ALUMINIUM PRODUCTION (Group 1)

A. Evidence for carcinogenicity to humans (*sufficient*)

The lung has been the most common site identified for which there is an excess cancer risk in populations of aluminium production workers. Overall, early studies showed a borderline excess in relative risk, with some studies showing a doubling of risk and some showing no excess. Smoking histories were not given in any of these studies. In one study in which populations in the industry were compared on the basis of their exposures to pitch volatiles, there was a relationship between incidence of lung cancer and length of exposure, and there was a significant excess of cancer among workers who had worked for 21 years or more[1].

In three studies in the same aluminium-producing area, an increased risk of bladder cancer was associated with work in aluminium production in plants where primarily the Söderberg process was used. In one study in which smoking was controlled for, while there was a borderline excess in risk for nonsmokers, the risk for smokers was markedly increased[1].

Excess mortality from lymphosarcoma/reticulosarcoma was noted in two cohort studies, which covered partially the same population[1].

Statistically significant excess risks for pancreatic cancer and for leukaemia were noted as isolated findings in two studies and in one study, respectively[1].

Some of these studies have been updated. In Canada, the mortality of a large group of men employed in aluminium production using the Söderberg process was examined between 1950 and 1977, and compared with the pertinent rates for the Province of Quebec. Workers 'ever' exposed to condensed pitch volatiles ('tar') exhibited significantly increased mortality from all cancers (304 observed, 246.6 expected), and from oesophageal and stomach cancer (50 observed, 32.8 expected), lung cancer (101 observed, 70.7 expected) and other malignancies (60 observed, 45.3 expected). Analysis of lung cancer mortality by increasing years of exposure, tar-years of exposure and years since first exposure to tar revealed a steady, statistically significant, increasing trend. No similarly clear-cut pattern was noted for cancers of the oesophagus or stomach. Deaths from cancer of the urinary organs (20 observed, 13.7 expected) and bladder (12 observed, 7.5 expected) were more numerous than expected, but not significantly so. Nonetheless, when mortality from cancer at each of these sites was analysed according to tar-years of exposure, significantly increasing trends were noted. Among workers 'never' exposed to tar, mortality was not elevated above expectancy for any cancer site[2].

The risk for bladder cancer was further investigated in a case-control study based on 488 bladder cancer cases occurring in 1970-1979 in regions of the Province of Quebec where five aluminium plants were operating using the Söderberg production process. A statistically significant odds ratio of 2.7, based on 45 exposed cases, was found for employment in Söderberg reactor rooms. The risk increased steadily with time worked in this department, with odds ratios ranging from 1.9 for those who had worked for one to nine years, up to 4.5 for those who had worked in the department for over 30 years. This trend was statistically significant. The risk also increased steadily with increasing estimated exposure to 'tar' and polycyclic aromatic hydrocarbons and remained almost unchanged after adjusting for cigarette smoking, length of employment and age[3]. This set of data was later reanalysed in an attempt to quantify the noted exposure-response relationship. More refined quantitative estimates of historical workplace exposure and more complete information on smoking habits were used. Estimates of bladder cancer risk were highly statistically significantly related to three exposure indices: years spent in the Söderberg potroom; cumulative exposure to benzene-soluble material, an indicator of overall exposure to tar volatiles; and cumulative exposure to benzo[*a*]pyrene, an indicator of exposure to polycyclic aromatic hydrocarbons. It was estimated that an aluminium smelter worker exposed to 0.2 mg/m^3 benzene-soluble material for 40 years has a likelihood of contracting bladder cancer approximately 2.5-fold that of a nonexposed person. Workers exposed to 5 μg/m^3 benzo[*a*]pyrene for 40 years had a likelihood of contracting bladder cancer approximately five-fold that of an unexposed person. Smoking did not confound the relationship[4].

There is sufficient evidence that certain exposures occurring during aluminium production cause cancer. Pitch volatiles have fairly consistently been suggested in epidemiological studies as being possible causative agents. Dose-response relationships have been clarified, and confounding by smoking controlled for.

B. Other relevant data

No effect on the incidence of sister chromatid exchanges in peripheral blood lymphocytes of workers in the aluminium industry was observed in one study. No increase in the incidence of structural chromosomal aberrations was observed in the lymphocytes of workers in an aluminium reduction plant exposed to coal-tar pitch volatiles (anode production area); analyses of the semen showed no effect on sperm morphology, sperm count or double-Y bodies, when compared to matched controls from the same area, but there was an excess of mutagenic urine samples among these workers as compared to controls. Urine samples from workers in an anode manufacturing plant were not mutagenic to *Salmonella typhimurium* in the presence of a metabolic system. Methanol extracts of sputum and bronchial expectorates, pooled separately for smoking and for nonsmoking workers in a Söderberg process potroom, were tested for mutagenicity to *S. typhimurium* in the presence of an exogenous metabolic system. Expectorates from smokers were

mutagenic, while those from nonsmokers yielded inconclusive results; samples from pooled controls were inactive[5].

References

[1]*IARC Monographs, 34*, 37-64, 1984

[2]Gibbs, G.W. (1985) Mortality of aluminum reduction plant workers, 1950 through 1977. *J. occup. Med., 27*, 761-770

[3]Thériault, G., Tremblay, C., Cordier, S. & Gingras, S. (1984) Bladder cancer in the aluminium industry. *Lancet, i*, 947-950

[4]Armstrong, B.G., Tremblay, C.G., Cyr, D. & Thériault, G.P. (1986) Estimating the relationship between exposure to tar volatiles and the incidence of bladder cancer in aluminum smelter workers. *Scand. J. Work Environ. Health, 12*, 486-493

[5]*IARC Monographs, Suppl. 6*, 60, 1987