FEEDBACK OF CLEANED EXHAUST AIR INTO WORKPLACE ATMOSPHERES—EXPERIENCES ON TESTING EQUIPMENT

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Under defined conditions, the feedback of cleaned exhaust air into workplace atmospheres is approved in the industry of the Federal Republic of Germany. Requirements to be met by capturing and precipitating systems are stipulated in technical regulations. These regulations differentiate according to:

- dust collecting machines and instruments for mobile use and
- central exhaust systems.

Dust collecting machines and instruments have to fulfil the conditions of a technical test. Occupational Safety Institute (BIA) is an authorized test institute for industrial vacuum cleaners, exhaust sweeping machines and dust collectors. Industrial vacuum cleaners and exhaust sweeping machines are used for the removal of deposited dust. Dust collectors are used for the exhaustion and precipitation of suspended dust emitted from individual dust sources. Technical requirements to be met by these systems were stipulated in 1973 for the first time. Since then, a total of 450 systems has been tested, about 50 percent of them being industrial vacuum cleaners and 33 percent dust collectors. Acccording to the size of these devices, suction volume flows range from about 100 to 4000 $m^3 \cdot h^{-1}$ (see Table I).

Table I
Dust Removal Equipment

equipment	application	exhaust flow rate [$m^3 \cdot h^{-1}$]	tested equipments number	tested equipments [%]
industrial vacuum cleaner	sucking up of deposite dust	100 - 1.000 (7.000)	220	49
exhaust sweeping machine		200 - 1.000	82	18
dust collector	sucking off of airborne dust on machines	80 - 4.000 (11.000)	148	33
Summary (1973 - 8/88) :			450	100

Table II contains a survey of dust technique demands on these instruments. According to their use for the removal of dust of variable nocuousness, instruments are graded in different categories (dust classification). In general, demands increase from the top to the bottom of the list mainly referring to the required throughput.

With the exception of category L, the specific load per unit filter surface must not exceed 200 $m^3 \cdot m^{-2} \cdot h^{-1}$. In addition to requirements concerning the effects, demands with regard to the construction rise as well beginning at category L and ending with category V.

Any dust capturing machine has to be equipped with precipitators primarily supposed to protect the main filter from being damaged by sharp-edged or pointed objects.

Precipitators are frequently combined with dust collecting containers or are integral elements of them.

With the exception of category L, any system has to be provided with a control device.

1. Indicating in industrial vacuum cleaners the decrease of the average air velocity in the exhaust tube below 15 $m \cdot s^{-1}$ (in this case, dust transport would no longer be maintained);
2. Indicating in exhaust sweeping machines that the low pressure in the broom chamber decreases below 50 $N \cdot m^{-2}$ so that dust may be emitted;
3. Ensuring in dust collectors that the volume flow—adjusted to the dust source—does not fall short of the required minimum. This function can be performed for instance by a suction air control flap installed between capturing element and dust collector system. The control flap is supposed to switch off the dust source (e.g. a brake lining processing machine) when the adjusted minimum value is reached.

The cleaning of systems graded in categories H, T and C is intended to separate the dust deposited on the filter and to transport it to the collecting basin. If filter change is possible without dust production, easy-change filters—obligatory for systems of category V—can be used alternatively.

Dust of systems in categories T, C and V has to be disposed of without dust occurrence, for example using densely locking,

Table II
Dust Removal Equipment
Effective Requirements

dust class	dust with limit values for occupational exposure	example	degree of penetration [%]	flow rate per m^2 filter plane [$m^3 \cdot m^{-2} \cdot h^{-1}$]
L - light	> 1 [$mg \cdot m^{-3}$]	chalk	< 5	≤ 500 (≤ 1000)
H - hazard	> 0,1 [$mg \cdot m^{-3}$] incl. L	quartz	< 1	≤ 200
T - toxic	toxic incl. L and H	lead	< 0,5	≤ 200
C - cancer	carcinogenic incl. L, H and T	asbestos	< 0,1	≤ 200
V - virus	pathogens incl. L, H, T and C	virus	< 0,05	≤ 200

robust plastic boxes incorporated in dust collecting containers.

Density checking of systems and the checking of operating instructions are important since dust disposal without risk cannot solely be ensured by construction measures but frequently is only possible in combination with instruction and their observation.

Systems are provided with a certificate of three years validity which certifies the suitability for the specific category of clean air feedback after each of dust technique requirements has been met.

At the beginning, BIA only tested requirements regarding dust technique. Since 1979, noise emission of machines and instruments has been checked as well.

Increasingly, manufacturers are demanding an overall safety technique test including mechanical and electrical safety. In case of positive test results, BIA certifies the fulfilment of any presently valid safety technique condition. Each year, the institute publishes a list of systems tested with positive results. At present, about 90 percent of devices meet overall safety technique requirements.

Small dust collectors—referred to the space volume of workplaces—are in general operated with low air volume flows. In accordance with valid regulations, air recycled from small dust collectors must only amount to 1/10 of the fresh air volume flow for working areas.

When different exhaust devices are connected with a central dust capturing system and exhaust air has to be fed back to workplace atmosphere after cleaning, the conditions are different. In this case, the proportion of recycled air is mostly distinctly above 1/10 of the fresh air volume flow.

The cleaned air of stationary dust collectors can only be fed back to working areas after having obtained the permission of authorities in charge of occupational protection or of professional associations. Permission is granted under the condition that the quartz fine dust concentration in cleaned air does not exceed 1/3 of the maximum workplace concentration value. Since a permanent control of quartz fine dust concentrations in recycled air is hardly realizable by technical means, an evaluation of systems after initial operation has to ensure that the required threshold value is not exceeded and that this condition can be constantly maintained.

In general, systems are evaluated after a certain period of operation. This time comprises between 4 and 6 weeks, i.e. when filters in the precipitator obtain their optimum efficiency.

An assessment of the system includes the concentration determination in recycled air and in workplace atmospheres. At the same time, the accordance of system performance data (volume flow, pressure etc.) with actual values (nominal values) is checked.

Parallel to measurements of recycled air, quartz fine dust concentrations in workplace atmospheres are determined to control whether emitted dusts are sufficiently captured by exhausting equipment. If threshold values for quartz fine dust in workplace atmospheres as well as in recycled air are observed, an exceptional permission for operating the systems with clean air feedback is given.

An exceptional permission is not granted if technical data of the collector do not guarantee a permanently safe observation of threshold levels for clean air. Cleaning type of precipitating elements (filters) and the so-called load per unit filter surface (air volume flow, referred to filter surface) are essential.

The pressure drop within the precipitator increases if dust deposits on filter elements grow higher. If dust is not extracted on time the suction volume may decrease due to higher pressure loss, thus deteriorating dust capture.

The risk of a higher dust exposure by reduced capturing degrees is the consequence.

Precipitating elements can either be cleaned continuously during operation (on-line cleaning) or discontinuously while out of operation (off-line cleaning). Continuous cleaning is mainly performed by a pressure drop-dependent control system or by a time control system. Discontinuous cleaning demands the observation of the maximum pressure loss between cleaning intervals stipulated for proper operation. To maintain the safe function of systems a continuous cleaning is preferable. The pressure loss in units that are discontinuously cleaned has to be registered and indicated. If pressure loss increases above maximum level, suitable measures to prevent risks have to be taken. For example, a special control system interrupts dust emitting procedures and restarts them after cleaning.

Another parameter of operational safety is the filter surface load. A too high filter surface load results in:

- premature filter wear and
- worse characteristics to cleaning.

Filter surface load must not exceed levels between 80 and 100 $m^3 \cdot m^{-2} \cdot h^{-1}$.

Test Results of Dust Measurements

BIA has performed numerous measurements in various industrial plants. Clean air as well as harmful material concentrations in workplace atmospheres were measured to evaluate the efficiency of dust capture in addition to dust precipitation.

1. Workplace atmospheres in foundry iron casting cleaning rooms.

   After 7 foundries had been found to exceed the levels of workplace concentrations, new exhaust systems recycling clean air were installed. The evaluation showed average fine dust concentrations of 0.43 mg/m³ and average quartz fine dust concentrations of 0.017 mg/m³ in cleaned air. Levels varied between 1.33 mg/m³ and 0.03 mg/m³ for fine dust concentrations and between 0.05 mg/m³ and 0.004 mg/m³ for quartz fine dust concentrations.

   Measuring results showed the observation of concentration threshold values for recycled air, partly the levels were even distinctly below these limits.

Measuring values for workplace atmospheres varied between 1.5 mg/m^3 and 0.3 mg/m^3 for the fine dust concentration and between 0.16 mg/m^3 and 0.03 mg/m^3 for the quartz fine dust concentration, thus proving the efficiency of exhaust systems.

2. Workplace atmospheres in rooms for the hand-grinding of quartz containing construction elements.

   In some inspected enterprises, grinding was performed in front of an exhaust wall with water screen. Dust included in suction air was supposed to be precipitated in the water screen. The air cleaned in this way was led to workplace atmospheres via a mist collector. Concentration measurements in the whole working room showed the following results: the average fine dust concentration was 1.5 mg/m^3, the quartz fine dust concentration of 0.3 mg/m^3 was on the average twice higher than that of the maximum workplace concentration value of 0.15 mg/m^3. In recycled air a fine dust concentration of 1.6 mg/m^3 and a quartz fine dust concentration of 0.32 mg/m^3 were measured. This outcome was the reason to demand the system to be improved.

   The exhaust wall was replaced by a cabin. Subsequent measurements had the following results: in the working area, the fine dust concentration could be reduced to 0.11 mg/m^3 on the average and the quartz fine dust concentration to 0.01 mg/m^3. At the same time, the fine dust concentration of recycled air decreased to 0.1 mg/m^3 and the quartz fine dust concentration to 0.004 mg/m^3 compared to the approved quartz fine dust clean air concentration of 0.05 mg/m^3 (1/3 of the maximum workplace concentration value). The outcome was decisive for granting an exceptional permission to operate the system since the limits for clean air as well as those for workplace atmospheres were observed.

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