Newhouse, Ex. 84–21; and Newhouse et al., Ex. 163; for anthophyllite: Meurman et al., Ex. 84–181; for tremolite and actinolite: Brown et al., Ex. 84–29; for mixed fiber types: Hughes and Weill, Ex. 84–135; Weill et al., Ex. 84–206; Jones et al., Ex. 84–138; Berry et al., Ex. 84–20; Elmes and Simpson, Ex. 84–42; Peto et al., Ex. 84–80; Lacquet et al., Ex. 84–144; Selikoff et al., Ex. 84–89; Robinson et al., Ex. 84–82; and Balselga-Monte and Segarra, Ex. 84–19).

Several investigators and committees have suggested that exposure to crocidolite and amosite is associated with a different carcinogenic potential than is exposure to chrysotile and anthophyllite, primarily with regard to the risk of mesothelioma (Enterline and Henderson, Ex. 84–122; McDonald and McDonald, Ex. 84–154; Weill et al., Ex. 84–206; Acheson and Gardner, Exs. 84–15, 84–216, and 84–243; Muir, Ex. 84–350; and the Advisory Committee on Asbestos, Ex. 84–216). Among the studies reviewed by OSHA, the variation in mesothelioma mortality among cohorts exposed to different fiber types, expressed as a percentage of all deaths attributed to mesothelioma, is as follows: for crocidolite, 1.26 to 16 percent (McDonald and McDonald, Ex. 84–154; Jones et al., Ex. 84–138; McDonald and Fry, Ex. 84–64; Hobbs et al., Ex. 84–132); for amosite-chrysotile mixtures containing less than 0.1 percent crocidolite, 4 to 7.7 percent (Hammond, Ex. 84–47; Peto, Ex. 84–168; Robinson et al., Ex. 84–82); for amosite, 2.7 percent (Seidman, Ex. 84–87); and for chrysotile, 0 to 0.5 percent (McDonald et al., Ex. 84–65; Nicholson et al., Ex. 84–72; Dement et al., Ex. 84–37; Rubino et al., Ex. 84–86). Mesothelioma has not been found to be a cause of death among miners exposed to anthophyllite (Meurman et al., Ex. 84–256). The Chronic Hazard Advisory Panel (CHAP) (Ex. 84–256) stated that it appeared that peritoneal mesothelioma was most commonly seen among workers exposed to amosite, less often among workers exposed to crocidolite, and rarely or never among workers exposed to chrysotile. However, as the Panel's report points out, large variations in the data describing peritoneal mesothelioma mortality from crocidolite exposure, frequent misdiagnosis of peritoneal mesothelioma, and the lack of risk data expressed in terms of unit exposure level complicate making definitive conclusions regarding the relationship between fiber type and mesothelioma risk.

For lung cancer, OSHA views the epidemiological evidence for differentials in risk by fiber types as being inconclusive and inconsistent. Some studies (Dement et al., Ex. 84–37; McDonald and Fry, Ex. 84–64) have found that workers exposed to chrysotile have approximately the same or higher risks of lung cancer compared to workers exposed to amphibole fibers, while other studies (McDonald and McDonald, Ex. 84–154; Henderson and Enterline, Ex. 84–158) have found that workers exposed to chrysotile have a lower relative risk of lung cancer. After comparing lung cancer risks per unit of cumulative exposure (also known as K_L, the lung cancer potency factor) among cohorts exposed to different fiber types, the CHAP (Ex. 84–256) reported that studies of workers exposed to chrysotile yielded both high and low values of K_L, as did studies of workers exposed to crocidolite or amosite. Therefore, a consistent pattern showing a higher lung cancer risk among workers exposed to chrysotile or amosite did not emerge. Dr. William Nicholson of the Mount Sinai School of Medicine (Ex. 94) agreed that these conflicting values for K_L demonstrate that no unique lung cancer risk could be attributed to a particular fiber type. OSHA also concluded (48 FR 51115) that some cross-cohort comparison studies failed to control for important variables such as fiber concentration, age distribution, length of followup observation period, and fiber size distribution.

In the November proposal, numerous studies were discussed that demonstrated that chrysotile, amosite, crocidolite, and anthophyllite asbestos fibers are carcinogenic when administered to laboratory animals via inhalation, injection, and implantation (NIOSH, Ex. 84–338; NIOSH/OSHA, Ex. 84–320; Wagner et al., Exs. 84–205, 94–96, 84–197; Davis et al., Ex. 84–120). In general, animal studies that used standardized asbestos samples from the Union Internationale Centre Cancer (UICC) have demonstrated that chrysotile was more fibrogenic and carcinogenic than amphibole asbestos. For example, Davis et al. (Ex. 84–120) showed that UICC reference samples of chrysotile exhibited a greater potential to produce fibrosis in rats via inhalation than the amphiboles; however, treatment of rats with factory samples of these two types of asbestos showed no difference in fibrogenic potential (Ex. 84–120). Bolton et al. (Ex. 236–C) treated SFF Wistar rats by intraperitoneal injection with UICC chrysotile and UICC crocidolite asbestos and found that chrysotile produced a higher incidence of mesothelioma than crocidolite over a dose range of 0.01 mg to 25 mg per rat. Although, in another study, UICC reference samples of chrysotile and amphiboles inhaled by rats showed similar potential to produce fibrosis and lung tumors (Ex. 84–96), the NIOSH/OHSA Asbestos Work Group commented that, based on the amount of dust deposited and retained in the lung, this study, in fact, showed that chrysotile was more fibrogenic and carcinogenic than the amphiboles (Ex. 84–320, p. 15). Both Canadian and Rhodesian chrysotile produced lower incidences of mesothelioma than crocidolite, amosite, or anthophyllite when these forms of asbestos were administered intrapleurally to laboratory animals (Ex. 84–197), but no differences in mesothelioma incidences among animals treated with these asbestos types were apparent in another study (Ex. 84–338). These latter studies (Exs. 84–197, 84–338) illustrate the conflicting findings of earlier animal experiments where UICC reference asbestos samples were not used.

At the informal hearing, Dr. John M.G. Davis of the Institute of Occupational Medicine, Edinburgh, Scotland, described recent animal experiments that he conducted to examine the relationship between fiber type and the development of asbestos-related disease (Tr. 7/9, pp. 3–79). In one rat inhalation study (Tr. 7/9, p. 16), 10 percent of the lung tissue taken from rats exposed to 10 f/cc UICC chrysotile showed evidence of scarring; only 1.5 and 2.5 percent of lung tissue taken from rats exposed to the same fiber concentration of crocidolite and amosite, respectively, were scarred. The same trend was observed for the incidence of malignant tumors found in exposed rats. Dr. Davis also discussed injection studies on rats (Tr. 7/9, p. 29) that showed, at doses ranging from 0.01 to 15 mg, that chrysotile produced the greatest number of mesothelioma tumors at every dose tested. Dr. Davis concluded from these studies that ". . . both by fiber number and by fiber mass, chrysotile appeared to be the most dangerous" (Tr. 7/9, p. 15).

The animal studies reviewed by OSHA and the work described by Dr. Davis suggest that chrysotile has a greater fibrogenic and carcinogenic potency than the amphiboles, a finding that contrasts with the findings of human epidemiological studies that suggest that the amphiboles have a greater potential for producing mesothelioma. Several explanations for these conflicting results were offered into the record. Dr. Davis testified that part of the reason for the different findings between animal and human studies is that

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