure to radiation.

Intervention levels are expressed in terms of dose which can be avoided in a time period, ΔT, corresponding to the duration of a specific protective action associated with the intervention, that is, the dose which the individual would be subjected in the absence of measurement, integrated in the ΔT period, minus the integrated dose which would be subject to the application of a protective measure. The action levels are expressed in radionuclide activity concentrations in water, milk and other foods. Intervention Levels (GILs) recommended for emergency protection measures are presented in Table2.

Table 2: (GILs) Generic Intervention Levels for Urgent Protection Actions

Protective Actions	Generic intervention level (dose avertable by the protective action)
Sheltering	10 mSv
Evacuation	50 mSv
Iodine prophylaxis	100 mGy
Temporary relocation	30 mSv in first month 10 mSv in a subsequent month
Permanent resettlement	1Sv in lifetime

4 CONSIDERATIONS GILs

The Generic Intervention Level for Urgent Protection Actions (GILs) provided in the publication IAEA Safety Series109/1/ were calculated using optimization. The following will show, briefly, the optimization calculation developed by IAEA Safety Series109/1/ to sheltering and then show an example involving sheltering. We emphasize that all the calculations for (GILs) followed the same methodology used to taking shelter and therefore are not showed in this paper.

5 CALCULATION TO SHELTERING

The publication /1/ in its page 76, developed a method to estimate optimized intervention levels for the movement of people and features the following equation to calculate the avoided dose that would justify a certain level of intervention:

$$\Delta\dot{E}(t) == \frac{a}{\alpha} \tag{1}$$

Where:

$\Delta\dot{E}(t) =$ individual dose avoided per unit time
$a =$ the individual cost of maintenance actions per unit of time
$\alpha =$ unit cost of avoided collective dose

The publication/1/, are also the following considerations:

The measure of protection for sheltering consists, in general, to remain in indoors with doors and windows closed. No need to transport and food is available. The most important cost in this case is that caused by loss of productivity in the population involved. This cost can be estimated from the annual per capita gross domestic product divided by the number of days in the year:

$$(\text{US}\,\$20000 \div 365 \cong US\$55\,)$$

The value used for the publication was 20,000US$(Sv-person)$^{-1}$also value based on annual gross domestic product per capita. However, the publication on page74,explains that there are factors that could modify the alpha value, and that for this calculation was considered a factor of 2 uncertainty causing the alpha value ranges between10,000 and40,000US$(Sv-person)$^{-1}$.

Thus, the calculation has to sheltering as follows:

$$\Delta\dot{E}(t) = \frac{a}{\alpha} = \frac{\$55/\,day}{\$10000\ until\ \$40000\ \ /\,Sv} \cong 1{,}5\ to\ 6mSv\ \ /\,day \tag{2}$$

As the approach for more than two days is considered detrimental to the population, the GIL was estimated for this time period. Then the dose value to justify avoided taking shelter is between 3 and 12mSv, it was then adopted the10 mSv value that is within this range.

6 SHELTERING EXAMPLE

For example we developed a calculation of the dose range of values that would justify taking shelter for two days for some countries of the European community based on the GDP per capita of 2013 the euro zone equivalent to US$ 34,060 as the International Monetary Fund (2013).

Table 3: Dose interval for Sheltering for 2 days for some countries of the European community based on the GDP per capita of 2013 in the euro zone

Country	PIB (US$)	a	alpha times two (Dose mSv)	alpha US$ 34,060 (Dose mSv)	alpha divided by two (Dose mSv)
Luxemburg	110423	303	9	18	36
Austria	48956	134	4	8	16
Netherlands	47633	131	4	8	15
Finland	47129	129	4	8	15
Ireland	45620	125	4	7	15
Belgium	45383	124	4	7	15
Germany	44999	123	4	7	14
France	42999	118	3	7	14
Italy	34714	95	3	6	11
Spain	29150	80	2	5	9
Cyprus	24761	68	2	4	8
Slovenia	22756	62	2	4	7
Greece	21857	60	2	4	7
Portugal	20727	57	2	3	7
Slovakia	17706	49	1	3	6
Lithuania	16003	44	1	3	5

Note that if the GDP of a country is high, higher shall be the dose value which justifies the sheltering, and if the GDP is low, lower doses justifies the sheltering. As we can see on table 3, the country that best fits the range found (3-12 mSv) in the SS-109[1] is Italy and this is because its GDP, US $ 34,714, is roughly equal to the GDP, US $ 34,060, of the European Community, which would reduce the expression (1) to the range below.

$$\Delta\dot{E}(t) = \frac{a}{\alpha} = \frac{\frac{\$}{365}}{\frac{\$}{2}\ until\ 2\$\ /\ Sv} = \frac{\frac{\$}{365}}{\frac{\$}{2}}\ until\ \frac{\frac{\$}{365}}{2\$} = \frac{2}{365}\ until\ \frac{1}{730} \cong 1{,}5\ to\ 6mSv\ /\ day \tag{3}$$

7 CONCLUSION

The GSG-2/2 / deals with the issue with greater scope and in fact provides a common term for the value system that should be used as a basis for the application of the Protection Actions. In this publication the dose values equivalent and effective dose are presented (general criteria), which must not be exceeded and if it happen or will trigger the protection actions, or will be accepted provided it is proven its justification through an optimization process. Still according to this reference, a set of generic standards, expressed in terms of projected dose is compatible with reference levels within a range of 20-100 mSv. Protective actions to keep the doses compatible with this range, prevent the occurrence of any deterministic effects and reduce the risk of stochastic effects to acceptable levels. Given the above, the concept of Avoided Dose is only useful for evaluating the efficiency of the options available for protection actions and never as an end in itself.

The BSS nº109 [1] treats the dose avoided as justification to trigger protective actions such as taking shelter or evacuation, but avoided dose does not tell us what is the acceptable dose, did not exist, in this publication, a reference level that can be used as a guide. When we adopted, for example, 10 mSv of avoided dose for taking shelter, the question is: how much dose, not avoided, are accepted? What is acceptable in a nuclear or radiological accident? In terms of Radiological Protection, considering the methodology used in the calculation to justify taking shelter and observing the example of dose to sheltering developed in this work to countries of the European community, which means exactly avoid these 10 mSv? Suppose in an accident dose projected for a given individual is 11 mSv and that with taking shelter are avoided 10 mSv, it would be wise to keep this individual trapped inside your own home, which should remain with doors and windows closed for two days to it receives only 1mSv? This can be a very controversial issue, especially after comparison with the Reference Levels proposed in reference [2] which are among 20-100mSv, and according to the publication ensure that there will be no deterministic effect and the risk of stochastic effect is within acceptable limits.

8 REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Intervention Criteria in a Nuclear or Radiation Emergency, IAEA Safety Series No. 109. Vienna (1994).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency, IAEA General Safety Guide -2. Vienna (2011).