94-289

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3M

July 20, 1994

NIOSH Docket Office
Robert A. Taft Laboratories
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Dear Sir or Madam:

Minnesota Mining and Manufacturing Company (3M) submits the enclosed comments to NIOSH for the docket record concerning NIOSH proposed rule, 42CFR84, in accordance with rulemaking procedures.

3M supports revision of the respirator approval standard. The comments enclosed are substantial and supported by technical knowledge, experience and data. We believe the suggested revisions to the proposed standard will improve the standard and result in improved respirators and respiratory protection for the users.

We appreciate NIOSH's consideration of these comments and information.

Respectively submitted,

Katherine E. Reed

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Enclosure

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3M COMMENTS TO NIOSH ON PROPOSED 42 CFR 84

1. Introduction

Minnesota Mining and Manufacturing Company (3M), through its Occupational Health and Environmental Safety (OH&ES) Division, is a major manufacturer and supplier of respiratory protection devices throughout the world. 3M has invented, developed, manufactured, and sold NIOSH approved respirators since 1972.

The 3M corporate philosophy of growth through innovation has been steadfastly applied to respirator development by the OH&ES Division. 3M provides a full line of respirators that are not only protective but also comfortable and friendly to the wearer, encouraging conscientious usage and hence, improve worker protection. It is from this basis of technology and experience that 3M offers comments to NIOSH on the proposed rule, 42 CFR 84.

As a major supplier of respirators, 3M and respirator users in all of North America will be significantly impacted by any revisions NIOSH adopts to the regulations governing respirator approvals.

2. 3M Supports Revision of Respirator Approval Tests

3M agrees that many of the test methods specified under the current certification regulations contained in 30 CFR 11 should be revised. Since their issuance several years ago, it has become evident that in many cases the tests are variable, difficult to control, difficult to correlate to reasonable production testing, and use obsolete technology. 3M has cooperated directly with NIOSH, and as a member of the Industrial Safety Equipment Association (ISEA), to discuss and suggest improvements in the approval testing procedures over the last ten years. 3M has exchanged information openly with NIOSH, including data from over a dozen workplace protection factor studies. 3M has always advocated that approval regulations be performance oriented, rather than design specific, to allow for further innovation and flexibility of design that will result in better performing and more comfortable products for the worker.

3. Economic Impact

3M believes NIOSH has severely underestimated the economic impact of the proposed regulatory changes. An ISEA survey of respirator manufacturers resulted in an estimated annual cost increase to users in excess of $100 million. This estimate is just for the revisions proposed to the particulate section alone. While revising the certification

regulations in a modular approach has benefit, NIOSH should provide an economic impact statement for the entire proposed revisions to 42 CFR 84. Looking only at one section at a time hides the total cost impact to industry, and to the economy, which could approach a half billion dollars.

While the regulation proposes six classes of particulate respirators, no guidance is provided on how these classes will be selected or used. This makes it difficult for manufacturers and users to predict cost increases because market mix and manufacturing volumes cannot be forecast. This could be remedied by NIOSH issuing a use and selection criteria before issuing 42 CFR 84 as a final rule. The use and selection criteria should be thoroughly reviewed, and issued through rulemaking procedures, possibly as a part of the Assigned Protection Factor module scheduled for late 1994.

4. NIOSH Reference to Health Care Respirators (TB)

While NIOSH is to be commended for proposing regulations concerning respirator usage for protection against contaminants in the health care workplace, particularly exposure to *Mycobacterium tuberculosis*, 3M submits that NIOSH must recognize that health care, and TB, constitute a small part of the respirator usage in this country. Consequently, while the needs of the health care workplace should be addressed, the certification regulations should not be slanted toward, nor driven by this tiny segment of respirator usage. NIOSH must follow their charter. Approval regulations should focus on and be workable for the much larger industrial and mining segments, which represent 98% of current respirator usage.

There are numerous and significant differences in industrial and health care applications that would suggest separate performance requirements for each. For example, health care is a "no-load" situation. Challenges like TB may represent a serious health threat to certain, susceptible individuals, where a very small, short duration exposure may cause disease. No Permissible Exposure Limit (PEL) or Threshold Limit Value (TLV) has been determined. The area of individual susceptibility is still an unknown and is being studied by the medical community.

Industrial applications, however, have heavier loadings, longer use, and the protection required is based on exposure limit concepts (TLV, PEL, REL, etc.), where some filter penetration and face seal leakage of the contaminant can be tolerated, since total dosage is the concern. This is the basis of respirator protection factors. These protection concepts are clearly not compatible nor has it been demonstrated that industrial applications of respirators optimized for health care settings will increase their protection for industrial workers.

NIOSH states that all particulate respirators approved under the proposed standard would meet the criteria of the proposed CDC guidelines for the prevention of TB, which it is projected would result in a cost savings for the health care industry. The criteria contained in the CDC proposal of 95% efficiency against a 1 micrometer particle as adequate for TB exposure has not been proven in clinical testing, nor has it been validated by rulemaking. In addition, the CDC proposal contains no other test parameters, such as test agent, flow rate, etc. to make the stated efficiency requirement meaningful. For example, the test could be run using a flow rate of one liter per minute and pass the test with most surgical masks which would provide little actual protection.

Further, from an industrial hygiene point of view, it may be inappropriate to require a less protective respirator for use against TB than is allowed against other contaminants, such as lead or cadmium, where any adverse health effect requires long term exposure.

NIOSH and CDC should reevaluate their implied position that a respirator, certified under the new regulation as a Class C Solid approved device, is the prudent choice for protection from TB. As future workplace data is developed for TB and other diseases, NIOSH should continue to evolve additional testing and selection criteria for this segment.

Part of the supporting reasoning offered by CDC in the proposed TB guidelines and OSHA in their TB enforcement policy for selection of HEPA respirators for use against TB was that less efficient classifications, Dust/Mist and Dust/Fume/Mist, were not tested in the NIOSH approval procedure under 30 CFR 11 for instantaneous, unloaded efficiency. This was not felt appropriate for health care where no loading, or filter caking would take place. This being the case, why should a health care respirator be subjected to the severe loading tests as specified in 84.184 (g)(1) and (g)(2)?

NIOSH should reconsider its position on respirator applications for health care and TB exposures and consider a separate approval category for these products with test requirements appropriate to their application.

5. Need for "Solids" and "Solids and Liquids" Approvals

The NIOSH proposal intends to certify respirator filters for use against "solids" and "solids and liquids". During the hearings held on June 23 and 24, the suggestion was made by one presenter to drop the solids classification. 3M strongly opposes this suggestion. Requiring that all filters approved pass the oil mist, or DOP test adds design limitations and significant cost to these filters that is not warranted for most industries.

A study titled "Aerosol Exposure In The Working Environment" conducted by the Danish Toxicology Center in 1986 in Denmark provides an excellent profile of aerosols

in typical industrial work places. In this study, the Center surveyed industry and compiled a list of all the aerosols present in various segments and then classified them as to solid or liquid categories. In Table 4.10 on page 42, the study identified 146 total aerosols present in industry, 105 or 71.9% of which were solid aerosols. The same table also shows that of the 41 identified liquid aerosols, as many as 19, or 46.3% are water based. It is interesting to note that in the European system, water based liquid aerosols are treated as a solid aerosol for respiratory protection selection. The reasoning is that the contaminant is, in fact, a solid merely being carried by the water. Therefore, only 22 of the 146 aerosols, or 15.1% were non-water based liquids. This remaining 22 encompasses liquids including acid, solvent, or oil based liquids. These data clearly support the need for a solid only approval, as this would be the needed filter for the vast majority of industrial applications. A liquid approval requirement for these users would increase costs significantly, with no discernible increase in worker protection.

NIOSH should also note the distribution of aerosols by industry given in Table 5.3 on page 60, and the conclusions to the report starting on page 111. The Danish report undeniably supports 3M's recommendation.

6. Definition of "liquids"

The NIOSH proposal contains requirements for certification of respirators for use against "solids" and "solids and liquids". However, these key terms are not defined. As stated earlier, there is also a lack of guidance regarding the selection and application of the proposed classes. Since dioctyl phthalate (DOP), an oil, is specified as the test agent for the "solid and liquid" approval, it would seem reasonable that this approval is only needed for oil-based liquid aerosols. Since the majority of liquids used in industry are not oil based, but are water, solvent, or acid based, however, the issue is legitimately raised whether an oil mist accurately predicts filter penetration for these aerosols and hence, correlates to protection in the workplace. In the vast majority of applications, a "solids-only" approval would be more appropriate. For example, in paint spray operations the paint starts as a liquid. The over spray, particularly the respirable particle sizes of concern, quickly dries to become a solid.

In fact, NIOSH seems to confirm this assumption by stating in §84.184(g)(2): "When testing for filter leakage of oil liquid particulate aerosols, a dioctyl.....". NIOSH needs to be clear on this matter and issue appropriate selection criteria through rulemaking. NIOSH should also justify the use of an oil test agent to predict filter penetration of other liquids, if that is their intention.

7. Selection of Dioctyl Phthalate (DOP) as a Test Agent

NIOSH states in Section II Background that the new filter performance requirements provide a particulate efficiency determination and classification system consistent with advances in respiratory protection technology. The selection of DOP as a test agent and the severe filter loading levels proposed, however, are contradictory to this stated position. In the past ten years, the technology advances in particulate filters have come through the development of modern electrostatic filter media. These new media provide excellent filter efficiency with extremely low pressure drops resulting in more comfort and increased wearability by the user. The new media have overcome the shortcomings of earlier electrostatic filters, such as rosin-wool, by being resistant to heat, humidity, and many other common industrial conditions that caused these earlier electrostatics to lose their charge and become less efficient. Further advances in filter technology, currently being researched by a number of companies, will be made in the area of improved electrostatic filters; not in the area of mechanical, fiber glass filters. These new technologies, if encouraged to develop, will result in filters that will be even more efficient, more stable, and with lower pressure drops than filters available today, or possible with mechanical, fiber glass technology. These attributes contribute to a more user friendly respirator that is more protective. The selection of DOP as a test agent and the unreasonable proposed loading levels will stifle this development, especially since its relevance to worker protection has not been shown by NIOSH.

DOP is an oil that specifically tends to saturate and cover charges on fibers of all electrostatic filters to a much larger degree than other materials or even other oils. DOP has been used to test HEPA filters for many years and, until recently, these filters have been mechanical, fiber glass media, which is 50 year old technology. Even in this case, the DOP test was designed and used as a short duration, instantaneous filter efficiency test; not the severe loading test proposed by NIOSH. Due to the saturation properties of DOP, its continued use as the filter efficiency test agent is extremely prejudicial against electrostatic filters and could limit their use or cause manufacturers to invest heavily into older alternate technologies, again with no improvement in worker protection. While this investment may be a burden to large manufacturers resulting in higher respirator prices to the users, small manufacturers may not have the resources to make this investment or survive.

Further, there is no evidence to suggest there are not other test agents available that would accurately and reliably assess the filter penetration characteristics of electrostatic filters. As stated, the more common liquids encountered in industry will be water, solvent, or acid based, which would support the selection of hydroflouric acid as the test agent. This would, in fact, be more realistic as it is common in many industries.

Finally, DOP provides no practical use as a surrogate to predict filter penetration against liquids or other oils commonly used in industry. The only common exposure to DOP, a

suspected carcinogen, will be respirator manufacturers' test personnel conducting NIOSH mandated tests. Given NIOSH's strong objection in the past to exposing test personnel to sodium saccharin, crystalline silica, and other suspected carcinogens, how can NIOSH justify exposing industrial hygienists, respirator manufacturers' test personnel and NIOSH personnel to DOP?

3M strongly suggests NIOSH consider the use of paraffin oil as the test agent. Paraffin oil is similar to the common oils encountered by respirator wearers in the actual industrial environment. It is much easier to control in test apparatus and is used with excellent results in regulatory testing in Europe.

8. Thermally Generated versus Cold Nebulized DOP

While NIOSH has not specifically addressed test methods or equipment in the proposed standard, the question was raised in testimony and discussion at the NIOSH hearing. If NIOSH insists on DOP as the test agent, instead of paraffin oil, then 3M has the following comments:

The thermally generated, or hot DOP systems are old technology. As stated, they were designed for instantaneous tests, not the extreme loading tests proposed. These systems are difficult to control in terms of particle size, test concentration, and flow rate. As a result, they exhibit a large amount of test variability that is attributed to the method and equipment. Part of this variation can be attributed to the thermal degradation of the DOP when it is heated. NIOSH has stated that, by their tests, 4% of the DOP in the test system is degradation product in as little as three hours. It would be nearly impossible to maintain the product test accuracy and precision NIOSH is proposing with this much test variability. 3M agrees with the view expressed by NIOSH during the hearing that there should be no difference between a cold or hot generated DOP providing the particle size, distribution, (particle charge), and chemical composition is the same. The known thermal degradation of DOP in the thermally generated systems precludes this from, in fact, being the case. For these reasons, selecting the worst case condition of the thermally generated DOP test method is not good policy.

The cold nebulized DOP test has the advantage of being newer, and better technology. The test method is much easier to control, exhibits much less variation, and produces more consistent, repeatable results. 3M testing has also shown much less machine to machine variation than is exhibited by thermally generated DOP machines.

Whether one test is more onerous for certain filter types is immaterial and should not be a concern to NIOSH. NIOSH should select the better method, which is the nebulized DOP, to assure consistency, accuracy, and precision of the test method. The allowed penetrations can then be measured with some confidence and adjusted, if necessary.

The cold nebulized method also has the capability of being adaptable to other test agents, such as paraffin oil, should NIOSH wish to make this change now or in the future.

9. §84.170 Particulate Respirators - Efficiency Requirements

NIOSH is proposing to test filters to very high efficiency requirements. While this may seem prudent, in reality, it does nothing to increase the protection to the worker using the respirator. In most cases, the increased efficiencies will come at the expense of higher pressure drops. Respirators with higher pressure drops almost always have increased face seal leakage. In addition, for the wearer, the respirator will be harder to breathe through, warmer, and therefore, more prone to being removed, and thus, reduces wear time. The end result of requiring increased filter efficiency under unrealistic conditions at the expense of increased pressure drop may actually be less protection to the user in the real industrial world.

These overly high efficiency performance requirements are not necessarily required by the majority of the workplace applications and can result in the user paying higher prices for unneeded filtration characteristics and possibly less protection.

The requirement that the Type B respirator be 99% efficient, when coupled with the test particle size and the proposed statistical treatment, is so close to Type A there appears to be little differentiation, nor practical application for this filter class. Certainly, in typical industrial particle size ranges and concentrations, the A and B could not be differentiated in workplace protection factor studies.

NIOSH should change the efficiency requirements for Types A, B, and C to 99.97%, 95%, and 90% respectively. This will provide an appropriate range and differentiation to meet the various needs of the workplace, including maintaining the 99.97% Type A, if appropriate, for the health care setting.

The proposed lower efficiency requirements proposed by 3M will not result in lower assigned protection factors (APF's). Current filters, certified to 30 CFR 11, which would measure in the area of 80% efficiency on the proposed tests, have proven to provide adequate respiratory protection to the users as evidenced by the number of well conducted workplace protection factor (WPF) studies that have found average WPF's well over 100 for half masks, and 5th percentile WPF's over 10.

NIOSH must recognize that the filter efficiency test is simply that; a filter screening test. While it does provide comparative data for filters, it does not assess total respirator performance as encountered in the workplace and should not be over emphasized as a selection criterion. For example, the sodium chloride aerosol is specified to have a count

median diameter of between 0.06 and 0.11 micrometers. It is highly unlikely that such an aerosol would ever occur outside of laboratory test apparatus. 3M has never seen such an environment in the dozens of industrial sites evaluated for potential workplace protection factor testing.

During the hearing, NIOSH asked questions regarding the assigned protection factor (APF) for half mask respirators with various types of filters. As stated by Thomas Nelson, representing the AIHA Respiratory Protection Committee, a 90% filter efficiency for the lowest performing filter would have a workplace protection factor of at least ten. The values used by NIOSH to calculate an apparent workplace protection factor are incorrect. The face fit factor of ten used by NIOSH includes filter leakage. A better estimate of face seal leakage would be a value of 0.01, the minimum required fit factor for quantitative fit testing as defined by the ANSI Z88.2 (1992) standard and the minimum fit factor for qualitative fit tests when using a validated protocol.

For filter efficiency NIOSH uses a value of 0.1. This is based on the worst case test proposed by NIOSH in the filter tests. This is not an appropriate value. The filter leakage, or penetration, will always be less than 10% since, as stated, the small size monodispersed particle aerosol used in the test will never exist outside the laboratory test equipment. Therefore, the filter efficiency against actual respirable aerosols will always be greater than that assessed in testing.

NIOSH, in designing the tests, has chosen conditions that are at the extremes for each separate facet of the test that can be varied. However, these numerous conditions do not act independently, and thus results in a testing scheme that grossly exaggerates needed performance. The tests are extremely over-designed when they are examined as a whole. For particle size, the most penetrating particle may be appropriate for a screening test, but that size particle will not likely occur in the workplace. Most operations have broader particle size distributions that are much larger and easier to filter than the narrow size range chosen by NIOSH. For example, paint spray has a mean aerodynamic diameter estimated at 2.9 to 9.7 micrometers (μm) [AIHAJ 51(3)132-138 (1990)]. Other industries where dusts are present show similar large particle size distributions: underground coal mining 17-20 μm, [AIHAJ 48(2)122-126 (1987)]; iron mining 6 μm, [AIHAJ 48(2)150-154(1987)]; battery manufacture >10 μm, [AIHAJ 54(10)576-583 (1993)]. For these industries, the test aerosol underestimates filter efficiency by a factor of at least 10. If the filter efficiency is 90% against the test aerosol at the most penetrating particle size, the efficiency will approach 100% at the sizes reported above. An article by Hinds and Bellin titled *Effect of Facial-seal Leaks on Protection Provided by Half-mask Respirators* (Applied Industrial Hygiene, Vol. 3, No. 5, May 1988) provides additional information on typical industrial particle size ranges. In Table I, of the 32 industrial contaminants listed, only four had a MMAD less than 2.0 μm; three of these being metal fume in welding operations where a small particle size would be expected.

In a similar manner air flow, humidity, filter loading, and test statistics each contribute to an overly designed test.

This practice of taking the most conservative, or worst case requirement for every test parameter results in totally unrealistic requirements when the tests are considered as a whole. This is in direct opposition to Presidential Executive Order 12498 (January 4, 1985) which states "regulations that seek to reduce health or safety risks should be based upon scientific risk assessment procedures, and should address risks that are real and significant rather than hypothetical or remote".

10. §84.180 Filter Type Identification

To maintain consistency, and to prevent one filter in the same class as being construed as superior to another, Class A filters, for both Solids, and Solids and Liquids, should be colored magenta. This will also be more consistent for those users who will change from the HEPA filters currently in use. All Class B and C filters colors should be left to the discretion of the manufacturer, who may use color to differentiate additional filter capabilities not covered in the approval scheme.

11. §84.181 and §84.182 Isoamyl Acetate Tightness Test

These paragraphs specify that particulate filter respirators be fit tested using isoamyl acetate. The reasoning for this test is not given and one can only conclude that it was maintained as an artifact from 30 CFR 11. 3M believes this test has no value. While facepiece fit is extremely important in providing protection to the wearer, this fit can only be assessed on the individual wearing the respirator. OSHA currently requires fit testing of all workers using tight fitting respirators. Fitting undefined sizes and unspecified numbers of people at NIOSH will, in reality, not predict the fit to an individual wearer.

There is no scientific basis to test a particulate filter respirator using a vapor as the test agent. Since fit is heavily affected by filter pressure drop, adding an organic vapor filter alters the fit results on a replaceable filter respirator. In the case of a disposable particulate respirator, passing this test would require creating a surrogate with organic vapor capability. Whether or not an appropriate, realistic surrogate can be made, given the difference in pressure drop, weight, compliancy, and etc. is questionable. It puts manufacturers, small, medium, and large, in the position of creating surrogates just for the exercise of passing meaningless tests with no benefit to the user.

During the public hearing when this issue was addressed, NIOSH (Campbell) stated that not all respirators would be modified, but only those in test. This statement confirms that

NIOSH has no experience in assessing the huge amount of R&D and manufacturing cost to produce small quantities of respirators that will never be sold.

In today's diverse work force, there are situations where respirator manufacturers need to market respirators in certain regions that are designed specifically to fit a small market segment, such as African-American, Hispanic, or Asian. As proposed, the undefined NIOSH test panel would prohibit this customization. The marketplace will eliminate respirators that do not fit a wide variety of their workers.

It should also be pointed out that while the proposed tests have been conducted under 30 CFR 11 for years, the tests have no validation to show that they predict fit for any segment of the population. Moreover, they contain no screening provision to assure the test subject selected by NIOSH can detect isoamyl acetate, making the results useless. 3M recommends that these tests be deleted from the schedule. If, for some valid reason, NIOSH insists that fit testing be a part of the approval testing, then they should consider a validated test method for particulate respirators, such as the Large Particle (greater than 2.0 micrometers) Quantitative Fit Test or the Bitrex Qualitative Fit Test using a modified protocol from the saccharin fit test published in the OSHA Lead Standard (29 CFR 1910.1025). Validation data for the Bitrex protocol is included for the record.

Proper face fit testing should not be left to predictability, but rather rely on fit testing results performed on the individual respirator user.

12. §84.184 Filter Loading Tests

3M believes the loading tests for both the solids and the liquids tests are excessive, unwarranted, and unnecessarily expensive.

For solids, where the sodium chloride test is specified, the loading to the 200 mg level provides no benefit to the user but does increase cost. Some types of filters will exhibit an initial reduction in efficiency as loading begins, then as the filter loads and caking starts, the efficiency will increase for the balance of the test. It does not require 200 mg to determine this point. If any loading test is to be included, a 50 mg loading would be more reasonable. Loading to the proposed 200 mg level requires a minimum of two hours test time per filter. This would be burdensome and expensive in terms of test time and personnel for certification, quality assurance, and audit testing and, in the end, would not result in valuable performance data.

The oil (DOP) loading test is even more unrealistic. Loading a filter to 200 mg level is not predictive of its use in any industrial setting. As described, DOP does not predict filter performance against typical liquids, nor even typical oils, used in industry. In a study conducted at General Motors facilities, concentration levels for machining and cutting oils were found to be generally less than 1 mg/m^3 [*AIHAJ (55) Jan 1994*]. Based

on this concentration, at a breathing rate of 30 liters/min., for 8 hours per day, a respirator would receive a total loading of 10.2 mg oil, or 5.1 mg oil per filter. This equates to nearly 20 days, or four work weeks, of use to reach the proposed 200 mg loading. In practical application, filters are changed or discarded much more frequently than this. In addition, these oils would not degrade filters as severely as DOP, but would perform more like paraffin oil as suggested earlier.

The extremely heavy loading of DOP has no performance attribute that assures better protection nor filter life to the user. Its only characteristic is the prejudicial elimination of the use of electrostatic filters and to impede technology advances that are expected in the future to enhance this forward looking concept.

If any loading test can be justified, it should be reduced to a 50 mg level that will assure reasonable filter performance and life. Any level above this only adds to the user's cost with no apparent benefit.

13. §84.184 Powered Air Purifying Respirator Tests

NIOSH has included PAPRs as a part of this section and has introduced test requirements that appear highly impractical, and that have not been proven.

The proposed filter loading tests of 2000 mg for PAPRs cannot be justified and should be reconsidered along with the loading tests of all filters. This extreme loading provides no additional protection to the user. The proposed loading test requires in excess of 22 hours to complete, which will be extremely costly in terms of test time alone. NIOSH has not shared with manufacturers how it might be possible to conduct such a test on an entire PAPR unit, as proposed.

3M strongly recommends that NIOSH revise the PAPR requirements in a future module after determining realistic requirements and test procedures. If NIOSH chooses to implement revisions, they should deal only with the test requirements for PAPR particulate filters and not the entire systems. The filter test requirements and procedures should obviously be the same for PAPRs as for other respirator filters.

At the time of considering the PAPR module, NIOSH should follow the lead of ANSI Z88.2-1992 and recognize a class of PAPR and airline respirators called "Loose-fitting facepiece" respirators. Workplace protection factor tests have conclusively shown their performance to be significantly different from PAPRs and airline systems using helmets or hoods.

14. §84.184(j) Filter Test Statistical Treatment

NIOSH has proposed a K factor of 2.22, which represents a 95% confidence limit that 95% of the filters produced meet or exceed specifications. 3M believes this K factor is too high, as are the statistical limits. The statistical treatment also assumes a normal distribution which is not necessarily true. In the case of Class A, or HEPA filters, most manufacturers 100% test at manufacture to remove those not meeting specification. The balance accepted are no longer normally distributed. Also, workplace aerosol sizes are almost always lognormal distributions, so this statistical treatment does, in fact, reduce the relationship of the test protocol to the real world.

By NIOSH's definition in §84.41(d)(2) a filter penetration failure would be considered a Major A defect. Per §84.41(g)(1) a Major A defect has an AQL of 1%. This AQL does not warrant the statistical precision proposed by NIOSH but will add greatly to the cost of filter testing and control.

Since the tests and test methods proposed are relatively new, it has not been shown by NIOSH, or anyone, that the proposed test methods' variability can operate with this level of precision. In fact, they cannot. Therefore, all allowed variability would be consumed by the variability of the test method itself, allowing for no variation of the filter. This is a real catch 22. It would be an impossible situation for manufacturers to address, made worse by the fact that manufacturers will have no knowledge of the test variability at NIOSH so that the outcome of certification or audit testing is not predictable.

3M strongly recommends that NIOSH reconsider the need and approach to the statistical treatment of test data. The statistical precision proposed by NIOSH will be very costly to respirator users, again with no apparent benefit. The added manufacturing and waste cost to meet this unreasonable requirement would be 25 - 30%.

15. Phase in Period or "Grandfather Period"

a) New approvals under 30 CFR 11:

NIOSH proposes that new submittals meeting the criteria of 30 CFR 11 continue to be accepted for 30 days after the publication of 42 CFR 84 as a final rule.

Meeting the requirements of 42 CFR 84 in a 30 day period provides little or no time for product development activities, performance testing, user needs analysis, or test equipment procurement and correlation. In addition, this immediately cuts out new respiratory protection devices in the development pipeline that may provide a benefit to the worker today, before modifications can be implemented to meet 42 CFR 84.

NIOSH should continue to accept new applications for approval under the criteria of 30 CFR 11 for six months after the date of the final rule of 42 CFR 84.

b) Sale of product previously approved under provisions of 30 CFR 11:

NIOSH proposes that manufacturers may no longer sell or distribute respirators certified to the criteria of 30 CFR 11 two years after the publication of 42 CFR 84 as a final rule.

3M believes this period should be extended to four years. 3M's internal historical data on new product development and introduction shows it takes an average of seven years to reach the market. This is true for an extremely diverse range of products, including respirators.

NIOSH has severely underestimated the development time required for filters, test equipment, products, and manufacturing capability to meet the proposed criteria. Previous standards revisions in Europe and the transferring of certification authority from Bureau of Mines to NIOSH have required well over two years. Filter media for all proposed classes of filters are not readily available and must be developed. With the extensive testing times suggested, it is doubtful if NIOSH could test, process, and issue approvals to all manufacturers for all the required new products in a two year time period, even if they were available today.

NIOSH has not provided selection and use criteria. The protection factor module is promised for late 1994. Without this information, however, manufacturers cannot begin to finalize product designs or even begin to design and order needed manufacturing equipment. After equipment has been ordered from a machine supplier, it typically takes eighteen months before the new equipment can be delivered, installed, shaken down, and started up to produce product.

Finally, prohibiting distribution of 30 CFR 11 approved respirators in the proposal is also questionable since the products are outside the manufacturer's control. Prohibiting distribution would likely restrict the availability of products during the changeover period, as distributors and users will draw down inventories to avoid the costs of obsolete inventory.

c) Extensions of approvals for products previously approved under 30 CFR 11:

NIOSH must continue to grant extensions of 30 CFR 11 approvals as long as manufacturers are permitted to sell them (four years suggested). Situations may occur that require a manufacturer to modify a product. If approval extensions cannot be obtained, the manufacturer may be forced to discontinue a product necessary for the end user to continue his plant operation in a safe and healthful manner. For example, a major supplier to respirator manufacturers recently experienced an explosion in their plant stopping all production for an extended period of time. Material substitutions by several

manufacturers were required which required approval extensions. Without this option, the manufacturer would be damaged economically as would the user.

16. §84.206(b) Particulate tests

This paragraph is confusing. It states, "...three such respirators will be tested, as appropriate, in accordance with the provisions of §§84.180 through 84.186; however, the maximum allowable resistance of complete particulate, and gas, vapor, or gas and vapor chemical cartridge respirators shall not exceed the maximum allowable limits set forth in §84.203". Since §84.184 contains the particulate filter loading tests, does NIOSH intend that airflow resistance be measured on complete units after filter loading? This is inconsistent with §84.183 which has no airflow resistance requirements after loading. It is also inconsistent with footnote 1 in the table in §84.203. NIOSH needs to clarify their intention.

17. §84.70 Self-contained Breathing Apparatus; Description

This paragraph, while not a part of this revision, appears to have changed from its counterpart in 30 CFR 11. Specifically, §84.70(b) has been subdivided differently, which alters the descriptions of the devices. This appears to be an editorial error that NIOSH should correct.

18. Summary

In summary, 3M believes the following items, discussed above, are critical to both manufacturers and users to help assure the proposed 42 CFR 84 will become a useful and improved regulation:

a) NIOSH should reconsider attempting to combine requirements for general industry respirators with those of health care, specifically TB.

b) Retain both solids-only and solids and liquids approval classifications.

c) Define "liquids" and select tests appropriate to water, solvent, or acid based liquids.

d) Develop an alternate to dioctyl phthalate (DOP) as a test agent, such as paraffin oil, already used in Europe.

e) Change filter efficiency requirements for class A, B, and C from 99.97%, 99%, and 95% to 99.97%, 95%, and 90%, respectively, so that Class B products will be developed and introduced.

f) Drop the requirement of fit testing a particulate filter respirator with a vapor.

g) Reduce filter loading levels from 200 mg to 50 mg.

h) Rewrite PAPR requirements in a separate module, dropping filter loading to the 50 mg level to be consistent with other filters.

i) Relax statistical treatment of data to realistic levels that will allow for test, test equipment, manufacturing, material, and product variations.

j) Extend "grandfather" period for new approvals to 30 CFR 11 criteria to six months.

k) Extend "grandfather" period for manufacture and sale of 30 CFR 11 approved products to four years, with approval extensions available throughout this period.

DEVELOPMENT OF A NEW QUALITATIVE TEST FOR FIT TESTING RESPIRATORS

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A new qualitative fit test was developed using Bitrex™ as the test agent. It was validated by running a series of paired qualitative and quantitative fit tests. Quantitative tests were conducted with a small corn oil aerosol, using a condensation nucleus counter as a detector. Qualitative fit tests were run with Bitrex and saccharin, following the established protocol for the saccharin fit test. Four models of NIOSH approved, replaceable filter respirators were used in the study. All were equipped with high efficiency filters. In some cases, respirators expected to be the correct size for test subjects were tested. In other cases, respirators expected to be too small or too large for the subjects were tested. Test results were analyzed using fit test method validation criteria recommended in the American National Standards Institute draft standard on fit testing (ANSI Z88.10). The Bitrex and saccharin tests were found to have virtually identical performance. Both met proposed ANSI requirements for a valid qualitative fit test.

INTRODUCTION

The importance of respirator fit testing has become widely recognized. The U.S. Occupational Safety and Health Administration (OSHA) has long included a fit testing requirement in its standard on respiratory protection[1]. More recent OSHA standards for protecting workers against lead, asbestos, benzene, and other specific substances have expanded fit testing requirements[2]. Increased emphasis on respirator fit testing is also evident in the latest American National Standards Institute (ANSI) respiratory protection standard, as well as in international standards such as the Australian Standard (AS) on selection and use of respiratory protective devices[3,4].

Broad acceptance of fit testing by employers requires that tests be simple to use, effective, and affordable. A number of qualitative and quantitative fit tests currently exist[5]. Each has certain advantages and disadvantages. In general, qualitative fit tests have the advantages of being simpler to use, easier to transport, quicker to conduct, and less expensive to set up and maintain. Quantitative fit tests offer the advantages of reduced subjectivity and expanded information about the magnitude of difference in the way various respirators fit a given worker.

At one time, quantitative fit tests were often cited as preferred fit test methods. In fact, the 1980 ANSI standard on respiratory protection allowed quantitative fit test results to be used for estimating the level of protection respirators could provide in the workplace[6]. That philosophy changed as researchers reported a lack of correlation between quantitative fit test results and the amount of protection respirators were actually providing[7-8]. The current ANSI standard and the latest OSHA standards now treat both qualitative and quantitative fit tests as pass/fail tests only[3,9].

Although debate may continue about the virtues of qualitative versus quantitative fit testing as more research is done, from a practical standpoint a majority of employers are likely to select simpler versions of available fit testing alternatives. Today, that generally means a qualitative fit test. The three most common qualitative fit tests are the isoamyl acetate, irritant smoke, and saccharin tests[4]. The isoamyl acetate and saccharin tests are considered to be validated fit test methods[5].

All qualitative fit test methods have limitations related to filter selection[4,5]. Isoamyl acetate requires use of organic vapor cartridges. Irritant smoke requires use of high efficiency filters. Saccharin requires use of an approved particulate filter (any class). If one test is preferred over another, changing filters for a fit test may be an option. However, if filters or cartridges have significantly different breathing resistance, face fit results may be affected[10].

All qualitative fit test methods also have limitations related to sensitivity of test subjects. Ability to detect the test agent is one concern. The type of response it elicits is another. The involuntary response caused by irritant smoke is considered positive by some and negative by others. Similarly, the sweet odor of banana oil and the sweet taste of saccharin are considered positive by some and negative by others.

An additional qualification important for all fit test methods is suitability of the test agent for human exposure. The National Institute for Occupational Safety and Health (NIOSH) raised questions about use of saccharin due to a 1977 report showing an increased incidence of bladder cancer in rats fed large quantities of saccharin[11]. Further review of the saccharin data has resulted in the conclusions that the carcinogenicity appeared to be a function of the rats' metabolism, and that the same result would not be expected in

humans[12]. More recently, use of irritant smoke as a fit test agent was questioned due to its potential to expose test subjects to high concentrations of hydrogen chloride[13].

Isoamyl acetate, irritant smoke, and saccharin continue to be widely recommended qualitative fit testing agents, and continue to be widely used with good success. Nevertheless, availability of additional options for qualitative fit testing options would clearly be useful.

After examining the positive and negative features of the existing qualitative fit tests, an alternate qualitative fit test was designed to take advantage of the positive features of each. It was concluded that the test agent should be a particle, suitable for use with any type of approved particulate filter. Such a test agent would allow the test to be used with all classes of particulate respirators. It would also allow gas and vapor respirators to be tested by adding a particulate filter with minimal additional breathing resistance. The particle size distribution of the saccharin mist was targeted (polydisperse aerosol with a count mean diameter of approximately 2.3 micrometers). It was also concluded that the test agent should have a more unpleasant characteristic than isoamyl acetate or saccharin, but less of an involuntary response than irritant smoke.

A further requirement was that the test agent selected had to be of low toxicity. Denatonium benzoate, commonly known by the trade name Bitrex™ was identified as a suitable candidate. It is commonly used as a taste aversion agent in household liquids that children should not be drinking. It carries an FDA approval and was included by NIOSH on a list of possible qualitative fit test agents[11]. Finally, a suitable fit test protocol was needed. The published protocol for the saccharin test was selected due to its current acceptance and past validation[2,14].

Once the test agent, materials, and protocol were identified, a suitable validation approach had to be defined. Procedures for validating qualitative fit test methods have been under active discussion within ANSI. A draft standard (ANSI Z88.10) has been published[15]. It was selected as the basis for evaluating suitability of Bitrex as a fit test agent.

EXPERIMENTAL DESIGN

Validation of the Bitrex qualitative fit test was conducted by running a series of paired qualitative and quantitative fit tests. Male and female test subjects were selected based on the anthropometric parameters of face length (menton-nasal root depression length) and face width (bizygomatic breadth), following criteria recommended by Los Alamos National Laboratory[16]. Test subjects were screened for sensitivity to Bitrex and saccharin (which was run as a control). The Bitrex™ sensitivity solution was made by dissolving 13.5 mg Bitrex in 100 ml of a 5% NaCl solution in water. The saccharin sensitivity solution was made by dissolving 0.83 grams of sodium saccharin in 100 ml of water. The sensitivity test included in the established protocol for the saccharin test[2] was then applied to both test agents.

A Latin square design was used to randomize the order of sensitivity testing. Test subjects were required to leave the lab area, get a drink, and rinse their lips in between tests. Additionally, a nebulizer with pure water was used to ensure validity of taste responses. Individuals found to be insensitive to either Bitrex or saccharin, or who gave an incorrect taste response to water, were omitted from the study. Respirator experience of test subjects selected was limited. Some had previous experience wearing respirators for personal use, but none had worn respirators while performing their jobs and none had

received training in respirator use. One further qualification was made. Since plans were to use a condensation nucleus counter (CNC) as a detector for quantitative fit testing, test subjects were asked if they smoked. If they did, they were asked not to smoke and to avoid smoky areas for at least one hour prior to any testing to avoid possible interferences with CNC particle counts inside respirator cavities.

Respirators selected for the study included four different models of NIOSH approved, negative pressure, half mask respirators with high efficiency filters. Each model was available in three facepiece sizes. The only modification made to the respirators was addition of a specially designed sampling probe to allow sampling inside the respiratory cavities[17]. Since the purpose of the test was to determine if a Bitrex™ qualitative fit test would identify poorly fitting respirators, test subjects were sometimes provided with respirators expected to fit well and sometimes provided with respirators expected to be too large or too small for their faces.

The target number of paired qualitative and quantitative tests to run was set by reference to the ANSI Z88.10 draft standard. It includes five minimum goals for data collection: 1) 100 paired qualitative and quantitative fit tests; 2) 50 quantitative fit tests resulting in fit factors greater than or equal to the required fit factor; 3) 50 quantitative fit tests resulting in fit factors less than the required fit factor; 4) 50 qualitative fit tests recorded as passes; and 5) 50 qualitative fit tests recorded as failures. The required fit factor was defined as 100 for this study, based on quantitative fit factor acceptance criteria recommended for half facepiece respirators in the ANSI A88.2-1992 standard.

Validation work was initiated by testing each subject from a full 25 member panel with four different respirators. An attempt was made to provide two correctly sized respirators and two incorrectly sized respirators (one size too small or too large) for each test subject.

This approach resulted primarily in qualitative fit test passes and fit factors greater than 100. In order to meet desired data collection criteria, additional testing was set up in a deliberate attempt to increase the number of qualitative fit test failures and fit factors less than 100. One approach was testing of a large size respirator on seventeen test subjects from the medium and small sectors of the face fit grid. Another approach was to test another full 25 member test panel, but to deliberately assign improperly sized respirators (too large or too small by one or two sizes) to all test subjects. This approach was repeated with 9 additional test subjects with a variety of face sizes to allow the recommended minimum number of qualitative fit test failures to be achieved. A Latin square design was employed for all multiple respirator panels to randomize the order of testing.

The paired qualitative and quantitative tests were conducted by running quantitative fit tests first, followed by qualitative fit tests. The test agent for the quantitative tests was corn oil. It was a polydisperse aerosol with a mass median aerodynamic diameter of 0.47 micrometers (count median diameter 0.28 micrometers) and a standard deviation of 1.45. The aerosol was generated with a TSI Model 9306D Multi-Jet atomizer. It was fed into a chamber with dimensions 8x8x8 feet. The concentration in the chamber was maintained at 15 mg/m^3.

For each test, the subject was asked to don a respirator, enter the test chamber, and connect the tubing from the probe on the front of the respirator to a sampling port. The sampling port led to a TSI Model 101 Condensation Nuclei Counter (CNC) capable of operating in a single particle count mode or photometric mode. Once the connection was made, the subject was asked to perform a standard set of one minute exercises[2]. Aerosol penetration into the respirators was continuously monitored with the CNC during the exercises. An IBM personal computer was used to store the data. An integrated fit factor

was then determined for each exercise, and an overall average fit factor calculated for each test.

Following completion of quantitative tests, subjects were asked to disconnect the sampling line and exit the chamber without touching or adjusting the respirator. A plug was then installed at the end of the sampling line, and qualitative fit testing immediately conducted. Both Bitrex and saccharin tests were run The order of the tests was alternated with each test sequence. A short interval was included between tests to allow any taste from the first test to diminish. The fit test solution used for the Bitrex test was made by dissolving 337.5 mg Bitrex in 200 ml of a 5% solution of NaCl in water. The fit test solution for the saccharin test consisted of 83.3 grams per 100 ml of water. For both tests, the published test protocol for the saccharin test was followed[2]. If Bitrex or saccharin was tasted, the result was recorded as a failure. If no taste was detected, the result was recorded as a pass.

It might be noted that the fit test solution for Bitrex deviated from that of saccharin in two ways. First, the saccharin fit test solution was a saturated solution, versus less than 4% of saturation for the Bitrex™ fit test solution. The taste response of Bitrex was too strong to use a highly concentrated solution with half facepiece respirators. Secondly, salt was added to the Bitrex solutions. This was done to increase the particle size distribution and maintain particle size consistency for sensitivity and fit test solutions.

RESULTS AND DISCUSSION

A total of 151 paired qualitative and quantitative fit tests were run. One test subject gave a questionable taste response during a qualitative test. He was run back through the

sensitivity test and found to be unable to provide a correct taste response. This resulted in his test results being invalidated. Thus, as shown in Table I, a total of 150 valid data sets were obtained. Each data set included a quantitative fit factor, a pass or fail for the Bitrex test, and a pass or fail for the saccharin test.

As summarized in Table II, overall results were identical for the Bitrex and saccharin tests. All test subjects with fit factors less than 100 had the same pass/fail response for both tests. The lowest fit factors observed for subjects who passed the Bitrex and saccharin tests were 77 and 91. All but four subjects with fit factors greater than 100 also had the same pass/fail responses for both tests. Of the four who had different responses, two passed the Bitrex test and failed the saccharin test. The other two passed the saccharin test and failed the Bitrex test. Thus, the overall number of passes and failures were identical.

The ANSI Z88.10 draft standard includes a number of criteria for determining the validity of a qualitative fit test. One criteria is test sensitivity. For test subjects with an unacceptable quantitative fit factor (less than 100 in this case), the fraction failing the qualitative test must be 0.95 or greater. Subjects with fit factors less than 100 failed the Bitrex and saccharin tests 48 of 50 times, indicating a test sensitivity of 0.96.

A second criteria is predictive value of a pass. Among test subjects who pass the qualitative fit test, a fraction of 0.95 must have an acceptable quantitative fit factor. Test subjects with fit factors greater than or equal to 100 passed the Bitrex and saccharin tests in 88 of 90 cases, indicating a predictive value of a pass of 0.98.

A third criteria is test specificity. More than half (0.5) the test subjects who have acceptable quantitative fit factors must pass the qualitative fit test. Test subjects with fit

factors equal to or greater than 100 passed the Bitrex and saccharin tests 88 of 100 times, indicating a test specificity of 0.88.

A fourth criteria is predictive value of a fail. More than half (0.5) the test subjects who fail the qualitative fit test must have unacceptable quantitative fit factors. Of the 60 test subjects who failed the Bitrex and saccharin tests, 48 had a fit factor less than 100, indicating a predictive value of a fail of 0.80.

The ANSI Z88.10 draft also recommends that confidence limits be calculated to allow uncertainty in the data to be considered. It is not specified whether 90%, 95%, or some other confidence limits should be selected, or how they should be applied. Study results summarized in Table III include 95% confidence limits. Lower confidence limits can be calculated from these numbers; however, it is not believed to be practical to compare the resulting lower confidence limit for test specificity to the acceptance requirement (0.95). The number of data points needed for validation of a fit test becomes unreasonable. In this case, 150 paired tests were needed to achieve 50 fit factors less than 100. A lower confidence limit value equal to or greater than the 0.95 criteria for test specificity would have required zero test subjects to pass the qualitative fit test and have a fit factor less than 100. That is an unrealistic expectation for a test involving subjective opinion of test subjects, especially when it is being validated by quantitative methods known to have significant variability themselves.

A final recommendation in the ANSI Z88.10 draft is that an evaluation be conducted on the distribution of fit factors obtained in the study. The purpose is to confirm that the observed fit factors bracket the required fit factor value selected. The distribution of fit factors used in this study is shown in Figure 1. Fit factors ranged from 2 to >50,000, with approximately 35% less than 100. This is believed to be a reasonable distribution for half

facepiece respirators with high efficiency filters. Large numbers of fit factors less than 100 are difficult to generate without inducing face seal leaks or otherwise creating artificial leaks that may not be relevant to field use of respirators.

Another useful way to look at the data is to compare quantitative fit test results for test subjects who passed the qualitative fit tests versus quantitative fit test results for subjects who failed the qualitative fit tests. These results are shown in Table IV. Bitrex and saccharin qualitative fit tests are clearly effective tools for identifying poorly fitting respirators.

CONCLUSIONS

Based on criteria established in the ANSI Z88.10 draft standard, Bitrex is a good alternative to consider for qualitative fit testing. Substitution of Bitrex sensitivity and fit test solutions into the established saccharin fit test protocol resulted in a qualitative fit test method able to reliably predict unacceptable fit of half facepiece respirators. Bitrex also shows good promise for use with full facepiece respirators. Since Bitrex has an extremely strong taste response, it had to be diluted to less than 4% of a saturated solution to allow its use with half facepiece respirators. Use of a more concentrated fit test solution would be expected to allow delivery of a fit test aerosol suitable for full facepiece respirators.

A fit factor of 100 was selected as the measure of reliable fit in this study, based on the current recommendation in ANSI Z88.2-1992. Since that number is based on application of an arbitrary safety factor of 10 to the assigned protection factor for half facepiece respirators, it must be understood that ability to detect fit factors less than 100 (or any

other number) will not necessarily assure that respirators will fit well or provide their rated level of protection under field use conditions.

Fit tests should be viewed as tools for helping to select suitably sized respirators for individual workers, and perhaps more importantly, as training tools for helping workers understand the importance of proper fitting and use of respirators. Passing a fit test is expected to increase the likelihood of achieving acceptable protection in the workplace; however, other factors such as respirator training, wear time, use habits, and maintenance, along with variability in workplace contaminants and exposure levels, will be at least as important as fit when assessing suitability of a respirator for protection of a specific worker involved with a specific job.

Note: Bitrex™ is a registered trademark of Macfarlan Smith Limited.

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TABLE I. Description of Valid Data Sets

Panel No.	No. Test Subjects	No. Valid Tests
1	25	100
2	17	17
3	25	24
4	9	9
Totals	76	150

TABLE II.. Results of 150 Paired Qualitative and Quantitative Fit Tests

	Passed Bitrex™ Test	Failed Bitrex™ Test	Passed Saccharin Test	Failed Saccharin Test
No. Tests with Fit Factors <100	2	48	2	48
No. Tests with Fit Factors ≥100	88	12	88	12

TABLE III. Performance of Bitrex™ and Saccharin Qualitative Fit Tests Vs. ANSI Z88.10 Draft Requirements.

Validation Criteria	Calculation Method	Test Requirement	Study Results	Confidence Limits (95%)
Test Sensitivity	$Fail_{FF<100}/Total_{FF<100}$	≥0.95	0.96	± 0.05
Predictive Value of QLFT Pass	$Pass_{FF\geq100}$/Total Pass	≥0.95	0.98	± 0.03
Test Specificity	$Pass_{FF\geq100}/Total_{FF>100}$	>0.5	0.88	± 0.06
Predictive Value of QLFT Failure	$Fail_{FF<100}$/Total Fail	>0.5	0.80	± 0.10

Where: $Fail_{FF<100}$ = Number of qualitative fit test failures where fit factor was <100

$Total_{FF<100}$ = Total number of tests where fit factor was <100

$Pass_{FF>100}$ = Number of qualitative fit test passes where fit factor was ≥100

$Total_{FF>100}$ = Total number of fit tests where fit factor was ≥100

Total Pass = Total number of qualitative fit test passes

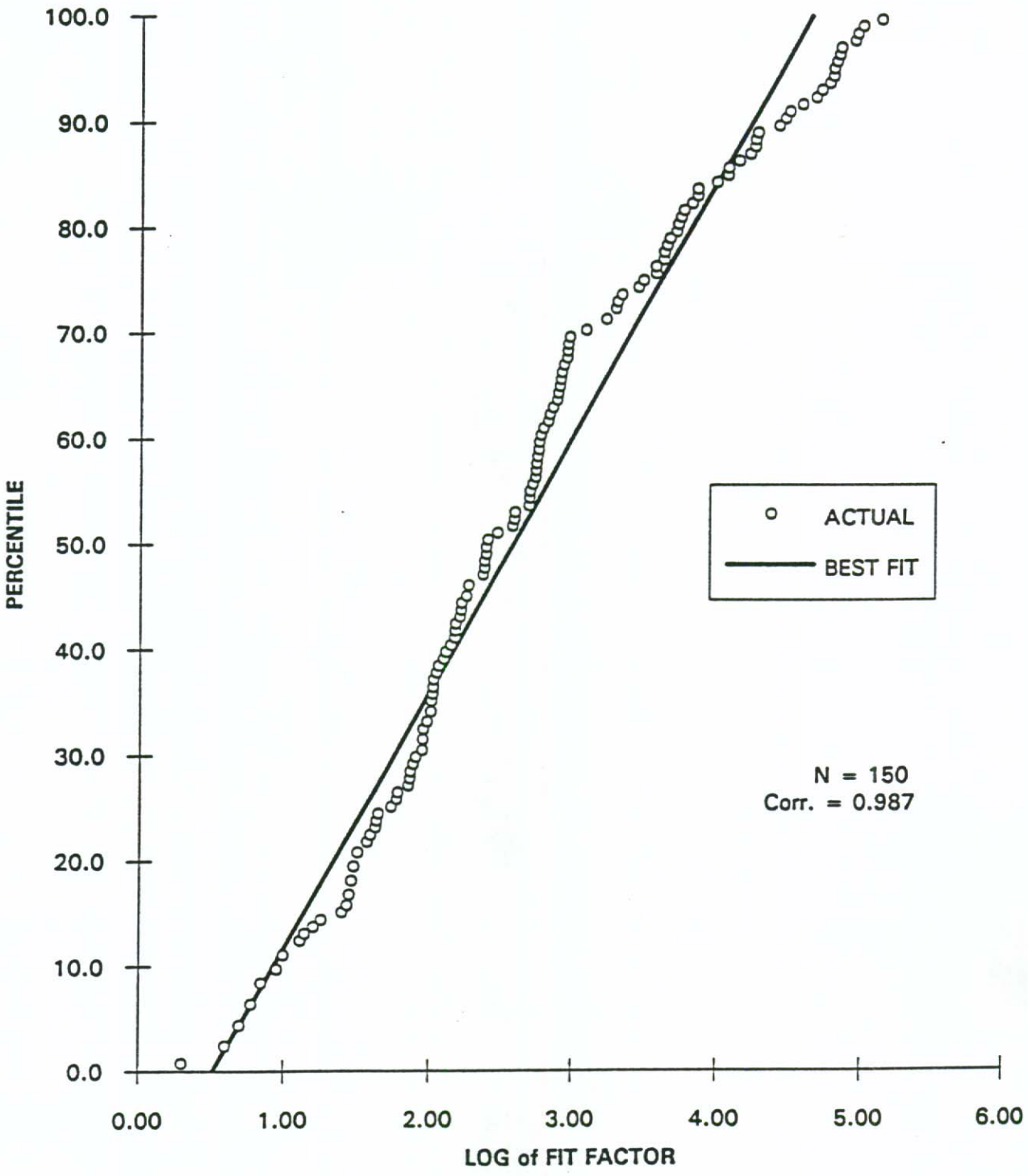
Total Fail = Total number of qualitative fit test failures

95% Confidence Limits = $1.96\ [P(1.00 - P)/n]^{1/2}$; When P = Study Result

TABLE IV. Fit Factors of Subjects Who Passed and Failed Qualitative Fit Tests

Test Subjects	No. Tests	Geom. Mean FF	Geom. Std. Dev	5th %tile FF
Pass Bitrex™	90	2096	7.90	70
Fail Bitrex™	60	30	3.98	3
Pass Saccharin	90	2095	7.90	70
Fail Saccharin	60	30	3.98	3
All	150	381	16.08	4

FIT FACTOR DISTRIBUTION



Effect of Facial-seal Leaks on Protection Provided by Half-mask Respirators

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Applications are presented of a computer model that gives the performance (overall protection factor including filter penetration and facial-seal leakage) of half-mask respirators for protection against aerosols. Input variables for the model are type of filter used, work rate of the wearer, QNFT-measured fit factor, and size distribution of the exposure aerosol. Based on the model, measurement errors due to loss of particles in leaks during qualitative fit testing (QNFT) measurements with current equipment are estimated to be less than 5 percent, but the change from high efficiency test filters to regular dust, fume, and mist (DFM) filters in use can reduce protection significantly. Overall protection factors are predicted for 33 industrial exposures based on assumed QNFT fit factors of 20 and 50. In these examples, DFM respirators with a QNFT fit factor of 50 have predicted protection factors from 21 to 2900, depending on aerosol size distribution. Overall protection factors for disposable and DFM filter respirators having a given facial-seal leak are presented graphically for a wide range of aerosol size distributions and two work rates. Also given is a contour chart showing the QNFT fit factor required to achieve an overall protection factor of 20 or 50 for a wide range of aerosol size distributions. For an unknown aerosol size distribution and average respirator performance (half-mask with DFM filters), a QNFT fit factor of 15 or more is required to ensure an overall protection factor of at least 10. Hinds, W. C.; Bellin, P.: Effect of Facial-seal Leaks on Protection Provided by Half-mask Respirators. Appl. Ind. Hyg. 3:158–164; 1988.

Introduction

Two mechanisms can diminish the respiratory protection provided by a half-mask respirator: 1) penetration through the filter or cartridge and 2) facial-seal leakage. In most cases where respirators are used for protection against gases or vapors, it is reasonable to neglect the cartridge penetration, in the absence of breakthrough, if the respirator is properly selected and used. On the other hand, for respirators used to protect against aerosols, both paths represent potentially important avenues of exposure and both are strongly particle size dependent[1-2] that is, the extent of exposure depends on the size of the aerosol particles present. Furthermore, the particle size dependence is controlled by the instantaneous flow rate through the respirator, so penetration and leakage depend on the work rate of the wearer and are constantly changing during each breathing cycle.

In normal use, the mass concentration and particle size distribution inside the respirator, that which the wearer is exposed to, differ greatly from that outside the respirator where these quantities are usually measured. This makes estimation of a respirator wearer's exposure in use and verification of adequate protection a difficult task.

Despite these complexities, there are many situations for which it is desirable to evaluate the actual exposure of a respirator wearer, that is the concentration or amount of contaminant he or she is breathing. Examples of such situations include the following: 1) good industrial hygiene practice where it is always desirable to know the actual exposure experienced by each worker (the "evaluation" component of "recognition, evaluation, and control"), 2) epidemiological studies where accurate exposure assessment is needed to establish associations between exposure and the occurrence of symptoms or disease, 3) liability protection, 4) industrial hygiene evaluation as follow-up to observed occurrence of disease or symptoms, and 5) design and development of improved respirators by respirator manufacturers.

Overall respirator performance for protection against aerosols depends on 1) filter penetration, 2) facial-seal leakage (air flow rate), and 3) particle penetration through facial-seal leaks (the relative ability of different size particles to pass through leaks). All three depend on breathing rate which in turn depends on the work rate of the wearer, and the first and third depend on the particle size distribution to which he or she is exposed. In this paper, work rate is expressed in kg-m/min. A work rate of 0 kg-m/min corresponds to workers standing still or seated; 622 kg-m/min (approximately 430 kcal/hr) represents moderate to hard work that can be sustained for a period of several hours. Inhaled volumes are 14.2 and 37.3 L each minute for 0 and 622 kg-m/min, respectively.[3] Work rate can exceed 622 kg-m/min for brief periods such as emergency situations or ladder climbing.

To put into perspective the role that the three factors identified above play in the performance of a respirator, the predictive

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that over the normal range of work rates, a corn oil QNFT measurement will indicate 97 percent of the potential mass leakage. Although there are significant differences in light scattering over the corn oil particle size range, leak penetration is not size dependent in this size range, and, consequently, the systematic measurement error is slight.

These calculations were also made using the recommended particle size limits for QNFT test aerosols given in ANSI Z88.2-1980, specifically a MMAD of 0.5 to 0.7 μm and a GSD of 2.0 to 2.4.[12] For these size distribution limits, the NaCl apparatus will indicate 93 to 96 percent and the corn oil apparatus 77 to 95 percent of the potential facial-seal leakage. The difference between the NaCl and corn oil results is due to the light scattering effect described above.

In the above analysis, penetration through high efficiency dust, fume, mist, and radionuclides (DFMR) filters was assumed to be zero. Although high efficiency cartridge filters have much lower penetration than DFM cartridge filters, great variation existed among the four brands tested. At a steady flow of 10 liters per minute (lpm), average submicrometer penetration ranged from 0.0008 to 1.41 percent; at 100 lpm, penetration ranged from 0.005 to 0.75 percent. Clearly, filter penetration can be neglected for the most efficient filter but not for the least efficient. Indeed, QNFT testing using the least efficient of the four DFMR filters tested would not be able to measure fit factors greater than about 100.

TABLE I. Aerosol Size Distributions for Various Industrial Operations and Predicted Overall Protection Factors for QNFT Fit Factor of 20 and 50

Operation	MMAD, μm	GSD	Predicted PF[A] QNFT FF = 20	Predicted PF[A] QNFT FF = 50	Ref.
Mining					
Open pit, general environment (ns)[B,C]	2.5	4.7	36	67	13
Open pit, in cab (2)	1.1	2.4	26	48	13
Coal mine, continuous miner (27)	4.6	2.5	56	132	14
Coal mine, continuous miner (8)	15.0	2.9	158	386	15
Coal mine, continuous miner (50)[C]	17.0	3.1	172	419	16
Coal mine, other operations (80)[C]	11.5	2.8	122	298	16
Oil Shale mine (26)	2.8	3.5	39	79	17
Smelting and Foundry					
Lead smelter, sintering (7)[C]	11.0	2.4	130	322	18
Lead smelter, furnace (8)[C]	3.3	15.7	47	79	18
Brass foundry, pouring (4)[C]	2.1	10.3	38	64	18
Brass foundry, grinding (3)[C]	7.2	12.9	52	90	18
Iron foundry, general environment (1)	2.8	5.1	38	70	19
Iron foundry, general environment (4)	16.8	4.4	127	290	20
Be-Cu foundry, furnace (16)	5.0	2.4	59	142	21
Nuclear fuel fabrication (66)	2.1	1.6	35	85	22
Non-mineral Dust					
Bakery (6)	12.1	4.2	99	222	23
Cotton gin (5)[C,D]	47.1	2.7	1150	2860	24
Cotton mill (10)	7.6	4.0	72	158	25
Swine confinement building (21)[C]	9.6	4.0	83	186	26
Woodworking, machining, sanding					
fine mode (6)	1.3	2.7	27	51	27
coarse mode (6)	33.1	2.6	687	1710	27
Wood model shop (9)	7.2	1.4	92	229	28
Metal Fume					
SMA (stick) Welding (ns)[D]	0.38	1.8	17	25	29
MIG Welding (ns)[D]	0.48	2.3	19	29	29
Lead fume (O_2-Nat. gas) (5)	0.37	2.1	17	26	30
Mist and Spray					
Pressroom, ink mist (10)	27.4	4.30	226	529	31
Spray painting, lacquer (ns)	6.4	3.4	68	152	32
Spray painting, enamel (ns)	5.7	2.0	67	165	32
Aerosol spray products (6)[C]	6.4	1.8	76	189	33
Other					
Forging (ns)[C]	5.5	2.0	65	161	34
Refinery, fluid catalytic cracker (4)[D]	6.2	2.4	70	171	35
Cigarette smoke (diluted) (5)	0.4	1.4	17	25	36
Pistol Range (2)	2.6	3.8	37	73	37
Diesel exhaust (age = 5–600 s) (5)	0.12	1.4	16	21	38

[A]Predicted protection factors are based on the following assumptions: measured QNFT fit factors are 20 or 50, QNFT test conducted at a work rate of 0 kg-m/min with perfect DFMR filters having average resistance, respirator is properly used at a work rate of 415 kg-m/min with average DFM filters.
[B]Number in parenthesis following the operation name is the number of size distributions on which the data in the table are based; ns = number of size distributions not specified.
[C]Average values for MMAD and GSD used (median values used for all others).
[D]Mass distribution parameters calculated from count distribution data.

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AEROSOL EXPOSURE IN THE WORKING ENVIRONMENT

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and
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December 30, 1986

P R E F A C E

The present project entitled "Aerosol Exposure in the Working Environment" was conducted at the Danish Toxicology Centre during the months of July through December, 1986.

The results obtained, as presented here, are based on published literature (periodicals, monographs and other reports), Danish data bank information and interviews with the Danish Health Service Centres. We found it necessary to use all three types of sources of information in order to obtain a sufficiently broad but also detailed picture of which aerosols workers are exposed to in their working environments.

In order to make an attemt of quantification of the exposure to aerosols, the above-mentioned information was combined with statistical information on the employment in the different branches in the Danish manufacturing industry.

The amount of information generated in the project is overwhelming, and from the basic facts presented numerous new results can be calculated. It should i.a. be possible to combine the lists presented on the occurence of the different aerosols in the different branches with statistical information on the employment in the same branches in other industrialized countries.

However, we are of the opinion that the relative importance of the solid aerosols as compared to the liquid aerosols will be approximately the same in all modern industrialized countries of the western world.

The present report should initially be read in its entirety so that the reader can be familiarized with the stepwise methods (and procedures) we have developed in order to get to the final picture and assessment of the aerosol hazards in the working environment. Thereafter, the report can be used as a manual or as a basis for further assessments.

The authors want to express their gratitude to Mrs. Birthe Arp Hansen, the National Labour Inspection, for fruitful discussions at the early stages of the investigation, and Mr. Ole Bruun, also from the National Labour Inspection, for many good advices and fruitful discussions at all stages of the investigation.

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CHAPTER 1

INTRODUCTION

1.1 General Remarks and Scope of the Investigation

Numerous materials of different origin and with different properties are being processed or otherwise used in our modern industrialized society, and it is a well established fact that some of these materials are more or less dangerous to health. As human exposure to many of the substances is an unavoidable complication, strong efforts shall be made to minimize such an exposure. Preventive measures are being taken of either administrative and legislative nature or technical solutions are introduced. The more efficient way to deal with the problems is generally to use a combination of these principles.

However, one essential prerequisite of successful implementation of countermeasures is that the range and magnitude of exposure to the dangerous substances is known. Other prerequisites are an indepth knowledge of the properties of the substances with regard to e.g. chemistry and toxicology and knowledge of the possible technical solutions, including their advantages and limitations.

The scope of the present investigation is to make an assessment of the nature of aerosol exposure (air pollutants in a particulate state) in the working environment i.e. to try answering the following important questions:

1) Which aerosols, liquid and solid, are found in the different branches of trade and industry, and in related activities?

2) Which work processes give rise to the formation of solid and/or liquid aerosols?

3) How many people are exposed to solid aerosols, and how many to pure liquid aerosols or liquid aerosols in combination with gases and vapours?

The results of the present investigation are based on statistical information on the number of employees in the different branches of trade and industry and related areas combined with information on the more important working processes and operations used in the brances and the types of air pollutants found, as described in literature and in other sources.

1.2 Classification of Air Pollutants

Depending on their physico-chemical properties, air pollutants exist in the solid, liquid or gaseous state. Solid and liquid substances can be dispersed in air as particles forming grit, dust, smoke, fume, mist or fog, all of which are heterogeneous systems which can be classified in common as aerosols. Gaseous substances, instead of being dispersed, are dissolved in the air, thus forming solutions of the gases or vapours in the atmosphere.

Table 1

Classification of air pollutants.

State of pollutants	Examples	Classification
Gaseous	Gases, vapours from liquids and solids	Gases
Liquid	Smoke, mist, fog	Aerosols
Solid	Grit, dust, fume, smoke	

1.3 Definition of "Aerosols"

In the present context the term "aerosol" is used to describe any particle, solid or liquid, which is suspended in air. The sizes of the particles as described by their diameter may be in the range from 1000 μ - 0.001 μ depending on which materials they consist of as well as the type of process by which they were formed.

Solid particles may either be pure chemical substances or mixtures of them. Liquid particles can be pure liquid chemical substances, solutions or suspensions.

The particles in aerosols interact with each other as well as with their surroundings. These interactions greatly influence the stability of aerosol systems and give rise to phenomena as coagulation, sedimentation and vapourization. The major forces playing a role in these processes are inertia, gravity, electrostatic attraction and repulsion, and Brownian diffusion, their relative importance being dependent on the size and mass of the particles, electrostatic charges, velocity of the particles, temperature and pressure.

1.4 Basic Mechanisms for the Formation of Air Pollutants in the Working Environment

Air pollutants are formed in the working environment as by-products when materials are subjected to e.g. mechanical forces or heat. Some materials are easily broken down or evaporated, while others need a substantial raise in temperature in order to be evaporated, or strong mechanical impacts to be disintegrated and dispersed. The initial formation of air pollutants during e.g. various processes at elevated temperatures can be referred to as primary processes. Once liberated to the surrounding atmosphere by a primary process the air pollutants in some cases can undergo secondary processes, and they are said to be more or less unstable.

As an example of the formation of an aerosol by a primary process, the spray painting aerosol can be mentioned. By this process small droplets are formed initially by the spray nozzle, but then in a successive step evaporation of solvent from the droplets takes place as a secondary process.

In some extreme cases the secondary processes are very closely linked to the primary formation process (ultra short time). This is the case e.g. when metal vapours are formed at the very high temperatures used during welding. The vapours formed initially condense immediately in a secondary process forming particles of the metals or oxidation products thereof. In such cases it is common practice to consider the formation as only one primary process giving rise to a solid aerosol (welding smoke), and the gases generally referred to in connection with the welding processes are of other origin e.g. nitrogen oxides formed from the atmospheric oxygen and nitrogen or carbonmonoxide formed from the use of carbon dioxide as a shielding gas.

Basically aerosols can be generated either by evaporation of materials and subsequent condensation or by dispersion of materials. These basic principles are used in the laboratory in the different aerosol generators when aerosols are to be studied. It is exactly the same mechanisms which in the industrial environment gives rise to the formation of aerosols as dust, smoke, fume, etc.

Formation of aerosols by evaporation and subsequent condensation can be expected in work processes involving elevated temperatures, if the materials can be evaporated.

Formation of aerosols by disintegration and dispersion can be expected in those work processes where mechanical forces are used e.g. cutting, grinding, turning, spraying, etc.

The formation of air pollutants in the working environment, specially aerosols, is in some cases the result of rather simple processes and in other cases of complex processes. Furthermore, in some cases rather stable aerosols are formed e.g. grinding dust, whereas in other cases more or less unstable aerosols are formed which can undergo further transformations. As an example the spray painting aerosol has already been mentioned. Further examples are given in Figure 1.

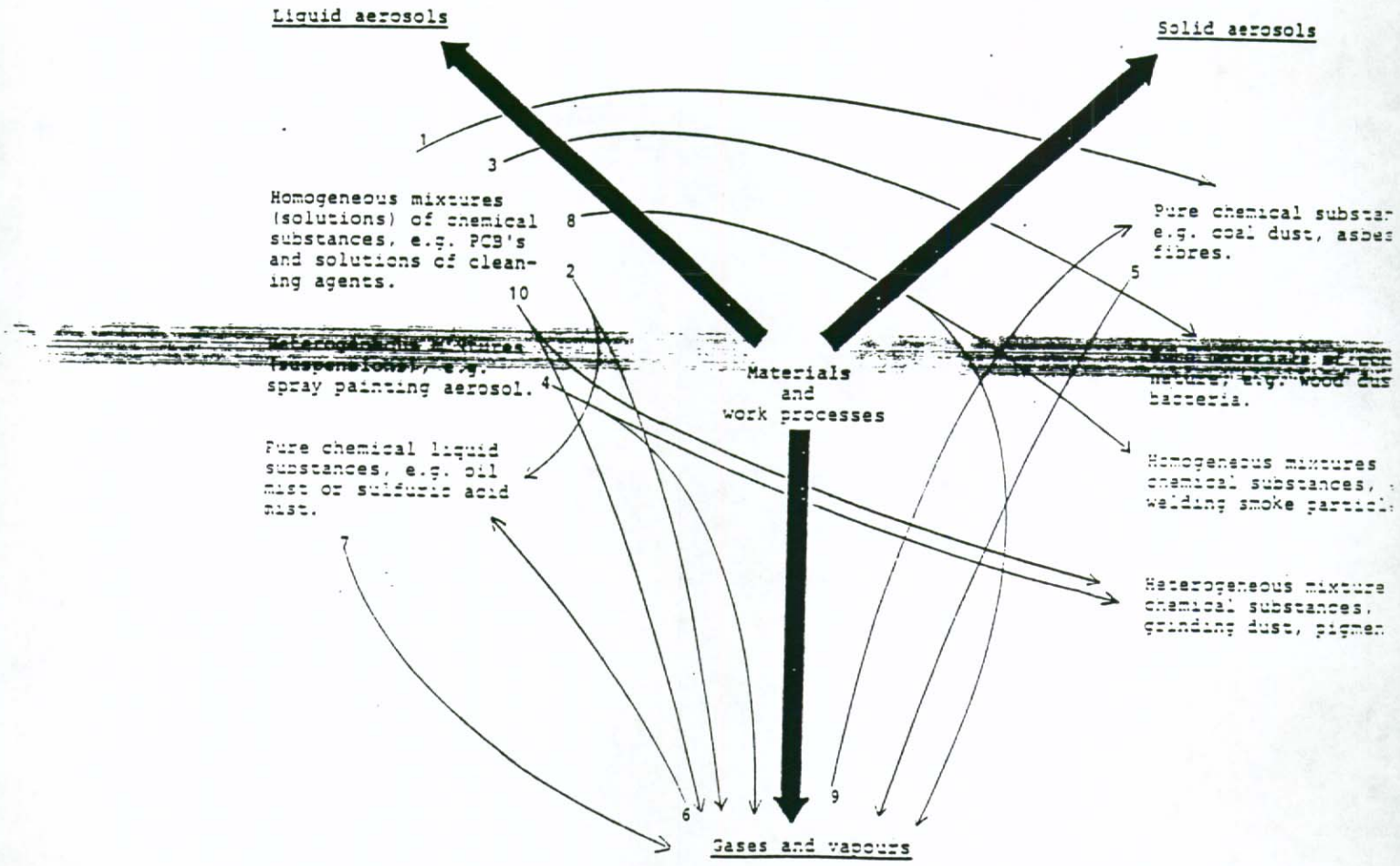

Figure 1. Examples on formation and conversion of aerosols.

1) Aqueous solution of cleaning agent e.g. phosphoric acid or oxalic acid. 2) Aqueous solution of cleaning agent e.g. triethanolamine. Furniture polish spray. 3) Bacteria suspended in water droplets. 4) Spray painting aerosol based on either water or organic solvents containing insoluble pigments. 5) Hydroquinone. Chloroacetophenone tear gas. 6) Polyaromatic hydrocarbons and oil vapours. 7) Ethylene glycol aerosol. 8) Polychlorinated biphenyls in solution. 9) Arsenic oxides. 10) Aqueous solution of sodium hydroxide partially converted to hydrogen carbonate.

1.5 Use of Respirators for Protection against Aerosols

When all other technical measures fail, respirators must be used in the working environment to protect people against inhalation hazards.

The air pollutants in the working environment exist either as gases or as particulates (aerosols). In a limited number of cases the same substances exist both as vapours and as particles.

In some cases only aerosols exist consisting of either solid or liquid particles, whereas in other cases only gases or vapours exist. In a number of cases aerosols of one chemical exist together with vapours of other chemicals, thus forming a complex mixture. Whatever situation is found in practice, it is essential for the selection of proper respiratory protective devices of the filtering type to establish whether the air pollutants are present as particles or as gases (vapours).

Where aerosols alone are present in the working environment suitable particle filters can be chosen, but when aerosols exist in combination with gases or vapours, socalled combined filters must be chosen. The particles of some aerosols are solid (e.g. dust) whereas other aerosols consist of liquid particles (e.g. mist) depending on the physical and chemical properties of the materials forming the particles.

Particle filters behave in different ways when filtering solid particles and when filtering liquid particles. For glass fibre filters e.g. the general tendency is that the filtration efficiency for solid particles increases with loading, whereas for liquid particles the filtration efficiency decreases with loading.

Consequently, it is essential for the selection of filters to have rather detailed information on the nature and properties of the air pollutants, incl. information on whether particles are solid or liquid, and whether gases and vapours are present too.

Generally, filters of high efficiency against liquid particles are more expensive than filters with a correspondingly high efficiency against solid particles. Consequently, it seems reasonable to have two separate classes of filters, one intended for use against solid aerosols only, and one for use against solid and liquid aerosols.

Another important difference between the filter types is that filters having a high filtration efficiency against solid and liquid aerosols generally have higher air flow resistance than filters having high efficiencies only against solid aerosols. This is of importance from a user's point of view. A respirator with a small breathing resistance is more comfortable to wear than one with a higher resistance.

This fact also supports the idea of having two classes of aerosol filters, one for protection against only solid aerosols, and one for protection against both solid and liquid aerosols.

Furthermore, such a classification seems justified not least if the majority of aerosols found in the working environment are solid aerosols. In the many cases where liquid aerosols are present (e.g. spray painting work) vapours are present additionally, and combined filters or even air supplied equipment will be needed to obtain proper respiratory protection.

1.6 How to quantify Exposure in the Working Environment

The very simple question: "How many people are exposed to aerosols in the working environment?" cannot be answered in a simple way. In order to make an assessment of the magnitude and importance of exposure in the working environment to specific substances one should consider what exposure is. In inhalation toxicology studies it is common practice to quantify exposure as the product of the concentration (c) of a certain substance and the time (t) during which the substance is inhaled. Following this concept in an assessment of aerosol exposure in the working environment one should consider the number and duration of situations in which one specific person is exposed to a specific aerosol in a certain period of time e.g. each day, each week or perhaps each year. In some work situations, e.g. the spraying of crops in agriculture, a realistic time span to consider would be a year (seasonal work).

This type of detailed analysis is almost impossible to perform for the entire industry, because it will require an indepth knowledge of the work routines etc. in each individual factory and workshop, and the work routines may differ substantially from factory to factory. However, it can be made in a limited number of cases, where individual factories or workshops are thoroughly analyzed.

Another problem which is difficult to overcome, except in analysis of individual workplaces in individual factories, is the assessment of exposure to more than one substance. In the majority of factories and workshops it is not unusual that several different substances will be present as air pollutants, and they will be present more or less simultanously.

This rises the question whether all people employed in the factory will be exposed to all the different substances or only to some of them. One can imagine a situation where one group of employees is exposed to one specific aerosol while another group of employees is exposed to another aerosol. Alternatively, both groups may be exposed to both aerosols. The situation is extremely complex in case more than two substances are present, and only in an indeed very limited number of investigations published in literature a more detailed picture of the actual exposure has been given.

In an extensive investigation like the present one, it therefore is impossible to quantify exposure following the above-mentioned principles, and the reason for this is that the information available in literature, data banks, etc. is not sufficiently detailed. Consequently, we decided to try to give an estimate of the exposure to solid and liquid aerosols following another principle as described in the following.

1.7 Exposure Indices

The method implies the use of socalled "exposure indices" for the individual branches and the individual aerosols. The exposure index of a certain aerosol X in a certain branch Y is the number of workers employed in branch Y where aerosol X has been found to be present. The exposure index of the aerosol X in all branches (1---Y) is the total number of workers in all branches where aerosol X is present. By classifying the aerosols in solid aerosols and liquid aerosols, and classifying e.g. water based aerosols separately, the exposure indices for the individual branches has been summed up to give an estimate of the number of workers exposed to the classes of aerosols chosen.

The following examples can be given:

Example 1

Tobacco dust is a solid aerosol. It has been reported present in the working environment during tobacco manufacturing. According to statistical information the number of people employed in the Danish tobacco industry in 1984 were 2146. Among these, 1638 were wage earners (workers). The exposure index of tobacco dust in the branch of tobacco manufacturing consequently is 1638.

As tobacco dust has not been reported present in other branches, the exposure index of tobacco dust in all branches is also 1638 (the exposure indices for all other branches are zero).

Example 2

Epoxy dust is another solid aerosol which has been reported present in the furniture industry, in certain branches of the fabricated metal industry and in other manufacturing industry.

If the number of workers employed in each of these branches are as follows:

Furniture industry	11361
Metal furniture industry	2876
Metal furniture industry other	642
Industrial paintshops	1262
Manufacture of agricultural machinery	4513
Other manufacturing industry	1273
Total No. of people (total exposure index)	21928

The exposure index for epoxy dust in each of the above-mentioned branches is the number of people employed in the particular branches, and the total exposure index for epoxy dust in all the branches is the total number of people employed in all the branches.

By performing this type of analysis for all the different types of aerosols in all branches and grouping the aerosols in solid and liquid aerosols, incl. water based aerosols, it is possible to calculate a total exposure index for solid aerosols and a total exposure index for liquid and water based aerosols.

The exposure indices as calculated according to the above principles will not give the true number of exposure situations or exposed people, because it does not take into account whether one group of people is exposed to one aerosol and another group of people is exposed to another aerosol or both groups are exposed to both aerosols in the branch. The use of exposure indices as outlined in the above examples implies that all people in each of the branches are potentially exposed to all types of aerosols found to be present in the branch where they are employed. The exposure index therefore is related to the probability of exposure to certain aerosols in certain branches. However, the exposure indices will give a picture of the relative importance of the hazards created by certain aerosols or classes of aerosols in the branches of trade and industry and at related activities.

Taking the above-mentioned examples, the exposure indices for tobacco dust and epoxy dust can be compared by dividing them, and the resulting figure indicates that for each individual potentially exposed to tobacco dust there will be thirteen other individuals who are potentially exposed to epoxy dust.

CHAPTER 2

STATISTICAL INFORMATION ON TRADE AND INDUSTRY AND RELATED ACTIVITIES

2.1 The International Classification System

In statistical work it is common practice to classify industrial and economic activities in certain groups, and the more commonly used system is the socalled ISIC-system (International Standard for Industrial Classification) as published by the United Nations (reference 1, this Chapter). The ISIC-system divides the different industrial and economic activities in Major Divisions, Divisions, Major Groups and Groups or Categories, and each of these are assigned one-, two-, three-, or four digit numbers for identification purposes. One major division is e.g. mining and quarrying which is made up of the four divisions: Coal mining, Crude petroleum and Natural gas production, Metal ore mining and Other mining. Among these Metal ore mining is further divided into the groups Iron ore mining and Non-ferrous metal ore mining.

A total of ten major divisions is described in the ISIC-system, and they are further subdivided in order to facilitate processing of statistical information e.g. on the number of people employed in different industries.

The entire classification according to ISIC is given together with further explanations in reference 1. The major divisions are shown in Table 2.1. The more detailed classification is given in Annex 1.

The use of the ISIC-system enables one to compare statistical information on an international level i.e. between countries in those industrialized parts of the world where the system has been adopted.

Table 2.1. Major Divisions of Industrial and Economic Activities

Major Division	
1	Agriculture, hunting, forestry and fishing
2	Mining and quarrying
3	Manufacturing
4	Electricity, gas and water
5	Construction
6	Wholesale and retail trade and restaurants and hotels
7	Transport, storage and communication
8	Financing, insurance, real estate and business services
9	Community, social and personal services
0	Activities not adequately defined

In the present project the ISIC-system has been used for linking together working processes and established or presumed exposure to aerosols with the different groups or categories of trade and industry in order to get information on the magnitude of aerosol exposure in industry and related areas with special emphasis to potential exposure to solid aerosols vs. liquid aerosols.

In the present report the term branch will be used at random referring to the terms major division, division, major group or group. As can be seen from the classifications listed in Annex 1, some of the major divisions are extensively divided in subsections (specially Major division 3, Manufacturing) whereas other major divisions are more broadly defined, e.g. Major division 5, Construction, which is not at all subdivided.

2.2 The Danish Classification System

The Danish statistical classification system is based on the international ISIC-system. It is however more detailed, as further subdivisions have been added to the groups. These subdivisions are characterized by a fifth digit added to the international 4-digit code of ISIC. The Danish classification system is described in reference 2.

2.3 Statistical Information on the Manufacturing Employment in Denmark

Extensive information on the employment in Denmark in the major divisions 2 and 3 (mining and quarrying, and manufacturing) has been published (reference 3).

According to the Danish statistical information the number of workers (wage earners) constitute from 56 to 80 per cent of the total staff employed depending on branch. The lower figure refers to the chemical industry and the higher figure refers to e.g. the wood industry and the textile industry. These different figures presumably reflect the different technological levels acquired by the branches respectively. However, as a mean value 70 per cent of the total staff employed in the Danish manufacturing industry (ISIC-codes 31-39) plus mining and quarrying (ISIC-code 29) are workers, and it seems reasonable to anticipate that this figure will be valid for the major industrialized countries of Europe.

A survey is given in Table 2.2. A more detailed survey is given in Danish in Annex 2 (reference 3).

Table 2.2. Danish Employment in Mining and Quarrying and Manufacturing, 1984

ISIC-code	Branch	Total employment	No. of wage earners	Wage earner per cent of
29	Mining & quarrying	1127	821	72.8
30	Manufacturing industry	379477	267065	70.3
31	Food, beverage and tobacco	75331	58498	77.6
32	Textile, wearing apparel and leather	29512	23321	79.0
33	Manufacture of wood and wood products, incl. furniture	23989	19161	79.9
34	Manufacture of paper and paper products. Printing and publishing	33507	20760	61.9
35	Manufacture of chemicals and chemical, petroleum, coal, rubber and plastic products	37247	20841	56.0
36	Manufacture of non-metallic mineral products, except products of petroleum and coal	17678	12907	73.0
37	Basic metal industries	6053	4659	77.0
38	Manufacture of fabricated metal products, machinery and equipment	150524	103079	68.5
39	Other manufacturing industries	5636	3839	68.1

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CHAPTER 3

SOURCES OF INFORMATION IN THE PRESENT INVESTIGATION

3.1 Major Types of Sources of Information

The essential information in the present investigation is information on the different types of aerosols found to be present in the branches or which are presumed to be present in the branches and information on the employment in the different branches of trade and industry and at related activities.

The information available on employment in the different branches has been discussed more detailed in Chapter 2 together with the classification of the branches in Denmark and at international level, and will not be further discussed here.

Information on the occurrence of aerosols in the different branches stems from the following three major types of sources:

1. Literature
2. Data bank information
3. Questionnaires

The information was collected during July-November, 1986. The final choice of sources was made after a preliminary screening was carried out in June, 1986.

3.2 Literature Sources. Periodicals

The results of analysis of the working environment are published in a variety of scientific papers in periodicals, monographs, books, research reports, etc. which are related to disciplines such as chemistry, medicine, biology, aerosol physics, etc.

Table 3.1. Periodicals included in the Investigation

Title of periodical	Origin	Language
American Industrial Hygiene Association Journal x)	US	English
American Journal of Industrial Medicine	US	English
Annals of Occupational Hygiene x)	UK	English
Archives des Maladies Professionelles de Médicine du Travail et de Sécurité Sociale	F	French
British Journal of Industrial Medicine	UK	English
Pas På (now Arbejdsmiljø)	DK	Danish
Prévention et Sécurité du Travail	F	French
Scandinavian Journal of Work, Environment and Health	DK, SF, N, S	English
Staub Reinhalt. Luft	D	German
Travail et Sécurité	F	French

x) Screened back to 1975.

Ten periodicals were chosen after the preliminary screening process. The ten periodicals are shown in Table 3.1. They were generally screened for information published during 1981-1985. The three more important ones were screened for information back to 1975. The periodicals represent to the best of our knowledge the most important sources for information on topics as industrial hygiene, industrial medicine, occupational health, accident prevention, etc. in the modern industrialized countries.

3.3 Literature Sources. Monographs and Reports

In Denmark the Working environment Fund has been established under the Working Environment Act of 1977. This fund is sponsoring research and investigation within the field of the working environment in Denmark. Most of the results are published in monographs and reports in Danish, giving results of investigations carried out in specific branches of trade and industry and related areas or on specific harmful substances found in the working environment, e.g. cobalt. Some of the reports give detailed information on exposure, chemical composition and particle size of aerosols found as air pollutants in the working environment. Other reports are based on the author's interpretation of different aspects of environmental health in certain industries combined with interviews with the workers.

3.4 Data Bank Information

The Danish Labour Inspection (The Danish Health and Safety Executive) has filed workplace measurements in its own data bank "ATABAS" since January 1, 1983. ATABAS is situated at the National Institute of Occupational Health. The information stored is the result of workplace measurements carried out in Denmark in all branches of trade and industry and related areas. The measurements were taken either because it was recognized that specific problems existed in the working environment (exposures exceeding current TLVS) or as a control of

preventive measures which had been introduced earlier because problems had existed. Table 3.2 gives the number of investigations carried out and analytical results stored in ATABAS. The data bank lists all the chemical substances identified in the workplace measurements and relates them to industrial branches, work processes and products. The entry codes are ISIC-number (see Chapter 2), work processes (special code) and CAS-numbers. The CAS-numbers are international code numbers used for identification of chemical substances. An example on the outprints from ATABAS is shown in Annex 2.

At an early stage of the present investigation other data bases were considered, primarily at DIMDI in Germany and CIS (ILO, Switzerland). However, trial runs on these either gave very little information of importance for the present study or only information which was already obtained from literature.

3.5 Questionnaires

The Health Service in Denmark is a nationwide network of health centres (BST-centres in Danish) which deals with all aspects of health and safety in the working environment. They promote health and safety e.g. by assisting undertakings all over the country in measuring physical and chemical hazards, and they give recommendations regarding technical installations and other matters of importance. At present they do not cover all branches.

A detailed survey of the branches covered by the Health Service is given in Annex 3.

The staff of the Health Service includes chemical engineers, physicians, technicians, nurses, physiotherapists, etc. They are all in very close contact with the undertakings in their local communities.

Table 3.2.

Number of Investigations and Analytical Results registered in ATABAS

	1983	1984	1985
Investigations	1892	1833	1659
Analytical results	13284	13078	11955

Of prime importance is that the centres have a thorough knowledge on the working environment at local level. The centres were asked to fill in questionnaires (example in Annex 4). More specific, they were asked to give information on the occurrence of aerosols in the working environment according to measurements carried out by the centres or according to their general experience obtained during their visits to the undertakings. More detailed, they were asked where aerosols occur, which substances they consist of and from which work processes they originate. A further important question was whether gases or vapours are present additionally. They were also asked to classify the aerosols in either of the three groups: Solid aerosols, liquid aerosols and water based aerosols.

For further details regarding the questionnaires Annex 4 should be consulted.

In order to ensure that the questions were correctly understood the questionnaires were sent to 4 selected Health Service Centres with a request for comments, and minor changes based on these comments were introduced before the final distribution of the questionnaires.

3.6 Practical Difficulties in the Interpretation of Information from the Different Sources

In the present investigation the major question to be answered is whether a substance is present in the working environment as an aerosol or as a gas (vapour). In many papers published, e.g. epidemiological studies, the authors have been more concerned with giving descriptions of the harmful effects of the substances to the major target organs, e.g. the liver of the exposed people. The physical state and the chemical composition of the air pollutants found in a certain industrial environment is not in all cases unambiguously described, and in such cases it is difficult to make a clear judgement as to whether the substances exist as aerosols or gases (or even in both states).

If the working process is more or less described, this will give a valuable indication of the nature of the air pollutants formed. Also indirect conclusions can be drawn if the chemical substance is identified and is generally known to be of low volatility. Another method is to look at the sampling methods used, if they are described, or the use of specific instrument types in the analysis. It is logical to assume that when filters are used during sampling, the substances identified have been present at least partly as particles, whereas when e.g. charcoal tubes have been used for sampling, the substances identified have been present as gases or vapours.

In a number of workplace investigations no direct sampling methods (e.g. filters or cascade impactors) have been used. Instead biological monitoring were used. This method implies that samples of blood or urine are taken from the people exposed. In such cases it may be difficult to decide whether the harmful substances were present as aerosols or gases and vapours.

The difficulties in interpretation of the published information are also met in evaluation of some of the data from ATABAS. The substances listed in ATABAS are listed by name and CAS-number, and it is obvious that e.g. cadmium and its inorganic compounds will be present as dust, as any chemist would know. Less straight forward is the answer in the case of α-pinen which is an organic solvent of relatively low volatility, and a molecular weight of 136 ($C_{10}H_{16}$). In this and similar cases it has been necessary to check with the National Institute of Occupational Health which sampling method they actually used when taking their measurements. In the case of α-pinen a filter method was used, and consequently it could be established to be present as an aerosol.

As referred to previously, it has also been important in the present investigation to obtain information on whether gases or vapours are present in addition to the aerosols, either because the aerosols themselves are sufficiently volatile or because other substances of high volatility are being used in the same work process or at another work process in the neighbourhood. This type of information is frequently given in the papers published in the periodicals, in monographs and reports and in the questionnaires from the Health Service Centres. However, it is not given in the outprints from ATABAS and can only be obtained by going back in the files and going through the original reports which form the basis for the ATABAS registration. At present, at least 6000 original reports are filed.

It is obvious that this will be extremely time consuming and therefore has not been possible within the frames of this investigation.

CHAPTER 4

AEROSOLS REPORTED PRESENT IN THE WORKING ENVIRONMENT

4.1 General Survey

The result of the systematic screening of the sources referred to in Chapter 3 is given in Tables 4.1 - 4.6. Results from the literature are given in Table 4.1 (solid aerosols) and Table 4.2 (liquid aerosols, incl. water based aerosols). Tables 4.3 and 4.4 give results obtained from the data bank, and Tables 4.5 and 4.6 give results from the questionnaires also grouped as solid and liquid aerosols.

In each of the tables the aerosols have been listed alphabetically, and to each aerosol, branch codes on two-digit level, have been added. The branch codes can be used for identifying those branches in which the aerosols have been reported to be present or are assumed to be present. For translation of the code numbers, the reader is referred to the survey given in Annex 1.

In those Tables where liquid aerosols are listed, information is also given on whether the aerosol is water based, in which case a "W" is added, or whether on some occasions it is water based which is indicated by "(W)". Furthermore, the additional presence of vapours has been referred to as far as information has been given or in case the presence of vapours can be predicted.

4.2 Number of different Aerosols reported present in the Working Environment from the different Sources of Information.

The number of different aerosols reported from the different sources of information is given in Table 4.7. It shall be stressed that on many occasions the different sources of information refer to the same aerosol, e.g. aluminium or mineral oil.

Table 4.1

Solid aerosols referred to in literature and correlated to ISIC-divisions.

Actinomycin spores 11
Aflatoxins 11, 71
Aluminium 37
Aluminium fluoride 37
Aluminium oxide 37
Antigens 11
Arsenic dust 32, 37, 38
Asbestos 29, 32, 34, 36, 37, 38, 41, 50, 71, 95

Bacteria and fungi 11, 32, 92
Beryllium 37, 38, 41
Benzidine dust (benzidine sulfate) 35
Bitumen fumes 32, 35, 50

Cadmium 37, 38
Cadmium selenosulphide 35
Cadmium sulphide 35, 37
Calcium (salts) 35
Carbon black 35
Chlorophenols and wood dust 12, 35
Chromium 32, 35, 41
Coal dust 21, 41
Coal tar fumes 41
Cobalt 37
Copper 37
Cotton dust 31, 32
Cured rubber dust 35

"Dust" 11, 22,31, 32, 34, 35, 36, 37, 38, 71, 92

EDTA 31
Endotoxins 11, 32
Enzymes (trypsin-like) 31

Fibres 35
Flax 32
Flour 11, 31
Fluorides 37
Fluorochemicals (ammoniumperfluorooctanoic acid) 35
Fungi 11, 34

Granite dust 29
Grain dust 71

Table 4.2

Liquid and/or water based aerosols referred to in literature and correlated to divisions. Additional information on the presence of vapours and gases.

Borine compounds W, 38

Cleaning agents W, 31, 38, 92
Cooking fumes 31
Cutting oils (W), 38

Epoxy and polyurethane aerosols (car painting) 95, (org. solvents)

Ink aerosol (from ink-jet recorders in hospitals) 93, (org.solvents)
Ink mist (newspaper printing) 34, (org. solvents)
Isocyanates 95, (vapours)

Lubricants (W), 38

NTA (nitrilotriacetic acid) W, 38

Oil mist 37, 38, (in some cases vapours)
Oxalic acid W, 71 (vapours may be present)

PCB's 41, (vapours may be present)
Phthalate esters 35

Silicon oil mist 37
Soot 35
Spray painting (W), 95, (in many cases vapours of organic solvents)
Sulphuric acid mist W, 38 (in some cases sulfur oxides)

Triethanolamin W, 38

Totally 18, incl. 9 water based

W = water based
(W) = water based in some cases

Table 4.3

Table of solid aerosols identified from ATABAS and correlated to ISIC-divisions.

Aluminium and aluminium oxide 37, 38, 39
Antimony 36, 38, 95
Arsenic compounds 33, 36, 38, 50, 91
Asbestos 38, 41, 50, 91, 93, 95
Asphalt 50

Beryllium 37, 38

Cadmium and its inorg. compounds 37, 38, 39, 93, 95
Calcium hydroxide 37
Christobalit (resp.) 37
Chromium and chromates 33,34,35,37,38,39,50,71,91,92,93,95,36,41
Cobalt and its inorg. compounds 33, 38
Copper dust, copper smoke 95,33,35,36,37,38,39,41,50,61,71,91,92, 94,34,93
Cotton dust 32

Epoxy dust 33, 38, 39

Fibres, non MMMF, respirable and non-respirable 34, 36, 91, 93
Fluorides 38, 92, 93

Iron oxide 33,35,36,37,38,39,41,50,61,71,91,92,93,95

Lead 11,33,34,35,36,37,38,39,41,590,61,71,91,92,93,94,95

Magnesium 37
Manganese and its compounds 36, 37, 38, 39, 50, 61, 93
Mineral dust 11,31,32,33,34,35,36,37,38,39,41,50,61,71,91,92,93,94,95
MMMF, non-respirable, respirable and total 23,29,33,35,36,37,38,39,41 50,61,71,91,92,93,95

Nickel (metal and its compounds) 36, 37, 38, 39, 93

Organic dust 11,31,32,33,34,35,36,37,38,39,41,50,61,71,91,93,95

PAH 31, 94
Phosphoric acid 38
Phthalic acid enhydride 35

Quartz 23,29,31,36,37,38,41,50,71,83,92,35,93,95

Respirable dust 31, 34, 36, 37, 38, 41, 61, 92, 93

Selenium 61, 91
Silver and its soluble compounds 38
Sodium hydroxide and other sodium containing compounds 38,31,35,93

Tin, organic 37, 38, 39, 95
Tin, inorganic 33, 34, 37, 38, 39, 91, 93
Tobacco dust 31
Total dust 39, 91, 93, 94

Welding smoke 38, 39, 93
Wood dust 33, 38, 50, 91, 93

Zink oxide 33,34,35,36,37,38,39,41,61,71,91,92,93,94,95

Table 4.4

Liquid and/or water based aerosols identified from ATABAS and correlated to ISIC-divisions. Additional information on the presence of vapours and gases.

1.6-Hexyldiisocyanate 38, 50, 91, 95, (vapours)

MDI 32, 33, 35, 36, 37, 38, 39, 41, 50, 91, 93, (vapours)
Mineral oil 32, 33, 34, 38, 50, 93, 94, 95, (in some cases vapours)

-Pinen 32, (vapours may be present)

Sulfuric acid (W) 34, 38, 93, (in some cases sulfur oxides)

TDI 32, 34, 35, 36, 38, 91, 93, (vapours)

Totally 6, incl. 1 water based

W = water based
(W) = water based in some cases

Table 4.5

Solid aerosols identified from BST-questionnaires and correlated to ISIC-divisions

Acrylates 32
Aluminium 38
Aluminium oxide (carbon monoxide may be present) 38
Ammonium chloride 38
Asbestos 38, 50

Bacteria (viruses) 92

Calcium 35
Cement dust (oil and other hydrocarbon vapours may be present) 36,50
Chromium and chromates 33
Cleaning agents 31
Concrete dust 36
Copper (carbon monoxide may be present) 33, 35, 38

Dust (phosphine and formaldehyde) 3
(in some cases also oil vapours and other organic vapours) 36,38
(in some cases nitrogen oxides, carbonmonoxide & dioxide) 92,95

Drugs (isopropanol may be present) 35

Enzymes (organic solvents may additionally be present) 31
Epoxy dust 38

Fluorides 35
Fly ash 36
Fumes (formaldehyde and phenol) 33

Gold (sulfur dioxide) 37

Iron (carbonmonoxide) 35, 38
Iron oxide 36, 38

Lead (carbonmonoxide) 35, 38
Lead oxide (carbonmonoxide may be present) 38

Melamine dust (formaldehyde) 35
Metals 36
Metal oxides (sulfur dioxide) 37, 38
MMMF 36, 50

Organic dust 35

Pesticides (vapours) 35
Polypropylene (vapours of decomposition products) 35
PVC-dust 35

Quartz (Carbon monoxide, hydrocarbons, sulfur dioxide, isopropanol) 36, 38

Silver (sulfur dioxide) 37
Soot 92

Titaniumdioxide 35
TNT-dust 35
Tobacco dust (flavour) 31

Welding fume (Nitrogen oxides, ozone, carbon monoxide) 35,36,38,71
Wood dust (incl. glue dust) 33, 36, 50

Zinc 38

Table 4.6

Liquid and/or water based aerosols identified from BST-questionnaires and correlated to divisions. Additional information on the presence of vapours and gases.

Arsenicals W, 33

Bacteria (viruses) W, 92
Bitumen 95

Ceramic materials W, 36
Chlorothene 95, (also vapours)
Chromates W, 33
Cleaning agents W, 31, 38, 71 (in some cases also vapours)
Cobalt aluminate W, 36
Concrete dust W, 36
Copper W, 33

Dust 38, 95 (in some cases oil and white spirit vapours)
(also in some cases CO)

Fatty acids W, 35

Hydrochloric acid W, 35, 38 (hydrogen chloride)

Mineral oil (W) 31, 36, 38, 50, 95
(in some cases NO_X and CO, CO_2)

Organic solvents 71, 95 (vapours)
Oxalic acid W, 71 (vapours may also be present)

Pesticides 35
Polyurethanes 50 (isocyanates, amines, org. solvents)

Silicone oils 36
Sodium hydrogen sulfite W, 31 (sulfur dioxide)
Spray painting (W) (solvent vapours) 33, 35, 38, 50, 71, 9
Sulfuric acid W (sulfur dioxide) 35, 38

Waxes (org. solvents may also be present) 95

Totally 23 incl. 15 water based

W = water based
(W) = water based in some cases

Table 4.7

Number of Aerosols reported from the different Sources of Information.

Source of information	No. of solid aerosols reported	No. of liquid aerosols reported, incl. water based
Literature	82	19 (9 water based)
ATABAS	39	6 (1 water based)
Questionnaires	41	23 (15 water based)

4.3 Alphabetical Listing of Solid and Liquid Aerosols and Main Entry to Branches

The combined results of our investigation have been listed in Tables 4.8 and 4.9 for solid aerosols and liquid aerosols, respectively. In the tables information is given for each aerosol on the branch or branches where the aerosol has been reported present. The branch codes are given on two-digit level.

The tables should be consulted when the reader wants to know whether a specific type of aerosol has been reported to be present in the working environment. Furthermore, the tables can be used as a main entry to the branch or branches in which it has been reported to be present.

Eventually, information is given, as far as possible, on whether gases or vapours are additionally present. For the liquid aerosols (Table 4.9) information is given whether the aerosol is water based, W, or water based in some cases, (W).

Table 4.8. Solid Aerosols in the Working Environment

Actinomycin spores 11
Acrylates 32
Aflatoxins 11, 71
Aluminium 37, 38, 39
Aluminium fluoride 37
Aluminium oxide 37,38,39 (Carbon monoxide may be present)
Ammonium chloride 38
Antigens 11
Antimony 36, 38, 95
Arsenic compounds 32, 33, 36, 37, 38, 50, 91
Asbestos 29, 32, 34, 36, 37, 38, 41, 50, 71, 91, 93, 95
Asphalt 50

Bacteria and fungi (incl. viruses) 11, 32, 92
Benzidine dust 35
Beryllium 37, 38, 41
Bitumen fumes 32, 35, 50

Cadmium and inorg. compounds 37, 38, 39, 93, 95
Cadmium selenosulphide 35
Cadmium sulphide 35, 37
Calcium (incl. salts) 35, 37
Carbon black 35
Chlorophenols (and wood dust) 12, 35
Christobalit 37
Chromium and chromates 32,33,34,35,36,37,38,39,41,50,71,91, 92,93,94 (Carbon monoxide may be present)
Cleaning agents 31
Coal dust 21, 41
Coal tar fumes 41
Cobalt and its inorg. compounds 33, 37, 38
Concrete dust 36
Copper dust, smoke 33,34,35,36,37,38,39,41,50,61,71,91,92, 93,94 (Carbon monoxide may be present)
Cotton dust 31, 32

Drugs 35 (Isopropanol may be present)
Dust 11,22,31,32,34,35,36,37,38,71,92

EDTA 31
Endotoxins 11, 32
Enzymes (trypsin-like) 31
Epoxy dust 33, 38, 39

Fibres 34, 35, 36, 91, 93
Flax 32
Fluorides 35, 37, 38, 92, 93
Flour 11, 31
Fluorochemicals (ammoniumperfluoro octanoic acid) 35
Fly ash 35, 36
Fumes (formaldehyde and phenol vapours) 33
Fungi 11, 34

Table 4.9. Liquid Aerosols in the Working Environment

Arsenicals 33, W

Bacteria 92, W
Bitumen 95
Borine compounds 38, W

Ceramic materials 36, W
Chlorothene 95 (also vapours)
Chromates 33, W
Cleaning agents 31,38,71,92, W (in some cases also vapours)
Cobalt aluminate 36, W
Concrete dust 36, W
Cooking fumes 31
Copper 33, W
Cutting oils 38, (W)

Dust 38, 95 (in some cases also vapours of oil and white spirit, CO in some cases)

Epoxy and polyurethane aerosols 95 (solvent vapours)

Fatty acids 35, W

1.6-Hexyldiisocyanate 38, 50, 91, 95 (vapours)
Hydrochloric acid 35, 38, W (hydrogen chloride)

Ink aerosol 93 (org. solvents)
Ink mist 34 (org. solvents)
Isocyanates 95 (vapours)

Lubricants 38, (W)

MDI 32,33,35,36,37,38,39,41,50,91,93 (vapours)
Mineral oil 31,32,33,34,36,38,50,93,94,95, (W)
(in some cases vapours)

NTA (nitrilotriacetic acid) 38, W

Oil mist 37, 38 (in some cases vapours)
Organic solvents 71, 95 (vapours)
Oxalic acid 71, W (in some cases vapours)

PCBs 41 (in some cases also vapours)
Pesticides 35
Phthalate esters 35
α-Pinen 32 (vapours may be present)
Polyurethanes 50 (vapours)

Silicone oil 36, 37
Sodium hydrogen sulfite 31, W (sulfur dioxide)
Soot 35
Spray painting aerosol 33,35,38,50,71,95, (W)
(in some cases vapours)
Sulfuric acid 34,35,38,93,(W) (sulfur oxides)

TDI 32, 34, 35, 36, 38, 91, 93 (vapours)
Triethanolamine 38, W

Waxes 95 (solvent vapours may be present)

Totally 147 different aerosols have been identified in our investigation. The number of solid aerosols is 105, and there are 41 liquid aerosols. Among the liquid aerosols, 15 have been identified as water based, and furthermore 4 have been identified as being water based under some circumstances. The results are summarized in Table 4.10.

Table 4.10

Number and physical State of identified Aerosols

Total number of aerosols	Liquid aerosols	Water based aerosols
146	41	15 (19)

CHAPTER 5

WHICH AEROSOLS ARE FOUND IN THE DIFFERENT BRANCHES?

5.1 Distribution of Aerosols in the Divisions

In order to give a survey of the occurrence of aerosols in the divisions, the Tables 5.1 (solid aerosols) and 5.2 (liquid aerosols) are presented.

The aerosols are listed alphabetically in each of the divisions. The tables give an impression of the number and types of aerosols occurring in each division. In these tables reference is not given to any additional presence of gases or vapours. For this information the reader is referred to the tables in the previous Chapter 4.

5.2 Number of Solid and Liquid Aerosols, incl. Water based Aerosols, in the branches

Table 5.3 gives the number of solid and liquid aerosols, including water based aerosols, in the divisions. Not surprisingly, it can be seen that the greatest number of aerosols are found in the divisions 31-39 which covers the manufacturing industry (Major division 3), and within these divisions the highest score is found in division 38 which is manufacturing of fabricated metal products, machinery and equipment. In this division, totally 58 aerosols have been found. Among these, 43 are solid aerosols and 15 are liquid aerosols. Of the 15 liquid aerosols, 5 are water based and 10 are other liquid aerosols.

A substantial number of solid as well as liquid aerosols is also reported in division 95. The total number of aerosols in this division is 23, and the major contribution seems to stem from the automobile repairing workshops.

From the columns of the table several conclusions can be drawn with regard to the relative importance of solid, liquid and water based aerosols. It can e.g. be seen that in some divisions, e.g. 11 and 12, no liquid aerosols have been reported. Of particular interest is the information on the number of liquid aerosols, including water based aerosols, in per cent of the total number of aerosols.

The Tables 5.1 and 5.2 should be consulted when the reader wants information on which aerosols have been reported present in a certain branch (division). Table 5.3, together with Fig. 2, is intended to give a comprehensive view of the occurrence of liquid aerosols as compared to solid aerosols.

Of special importance for the choice of respirators for protection against aerosols in the working environment is the number of solid and water based aerosols and their percentage of the total number of aerosols in the working environment. In the present drafts for the forthcoming European standards on respirator filters it has been suggested that in some of the filter classes, filters shall be classified according to their ability to protect against:

1) Solid aerosols, including water based aerosols and
2) Solid and liquid aerosols.

This classification seems reasonable in the light of the results given in the last column of Table 5.3.

Table 5.1

Occurrence of solid aerosols in the different branches, based on data from ATABAS, BST- questionnaires and literature.

Major division 1. Agriculture, hunting, forestry and fishing

11. Agriculture and hunting

Actinomycin spores
Aflatoxins
Antigens
Bacteria
Dust
Endotoxins
Flour
Fungi
Insecticides (pesticides)
Lead
Lipopolysaccharides
Mica
Mineral dust
Organic dust

12. Forestry and logging

Chlorophenols
Organic dust
Wood dust

Major division 2. Mining and quarrying

21. Coal mining

Coal dust

22. Crude petroleum and natural gas production

Dust
Metals
PAH

23. Metal ore mining

MMMF
Quartz
Radioactive aerosol

29. Other mining

Asbestos
Granite dust
Mica
MMMF
Potash dust
Quartz
Talc

Major division 3. Manufacturing

31. Manufacture of food, beverages and tobacco

Cleaning agents
Cotton dust
Dust
EDTA
Enzymes
Flour
Mineral dust
Organic dust
PAH
Phosphoric acid
Quartz
Respirable dust
Sodium hydroxide and sodium compounds
Tea dust
Tobacco dust

32. Textile, weaving apparel and leather industries

Acrylates
Arsenic dust
Asbestos
Bacteria
Bitumen fumes
Chromium
Cotton dust
Dust
Endotoxins
Flax
Fungi
Hemp
Leather dust
Mineral dust
Organic dust
Vegetable dust

33. Manufacture of wood and wood products, including furniture

Arsenic compounds
Chromium and chromates
Cobalt and inorg. compounds
Copper
Epoxy dust
Fumes
Iron oxide
Lead
Mineral dust
MMMF
Organic dust
Tin, inorg.
Wood dust
Zinc oxide

34. Manufacture of paper and paper products; printing and publishing

Asbestos
Chromium and chromates
Copper
Dust
Fibres, non MMMF
Fungi
Lead
Mineral dust
Organic dust
Tin, inorg.
TNF
Zinc oxide

35. Manufacture of chemicals and chemical, petroleum, coal, rubber and plastic products

Benzidine dust
Bitumen fumes
Calcium
Chromium and chromates
Copper
Dust
Drugs
Fibres
Fluorides
Fluorochemicals
Hydroquinones and other benzenediols
Iron oxide
Ispagula powder
Lead

Magnesium and salts
Melamine dust
Mercury and comp.
Mineral dust
MMMF
Organic dust
PAH
Pesticides
Phthalic acid anhydride
Pigments
Polypropylene dust
PVC-dust
Quartz
Rubber dust
Sodium hydroxide and compounds
Soot
Talc
Titanium dioxide
TNT-dust
Welding smoke
Zinc oxide

36. Manufacture of non-metallic mineral products, except products of petroleum and coal

Antimony
Arsenic compounds
Asbestos
Cement dust
Chromium and chromates
Concrete dust
Copper
Dust
Fibres, non MMMF
Fly ash
Iron oxide
Lead
Manganese
MMMF
Metals
Mineral dust
Nickel
Organic dust
Quartz
Resp. dust
Welding smoke
Wood dust
Zinc oxide

37. Basic metal industries

Aluminium
Aluminium fluoride
Aluminium oxide
Arsenic dust
Asbestos
Beryllium
Cadmium and inorg. comp.
Calcium hydroxide
Christobalite
Chromium and chromates
Cobalt
Copper
Dust
Fluorides
Fluorochemicals
Gold
Iron
Iron oxide
Lead
Magnesium
Manganese
Metals
Metal oxides
Mineral dust
MMMF
Molybdenum
Nickel
Nickel oxide
Organic dust
PAH
Quartz
Resp. dust
Silver
Tin, inorg.
Tin, org.
Vanadium pentoxide
Wolfram
Zinc
Zinc oxide

38. Manufacture of fabricated metal products, machinery and equipment

Aluminium
Aluminium oxide
Ammonium chloride
Antimony
Arsenic compounds
Asbestos
Beryllium

Cadmium and inorg. comp.
Chromium and chromates
Cobalt and inorg. comp.
Copper
Dust
Epoxy dust
Fluorides
Iron
Iron oxide
Lead
Lead oxide
Manganese
Manganese dioxides
Metal
Metal oxides
Mica
Mineral dust
MMMF
Nickel
Organic dust
Phosphoric acid
Pottery dust
Quartz
Respirable dust
Silanes
Silver and solub. compounds
Sodium hydroxide and solub. comp.
Soldering smoke
Soot
Tin, inorg.
Tin, org.
Welding smoke
Wolfram
Wood dust
Zinc
Zinc oxide

39. Other manufacturing industries

Aluminium
Aluminium oxide
Cadmium and inorg. comp.
Chromium and chromates
Copper
Epoxy dust
Iron oxide
Lead
Manganese
Mineral dust
MMMF
Nickel
Organic dust
Tin, inorg.
Tin, org.
Total dust
Welding smoke
Zinc oxide

Major division 4. Electricity, gas and water

41. Electricity, gas and steam

Asbestos
Beryllium
Chromium and chromates
Coal dust
Coal tar fumes
Copper
Fly ash (pulverized fuel ash)
Iron oxide
Lead
Mineral dust
MMMF
Nickel
Organic dust
PAH
PCB
Quartz
Respirable dust
Welding smoke
Zinc oxide

Major division 5. Construction

50. Construction

Arsenic compounds
Asbestos
Asphalt
Bitumen fumes
Cement dust
Chromium and chromates
Copper
Iron oxide
Lead
Manganese
Mica
Mineral dust
MMMF
Organic dust
Quartz
Wood dust

Major division 6. Wholesale and retail trade and restaurants and hotels

61. Wholesale trade

Copper
Iron oxide
Lead
Manganese
Mineral dust
MMMF
Organic dust
Respirable dust
Selenium
Zinc oxide

63. Hotels, rooming houses, etc.

PAH

Major division 7. Transport, storage and communication

71. Transport and storage

Aflatoxins
Asbestos
Chromium and chromates
Copper
Dust
Grain dust
Iron oxide
Lead
Mineral dust
MMMF
Organic dust
PAH
Quartz
Zinc oxide

Major division 8. Financing, insurance, real estate and business services

83. Real estates and business services

Organic dust
Quartz

Major division 9. Community, social and personal services

91. Public administration and defence

Arsenic compounds
Asbestos
Chromium and chromates
Copper
Fibres, non MMMF
Iron oxide
Lead
Mineral dust
MMMF
Organic dust
Selenium
Tin, inorg.
Total dust
Wood dust
Zinc oxide

92. Sanitary and similar services

Bacteria (viruses)
Chromium and chromates
Copper
Dust
Fluorides
Iron oxide
Lead
Mineral dust
MMMF
Organic dust
Quartz
Respirable dust
Zinc oxide

93. Social and related community services

Asbestos
Cadmium and inorg. comp.
Chromium and chromates
Copper
Fibres, non MMMF
Fluorides
Insecticides and pesticides
Iron oxide
Lead
Manganese
Mineral dust
MMMF
Nickel
Organic dust
Quartz
Respirable dust

Tin, inorg.
Total dust
Welding smoke
Wood dust
Zinc oxide

94. Recreational and cultural services

Copper
Lead
Mineral dust
Organic dust
PAH
Total dust
Zinc oxide

95. Personal and household services

Antimony
Asbestos
Cadmium and inorg. comp.
Chromium and chromates
Copper
Iron oxide
Lead
[redacted]
Organic dust
Quartz
Tin, org.
Zinc oxide

Table 5.2

Occurrence of liquid aerosols in the different branches, based on data from ATABAS, EST- questionnaires and literature

Major division 1. Agriculture, hunting, forestry and fishing

None

Major division 2. Mining and quarrying

None

Major division 3. Manufacturing

31. Manufacture of food, beverages and tobacco

Cleaning agents W
Cooking fumes (W)

Mineral oil (W)
Sodium hydrogen sulfite W

32. Textile, weaving apparel

MDI
Mineral oil
α-Pinen
TDI

33. Manufacture of wood and wood products, including furniture

Arsenicals W
Chromates W

MDI
Mineral oil

Spray painting (W)

34. Manufacture of paper and paper products; printing and publishing

Ink mist

Mineral oil

Sulfuric acid (W)
TDI

35. Manufacture of chemicals and chemical, petroleum, coal, rubber and plastic products

Fatty acids W
Hydrochloric acid W
MDI
Pesticides
Phthalate esters
Soot
Spray painting (W)
Sulfuric acid (W)
TDI

36. Manufacture of non-metallic mineral products, except products of petroleum and coal

Ceramic materials W
Cobalt aluminate W
Concrete dust W
Copper W
MDI
Mineral oil (W)

Silicone oils
TDI

37. Basic metal industries

MDI

Oil mist

Silicone oil mist

38. Manufacture of fabricated metal products, machinery and equipment

Borine compounds	W
Cleaning agents	W
Cutting oils	(W)
Dust	
1.6-hexyldiisocyanate	
Hydrochloric acid	W
Lubricants	(W)
MDI	
Mineral oil	
NTA (nitrilotriacetic acid)	W
Oil mist	
Spray painting	(W)
Sulfuric acid	(W)
TDI	
Triethanolamine	W

39. Other manufacturing industries

MDI

Major division 4. Electricity, gas and steam

41. Electricity, gas and steam

MDI

PCB's

Major division 5. Construction

50. Construction

1.6-hexyldiisocyanate

MDI

Mineral oil
Polyurethanes
Spray painting (W)

Major division 6. Wholesale and retail trade and restaurants and hotels

None

Major division 7. Transport, storage and communication

71. Transport and storage

Cleaning agents W

Organic solvents
Oxalic acid W

Spray painting (W)

Major division 8. Financing, insurance, real estate and business services

None

Major division 9. Community, social and personal services

91. Public administration and defence

1.6-hexyldiisocyanate

MDI

TDI

92. Sanitary and similar services

Bacteria (viruses) W

Cleaning agents W

93. Social and related community services

Ink aerosol
MDI
Mineral oil
Sulfuric acid (W)
TDI

94. Recreational and cultural services

Mineral oil

95. Personal and household services

Bitumen
Chlorothene
Dust
Epoxy and polyurethane aerosols
1.6-hexyldiisocyanate
Isocyanates
Mineral oil
Organic solvents
Spray painting (W)
Waxes

Table 5.3 Distribution of solid and liquid aerosols, including water based, in the divisions of all economic activities. Data from all sources of information.

ISIC code	Branch	Number of solid aerosols	Number of liquid aerosols	Total number of aerosols	Number of water based aerosols	Number of other liquid aerosols	Number of liquid aerosols in percent of total	Number of solid and water based aerosols	Numbe solid water aeros perce total
11	Agriculture & hunting	14	0	14	0	0	0	14	10
10	Forestry & logging	3	0	3	0	0	0	3	10
21	Coal mining	1	0	1	0	0	0	1	10
22	Crude petro- & natural gas production	3	0	3	0	0	0	3	10
23	Metal ore mining	3	0	3	0	0	0	3	10
29	Other mining	7	0	7	0	0	0	7	10
31	Manufacture of food, beverages & tobacco	15	4	19	2 (4)	2	21	17 (19)	
32	Textile industry	16	4	20	0	4	20	16	
33	Wood and wood products	14	5	19	2 (3)	3	26.3	16 (17)	
34	Paper and printing	12	4	16	(1)	4	25	12 (13)	
35	Chemicals	35	9	44	2 (4)	7	20.5	37 (39)	
36	Non-metallic mineral products	23	8	31	4 (5)	4	25.8	27 (28)	
37	Basic metal industry	38	4	42	0	[illegible]	[illegible]	[illegible]	
38	Fabricated metal products	43	15	58	5 (9)	10	25.9	48 (52)	
39	Other manufacturing industry	18	1	19	0	1	5.2	18	
41	Electricity, gas & water	19	2	21	0	2	9.5	19	
50	Construction	16	5	21	(1)	5	23.8	16 (17)	
61	Wholesale trade	10	0	10	0	0	0	10	1
63	Hotels	1	0	1	0	0	0	1	1
71	Transport & storage	14	4	18	2 (3)	2	22.2	16 (17)	
83	Real estate & business service	2	0	2	0	0	0	2	1
91	Public administration & defence	15	3	18	0	3	16.7	15	
92	Sanitary & similar services	13	2	15	2	0	13.3	15	1
93	Social & related community services	21	5	26	(1)	5	19.2	21 (22)	
94	Recreational & cultural services	7	1	8	0	1	12.5	[illegible]	
95	Personal & household services	13	10	23	(1)	10	43.5	[illegible] (14)	

Number of liquid aerosols in per cent of total number of aerosols in the divisions.

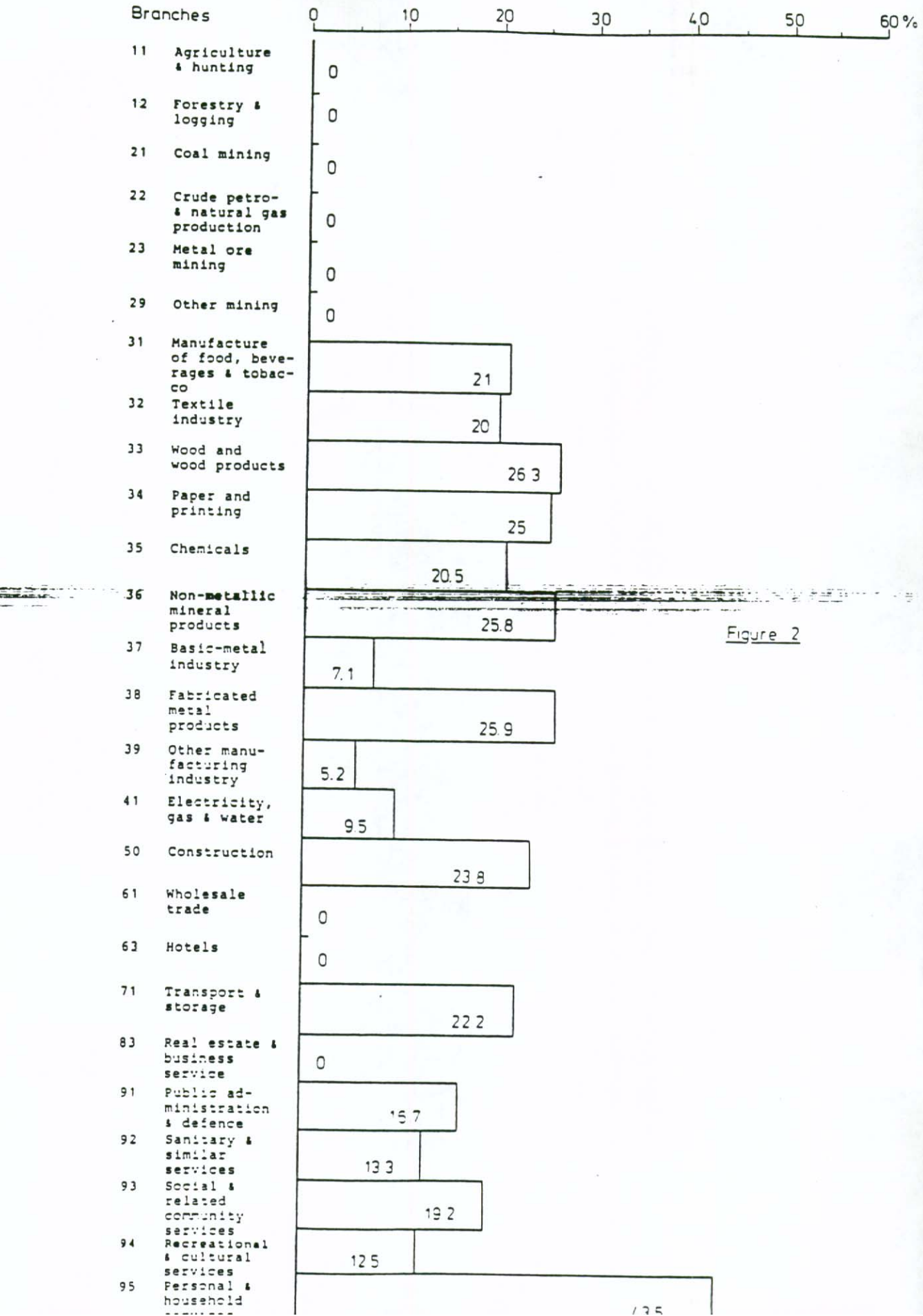

Figure 2

CHAPTER 6

EXPOSURE INDECES

6.1 Exposure Indeces for the Manufacturing Industry in Denmark

The concept of exposure indeces was introduced and explained in Chapter 1, section 1.7, where two examples were given. These examples were presented at an early stage of the investigation and were based on a limited amount of information. In the present context they only serve the purpose of illustrating principles for calculation of exposure indeces.

Exposure indeces can, according to the definition laid down, be used in different ways and at different levels to describe the probability of exposure to certain substances in the working environment. The exposure index of a certain aerosol in a particular branch or group of branches can be calculated or the total exposure index of certain types of substances in all branches can be calculated. As the amount of information is overwhelming in the present investigation, numerous different results can be calculated.

We have chosen to present the exposure indeces for the different solid and liquid aerosols in the manufacturing industry, incl. mining, in Denmark. This corresponds to the major divisions 2 and 3 of the ISIC-code. The indeces for the solid aerosols are given in Table 6.1, and for the liquid aerosols in Table 6.2.

The exposure indeces for each of the solid aerosols have been added up to give a total exposure index for solid aerosols, and the total exposure index for the liquid aerosols have been calculated in the same way. Finally,

Table 6.1

Exposure Indeces for Solid Aerosols in the Manufacturing Industry

Acrylates	23321	
Aluminium	111577	
Aluminium fluoride	4659	
Aluminium oxide	111577	
Ammonium chloride	103079	
Antimony	115986	
Arsenic compounds	163127	
Asbestos	165547	
Bacteria and fungi (incl. viruses)	23321	
Benzidine dust	20841	
Beryllium	107738	
Bitumen fumes	44162	
Cadmium and inorg. compounds	111577	
Cadmium selenosulphide	20841	
Cadmium sulphide	20841	
Calcium (incl. salts)	25500	
Carbon black	20841	
Chlorophenols (and wood dust)	20841	
Christobalit	4659	
Chromium and chromates	208567	
Cleaning agents	58498	
Cobalt and its inorg. compounds	126899	
Concrete dust	12907	
Copper dust, smoke	185246	
Cotton dust	81819	
Drugs	20841	
Dust	244065	
EDTA	58498	
Endotoxins	23321	
Enzymes (trypsin-like)	58498	
Epoxy dust	126079	
Fibres	54508	
Flax	23321	
Fluorides	128579	
Flour	58498	
Fluorochemicals (ammoniumperfluoro octanoic acid)		20841
Fly ash	33748	
Fumes (formaldehyde and phenol vapours)		19161
Fungi	20760	

Gold	4659
Granite dust	821
Hemp	23321
Hydroquinones and other benzenediols	20841
Iron	128579
Iron oxide	124484
Ispagula powder	20841
Lead	185246
Lead oxide	120645
Leather dust	23321
Magnesium	4659
Magnesium salts	20841
Manganese and its compounds	124484
Melamine dust	20841
Metals	120645
Metal oxides	107738
Mica	103900
Mineral dust	267065
MMMF	165307
Molybdenum	4659
Nickel	107738
Nickel oxide	4659
Nickel and its compounds	124484
Organic dust	267065
PAHs	83998
Pesticides	20841
Phosphoric acid	161577
Phthalic acid anhydride	20841
Pigments	20841
Polypropylene	20841
Potash dust	821
Pottery dust	103079
PVC-dust	20841
Quartz (silica)	200805

Silanes	103079
Silver and its soluble compounds	107738
Sodium hydroxide and other sodium containing compounds	182418
Soldering smoke	103079
Soot	123920
Talc	21662
Tea dust	58498
Tin, organic	111577
Tin, inorganic	151498
Titanium dioxide	20841
TNF-dust	20760
TNT-dust	20841
Tobacco dust	58498
Vanadium pentoxide	4659
Vegetable dust (fibres)	23321
Welding smoke	140666
Wolfram	107738
Wood dust	135147
Zinc	107738
Zinc oxide	185246

Table 6.2

Exposure Indeces for Liquid Aerosols in the Manufacturing Industry

Arsenicals	19161
Borine compounds	103079
Ceramic materials	12907
Chromates	19161
Cleaning agents	161577
Cobalt aluminate	12907
Concrete dust	12907
Cooking fumes	58498
Copper	19161
Cutting oils	103079
Dust	103079
Fatty acids	20841
1.6-Hexyldiisocyanate	103079
Hydrochloric acid	123920
Ink mist	20760
Lubricants	103077
MDI	187807
Mineral oil	237726
NTA (nitrilotriacetic acid)	103079
Oil mist	107738
Pesticides	20841
Phthalate esters	20841
α-Pinen	23321
Silicone oil	17566
Sodium hydrogen sulfite	58498
Soot	20841
Spray painting aerosol	143081
Sulfuric acid	144680
TDI	180608
Triethanolamine	103079

a total exposure index for aerosols (liquid and solid) in the manufacturing industry has been calculated. The results have been summarized in Table 6.3.

Table 6.3

Exposure Indeces for Solid Aerosols, Liquid Aerosols and all Aerosols in the Manufacturing Industry, incl. Mining in Denmark

Type of aerosol	Exposure index
Solid	7 324 940
Liquid	2 366 901
All (liquid and solid)	9 691 841

These figures give an impression of the relative importance of solid and liquid aerosols. From the above figures the exposure index for solid aerosols in per cent of the total exposure index for aerosols has been calculated together with the corresponding figure for liquid aerosols. These figures are:

Solid aerosol exposure index in % = 75.6 %

Liquid aerosol exposure index in % = 24.4 %

6.2 Exposure Indeces for the more important Solid and Liquid Aerosols

As it can be seen from the Tables 6.1 and 6.2 some aerosols have high exposure indeces while others have low ones. The exposure index is high if the aerosol has been found to be present in many branches and if many people are employed in these branches. If an aerosol has been reported to be present in only one or few branches,

the exposure index generally will be small. The highest exposure indices for the solid aerosols have been found to be approx. 267000, and the lower ones to be approx. 800. A total of 92 solid aerosols and 30 liquid aerosols were found in the major divisions 2 and 3.

In order to give an impression of the more important aerosols as judged from the magnitude of their exposure indeces, those with values exceeding a 100000 have been listed in the Tables 6.4 and 6.5.

6.3 Exposure Indeces for Aerosols in other Industrialized Countries than Denmark

The exposure indeces as calculated in the preceeding sections have been based on statistical information on the workers' employment in the branches in Denmark as given in Table 2.2 which is an extract of Annex 2.

The employment in the different branches will differ from country to country in absolute numbers. The distribution of the different aerosols in the branches, however, we think will be approximately the same in the major industrialized countries. It therefore should be possible by means of the distributions of aerosols given in the present report to calculate exposure indeces in other countries than Denmark, if the employment in the different branches is known - which generally is the case.

Table 6.4

Exposure Indeces for the more important Solid Aerosols

Aerosol	Exposure index
Mineral dust	267065
Organic dust	267065
Dust	244065
Chromium and chromates	208567
Quartz	200805
Copper	185246
Lead	185246
Zinc oxide	185246
Asbestos	165547
MMMF	165307
Arsenic compounds	163127
Phosphoric acid	161577
Tin, inorg. comp.	151498
Welding smoke	140665
Fluorides	128579
Iron	128579
Cobalt	126829
Epoxy dust	126079
Manganese	124484
Nickel and its compounds	124484
Iron oxide	124484
Soot	123920
Lead oxide	120645
Metal	120645
Aluminium	111577
Aluminium oxide	111577
Cadmium and its inorg. compounds	111577
Tin, org. compounds	111577
Beryllium	107738
Metal oxides	107738
Nickel	107738
Wolfram	107738
Zinc	107738
Silver	107738
Mica	103900
Soldering smoke	103079
Silanes	103079
Pottery dust	103079

Table 6.5

Exposure Indeces for the more important Liquid Aerosols

Aerosol	Exposure Index
Mineral oil	237726
MDI	187807
TDI	180608
Cleaning agents	161577
Sulfuric acid	144680
Spray painting aerosol	143081
Hydrochloric acid	123920
Oil mist	107738
Borine compounds	103079
Cutting oils	103079
Dust	103079
1,6-Hexyldiisocyanat	103079
Lubricants	103079
NTA (nitrilotriacelic acid)	103079
Triethanolamine	103079

CHAPTER 7

IMPORTANT WORKING PROCESSES AND OPERATIONS IN THE DIFFERENT BRANCHES OF TRADE AND INDUSTRY AND RELATED ACTIVITIES

7.1 Working Processes and Products

Working processes and operations can be defined as activities where raw materials or more complex materials are stored, transported or processed in some way. By the processing materials can be changed in e.g. size and shape, and/or materials can be joined together to form a product with certain desired properties. In the present context working processes and operations also include work necessary for running and maintaining the production facilities.

The manufacture of any product implies the use of a number of working processes and operations. Some products are relatively simple and need only few working processes and operations to be finished, e.g. nails, whereas other products are the result of numerous working processes and operations, e.g. an automobile.

Many different types of working processes and operations are used in the different branches (divisions, major groups and groups) of trade and industry, but not all of them are used in all branches. However, the majority of them are being used in more than one branch.

A comprehensive survey of the important working processes has been given in Patty's Industrial Hygiene (Reference 1). The survey discusses typical working processes in typical industries, and refers to the air pollutants of major importance associated with the processes.

Generally, it can be stated that in branches where many different working processes and materials are used, also the biggest number of different air pollutants will be found. This is typically the case in division 38, manufacturing of fabricated metal products, machinery and equipment.

7.2 Information on Working Processes and Products from the Data Bank ATABAS

The data bank ATABAS gives exhaustive information also on the types of working processes and the production in connection with the reported air pollutants. A total of 275 working processes and 281 types of production have been referred to. Unfortunately, the information is available in Danish only. However, it will be possible to extract the necessary information for substances and branches of particular interest, but it will be time consuming and could not be made within the given frames for the present investigation. However, the original outprints in Danish from ATABAS will be available at request for those readers who are particularly interested.

7.3 Information on Working Processes and Branches from the other Sources of Information

Information on working processes, branches and aerosols reported present in the branches is given in Annex 5, in special schemes. In these schemes, branch codes have been given on 4-digit level. This ensures a most detailed picture of the specific branches, working processes and types of aerosols formed in connection with each branch and process.

A list of important working processes has been given in Table 7.1. The processes have been grouped in five categories and listed alphabetically within each category.

At all these processes, aerosols can be formed to a greater or smaller extent, and the particles of the aerosols can consist of the materials which are being processed, or of auxiliary substances used in the process e.g. cutting oils and lubricants. In some of the processes, gases or vapours from the materials and substances will be formed as well, e.g. due to high temperatures. A number of examples have been given in Fig. 1 (page 5) which illustrate the complexity of the formation of air pollutants in the working environment. In order to give an impression of those processes, which we consider being of a more hazardous nature, these have been marked with an "x" in Table 7.1. We consider them specially hazardous, because some of them give rise to large amounts of aerosols of harmful substances whose spreading is difficult to control. In some cases, gases and vapours will be released as well, in large quantities, and in some cases, the pollutants formed are of a highly toxic nature.

Table 7.1

Classification of important working processes.
Processes of particular danger are marked with an "x".

Category	Examples
I Manufacturing processes	
Bending	Iron- and steel plates
Casting x)	Cast iron articles
Crushing	Stones
Cutting x)	Metal & plast materials
Drilling	Metal & plast materials
Folding	Metal plates
Grinding	Chemicals
Melting x)	Lead, copper and brass articles
Milling	Flour
Moulding x)	Metal, rubber and plast materials
Rolling	Metal sheets
Sawing	Wood materials
II Joining processes	
Gluing	Plast objects. Chipboard production
Laminating	Plywood production
Sewing	Wearing appareil
Soldering x)	Electronic equipment
Welding x)	Fabricated metal articles maintenance and repair work

III Surface treatment

a) Cleaning processes	Examples
Cleaning	Maintenance work
Degreasing x)	Metal articles
Desinfection	Food industry
High pressure cleaning x)	Food industry
Polishing	Metal articles
Sand blasting x)	Metal articles
Shot blasting x)	Metal articles

b) Coating processes	
Coating	Dip baths
Electolysis x)	Galvanized articles
Lubrication	Machinery
Printing	Newspapers, books
Spray painting x)	Ships, automobiles

IV Transportation and handling

Bottling operations	Drugs, beverages
Conveyoring	Grains
Filling operations	Chemicals
Handling	Tea, tobacco
Loading and unloading	Coal
Mixing	Fertilizers
Packing	Chemicals
Tanning and similar processes	Leather articles

V Other processes

Chemical processes and production	Chemicals
Construction and building	Concrete buildings
Demolishion work	Buildings
Drying	Pottery work
Fermentation	Medicinal industry
Filtration	Pigments
Freeze drying	Food industry
Grannulation	Chemicals
Insulation work	Polyurethane foam
Mining and drilling	Coal
Spraying x)	Pesticides

References:

1) Patty's Industrial Hygiene and Toxicology.
Volume 1. Third Revised Edition.
John Wiley & Sons.
New York. 1978, p. 1149-1220

CHAPTER 8

REFERENCES

8.1 Tables giving References to the Sources of Information

In order to enable the reader to seek further detailed information on certain aerosols, their reported presence and their properties the Tables 8.1 (solid aerosols) and 8.2 (liquid aerosols) have been prepared. In each of the tables the divisions have been listed, and for each division the aerosols have been listed alphabetically. For each aerosol one or more references are given. An "A" refers to ATABAS (the data bank) and a "Q" refers to the questionnaires from the Health Service Centres. All figures given in the tables refer to the list given in section 8.2. A total of 227 references have been given covering different periodicals, monographs and research reports. In a number of cases reference has been given to papers of more general interest which could be of importance for further studies.

Table 8.1

References, Solid Aerosols

Major division 1. Agriculture, hunting, forestry and fishing

11. Agriculture and hunting

Actinomycin spores 1, 2
Aflatoxins 3, 14
Antigens 4
Bacteria 5, 11
Dust 6, 7, 8, 9, 10
Endotoxins 5
Flour 210
Fungi 5
Insecticides (pesticides) 12, 13
Lead A
Lipopolysaccharides 50
Mica 15
Mineral dust A
Organic dust 6, 7, 8, 9, 10, 16

12. Forestry and logging

Chlorophenols 17
Organic dust 16
Wood dust 18

Major division 2. Mining and quarrying

21. Coal mining

Coal dust 20, 21, 22, 23

22. Crude petroleum and natural gas production

Dust 24, 25
Metals 24
PAH 24

23. Metal ore mining

MMMF A
Quartz A
Radioactive aerosol 26

29. Other mining

Major division 3. Manufacturing

31. Manufacture of food, beverages and tobacco

32. Textile, weaving apparel and leather industries

33. Manufacture of wood and wood products, including furniture

Arsenic compounds A
Chromium and chromates Q, A
Cobalt and inorg. compounds A
Copper A, Q
Epoxy dust A
Fumes Q
Iron oxide A
Lead A
Mineral dust A
MMMF A
Organic dust A
Tin, inorg. A
Wood dust A, Q, 56, 57, 58, 59, 60, 19
Zinc oxide A

34. Manufacture of paper and paper products; printing and publishing

Asbestos 61
Chromium and chromates A
Copper A
Dust 62
Fibres, non MMMF A
Fungi 62
Lead A, 63
Mineral dust A
Organic dust A
Tin, inorg. A
TNF 64
Zinc oxide A

35. Manufacture of chemicals and chemical, petroleum, coal, rubber and plastic products

Benzidine dust 65
Bitumen fumes 46
Calcium Q
Chromium and chromates A, 66
Copper A, Q
Dust Q, 67, 68, 69, 70, 71, 72, 214
Drugs Q
Fibres 73, 74
Fluorides Q
Fluorochemicals 75
Hydroquinones and other benzenediols 76
Iron oxide A
Ispagula powder 77
Lead A, Q, 63

Magnesium and salts A
Melamine dust Q
Mineral dust A
MMMF A, 79
Organic dust A, Q, 16
PAH 80, 203
Pesticides Q
Phthalic acid anhydride A
Pigments 72, 81, 82
Polypropylene dust Q
PVC-dust Q
Quartz A
Rubber dust 71
Sodium hydroxide and compounds A, 83
Soot 71
Talc 71
Titanium dioxide 81
TNT-dust 84, Q
Welding smoke Q
Zinc oxide A

36. Manufacture of non-metallic mineral products, except products of petroleum and coal

~~Antimony A~~
~~Arsenic compounds A~~
Asbestos 85, 86, 43
Cement dust Q
Chromium and chromates A
Concrete dust Q
Copper A
Dust Q, 88, 215, 216
Fibres, non MMMF A, 89
Fly ash Q
Iron oxide A, Q
Lead A, 90, 63
Manganese A
MMMF A, Q, 91, 74
Metals Q
Mineral dust A, 88
Nickel A
Organic dust A
Quartz A, Q, 33, 216
Resp. dust A
Welding smoke Q
Wood dust Q
Zinc oxide A

37. Basic metal industries

38. Manufacture of fabricated metal products, machinery and equipment

Cadmium and inorg. comp. A, 133
Chromium and chromates A, 135, 136, 137
Cobalt and inorg. comp. A
Copper A, Q, 137
Dust Q, 139, 217
Epoxy dust A, Q
Fluorides A
Iron Q, 135
Iron oxide A, Q
Lead A, Q, 130, 141, 142,, 143, 144, 145, 146, 63
Lead oxide Q
Manganese A
Manganese dioxides A, 147
Metal 148
Metal oxides Q
Mica 15
Mineral dust A
MMMF A
Nickel 136, 137, 135, 158
Organic dust A
Phosphoric acid A, 149
Pottery dust 150
Quartz A, Q, 151
Respirable dust A
Silanes 152
Silver and solub. compounds A
Sodium hydroxide and solub. comp. A
Soldering smoke 217, 218
Soot Q, 153
Tin, inorg. A
Tin, org. A
Welding smoke A, Q, 135, 136, 137, 138, 154, 155, 156, 218
Wolfram 102
Wood dust A, 130
Zinc A
Zinc oxide A

39. Other manufacturing industries

Aluminium A
Aluminium oxide A
Cadmium and inorg. comp. A
Chromium and chromates A
Copper A
Epoxy dust A
Iron oxide A
Lead A
Manganese A
Mineral dust A
MMMF A
Nickel A
Organic dust A
Tin, inorg. A
Tin, org. A
Total dust A
Welding smoke A
Zinc oxide A

Major division 4. Electricity, gas and water

41. Electricity, gas and steam

Asbestos A, 159
Beryllium 159
Chromium and chromates 159
Coal dust 160, 219
Coal tar fumes 161
Copper A
Fly ash (pulverized fuel ash) Q, 162, 163, 164
Iron oxide A
Lead A, 164
Mineral dust A
MMMF A
Nickel 164, 159
Organic dust
PAH 159, 165
PCB 159
Quartz A
Respirable dust A
Welding smoke 219
Zinc oxide A

Major division 5. Construction

50. Construction

Arsenic compounds A
Asbestos A, Q, 167, 168, 169, 170
Asphalt A
Bitumen fumes 46, 172
Cement dust Q, 220, 221
Chromium and chromates A
Copper A
Iron oxide A
Lead A
Manganese A
Mica 15
Mineral dust A
MMMF A, Q, 173, 220
Organic dust A
Quartz A, 33
Wood dust A, Q

Major division 6. Wholesale and retail trade and restaurants and hotels

61. Wholesale trade

Copper A
Iron oxide A
Lead A
Manganese A
Mineral dust A
MMMF A
Organic dust A
Respirable dust A
Selenium A
Zinc oxide A

63. Hotels, rooming houses, etc.

PAH 203

Major division 7. Transport, storage and communication

71. Transport and storage

Aflatoxins 14, 3
Asbestos 131, 174
Chromium and chromates A
Copper A
Dust 175, 176, 202, 222, 223
Grain dust 177
Iron oxide A
Lead A, 176
Mineral dust A
MMMF A
Organic dust A
PAH 176
Quartz A
Zinc oxide A

Major division 8. Financing, insurance, real estate and business services

83. Real estates and business services

Organic dust 16, 224
Quartz A

Major division 9. Community, social and personal services

91. Public administration and defence

Arsenic compounds A
Asbestos A
Chromium and chromates A
Copper A
Fibres, non MMMF A
Iron oxide A
Lead A
Mineral dust A
MMMF A
Organic dust A
Selenium A
Tin, inorg. A
Total dust A
Wood dust A
Zinc oxide A

92. Sanitary and similar services

Bacteria (viruses) Q, 179, 180
Chromium and chromates A
Copper A
Dust Q, 225
Fluorides A
Iron oxide A
Lead A
Mineral dust A
MMMF A
Organic dust 16
Quartz A
Respirable dust A
Zinc oxide A

93. Social and related community services

Asbestos A
Cadmium and inorg. comp. A
Chromium and chromates A
Copper A
Fibres, non MMMF A
Fluorides A
Insecticides and pesticides 181
Iron oxide A
Lead A
Manganese A
Mineral dust A
MMMF A
Nickel A
Organic dust A
Quartz A
Respirable dust A

Tin, inorg. A
Total dust A
Welding smoke A
Wood dust A
Zinc oxide A

94. Recreational and cultural services

Copper A
Lead A
Mineral dust A
PAH A
Total dust A
Zinc oxide A

95. Personal and household services

Antimony A
Asbestos A, 182, 183
Cadmium and inorg. comp. A
Chromium and chromates A, 185
Copper A
Iron oxide A
Lead A, 146, 63, 145, 185
~~Mineral dust A~~
~~MMMF A~~
Organic dust A
Quartz A
Tin, org. A
Zinc oxide A

Table 8.2

References, Liquid Aerosols

Major division 1. Agriculture, hunting, forestry and fishing

None

Major division 2. Mining and quarrying

None

Major division 3. Manufacturing

31. Manufacture of food, beverages and tobacco

Cleaning agents Q, 35, 36, 207, 208
Cooking fumes 209

Mineral oil Q
Sodium hydrogen sulfite Q

32. Textile, weaving apparel

MDI A
Mineral oil A
α-Pinen A
TDI A

33. Manufacture of wood and wood products, including furniture

Arsenicals Q
Chromates Q

MDI A
Mineral oil A

Spray painting Q

34. Manufacture of paper and paper products; printing and publishing

Ink mist 186

Mineral oil A

Sulfuric acid A
TDI A

35. Manufacture of chemicals and chemical, petroleum, coal, rubber and plastic products

Fatty acids Q
Hydrochloric acid Q
MDI A
Pesticides Q
Phthalate esters 187, 188
Soot
Spray painting Q
Sulfuric acid Q
TDI A

36. Manufacture of non-metallic mineral products, except products of petroleum and coal

Ceramic materials	Q
Cobalt aluminate	Q, 215
Concrete dust	Q
Copper	Q
MDI	A
Mineral oil	Q
Silicone oils	Q
TDI	A

37. Basic metal industries

MDI A

Oil mist 189

Silicone oil mist Q

38. Manufacture of fabricated metal products, machinery and equipment

Borine compounds 36, 149
Cleaning agents Q, 36, 149, 218, 227
Cutting oils 190, 191, 92, 193
Dust Q
1.6-hexyldiisocyanate A
Hydrochloric acid Q
Lubricants 190
MDI A

Mineral oil A, Q
NTA (nitrilotriacetic acid) 149, 35, 36
Oil mist 189, 191
Spray painting 185, 194
Sulfuric acid Q, A
TDI A
Triethanolamine 149

39. Other manufacturing industries

MDI A

Major division 4. Electricity, gas and steam

41. Electricity, gas and steam

MDI A

PCB's 195, 196

Major division 5. Construction

50. Construction

1.6-hexyldiisocyanate A

MDI A

Mineral oil A, Q
Polyurethanes Q, 197
Spray painting Q, 185, 194

Major division 6. Wholesale and retail trade and restaurants and hotels

None

Major division 7. Transport, storage and communication

71. Transport and storage

Cleaning agents Q

Organic solvents Q
Oxalic acid 175

Spray painting Q, 185, 194

Major division 8. Financing, insurance, real estate and business services

None

Major division 9. Community, social and personal services

91. Public administration and defence

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MDI A, 197

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92. Sanitary and similar services

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MDI A
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94. Recreational and cultural services

Mineral oil A

95. Personal and household services

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CHAPTER 9

DISCUSSION AND CONCLUSIONS

9.1 The Importance of Solid and Liquid Aerosols in the Working Environment

Solid as well as liquid aerosols occur frequently in the working environment.

They can consist of substances of different nature and chemistry having different toxicological effects. Some substances are highly toxic and can give rise to acute intoxications after short-term exposure, while other substances have cronic effects which are induced only after long-term exposure.

The present study, however, has not been concerned with a grading of the toxicological properties of aerosols in the working environment. Its only concern has been to attemt to give a survey of the solid and liquid aerosols one can expect to find in the working environment, whether these occur frequently or less frequently, and whether rather few or many workers are potentially exposed to these aerosols.

The survey given in Chapter 4 gives information on which aerosols one can expect to find in the working environment. A total of 146 solid aerosols and 41 liquid aerosols have been reported present in the working environment. Among the liquid aerosols, 15 were reported as being water based, and 4 additional ones as being water based occasionally.

It is likely that it will be asked why relatively few liquid aerosols have been described in literature and elsewhere as compared to the number of solid aerosols.

There may be several possible reasons for that:

1) The number of liquid aerosols in the working environment is actually much smaller than the number of solid aerosols, and this fact is reflected in the smaller number of liquid aerosols reported.

2) The existence of a number of different liquid aerosols in the working environment has not been reported because:

   a) their existence has not yet been recognized or
   b) their existence has been recognized, but measurements have not been made, because these aerosols in many cases are more difficult to measure than solid aerosols.

We think, based on our findings as presented here, that actually the number of liquid aerosols is much smaller than the number of solid aerosols.

We also think that the existence of some liquid aerosols has not yet been realized, but this will also apply to some degree to the solid aerosols.

From the answers received in the questionnaires, it is also clear that a number of liquid aerosols have been realized as existing, but measurements have not been carried out, because the aerosols are short-lived due to e.g. fast evaporation, and therefore need advanced analytical measuring equipment for their characterization.

We therefore conclude that solid aerosols constitute a greater hazard in the working environment, solely because their number far exceeds the number of liquid aerosols.

The exposure indeces as calculated and presented in Chapter 5 gives an indication of the probability of exposure to each of the aerosols listed, and to solid aerosóls and liquid aerosols taken as separate groups and compared to one another. The total exposure index for solid aerosols calculated in per cent of the total exposure index for all aerosols is 75.6, and the corresponding total exposure index for liquid aerosols is 24.6.

We think that these figures indicate that the number of situations where workers in the manufacturing industry are exposed to solid aerosols in their working environment far exceeds the number of situations where they are exposed to liquid aerosols.

We also think that the magnitude of the exposure indeces indicates that exposure to solid aerosols will occur approx. three times as frequently as exposure to liquid aerosols in the manufacturing industry.

9.2 Selection and Use of Respirators for Protection against Aerosol Hazards

As referred to in Chapter 5, the present draft for a European standard for particle filters (reference 1) allows for a subclassification of filters in two groups, one containing filters for protection against solid aerosols, including water based aerosols, and one containing filters for protection against solid and liquid aerosols in general.

Referring to the discussion in Section 1.5 we think that the results of the present investigation support the idea of having this subclassification for the particle filters.

One argument against this subclassification has been that it may be difficult for the user to make an assessment of the aerosol hazard facing him, and therefore it may be difficult for him to choose the right filter.

This may be true to some degree, but we are of the opinion that, referring to Table 4.9 and Fig. 1, there is a great danger that on many occasions where liquid aerosols are present in the working environment there will be additional risk of inhalation of gases or vapours. In these situations, combined filters should be used instead of only particle filters, and we think that neglect of this fact is a bigger problem than generally anticipated, and it may well be a bigger problem for the user than the problem of estimating whether an aerosol consists of solid particles or liquid particles.

References

1) Document CEN/TC 79/SG 4-168 E.
Draft prEN 143, August 1986.
Respiratory Protective Devices. Particle Filters, Requirements, Testing, Marking.
European Standard.

ANNEX 1

INDEXES TO THE INTERNATIONAL STANDARD INDUSTRIAL CLASSIFICATION OF ALL ECONOMIC ACTIVITIES

Present version of ISIC				Corresponding major group and group(s) of preceding version of ISIC	Differences in scope of major groups and groups between present and preceding version of ISIC
Division	Major Group	group	Title of category		
			Major Division 1. Agriculture, Hunting, Forestry and Fishing		
11			Agriculture and Hunting	01, 03	Excluded are cemetery upkeep; veterinary services and animal hospitals and care centres; and leasing and renting out of agricultural machinery and equipment.
	111	1110	Agricultural and livestock production	011	Landscape gardening is included.
	112	1120	Agricultural services	012	Landscape gardening; cemetery upkeep; veterinary services and animal hospitals and care centres; and leasing and renting out of agricultural equipment and machinery without drivers are excluded.
	113	1130	Hunting, trapping and game propagation	030	
12			Forestry and Logging	02	
	121	1210	Forestry	021	
	122	1220	Logging	022	
13	130		Fishing	04	Excluded are factory-type vessels engaged in processing only which can be treated as separate establishments.
		1301	Ocean and coastal fishing	041, 042	Excluded are factory-type vessels engaged in processing only, i.e., not also catching and taking fish, crustacea and other ocean and coastal water products, which can be treated as separate establishments; and the operation of cultivated oyster, pearl and layer beds and farms.
		1302	Fishing not elsewhere classified	043	The operation of cultivated oyster, pearl and layer beds and farms is included.
			Major Division 2. Mining and Quarrying		Excluded in the case of each of the groups of this major division are the activities performed on a fee or contract basis, of developing and preparing mineral properties and sites or prospecting for minerals.
21	210	2100	Coal Mining	110	Included is the agglomeration, at the mining site, of coal or lignite into briquettes and packaged fuels.
22	220	2200	Crude Petroleum and Natural Gas Production	130	
23	230		Metal Ore Mining	12	
		2301	Iron ore mining	121	
		2302	Non-ferrous metal ore mining	122	
29	290		Other Mining	14, 19	
		2901	Stone quarrying, clay and sand pits	140	
		2902	Chemical and fertilizer mineral mining	192	
		2903	Salt mining	191	
		2909	Mining and quarrying not elsewhere classified	199	
			Major Division 3. Manufacturing		
31			Manufacture of Food, Beverages and Tobacco		
	311-312		Food manufacturing	20, 312	
		3111	Slaughtering, preparing and preserving meat	201	The fabrication of meat pies and puddings is included
		3112	Manufacture of dairy products	202	
		3113	Canning and preserving of fruits and vegetables	203	
		3114	Canning, preserving and processing of fish, crustacea and similar foods	204	Included are factory-type vessels engaged in the processing only of fish, crustacea and other ocean and coastal water products which can be treated as separate establishments

Present version of ISIC				Corresponding major group and group(s) of preceding version of the ISIC	Differences in scope of major groups and groups between prese and preceding version of ISIC
Division	Major group	Group	Title of category		
		3115	Manufacture of vegetable and animal oils and fats	312 and part of 209	The part of 209 consists of the manufacture of olive oil, margarine, compound cooking fats and blended table and salad
		3116	Grain mill products	205	
		3117	Manufacture of bakery products	206	The manufacture of macaroni, spaghetti, noodles and similar products is included.
		3118	Sugar factories and refineries	207	
		3119	Manufacture of cocoa, chocolate and sugar confectionary	208	
		3121	Manufacture of food products not elsewhere classified	209	Excluded are the manufacture of meat pies and puddings;olive oil, margarine, compound cooking fats and table and salad oil and of prepared feeds for animals and fowl.
		3122	Manufacture of prepared animal feeds	Part of 209	
	313		Beverage industries	21	Excluded is ethyl alcohol distilled from sulphite residues of pulp manufacturing; included is the bottling of natural spring and mineral water at the source.
		3131	Distilling, rectifying and blending spirits	211	Excluded is ethyl alcohol distilled from sulphite residues of pulp manufacturing
		3132	Wine industries	212	
		3133	Malt liquors and malt	213	
		3134	Soft drinks and carbonated waters industries	214	The bottling of natural spring and mineral waters at the sour included.
	314	3140	Tobacco manufactures	220	
32			Textile, Wearing Apparel and Leather Industries		
	321		Manufacture of textiles	23, 244	Excluded are the repair services listed below, in respect of each group.
		3211	Spinning, weaving and finishing textiles	231	Excluded is the manufacture of woven carpets and rugs
		3212	Manufacture of made-up textile goods except wea ing apparel	244	Excluded is the repair for the general public of the household made-up textile goods of this group.
		3213	Knitting mills	232	Excluded are establishments primarily engaged in the repair of knit wear for the public.
		3214	Manufacture of carpets and rugs	Part of 231, part of 239	Excluded is the repair of carpets, rugs and mats for the gene public
		3215	Cordage, rope and twine industries	233	
		3219	Manufacture of textiles not elsewhere classified	239	Excluded is the manufacture of unwoven carpets and rugs and mats and matting, except of rubber. Included is the manufact of linoleum and other hard-surfaced floor covering (excluding rubber, plastic or cork) irrespective of type of backing material.
	322	3220	Manufacture of wearing apparel, except footwear	243	The manufacture of umbrellas and canes and the repair of wearing apparel for the general public, are excluded.
	323		Manufacture of leather and products of leather, leather substitutes and fur, except footwear and wearing apparel	29	Establishments specializing in the repair of luggage, handbags and other leather goods for the public, are excluded.
		3231	Tanneries and leather finishing	291	
		3232	Fur dressing and dyeing industries	292	
		3233	Manufacture of products of leather and leather substitutes, except footwear and wearing apparel		Establishments specializing in the repair of luggage, handbags and other leather goods for the general public, are excluded.
	324	3240	Manufacture of footwear, except vulcanized or moulded rubber or plastic footwear	241	The production of footwear by moulding plastic material and the manufacture of footwear made entirely of wood are excluded.
33			Manufacture of wood and wood Products, including furniture	25	Includes the manufacture of footwear made entirely of wood
	331		Manufacture of wood and wood and cork products, except furniture		

Present version of ISIC				Corresponding major group and group(s) of preceding version of the ISIC	Differences in scope of major groups and groups between present and preceding version of ISIC
Division	Major group	Group	Title of category		
		3311	Sawmills, planing and other wood mills	251	
		3312	Manufacture of wooden and cane containers and small cane ware	252	
		3319	Manufacture of wood and cork products not elsewhere classified	259	Includes the manufacture of footwear made entirely of wood
	332	3320	Manufacture of furniture and fixtures, except primarily of metal	260	Excluded are the manufacture of furniture and fixtures primarily of metal and the production of moulded plastic furniture
34			Manufacture of Paper and Paper Products; Printing and Publishing		
	341		Manufacture of paper and paper products	27	
		3411	Manufacture of pulp, paper and paperboard	271	The manufacture of off-machine coated, glazed, gummed and laminated paper is excluded.
		3412	Manufacture of containers and boxes of paper and paperboard	Part of 272	
		3419	Manufacture of pulp, paper and paperboard articles not elsewhere classified	272	Excludes the manufacture of containers, boxes and bags of paper and paperboard.
	342	3420	Printing, publishing and allied industries	280	
35			Manufacture of Chemicals and Chemical, Petroleum, Coal, Rubber and Plastic Products		
	351		Manufacture of industrial chemicals	311, part of 319	The manufacture of white spirit and composite thinners is excluded; the manufacture of ethyl alcohol from sulphite residues of pulp manufacturing is included.
		3511	Manufacture of basic industrial chemicals except fertilizer	Part of 311	The manufacture of white spirits and composite thinners is excluded; the manufacture of ethyl alcohol from sulphite residues of pulp manufacturing is included.
		3512	Manufacture of fertilizers and pesticides	Part of 311, part of 319	
		3513	Manufacture of synthetic resins, plastic materials and man-made fibres except glass	Part of 311	
	352		Manufacture of other chemical products	313, 319	The manufacture of composite thinners is included.
		3521	Manufacture of paints, varnishes and lacquers	313	The manufacture of composite thinners is included.
		3522	Manufacture of drugs and medicines	Part of 319	
		3523	Manufacture of soap and cleaning preparations, perfumes, cosmetics and other toilet preparations	Part of 319	
		3529	Manufacture of chemical products not elsewhere classified	Part of 319	Included is the manufacture of prepared photo-chemical materials and sensitized film, paper and cloth.
	353	3530	Petroleum refineries	321	The manufacture of white spirits is included.
	354	3540	Manufacture of miscellaneous products of petroleum and coal	329	Excludes the manufacture of coal and lignite briquettes and packaged fuels at mining sites. Includes coke ovens in iron and steel works which it is feasible to treat as separate establishments.
	355		Manufacture of rubber products	30	
		3551	Tyre and tube industries	Part of 300	
		3559	Manufacture of rubber products not elsewhere classified	Part of 300	
	356	3560	Manufacture of plastic products not elsewhere classified	Part of 399 and certain activities from a number of other groups.	
36			Manufacture of Non-Metallic Mineral Products, except Products of Petroleum and Coal		
	361	3610	Manufacture of pottery, china and earthenware	333	

Present version of ISIC				Corresponding major group and group(s) of preceding version of ISIC	Differences in scope of major groups and groups between pres and preceding version of ISIC
Division	Major group	Group	Title of category		
	362	3620	Manufacture of glass and glass products	332	
	369		Manufacture of other non-metallic mineral products	331, 334, 339	
		3691	Manufacture of structural clay products	331	
		3692	Manufacture of cement, lime and plaster	334	Included is the manufacture of Keene's and similar cement an of lime and plaster
		3699	Manufacture of non-metallic mineral products not elsewhere classified	339	Excluded is the manufacture of Keene's and similar cement li and plaster.
37			Basic Metal Industries		
	371	3710	Iron and steel basic industries	341	Excluded are coke ovens in iron and steel works which it is sible to treat as separate establishments.
	372	3720	Non-ferrous metal basic industries	342	
38			Manufacture of Fabricated Metal Products, Machinery and Equipment		
	381		Manufacture of fabricated metal products, except machinery and equipment	35, part of 26	Excluded are the manufacture of small arms and accessories a specialized repair and servicing of hand tools, locks and ot hardware, and cutlery for the general public. Included are t manufacture of small metal ware; and the production of machi precision hand tools.
		3811	Manufacture of cutlery, hand tools and general hardware	Part of 350	Excluded are the specialized repair and servicing of hand to locks and other hardware and cutlery for the general public. Included is the manufacture of machinists' precision hand to
		3812	Manufacture of furnitures and fixtures primarily of metal	Part of 260	
		3813	Manufacture of structural metal products	Part of 350	
		3819	Manufacture of fabricated metal products except machinery and equipment not elsewhere classified	Part of 350	Excluded is the manufacture of small arms and accessories. cluded is the manufacture of small metal ware.
	382		Manufacture of machinery except electrical	36	Included are the fabrication and assembly of digital and ana computers, and accessories; the manufacture of small arms an accessories; and the production of all engines and turbines which are not made in establishments mainly engaged in manufacturing transport equipment or in manufacturing specia engines and turbines for given types of transport equipment. Excluded are the production of vacuum cleaners, floor polish and waxers and of certain electrical household cooking and laundry equipment; establishments specializing in the repair servicing and installation of household refrigerators, house hold washing machines and laundering equipment, household cooking equipment, etc. and of typewriters for the general public; and the production of machinists' precision hand too
		3821	Manufacture of engines and turbines	Part of 360	Included is the production of all engines and turbines which are not made in establishments mainly engaged in manufacturi transport equipment or in manufacturing specialized engines and turbines for given types of transport equipment.
		3822	Manufacture of agricultural machinery and equipment	Part of 360	
		3823	Manufacture of metal and wood working machinery	Part of 360	Excluded is the manufacture of machinists' precision hand to
		3824	Manufacture of special industrial machinery and equipment except metal and wood working machinery	Part of 360	
		3825	Manufacture of office, computing and accounting machinery	Part of 360	Included is the fabrication and assembly of digital and anal computers and accessories. Excluded is the repair of type- writers for the general public.
		3829	Machinery and equipment except electrical not elsewhere classified	Part of 360	Included is the manufacture of small arms and accessories. Excluded are the production of vacuum cleaners, floor polish and waxers and certain electrical household cooking equipment and establishments specializing in the repair, servicing and installation of household refrigerators, household washing machines and laundering equipment, household cooking equipment, etc.
	383		Manufacture of electrical machinery apparatus, appliances and supplies	37	Included are the manufacture of vacuum cleaners, floor polis and waxers and certain electrical household cooking equipmen and the production of gramophone records and pre-recorded magnetic tapes. Excluded are the fabrication and assembly o

Present version of ISIC				Corresponding major group and group(s) of preceding version of ISIC	Differences in scope of major groups and groups between present and preceding version of ISIC
Division	Major group	Group	Title of category		
					digital and analog electronic computers and accessories and establishments specializing in the repair, servicing and installation of radio and television sets, gramophones, tape recorders and household and personal electrical appliances for the general public.
		3831	Manufacture of electrical industrial machinery and apparatus	Part of 370	
		3832	Manufacture of radio, television and communication equipment and apparatus	Part of 370	Excluded are the fabrication and assembly of digital and analog electronic computers and accessories; and establishments specializing in the repair, servicing and installation of radio and television sets, gramophones and tape recorders for the general public. Included is the production of gramophone records and pre-recorded magnetic tapes.
		3833	Manufacture of electrical appliances and housewares	Part of 370	Included is the manufacture of vacuum cleaners, floor polishers and mixers and certain household cooking equipment. Excluded are establishments specializing in the repair of household and personal electrical appliances for the general public.
		3839	Manufacture of electrical apparatus and supplies not elsewhere classified	Part of 370	
	384		Manufacture of transport equipment	38	Excluded are group 384 (Repair of motor vehicles) and the repair of motorcycles, bicycles and other vehicles for the general public. The manufacturing of engines and turbines for transport equipment is covered in the categories of the major group only if carried on in establishments primarily engaged in fabricating and assembling the specified transport equipment or in producing specialized engines or turbines for the specified transport equipment.
		3841	Shipbuilding and repairing	381	
		3842	Manufacture of railroad equipment	382	
		3843	Manufacture of motor vehicles	383	
		3844	Manufacture of motorcycles and bicycles	385	Excluded are establishments specializing in the repair of motorcycles and bicycles for the general public.
		3845	Manufacture of aircraft	386	
		3849	Manufacture of transport equipment not elsewhere classified	389	Excluded are establishments engaged in the repair of baby carriages, sleighs, etc..
	385		Manufacture of professional and scientific and measuring and controlling equipment not elsewhere classified, and of photographic and optical goods	391, 392, 393	Excluded are the production of photo-chemical materials and sensitized film plates and paper; and establishments specializing in the repair of cameras, binoculars and photographic equipment, and watches and clocks for the general public
		3851	Manufacture of professional and scientific, and measuring and controlling equipment not elsewhere classified	391	
		3852	Manufacture of photographic and optical goods	392	Excluded are the production of photo-chemical materials and sensitized film, plates and paper; and establishments specializing in the repair of cameras, binoculars and photographic equipment for the general public.
		3853	Manufacture of watches and clocks	393	Excluded are establishments specializing in the repair of watches and clocks for the general public
39	390		Other Manufacturing Industries	394, 395, 399	Excluded are the moulding and extruding of plastic goods; the fabrication of small metal ware; the production of gramophone records and pre-recorded magnetic tapes; and establishments primarily engaged in repairing jewellery, musical instruments, athletic goods, toys, fountain pens, etc. for the general public. Included is the production of umbrellas and canes.
		3901	Manufacture of jewellery and related articles	394	Excluded are establishments primarily engaged in the repair of jewellery.
		3902	Manufacture of musical instruments	395	Excluded are the production of gramophone records and pre-recorded magnetic tapes; and establishments primarily engaged in the repair of musical instruments for the general public.
		3903	Manufacture of sporting and athletic goods	Part of 399	Excluded are the production of these goods by moulding or extruding plastic materials; and the repair of sporting and athletic goods for the general public.
		3909	Manufacturing industries not elsewhere classified	Part of 399	Excluded are the production of the goods by moulding or extruding plastic materials; and the repair of the goods for the general public

Present version of ISIC				Corresponding major group and group(s) of preceding version of ISIC	Differences in scope of major groups and groups between present and preceding version of ISIC
Division	Major group	Group	Title of category		
			Major Division 4. Electricity, Gas and Water		
41	410		Electricity, Gas and Steam	51	Included are establishments which sell a significant amount of electricity to others, as well as produce electricity for the parent enterprise.
		4101	Electric light and power	511	Included are establishments which sell a significant amount of electricity to others, as well as produce electricity for the parent enterprise.
		4102	Gas manufacture and distribution	512	
		4103	Steam and hot water supply	513	
42	420	4200	Water Works and Supply	521	
			Major Division 5. Construction		
50	500	5000	Construction	400	Included are the activities of preparing and constructing mining sites and drilling crude oil and natural gas wells on a fee or contract basis; and unit of enterprises which are primarily engaged in construction and which can be separately reported.
			Major Division 6. Wholesale and Retail Trade and Restaurants and Hotels		
61	610	6100	Wholesale Trade	611	Excluded is the bottling of spring and mineral water at the sour
62	620	6200	Retail Trade	612	Included is the renting of household and personal goods to the general public.
63			Restaurants and Hotels		
	631	6310	Restaurants, cafés and other eating and drinking places	852	Included are [illegible] operated as independent businesses, and dining and cooking facilities in plants and offices which can be separately reporte
	632	6320	Hotels, rooming houses, camps and other lodging places	853	
			Major Division 7. Transport, Storage and Communication		
71			Transport and Storage		
	711		Land transport	711-714, 719	Excluded are dining-car services operated as an independent busi and ambulance services. Included is the leasing and rental of r road cars.
		7111	Railway transport	711	Included are suburban railroads. Excluded is dining-car service operated as an independent business.
		7112	Urban, suburban and inter-urban highway passenger transport	712	Excluded are suburban railroads.
		7113	Other passenger land transport	713	Excluded are the rental of automobiles without drivers; and ambulance services
		7114	Freight transport by road	Part of 714	
		7115	Pipeline transport	719	
		7116	Supporting services to land transport	Part of 714	Included are the rental of automobiles without drivers; and the leasing and rental of railroad cars.
	712		Water transport	715, 716	Included is the leasing and rental of ships.
		7121	Ocean and coastal water transport	715, part of 716	
		7122	Inland water transport	Part of 716	
		7123	Supporting services to water transport	Part of 716	Included is the leasing and rental of ships.
	713		Air transport	717	Included is the leasing and rental of aircraft
		7131	Air transport carriers	Part of 717	
		7132	Supporting services to air transport	Part of 717	Included is the leasing and rental of aircraft
	719		Services allied to transport	718, 72	Excluded are the leasing and rental of railroad cars, ships and aircraft.
		7191	Services incidental to transport	718	Excluded are the leasing and rental of railroad cars, ships and aircraft
		7192	Storage and warehousing	720	
72	720	7200	Communication		

Present version of ISIC				Corresponding major group and group(s) of preceding version of ISIC	Differences in scope of major groups and groups between present and preceding version of ISIC
Division	Major group	Group	Title of category		
			Major Division 8. Financing, Insurance, Real Estate and Business Services		
81	810		Financial Institutions	62	
		8101	Monetary institutions	Part of 620	
		8102	Other financial institutions	Part of 620	
		8103	Financial services	Part of 620	
82	820	8200	Insurance	630	
83			Real Estate and Business Services		
	831	8310	Real estate	640	
	832		Business services except machinery and equipment rental and leasing	83	Included are establishments primarily engaged in geological surveys and prospecting on a fee or contract basis. Excluded are the leasing and rental of machinery and equipment; and authors, music composers and other artists who work on own account (are self-employed).
		8321	Legal services	831	Included are notaries public.
		8322	Accounting, auditing and bookkeeping services	832	Excluded are establishments primarily engaged in data processing and tabulating services of a general character on a fee or contract basis.
		8323	Data processing and tabulating services	Part of 832	
		8324	Engineering, architectural and technical services	833	Included are establishments primarily engaged in geological sur- [illegible] on a fee or contract basis.
		8325	Advertising services	Part of 839	
		8329	Business services, except machinery and equipment rental and leasing, not elsewhere classified	Part of 839	Excluded are notaries public; and authors, music composers and other artists who work on own account (are self-employed).
	833	8330	Machinery and equipment rental and leasing	Part of 839	Included is the rental and leasing of agricultural machinery and equipment.
			Major Division 9. Community, Social and Personal Services		
91	910	9100	Public Administration and Defence	810	
92	920	9200	Sanitary and Similar Services	522	Included are char, chimney and window cleaning, janitor, exterminating, fumigating and disinfecting, and similar services.
93			Social and Related Community Services		
	931	9310	Education services	821	
	932	9320	Research and scientific institutes	823	
	933		Medical, dental, other health and veterinary services	822, part of [illegible]	Included are ambulance services
		9331	Medical, dental and other health services	822	Included are ambulance services
		9332	Veterinary services	Part of 012	
	934	9340	Welfare institutions	825	
	935	9350	Business, professional and labour associations	826	
	939		Other social and related community services	824, 829	
		9391	Religious organizations	824	
		9399	Social and related community services not elsewhere classified	829	
94			Recreational and Cultural Services		
	941		Motion picture and other entertainment services	841 - 842	Included are authors, music composers and artists who work on own account (are self-employed).
		9411	Motion picture production	Part of 841	
		9412	Motion picture distribution and projection	Part of 841	
		9413	Radio and television broadcasting	Part of 842	Excludes are entertainers and producers of programmes for radio and television who work on own account.

Present version of ISIC				Corresponding major group and group(s) of preceding version of ISIC	Differences in scope of major groups and groups between pres and preceding version of ISIC
Division	Major group	Group	Title of category		
		9414	Theatrical producers and entertainment services	Part of 842	Excluded are actors, entertainers and directors of plays who work on own account.
		9415	Authors, music composers, and other independent artists not elsewhere classified	Part of 839, part of 842	
	942	9420	Libraries, museums, botanical and zoological gardens, and other cultural services not elsewhere classified	827	
	949	9490	Amusement and recreational services not elsewhere classified	843	Included is the operation of football, racing and similar po
95			Personal and Household Services		
	951		Repair services not elsewhere classified	242, 384, parts of certain other groups	
		9511	Repair of footwear and other leather goods	242, part of 293	
		9512	Electrical repair shops	Part of 370 and of 380	
		9513	Repair of motor vehicles and motorcycles	384, part of 385	
		9514	Watch, clock and jewellery repair	Part of 395 and of 394	
		9519	Other repair shops not elsewhere classified	Parts of 350, 392, 395 and 399	
	952	9520	Laundries, laundry services, and cleaning and dyeing plants	854	Included are the parts of 243, 244 and 252 consisting of the specialized repair of wearing apparel and household textiles for the general public.
	953	9530	Domestic services	851, part of 859	
	959		Miscellaneous personal services	855, 856 and part of 859	Excluded are rental of household and personal goods to the g public; char, chimney and window cleaning, disinfecting and exterminating and janitorial services, operation of football racing and similar pools; and domestic services furnished by business establishments. Included is the upkeep of cemeteri
		9591	Barber and beauty shops	855	
		9592	Photographic studios, including commercial photography	856	
		9599	Personal services not elsewhere classified		Excluded are rental of household and personal goods to the g public; char, chimney and window cleaning, disinfecting and exterminating and janitorial services, operation of football racing and similar pools; and domestic services furnished by business establishments. Included is the upkeep of cemeteri
96	960	9600	International and Other Extra-Territorial Bodies		
			Major Division 0. Activities not Adequately Defined		
0	000	0000	Activities not adequately defined.		

ANNEX 2

MANUFACTURING EMPLOYMENT IN DENMARK

Tabel 8. Antal virksomheder, antal beskæftigede (årsgennemsnit), antal arbejdstimer og lønudgift i industrien 1984

ISIC 1968	Industrigruppe	Antal virksomheder 1	Antal beskæftigede i alt (3 + 4 + 5) 2	Antal beskæftigede indehavere 3
29	**Råstofudvinding**[2]	**82**	**1 127**	**20**
29011, 13	Grusgrave, stenbrud, kalk- og kridtbrud	72	779	17
29030, 90	Saltudvinding og anden ikke- metalisk råstofudvinding	10	348	3
3	**Industri i alt**	**6 735**	**379 477**	**1 444**
31	**Nærings- og nydelsesmiddelindustri**	**841**	**75 331**	**113**
31111	Svineslagterier inkl. tilhørende kødkonservesald. og pølsemagerier	59	16 849	–
31112	Kødvare- og kødkonservesfabrikker	36	3 964	4
31113, 15	Kreatursslagterier og talgsmelterier	17	844	14
31117	Fjerkræslagterier	20	1 675	4
31121	Mejerier	186	7 176	8
31122	Smelteostfabrikker	16	702	2
31123	Mælkekondenseringsfabrikker	15	1 430	–
31124	Konsummælkefabrikker	16	1 138	–
31130	Grønt- og frugtkonservesfabrikker	47	2 758	1
31141	Rygning og saltning af fisk	20	620	4
31142	Fiskehermetik-, fiskefars- og fiskefiletfabrikker (inkl. dybfrysning af fisk)	83	8 015	14
[illegible]	Oliemøller og margarinefabrikker	[illegible]	[illegible]	[illegible]
[illegible]	Fiskemelsfabrikker	[illegible]	[illegible]	[illegible]
[illegible]	Destruktionsanstalter og kødmelsfabrikker	[illegible]	[illegible]	[illegible]
31160	Møller	15	1 214	–
31171	Brødfabrikker	41	1 749	14
31172–73, 79	Kiks-, vaffel- og kagefabrikker samt anden fremstilling af bagervarer	29	2 356	13
31180	Sukkerfabrikker og -raffinaderier	7	2 351	–
31190	Chokolade- og sukkervarefabrikker	31	3 743	14
31211	Kartoffelmels- og andre stivelsesfabrikker	7	427	–
31219	Fremstilling af næringsmidler i øvrigt	48	1 786	10
31220	Fremstilling af færdige foderstoffer	49	1 005	3
31310	Sprit- og likørfabrikker	6	755	–
31330	Bryggerier og maltfabrikker	27	8 489	–
31340	Mineralvandsfabrikker	15	761	5
31400	Tobaksfabrikker	14	2 146	–
32	**Tekstil-, beklædnings- og læderindustri**	**717**	**29 512**	**222**
32111	Uldspinderier og -væverier	15	735	2
32112	Bomuldsspinderier og -væverier	14	1 064	2
32113	Fremstilling af garner og stoffer af kemofibre	12	1 774	–
32115–16	Andre spinderier og væverier i øvrigt	10	307	2
32117	Tekstilfarverier og -imprægneringsfabrikker	14	900	–
32123	Flag- og teltfabrikker (inkl. sejlmagerier)	27	648	4
32124	Fremstilling af gardiner, sengetæpper og linned	11	228	7
32121, 29	Tekstilvareindustri i øvrigt	41	1 226	7
32130	Trikotagefabrikker	164	5 609	73
32140	Tæppefabrikker	19	1 114	4
32151	Reblagerier	7	379	–
32152	Fiskenetfabrikker	18	378	2
32190	Anden tekstilindustri	7	265	–
32211	Herrekonfektionsfabrikker	54	3 081	10
32212	Kjolekonfektionsfabrikker	122	4 354	43
32213	Konfektionsfabrikker for dameovertøj	44	2 224	17
32214	Skjortefabrikker	6	238	–
32215, 19	Konfektionsindustri i øvrigt	45	1 175	20
32294	Buntmagerier	13	435	3
32293, 95–96, 99	Anden beklædningsindustri i øvrigt	7	123	3
32310	Garverier	7	360	2
32330	Lædervarefabrikker	25	732	9
32401	Skofabrikker	18	1 671	8
32403	Træsofabrikker	13	276	8
32409	Skoindustri i øvrigt	3	216	–

Anm. Antal virksomheder exkl. hjælpeenheder. Antal beskæftigede og arbejdstimer inkl. hjælpeenheder, exkl. hjemmearbejdere.
[1] Som følge af afrunding kan summen af de enkelte tal afvige fra det i tabellen anførte totaltal. [2] Exkl. olieudvinding og -efterforskning.

Antal beskæftigede		Arbejdstimer for arbejdere[1]	Lønudgift			
Funktionærer	Arbejdere		I alt (8 + 9 + 10)	Funktionærer	Arbejdere	Hjemmearbejdere m.m.
4	5	6	7	8	9	10
		1 000	1 000 kr.			
286	821	1 510	164 327	49 291	114 365	671
187	575	1 058	110 745	30 475	79 660	610
99	246	451	53 582	18 816	34 705	61
110 968	267 065	446 025	55 761 781	20 278 342	35 160 322	322 117
18 720	58 498	97 189	11 135 466	3 040 023	8 079 050	16 393
2 323	14 526	24 159	2 569 733	398 680	2 170 954	99
811	3 149	5 542	620 982	147 484	473 169	329
138	692	1 235	145 215	25 793	119 113	309
208	1 463	2 289	191 915	34 787	156 894	234
1 200	5 958	11 298	1 090 958	203 883	883 575	3 500
109	591	1 025	90 676	18 108	72 022	546
462	968	1 802	224 041	80 223	143 749	69
364	774	1 399	176 347	61 541	114 609	197
1 018	1 737	3 001	395 437	173 727	220 465	1 245
116	500	779	77 373	21 343	55 767	263
940	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
188	[illegible]	999	121 950	35 782	85 875	313
76	294	562	65 150	14 291	50 826	33
480	734	1 270	187 772	87 101	100 019	652
316	1 417	2 565	279 911	56 810	221 193	1 908
434	1 909	2 939	291 486	75 329	215 920	237
607	1 744	3 010	328 174	112 846	215 328	-
1 378	2 351	3 752	515 904	235 517	277 619	2 768
209	218	372	76 182	40 606	35 499	77
819	957	1 631	261 169	140 892	119 973	304
351	651	1 243	158 078	63 635	93 927	516
351	404	652	123 968	64 470	58 495	1 003
2 122	6 366	10 255	1 485 131	465 405	1 019 718	8
206	550	933	117 228	35 178	81 950	100
508	1 638	2 587	294 114	94 737	199 334	43
5 969	23 321	36 266	3 464 885	995 267	2 397 720	71 898
112	621	1 042	102 936	19 483	83 356	97
274	788	1 224	139 700	48 385	91 251	64
459	1 315	2 201	249 034	82 173	166 490	371
84	221	351	37 720	14 901	22 175	644
181	719	1 245	124 730	33 897	90 567	266
191	453	704	78 562	31 559	46 703	300
50	171	293	27 772	7 334	20 115	323
292	937	1 405	141 587	45 702	93 403	2 482
1 040	4 496	6 950	631 562	177 652	428 133	25 777
360	750	1 314	176 596	74 759	101 531	306
107	272	453	52 705	20 255	32 450	-
82	294	510	52 539	14 550	37 583	366
72	193	346	43 342	13 378	29 955	9
532	2 539	3 813	333 545	82 115	248 660	2 770
723	3 588	5 250	441 727	110 545	315 978	15 104
392	1 815	2 664	231 964	58 096	167 764	8 114
44	194	282	24 190	6 899	17 129	162
195	960	1 487	125 143	29 599	85 326	11 118
129	303	471	51 096	19 062	30 780	1 254
36	84	129	12 540	5 150	6 899	491
92	268	437	47 739	15 873	31 742	124
160	563	978	82 029	23 239	56 475	2 255
293	1 372	2 157	196 453	45 533	149 553	1 370
45	225	373	30 047	[illegible]	22 914	54
34	182	288	28 567	[illegible]	20 588	187

Tabel 8 (fortsat). Antal virksomheder, antal beskæftigede (årsgennemsnit), antal arbejdstimer og lønudgift i industrien 1984

ISIC 1968	Industrigruppe	Antal virksomheder 1	Antal beskæftigede: I alt (3 + 4 + 5) 2	Antal beskæftigede: Indehavere 3
33	**Træ- og møbelindustri**	735	23 989	254
33111-12	Savværker og træimprægneringsanstalter	80	1 592	26
33113	Fremstilling af spånplader, finér m.v.	25	1 191	4
33114	Fremstilling af bygningsartikler	97	5 137	20
33121	Træemballagefabrikker	32	585	10
33191, 97	Trævare- og ligkistefabrikker	49	950	24
33192-93, 98	Træindustri i øvrigt	14	272	7
33201	Træ- og polstermøbelfabrikker	430	14 075	161
33203	Madrasfabrikker	8	187	2
34	**Papir- og grafisk industri**	831	33 507	247
34110	Papir- og papfabrikker	12	2 104	-
34120	Papir- og papemballagefabrikker	68	5 481	12
34191	Tapetfabrikker	3	95	-
34199	Papir- og papvareindustri i øvrigt	35	1 224	7
34211-12	Reproduktionsanstalter og sætterier	111	1 745	30
34221	Bogtrykkerier	265	4 897	101
34222	Offsettrykkerier (plantryk)	[illegible]	[illegible]	[illegible]
34223	Serigrafiske trykkerier	[illegible]	[illegible]	[illegible]
34224, 29	Anilintrykkerier og trykkerier i øvrigt	31	[illegible]	[illegible]
34230	Bogbinderier	79	1 872	35
34240	Dagblade	50	10 369	-
35	**Kemisk industri m.m.**	847	37 247	63
35111	Fremstilling af ilt og andre industrigasser	13	488	-
35119	Anden fremst. af kemiske grundstoffer og primære kemiske forbindelser	20	4 477	-
35121	Fremstilling af kunstgødning	4	1 171	-
35122	Fremstilling af færdigblandede bekæmpelsesmidler	5	146	-
35131	Fremstilling af basisplast	20	649	2
35132-33	Fremstilling af plader, folier og rør m.v. af plast samt klæbestrimler	61	4 225	4
35210	Farve- og lakfabrikker	34	2 749	1
35220	Medicinalvarefabrikker	43	6 816	-
35231	Sæbefabrikker	28	2 014	-
35232	Kosmetikfabrikker	11	317	-
35293	Fremstilling af stearinlys	17	323	3
35291-92, 94-95, 99	Anden kemisk industri	37	843	4
35300	Mineralolieraffinaderier	3	559	-
35401-02, 09	Fremstilling af asfalt, tagpap og andre olie- og kulprodukter	68	1 142	-
35510	Vulkaniseringsanstalter m.v.	22	527	7
35590	Gummifabrikker	24	1 964	1
35601	Fremstilling af plastemballage	70	3 935	5
35609	Anden fremstilling af plastvarer	167	4 902	36
36	**Sten-, ler- og glasindustri**	400	17 678	56
36101	Porcelæns- og fajancefabrikker	6	2 117	2
36102	Fremstilling af keramik og lervarer	22	453	13
36201-02	Glasværker og glasbearbejdning	36	2 302	7
36911	Teglværker	45	1 344	9
36912	Fremstilling af molerprodukter m.v.	4	264	-
36921-22	Cementfabrikker samt kalk- og kridtværker	5	1 547	-
36923	Mørtelfabrikker	15	91	-
36991	Stenhuggerier	16	170	3
36992	Fremstilling af færdigblandet beton	69	853	1
36993	Betonvarefabrikker	136	5 519	18
36994-96, 99	Fremstilling af andre sten-, ler- og glasprodukter	46	3 018	3
37	**Jern- og metalværker og støberier**	79	6 053	16
37101	Jern- og stålværker	12	2 105	3
37102	Jernstøberier	27	2 025	4
37201	Metalværker	14	781	1
37202	Metalstøberier	26	1 142	8

Antal beskæftigede		Arbejdstimer for arbejdere¹	Lønudgift			
Funktionærer	Arbejdere		I alt (8 + 9 + 10)	Funktionærer	Arbejdere	Hjemmearbejdere m.m.
4	5	6	7	8	9	10
		1 000	1 000 kr.			
4 574	19 161	32 498	3 036 693	755 759	2 269 138	11 995
312	1 254	2 129	197 819	51 084	145 843	892
234	953	1 641	156 887	38 244	118 255	388
1 108	4 009	6 861	706 595	186 995	518 361	1 239
86	489	795	68 381	14 862	53 169	350
188	738	1 287	119 977	31 589	87 528	860
63	202	336	33 966	10 559	23 297	110
2 553	11 361	19 191	1 729 990	417 014	1 305 050	7 926
30	155	258	23 278	5 412	17 636	230
12 500	20 780	35 042	5 909 409	2 357 967	3 415 803	135 639
477	1 527	2 815	341 315	97 069	244 246	-
1 318	4 151	6 921	871 753	240 770	630 452	531
43	52	89	13 171	6 536	6 620	15
424	793	1 311	182 348	77 913	103 589	846
537	1 178	2 101	331 551	114 592	214 163	2 796
1 474	3 322	5 625	832 414	274 607	550 802	7 005
1 273	2 735	4 754	755 111	262 634	487 418	5 058
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
493	636	1 096	218 864	98 418	120 082	404
377	1 480	2 410	279 245	71 016	207 351	878
5 902	4 467	7 355	2 017 090	1 066 040	813 287	117 763
18 343	20 841	34 668	5 876 608	3 060 015	2 799 702	16 891
227	261	464	80 140	42 534	37 519	87
2 216	2 261	3 730	767 118	434 576	331 875	667
457	714	1 374	208 442	92 898	115 544	-
80	66	113	22 780	14 639	8 128	13
208	441	760	95 597	36 479	58 668	450
1 216	3 005	4 964	661 327	233 930	425 708	1 689
1 793	955	1 599	448 197	316 169	131 518	510
4 057	2 759	4 388	1 163 683	785 531	377 694	458
1 168	846	1 391	315 742	207 066	106 815	1 881
175	142	229	46 299	31 445	14 553	301
64	256	405	34 107	8 948	25 064	95
508	331	562	135 581	89 042	46 128	411
503	56	85	116 114	109 623	6 164	327
450	692	1 269	181 313	84 274	96 854	185
181	339	582	70 375	27 595	42 527	253
480	1 483	2 433	277 456	82 883	191 806	2 767
1 059	2 871	4 693	567 026	196 039	368 482	2 505
1 503	3 363	5 929	685 311	266 344	414 665	4 302
4 715	12 907	21 866	2 600 371	846 951	1 747 558	5 862
425	1 690	2 804	292 365	73 984	218 381	-
69	371	608	49 871	9 840	39 928	103
830	1 765	2 935	325 670	94 953	228 667	2 050
279	1 056	1 925	193 226	50 150	142 597	479
52	212	372	40 166	10 995	29 171	-
537	1 010	1 758	249 157	100 930	148 018	209
35	56	95	13 625	6 267	7 253	105
47	120	198	21 946	6 412	15 239	105
325	527	977	131 093	54 539	75 792	562
1 371	4 130	7 091	819 504	240 582	577 857	965
1 045	1 970	3 312	463 838	198 099	264 595	1 144
1 378	4 659	7 832	859 779	249 478	609 616	685
553	1 549	2 614	314 376	99 960	214 334	182
348	1 673	2 809	277 952	63 572	213 981	399
252	518	888	125 970	49 513	76 409	51
215	919	1 512	141 468	36 433	104 892	143

Tabel 8 (fortsat). Antal virksomheder, antal beskæftigede (årsgennemsnit), antal arbejdstimer og lønudgift i industrien 1984

ISIC 1968	Industrigruppe	Antal virksomheder 1	Antal beskæftigede	
			I alt (3 + 4 + 5) 2	Indehavere 3
38	Jern- og metalindustri	2 350	150 524	438
38110	Fremstilling af værktøj, beslag samt bestik	79	2 990	20
38121	Metalmøbelfabrikker	84	3 971	18
38122	Lampefabrikker	27	965	6
38131	Fremstilling af jern- og metalkonstruktioner (ekskl. stationære tanke)	169	7 552	35
38132	Fremstilling af stationære beholdere	39	2 654	12
38133	Rørfabrikker	14	1 150	2
38190	Fremstilling af centralvarmekedler	13	802	4
38191	Metalemballagefabrikker	34	3 334	2
38192	Fremstilling af ovne og radiatorer m.m.	27	1 047	2
38193	Armaturfabrikker	39	3 205	-
38194	Fremstilling af bolte, skruer og søm	17	990	1
38195–96	Galvaniseringsanstalter og industrilakering	84	1 812	26
38197	Fremstilling af ljedre og kæder	11	295	3
38198	Fremstilling af tråd og trådvarer	22	576	7
38199	Fremstilling af andre jern- og metalvarer	101	2 478	14
38210	Fremstilling af motorer (bortset fra elektr. motorer og skibsmotorer)	6	219	3
38220	Fremstilling af landbrugsmaskiner	96	6 210	12
38231	Fremstilling af maskiner til træbearbejdning	20	415	11
38232	Fremstilling af maskiner til metalbearbejdning	84	2 722	23
38233	Fremstilling af støberimaskiner og maskiner til valsning af metaller	5	187	-
38241	Fremstilling af tekstilmaskiner og tilbehør	7	533	4
38242	Fremstilling af maskiner og app. til næringsmiddel- og kemisk industri	117	6 079	27
38243	Fremstilling af maskiner til skotøjs-, papir- og papvareindustrien samt grafisk industri	15	570	3
38249	Fremstilling af industrimaskiner i øvrigt	41	2 998	6
38251	Fremstilling af kontormaskiner	15	1 775	3
38252	Vægtfabrikker	8	173	2
38292–93	Fremstilling af husholdningsmaskiner	12	2 298	-
38294	Fremstilling af internt transportmateriel	109	5 246	19
38295	Fremstilling af tandhjul og transmissionsaksler	16	587	7
38299	Underleverandørfabrikker med jern- og metalforarbejdning	80	1 771	27
38291, 95, 97, 99	Maskinfabrikker i øvrigt	266	24 289	32
38311	Fremstilling af el-motorer samt el-apparatur til maskiner	83	5 806	10
38321	Radio- og fjernsynsfabrikker	25	3 447	-
38329	Fremstilling af telemateriel i øvrigt	84	7 700	9
38331–32	Fremstilling af el-husholdningsmaskiner	16	1 419	4
38392	Akkumulator- og tørelementfabrikker	8	1 109	1
38391, 93, 99	Kabelfabrikker og fremstilling af elektrisk materiel i øvrigt	50	5 155	5
38411	Jernskibsværfter	22	12 124	-
38412	Træskibsværfter og bådebyggerier	82	1 872	47
38413	Skibsmotorfabrikker	14	3 282	1
38419–20	Fremstilling af skibs- og banemateriel i øvrigt	39	2 241	2
38422	Karrosserifabrikker m.v.	73	3 234	13
38429	Bilindustri i øvrigt	28	1 502	6
38440	Cykel- og knallertfabrikker m.v.	9	556	-
38491–92	Anden transportmiddelindustri	10	301	2
38511–12	Fremstilling af medicinske instrumenter og apparater m.v.	39	3 540	3
38513	Fremstilling af ikke-elektriske måleinstrumenter	20	1 049	3
38514	Fremstilling af elektriske måleinstrumenter	41	4 436	2
38520	Fremstilling af optisk og fotografisk udstyr	27	1 438	1
39	Anden industri	135	5 636	35
39011	Guld- og sølvvarefabrikker	22	549	7
39020	Fremstilling af musikinstrumenter	9	203	8
39030	Fremstilling af sportsrekvisitter	12	318	-
39091	Legetøjsfabrikker	11	2 112	3
39092	Fremstilling af børstevarer	10	422	2
39093	Pibefabrikker	5	105	3
39094–97, 99	Anden industri i øvrigt	66	1 927	12
2 + 3	Råstofudvinding og industri i alt 1984	6 817	380 804	1 464
2 + 3	Råstofudvinding og industri i alt 1983	6 571	362 741	1 642

Antal beskæftigede		Arbejds-timer for ar-bejderel	Lønudgift			
Funktio-nærer	Arbej-dere		I alt (8 + 9 + 10)	Funktio-nærer	Arbej-dere	Hjemmear-bejdere m.m.
4	5	6	7	8	9	10
		1 000	1 000 kr.			
47 007	103 079	174 448	22 116 685	8 679 739	13 386 147	48 799
685	2 285	3 865	400 000	120 349	278 717	934
1 079	2 876	4 863	549 148	192 017	355 859	1 270
317	842	1 028	125 756	53 528	70 802	1 426
1 870	5 647	10 236	1 176 652	347 508	826 874	2 270
798	1 844	3 135	400 017	148 441	251 308	268
328	822	1 451	176 350	58 643	117 649	58
178	620	1 023	105 296	30 100	75 157	39
766	2 566	4 282	497 427	152 643	344 334	450
244	801	1 336	140 166	39 743	100 382	41
824	2 381	3 976	445 013	144 473	300 076	464
211	778	1 300	137 085	37 777	98 883	425
324	1 262	2 321	242 877	57 765	184 212	900
80	212	360	44 360	15 757	27 746	857
160	409	712	79 100	26 942	51 676	482
579	1 885	3 149	322 754	96 640	224 314	1 800
90	126	224	35 501	17 409	18 092	-
1 585	4 513	7 812	839 005	284 240	553 191	1 574
116	288	523	51 924	19 080	32 793	51
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1 145
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	74
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	96
2 066	3 986	6 967	935 821	391 790	543 233	798
197	370	663	93 780	40 221	53 440	119
806	2 186	3 680	426 369	142 880	282 899	590
1 261	511	895	295 500	229 168	66 175	257
78	93	148	25 894	14 284	11 463	147
481	1 817	2 950	318 969	88 067	230 272	630
1 657	3 570	6 235	799 334	320 052	478 267	1 015
117	463	765	82 529	22 928	59 361	240
341	1 403	2 400	239 932	52 060	177 113	759
8 478	15 779	25 232	3 540 575	1 518 646	2 014 354	7 575
2 217	3 379	5 629	823 562	408 020	412 434	3 108
1 070	2 377	4 001	471 545	194 715	269 837	6 993
3 170	4 521	7 489	1 157 848	604 232	550 283	3 333
363	1 052	1 798	194 570	63 475	131 057	38
358	750	1 265	152 714	62 794	89 814	106
1 980	3 170	5 248	780 799	367 209	411 173	2 417
2 602	9 522	15 899	1 899 123	517 766	1 381 190	167
310	1 515	2 540	241 766	49 499	191 664	603
1 348	1 933	3 252	533 078	269 482	263 576	20
553	1 686	2 922	328 541	100 264	227 940	337
768	2 453	4 237	448 377	133 834	313 866	677
358	1 138	1 932	199 320	60 270	138 453	597
150	508	830	80 474	26 028	54 214	232
51	248	401	37 807	9 130	28 555	122
1 125	2 512	4 260	499 960	212 277	285 421	1 262
491	555	919	154 069	93 957	59 790	322
2 461	1 973	3 230	747 795	490 525	255 328	942
653	784	1 269	213 558	120 161	92 629	769
1 762	3 839	6 218	761 685	294 143	453 587	13 955
185	357	579	72 923	28 465	43 700	758
25	170	307	29 483	4 946	24 439	98
135	183	309	45 152	22 997	22 355	800
662	1 447	2 282	276 729	105 565	167 846	2 318
98	322	518	51 091	15 342	34 663	76
16	96	137	12 840	2 759	10 029	52
841	1 274	2 103	272 477	112 069	150 555	9 853
111 254	267 886	447 534	55 925 108	20 328 633	35 274 687	322 788
107 075	254 024	425 568	50 909 238	18 445 953	32 142 542	320 743

ANNEX 3

BRANCHES COVERED BY THE HEALTH SERVICE

Branches covered by the Health Service

Major Division 2

2901	Stone quarrying, clay and sand pits.
2902	Chemical and fertilizer mineral mining.
2903	Salt mining.
2909	Mining and quarrying not elsewhere classified.

Major Division 3

3111	Slaughtering, preparing and preserving meat.
3114	Canning, preserving and processing of fish, crustacea and similar foods.
3119	Manufacture of cocoa, chocolate and sugar confectionary.
3140	Tobacco manufacture.
3211	Spinning, weaving and finishing textiles.
3212	Manufacture of made-up textile goods, except wearing appareil.
3213	Knitting mills.
3214	Manufacturing of carpets and rugs.
3215	Cordage rope and twine industries.
3219	Manufacture of textiles not elsewhere classified.
~~3220~~	~~Manufacture of wearing appareil, except footwear.~~
3231	Manufacture off leather and products of leather, leather substitutes and fur, except footwear and wearing appareil.
3232	Fur dressing and dyeing industries.
3233	Manufacture of products of leather and leather substitutes, except footwear and wearing appareil.
3240	Manufacture of footwear, except vulcanized or moulded rubber or plastic footwear.
3511	Manufacture of basic industrial chemicals except fertilizers.
3512	Manufacture of fertilizers and pesticides.
3513	Manufacture of synthetic resins, plastic materials and man-made fibres except glass.
3521	Manufacture of paints, varnishes and lacquers.
3522	Manufacture of drugs and medicine.
3523	Manufacture of soap and cleaning preparations, perfumes, cosmetics and other toilet preparations.

3529	Manufacture of chemical products not elsewhere classified.
3530	Petroleum refineries.
3540	Manufacture of miscellaneous products of petroleum and coal.
3551	Tyre and tube industry.
3559	Manufacture of rubber products not elsewhere classified.
3610	Manufacture of potting, china and earthenware.
3620	Manufacture of glass and glass products.
3691	Manufacture of structural clay products.
3699	Manufacture of non-metallic mineral products not elsewhere classified.
3710	Iron and steel basic industries.
3720	Non-ferrous metal basic industries.
3839	Manufacture of electrical apparatus and supplies not elsewhere classified.
3841	Shipbuilding and repair.
3843	Manufacture of motor vehicles.

Major Division 5

5000 Construction.

Major Division 9

9200 Sanitary and similar services.

9513 Repair of motor vehicles and motorcycles.

Arbejdsministeriets bekendtgørelse nr. 365 af 13. august 1980

Bekendtgørelse om ændring af bilag til bekendtgørelse om bedriftssundhedstjeneste

(Udbygning af bedriftssundhedstjeneste)

I henhold til bekendtgørelse nr. 288 af 22. juni 1978 § 2, fastsættes følgende:

Ved afgrænsning af brancher omfattet af pligten til at oprette bedriftssundhedstjeneste anvendes Danmarks Statistiks erhvervsgrupperingskode af 1. april 1977.

§ 1

I. Den 1. juli 1978 omfattes følgende virksomheder af bekendtgørelsen:

1. Læderindustri og garverier. 323

a. Garverier. 32310

1) herunder læderfarverier.

b. Pelsberedning m.v. 32320

1) herunder garvning, farvning, rensning og lignende af egne pelsskind samt slagtning af pelsdyr (pelsning). Fremstilling af beklædningsgenstande hører under anden beklædningsindustri 3229, 32294.

c. Lædervarefabrikker. 32330

1) herunder fremstilling af kufferter, tasker, mapper, punge, bælter og urremme m. m. af læder, plastic m.v. og maskindele af læder.

2) skotøjsfabrikker hører under fodtøjsindustri 324, 32401.

2. Gummiindustri. 355

1) herunder fremstilling og reparation af alle former af gummiprodukter på basis af såvel natur som syntetisk gummi, guttaperka, ballata og lignende.

a. Vulkaniseringsanstalter m.v. 35510

1) herunder fremstilling af slidbanedæk, gummidæk og gummislanger til hjul.

b. Gummifabrikker. 35590

1) herunder fremstilling af gummistøvler, gummifodtøj og gummilegetøj.

3. Jern- og metalværker, støberier. 37

Stålværker og jernstøberier 3710

a. Jern- og stålværker. 37101

1) herunder hærderier samt fremstilling af jern og stål i blokke, stænger og plader.

b. Jernstøberier. 37102

1) herunder fremstilling af maskinstøbegods, kloakstøbegods, smedegods og støbte rør. Andre rør er undtaget.

Metalværker og støberier 3720

c. Metalværker. 37201

d. Metalstøberier. 37202

1) herunder varmepresset metalgods.

4. Renovationsvirksomhed og kloakvæsen. 9201

Kloakvæsen og renovationsvæsen 9201

a. Kloakvæsen. 92011

b. Renovationsvirksomheder. 92012

1) herunder renholdningsselskaber, lossepladser og forbrændingsanstalter.

5. Skibsværfter og bådebyggeri. 3841

a. Jernskibsværfter. 38411

1) herunder stålskibe på 100 BRT og derover.

b. Træskibsværfter og bådebyggerier. 38412

c. Skibsmotorfabrikker. 38413

1) herunder forbrændingsmotorer, dampmaskiner og -turbiner til fremdrift af skibe.

d. Fremstilling af skibsmateriel i øvrigt. 38419

1) herunder fremstilling af flåder og lignende flydende materiel.

2) skibsophugning er undtaget.

6. Fodtøjsindustri. 324

a. Skotøjsfabrikker. 32401

1) herunder hjemmesko. Gummifodtøj hører under gummiindustri 355, 35590.

b. Håndskomagere. 32402

1) skotøjsreparationer er undtaget.

c. Træskofabrikker. 32403

d. Fodtøjsindustri i øvrigt. 32409

1) herunder hæle og andre dele til fodtøj.

7. Slagteri- og kødvaretilberedning. 3111

a. Svineslagterier. 31111

1) herunder slagteriernes kødkonservesafdelinger og polsemagerier.

b. Kødvare- og kødkonservesfabrikker. 31112

1) herunder kødekstrakt, bouillonterninger, fedevarer, polser og fars.

c. Kreaturslagterier. 31113

d. Offentlige slagtehuse. 31114

e. Talgsmelterier. 31115

f. Tarmrenserier. 31116

1) herunder enheder, der på slagterierne, men for tarmrenseriernes regning udfører forberedende tarmbehandling.

g. Fjerkræslagterier. 31117

1) herunder konservering af fjerkræ.

h. Kødtilberedning i øvrigt. 31119

1) herunder røgning og saltning af indleverede kødvarer. Hjemmeslagtere hører også under denne branche.

8. Chokolade- og sukkervarefabrikker. 31190

1) herunder lakrids, tyggegummi og skumvarer.

II Den 1. juli 1979 omfattes følgende virksomheder af bekendtgørelsen:

9. Kemisk industri. 35

Kemisk råstofindustri 351

a. Fremstilling af ilt og andre industrigasser. 35111

1) herunder andre komprimerede luftarter samt flydende og fast kulsyre.

b. Anden fremstilling af kemiske grundstoffer og primære kemiske forbindelser. 35119

1) herunder emulgatorer, enzymer, osteløbe, garveekstrakt, soda og farvestoffer. Endvidere sulfonamider, ikke doserede og ikke i detailpakninger, samt pesticider i form af isolerede kemiske forbindelser.

Fremstilling af kunstgødning og færdigblandede bekæmpelsesmidler 3512

c. Fremstilling af kunstgødning. 35121

1) herunder fremstilling af superfosfat.

d. Fremstilling af færdigblandede bekæmpelsesmidler. 35122

1) herunder træimprægneringsmidler uden bindemiddel.

Fremstilling af basisplast og plasthalvfabrikata m.v. 3513

e. Fremstilling af basisplast. 35131

1) herunder kunstharpiks.

f. Fremstilling af plader, folier, rør m.v. af plast. 35132

1) herunder fremstilling af dug, bånd, monofilamenter, slanger, stænger og profiler af plast.

g. Fremstilling af klæbestrimler. 35133

h. Fremstilling af plastemballage. 35601

1) herunder fremstilling af poser, spande, flasker, kasser æsker og anden emballage af plast.

i. Anden fremstilling af plastvarer. 35609

1) fremstilling af legetøj, skilte og navneplader samt lampeskærme er undtaget.

Fremstilling af andre kemiske produkter 352

j. Farve- og lakfabrikker. 35210

1) herunder fernis og fortynder. Kunstnerfarver er undtaget.

k. Medicinalvarefabrikker. 35220

1) herunder hormoner, vitaminer og antibiotica uanset indpakning, endvidere andre lægemidler, doserede eller i detailpakninger.

Fremstilling af sæbe- og toiletmidler 3523

l. Sæbefabrikker. 35231

m. Kosmetikfabrikker. 35232

1) herunder parfume, tandpasta, barbersprit, shampoo og lignende.

Fremstilling af øvrige kemiske produkter 3529

n. Sprængstoffabrikker. 35291

1) patron- og granathylstre er undtaget.

o. Pudse- og rensemiddelfabrikker. 35292

1) herunder møbelpolitur, bonevoks, skosværte og ovnsværte.

p. Fremstilling af stearinlys. 35293

q. Limfabrikker. 35294

r. Fremstilling af lysfølsomt papir og pap. 35295

s. Kemisk industri i øvrigt. 35299

1) herunder tændstikker, trykfarver, blæk, tusch, antifrostpræparater samt organiske overfladeaktive stoffer.

10. Konfektionsfabrikation. 3221

1) omfattet er kun egentlig konfektion og således ikke fremstilling af tekstiler og tekstilvarer, skrædderi, buntmageri m. m. der hører under tekstilindustri 321 og anden beklædningsfremstilling 3229.

a. Herrekonfektionsfabrikker. 32211

1) herunder arbejdstøj.

b. Kjolekonfektionsfabrikker. 32212

1) herunder kjoler, bluser, nederdele og buksedragter.

c. Konfektionsfabrikker for dameovertøj. 32213

1) herunder dameyderbeklædning i øvrigt.

d. Skjortefabrikker. 32214

1) herunder herrepyjamas.

e. Fremstilling af korsetter m.v. 32215

f. Anden konfektionsindustri. 32219

1) herunder undertøj, nattøj til damer; badedragter, småbørnsbeklædning, kimonoer, slips og kitler.

11. Mineralolie- og asfaltindustri. 353–354

Mineralolieindustri 353

a. Mineralolieraffinaderier. 35300

Fremstilling af asfalt, tagpap, smøremidler og andre kulprodukter 354

b. Asfaltfabrikker. 35401

1) herunder tjæreprodukter.

2) udlægning af asfalt samt asfaltfabrikkernes entreprenørafdelinger hører under bygge- og anlægsområdet 50.

c. Tagpapfabrikker. 35402

d. Anden fremstilling af olie og kulprodukter. 35409

1) herunder blanding og krakning af mineralolier.

12. Sten-, ler- og glasindustri. 36

1) herunder fremstilling af ikke-metalliske mineralprodukter.

Porcelænsindustri 361

a. Porcelæns- og fajancefabrikker. 36101

b. Fremstilling af keramik- og lervarer. 36102

c. Porcelænsmalere og -brænderier. 36103

1) herunder klinkerier.

Glas- og glasvareindustri 362

d. Glasværker. 36201

1) herunder vinduesglas, glasflasker, serviceglas m.v.

e. Glasbearbejdning. 36202

1) herunder slibning og mattering, spejlfabrikker samt fremstilling af isolationsruder på grundlag af indkøbt glas.

Fremstilling af tegl, cement og andre mineralske produkter 369

f. Teglværker. 36911

1) herunder fremstilling af mursten, tagsten, drænrør samt keramikfliser til vægbeklædning.

g. Fremstilling af molerprodukter m.v. 36912

1) herunder fremstilling af kiselgurprodukter samt ildfast mørtel.

2) udvinding af moler og kiselgur fra brud hører under anden råstofudvinding 29, 29090.

Cementfabrikker, kalk- og kridtværker, mørtelfabrikker 3692

h. Cementfabrikker. 36921

i. Kalk- og kridtværker. 36922

1) herunder fremstilling af brændt kalk. Rå kalk og jordbrugskalk hører under anden råstofudvinding 29, 29013.

2) kalkbrud, stenbrud, grusgravere og skærvefabrikker hører under 2901.

j. Mørtelfabrikker. 36923

Anden sten-, ler- og glasindustri 3699

k. Stenhuggerier. 36991

1) herunder stensliberier og fremstilling af gravmonumenter, marmorvarer og møllesten.

l. Fremstilling af færdigblandet beton. 36992

m. Betonvarefabrikker. 36993

1) herunder beton- og cementstøberier (cementvarefabrikker), fremstilling af betonmursten, -tagsten, -fliser, -trappesten og træbeton. Endvidere terrazzo-, klinke-, beton- (lecabeton), slaggebeton- og asbestcementfabrikker.

n. Fremstilling af glasuld og glasfiber. 36994

o. Fremstilling af kalksandsten og gipsplader. 36995

p. Fremstilling af slibematerialer. 36996

q. Fremstilling af andre sten-, ler- og glasprodukter. 36999

1) herunder bremseskiver, asbestvarer, pakninger med mineralske bestanddele, kryolitfabrikker, kunstgipserier, rockwool samt ekspanderet ler.

13. Tobaksindustri. 314

1) herunder fremstilling af alle former for tobaksvarer, cigarer, cigaretter, shagtobak og lignende.

2) tobaksfabrikkernes engrosoplag betragtes som lokale hjælpeenheder.

III. Den 1. juli 1980 omfattes følgende virksomheder af pligten til at oprette bedriftssundhedstjeneste:

14. Tekstilindustri. 321

Spinderier, væverier og efterbehandling af tekstiler 3211

a. Uldspinderier og -væverier. 32111

1) herunder uld sammen med korte kemofibre

2) herunder konfektionerede boligtekstiler fremstillet af stoffer vævet i egen virksomhed

b. Bomuldsspinderier og -væverier. 32112

1) herunder bomuld sammen med korte kemofibre.

2) herunder konfektionerede boligtekstiler fremstillet af stoffer vævet i egen virksomhed.

c. Fremstilling af garner og stoffer af kemofibre. 32113

1) fremstilling af garner og stoffer af korte kemofibre sammen med uld hører til 32111 og sammen med bomuld hører til 32112.

d. Håndvæverier. 32114

e. Fremstilling af bånd, possement og elastik. 32115

1) herunder etiketter, tyl, blonder og kniplinger.

f. Andre spinderier og væverier. 32116

1) herunder hør og tynde garner af hamp og jute.

g. Tekstilfarverier og -imprægneringsfabrikker. 32117

1) herunder også virksomheder, der alene udfører mercerisering, dekatering o. l. synlig efterbehandling.

2) farvning, mercerisering, dekatering efterbehandling i forbindelse med spinvævning, strikning eller reblagning henhører under virksomhedens hovedaktivitet.

3) imprægnering af stoffer med plast olie hører under 32190. Tekstilstoffer trukket med gummi hører under gummbrikker 35590.

4) garderoberenserier og garderobefarer er undtaget.

Fremstilling af færdige tekstilvarer e beklædningsgenstande 3212

h. Fremstilling af broderier. 32121

i. Plissé- og hulsomforretninger. 32122

1) herunder fremstilling af stofknap slåning af knaphuller samt kunststopning

j. Flag- og teltfabrikker (incl. sejlmage 32123

1) herunder fremstilling af pressenni og markiser.

k. Fremstilling af gardiner, sengetæppe linned. 32124

l. Anden tekstilvareindustri. 32129

1) herunder fremstilling af dyner, pu stoftryk, malerlærred, autoindtræk og m samt sække.

m. Trikotagefabrikker. 32130

1) herunder fremstilling af strømper.

2) konfektionering udelukkende eller sten udelukkende på grundlag af indk trikotagestoffer hører under konfektionsf ~~ketion 3221~~

n. Tæppefabrikker. 32140

1) herunder fremstilling af måtter og l re af jute, sisal og kokos.

o. Rebslagerier. 32151

p. Fiskenetfabrikker. 32152

q. Anden tekstilindustri. 32190

1) herunder halmvarefabrikker, fremling af rørvæv, opkradsning af gammelt shoddyfabrikker, tvistfabrikker, vatfabri samt filt- og krølhårsfabrikker.

2) herunder imprægnering af tekstilst med plast eller olie.

Anden beklædningsfremstilling 3229

r. Skrædderforretninger. 32291

1) herunder skræddermestre, som frem ler damedragter og -frakker.

s. Kjolesyning m.v. 32292

1) herunder syersker.

2) fabriksmæssig fremstilling af kjoler under konfektionsindustri 32212.

t. Hattefabrikker 32293

u. Buntmagerier 32294

1) pelsberedere og pelsfarvere hører u pelsberedning 32220.

w. Damehatte- og modevarefremstilling. 3

x. Handskefabrikker. 32296

y. Beklædningsindustri i øvrigt. 32299

1) herunder fremstilling af indlæg o. l.

2) fremstilling af parasoller og paraer er undtaget.

15. Fiskeindustri. 3114

a. Røgning og saltning af fisk. 31141

b. Fiskehermetik-, fiskefars- og fiskefilbrikker 31142

1) herunder dybfrysning af fisk.

16. Akkumulator- og tørelementfabri 38392

1) herunder fremstilling af tørreleme akkumulatorkasser og udskiftning af a mulatorelementer med indbygning.

17. Stenbrud, skærvefabrikker, skærveknuserl, boring i granit og sandsten. 29 anden råstofudvinding.

Grusgrave, stenbrud, kalk- og kridtbrud 2901

a. Ler- og grusgrave samt stenbrud. 29011

b. Kalk- og kridtbrud. 29013

1) herunder udvinding af jordbrugskalk samt indsamling af kalkholdige skaller.

c. Udvinding af mineraler til godnings- og kemisk brug. 29020

1) herunder kaliboring.

d. Saltudvinding. 29030

e. Anden ikke-metallisk råstofudvinding i øvrigt. 29090

1) herunder brydning af kiselgur, flint og moler. Endvidere henhører fremstilling af briketter og torvestrøelse til denne branche.

18. Skorstensfejere. 92023

19. Autobranchen. 3843 karosserifabrikker, 9513 autoreperation.

a. Fremstilling af biler. 38431

1) samling af biler, lokalt kombineret med engroshandel, opfattes som en virksomhed ~~men med udskillelse af bifunktion. En kombineret~~ enhed henføres normalt til fremstilling, når mindst 30 pct. af omsætningen hidrører fra samling.

b. Karosserifabrikker. 38432

1) herunder fremstilling af påhængsvogne, landbrugsvogne, campingvogne, skurvogne, lad til biler og tippelad.

2) karosseriopretning hører under autoreperation 95132

c. Bilindustri i øvrigt. 38439

1) herunder motorer, bremser, gear, hjul o. l.

2) gummi hører under gummifabrikker 35590, plast hører under anden fremstilling af plastvarer 35609, glas til billygter o. l. hører under glasbearbejdning 36202.

3) elektrisk udstyr til biler er undtaget.

d. Autoreparationsværksteder. 95131

e. Karosseriværksteder. 95132

1) karosserifremstilling hører under karosserifabrikker. 38432

f. Autolakererier. 95133

g. Autoelektrikere. 95134

h. Autoservice i øvrigt. 95139

1) herunder autobugsering.

IV. Den 1. juli 1981 omfattes følgende virksomheder af pligten til at oprette bedriftssundhedstjeneste:

20. Bygge- og anlægsområdet. 50

a. Bygge- og anlægsvirksomhed uden nærmere angivelse. 50000

b. Offentlig bygge- og anlægsvirksomhed. 50110

1) herunder bygge- og anlægsvirksomhed, der udføres af offentlige (herunder koncessionerede) virksomheder eller forvaltningsorganers eget personale, men derimod ikke udliciteret arbejde.

c. Entreprenørvirksomheder m.v. 5012

1) læsseentreprenører og kørselsentreprenører er undtaget. Maskinstationer der udfører landbrugsarbejde er undtaget.

2) virksomheder, der ikke selv har arbejdskraft, men som indgår hovedentreprisekontrakter til udførelse af underentreprenører, medregnes.

d. Almindelige entreprenørforretninger. 50121

1) herunder entreprenørforretninger, der påtager sig arbejde inden for et videre felt af bygge- og anlægsarbejde.

2) anlægs- og byggeforretninger med mere specialiserede arbejdsområder henføres til en af grupperne 50122–50199.

e. Dræningsmestre. 50122

f. Brolæggermestre. 50123

g. Kloakmestre. 50124

h. Murerforretninger. 50130

i. Tømrer- og snedkerforretninger. 50140

1) herunder maskinsnedkerier, der selv opstiller de fremstillede bygningsmaterialer. Snedkerier og fabrikker, der fremstiller bygningssnedkerartikler til salg, er undtaget.

j. Malerforretninger. 50150

1) herunder bygningstapetserere.

2) møbellakererier, møbellakererier og industrilakering er undtaget. Autolakerier hører under autoreparation 95133.

k. Blikkenslagerforretninger. 50160

l. Elektroinstallationsforretninger. 50170

1) herunder også el-installatører med butikshandel.

2) reparation af elektriske husholdningsmaskiner er undtaget.

m. Glarmesterforretninger. 50180

1) herunder også glarmestre med butikshandel.

2) rammelistefabrikker er undtaget.

n. Gulvbelægnings- og terrazzoforretninger. 50191

1) herunder gulvafhøvling o. l.

o. Isoleringsforretninger. 50192

p. Tagtækkere og tagpapdækkere. 50193

q. Brøndborere. 50194

r. Ovnsætning. 50195

1) herunder reparation af kakkelovne.

s. Stilladsforretninger. 50196

t. Byggevirksomhed i øvrigt. 50199

1) herunder stukkatører, facadesandblæsning, lynafledersætning og møllebyggere.

V. Vejledende retningslinier om afgrænsningsproblemer.

På virksomheder, hvis hovedaktivitet henhører under de ovennævnte brancher m.v., skal samtlige ansatte omfattes af bedriftssundhedstjenesten, uanset om de pågældende personalegrupper beskæftiges ved egentlig produktion eller ved diverse servicefunktioner ~~såsom administration, kantine, rengøring~~ kørsel m.v.

Ved virksomhed forstås i denne forbindelse den lokalukonomiske enhed. Ved hovedaktivitet forstås i denne forbindelse den del af den egentlige produktion, hvorved flest beskæftiget.

På virksomheder, hvor der i en afgrænset del af virksomheden udføres en produktion der hører under de ovennævnte brancher m.v., men hvor denne produktion ikke er hovedaktiviteten, skal kun de i denne del af virksomheden beskæftigede omfattes af bedriftssundhedstjenesten.

VI. I supplerende bilag vil blive fastsat, hvilke virksomheder, der bliver omfattet af bekendtgørelsen i senere etaper af udbygningen.

§ 2

Bekendtgørelsen træder i kraft ved bekendtgørelsen i Lovtidende.

Arbejdsministeriet, den 13. august 1981

SVEND ALKEN

Ulrich Burg

ANNEX 4

QUESTIONNAIRE USED FOR THE HEALTH SERVICE

Aerosol[x] Exposure in the Working Environment

As part of a project the Danish Toxicology Centre is trying to make a survey of aerosol exposure in the Danish working environment. The aim of the project is to form a basis for correct selection and use of respiratory protective devices. As we are convinced that the Health Service Centres, due to their close and frequent contact to factories, workshops and undertakings in general, have acquired specially important knowledge about workplace exposure, we hereby ask you to share this know-how with us.

Three questionnaires have been elaborated (annexes 2, 3 and 4) which you are requested to fill in as detailed as possible. We are well aware that it will be time consuming, but we expect that the result of our investigation will lead to improvements in the working environment.

Annex 2 is intended to give a general description of your health Service Centre and the undertakings in your local community.

Annex 3 is intended to give your subjective evaluation of the presence of solid and liquid, incl. water based, aerosols in the undertakings. The answers given in this annex shall be based on your own experiences from visiting the different work places.

Annex 4 is intended listing of measurements of aerosols carried out by your centre or on behalf of your centre.

We are aware that some of the Health Service Centres have conducted a substantial number of measurements and suggest that in Annex 3 information is given, as far as possible, for all undertakings, and that the results of the measurements are grouped in such a way that information given in Annex 4 supports the information given in Annex 3, as far as possible.

[x] See Definition

We would like to stress that information on factories, workshops, etc. where the presence of aerosols do not constitute a problem is valuable.

The participating Health Service Centres will be informed on the results of our investigation as far as possible, and reference will be made to their participation.

In case any information is confidential, we will ensure its confidentiality.

Further questions can be adressed to either Erik Balieu or Lisbeth Valentin Hansen at the Danish Toxicology Centre.

The questionnaires shall be returned not later than September 24, 1986.

Sincerely yours,
DANISH TOXICOLOGY CENTRE

Erik Balieu
M.Sc.

Enclosure

Enclosure 1

DEFINITION

In the present context an aerosol is defined as particles, solid or liquid, suspended in the air.

Further description

Aerosols are formed in connection with numerous industrial processes, and may consist of particles of different sizes. Generally, particle sizes will be in range of 1000 µ - 0.001 µ.

Solid particles can either be pure chemical substances or mixtures.

Liquid particles can either be pure chemical substances or mixtures, incl. solutions and suspensions.

In the present investigation it will be important to make a distinction between liquid particles consisting of water (e.g. high pressure cleaning with cleaning agents) and liquid particles of other liquid substances (e.g. oil mist or spray painting aerosol).

Enclosure 2

GENERAL DESCRIPTION OF THE HEALTH SERVICE CENTRE.

1. Name of the health service centre: .....

Address of the health service centre: .....

.....

Staff employed with measurements in the working environment:

Number: .....

Educational background: .....

GENERAL DESCRIPTION OF THE UNDERTAKINGS IN YOUR LOCAL COMMUNITY.

2. In order to give a description of the local community of your Health Service Centre you are asked to give an estimate of the number of undertakings belonging to your Centre.

Number of undertakings: .....

Approx. number of employees: .....

2.1 Describe the more important factories/production facilities in your local community:

.....

.....

2.2 Number of measurements on aerosols[x] carried out in the undertakings during 1984 - 1986:

.....

In case information is available from earlier than 1984, please state:

.....

2.3 Number of planned measurements on aerosols in 1986 - 1987:

.....

3. Any other information:

.....

.....

.....

Date: Signed:

[x] See definition

Enclosure 3

SUBJECTIVE EVALUATION AND DESCRIPTION OF THE PRESENCE OF AEROSOLS[x] IN THE WORKING ENVIRONMENT

In addition to the measurements reported in enclosure 4, it will be of great importance to have your personal evaluation and description of aerosols[x] present in the working environment of the undertakings in your local community. As the presence of liquid aerosols is generally less frequently described and only supported by measurements in relatively few cases, it will be of special importance to obtain information on such types of aerosols.

We ask you to give a short description of the working process, the number of people employed and your personal evaluation of the magnitude of the problem, and last but not least, a description of the type of aerosol, whether it is solid or liquid, and if possible its chemical composition.

1. Industry/workshop: .....
2. Process: .....
3. Product manufactured: .....
4. Type of aerosol[x]:

   4.1: Solid: .... 4.2: Liquid .... 4.3: Water based: .....

   4.4: Chemical composition: .....

   4.5: Evaluation of the exposure: Important problem: .....

   Problem: .....

   Less important: .....
5. Are gases/vapours present additionally: (Yes/no, description)

   .....

   .....
6. Number of people exposed: .....
7. Time for observation of the exposure: .....
8. Statement of whether the observed exposure is supported by measurements reported in enclosure 4:

   .....

   .....
9. Other information:

   .....

   .....
10. Name of contact person at your Centre: .....

Date: Signed:

[x]See definition

ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Community, social and personal services

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
00	Sanitary and similar services	Waste water cleaning and treatment	Bacteria	+			
			Fungi	+			
	Social and related community services	Pest control (spraying of pesticides)	Pesticides	+			
13	Repair of motor vehicles	Rust prevention work	Paints and laquers	+		+	Organic vapours
		Brake and clutch work	Asbestos	+			
		Spray painting	Spray painting aerosol	+		+	Organic vapours
			(isocyanates i.a.)			+	

5b

Results from AMF-reports and Monographs

ıble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 321 Manufacture of textiles

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
19	Manufacture of clothing	Sewing/cutting	Various	+	-	-	No statement might be e.g formaldehyde

ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 311-312 Food, manufacturing

ISIC Table	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
311	Slaughtering	Handling cutting, sawing	Cleaning agents Various dust	+	+		
312	Man. of food products (not elsewhere classified)	Frying, cooking	Cooking fumes			+	
3116	Man. of grain mill products	Mixing, filling	Flour dust	+			
3117	Man. of bakery	Cutting grinding, mixing	Flour dust	+			
3140	Man. of tobacco	Handling, mixing	Tobacco dust	+			?

ıble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 324 Textile, Wearing Apparel and Leather Industries

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
40	Manufacture of footware	Sewing, cutting, gluing	Various dust and vapours	+		+ ?	+

ıble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 352 Manufacture of Chemicals etc.

ıIC ıde	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
523	Manufacture of soap etc.	Mixing filling	Dust	+	+ ?	+ ?	?

e IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 361 Manufacture of Non-metallic Mineral Products

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
10	Manufacture of pottery	Painting, grinding			+		-

ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 369 Manufacture of Non-mineral Products

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
9	Manufacture of non-metallic mineral (not elsewhere classified)	Stone-masoning	Quartz, various dust	+	(+) x)		

abl

'able IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 38 Manufacture of Machinery, except electrical

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
825	Manufacture of electronics	Joining, soldering, gluing	Dust Soldering smoke	+ +	 -		+
829	Manufacture of machinery	Welding, cutting, grinding	Metal dust, soldering smoke, welding fumes, organic vapours, cleaning agents	+	+	+	+

ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 4. Electricity, Gas and Steam. 41 Electricity, Gas and Water

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
01	Electric light and power	Handling	Coal dust combustion residuals Welding fumes SO_2, CO Other vapours and gases	+	?	+	+[x)]

x) in some

.ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 5. Construction

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
50	Insulation	Handling / insulation	Dust + manmade min.fibres	+			
	Construction	Handling / building	Dust	+			

Table

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 7. Transport, Storage and Communication

SIC code	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
111	Railway transportation	Transportation	Various dust and vapours	+x)			+
192	Storage and warehousing	Fork-lift transportation	Various dust and vapours	+			+
192	Storage and warehousing	Handling of grain-products	Grain-dust	+			

x) Low concentration

ıble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 8. Financing, Insurance, Real Estate and Business Services

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
29	Technical services	Cleaning, repair of photocopying machines	Various dust and vapours	+			+

ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 9. Community, Social and Pers. Services

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
00	Chimney cleaning	Sweeping, cleaning	Coal dust, soot various dust	+			?
00	Cleaning	Cleaning	Various cleaning agents		+		
00	Disinfection	Disinfection	Various cleaning and disinfectant agents		+		

5c

Results from Questionnaires

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 311-312 Food manufacturing.

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
111	Slaughtering, preparing and preserving meat	High pressure cleaning	Cleaning agents, sodium hydroxide, tenside, glycol ethers, EDTA		+		
		Weighing and handling of spices, etc.	Various dust	+			-
		Surface treatment of tiles	Mineral oil			+	-
114	Canning, preserving and processing of fish, crustacea and similar foods	High pressure cleaning	Cleaning agents		+		
		Preservation of lobsters	Sodium hydrogen sulfite		+		Sulfur-dioxide

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 311-312 Food manufacturing.

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
119	Manufacture of cocoa, chocolate and sugar confectionary	Packing etc.	Enzymes	+			Organic solvents

Table

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 314 Tobacco manufacturers.

ISIC Code	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
3140	Tobacco manufacturers	Handling and processing	Tobacco dust	+			(Flavour)

ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 321 Manufacture of textiles.

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
211	Spinning, weawing and finishing textiles	Weawing	Acrylates	+			-

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 33 Manufacture of wood and wood products, including furniture.

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
33	Manufacture of wood and wood products etc.	Spray painting	Paints and lacquers	(+)		+	Organic solvents
		Sawing and cutting	Wood dust	+			
311	Sawmills, planing and and other wood mills	Wood preservation	Arsenicats, cupper, chromates	(+)	+		
320	Manufacture of furniture and fixtures, except primarily of metal	Cutting and sawing	Fumes	+			Formalde-hyde, phenol

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 351 Manufacture of industrial chemicals.

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
351	Manufacture of industrial chemicals	Spray painting	Paints and lacquers	(+)		+	+
512	Manufacture of fertilizers and pesticides	Handling and processing	Pesticides etc.	+		+	+
		Handling, milling and grinding	Dust, fluorides, sulfuric acid	+	+		

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 352 Manufacture of other chemical products.

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
522	Manufacture of drugs and medicine	Handling and filling operations	Drugs, raw materials etc.	+			-
		Handling, filling and manufacture	Raw materials, numerous chemical compounds	+			Isopropa-nol
523	Manufacture of soap and cleaning preparations, perfumes, cosmetics and other toilet preparations	Handling, filling and manufacture	Fatty acids		+		

Table

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 352 Manufacture of other chemical products.

ISIC Code	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
3529	Manufacture of chemical products, not elsewhere classified	Filling, handling and casting of ammunition	Trinitrotoluene	+			(+)
		Manufacturing processes	Dusts of glues	+			
		Drilling in PC-boards	Cupper, organic dust	+			
		Galvanizing PC-boards	Sulfuric and hydrochloric acid		+		Sulfur dioxide

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 356 Manufacture of plastic products, not elsewhere classified.

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
560	Manufacture of plastic products, not elsewhere classified	Dying of plastic products	Lead, chromium, copper, iron, calcium, titanium etc.	+			(+) (polyethylene and polypropylene ?)
		Manufacture of non-wowen textiles	Polypropylene	+			
		Handling, filling and casting operations	Raw materials	+			
		Welding	Welding smoke	+			Nitrogen oxides
		Cutting	PVC-dust	+			
		Die casting of plastic products	?	+			Aldehydes, hydrocarbons acrylonitril free radicals

ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 356 Manufacture of plastic products, not elsewhere classified.

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
50	Manufacture of plastic products, not elsewhere classified	Casting of melamine plast products	Melamine plast	+			Formaldehyde

Table IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 36 Manufacture of non-metallic mineral products, except products of petroleum and coal.

ISIC Code	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
3610	Manufacture of pottery, china and earthenware	Spraying of ceramic dyes and pigments	Cobalt aluminate (20% Cobalt)	+	+		
		Cleaning of filter press	Ceramic material	(+)	+		
691	Manufacture of structural clay products	Burning of e.g.tiles	Dust Oil mist	+		+ +	(Nitrogen (oxides, (carbon (monoxide, (carbondi- (oxide
699	Manufacture of non-metallic mineral products, not elsewhere classified	Surface treatment of concrete elements	C_9-C_{11} oils and Silicone oils			+	+
		Stone cutting	Dust, quartz	+			

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 36 Manufacture of non-metallic mineral products, except products of petroleum and coal.

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
99	Manufacture of non-metallic mineral products, not elsewhere classified	Binding of steel re-inforcements	Iron oxide	+			
		Mineral wool manufacture	MMMF (fibres)	+			
		Grinding of concrete elements	Concrete dust	+	+		
		Concrete mixing and preparation	Cement, fly ash, quartz, metals	+			Oil vapours?
		Cutting of wood (chipboards)	Wood and glue dust	+			

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 36 Manufacture of non-metallic products, except products of petroleum and coal.

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
599	Manufacture of non-metallic mineral products, not elsewhere classified	Casting of concrete elements	Mineral oils (incl. petroleum)			+	(-)
		Handling and filling of raw materials	Dust	+			
		Cutting of gas concrete elements	Dust	+			(+)
		Welding of steel reinforcements	Welding smoke	+			+

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 37 Basic metal industries.

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
720	Non-ferrous basic metal industries	Casting of noble metals	Gold, silver and metal oxides	+			Sulfur-dioxide

'able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 38 Manufacture of fabricated metal products, machinery and equipment.

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
381	Manufacture of fabricated metal products, except machinery and equipment	Surface coating	Epoxy dust	+			
		Turning and cutting	Mineral oils			+	
		Cutting of metal parts	Inert dust	+		+	Oil and white spirit
		Forging of brass	Oil and smoke, incl. lead	+		+	Carbon monoxide
		Spray painting	Paints and lacquers	(+)		+	Organic solvents
		Casting	Iron, copper, aluminium oxide and lead oxide	+			Carbon monoxide

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 38 Manufacture of fabricated metal products, machinery and equipment.

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
381	Manufacture of fabricated metal products, except	Casting	Silicondioxide (α-quartz)	+			Carbon monoxide, hydrocarbons, benzene, sulfur dioxide
		Casting	Silicondioxide (quartz)	+			Isopropanol
			Metal oxides				
		Welding	Dust, welding fume	+			Nitrogen oxides, ozone carbon monoxide, carbon dioxide
		Cleaning and cold degreasing	Hydrochloric acid		+		Hydrogen choloride

Table

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 38 Manufacture of fabricated metal products, machinery and equipment.

ISIC Code	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
3819	Manufacture of fabricated metal products, except machinery and equipment, not elsewhere classified	Cleaning	Cleaning agents, organic solvents			+	+
		Galvanizing	Ammonium chloride, hydrochloric acid	+	+		Hydrogen chloride

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 38 Manufacture of fabricated metal products, machinery and equipment.

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
382	Manufacture of machinery, except electrical						
321	Manufacture of engines	Cutting, grinding, forging, drilling etc.	Dust	+			(+) phosphine and formaldehyde
329	Machinery and equipment, except electrical, not elsewhere classified	High pressure cleaning	Cleaning agents		+		+

Table

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 38 Manufacture of fabricated metal products, machinery and equipment.

SIC code	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
383	Manufacture of electrical machinery apparatus, appliances and supplies						
331	Manufacture of electrical industrial machinery and apparatus	Spray painting	Paints and lacquers	(+)		+	Organic solvents
332	Manufacture of radio, television and communication equipment and apparatus	Grinding and polishing of aluminium profiles	Aluminium dust and mineral oil	+		+	

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 38 Manufacture of fabricated metal products, machinery and equipment.

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
139	Manufacture of electrical apparatus and supplies, not elsewhere classified	Manufacturing of lead batteries	Sulfuric acid (15%)		+		Vapours?
			Lead oxide	+			

Table IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 38 Manufacture of fabricated metal products, machinery and equipment.

ISIC Code	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
384	Manufacture of transport equipment						
3841	Shipbuilding and repairing	Steam cleaning of tubes	Oil?		+		Oil?
		Cutting of tubes	Iron, zinc	+			
		Welding of steel (not stainless)	Welding smoke	+			+
		Flame cutting	Welding smoke	+			Nitrogen oxides, carbonmonoxide
		Cleaning processes	Cleaning agents		+		
		Grinding	Dust	+			Styrene, acetone etc.

ıble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 3. Manufacturing. 38 Manufacture of fabricated metal products, machinery and equipment.

;IC ɔde	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
41	Shipbuilding and repairing	Painting (spray?)	Paints and lacquers	+		+	+
		Cutting of gasket materials	Asbestos fibres	+			
		Shotblasting and priming	Iron and iron oxide	+			Organic solvents

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 5. Construction

SIC code	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
000	Construction	Demolishion	Asbestos fibres	+			
			MMMF	+			
		Insulation work	Polyurethanes	(+)		+	Isocyanates, amines
		Spray painting	Paints & lacquers	(+)	+	+	(org.solvents (+)
		Washing and cleaning of vehicles and machines	Cleaning agents		+		
		Shuttering work	Mineral oils?			+	
		Demolishion	Cement dust				
			Wood dust				

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 7. Transport, storage and communication.

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
71	Transport and storage						
11	Railway transport	Welding (Repair and maintenance work)	Welding fume	+			+
		Washing and cleaning operations	Cleaning agents		+		
			Organic solvents			+	Organic solvents
			Oxalic acid			+	(+)
16	Supporting services to land transport	Painting (road stripes)	Paints and lacquers	+		+	Organic solvents

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 9. Community, social and personal services.

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
00	Sanitary and similar services	Aeration and other treatment of sewage effluents	Bacteria and viruses	(+)	+		(+)
		Cleaning of incinera-tors	Dust, soot	+			

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: 9. Community, social and personal services.

SIC code	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
95	Personal and household services	Spray painting (rust prevention)	Mineral oil, waxes, bitumen, paraffine waxes			+	Organic solvents 30-60% white spirits
13	Repair of motor vehicles and motorcycles	Cleaning operations	Hydrocarbon solvents chlorothene			+	+
		Spray painting	Paints and lacquers			+	+
		Grinding and polishing	Dust	+			
		Engine washing and cleaning	Mineral oil and dust			+	+

Enclosure 4

MEASUREMENTS CARRIED OUT ON AEROSOLS[x]

1. Industrial branch/category: .....

2. Work process: .....

3. Product: .....

4. Type of aerosol[x]:

   4.1: Solid: .... 4.2: Liquid: .... 4.3: Water based: .....

   4.4: Particle size: .....

   4.5: Particle size distribution: .....

   4.6: Chemical composition or content: .....

   .....

   4.7: Concentration: .....

   .....

5. Are gases/vapours present additionally: (Yes/no, description)

   .....

   .....

6. Number of people exposed: .....

7. Number of measurements taken: .....

8. Sampling method: .....

9. Sampling place: .....

10. Analytical method: .....

11. Time when measurements were taken: .....

12. In case measurements and analysis were carried out by other laboratories, please state which:

    .....

13. Any other information:

    .....

    .....

14. Name of contact person at your Centre: .....

Date: Signed:

[x]See definition

ANNEX 5

SUPPLEMENTARY TABLES ON BRANCHES, OCCURRENCE OF AEROSOLS AND WORKING PROCESSES

5a

Results from Literature

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IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Agriculture, Hunting, Forestry and Fishing. 1.

C e	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
0	Agriculture and hunting	Cleaning stables, poultry confinement buildings etc.	Spores, microorganisms, antigens, "organic dust" etc.	x			
		Handling of crops, corn etc.	"dust", Aflatoxins	x			
		Spraying with pesticides	Insecticides, pesticides etc.	x	(x)		can be predicted in some cases
		Harvesting	Pesticide contaminated dust	x			
		Cotton ginning					

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IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Agriculture, Hunting, Forestry and Fishing. 1.

C e	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
	Forestry and logging	Sawing and cutting	Wood dust	x			
		Impregnation	Wood dust contaminated with chlorophenols and chlorophenol solutions	x	x		x

ıble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Agriculture, Hunting, Forestry and Fishing. 1.

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
10	Agriculture and hunting	Cleaning stables, poultry confinement buildings etc.	Spores, microorganisms, antigens, "organic dust" etc.	x			
		Handling of crops, corn etc.	"dust", Aflatoxins	x			
		Spraying with pesticides	Insecticides, pesticides etc.	x	(x)		can be predicted in some cases
		Harvesting	Pesticide contaminated dust	x			
		Cotton ginning					

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IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Agriculture, Hunting, Forestry and Fishing. 1.

C e	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
	Forestry and logging	Sawing and cutting	Wood dust	x			
		Impregnation	Wood dust contaminated with chlorophenols and chlorophenol solutions	x	x		x

.ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Mining and Quarrying. 2.

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
)0	Coal mining	Mining, drilling and heading machine operation	Coal dust	x			
)0	Crude petroleum and	Retorting of oil shale	Dust PAH "Toxic metals"	x x x		(x)	x i.a. CO, NO_x, NH_3, H_2S, CS_2, SO_2, HCN, HNO_3, HCHO, CO_2

ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Mining and Quarrying. 2.

C e	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
0	Metal ore mining	Mining and drilling	Radioactive aerosol of uranium, incl. radon and thoron daughters	x			

ıble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Mining and Quarrying, 2.

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
90	Other mining						
901	Stone quarrying	Mining and drilling	Granite dust	x			
902	Chemical and fertilizer mineral mining	Mining and drilling	Potash dust	x			
909	Mining and quarrying not elsewhere classified	Mining and drilling	Talc dust	x			
		Mining and drilling	Asbestos fibres	x			
			Silica	x			
			Mica	x			

ıble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing. 3. 31 Food, Beverages and Tobacco.

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
1-2	Food manufacturing	Handling	Tea dust	x			
14	Canning, preserving and processing of fish, crustacea and similar foods	Smoking of fish	PAH	x		(x)	
15	Manufacture of vegetable and animal oils and fats	Cleaning and transportation	Cotton dust	x			

ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 32 Textile, Wearing Apparel and Leather Industries.

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
1	Manufacture of textiles	Handling, transportation	Cotton dust	x			
			organic dust	x			
11	Spinning, weaving and finishing textiles	Picking, carding and spinning	Endotoxins (lipopolysaccharide)	x			
			Bacteria	x			
			Vegetable fibres	x			
			Cotton dust				
			Flax				
			Jute				
			Hemp				
19	Manufacture of textiles not elsewhere classified. Manufacture of insulation boards		Asbestos fibres	x			

ıble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 32 Textile, Wearing appareil and Leather Industry

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
31	Tanneries and leather finishing	Tanning	Arsenicals	+			+
		Dying	Chromium	+			+
			Dyers				
		Dressing					

ıble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 32 Textile, Wearing Appareil and Leather Industry

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
40	Manufacture of footwear, except of moulded or vulcanized rubber or plastic	Manufacture	Dust of leather containing contaminated with chromates	x			

ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 33 Manufacture of Wood and Wood Products, incl. Furnitu

C e	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
	Manufacture of wood and wood- and cork products, except furniture	Sawing, grinding etc.	Wood dust	x			
		Plywood production (sawing, gluing)	Wood dust				Terpenes, PAH, formaldehyde phenol, tributyltin-oxide etc.
	Manufacture of furniture and fixtures, except primarity of metal		Wood dust				

ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 341 Manufacture of Paper and Paper Products

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
11	Manufacture of pulp, paper and paperboard	Chipping, transportation	Dust	x			x
			Mold spores	x			
11	Wine filter production	Addition of fibres	Asbestos fibres	x			
20	Printing, publishing and allied industry	Newspaper printing	Ink mist			x	

ɔle

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 351 Manufacture of Industrial Chemicals

ɔle	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
11	Manufacture of basic industrial chemicals, except fertilizers	Handling and processing	Pentachlorophenol dust	x			x
			PAH	x			
12	Manufacture of fertilizers and pesticides	Handling and processing	Dust containing nitrates	x			
13	Manufacture of synthetic resins, plastic materials and manmade fibres, except glass	High temperature fusing of quartz and carbon	Silicon carbide fibres	x			x (CO and SO_2)
			Quartz	x			
			PAH	x			

.ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 351 Manufacture of Industrial Chemicals

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
13	Manufacture of synthetic resins, plastics etc	Synthesis	Phtalic anhydride	x			
		Di-(2-ethylhexyl)-phthalate				x	
21	Manufacture of paints, varnisters and laquers	Handling and processing	Titaniumdioxide dust	x			
		Filling operations, milling, crushing and weighing	Cadmium sulfide dust	x			
			Cadmium seleno-sulfide dust	x			
		Handling and processing	Benzidine sulfate dust	x			

ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 351 Manufacture of Industrial Chemicals

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
22	Manufacture of drugs and medicines	Filling operations, handling	Ispagula powder	x			
29	Manufacture of chemical products, not elsewhere classified	Production of ammonium-perfluorooctanoate	Ammoniumperfluoro-octanoate	x			
		Production of carbon black	Carbon black dust	x			
		Production of benzene diols	Hydroquinone	x			+ Quinone vapours may be present
			Catechol	x			
			Resorcinol	x			

ıble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 352 Manufacture of other Chemical Products

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
29	Manufacture of chemical products, not elsewhere classified	Filling and packing of munition	TNT-dust	+			
		Handling and processing	Carbon black dust	+			
		Production of fluoro-chemicals	Ammoniumperfluoro-octanoic acid	+			

ıble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 354 Manufacture of miscellaneous Products of Petroleum and Coal

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
40	Manufacture of miscellaneous products of petroleum and coal	Coke oven work	PAH	+			
		Handling and processing	Fly ash	+			

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 355 Manufacture of Rubber Products

SIC Code	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
551	Tyre and tube industry	Tyre manufacturing	Dust containing hexamethylene-tetramine-resorcinol	x			x Formaldehyde and ammonia in small amounts
559	Manufacture of rubber products, not elsewhere	Includes more than ten different processes	Carbon black	x			x During some processes, organic solvent vapours are present
			Talc	x			
			Cured rubber dust	x			
			Silicone oil mist			x	

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 356 Manufacture of Plastic Products, not elsewhere classified

SIC Code	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
3560	Manufacture of plastic products, not elsewhere classified	Blowing of hollow articles	Dust	x			x Numerous gases and vapours
		Manufacture of polypropylene and polypropylene products. Heating processes	Decomposition products	x		(x) possible	x Numerous gases and vapours of all classes
		Production of polyethylene bags	Soot	+			Numerous irritant gases
		Production of fibrous materials	MMMF and other fibres	+			

ıble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 36 Manufacture of non-metallic Products, except Products of Petroleum and Coal

;IC ɔde	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
510	Manufacture of pottery, china and earthenware	Production	Lead containing dust	x			
599	Manufacture of non-metallic mineral products not elsewhere classified	Mixing and grinding of asbestos cement	Asbestos fibres Dust	x x			
		Glass fibre, paper manufacturing	MMMF	x			
	Stone product manufacturing	Cutting, grinding etc.	Dust	x			
		Production of rock wool	Man-made mineral fibres	x			
		Asbestos textile production	Asbestos fibres	x			

ble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 37 Basic Metal Industries

IC de	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
10	Iron and steel basic industries	Casting, moulding, smelting	Silica (quartz)	x			
			PAH, incl. BAP	x			
			Metals	x			
	Ferro-alloy manufacture		Vanadium dust	x			
	Steel rolling plant	Tandem mill operators	Oil mist			x	
			Asbestos	x			

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 37 Basic Metal Industries

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
3720	Non-ferrous metal basic industries						
	Aluminium plant	Electrolysis	PAH	x			x (PAH-vapours
			Lead	x			
			Fluorides	x			x (CO, CO_2, SO_2)
			Dust	x			
			Aluminium oxide	x			
			Sodium, aluminium fluoride fibres	x			

ıble

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 37 Basic Metal Industries

;IC ɔde	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
720	Beryllium plant	Melting and pouring	Beryllium dust	x			
	Brass foundry	Melting and casting	Lead	x			
			Copper	x			
			Zinc	x			
	Cadmium refining	Handling, filtration, melting and casting	Cadmium containing dust	x			
	Copper smelting	Handling, smelting	Arsenic oxide	x			(x) (possibly also ASH_3)

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 37 Basic metal Industries

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
720	Copper smelter	Roasting and electro-lysis	Dust containing arsenic, copper and lead	x			
	Hard metal	Smelting	Cobalt containing dust	x			
			Tungsten carbide	x			
	Lead smelter	Smelting	Lead	x			
	Nickel refining	Smelting, electrolysis	Nickel	x			x $Ni(CO)_4$
			Nickel oxide	x			
			Nickel sulfide	x			

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 37 Basic Metal Industries

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
720	Vanadium factory		Vanadium dust	x			
	Zinc plant		Cadmium dust	x			

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3. 38 Manufacture of fabricated metal products, machinery and equipment

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
381	Manufacture of fabricated metal products, except machinery and equipment	Metal machining, cutting	Cutting oils			x	
			Lubricant oils			x	
		Metal cleaning and degreasing	Organic solvents			x	
			Aquous solutions of e.g. Friethanol amine Boron compounds Nitrilotriacetic acid EDTA		x		
		Sand blasting	Quartz dust	x			

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
819	Manufacture of fabricated metal products, except machinery and equipment not elsewhere classified	Sanitary whiteware production	Pottery dust	+			
		High speed can making	Lead	+			
829	Machinery and equipment except electrical not elsewhere classified	Hot forging (artillery shells)	Oil, soot metal	+		+	Nitrogen oxides, Sulfur oxides, Aldehydes, Carbonmon-oxide

'able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
3832	Manufacture of radio, television and communication equipment	Manufacture of semi-conductors	Silica dust	+			Numerous gases
			Caustics				
			Arsenicals	+			+
3839	Manufacture of electrical apparatus and supplies not elsewhere classified	Manufacture of batteries (alkaline)	Cadmium	+			
		Manufacture of lead-acid batteries	Arsenic dust (arsenic oxide)	+			Arsine

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
841	Shipbuilding and repairing	Boatbuilding and repairing	Asbestos	+			
			MMMF	+			
		Cutting, drilling, grinding etc.	Paints and laquers		+	+	+
			Lead	+			
			Wood dust	+			
		Welding	Welding smoke				

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Manufacturing 3

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
843	Manufacture of motor vehicles	Automobile assembly (grinding, soldering)	Lead dust	+			
		Brake and clutch factory	Asbestos fibres (chrysotile)	+			

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Electricity, gas and water 4

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
101	Electric light and power	Cleaning and handling	Fly ash (containing nickel, cadmium, lead and zink)	+			
		Handling of fuel oil	PAH	+			
		Insulation work	Asbestos	+			
		Maintenance work	PCB			+	
			Metals (e.g. Cr.Ni.Be)			-	

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Electricity, Gas and Water. 4

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionally present
					Water based	Other	
1102	Gas manufacture and distribution	Coke oven work	PAH	+			Various gases
			Coal tar fumes	+			
			Coal dust	+			

able

IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Construction 5

SIC ode	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionall present
					Water based	Other	
000	Construction	Building etc.	Asbestos fibres	+			

Table IMPORTANT WORKING PROCESSES AND OPERATIONS.

Major Division: Transport, storage and communication 7

SIC Code	Divisions, major groups or groups	Processes and/or operations	Aerosols	Solid aerosol	Liquid aerosols		Vapours additionall present
					Water based	Other	
/111	Railway transport	Railway workshop (maintenance work)	Asbestos	+			
		Cleaning operations	Dust	+			
			Oxalic acid		+		
/191	Services incidental to transport	Dockyard workers	Alfatoxins	+			
			Lead	+			
			PAH	+			
			Dust	+			
		Operation of grain elevators	Grain dust	+			