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Amiantus Arbeits- und Umweltschutz

Amiantus Occupational and Environmental Safety & Health

To: All General Managers

cc: AGL

INFORMATION AAU 9 22th January, 1981

For your information you will find attached three papers dealing with the question whether crocidolite is more dangerous than chrysotile:

1. Dr. J.M.G. Davis (Institute of Occupational Medicine, Edinburgh/UK),
   Evidence for variations in the pathogenic effects of the different forms of commercially used asbestos - A review of the literature

2. Prof. E.G. Beck und Dr. F. Tilkes (Hygiene-Institut des Klinikums Giessen, FRG),
   Summary and conslusion of an appraisal of literature on the question whether crocidolite must be considered to be more dangerous than chrysotile

3. Dr. K. Robock,
   Some thoughts to the question: Is crocidolite more dangerous than chrysotile?

While the conclusions of Dr. Davis and Prof.Beck/Dr.Tilkes are based on the currently available literature on epidemiological studies, animal experiments and cell toxicological tests Dr. Robock's paper concentrates on the physical and chemical-physical criteria concerning this problem.

All three papers come to the result that according to the current state of knowledge, the appraised studies do not allow definitely the statement whether there is a significant difference in the carcinogenic resp. toxicological effect between crocidolite and chrysotile.

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an: Alle Unternehmensleiter

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INFORMATION AAU 9 22. Januar 1981

Zu Ihrer Information erhalten Sie als Anlage folgende drei Arbeiten, die sich mit der Frage beschäftigen, ob Krokydolith gefährlicher ist als Chrysotil:

1. Dr. J.M.G. Davis (Institute of Occupational Medicine, Edingburgh), Evidence for variations in the pathogenic effects of the different forms of commercially used asbestos - A review of the literature

2. Prof. E.G. Beck und Dr. F. Tilkes (Hygiene-Institut des Klinikums der Justus-Liebig-Universität Giessen), Summary and conclusion of an appraisal of literature on the question whether crocidolite must be considered to be more dangerous than chrysotile

3. Dr. K. Robock, Some thoughts to the question: Is crocidolite more dangerous than chrysotile ?

Während sich die Schlußfolgerungen von Dr.Davis und Prof.Beck/Dr.Tilkes auf die bis heute existierende Literatur über epidemiologische, tierexperimentelle und zelltoxikologische Studien stützen, geht Dr.Robocks Abhandlung stärker auf die physikalische und chemisch-physikalische Fragestellung zu diesem Problem ein.

Alle drei Arbeiten kommen zu dem Ergebnis, daß die ausgewerteten Studien nach dem heutigen Stand der Wissenschaft keine endgültige Aussage darüber zulassen, ob ein signifikanter Unterschied in der kanzerogenen bzw. toxischen Wirkung zwischen Krokydolith und Chrysotil besteht.

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Some Thoughts to the Question:

IS CROCIDOLITE MORE DANGEROUS THAN CHRYSOTILE?

The recommendation to ban the use of crocidolite as well as a legislation laying down a ten times more severe limit value for that fibre emanates from England on the assumption of a considerably higher health hazard for crocidolite (amphibole asbestos) in comparison with chrysotile (serpentine asbestos).

What conclusions could current opinions provide?

1. Epidemiological Studies

Two publications are mainly being used for primary argumentation:

- Diffuse Pleural Mesothelioma and Asbestos Exposure in the North Western Cape Province, WAGNER et al. - 1960 (1)

- Factory Populations Exposed to Crocidolite Asbestos - A Continuing Survey, JONES - 1976 (2)

Persons dealt with in both these papers were predominantly exposed to crocidolite.

From all mesothelioma cases which had been reported todate from all over the world

- between 20 - 50 % (depending on the respective national situation) are not related to asbestos exposure and

- those cases which are considered to be asbestos related are no longer attributable exclusively to crocidolite exposure.

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2. Animal Experiments

None of the animal experiments conducted so far give any definite indication that crocidolite causes a more frequent incidence of mesothelioma or that smaller quantities of crocidolite fibres by comparison with chrysotile fibres would cause mesothelioma (BOTHAM / HOLT - 1972; WAGNER, BERRY, SKIDMORE, TIMBRELL - 1974; REEVES et al. - 1971 and 1973) - (3 - 6).

Even the considerable variations in fibre concentrations used in the extensive animal experiments of REEVES (54 mio fibres/m³ for chrysotile, 864 mio fibres/m³ for amosite and 1105 mio fibres/m³ for crocidolite) did not indicate stronger biological effects (malignancies) of amphibole asbestos. Moreover, fibre length distributions of these samples were not comparable.

Animal inhalation tests of concentrations with equal numbers of fibres and comparable distributions of fibre length showed identical biological effects (malignancies) for all fibre types. (DAVIS - still unpublished paper presented at the 5th International ILO Conference on Pneumoconiosis, Caracas - 1978).

In animal inhalation tests with the various types of asbestos and with different fibre lengths it was shown that fibres longer than 20 µm produced stronger carcinogenic effects than those shorter than 20 µm, irrespective of the asbestos type. "Dust clouds with almost no fibres over 20 µm in length produced no bronchial carcinomas and very little fibrosis." (DAVIS - 1979) - (7). In this latest work, no malignancies were encountered with the application of amosite and crocidolite despite of high concentrations (5 - 10 mg/m³), if fibre lengths were shorter than 20 µm. However, chrysotile produced malignancies as fibres were longer than 20 µm.

If according to current epidemiological knowledge and the experience gained from animal experiments there are no significant differences in the potential health hazards of asbestos fibre types, the question arises whether and what other scientific criteria could indicate to what extent it is justified to assume different health hazards for crocidolite and chrysotile.

3. Concentration of Fibre Numbers

By reason of the specific structure of amphibole asbestos there develops for a number of working processes a higher concentration of fibre numbers in the airborne dust (fine dust) than with serpentine asbestos as the latter tends to retain its fibre bundles (8, 9, 11). Amphibole asbestos fibres have the tendency to split up into thinner fibres, i.e. respirable fibres.

The aforementioned papers of REEVES indicate the strongly differing fibre number concentrations produced in the dust chamber by almost equal mass concentrations (chrysotile 47.9 ± 3.0 mg/m³, amosite 48.6 ± 3.0 mg/m³ and crocidolite 50.2 ± 3.6 mg/m³.

It is therefore correct to maintain that with certain working processes there exists a potentially higher health hazard with an equal mass unit of crocidolite than with chrysotile. However, these conditions can reverse if the fibre bundles split into elementary fibrils, since the elementary fibre of chrysotile is considerably thinner (1/10) than those of amphibole asbestos (8, 9, 10).

If however suitable processes or technical measures are being applied to observe or go below the prescribed limit values, there is no higher risk potential for a worker handling crocidolite. Due to the technical measures this worker is not exposed to higher fibre number concentrations than the worker handling chrysotile.

It would thus appear that the question whether crocidolite is more dangerous than chrysotile depends entirely on the fact whether one fibre of crocidolite presents a greater hazard than one fibre of chrysotile.

To assess this problem, their physical and chemical properties may give some useful indications.

4. Physical / Chemical Properties

4.1 Solubility

The leaching of magnesium from the crystal grid makes chrysotile soluable whereas this is not the case with amphibole (8 - 11).

This process eventually facilitates for chrysotile fibres
- an easier decomposition through structure changes in the biological milieu as well as
- the change in surface adsorption properties.

On the other hand, the solubility might cause splitting of fibre bundles into thinner fibrils (through a reduction in the cohesive force). Moreover, the leaching of magnesium may cause a localised physiological disturbance in the tissue milieu.

4.2 Elastic Properties

The terms "soft" and "harsh" which are used to denote the flexibility of fibres are applicable to both, chrysotile and crocidolite (11). The flexibility of fibres depends on the mineralogical-petrographical peculiarities of the deposits where the fibres are mined.

However, with commercial asbestos types the proportion of "harsh" fibres is greater with amphibole asbestos than with chrysotile.

Harsh and stretched fibres are thought to be more dangerous by reason of greater migration ability. However, it should be remembered that such fibres more easily split transversely. This favours - through the reduction in fibre length - the potential elimination of fibres and thus reduces their potential health hazard.

The dangers from flexible, softer fibres are attributable to the possibility of increased splits in length resulting in finer fibrils which increases the number of fibres per mass unit (by retention of length).

4.3 Inhalability

Apart from the density the inhalability of a fibre depends almost exclusively on its diameter (aerodynamic diameter). This means that a stretched fibre (predominantly amphibole asbestos) is easier inhalable but at the same time it is also easier exhalable by comparison with a curved fibre with a larger (projected) diameter (chrysotile) - (12, 13).

4.4 Surface Properties

According to new scientific concepts it could be possible that apart from fibre dimension certain surface properties of fibres (adsorption behaviour) may have causal significance for carcinogenic effects.

On this assumption higher potential health hazards may be attributable to chrysotile fibre bundles by reason of their greater (inner and outer) specific surface area* by comparison to the thinner single fibres of amphibole asbestos (9 - 10).

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* Specific surface area of

commercial	chrysotile fibres:	30.000 - 90.000 cm^2/g
"	amphibole "	6.000 - 20.000 cm^2/g
(i.a.	amosite:	3.000 - 8.500 cm^2/g
(	crocidolite:	1.000 - 10.000 cm^2/g

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4.5 Fibre Dimensions

According to certain investigations (7, 14) the fibre diameter as well as the fibre length distribution of respirable fibrous materials would appear to be of great significance. Subsequently, differential health hazards may be attributable to the inhalation of different ranges of fibre lengths.

5. Conclusively it may be stated:

It must be reiterated that in view of current scientific knowledge about the biological effects of mineral fibres there is no justification for any differentiation in respect of the potential health hazards of various asbestos fibres. Particularly in view of WAGNER's remark: The British standard for crocidolite has a purely arbitrary basis - (15).

Priv.-Doz. Dr. rer.nat. K. Robock

Enclosure:

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Summary and conclusion of an appraisal of literature on the question whether crocidolite must be considered to be more dangerous than chrysotile

E.G. Beck and F. Tilkes

The following conclusions represent a simplified summary of an appraisal of literature on the a.m. question. This appraisal covered epidemiological studies of occupational exposure to crocidolite or chrysotile in relation to tumour incidence, animal experiments with various methods of fibre application to promote tumour induction as well as cell experiments to assess the effects of respirable crocidolite and chrysotile fibres (membrane pathogenicity, toxicity).

Neither the results of the epidemiological studies which were examined nor those from animal and cell experiments were in any way suitable to present conclusive evidence as to whether crocidolite is more dangerous than chrysotile.

EPIDEMIOLOGY

Evidence from epidemiological investigations indicates that the various aspects make it virtually impossible to establish valid comparisons of crocidolite or chrysotile exposure:

- lack of or inadequate dust measurements,
- vague indication of duration and degree of exposure
- difference in size of cohorts and particularly
- the rarety of exposure to one type of asbestos in contrast to the common exposure to fibre mixtures (Becklake, 1976).

For crocidolite exposure the following epidemiological studies were consulted: Wagner et al., 1960; Harrington et al., 1971; Webster, 1973; McNulty, 1962; Jones et al., 1976, 1979; and for chrysotile exposure: McDonald et al., 1973, 1974, McDonald and McDonald, 1977, 1978, McDonald 1978, Rubino et al., 1979; Nicholson et al., 1979; McDonald and Liddell, 1979; McDonald et al., 1980.

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ANIMAL EXPERIMENTS

To test carcinogenicity of respirable asbestos fibres a variety of experiments had been conducted with different types of animals. Experiments concentrated on intrapleural and intraperitoneal injections as well as inhalation tests, all of which induced tumours. For extrapolating these results to human conditions it is essential that the chosen experimental method can simulate to a large extent peculiarities of the human organism. Although inhalation tests are most suitable, in this respect it must be realized that for comparative evaluation there is some disadvantage of lesser tumour frequency.

Intrapleural injections

In comparisons of carcinogenicity of chrysotile as compared with crocidolite fibres, several authors (Wagner, 1962; Wagner and Berry 1969; Wagner et al., 1970, 1973; Stanton and Wrench, 1972) have established an almost equal tumour frequency. These investigations were conducted with fairly comparable dust fractions and concentrations.

However, with UICC-Standard asbestos dust, most tumours were induced by the crocidolite samples (Wagner et al., 1972), which however was not confirmed by other authors (Stanton and Wrench, 1972). In their investigations the rate of tumours induced by chrysotile and crocidolite was equally high.

Intraperitoneal injections

Numerous investigations with various types of asbestos confirmed their carcinogenicity but did not permit any direct comparison between chrysotile and crocidolite (Reeves et al., 1971; Pott et al., 1972, 1974, 1976; Engelbrecht and Burger, 1973).

Unpublished investigations of numerical dosage of chrysotile and crocidolite fibres with comparable length distribution showed up a similar incidence of tumours from both types of asbestos (unpublished, Tilkes et al.).

Moreover, it was established, that the latency period is shorter for chrysotile than for crocidolite exposure which confirmed earlier investigations (Wagner et al., 1970).

Inhalation tests

These investigations which are most comparable to human exposure were conducted with various species of animals (i.a. Reeves et al., 1974; Wagner et al., 1974, 1979; Davis 1980).

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Direct comparisons of the carcinogenicity of chrysotile vis-a-vis crocidolite were only carried out by some authors (Reeves, et al., 1974; Wagner et al., 1974; Davis, 1980),who found tumours of the lung and the pleura after inhalation particulary in rats. Individual inhalation experiments showed variable tumour incidences; in certain results it was chrysotile which induced more tumour cells than crocidolite, in other cases it was the reverse. Earlier inhalation experiments are only comparable to a limited extent, as different types of dusts, different dust preparation as well as different dust concentrations were used. An important disadvantage of these experiments must be attributable to gravimetric dosage. Only one particular inhalation experiment conducted by Davis during 1980 can be evaluated as fibre numbers per volume had been specified apart from indications of individual fibre length. By almost comparable fibre numbers chrysotile caused the higher tumour frequency than crocidolite.

Cell experiments

During the examination of biological effects of respirable mineral fibres (asbestos and man-made mineral fibres) on phagocytosed human and in-vitro cells as well as those of other mammals it was shown that the membrane pathogenicity resp. toxicity depended on dust dosage as well as fibre dimension (length/diameter). The phagocytosis of natural and man-made mineral fibres (about $\gtrsim$ 5-10 µm) remains incomplete. Fibres which have not been completely incorporated cause a localised membrane damage of the cell. Any increase in dust dosage and fibre length enhances the toxicity as well.

Several authors have proved that gravimetric dosage considerably increases chrysotile toxicity compared to crocidolite (Allison, 1972; Davis et al., 1974; Bey and Harington, 1971; Miller and Harington, 1972; Robock and Klosterkötter, 1971, 1973).

In case of equal fibre number concentration and relatively equal fibre length distribution, there were no differences in the toxicity of chrysotile and crocidolite.

The numerical dosage took into account that the dimension of fibres and thus the individual fibre is most significant for the pathogenicity of asbestos related diseases, which compensates the discrepancies in the number of fibres per mass unit caused by variable specific weights and aspect ratios. (Chamberlain and Brown, 1978; Tilkes and Beck, 1979)

Conclusion

In conclusion it must be reiterated that none of the scrutinized papers of epidemiological investigations, animal experiments and cell toxicological tests give any clear indication about a significant difference in the carcinogenic and toxicological effects between carcinogenicity resp. toxicity between crocidolite and chrysotile.

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