The Secrets of Pyrotechnic Whistles

Stargate 2000

Joseph A. Domanico

VP Publications / Webmaster

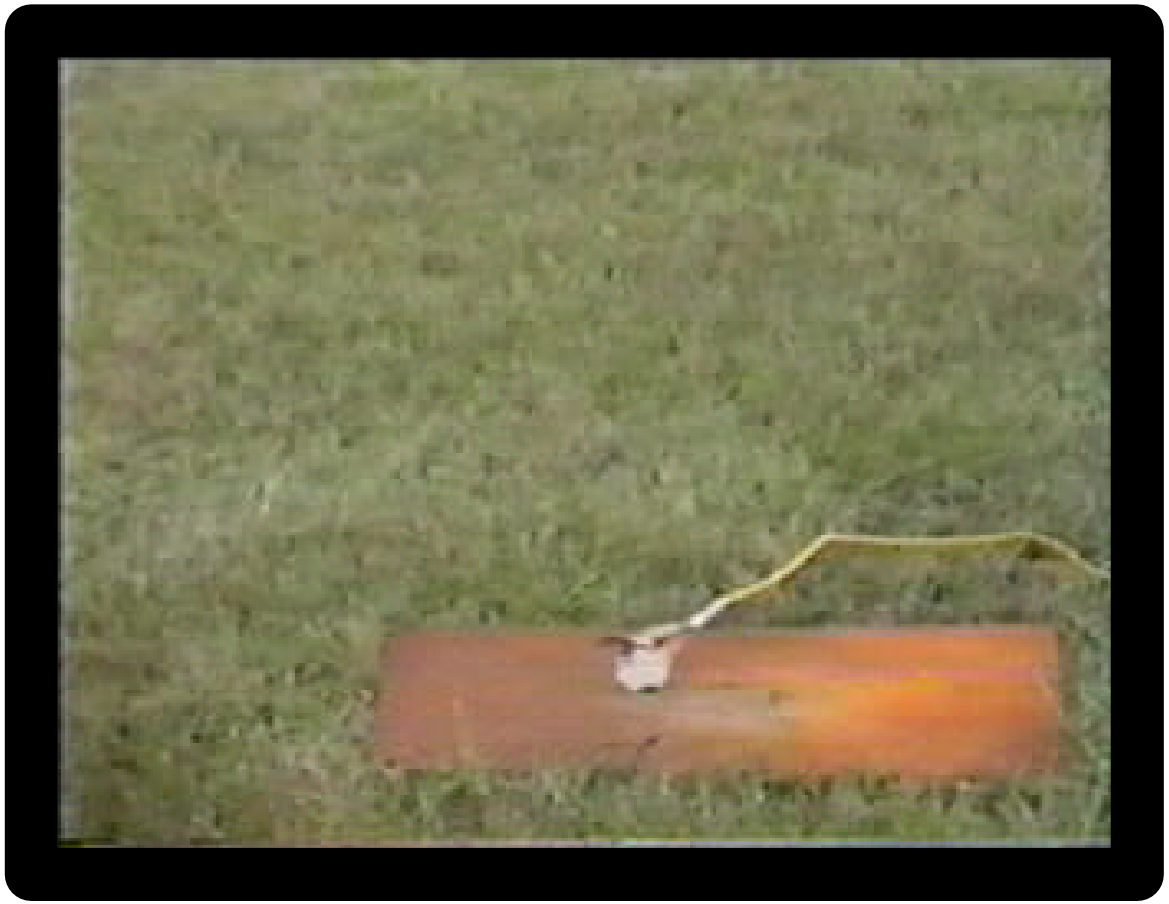
Crackerjacks, Inc.

drpyro@home.com

Who Was That Masked Man?

- Crackerjacks, Inc
  - Vice President
  - Publications
  - Webmaster: www.crackerjacks.org
- Department of the Army
  - Chief, Pyrotechnics Team (26 years)
  - LTC Maryland Army National Guard

Vibrational Burning



Major Chemicals for Pyrotechnic Whistles

Gallic Acid	$C_7H_6O_5$
Sodium Salicylate	$C_7H_5NaO_3$
Potassium Picrate	$C_6H_2KN_3O_7$
Potassium Benzoate	$C_7H_5KO_2$
Potassium Dinitrophenate	$C_6H_3N_2O_5K$
Potassium Hydrogen Phthalate	$KC_8H_5O_4$

Formulation Efficiency

Potassium Benzoate : Potassium Perchlorate

For Carbon Monoxide Only:

$$2\ KC_7H_5O_2 \cdot 3\ H_20 + 4\ KClO_4 \rightarrow K_2O + 4\ KCl + 11\ H_2O + 14\ CO$$

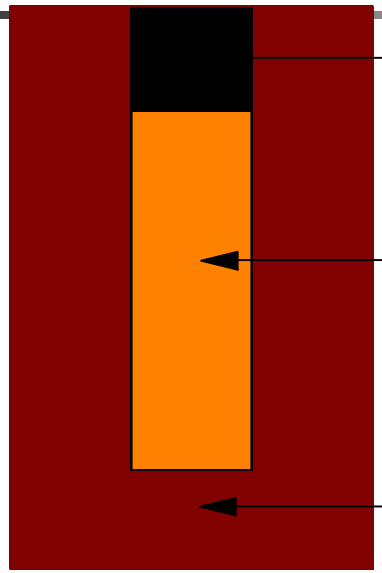
yields stoichiometric fuel:oxidizer ratio of **44:56**

For Carbon Dioxide Only:

$$4\ KC_7H_5O_2 \cdot 3\ H_20 + 15\ KClO_4 \rightarrow 2\ K_2O + 15\ KCl + 22\ H_2O + 28\ CO_2$$

yields stoichiometric fuel:oxidizer ratio of **29:71**

Typical Whistle Design



Air Void

Whistle Composition

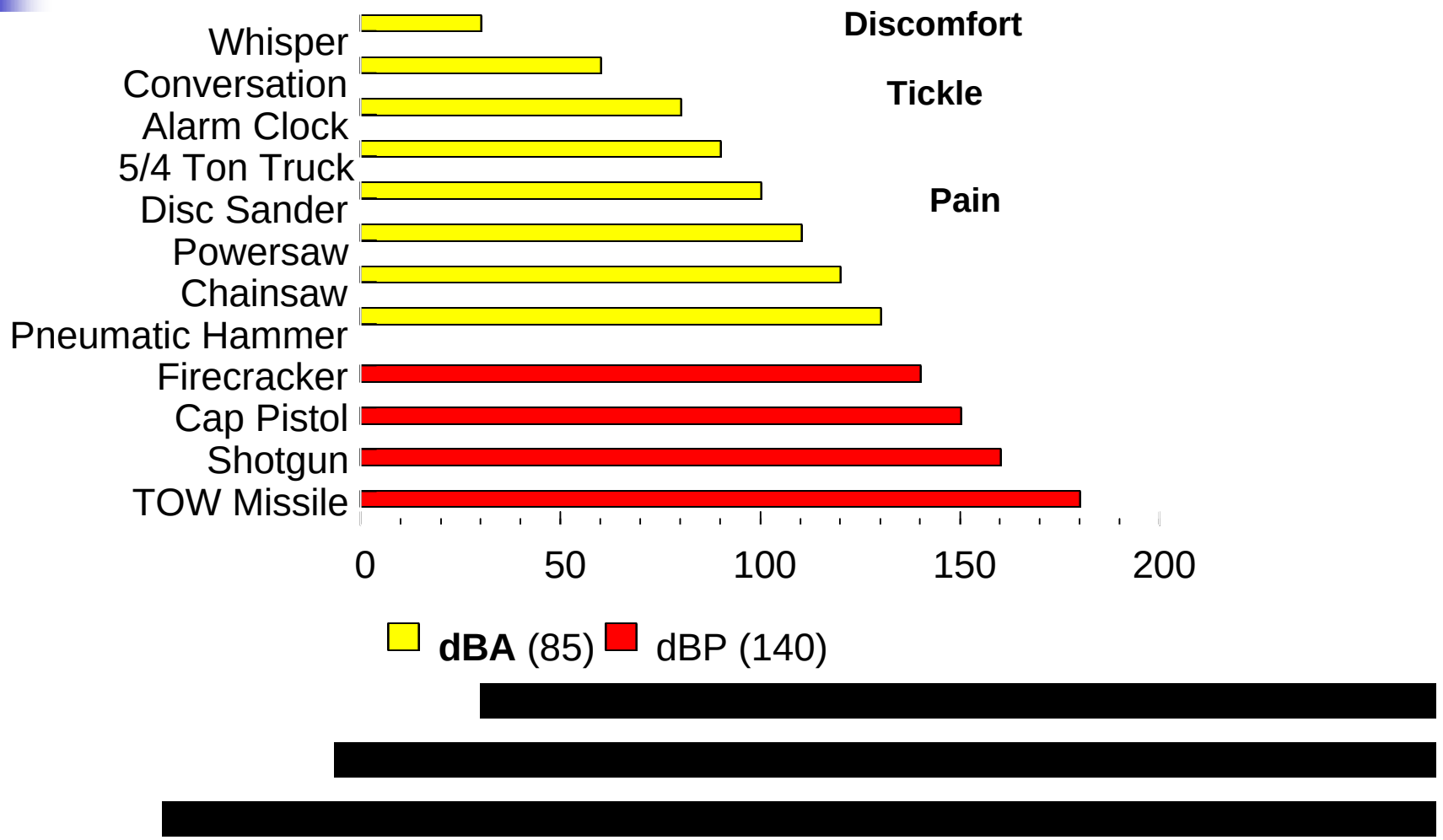
Solid Acrylic Rod

Potassium Benzoate 27 PBW

Potassium Perchlorate 73 PBW

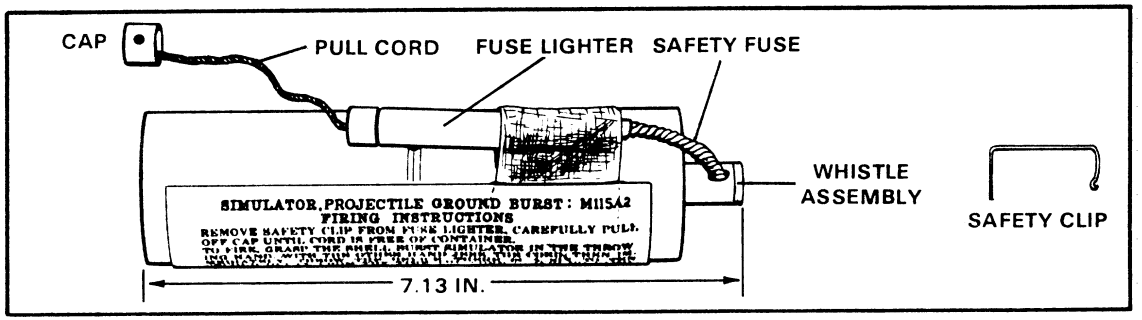
40mm Whistle

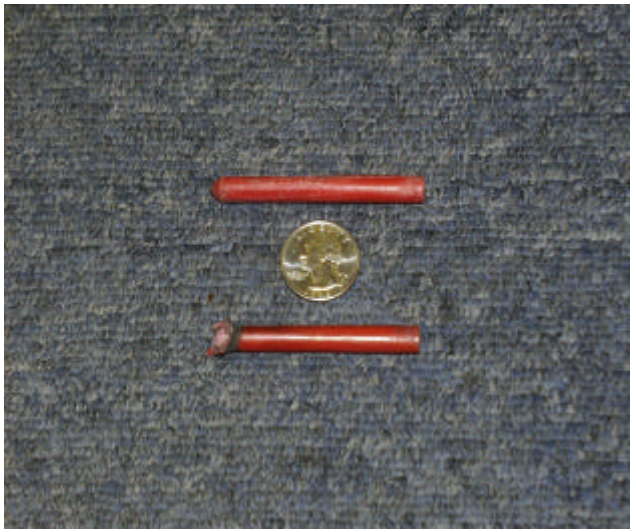
Typical Noise Levels

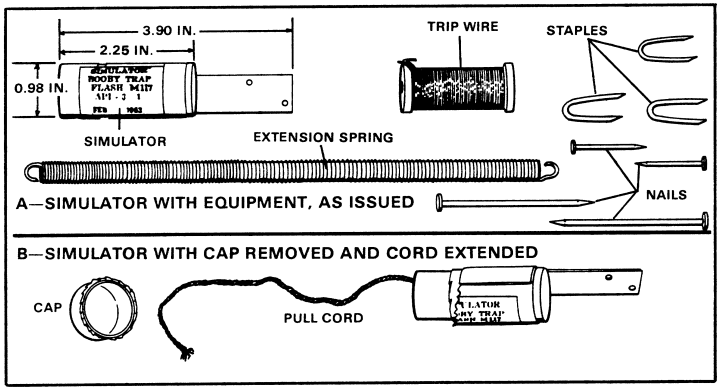


Current uses

Incoming artillery shell







Training booby trap

➡ **Entertainment fireworks**

Artillery Simulator
(small whistle....loud blast)

Output Energy Comparison

Composition	Cal per gram
Base Whistle Composition	3,394
Photoflash	2,491
Bullseye Smokeless Powder	1,753
A1A Ignition Mix	903
Red Smoke Mix	895

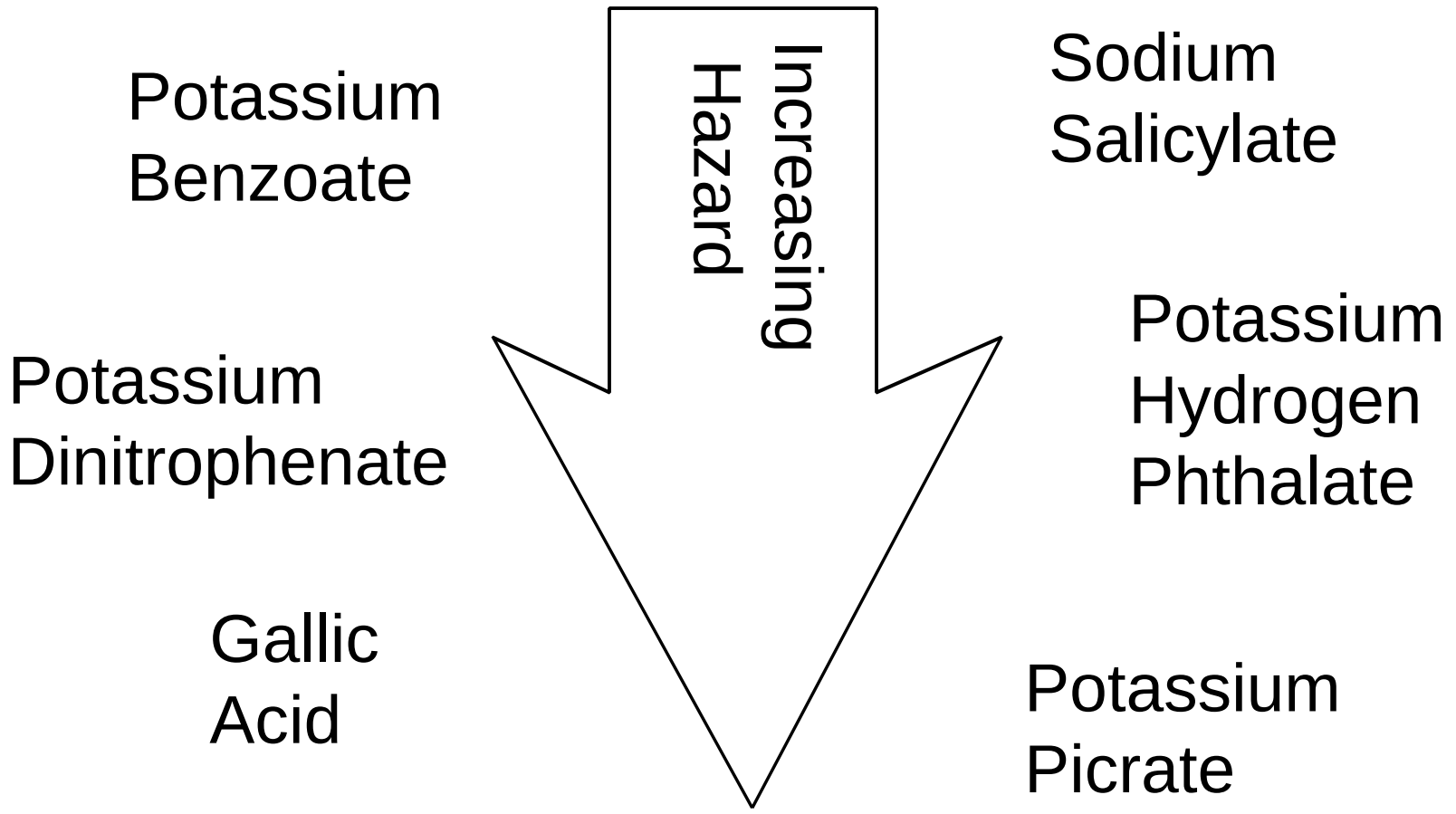
Ignition Temperatures

Composition	(degrees C)
Bullseye Smokeless Powder	192
Red Smoke Composition	198
Pyrotechnic Whistle Composition	432
A1A Ignition Composition	437
Photoflash Composition	545

Possible Formulations

Gallic Acid	24				
Sodium Salicylate		28			
Potassium Picrate			50		
Potassium Benzoate				30	
Potassium Dinitrophenate					70
Potassium Chlorate	73				
Potassium Perchlorate		75		70	
Potassium Nitrate			50		30

Pyrotechnic Whistle Fuels



Detonation Tendency

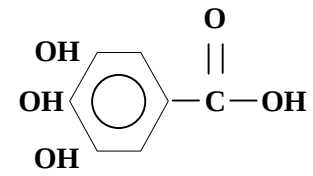
High

Low

Low

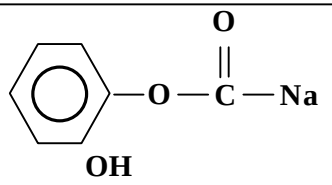
High

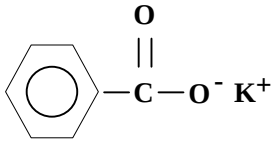
High



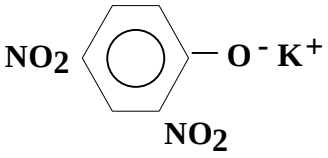
Gallic Acid

Sodium Salicylate

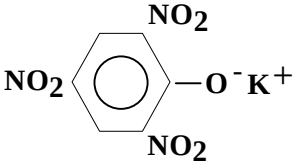




Potassium Benzoate

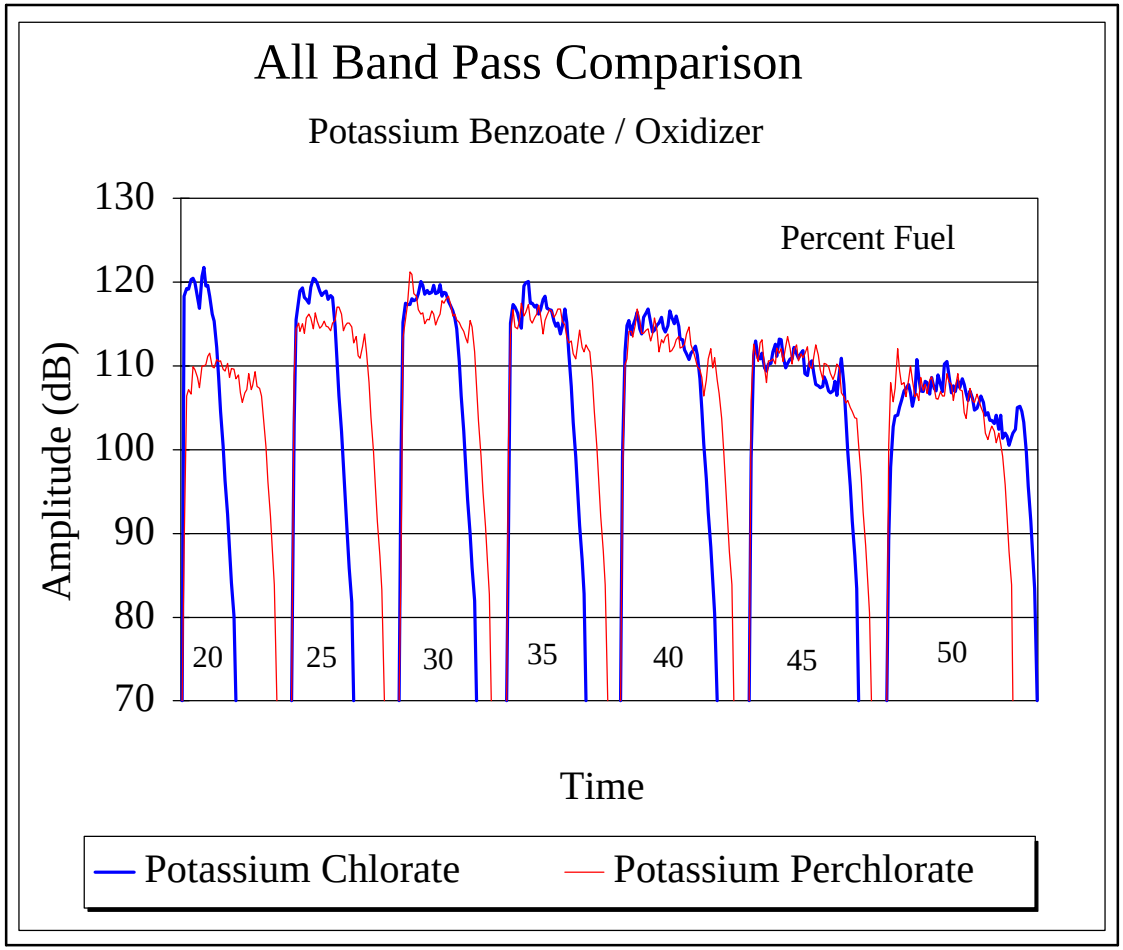


Potassium Dinitrophenate



Potassium Picrate

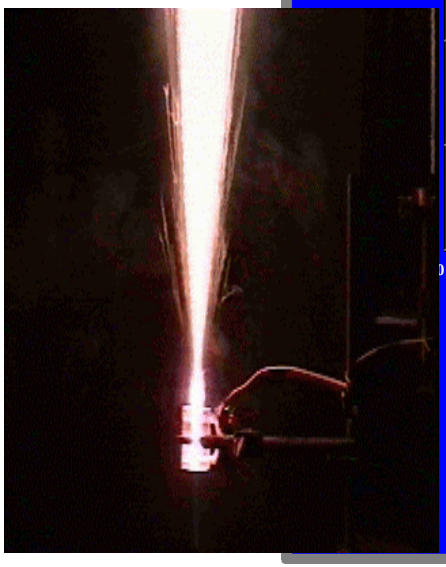
Oxidizer Substitution

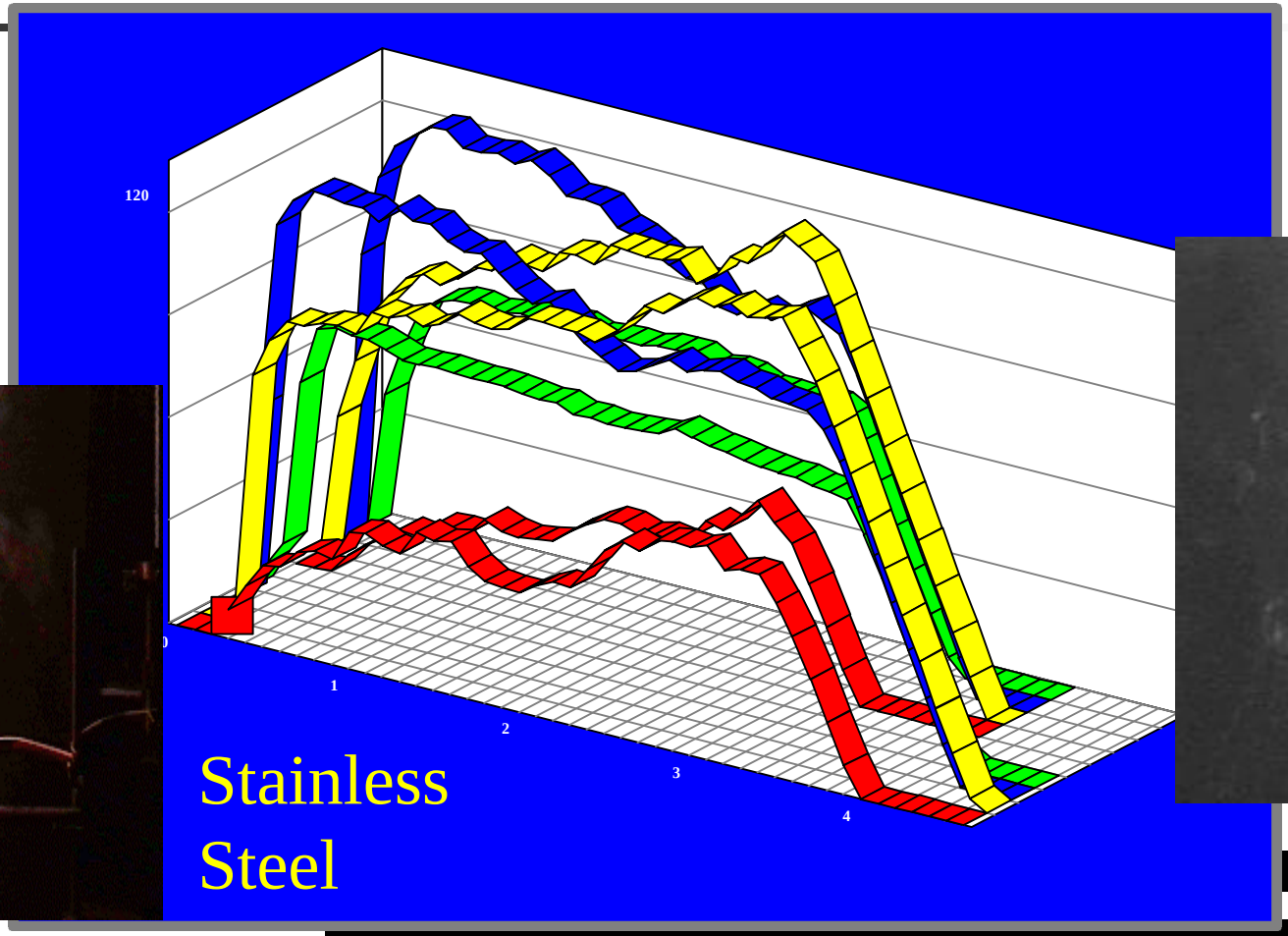


Equipment Information

Company	RION
Model	NA-29
Measurement Range	27-130 dB(A)
Frequency Range	20-8000 Hz (9 octaves)
Dynamic Range	50 dB (80-130)
Capacity	1500 screens
Store period	2 ms to 10 sec
RS-232 Interface	9600 baud rate
Battery life (AA)	4 hours

Frequency Band Comparison

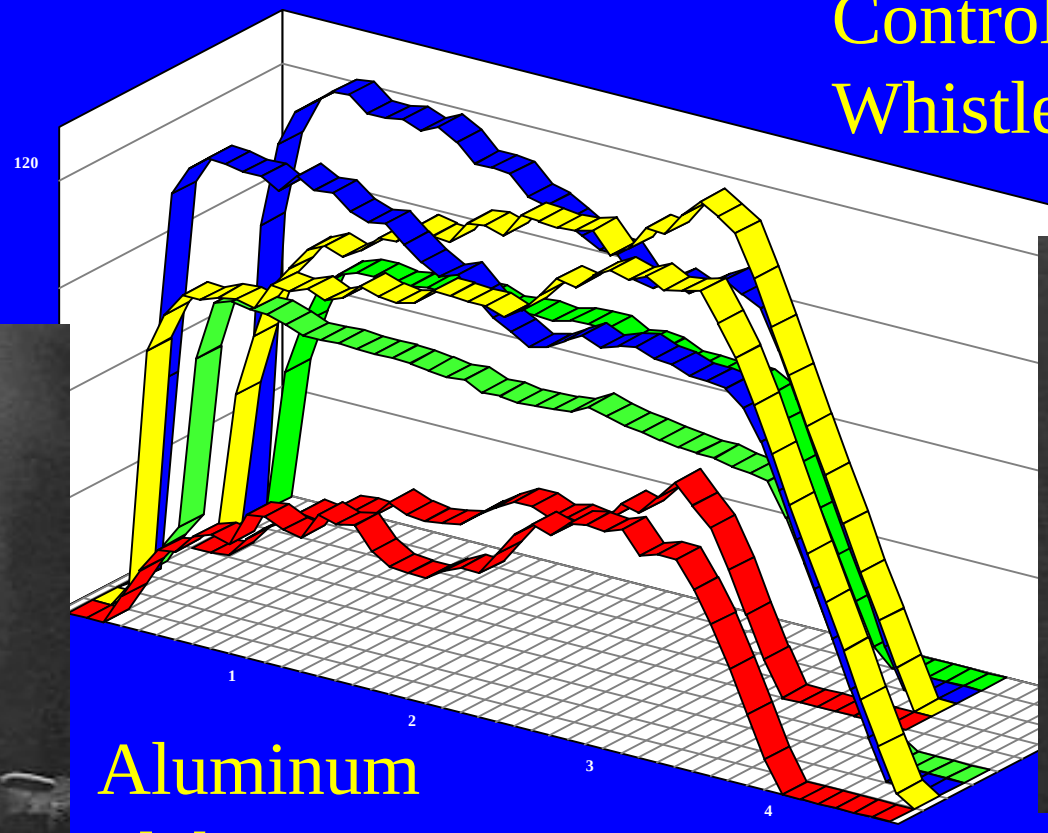




Control
Whistle

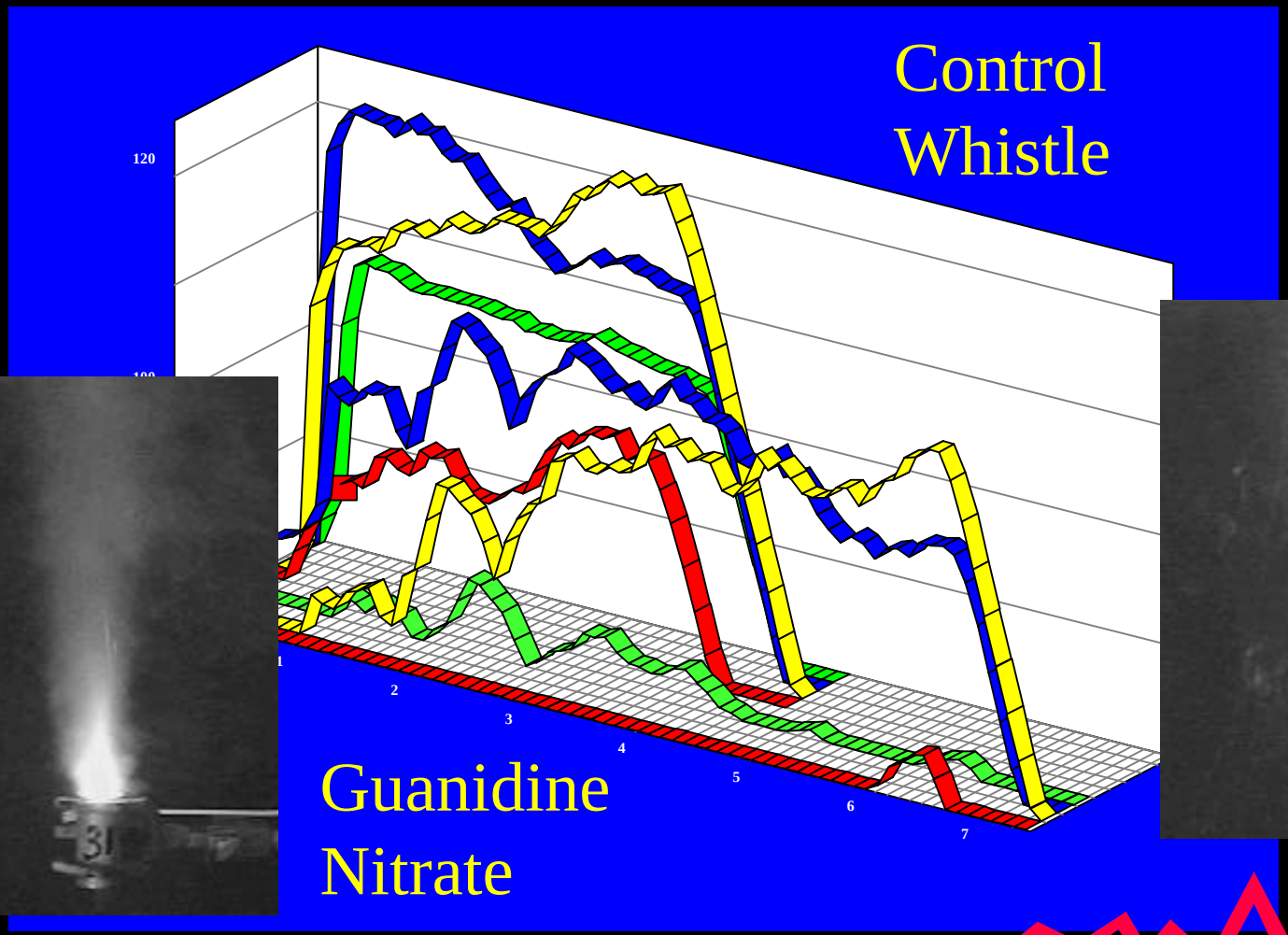
Frequency Band Comparison

Control
Whistle



Aluminum
Flake

Frequency Band Comparison



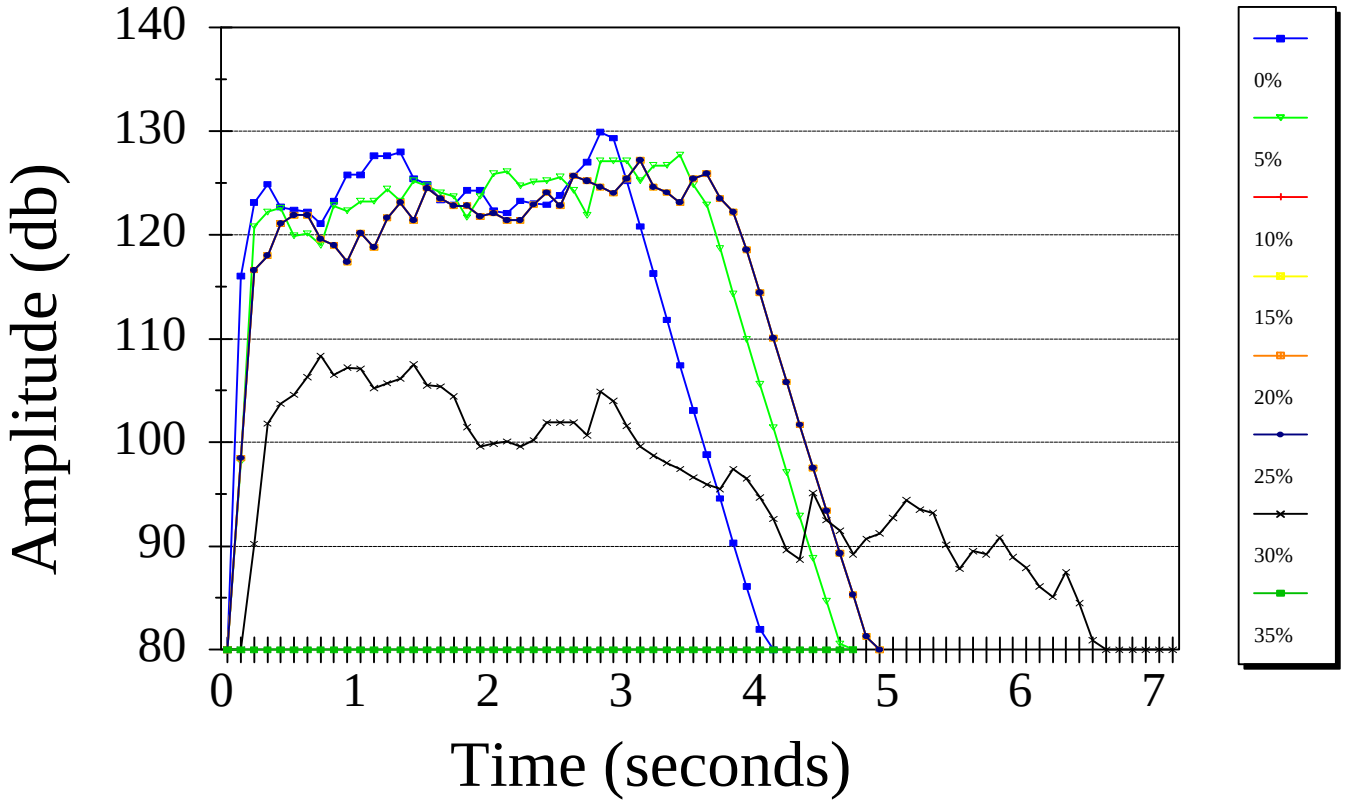
Control
Whistle

Guanidine
Nitrate

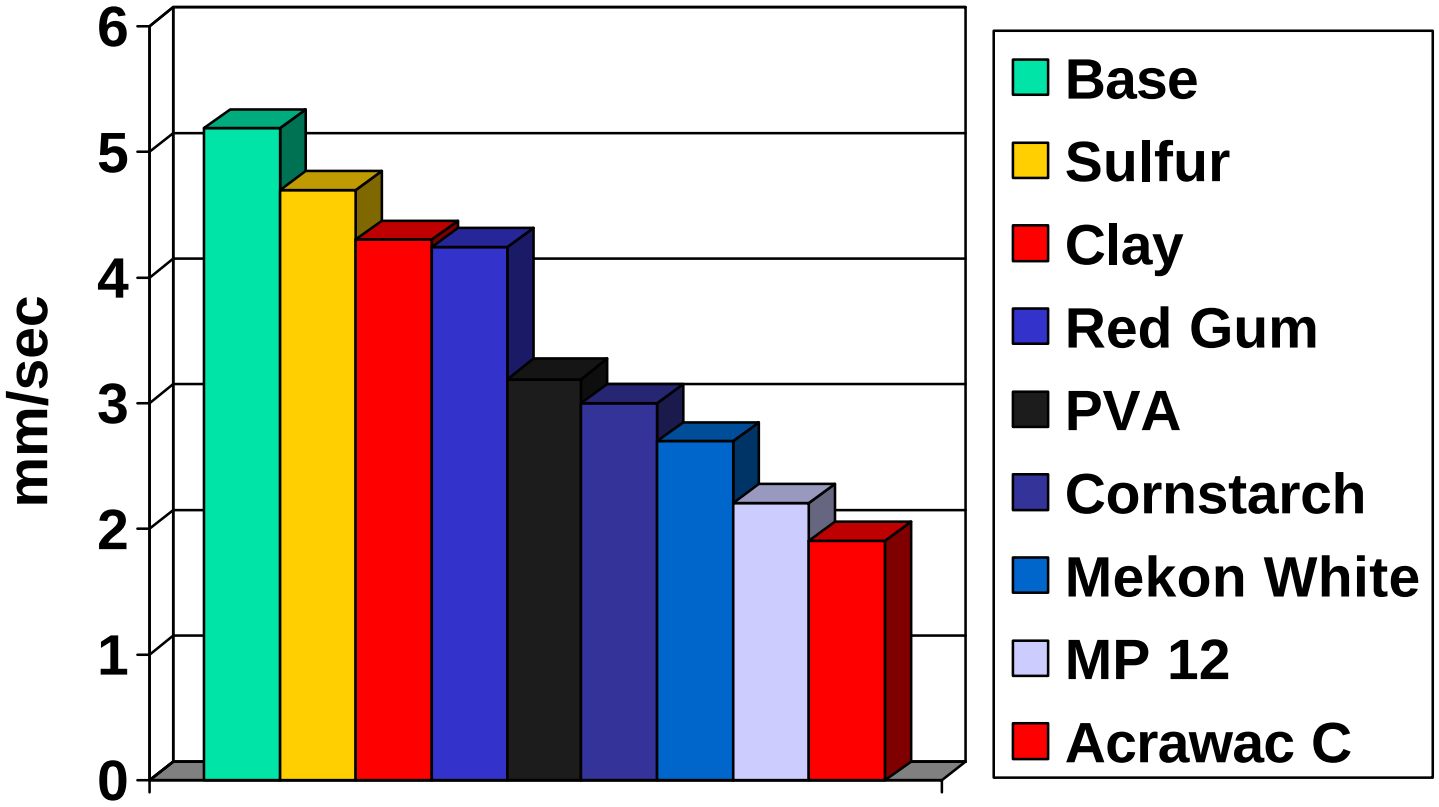
Burn Rate Reduction

Frequency Band Analysis

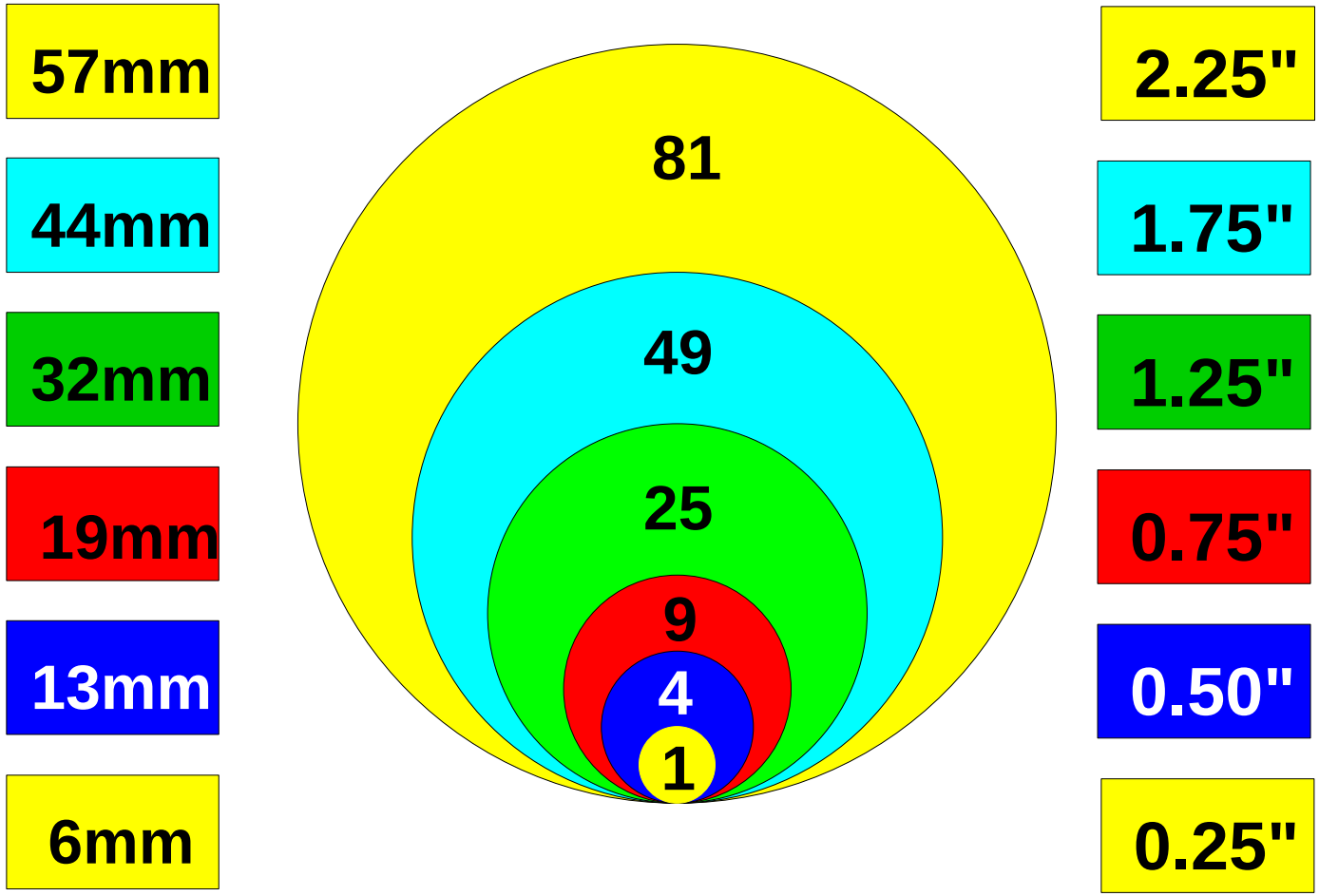
2K Band Response vs Percent Red Gum



Burning Rate Reduction



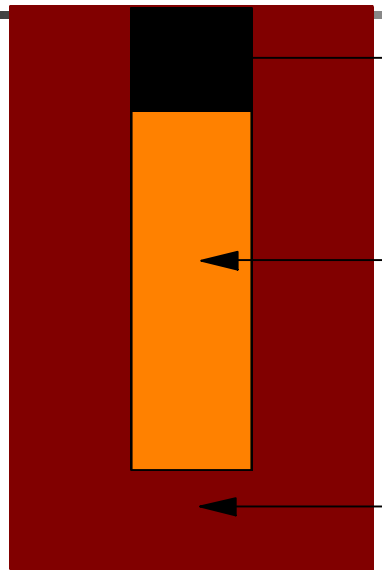
Amplitude Increase by Diameter



Actual Diameter Effect

UAV Whistle Submunition

Typical Whistle Design



Air Void

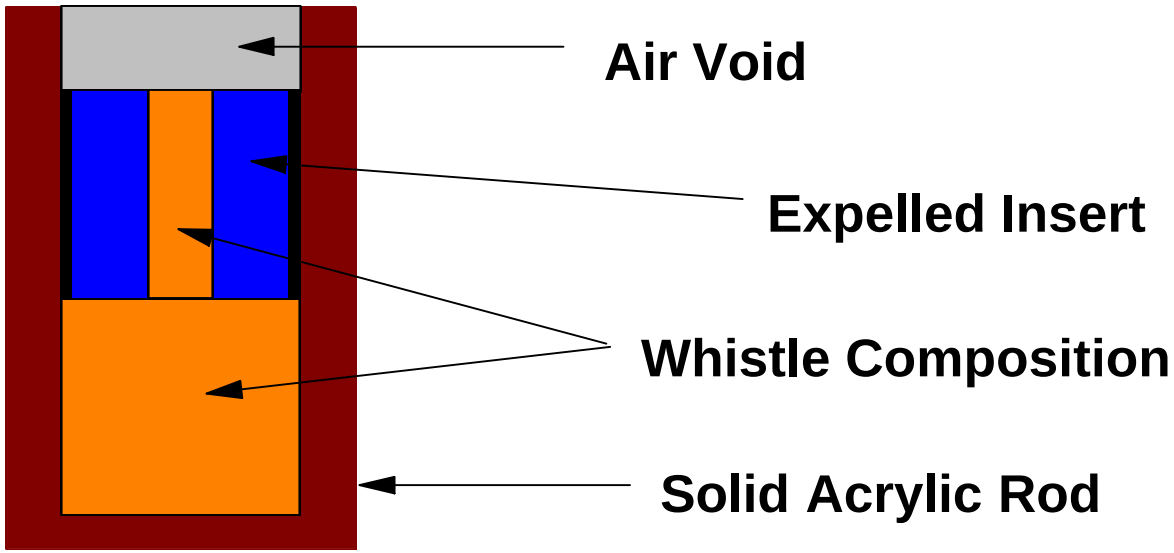
Whistle Composition

Solid Acrylic Rod

Potassium Benzoate 27 PBW

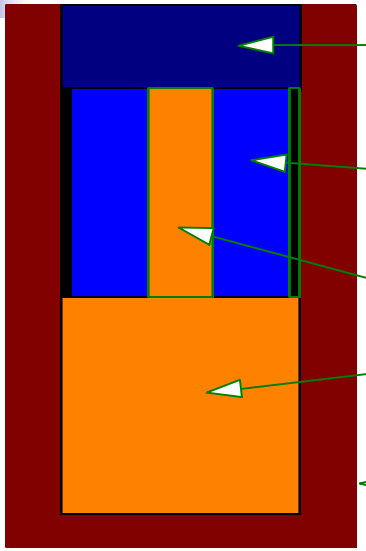
Potassium Perchlorate 73 PBW

High – Low Whistle Design



Potassium Benzoate 27 PBW	Potassium Perchlorate 73 PBW

Hi-Lo Whistle Design



Air Void

Expelled Insert

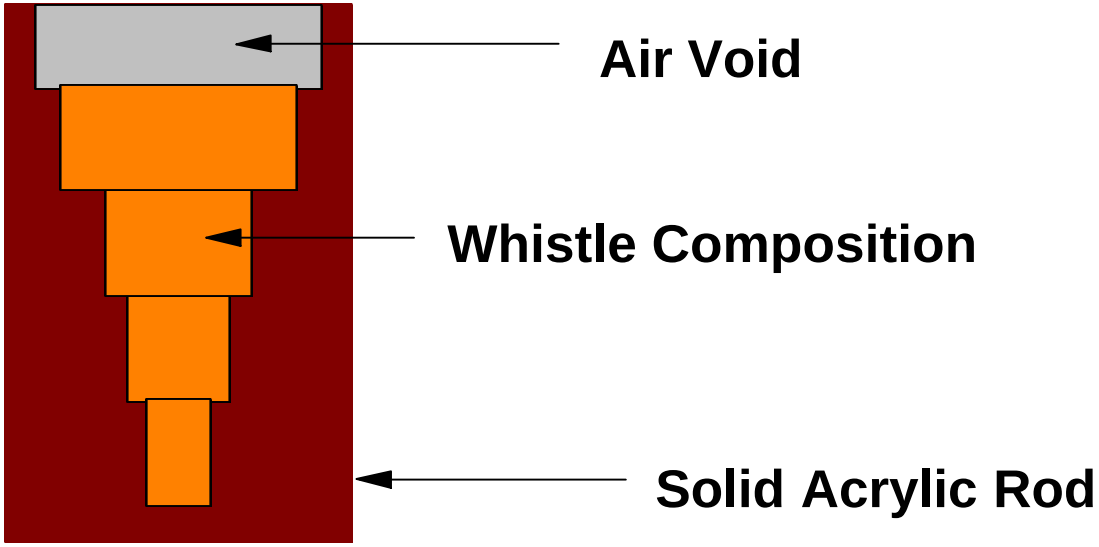
Whistle Composition

Solid Acrylic Rod

Potassium Benzoate 27 PBW

Potassium Perchlorate 73 PBW

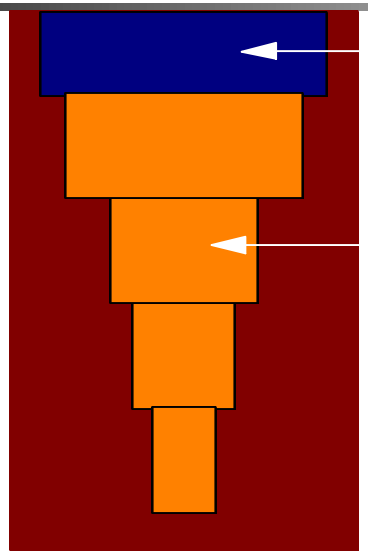
Step Whistle Design



Potassium Benzoate 27 PBW

Potassium Perchlorate 73 PBW

Step Whistle Design

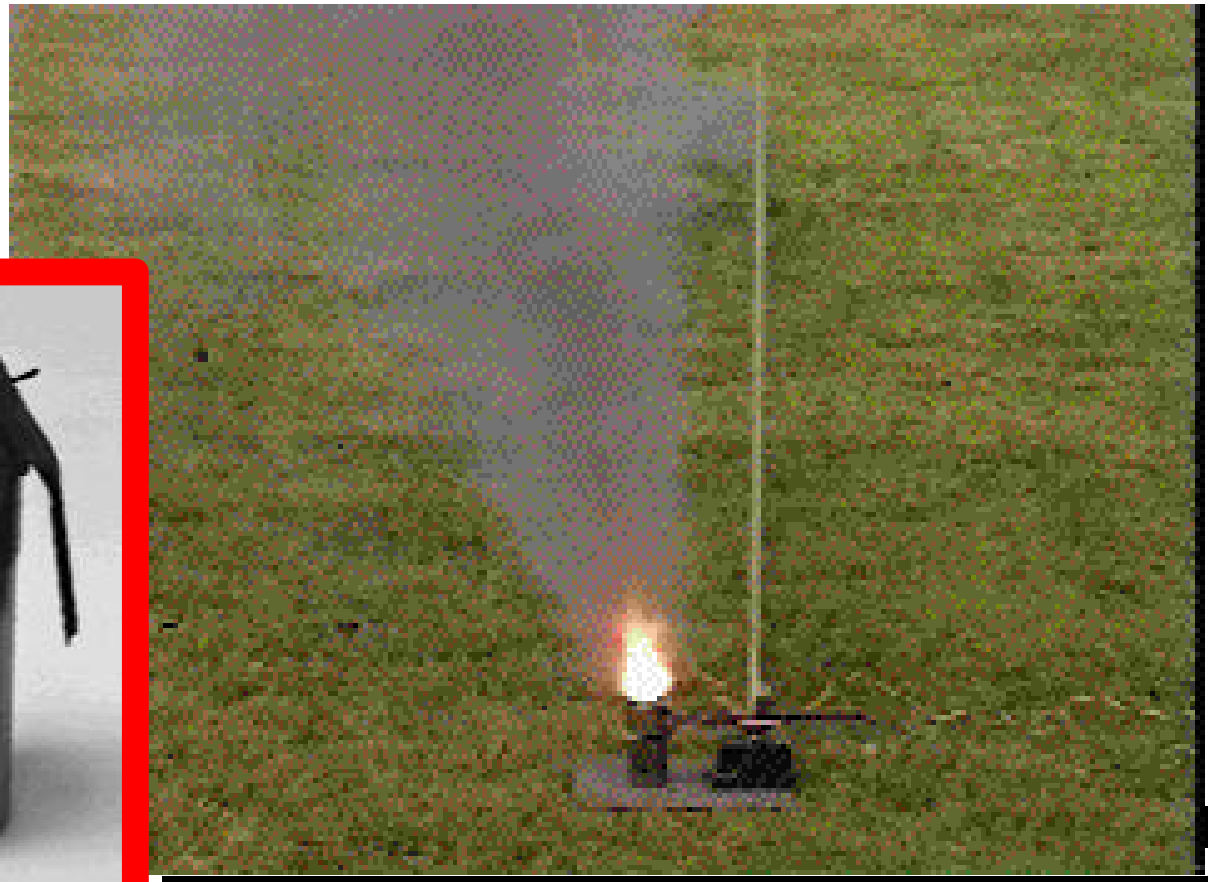


Air Void

Whistle Composition

Potassium Benzoate 27 PBW	Potassium Perchlorate 73 PBW

35mm Whistle Grenade

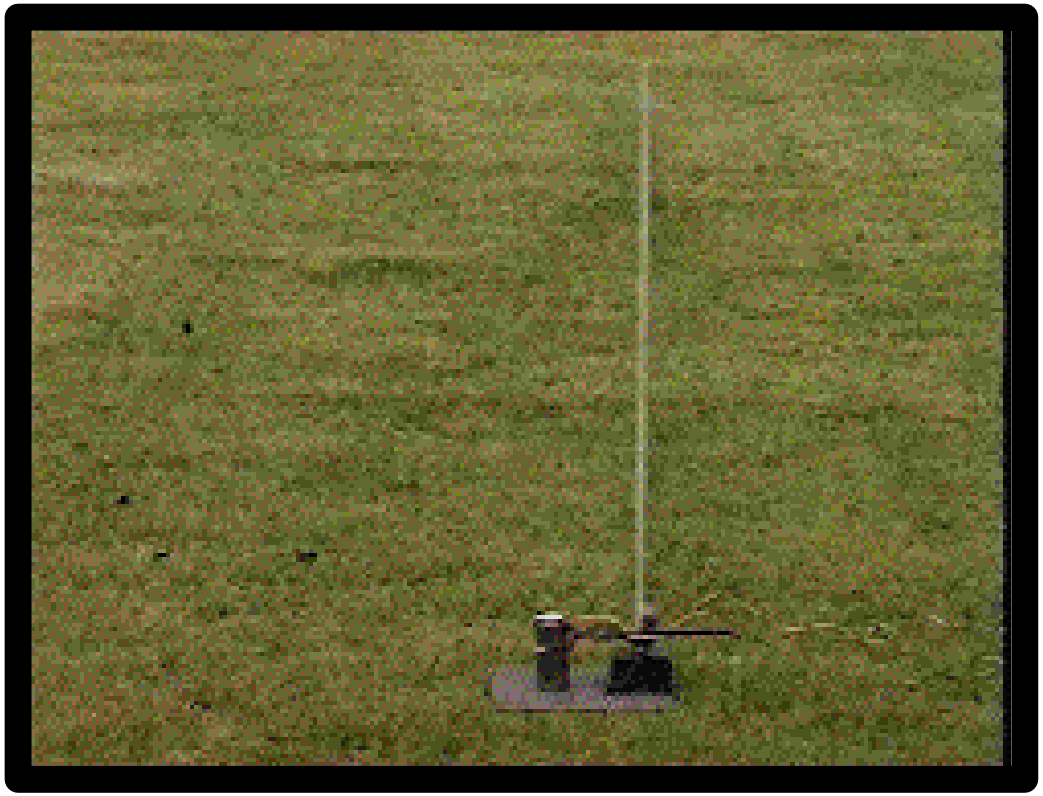


Small E.G.A.D.

4 inches high

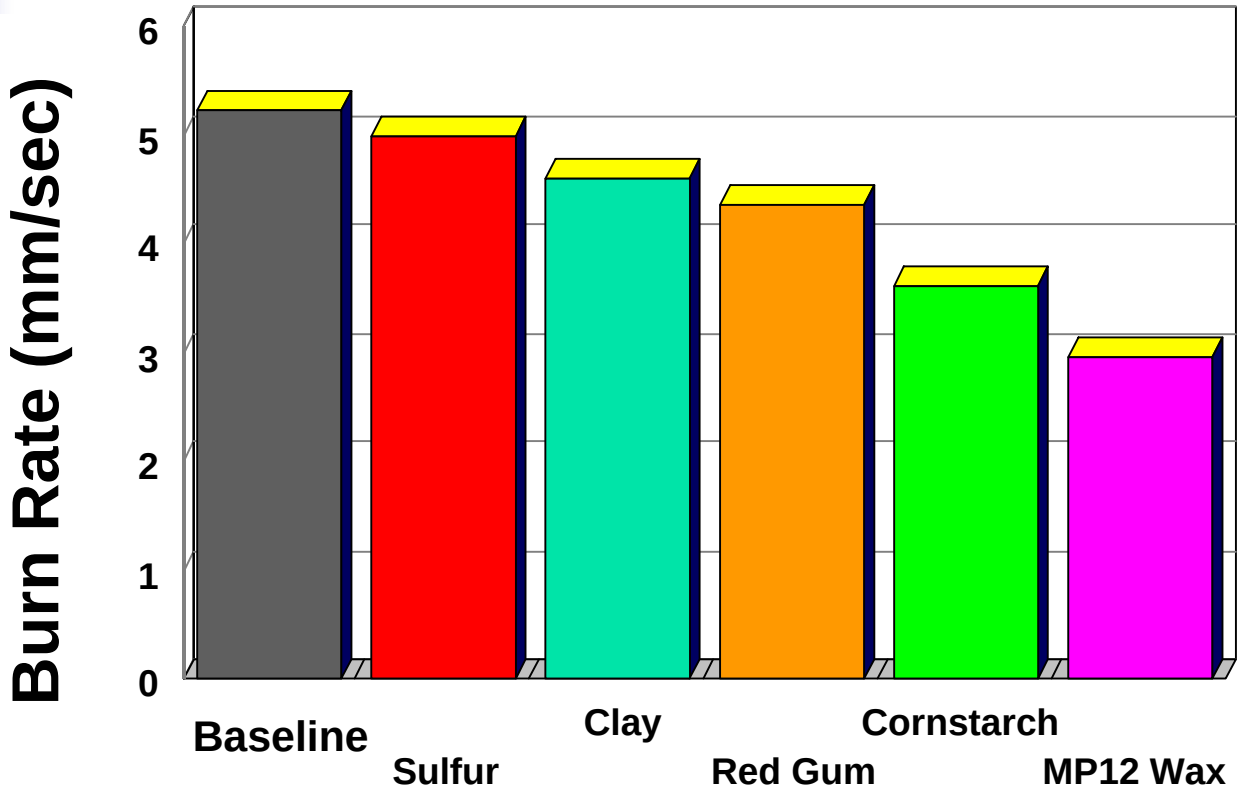
M201A1 fuze

Reduced effects



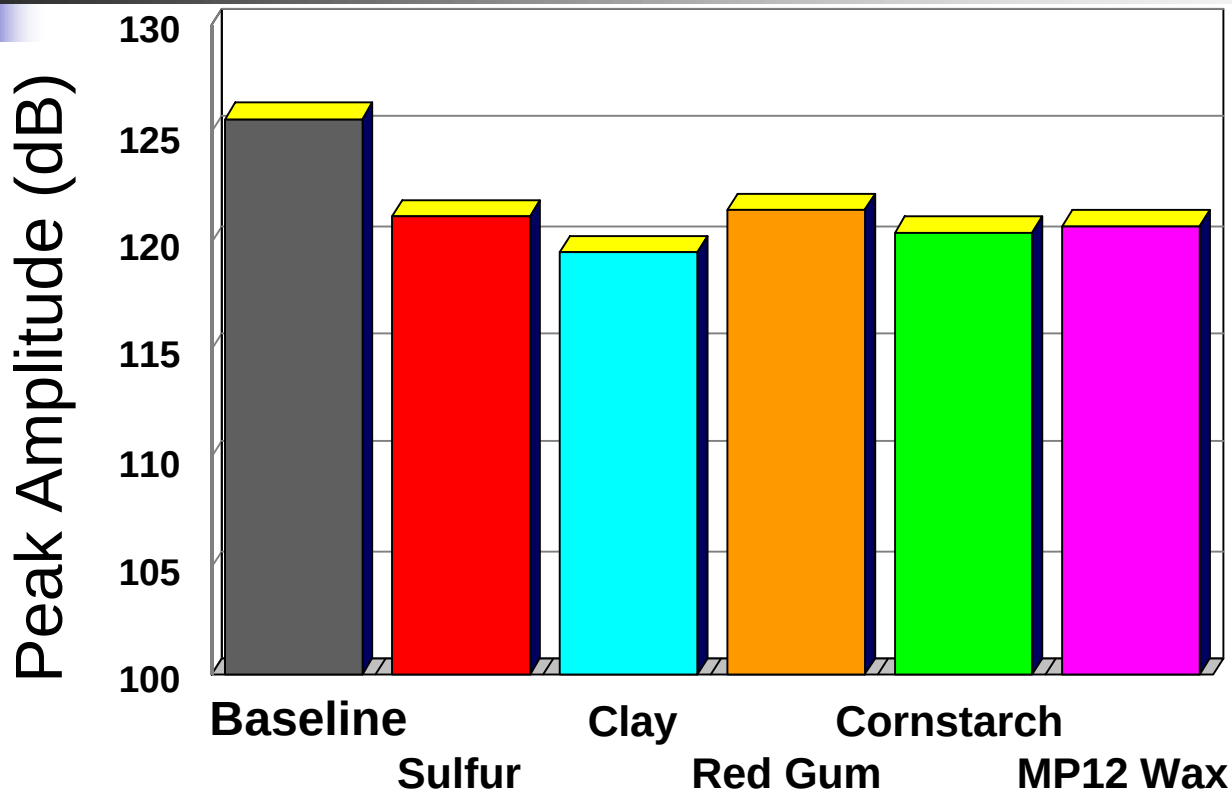
Expendable Ground Acoustic Device

Binder Effect



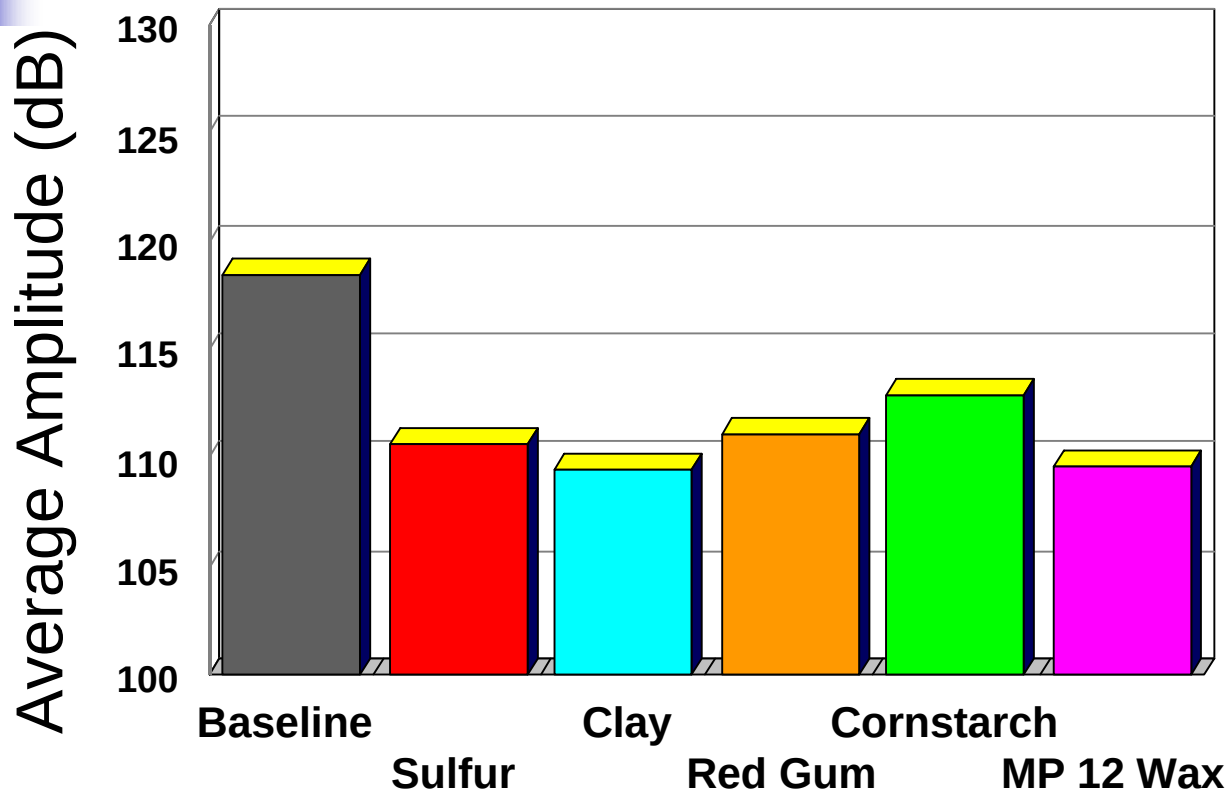
5% Binder

Binder Effect



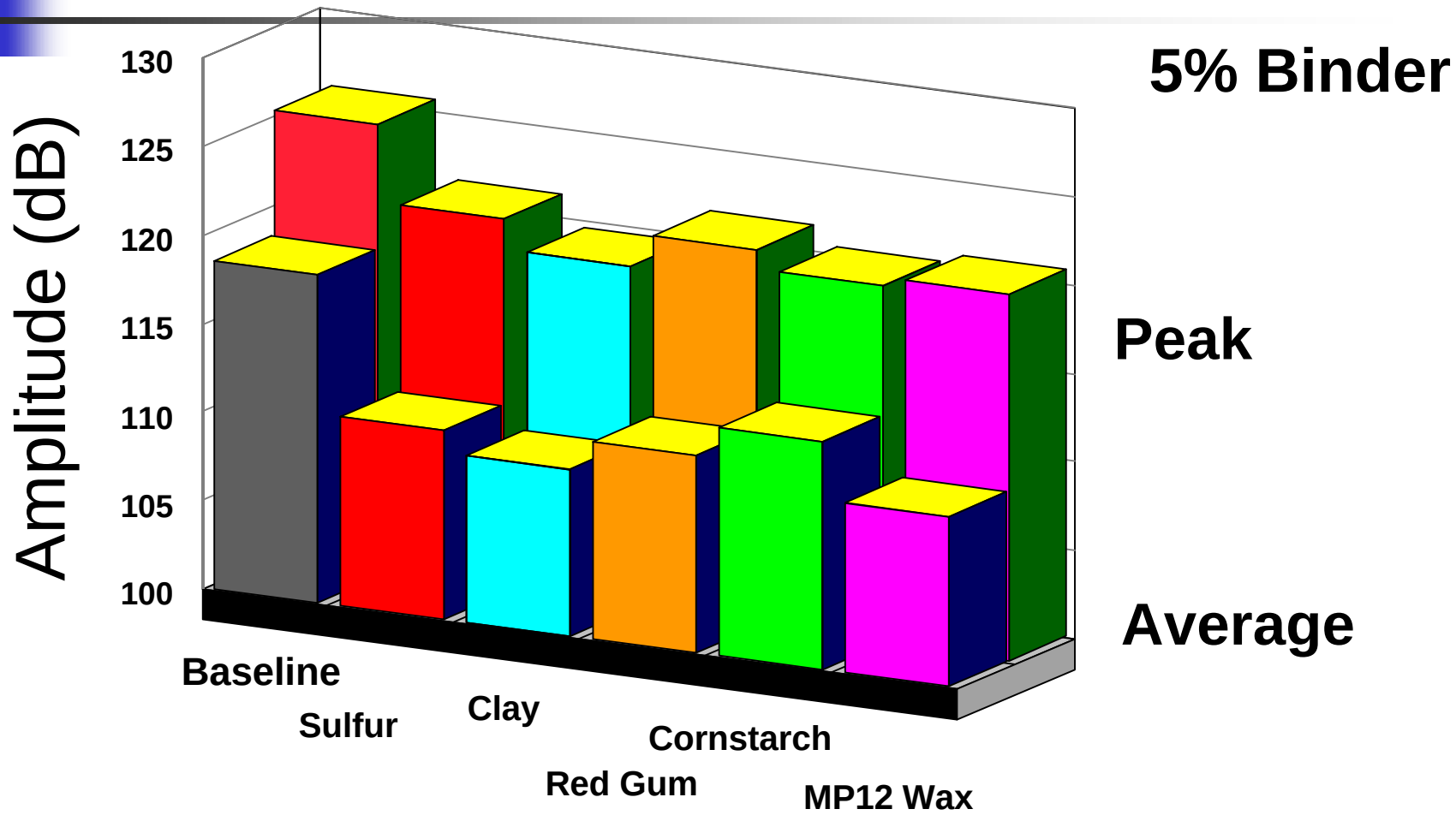
5% Binder

Binder Effect

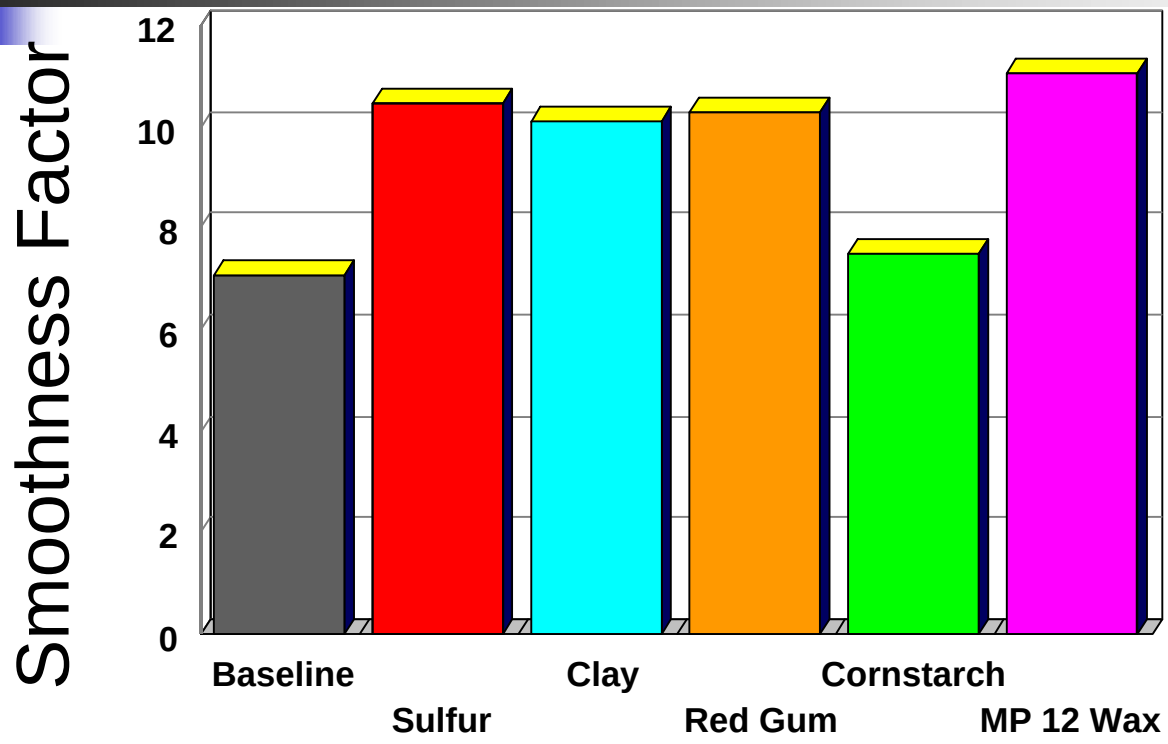


5% Binder

Peak vs Average Amplitude



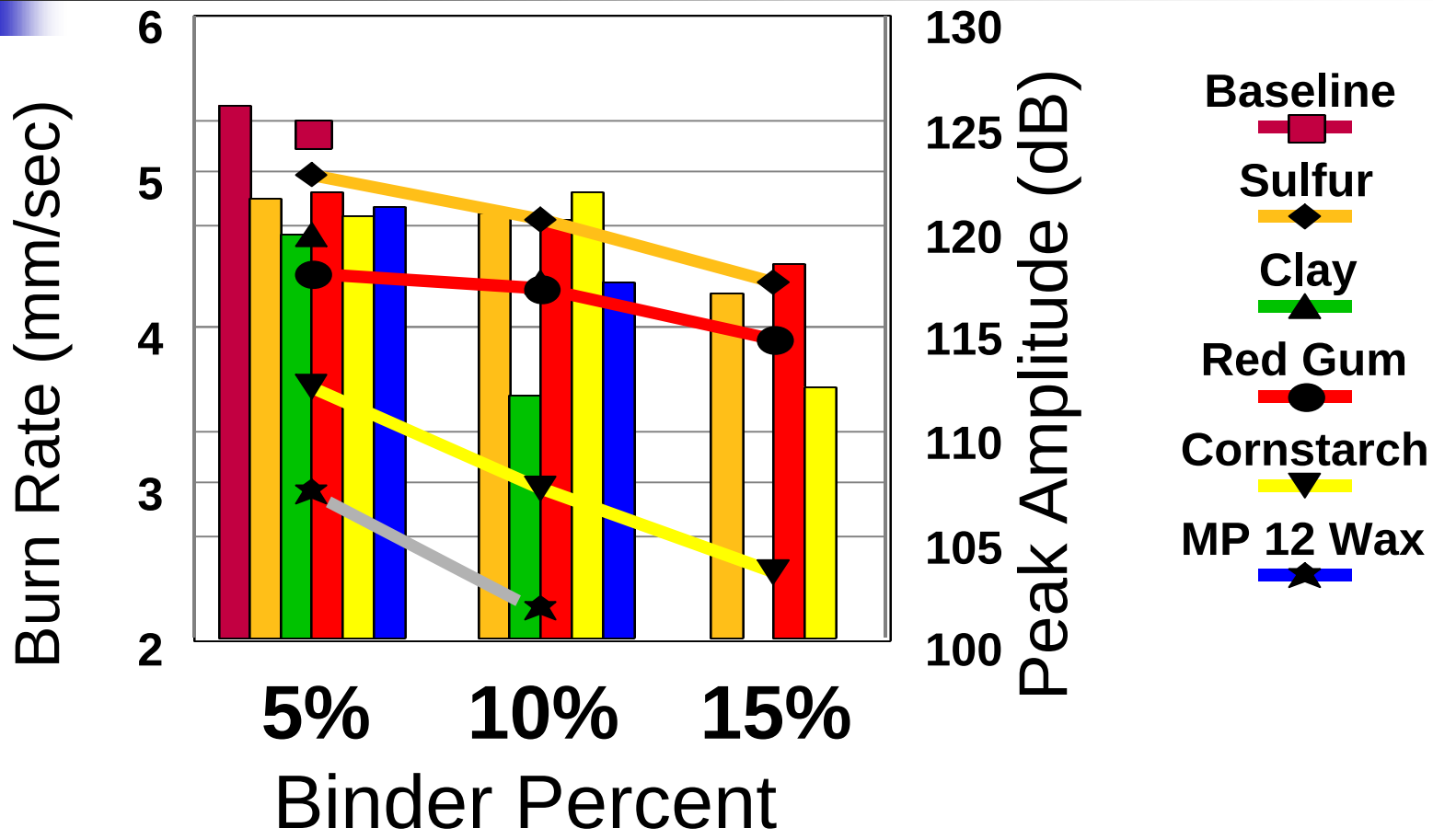
Whistle Quality



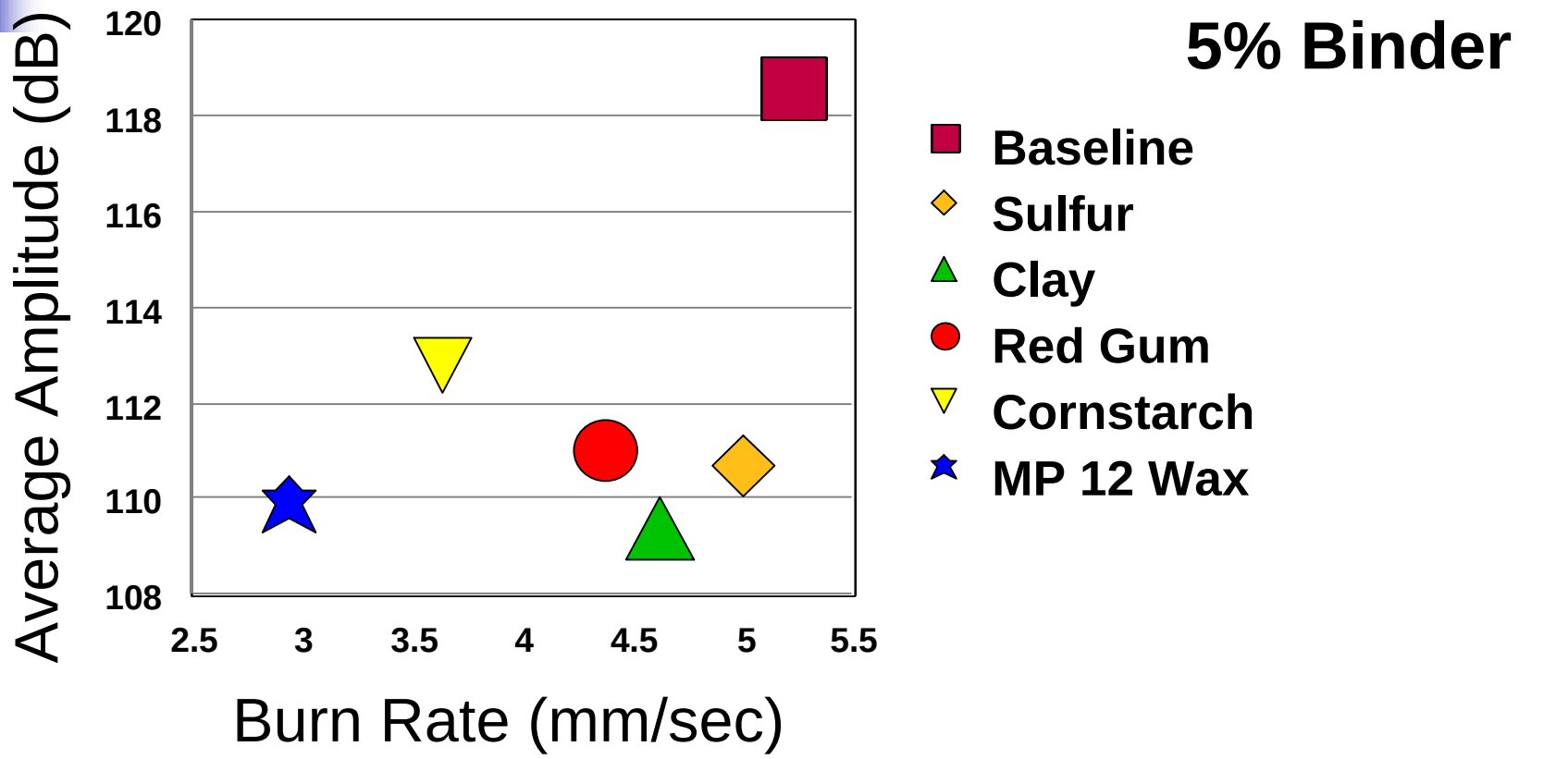
5% Binder

(Peak Amplitude Minus Average Amplitude)

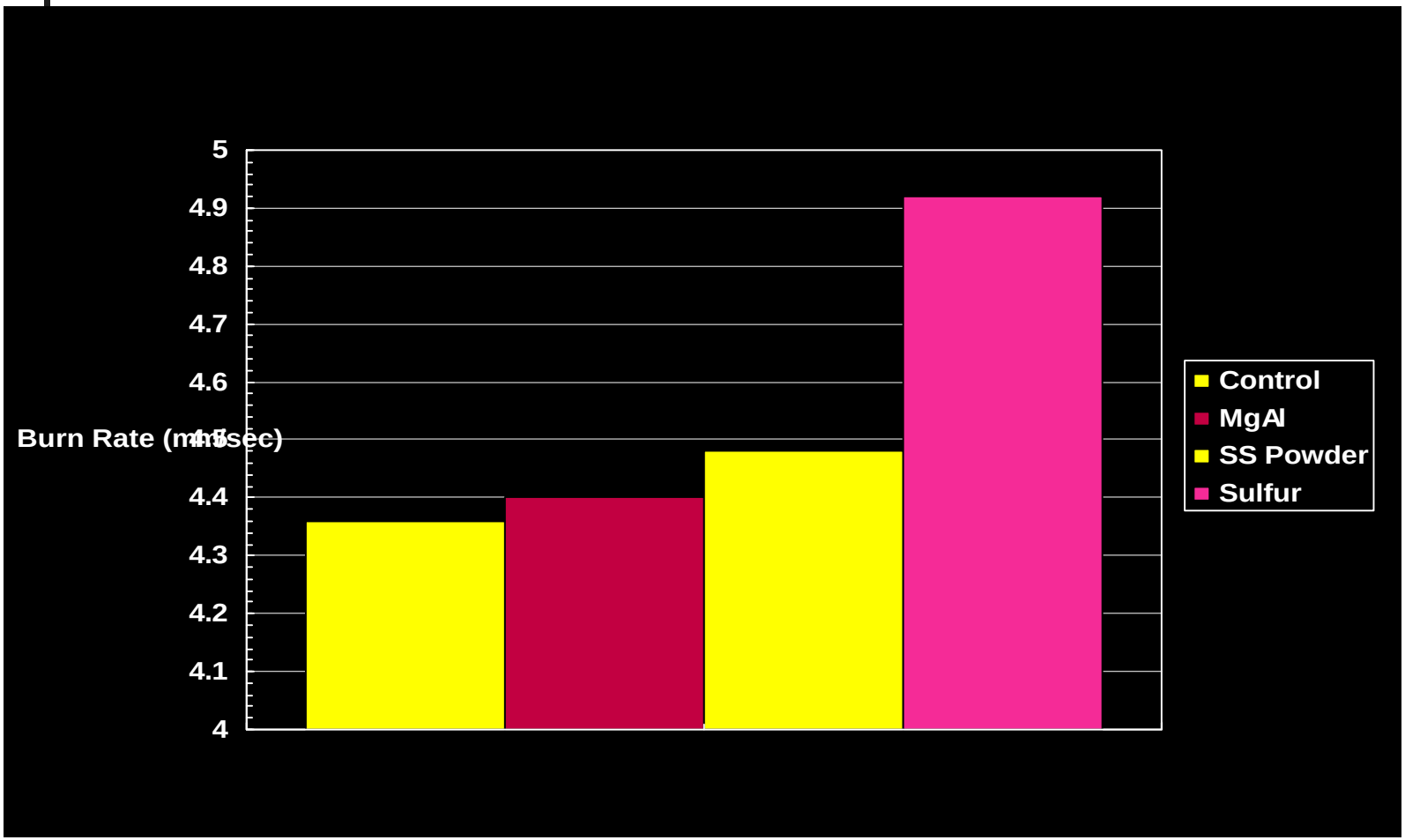
Burn Rate vs Binder Percent vs Amplitude



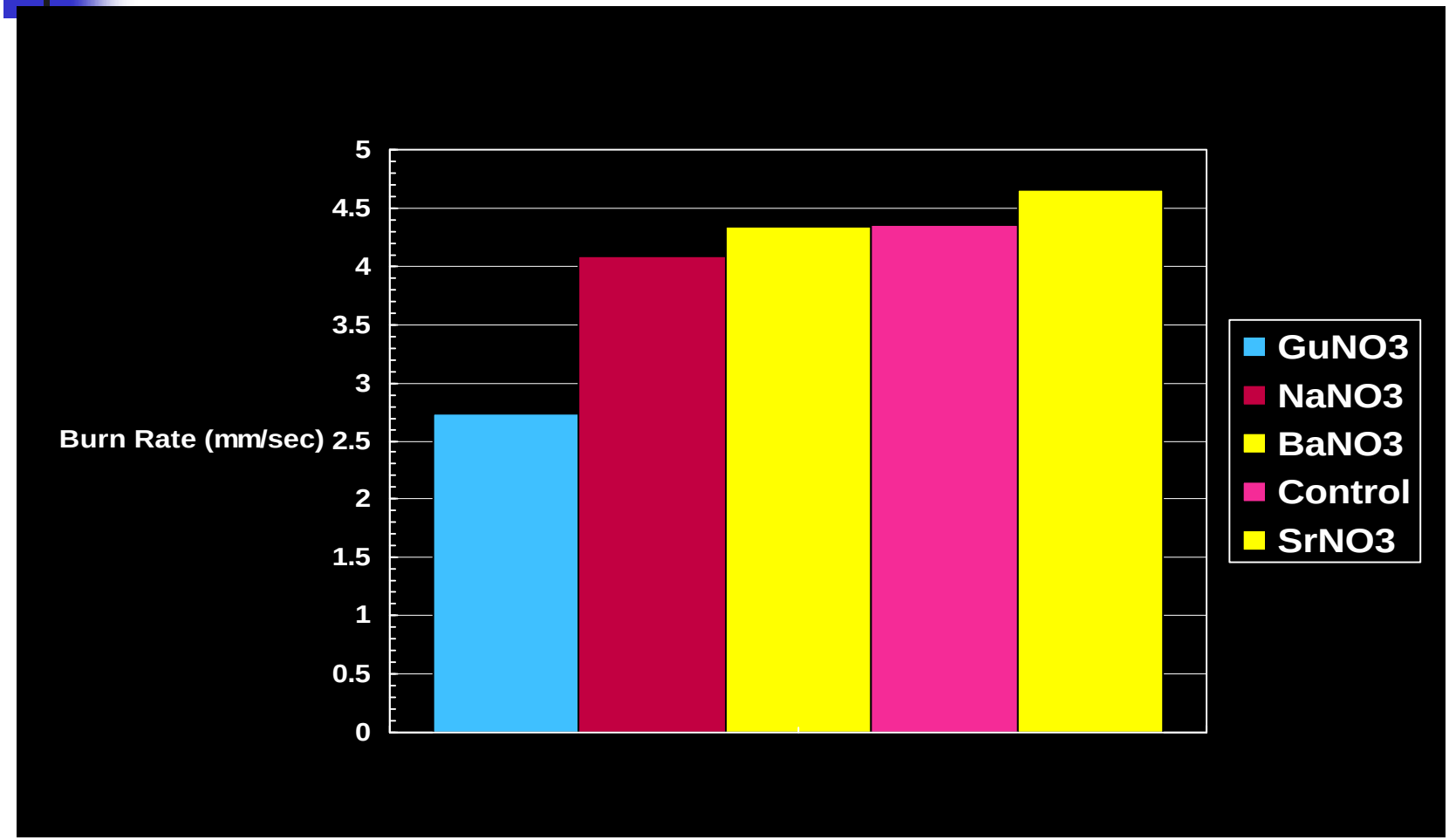
Burn Rate vs Average Amplitude



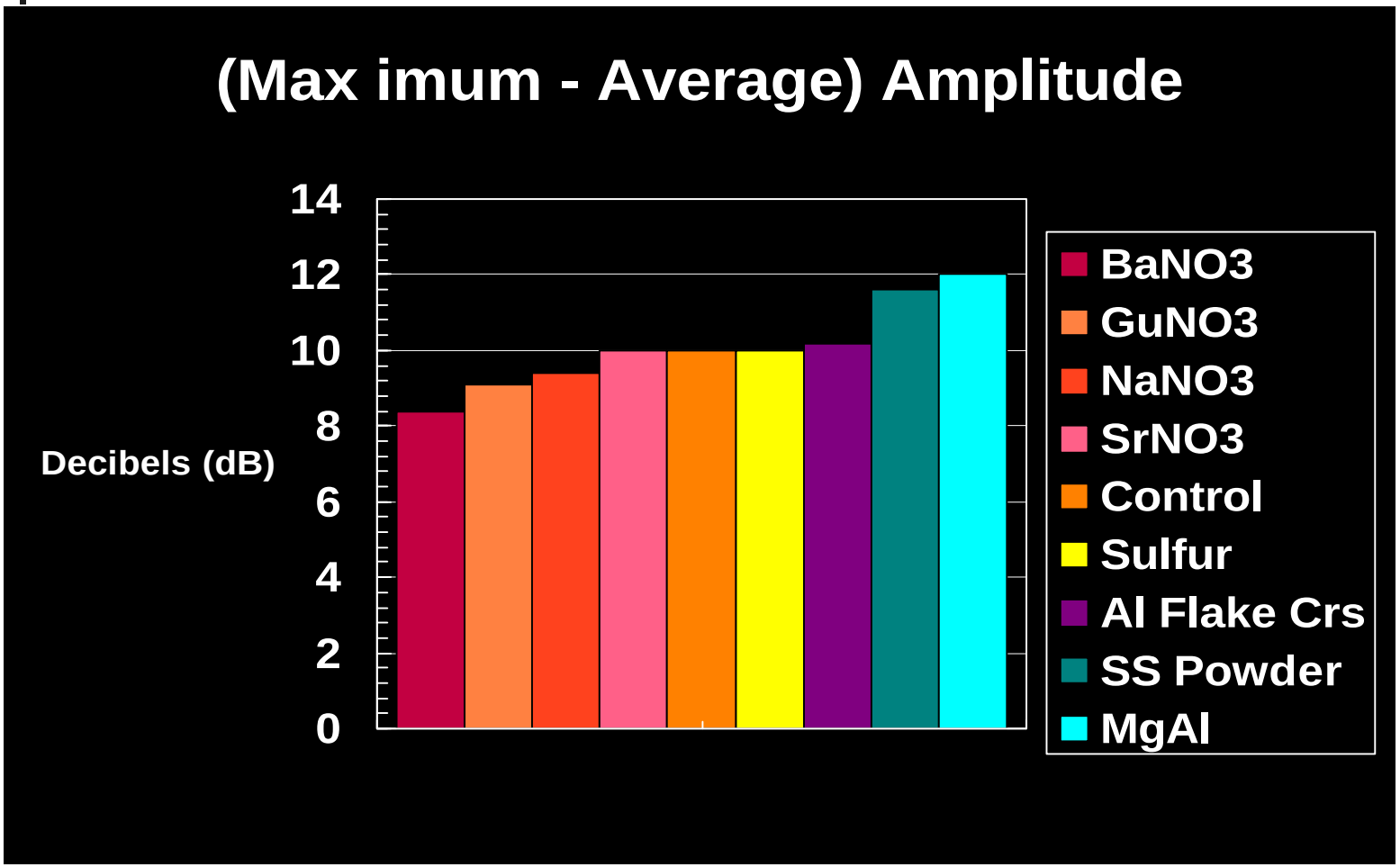
Burn Rate Comparison +10%



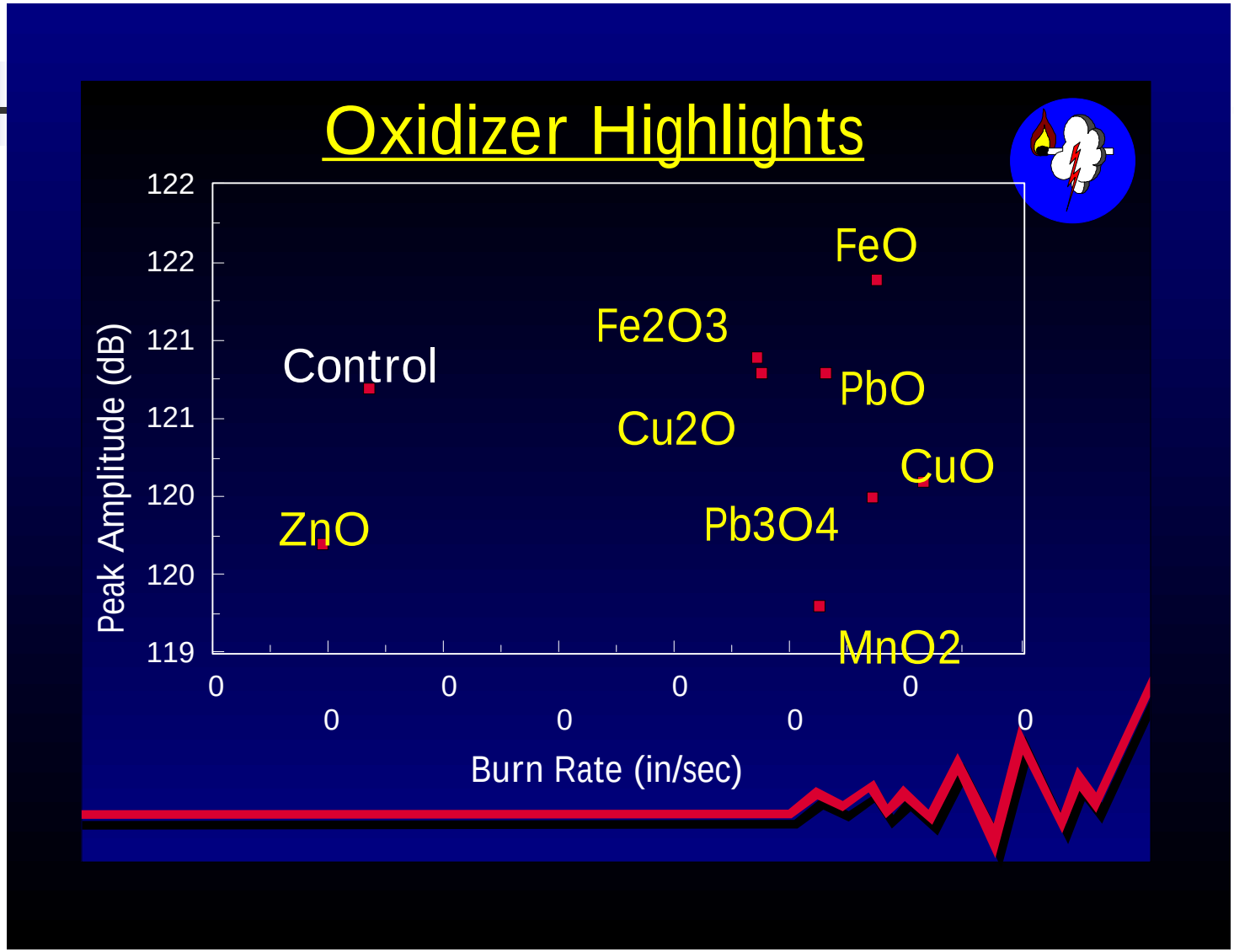
Burn Rate Comparison +10%



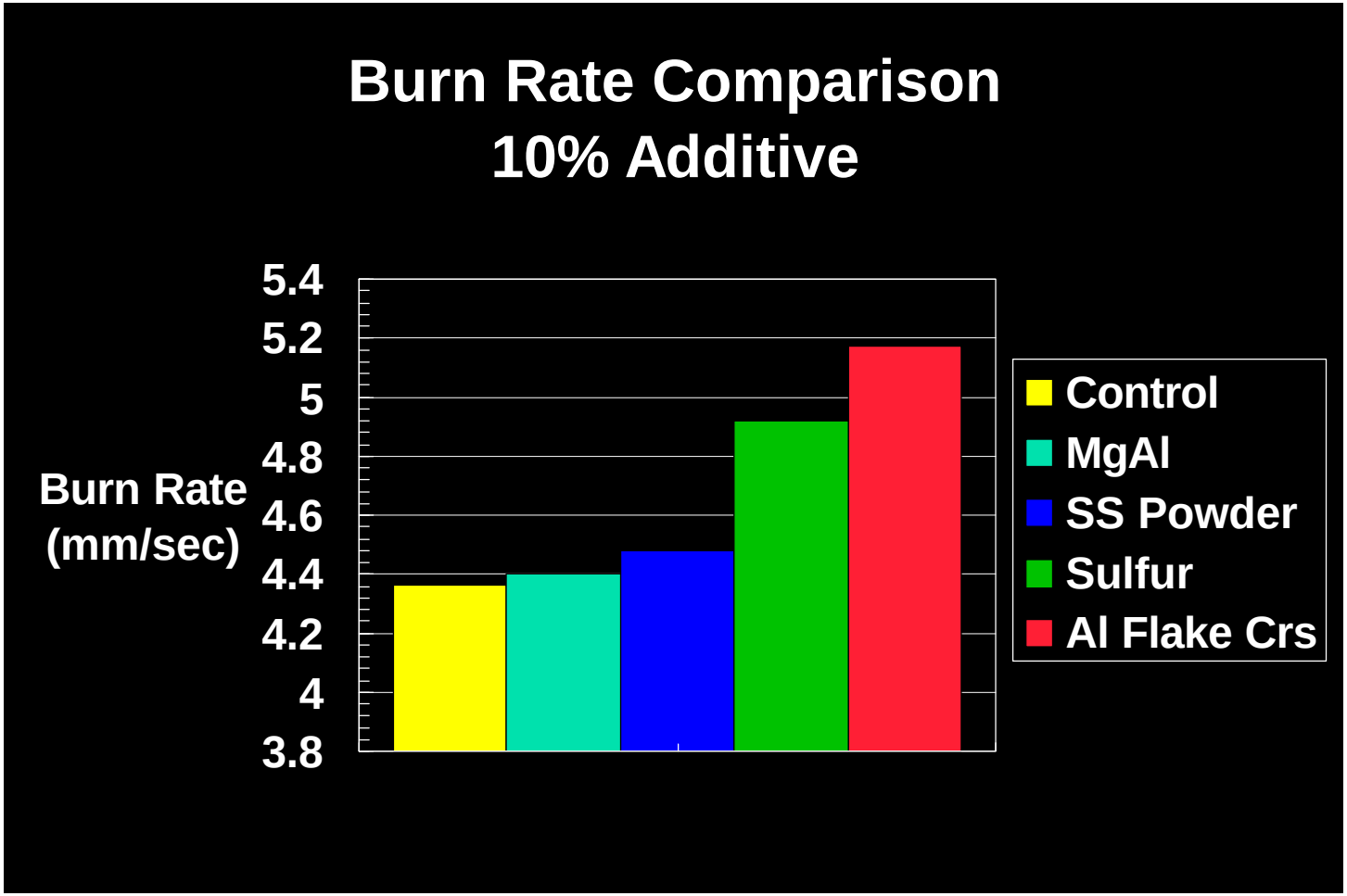
Smoothness Factor



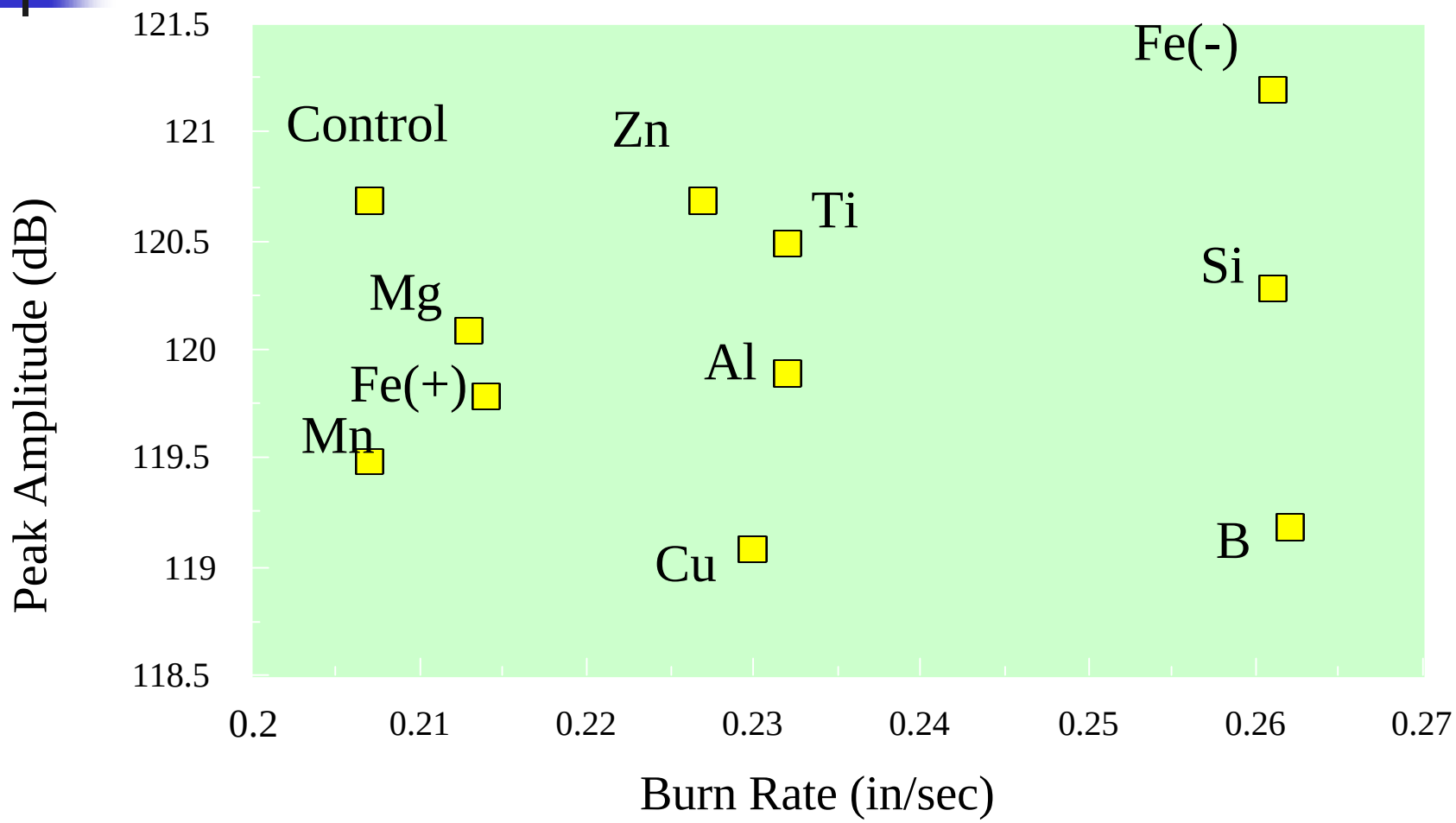
Amplitude Increase



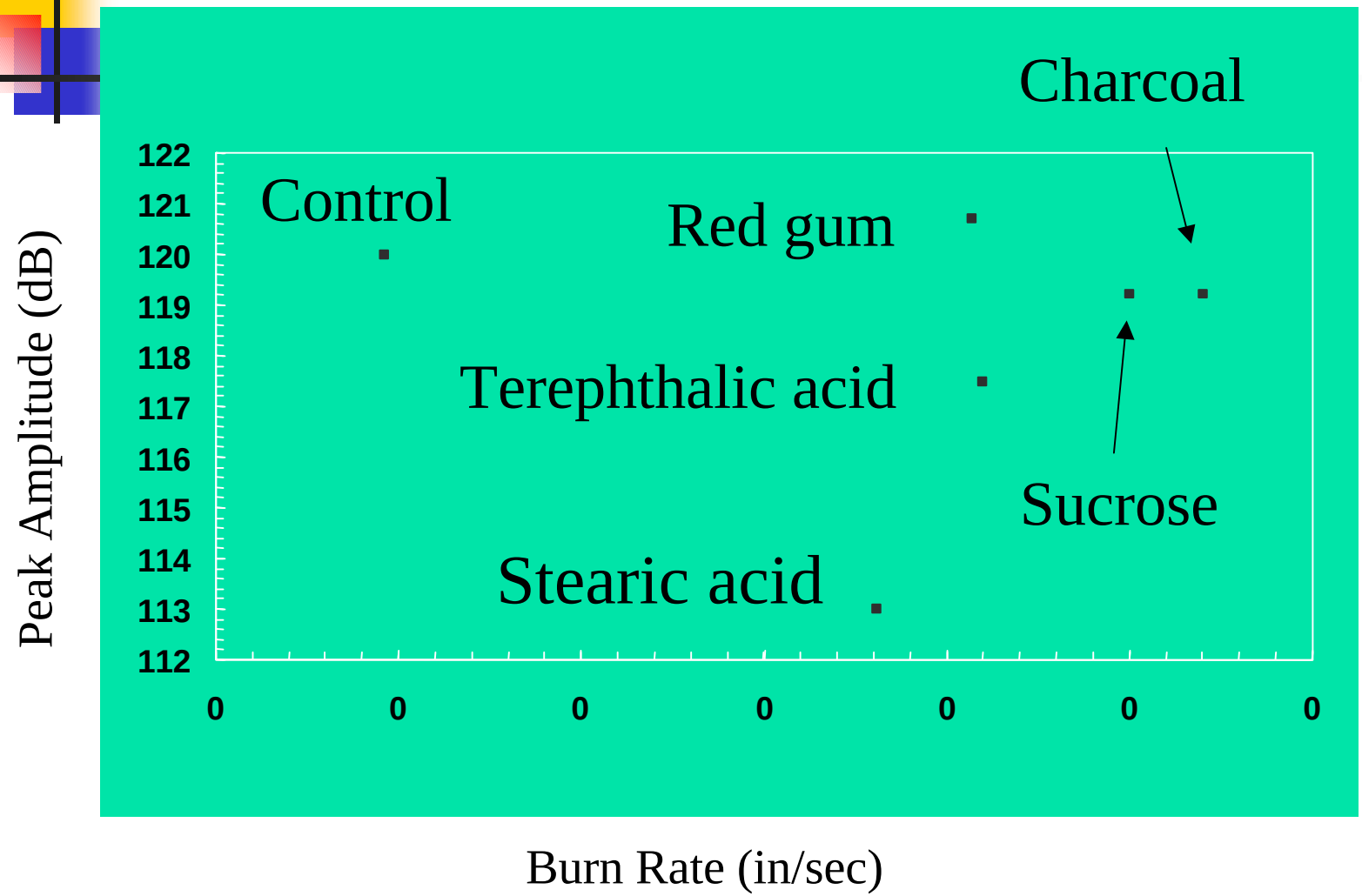
Fuel Effect on Burn Rate



Inorganic Fuel Highlights

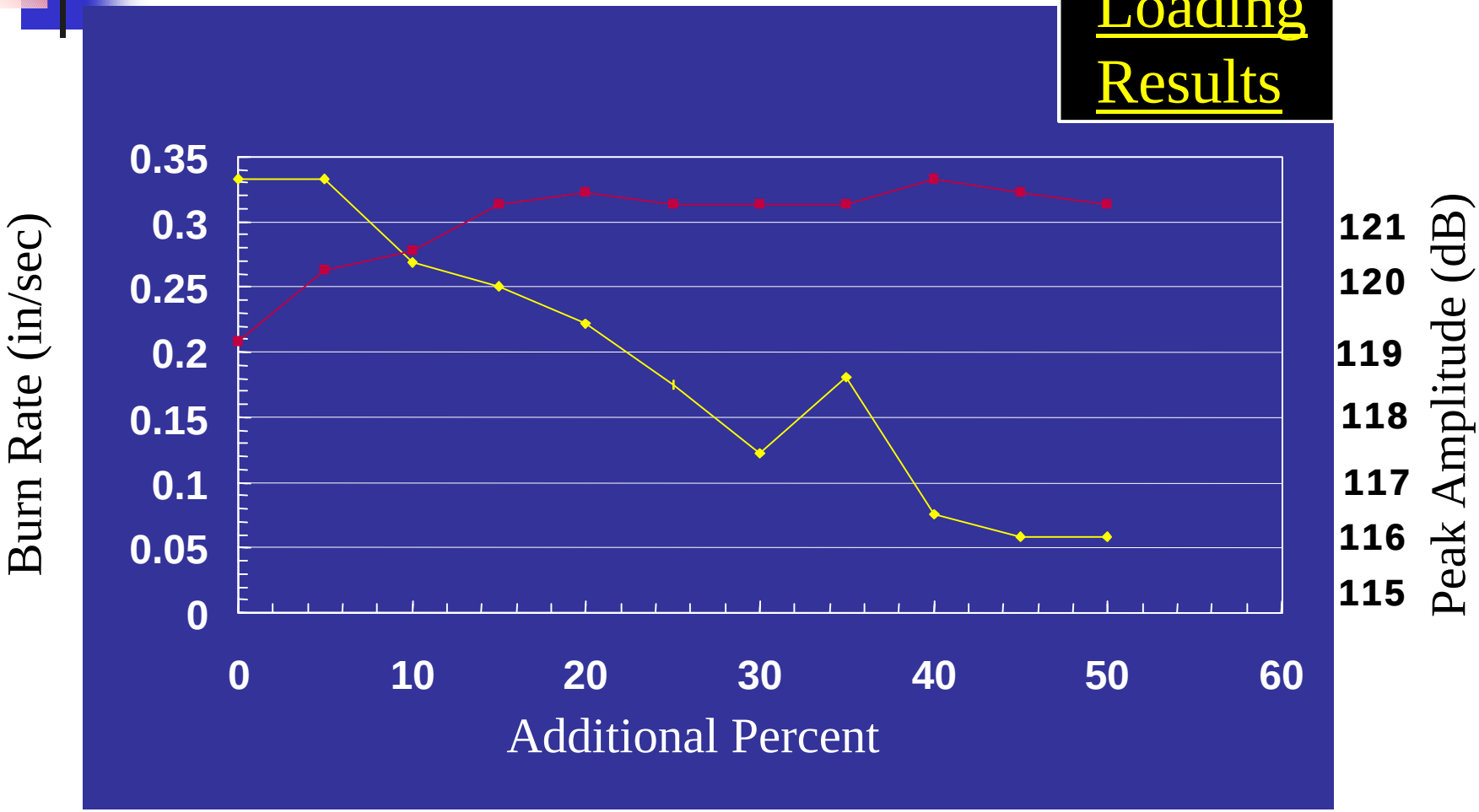


Organic Fuel Results



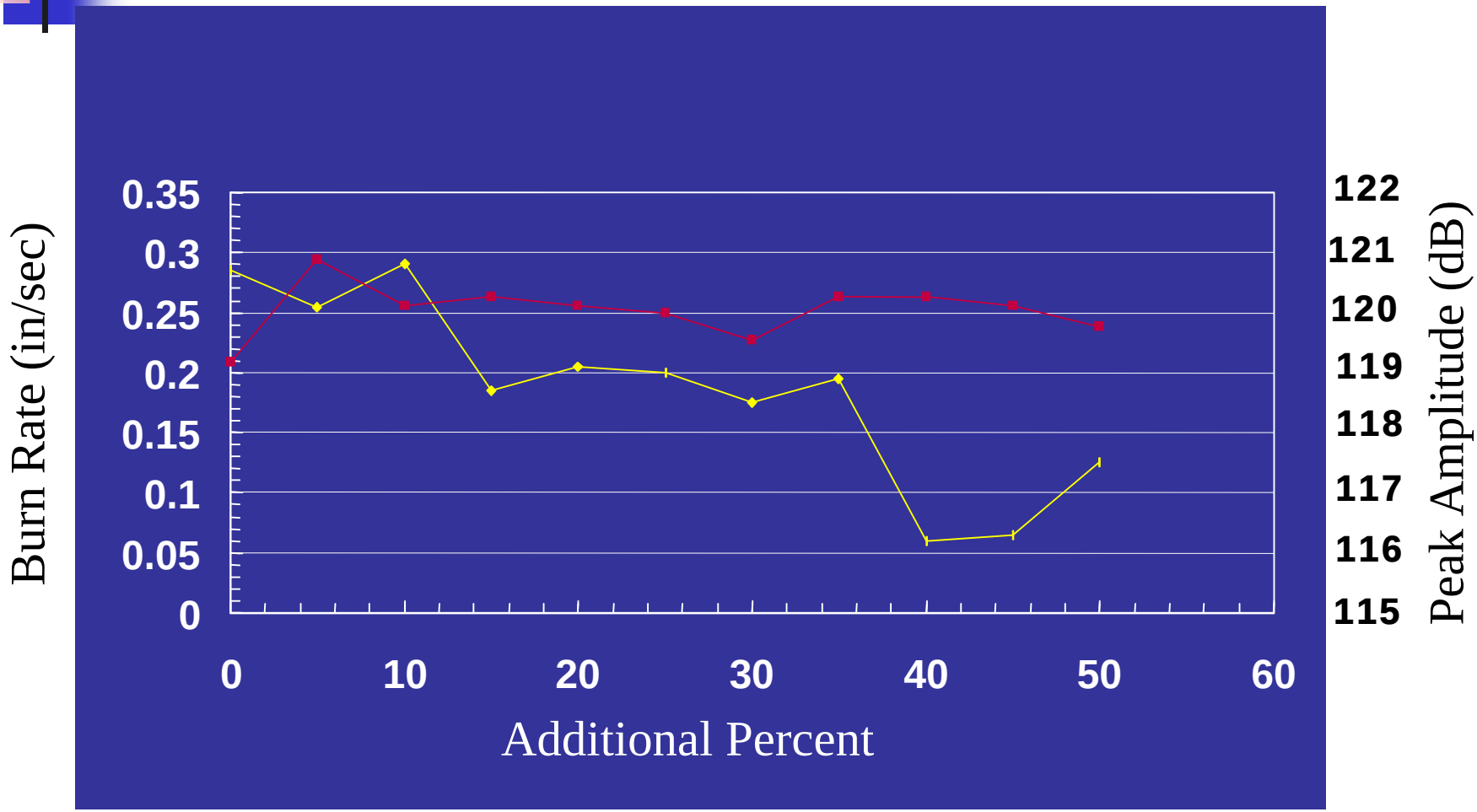
Fine Powdered Iron

High Loading Results

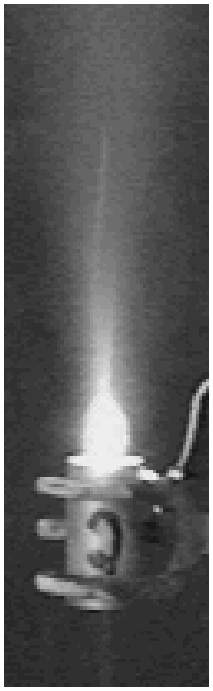
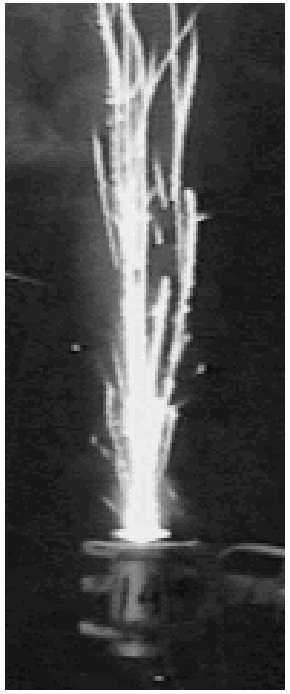
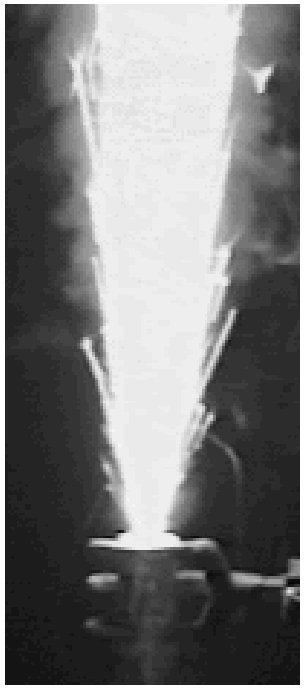
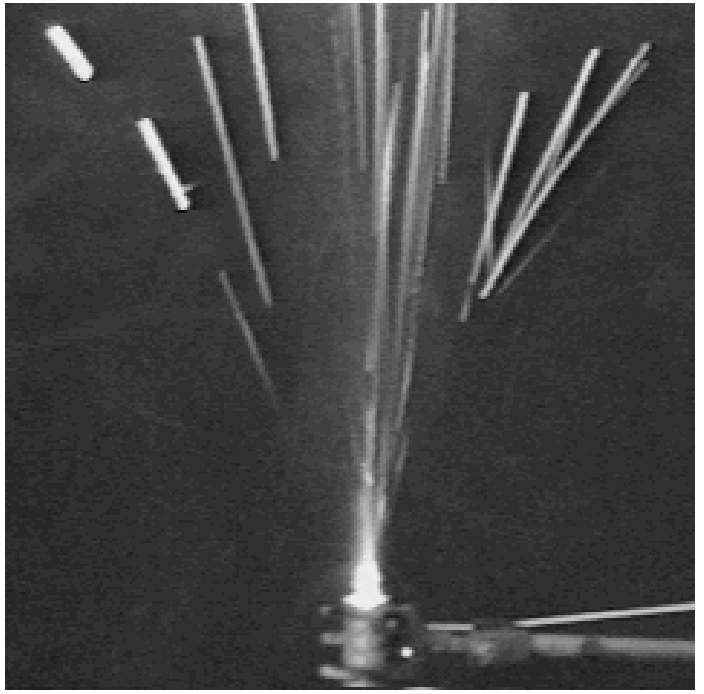


Black Copper Oxide

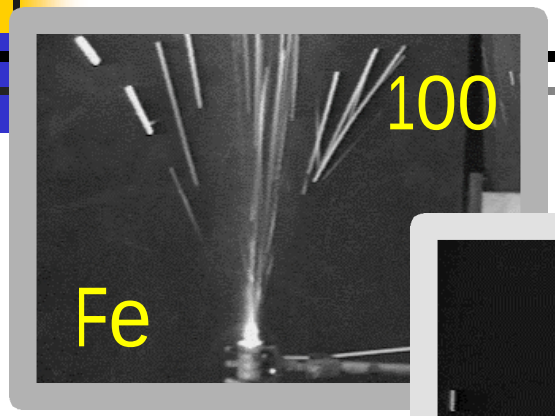
High Loading Results

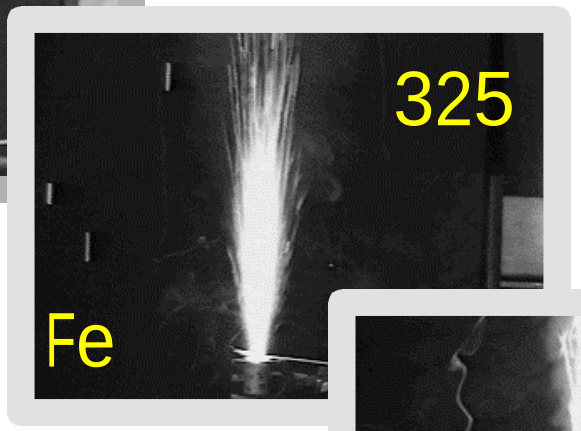


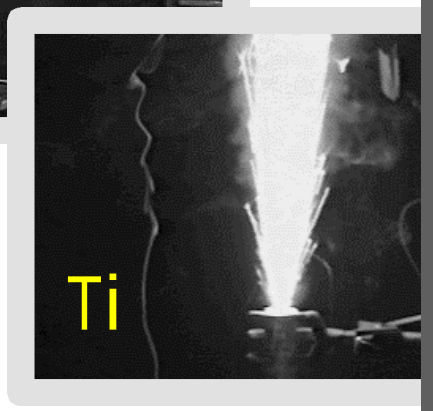
Flame Reduction

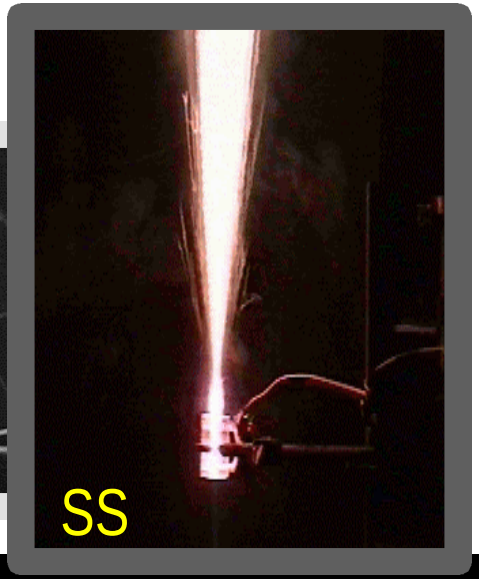





Spark Comparison



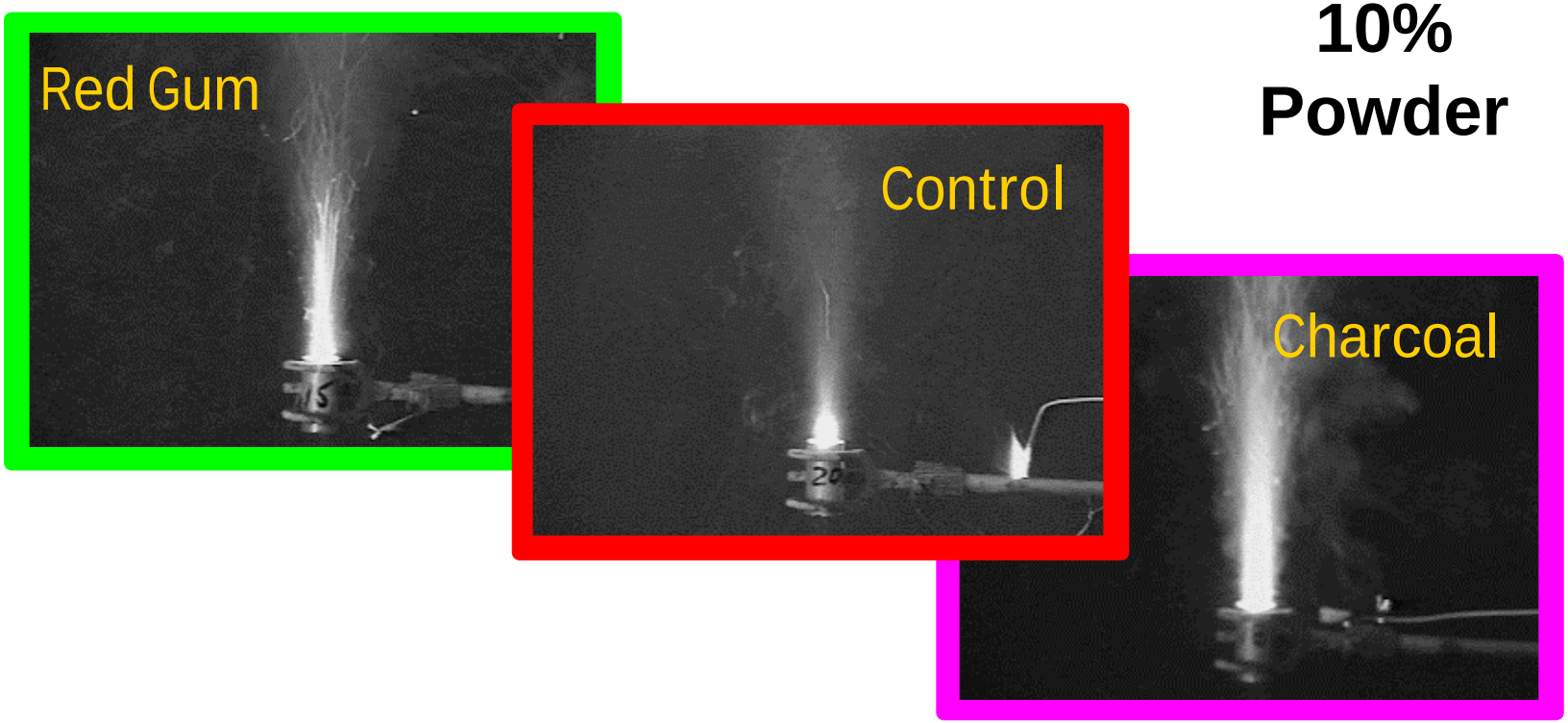






10% Metal Powder

Spark Comparison



10% Powder

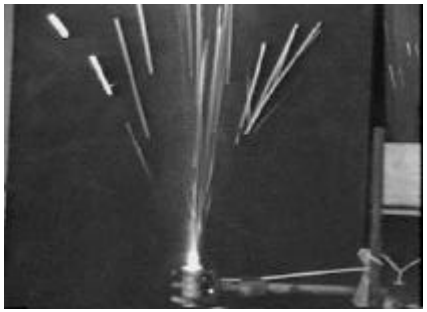
Flame Shape Comparison

Control

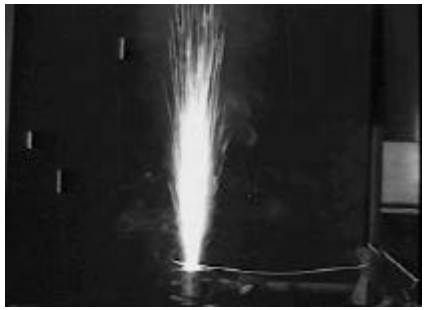
Zinc

Magnesium

Charcoal

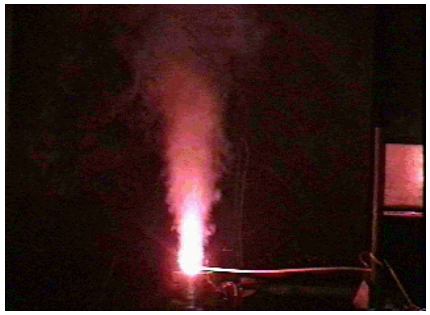


Coarse Iron



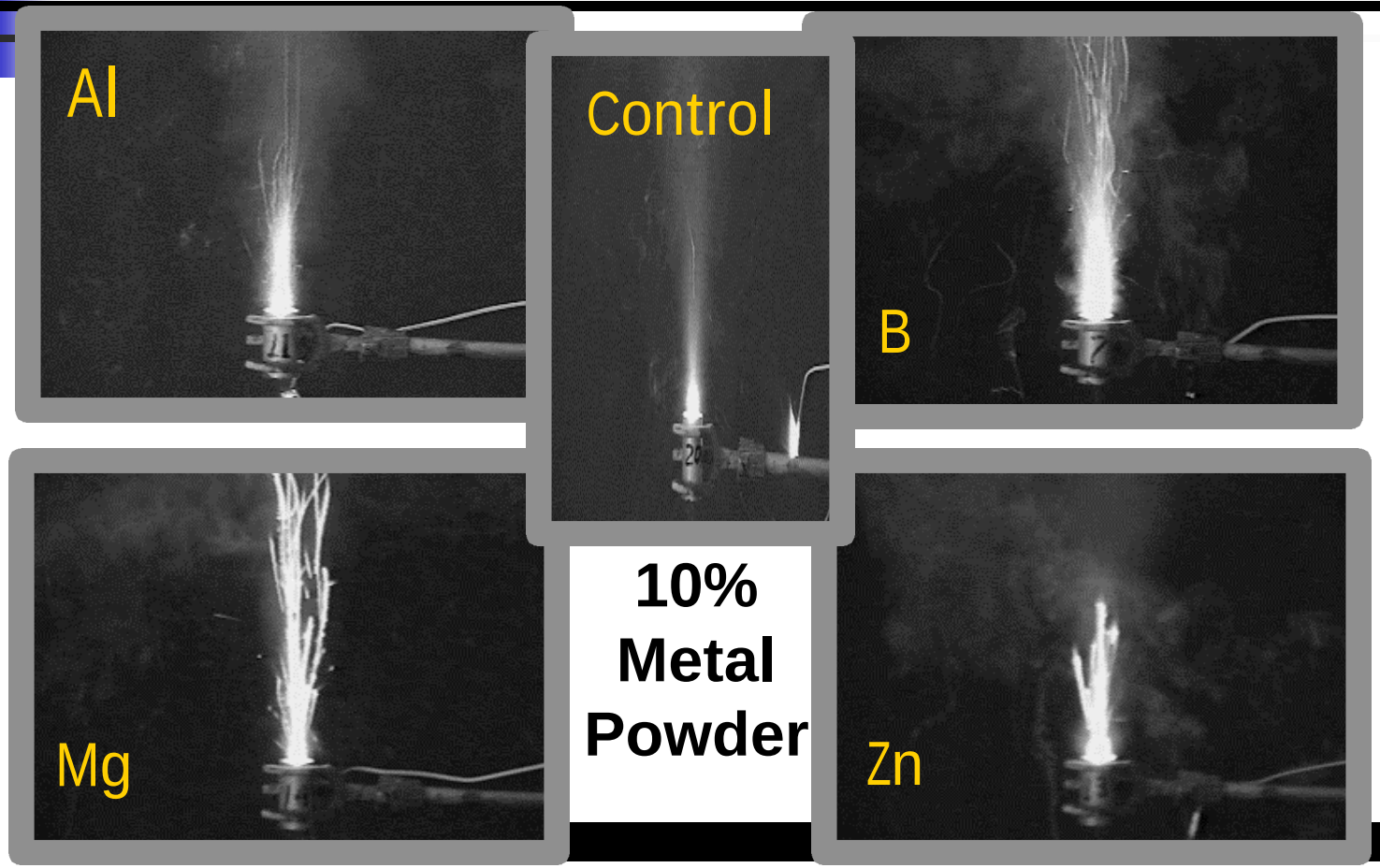
Fine Iron

Titanium



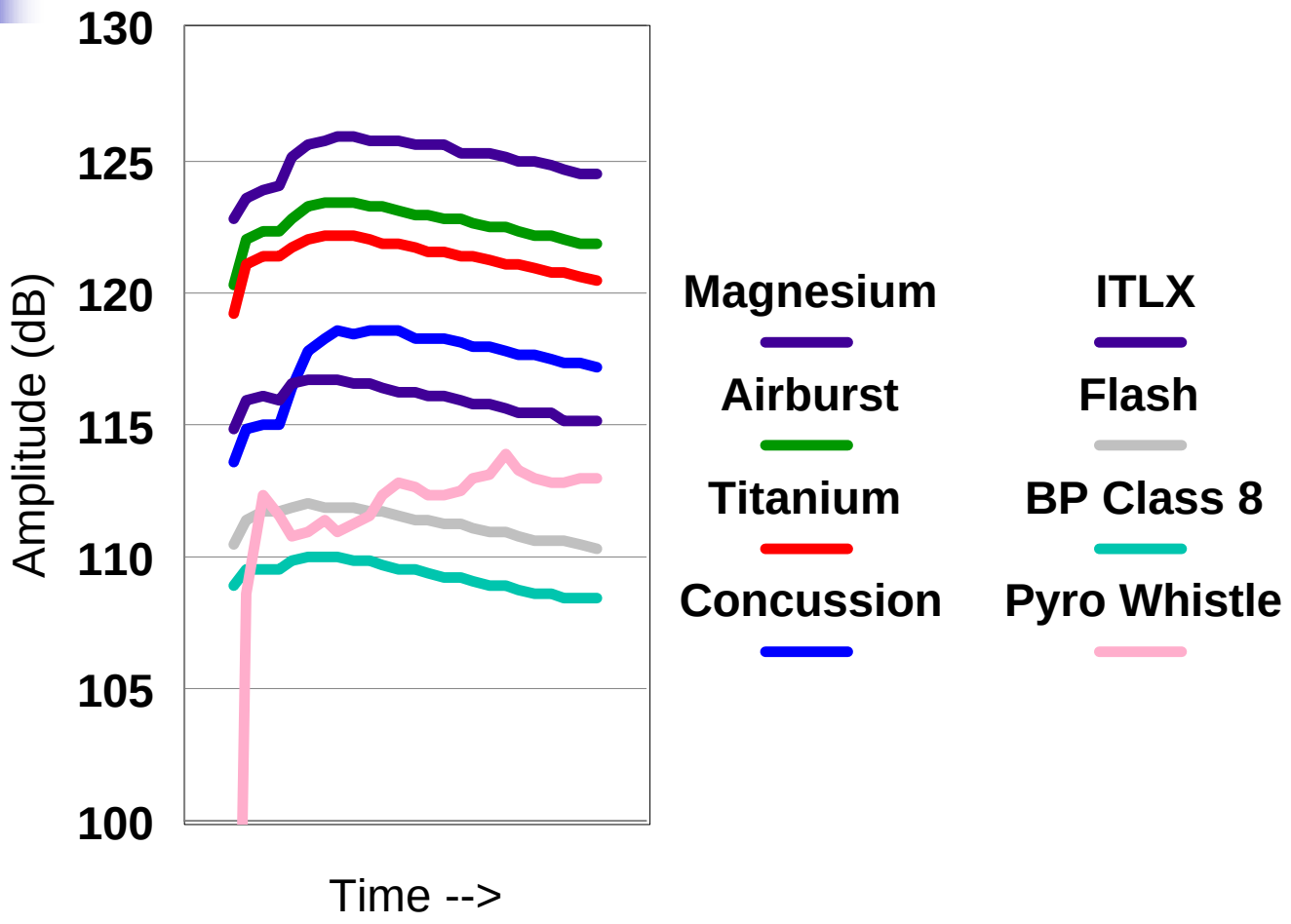
Strontium Nitrate

Spark Comparison

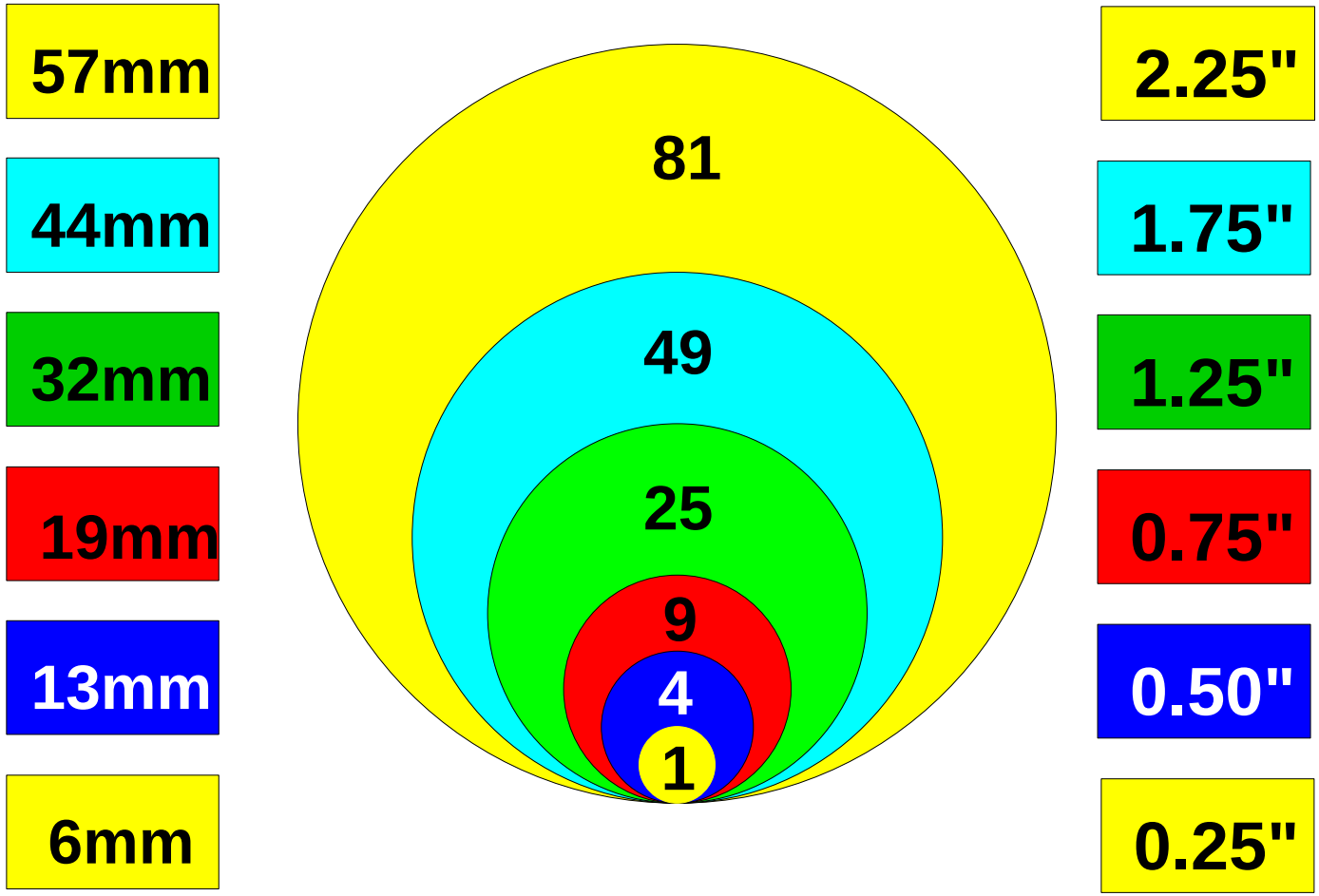


Increased Compaction Pressure

Whistle vs Blast Comparison



Amplitude Increase by Diameter



3 Inch Diameter Test Whistle