



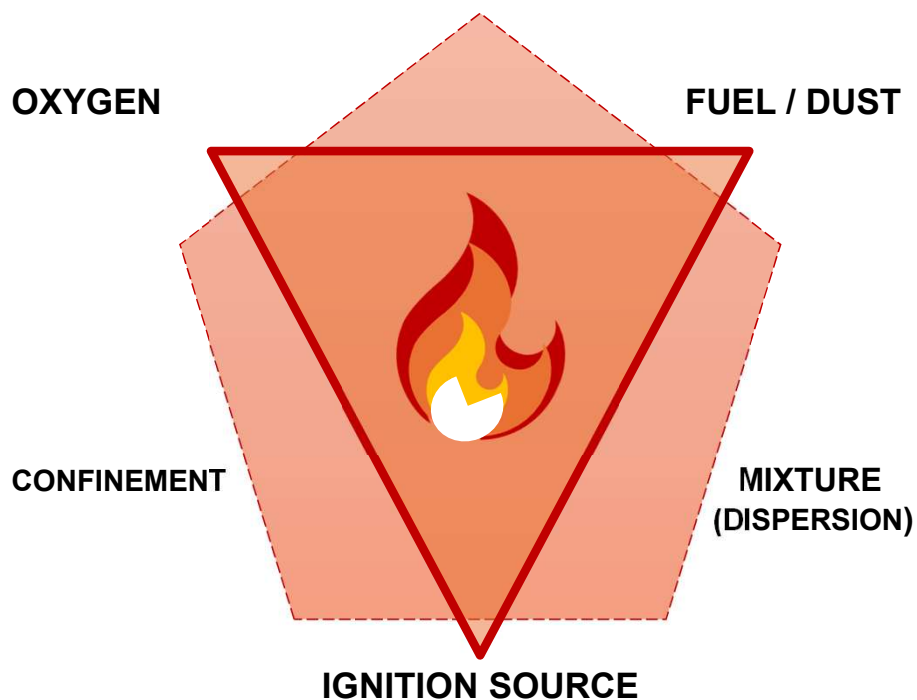
CLASSIFYING CHEMICALS WITH EXPLOSIVE AND EXPLOSIVE-LIKE PROPERTIES

A practical guide for SDS Creators, GHS Experts & Chemical Safety Professionals

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GHS EXPLOSIVES — THE BIG PICTURE

WHAT IS AN EXPLOSIVE?



EXPLOSIVES OR CHEMICALS WITH EXPLOSIVE-LIKE BEHAVIOR

- I. **Conventional Explosives**
 1. Unstable Explosives
 2. Divisions 1.1-1.6
- II. **Desensitized Explosives**
- III. **Self-Reactive Chemicals** (Types A-G)
- IV. **Organic Peroxides** (Type A-G)
- V. **Oxidizers+ Fuel Mixtures** (Blasting Agents)
- VI. **Related but Distinct Hazards**
 1. **Combustible Dust (HNOC)**
 2. Chemicals involving rapid combustion or pressure hazards but not true explosive decomposition
 - a. **Flammable Gases**
 - b. **Aerosols**
 - c. **Pyrophoric Gases**

CLASSIFICATION PATHWAY

01 Determine if the substance or mixture qualifies as an “explosive chemical”

Intentional explosives → go straight to division assignment (Propagates detonation or deflagration)

02 Perform or reference UN Test Series (mandatory reference- Part 1 of the UN Recommendations on the Transport of Dangerous Goods- Manual of Tests and Criteria)

- **Step 1 (Test Series 1):** Screen for explosive effects (e.g., does it propagate detonation or deflagration?)
- **Step 2 (Test Series 2–4):** Acceptance procedure — determines if it has **explosive properties** and can be accepted as an explosive
- **Step 3 (Test Series 5–7):** Assigns the specific hazard division based on the type and severity of hazard (mass explosion, projection, fire, etc.)
- **Additional screening:** Check for explosive chemical groups, oxygen balance, decomposition energy (<500 J/g and onset <500°C may exclude some organics), etc. For certain ammonium nitrate emulsions/suspensions/gels (ANE intermediates for blasting), **Test Series 8** decides if they qualify as **oxidizing liquids/solids** instead of explosives

03 Assign the classification

- Unstable Explosive (exploding bomb and H200)
- Explosive Class 1.1-1.6
- Desensitized Explosive (uses flammable pictogram)
- Oxidizer (Class 5.1)
- Self-Reactive Chemical (A-G) (MAY use exploding bomb pictogram)
- Organic Peroxide (A-G) (MAY use exploding bomb pictogram)
- Combustible Dust (HNOC pictogram)

04 IMPORTANT NEXT STEPS!

Coordination with other regulations: Align with **DOT** (49 CFR) for transport and **ATF** (27 CFR 555) for storage/handling of explosive materials. Blasting agents may have specific definitions under OSHA 1910.109.

- IME has great resources for understanding transport and regulations in their [Safety Library Publications](https://www.ime.org/aws/IME/pt/sp/slps) (<https://www.ime.org/aws/IME/pt/sp/slps>)

GHS EXPLOSIVES DIVISIONS 1.1-1.6

Div.	Primary Hazard	Description	Common Examples
1.1	Mass explosion	Almost the entire quantity explodes virtually instantaneously	TNT, RDX, PETN, HMX, dynamite, C-4, black powder (bulk)
1.2	Projection hazard	Dangerous fragments/projections; no mass explosion	Certain munitions, projectiles, warheads, some bombs
1.3	Fire + minor blast/projection	Vigorous burning, radiant heat; minor blast or projection	Smokeless powder, rocket propellants, many fireworks
1.4	Minor explosion hazard	Effects largely confined to the package; limited fragments	Small-arms ammunition, consumer fireworks, some detonators
1.5	Very insensitive + mass explosion	Mass explosion hazard but extremely difficult to initiate	Certain ANFO & emulsion blasting agents (pass Series 5)
1.6	Extremely insensitive articles	Negligible chance of accidental initiation or propagation	Specialized military articles (rare in commercial use)

NOTE: The same chemical can fall into different divisions (or can be excluded from Class 1) depending on moisture, dilution, particle size, and packaging. ALWAYS use UN test data.

SENSITIZED • DESENSITIZED • UNSENSITIZED

UNSENSITIZED

Inherently less sensitive

- Naturally low sensitivity (e.g., many Division 5.1 Oxidizers)
- Still explosive but hard to initiate
- Often used as blasting agents
- Requires strong booster / initiator

DESENSITIZED

Phlegmatized on purpose

- Wetted, diluted or mixed to suppress explosive properties
- GHS Chapter 2.17 (new dedicated class)
- Must still meet burning-rate & energy criteria
- Exempt from full Explosives class if criteria met
- Uses Flame (GHS02) placard, was formerly classified under flammable solid or liquid

SENSITIZED

Made more responsive

- Additives or conditions that increase sensitivity to initiation
- Common in some blasting formulations
- Higher risk of accidental initiation
- May move a material into Explosives class- Typically 1.5 Explosive

DESENSITIZED EXPLOSIVES (GHS 2.17 & UN MANUAL OF TESTS & CRITERIA PART V, 51.4)

ENTRY CRITERIA – When is a material classified as a Desensitized Explosive?

A phlegmatized explosive is placed in this class unless, in its desensitized state, it meets any of the following (in which case it stays in or returns to Explosives):

- It is intended to produce a practical explosive or pyrotechnic effect
- It has a mass explosion hazard (UN Test Series 6(a) or 6(b)) OR corrected burning rate $> 1\,200$ kg/min
- Exothermic decomposition energy < 300 J/g (may then fall under other physical hazard classes)
- Extremely sensitive or thermally unstable (Series 3)

IF NONE OF THE ABOVE APPLY → classify as Desensitized Explosive and assign Category 1–4 by burning rate.

CATEGORY ASSIGNMENT – Corrected Burning Rate (A_e) from UN Burning Rate Test (External Fire)

Category	Corrected Burning Rate (A_e)	Hazard Statement	Practical Meaning
1	≥ 300 kg/min and $\leq 1\,200$ kg/min	H206	Fire, blast or projection hazard; highest risk if desensitizer lost
2	≥ 140 kg/min and < 300 kg/min	H207	Fire or projection hazard
3	≥ 60 kg/min and < 140 kg/min	H207	Fire or projection hazard (lower intensity)
4	< 60 kg/min	H208	Fire hazard; still protect the phlegmatizer

Key SDS requirements: Communicated explosive properties (Test Series 2 results) – Maintain homogeneity of the desensitizer – Warn that loss of phlegmatizer increases explosion risk – Do not classify additionally as Flammable Liquid/Solid or Explosive

UNSTABLE EXPLOSIVES — WHO DEALS WITH THEM?

Definition

An explosive which is thermally unstable and/or too sensitive for normal handling, transport or use. Assigned hazard statement H200 — Unstable Explosive.

PRIMARY RESPONSIBILITY OWNERS

Manufacturers & Formulators

Identify during R&D and scale-up; stabilize or reject

SDS / Classification Teams

Assign H200; NEVER TRANSPORT as ordinary Division 1.x

Process Safety (PSM)

Control temperature, friction, impact; special handling SOPs

Transport Regulators

Generally prohibited or heavily restricted; special packaging

SELF-REACTIVES & ORGANIC PEROXIDES

SELF-REACTIVE SUBSTANCES

GHS Chapter 2.8

Thermally unstable liquids or solids liable to undergo a strongly exothermic decomposition even without oxygen.

Types A–C (D–G no strong explosion properties) based on detonation, deflagration and thermal behaviour.

Type A can detonate → treated almost like explosives.

Major cause of unexpected plant explosions when temperature control is lost.

ORGANIC PEROXIDES

GHS Chapter 2.15

Organic compounds containing the bivalent –O–O– structure.

Also classified Types A–C (D–G no strong explosion properties)

Can be explosive, self-reactive, or both.

Temperature-controlled storage is often mandatory.

Frequently involved in storage and transport incidents.

OXIDIZERS & BLASTING AGENTS: CRITICAL CORRELATION

THE CORRELATION

Many strong oxidizers contain (or can supply) both oxidizing and reducing potential. When mixed with fuels, organic contaminants, or subjected to heat + confinement, they can transition from simple oxidizers into powerful blasting agents or detonable systems.

Classic example: Ammonium nitrate (AN) is classified as an oxidizer, yet AN + ~6% fuel oil = ANFO, a widely used blasting agent.

KEY CHEMICAL EXAMPLES

- Ammonium nitrate + diesel/fuel oil → ANFO
- AN + organics, chlorides or acids → sensitised explosive
- Ammonium perchlorate + fuels → rocket propellants / explosives
- Chlorates / perchlorates + organic matter → violent mixtures
- Metal nitrates + reducing agents → energetic systems
- Contaminated or confined pure AN can undergo DDT

WHY THIS MATTERS FOR HAZARD COMMUNICATORS

Classification as “Oxidizer” alone can understate real-world explosion risk. SDS must address:

- Risk of contamination with fuels, organics, chlorides or acids
- Dangers of confinement, heat, or large quantities (possible DDT)
- Need for strict segregation from combustibles and incompatibles
- Historical incidents (Oppau, Texas City, West Texas, Beirut, Toulouse) show that oxidizer storage/handling failures produce mass-explosion outcomes
- Communicate both the intrinsic oxidizer hazard and the conditions that turn the material into a blasting-agent-like system

A PRACTICAL OVERVIEW OF MECHANISMS THAT TURN OXIDIZING SUBSTANCES INTO EXPLOSION HAZARDS

1. THERMAL DECOMPOSITION UNDER CONFINEMENT

Many oxidizers (e.g., ammonium nitrate, ammonium perchlorate, chlorates) can decompose exothermically when heated. Under confinement, gas pressure builds rapidly and can transition to explosion (DDT). Pure material may appear stable until heat + limited venting is present.

2. OXIDIZER + FUEL / COMBUSTIBLE MIXTURES

Intentional (ANFO, emulsions) or accidental mixing of oxidizers with organics, oils, waxes, plastics, sawdust, or solvents creates classic fuel–oxidizer explosives. Even low levels of organic contamination (coatings, residues) can significantly increase sensitivity and power.

3. INCOMPATIBLE CONTAMINANTS & CATALYSTS

Chlorides, acids, heavy metals, nitrites, or reducing agents can lower decomposition temperature, catalyze runaway reactions, or form highly unstable intermediates (e.g., ammonium chlorate). Process residues and cross-contamination are frequent hidden sources of risk.

4. PROCESS, STORAGE & TRANSPORT RISKS

Evaporation, neutralization, concentration, caking, and long-term storage can create localized high-risk conditions. Organic anti-caking agents, steam, closed vessels, and fire exposure convert normally stable oxidizers into explosion scenarios. SDS must address these pathways.

For SDS & process safety: Classify correctly, segregate from combustibles & incompatibles, control temperature/confinement, and document all known sensitizing contaminants.

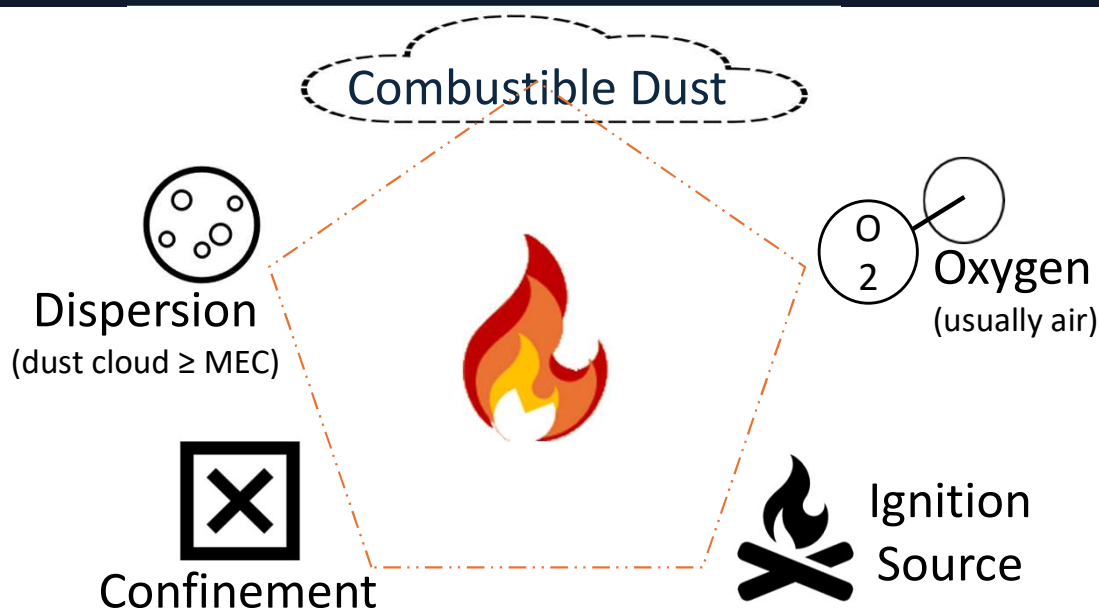
COMBUSTIBLE DUST- AN INTRODUCTION

EXPLOSION SEVERITY (Kst / St Class)

St 1 Weak • sugar, flour, many organics

St 2 Strong • wood flour, some plastics

St 3 Very strong • Al, Mg, some pharma



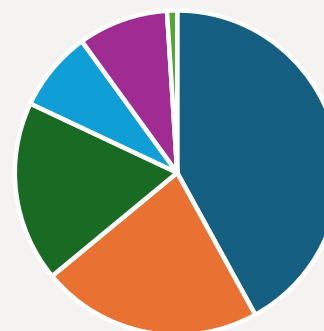
CLASSIFICATION & SDS IMPLICATIONS

- Key parameters for assessment: Kst, Pmax, MEC, MIE, MIT. Hybrid mixtures (dust + flammable gas/vapor) significantly increased risk.
- SDS should identify whether the solid can form an explosible dust cloud and list relevant prevention measures (housekeeping, ignition control, segregation).

BIGGEST MANUFACTURING EXPLOSION HAZARDS

- 1 Flammable Vapor / Gas + Confinement 42%**
Especially in vessels, dryers, and poorly ventilated areas; hybrid mixtures with dust raise severity.
- 2 Combustible Dust Clouds 22%**
Usually from powder handling, drying or grinding. Secondary explosions after a primary event are frequently more destructive than the first.
- 3 Organic Peroxides & Self-Reactive 18%**
Temperature excursions, contamination, or loss of inhibitors lead to runaway decomposition and explosion.
- 4 Oxidizer + Fuel Mixtures 8%**
ANFO-type compositions, nitrate + organic, chlorate mixes — often created unintentionally during processing, storage or cleaning.
- 5 Other/Hybrid/Physical 9%**
Hybrid mixtures (dust + flammable gas/vapor), physical explosions such as BLEVEs, Pressure-vessel ruptures, less common energetic-material events
- 6 True Explosives & Desensitized 1%**
Materials that should never have left the lab, accidents with class 1.x, or desensitized that lost their phlegmatizer during drying or storage.

Types of Explosion Incidents in Chemical Manufacturing



- Flammable gas/ vapor (incl. VCEs)
- Combustible Dust
- Organic Peroxides & Self- Reactive (runaway/reactives)
- Oxidizer- related (e.g., AN)
- Other/Hybrid/Physical (BLEVE etc.)
- True Explosives & Desensitized

KEY TAKEAWAYS



Unstable is not just another division

H200 materials require special handling; they are generally too dangerous for normal transport and use.



Desensitization is a controlled process

It has clear energy, sensitivity and burning-rate gates. Fail any one and you stay in Explosives.



Oxidizers + fuels = hidden explosives

Many of the worst manufacturing explosions start with materials that were never intended to be explosives.



Dust is an explosive-like hazard

Communicate it on the SDS; control the five elements of the explosion pentagon.



Self-reactives & peroxides have dangers in the same family

They share the same runaway-decomposition physics that make explosives dangerous.

QUESTIONS & DISCUSSION

For further questions, please contact me:

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References:

- GHS Rev. 7/8/9/10
- UN Manual of Tests and Criteria
- OSHA Combustible Dust NEP
- NFPA 652/654
- Institute of Makers of Explosives Safety Library Publications <https://www.ime.org/aws/IME/pt/sp/slps>
- Eckhoff, R. K. – Explosion Hazards in the Process Industries (2nd / later editions).
- U.S. Chemical Safety and Hazard Investigation Board (CSB) – Combustible Dust Hazard Study (2006) and subsequent investigation reports. Documents 281 combustible dust incidents (1980–2005) and numerous reactive chemical and flammable vapor events.
- Zhou et al. / related Chinese hazardous chemical accident analyses (2015–2021 and 2000–2020 large-accident studies).
- NFPA 660 (Standard for Combustible Dusts and Particulate Solids) and predecessor standards (NFPA 652/654)
- Process safety literature on reactive chemicals (e.g., CSB Reactive Hazard Investigation)
- Marsh / other loss databases and industry reviews of major ammonium nitrate and oxidizer incidents (Oppau, Texas City, Toulouse, Beirut, West Texas, etc.)