In-Process Classification of Explosives

Presented by

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Outline:

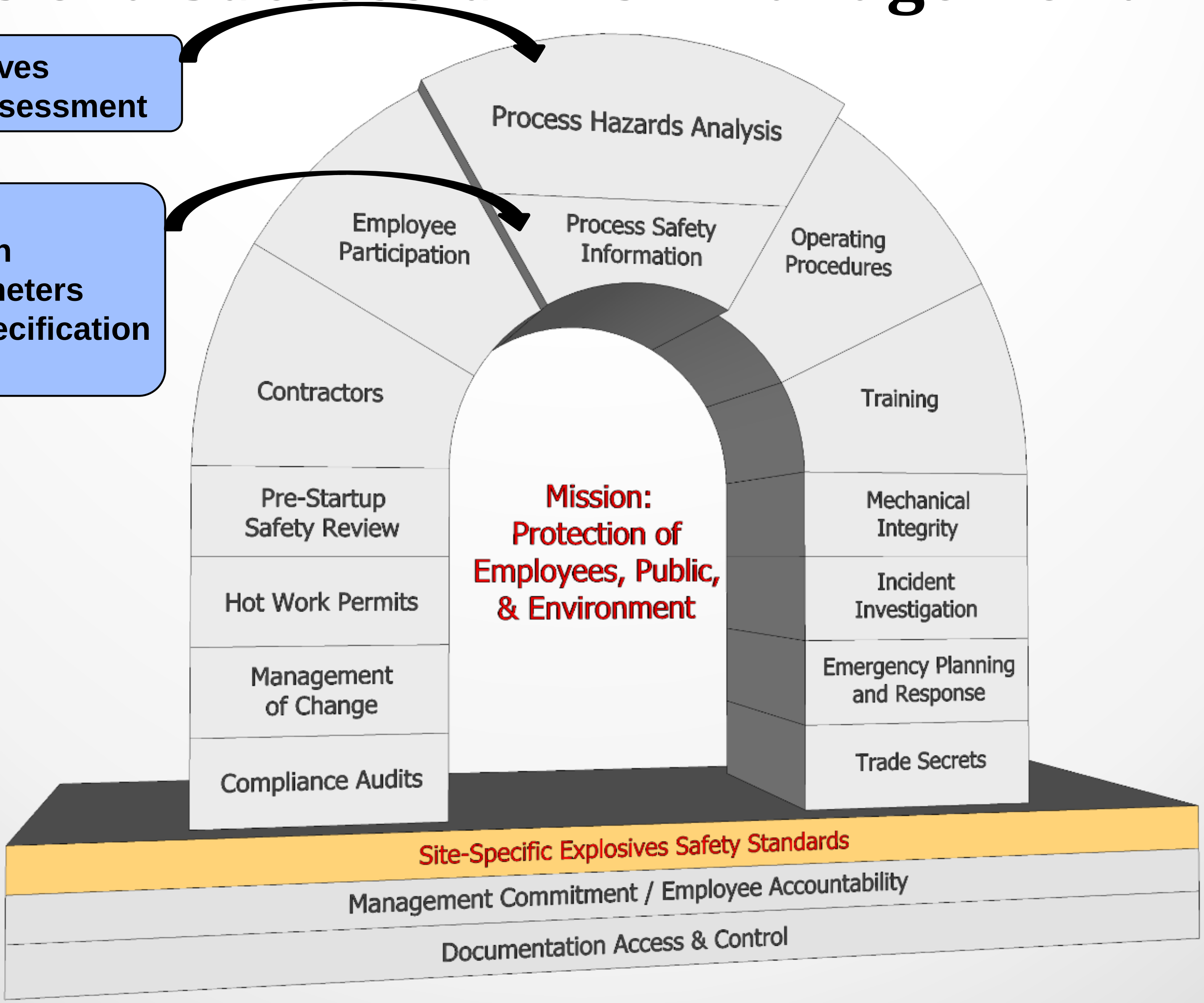
1. Key Concepts
2. In-Process Classification
3. Explosives Testing Users' Group

1. Key Concepts

Elements of a Successful Risk Management Program

Explosives Risk Assessment

- **Test Data**
- **Process Information**
  - **Process Parameters**
  - **Equipment Specification**
- **Etc.**



Fundamental Principles of Explosives Safety

1. Thorough & Accurate Process Hazards Analysis (PHA)
2. Understand the Nature of Explosives during:
   "In Process", Storage, or Transportation
3. Proper Facility Design and Siting
4. Site-Specific Explosives Safety Standards based on lessons learned and PHAs
5. Rigorous Process Control
6. Explosives Safety Systems and Protocols
7. Explosives Safety Accountabilities at all Organizational Levels

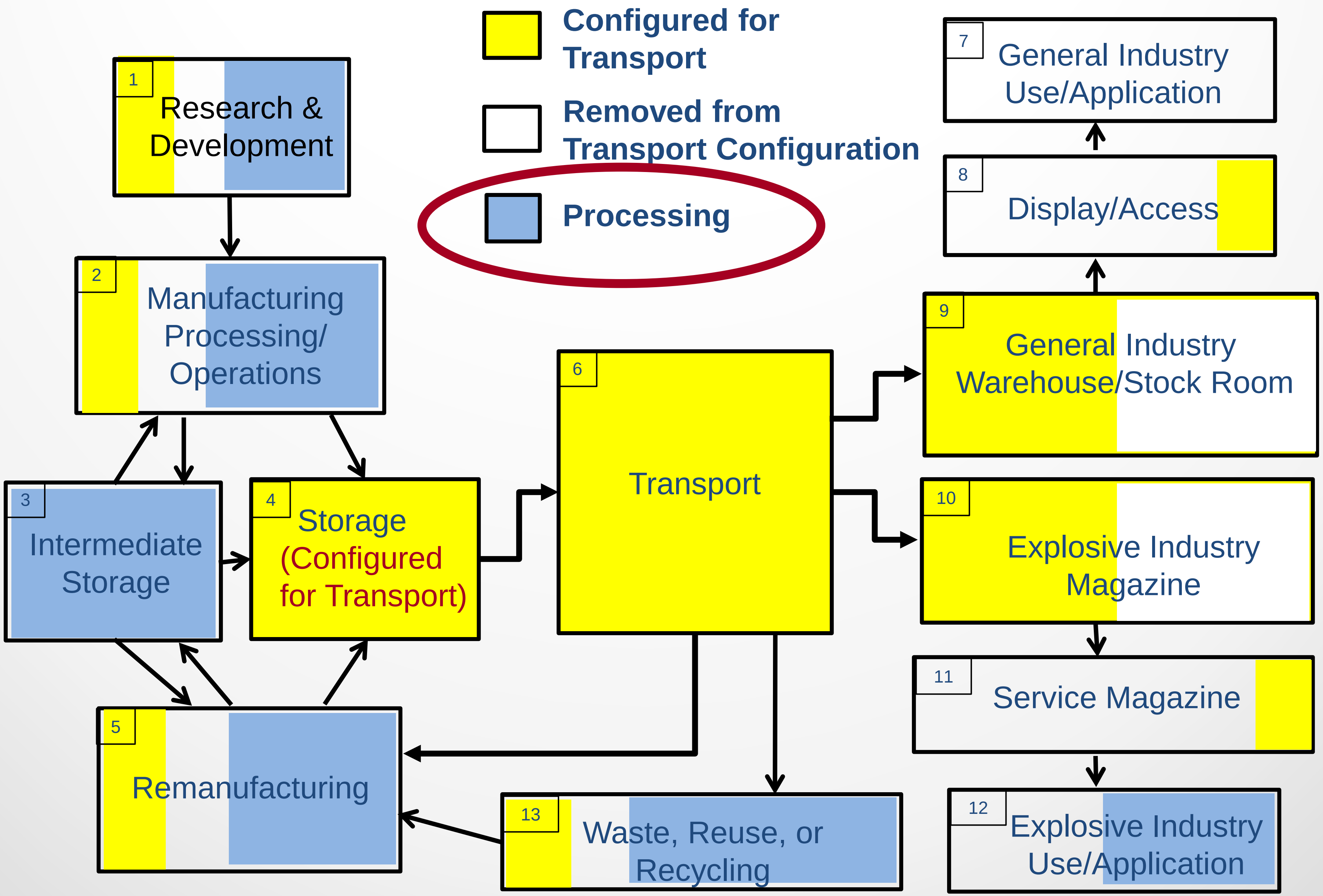
Explosives Classification Systems

- Transport
- Storage
- In-Process

Key Parameters for Explosives

	Manufacturing	Storage	Transport	Use
Composition	Variable	Constant/ Variable	Constant	Constant/ Variable
Physical State	Variable	Constant	Constant	Constant/ Variable
Configuration/ Confinement	Variable	Constant/ Variable	Constant	Variable
Quantity	Variable	Constant/ Variable	Constant	Variable
Conditions	Variable	Variable (Bounded)	Variable (Bounded)	Variable
Initiation Stimulus	Variable	Variable (Bounded)	Variable (Bounded)	Variable

Life Cycle Stages of Explosives



In-Process Classification of Explosives

Issue:

- **No *In-Process Classification Testing*** protocol or standards established prior to 2002

Resolutions:

- 2002: SMS published a paper entitled: "***In-Process Hazard Classification of Explosives***"
- 2003: Paper adopted by the **International Fire Code (IFC)** and **NFPA 495**
- 2009: ***Explosives Testing Users Group (ETUG)*** formed
- 2015:
  - **"ETUG-GS01-15: ETUG Standard for In-Process Classification of Explosives"** officially adopted
  - **ETUG Test Methods Matrix™** online for public access

In-Process Classification of Explosives

"ETUG-GS01-15: ETUG Standard for In-Process Classification of Explosives"

- Developed for the Explosives Industry
- Builds on UN MTC, DoD and ATF Classification Systems
- Referenced by NFPA 495 "Explosive Materials Code"
  - Specific Reference to the Standard
  - ETUG-GS01-15 Flowcharts Incorporated
- US Building Codes reference NFPA 495 for explosive operations

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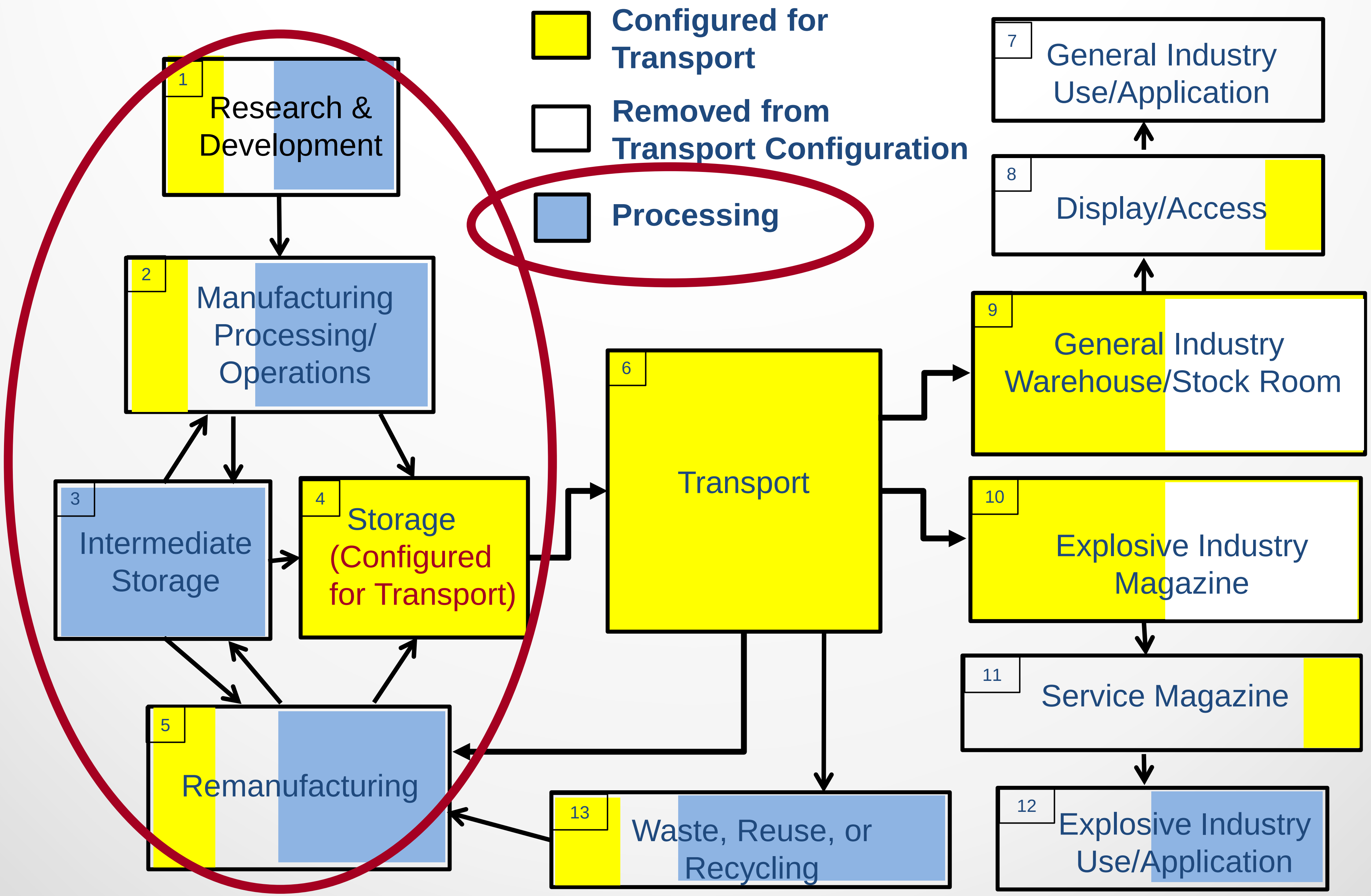
Life Cycle Stages of Explosives



In-Process Definition by Lifecycle *Stage*

R&D, Processing/Manufacturing/Remanufacturing

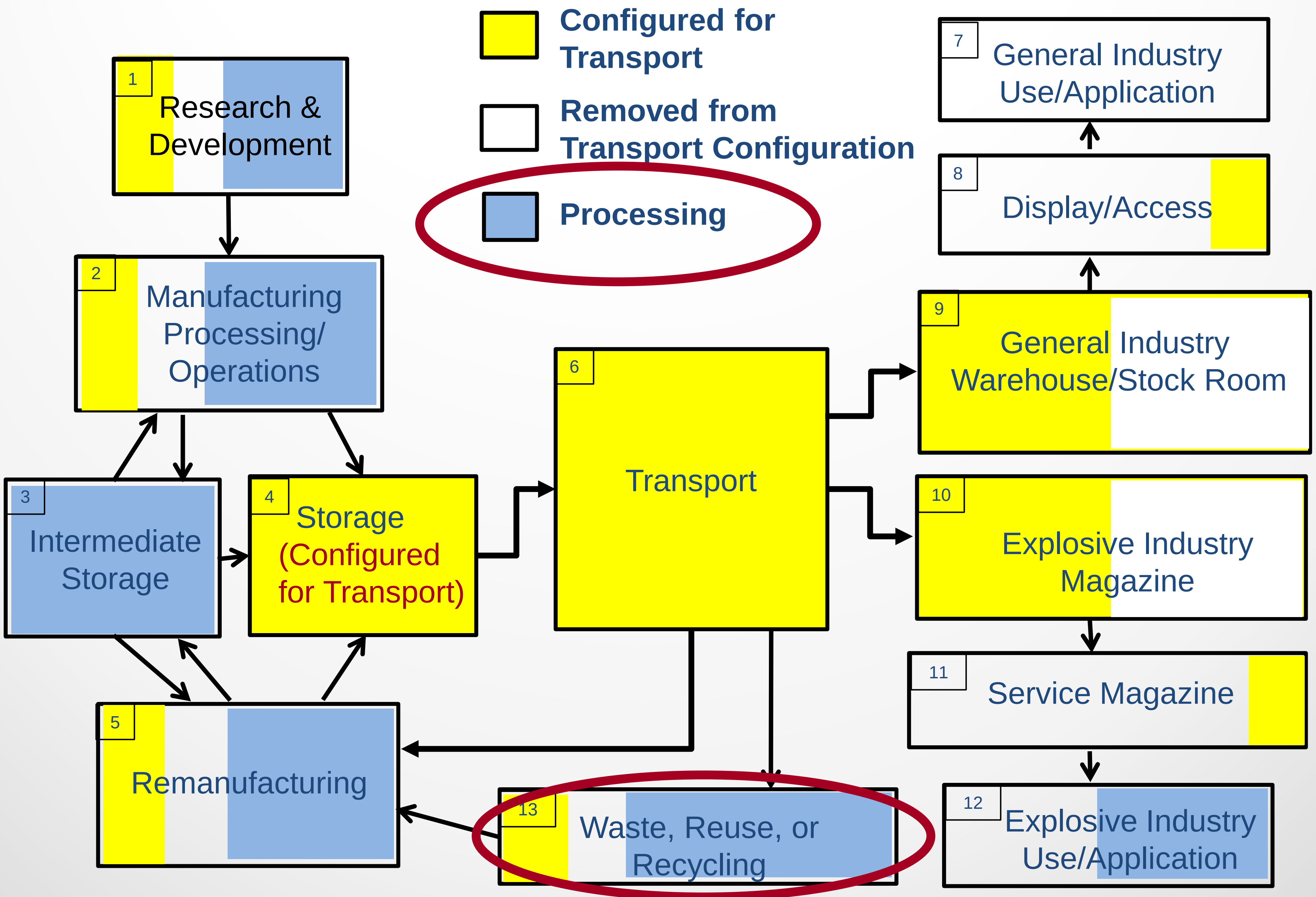
- Feeding
- Mixing
- Blending
- Extruding
- Pressing
- Casting
- Curing
- Cutting/Machining
- Assembly/Disassembly
- System Integration
- Waste handling/processing
- Packaging (finished goods)
- etc.

Storage

- Intermediate

In-Process Classification of Explosives

Life Cycle Stages of Explosives



In-Process Definition by Lifecycle *Stage*

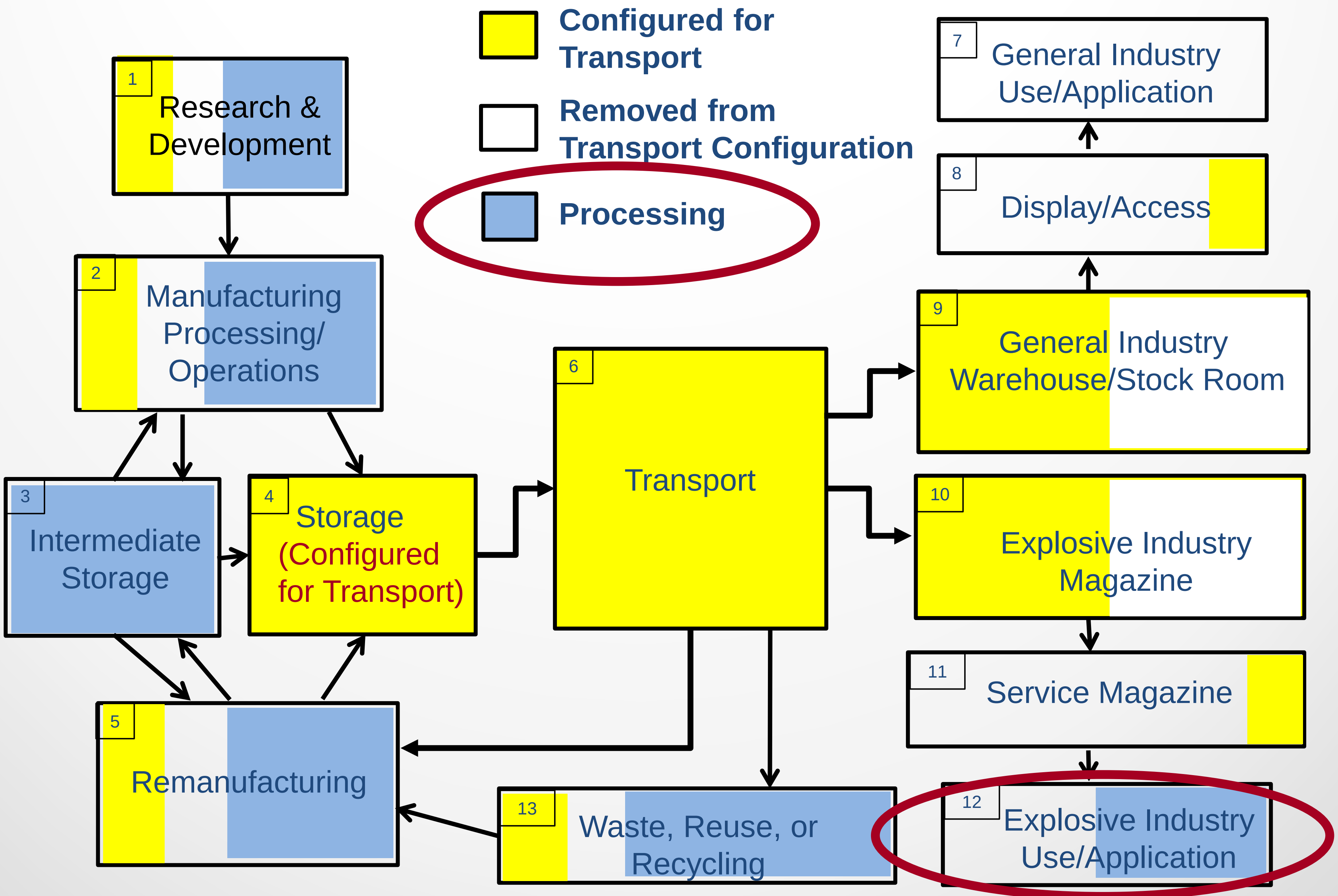
Waste/Recycling/Reuse

- OB/OD
- Contain Burn/Detonation
- Segmenting
- Super Critical Water Oxidation
- Cryo-washout
- Cryo-fracture
- Hydrolysis
- etc.

Decontamination, Demolition, Remediation

- Explosive Operating Buildings
- Test Facilities/Sites
- Test Ranges

Life Cycle Stages of Explosives



In-Process Definition by Lifecycle *Stage*

Use/Application

- Unpacking
- Handling
- Staging
- Final Assembly
- System Integration
- Setup
- Functioning

In-Process Classification of Explosives

The ***Best Tool*** for Defining In-Process Test Parameters?

ANSWER:

Systematic Risk Assessment

- Define Energy Stimuli
- Normal & Abnormal Scenarios/Conditions
- Key Parameters
  - Explosive Composition
  - Physical State
  - Configuration/Confinement
  - Materials of Construction
  - Surface Finishes
  - etc.

Sensitivity Test Equipment

Relative Sensitivity

Impact

- Bureau of Explosives (cm)
- Modified Type 12 Impact (cm)
- Rotter Test
- 30 kg. Fallhammer (m)

Friction

- BAM Friction Apparatus
- Rotary Friction Test

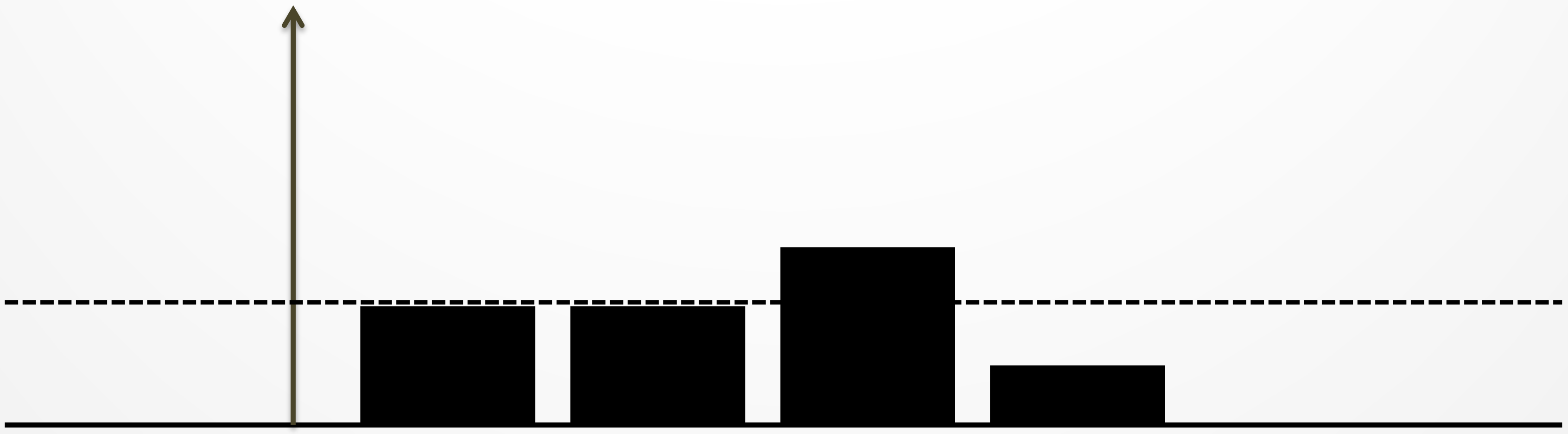
ESD

- Stationary Electrode (J)

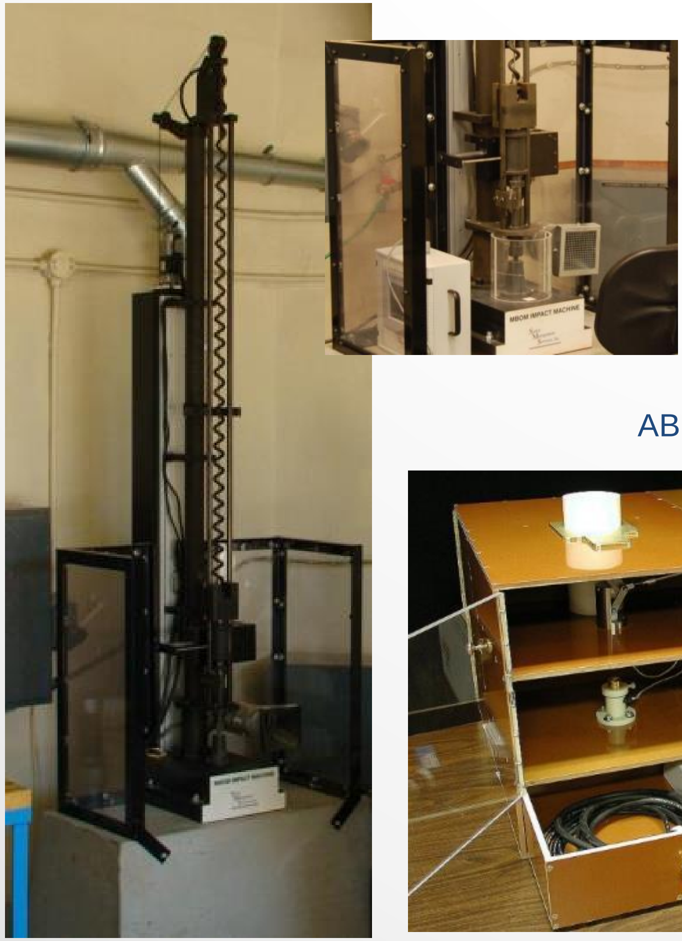
Data Simulates In-Process Conditions

- Modified Bureau of Mines Impact Machine (J/m^2)
- ABL Friction Machine (lb_f @ 1 to 8ft/sec converted to N/m^2@ velocity)
- Approaching Needle Machine (J)

Relative Comparison



Sensitivity Test Equipment:
Simulate In-process Energies and Conditions



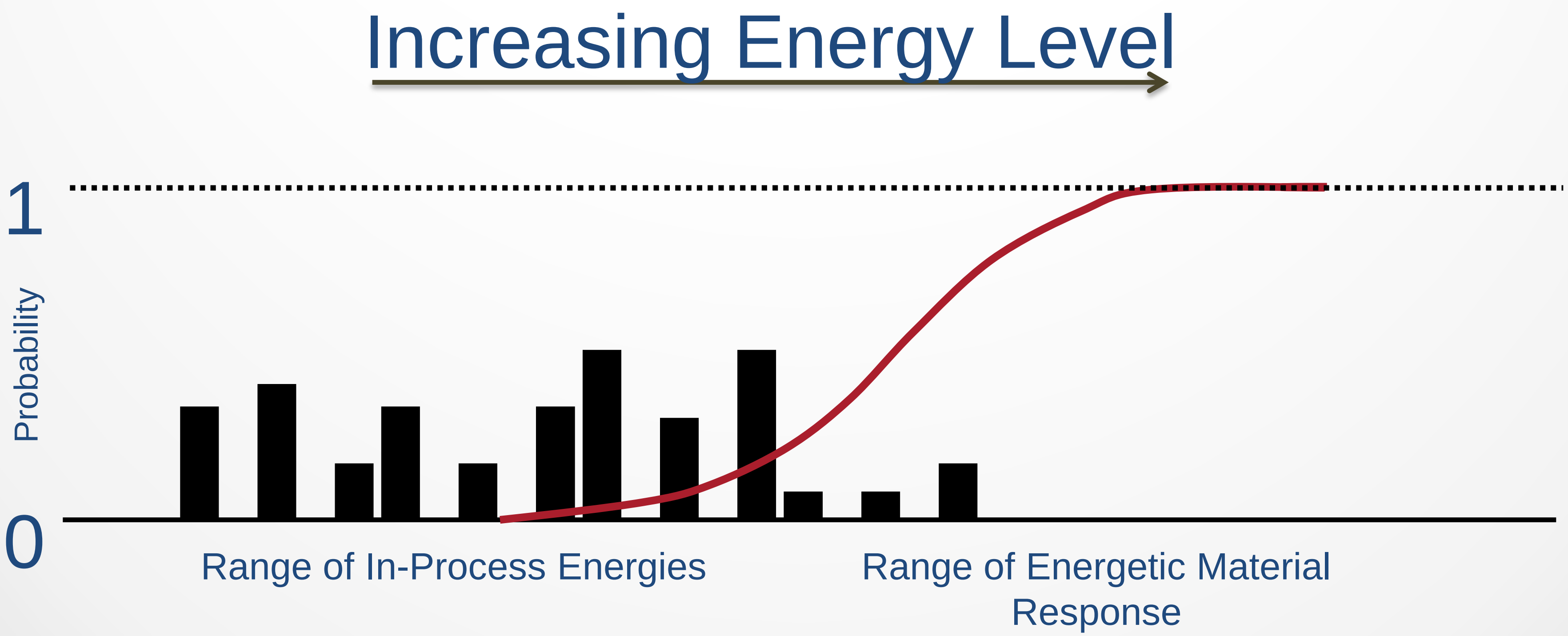
Modified Bureau of Mines Impact

ABL ESD

ABL Friction

SBAT

In-Process Energies verses Material Response Data



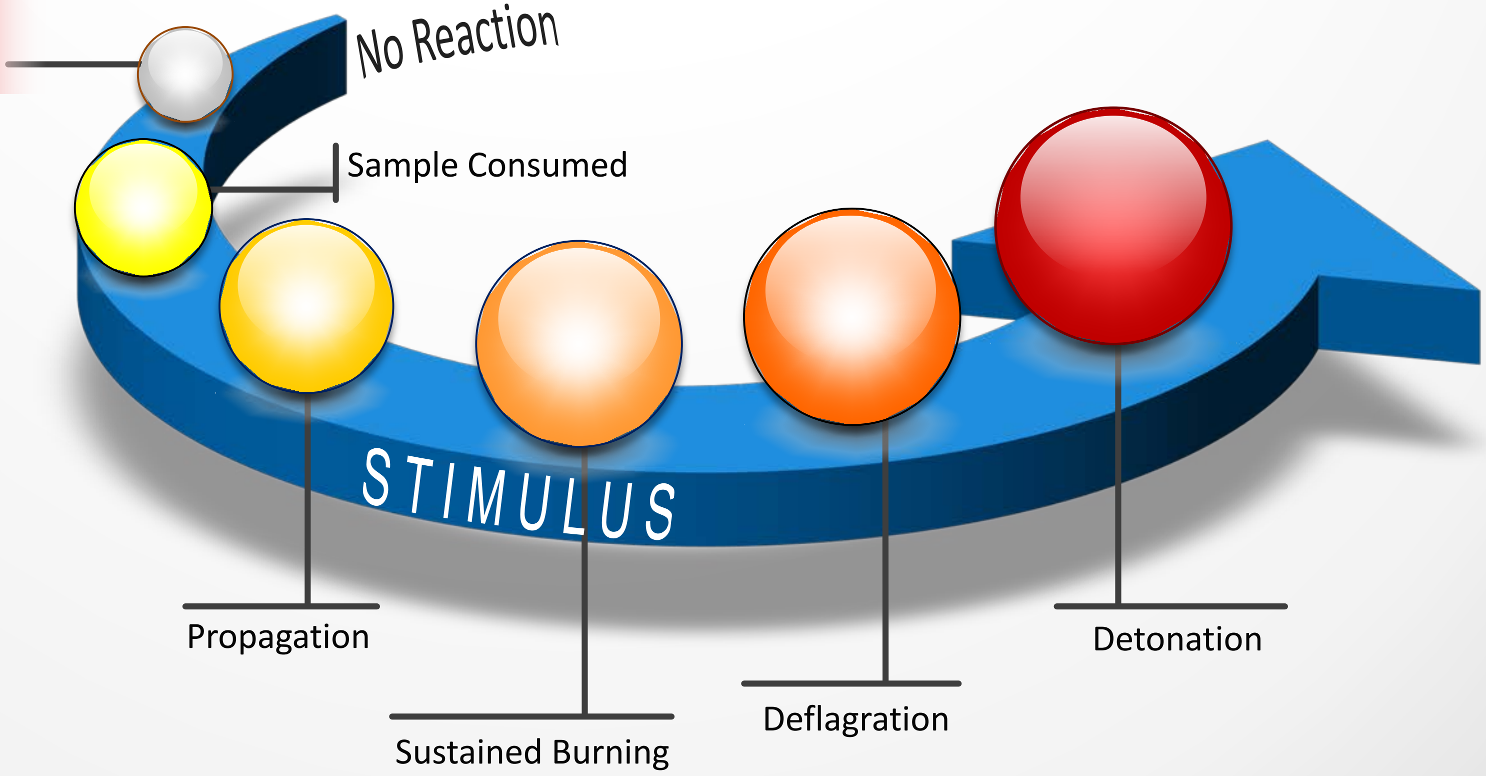
In-Process Sensitivity Testing

Focuses on the Onset of Reaction

Onset/Partial Reaction

Primary
- Visible Light
- Gas Detection
- Charring
- Smoke/Jetting

Secondary
- Audible



Reactivity Tests

(Modified to Simulate In-Process Conditions)

- Propagation
- Small-Scale Burn
- Sub-Scale Burn/External Fire
- Critical Height
- Internal Ignition Tests
- Pressure/Time
- Koenen
- Cap Sensitivity Test
- Deflagration to Detonation Transition DDT
- Card Gap
- Critical Diameter
- TNT Equivalence
- Process Simulation

Reactivity Tests

(Modified to Simulate In-Process Conditions)

Why In-Process Classification/Characterization Testing is Important to all of us

- Process/Equipment Design & Operations – Safe & Reliable
- Facility Design, Siting, & Construction
- Attended vs. Remote Operations
- Appropriate Work Station Protection
- Aging and Surveillance
- Regulatory Compliance

2. In-Process Classification System

Systematic Risk Assessment is ***<u>Coupled with</u>*** "In-Process" Classification/Characterization

- Simple to Complex Systems/Processes
- Multitude of potential scenarios
- Variations in energetic material
  - Compositions
  - Physical States
- System insult energies (normal & abnormal)
- Variable process configurations and confinement

In-Process Characterization System Test Series

<u>Substances</u>

Sensitivity tests (fundamental handling/ processing tests)

- **IP Series 1**: Sensitivity testing for safe testing and risk assessment
  - Impact sensitivity test
  - Friction sensitivity test
  - ESD sensitivity test
  - Thermal sensitivity test

Reactivity tests (In-Process Hazards Characterization)

- **IP Series 2**: Presence of explosive properties
- **IP Series 3**: Flame and shock sensitivity tests
- **IP Series 4**: Hazards with processing configuration

<u>Articles</u>

Sensitivity tests (fundamental handling/ processing tests)

- **IP Series 5**: Sensitivity testing for risk assessment

Reactivity tests (In-Process Hazards Characterization)

- **IP Series 5**: Susceptibility of configuration to propagation

In-Process Characterization System Test Series

	Initiation	Sustained Reaction	Fire/Explosion Transition
Substances	IP Series 1 & 2	IP Series 3	IP Series 4
Articles	IP Series 5	IP Series 5	IP Series 5

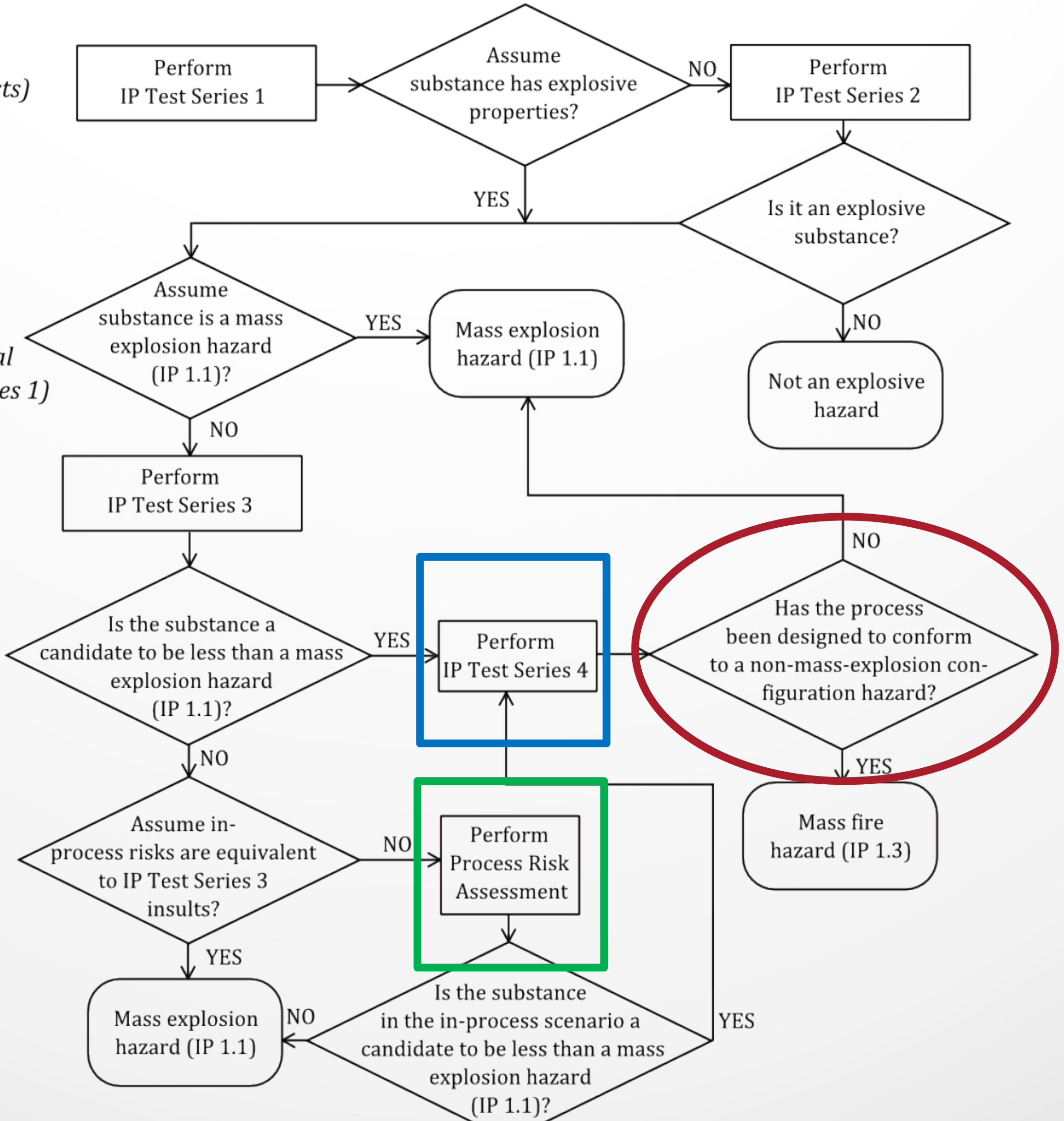
Energetic ***Substances*** Classification Decision Tree for In-Process Operations

IP Test Series 1
(Required Fundamental Handling and Processing Tests)
Impact Sensitivity Test
Friction Sensitivity Test
ESD Sensitivity Test
Thermal Sensitivity Test

IP Test Series 2
(Equivalent to the UN Manual of Test and Criteria Test Series 1)
UN Gap Test
Koenen Test
Time/Pressure
Internal Ignition Test

IP Test Series 3
Small-Scale Burning Test
#8 Cap Sensitivity Test
Shock Sensitivity Test

IP Test Series 4
Process Simulation Test
Critical Diameter Test
Critical Height Test
Koenen Test
Internal Ignition Test



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Energetic Substances Classification Decision Tree for In-Process Operations

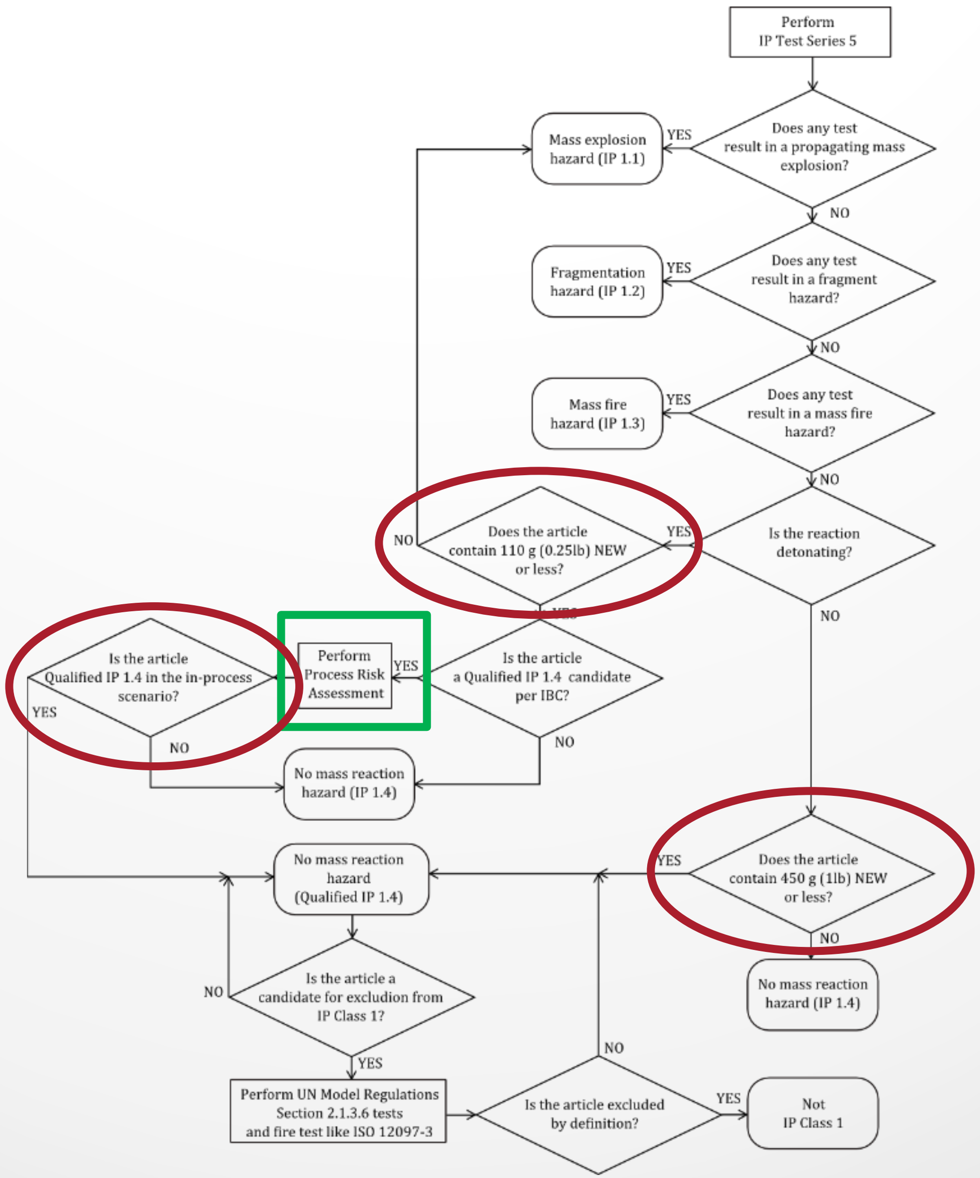
IP Test Series 3

Small-Scale Burning Test
#8 Cap Sensitivity Test
Shock Sensitivity Test

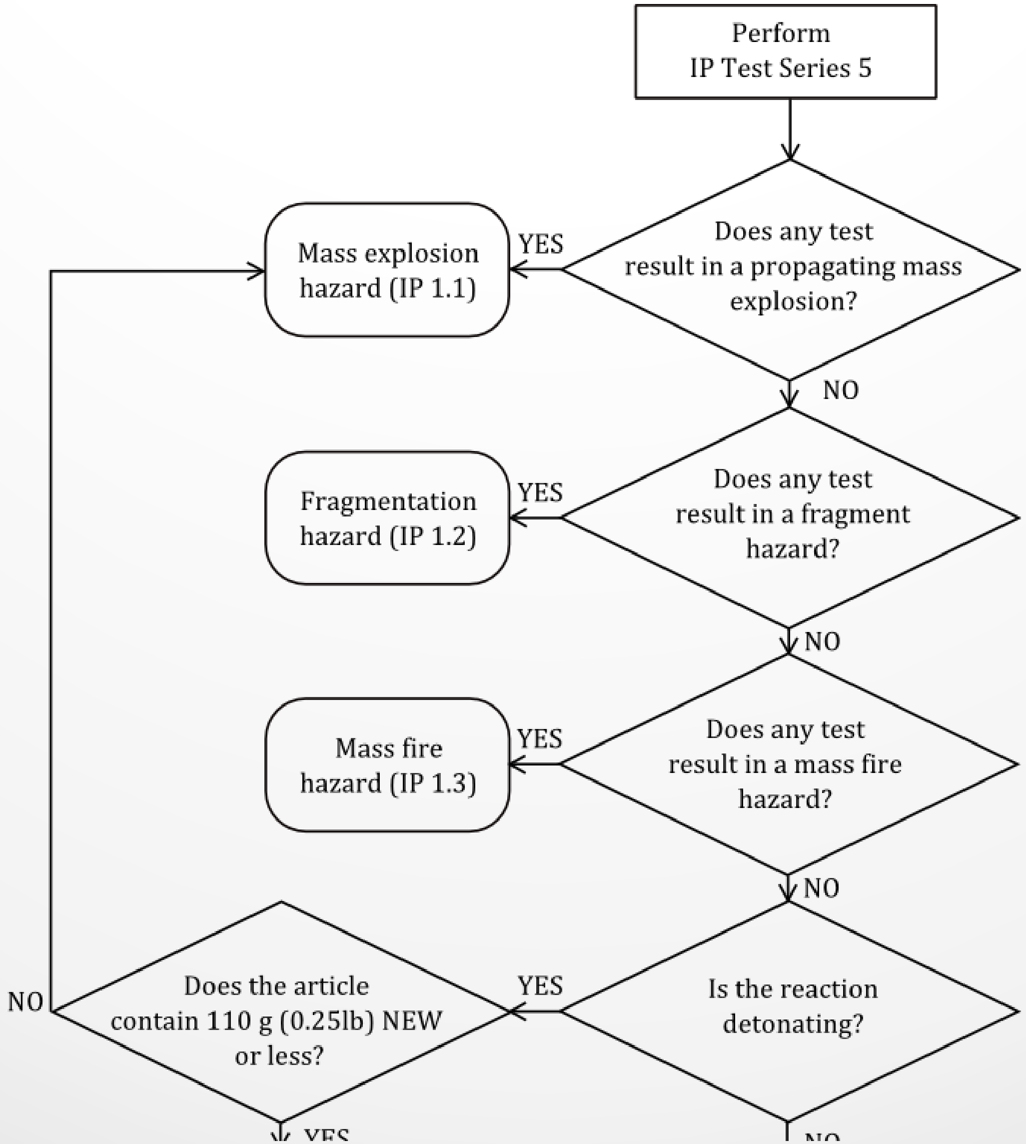
IP Test Series 4

Process Simulation Test
Critical Diameter Test
Critical Height Test
Koenen Test
Internal Ignition Test

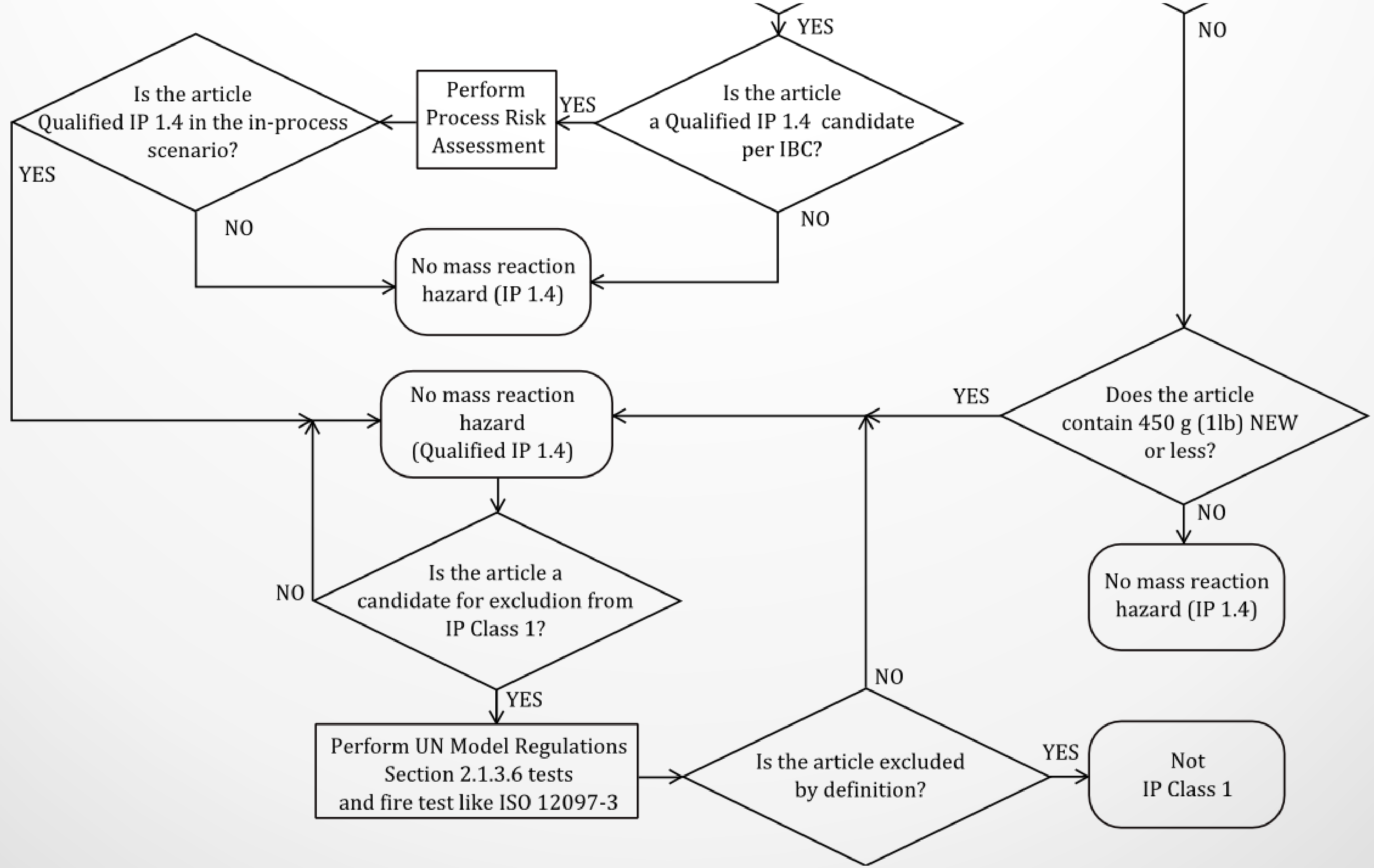
Energetic Articles Classification Decision Tree for In-Process Operations



Energetic Articles Classification Decision Tree for In-Process Operations



Energetic Articles Classification Decision Tree for In-Process Operations



In-Process Characterization System

IP Class 1 Division 1 (IP 1.1) - Mass explosion hazard

IP 1.2 - Fragment hazard (articles)

IP 1.3 - Mass fire, minor fragment hazard

IP 1.4 - No mass reaction hazard (articles)*

IP Qualified 1.4 (IP 1.4Q) - Non-propagating articles

IP 1.5 classed as IP Division 1.1

IP 1.6 - (Not yet addressed)

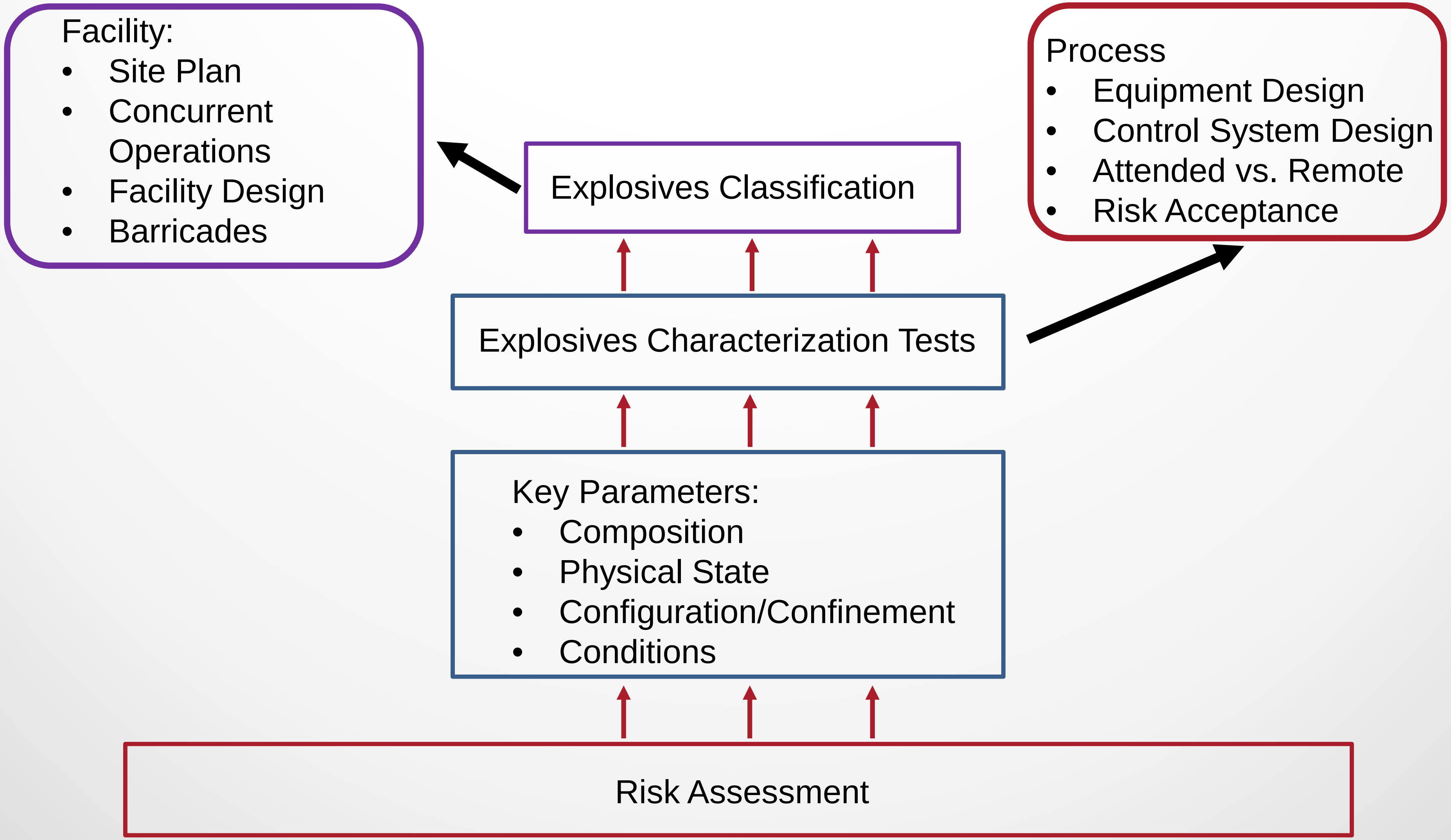
* IP DIVISION 1.4 NOT APPLICABLE FOR SUBSTANCES UNLESS PACKAGED

Application of In-Process Classification Test Data:

- Support the *risk assessment* for:
    - Development (R&D) of new energetic materials and articles
    - Scale-up, Process Design, and Manufacturing of energetic materials/articles
    - Characterization of Home-Made Explosives (HME), Improvised Explosive Devices (IEDs) and NANO-Energetic Materials for safe identification, handling, and disposal
- Safe Process Design
    - Operating Parameters
    - Equipment Design/Specification
- Facility Design and Siting
    - Maximum Credible Event Analysis

Note: The In-Process Classification System does **NOT** define Too Sensitive, Too Thermally Unstable, or *Forbidden* since these can only be determined by the risk assessment and acceptance for a given in-process configuration.

Relationship of ***Risk Assessment*** to *In-Process Classification of Explosives*



Summary

- ***In-Process Classification of Explosives***:
  - is dependent on systematic risk assessment of the process configuration/conditions
  - addresses the variable and unique aspects of explosives in “non-transport” configurations
  - is essential for proper:
    - Process Design
    - Facility Design
    - Facility Siting

3. Explosives Testing Users Group (ETUG)

ETUG Participants

LABORATORIES	
Applied Research Associates, Inc. /Air Force Research Lab (Tyndall Air Force Base)	DHS S&T/Transportation Security Laboratory
ARDEC – Picatinny Arsenal	Dugway Proving Grounds - AMTEC Corporation
Army Research Lab – Aberdeen Proving Grounds	Edwards Air Force Base
ATF/National Center for Explosives Training & Research	Eglin Air Force Base
BAE Systems: Kingston TN	Energetic Materials Research and Testing Center (EMRTC)
BAM – German National Laboratory	Federal Bureau of Investigation (FBI)
Battelle – Ohio Laboratory	Lawrence Livermore National Laboratory
Canadian Explosive Research Laboratory (CERL	Los Alamos National Laboratory

ETUG Participants

LABORATORIES	
Naval Air Warfare Center (China Lake)	Safety Management Services, Inc./TEAD
Naval Research Laboratory	Sandia National Laboratory : Albuquerque, NM
NSWC-Indian Head Division	Sandia National Laboratory : Livermore, CA
NTK Aviation America, Inc.	Australian Munitions: Mulwala, Australia
Orbital ATK: ABL, Bacchus, Elkton, Lake City, Promontory,	TNO – Netherlands National Laboratory
Rocky Mountain Scientific Laboratory	Vista Outdoors: Federal Cartridge

ETUG Charter

The ET Users Group Participants collaborate to ***improve*** and ***standardize*** ***in-process characterization test methods*** for explosives, propellants and pyrotechnic materials.

– Based on **"ETUG-GS01-15: ETUG Standard for In-Process Classification of Explosives"**

Our approach includes ***systematically minimizing the variables*** associated with energetic materials testing to enable consistent/repeatable test data and interpretation of test results.

This will be accomplished by:

– Developing procedures and methods
– Applying technologies
– Reaching consensus
– Performing periodic "Round Robin" test series on standard materials

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ETUG Charter Includes

Sensitivity Testing: Ability to initiate from an energy stimulus

- Friction, Impact, ESD, Dust Explosibility, Auto-ignition Temperature, etc.

Requirements:

- Must Simulate ***In-Process Energy Stimuli*** & ***Conditions***
- Data must be in ***Engineering Units***

Reactivity Testing: Propagation characteristics after ignition, including: rapid burning, deflagration or detonation

Requirements:

- Must Simulate ***In-Process:***
  - ***Energy Stimuli***
  - ***Configuration***
  - ***Conditions***

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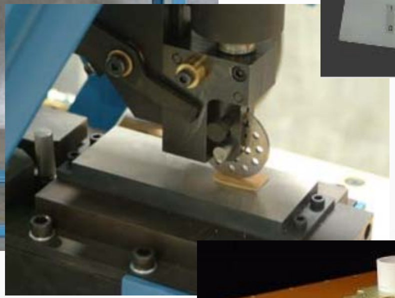
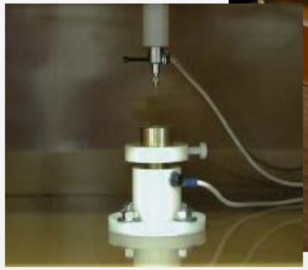
ETUG Standardization Efforts Include

- Detailed Procedures & Protocols
- Machine Verification (Specifications, Calibration, etc.)
- Test Sample
  - Consistent Sample and Environmental Conditions
  - Consistent and Repeatable Sample Application
- Non-subjective Reaction Detection
- Proper application of Statistics
  - Data Collection
  - Data Comparison

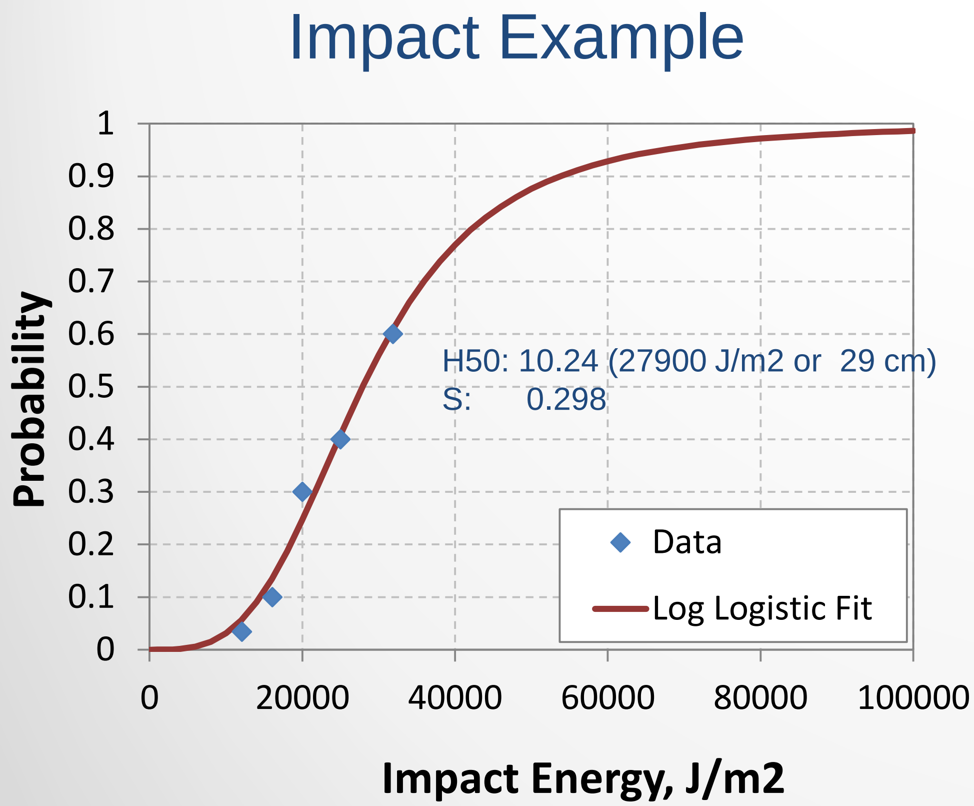
Sensitivity Test Equipment
ETUG Initial Focus

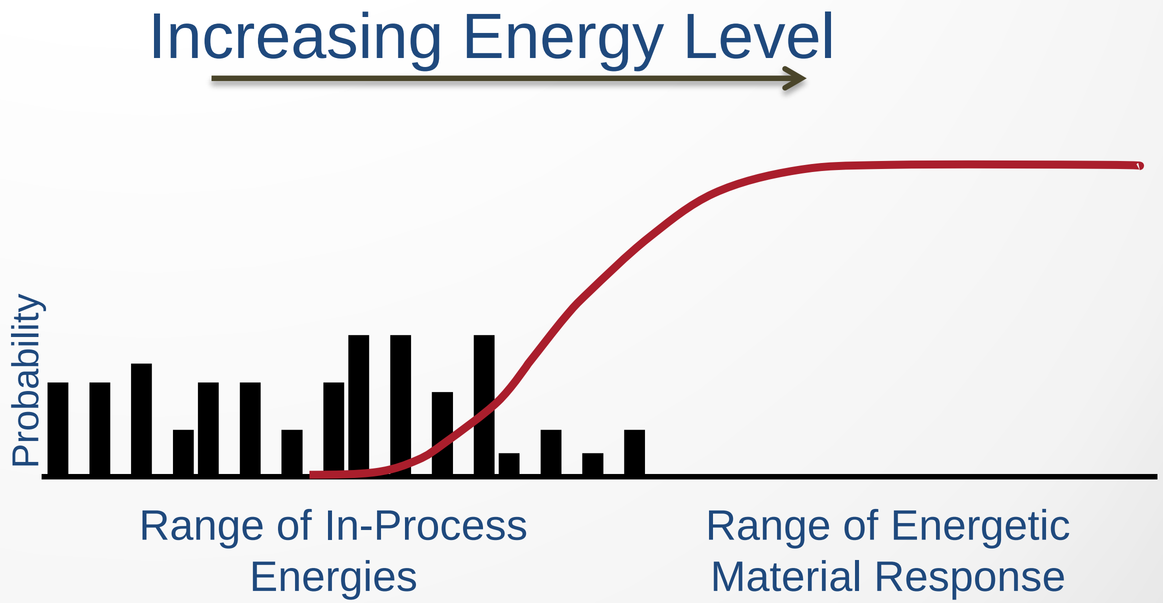
- Friction:
  - ABL Friction
  - BAM Friction
- Impact
  - MBOM Impact
  - BAM Friction
- ESD
  - Approaching
- Thermal
  - DSC
  - SBAT





In-Process Energies verses Material Response Data





Detailed Procedures

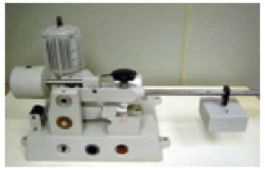
- Procedures in ETUG website library
- Procedures Address
  - Machine Verification
  - Verify Site Repeatability
  - Gas Analyzer Verification
  - High-Speed Video Application
  - Sample Receipt and Preparation
  - Bruceton Testing

Title: BAM Friction Test	No.: X	Page: 1 of 10
Reference: UN Test 3 (b) (i), AOP-7, Ed. 2, Rev. 1	Rev: X	Date: X

TERMS OF USE NOTICE

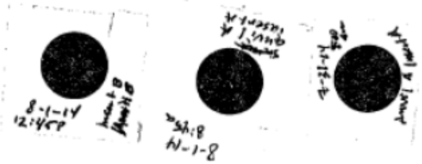
This procedure was developed for personnel, operations, and facilities at the Safety Management Services, Inc. (SMS) Test Site, which may be different from your test site. Use of this procedure constitutes an agreement to hold harmless SMS (www.smsenergetics.com), the ET Users' Group (www.etusersgroup.org), or any associated entity for damages caused by the use or misuse of this content. The user is fully responsible to ensure that the procedures and testing at their facilities comply with all applicable codes and standards.

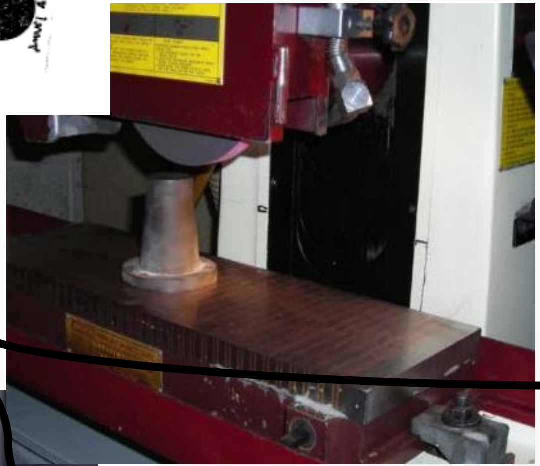
THIS TRAINING MODULE IS TO BE USED AS A COMPANION TO THE ET USERS' GROUP TEST METHODS MATRIX™

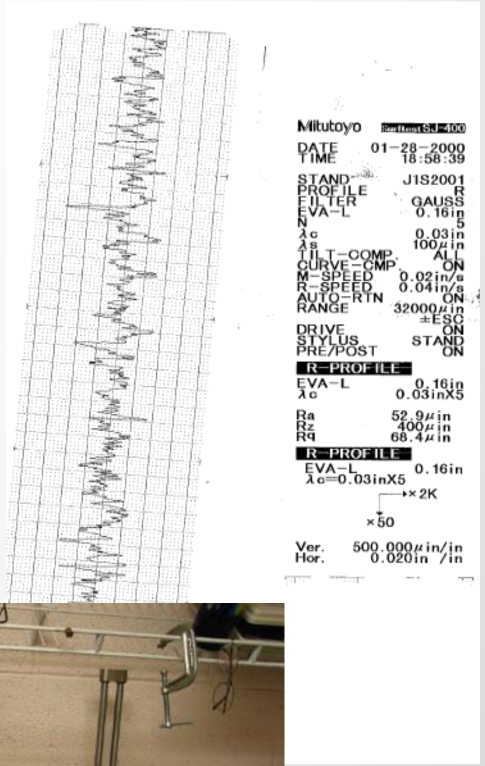
1.0	SCOPE	
1.1	This document describes the basic safety requirements and procedures for conducting a BAM Friction Test. Sample preparation, test configuration, and test operations, for the BAM Friction Test are prescribed. The procedure for analyzing, evaluating and interpreting the data is also described. This test is used to determine the sensitivity of a substance when subjected to a sliding frictional force. 	
1.2	This procedure is approved for use with materials that present no worse than the following hazards:	
1.2.1	☒ **Forbidden: 150 mg maximum**	☒ Propellants: 5 grams maximum
1.2.2	☒ **HME/ IED: 150 mg maximum**	☒ Pyrotechnics: 5 grams maximum
1.2.3	☒ Wetted primaries: 5 grams maximum	☒ Solids
1.2.4	☒ Secondaries: 5 grams maximum	☒ Liquids
2.0	REQUIREMENTS	
2.1	**Except as provided in Section 7.0, changes as defined in the Management of Change Protocol (see Section 3.2) must be properly reviewed so that any hazards introduced by the change are identified and controlled prior to implementation of the change.**	
2.2	Copies of this procedure shall be made available in the testing area control room.	
2.3	Persons conducting this test must be trained in this procedure and the applicable support procedures. The record of this training must be properly documented.	
2.4	The general operating procedure for the test site shall be the overall governing procedure and shall be followed in conjunction with the safety rules and techniques in this procedure.	
3.0	APPLICABLE DOCUMENTS	
3.1	General Operating Procedure for the test site	
3.2	Management of Change Procedure for Testing, current revision.	
3.3	Definition of Terms for Explosives, current revision	
3.4	Energetic Material Transportation, current revision	
3.5	Firing Procedure, current revision	

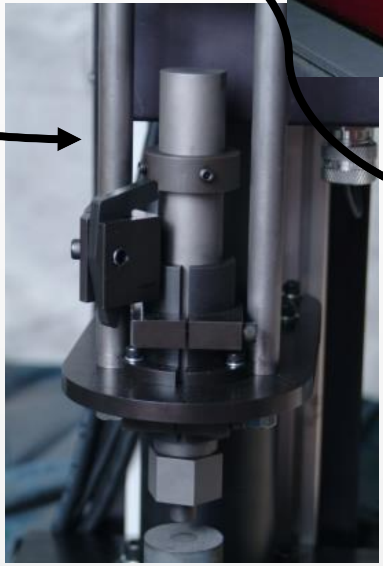
Machine Verification: Example
Modified Bureau of Mines (MBOM) Impact

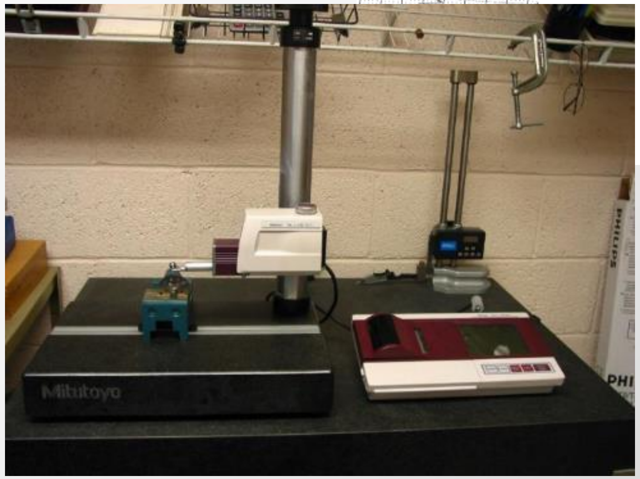
- Home position
- Verify full impact
- Surface finish
- Inspect surfaces
- Drop weight guide bar alignment
- Drop time (60 cm): 365 ms
- No binding in collar
- Verify weights





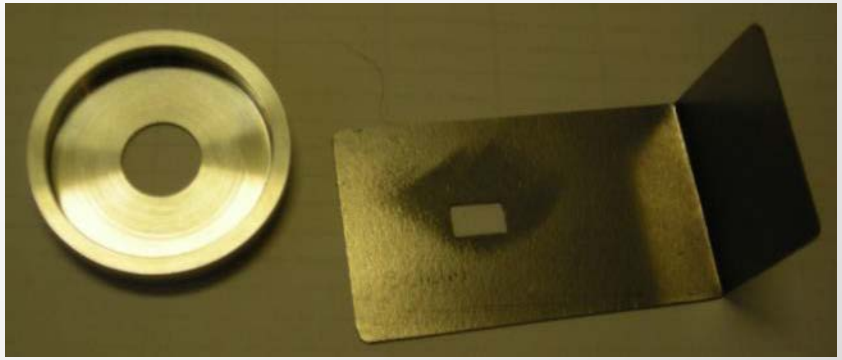






Standard Test Samples Used

- Test Samples Used:
  - HMX 4 micron, shipped to each test site
  - Smokeless Powder
    - Hodgdon Clays, purchased by each lab or shipped from SMS to Germany and the Netherlands
    - Hodgdon Varget, purchased by SMS and manufactured by Thales
- Sample Conditioning:
  - Sample dried for 20-24 hours at 50°C
  - Prior to testing: Sample conditions at 65-75°F and 10-45% r.h. for 2 hours prior to testing
  - Moisture content measured
- Sample Application
  - Use of sample templates
  - On-line demonstration



Standardized Reaction Detection

- **Gas Analyzer**: Impact, Friction, & ESD
  - Numerical result of CO concentration
  - 1+ppm changes in CO
- **High Speed Video (HSV):** Impact & Friction
  - Jetting or Light
  - Video documentation
- **HSV & Algorithm (GoDetect-ESD):** ESD
  - Automatic Reaction Detection based on criteria:
    - Buoyancy, brightness, shape, uniformity, and color.
  - Video documentation

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Standard Gas Analyzer and Chambers

ABL Friction Chamber

ABL ESD Chamber

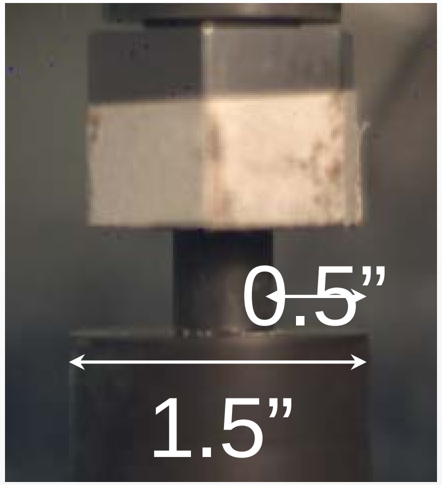
MBOM Impact Chamber

*Drawings on the website www.etusersgroup.org/round-robin-current

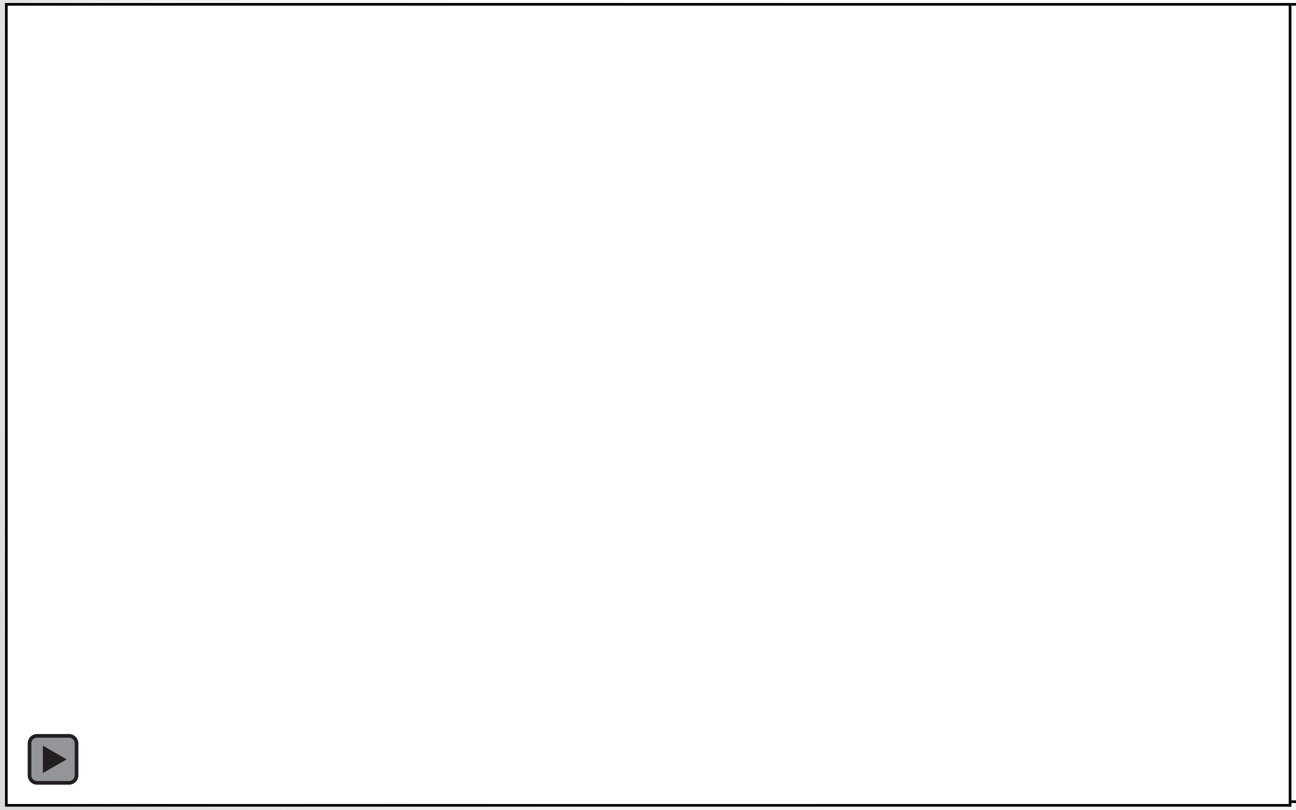
HSV Reaction Determination: Jetting

- Considered a Go if jet speed is greater than 1000 inches per second for heights 20cm or less
  - If when filming at 2000 frames per second, in one frame the particles travel from under the insert to the edge of the anvil
- Video of No-Go and Jetting reactions are here:

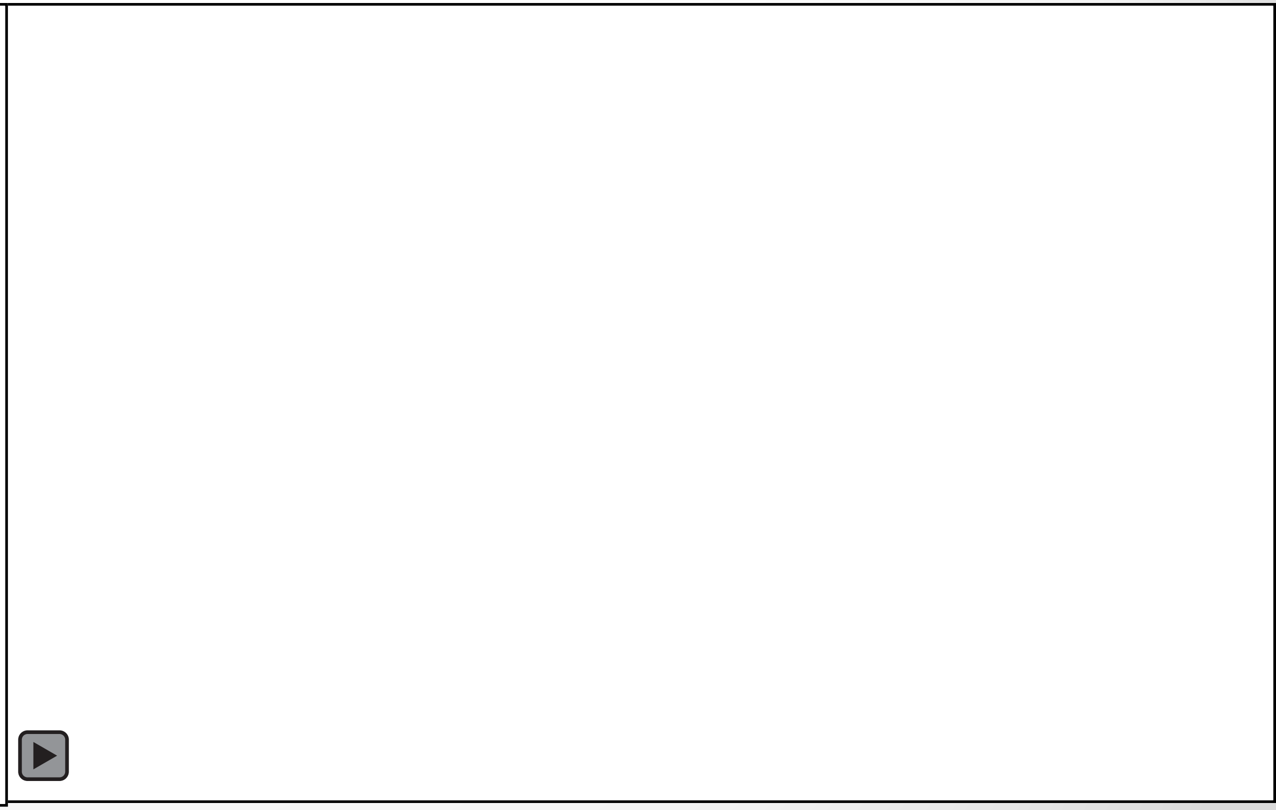
http://www.etusersgroup.org/reaction-detection-discussion/



Reaction Determination: Jetting



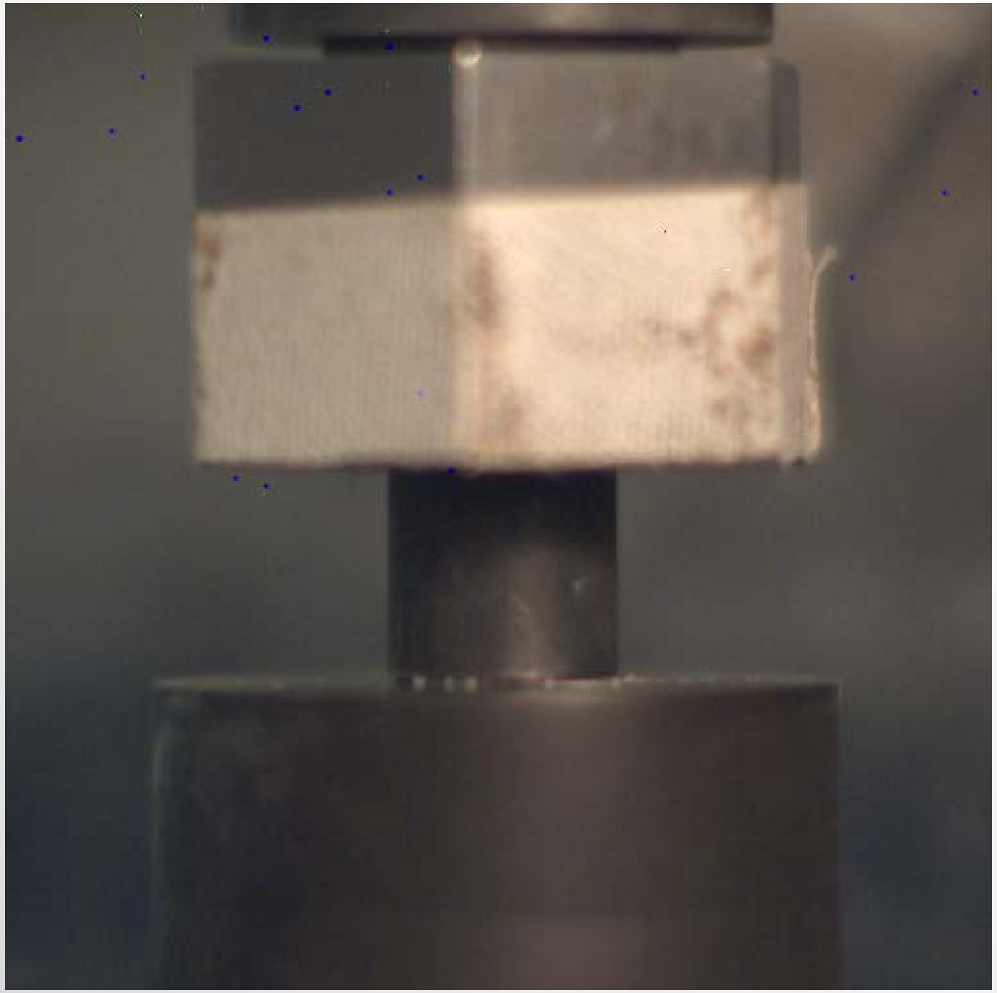
No-Go



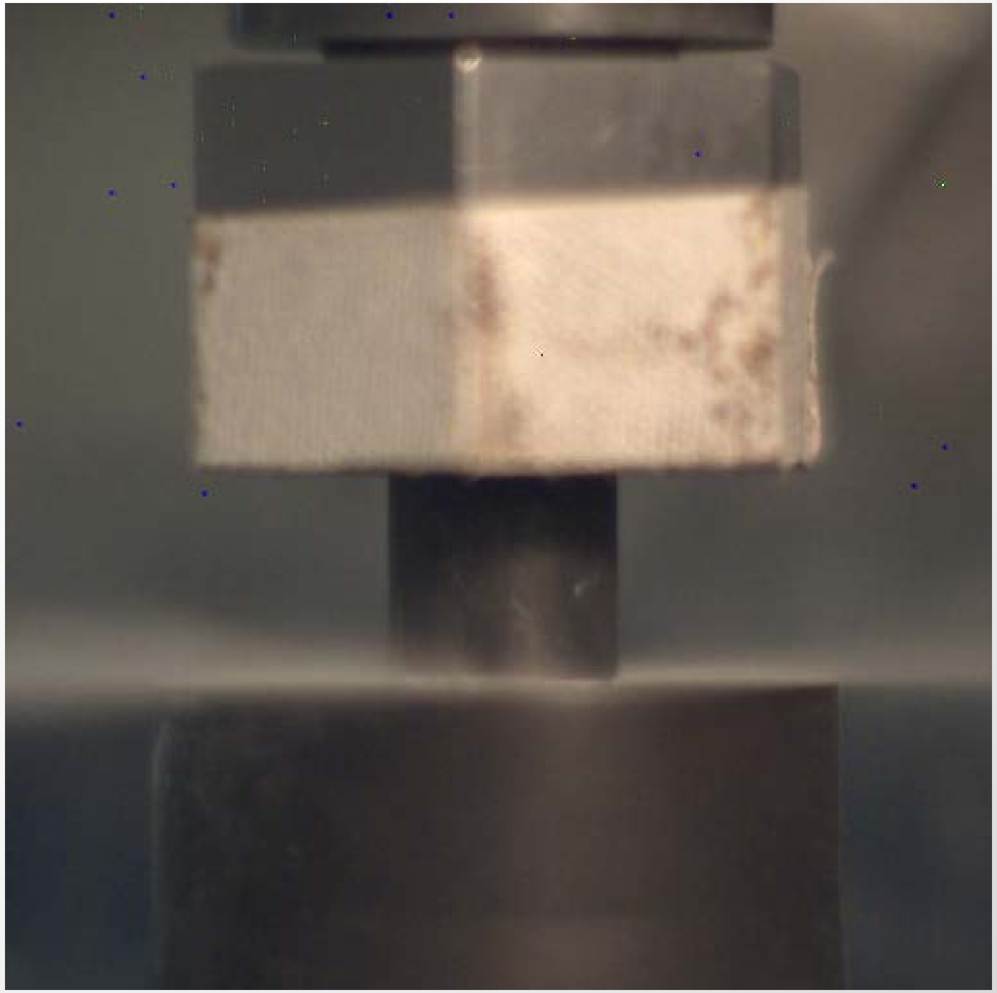
Go-jetting

Impact Jetting

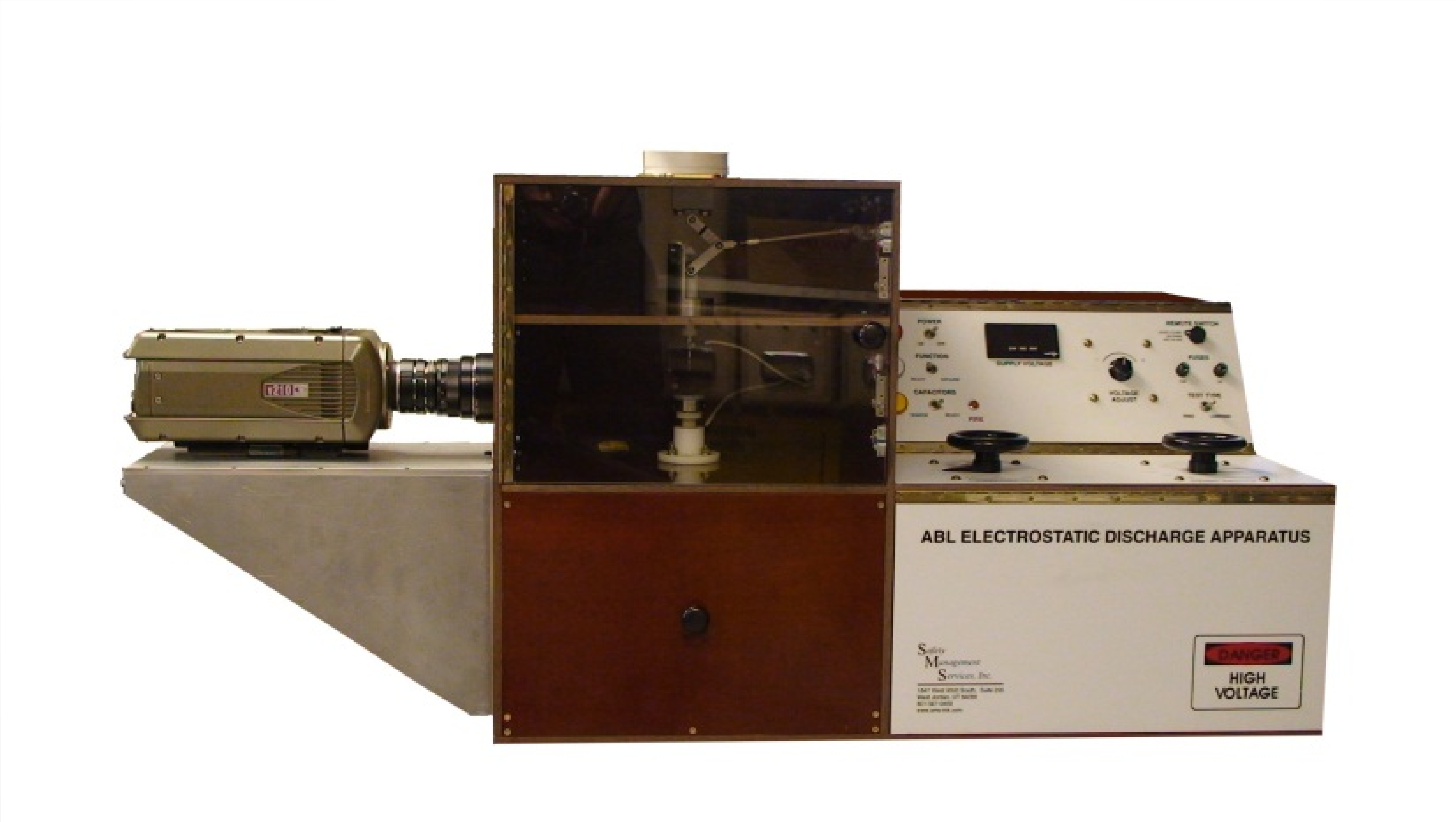
Frame 1



Frame 2

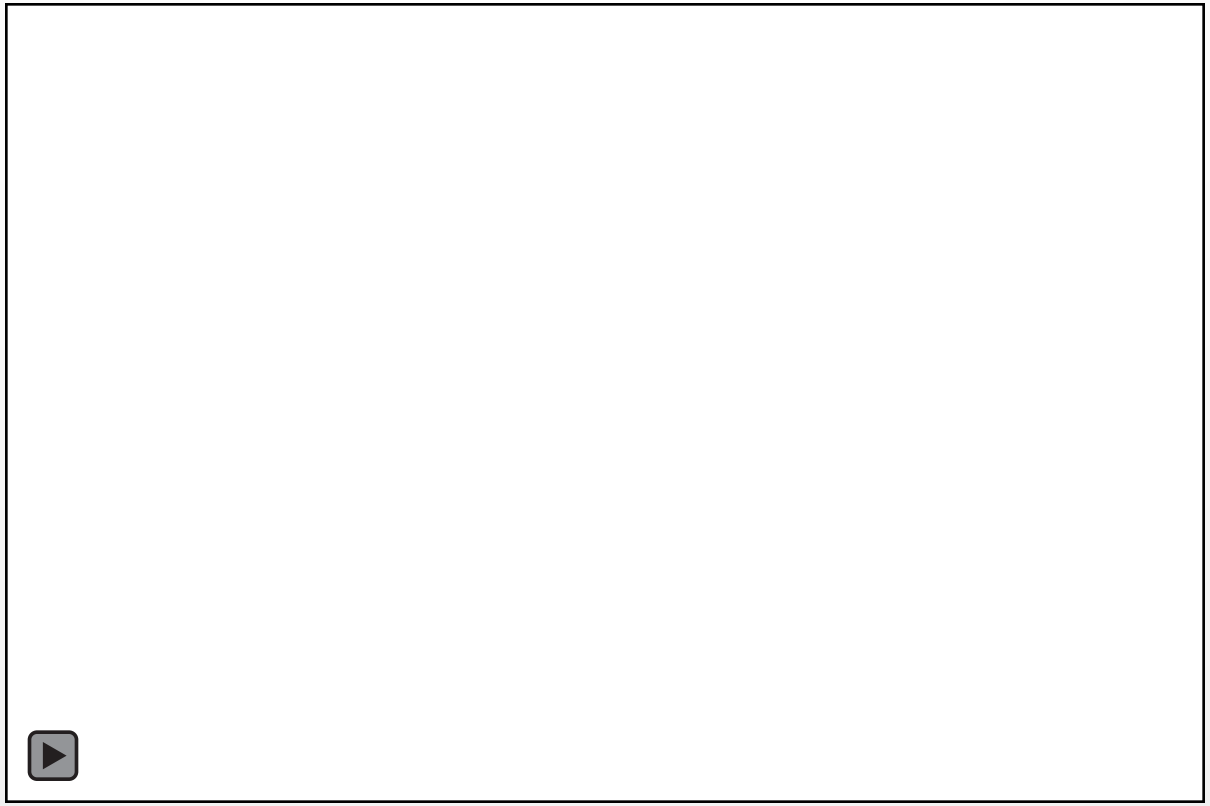


High-Speed Video w/ Algorithm (Automated)



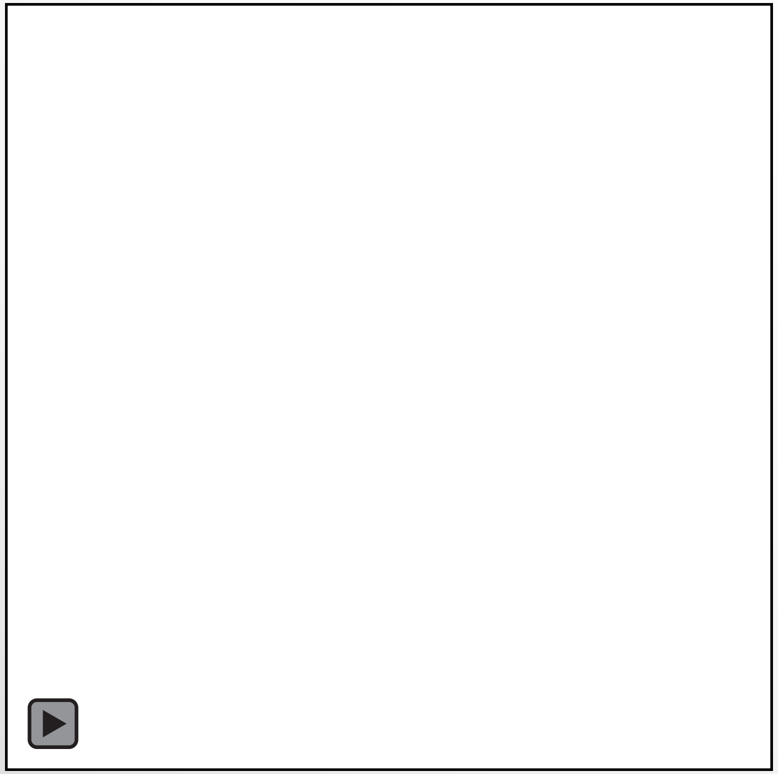
Case Study: Automated HSV-ESD

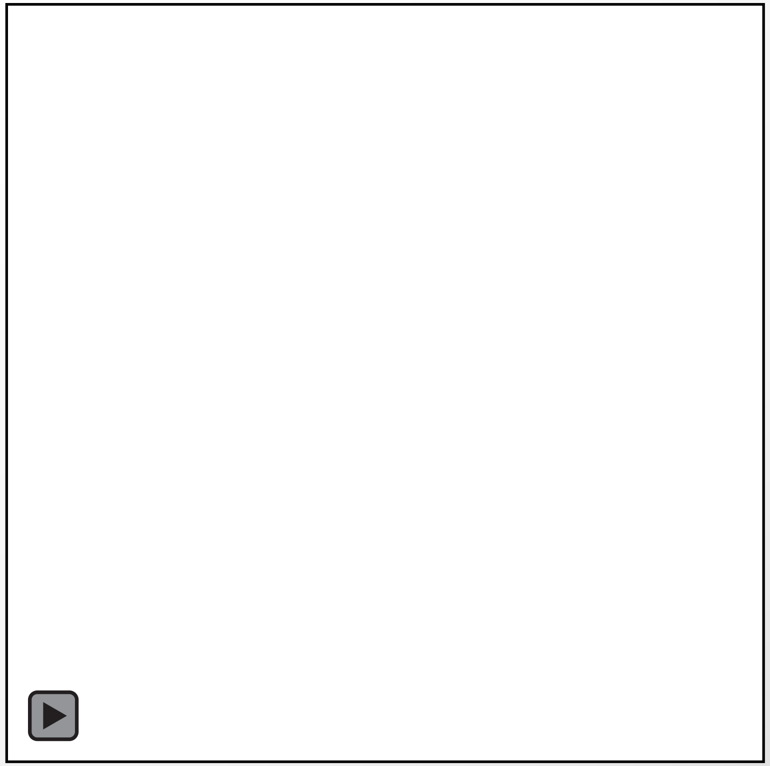
- Video of ESD tests at Normal Speed



Case Study: Automated HSV-ESD

- High-speed video (at lower frame rate than what is used in GoDetect algorithm)





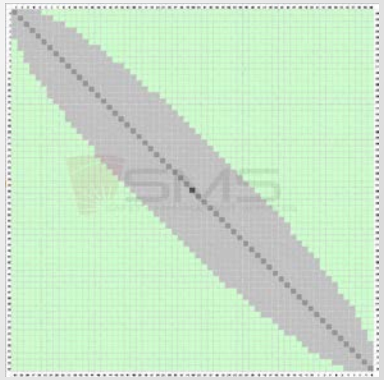
Statistical Comparison of Results

- Statistics used to determine if results between laboratories are statistically different.
  - The SRC Method (as adopted by the ET Users Group) uses a t-value. t-value is a measure of the difference between results, with higher values indicating greater disagreement. t-values greater than 3.75 indicate a statistically significant difference. Can be used with Probit, Bruceton, SEQ, Langlie, or other adaptive test method.

T-Statistic (ESD)	SMS	ATK	NRL (Trial 1)	NRL (Trial 2)
SMS	-	0.81	0.02	1.50
ATK	0.81	-	0.27	1.02
NRL (Trial 1)	0.02	0.27	-	0.61
NRL (Trial 2)	1.50	1.02	0.61	-

T-Statistic (Impact)	SMS	ATK	NRL (Trial 1)	NRL (Trial 2)
SMS	-	2.49	3.56	1.80
ATK	2.49	-	7.67	4.56
NRL (Trial 1)	3.56	7.67	-	1.41
NRL (Trial 2)	1.80	4.56	1.41	-

  - A Chart Significance Method (also adopted by the ET Users Group), can be used to determine statistical significance for trials completed at a given energy level.



Summary

- **ETUG Participants** are fulfilling our **Charter**
- The **ETUG TMM** facilitates **test standardization** and **technical collaboration**
- The **ETUG Library** is a resource for the **standard procedures** and **protocols** developed to date
- **Our standards** are being validated via **Round Robin testing**
- ***Standardized Testing*** based on **sound principles** results in:
  - **Accurate & Repeatable Test Results**
  - **User Confidence**
- **In-Process Classification/Characterization** required for **proper facility siting, risk assessment,** and **risk management**

ET Users Group

4. ETUG Test Methods Matrix™
Database

*A **Resource** for In-Process Classification and Characterization Information*

ETUG Test Methods Matrix™ Database

Location: www.etusersgroup.org/test-methods-matrix

Objectives:

1. Documents the Technical Basis for ***In-Process*** and ***UN Tests***
2. An **informal tool** to facilitate technical discussions

Sponsor: ETUG

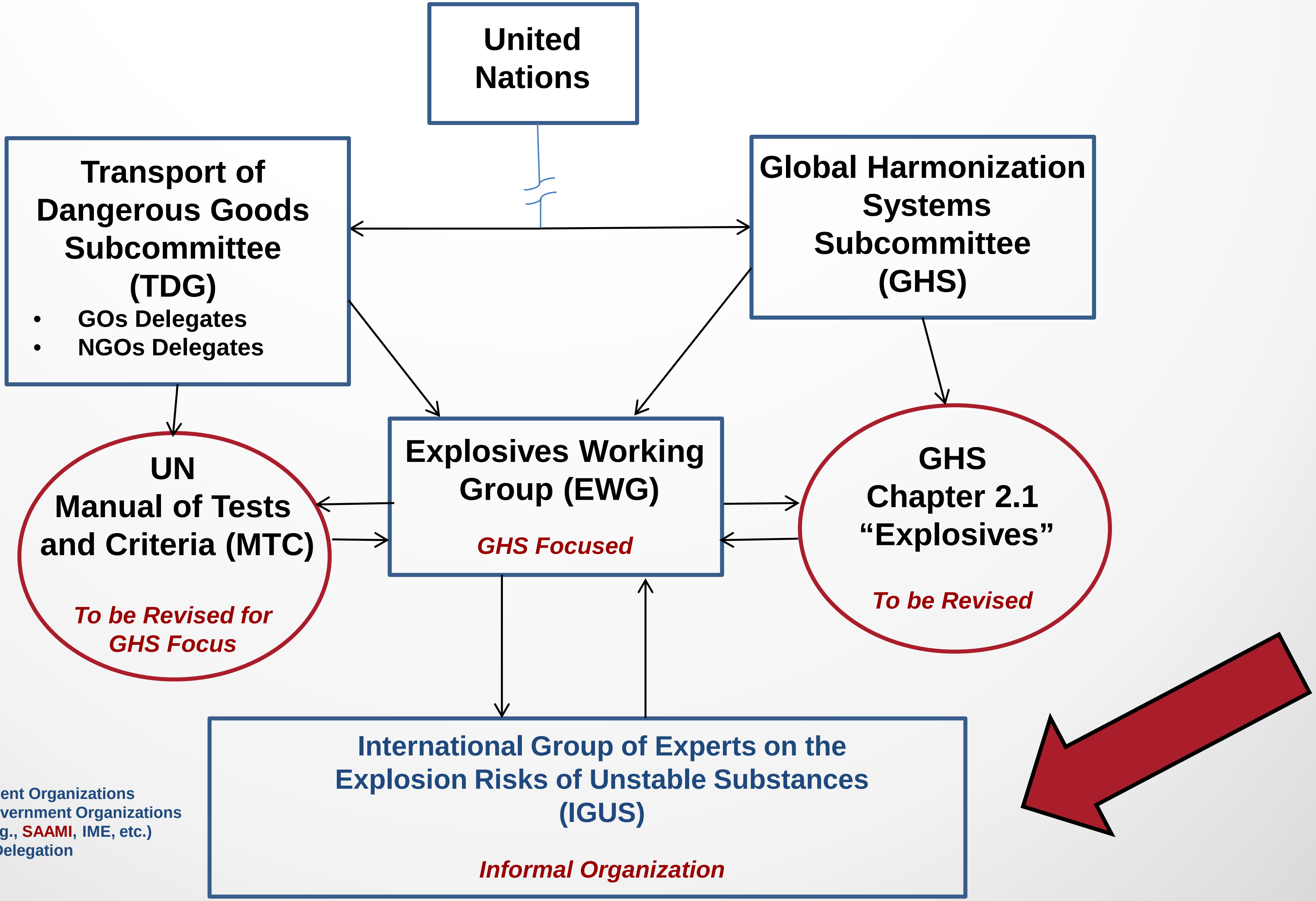
Data base Stewards/"gate keepers":

– **ETUG**: In-Process Classification
– **IGUS**[1,2]: UN MTC

1. International Group of Experts on the Explosion Risks of Unstable Substances (IGUS)
2. IGUS is comprised of members of the United Nations Explosives Working Group (UN EWG)

ET Users Group

UN EWG Charter



- GOs: Government Organizations
- NGOs: Non-Government Organizations (e.g., SAAMI, IME, etc.)
- SMS on SAAMI Delegation

Demonstration

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TEST METHODS MATRIX™

Introduction

The purpose of the ET Users Group is to improve and standardize In-Process Test methodologies. To facilitate this purpose, the ET Users' Group Test Methods Matrix™ has been adopted and is being developed by participating members. This Test Methods Matrix™ database outlines the purpose, key test parameters, and indicators for each sensitivity and reactivity characterization test prescribed in the technical paper entitled "In-Process Hazard Characterization of Explosives" (click to view). In-Process testing simulates in-process conditions and is used to augment risk-assessment of processing and handling of propellants, explosives, and pyrotechnics (PEP) materials and articles. The database documents the technical basis for each test and provides pictures and videos of various reaction types. This allows each test to be technically scrutinized to determine improvements and required standardization.

Additionally, the ET Users Group Test Methods Matrix™ has a section on the UN Manual for Testing and Criteria. This section is outlined based on the test series listed in the UN Manual and follows the same format as discussed above. The UN Manual tests are included in the database since many of the in-process tests use similar or the same test parameters. The International Group of Experts on the Explosion Risks of Unstable Substances (IGUS) has stewardship for any additions or modifications to this section.

In-Process (IP) Tests

IP Series 1: Is the bulk material very sensitive?

- Impact
- Friction
- ESD
- Thermal

IP Series 2: Is the bulk material explosive?

- Zero gap test
- Internal ignition test

IP Series 3: Is the material a candidate to be less than a mass/ high explosion hazard (1.1) for the current process?

- Substance thermal stability test
- Small-scale burning test
- Cap sensitivity test
- NOL Card Gap Test

IP Series 4: What are the design restrictions to conform to a non-mass/ high explosion hazard configuration?

- Critical height
- Critical diameter
- Internal ignition test

UN Tests

UN Series 1: Is the material potentially explosive?

- Test 1 (a) UN Gap test
- Test 1 (b) Koenen test
- Test 1 (c) (i) Time/pressure test
- Test 1 (c) (ii) Internal ignition test

UN Series 2: Is the substance too insensitive for inclusion in Class 1?

- Test 2 (a) UN Gap test
- Test 2 (b) Koenen test
- Test 2 (c) (i) Time/pressure test
- Test 2 (c) (ii) Internal ignition test

UN Series 3: Is the substance too dangerous for transport in the form in which it was tested? and Is the substance thermally stable?

- Test 3 (a) (i): BOE Impact
- Test 3 (a) (vii): MBOM Impact
- Test 3 (b) (i): BAM Friction
- Test 3 (b) (iv): ABL Friction
- Test 3 (c) (i) Thermal stability test at 75°C
- Test 3 (c) (ii) SBAT thermal stability test at 75°C
- Test 3 (d) Small-scale burning test

Demonstration

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TEST METHODS MATRIX™

UN Gap Test

Contents [hide]

Test Details

Test Purpose

The purpose of the UN Gap Test is to measure the ability of a substance to propagate a detonation from defined shock and confinement.

INTRO

+ Main

UN SERIES 1

+ Test 1 (a) UN Gap test
+ Test 1 (b) Koenen test
+ Test 1 (c) (i) Time/pressure test
+ Test 1 (c) (ii) Internal ignition test

UN SERIES 2

+ Test 2 (a) UN Gap test
+ Test 2 (b) Koenen test
+ Test 2 (c) (i) Time/pressure test
+ Test 2 (c) (ii) Internal ignition test

UN SERIES 3

+ Test 3 (a) (i): BOE Impact
+ Test 3 (a) (vii): MBOM Impact
+ Test 3 (b) (i): BAM Friction
+ Test 3 (b) (iv): ABL Friction
+ Test 3 (c) (i) Thermal

Test Variations

The UN Gap Test is used in both Test 1 (a) and Test 2 (a). In UN Test 1 (a) no gap is between the booster and substance. In UN Test 2 (a) there is a PMMA spacer between the booster and the substance.

Key Parameters

Key Parameter	Objectives	Origin	Specs
Number of trials	Sufficient to ensure a repeatable result		2 trials
Booster	Provide a strong, repeatable, stable shock front to the top of the sample		160 grams of RDX/wax (95/5) or PETN/TNT (50/50), 50 mm diameter, ~50mm length
Confining medium (steel tube)	Provide confinement, increasing the susceptibility of the substance to detonation; evidence of reaction type		UN Gap (new): Cold-drawn, seamless, carbon steel tube 48 ± 2 mm (1.875-in) OD, 4.0 ± 0.1 mm wall (40 ± 2.2 mm (1.5-in) ID), 400 ± 5 mm (16-in) long. UN Gap (legacy): Cold-drawn, seamless, carbon steel tube 47.6mm (1.875-in) OD, 5.6mm wall (36.5mm (1.44-in) ID), 406mm (16-in) long. NOTE: MIL-STD-1751A

Indicators

Indicators	Detection Method	Assessment*
Damage to the witness plate	Visual post-test inspection	Hole punched through the witness plate: Class 1
Damage to the steel tube	Visual post-test inspection	Complete fragmentation of the tube: Class 1

*OR relationship

No-Go Reaction Example Photo

+ stability test at 75ºC
+ Test 3 (c) (ii) SBAT thermal stability test at 75ºC
+ Test 3 (d) Small-scale burning test

UN SERIES 4
+ Test 4 (a) Thermal stability test
+ Test 4 (b) (ii) 12 meter drop

UN SERIES 5
+ Test 5 (a) Cap sensitivity test
+ Test 5 (b) (ii) USA DDT test

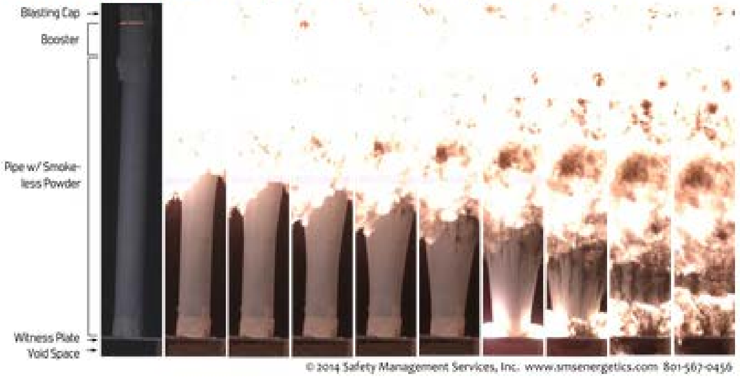
UN SERIES 6
+ Test 6 (a) Single package test
+ Test 6 (b) Stack test
+ Test 6 (c) External fire test
+ Test 6 (d) Unconfined package test

UN SERIES 8
+ Test 8 (b) ANE Gap test
+ Test 8 (d) (i) Vented Pipe Test

PRODUCT SPECIFIC
+ Super Large Scale Gap Test
+ Klieboldt or Ammunition Test

Go Reaction Example Photo

Go Reaction Example from High-speed Video



No-Go Reaction Example Video

Go Reaction Example Video

Comments (1)

Clint Guymon

January 8, 2015 at 3:05 pm | #

Updated test details image and updated key parameters

Reply

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Submit Comment

TERMS OF USE

ETUG Test Methods Matrix™
Go-Forward Plan

Tasks

- Gather additional Origin Information
- Expand example Test Photos and Videos
- Strengthen IP 1.5 and IP 1.6 portions of the data base

Collaboration

- Test Labs & Sites
- Industry
- UN EWG & IGUS
- DDESB, JHC, DOE, DOT, & ATF

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Summary

- ***In-Process Classification*** utilizes key process parameters
- The ***ETUG TMM*** can facilitate technical collaboration
- ***Standardized Testing*** based on sound principles results in:
  - Accurate & Repeatable Test Result
  - User Confidence
- ***In-Process Classification/Characterization*** required for proper facility siting, risk assessment, and risk management

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