

SILICOSIS IN SAND-BLASTERS: THE EXAMINATION OF SANDS ASSOCIATED WITH SAND-BLASTING

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THE process of sand-blasting is one which carries a relatively high risk of silicosis. Indeed, according to the Chief Inspector of Factories and Workshops,¹ "no other silicosis-producing industry shows such grave figures for the average working lifetime of fatal cases, or figures comparable to the sand-blasting trade, except the manufacture of scouring powders". This process is therefore of special importance to all who are interested in silicosis.

The view recently put forward by Jones² that in a large number of cases the substances mainly responsible for silicosis are the fibrous silicate minerals, particularly sericite (a complex aluminium silicate, sometimes called secondary white mica) has aroused considerable interest. It seems natural to ask therefore if any evidence is obtainable to show whether the silicosis of sand-blasters might also be due to these silicate minerals.

The sands used in sand-blasting contain a very high percentage of free silica and relatively little of any other material, so that it would appear at first sight that the amount of these possibly harmful silicate minerals which might be present in sand-blasting operations must be insignificant and their effect as a possible cause of silicosis negligible. But the gold-bearing quartz conglomerate ("Banket") of the Transvaal contains between 80 and 90 per cent. of free silica, yet the many cases of silicosis which have occurred in the South African mines are believed by Jones to be really due to the aggregates of minute acicular fibres of sericite which are found between the quartz pebbles and quartz grains. It will also be admitted that the composition of a sand or quartz rock in bulk is not necessarily a true indication of the composition of the dust which may be inhaled from air in which such sand or rock has been dispersed in very fine particles. Hence it seemed desirable to make examinations of sand-blasting materials to ascertain (*a*) to what extent complex aluminium silicates, *e.g.* sericite, are present, and if so (*b*) whether they tend to become concentrated in the finer lighter portions which are liable to be inhaled by the workers, so that while the bulk material contains only small, apparently negligible amounts, the fine dust contains quantities that may be definitely harmful.

¹ *Annual Report of Chief Inspector of Factories and Workshops* (1933), p. 60; see also (1934), p. 63.

² W. R. Jones, *J. Hygiene* (1933), **33**, 307.

In response to a request for samples of sand used in sand-blasting, Mr E. L. Macklin, H.M. Superintending Inspector of Factories, North Midland Division, kindly sent six samples. Certain examinations of these sands were made, but as I was ignorant of the exact relation of these materials to the sand-blasting operations I paid a visit to the two works from which samples had been obtained, and personally saw the sand-blasting processes. I also selected further samples for examination. Lungs from cases of silicosis arising in workers at both these works, referred to as works A and B, had already been examined by Prof. M. J. Stewart and myself.

The results of the examinations of sands, etc., are best considered in relation to each of the works separately, as the sand-blasting processes differ considerably in the two cases.

WORKS A

The process carried out here is that of shot blasting in chambers. It is used to remove adherent moulding sand, scale, etc., from castings of various sizes, some of them very large. The amount of adherent moulding sand may be considerable. Hence although shot is the blasting agent, much sand is introduced into the chambers, and is the principal constituent of the dust there.

In preparing sand for moulds, various mixtures are made according to the type of casting required. As some ten varieties of sand are used, and about forty different moulding mixtures, the composition of the sand entering the blasting chambers is constantly varying. Samples of two of the sands used in making the moulding mixtures were supplied, viz. (*a*) Durham sand, in fairly common use here for the last six years, and (*b*) moulders' sand delivered from Belgium, which is in greatest use. A sample of the sand (*c*) lying in the blasting chamber after completion of blasting operations was also supplied.

The particle size of these three samples is roughly indicated by the following:

	Sample <i>a</i>	Sample <i>b</i>	Sample <i>c</i>
	%	%	%
Retained by 30-mesh sieve	45.7	16.9	17.4
Retained by 60-mesh sieve	42.9	73.5	21.1
Retained by 90-mesh sieve	8.9	4.8	21.0
Passed by 90-mesh sieve	2.4	4.8	40.5

Of sample *c*, 24.4 per cent. could be removed by a magnet and was mainly coarse, consisting of fragments of shot and pieces of iron from the castings. Hence the fineness of the actual sand in this material was greater than is indicated by these figures. In addition there was much dust which is removed from the chambers during the actual blasting process. This exhaust dust will be referred to later.

As was pointed out above, the nature of the sand entering the chambers is always varying so that it is not possible to determine the nature and fineness of the sand before blasting is carried out; the sands *a* and *b* are not the only ones that enter into the composition of the moulding mixtures. But there is no doubt that the difference between the fineness of these and that of *c* does

represent an actual fact, namely that during the blasting process the particle size of the sand is greatly reduced, so that a considerably greater quantity of very small sand particles is produced.

As no sieve of mesh smaller than 90 was available, the finer part of the last fraction of *c* was obtained by stirring it with a considerable volume of water, allowing a few moments for partial settlement and pouring the supernatant liquid through a filter. The material on the filter was dried and analysed. An analysis of a portion of the original sample was also made. The results are as follows:

	Original sample of spent dust. 24.4% removed by magnet Residue %	Water-separated portion of finest fraction. 4.3% removed by magnet Residue %
Loss on ignition	Nil	0.24
SiO ₂	91.58	92.92
Fe ₂ O ₃	3.96	3.42
Al ₂ O ₃	2.62	2.90
CaO	0.54	0.28
	<hr/> 98.70	<hr/> 99.76

For the purposes of this investigation the figures for Al₂O₃ are the most important. From the analysis of sericite by Shannon (quoted by Jones) the above figures for Al₂O₃, *assuming that all of it is present as sericite*, correspond to 7.0 and 7.7 per cent. of sericite respectively.¹ This sericite would contain 3.26 and 3.61 per cent. of SiO₂ respectively, so that the *free* silica in the above materials would amount to 88.32 and 89.31 per cent. No very great concentration of aluminous material in the finer portions of sand is disclosed by the above figures.

The assumption that all the Al₂O₃ is present as sericite is, of course, unlikely to be entirely true; some of it may be contained in amorphous clays. But that some sericite, or similar substance, is probably present is indicated by the results of examination by the petrological microscope, kindly made for me by Prof. A. Gilligan, who definitely recognised minerals of a micaceous nature.

During the visit to this works it was realised that the material most closely corresponding to what is inhaled by the workers is the dust which is contained in the exhaust air removed from the chambers. Two processes for the removal of dust from exhaust air are in use at this works. In some chambers a wet process is employed, so that a stream of water carrying the dust issues from the extractor. This flows into a tank which has an outlet near the top into a second tank at a somewhat lower level, and this in turn has an outlet into a third tank. A sample of the sludge in the first tank was taken for analysis. (The second and third tanks had recently been emptied and sludge from them was not available.)

¹ In order to ascertain how far some of the Al₂O₃ might arise from metallic aluminium present in fine dust from castings or shot, the material removed by magnet was analysed and found to contain decidedly less than 1 part of aluminium to 230 parts of iron. Hence the iron or steel present during the process may be ignored as a source of Al₂O₃.

In other chambers a dry process is used, and all the extracted dust is delivered into one receptacle. A sample of this dust was also taken.

The fineness of these samples was found to be as follows:

Dried sludge from wet extraction ...	98.5 per cent. passed 90-mesh sieve
Dust from dry extraction	97 per cent. passed 90-mesh sieve

These figures give a very inaccurate impression of the relative fineness of the two samples, as almost all the material passed through the sieve. Inspection alone was sufficient to show that actually the dry-extracted dust was finer than the dried sludge; the former had the appearance of flour while the latter was definitely coarser than flour. This difference is, of course, to be expected since the former represents the whole of the exhaust dust while the latter represents only what has remained in the first settling tank while the lighter and finer particles have been carried over to the second and third tanks.

Analysis of the two samples gave the following results:

	Dried sludge from wet extraction %	Dust from dry extraction %
Loss on ignition	- 0.22	- 0.12
SiO ₂	78.80	75.28
Fe ₂ O ₃	17.84	17.70
Al ₂ O ₃	2.44	5.52
CaO	0.56	0.72
	<hr/> 99.42	<hr/> 99.10

These figures for Al₂O₃ correspond to 6.52 and 14.73 per cent. of sericite, containing 3.03 and 6.86 per cent. of combined SiO₂ respectively. Hence if all the alumina were present as sericite the sludge would contain 6.52 per cent. of sericite and 75.77 per cent. of free silica, while the dry dust would contain 14.73 per cent. of sericite and 68.42 per cent. of free silica.

Bearing in mind the fallacy of making exact comparisons from materials from different chambers, or from the same chamber at different times owing to the varying composition of the sand entering the chambers, there is nevertheless a definite suggestion here that there is a concentration of material other than free silica in the lighter portions of the dust which will remain suspended in the air for the greatest time and be liable to be inhaled by workers. Moreover the *possible* amount of combined silicates present in the dry dust, approximately 15 per cent., must be regarded as considerable; nevertheless it only amounts to about one-fifth of the amount of finely divided free silica present.

WORKS B

The process investigated here is blasting by sand in a cabinet. Small articles, without adherent moulding sand, are subject to this process for the purpose of producing a special finish. Since the only sand present is that used in the blast, its composition remains reasonably constant, so long as the same source of supply is maintained.

Two samples of sand used by this firm were examined, one in use at the present time, the other up to 1929, at which date an employee (a sand-blaster who subsequently died of silicosis) gave up his employment here. These were:

(a) Sand before use in sand-blasting plant, known as Reigate sand, and not in use here before 1930.

(b) Coarse Calais sand as supplied in 1929.

A sample of the sand *c* lying in the cabinet after completion of sand-blasting operations was also supplied.

The fineness of these samples is roughly indicated by the following:

	Sample <i>a</i> %	Sample <i>b</i> %	Sample <i>c</i> %
Retained by 30-mesh sieve	54.3	49.5	10.2
Retained by 60-mesh sieve	44.2	49.0	31.0
Retained by 90-mesh sieve	0.9	1.4	21.5
Passed 90-mesh sieve	0.5	0.1	37.3

There is again ample evidence of a great reduction in the size of the sand particles during the sand-blasting process. Practical experience supplies evidence at least as convincing as the above figures for fineness, for after use for a certain length of time in the cabinet the sand becomes so fine that it ceases to be able to produce the desired finish on the articles treated, and has to be replaced by a fresh supply of the original coarse sand.

Analysis was made of samples *a* and *b* and of the finer, water-separated portion of the last fraction of *c*. The results were as follows:

	Sample <i>a</i> %	Sample <i>b</i> %	Water-separated portion of last fraction of <i>c</i> %
Loss on ignition	0.66	0.40	0.18
SiO ₂	97.10	98.84	96.84
Fe ₂ O ₃	1.30	0.42	1.44
Al ₂ O ₃	0.26	0.10	0.66
CaO	0.34	0.54	0.42
	<u>99.66</u>	<u>100.30</u>	<u>99.54</u>

The Al₂O₃ in the third column would correspond to 1.76 per cent. of sericite.

The exhaust dust from the cabinet is recovered by a dry process. A sample of this dust was obtained. It had the appearance of flour; 97.6 per cent. passed the 90-mesh sieve. Analysis showed the following:

	%
Loss on ignition	...	...	...	...	0.22
SiO ₂	...	...	...	...	95.48
Fe ₂ O ₃	...	...	...	...	3.32
Al ₂ O ₃	...	...	...	...	0.22
CaO	...	...	...	...	0.56
					<u>99.80</u>

The Al₂O₃ of this specimen corresponds to 0.59 per cent. of sericite.

There is little evidence of any appreciable concentration of aluminous material in the finer portions of the sand, and the amount of sericite which might possibly be present in inhaled dust must be considered negligible.

Apart from the question of sericite the results of this investigation draw attention to two important points. The first is that during sand-blasting the sand present, whether used as the abrasive agent or introduced on the articles treated, is rapidly ground to very fine particles as the result of repeated high-speed impacts between sand and metal. A fine siliceous dust is thus produced in considerable quantity and the concentration of this dust within cabinets and chambers must be exceedingly high. This fact is, of course, well known, but it deserves emphasis in any consideration of the actual cause of sand-blasters' silicosis. The second is that the substitution of steel shot for sand as the blasting agent is of limited value as a precautionary measure against the production of silicosis, if much sand is introduced on the articles to be treated; for the same grinding of sand, with the production of much fine siliceous dust still occurs. Indeed, if under such circumstances the workers concerned relax any of the usual precautions against dust inhalation, in the belief that the introduction of steel shot has made the occupation safe, the substitution may well produce more harm than good.

So far as the chief object of this investigation is concerned, the results show that, in the chamber process examined, the inhaled dust contains appreciable amounts of aluminous material, some of which, at any rate, is of a micaceous nature, and may be sericite or similar mineral. In the cabinet process examined the amount of aluminous material is negligible. Cases of silicosis have occurred at both the works where these different processes are carried on. But the obvious inference from these facts, namely that sericite cannot be concerned to any considerable extent in the production of sand-blasters' silicosis cannot be drawn without considerable evidence on many other points. It would be necessary, for example, to know the composition of the inhaled dust not on a single occasion only, but over a long period during which the workers concerned inhaled dust and subsequently contracted silicosis. An analysis of the relative incidence of silicosis in all workers engaged on processes similar to the two which have been described would be very useful, particularly if it could be shown that wherever these processes are carried out there is a difference in the composition of inhaled dust similar to that noted here. This difference may well be constant, for the types of sand involved in the two processes are selected with entirely different objects in view. In the chamber process as carried on at works A the sand, being introduced from the moulds, has been selected solely for its properties for moulding, whereas in the cabinet process as used at works B only abrasive properties would be required, such as would be found in a hard, coarse, purely quartz material; the softer sands used for moulding and containing small amounts of clay and other minerals would apparently be unsuitable.

Apart, however, from aluminous material the inhaled dust in both processes has one common constituent, namely free silica in an extremely finely divided form, and even where aluminous material may be present in appreciable amount, this amount, even at its possible maximum, is considerably exceeded

by that of the free silica. If therefore it is assumed that this aluminous material, *e.g.* as sericite, etc., is the most active agent in the production of silicosis in sand-blasters one must also assume that as a silicosis-producing agent such aluminous material must be vastly more potent than very finely divided free silica. I do not believe that we have sufficient evidence to establish this view, and prefer, for the present at any rate, to ascribe to finely divided particles of free silica the major role in the production of sand-blasters' silicosis.

I wish to express my thanks to Mr E. L. Macklin for his ready co-operation, and to Mr Knapman, a member of his staff, who accompanied me on my visit to the works mentioned.

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