5. Summary of Data Reported and Evaluation

5.1 Exposure data

Vanadium is widely distributed in the earth's crust in a wide range of minerals and in fossil fuels. Vanadium pentoxide, the major commercial product of vanadium, is mainly used in the production of alloys with iron and aluminium. It is also used as an oxidation catalyst in the chemical industry and in a variety of minor applications. Exposure to vana-

dium pentoxide in the workplace occurs during the refining and processing of vanadium-rich mineral ores, during the burning of fossil fuels, especially petroleum, during the handling of vanadium catalysts in the chemical manufacturing industry and during the cleaning of oil-fired boilers and furnaces. Exposure to vanadium can also occur from ambient air contaminated by the burning of fossil fuels and, at much lower levels, from contaminated food and drinking-water.

5.2 Human carcinogenicity data

No data were available to the Working Group.

5.3 Animal carcinogenicity data

Vanadium pentoxide was tested for carcinogenicity in a single study in mice and rats by inhalation exposure. In both male and female mice, the incidences of alveolar/bronchiolar neoplasms were significantly increased, and there were also increases in male rats. It was uncertain as to whether a marginal increase in alveolar/bronchiolar neoplasms in female rats was related to exposure to vanadium pentoxide.

5.4 Other relevant data

Vanadium pentoxide is rapidly absorbed following inhalation, but poorly through dermal contact or ingestion. Elimination from the lung is initially fast, but complete only after several days. Lung retention can increase due to impaired health status of the lung. Distribution of vanadium pentoxide is mainly to the bone and kidney.

The major non-cancer health effect associated with inhalation exposure to vanadium pentoxide involves acute respiratory irritation, characterized as 'boilermakers bronchitis'. This clinical effect appears to be reversible. Green coloration of the tongue is another frequently observed clinical manifestation of intoxication with vanadium pentoxide.

Vanadium has been recognized as an essential nutritional requirement in animals of high order, but its function is not clear. Vanadium pentoxide has important effects on a broad variety of cellular processes. It stimulates cell differentiation, it causes cell and DNA injury via generation of reactive oxygen species and it alters gene expression. The many biochemical effects induced by vanadium pentoxide, such as the inhibition of a number of different enzymes, can explain many of the metabolic effects observed in experimental animals treated with this compound.

Vanadium pentoxide can pass the blood–placenta barrier. It has been reported to be teratogenic in rodents and it affects sexual development in pre-pubertal animals, the toxicity in males being greater than that in females. The reduced fertility seen in male mice was confirmed by a reduction in sperm motility *in vitro*.

Vanadium pentoxide is mutagenic *in vitro* and possibly *in vivo* in mice. It shows clastogenic and aneugenic activity in cultured mammalian cells, the latter effect probably being due to disturbance of spindle formation and chromosome segregation. Vanadium pentoxide has been reported to inhibit enzymes involved in DNA synthesis and repair of DNA damage. Data on genetic effects in humans exposed to vanadium pentoxide are scarce.

5.5 Evaluation

There is *inadequate evidence* in humans for the carcinogenicity of vanadium pentoxide.

There is *sufficient evidence* in experimental animals for the carcinogenicity of vanadium pentoxide.

Overall evaluation

Vanadium pentoxide is *possibly carcinogenic to humans (Group 2B)*.