SOME QUESTIONS ABOUT REFERENCE LEVELS. AS AN EXAMPLE THE SEGREGATION DISTANCE FOR PACKAGE CONTAINING RADIOACTIVE MATERIAL TRANSPORTED IN A AIRCRAFT

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ABSTRACT

The aim of the present paper is that many stakeholders forgot that the reference levels are not dose limitation as they assume. The reference levels are based on a scenery and if this scenery change the reference levels also change. In this case we take as an example the establishment of the minimum segregation distance in the radioactive materials transportation by aircraft. We present the IAEA scenery in these following situations: a) below main deck stowage of one group of packages in passenger aircraft; b) below mains deck stowage of multiple groups of packages in passenger aircraft, and c) main deck storage on combi or cargo aircraft, and we will show the factors that we can vary to adapt an actual particular situation. In a table we show the distance calculated by the IAEA scenery and that adopted in the ICAO Technical Instruction and assumed by the IATA. The arguments presented in this paper are relevant in the case when the distance between the package containing the radioactive material and the individual that receive the dose is less than the distance presented in the table of the ICAO Technical Instruction and there is not any possibility to transport in a bigger aircraft.

Key Words: reference level, aircraft transport of radioactive material; Transport Index in aircraft, dose limit in aircraft

1. Introduction

The aim of the present paper is that many stackholders forgot that the reference levels are not dose limitation as they assume. The reference levels are based on a scenery and if this scenery change the reference levels also change. In this case we take as an example the establishment of a minimum segregation distance in the radioactive material transportation by aircraft. We present the IAEA scenery in these fallowing situations: a) below main deck stowage of one group of packages in passenger aircraft. b) below main deck stowage of multiple groups of packages in passenger aircraft, and c) main deck stowage on combi or cargo aircraft[(1)]. In this IAEA example we show the parameters can be modified to give less doses than that assumed. We also prove that the IAEA example never will be followed.

2. Annual Dose Received by Crew and the Representative Person of Public

The IAEA model use this equation to determine the reference dose rate (RDR) for crew and members of the public, to be used as a basis for establishing the minimum segregation distance

RDR(mSv/h) = DV (mSv/a) / MAPT (h/y) x RTF (1)

Where

DV is the annual dose limits for crew (workers) and members of the public, ι. e. 5mSv/y for crew and 1 mSv/y for the representative person for the public.

MAPT is the maximum annual travel periods for crew and for the representative person of the public

RTF is the radioactive traffic factor defined as the ratio annual number of journey made in company with category II-YELLOW and category III-YELLOW package of radioactive material to the annual total of all journey

3. Below Main Deck Storage of one Group of Package in Passenger Aircraft

According to the model used by the IAEA the segregation distance S is given by the equation

$S = [(TI.TF_f) / (100xRDR]^{112} (1+r)-(r+0.4)$ (2)

Where

S, r and 0,4 are in meters and they are shown in the figure 1

TI is the transport index which, when divided by 100, is an expression of the radiation level at 1 m from the package surface (mSv/h).

TF_f is the transmission factor of the passenger compartment floor, ι. e. the fraction of radiation which posses through the aircraft structures between the source and the dose point (dimensionless)

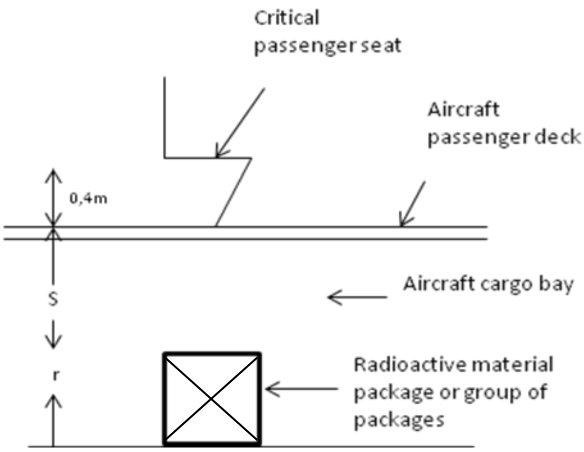

Figure 1 Typical configuration of passenger and cargo in passenger aircraft, used for determining the segregation distance S.

The transmission factor (TF_f) varies with the energy of the radiation emitted from the package and the aircraft floor construction. The IAEA publication informs that the typical factors range from 0.7 to 1.0. The combination of TI, transmission factor and package size shown in table 1 were selected by the IAEA as conservative but realistic models.

Table 1 – Transmission Factors

Transport Index (TI)	Transmission Factor (TF_f)	Package Radius (r) (m)
0 – 1.0	1.0	0.05
1.1 - 2	0.8	0.10
2.1 - 50	0.7	0.40

To determine the RDR given equation (1) the IAEA assume DV as 1 mSv/y, MAPT as 500 h/y (normal crew fly per year) and a RTF of 0.1. In this case

RDR = (1 mSv/y) / (500 h/y) (0.1) = 0.02 mSv/y (3)

Putting this value in equation 2 and using the values of the table 1 were determined the values shown in table 2 second column that can be compared with the value presented in the ICAO Technical Institution [(2)] and Assumed by the IATA [(3)]

Table 2. Variation of segregation distance with transport index for a single of packages stowed below main deck on a passenger aircraft

Total TIs for packages in the group	Vertical segregation distance (from top of group of packages to floor of mains deck (m))	
	Calculated here [a]	**In 1995-1996 ICAO Technical Instructions[b]**
1.0	0.29	0.30
2.0	0.48	0.50
3.0	0.63	0.70
4.0	0.86	0.85
5.0	1.05	1.00
6.0	1.23	1.15
7.0	1.39	1.30
8.0	1.54	1.45
9.0	1.68	1.55
10.0	1.82	1.65

[a] Calculated using Eq. (6) and assumptions outlined in this appendix.

[b] ICAO Technical Instruction for the Safe Transport of Dangerous Goods by Air [5].

Maintaining the same calculation model we can discuss as we can be more realistic and decrease the distance without decrease the safety, ι. e. maintaining the same annual dose of I mSv.

i – as the own IAEA tells in the publication, the actual seat height in most aircraft would be approximately 0.5 m and it is conservative to assume here 0.4 m. In this case we can substitute in equation 2 the 0.4 m by the actual value of the particular aircraft considered

ii – Substitute the package radius (r) given in table 1 for the actual radius.

iii – Substitute the transmission factor (TF_f) given in table 1 by the actual factor remembering that as IAEA mention it is typical transmission factor and probably is a medium value for electromagnetic energy in the range of 5 KeV and 3 MeV that are the energy assumed by the radioisotopes majority. In this case if we transport ^{131}I with e medium energy of 364 KeV (100%) or the Mo with medium energy of 740 (100%) the transmission factor will be less.

iv – Was considered that the commuters as sales person fly 500 h/y with a RTF equal to 0.1, this means that fly 500 h / y and in presence of radioactive material package during 50 h/y. Probably, the fly hours for year is very big and the RTF is excessively big considering that this fellow commuters only occasionally will be seat exactly over the group of package. In this case we think that comduing a RTF of 0.02 or 0.03 is more realistic í. e. only one long fly travel of 10 h or 15 h for year in the worse condition seat over the group package This consideration increase the RDR from 0,02 mSv/h to 0,06 mSv/h or 0,1 mSv/h and decreases enough the distance S.

As a last suggestion it is possible for a particulate aircraft to do an experimental measurement and by the hours of fly obtain an actual dose on the seat over the group of package

4. Below Main Deck Stowage of Multiple Groups of Packages in Passenger Aircraft

The IAEA gives as an example a configuration of five groups of packages, each having a different total TI value, with equal spacing distance S' between groups, as decipted in figure 2. The highest radiation level for passengers would be at the seat directly above the centre group of packages.

For a configuration such as that shown in figure 2 the inverse square law gives:

$$RDR = TI_{\imath} \sum_{\imath=1}^{5} (TI / 100\ (1.0 + r)^2 / (AMD_{\imath})^2 \qquad (4)$$

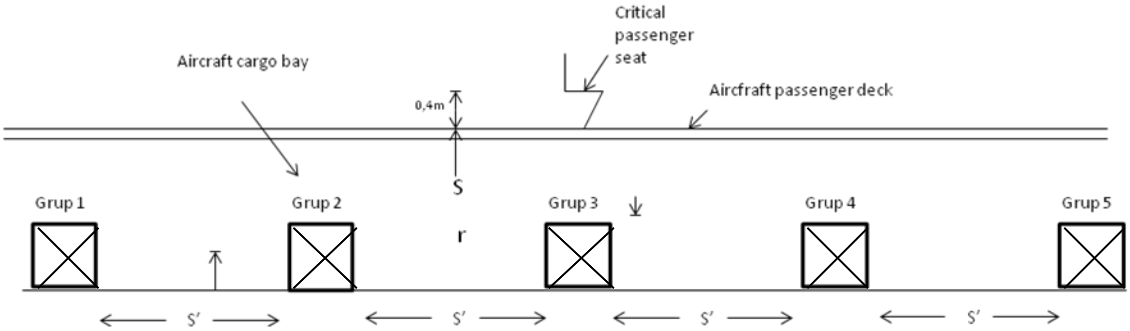

Figure 2. Typical configuration of passenger and special cargo in passenger aircraft, used for determining the segregation distance S and spacing distance S'

If it is assumed that

$TI_{\acute{\imath}} = 4$, $\acute{\imath} = 1$ to 5

$r_{\acute{\imath}} = 0.4m$, $\acute{\imath} = 1$ to 5

$TF_f = 0.7$

Then RDR = 0,02 mSv / h It is noted that

$ADM_1 = ADM_5 = \sqrt{(r + S + 0.4)^2 + (4r + 2S')^2}$

$ADM_2 = ADM_4 = \sqrt{(r + S + 0.4)^2 + (2r + S')^2}$

$AMD_1 = r + S + 0.4$

Equation (4) and (5) combine to give on equation with two unknowns S and S’. Various combinations of S and S’ would allow a consignment of packages having a total TI of 20 to be carried with a segregation distance S less than 2.9m. For example, placing the five groups, each with a total TI of 4 as shown in figure 2, a segregation distance S of 1.6m with a spacing distance S’ of 2.11m would give a maximum radiation at seat height of 0.02mSv/h. This various combinations of segregation and spacing would safely control the radiation exposure of passengers for large TI consignments

All the discussion presented in the least chapters is valid also for this chapter.

In this chapter we can add that we can:

i) change the combination of S and S’

ii) Put the package in only one place because the more inner package will be shealded by the external ones.

iii) Put the packages n a place with the bigger distance from the passengers, pilots and crews

5. Main Deck Stowage on Combi or Cargo Aircraft

For this condition, all parameters previously assumed are used, except FT_w (transmission factor for the wall of an ocupped comportment) is assumed (without verification) to be greater or equal to 0,8.

For the crew, the fallowing assumption[I] was made

MATP = 1000 h/y

RTF = ¼

MAET = (1000h/y) (1/4) = 250h/y

DV = 5.0 mSv/y

RDR = (5.0 mSv/y) / (250h/y) = 0,02 mSv h/y

[I] The values of MATP and RFT assumed here for the crew members have not been verified for actual flight situations

The MATP and MAET values used before for passengers in passenger aircraft are used here also. With this assumptions, the calculations for passengers in a combi and for crew in a cargo aircraft will result in the same segregation distance.

The situation for combi or cargo aircraft is depicted in fig. 3 the minimum horizontal distance between the seat back and a seated parson and the inside wall of the occupied compartment is also assumed to be 0.4m. this is probably a conservative value because, if the cargo is forward, the passenger´s feet will be against the partitation; and if the cargo is aft, there will usually be instruments, a gallery, toilets or at least luggage or seat-reclining space between the partitation and the rear set. In this situation AMD continue to be:

AMD = S + 0.4 + r and

S = [(TI x TF_w) / (100 x RDR)] (1+r) – (r + 0.4)

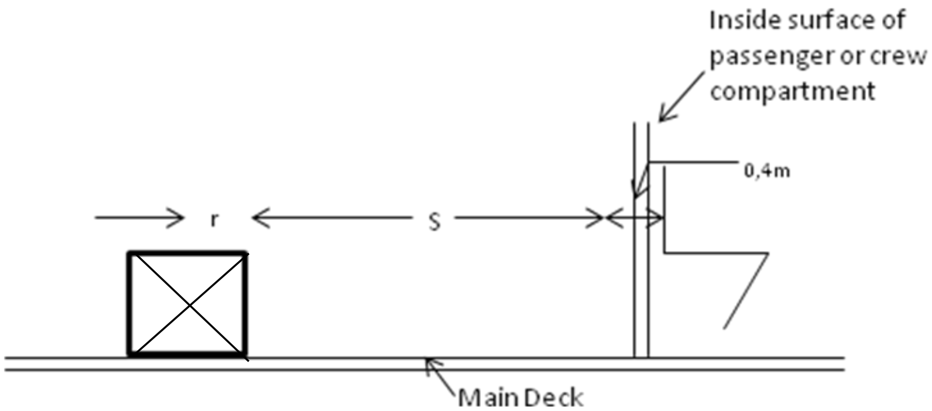

Fig. 3 Typical configuration of main deck stowage on a combi or cargo aircraft

The Calculated segregation distances for combi and cargo aircraft are shown in table 3

Table 3. Variation of segregation distance with transport index for main deck stowage on a combi or cargo aircraft

Total of TIs for packages in the group	Horizontal segregation Distance (from forward face of group of packages to inside wall of occupied compartment (m))
1.0	0.29
2.0	0.48
5.0	1.18
10.0	2.00
20.0	3.16
30.0	4.05
40.0	4.80
50.0	5.46
100.0	8.05
150.0	10.04
200.0	11.72

The discussion presented in the two last chapter are valid also for this chapter

6. Conclusions

i. We see that we can vary several parameters assumed by the IAEA that change completely the situation
ii. The suggestion is to put in the passengers aircraft or combi and cargo aircraft the package more far from the people ι. e., passengers, pilots and crew
iii. Probably the best maintain the packages joints so that one package is shielded by the others around
iv. Probably if we satisfy our items 2 and 3 will not be necessary limitate the TI for aircraft
v. The model introduced by the IAEA shown here is the worse case and when possible do not would be followed
vi. The IAEA indebt cab inspire the interested fellow or organization fallow the example because is considered the IAEA suggestion.
vii. The IAEA in his article forgot to mention that preferibly is better do not dispose the package according the example given by it.

References

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[2] International Civil Aviation Organization. Technical Instructions for the Safe Transport of Dangerous Goods by Air, 1998-1999 Edition ICAO Montreal (1996)
[3] International Air Transport Association. Dangerous Goods Regulation, 37 the Edition, IATA, Montreal (1996)