P R I K A Z I

Reviews *Обозрения*

Arh. hig. rada, *9* (1958)

DUST DETERMINATION AND THE RISK OF SILICOSIS

by

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(Received for publication December 3, 1958.)

In the Netherlands many dust determination have been carried out in order to estimate the risk of silicosis in different branches of industry, e. g. ceramic industry, foundries, stone cutting and mining. For these determinations we use chiefly the thermal precipitator. The deposited dust particles are counted after incineration under the microscope in dark field. In order to obtain some idea of the silica content these particles are treated with hot hydrochloric acid. The composition of the smaller particles often differs from that of the coarse material.

A coordinated research is planned to study the dust and silica content of the air in foundries and the occurrence of silicosis in foundry-workers.

1. INTRODUCTION

The determination of the risk of silicosis arising in factories might be considered as a medical task. But silicosis, if found in men by a medical examination, will in many cases have been developed to such a degree that a recovery is impossible and that preventive measures will only be useful for their successors. Therefore there is a need to be able to determine the risk of silicosis by taking measurements in factory buildings under the various conditions which normally occur. The results of these measurements will then indicate what measures, if any, should be taken in order to prevent the occurance of silicosis. For this purpose dust determinations are carried out in Holland by thermal precipitator in particular. The following is intended as a brief survey of the method followed, to give some results and to examine whether these measurements answer the purpose and to what extent.

2. MEASURING METHOD

2.1. It may be desirable to mention once again some facts concerning the possible roll of the smalles dust particles in the pathogenesis of silicosis. Zebel (1) constantly found with electronic-optical measurements of dust particles from the lungs of miners with and without silicosis a maximum number of particles having a diameter of less than 0.5 micron, and, as the graphs show, many particles with diameters under 0.2 micron. Policard, Collet and Ralyte (2) obtained similar results; they found a percentange of dust particles with diameters of less than 0.1 micron, which varied to a maximum of 84%. Dautrebande, Beckman and Walkenhorst (3) gave a survey wherein they supported the view that the smallest particles (diameters of less than 0.2 micron) are particularly important. Davies (4) gives a retention curve for dust particles (with s. g. 1) which has one maximum at a diameter of about 1.8 micron, and a second maximum at a diameter less than 0.1 micron. Theoretically both maxima can be readily explained; with very small particles the Brown movement in particular is much in evidence.

On account of these and similar data it seems less desirable to limit dust counts to particles greater than e. g. 1 micron, as has been done. When counting the particles under the microscope in light field, particles having diameters under about 0.2 micron can not be observed (5) (6). We therefore prefer counting the particles under the microscope in dark field, a method which, in our experience, give reasonable reproducible results and is not too tiring to the eye.

2.2. It is fairly well established that silicosis can only occur after inhalation of dust that contains free crystalized silicon dioxide. In addition to quartz, trydimite and cristobalite should be mentioned (7) (8) (9).

2.3. The measuring method has already been described before (10), and briefly amounts to the following:

In the factory dust determinations are carried out by sucking a small volume of air (usually 50 cu cm) through a thermal precipitator. As the concentration of dust mostly shows rather sharp fluctuations many measurements are as a rule necessary to obtain an reliable impression. If required, it can at the same time be examined by means of a direct indicating, possibly registrating, dustmeter which is based on measuring the dispersion of light (11), whether the fluctuations of the concentration of dust are larger or not and how these fluctuations are divided acording to time and space. The dust lines obtained by the thermal precipitator are counted in the laboratory under the microscope, then heated to about 400° C and counted again. Counting takes place under the microscope, without projection, in dark field, at a magnification of about 450. The dust remaining after heating, which no longer contains organic dust, is designated glow-resistant dust.

2.4. The quartz concentration of the dust is often determined by means of diffractive radiographs of dust, which is collected from air by means of paper filters. However, this dust also contains particles coarser than those found by means of the thermal precipitator; these particles, in so far as they are larger than about 3 micron do not cause silicosis, as they do not reach the pulmonary alvioli.

The dust, separated by means of thermal precipitator, is in many cases treated with warm and concentrated hydrochloric acid in an acid-cell specially designed for this purpose (based on an idea of the Transvaal Chamber of Mines). In this treatment most dust particles dissolve, but not the quartz (or tridymite or cristobalite) particles; when correctly varried out not more than 5% at the most of these particles are lost, e. g. by washing off. Therefore in most cases the remaining acid-resistant dust consists almost entirely of quartz particles.

2.5. Based on our experience the maximum allowable concentration of quartz particles seems to lie at about 400 particles per cu. cm of air, determined by the method described above. This limiting value should however not be considered as a limit determined from the data available, but merely as a control point. For a true determination of a limit far too few data are available and it seems in view of the long time of development of silicosis very difficult indeed to obtain a greater certainty on this subject.

3. SOME RESULTS

3.1. In table I some of the results of dust measurements in several ironfoundries are summarized.

Table I.

Operations	Number of measurements	Average number of particles/cu cm of air		Remarks
		glow-resistant	acid-resistant	
a. casting large pieces	134	2.000	500	
b. casting small pieces		5.000	500	
c. same hall as *b*	83		500	see 3.2
d. fettling shop	76	5.000–97.000	330	see 3.3
e. casting small pieces	34	3.300	430	
f. normal foundry	21	1.000	±200	
g. same as f, during sandblasting		4.000	1.800	see 3.4
h. rotating sand dryer	27	7.500	100	see 3.5

3.2. Although the average number of acid-resistant particles in the foundry-department, mentioned under *b* and *c* of the table, turned out to be about the same as determined in two investigations with a time-interval of about one year, we must mention that this is not valid for all parts of these investigations. At one spot an average concentration of about 2.300 acid-resistant particles per cu cm of air was found during a first series of 8 measurements; during later series the average was only 330. Other spots in the same hall also gave considerable higher figures during the former series than thereafter, but we were unable to discover the cause. This shows that it is quite wrong to draw conclusions from an examination, during which too few measurements were carried out. We may add to the above examination that we found higher concentrations of dust during the shake in of the moulds than during the shake out.

3.3. In a fettlingshop (d) three investigations were carried out at intervals of some months. Welding was also done in this department. The concentrations of glow-resistant particles found were all high and with extremely sharp fluctuations (5.000–97.000 particles per cu. cm of air). The concentrations of acid-resistant particles found also varied greatly, though the averages of the latter amounted to 330, 325 and 325 particles per cu. cm of air respectively during the three examinations. In all, the results of 17 out of 76 determinations showed more than 400 acid-resistant particles per cu. cm of air.

3.4. The investigations, mentioned under f and g of table I, give a picture of the influence of sandblasting; during sandblasting the concentration of acid-resistant particles lay between 600 and 4.700 particles per cu. cm of air and was resistant in all cases much too high. As is perhaps known, the application of quartz-containing material for blasting (sandblasting) is now prohibited in the Netherlands.

3.5. The results, mentioned under h, were rather surprising to us. Notwithstanding the high concentration of fine dust particles and the high concentration of quartz of the worked-up material the risk of silicosis should in this case be considered small. This conclusion proved to be in concurrence with a medical examination of labourers at similar dryers in our country (not published), during which not a single case of silicosis was found. Otherwise the concentration of quartz in the finest fraction of sand smaller than 50 micron which is obtained by sifting out turned out to amount to only about 50%. The sand probably consists of coarse grains of quartz together with fine particles of clay which give indeed rise to a dispersion of dust, but which do not cause any risk of silicosis.

3.6. In the ceramic industry the acid-treatment of dust deposits is not used. Several super-heated silicates are only slowly dissolved or are not dissolved at all in this process, so that the results are any how no standard to go by. Some of the results in this branche of industry are summarized in table II. The quartz content is, in these cases, determined by means of diffractive radiographs. The maximum allowabled concentrations are not more than a rough estimation, holding only for the described way of determination of the dust concentration.

Table II.

Operations	Number of measure-ments	Average number glow-resistant particles cu cm of air	Quartz content	max. allowable number of particles
a. tile-presses	8	800	27%	900
b. ,,	34	650		
	14	1.200	18–30%	850–1.100
c. ,,	43	1.500		
	12	1.400	25%	950
d. ,,	48	4.000	25%	950
e. manufacture of small articles	98	±2.000	—	±1.500
f. crushing mill	48	650	12%	1.500
g. scouring work-stands	40	900	14%	1.300
h. processing saw material	64	800	15%	1.250

4. DISCUSSION

4.1. On the incidence of silicosis in our country I cannot now give any figures. It is indeed known from foreign reports (12) (13) (14) (15) that silicosis fairly often occurs in foundries. We know that in the ceramic industry in our country quite a few cases of silicosis have been found, in the foundries (sandblasters excepted) relatively few. In the foundry mentioned under 3.2 cases of silicosis occurred; but is very likely that the dispersion of dust used to be stronger there (about 10 years ago) than it is nowaday.

4.2. The general impression from the results stated is that in foundries the concentrations of dust lie on the verge of the admissable, in fairly many cases they are even inadmissable. In view of the uncertainty of the admissable concentration this is in reasonable agreement with the medical experiences. It seems that the risk of silicosis would be smaller in the ceramic industry and greater in only a few departments. This is, as far as I can see, not in agreement with the medical experiences. It is clear that we do not yet know as much as we should wish of the connection between concentration of dust and risk of silicosis. If we confine ourselves to comparing identical activities in different places we are however in a position to give practically serviceable conclusions.

4.3. The examinations mentioned under 3, have almost all led to some practical suggestions regarding the steps to be taken, in a single case (see 3.5.) to the advice to leave things as they are. It would lead beyond the subject here under discussion to go further into this matter.

4.4. In order to obtain a more detailed impression plans have now been made in the framework of the »Commissie voor Arbeidsgeneeskundig Onderzoek T. N. O.«, (Commission for Research Industrial Medicine T. N. O.) founded in 1957, for a coordinated research into the occurence of silicosis in foundries. It is the intention thereby to subject all factory-hands in certain iron- and steelfoundries to a medical examination and at the same time make a rather extensive investigation into the dispersion of dust, both as regards quantity and nature of the dust and as regards the conditions which influence this dispersion of dust. Though the silicosis that is now found may have been caused by the inhalation of dust of quartz ten or twenty years ago and the situation has been changed almost everywhere and in various respects during the last twenty years, it is yet hoped that a better impression of the relation between dispersion of dust and silicosis will be obtained in this way.

4.5. In 1954 I spoke optimisticalyy of the possibility for international standardization of dust-measurements (10). Since then little progress has been made in this matter, notwithstanding many discussions. New research-methods have come to the front (a. o. the so-called millipore and similar filters), which offer many possibilities. It seems to me that this problem has not yet reached a stage in which an agreement seems likely. As yet a clear mention of the method applied and a general exchange of data and opinions on the subject appear to be the most effective.

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Sadržaj

ODREĐIVANJE PRAŠINE I OPASNOST OD SILIKOZE

U Holandiji je izvršen velik broj određivanja prašine radi procjene opasnosti od silikoze u različitim industrijskim granama, na pr. u keramičkoj industriji, ljevaonicama, obradi kamena i rudarstvu. U tim određivanjima najčešće se upotrebljava termalni precipitator. Taložene čestice prašine se nakon spaljivanja broje pod mikroskopom u tamnom polju. Kako bi se ocijenio sadržaj silicijeva dioksida, uzorci se obrade toplom solnom kiselinom. Sastav manjih čestica se često razlikuje od krupnijih čestica.

U programu je koordinirani studij prašine i sadržaja silicijeva dioksida u ljevaonicama i pojave silikoze kod ljevača.

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Primljeno 3. XII. 1958.