MEMORANDUM

TO: All Member Associations AIA/7/3

FROM: Sir Neville Stack 10 July 1979

RESEARCH REPORT - ASBESTOS
INVESTIGATIONS INTO HEALTH HAZARDS THROUGH DUSTS EMITTED
BY BRAKE LININGS CONTAINING ASBESTOS
Issued by the German Federation of Industrial Accident Insurance
and Industrial Safety Corporations e.V.

Attached is a translation of the significant parts of the above-mentioned document which indicate that it is a very important piece of research. The report is the result of considerable work by more than one independent institution, and therefore should carry considerable weight with authorities. The main conclusion is that when a brake has been in use the dust emitted from the lining contains virtually no asbestos, which means that the effect on the environment is almost nil.

However, it is stated that all the investigations have been done on German brakes, and it is understood that there is a considerable difference in the asbestos content of American brakes.

It is also pointed out that there is a difference in usage between America and Germany; the Americans use a larger brake pad and do not drive so fast, which means that less heat is generated when the brake is applied.

We are obtaining copies of the original German report, which will be sent to Member Associations. Would you please make sure that companies within your Associations which manufacture brake linings are advised of this report.

T N Stack

Sir Neville Stack

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RESEARCH REPORT

ASBESTOS

INVESTIGATIONS INTO HEALTH HAZARDS THROUGH DUSTS EMITTED BY BRAKE LININGS CONTAINING ASBESTOS.

Issued by the German Federation of Industrial Accident Insurance and Industrial Safety Corporations e.V.

FOREWORD

Because of its particular physical and chemical properties, asbestos has become a much sought-after natural product. Its resistance to high temperatures, inflammability and fibrous structure have helped to solve numerous technological problems to the extent that we now encounter asbestos in a multitude of products. Unfortunately however, asbestos is hazardous to health - especially its carcinogenic properties have arrested the attention of the public in more recent times.

Long before asbestos made the headlines, the Industrial Accident Insurance and Industrial Safety Corporations of Germany studied the risks of asbestos, and by issuing an accident prevention code were able to implement and intensify technical and occupational medical preventive measures. One of the questions posed in this process was whether the dust emitted by brake linings which contain asbestos is also capable of causing asbestos illnesses. This is a vital question, since upon its answer depends whether or not a large number of motor vehicle mechanics in particular need to undergo regular medical examinations. The present scientific investigations are intended to throw light on this subject.

The many forms which the problem took in actual research however is demonstrated by the fact that four scientific institutes took part in the research project. Organisational procedures too entailed many problems; as one example, to ensure the scientific validity of the results more than 200 motor vehicle mechanics and employees in the brake lining industry in the Federal Republic had to be found who had had more than 10 years of exposure to dust, in order to have them examined at the Institute for Occupational and Social Medicine in Erlangen.

The final phase of the joint investigations revealed yet another important aspect: similar investigations in the USA had come to conclusions that did not always coincide with our own. This is due to the fact that American brake linings are essentially different from German in terms of composition and hardness, a requirement which has to do with different driving habits in the USA (speed limits). We shall have to deal with this new aspect in the near future, especially since increasing numbers of American motor vehicles are to be expected on the German market.

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Foreword - continued.

This research project was financed with the aid of the Federation of German Industrial Accident Insurance and Safety Corporations, the General Committee of the Iron and Steel IAISC and the IAISC of the Chemical Industry.

May we express our thanks to all those who have contributed to the successful outcome of this report.

Hopf
Chairman

Dr. Bischoff
Vice-Chairman

Bonn, December 1978

CONTENTS

SUMMARY

The investigations into the dangers of dusts emitted by brake linings containing asbestos carried out by the Dust Research Institute of the Federation of Industrial Accident Insurance and Industrial Safety Corporations and the Bavarian State Institute for Occupational Safety within the scope of the overall research programme may be summarized in terms of their results as follows:

1. Brake linings used in the brake systems of motor vehicles contain 10 to 70 % by weight of asbestos; this value usually lies between 20 and 30 % by weight. In all the cases examined, the asbestos used was Chrysotile; other types of asbestos are obviously not used.

2. The principal dust sources encountered in the handling of asbestos brake linings are :

a) in manufacture, the finishing stage comprising the operations grinding, drilling, turning, sawing and milling,

b) in the vehicle workshops, the brake service centres with the operations grinding and turning of brake linings as well as flushing the dust from brake drums.

3. In the finishing stage of lining manufacture, the operations grinding and drilling may as a rule be regarded as ongoing operations. The average expsoure time for the operative is

6-8 h/shift for grinding

4-6 h/shift for drilling.

The operations sawing, turning and milling are carried out only occasionally and only by some lining manufacturers.

In motor vehicle workshops, the operations that suggest the emission of asbestos dust are grinding, turning and flushing, although these operations are generally short-term only. The time of exposure for operatives in the workshop is difficult to assess accurately, but we can assume the following averages

< 1 h/shift, usually < 3 h/week for grinding and turning

< 1-3 h/shift for brake drum flushing.

4. The Chrysotile asbestos content in suspended dust found at the finishing stage of brake lining manufacture is on average 20 % by weight and thus in the order of the volume of asbestos contained in brake linings themselves. Conditions in vehicle workshops for the operations grinding and turning are similar, although the values are on average lower here.

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4. continued.

It was not possible to find clear evidence of the presence of Chrysotile in dusts caused by brake drum flushing. By the fact of its morphology the dust contained practically no fibres at all.

5. The microdust concentrations of Chrysotile asbestos during the operations grinding, drilling, sawing, turning and milling in finishing during brake lining manufacture were just above and below the limit value of 0.15 mg/m³.

In the brake maintenance departments of motor vehicle workshops, the limit for Chrysotile asbestos during the actual operations of grinding and turning is in fact exceeded. In the workshop area however the average values were considerably below this limit. Since no evidence of asbestos in dusts caused by brake drum flushing can be provided, the assessment was based on the MAK value for inert dust of 8.0 microdust/m³. This value was considerably exceeded during the actual flushing operation. Concentration in the work area however was on average below this MAK value.

6. Test bed and laboratory experiments showed that :

a) by mechanical loading (microgrinding) the fibres located in the friction area during the braking process are destroyed to such an extent that practically no fibres can be found in the resulting friction dust, in terms of morphology.

b) Under the influence of temperature, the crystalline lattice of Chrysotile probably transforms into an amorphous intermediate phase. It must be assumed that local temperatures in excess of 500°C are generated in the friction surface.

c) The tempering of samples taken from crushed brake linings in the laboratory at over 800°C causes the formation of Forsterite. Under test bed conditions, Forsterite in the friction dust could only be found with very high asbestos contents (some 60%) in the friction lining. In none of the examined cases was it possible to detect Forsterite in brake drum dust as generated by flushing in the vehicle workshops.

CONCLUSIONS

The results of the supplementary investigations confirmed that the asbestos content in brake friction dust is considerably lower than in the brake linings themselves. There were however wide variances in the extent of asbestos contained in the friction dust. While only traces of Chrysotile asbestos (10^{-3} to $5 \cdot 10^{-1}$ %) were detected in the friction dust samples from 40 German vehicle workshops, there are American brake linings whose friction dust may contain 10 to 30 % Chrysotile asbestos. Asbestos in the order of 2 to 4% has been detected in the friction dust from French workshops.

The reasons for this should first of all reside in the varying composition of the friction linings themselves, and secondly in the variety of conditions under which they are used. Thus European and Japanese linings contain as a rule 10 to 30 % asbestos, while American products contain as much as 60%. In addition, American vehicles are fitted with larger brakes than, say, German vehicles and are generally driven at lower speeds with the result that the heat loading on American brakes is lower. However, the wear and hence the dust emission of the linings is largely determined by the temperature. Even the type of bonding agent used is significant. Thus linseed oil which is used as a bonder for linings in light-duty brakes starts to decompose at as low as 230°C.

These investigations into the asbestos content of brake lining friction dust in motor vehicle brake drums represent an important supplement to the pertinent results of the research programme into hazards to health caused by dusts emitted by asbestos friction linings. They confirm those findings and support the conclusions from them in so far as German brake linings are concerned, but demonstrate on the other hand that other circumstances may be encountered, at least in the case of American linings. The reasons for these differences have yet to be fully clarified.

DISCUSSION OF RESULTS

Man's need for fast transport facilities is as old as civilization itself. However, the high speeds made possible by modern technologies have brought about many new dangers. Apart from fire and war, the braking of energies of motion is perhaps the greatest among the self-induced, exogenous hazards to human life. In order to minimize these risks, people employed in the friction lining industry, the lining processing sectors of the motor vehicle industry and the brake maintenance departments of vehicle workshops and garages are contributing valuable work. Friction linings on the other hand contain asbestos, a material hazardous to health, although in composite form. The amount of Chrysotile asbestos in friction linings is between 10 and 73%, usually between 20 and 30 %. According to American assessments, each private car consumes some 3 or 4 sets of brake linings and 2 clutch linings in its life, while goods vehicles and public transport vehicles require many more. In the highly motorized industrial nations, this fact is expressed as a production figure for brake and clutch linings containing asbestos, of which not less than 6500 t and 7000 t were produced in the Federal Republic of Germany in the first quarter of 1971 and 1972 respectively. The annual asbestos consumption of the USA for the manufacture of brake linings was approx. 55,000 t and approx. 2000 t for the production of clutch linings.

The latest estimates for 1972 in the USA gave a total figure of 907,871 persons potentially exposed to lining dust through their occupations: 833,535 motor mechanics, 67,679 garage workers and some 6,657 employees in the friction lining industry.

There are no reliable figures on persons in the Federal Republic of Germany currently exposed to lining dust and hence to asbestos in the course of their work. And there is even less information available in Germany on the nature and extent of the health hazards that can be causally attributed to such exposure with the degree of probability required for purposes of statutory accident prevention.
So what is the current state of medical knowledge on this ?

Bibliographical material on the subject shows that persons occupationally exposed to brake lining dust can expect a fibrogenous and even carcinogenic health risk as a result of asbestos effects. Thus in the USA in 1963, out of 7510 employees in the friction lining industry 29 deaths of asbestos pulmonary cirrhosis were recorded (= 3.86%). In 21 of the 29 deaths, asbestosis was the primary cause.

More recent epidemiological findings by Selikoff's working party point especially to the asbestos risk among New York automobile mechanics. A provisional cross-sectional study of 84 active and 6 retired (for age reasons) automobile mechanics each with at least 10 years working experience behind them, and of whom some 2/3 had been engaged in brake maintenance, revealed diminished vital capacities in no less than 29% of the subjects and radiological changes in terms of asbestos inhalation effects in 27%. More particularly, these 24 subjects revealed minor irregular shadows of type s or t with a scatter of 1/0(9 x), 1/1(6 x), 1/2(2 x) and 2/2(2 x) as well as indications of pleural fibrosis ($\geq$ 1 a) and/or pleural calcification

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(5 x).

In Great Britain 14 out of 718 recently diagnosed asbestosis cases (= 2 %) in the years 1955-1969 are persons occupationally exposed to brake lining dust. Epidemiological investigations in Italy revealed 59 cases of asbestosis out of 204 employees in the friction lining industry. In Switzerland on the other hand, of 39 persons in automobile brake maintenance, there was only one questionable instance of asbestosis. Neverthless regular control examinations of this occupational group are regarded as necessary.

Less comprehensive is the available knowledge of carcinogenic asbestos risks in exposure to friction lining dust. In Great Britain in 1965 Newhouse and Thompson recorded 1 mesothelioma patient following occupational crocidolite (blue asbestos or ironstone) exposure during brake lining manufacture and in 1974 Greenberg and Davies recorded a further case of mesothelioma after exposure of a motor mechanic.

In the USA, Enterline and Kendrick - 1967 - reported indications of a marginally increased mortality rate from carcinomae of the breathing organs among employees in the friction lining industry. From Canada, McDonald and his colleagues in 1970 reported 2 cases of mesothelioma following occupational exposure to asbestos in the fitting of brake linings plus a further case of mesothelioma after exposure during brake lining manufacture.

In West Germany in 1972, Otto published the case of a 50-year-old fitter with pathological-anatomical pleuramesothelioma after many years employed in the fitting of brake linings.

A study of available subject literature - especially with regard to fibrogenous asbestos risks - shows however that the particular circumstances of exposure to brake lining dust were frequently inadequately investigated to facilitate a differentiated consideration of the hazards. More particularly, it is essential to distinguish exposure to dust from new or used brake linings. Technical investigations into dust in recent years have repeatedly shown that the dust generated by lining friction - as opposed to dust during the finishing and handling of new linings - as a rule contains only traces of free Chrysotile fibres, i.e. of the order of 1%.

Even Schütz' working party was unable to provide clearer infrared-spectrographical evidence of Chrysotile within the scope of this joint research programme, using site measurements as well as laboratory and test-bed experiments on dusts caused by brake drum flushing with compressed air. Under phase-contrast and electron-microscopic scrutiny, the dust contained merely isolated fibres which could not even be definitely identified as asbestos. The assessment of dusts in the air-flushing of brake drums was therefore initially based on the MAK value for inert microdust of 8.0 mg/m³.

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By contrast we find some reports from the USA with partially high fibre concentrations in brake drum dust during peak samples lasting several seconds. Hatch for example has found peak values of 43 $\pm$ 2.1 fibres/ml during drum flushing, while Knight and colleagues have found as many as 87 fibres/ml. The latest findings by Selikoff's working party on flushing operations of car brake drums point in the same direction, with recordings of 6.6, 13.6, 13.8 and 29.4 fibres per ml.

The hypothesis posited at the beginning of this discussion must be seen against this background: Does occupational exposure over many years to dusts emitted by asbestos brake linings of employees in the 3 most important risk sectors have medically probable, demonstrable and detrimental subsequent effects on the pulmo-cardial system, especially in terms of specific fibrogenous asbestos inhalation consequences ?

Our occupational medical and epidemiological investigative results are thus based upon the knowledge of work-specific differences in occupational exposure to brake lining dust. As a result, 3 aspects are of particular importance:

1. The formation of adequate random sampling.
2. The representativeness of occupational characteristics for the following areas:
   - industrial finishing in friction lining manufacture (risk group a)
   - brake maintenance services, with exposure primarily during the operations of grinding and turning of linings (risk group b) and
   - brake maintenance services, with exposure primarily during flushing and brushing out of brake drum dust (risk group c).
3. A period of 10 years or more occupational exposure to the development of asbestos effects.

Thus far, the epidemiological artifice of a casuistic cross-sectional study with retrospective assessment would seem to be adequate for the hypothesis under scrutiny. However, the results obtained are unable to give any answers to the following essential questions:

A) What type and how great are the carcinogenic risks of occupational exposure to brake lining dust ?

B) Does the surprisingly often demonstrated finding of so-called chronic-obstructive bronchitis, as opposed to fibrogenous asbestos-inhalation, represent an overfrequent risk of occupational exposure to brake lining dust ?

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C) What effect has the change in workplace conditions since the beginning of the Fifties had on the prevalence of the consequences of asbestos inhalation, e.g. through

- improvements in dust protection by way of extraction technology,
- increasing use of disc brakes for private cars, and
- flushing of brake drums by means of cleaning detergents.

The answers to questions A), B) and C) would require specific longitudinal - as opposed to cross-sectional -studies including future measurements as well as suitable comparative groups.

Re 1:

Our random samples from the individual risk groups each containing between 43 and 63 persons were kept satisfactorily large. With 50 separate companies throughout West Germany and the resultant organisational difficulties, this was only possible in close cooperation with the Headquarters for Accident Prevention and Occupational Medicine of the Federation of Industrial Accident Insurance and Safety Corporations in Bonn.

Re 2:

The representativeness of activities in the 3 key risk groups was ensured in a variety of ways:

- The selection of each subject and the collation of important dust-protection data at the workplace was carried out by experienced technical supervisors with many years service in occupational safety;
- The investigative results reported by Schütz' working party on dust hazards through asbestos brake linings relate to approx. 85% of the workplaces in those companies in which our subjects were employed;
- The additional detailed survey of occupational and industrial case histories carried out by an occupational physician extends to the entire working life of each subject.

In this way it was found that a sharp delineation in brake maintenance services between activities involving exposure to dusts emitted by new linings on the one hand and brake drum dust on the other does not appear admissible, at least for the period of the subject's entire past working life. In other words, the random sample of risk group c) contains not just employees who have only always flushed or brushed out brake drum dust. It is difficult to ascertain the time spent on operations such as grinding or drilling of unused linings. Thus for example of the

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19 men with suspected findings in terms of initial consequences of asbestos inhalation (Type II), or with minimal (Type III) and equivalent findings (Type IV), no less than 11 stated that they had handled unused brake linings in the manner mentioned in addition to their primary activities of flushing and brushing out brake drums.

Re 3:

With regard to the exposure period, a process of elimination guaranteed a minimum of 10 years occupational exposure to brake lining dust in each case. This fact is expressed in the left-shift spread of exposure periods with arithmetical averages between 16 and 21 years and maximum values between 25 and 44 years (cf. Table 6 and Fig. 2).

The foregoing points indicate both possibilities and limits of a discussion of results, on the assumption that the occupational medical appraisal of the findings on a person exposed to asbestos dust must today be basically three-dimensional. By this we mean both the aspect of occupational disease diagnosis and rival health hazards, which could cast doubt on suitability for hazardous work in accordance with the principles of the industrial safety corporations. This situation was taken into account by the definition of types of findings as I = $\hat{=}$ AIF probable, II $\hat{=}$ AIF possible (suspect findings), and III = $\hat{=}$ AIF unlikely on the one hand, and on the other the rival finding designated as IV $\hat{=}$. This in turn was based on suitable procedures of primary and secondary data gathering, such that the detailed information on each subject could be reduced from more than 100 target features - with the extensive elimination of perturbances - to one or two types of findings. The risk assessment is thus based on the frequency of peculiarities noted according to types of findings in work-specific sub-groups. After consideration of the pros and cons the assertion of a tolerable residual risk for findings in terms of probable asbestos inhalation consequences Type I) of less than 1 % would appear acceptable under the prevailing circumstances.

If we look through the results submitted, we find that there is evidence - with the degree of probability decisive for the area of statutory accident insurance - that many years of occupational exposure to brake lining dust can lead causally to fibrogenous asbestos inhalation effects. But an assessment differentiated by risk groups points to apparent differences in the risk of disease, these differences arising out of the frequency of symptoms in findings group type I and to a certain extent in II. We should point out here that the definition of findings type I - as opposed to type II - in terms of occupational medicine is based on a "reasonable suspicion" of an occupational disease under Section 5 of the 7th BKVO*.

*BKVO = Berufskrankheitsverordnung - Occupational Disease Code.

Discussion of Results - continued.

The number of occupational diseases to be indicated under Figure 30 of the Appendix to the 7th BKVO is 3 in risk group a) and 2 in risk group b). In relative terms, 5.9% and 3.2% respectively of the male subjects in both risk groups clearly exceed the tolerable residual risk of less than 1 %. To this fact must be added that the employees in risk group a), while being some years older on average, had nevertheless had some years less exposure to brake lining dust than the subjects in risk group b). The relative frequency of insured persons with suspect findings in terms of potential asbestos inhalation effects (Type II) is 16% in both sub-groups. For these persons intensified monitoring by for example more frequent examinations is to be recommended in accordance with principle G 1 of the industrial accident insurance corporations. All in all, we may assume that the male groups are exposed to a somewhat higher disease risk in the finishing stage of the lining manufacturing industry (risk group a) than in motor vehicle maintenance, especially with exposure to dust from new and used brake linings (risk group b).

Female employees are only engaged in lining manufacture to any noteworthy extent. The random sample of 43 female workers did not reveal any peculiarities compared to their male counterparts in terms of age distribution and length of exposure to brake lining dust (Table 6 and Fig. 2). The results of the investigations however differ considerably. The probable presence of fibrogenous asbestos inhalation effects (Type I) was found in none of the subjects, while potential effects (suspect findings, Type II) were only approx. half as frequent (7%) as in males. The length of exposure to dust from the drilling (twice) and grinding (once) of unused linings for the 3 women of findings Type II was 18, 20 and 11 years respectively. The reasons for the differences between the sexes with regard to probable and possible inhalation effects may be discussed as follows:

- the known difficulties of early radiological diagnosis of fibrogenous asbestos inhalation effects in women through mammary shadow superimposition;
- the high percentage of non-smokers among women (approx. 70%), as opposed to their male colleagues (approx. 24% non-smokers), and
- less dust concentrations at women's workplaces despite nominally similar work in drilling, grinding, sawing and turning, e.g. as a result of smaller workpieces.

Rival findings of Type IV are numerically predominant in the female employees. Their relative frequency exceeds by approx. 35% that of the three male random samples (Table 8). The main cause of an assumed unsuitability for activities at risk through asbestos dust for 12 out of the 15 women (80%) - despite the large proportion of non-smokers - is represented by varying degrees and configurations of chronic-obstructive bronchitis. The same statement is also true

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for 10 of the 12 male workers (83%) with Type IV findings in risk group a). A long way behind comes obesity in terms of excessive or extreme overweight as the second most frequent cause of unsuitability in males (once) and females (3 times) in risk group a). Only approximately half the men (45%) and women (51%) in this risk group showed a spectrum of findings in the normal range (Type V). These included subjects of both sexes with as much as 25 years length of occupation. One of the causes of these varying effects of quantitatively and qualitatively potentially equivalent conditions of exposure can be stated as the individual's disposition.

The two employees in risk group b) with Type I findings already mentioned have certain particular features. Investigations in each case detected the combination of findings of Type I with those of Type IV. In both instances, the effects of asbestos inhalation are rivalled by chronic-obstructive bronchitis with nicotine abuse and moderate overweight. In addition, the duration of exposure to brake lining dust with grinding and turning and to brake drum dust during flushing or brushing out of brake drums of 29 and 37 years is high in relation to the ages of 43 and 53 respectively. Hence the age of entry into the risk occupation is calculated as being 14 and 16 years respectively. In 5 of the 10 employees with findings of initial asbestos inhalation effects (type II) also, the age of entry into the brake maintenance trade is 14 to max. 18 years (cf. Fig. 5). The average exposure period of all 10 employees in this group is 20 years and thus also comparatively high. The frequency of findings in the normal range (Type V) in risk group b) employees with many years of exposure corresponds - at 47.6% - with that of risk group a).

The lack of evidence of fibrogenous inhalation effects (Type I) in the 53 men in risk group c) may be taken as an indication of a relatively low workplace risk factor, especially in view of their long years of exposure. The reader is moreover referred to the detailed casuistic description of the examination results on 4 employees with findings of initial inhalation effects (Type II).

Here we find the following peculiarities :

- exposure commences in 15th year (twice),
- exposure not only to brake drum dust but also to dust from unused linings during grinding and turning (once), and
- differential diagnosis rendered difficult by findings combination II/IV (4 times).

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These findings are rivalled in each instance by an initial to moderate obstructive bronchitis with reasons for suspecting an initial fibrogenous inhalation effect. It is known that peribronchitic alterations in the X-ray picture can however lead to qualitatively similar, small, irregular and linear shadows as a nascent pulmonary asbestos fibrosis. Thus the importance of the Type II findings in 7.5% of the random sample is somewhat diminished, and the percentage of men in risk group c) with findings in the normal range (Type V = 64%) clearly exceeds those of the other three groups (45%, 51%, 48%, cf. Table 8).

In terms of occupational medicine, we should finally look at another result of this study in greater detail. This is the frequency and reasons for restricted suitability and/or unsuitability for work at risk from asbestos dust, which have been summarized here as rival findings of Type IV, as based on the non-suitability criteria as contained in Fig. 3.3 of principle G1*. The application of these criteria to all the 210 subjects with many years of exposure to brake lining dust in all three risk groups reveals in no fewer than 53 subjects (= 25.2%) medical doubts about the continuation of their former activity. Two diagnoses are by far the most significant reasons :

- the chronic-obstructive bronchitis of 41 of the 53 persons with Type IV findings (= 77%), and
- obesity in terms of excessive or extreme overweight (13%).

Table 9:
Absolute and relative frequancies of important diagnosis groups as reasons for restricted suitability and/or non-suitability for work at risk from asbestos dust for n = 53 employees exposed to brake lining dust, subdivided into risk groups and sex.

Diagnosis Group	Risk Group	Total
Chronic-obstructive bronchitis		
Obesity		
Other disorders		
Total		

G1* - Danger from mineral dust hazardous to health.

Discussion of Results - continued.

In another 5 men (9%) there are other disorders which restrict the functioning of lungs, heart and circulation. Details as to the distribution of diagnoses over the male and female workers in the three risk groups are shown in Table 9.

The prevalence of chronic-obstructive bronchitis as a non-suitability criterium is:

- 19.2% related to all 210 subjects,

- between 65 and 89% related to the 53 subjects with Type IV findings.

On the basis of our long years of occupational medical and epidemiological experience, we can state that these frequency figures are notably high in comparison with investigative results from other groups of subjects exposed to dusts. It should be pointed out here that measurements of respiratory capacity by Selikoff's working party found indications of obstructive ventilation disorders in 32 out of 87 motor vehicle mechanics, i.e. 37%.

In accordance with the epidemiological investigative results set forth here on the subject of health hazards through dusts emitted by brake linings containing asbestos, the following assessments of the material hypothesis, conclusions and recommendations would seem to be adequately covered, all due care being considered :

Assessment of Material Hypothesis

The material hypothesis must be assumed in the following form: Long years of occupational exposure to dusts emitted by brake linings containing asbestos may, in employees in two of the three most important risk groups, and in individual cases, provoke detrimental repercussions on the pulmo-cardial system, and more particularly by way of specific, fibrogenous asbestos inhalation effects, such repercussions being demonstrable with a degree of probability acceptable in terms of specialist internal and occupational medicine.

SUMMARY (9.65)66)

Since 1973 the Federal Republic of Germany has had far-reaching regulations on the protection of persons exposed to asbestos. This raises the question of whether persons occupationally exposed to dusts emitted by brake linings containing asbestos should be generally considered as in danger from fibrogenous inhalation effects or not.

To investigate this workplace-related problem, a cross-sectional study of a selected group was carried out with retrospective considerations. This group consisted of 210 employed men and women each with at least 10 years' exposure to brake lining dust in 3 risk groups and from approx. 50 different firms. The data gathered for each subject resulted in

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approx. 200 details - over 40,000 in all - both on their case histories, with special consideration of occupation and workplace, as well as on the findings. The subsequent detailed occupational medical and internal investigations made use of physical, clinical, ECG, X-ray and the latest pulmonary function analytical processes.

The occupational medical evaluation of the findings on a subject exposed to asbestos must today be carried out three-dimensionally. The comprehensive data material had to be reduced in terms of fibrogenous inhalation effects according to the quality of the findings to a few types with definite degrees of diagnostic certainty :

Type I ≙ probable effects; Type II ≙ possible effects (suspect findings); Type III ≙ no assumption of effects.
Rival and normal findings were grouped under Type IV and Type V respectively.

The risk assessment is primarily based on findings in terms of probable effects (Type I). Suspect findings in terms of initial effects (Type II) were not however disregarded. The prevalence of findings of Types I and I respectively were:

a) 5.9% and 15.7% for 51 men engaged in the industrial finishing of brake linings or processing them in the automotive industry (risk group a),

   0.0% and 7.0% for 43 women in the same risk group a),

b) 3.2% and 15.9% for 63 men processing mainly used and unused brake linings in motor vehicle brake maintenance (risk group b),

c) 0.0% and 7.5% for 53 men flushing or brushing out brake drums in the brake maintenance trade (risk group c).

From this we can conclude that long years of occupational exposure to brake lining dust can causally lead to fibrogenous inhalation effects with the degree of probability decisive for the area of compulsory accident insurance. The risk of disease would appear to be somewhat higher for group a) than for group b), and is relatively lowest for risk group c).

A rival finding is the above-average prevalence in 19.2% of the 210 subjects examined of chronic-obstructive bronchitis as a non-suitability criterion for jobs at risk through asbestos.

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Discussion of Results - Conclusion.

The results obtained justify the realization of occupational medical prevention preferred for employees in risk groups a) and b). Details proposals shall be submitted on this. It is also recommended that ways be found to ensure in future that youths under the age of 18 years are not exposed to dusts emitted by brake linings containing asbestos in risk groups a), b) and c).

Pages 94,95

RESULTS

Macroscopically, all animals showed distinct dust nodules on the omentum as well as on the liver, pancreas and other organs. In the group AB I growths in the upper abdominal cavity between omentum, liver, pancreas and stomach were quire marked in almost all animals, such that a fibrogenous effect must be ascribed to this dust. In Group AB II there were only minor growths in a few animals; no specific fibrogenous effect should be inherent in this dust.

In both groups (AB I and AB II) the first tumors appeared 9 months after the start of experiments. At that time 39 rats in Group AB I and 40 rats in Group AB II were dead. The tumors were either solid, sizeable (up to 5 cm) growths primarily on the stomach, liver or lower abdominal area or disseminated to matchstick-sized nodes spread throughout the entire peritoneal cavity. Haemorrhagic ascites with grit-like white grains were often exuded on opening the abdomen. Large, subcutaneous tumors were also found at various parts of the body. Histologically speaking, the abdominal tumors were mesotheliomae, sarcomae and carcinomae at various stages of development; transitional stages of the various types were frequently observed.

The cumulative appearance of tumors over a period of time is shown in Figure 1, which shows abdominal tumors of both test groups. Two additional graphs show the occurrence of tumors with haemorrhagic ascites. By the end of the experiments, 89 animals in Group AB I (=45%) and 22 in Group AB II (=11%) showed tumors of the abdomen, and in 30 cases (AB I) and 5 cases (AB II) this was accompanied by haemorrhagic ascites.

The occurrence of subcutaneous tumors is reflected in Figure 2. The differences in frequency are in the usual range of distribution.

DISCUSSION OF RESULTS

In terms of carcinogenic properties there were distinct differences between the two dust samples. Sample AB I with a 45 % tumor incidence possesses unequivocal carcinogenic properties, for which the asbestos fibres contained in the dust sample should be primarily responsible. Compared with the results given in subject literature, this tumor rate must be regarded as relatively high.

It is more difficult to assess the results of the second test group AB II. A tumor rate of 11 % (n 22) is around the limit of a potential spontaneous frequency. In numerous dust control groups of investigations by Pott et al. the tumor rate was between 2 and 8 %, with a maximum of 10 %. We can conclude therefore that the occurrence of 11 % tumors with the given dust dose does not safely exclude the carcinogenic effect of the AB II dust. If we further remember that 40 animals had already died spontaneously by the appearance of the first tumors at the "9 months" test period, the tumor rate would increase to just 14%.

With regard to the fibrogenous properties there were distinct differences between the two dust samples. Sample AB I develops definite fibroblastic properties under the given test conditions, while AB II shows rare and also very minor coalescences with a single application of 50 mg per animal. Subject literature shows that tumors from fibrous dusts arise under concentrations that no longer exert any fibroblastic effects. Hence no indirect conclusions can be drawn from the extent of the coalescences with regard to the presence or absence of oncogenous properties of sample AB II.

CONCLUSIONS AND RECOMMENDATIONS

Page 100 to 102

It is a generally accepted fact in practice and science today that occupational exposure to asbestos dust can become a health hazard at the most varied kinds of workplaces. The Legislature have acknowledged scientifically proven findings and have taken account of both the fibrogenous risk as No. 4103 (asbestos dust pulmonary disorder) and the carcinogenic risks with No. 4104 (asbestos dust pulmonary disorders in conjunction with lung cancer) and No.4105 (asbestos-induced mesothelioma of the costal pluera and peritoneum) in the schedule of occupational disorders. Apart from other factors, the concentration and duration of inhalation of asbestos microdust are of vital importance. Particular difficulties arise in connection with an appraisal of the health risk for those occupational groups exposed to very slight dust concentrations or exposed to sporadic concentrations only. Those persons working in motor vehicle workshops on brake repairs are especially difficult to assess.

The following conclusions may be drawn from the investigations:

Group a:
Industrial Machining and Processing of Brake Linings

This group comprises persons handling brake linings in the finishing stages of manufacture (e.g. sawing, grinding, drilling, turning and milling) as well as those carrying out comparable work in the automative industry.

The average Chrysotile microdust concentrations found in these activities are in the range of 0.09 to 0.20 mg/m³. Thus the results of measurements are within the range of the current MRK value of 0.10 mg/m³.

In terms of occupational disorders, persons carrying out these activities, and especially three of the 94 examined cases, showed probable fibrogenous asbestos inhalation effects.

The experiments carried out on animals show that dust samples taken from this area possess both fibrogenous and carcinogenic properties.

All the results correspond in so far as they call for measures for technical and medical safety at work in the industrial machining and processing of brake linings.

We therefore recommend that

1. technical protection measures such as improved enclosure of the dust sources, increased air extraction etc. be implemented to keep the concentrations of Chrysotile microdust below the TRK value, and

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2. persons carrying out the afore-mentioned activities undergo occupational medical preventive examinations according to principle G1 of the industrial insurance and industrial safety corporations by way of

   - general basic examination
   - follow-up examinations at medium intervals (e.g. two years) and
   - detailed examinations at the usual intervals (five years).

Group b:
Hand machiningof Brake Linings

This group comprises persons handling unused and used brake linings in motor vehicle workshops. To a lesser degree of time (approx. 20%) brake drums are also blow-flushed or otherwise cleaned.

The concentrations of Chrysotile microdust founds in these activities are between 0.03 and 0.79 mg/m³. The results measured are thus distinctly above the current TRK value for Chrysotile. It must be remembered however that the proportion of these activities are often just one hour per shift or less than three hours per week.

Of the 63 persons examined in this group, two showed probable fibrogenous inhalation effects from asbestos.

The results indicate therefore that, with regard to the hand machining of brake linings, measures for technical and medical safety at work cannot be disregarded.

No animal experiments with group b dusts were carried out since these dusts are not essentially different from those in group a in terms of composition.

For the hand machining of used and unused brake linings, we therefore recommend that

1. technical measures such as enclosing dust sources and extraction of generated dusts be implemented to keep the concentrations of Chrysotile microdust under the TRK value, and that

2. persons carrying out the aforesaid activities undergo occupational medical preventive examination according to principle G1 of the industrial accident insurance and industrial safety corporations as follows:

   - general basic examination
   - follow-up examinations at extended intervals (three years)
   - detailed examinations at the usual intervals (five years).

For short-term exposure, the indications given in the description of the effects of asbestos dust should be observed.

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Group c:
Flushing of Brake Drums

This group comprises persons who air-flush or otherwise clean brake drums in motor vehicle workshops. Brake linings are also machined to a lesser time degree (less than 10%).

The concentrations measured during these activities show very high values averaging approx. 60 mg/m³ during the relatively brief flushing operation. However only sparsely scattered asbestos fibres were found. This does not indicate a zero risk, but the risk is substantially lower than in the hand machining of brake linings.

There are indeed indications that far greater concentrations of asbestos fibres are to be found in the flushing of American brake drums.

The medical cross-section showed that none of the 53 men carrying out this activity had fibrogenous inhalation effects that were demonstrable to any degree of probability. Only 4 subjects showed suspect findings.

Almost no fibrogenous effects were shown in this group by animal experiments. The results of animal studies into carcinogenic risks show that compared with dusts from establishments carrying out the industrial machining and processing of brake lining, the oncogenous properties are very slight. No definite statement can be made however, since the tumor rate was on the border of the anticipated spontaneous tumor rate.

The results indicate that the fibrogenous risk is slight. However on the basis of animal tests a minor carcinogenic effect cannot be ruled out at the present time. No assessment of the carcinogenic risk can be made, by ascertaining the dust concentration at the workplace owing to a lack of MAK values for carcinogenic materials.

We recommend that

1. the high microdust concentrations sometimes caused by the cleaning of brake drums be minimized by technical precautions;
2. owing to the slight fibrogenous risk involved, no preventive examinations under principle G1 be carried out for the time being; this finding must be reviewed as and when new information on the carcinogenic risk is available;
3. to clarify outstanding questions,
   - the 53 persons in Group c cross-section be subject to continued medical surveillance, even after leaving their employment;
   - special investigations be carried out into the causes of the different asbestos contents in the brake drum dusts of German and American vehicles;
   - continued animal experiments be undertaken to assess the carginogenic risk inference of brake drum dust.

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When appraising the overall results it should be remembered that the findings of the cross-sectional examination only permit statements with regard to the fibrogenous risk. In the case of inhalation of concentrations of asbestos microdust at the workplace which leads to a fibrogenous risk, a carcinogenic risk must also be assumed.

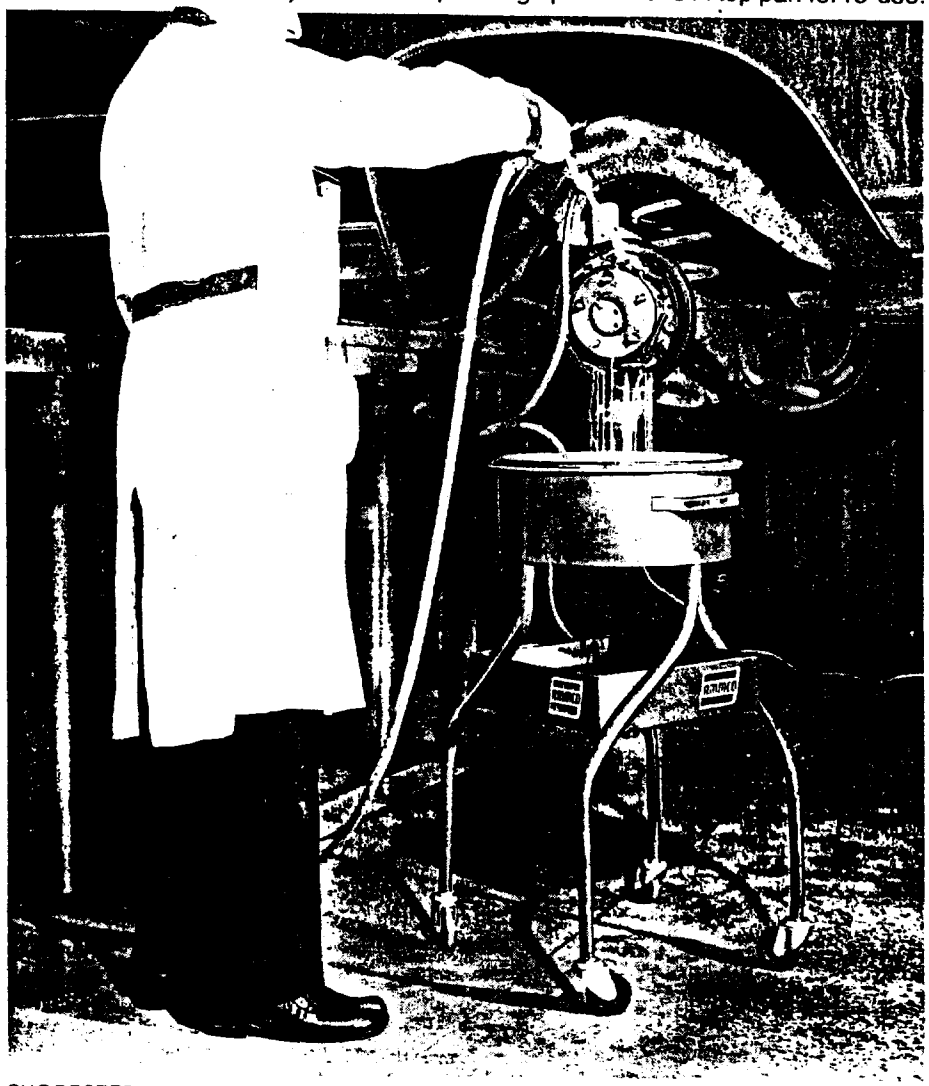
MODEL 1250
NEW! AMMCO BRAKE ASSEMBLY WASHER

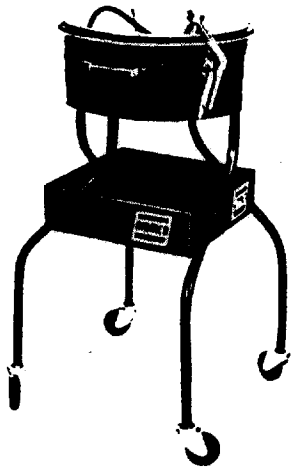
Stop blasting dirt-laden air around your shop!

Start your brake jobs right; clean brake assemblies with the AMMCO Model 1250 Washer and you'll work faster, easier and cleaner. No need to fight grease, dirt and oil or air-blast clouds of dirty, asbestos-laden air around the shop. One ounce of AMMCO No. 1256 Brake Washer Concentrate mixed with 1 gallon of water makes an efficient, non-toxic, non-flammable cleaning solution that leaves no residue and does not affect rubber, Neoprene or friction material. Discard the solution as easily as soapy water.

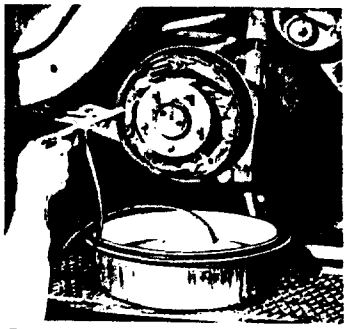
Just roll the Washer to the job, connect an air line and you're ready to wash. The specially designed gun and nozzle directs a properly atomized stream of cleaning solution where you want it for best results.

You can wash and disassemble at the same time. Parts drop into the pan and stay there until they're inspected and re-used or discarded. Solution returns to the sump through perforations in top pan for re-use.

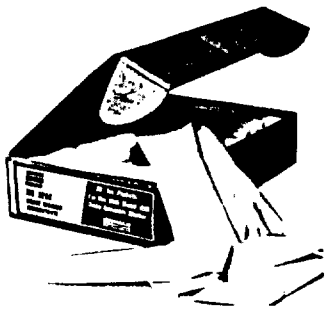




Brake parts are dropped into top pan as they're removed. Nothing lost, no mess. Solution drains into pan for recirculation.



Parts pan and sump can be removed from portable stand for close-quarters work.



No. 1256 Brake Washer Concentrate. Carton of twenty 1 oz. packets. One packet dissolved in 1 gal. of water cleans many brake assemblies. $14.90 per carton.

SUGGESTED DEALER NET **$149.50**

Price and specifications subject to change without notice

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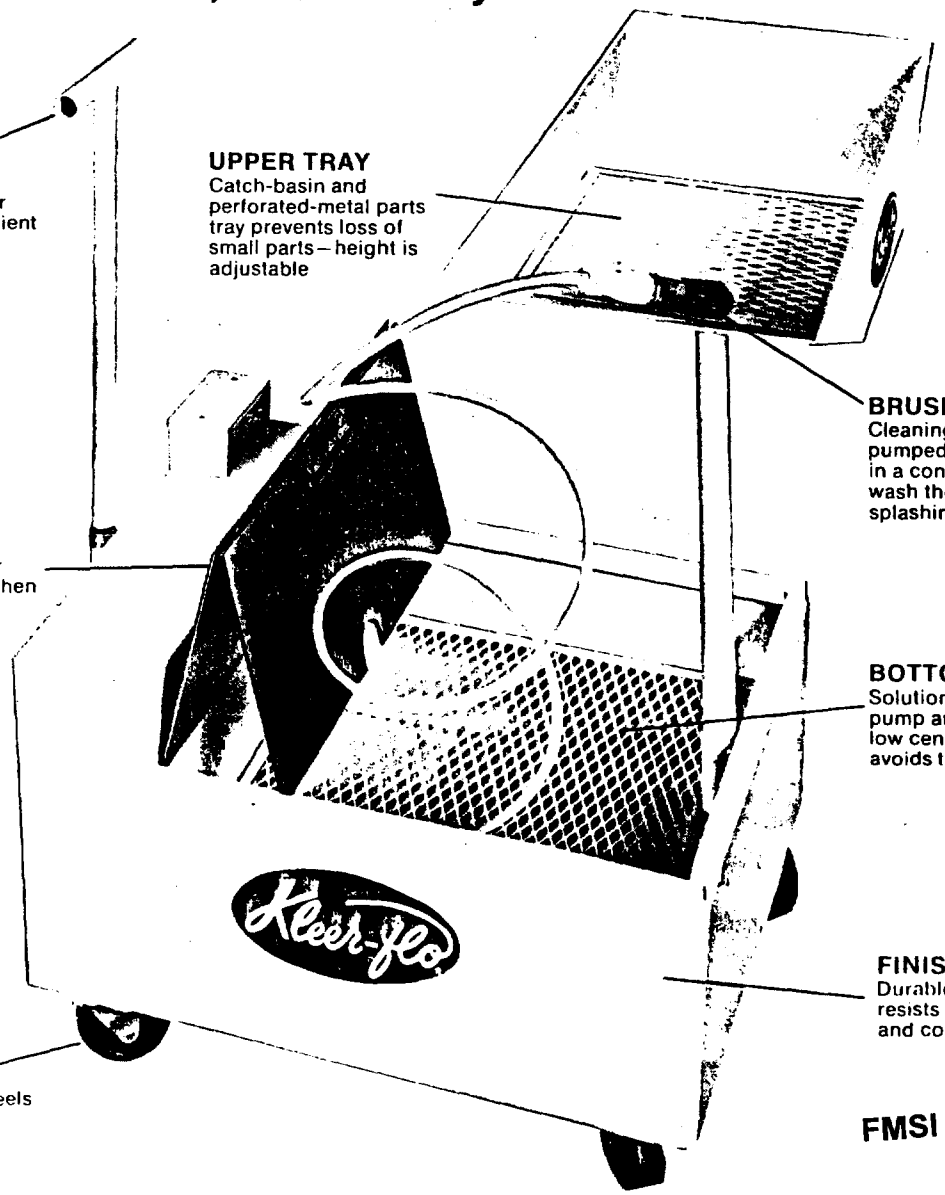
BRAKE WASHER

Model LW-22

for cars and trucks

The safe, convenient, efficient way to clean all brake assemblies



HANDLE
Easy to position under each axle with convenient T-handle

UPPER TRAY
Catch-basin and perforated-metal parts tray prevents loss of small parts—height is adjustable

BRUSH
Cleaning solution is pumped through brush in a controlled flow to wash thoroughly without splashing

COVER
Cover closes over solution supply when not in use

BOTTOM TANK
Solution supply and pump are in the base—low center of gravity avoids tipping and spilling

FINISH
Durable epoxy finish resists scratching, rust and corrosion

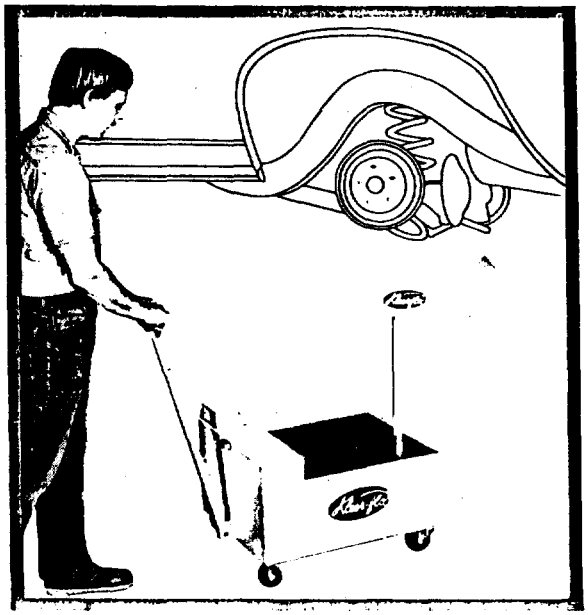
CASTERS
Four large caster wheels roll easily

FMSI 04789

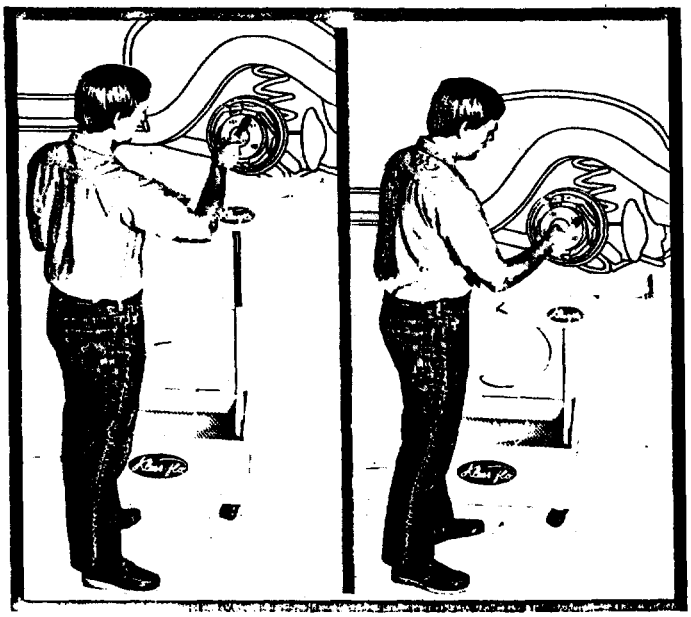
The Kleer-Flo Brake Washer removes asbestos fiber dust, grease and road dirt from brake assemblies. Kleer-Flo Greasoff™ No. 19 circulates through the brush to clean thoroughly—yet safely—eliminating the dangerous practice of blowing asbestos-laden dust into the air. Washing with the Kleer-Flo Brake Washer increases efficiency, too!

Each mechanic works at the most comfortable height for him. He works faster with clean parts and avoids delays because parts are held at the axle, where they're easiest to find. And the low center of gravity, caster wheels and T-handle move the unit easily from wheel to wheel. The solution passes through a barrier filter as it recirculates.

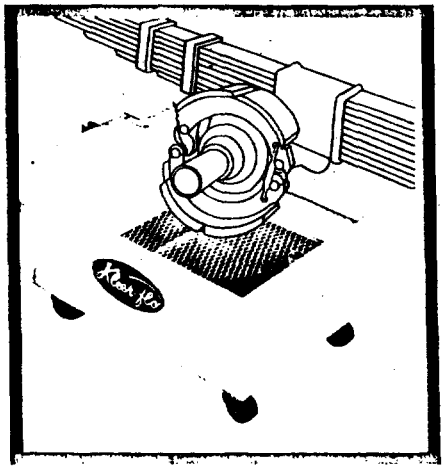
The Kleer-Flo Brake Washer helps you work faster and safer!



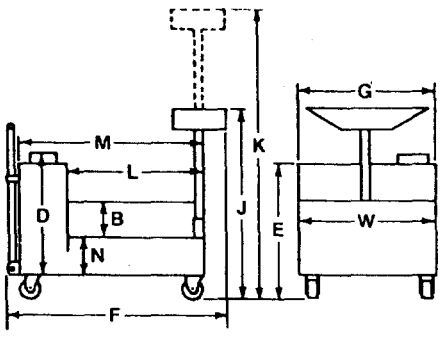
ROLLS INTO POSITION quickly, safely – thanks to the T-handle, caster wheels and low center of gravity.



HEIGHT ADJUSTS to enable each mechanic to work at best height for him. Reduces fatigue, prevents spilling and loss of small parts.



ACCOMODATES LARGE TRUCKS by simply removing the adjustable tray and using the base to catch solution and hold parts



SPECIFICATIONS

MACHINE OVERALL		
Length	F	32"
Width	G	18"
Height	E	18"
Drain Pan Up (Max)	K	51"
Drain Pan Down	J	36"
MACHINE INSIDE		
Length	M	25½"
Width	W	18"
Depth	D	15½"
WORKING SPACE		
Length	L	19¾"
Width	W	18"
Depth	B	4½"
Reservoir Depth	N	5½"
ENGINEERING DATA		
Pump Motor H.P.		Fract.
Elec. Requirements		110V., 60Hz., 1 Ph.
Work Shelf Capacity Lbs.		100 Lbs.
LIQUID CAPACITY (Machine) Gals.		6

MISCELLANEOUS
Tank Drain
Swivel Casters
Flow Thru Cleaning Brush
Adjustable Drain Pan
Shipping Weight, Lbs. 110 Lbs.

For use with Kleer-Flo Greasoff™ No. 19 only.

Kleer-Flo Greasoff™ No. 19 Brake Cleaning Concentrate

Specially formulated for use in the Kleer-Flo Brake Washer. Diluted with 5 parts of water to 1 part Concentrate, it aids in effective removal of oil, grease, dirt and asbestos fiber dust. The synthetic detergents in this product are bio-degradable. 1-gallon plastic bottle, packed 4 per carton.

Kleer-Flo

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6600 Washington Avenue South, Eden Prairie, Minnesota 55344
Phone 612/941-6710

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