Military Technical College
Kobry El-Kobbah,
Cairo, Egypt

5th International Conference
on
Chemical & Environmental
Engineering
25 - 27 May, 2010.

EM-1

PERFORMANCE ANALYSIS OF HIGH BLASTING EXPLOSIVES (HBX)

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ABSTRACT

High Blasting Explosives (HBX) is one of the important generations of the high explosives (HE). HBX Include energetic materials like TNT and RDX, as the base of formulae and enhancer from aluminum powder and desensitizer. Aluminum powder is frequently added to explosives and propellants to improve their efficiency. Number of gaseous products are formed, but since the heat of formation of the oxide is very high (16260 kJ/kg), the addition of aluminum results in a considerable gain in the heat of explosion, and a higher temperature is imparted to the fumes. It is believed that aluminum may not completely react in the primary detonation wave front, and the reaction proceeds to completion in the fume zone ("positive - heating"). Parameters for different compositions are calculated theoretically, and by a computer program for a comparison. The selected composition samples are then formulated and tested. Experimental results and calculations show that mixing aluminum powder with TNT and RDX exhibited improvements in performance parameters as well as other properties such as stability and sensitivity. One of the examined compositions gave the best results and accordingly it's recommended to be used for mass production in different warhead fillings.

Keywords

TNT, RDX, HBX, detonation Parameters, Sensitivity, density, stability, lead block (Trauzl) tests.

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1. INTRODUCTION

High explosives are the materials that are known as energetic materials based on chemical compounds, or mixtures of chemical compounds and have ability to detonate, or be initiated and undergoes very rapid, self-propagating decomposition, resulting in:

(1) The formation of more stable material;
(2) The liberation of heat;
(3) The development of a sudden pressure effect through the action of heat on produced gases [1,2]

According to the definitions it must be insensitive over its life cycle when there is specific application or be desensitized to accept process treatment like flow during manufacturing and maintain its physical properties. They may be used independent of, or form a part of, ammunition. An advance in Basic research provides new materials and new applications [3-8].

Most military explosives consist of mixtures of material, at least one of which is high explosive. These mixtures, or formulation, are used instead of pure high explosive material to achieve one or more desirable properties that are not present in the pure high explosive. High explosives material can be classified into three classes: secondary explosives such as DATB, HMX, NQ, PETTN, RDX, etc, primary explosive molecules such as Leadazide, Lead styphnate, DXW-1and the last class for others such as explosives of ammonium nitrate, ammonium perchlorate, and potassium nitrate. Another classification appeared to illustrate uses and functions, for example classification by general warhead function, manufacturing procedure, warhead effects…etc [9-11].

Aluminum powder is used as a metal fuel to increase the total energy of the explosive. This use of aluminum in explosive was first proposed in the nineteenth century. Aluminum powder is available in a number of grades and particle sizes ranging from a flake "bomb" grade (MIL-A-512) to small (<10 µm) spherical particles (MIL-A-23950). Definition of HBX refer to The history of HBX, which is a form of high blast explosive made from TNT, RDX, aluminum, lecithin, and wax. It was firstly developed during WWII to replace the more shock-sensitive TORPEX used in depth bombs and torpedoes [12-19].

Importance of the product HBX – explosive, generally has take place because this selection study should finalized with successfully dissertation and fruit efforts in the field of military. Justifications of HBXs, an optimized practically to produce the maximum damage and performance in a number of damage modes, including fragmentations on missile warhead and air blasting on air force bomb [20-22].

This study was intended to produce charging materials with more advanced characteristics in perfect ultimate damage than TNT and RDX that are already used in the air force bombs. The better way to reach the aim of this project is to Study the Performance and Applications of adding a content of aluminum powder to high explosives charge through preparing different types of mixtures with different percentage of the based component. The performance of these different mixtures are studied by simulation and experimental methods in order to obtain the optimum mixture from different points of view including the performance, sensitivity, stability and ability to ignition [23-27].

2. Experimental Work and Tests

Safety instructions were considered during preparations. Formulations of HBX explosives are prepared by selecting the basic raw materials from high quality product. First, these materials were checked by means of visual inspection and special sieves from the foreign materials, and then subjected to weighing process to prepare the needed input quantity for mixing. Using casting method equipments for manufacturing process and many types of apparatus for testing. Four formulae of HBX explosives are prepared by the same procedure and condition, for each formulation three products are produced, with finalized of a twelve products as a total prepared products. The percentages of ingredients for formulae are shown in Figure 1. The compositions consist seven items each one have specified function on the process (see table 1).

The whole process time from preparations until casting took about two hours. The products (sample shown in Figure 2) subjected to many experimental tests. They include tests to ensure the heat stability, the perfect impact sensitivity to classified into explosives materials and sustained transportations, the reliability of storing, inform about the performance and optimum damage, inform about the productionability, and detonation-ability. The TNT material is used as a reference material and to calibrate the measuring devices, since it was counted to be specified.

Computer program prepared by using Q.BASIC programming language was used for calculation of the main explosive characteristics of various explosive compositions. Input data are summary formula, density, energy of formation.

3. Results and Discussions of Experimental Setup

Table 2 showed comparison of theoretical calculations with computer program out put. In term of comparison, results for TNT were obtained in this table. There are comparable values of theoretical calculations and computer output. The results show a decreasing in parameters of OB%, PoD, VoD, and volumes of gases when Al-powder increased and inverse result for heat of detonation. Compared to TNT parameters, TNT has the least negative OB% and different composition of HBX give better values of other parameters.

Figure 3 give results of measured deflagration temperature, increasing of aluminum powder percentage decrease the deflagration point when comparing between comp-1, comp-2 and comp-3. Moreover, and in comp-4, with the minimum value of the desensitizer material the deflagration point give its minimum value.

The concluded summary results of impact sensitivity test are shown in Figure 4. They give highly agreement with the theory in this area**.** The aluminized high explosive with a lower desensitizer comp-4 gives the higher sensitivity (lower impact value), and the other composition influenced directly with RDX contents. The average moisture contents of the test powders based on three independent moisture measurements on each powder are shown by Figure 5, the moisture content was found to be lowest for different HBX compositions and highest for the TNT. Since the moisture, content of TNT was much higher than that of the other powders of each formula. Furthermore, the rate of moisture measured was decreased when aluminum powder increased.

Results of Trauzl test (figure 6) introduced a discussion described on the question “can adding aluminum powder to the explosive charge improve the explosive charge performance or not”.

The answer can be illustrated by the lead block Trauzl results when a comparative observation was registered to see the different of volumes between charge of HBX–test and charge of TNT– test. Both charges are tested in the same conditions, and found that aluminized charge provided higher mean value 27cm^3 compared to the charge of pure TNT 18 cm^3.

HBX has higher densities, these higher energy densities of explosive explain easier to initiate and quickly detonated. HBX Substance was subjected to the Thermal Stability Test Table 3, (Test Method at 75 °C) and the evidence of tests gave an explosive behaviors result (i.e. fails the test). Optimum results of tests showed in Table 4, represent specifications of the main properties for the selected explosive composition (HBX) formula of composition -2.

4. Conclusion

From different simulation and experimental results, the following point can be concluded.

1- Many experiments and tests, which are conducted to investigate the compatibility of this material show that the additions of the aluminum powder increase the density, improve the power, sensitivity and change stability, electrical properties within the accepted range. The pass of any critical test in series, it's judged to have excellent properties.

2- HBX explosives will give more advance characteristics in perfect ultimate damage than our familiar available materials such as TNT that used for air force bomb and warheads.

3- Results of tests are satisfactory and the performance is as desired. Then a management decision beyond the laboratory level has made to proceed with limited pilot production for further work on HBX as new explosive. Results of pilot production will be the base for future material production to solve high consumable of energetic materials of several hundred kilograms that should be used for charging bombs.

4- This agreement of results will encourage any safety committee when decided to go ahead to use this type of explosive in different warheads loading.

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References

[1] Carle, V., Thomas F., "MILITARY EXPLOSIVES" Department of Army Technical Manual, USA, 1984.

[2] Joseph, C., "Tactical Missile Warheads," Volume 155, progress in AIAA, USA, 1993.

[3] Commander, Naval Ordnance Systems Command. Safety and Performance Tests for Qualification of Explosives. NAVORD OD 44811. Washington, D.C.: GPO, 1972.

[4] Meyer R., "Explosives'' 5th edition, VCH Germany 1987.

[5] Taha, M.A.G., "EXPLOSIVE MATERIAL TECHNOLOGY", department of technical industry, (Arabic version), Iraq. 1986

[6] Basil, T .F., "ENCYCLOPEDIA of explosives''vol 10, US Armey research and command. Picatinny Arsenal New Jersey 1980.

[7] Urbanski, T., "CHEMISTRY and TECHNOLOGY OF EXPLOSIVES", Volume1, Pergamon Press, Oxford, New York 1984.

[8] Urbanski, T., "Chemistry and Technology of explosives" vol.3, Pergamon Press, Oxford, New York 1984.

[9] Muhammad, S., "Test Methods for Explosions," Springer, New York, 1995.

[10] Patrick, B., "DETONATION PROPERTIES OF EXPLOSIVES CONTAINING NANOMETRIC ALUMINUM POWDER''-Defense Research & Development Canada – Valcartier 2002.

[11] Jacqueline, A., “ The Chemistry of Explosives” Volume (3), Royal Society of Chemistry Cambridge, UK.2004
[12] Tadao, y, N., “SafEty of Reactive Chemicals AND Pyrotechnics” , ELSEVIER Amsterdam,1995
[13] GPO, D.C., “Military Explosives”. Vol. 2, 1st. Departments of the Army and Air Force, NAVORD OP 3000, Washington.1998
[14] Ford Ham, S., “High explosives and propellants” second edition - Pergamon Press ,Oxford ,New York.1980
[15] Makhov, M. N. and V. I. Arkhipov., “.Method for Estimating the Acceleration Ability of Aluminized High Explosives’’. Russian Academy of Sciences, ul. Kosygina 4, Moscow , 2007
[16] Naminosuke, Kubota., “Propellant and Explosives”, thermochemical aspects of combustion. Wiley – VCH.2001
[17] David, H., “secondary explosives” An International Journal of Propellants,Explosives,Pyrotechnics,Volume (11), 1986
[18] Ohio, LINK EJC., “POWDERED EXPLOSIVE” Volume (12), An International Journal of Propellants,Explosives,Pyrotechnics WILEY ,1992
[19] Ohio, LINK EJC., “CHARACTERIZING mixtures” An International Journal of Propellants, Explosives, Pyrotechnics WILEY, Volume (13) 1998.
[20] Baytos, .J. F., "High-Temperature Vacuum Thermal Stability Tests of Explosives," LA-5829-MS, Los Alamos National Laboratory, January 1975.
[21] Pidoll, Von, U.; Brzostek, E.; Froechtenigt, H.-R., “DETERMINING the incendivity of electrostatic discharges without explosive gas mixtures” Volume 40, Issue 6, Page(s): 1467 – 1475, Nov.-Dec. 2004.
[22] Gagliardi, F. J., “Small-Scale Performance Testing for Studying New Explosives”, 6th VACETS Technical International Conference Milpitas, CA, USA June 2005.
[23] Davis, T.L. “Chemistry of Powder and Explosives”. New York, 1943.
[24] Faber, Henry B. “The History and Development of Military Pyrotechnics”. Military Pyrotechnics, vol I. Washington, DC: Government Printing Office, 1919.
[25] Fair, H. and Walker R., ed. “Energetic Materials”. Technology of the Inorganic Azides, vol 2. New York: Plenum Press, 1977.
[26]Pristera, F. “Explosives”. Encyclopedia of Industrial Chemical Analysis, vol 12. New York: John Wiley and Sons, 1971.
[27] Yinon, J. and Zitrin, S. “The Analysis of Explosives”. Peragamon Series in Analytical Chemistry, vol 3. New York: Peragamon Press, 1981.

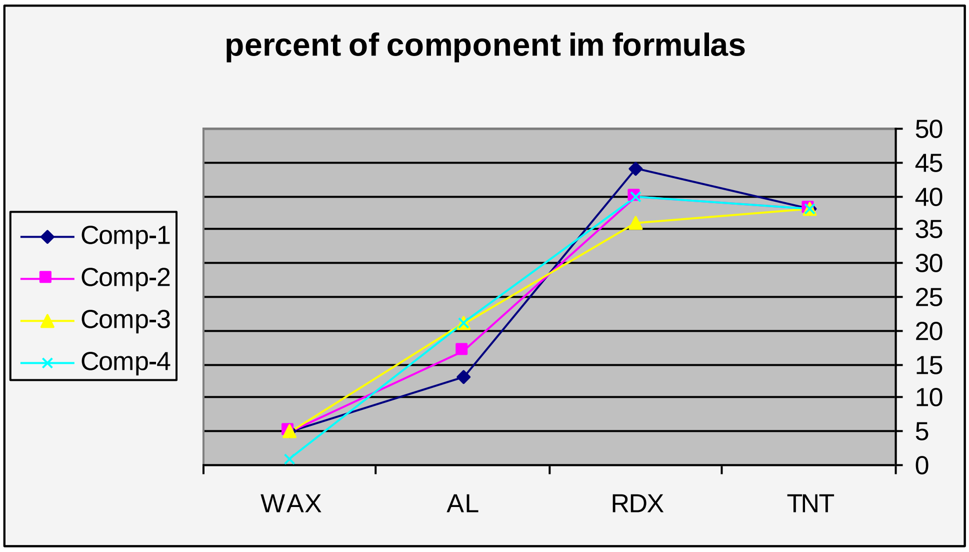

Figure 1: Percentages of Raw Materials

Figure 2: Sample of the Products

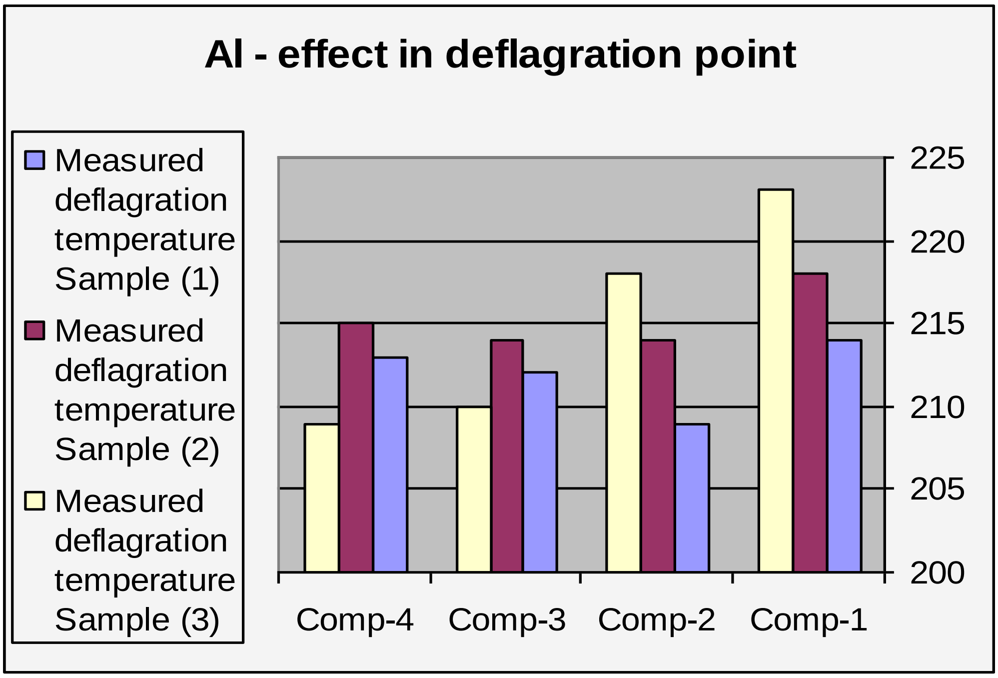

Figure 3: Aluminum Effect in Deflagration Point

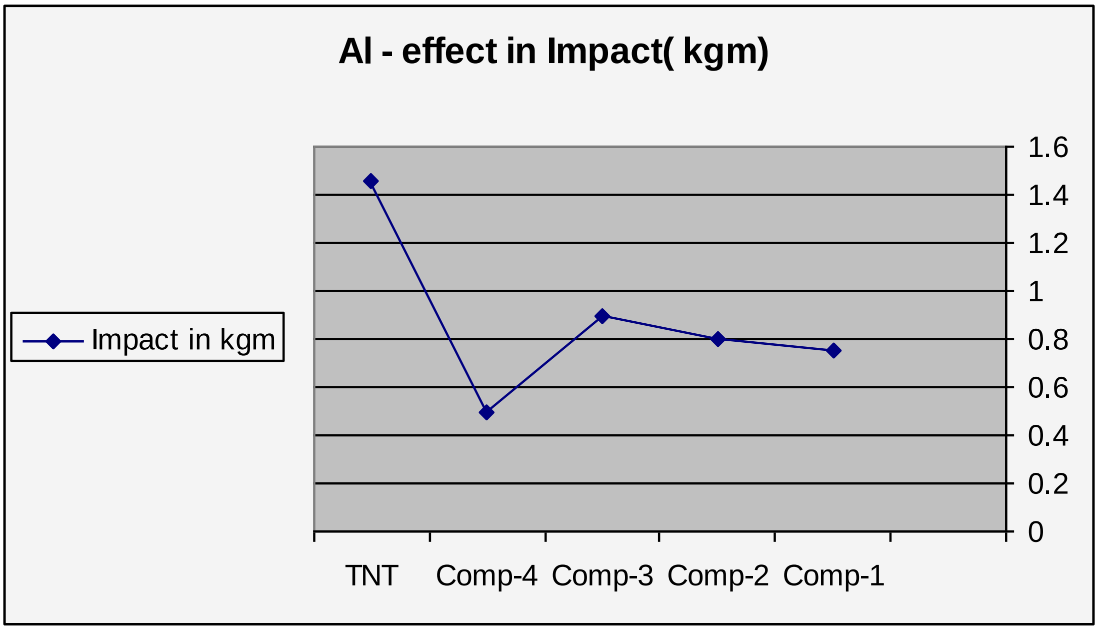

Figure 4: Aluminum Effect in Impact Sensitivity

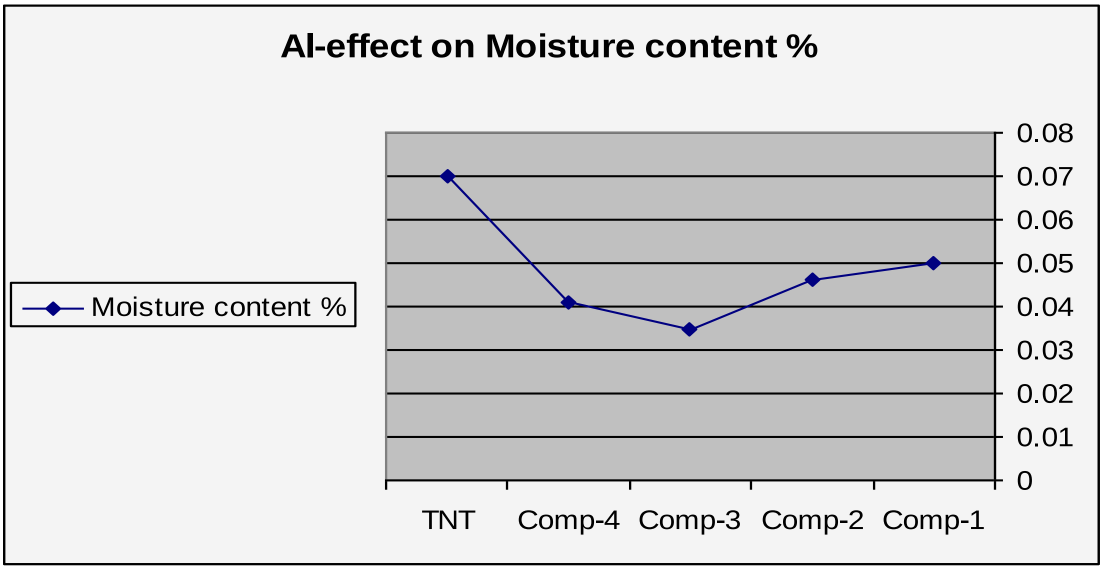

Figure 5: Aluminum Effect in Moisture Content

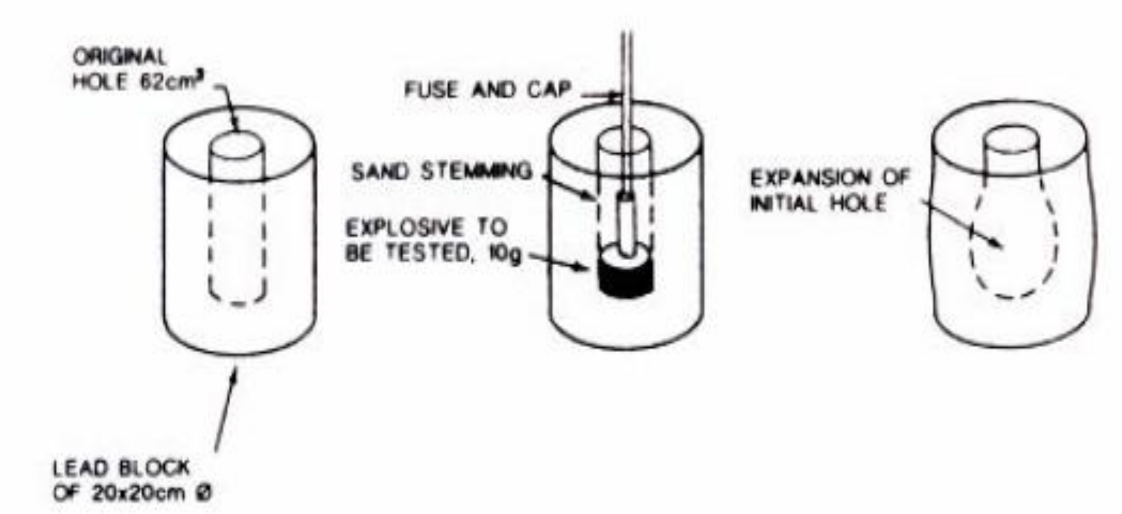

Figure 6: Results of Trauzl test

Table 1: Chemical Raw Materials Specifications

No.	Material name	function
1.	Trinitrotoluene (TNT)	Energetic Material, liquid medium for cast filling process
2.	PARAFFIN WAX	main desensitizer
3.	PURE (RDX)	Excellent Energetic Material.
4.	Calcium chloride ($CaCl_2$)	Salt as second desensitizer
5.	Nitrocellulose (NC)	Filler
6.	Lecithin	1. Reduces viscosity and betters yield. 2. Reduction of expensive material. 3. Controls RDX crystallization. 4. Controls the flow properties of melt TNT. 5. Helps in the homogeneous mixing of ingredients 6. An anti sludge additive.
7.	Aluminum powder	Performance enhancer

Table 2: Results of calculated PARAMETER (calc) and Computer Output (cmpu).

Composition	O.B%		no. of moles (mol/g)		Volume (L/Kg)		Heat of detonation (Q) kcal/Kg		Detonation velocity (km/s)		Detonation pressure (kBar)	
	Calc.	cmpu.	Calc.	cmpu.	Calc.	cmpu.	Calc.	cmpu.	Calc.	cmpu.	Calc.	cmpu.
COMP-1	-69.4	-69.4	34	34	761	768	1530	1530	8.012	8.012	293	293
COMP-2	-72.1	-72	33	32	739	728	1667	1667	8.091	8.091	304	304
COMP-3	-74.8	-75	30.54	31	684.1	689	1805	1805	8.185	8.185	317	317
COMP-4	-60.3	-60	39.05	31	874.7	693	1808	1808	8.56	8.56	354	354
PURE TNT	-74		22		493				6.950		177	

Table 3: result of thermal stability test.

Heating Temperature of sample	Period (hour)	Remark	
		discoloration	weight loss
75˚C	First 48 hour	no. change(-)	3.089%
75˚C	Second 48 hour	little change (-)	3.089%
75˚C	Third 48 hour	burned	-----

Table 4: Optimum Test Results (Composition-2)

NO	TEST	RESULT	REMARK
1.	Visual test	Colour: Grey to silver white.	
2.	Mp.	90˚C	after TNT melt
3.	Ash content	0,0102	loss represent aluminum powder
4.	Moisture content.	1.089	represent TNT, RDX
5.	Apparent density	1.89 g/cm^3	
6.	Particle size	appeared as fine particle size	
7.	Deflagration temperature	213	
8.	impact sensitivity	16 cm	
9.	Thermal stability test	no. change on Colour or weight	ignite at 2nd 48hour
10.	Electrostatic sensitivity test	Sensitive to electric discharge	
11.	Lead block Trauzl test	27cm^3	