Contributing Factors to Proper Tracer Performance

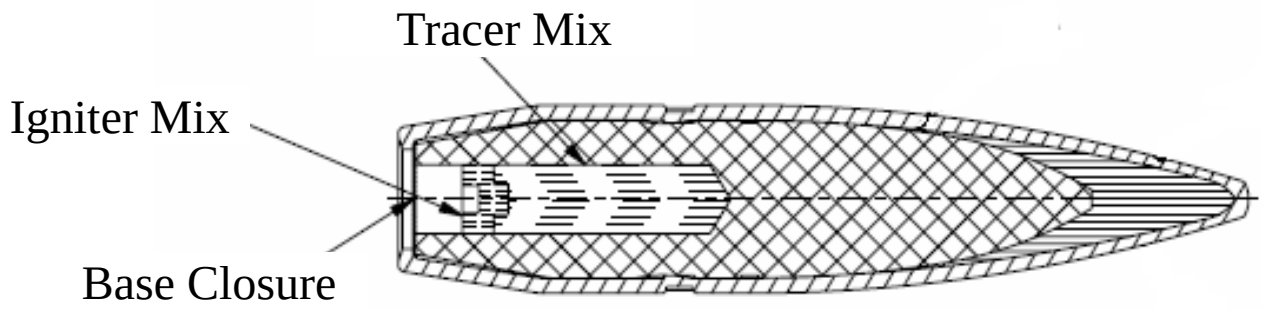
Thomas Gmyrek, ARDEC
Kaleb Luna, Orbital ATK

Tracers 101

Tracers are projectiles that are produced with a pyrotechnic charge allowing the trajectory to be visible to the naked eye

Typical Components : Strontium Nitrate – Oxidizer that creates red color when lit
Magnesium – Ignites for pyrotechnic effect
PVC - Binder

Typical tracer configurations for US Army tracer projectiles



When correctly matched with ball ammunition, tracer provides a significant advantage when engaging both point and area targets

Current Requirements and Scoring

Caliber .50 Requirement

1600 Yards

7.62mm Requirement

15 Yards | 100-850 Yards

5.56mm Requirement

14 Yards | 76-984 Yards

Traditional methods of scoring involve human witnessing at various distances. This method has a high level of subjectivity between what is called full luminosity and what is faint enough to be considered a “blind”.

Current testing methods at LCAAP also include the usage of camera systems that automatically score acceptable trace at various witnessing distances.

Broken Tracer Column

Deformation of a tracer column is a known failure mode for tracer munitions that will often affect its probability of ignition.

The greatest probability of a broken tracer column occurs when there is both a high pyrotechnic charge and a high core insertion pressure.

If the conical profile is not maintained and its surface area is compromised, it will not fully ignite.

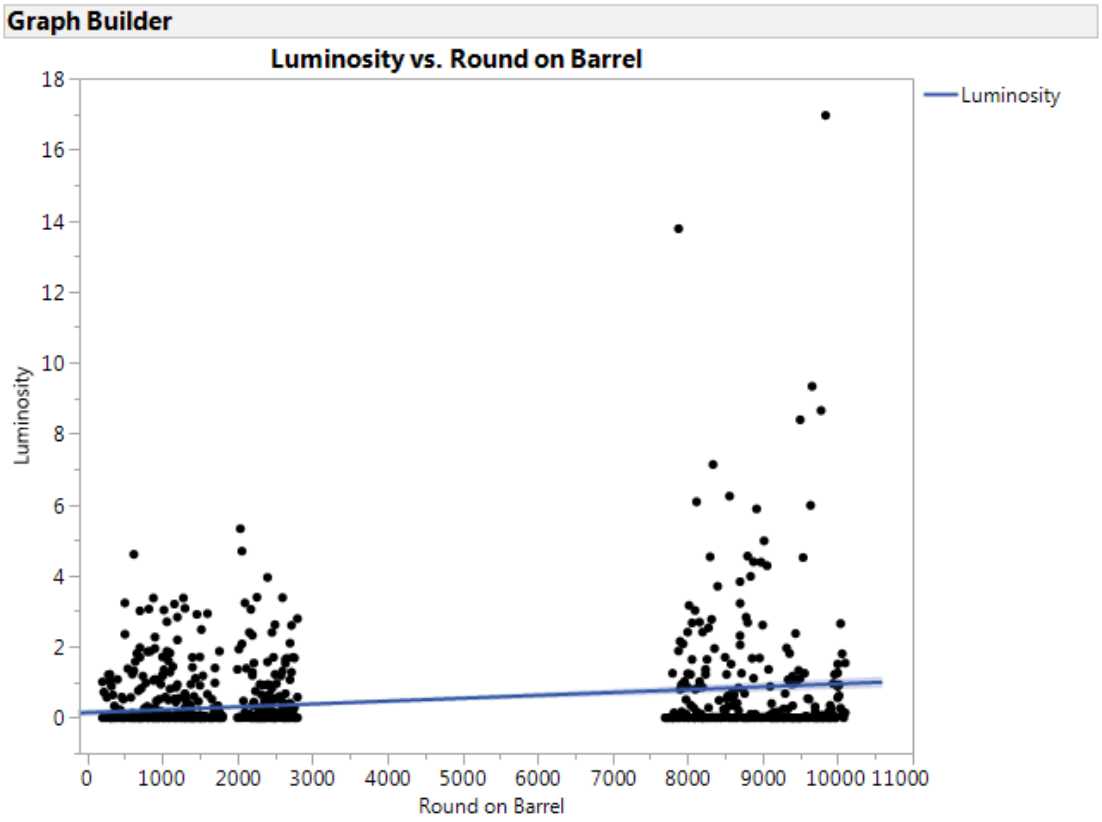
The usage of a flow agent in the pyrotechnic is critical when attempting to achieve proper charging height.

Barrel Life

Tests conducted with 7.62mm ammunition in 2017 as part of the Muzzle Signature Program tracer signatures over the life of a barrel.

Analysis showed a relationship between round count and variability in luminosity.

Rounds seen with high muzzle luminosity often failed to maintain ignition and had inconsistent luminosity.

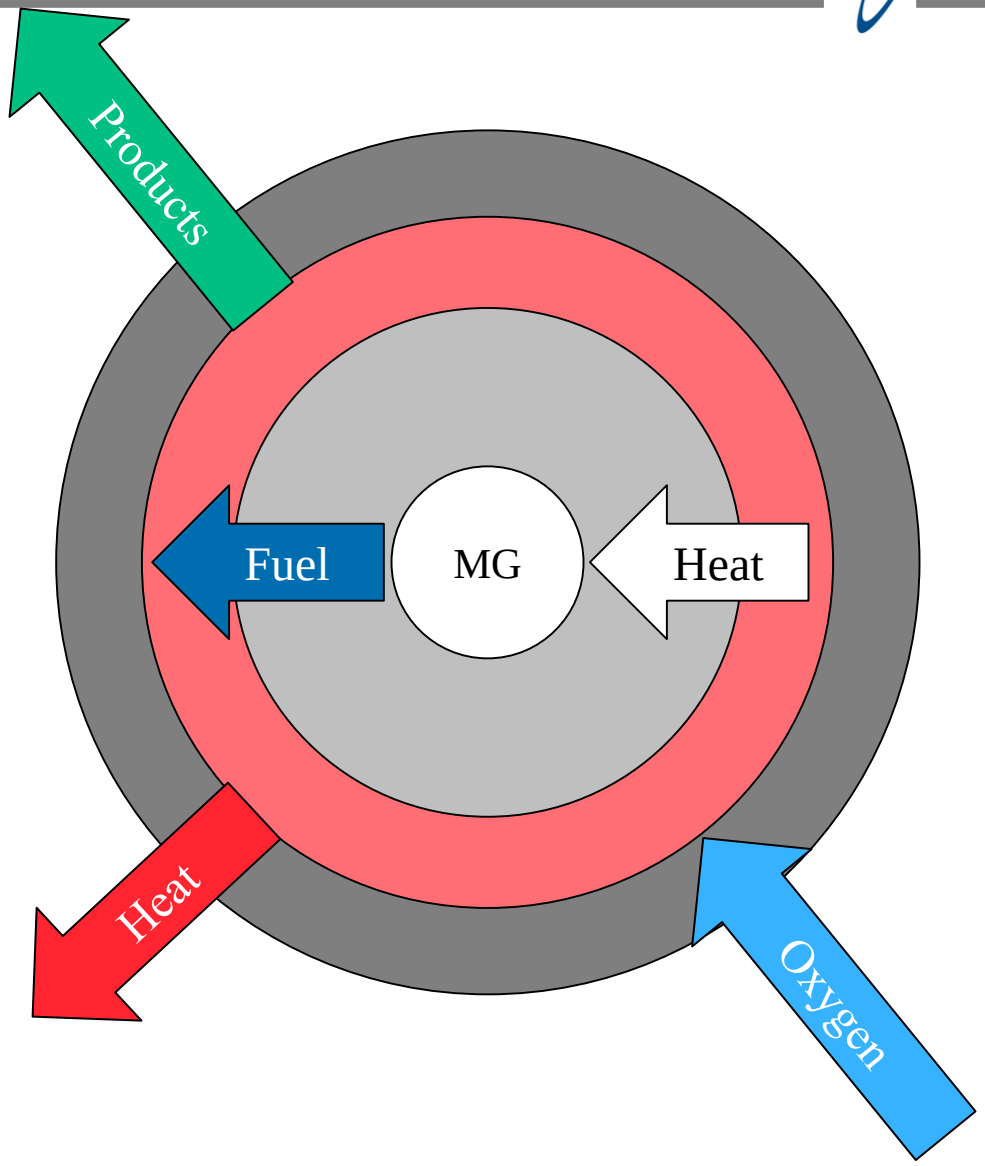


Magnesium Burn

Magnesium content contributes significantly to the heat and light output of a tracer projectile.

The rate of energy release is heavily dependent on the particle size of the magnesium.

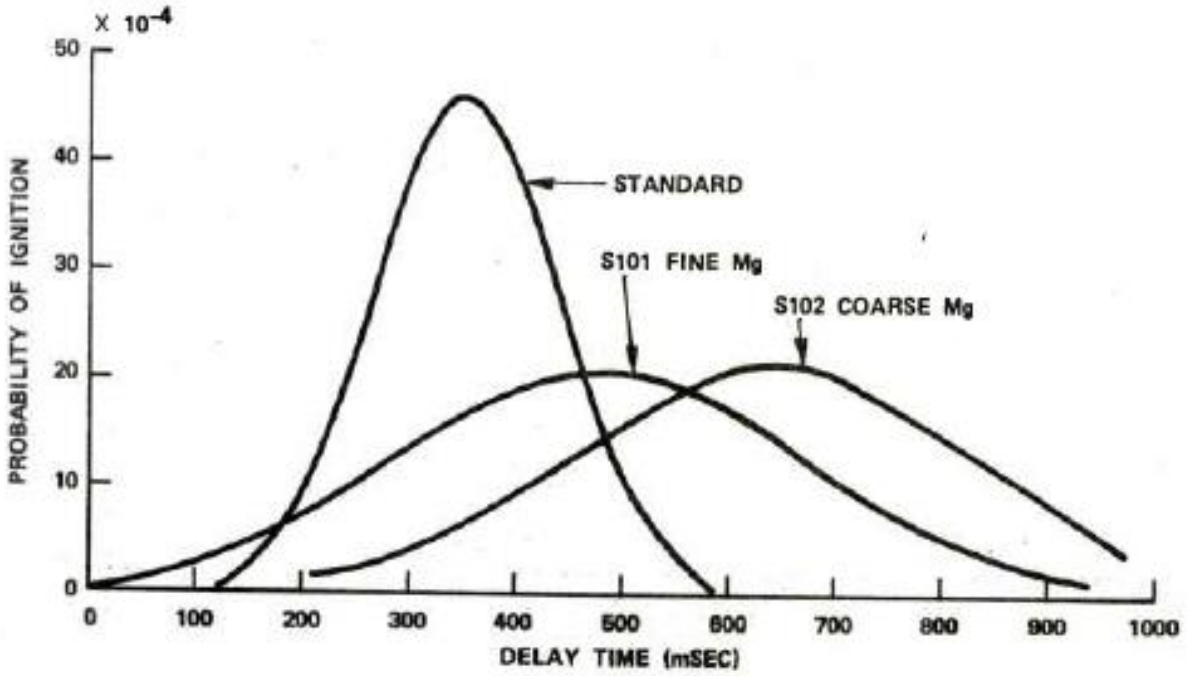
If proper magnesium particle size is not maintained, the tracer will either burn bright for a short period of time, or burn dim for a long period of time



Magnesium Burn

Studies conducted in 1979 by Dr. Gerald Holst on large caliber also looked at Mg granularity. Dr. Holst's investigations focused primarily on the impact of grain size in terms of probability of ignition and delay in ignition instead of luminosity.

The study revealed that there is a clear optimal grain size and that the failure mode for both fine and coarse grains will look similar.



Deformed Closure

Due to past experiences within the Caliber .50 family with base closures causing a number of ballistic defects, an investigation was started to see its impact on tracer ignition.

Caliber .50 tracer projectiles were intentionally made with poorly cut and partial base closures and fired.

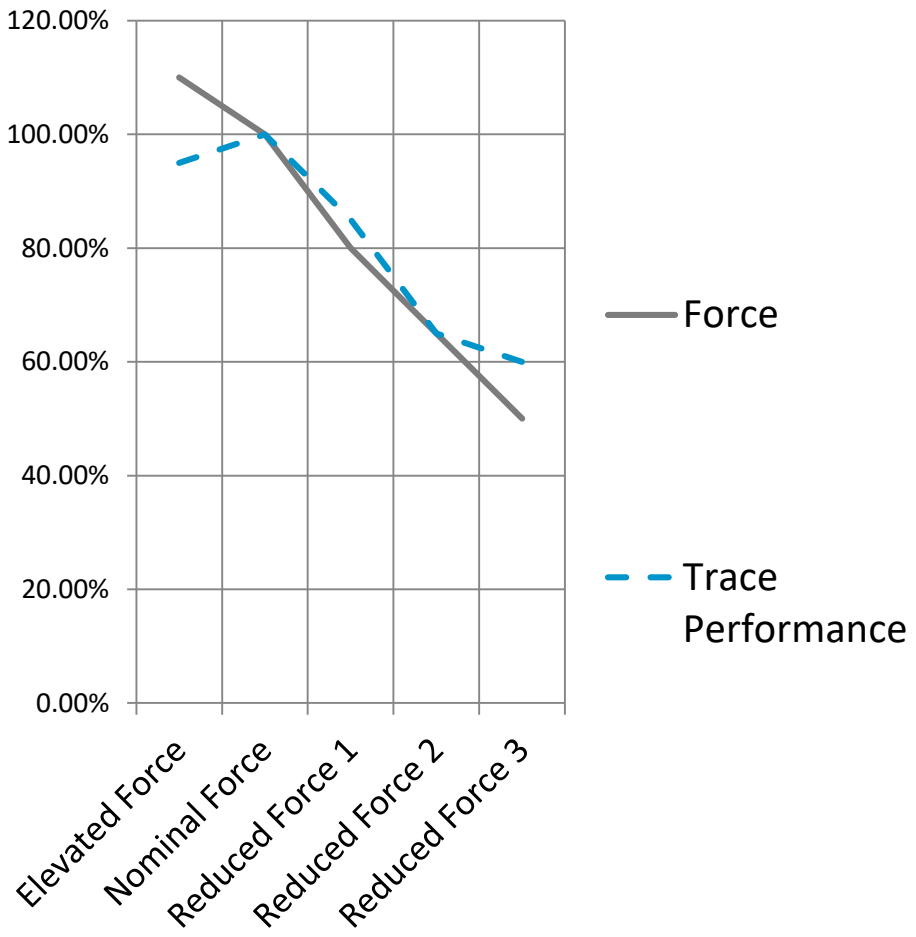
There were no trace performance defects observed during this testing.

Consolidation Forces

Experiments have been conducted by Orbital ATK intending to study how the force applied during the tracer consolidation process can affect trace performance.

The study has shown a close relationship between reduced consolidation force and reduced trace performance. Testing with elevated force levels also suggested a slight decline in trace performance.

This suggests that an ideal consolidation pressure can be established, depending on the specific characteristics of a given tracer round.

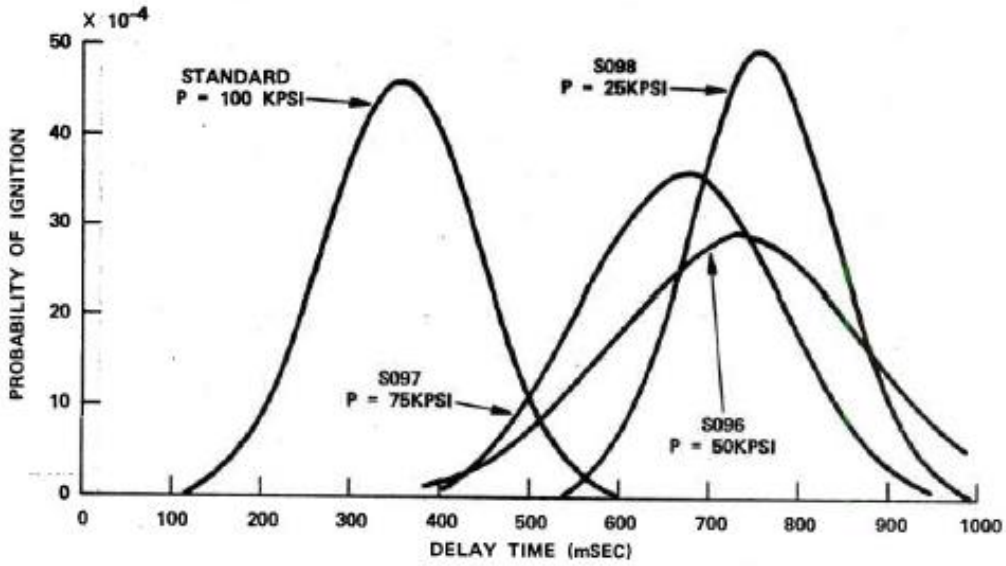


Consolidation Forces

Studies conducted in 1979 by Dr. Gerald Holst on large caliber corroborate a relationship between forces and ignition time.

While it is previously known that lower forces would often have a spill out of pyrotechnic, it also appears to cause a delay in ignition.

Parameters that influence ignition delay are more critical in tracer projectiles that require a standoff ignition such as 7.62mm and 5.56mm

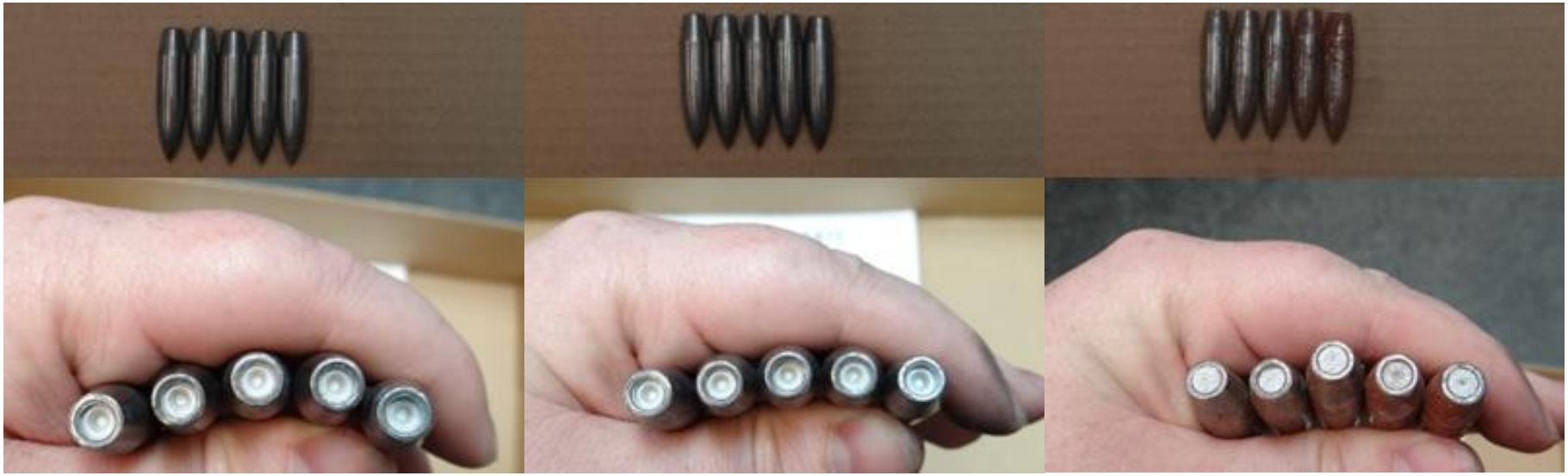


Humidity

Due to the potential variability in seasonal humidity, moisture exposure is a significant environmental factor for tracer columns.

Orbital ATK performed a test consisting of 3 levels of moisture exposure in a temperature controlled environment
Control – Cores stored in a sealed M2 ammunition can
Ambient – Cores stored in an open M2 ammunition can and exposed to moderate humidity
Humid – Cores stored in a closed M2 ammunition can with a wet cloth to increase humidity

CONTROL AMBIENT HUMID



Humidity

After a period of exposure, the cores were processed and shot.

For cores from the “Humid” category, the tracer column was visibly affected with swelling beyond the cavity in some cases.

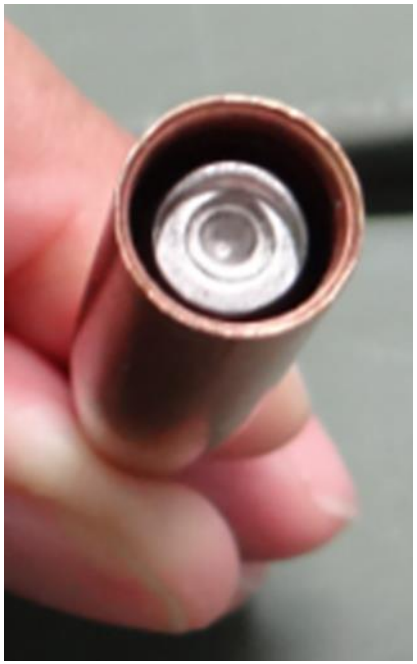
Cores from the Control and Ambient Samples both performed well, while the sample exposed to high humidity experienced failures to ignite.

This testing revealed that there is a strong relationship between humidity and tracer performance due to the hydroscopic characteristics of the mix and the subsequent structural changes to the tracer column.

Deformed Core

Given other evidence that disruption of the tracer column can result in trace performance defects, testing was conducted at LCAAP to simulate a potential cause. This test used excessive core seating pressures to significantly deform the rear of the core in an attempt to disrupt the tracer column.

The sample with significant core deformation shot 100%, with no defects observed. While not completely definitive, the results of this test do not support the hypothesis that deforming the rear of the core during bullet assembly results in tracer defects.

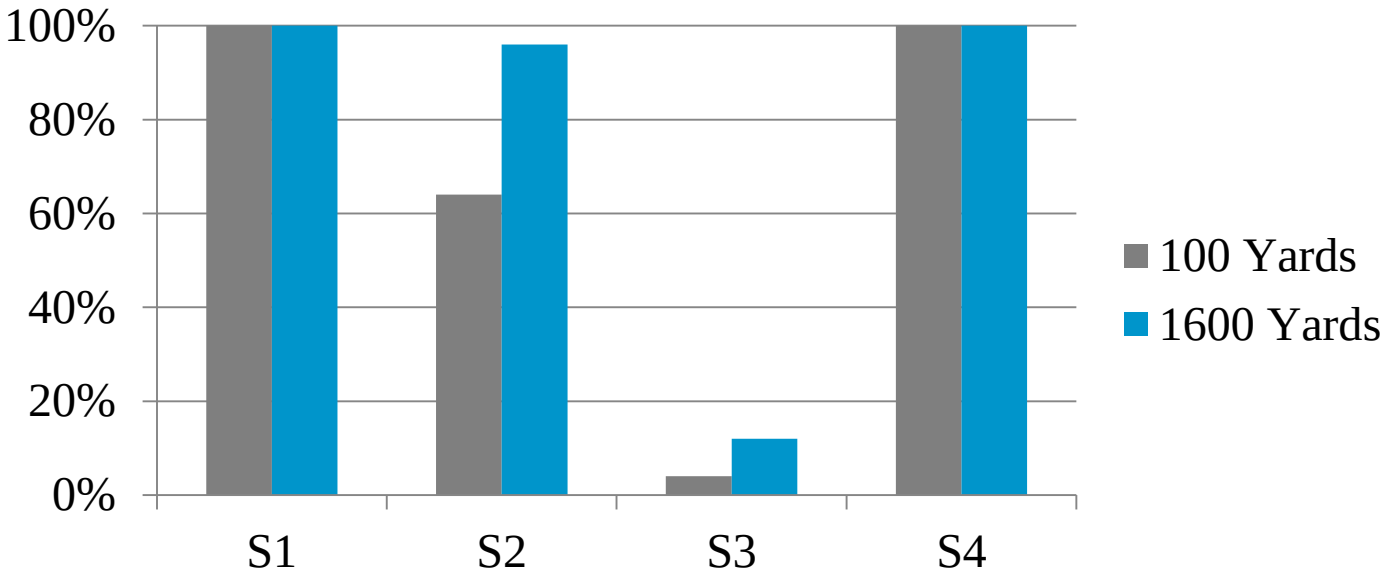


Igniter/Trace Mixing

Depending on tracer column configuration and production techniques, there is a possibility for some quantity of tracer mix to intermingle with the charge of igniter mix.

Testing was conducted to simulate potential blending of the trace mix (R-256) with the igniter mix (I-570).
S1 - “Control” Samples
S2 - “Minor” quantity of R-256 blended with the standard I-570 Charge
S3 - “Severe case” quantity of R-256 blended with the standard I-570 Charge
S4 - “Severe case” quantity of R-256 added before the standard I-570 Charge without blending

The results below indicate that mixing of tracer and igniter mix is undesirable and should be avoided.



Conclusions

There are many factors which are important to the proper functioning of tracer ammunition. The factors discussed in this presentation have varying degrees of impact, but come from studies and investigations undertaken to better understand the causes of trace performance defects.

Through various studies, it has been determined that some of the key contributors of proper tracer ignition are magnesium particle size, consolidation forces, and humidity. While other factors can also contribute, these seem to have a large degree of impact and can produce partial or total failure.

Understanding these factors is key to ensuring effective and reliable performance that the warfighter can count on.

Contact Info

Thomas Gmyrek
Caliber .50 Production Team Lead ARDEC,
Picatinny Arsenal
Thomas.a.Gmyrek.civ@mail.mil
973-724-5076

Kaleb Luna
Caliber .50/7.62mm Bullet Mfg. Engineer
Orbital ATK,
Lake City Army Ammunition Plant
kaleb.luna@orbitalatk.com
816-796-5546