DATA SHEET No 15
Safety Guidelines for Processing & Handling Titanium

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Safe procedures exist for titanium melting, casting, and other manufacturing operations and fabrication processes including machining and welding, and for the handling of raw materials particularly sponge and other fines. The more important of these are summarised below, but those considering working with titanium should review in detail recommendations and guidance specific to the processes they plan to use. Titanium is a reactive metal, and in the past, ignorance and inappropriate practices in handling and processing have given rise to serious and sometimes fatal accidents.

Extraction: Titanium sponge, the first stage product of extraction includes fines of high surface area and low mass which are a fire hazard. Precautions are required in the areas where sponge is processed, handled and stored, to avoid mechanical or electrical sparking (including static discharge) or frictional heating – e.g. in crushers, compactors, mixers and blenders. Magnesium, used in the Kroll extraction process presents a separate potential hazard in its own right.

Melting: Titanium melts at around 1600^{o}C. The molten metal is most commonly contained under vacuum or argon in a water-cooled copper crucible. Instances of leakage of water into the melting space, which creates conditions for a steam - hydrogen explosion, have resulted in the complete wrecking of the furnace and surrounding equipment. Thus, cooling water flow and temperature and furnace power should be interlinked; furnaces should have two water supplies the back-up supply preferable being gravity fed. Other furnace safety features to monitor pressure, control and limit explosion damage and protect melt shop personnel are normal. Electrodes produced from bulk welded revert must be securely held together at all points to avoid arcing from the electrode to the crucible wall. NaK (liquid sodium potassium) is a desirable and safer alternative for crucible cooling.

Fines and Sponge: Fine particles of titanium powder easily disperse in air, and their low mass enables them to remain suspended. Ignition can result in a violent explosion. Precautions against sparks and frictional heating as identified above are essential, in addition to control of handling and processing to avoid dust generation or fines accumulation.

Confined Space Entry and Inert Gases: Argon is commonly used in vessels and other equipment in conjunction with melting, processing and handling of titanium. Air and oxygen may be excluded in confined spaces, and the use of breathing apparatus, or a full check of the air quality in a confined space is essential before entry is attempted for any reason whatsoever, - however brief the planned visit may be. The UK Health and Safety Executive guidance notes HSE L101 and Information Document HSE 288/6 provide further information.

Inhalation of Particulates: The UK limit for inhalation is 4mg/m^3 of inhalable titanium dioxide (TiO_2) particulates in an 8 hour day.

Heating and Heat Treatment : Titanium in bulk, e.g. ingots, billets, may safely be heated for working at temperature typically up to 1200^{o}C. Electric furnaces using atmospheric air are acceptable, as are gas or oil fired furnaces in which a minimum 3% excess of oxygen is maintained. Direct flame impingement onto the titanium must be avoided. Controlled atmosphere furnaces using hydrogen, nitrogen or cracked ammonia are totally unsuitable for titanium. At higher temperatures titanium may react at contact points with refractory hearths

or bearers, and with mill scale if present from previous heating of carbon and low alloy steels. Furnaces in which titanium is to be heated should be cleaned before charging, and in the case of refractory hearths, the titanium should be laid for its protection on sheets of stainless steel.
Unless a thermally oxidised finished is desired or acceptable, heat treatment of titanium in vacuum or argon is essential if there is to be no further surface processing, e.g. machining or pickling after heat treatment.

Descaling and Pickling: Hot salt baths and strong mixed acids, (typically hydrofluoric and nitric acids), used for descaling and pickling of titanium must be operated in accordance with supplier instructions and with mandatory use of safety clothing, face masks, gloves and other protective equipment. The UK Health and Safety Executive Information Document HSE 652/1 provides further information.

Grinding Titanium: Dry grinding fines present a particular hazard, and may be ignited by sparks from the grinding process. Effective dust extraction combined with regular removal of accumulated dust is essential. Care is required in the design of extraction equipment to avoid corners where dust can collect, and to facilitate regular and thorough cleaning.

Machining Titanium: Accumulations of titanium turnings represent a fire hazard, particularly if mixed with oily rags, paper or other easily ignited waste materials. Machines should be regularly cleared of swarf, which should be placed in sealed drums, clearly marked and segregated from other waste.

Fabricating Titanium: The use of gloves is recommended particularly for handling sheet with sheared edges, which may be uneven and very sharp. Fabrication scrap should be cleared regularly from the workplace and kept separate from other metal scrap and waste materials in clearly marked containers. The UK Health and Safety Executive Information Document HSE 668/25 provides further information.

Welding Titanium: Whilst there is ozone but generally no fume generated when TIG (GTAW) welding of titanium, both fume and ozone are issues with MIG (GMAW). No data yet exists on these hazards as related to titanium. The UK Health and Safety Executive Information Document HSE 288/6 provides further information.

References additional to those given in the text:

1. Occupational Exposure Limits - Guidance Note EH40 Department of Employment (HMSO).
2. Documentation of the Threshold Limit for substances in Workroom Air Values - American Conference of Government Industrial Hygienists.
3. Production, Processing, Handling and Storage of Titanium Leaflet NFPA 481. National Fire Protection Associations (U.S.A.).
4. 'Safety Related Problems in the Titanium Industry in the last 50 years', Eldon Poulson, Journal of Metals, May 200 pp 13 –17

FOR FURTHER INFORMATION

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