GESAMTVERBAND DER ALUMINIUMINDUSTRIE e.V.

SAFETY INSTRUCTIONS FOR HANDLING AND PROCESSING ALUMINIUM POWDER

June 2007

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INTRODUCTION

Aluminium powder can be safely transported, stored and processed if a few basic safety instructions are followed, as detailed, for example, in the relevant material safety sheet.

Nevertheless, as when dealing with combustible powders in general, the processing of aluminium powders involves a residual risk that is often underestimated. A precise knowledge of the specific properties of aluminium powder and safety measures that take these into account allows this risk to be minimised and permit the material to be handled safely.

This brochure gives an overview of the causes of safety risks and how to avoid them, and provides information on the correct way to handle aluminium powders. It is aimed mainly at the manufacturers of powder coatings, who incorporate aluminium powder in metal-effect powder coatings and all other users that have to deal with pure aluminium powders or powder mixtures with a high aluminium content.

The brochure is not aimed at users of dry-blended or bonded metallic powder coatings with an aluminium powder content less than 10% where one can rule out that there will not be any enrichment of the aluminium powder content above this figure during processing or in the resultant products, as in such cases the risk is due to the main components of the respective mixture (see Glossary: PTB-Bericht W50).

These safety instructions relate to the handling of aluminium powders in general and thus also include other methods of processing aluminium pigment powders. They are strongly oriented towards the existing German legislation for aluminium powder manufacturers.

By contrast, experience gained by users handling desensitised/stabilised aluminium powders has already shown that there is a significant reduction in the hazard potential. Regardless of this, however, it is imperative that one regards these safety instructions as the current best practice of German aluminium-pigment manufacturers and as a recommendation for the safest way of dealing with aluminium powders.

I. CHARACTERISTICS OF ALUMINIUM POWDERS AND THEIR HAZARD POTENTIAL

What are the most important properties of aluminium powder for correctly assessing the hazard potential?

- Aluminium powder is combustible and classified as being flammable.
- Mixtures of aluminium powder and air are ignitable over a wide range of concentrations and can cause violent dust explosions.
- Highly flammable hydrogen can form on contact with water or other chemicals and present an additional risk of explosion, and possibly be responsible for causing a secondary dust explosion.
- The strong electrostatic charge on aluminium powder can lead to electrical discharges, which can possibly ignite a cloud of aluminium dust.

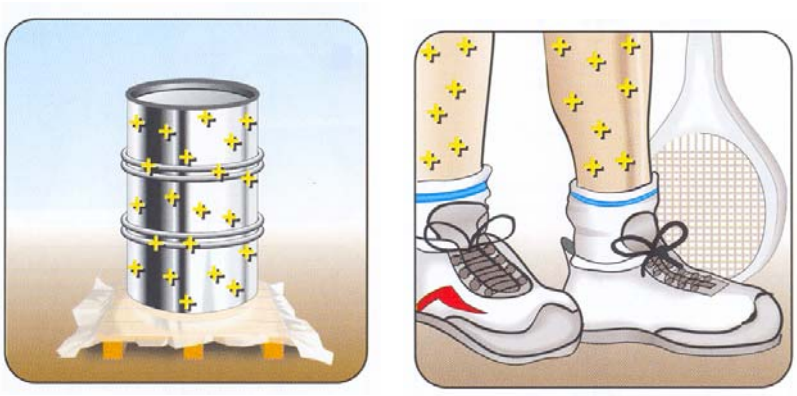

Fig. 1 Examples of electrostatic charges [1]
left: metal drum on insulated base / right: person with insulated footwear

How stable and how reactive is aluminium powder?

- When aluminium powder burns, aluminium oxide is produced. No hazardous reaction products are formed.
- A strongly adherent, compact oxide film protects the aluminium surface (largely insoluble at pH 4.5 – 8.5).
- Hazardous reactions:
    - Aluminium reacts strongly with acids and alkalis (and also with water after prolonged contact) with the formation of highly flammable hydrogen. There is a danger of a fire or an explosion.
    - Aluminium reacts strongly with oxidants (e.g. nitrates, sulphates, halogens, peroxides). There is a danger of a fire or an explosion
    - Aluminium can react strongly on contact with halogens and simple halogenated hydrocarbons with the formation of, for example, hydrogen chloride or hydrochloric acid vapour.

II. STORAGE, HANDLING AND PROTECTIVE EQUIPMENT

How should aluminium powder be stored?

- The use of loading aids is imperative when unloading or placing in storage. Containers must not be thrown about or subjected to any other form of treatment that might cause damage.
- Storage should preferably be in rooms with a fire-resistant or non-combustible construction.
- One should ensure that there is good natural or forced ventilation of the storeroom and areas used for processing.
- Only those containers used by the metal pigment manufacturer for transport purposes should be used for storage. These original containers should be kept tightly sealed at all times. Damaged or leaking containers should be replaced immediately.
- The containers should be stacked in an orderly manner with a broad passageway for access. The height of the stack should be kept to a minimum.
- Aluminium powder should not stored in areas where there are flammable liquids or other combustible materials. The reason for this is that different fire fighting techniques are used in the event of a fire.
- Aluminium powder should not be stored together with incompatible substances, such as oxidants.
- Avoid accumulations of dust on floors, walls and other places in storage areas. In this respect, attention should be given to avoiding grooves and potential sites for deposits.
- Aluminium powder should be stored in a cool place, i.e. in the open it should be protected against direct sunlight. In addition, containers should be stored far enough away from steam pipes or radiators to prevent heating.
- Smoking and naked flames must be strictly prohibited in storage areas.
- Aluminium powder should be stored dry and any contact with water avoided. One should ensure that the containers are always protected against rain, snow and humidity. Leaks in steam pipelines, water pipes, radiators or roofs should be repaired immediately in order to avoid products coming into contact with water.
- There should not be any automatic fire-extinguishing systems (e.g. using sprinklers or carbon dioxide) in areas where aluminium powder is stored.
- If at all possible storage should be away from frequented areas.

Fig. 2 Avoid electrostatic charges: use conductive, earthed packaging materials (do not use plastic sacks or plastic containers) [1]

What should be taken into account when handling aluminium powders?

- Work in a low-dust environment and avoid dust formation. This means avoiding any conditions that can lead to powder particles being disturbed and forming a cloud of dust, especially when filling or transferring aluminium powders.
- Product containers should be kept closed, and only opened for a short time in order to take out material. Closing immediately after use provides protection against possible sources of ignition, impurities and humidity.
- The focus has to be on cleanliness in all areas where aluminium powder is stored and handled. Accumulations of dust on floors, walls and other places have to be avoided by the adoption of regular cleaning procedures.
- Strict avoidance of all potential sources of ignition (see also III., section “How can possible sources of ignition be avoided?”
- Avoid the ingress of oxygen by inerting in special cases.
- Where dust formation is possible and aluminium powder is being handled in the open, it is strongly recommended that employees wear personal protective equipment (for details see II., section “What protection should there be for people, equipment and buildings? Personal protective equipment”

Protective equipment is also absolutely essential when containers balloon out as a result of hydrogen formation following contact with moisture. If it is possible to do so without incurring any risks, the container should be isolated in a cool, dry, well ventilated place.

What protection should there be for people, equipment and buildings?

Personal protective equipment

Whenever dealing with aluminium powder in the open one should always wear at least the following personal protective equipment and no-one without protection should be allowed into the area.

- Respiratory protection: dust mask filter class FFP 1 (DIN EN 149) for normal dust formation; depending on the legal requirements, choose a higher class of protection for high dust concentrations (P2).
- Hand protection: leather gloves with long cuffs (DIN EN 388/407).
- Head / face protection: helmet with mesh for protection against heat or flames (DIN EN 166, wire mesh or plastic visor).
- Work wear: fire-retardant special fabric, rendered conductive (EN 531/1149-1/2), trousers without turn-ups, closed pockets.
- Foot protection: conductive safety shoes (DIN EN 345 S1-3).

Fig. 3: left: Personal protective equipment with hand, head, face, and foot protection as well as work wear with special fire retardant fabric.
Above: detailed view of a helmet with mesh for protection against heat or flames

Equipment and buildings

- Ensure that there is adequate natural or forced ventilation in storage and work areas.
- Avoid sources of ignition: introduce a strict ban on smoking and a ban on naked lights, blowtorches, welding equipment and naked flames in the storage and work areas.
- When handling/using aluminium powder one should use tools or shovels that do not produce sparks (aluminium, wood, brass, stainless steel). Do not use plastics or low-alloy steels.
- Classification of the working area into explosion-hazard zones in accordance with European Directive 1999/92/EC and use of explosion-proof electrical and mechanical devices appropriate for the application in accordance with ATEX Product Guideline 94/9/EC
- Where local exhaust ventilation is used to avoid dust formation, applicable regulations and procedures must be adhered to (e.g. BGR 109). There is a danger of a dust explosion if aluminium powder accumulates in the ventilation system and filter.

What health risks are involved?

Aluminium pigments have no associated toxicity. If handled correctly, many years of experience indicates that no harmful effects whatsoever are known.

- Dust can cause irritation to the eyes and respiratory tract.

Hygiene

- Pay attention to hygiene when working: do not eat, drink, smoke or take snuff when dealing with the product. Clean the skin with soap and water. Change work clothes if contaminated and before leaving the works.

III. CAUSES OF FIRES AND EXPLOSIONS AND HOW TO AVOID THEM

What can cause a fire or an explosion?

In order for a fire or explosion to occur, three elements must be present simultaneously:

- a combustible substance (in this case: aluminium powder)
- oxygen
- a source of ignition

What measures can be adopted to prevent fires and explosions?

- Limit the dust concentration by avoiding the release of dust or cloud formation.
- Inert by preventing the ingress of oxygen (e.g. within closed units).
- Avoid sources of ignition.
- In addition one can reduce the damaging effects of explosions by adopting constructive explosion protection measures, such as a construction that is blast-resistant or resistant to explosion shockwaves, and explosion isolation and suppression.

What are possible sources of ignition for aluminium powder?

- Naked flames
  e.g. flames from matches or cigarette lighters, furnaces, blowtorches, welding or cutting flames, combustion engines
- Hot surfaces
  e.g. walls of boilers, hot pipe work, soldering irons, parts of machines (bearings) that overheat, hot gases
- Electric sparks and sources of sparks

e.g. loose contacts, overloaded power cables, faulty control systems, arcs and sparks on switches, light bulbs, flashlights, electrical as well as battery-operated equipment

- Electrostatic discharges
  non-earthed parts of plant or containers, unsuitable tools und fixtures, unsuitable clothing
- Friction or mechanical sparks
  e.g. grinding, hammering of machine parts, tools, containers
- lightning strikes
  Voltage surges in cables or plant caused by a lightning strike

How can possible sources of ignition be avoided?

- Observe a general ban on smoking; only allow smoking in designated areas that are marked accordingly and that are far enough away from the processing and storage areas.
- Do not allow matches, lighters or other items that can produce spark to be taken into the processing or storage areas.
- Do not allow any naked flames, lights or sparks in the processing and storage areas or in dusty areas. Introduce a system of hot-work permits for work involving an ignition risk.
- Avoid friction sparks and inadvertent metal–metal or metal–concrete contact.
- Avoid any contact whatsoever of aluminium powder or items made from aluminium with rust or rusty metal parts as incendive sparks can be produced (thermite reaction).
- Avoid electrostatic charges as otherwise electrostatic discharge sparks can occur.

How can electrostatic discharges be avoided?

Protection against electrostatic discharges is essential, particularly in view of the low minimum ignition energy of fine powders (< 1 mJ).

- Only use conductive tools and containers (do not use plastic tools or plastic containers, or plastic sacks for transfer processes) as aluminium powder builds up an electrical charge when in contact with a non-conductive surface. When cleaning, for example, only use brushes with natural bristles (coconut, horsehair, etc.).
- Earthing is absolutely essential (see also BGR 132 “Avoidance of ignition hazards due to electrostatic charges”).
- When handling and processing aluminium powders it is essential that there is electrical contact between the plant components and that they are earthed to discharge static electricity.

Portable items (e.g. for filling containers or transferring the contents from one container to another) also have to be connected in an electrically conductive manner and earthed. Thus even when transferring the contents by hand connect earthing, clips to the containers and ensure that the tools used are adequately earthed via the person using them or earth them separately.

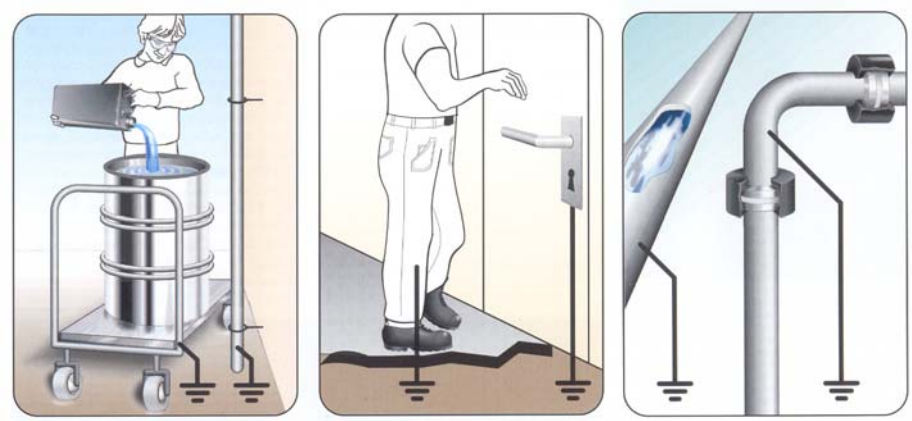

Fig. 4 Examples of how to avoid spark discharges by earthing all conductive parts and products [1]

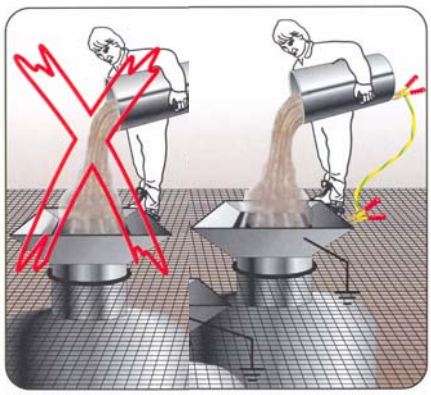

Fig. 5 Earth all portable and fixed items of equipment [1]

What effect does inerting have?

Inerting with nitrogen can markedly increase safety for certain processes, parts of the plant and equipment, especially if one cannot be certain that all possible sources of ignition have been eliminated (e.g. processes to fill, transfer and empty powder having a high aluminium content on a large scale, and mixing processes).

- When mixing aluminium powder with other dry constituents one should avoid frictional heat. The best mixer for a dry mixing operation is one that does not have any moving parts (e.g. a double-cone mixer). It is recommended to inert mixers – especially those with moving internal parts – by nitrogen blanketing because dust clouds will form on a large scale.

- Do not create a completely inert atmosphere when creating large amounts of fresh surface, e.g. by secondary granulation. One needs an oxygen content of approx. 5% here to ensure saturation of the new surfaces.

- Remove nitrogen carefully from working areas to eliminate any risk of suffocation.

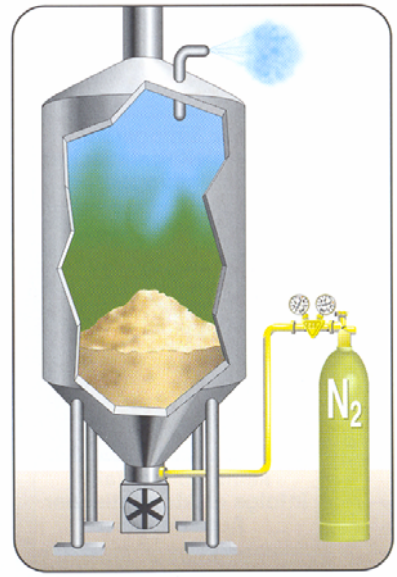

Fig. 6 Avoidance of an explosible atmosphere: inerting [1]

IV. MEASURES TO BE TAKEN IN CASE OF SPILLAGE, ACCIDENTS AND FIREFIGHTING

What needs to be considered if aluminium powder escapes?

- Collect spilt aluminium powder immediately avoiding dust formation. Use brushes with natural hair bristles and conductive shovels that do not produce sparks. Do not flush away with water or aqueous cleaners.
- Do not use a vacuum cleaner.

What needs to be considered when fire fighting?

- Use a suitable extinguishing medium – dry sand or extinguishing powders for Class D fires.
- Keep sufficient quantities of dry sand and shovels available.
- Covering with sand has to be carried out carefully using a long-handled shovel.
- Strictly avoid stirring up the burning powder.
- Never use water, carbon dioxide or foam on burning aluminium.
- Information on the correct way to tackle metal fires should also be given to external fire fighters.

What first-aid measures should be adopted?

- Toxicology: aluminium pigments have no associated toxicity. Many years of experience indicates that, if handled correctly, there are no harmful effects whatsoever.
- Inhalation: remove the person from the hazardous area and make sure he or she gets fresh air.
- Contact with the skin: wash with soap and water, remove contaminated clothing. In general the product is not irritating to the skin.
- Contact with the eyes: flush with plenty of water; seek medical attention for eyes if irritation persists.
- Ingestion: do not induce vomiting, seek medical attention.

V. OTHER INSTRUCTIONS AND CHARACTERISTICS

What is important for environmental protection?

- Keep product out of sewers or drains, or water courses.
- Inform authorities if large quantities of product enter sewers or drains, or water courses.
- Aluminium powder is not classified as being water-polluting.

What needs to be considered when collecting and disposing of waste?

- Collect waste in sealable sheet-metal containers (protected against dripping water and splashes). Avoid mixing with sweeps.
- Ensure that disposal is via a secure landfill or incineration plant, observe local regulations.
- Packaging material can be recycled when completely empty and cleaned.
- Waste that has become damp should only be collected in special containers from which it is possible for any hydrogen to escape.
- European waste code: 12 01 04 non-ferrous dust and particles (Council Decision 2000/532/EC)

Dust limit values
Aluminium is classified as an inert dust and is subject to the general dust limit value (TRGS 900).

German limit values:	10 mg/m3 (for total dust) 3 mg/m3 (for respirable dust)

National legislation has to be considered.

Fire and explosion characteristics

Combustibility:	Combustion class number BZ 4 (spread of a glowing fire)
Lower explosion limit:	30 g/m3 (fine powder) to 60 g/m3 (coarser powder)

Kst value:	> 300 bar m/s (with finer particles up to 1100 bar m/s) corresponds to dust explosion class 3
Max. explosion pressure:	up to 12.5 bar (depending on fineness)
Minimum ignition energy MIE:	< 1 mJ (for the finest powder, increases rapidly for coarser powders)
Ignition temperature of dust cloud:	> 400 °C
Ignition temperature of dust layer:	> 230 °C
Limiting oxygen concentration in N_2:	5 % (BGR 104)

Hazardous substances labelling

Specification: aluminium powder, desensitised

Labelling in accordance with Directive 2001/59/EC:

- Danger symbol: “F” highly flammable
- Risk phrases
  R 10 Flammable
  R 15 Contact with water liberates extremely flammable gases
- Safety phrases
  S 7/8 Keep container tightly closed and dry
  S 43 In case of fire use dry sand or dry extinguishing powders for Class D fires, never use water

Transport class

UN 1309, aluminium powder, coated; Class 4.1 flammable solid material; Packaging group II (ADR/RID 2007)

APPENDIX

GLOSSARY

Flammability
A substance is regarded as being flammable if it continues to burn once it has caught fire even if the source of the ignition is removed. Consequently, light metals and their alloys (such as aluminium) in powder form are flammable.

Explosion
A violent oxidation or decomposition reaction with an increase in temperature, pressure or both simultaneously. In connection with the topics discussed, so-called dust or detonating gas explosions are of interest.

Explosion limits
Explosion limits are the lower and upper limits of the concentration range of a flammable substance in air between which a mixture of the substance and air can be made to explode by means of heating or sparks

Kst value: maximum rate of pressure rise (dp/dt max)
The maximum rate of pressure rise determined under specified test conditions in a closed container when explosion of an explosible atmosphere occurs.

Maximum explosion pressure (p max)
The maximum pressure determined under specified conditions in a closed container when explosion of an explosible atmosphere occurs.

Minimum ignition energy (MIE)
The smallest quantity of electrical energy stored in a capacitor that upon discharge is sufficient to ignite the most easily ignitable mixture of dust and air under specified test conditions.

Minimum ignition temperature of dust cloud
The lowest temperature of a hot surface at which the most flammable mixture of dust and air ignites under specified test conditions.

Minimum ignition temperature of dust layer
The lowest temperature of a hot surface on which ignition of a layer of dust occurs under specified test conditions.

Limiting oxygen concentration (LOC)
The maximum oxygen concentration in a dust/air/inert gas mixture at which an explosion does not occur under specified test conditions

Dust limit value: workplace limit value

The dust limit value is the concentration of a substance in the air at a workplace that generally speaking does not impair a worker's health (Paragraph 3 Section 5 of German Ordinance on Hazardous Substances, GefStoffV).

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National legislation has to be considered.

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