Comparative and Simulation Shielding Structures in Satellites with Presence Telecommunication and Electronic Devices

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ABSTRACT:
During mission all of the telecommunication and electronic components in satellites expose to ionizing radiation. This factor can cause damage to the structure and function of the satellite. This paper examines the different structures that make radiation shielding satellites in GEO orbit. In this work, the amount of ionizing radiation is calculated using the MCNPX code. The simulation results indicate the importance of each factor in designing shielding.

KEYWORDS: GEO orbit, ionizing dose, Shielding.

1. INTRODUCTION

Telecommunication and Electronic components in satellites into environment are exposed to radiation during their mission in space. This radiation can cause damage to the performance and function of the satellite [1] . Over the long term, High radiation dose will accumulate on many parts satellites. The most energetic particles in the vicinity of the satellite can be damaging ionizing radiation [1]. In order to design appropriate shielding to reduce the effects of radiation damage on the telecommunication and electronic components of various structures used in the simulation. In each of these structures, the results of calculation of Total ionizing dose (TID[1]) for the bulk of the aluminum and mixed material structures have been put in a position as a benchmark to compare and optimize the design of the shield. The radiation shield thickness required always trying to lose weight to reduce the cost of launching satellites should be optimized. TID on the telecommunication and electronic components can assess properly in satellite using by radiation software. It is mainly caused by protons, electrons and galactic cosmic ray. TID may cause drift in parameters of the active elements in satellite system. Therefore Carbon materials such as aluminum and PEEK (Poly Ether Ether Ketone) with Aluminum can be used hybrid structure for satellite structures [1-3]. Most of satellites is used a honeycomb structure in building for layered shielding [4]. The main advantage is located heat tube in honey comb structure for thermal on satellites [5-6]. Shielding effectiveness of the shield or coat of the spacecraft structure with a thin layer of high atomic number materials such as tantalum can be greatly improved. The aim of this work is to study the different structures proposed for radiation shield in satellite. Details of the incident particle are MCNPX software packages. This code is a special code for the space environment and the effects of radiation on electronics which It use for the simulation of particle transport and ionizing dose. This code is a code that has multiple functions in different places such as Monte Carlo method which is used for space radiation.

In this work, we computed “orbit generator” algorithm in order to define high altitude satellite’s geosynchronous directly above the earth equator (0^{o} latitude) route at ~36000 km for 18-year length of mission. We have simulated the maximum solar radiation of the space environment to model the worst case scenario. For these simulations, NASA’s latest edition of proton AP-8 [7] and electron AE-8 [8] flux models have been used. In table 2, Trapped particles in different orbits can be shown.

Table 1. Energy particles' range due to their location [4]

Particle	Energy	Location
Trapped Proton	0.1 MeV -10 MeV	LEO, MEO & GEO
Electron	100kev-1 MeV	MEO & GEO
Solar Proton	5 MeV -10 MeV	LEO, MEO & GEO
Plasma	30ev-100Kev	LEO,MEO & GEO

[1] . Total Ionizing Dose (TID) is the amount of deposited energy per unit mass of material by ionizing radiation

2. MATERIALS AND METHODS

In this study, a comparison from ionizing dose in the different structures is used. For proper comparison , these structures respectively with the letters 'A', 'B', 'C', 'D', 'E', 'F' and 'H' are named. The main characteristics of these structures are given in Table 2. Structures 'A' and 'B' are the only structures that only the outer shield is formed from aluminum. Housing Electronic structure of 'B' equal to 2 mm in thickness and other 'A', 'C', 'D', 'E' and 'F' structures have 1 mm thick for telecommunication and electronic elements. The structures of ‘C’ to ‘H’, body panels are honeycomb networks which they also made use of thin layers of aluminum or PEEK. The thickness of each layer is summarized in Table 1. 'F' structure is the most general structure which has outer and inner panels which each panels is made of a honeycomb structure. Also, a layer made of tantalum will take in parallel with internal shielding enclosure surrounding the telecommunication and electronic components. 'H' structure is similar 'F' structure; the only difference is that chamber that in this case the structure has been removed. In Figure 1, 'E' and 'F' of the cross-sectional area can be observed.

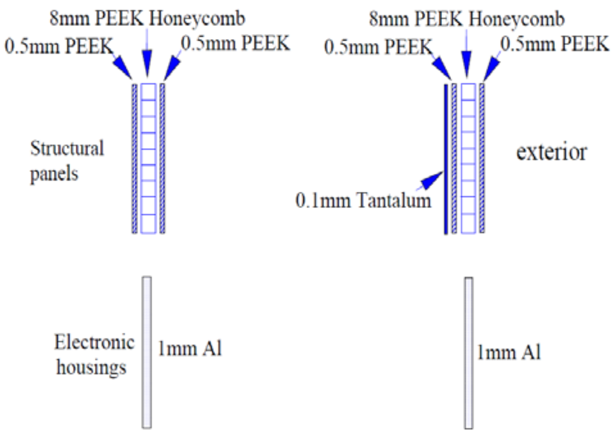

Fig. 1. The shielding structure for the two-mode E (left) and F (right)

Table 2. Dose and condensing the thickness of the structures

Structure	Outer Shielding	Inner Shielding	Box
A	1mm Al	×	1 mm Al
B	1 mm Al	×	2 mm Al
C	0.1 mm Al	0.1 mm Al	1 mm Al
D	0.1 mm Al	0.1 mm Al	1 mm Al
E	0.5 mm PEEK	0.5 mm PEEK	1 mm Al
F	0.5 mm PEEK	0.5 mm PEEK	1 mm Al
H	0.5 m PEEK	0.5 mm PEEK	×

3. SIMULATION RESULTS

The aim of this work to evaluate and compare the Total Ionizing Dose has exposed telecommunication and electronic components in different structures. Figure 2 and Table 2, the thickness of the condensate, dose and multiplying these two values for each of the above structures are visible.

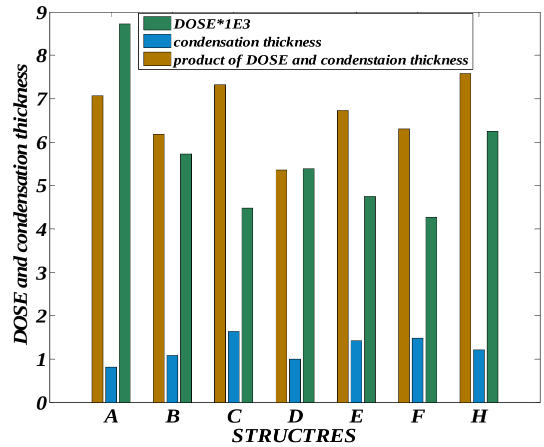

Fig. 2. Dose depending on the thickness of the shielding structures

Table 3. Dose and condensing the thickness of the structures

Indicator	Dose (rad)	Thick condensation (g/cm2)	Dose multiplied by the thickness of the condensation
A	8.73e -3	8.10e -1	7.07e -3
B	5.72e -3	1.08	6.17e -3
C	4.48e -3	1.64	7.32e -3
D	5.39e -3	9.92.e -1	5.35e -3
E	4.75e -3	1.42	6.73e -3
F	4.26e -3	1.48	6.31e -3
H	6.25e -3	1.21	7.58e -3

In Table 3, each of the effective doses and the thickness of the condensate, which is an estimate of the amount of mass, are visible. These two effects have to be considered simultaneously, so in Table 2, the last column of each factor is multiplied. Since the dose and mass is low, structure is suitable for the panel. So for comparing, this parameter to be considered from the maximum to minimum amount. In this comparison, the effects of both factors are equal and consider with unique power. With the importance of this issue can raise issues of importance allowing for the effects of allocating more power in each multiplication of the two factors applied.

Table 4. Structures arrangement with respect to the shield structure

TID	F< C < E < D < B < H < A
Thick condensation	C > F > E > H > B > D >A
The effect of both factors	D < B < F < E < A < C < H

Base Allowable Radiation Dose for Satellite Components [6], recognizing the allowable radiation dose for every element which is used in a satellite is essential. These dose levels are achieved from related datasheets in space specification components. This situation presents a challenge for system designers, since elements typically have lower failure levels and larger variability in presence radiation. Table 5 presents radiation dose when there is 'D' structure in inner and outer satellite.

Table 5. Thickness to deal with the effects of the threshold values TID for 'D' structure

Telecommunication and Electronics elements	TID (krad)	Thickness (mm)
Power Supply	25	4.78
EPC	40	4.22
Low Noise Amplifier(LNA)	50	4.00
Phase Lock Oscillator	100	3.40
Digital Controller	300	2.59

It should be noted that these results have been obtained for a dose of protons in the solar events. Figure 3 presented ssatellite position in space.

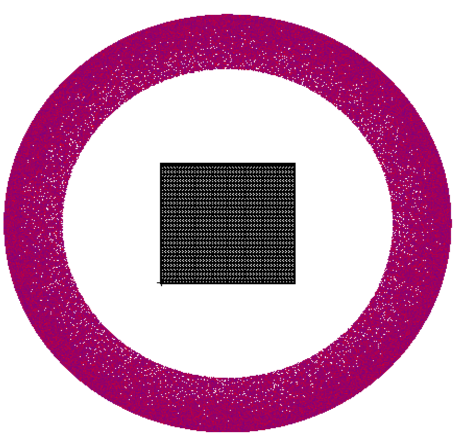

Fig. 3. Satellite position relative to the radiation environment

Figure 4 shows TID in silicon versus condensation thickness for 'F' structure.

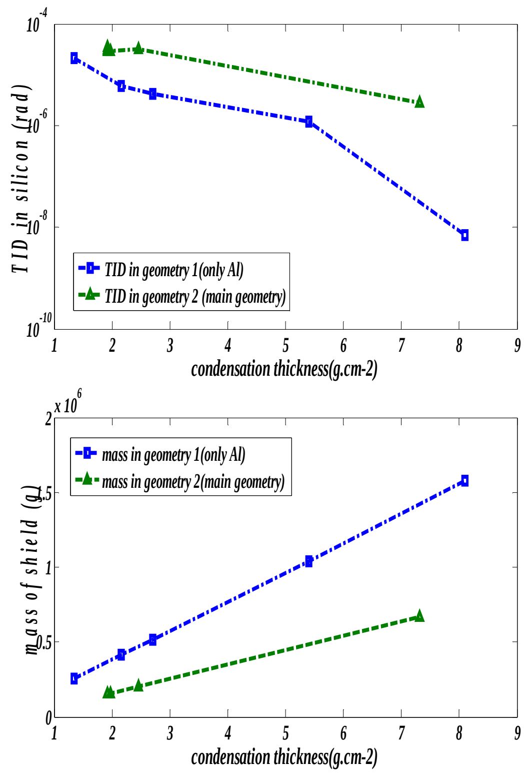

Fig. 4. Simultaneous comparison of mass and thickness of condensate in terms of dose and combination aluminum shield for 'D' structure.

4. CONCLUSION

Allowing for the importance of both mass and dose equivalent, 'H' structure has the worst structure in terms radiation shielding. The main difference for this structure is the lack of housing, so we can realize the importance shielding structures. 'D' structure of this conclusion is the best structure. This structure is reduced all factors affecting the dose in presence the inner and outer shielding. Also, there is a honeycomb structure with PEEK material that is embedded in the inner shielding. The only major difference with 'F' structure is the absence of tantalum in the structure. It should be noted that this survey was conducted only for the solar protons. There is a heavy material such as tantalum from protecting the electron beam.

To characterize the full effect of heavy material such as tantalum, the calculations must be performed for electrons. After the 'D' structure, 'B' shielding is the best structure. Then the' E' and 'F' structures have the best performance. Since 'F' structure has a heavy layer of tantalum in its layers. Therefore each shielding which has heavy material in layers perform against radiation particles well. Ultimately, 'A' structure does not function properly due to radiation. 'A' shielding is a simple structure. The key distinction relative to other structures except 'B' structure is the absence of a inner shielding. The results of the survey can be realized to the importance of internal structural panel.

5. ACKNOWLEDGMENT

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