International Bomb Disposal and Counter IED Organization Testing Standards Program

Inert Explosive Simulants

Document #: IBDO-inertsimulants-2023-001

Disclaimer

All of the information provided in this document is based on all of the information that was available at the time of this document's development. This document is designed as a guide for any person or party that is looking for guidance on evaluating inert explosive simulants that are used for training either visually or in x-ray. This guide provides the end user the information on how to evaluate commercial off the shelf inert explosive simulants. This guide does not determine which product or manufacture is better than another and only provides a method to test these products and validate specific aspects that need to be present to provide accurate training example of real explosive threats.

This guide is a living document and is open to feedback from the various end users of inert explosive simulants. The evaluation methods inside of this standard can be changed or even expanded based on end user input. Manufactures do not have the ability to determine these standards and only actual end users of the products can determine the requirements of this standard. This is to ensure that the standards are driven by the actual end users and not the manufactures.

Inert explosive simulant manufactures are welcomes to submit their products to the IBDO for evaluation based on the standards listed in this document. IBDO will develop a "Approved Products" list based on the testing and evaluation guidelines listed in the document. Procedures for submitting products for approval to the IBDO "Approved Products" list are included in this document.

This guide is a end user tool that provides methods to test and evaluate Inert explosive simulants based on their mission requirements. How the test is conducted by the end user is not the responsibility of the IBDO. Products submitted by manufactures will be looked at based on the testing methods listed in this standard. Manufactures are responsible for conducting the testing and submitting it to the IBDO for review. The IBDO will verify that the test results are accurate and either approve or reject the vendors submission.

Table of Contents

Contents

No table of contents entries found.

Background

Inert Explosive simulants have been used for many years for training in the identification of the IED threat. Today these Inert training aids need to provide not only visual accuracy but also provide realistic responses in x-ray technologies. Because there are no standards for Inert explosive simulants many end users have no real way to verify that an Inert explosive training aid is responding correctly and matches how the real explosive would respond.

Classification of Simulants

These inert explosive simulants can also be very expensive so ensuring that they are actually responding just like the real explosive is key and ensures when they are used in training, they are providing realistic responses in the detection technology they are being used in.

This standard will look at these Inert explosive simulants based on the following requirements;

1. Visually and tactilely matches the real explosive they are simulating.
2. Density matches the real explosive they are simulating.
3. Average effective atomic number (Z *eff*) matches the real explosive they are simulating.
4. The simulant has no hazardous chemicals used in their manufacture that could potentially harm the end users.
5. Technically accurate in an x-ray image when compared to a real explosive product.
6. The simulant is clearly marked as “INERT” to avoid being mistaken as a real explosive product.
7. Cost of the Simulant based on market pricing

Based on all of the above requirements each product will be placed into specific categories that gauge the overall quality of the product. These categories will also recommend what these simulants should and should not be used for in training scenarios. The categories will be broken down as follows:

Category A: Highest level of quality and can be used as a visual training aid and also used in both portable and checkpoint security x-ray systems. These will trigger x-ray auto detection algorithms that have the ability to detect this type of explosive. They have no hazardous chemicals in the mixture and are safe to handle outside of the packaging. They match the real explosive they are simulating in density and Z*eff* by a margin no greater than +/- 0.6. They are cost effective and are clearly marked as inert and cannot be mistaken as a real explosive.

Category B: High level of quality and can be used as a visual training aid and used in both portable and checkpoint security x-ray systems. These will trigger x-ray auto detection algorithms that have the ability to detect this type of explosive. They have no hazardous chemicals in the mixture and are safe to handle outside of the packaging. They are close to the real explosive they are simulating in density and Z*eff* by a margin no greater than +/- 1.0. They are semi cost effective and are clearly marked as inert and cannot be mistaken as a real explosive.

Category C: Good quality and can be used as a visual training aid and used in both portable and checkpoint security x-ray systems. These will trigger x-ray auto detection algorithms that have the ability to detect this type of explosive. They have no hazardous chemicals in the mixture and are safe

to handle as long as they stay in the packaging. They do not match the real explosive they are simulating in density and *Zeff* and are off by more than +/- 1.5. They are semi cost effective and are marked as inert and should not be mistaken as a real explosive.

Category D: Average quality and can be used as a visual training aid but lack the tactile qualities of the real explosive they are simulating. They should not be used in either portable and checkpoint security x-ray systems. They will not trigger x-ray auto detection algorithms that have the ability to detect this type of explosive. They have some hazardous chemicals in the mixture and are safe to handle as long as they stay in the packaging. They do not match the real explosive they are simulating in density and *Zeff* and are off by more than +/- 3.0 They are semi cost effective and are marked as inert and should not be mistaken as a real explosive.

Category E: Below Average quality and can be used as a visual training aid but lack the tactile qualities of the real explosive they are simulating. They should not be used in either portable and checkpoint security x-ray systems. They will not trigger x-ray auto detection algorithms that have the ability to detect this type of explosive. They have some hazardous chemicals in the mixture and are safe to handle as long as they stay in the packaging. They do not match the real explosive they are simulating in density and will turn the wrong color in a materials discrimination image. They are cost effective and are marked as inert and should not be mistaken as a real explosive.

Administrative Requirements

Each Simulant will be tested using a process that can be completed by the manufacture and the end user. The testing is designed that anyone can complete it and gives the end user to verify that what the manufacture is claiming is accurate. This is a much different process than most standards as they do not allow for end users to accomplish the testing or require very costly test objects.

IBDO will accept manufacture testing for potential acceptance and to be listed in the IBDO approved products list. This process will be detailed in the last part of the guide and provide the process manufactures will use for submission of any product to the IBDO.

End users will also have the ability to submit products they have tested and this process can also be used to add a product to the Approved products list. This process will be the same as the one used for the manufactures but IBDO will verify that they testing was completed accurately. If a manufacture improves a product or wants to appeal an end user submission, they will use the same process for submitting a product for review.

Due to potential quality control concerns all products that are on the approved products list will require that they be “reverified” on an annual basis. This will ensure that each manufacture is maintaining the mixture and none of the previously measured requirements are still valid.

Part of the submission by the manufactures will be a Safety Data Sheet (SDS) and will detail all required information in sections 1-16 on the SDS. Any chemical that has no hazards does not need to be listed and can be listed as “Proprietary” but all chemicals with hazards MUST be listed by name. This SDS information will be posted along with the product name if it is becoming an approved product by the IBDO.

Categories

Commercial Explosives

Commercial explosives are manufactured and most are used for mining and blasting applications. Also included in this list are military grade explosives that are specific to military applications. If a manufacture has a product that simulates one of these commercial explosives, they must provide the explosive manufactures Technical Data Sheet (TDS) and Safety Data Sheet (SDS). These manufactures technical documents will allow us to determine the density in g/cc and the range for the average atomic number (*Z eff)*. The following are products that will fall into the "Commercial" explosives category:

A. Dynamites
B. Emulsions
C. Water gels
D. Binary's
E. CAST Boosters
F. Ammonium Nitrate (AN)
G. Ammonium Nitrate and Fuel Oil (ANFO)
H. Plastic Explosives
I. PETN Powder
J. RDX Powder
K. CAST and Flake TNT
L. Comp B Flakes
M. Sheet/Deta Sheet Explosives
N. Detonator Slip on Boosters
O. Black Powder
P. Black Powder replacement
Q. Smokeless Powders
R. Flash Powders
S. UREA Nitrate
T. Potassium Per Chlorate
U. Potassium Nitrate
V. Potassium Chlorate
W. Calcium Nitrate
X. EDGN (liquid)
Y. Nitromethane (liquid)
Z. Nitro Glycerin (Liquid)
AA. Detonating Cord

Note 1: DO NOT submit real explosives like cold pack AN or any other real explosive material

Note 2: If the simulant cannot be removed from the packaging due to safety concerns do not submit this material for testing

Note 3: Ship all items as per required regulations and if shipping internationally the code for customs is 90230

Homemade Explosives

Homemade explosives are not manufactured commercially and produced by criminals and terrorist. These mixtures are typically very volatile and, in some cases, very sensitive to heat shock and friction. The mixtures do have baseline ingredients and semi set amount to be used for their manufacturing. However, many of these are subject to wide variations on how much of each part of the mixture they combine. These ad hoc mixtures will cause wide variations in the density g/cc and the Z *eff* of the explosive. Explosives that are subject to these variations the simulant manufacture will detail what mixture they are trying to simulate and any reference they have for density and Z *eff.* The following are products that will fall into the "Homemade" explosives category:

A. TATP (crude and pure)
B. HMTD (crude and pure
C. Ammonium Nitrate and Aluminum Mixtures
D. Poor man's C-4
E. Mixtures using a Potassium Chlorates as the Oxidizer
F. Armstrong Mix
G. Calcium Ammonium nitrate mixtures
H. MEKP (Liquid)
I. Peroxide (Liquid) pure

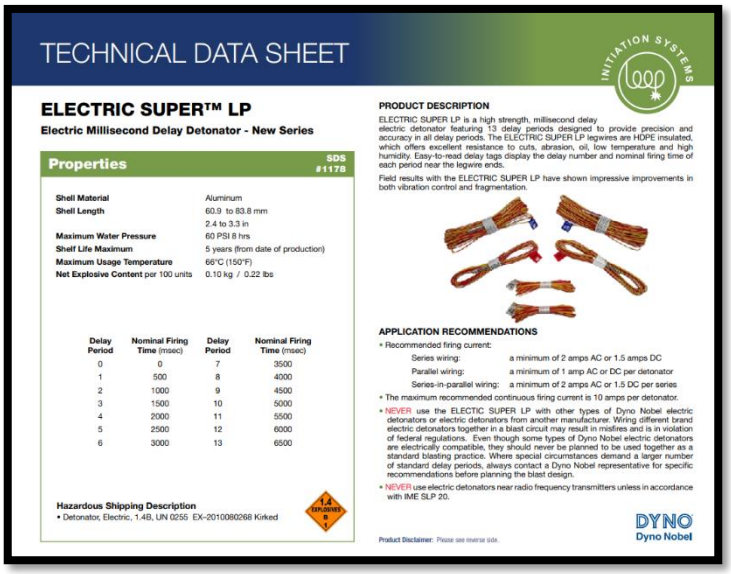
Note 1: There are many potential mixtures that can be classified as an HME. If you are a simulant manufacture and have developed an inert HME that is not on the above list please submit to the IBDO the information and once verified we will add it to the list of HME's.

Note 2: If the simulant cannot be removed from the packaging due to safety concerns do not submit this material for testing

Note 3: Ship all items as per required regulations and if shipping internationally the code for customs is 90230

Detonator/Initiators

Detonators and initiators can be commercially manufactured or they can be improvised. We will cover both of these type in this category. If a simulant manufacture has a product that simulates a commercially manufactured product, they must provide the explosive manufactures Technical Data Sheet (TDS) and Safety Data Sheet (SDS). These manufactures technical documents will allow us to determine the what type of internal components should be present inside of the detonator. Simulant manufactures will be required to submit a technical



TECHNICAL DATA SHEET

INITIATION SYSTEMS

ELECTRIC SUPER™ LP

Electric Millisecond Delay Detonator - New Series

Properties SDS #1178

Shell Material	Aluminum
Shell Length	60.9 to 83.8 mm 2.4 to 3.3 in
Maximum Water Pressure	60 PSI 8 hrs
Shelf Life Maximum	5 years (from date of production)
Maximum Usage Temperature	66°C (150°F)
Net Explosive Content per 100 units	0.10 kg / 0.22 lbs

Delay Period	Nominal Firing Time (msec)	Delay Period	Nominal Firing Time (msec)
0	0	7	3500
1	500	8	4000
2	1000	9	4500
3	1500	10	5000
4	2000	11	5500
5	2500	12	6000
6	3000	13	6500

Hazardous Shipping Description
• Detonator, Electric, 1.4B, UN 0255 EX-2010080268 Kirked

1.4 EXPLOSIVES B 1

PRODUCT DESCRIPTION

ELECTRIC SUPER LP is a high strength, millisecond delay electric detonator featuring 13 delay periods designed to provide precision and accuracy in all delay periods. The ELECTRIC SUPER LP legwires are HDPE insulated, which offers excellent resistance to cuts, abrasion, oil, low temperature and high humidity. Easy-to-read delay tags display the delay number and nominal firing time of each period near the legwire ends.

Field results with the ELECTRIC SUPER LP have shown impressive improvements in both vibration control and fragmentation.

APPLICATION RECOMMENDATIONS

• Recommended firing current:

Series wiring:	a minimum of 2 amps AC or 1.5 amps DC
Parallel wiring:	a minimum of 1 amp AC or DC per detonator
Series-in-parallel wiring:	a minimum of 2 amps AC or 1.5 DC per series

• The maximum recommended continuous firing current is 10 amps per detonator.

• NEVER use the ELECTIC SUPER LP with other types of Dyno Nobel electric detonators or electric detonators from another manufacturer. Wiring different brand electric detonators together in a blast circuit may result in misfires and is in violation of federal regulations. Even though some types of Dyno Nobel electric detonators are electrically compatible, they should never be planned to be used together as a standard blasting practice. Where special circumstances demand a larger number of standard delay periods, always contact a Dyno Nobel representative for specific recommendations before planning the blast design.

• NEVER use electric detonators near radio frequency transmitters unless in accordance with IME SLP 20.

DYNO Dyno Nobel

Product Disclaimer: Please see inverse side.

drawing of the simulated detonator and provide a reference from either an explosive manufacture of a Patent drawing of a similar type detonator.

The detonator simulant “MUST” have either a hole drilled into the detonator shell or the end of the detonator shell where the main charge is located cannot be capped. The detonator simulant must also have a “INERT” sticker wrapped around the wires near where they enter in the shell.

The improvised detonators will require that a reference be provided that shows it was actually used by terrorist and is not a “made up” product. The simulant manufacture will provide a detailed explanation on how this detonator works and the type of chemicals being simulated. The following list of detonator/initiators is provided for this category:

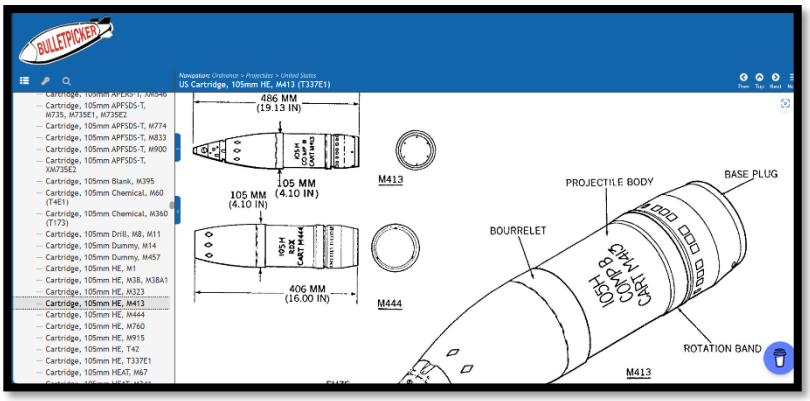
A. Commercial bridge wire aluminum instantaneous
B. Commercial bridge wire copper instantaneous
C. Commercial bridge wire aluminum delay
D. Commercial bridge wire copper delay
E. Commercial fuzehead aluminum instantaneous
F. Commercial fuzehead copper instantaneous
G. Commercial fuzehead aluminum delay
H. Commercial fuzehead copper delay
I. Commercial non-electrical
J. Commercial e-matches
K. Shock tube detonator
L. Military Time fuze
M. Commercial time fuze
N. Commercial hobby fuze
O. Improvised copper
P. Improvised flashbulb/light
Q. Improvised metal shell
R. Improvised nonmetal shell

Note 1: Ship all items as per required regulations and if shipping internationally the code for customs is 90230

Note 2: Detonators will be shipped separately from explosive simulants so they do not get confused as being an explosive charge with a detonator inserted in x-ray.

Ordnance:

Inert replica or simulated ordnance products do not need to be shipped for testing and only a x-ray of the item in a materials discrimination and grey scale Image will be used to verify the density quality vs the real ordnance item. The inert replica manufacture will also be required to submit the weight of the ordnance item along with the diameter and length. The inert replica manufacture will also be required to provide a reference of the ordnance item that provides the dimensions of the real ordnance item. Inert replica manufactures can use references like Bullettpicker or CATUXO to obtain the real ordnance items technical specifications.



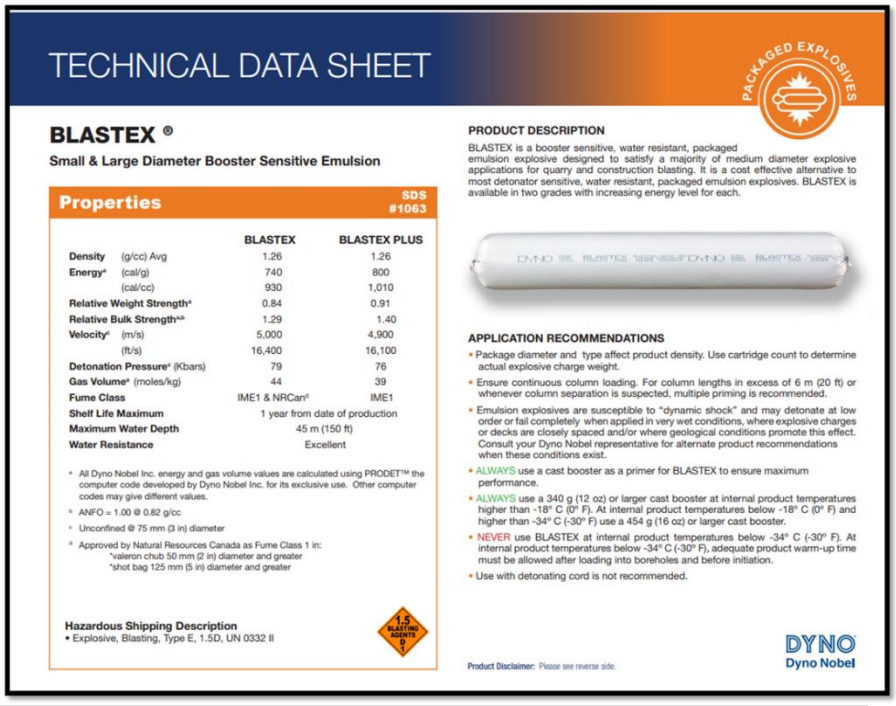
Bulletpicker: [Home (bulletpicker.com)]

CATUXO: [CAT-UXO]

A photo if the inert replica ordnance item will be provided that show digital calipers measuring the diameter of the ordnance as it is detailed in the real ordnances technical reference. This will also include an image of the length being measured of the ordnance item.

Measuring Density:

Inert simulants that require a density measurement in g/cc will be done using a mass and volume method. To make this process simple and able to be conducted by end users the mass and volume method is what IBDO has adopted. Other methods can be submitted but you must submit the products density measurement based on the procedure listed below. The measurement will be done at a min of three times and all three measurements will be submitted. To verify this for a simulant to be placed in the “approved” list, IBDO will use the simulant that was submitted and conduct the same test to verify that it matches what the vendor submitted.



TECHNICAL DATA SHEET

PACKAGED EXPLOSIVES

BLASTEX ®

Small & Large Diameter Booster Sensitive Emulsion

Properties SDS #1063

		BLASTEX	BLASTEX PLUS
Density	(g/cc) Avg	1.26	1.26
Energy[a]	(cal/g)	740	800
	(cal/cc)	930	1,010
Relative Weight Strength[a]		0.84	0.91
Relative Bulk Strength[a,b]		1.29	1.40
Velocity[c]	(m/s)	5,000	4,900
	(ft/s)	16,400	16,100
Detonation Pressure[a]	(Kbars)	79	76
Gas Volume[a]	(moles/kg)	44	39
Fume Class		IME1 & NRCan[d]	IME1
Shelf Life Maximum		1 year from date of production	
Maximum Water Depth		45 m (150 ft)	
Water Resistance		Excellent	

- All Dyno Nobel Inc. energy and gas volume values are calculated using PRODET™ the computer code developed by Dyno Nobel Inc. for its exclusive use. Other computer codes may give different values.
- ANFO = 1.00 @ 0.82 g/cc
- Unconfined @ 75 mm (3 in) diameter
- Approved by Natural Resources Canada as Fume Class 1 in:
  - *valeron chub 50 mm (2 in) diameter and greater
  - *shot bag 125 mm (5 in) diameter and greater

Hazardous Shipping Description
- Explosive, Blasting, Type E, 1.5D, UN 0332 II

1.5 BLASTING AGENTS D

PRODUCT DESCRIPTION

BLASTEX is a booster sensitive, water resistant, packaged emulsion explosive designed to satisfy a majority of medium diameter explosive applications for quarry and construction blasting. It is a cost effective alternative to most detonator sensitive, water resistant, packaged emulsion explosives. BLASTEX is available in two grades with increasing energy level for each.

APPLICATION RECOMMENDATIONS

- Package diameter and type affect product density. Use cartridge count to determine actual explosive charge weight.
- Ensure continuous column loading. For column lengths in excess of 6 m (20 ft) or whenever column separation is suspected, multiple priming is recommended.
- Emulsion explosives are susceptible to “dynamic shock” and may detonate at low order or fail completely when applied in very wet conditions, where explosive charges or decks are closely spaced and/or where geological conditions promote this effect. Consult your Dyno Nobel representative for alternate product recommendations when these conditions exist.
- ALWAYS use a cast booster as a primer for BLASTEX to ensure maximum performance.
- ALWAYS use a 340 g (12 oz) or larger cast booster at internal product temperatures higher than -18° C (0° F). At internal product temperatures below -18° C (0° F) and higher than -34° C (-30° F) use a 454 g (16 oz) or larger cast booster.
- NEVER use BLASTEX at internal product temperatures below -34° C (-30° F). At internal product temperatures below -34° C (-30° F), adequate product warm-up time must be allowed after loading into boreholes and before initiation.
- Use with detonating cord is not recommended.

Product Disclaimer: Please see reverse side.

DYNO Dyno Nobel

The simulant manufacture will also provide a technical data sheet for the explosive from the manufacturer of the real explosive. This will provide the density of the real explosive they are simulating and be the standard for that simulant to be measured.

Step 1: Take a digital scale and ensure it is zeroed and set for grams.

Step 2: Weigh a 15ml/ 1 tbsp measuring spoon on the scale and write down the weight in grams. Next zero the scale with the spoon on it and this will take off the weight of the spoon for when we measure the simulant packed into the spoon.

Step 3: Using the 15 ml/ 1 Tbsp measuring spoon fill it to the very edge and as tight as possible with the simulant. Using a straight edge ensure that the material is even with the edge of the measuring spoon and not heaped higher than the edge.

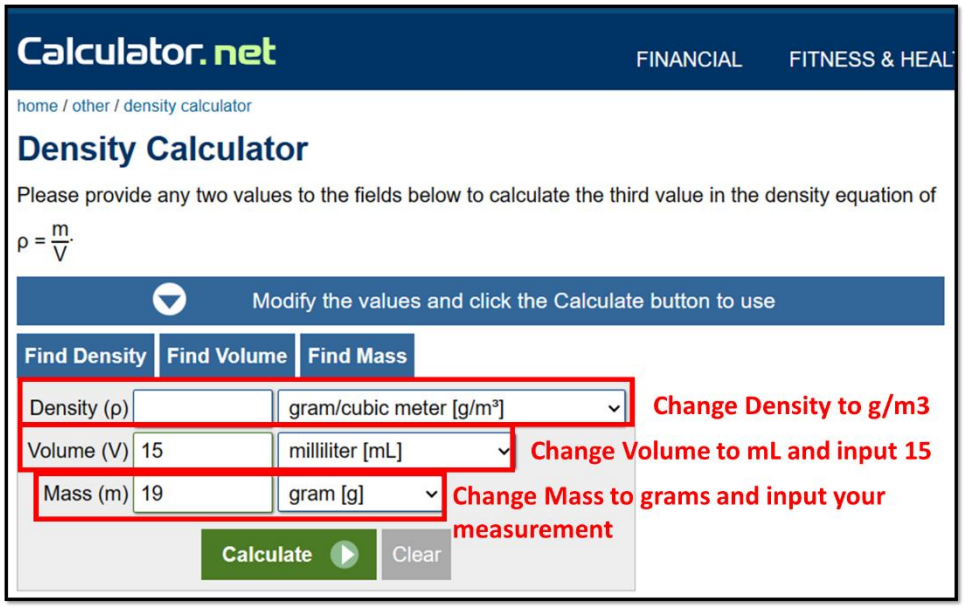
Step 4: Now measure the spoon with the material packed into it and write down the number in grams.

Step 5: Repeat steps 1-4 two more time but each time use a different part of the simulant for testing. Take down all three measurements and annotate them on the IBDO submission form.

Step 6: Using the below link (online density calculator) input the mass and volume data for each measurement.

Density Calculator: Density Calculator

Change all of the settings in the calculator as shown in the image.



Measuring Average Atomic Number (Z *eff*):

There are two different methods that can be used to submit the Z eff of a simulant. In each case there is a specific process that will be used to ensure the measurement is accurate and can be compared to the real explosive material. Because there are many potential ways to skew these numbers the below listed methods are the only methods the IBDO will accept.

Method 1: X-Ray Zeff measurement

There are x-ray systems on the market that have ability to provide a Z *eff* measurement but there is a specific way this must be done to ensure accuracy. Because x-ray Z *eff* measurements are a “guess” and are never 100% accurate IBDO will require that a baseline measurement of a know material be conducted. To accomplish this the simulant manufacture will be required to x-ray and measure a 1 in

thick piece of Delrin copolymer plastic. This calibration piece will be 4 in x 4 in and 1 in thick and used to verify the *Zeff* accuracy of the x-ray systems measurement.

When the simulant material is tested it must also be presented to the x-ray in a 1 in thick and 4 in x 4 in section. Simulant manufactures should make sure that the thickness is as close to 1 in as possible but not over.

The known Z *eff* of Delrin copolymer is 6.9

When the test piece is measured laying flat in the x-ray the *Zeff* reading will be taken and written down on the IBDO submission form. The difference between the simulant measurement and the Delrin will be used to adjust the measurement of the simulant.

Example:

Delrin is measured at 6.5 in x-ray

Difference between Delrin known Zeff (6.9) and x-ray measurement is (+4)

Simulant is measured at 6.7

Adjusted simulant measurements is +4 = 7.1 Z *eff*

Along with the above measurements a x-ray image of both the Delrin and simulant test pieces next to each other with a 1 in gap will be provided in the simulant manufactures submission.

Method 2: Simulant Chemical Formula(s)

The method will require that the simulant manufacture submit a copy of the real explosive manufactures Safety Data Sheet (SDS) that lists the chemicals used in that explosive. If there is no commercial product for reference a creditable source that lists the chemical formula of the explosive mixture can be used. This will be used as a reference to verify if the simulant is within the Z *eff* range of the real explosive.

The simulants chemical formula (mixture) will be used to calculate the Z *eff* using the below formula. Manufactures will provide the complete chemical mixture and show the math calculating the Z *eff.* Along with this information a side-by-side x-ray in a materials discrimination image of the simulant in a 1 in thick by 4x4 in block next to a Delrin 1 in thick by 4x4 block.

$$Z_{\text{eff}} = \sqrt[2.94]{f_1 \times (Z_1)^{2.94} + f_2 \times (Z_2)^{2.94} + f_3 \times (Z_3)^{2.94} + \cdots}$$

where

- f_n is the fraction of the total number of electrons associated with each element, and
- Z_n is the atomic number of each element.

An example is that of water (H_2O), made up of two hydrogen atoms (Z=1) and one oxygen atom (Z=8), the total number of electrons is 1+1+8 = 10, so the fraction of electrons for the two hydrogens is (2/10) and for the one oxygen is (8/10). So the Z_{eff} for water is:

$$Z_{\text{eff}} = \sqrt[2.94]{0.2 \times 1^{2.94} + 0.8 \times 8^{2.94}} = 7.42$$

Inert Explosive Simulants