Handling Guidelines for Titanium Powder

Customer Awareness

Brilliance inspired by titanium

Cristal: one company, five continents

For decades the Cristal family of organizations has invested in the future of titanium.

From October 2012, we make our commitment to the brilliance of titanium clearer when we bring all our companies under one name: **Cristal.**

Cristal: complete titanium specialists

Mineral sands mining

Leucoxene

Rutile

Zircon

Ilmenite

Titanium Dioxide (TiO_2)

TiONA® TiO_2

Titanium performance chemicals

CristalACTiV™

Ultrafine TiO_2

Titanium Tetrachloride

Titanium metals and alloy powders

CP

Ti6Al4V

CRISTAL

Cristal cares

Safety and care are at the core of everything we do.

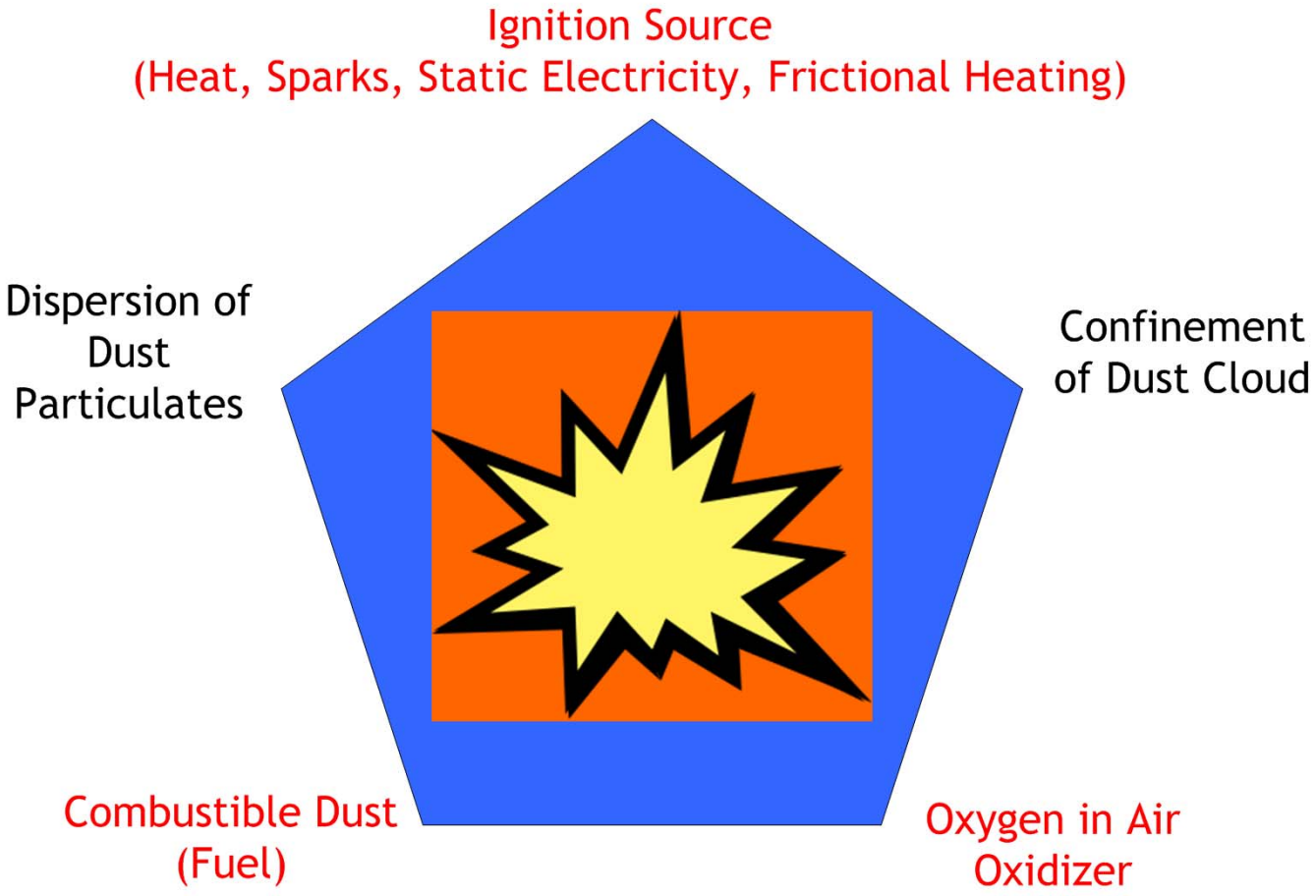
We are committed to looking after the people and places we work with, and to making the world a cleaner, brighter place through the brilliance of titanium.

- Cristal is in the top quartile of chemical companies in safety performance
- All workplace injuries, illnesses and adverse environmental impacts are preventable: we will never accept them
- We are continually improving our environmental performance, from waste disposal to sustainable product development

Titanium Powder Handling

- Cristal's focus is on customer awareness, understanding the risks associated with processing titanium powder
- Few companies have extensive experience working with Ti though some have experience working with other types of powders
- "There is a lot of information on what not to do, but few guidelines on safe practices"
- These guidelines are neither inclusive nor instructive of all necessary precautions for handling titanium powders, but are intended to promote awareness and the safe handling and processing of titanium powder. Cristal makes no any warranty, express or implied, or assumes any legal liability or responsibility with respect to the information contained within this presentation. It is the responsibility of each individual handling and processing titanium powder to do so in a safe and responsible manner.

Requirements for Fire and Explosion Hazard- Explosion Pentagon



Flammable Solids
Testing to Determine Combustibility

- Preliminary screening test employed to determine fire risk (combustibility)
  Referenced in NFPA 484 2012 Standard for Combustible Metals

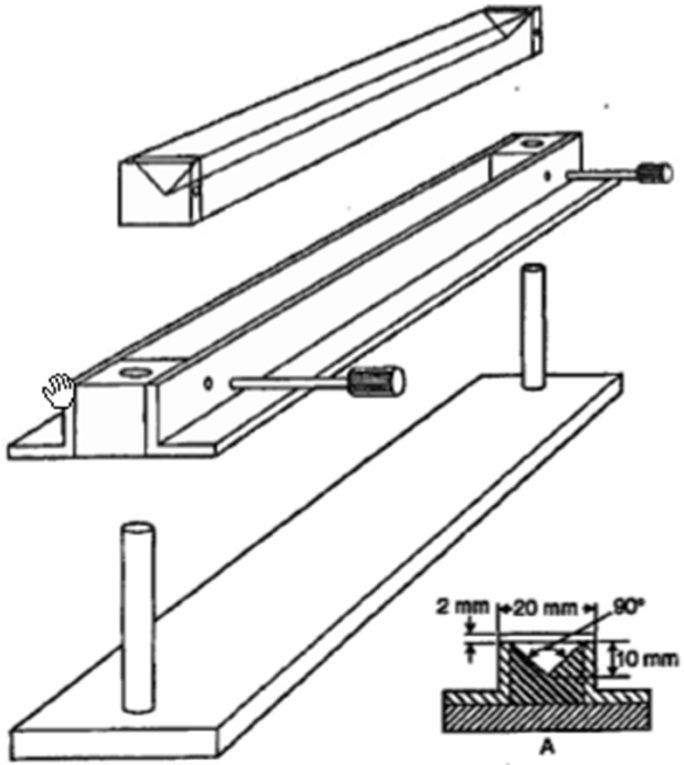
- Prescreening test:
  Unbroken powder train about 250 mm (9.84”) L x 20 mm (0.79”) W x 10 mm (0.39”) H on a low heat conducting base

  Hot flame from a gas burner (min. temperature 1000˚C) until powder ignites, or for 5 minutes

  Must burn within 5 minutes, and propagate over 200 mm (7.87”) within 20 minutes

Flammable Solids
Testing to Determine Combustibility

- Results of pre-screening test:
  - No reaction
  - Glowing but no propagation
  - Propagation but greater than 20 minutes
  - Propagation in under 20 minutes
- If propagates under 20 minutes, burn rate test is employed on a triangular cross-section of powder
  - Powder is classified within division 4.1, and considered as readily combustible if it can be ignited and reaction spreads over entire sample length within 10 minutes
- Packing group criteria for readily combustible materials of Division 4.1 are assigned as follows:
  - (i) Packing Group II – reaction spreads over entire length of sample in 5 minutes or less.
  - (ii) Packing Group III – reaction spreads over entire length between 5 and 10 minutes

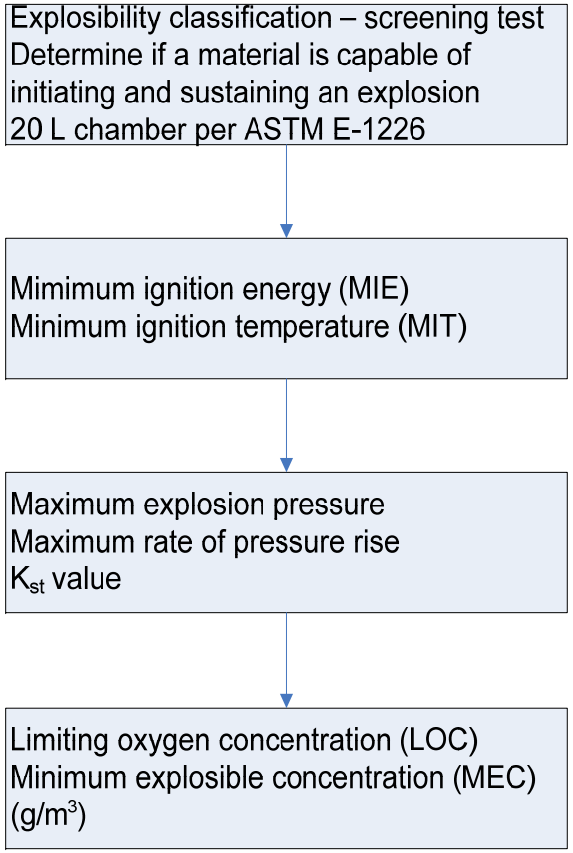


Note: For U.S. standard measurements, 1 mm = 0.039 in.

FIGURE A.4.2.5 Fixture for Preparation of Sample for Burning Rate Test.

Explosibility Determination

Testing and powder properties related to ability of dust to explode



- MIE - indicates the ease of igniting a suspended dust cloud
- MIT - temperature to cause suspended dust to auto-ignite
- K_{st} is the deflagration index, measures relative explosion severity to other dusts

- LOC - minimum amount of oxygen needed to sustain an explosion
- MEC - minimum amount of dust to cause a significant pressure rise: “How easily can a dust cloud be formed”

Explosion Severity

Dust Explosion Classs	Kst (bar.m/s)	Characteristic	Typical Materials
St 0	0	No Explosion	Silica
St 1	>0 and <200 ITP CP 92	Weak Explosion	Iron 50, CP Ti 92, Granulated Sugar (fine) 140, Zinc 176
St 2	>200 and <300	Strong Explosion	Acrawax 275
St 3	>300	Very Strong Explosion	Aluminum 400, Magnesium 508

20L test chamber for explosivity testing – ASTM E-1226

Powder Handling Guide

- Cristal created a powder handling guide that gives handling guidance for working with titanium powders
- Handling guide is sent to each customer prior to supplying powder

Storage of Powder

- Store in a closed container when possible to prevent accidental dust generation and to prevent possible contamination
- Protect containers from physical damage
- Welding, grinding, or other processing that can generate heat and sparks should not be performed around any titanium powder. Smoking shall not be permitted in storage areas
- Storage containers of titanium powders must be kept separate from other chemicals in a storage area

Storage of Powder

- Water from automatic sprinkler systems can contribute to material hazard in the event of a powder fire. Contact of burning titanium with water in a fire event will evolve flammable hydrogen gas, which may result in fire or detonation of hydrogen, and the potential to disturb more powder and spread the fire. If you choose to disable the sprinkler system to eliminate this potential hazard, be sure to discuss with your insurance carrier before doing so

No active sprinklers!

- NFPA 484 requires that in areas where titanium dust may be present, all electrical equipment must comply with Class 2, Division 1, Group E of the National Electrical Code
- Review with local building authority for restrictions on building, storage piles, and total allowable quantities
- Where powered fork-trucks and fork-lifts will be employed, reference NFPA 505

Housekeeping

- Continuous housekeeping and cleaning must be maintained to minimize accumulation of titanium powder on floors and horizontal surfaces such as ducts, pipes, hoods, ledges, beams, suspended ceilings and other concealed surfaces within the facility. Equipment must be maintained to minimize the escape of dust.
- Review NFPA 484 for general housekeeping practices for titanium powders
- Vacuuming should never be performed, even with an explosion-proof vacuum cleaner, to pick up any waste or spilled powder. Fires or explosions while vacuuming may occur.
- A natural-fiber broom and non-sparking (i.e., aluminum) dust pan should be employed for removing powder. Shovel or sweep material into a metal waste container with a sealing lid. Use non-sparking tools and equipment.
- Surfaces must be cleaned in a manner that minimizes the generation of dust clouds. Vigorous sweeping or use of compressed air must be avoided as they may produce hazardous dust clouds.

No vacuuming!

Handling/Use

- Electrically ground powder storage drum while using material
- The following are some of the steps that can be taken to prevent static charge accumulation:
  - conductive flooring and footwear
  - personnel-grounding devices
  - anti-static or conductive clothing

Prevent static discharge!

- Suggest using ground-connected metallic apparatus to prevent electrostatic charges from causing ignition. All equipment used to process titanium powder should be electrically bonded and grounded to prevent accumulation of static electricity.
- Use proper personal protection equipment (PPE) guidelines when working with powder. Fire resistant clothing, full leather footwear, safety glasses and/or full face shield, and leather gloves.

Handling/Use

- Use non-metallic (non-sparking), non-static inducing scoops and tools **(**such as aluminum or beryllium-copper**).**
- When powder is being processed, argon gas blanketing of processing equipment will reduce combustion risks and minimize oxygen pick-up.
- While loading powder into any processing equipment, keep main supply of feed material at least four feet from entrance or discharge of equipment.
- Keep a well supplied stock of suitable extinguishing media nearby during processing. Suitable media include dry sand, talc, salt, and Class D extinguishing agents.
- Where Class A, B, C fire extinguishers are present in the areas where titanium is stored or processed, they must be marked "Not for use on Combustible Metal Fires."

Metal Fire Extinguishing Agents per NFPA 484

Extinguishing Agents	Alkali Metals (Calcium, Sodium)	Lithium	Aluminum	Iron & Steel	Magnesium	Niobium	Tantalum	Titanium	Zirconium
Coke (carbon mirospheroids	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Met-L-X	Yes*	No	Yes*	Yes	Yes*	Yes*	Yes*	**Yes***	Yes*
Lith-X	Yes*	Yes*	No	No	No	No	No	No	No
Copper powder	Yes*	Yes*	Yes	No	No	No	No	No	No
Dry flux	Yes	Yes	Yes*	No	Yes*	No	No	No	No
Dry sand	Yes	Yes	Yes*	Yes	Yes*	Yes*	Yes*	**Yes***	Yes*
Dry lithium chloride	Yes	Yes	No	No	No	No	No	Yes	Yes
Dry soda ash	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes
Dry sodium chloride	Yes	Yes	Yes*	No	Yes*	Yes*	Yes*	**Yes***	Yes*
Water	No	No	No	Yes	No	No	No	No	No
Foam	No	No	No	Yes	No	No	No	No	No
Argon	Yes*	Yes	Yes*	Yes	Yes*	Yes*	Yes*	**Yes***	Yes*
CO_2	No	No	No	No	No	No	No	No	No
Nitrogen	Yes*	No	No	Yes	No	No	No	No	No
Halon	No	No	No	No	No	No	No	No	No

*Preferred extinguishing agent

Emergency Precautions

- Maintain a safe perimeter around equipment to insure adequate access to eliminate power to equipment in an emergency.
- Maintain a safe perimeter to insure adequate space to back away from equipment and/or powder in the event of a fire.
- Do not spray any titanium fires with water; contact with water in fire event will evolve flammable hydrogen gas – resulting in fire and/or explosion.
- Extinguishing agents should be applied in a manner that does not disturb or disperse accumulated dust to form a dust cloud. In the case a dust cloud is produced as a result of the fire fighting, a deflagration hazard will be present.
- All burnt materials and sand, once cooled, should be shoveled into a metal drum and allowed to sit and complete cooling undisturbed. The lid should be locked into place and the drum disposed of following all federal and local guidelines.

Questions/Comments?