Recommendations for Good Working Practice

Paper recycling – activities involving hazardous substances and biological agents in the treatment of waste paper and paperboard

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The recommendations for good working practice have been drawn up by the Paper Recycling Working Group.

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1 General remarks

If workers perform activities involving hazardous substances or if hazardous substances are released during activities, the employer is obliged under the Hazardous Substances Ordinance [1] to perform a risk assessment according to the Occupational Safety and Health Act and to take measures to ensure the safety and protect the health of workers. The same procedure also applies under the Biological Agents Ordinance (BioStoffV) [2] to activities involving biological agents.

When the protective measures are being laid down attention must be paid to the order of priority: substitution (replacement by less hazardous substances or processes), technical minimisation of the exposures, organisational measures and personal protective measures. For hazardous substances with an occupational exposure limit the compliance with these must be established by means of workplace measurements (TRGS 402 [3]), where no equivalent assessment procedures are described.

The recommendations for good working practice "Paper recycling – activities involving hazardous substances and biological agents during the treatment of waste paper and paperboard" constitute a sector-specific aid for the risk assessment and for the selection of suitable protective measures during activities for the treatment of waste paper.

They have been drawn up by the measuring bodies of the federal states of Baden-Württemberg and Hesse, the Federal Institute for Occupational Safety and Health (BAuA), the German Social Accident Insurance Institutions for Transport and Traffic (BG Verkehr) and for the Trade and Distribution Industry (BGHW) and the BDE Federation of the German Waste, Water and Raw Material Management Industry.

The recommendations for good working practice may be applied in connection with hazards due to released particles as standardised working procedures under TRGS 400 [4] on the basis of the Hazardous Substances Ordinance [1]. The protective measures specified have been compiled on the basis of workplace measurements under TRGS 402 [3]. When they are applied it may be assumed that the Limit Values for respirable and inhalable particles according to TRGS 900 [5] and Annex I No. 2.3 Para. 2 of the Hazardous Substances Ordinance [1] have been complied with.

In order to ensure the permanent effectiveness of the measures taken, they must be regularly checked. This can be done with the help of the present recommendations for good working practice. Workplace measurements are then normally not required.

Waste paper and paperboard may be contaminated with biological agents, such as moulds, bacteria or endotoxins. The present recommendations for good working practice include supplementary instructions for the risk assessment during activities involving biological agents [2].

2 Scope

These recommendations apply to facilities treating waste paper which occurs

- as commercial waste/industrial waste,
- as production waste or
- as domestic waste

and which is passed on for recycling after appropriate treatment. This also includes facilities which perform this on the site of a paper factory.

The recommendations apply to workplaces in facilities which store, treat (sort, shred) and handle (compress, bundle, transport) waste paper. Individual process stages may be simplified or dispensed with entirely. The further processing of the waste paper which are sorted and compressed to form bales or passed on in loose form does not fall within the scope of these recommendations for good working practice.

Similarly these recommendations apply to facilities which operate stationary installations for document shredding. Mobile document shredding installations do not fall within the scope of these recommendations.

Waste paper within the meaning of the present recommendations encompasses all standard types according to the European list of standard grades of recovered paper and board [6]. With the exception of used craft sacks with polycoated paper which have previously contained dusty materials, such as cement, powdered paint and taste enhancers, all waste paper falls within the scope of the present recommendations.

Cleaning and maintenance work, where these are part of the day-to-day working sequence (e.g. cleaning jobs at the end of a shift), also fall within the scope of the present recommendations. Where cleaning and maintenance jobs are performed in the context of operational disturbances additional protective measures must be taken.

3 Information gathering

Waste paper is collected both at commercial facilities where it arises and at private households. As regards the collection systems a distinction is drawn between fetching and bringing systems. Basically the treatment of waste paper involves qualitative processing which is conducted manually, partly automatically or fully automatically. Undesirable materials such as metal, cord, glass, textiles or plastics are removed as far as possible and the waste paper is classified into defined waste paper grades. The list of the standard European grades and their qualities are given in the standard DIN EN 643 [6].

3.1 Working processes and activities

Figure 1 shows the process sequence for a waste paper treatment facility. The process stages are independent of the origin of the waste paper collected. Below the individual working steps of such a facility are described in greater detail.

- *Material feed*

After weighing the loose paper is tipped in the often covered delivery area (e.g. sorting hall, delivery boxes). Before and during the tipping operation the workers employed there can conduct a visual inspection of the material in order to remove larger extraneous constituents.

- *Sorting*

The paper is fed onto the charging belt using a wheel loader or a forklift. Extraneous constituents and undesirable types of paper and paperboard are separated off.

Depending on the facility an automatic sorting module is inserted. In the optical sorting operation previously specified materials (brown, grey and multi-coloured paperboard, dyed paper etc.) are sluiced out by means of colour recognition and compressed air jet.

The PCC material (paper, paperboard, cardboard packaging) can then be post-sorted by hand in a sorting booth as required. Any extraneous constituents and undesirable paper or paperboard that has remained can then be separated off.

- *Compression*

The sorted paper fractions are often pressed into bales using a bale press and tied with wire. Then these are carried away and put into intermediate storage in a storage hall using a forklift with bale clamp.

- *Document shredding*

Some treatment facilities also operate document shredding installations. Here the documents are delivered in sealed containers. The containers are only opened in the installation; then the documents are completely shredded. Subsequent treatment proceeds automatically. Access to the document shredding installation is subject to internal restrictions.

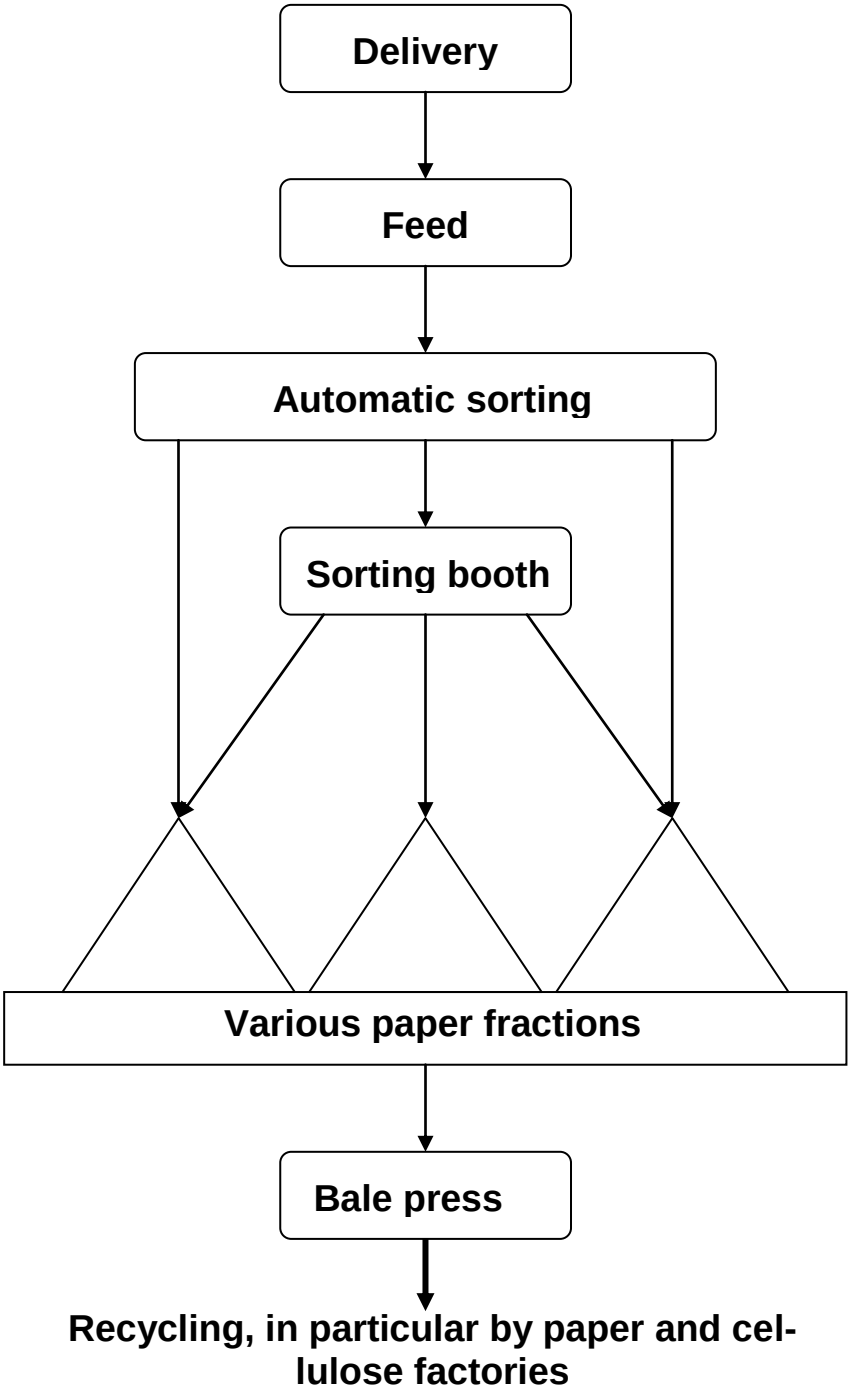

Figure 1 Flow chart of a waste paper and paperboard treatment plant

3.2 Substances arising during treatment of paper

During the treatment of paper, paperboard and cardboard packaging both hazardous substances and biological agents may arise at the workplace.

During activities conducted within the framework of the treatment inhalable and respirable particles are released. In addition it must be assumed that the air is polluted by diesel exhaust from the delivery vehicles.

The processing of paper and cardboard packaging delivered wet or contaminated and which contain impurities (e.g. biological waste) can also cause increased air pollution form biological agents, such as moulds, bacteria and endotoxins. These exposures must be evaluated independently of the hazardous substances.

3.2.1 Hazardous substances

- *Airborne particles*

Depending on the origin of the paper, paper dust may contain among other things small quantities of stuffing materials, dyes, surface refining and coating substances and adhesives from glued spines. Furthermore it is possible that there will be contaminants from the use, transport and storage of paper, paperboard and cardboard packaging in the form of dust constituents.

Paper dusts largely have grain sizes of smaller than 0.5 mm and are combustible. The lower explosion limit of dry paper dust is approx. 30 g/m³. The smoulder temperature of the deposited dusts is approx. 320 °C and the ignition temperature of the swirling dusts approx. 400°C [7].

During the working processes and activities described under 3.1 particles of varying size are released. Furthermore exposure to particles may arise as a result of open conveying systems or of transport devices without cover. Cleaning work, especially involving inadmissible blowing, will lead to an above-average particle exposure.

For the inhalable and respirable particle fraction the occupational exposure limits are 10 mg/m³ and 3 mg/m³, respectively [5].

- *Diesel particulate matter*

Exhaust fumes from diesel engines are a complex substance mixture of gaseous and particulate fractions. The particulate fraction (known as diesel particulate matter (DPM)) is classified as carcinogenic (category 2 according to DFG) [8]. Gaseous constituents of the exhaust gases from diesel engines include, for example, nitrogen oxides and carbon dioxide.

Exposures due to diesel particulate matter may arise when waste paper is delivered. The waste paper is frequently delivered in a hall to avoid exposure to the direct influence of weather. For this purpose the vehicles must enter the hall wholly or partially. The vehicles, which are licensed for travel on public roads, are often not fitted with diesel particle filters. During the delivery the doors of the hall are open. The engines are switched off during waiting times.

In the working areas the material delivered is transported mainly using diesel, gas-powered and electrically powered forklifts and wheel loaders. According to TRGS

554 "Exhaust fumes from diesel engines" [9] diesel vehicles in enclosed and partially enclosed working areas must be fitted with particle filters or the diesel exhaust fumes must be extracted directly at the point of origin.

In view of the known cross-sensitivity of the measuring procedure for the determination of diesel particulate matter to paper dust no DPM measurements were conducted.

For diesel particulate matter there is at present no health-based occupational exposure limit. In view of the carcinogenic effect it must be ensured under the Hazardous Substances Ordinance that the exposures are minimised in accordance with the state of the art.

3.2.2 Biological agents

During the treatment of paper, paperboard and cardboard packaging there arise exposures to biological agents, i.e. microorganisms. These microorganisms are introduced into the process with organic contaminants or colonise paper that has become wet. They can be a hazard to workers when airborne, i.e. as a dust constituent, and as smear infection and in the form of fungal disorders of the skin.

At the workplaces there arise airborne concentrations of moulds and bacteria which are higher than in the surrounding area. No data is available on exposure to viruses and parasites. The classification of biological agents into risk groups is conducted according to the infection risk they represent. Experience has shown that this concerns mainly moulds and bacteria of risk groups 1 and 2, and the latter can cause infectious diseases in humans. Possible toxic and sensitising effects of biological agents must be considered in addition in the risk assessment.

For the evaluation of the pollution due to microorganisms at the workplace the sum parameters were established in the past for moulds, bacteria and endotoxins. Endotoxins are structural constituents of gram-negative bacteria and can cause inflammations of the airways or flu-like symptoms. There are no occupational exposure limits for biological agents. The figures for the outside air are taken as an evaluation criterion. In the area of waste treatment a technical control value (TCV) (limiting value based on technical parameters) was laid down for mesophilic moulds in the air in sorting booths, in cabins and at control panels [10].

4 Assessment of exposure to hazardous substances

If during the treatment of waste paper the protective measures listed in section 5 are taken no workplace measurements have to be conducted. The risk assessment for activities involving hazardous substances can be concluded in accordance with TRGS 402 [3] with the finding **"Protective measures adequate"**.

In order to take over this finding for the individual facility the documentation of the hazardous substances and the description of the activities and protective measures must confirm compliance with the protective measures described in these recommendations.

For the risk assessment of the individual working areas and activities the exposures given in Table 1 can be referred to. The 95 percentiles are used as the basis of the evaluation. For justification purposes reference should be made to the evaluation of extensive workplace measurements in Annex 1. The occupational exposure limits for the inhalable and respirable particle fraction are complied with.

Table 1 Hazard substance exposures during the treatment of paper with fulfilment of the protective measures of the present recommendations

Working area / Activities	respirable particle fraction [mg/m³]	Inhalable particle fraction [mg/m³]
Document shredding	2.07	4.35
Only compression to bales	0.30	5.92
Sorting installations		
of which		
delivery/material feed	1.34	8.62
bale press	0.60	6.31
hall	1.53	8.50
sorting booth	0.79	9.23
workers with different activities	1.78	6.39

When the present recommendations for good working practice are being applied there are other requirements of the Hazardous Substances Ordinance, and in particular those concerning information gathering and risk assessment for working areas of the facility not covered here in which activities involving hazardous substances are performed and for which the present recommendations do not apply.

For other possible working areas of the facility reference should be made to relevant recommendations. If plastic waste is also compressed in the facility the recommendations for good working practice can be referred to for good working practice for the material recycling of plastic waste [11].

5 Protective measures for paper treatment facilities

Below the protective measures are listed which have to be taken for the various activities in the area of paper recycling. When the required measures are implemented the present recommendations apply as a standardised working procedure according to TRGS 400 [4]. The occupational exposure limits for the respirable and inhalable particle fraction are complied with. This considerably reduces the effort required for deriving protective measures within the framework of the risk assessment. Furthermore the present recommendations contain other instructions for the employer, such as additional hazardous substances information, including information on substitute processes, technical minimisation measures and other measures of substance-related occupational safety and health.

In addition the requisite measures for the use of diesel vehicles according to TRGS 554 [9] are listed.

Furthermore the requisite measures within the framework of fire and explosion safety and workers' skin protection are described in greater detail.

The additional remarks given in Annex 2 support the employer in the assessment of the exposures due to biological agents. The specifications of TRBA 214 [10] apply.

5.1 Measures to reduce the exposures to hazardous substances

5.1.1 Airborne particles

The machines and installations for paper recycling must comply with the installation and operating conditions specified by the manufacturer. Covers mounted on the machines and installations and other protective devices may not be opened, removed or otherwise handled during operation.

Particles´ release at stationary machines, transfer points and charging points must be effectively minimised by one or more of the technical measures below. They include

- extraction
- enclosure
- encasement to prevent spread to the side
- jets to spray water mist

The minimisation of dropping heights will lead to a reduction in particle emissions at the transfer points.

Structural measures must be taken to prevent particles from passing into adjacent unpolluted working areas.

Cleaning work, especially the removal of dust deposits, must be performed regularly. This concerns mainly the whole floor in the delivery area, where particles are constantly swirled up by the delivery traffic. To avoid the swirling of particles as far as possible use must be made of industrial vacuum cleaners (dust class H).

It is not permissible to blow the floors. The use of compressed air for blowing is only permissible if the locations to be cleaned are not accessible to industrial vacuum cleaners. If the use of compressed air is unavoidable, the workers must wear particle-filtering respiratory protective equipment of at least class 2. Respirator masks with

particle filters are recommended. Semi-face masks with particle filters or blower-supported hoods normally offer a tighter fit and hence better protection than particle-filtering semi-face masks (FFP2). Further instructions concerning the selection of suitable respiratory protective equipment are given in the Berufsgenossenschaft Rule (BGR) 190 [12]. In a set of operating instructions it must be clearly laid down when and where it is permitted to clean by blowing off with compressed air.

Vehicle cabins and control panels of machines and installations must be ventilated in such a way that the risk to workers is minimised (filtration of breathing air). They must be cleaned after every shift. The doors and windows of vehicle cabins must be kept closed during operation. Entries and exits to and from the polluted area must be reduced as far as possible. Vehicle cabins must be air-conditioned.

A heatable sorting booth must be installed for manual sorting. By implementing structural and ventilation measures (self-closing doors, vertical blinds, closed windows, prevention of air inlet through chute shafts, positive pressure) it must be ensured that no polluted air can flow into the sorting booth. When designing and dimensioning the sorting booth attention must be paid to compliance with ventilation requirements to the state of the art [13]. With reference to inspection and maintenance schedules a regular maintenance and care of the ventilation system must be conducted and documented. The ventilation installations must be tested as required, and at least annually, by a qualified person [14]. A record must be kept of the result of the tests.

Mechanical sorting installations must be installed outside the sorting booth. Transfer points of sorting and conveyor belts within the sorting booth must be excluded or enclosed.

For all working areas operating instructions must be drawn up. Workers must be given regular instruction.

The workers must be equipped with safety shoes of protection category S2 according to DIN EN ISO 20345 [15] and suitable work clothing in the form of a body-covering working suit according to DIN EN 340 [16].

Eating, drinking, smoking and the taking of snuff is not permissible at the workplaces.

At all workplaces the principles for the prevention of hazards according to GefStoffV [1] must be complied with, see also TRGS 500 [17].

5.1.2 Diesel particulate matter and exhaust fumes

The operation of diesel-powered forklifts without exhaust fume post-treatment system or particle filter is not permissible in completely or partially enclosed working areas. If diesel-powered forklifts are used, they must have an exhaust fume post-treatment system or a particle filter which is in accordance with the FOEN (Federal Office for the Environment, Switzerland) filter list of tried and tested particle filter systems for equipping diesel engines (formerly: VERT filter list)[1]. The exhaust fume emissions of the engines must be monitored in accordance with the provisions of TRGS 554, An-

[1] http://www.bafu.admin.ch/publikationen/publikation/01010/index.html

nex 3. When new forklifts are being purchased, a test according to TRGS 554, Annex 4 [9] must be conducted to decide on the type of drive system.

For transport operations in the working areas preference must be given to the use of gas-powered and electrical forklifts. Gas-powered forklifts must be regularly serviced to minimise the pollution from carbon monoxide and adjusted in accordance with the manufacturer's data.

5.2 Measures of fire and explosion safety

In facilities which fall within the scope of the present recommendations there is a high fire risk. Not only paper and card, but also and mainly the particles released during the processing may be combustible and may form as a particle-air mixture an explosive atmosphere under certain circumstances.

Under Article 5 of the Occupational Safety and Health Act [18] in conjunction with Articles 6 and 11 of the Hazardous Substances Ordinance [1] the employer must also identify the risk to workers from fires and explosions and take minimum operational measures of fire and explosion safety. In cases of doubt a fire safety report by an expert must be obtained.

Basically the specifications of the respective regional construction regulations (Landesbauordnung) and industrial construction regulations must be met with a view to fire and explosion safety. Further measures regarding structural, technical, operational and organisational fire and explosion safety may be necessary as the result of the risk assessment.

The formation of an explosive atmosphere is not to be expected if dust deposits are avoided in the working premises, if they are removed at appropriate intervals by moist and wet procedures or using suitable industrial vacuum cleaners (no compressed air) and if dust removal equipment is regularly cleaned and properly maintained.

Detailed instructions concerning fire and explosion safety can be found in TRGS 720-722 [19-21] and the Berufsgenossenschaft Information BGI 560 [22].

5.3 Protective measures in the case of dermal exposure

For workers in paper treatment installations there is only a low risk even with longer-term skin contact with airborne particles. This concerns mainly the hands in contact with contaminated surfaces (see Annex 2). During sorting there is also a mechanical risk from cutting and stick injuries.

In the facility an activity-related skin protection plan must be drawn up and displayed. In the skin protection plan the necessary protection, cleaning and care measures must be allocated in a clear and comprehensible form to the corresponding jobs which are harmful to the skin. When drawing up the skin protection plan it is advisable to provide occupational medical support.

The aids listed in TRGS 401 [23] for estimating the risk and for selecting and evaluating personal protective equipment and skin protection agents must be referred to. The result must be documented.

6 Effectiveness check

When applying the present recommendations for good working practice the measures and requirements laid down in section 5 must be complied with.

At regular intervals or after modifications of processes and installations the functioning and effectiveness of the protective measures in place must be checked. In particular the intervals laid down by manufacturers for tests and services must be adhered to. All tests and repair measures on the installations must be documented.

If plastic waste is sorted, compressed or recycled alongside paper waste in facilities, the recommendations for good working practice for the material recycling of plastics [11] may be referred to in addition.

The user of the present recommendations must check the conditions for any changed validity of the present recommendations and document the result where there are any procedural changes and otherwise regularly, at least annually.

When these recommendations are being applied other requirements of the Hazardous Substances Ordinance shall continue to apply, especially those on information gathering and risk assessment for working areas of the facility not mentioned here where activities involving hazardous substances are carried out and for which the present recommendations do not apply.

The present recommendations for good working practice are available at www.baua.de. They are regularly reviewed and adapted to the state of technical and legal development. The user of the present recommendations should therefore always ensure that the current version is being used.

7 Literature

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[37] TRBA 500: Grundlegende Maßnahmen bei Tätigkeiten mit biologischen Arbeitsstoffen. *(Basic measures to be taken for activities involving biological agents)* BArbBl. Issue 6, 1999, pp. 81-82

The current versions of the literature references listed must be used.

Annex 1 Principles of the assessment of exposures to hazardous substances

In the treatment of waste paper the measuring bodies of the federal states of Baden-Württemberg and Hesse, the BAuA [24] and the German Social Accident Insurance Institutions for Transport and Traffic (BG Verkehr) and for Trade and Distribution Industry (BGHW) conducted workplace measurements in the period 2004 to 2009 to identify exposures to hazardous substances and biological agents in 53 facilities. Below the evaluations of the measuring results are given in detail for the exposures to hazardous substances in these facilities.

Results of the workplace measurements

The workplace measurements to identify exposures to respirable and inhalable particle fractions were conducted mainly in facilities where the waste paper was sorted after delivery. Between delivery and sorting there were different intervals. Mostly the waste paper was passed on for sorting immediately on delivery. The sorted waste paper was then either compressed into bales or passed on in uncompressed form to the further processing facilities, normally paper manufacturers. In some facilities there was no sorting, only compression of the waste paper delivered. Compressed paper bales were stored both in covered storage areas and closed halls, and in the open. Uncompressed waste paper was not stored in the open.

For document shredding it was only possible to conduct workplace measurements in facilities with stationary installations to a small extent. This was due in particular to the fact that there were access restrictions here because secure handling of partly sensitive customer documents had to be ensured.

Table 2 gives an overview of the shift average values identified in workplace measurements for the inhalable and respirable particle fractions. It was possible to bring together the measurements by personal air sampling and by stationary sampling since no differences were established between them.

- *Facilities without sorting*

The shift average values listed in Table 2 for the inhalable and respirable particle fractions show that in facilities which only compress waste paper and in facilities with document shredding the **occupational exposure limits for the inhalable and respirable particle fractions are complied with throughout**.

- *Sorting facilities*

The sufficiently large number of measuring results means that it is possible to consider the individual activities and working areas in sorting facilities in a differentiated way. Specifically these are

- delivery and material feed,
- bale press,
- the hall with all installations and workplaces in it,
- workers working at different workplaces and
- the sorting booth.

Table 2 List of the shift average values for the inhalable and respirable particle fractions

	Number of facilities	Number of measuring results	Median [mg/m³]	95-percentile [mg/m³]	Maximum value [mg/m³]
Inhalable particle fraction (occupational exposure limit 10 mg/m³ [5])					
Document shredding	6	11	2.02	4.35	4.50
only compression	7	16	0.90	5.92	7.48
Sorting installations	41	266	2.18	7.74	19.9
of which					
delivery/material feed	25	74	2.41	8.62	19.9
bale press	18	45	2.20	6.31	7.21
hall	15	24	1.93	8.50	18.2
sorting booth	26	86	2.09	9.23	13.6
workers	17	37	2.42	6.39	6.87
respirable particle fraction (occupational exposure limit 3 mg/m³ [5])					
Document shredding	6	6	0.45	- [2]	2.07
only compression	4	12	0.15	0.30	0.38
Sorting installations	36	159	0.35	1.50	4.20
of which					
delivery/material feed	25	53	0.31	1.34	4.20
bale press	15	30	0.34	0.60	0.75
hall	13	23	0.28	1.53	1.95
sorting booth	7	11	0.34	0.79	0.84
workers	23	42	0.55	1.78	1.92

Delivery and material feed

Waste paper was delivered by company and external vehicles and the waste paper was then fed by the workers of the sorting facilities to the subsequent process. Normally one or two workers worked at delivery and material feed.

For the respirable particle fraction it was found in one case that the occupational exposure limit was exceeded during delivery. The reason for this was considered to be the unfavourable air conditions in the delivery area.

In one case again the occupational exposure limit of 10 mg/m³ for the inhalable particle fraction was also exceeded. It was possible to attribute this to the cleaning work conducted with compressed air in another area of the hall.

[2] Because of the small quantity of data no 95-percentile was calculated

To summarise it can be assumed that the **occupational exposure limits for both particle fractions are complied with in the delivery and material feed area**. This is verified by 95-percentiles of 8.62 mg/m³ and 1.34 mg/m³ respectively identified for the inhalable and respirable particle fractions.

Bale press

At the bale press the individual paper fractions and in some facilities also plastic waste are compressed. During the compression of plastic waste no measurements were conducted or were interrupted for the corresponding period.

The measuring results in Table 1 show that **with a functioning extraction system at the bale press the occupational exposure limits for the respirable and inhalable particle fractions are complied with**.

Measurements conducted where the extraction system at the bale press was not in operation or where malfunctions in the press were being rectified and cleaning work carried out are not considered in the data collective in Table 2. In these cases there arose sometimes substantially excessive values of up to five times the occupational exposure limits for both particle fractions.

If used craft paper bags were compressed in the bale presses, the shift average values identified were definitely among the highest values identified. If it is considered that the compression of such bags with paint powder residues, cement residues or residues of glutamate generally lasted no longer than 30 minutes, it must be assumed that during this period the allowable short-time values were exceeded at the level of double the occupational exposure limit (inhalable particle fraction: 20 mg/m³; respirable particle fraction: 6 mg/m³). It can also be concluded that with a more extended compression time for such bags it is to be expected that the occupational exposure limit will also be exceeded on a shift average. In view of these increased exposures the compression of craft paper bags was not included in the scope of the present recommendations for good working practice.

As Table 2 shows there are no significant differences in exposures during compression if this proceeds in facilities with sorting or in facilities where only compression takes place.

Other installations and workplaces in the hall

Further measurements were conducted by stationary sampling in the hall on selected installations where increased exposures were expected. These were not permanent workplaces. The workers in general only had jobs here connected with checks and the rectification of malfunctions. The measuring results thus represent the "worst case" and supply information on possible increased exposures of workers when they are present at such installations or work on them. Similarly measurements were conducted in the proximity of the bale depository.

With one exception the particle exposures **identified at the various installations in the hall were below the occupational exposure limits for both particle fractions**. Only in one case was the occupational exposure limit for the inhalable particle fraction exceeded at 18.2 mg/m³ directly at one installation for fine sorting. But this was an installation on which the workers were not working at any time during the measurements.

Some workers performed different activities. It was therefore not possible to make an allocation to individual activities or workplaces. The workers were subjected to measurements by personal air sampling. This included in particular foremen and shift managers, as well as forklift and wheel loader drivers. These workers also partly performed activities in the open during the measurements.

The **exposures identified in these workers were throughout below the occupational exposure limits for both particle fractions**. There were a maximum of about 68 % of the occupational exposure limits.

Sorting booth

In the sorting booth there were a number of workplaces directly at the sorting belt which were occupied by two to six workers according to the facility concerned.

The shift average values for the respirable particle fraction were always substantially below the relevant occupational exposure limits in the sorting booth. For the inhalable particle fraction readings which exceeded the occupational exposure limit by as much as about 40 % were found in four cases. It is considered that the reason for this was mainly the fact that the ventilation system was not fully operational in the sorting booth and cleaning work by sweeping was being conducted. **The 95-percentile for the exposures to inhalable particle fraction is, at 9.3 mg/m³, below the occupational exposure limit**.

Annex 2 Information on exposures to biological agents during the treatment of waste paper

Activities involving biological agents are governed by the Biological Agents Ordinance. Biological agents under the Biological Agents Ordinance are in the widest sense microorganisms which may cause infections and sensitising or toxic effects in humans. There are no limit values for biological agents. As for other areas of waste treatment, the Technical Rules for Biological Agents – TRBA 214 [10] also apply to paper recycling. They lay down a technical control value according to TRBA 405 [27] for mesophilic moulds in the air in sorting booths, cabins and control stands. This is $5x10^4$ CFU/m³ (colony-forming units per m³ breathing air).

Below representative measuring results for biological agents in paper recycling are shown which must be considered in the context of the risk assessment (LASI-LV 23 [25], TRBA 400 [26]). As a supplement to TRBA 214 [10] reference should be made to specific protective measures. The present recommendations contain experience gained with comparable activities which must be taken into account in the risk assessment according to Article 5 Biological Agents Ordinance.

A2.1 Exposures measured for biological agents

The workplace measurements to identify exposures suffered by workers in relation to airborne biological agents were conducted in the same facilities and at the same workplaces as the hazardous substance measurements. The contamination of the outside air was identified as a reference quantity. Bacteria, moulds and endotoxins were collected using the measuring strategy laid down in TRBA 405 [27] and analysed using standardised measuring procedures. Moulds were found to be a lead parameter for contamination by biological agents in the air at workplaces in paper recycling.

- *Bacteria*

The sampling of airborne bacteria was conducted using filtration air germ collectors or according to VDI Regulation 4252 Sheet 3 [28] using impingers. The analysis was conducted as a function of cultivation. The bacteria were cultivated on CaSo agar, a universal medium for various bacteria, on Difco actinomycetes isolation agar on the basis of VDI Regulation 4253, Sheet 3 [29]. The results are given in colony-forming units (CFU) per m³ breathing air.

Table 3 shows the readings obtained for exposures to bacteria in the facilities. The values identified in the installations were above the respective outside air reference by a factor of 10 to 100.

To evaluate the risk of bacterial contamination it must be known what bacteria are involved in the main. Some type of actinomycetes play a part in the development of exogenic-allergic alveolitis which is recognised as an occupational disease, BK 4201. For this reason the bacteria were cultivated in addition on Difco actinomycetes isolation agar in 8 facilities. The concentration at the workplaces was two orders of magnitude above that of the outside air reference.

Table 3 List of values measured for bacteria

	Number of facilities	Number of measuring results	Median [CFU/m³]	95-percentile [CFU/m³]	Maximum value [CFU/m³]
Bacteria (CaSo-cultivated)					
All	11	27	8,000	95,900	280,000
of which					
sorting booth	11	12	14,200	78,600	89,000
other workplaces	11	15	6,600	153,200	280,000
outside air reference	11	12	289	3,132	3,610
Bacteria (Difco actinomycetes isolation agar-cultivated)					
sorting booth	8	8	17,600	31,100	34,700
other workplaces	8	8	5,900	105,000	145,000
outside air reference	8	8	108	2,260	3,280

In 3 facilities the bacteria were identified on a representative basis in the sorting booths via an analysis of the 16S-RNA genes present in the samples. For the following species of bacteria at least one bacteria type of risk group 2 according to TRBA 466 [30] was identified, i.e. bacteria with health-harming potential for workers:

Acinetobacter
Aerococcus
Alcaligenes
Citrobacter
Enterobacter
Klebsiella
Pantoea
Proteus
Shigella
Staphylococcus

- *Moulds*

The sampling was conducted using filtration air germ collectors. The analysis was conducted as a function of cultivation on DG-18 agar, which covers a wide range of moulds. The measurements were conducted using the methods of the BGIA Folder, Code 9420 [31], or according to VDI Regulation 4252, Sheet 2 [32] and 4253 Sheet 2 [33]. The results are given in colony-forming units (CFU) per m³ breathing air.

Table 4 gives an overview of the exposures in relation to moulds in the treatment of waste paper. The concentrations of airborne moulds were 10- to100-fold the respective outside air reference. For the 11 facilities in which no outside air reference was measured, the median value of the outside air values determined, which is in the range of the known background values of the environment, can be used.

Table 4 List of the values measured for moulds

	Number of facilities	Number of measuring results	Median [CFU/m³]	95-percentile [CFU/m³]	Maximum value [CFU/m³]
Moulds total					
All	33	73	44,000	631,000	1,840,000
of which					
sorting booth	30	34	51,600	627,300	1,027,500
other workplaces	26	39	38,000	495,000	1,840,000
outside air reference	22	24	1,539	9,935	40,000
Aspergillus fumigatus					
sorting booth	9	9	1,130	5,630	7,700
other workplaces	9	9	286	21,000	33,000
outside air reference	9	9	33	99	100

Compliance with the technical control value (TCV) for moulds of $5x10^4$ CFU/m³ in the sorting booths is shown in Figure 2. For 16 of 34 measurements, i.e. in 14 of 31 sorting booths, the TCV was complied with, which corresponds to more than half the sorting booths (17 of 31). In three sorting booths measurements were conducted at two points in each case; in two sorting booths both measured values were below the TCV, and in one both were above it. 12 measured values (11 sorting booths) were above 10^5 CFU/m³. The measurements demonstrate that the TCV can basically be complied with, if technical and hygienic standards are met in the sorting booths in paper recycling facilities.

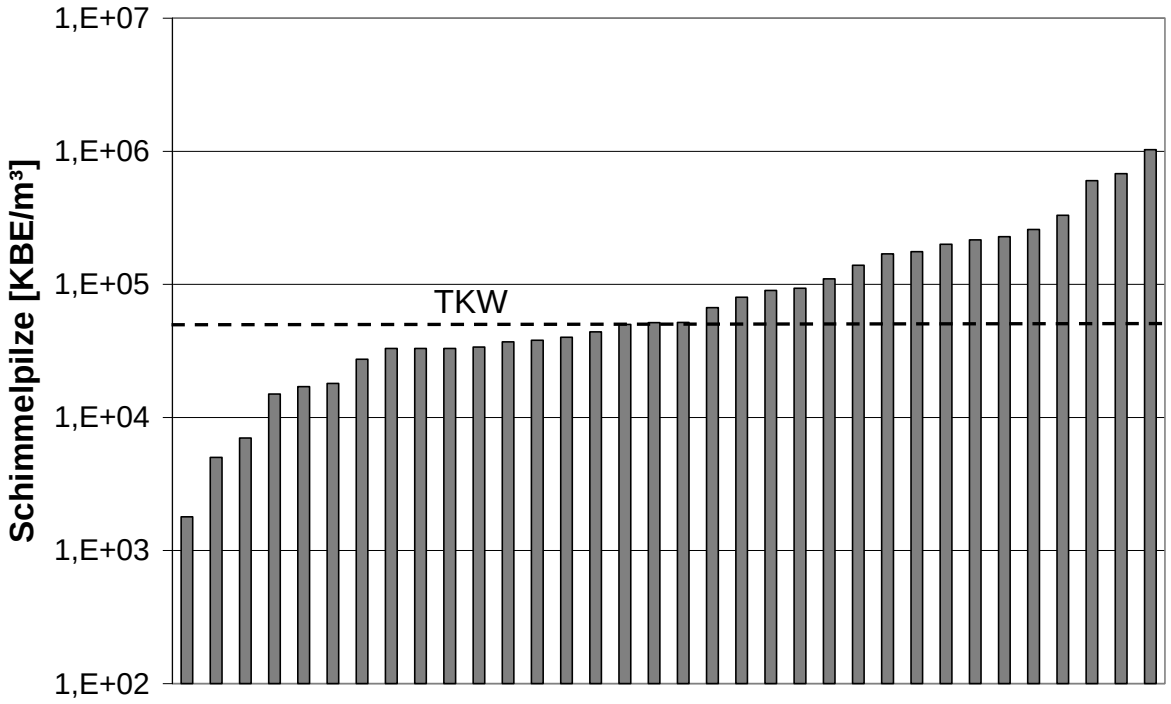

Figure 2 Mould concentration in the air of 31 sorting booths (34 measurements) during the manual sorting of waste paper. The technical control value (TCV) according to TRBA 214 [10] is $5x10^4$ CFU/m³ for these workplaces.

For 10 facilities the moulds were identified sometimes down to species level on the basis of morphological features. For *aspergillus fumigatus*, a human-pathogenic mould of risk group 2 with allergenic potential, the concentration at the workplaces was above the outside air reference by a factor of 100 (Table 4). Aspergillus fumigatus can cause in humans an aspergilloma and allergic bronchopulmonary aspergillosis. Table 5 lists the most frequently occurring species of mould and assigns the relevant risk group and any additional information for the risk assessment. About 90 % of the moulds identified at the workplaces belong to the species *aspergillus* and *penicillium*, which are classified in TRBA/TRGS 406 [36] as airway-sensitising. At the workplaces examined moulds were identified which were also found in the outside air, such as *aspergillus fumigatus*, only in higher concentration (Table 4). On the other hand, there are moulds such as *A. versicolor. A. ochraceus or Rhizopus stolonifer* which clearly tend to be brought in by the paper

Table 5 The most frequent moulds in 10 facilities in the areas of sorting booths (Sc), at other workplaces (Wp) and outside air reference (outside); risk groups according to TRBA 460 [34]. Additions: A. allergenic potential; + risks for persons with impaired immunity

Species	Identified at measuring points (max. 10)			Risk group
	Sc	Wp	outside	
Aspergillus fumigatus	9	10	9	2, A
Aspergillus flavus	6	5	4	2
Aspergillus versicolor	9	10	2	1, +
Aspergillus niger	10	9	5	1, +
Aspergillus ochraceus	7	4	0	1
Penicillium chrysogenum	10	8	4	1
Penicillium roqueforti	6	5	1	1
Rhizopus stolonifer	9	7	2	1
Chrysonilia sitophila	6	3	1	1

- *Endotoxins*

The airborne endotoxins were collected in the inhalable particle fraction with stationary instruments and personal instruments on filters, they were extracted in endotoxin-free water and the endotoxic activity was determined using the limulus amebocyte lysate (LAL) test (BGIA Folder, Code 9450 [35]). The results are given in endotoxin units (EU) per m³ breathing air.

Endotoxins are structural components of gram-negative bacteria and can lead to inflammation of the airways or flu-like symptoms. Endotoxins are known to cause byssinosis and lead to symptoms such as Organic Dust Toxic Syndrom (ODTS), hayfever or humidifier fever. There is no limit value or TCV for endotoxins.

Table 6 shows a list of the endotoxin exposures in the facilities. The endotoxin concentrations identified at the workplaces were generally above those in the outside air.

In two cases it was also possible to measure endotoxin exposures during document shredding. These were 8 and 24 EU/m³ and therefore below the exposures identified in paper sorting facilities.

Table 6 List of values measured for endotoxins

	Number of facilities	Number of measuring results	Median [EU/m³]	95-percentile [EU/m³]	Maximum value [EU/m³]
Endotoxins					
All	15	71	469	2,859	6,830
of which					
sorting booth	15	33	671	4,117	6,830
other workplaces	14	38	290	1,628	4,196
outside air reference	13	14	6	112	165

A2.2 Protective measures with respect to biological agents

The measuring results obtained in paper recycling facilities demonstrate pollution by biological agents. At workplaces involving direct and enduring contact with waste paper in particular, such as in the area of the belt feed, the press or in the sorting booths, the workers are subject to partly high exposures in relation to biological agents with pathogenic potential (risk group 2 and allergenic potential); pollution which must be considered regardless of compliance with occupational exposure limits for the respirable and inhalable particle fraction. A risk assessment according to the Biological Agents Ordinance [2] must be conducted and protective measures drawn up on the basis of the assessment.

The general principles of hygiene for activities involving biological agents as laid down in TRBA 500 [36] and TRBA 214 [10] for waste treatment facilities must be adhered to. This concerns in particular also the operation of sorting booths. Attention must be paid here especially to ensuring an effective and maintained ventilation system. The evaluation of the concentration of biological agents at the workplace with reference to a TCV is intended to help the employer assess the effectiveness of these protective measures.

It is recommended that the measurement of airborne moulds be taken as lead parameter for checking the effectiveness of protective measures with regard to biological agents in the air at workplaces in paper recycling.

Wet paper is a breeding ground for microorganisms. Clearly mould-contaminated waste paper may not be sorted manually and must be disposed of immediately.

Spraying waste paper with water mist may lead to an increase in pollution from biological agents.