Data on Pyrophoricity of Thorium

- Thorium (Th): Specific gravity, 11.6; density, melting point, 3090°F (1700°C). Thorium is pyrophoric and radioactive. As a dry powder it has a low ignition temperature. Thorium powder is shipped under helium or argon gases in special containers. When poured through air, it is subject to ignition by electrostatic spark. It should be handled cautiously with a nonsparking spoon or scoop. Containers and tools should be grounded. Ignition has occurred due to chemical reaction between finely divided thorium and water at ordinary temperatures.
  -- University of Pittsburgh Safety Manual: Combustible Metals, 9/2013

- The self-ignition temperatures of aerogel and suspended solid in air are 280 and 270° C, respectively; the low concentration ignition limit of suspended solid in air is 75 g/m^3 ; explosion pressure is 630 kPa max; maximum rate of pressure rise is 84 MPa/s; explosion-proof oxygen content in inert gas is 4 vol% max; minimum suspended solid in air ignition energy is 5 mJ. The products with such characteristics of inflammability and explosion risk are placed in the 'High explosion hazard' class of danger according to the 'Guide to Legislation and Health and Safety ' in the European PM Industry.
  --Neikov, O. D., Naboychenko, S. S., & Dowson, G. (2009). Handbook of non-ferrous metal powders: technologies and applications. p533

- **Autoignition:** 130°C.
  Firefighting: Contact the local, state, or Department Of Energy Radiological Response Team. Do not use water. Use graphite, soda ash, powdered sodium chloride, or suitable dry powder.
  Fire potential: May burn but does not ignite readily.
  Hazards: Some of these materials may burn, but most do not ignite readily. Uranium and Thorium metal cuttings may ignite spontaneously if exposed to air. Extremely flammable; will ignite itself if exposed to air. Burns rapidly, releasing dense, white, irritating fumes. Substance may be transported in a molten form. May re-ignite after fire is extinguished. Nitrates are oxidizers and may ignite other combustibles. May explode from heat or contamination. Some may burn rapidly. Some will react explosively with hydrocarbons (fuels). May ignite combustibles (wood, paper, oil, clothing, etc.). Containers may explode when heated. Runoff may create fire or explosion hazard.
  -- International Bio-Analytical Industries, Inc. Thorium Metal MSDS

- **Air & Water Reactions** Pyrophoric material, spontaneously ignites in air.
  Fire Hazard Excerpt from GUIDE 162 [Radioactive Materials (Low to Moderate Level Radiation)]: Some of these materials may burn, but most do not ignite readily. Uranium and Thorium metal cuttings may ignite spontaneously if exposed to air, refer to GUIDE 136. Nitrates are oxidizers and may ignite other combustibles, refer to GUIDE 141. (ERG, 2012)
  Firefighting Excerpt from GUIDE 162 [Radioactive Materials (Low to Moderate Level Radiation)]: Presence of radioactive material will not influence the fire control processes and should not influence selection of techniques. Move containers from fire area if you can do it without risk. Do not move damaged packages; move undamaged packages out of fire zone. SMALL FIRE: Dry

chemical, CO2, water spray or regular foam. LARGE FIRE: Water spray, fog (flooding amounts). Dike fire-control water for later disposal. (ERG, 2012)
-- Cameo Chemicals Chemical Datasheet, THORIUM METAL, PYROPHORIC

- …powdered form of thorium requires special handling techniques because of its low ignition temperature. In the dry state, it must be handled under a helium or argon atmosphere. The dry metal powder should not be in air because even the friction of the particles falling through the air or against the edge of a glass container may produce electrostatic ignition of the powder.

  Powdered thorium is usually compacted into solid pellets weighing about 1 oz. (28 g) each. In this form it can be safely stored or converted into alloys with other metals. Improperly compacted thorium pellets have been known slowly to generate sufficient heat through absorption of oxygen and nitrogen from the air to raise a steel container to red heat. Thorium is handled by remote control because of the toxicological effects of the metal.
  Robert E. Solomon (2012). Fire and Life Safety Inspection Manual. p675

- **Table 17-18: Explosibility of Metal Powders.** E. Petrik synopsis: Thorium is listed under "Severe," the highest-risk category, along with atomized aluminum, magnesium, titanium, zirconium, etc. This book also contains recommendations for mitigating explosion hazards, including grounding to avoid electric sparks and using non-sparking tools. It also discusses the hazards attendant upon blending explosive powders.
  W. H. Cubberly (1989). Tool and Manufacturing Engineers Handbook, Desk Edition. p17-51

- **Table 1.** E. Petrik synopsis: The ignition and explosibility of thorium is categorized as "Severe," the highest-risk category, along with with atomized aluminum, magnesium, titanium, zirconium, uranium, etc.
  Ignition temperature: 270 C (cloud), 280 C (layer). For comparison, uranium is 20 C (cloud), 100 C (layer); titanium is 330 C (cloud), 510 C (layer), magnesium is 620 (cloud), 490 (layer), and atomized aluminum is 650 (cloud), 760 (layer).
  Minimum explosive concentration (oz/cu ft): 0.075 (~2 g/cu ft). For comparison, titanium and atomized aluminum are 0.045.
  Minimum igniting energy for dust cloud (mJ): 5. For comparison, uranium is 45, titanium is 25, zirconium is 15, and atomized aluminum is 50. The only lower value is that of thorium hydride: 3.
  Maximum pressure (psig): 48. This is somewhat lower than most of the others, but not by a great deal.
  Maximum rate of pressure rise (psi/s): 3300. This is about half of titanium's value, and 1/6 of atomized aluminum's.
  Index of explosibility: >10. All metals in the "Severe" category have this rating.
  This document also contains data about the explosibility of thorium in CO_2 and N_2 atmospheres. The document notes, "Pyrophoricity Generally, pyrophoricity becomes evident when the particle diameter of a dust is less than 1 micron; however, uranium, uranium hydride, and zirconium having average particle diameters greater than 1 micron ignited at room temperature when dispersed in air. Quiescent layers of uranium, uranium hydride, and thorium hydride

ignited within minutes on exposure to air. Pyrophoricity was not observed with the other dusts studied, probably because of coarseness of the particles or surface contamination."
Murray Jacobson, Austin R. Cooper, and John Nagy, (2964). Explosibility of Metal Powders.

- This reference is more optimistic than the others, which is encouraging since they actually did extensive machining of thorium:
  "Machining of thorium presents no particular difficulty, since it is comparable to mild steel in this respect. Clean thorium metal when machined with a coolant presents no oxidation or fire hazard." p. 4
  "Thorium may be machined easily using conventional tools and methods. Its machining qualities are comparable to those of mild steel. A coolant is customarily used, and it was found that a sulphonated cutting oil worked satisfactorily. Little or no fire hazard has been found when machining clean metal using a coolant…. [M]illing, turning, drilling, and sawing may be performed using standard tools and conventional practices." p. 47-48
  Oak Ridge National Laboratory: J. H. Frye, Jr. et al. (1951). Interim report on metallurgy of thorium and thorium alloys.

- Another optimistic practical take:
  "Alex was pretty dismissive of using any special precaution against thorium's pyrophoricity, even while machining. He said that once a fire gets going you can't put it out, but it needs to be held at high temperature for a while to ignite. I don't think he said exactly how long at what temperature and I didn't ask for further clarification."
  --Alex Besenyo of IBI Labs, which does machining of Th and U, via Zack Lasner