" The effect of the hole diameter of the collimation and atomic number of the shield on the Gamma Ray Buildup Factor for Water Double Layer Absorber "

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Abstract

The effects of the hole diameter of the collimation (1)cm and (2)cm ,and the effect of the atomic number of the shield on the gamma ray buildup factors for a double layer absorbers have been investigated in the present work

Four types of the double layer absorbers (one of it is water) were use which they are:(brass-water),(Cu-water),(Fe-water)and(Al-water).Also ,the basin which used in this study to contain the material and water of (10x10x30)cm^3 dimensions. The type of the detector was NaI(TI) 3"x 3" scintillation detector with high detection efficiency.

From the results of the measured buildup factors refers to the gamma ray buildup factors are increase with increasing the thickness of the studied double layer absorbers. And the buildup factor decrease with increase the hole diameter of the collimation. Also, the buildup factors are increase with increase the atomic number of the shield. All the results were explained.

For all relation between the buildup factors and the penetration depth (thickness of the absorber) we get of a fitting formulas to make the get of the needed information's is easy.

1- Introduction

Many workers studied theoretically the gamma ray buildup factor for water with other materials as double and multi layer shields because the importance of water which use in reactors for cooling the core of it and of course the water beside other materials that reactor core and walls consist with. In 1993 ,H.Hirayama and Y.Hanrima[1] calculated gamma ray buildup factor for double layer of water and lead with two sources (point and plane) with energies (0.5,1,3,6 and 10)MeV .In 1994 K.Shin and H.Hirayama [2] formulated a new relation to calculate gamma ray buildup factor for point source in multilayer shields of water ,iron and lead for the source energies (1 and 10) MeV .Also ,in 1995 ,K.Shin and H.Hirayama[3] published a study for an expression to calculate gamma ray buildup factor for point source with energies (0.5,1 and 10)MeV for water , iron and lead by **monte carlo** method. In 1998 ,K.Shin and H.Hrayama [4] studied the pervious materials but with plane source for penetration depth up to 40 m.f.p. In 1999 ,A.Assad ,et.al.[5] published a new formula to calculate gamma ray buildup factor for point source with energy range 40 KeV to 10 MeV using shields of multilayer from water , Al , Fe and Pb for depths up to 30 m.f.p,M.Guvendik and N.Tsoulfanidis in 2000 [6] suggested a formula to calculate gamma ray buildup factor for point source in energy range (0.5-6)MeV for double layer shields of water , lead , steel and concrete with thickness from 1 m.f.p to 10 m.f.p. In 2004,C.Suteam ,M.Chiron and G.Arnaud [7] showed a modified formula for calculating gamma ray buildup factor.

2- The Present Work:

From the survey above one can see that all the studies are theoretical and no one of them is experimental , so , the present work give the experimental side for study the gamma ray buildup factor to know more about this subject and make a comparison between the theoretical and experimental result for buildup factor in double layer absorbers consist of water with other materials. Also study the effect of the hole diameter of the collimation on it and atomic number of the shield on it also.

3- The Experimental Arrangements

Figure (1) shows the block diagram for the electronic system which used in this study The materials which used with water to make a double layer shields are (brass , Cu , Fe and Al)all at a same thickness (2cm). The water and the other materials put in a basin of $(10\times10\times30)cm^3$ dimensions. And the table bellow show the Property of the materials above.

Shield Material	Atomic Number (Z)
Aluminum	13
Iron	26
Copper	29
Brass	29.28[8]

The radioactive source was used in this study which they are : Cs-137 which emits gamma photons of 0.662 MeV energy and the activity is 132.29 μC.The source as disk shape of 2 cm diameter.

4-Buildup Factor Calculation:

Can be calculation buildup factor (B) from the equation followed [8] .

$$B = \frac{(I / I_O)_{w_0}}{(I / I_O)_w} ....(1)$$

Where :

$\left(I / I_0 \right)_{W_0}$: Ratio of intensity of gamma ray in material to in air with out collimation.

$\left(I / I_0 \right)_{W}$: Ratio of intensity of gamma ray in material to in air with collimation.

In addition to can be calculation standard of statistical deviation and fractional statistical deviation from follow:[8]

$$S.D = B.[1/ I(W) + (1/ I_O(W_O)]^{1/2} ....(2)$$

$$F.S.D = \frac{S.D}{B} \times 100\% ....(3)$$

Where:

S.D: standard of statistical deviation.

F.S.D: fractional statistical deviation.

5- The Results and Discussions

The experimental results for the present work for the hole diameter of the collimation (1cm) and (2 cm) for the used Cs-137 source are tabulated in the tables (1) , (2) , (3) and (4) for the double layers (brass-water) , (Cu-water) , (Fe-water) and (Al-water) respectively .While , The effect of the studied factors as follows:

5.1. The Effect of the Absorber Thickness:-

From the tables (1) to (4) one can see that the gamma ray buildup Factors are increase with increase the thickness of the absorbers. This result can be explain by increasing the thickness of the absorber means increase the orbital electrons of the absorber and then increase the interaction probability to produce the scattered photons and secondary electrons and will increase the buildup factors for the studied materials. This result agrees with the other studies qualitatively [1-7]. This result agreement with studies [1, 2, 3, 4, 5, 6, 7].

5.2. The Effect of the hole diameter of the collimation

To investigate the effect of the hole diameter of the collimation on the values of the gamma ray buildup factors , the results were drown from the tables (1,2,3,4) in the figure (2) the buildup factors for (brass-water) for both the hole diameter of the collimation (1& 2)cm and for the Cs-137 source. In the same way we draw the results for (Cu-water) in figure (3), (Fe-water) in figure (4) and (Al-water) in figure (5).

From the above four figurers one can see that the buildup factors at the hole diameter of the collimation (1cm) are greater than that the hole diameter of the collimation (2cm) for all used double layer absorbers. The explanation for these results that the build up proportional inversely with the hole diameter of the collimation, therefore its increased with creasing the hole diameter of the collimation.

5.3. The Effect of the Atomic number of the shield:-

To show the effect of the of the Atomic number of the shield on the gamma ray Buildup factors for the studied double layers and for the Cs-137 source, we draw the present work results in the figure (6) for (brass-water), (Cu-water), for (Fe-water),and for (Al-water).From the fig (6) can see that the gamma ray build up factor increased with an increased of the Atomic number of the shield. Therefore the value of the buildup factor in water as double layer shielding for (brass-water) larger than (Cu-water), for (Fe-water),and for (Al-water).To explain this result the probability of Compton scattering proportional to increasing the atomic number of the shield ,and that means the increasing the atomic number lead to increasing the Compton scattering therefore the build up factor increased with an increased the atomic number of the shields.

5.4.Buildup Factor Fitting Formulas:-

For each relation between the measured buildup factors with penetration depth in (m.f.p.), a fitting was done to get a fitting formula which can be use to get the buildup factor at any studied (m.f.p) is easy. So, in the figures (2)to (5) one can see the fitting formula and the correlation coefficient(R^2).

Note: the value of (y) in fitting means "buildup factors" and (x) means "m.f.p".

6-The conclusion:

From this study one can conclude the following:

1- The measured gamma ray buildup factors increase with increase the thickness of the studied double layer absorbers for all distances and source energies.

2- When the hole diameter of the collimation e is increase then the buildup factor will decrease.

3- When the Atomic number of the shield increase , then the buildup factor will decrease .

4- Fitting formulas were done for every case to gate any value of buildup factor at any penetration depth with high accuracy.

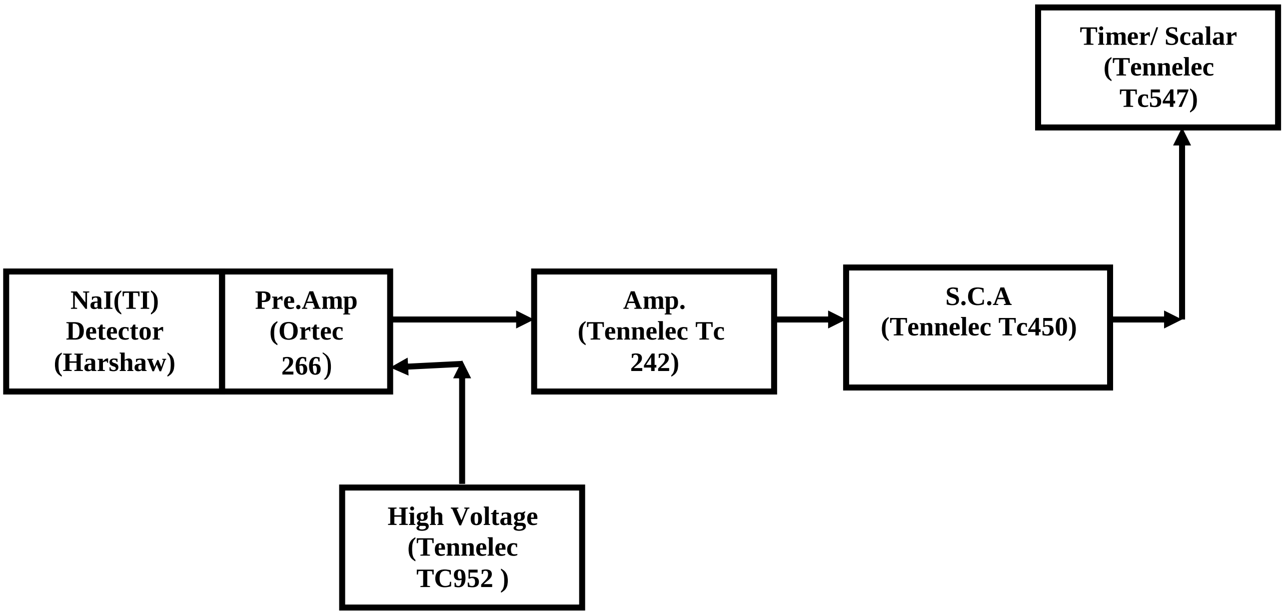

Figure (1) The block diagram of the electronic detection system.

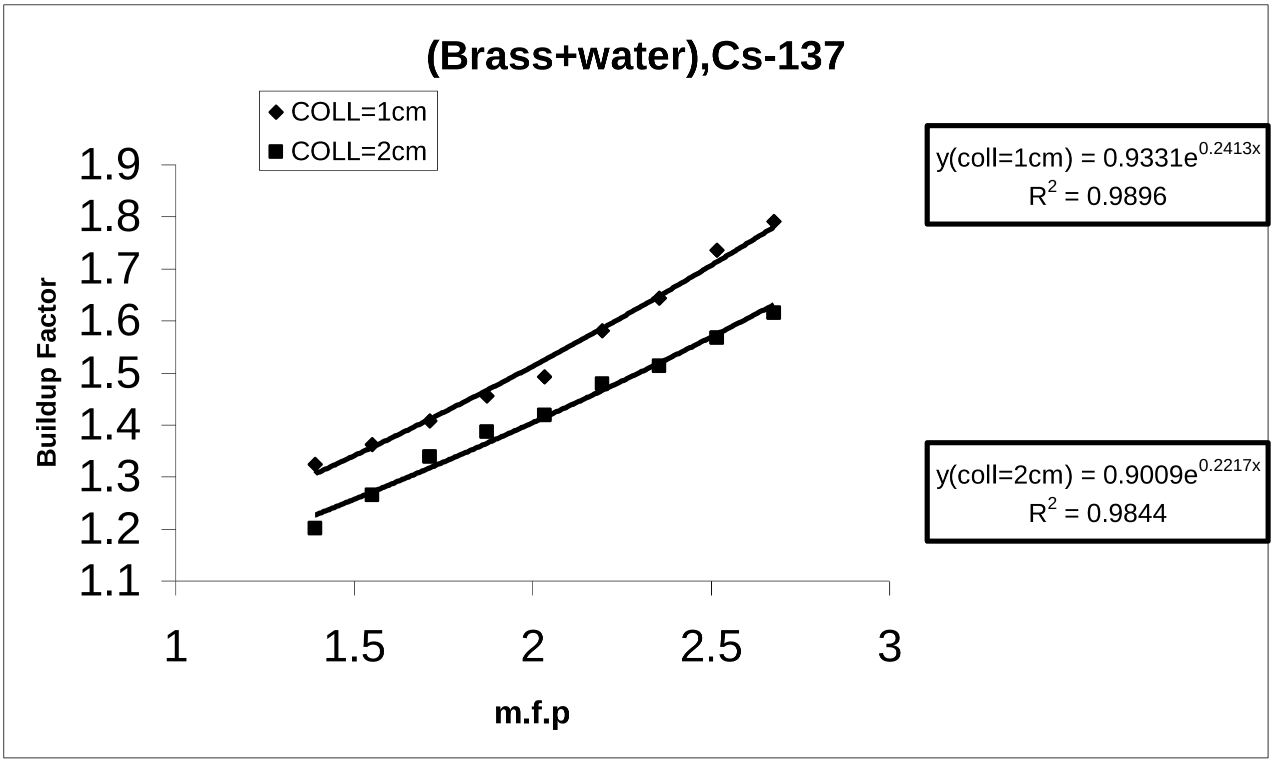

Figure (2) The effect of the hole diameter of the collimation on the buildup factors using Cs-137 source for (brass-water)double layer.

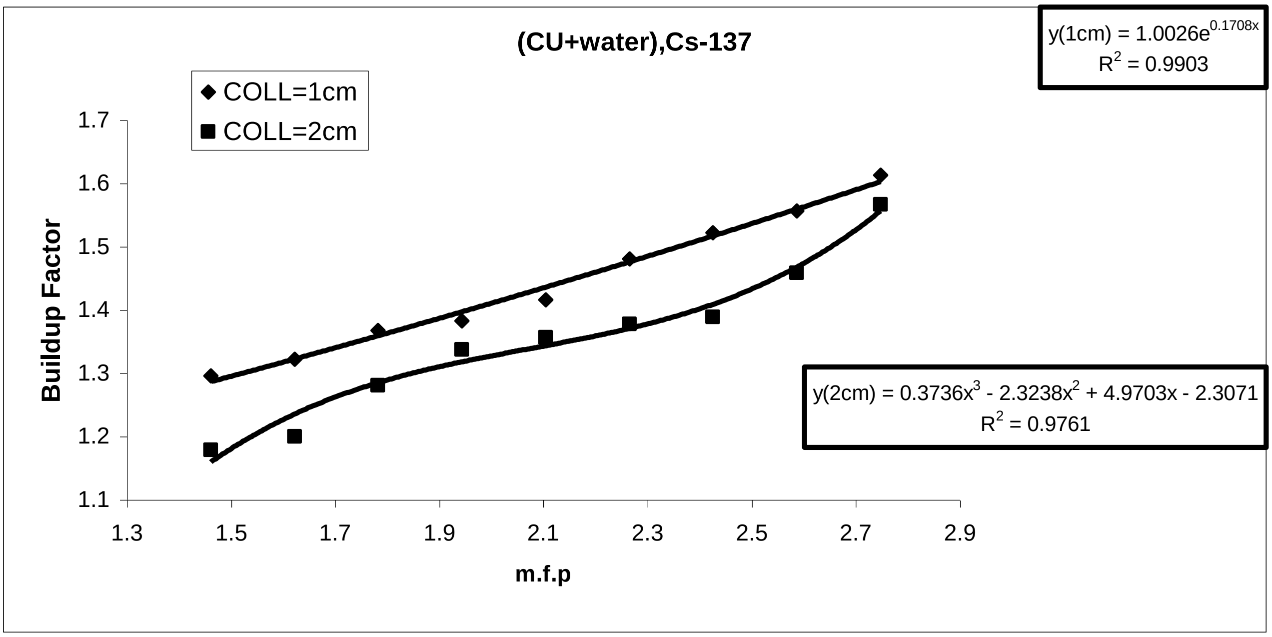

Figure (3) The effect of the hole diameter of the collimation on the buildup factors using Cs-137 source for (Cu-water)double layer.

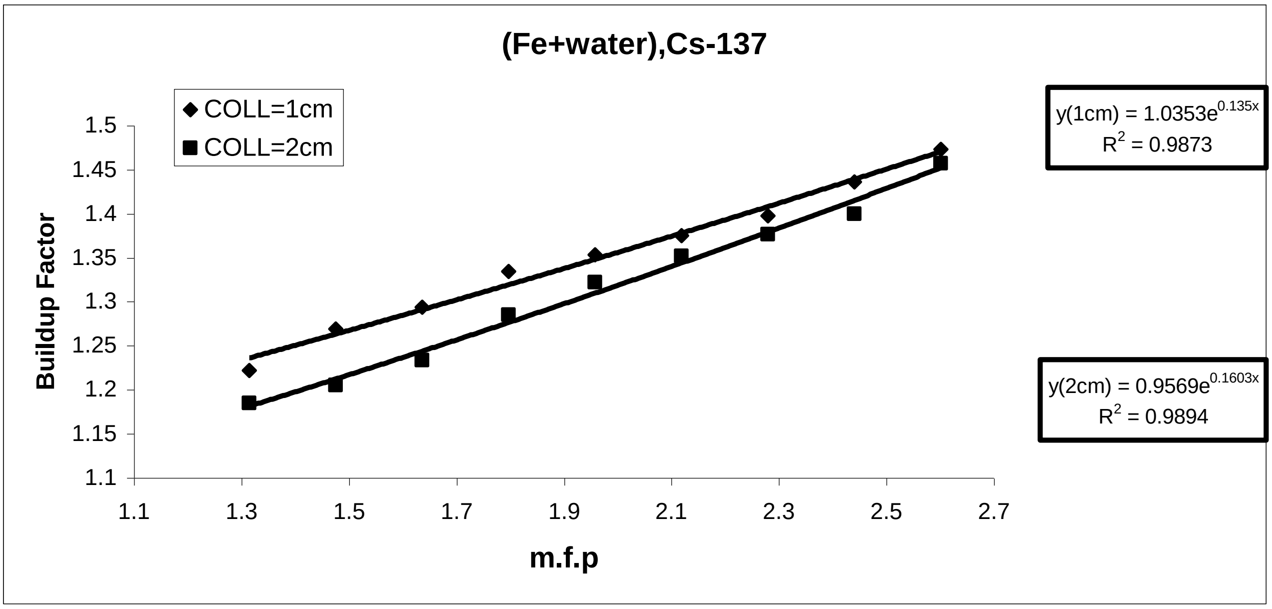

Figure (4) The effect of the hole diameter of the collimation on the buildup factors using Cs-137 source for (Fe-water)double layer.

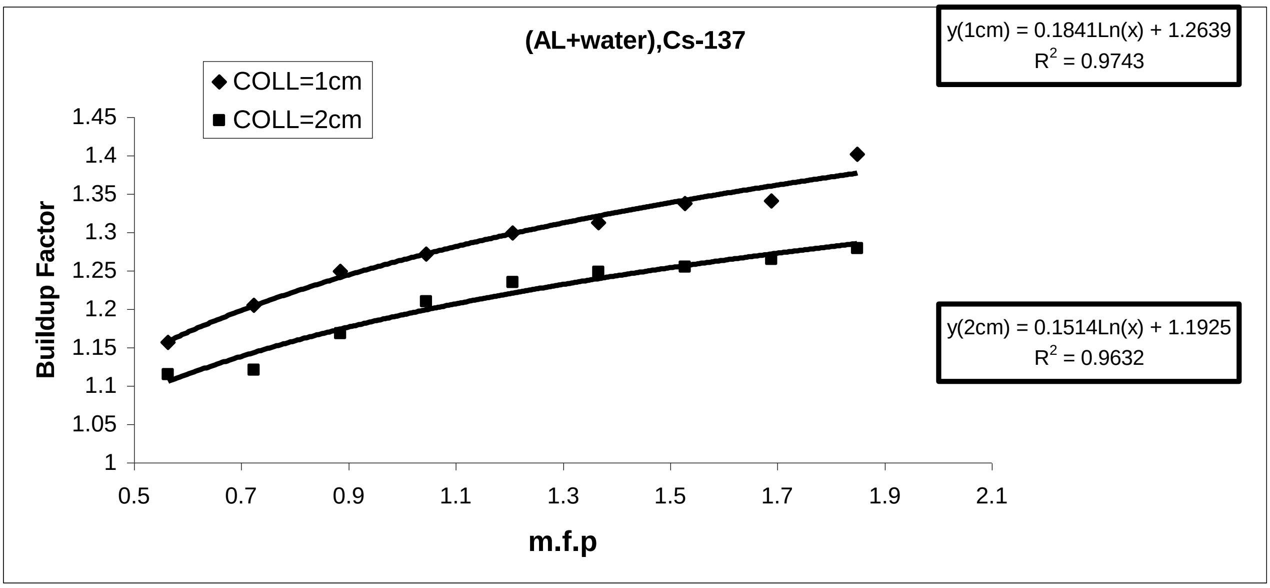

Figure (5) The effect of the hole diameter of the collimation on the buildup factors using Cs-137 source for (Al-water)double layer.

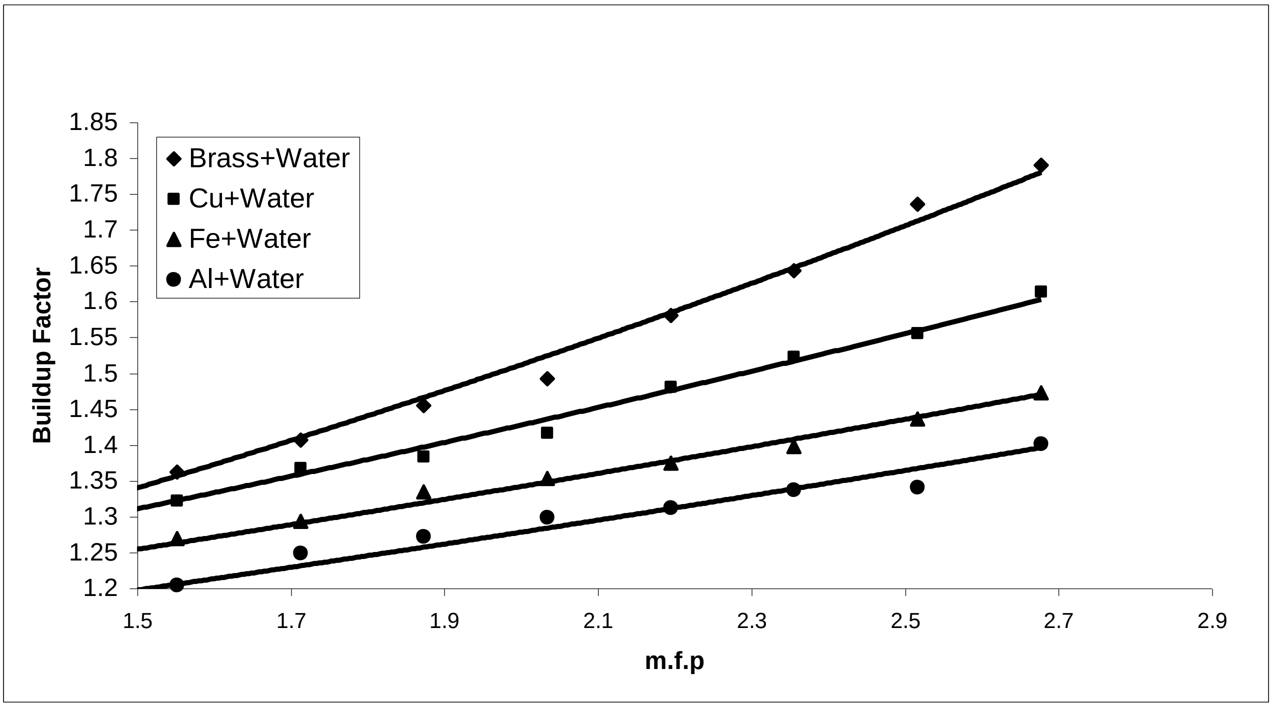

Figure (6) The effect of the Atomic number of the shield on the buildup factors using Cs-137 source.

Table (1) The experimental results for the buildup factors using Cs-137 source for (brass-water) double layer

نوع الدرع	Thickness		I(C/min)		(I/I_O)		Buildup Factor	S.D ±	F.S.D %
	cm	m.f.p	I (W)	$I(W_0)$	W	W_0			
	Diameter =1 cm								
Brass	Air		142257	269845					
	Glass(0)	0	137766	259894	1	1	1	0.0033326	0.333263
	0.15	0.09225	126054	246885	0.914986	0.949945	1.038207	0.0035665	0.346173
	0.45	0.27675	116195	235873	0.843423	0.907574	1.07606	0.0036956	0.35841
	0.75	0.46125	107093	222260	0.777354	0.855195	1.100135	0.0038851	0.37198
	1.05	0.64575	100159	217221	0.727023	0.835806	1.149629	0.0040367	0.381939
	1.35	0.83025	95171	209336	0.690816	0.805467	1.165964	0.0041548	0.390953
	1.65	1.01475	82655	188266	0.599967	0.724395	1.207393	0.004535	0.417254
	2	1.23	74886	175636	0.543574	0.675799	1.243251	0.0048738	0.436431
Brass+Water	2+2	1.3908	60594	151311	0.439833	0.582203	1.323691	0.0054687	0.480751
	6	1.5516	55604	142900	0.403612	0.54984	1.362298	0.005782	0.499822
	8	1.7124	49347	130957	0.358194	0.503886	1.40674	0.0063641	0.528212
	10	1.8732	44290	121580	0.321487	0.467806	1.455132	0.0069346	0.555009
	12	2.034	39955	112485	0.290021	0.432811	1.492345	0.0074078	0.582394
	14	2.1948	37062	110541	0.269021	0.425331	1.581031	0.0077989	0.600235
	16	2.3556	35154	108974	0.255172	0.419302	1.643213	0.0080495	0.613374
	18	2.5164	32052	104944	0.232655	0.403795	1.735595	0.0085351	0.638186
	20	2.6772	30063	101542	0.218218	0.390705	1.790438	0.0088057	0.656594
	Diameter =2 cm								
Brass	Air		209065	269845					
	Glass(0)	0	200540	259894	1	1	1	0.002972	0.297225
	0.15	0.09225	187425	248885	0.934602	0.95764	1.024651	0.003134	0.305833
	0.45	0.27675	177929	238773	0.887249	0.918732	1.035484	0.003243	0.313182
	0.75	0.46125	169533	230260	0.845382	0.885977	1.048019	0.003354	0.320023
	1.05	0.64575	160883	222221	0.802249	0.855045	1.06581	0.003489	0.327349
	1.35	0.83025	141087	205336	0.703535	0.790076	1.123008	0.003883	0.345802
	1.65	1.01475	122949	188266	0.61309	0.724395	1.181549	0.004332	0.366675
	2	1.23	108820	168636	0.542635	0.648865	1.195766	0.00465	0.388837
Brass+Water	2+2	1.3908	96638	150311	0.481889	0.578355	1.200183	0.004949	0.41232
	6	1.5516	85938	140900	0.428533	0.542144	1.265116	0.005476	0.432822
	8	1.7124	75471	130957	0.376339	0.503886	1.338916	0.006119	0.457014
	10	1.8732	67698	121580	0.337579	0.467806	1.38577	0.006645	0.479547
	12	2.034	60957	112085	0.303964	0.431272	1.418824	0.00714	0.503257
	14	2.1948	57858	110845	0.288511	0.426501	1.478283	0.007582	0.512887
	16	2.3556	53995	105889	0.269248	0.407431	1.51322	0.008002	0.528811
	18	2.5164	50586	102755	0.252249	0.395373	1.567391	0.008513	0.543141
	20	2.6772	48158	100780	0.240142	0.387773	1.61477	0.008945	0.553964

Table (2) The experimental results for the buildup factors using Cs-137 source for (Cu-water) double layer

نوع الدرع	Thickness		I(C/min)		(I/I_O)		Buildup Factor	S.D ±	F.S.D %
	cm	m.f.p	I (W)	$I(W_0)$	W	W_0			
					Diameter =1 cm				
Cu	Air		141576	275890					
	Glass(0)	0	137627	260043	1	1	1	0.0033333	0.33334
	0.15	0.0975	128227	248291	0.931699	0.954807	1.024802	0.003545	0.343892
	0.45	0.2925	111823	224176	0.812508	0.862073	1.061003	0.0038237	0.366108
	0.75	0.4875	96817	200610	0.703474	0.771449	1.096628	0.0041359	0.391325
	1.05	0.6825	91149	193701	0.66229	0.744881	1.124704	0.0042687	0.401667
	1.35	0.8775	82189	177290	0.597187	0.681772	1.14164	0.0045866	0.42199
	1.65	1.0725	73013	160278	0.530514	0.616352	1.161802	0.0049862	0.44649
	2	1.3	66429	147940	0.482674	0.568906	1.178654	0.0053128	0.467046
Cu+Water	2+2	1.4608	53283	130460	0.387155	0.501686	1.295827	0.0059476	0.514129
	6	1.6216	48534	121273	0.352649	0.466357	1.322442	0.0064714	0.537122
	8	1.7824	45494	117542	0.33056	0.45201	1.367406	0.006899	0.552164
	10	1.9432	42032	109858	0.305405	0.422461	1.38328	0.0072951	0.573533
	12	2.104	37198	99564	0.270281	0.382875	1.41658	0.007895	0.607676
	14	2.2648	32478	90855	0.235986	0.349385	1.480533	0.0084843	0.646503
	16	2.4256	29820	85788	0.216673	0.329899	1.52257	0.0089906	0.672244
	18	2.5864	27541	80977	0.200113	0.311398	1.556111	0.0093551	0.697558
	20	2.7472	25049	76367	0.182006	0.293671	1.613518	0.0098543	0.728124
					Diameter =2 cm				
Cu	Air		209065	275890					
	Glass(0)	0	200540	260043	1	1	1	0.002972	0.297188
	0.15	0.0975	187235	247291	0.933654	0.950962	1.018538	0.00312	0.306345
	0.45	0.2925	168680	225371	0.841129	0.866668	1.030363	0.003317	0.321955
	0.75	0.4875	150064	203176	0.7483	0.781317	1.044123	0.003554	0.340377
	1.05	0.6825	140965	194987	0.702927	0.749826	1.066719	0.003729	0.349607
	1.35	0.8775	127135	179610	0.633963	0.690693	1.089485	0.003993	0.366514
	1.65	1.0725	118242	167901	0.589618	0.645666	1.095059	0.004157	0.379646
	2	1.3	100744	147290	0.502364	0.566406	1.127483	0.00461	0.408846
Cu+Water	2+2	1.4608	85234	130278	0.425022	0.500986	1.178729	0.005193	0.440549
	6	1.6216	77974	121340	0.38882	0.466615	1.20008	0.005508	0.458978
	8	1.7824	70728	117460	0.352688	0.451695	1.280721	0.006096	0.475943
	10	1.9432	63008	109273	0.314192	0.420211	1.337436	0.00669	0.500224
	12	2.104	56585	99542	0.282163	0.382791	1.356628	0.007142	0.526484
	14	2.2648	50841	90858	0.25352	0.349396	1.378177	0.007633	0.553853
	16	2.4256	47493	85564	0.236826	0.329038	1.389368	0.00795	0.572214
	18	2.5864	42756	80866	0.213204	0.310972	1.458561	0.008721	0.597952
	20	2.7472	37875	76954	0.188865	0.295928	1.566875	0.009835	0.627674

Table (3) The experimental results for the buildup factors Cs-137 source for (Fe-water) double layer

نوع الدرع	Thickness		I(C/min)		(I/I_O)		Buildup Factor	S.D	F.S.D
	cm	m.f.p	I (W)	$I(W_0)$	W	W_0		±	%
					Diameter =1 cm				
Fe	Air		142228	275438					
	Glass(0)	0	137579	260043	1	1	1	0.003334	0.333378
	0.15	0.08655	128045	247220	0.930702	0.950689	1.021476	0.00354	0.344307
	0.45	0.25965	113069	225345	0.821848	0.866568	1.054414	0.00393	0.364442
	0.75	0.43275	96276	196803	0.699787	0.756809	1.081485	0.004342	0.393294
	1.05	0.60585	88079	185322	0.640207	0.712659	1.11317	0.004612	0.409261
	1.35	0.77895	83054	177013	0.603682	0.680707	1.127591	0.004904	0.420591
	1.65	0.95205	77252	166925	0.56151	0.641913	1.143191	0.00511	0.435148
	2	1.154	68293	150772	0.496391	0.579796	1.168023	0.005468	0.461252
Fe+Water	2+2	1.3148	59498	137439	0.432464	0.528524	1.222122	0.005898	0.490747
	6	1.4756	54068	129712	0.392996	0.49881	1.269249	0.00645	0.511904
	8	1.6364	49034	119919	0.356406	0.461151	1.293891	0.006861	0.536031
	10	1.7972	44008	110986	0.319874	0.426799	1.334269	0.007323	0.563323
	12	1.958	42249	108084	0.307089	0.415639	1.35348	0.007574	0.573771
	14	2.1188	39195	101849	0.284891	0.391662	1.37478	0.007965	0.594407
	16	2.2796	36253	95789	0.263507	0.368358	1.397908	0.008263	0.616632
	18	2.4404	32656	88633	0.237362	0.34084	1.43595	0.009019	0.647339
	20	2.6012	28730	79998	0.208825	0.307634	1.473162	0.009792	0.687802
					Diameter = 2 cm				
Fe	Air		209065	275890					
	Glass(0)	0	200540	260043	1	1	1	0.002972	0.297188
	0.15	0.08655	185975	245920	0.927371	0.94569	1.019753	0.003134	0.307302
	0.45	0.25965	164748	220219	0.821522	0.846856	1.030838	0.003358	0.325742
	0.75	0.43275	141497	197109	0.70558	0.757986	1.074274	0.003743	0.348434
	1.05	0.60585	130514	186343	0.650813	0.716585	1.101062	0.003974	0.36095
	1.35	0.77895	114590	168513	0.571407	0.64802	1.134077	0.004342	0.382897
	1.65	0.95205	107151	158925	0.534312	0.611149	1.143805	0.004521	0.395283
	2	1.154	92210	138839	0.459809	0.533908	1.161153	0.004933	0.424822
Fe+Water	2+2	1.3148	84257	129428	0.420151	0.497718	1.184617	0.005244	0.44266
	6	1.4756	76848	120072	0.383205	0.461739	1.204939	0.005566	0.461964
	8	1.6364	70653	112986	0.352314	0.43449	1.233246	0.005915	0.479628
	10	1.7972	64843	108084	0.323342	0.415639	1.285447	0.006385	0.496729
	12	1.958	59415	101849	0.296275	0.391662	1.321955	0.006824	0.516229
	14	2.1188	54638	95789	0.272454	0.368358	1.352	0.007248	0.536115
	16	2.2796	49105	87633	0.244864	0.336994	1.376252	0.007758	0.5637
	18	2.4404	44081	79998	0.219812	0.307634	1.399534	0.008302	0.593176
	20	2.6012	40153	75863	0.200224	0.291733	1.457028	0.008992	0.617142

Table (4) The experimental results for the buildup factors using Cs-137 source for (Al-water) double layer

نوع الدرع	Thickness		I(C/min)		(I/I_O)		Buildup Factor	S.D ±	F.S.D %
	cm	m.f.p	I (W)	$I(W_0)$	W	W_0			
					Diameter =1 cm				
Al	Air		142365	276540					
	Glass(0)	0	137766	258371	1	1	1	0.003335231	0.333523
	0.15	0.03015	128123	244230	0.930005	0.943968	1.015014	0.003556881	0.344957
	0.45	0.09045	123038	238413	0.893094	0.921485	1.031789	0.003666259	0.351027
	0.75	0.15075	118785	231582	0.862223	0.895082	1.03811	0.003771953	0.356885
	1.05	0.21105	113031	223099	0.820456	0.862295	1.050994	0.003880056	0.365095
	1.35	0.27135	107831	216055	0.782711	0.835069	1.066893	0.004052619	0.372857
	1.65	0.33165	102580	210736	0.744596	0.814511	1.093897	0.004251576	0.380707
	2	0.402	91375	190933	0.663262	0.737971	1.112638	0.004575859	0.402261
Al+Water	2+2	0.5628	83597	181619	0.606804	0.701972	1.156834	0.004834981	0.41795
	6	0.7236	75954	171862	0.551326	0.66426	1.20484	0.005249633	0.435712
	8	0.8844	65974	154809	0.478884	0.598349	1.249464	0.005809276	0.464941
	10	1.0452	57982	138506	0.420873	0.535336	1.271967	0.006291625	0.494638
	12	1.206	50772	123890	0.368538	0.478844	1.299308	0.006846699	0.526949
	14	1.3668	44690	110143	0.324391	0.425711	1.312341	0.007360291	0.560852
	16	1.5276	39493	99194	0.286667	0.383393	1.337413	0.007957574	0.594997
	18	1.6884	36494	91916	0.264898	0.355262	1.341127	0.008297802	0.618719
	20	1.8492	33046	86993	0.239871	0.336235	1.401734	0.008745488	0.646189
					Diameter =1 cm				
Al	Air		209065	267561					
	Glass(0)	0	200540	258727	1	1	1	0.002975	0.297517
	0.15	0.03015	192040	251564	0.957614	0.972314	1.015351	0.003077	0.303024
	0.45	0.09045	185243	244230	0.923721	0.943968	1.021919	0.003149	0.308104
	0.75	0.15075	178096	237413	0.888082	0.91762	1.03326	0.003239	0.313481
	1.05	0.21105	169981	230012	0.847616	0.889014	1.04884	0.003355	0.319853
	1.35	0.27135	164745	223599	0.821507	0.864228	1.052003	0.003416	0.324689
	1.65	0.33165	156642	217455	0.781101	0.840481	1.07602	0.003566	0.331401
	2	0.402	148876	210736	0.742376	0.814511	1.097168	0.003715	0.33856
Al+Water	2+2	0.5628	132708	190933	0.661753	0.737971	1.115175	0.003986	0.35739
	6	0.7236	125581	181619	0.626214	0.701972	1.120977	0.004114	0.367002
	8	0.8844	114038	171862	0.568655	0.66426	1.168126	0.004462	0.381938
	10	1.0452	99173	154809	0.49453	0.598349	1.209935	0.004921	0.40673
	12	1.206	86912	138506	0.43339	0.535336	1.235231	0.005345	0.432733
	14	1.3668	76913	123890	0.383529	0.478844	1.248521	0.005731	0.459058
	16	1.5276	68042	110143	0.339294	0.425711	1.254698	0.006118	0.487605
	18	1.6884	60773	99194	0.303047	0.383393	1.265127	0.006517	0.51513
	20	1.8492	55704	91916	0.27777	0.355262	1.278981	0.006867	0.53695

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"تأثير قطر فتحة المسدد والعدد الذري للدرع على عامل تراكم أشعة كاما في الماء كمادة ماصة ثنائية الطبقة "

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الخلاصة:

درس في هذا البحث تأثير قطر فتحة المسدد (1) سم و (2) سم وتأثير العدد الذري للدرع على عامل تراكم أشعة كاما في المواد الماصة ثنائية الطبقة. أربعة مواد ثنائية الطبقة استخدمت في هذا البحث (حيث الماء أحدها) وهي : (البراص – الماء) و(النحاس – الماء) و (الحديد – الماء) و (الألمنيوم – الماء) .الحوض المستخدم الذي يحوي المادة والماء بأبعاد (10x10x30) سم^3. الكاشف المستخدم هو NaI(Tl) بأبعاد ("3"x3)عالي الكفاءة. كانت النتائج لقيم عامل التراكم المقاسة تشير الى عامل التراكم يزداد بزيادة سمك المادة ثنائية الطبقة المدروسة . وان عامل التراكم يقل بزيادة قطر فتحة المسدد،
وكذلك إن عامل التراكم يزداد بزيادة العدد الذري للدرع و.كل هذه النتائج قد تم تفسيرها . ولكل علاقات عامل التراكم مع السمك تم إيجاد معادلات ملائمة التي تمكن الباحث من الحصول على المعلومات بسهولة.