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Improvement of Gamma-Ray Attenuation Properties of PE/Pb Composites

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Abstract: This research deals with a study of the properties of radiation attenuation in full energies within an energy range (0.6 - 5MeV) in shielding of composite materials consisting of polyethylene PE reinforced with Pb lead material as a reinforcing or strengthening material and with different concentrations or weight ratios (15%, 30%, 45). %, 60% and 75% .

The study bases on determining the attenuation properties by calculating the linear attenuation coefficient of gamma rays, the thickness of the half layer, the thickness of the decimal layer, and the transmittance in the studied shielding samples .

The results of the calculations of the results of the XCOM.com program shows that the linear attenuation coefficient values increase with the increase with the concentration of lead powder as a reinforcing material in the polyethylene sample that used for the manufacture of superimposed shielding, in other words by increasing the density of the shielding material and decreasing according to the increase in the energy of the gamma ray photons.

It also shows that the half layer thickness and decimal layer thickness values decreased with increasing of the concentration of lead powder as a reinforced material in the polyethylene sample that used to manufacture the superimposed shields and it is increasing according to the increase of the energy of the gamma ray photons ..

By studying the change of permeability values with the thickness of the shielding material for all types of , it was found that it decreases with increasing the thickness of the shielding layers and it decreases its values with increasing the concentration of lead powder as a support material in the polyethylene sample and with the same manner for the incident radiation energies at values of 0.6, 1.5 and 5 MeV units .

The dependence of the permeability values on the energy of the rays was also studied, as it was found that with the increase of the energy of the interacting gamma photons, the permeability values of the rays within the material increased as the concentration and thickness of the shield material increased .

The study concludes that the best are shielding are the polyethylene superimposed shielding supported with the highest percentage of weight for lead powder (PE / 75% Pb) which is the most dense armor (ρ = 3.013857 g / cm3) because it gives the best results among other shielding. It is used as a shielding to obtain the highest value for linear attenuation and the lowest values for both the half-layer thickness and the decimal layer thickness and the lowest permeability to the gamma rays and for all the corresponding energy and thickness values.

1. Introduction

Radiation shielding nuclear shields perform many functions. One of the most important of these functions is to reduce The exposure to people in places where radiation is found, and they are also used in nuclear reactors to reduce the intensity of kamma rays in the nuclear reactor container to protect it from the high temperature which is resulting from the absorption of these rays, especially after the great scientific progress that began to focus on the subject of the use of radioactive materials and radiation sources. The other in the medical and agricultural fields, as well as other scientific fields such as building nuclear research reactors, as well as q In the field of generating energy and in the various aspects of life .

There are many factors that affect directly the design of protective nuclear shielding against radiation or the selection of its materials, and among these influences, if not the most important of them is the issue of the repeated scattering of radiation when Kama ray is passed into the nuclear shieling material, . And returning to the meter again as a collided ray, that is, subtracted from the theoretical calculations and finally. the introduction of a specific and important factor is resorted to the theoretical calculations to approximate their results with the practical results, and this factor is what is called a factor Accumulation (Buildup Factor) ,to avoid this big difference between practical results and theoretical calculations .this factor is often given in the form of ready tables with values that vary from one substance to another and from one energy to another [1] .

It was found that the properties that the composite materials possess of the properties that are suitable for many industrial applications have gained an important place among the different engineering materials. Metal-reinforced polymers have been developing to replace lead metal in shielding medical devices, especially those are used in nuclear medicine, after they had small shielding properties. If it compared to lead, their advantages are : that they are non-toxic and easy to form (they can be as the form of a film or thin sheet) as well as low cost.. (2)

The studies that dealt with the shielding properties were varied between theoretical research in its theses and practical in its direct measurements. The theoritcal research assumes that the homogeneous medium is infinite (infinit medium), which indicates that the flux or the beam emitted from the source all falls and interacts with the shielding material as there is no possibility of the penetration of radiation outside the shielding. As for the practical experiments, they are restricted by conditions and facts. The most important of which is that the homogeneous medium is dimensional (finite) Therefore, the potential of the radiation to penetrate outside the shielding is possible and depends on the dimensions of the shielding

2. Previous studies

In 2014, Khaled Rashad and Rifka Amer prepared a polymeric-based composite material by manual pour method. The composite material was prepared from epoxy resin as a base material supported with Magnesium Oxide (MgO) powder and with different fraction weigh. It was subjected to a bending test and a hardness test. The results showed that The values of the modulus of elasticity increase with the increase of the weight fractions of the additive magnesium oxide[3],[4].

In the same year, Abdullah and his companions used titanium and alumina powders with different weight ratios to produce a composite material. Mechanical tests such as shock, compression resistance and hardness tests were conducted for unsaturated polyesters reinforced with titanium or alumina powder and with different weight ratios. The reinforced unsaturated polyester is The alumina particles showed higher resistance in the compression test, while the titanium particles strengthened polyester gave higher shock resistance and hardness than those given by the alumina particles hardened models [5].

In the same year, researcher Zuhair prepared protective shields from nuclear radiation using polymers, where he prepared high-density polyethylene with 38% of its weight as lead (as an additive), epoxy with 33% of its weight as lead, and epoxy with 33% of its weight as aluminum (Al as an additive). The attenuation coefficient and the accumulation factor were measured for these types as individual shields. It was found that the attenuation factor increases with the increase in the additive and decreases with the increase in energy, and on the contrary it was found that the accumulation factor decreases with the increase of the additive and increases with the increase of energy [6].

In 2016, Lamees S. Faiq added different concentrations of cadmium frit to the epoxy resin. The composites were prepared by mixing frite with epoxy by manual method and in different proportions. The effect of ferritic content on tensile, hardness and thermal properties such as thermal conductivity, diffusion was studied. Thermal, specific heat, as well as insulation resistance. The use of ferritic powders as a hardening agent to form complexes led to the improvement of the properties of these compounds. All measured properties improved with increasing stiffening content. The results showed the important role of adhesion between stiffeners and polymers on the properties of the composition. It was found that the uniform distribution of the filler particles in all directions of the superposition leads to improved properties [7],[8].

In 2017, the researcher, Virgin, manufactured a protective shield from kama rays, where she prepared samples of the silicon superposed by adding lead powder with a granular size of 300μm (81% of its weight, and samples of silicon by adding lead powder with a granular size of 600 μm) by 78% of its weight, and samples Other than the silicon superposed by adding aluminum powder with a grain size of 20) by 74% of its weight, and the attenuation factor was measured for each of them, as it was observed that the shield of the superposed silicon with lead (the silicon-lead superposed) with a size of 300μm) attenuates the rays better than the rest of the types, and that the shields The silicon-lead superimposed) for both sizes attenuate the rays better than the silicon-aluminum superimposed shield. The mechanical properties such as tensile testing of pure silicon samples, the two types of silicon-lead composite samples, and the silicon-aluminum composite samples were also studied. The pure silicon samples gained the highest value in elongation of 4.4% as well. Tensile testing of pure silicon samples was performed before and after irradiation, and the test showed a match in the results, ie no change occurred in the sample composition [9].

In 2017, Najwa studied the radiation shielding properties of a composite material consisting of unsaturated polyester resin filled with granite and iron particles, where granite particles were added to the unsaturated polyester resin at 10% and then different concentrations of iron metal powder were added in weight percentages (5,10,15%). , 20) The results showed that increasing the iron concentration in the compound material leads to an increase in the linear attenuation coefficient, also it was found that the permeability coefficient decreases with the increase in the thickness of the sample. It was also observed that the relaxation time λ, the HVL half thickness layer, and the TVL layer decreased with increasing the iron concentration. In the combined material, it was also found that the penetration depth X (mfp) of all the prepared samples increased with increasing thickness and concentration [10].

1. Composite Materials

They are the solid materials resulting from mixing of two or more material, so that each substance represents a separate phase in the system, and its purpose is to obtain materials with appropriate properties that combine the properties of the raw materials involved in the preparation of the composite material bypassing the undesirable properties to be more suitable for industrial applications. The composite material consists of the matrix material and the reinforcement materials .

2. material and mothed

2.1. Matrix Material

It is one of the components of the composite material. Its main function is to bind the reinforcing material, and to maintain the reinforcement material from weather conditions, temperature change, oxidation and corrosion, as well as to transfer the load to the strengthening materials [12],[13].

2.2. Reinforcement Materials:

They are the materials that strengthen the matrix material, and it may be a mineral, ceramic or polymeric materials, which has general characteristics that depend on the type of material and the purpose for which it is used, and is classified according to the shape and dimensions to; Particles, fibers, flakes, or as a net of materials [14] ..depending on the shape of r:

2.3. Polymers

They are organic materials composed of long molecules formed by repeating one or several types of small units called the monomer, which represents the basic unit for building the polymer [14,13] .

2.4. Polyethylene:

Polyethylene is a polymer composed of long series of ethylene monomer (called IUPAC Ethene). In the industry it is denoted by PE in the same pattern other polymers that they are denoted such as Polypropylene PP and Polystyrene PS .

The ethylene molecule, C2H4 is CH2 = CH2, is two methylene groups linked by a double bond. [16]

Polyethylene Intensity = 0.941g / cm3 z

Gamma Interaction With Matter : 2.5

(Kama rays) is the name given to electromagnetic radiation that comes from the nucleus. This radiation has a very short wavelength is ranging between (3´10-8-10-11cm), so its energy is large. The processes that occur when a gamma ray passes through the material are complex processes, and some properties related to these processes , they can be understood by applying classical mechanics (Maxwell's equations), but the correct physical situation can only be described using quantum electromagnetic theories. The photon interacts with material in three main ways, namely [18].

Photo Electric Effect remark:

The photoelectric phenomenon is an interaction between a kama-ray photon and an electron attached to the atom. As a result of this process, the photon gives all its energy to the orbiting electron, then the latter is ejected and becomes free, as in Figure (1) [19].

$$\tau_a = const \frac{Z^n}{(E_\gamma)^3} \quad {cm^2}/{atom}$$

2. Compton Scattering

It is an inflexible scattering that occurs between the falling photon and the electrons or the outer orbits of the atoms. These electrons are weakly bound to the nucleus, which causes the fallen photon to lose part of its energy for those electrons, causing the electron to be emitted outside the atom space at an angle with a kinetic energy E in such a way that the fallen photon, the rectilinear and the electron maintain the law of saving energy and momentum [20,21,19]

$$E_e = h\nu - h\nu' \tag{3}$$

From equation (3), by applying the laws of energy saving , the energy of the electron is given by

$$E_e = \frac{(h\nu)^2}{0.51} \frac{(1-\cos\theta)}{[1+(h\nu/0.511)(1-\cos\theta)]} \tag{4}$$

The energy of a crossed photon can be illustrated by the equation:

$$h\nu' = \frac{h\nu}{1 + [(1 - \cos\theta)h\nu / 0.511]} \qquad (5)$$

The relationship of the absorption coefficient of the Compton phenomenon to both the atomic number and the energy of the photon is described in figure (1).

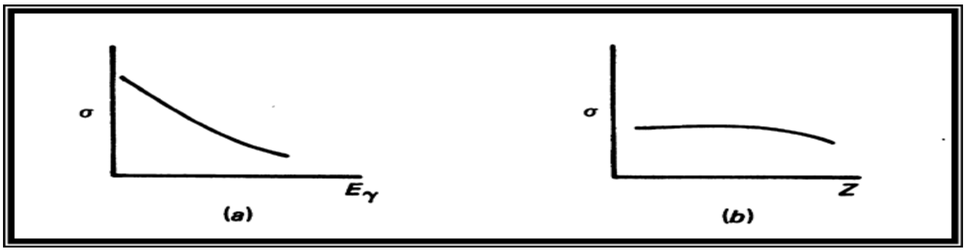

Figure (1) - a the energy of the photon. b - The atomic number of the substance

When the energy of the photon reaches (1.022 MeV), meaning twice the static mass of the electron, the production of the pair becomes possible, as the photon fades into the field of the columned nucleus, transforming it into an electron - positron [21].

$$E^{+} + E^{-} = h\nu - 2m_0c^2 \qquad (6)$$

$$\mu(cm^{-1}) = \tau + \sigma + \kappa \qquad (7)$$

$$\mu_m(cm^2/gm) = \frac{\mu}{\rho} \qquad (8)$$

The coefficient of linear absorption of matter, and physics (the probability of interaction of a photon per unit distance from the substance) is defined.

Mass absorption coefficient.

Simulation and XCOM database software : 2.5:

The XCOM (version 3.1) program is a web-based database that can be used to calculate the photon cross-sections of the scattering represented by Comton scattering, photoelectric absorption and pair output, as well as the total attenuation coefficients for any element, compound or mixture (Z 100) at energies ranging from 1 kEV to 100 KEV.

This work is supported by the National Institute of Standards and the Technology Standard Reference Data Program, and by the US Department of Energy (OHER) .

Scattering and absorption data for photons (x-rays and gamma rays) are required for many scientific, engineering and medical applications. the number of materials in which we need photon cross-sections is large and increasing. The tables available usually contain cross-sections of many but not all of the elements, and some tables also contain data for a limited number of compounds and mixtures. In practice, it is not possible to satisfy all the comprehensive needs via printed tables. Moreover, we often need cross-sections at photon energies other than those listed in the tables. (23)

4. Results and discussion

In this chapter, data tables of the readings that obtained by using the XCOM code program and the results of calculations of attenuation characteristics and shielding density by using the mathematical relationships that shown in the previous chapter will be presented and the results will be presented in forms and diagrams to study the attenuation characteristics of the shields used, as well as to determine the most efficient one in attenuating gamma rays with specific energies. In this research .

Tables (1), (2), (3) and (4) below show the readings and results of the calculations used for the study .

Table 1: The values of the mass attenuation factor m (cm2 / g) computed using the XCOM code program.

		μm	cm2/g			E (MeV)
		Density p				
3.013857	2.092136	1.602153	1.298128	1.091084	0.941	
PE/75%Pb	**PE/60%Pb**	**PE/45%Pb**	**PE/30%Pb**	**PE/15%Pb**	**PE**	
0.1166	0.1116	0.1067	0.1018	0.0969	0.091980	0.6MeV
0.08672	0.08553	0.08434	0.08315	0.08196	0.080780	0.8MeV
0.07142	0.07166	0.0719	0.07214	0.07238	0.072630	1MeV
0.05394	0.05498	0.05601	0.05704	0.05807	0.059100	1.5MeV
0.04187	0.04159	0.0413	0.04102	0.04074	0.040450	3MeV
0.03965	0.03781	0.03597	0.03413	0.03229	0.030450	5MeV

Table (2): Linear attenuation coefficient values μ (1 / cm) computed using the XCOM code program

		μ (1/cm)				**E** (MeV)
PE/75%Pb	**PE/60%Pb**	**PE/45%Pb**	**PE/30%Pb**	**PE/15%Pb**	**PE**	
0.351416	0.233482	0.17095	0.132149	0.105726	0.086553	0.6
0.261362	0.17894	0.135126	0.107939	0.089425	0.076014	0.8
0.21525	0.149922	0.115195	0.093647	0.078973	0.068345	1
0.162567	0.115026	0.089737	0.074045	0.063359	0.055613	1.5
0.12619	0.087012	0.066169	0.053249	0.044451	0.038063	3
0.119499	0.079104	0.057629	0.044305	0.035231	0.028653	5

Table 3: The values of the HVL half thickness (cm) as a function of the gamma ray energy E (MeV)

		HVL (cm)				**E** (MeV)
PE/75%Pb	**PE/60%Pb**	**PE/45%Pb**	**PE/30%Pb**	**PE/15%Pb**	**PE**	
1.972442	2.968735	4.054685	5.245176	6.556068	8.008339	0.6
2.652061	3.873621	5.129652	6.421634	7.751134	9.11868	0.8
3.220201	4.623371	6.017174	7.401703	8.777051	10.14191	1
4.263751	6.026024	7.724243	9.361131	10.93995	12.46374	1.5
5.492876	7.966116	10.47542	13.01704	15.59359	18.21031	3
5.800422	8.762517	12.02766	15.64485	19.67429	24.19071	5

Table (4): The values of the TVL (cm) decimal thickness as a function of the gamma ray energy E (MeV).

		TVL (cm)				**E** (MeV)
PE/75%Pb	**PE/60%Pb**	**PE/45%Pb**	**PE/30%Pb**	**PE/15%Pb**	**PE**	
6.55231	9.861923	13.46937	17.4241	21.77878	**26.60313**	0.6
8.809956	12.86789	17.04033	21.33221	25.74871	**30.2916**	0.8

10.69728	15.35851	19.98862	24.58793	29.15673	**33.6907**	1
14.16387	20.01802	25.65938	31.097	36.34173	**41.40365**	1.5
18.24694	26.46287	34.79859	43.24166	51.80079	**60.49334**	3
19.26858	29.10845	39.95501	51.97108	65.35659	**80.35979**	5

1) Linear attenuation coefficient :

The form of the linear attenuation coefficient relationship as a function of the gamma ray energy in the shields of the superpositions are under study shown in Figure (1) shows that the linear attenuation coefficient relationship is a decreasing exponential relationship that applies to the mathematical foundations as it decreases greatly with the increase of the radiation energy at the low energies up to a value of 1.5Mev Then the decrease is less severe at higher energies and the values of the linear attenuation coefficient are as a function of the greater energy for the PE shield / 75% Pb than for the PE / 15% Pb shield.

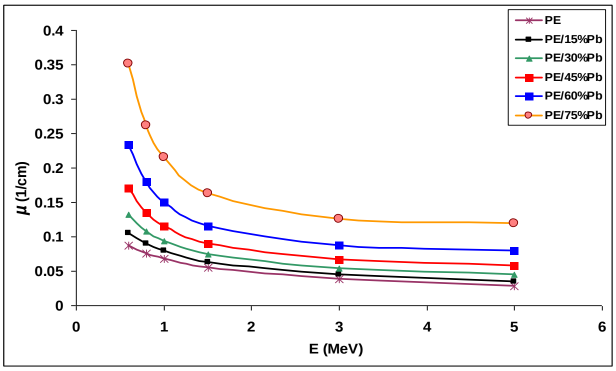

Figure 1: Represent linear attenuation coefficient values (cm-1) μ as a function of gamma ray energy E (MeV) for all types of superposition shields .

We note from Figure (2) the values of the linear attenuation coefficient are directly proportional to the density of the shield material, and this same behavior is for all radiation energies other than the attenuation values are greater at the lowest energies and for all density values, and this indicates that the shields of the compound with a concentration of 75%, which has the most density of Between the shields, it has a relatively large attenuation coefficient value and the studied energies density .

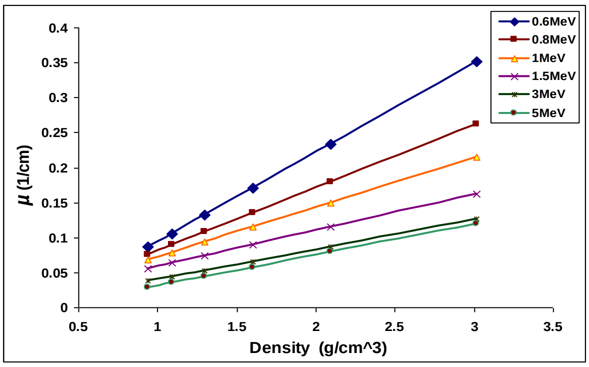

Figure (2): represent the values of the linear attenuation coefficient as a function of the shield density in units g / cm3) at different energies of the gamma rays

HVL and TVL thickness: 2)

By noting that the results of the HVL and TVL values are drawn in Figures (3) and (4), we find that these quantities increase with the increase in the incident radiation energy for all types of shields and exponentially where the amount of increase at low energies is more pronounced and changed than at high energies and the values of HVL and TVL are for all The energies are of greater values when the PE armor has a concentration of 15% than when the concentration of 75%

of the reinforcement material, meaning that the values of these quantities are inversely proportional to the concentration of the reinforcing material of the overlay armor .

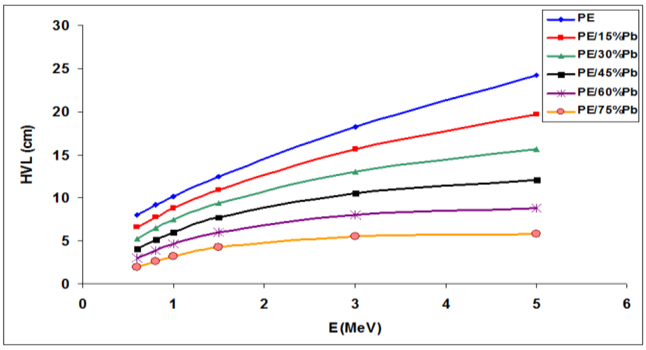

Figure 3: Represent the values of the HVL half-layer thickness (cm) of the shield material as a function of the gamma ray energy E (MeV)

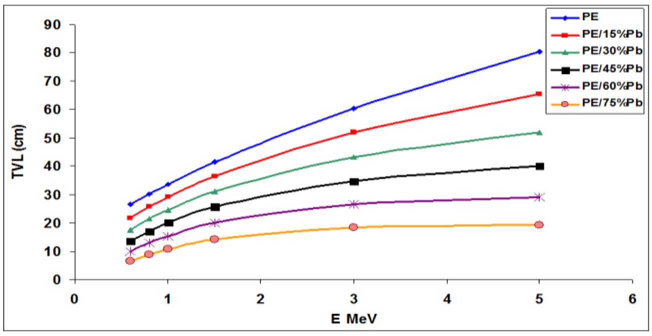

Figure (4): represent the values of the decimal layer thickness TVL (cm) of the shield material as a function of the gamma ray energy E (MeV)

To study the dependence of the values of HVL and TVL for gamma radiation on the density of the shield material, the relationship of these variables was drawn as a function of the density of the shield used and for all the values of gamma ray energies specified in this paper . we find that the relationship of HVL and TVL is in the form of a decreasing exponential relationship with the values of the armor density and has the lowest values at the low energies and for all the density values. This gives a clear indication that the penetration of gamma rays in the material decreases with the increase in the density of the material. It indicates the preference of the material with high efficiency in blocking radiation, which is evident in the shield of the compound with a concentration of 75% of the reinforcing material in the polymer.

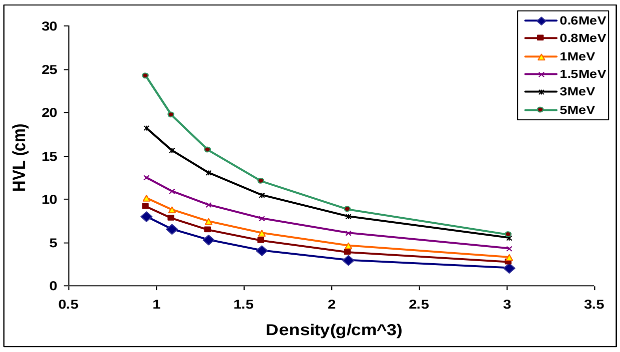

Figure (5): represents the values of the HVL half-layer thickness (cm) as a function of the shield density in units of g / cm3)

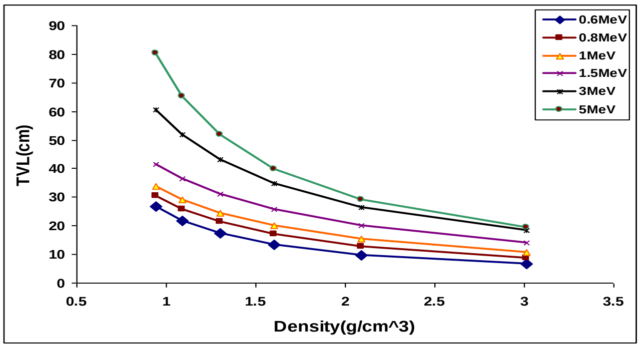

Figure (6): Represent the values of the decimal layer thickness TVL (cm) as a function of shield density in units of g / cm3) at different energies of the gamma rays .

TF factor: 3)

The armor penetration factor was studied as a function of the thickness of the shielding material for studying the transmittance of shields to the rays . The action of this factor can be observed through Table (5) and Figures (8), (7) and (9) which represent the values of this factor as a function of the thickness of the shield superimposed at energies (0.5). It is evident from the figures that the relationship of TF is decreasing with the thickness of the shield and decreases with increasing the concentration of the reinforcing material, and its value decreases with the increase of energy and for all types of armor.

Table (5): TF penetration factor values as a function of shield material thickness X and (cm)

		TF	**(At E=0.6MeV)**			***X*** (cm)
PE/75%Pb	**PE/60%Pb**	**PE/45%Pb**	**PE/30%Pb**	**PE/15%Pb**	**PE**	
0.703691	0.791772	0.842864	0.87621	0.899671	0.917087	1
0.495181	0.626902	0.71042	0.767744	0.809408	0.841048	2
0.348455	0.496363	0.598787	0.672705	0.728201	0.771315	3
0.245204	0.393006	0.504696	0.589431	0.655141	0.707363	4
0.172548	0.311171	0.42539	0.516465	0.589412	0.648713	5
0.121421	0.246377	0.358546	0.452532	0.530277	0.594926	6
0.085443	0.195074	0.302205	0.396513	0.477075	0.545599	7
0.060125	0.154454	0.254718	0.347429	0.42921	0.500362	8
0.04231	0.122292	0.214693	0.304421	0.386148	0.458875	9
0.029773	0.096828	0.180957	0.266736	0.347406	0.420828	10
		TF	**(At E=1.5MeV)**			***X*** (cm)
PE/75%Pb	**PE/60%Pb**	**PE/45%Pb**	**PE/30%Pb**	**PE/15%Pb**	**PE**	
0.849959	0.891343	0.914172	0.92863	0.938606	0.945905	1
0.72243	0.794493	0.83571	0.862353	0.880982	0.894737	2
0.614036	0.708166	0.763983	0.800807	0.826895	0.846336	3
0.521905	0.631219	0.698412	0.743653	0.776129	0.800553	4
0.443598	0.562633	0.638469	0.690578	0.728479	0.757248	5
0.37704	0.501499	0.58367	0.641291	0.683755	0.716284	6
0.320468	0.447008	0.533575	0.595522	0.641777	0.677537	7
0.272385	0.398437	0.487779	0.55302	0.602376	0.640886	8
0.231516	0.355144	0.445914	0.51355	0.565393	0.606217	9
0.196779	0.316556	0.407642	0.476898	0.530682	0.573424	10
		TF	**(At E=5MeV)**			***X*** (cm)
PE/75%Pb	**PE/60%Pb**	**PE/45%Pb**	**PE/30%Pb**	**PE/15%Pb**	**PE**	

0.887365	0.923944	0.944	0.956662	0.965382	0.971754	1
0.787416	0.853673	0.891135	0.915202	0.931963	0.944305	2
0.698725	0.788746	0.841232	0.875539	0.899701	0.917632	3
0.620024	0.728757	0.794122	0.837595	0.868555	0.891712	4
0.550187	0.673331	0.749651	0.801295	0.838488	0.866524	5
0.488216	0.62212	0.707671	0.766569	0.809461	0.842048	6
0.433226	0.574804	0.668041	0.733347	0.781439	0.818263	7
0.384429	0.531087	0.63063	0.701566	0.754388	0.79515	8
0.341129	0.490695	0.595315	0.671161	0.728273	0.77269	9
0.302706	0.453375	0.561977	0.642074	0.703061	0.750865	10

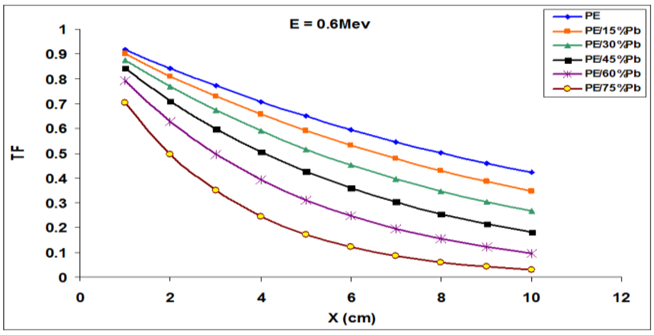

Figure (7): Represent the values of the penetration factor TF as a function of the shield material thickness X (cm) for all types of superposition shields at a gamma ray energy E = 0.6MeV

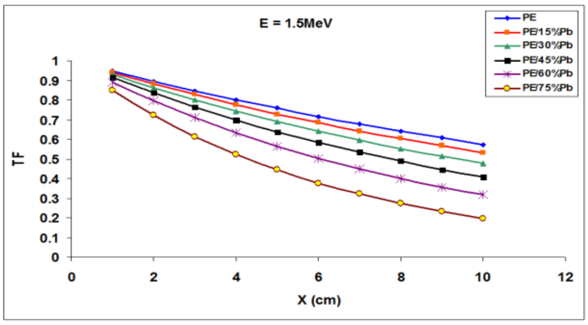

Figure (8): Represent the values of the penetration factor TF as a function of the shield material thickness X (cm) for all types of superposition shields at the gamma ray energy E = 1.5MeV

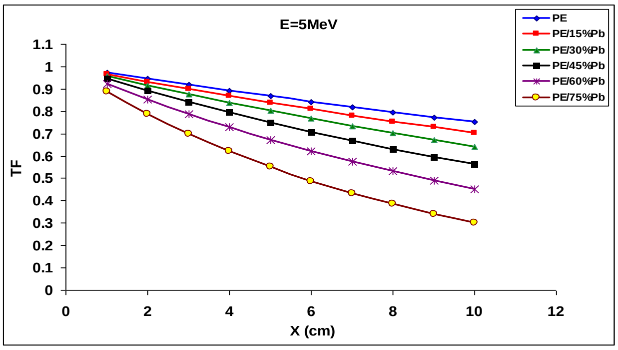

Figure 9: Represent the values of the penetration factor TF as a function of the shield material thickness X (cm) for all types of superposition shields at gamma ray energy E = 5MeV

Figures (11), (10) and (12) have been drawn in the form of plots to give a clearer picture of changing the values of the linear attenuation coefficient, the thickness of the half layer, and the thickness of the decimal layer as a function of both the energy of the incident rays and the type of shield material represented by the percentage of addition of the reinforcement material or in other words density Shielding .

It is evident from Figure (10) that the largest value of the attenuation coefficient is at 0.6MeV energy using the PE shield / 75% Pb, which gives at this energy the lowest value for both HVL and TVL as shown in Figures (11) and (12) and from this it can be We conclude that the PE / 75% Pb superimposed shield is the best studied shield in its use as a radiation shield against gama rays .

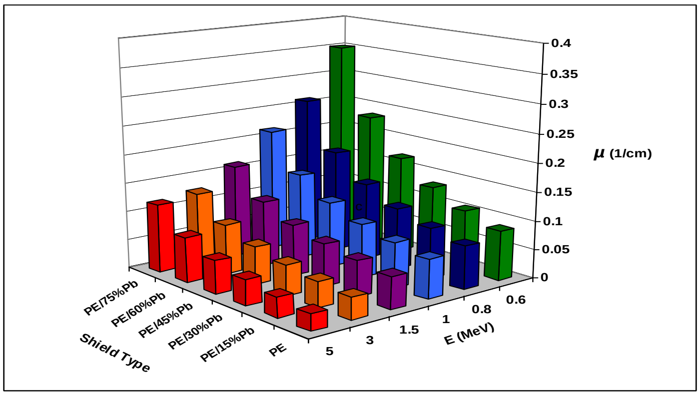

Figure 10: The plot of the linear attenuation coefficient is represented by the shield type and the E-ray energy.

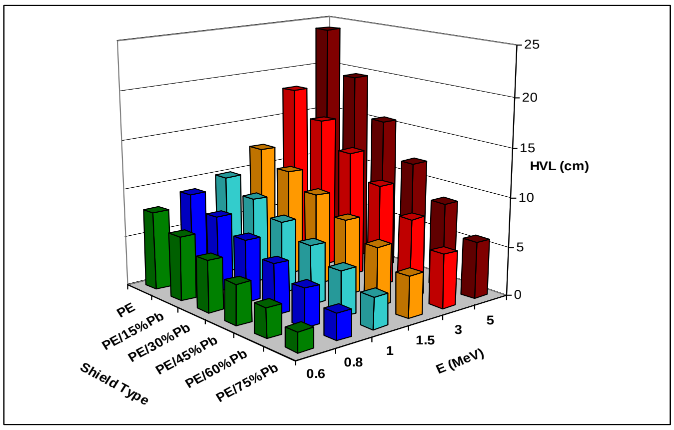

Figure 11: The relationship diagram represents the thickness of the TVL with the shield type and the energy of the E-bea.

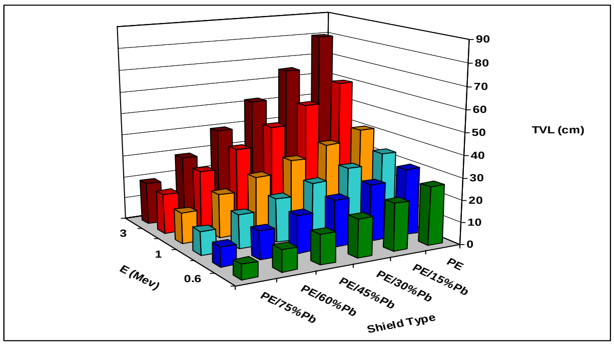

Figure (12): The relationship diagram represents the thickness of the HVL decimal layer by the type of shielding and the radiation energy

5. Conclusions:

From the above, we can give some important conclusions drawn from this study

1. The linear attenuation coefficient values increase by increasing the concentration of lead powder as a reinforcing or reinforcing material in the polyethylene sample used to

manufacture superimposed shields or in other words by increasing the density of the shield material and decreasing according to the increase in the energy of the gamma ray photons .

2. The half-layer thickness and decimal layer thickness values decrease with increasing the concentration of lead powder as a support material in the polyethylene sample used to manufacture the superimposed shields and increase according to the increase in the energy of .
3. The permeability values in all types of shields used decrease with the increase of the thickness of the studied shield layers and their values decrease by increasing the concentration of lead powder as a support material in the polyethylene sample used to manufacture the overlapping shields with the same behavior for the incident radiation energies at values of 0.6, 1.5 and 5 MeV units.
4. With an increase in the energy of the interacting gamma photons, the values of transmittance to rays within the material increase as the concentration and thickness of the shield material is constant.
5. The best shields used are polyethylene overlay shields reinforced with the highest weight ratio of lead powder material (PE / 75% Pb) which is the most dense armor (ρ = 3.013857 g / cm3) because it gives the best results among other shields where it has been used. As a shield to obtain the highest value of the linear attenuation coefficient and the lowest values for each of the half-layer thickness and the thickness of the decimal layer and the lowest permeability to the gamma rays and for all the corresponding values of energy and thickness.

6. Recommendations:

Some recommendations can be made for future work and studies to search for compositions with high attenuation properties to be used as shields that suit the applications and practices in which direct exposure to gamma rays was dealt with, whether in the educational, research, medical and other fields:

1. Study the possibility of testing various other polymers as a base material.
2. Studying the possibility of using reinforcing materials with different atomic numbers.
3. Study the possibility of using powders for strengthening materials composed of a mixture of two or more materials, their oxides, or their compounds.
4. Studying the attenuation properties of gamma rays at other energies higher or lower than the studied range and their effect on the studied radiation attenuation properties.
5. Study the properties of radiation attenuation of other rays such as X-rays or beta rays and other materials and various compositions.

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