Managing naturally occurring radioactive material (NORM) in mining and mineral processing — guideline

NORM–4.1

Controlling NORM — Dust control strategies

Government of Western Australia
Department of Mines and Petroleum
Resources Safety

The Chamber of Minerals & Energy
Western Australia

MIAC

Reference

The recommended reference for this publication is:

Department of Mines and Petroleum, 2010. Managing naturally occurring radioactive material (NORM) in mining and mineral processing — guideline. NORM–4.1 Controlling NORM — Dust control strategies: Resources Safety, Department of Mines and Petroleum, Western Australia, 37pp. <http://www.dmp.wa.gov.au/>

Published February 2010

Contents

List of Figures

1. General information

1.1. Purpose

To provide guidance on a variety of strategies that may assist in minimisation of radiation exposure arising from dust inhalation.

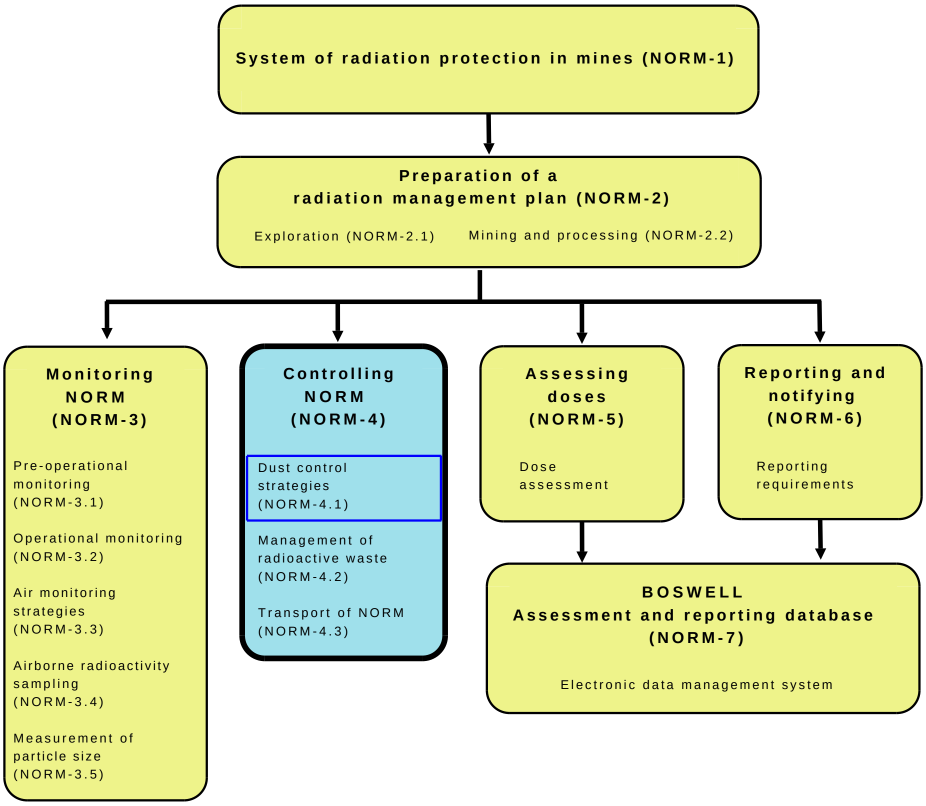
1.2. Scope

This guideline applies to all exploration, mining and mineral processing operations in Western Australia that use or handle naturally occurring radioactive material (NORM) and come within the scope of Part 16 of the Mines Safety and Inspection Regulations 1995 [1].

1.3. Relationship to other NORM guidelines

The flowchart in Figure 1.1 shows how the Radiation Safety Guidelines are arranged.

Figure 1.1.: Relationship to other NORM guidelines



2. Guidance

2.1. Introduction

In most exploration, mining and mineral processing operations, measures are taken for dust control to protect workers against hazards associated with non-radioactive dust. These measures usually limit the airborne concentrations of radioactive dust sufficiently to meet the radiation protection requirements.

To ensure that methods for controlling dust at mining and processing facilities are in place and sufficiently adequate, programs for the sampling and control of dust should be formalised. The following measures are suggested:

1. The generation of dust in operations should be minimised by the use of appropriate mining techniques such as proper blasting patterns and timing, the use of water and other means of suppressing dust and the use of appropriate equipment.
2. Where dust is generated, it should be suppressed at the source. Where necessary and practicable, the source should be enclosed under negative air pressure. Air may have to be filtered before being discharged to the environment.
3. Dust that has not been suppressed at the source may be diluted to acceptable levels by means of frequent changes of air in the working area. Again, the exhaust air may have to be filtered before being discharged to the environment.
4. Care should be taken to avoid the re-suspension of dust as a result of high air velocities.
5. Where methods of dust control do not achieve acceptable air quality in working areas or where such controls are not practicable, appropriate respiratory protection should be provided to employees.

The main emphasis of this guideline is on dust control issues in the mineral sands industry; but the main principles of dust control suggested in this document can be applied in any other industry where dust containing naturally occurring radionuclides may present an occupational hazard.

2.2. General principles

Typically, the following measures are put in place to minimise exposure of employees to airborne dust:

2.2.1. Mineral exploration

Measures include:

- ‘wet’ drilling methods;
- dust collection systems utilised wherever possible;
- the re-suspension of dust, particularly during the maintenance of drilling rigs, is minimised by cleaning the equipment prior to any repairs/maintenance being undertaken;

- cutting of drilling core is carried out by ‘wet’ methods wherever possible; and
- the use of a dust ‘boot’/‘skirt’ to seals the area around the drill hole to prevent the escape of dust into the working environment.

2.2.2. Surface mining

Generally, NORM–bearing dust at mine sites does not represent significant occupational radiation exposure hazard. Typically, the concentrations of radionuclides in ores and mineral concentrates are relatively low, and only on rare occasions the areas where the ore and/or concentrate is stored are classified as ‘controlled’. In some branches of industry such as mining of heavy mineral sands, the processed concentrates typically contain relatively high levels of moisture and consist predominantly of mineral grains that are not susceptible to being wind-swept for long distances.

Other measures that need to be considered include:

- the amount and surface of ‘open’ areas at a mine site should be minimised;
- only those areas that are absolutely necessary to be cleared of vegetation and topsoil are cleared, and these, wherever possible, cleared just prior to the required period of use;
- after the completion of mining, areas are rehabilitated and re-vegetated as soon as possible;
- the cabins of mining machinery should be enclosed;
- the surface of the stockpiles of ore, concentrate and waste materials should be either stabilised by using appropriate surface suppression agents or kept wet by using a specifically designed sprinkler system and, where required, installation of shade cloth fencing;
- the levels of dust that could be generated from the roads on a mine site can be minimised by applying appropriate vehicle speed limits, regular grading and maintenance of these roads (including watering); and
- dust control is essential at the initial stages of ore processing such as crushing, particularly in cases where the ore contains significant amount of naturally occurring radionuclides (such as at uranium mining sites) and dust collection/extraction may need to be implemented.

2.2.3. Underground mining

In cases where the dust in underground workings needs to be controlled, particularly in situations where naturally occurring radioactive material (such as uranium) is mined – an appropriate advice is required from a qualified ventilation engineer and a radiation protection specialist (as potential levels of radon/thoron may need to be controlled simultaneously). The following dust control measures may be considered:

1. Dilution ventilation (reduces concentrations of airborne dust).
2. Displacement ventilation (confines the dust source and keeps it away from workers by putting the dust away from them).
3. Water sprays / wetting using water or foam using different wetting agents – depending on the dust particle size and the density of the mined ore.
4. Dust collection/extraction systems.
5. Enclosing the cabins of mining equipment.
6. Special dust control measures would be required for other areas such as continuous miners, longwall mining, roof bolters.

It should be borne in mind that the primary objection is the identification of all possible sources of the generation of dust in a particular underground mine and reducing the amount of dust at the source – in the processes of ore extraction, drilling, conveying and handling, blasting and crushing (where applicable).

2.2.4. Processing (uranium minerals)

As the processing of uranium is typically carried out using solvent extraction there is a little potential for dust generation except in the process of ore crushing (addressed above) and the drying and packing of the final product.

The processing equipment used for the drying and packing of uranium product typically operates under negative pressure – to restrict the release of dust into the working environment. The levels of the generated dust are not expected to be significant under the normal operational conditions; however it is usual for employees in these areas to wear respiratory protection equipment (please see Appendix C) – in cases of unforeseen spillages of the product and/or during the process of cleaning up the dust collected on the surface of the equipment.

2.2.5. Processing (thorium minerals)

Dust control in processing of ores and concentrates containing thorium is very important as the inhalation of dust contain thorium results in an internal dose which is typically 100% higher in comparison with the inhalation of uranium-bearing dust with the same gross alpha activity concentration (please refer to the guideline NORM–5. Dose assessment for more information).

The most common thorium-bearing dusts are generated in the processing and separation of heavy mineral sands.

The most significant radioactive mineral, monazite, is often the last mineral to be separated in the typical process. Monazite therefore exists as a contaminant in all the processing sections, becoming progressively concentrated as each of the other valuable heavy minerals are removed.

Monazite is softer and finer than the other ‘heavy’ minerals, and this typically results in the concentration of this mineral in airborne dust being up to 30 times higher than in the bulk concentrate that is being processed. This is particularly evident in the final stages of the separation process.

Many design features of the dry separation building, as well as the nature of process equipment and techniques, exacerbate the generation of dust when:

1. Material is continually moving and because some equipment is not enclosed, it is readily suspended.
2. The process involves the extensive piped or conveyor transport of dry sand between floors and separation equipment.
3. One force involved in the separation process is gravity and so material is again likely to become suspended through air displacement.
4. The existence of numerous exposed beams, pipes, cable trays and other surfaces provide settling points for airborne dust.
5. Most efficient separation requires hot and dry conditions — therefore fine particles can be carried by local thermal air currents.
6. Abrasion and attrition generate small particles which are more likely to become suspended.
7. Separation techniques such as vibrating screens and air agitation (e.g. air tables) are specific generators of dust.

8. The buildings are multi-storey with open grid-mesh flooring which hinders effective spillage identification and control.
9. Separation equipment is often designed 'to spill' mineral in the case of overload (for reasons of metallurgical convenience).

In addition to the physical concentration process and plant design, operation of the plant is reliant on frequent visual inspections and manual adjustments of equipment settings (i.e. close operator-plant contact is required). There are also a number of operating practices that aggravate dust generation such as:

- the use of compressed air and dry sweeping methods for housekeeping tasks;
- manual cleaning (pulling) of machine screens and feed slips;
- paddling air table decks to clean cloth substrates; and
- overfilling of surge bins.

The primary emphasis in this guideline is on engineering controls for dose reduction. However, because of the nature and complexity of dust control in mineral processing plants, other exposure mitigation strategies are also suggested. These other control strategies are briefly described in Section 2.4 on page 7 and include metallurgical controls and administrative controls such as work procedures, job rotation and the use of personal protective equipment.

2.3. Overview of engineering controls

The reliance should primarily be placed on measures to make plant and process intrinsically safe, and that managerial procedures or personal protection should be regarded as secondary and supplementary measures.

Some general engineering principles of atmospheric dust control are:

- suppression (or prevention) at the source;
- enclosure or containment;
- provision of local exhaust;
- dilution and rapid removal; and
- isolation and process modification.

2.3.1. Suppression

Prevention of dust formation is usually carried out by wetting (application of fine water mist spray) or electrostatic attraction, in the mineral sands industry. The process reliance on magnetic, electrostatic and gravitational separation of dry mineral renders this control option impractical with conventional separation technology. However, dust suppression should be practical in other industries and, overall,around processing buildings and product and tailing stockpile areas as appropriate. Alternative mineral sands separation technology using wet magnets results in a significant decrease of dust concentration in a particular operation.

2.3.2. Local exhaust ventilation

Local exhaust ventilation involves controlling dust at the source by collecting and removing all airborne material. Dust extraction hoods on all dust generating equipment, apart from presenting a complex engineering problem, involve significant capital outlay. However, where other methods are not practicable or fully effective, this may be the only option available. Priority areas would be potentially high dust generating sources such as screens, mineral discharge and feed points, conveyors and elevator discharge points and, in mineral sands industry – air tables. The air tables and large screen decks would require canopy type hoods, with an extraction system capable of providing sufficient capture velocity to remove dust particles. Appendix B on page 22 contains photographs showing a number of these dust control systems.

The local exhaust ventilation systems require high standards of design, installation, operation and maintenance to ensure that their performance remains optimal. It is also important when designing dust control equipment to include in the design evaluation the ultimate fate of any dust collected or diverted from the workplace environment and any additional procedures involved. Attention must be given to the final filtration and discharge of the ventilation air and to procedures for disposing of used filters and collected dust.

2.3.3. Enclosure

In the short term, satisfactory results may be obtained by simply enclosing machines. However, if dust is generated and not removed, it will ultimately be released into the workplace atmosphere. The use of enclosures to contain the dust may limit the number of points requiring exhaust ventilation.

The placement of a covering on the grid-mesh floors around separation equipment will reduce dust concentrations by effectively limiting dust migration to lower floors. However, when other occupational hygiene issues are considered (such as protecting employees from noise and heat stress), this measure may be impractical.

2.3.4. Dilution and rapid removal (general mechanical ventilation)

Dilution ventilation involves the provision of general exhaust or mechanical ventilation to remove dust-laden air from the working environment. It is also important in underground workplaces where, in addition to dust, relatively high radon/thoron concentrations are expected or measured. The clean air dilutes the dusty air in the workplace, lowering the overall dust concentration.

With dilution ventilation, it is important not to use such a high velocity that the situation at an occupied workplace worsens because dustier air is being delivered to it.

The introduction of dilution ventilation in a plant processing dry mineral, with the resultant increased ventilation rate, may also liberate finer particles from surface deposits into the air. This would be particularly relevant if neglect of housekeeping had resulted in significant build-up of dust and fine mineral grains inside the plant. In addition, a higher air velocity, particularly if it is upward, may keep larger particles in the air for longer. Therefore, dilution ventilation must be introduced with care if it is to be a viable control option.

In the control of airborne dust, attention should be focused, in the first instance, on proposals that utilise containment and extraction principles and improved housekeeping standards. General and specific recommendations on these particular engineering controls are suggested in Sections 2.5.4 on page 11 and 2.5.5 on page 14.

2.3.5. Isolation and process modification

Isolation of the hazardous process stream may be achieved by suitable metallurgical or process stream modifications.

The provision of rooms or cubicles in controlled areas with filtered air supplies in both surface and underground workplaces is a form of personal protection. Self-closing doors should be fitted, preferably in a simple airlock with two doors. Air-conditioned cabs on mining, loading and transport machinery might also be considered in certain circumstances. Stores where products are held prior to dispatch should be well ventilated to prevent the accumulation of radon and thoron daughters, although good natural ventilation is likely to be sufficient.

2.4. Secondary control methods

2.4.1. Personal protective equipment

In certain circumstances, personal protection of the individual employee is necessary. However, personal protection does not eliminate or rectify the conditions causing the hazard, and devices can become ineffective without the knowledge of the wearer. The use of personal protective equipment such as respirators, is considered acceptable while engineering controls are being developed and implemented, or where such controls are not practicable. In general however, personal protective devices should be regarded as being supplementary to process/procedural modifications and engineering control measures, and not to be used in preference of such modifications and measures. To be effective, the use of personal protection must be supported by a comprehensive personal protection program that details use, fitting, cleaning and maintenance. Information concerning the essential elements of a site respiratory protection program can be found in the Appendix C on page 29.

2.4.2. Procedural changes

Sometimes a less hazardous method of performing a task can be substituted for the original method (e.g. vacuuming instead of dry sweeping).

The most cost-effective way of minimising exposure is for workers to withdraw from the source of dust for as long as the process allows. For example, occupancy of the section of the plant where the radioactivity concentration in mineral dust is the highest should be limited only to that which is absolutely necessary for the operating and maintenance of the equipment.

2.4.3. Housekeeping

Spillage may contribute significantly to dust re-suspension. When examining solutions to a dust problem, due attention must be paid to housekeeping and operating practices that can reduce spillage.

A positive attitude towards cleanliness at places of work in the plant should be encouraged, as the re-suspension of dust deposited on surfaces can exacerbate the problem of airborne contamination. Regular campaigns to minimise spillage, accumulation and disturbance of dust should be conducted; and routine actions to recover and return spilt material to the process should be devised and implemented. In many cases, a continuous plant clean-up program will be very useful.

An effective and integrated plant vacuum cleaning system would greatly facilitate the implementation of a housekeeping program.

2.4.4. Training and supervision

All employees working in controlled areas, as designated by the level of airborne radioactivity, must be informed of the hazards from exposure to radioactive dust and the precautions necessary to prevent damage to their health. They should be made aware of the need to carry out their work so that as little airborne dust as possible is produced, and of the importance of the proper use of all safeguards against radiation exposure. Adequate training, both in the proper execution of the task and in the use of all associated engineering controls, as well as of any personal protective equipment, is essential.

Competent supervision is also essential in the overall strategy to reduce or eliminate employee exposure to radioactive dust. Supervisors need to ensure that in addition to the provision and maintenance of all equipment necessary for the task, such equipment is used and work procedures are carried out in a safe and efficient manner.

Supervisors must have a good knowledge of the operation and must also be able to recognise potential radioactive dust exposure pathways or the implications of unusual occurrences.

2.4.5. Job rotation

Where no practical means of control is available in process areas with high levels of airborne contamination, job rotation may be considered in order to reduce the exposure of individual workers. Job rotation should only be used in exceptional circumstances and should not be used as a substitute for the development and use of appropriate radiation control methods.

2.5. Engineering guidelines for minimising dust emissions

The guidance in this part is mostly relevant to the mineral sands industry handling and processing thorium-bearing minerals, where the potential for the internal radiation exposure due to the inhalation of the airborne dust is the highest. However, most of these suggestions could also be implemented in any other industry where NORM is handled and processed in the dry form and there is a relatively significant potential for the generation of dust.

2.5.1. New plants and modifications to existing plants

Isolation of the monazite and ilmenite separation circuits should be considered for new plant design; the monazite circuit being a primary radiation source and ilmenite circuit being a primary dust source throughout the dry plants where isolation is not provided.

Early separation and isolation of the monazite stream should be considered by the application of appropriate metallurgical design in all new plants and in any major modifications to existing plants. If most of monazite could be removed in the first separation stage, airborne radioactivity concentrations in the other stages would be significantly reduced.

Additional illustration on the effectiveness of the dust control inside the mineral sands dry separation plant:

In Appendix B, Figure B.1 on page 22 shows the interior of a plant with no dust control while Figure B.2 shows a plant with dust control. The plant with dust control has enclosures and dust extraction systems.

2.5.2. Implementation of control strategies

If radioactive dust levels are relatively high over a significant period of time (i.e. six months or more), then the formulation of appropriate control strategies or action plans, within a time-frame that is acceptable to the appropriate authority is required.

The control strategy selection process should not only look at a single method in isolation, but at a combination of methods to achieve efficient workplace control. Technical feasibility and practical considerations such as strategy acceptance by employees, regulatory considerations, operational practicality will limit the number of available strategies.

The implementation of control strategies should be performed in such a manner so that the effectiveness of successive stages can be readily evaluated and subsequent priorities reassessed.

It is recommended that adopted measures form a part of site's radiation management plan and, as such, submitted to the appropriate authority for its information and approval, where required. These documents would typically contain:

1. The location and nature of the particular measures it is proposed to be implemented in the period.
2. The relationship of the particular program to the overall radiation exposure reduction strategy for the particular workplace, and the priorities in implementation that apply to that strategy.

2.5.3. General suggestions for dust control

The proposed suggestions are designed to reduce the uncontrolled passage of airborne dust between floors (where applicable), to facilitate disposal and collection of dust and to provide discrete areas for dust clean up.

As a first step in the engineering design of any modification, a check on the structural capacity of the building frame either as existing or as necessarily strengthened to accept added loads, will be required.

The following general suggestions are proposed where practical:

1. Open grid-mesh floors should be altered to solid steel, continuous steel plate flooring, sealed against dust losses. These should be installed progressively outwards from equipment and principal access routes. This suggestion must be balanced against possible increase in exposure of employees to noise and heat, and should be only implemented after the advice from a qualified occupational hygienist.
2. Dust proof chutes, which connect discrete solid floor areas at each level with dust collection bins at floor level, should be incorporated into plant design. Each system should be vented to minimise dust emissions caused by batch discharges of dust (see Figure 2.4 on page 12). They may also be linked to machine enclosures (see Figure 2.5 on page 13, Figure 2.6 on page 13, Figure 2.1 on the following page and Figure 2.2 on the next page).
3. Integrated vacuuming system should serve strategic points at each section and operating level to facilitate equipment cleanup and housekeeping (see Figure 2.3 on page 11).
4. Discrete operating sections should be isolated to reduce dust migration by convection currents.
5. Thermal convection currents should be reduced by enclosing and insulating equipment that handles hot mineral (e.g. feed elevators, driers). This should allow better ventilation without causing increased dust circulation.
6. Operational areas should be designed such that they can be seen by operators to respond to regular cleaning and careful product control and therefore encourage a positive response to routine hygiene and process control procedures.

Figure 2.1.: Schematic arrangement for a vented hood over air table.

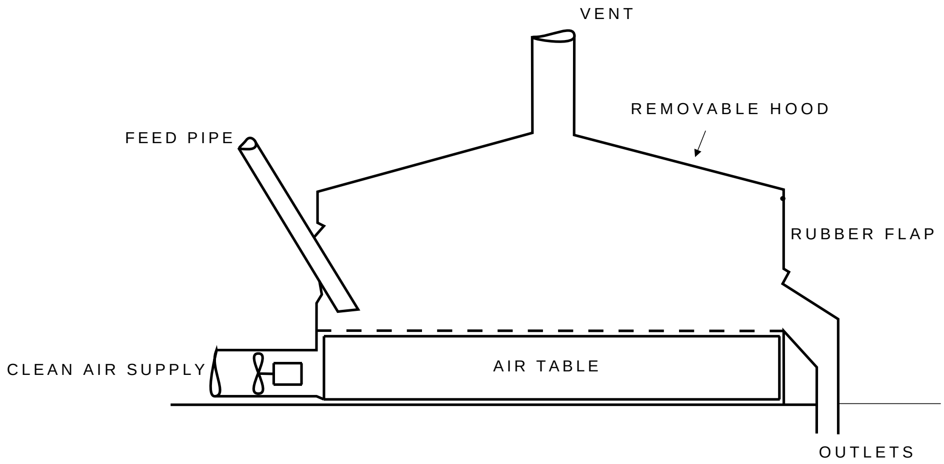


Figure 2.2.: Schematic arrangement for ventilation of feeds to bins and hoppers.

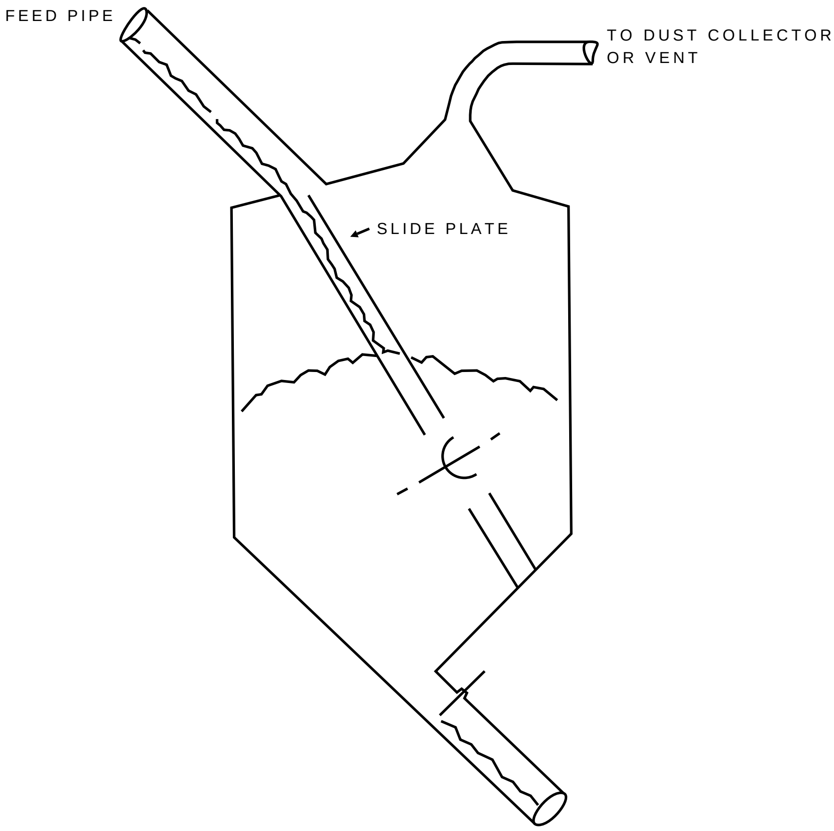
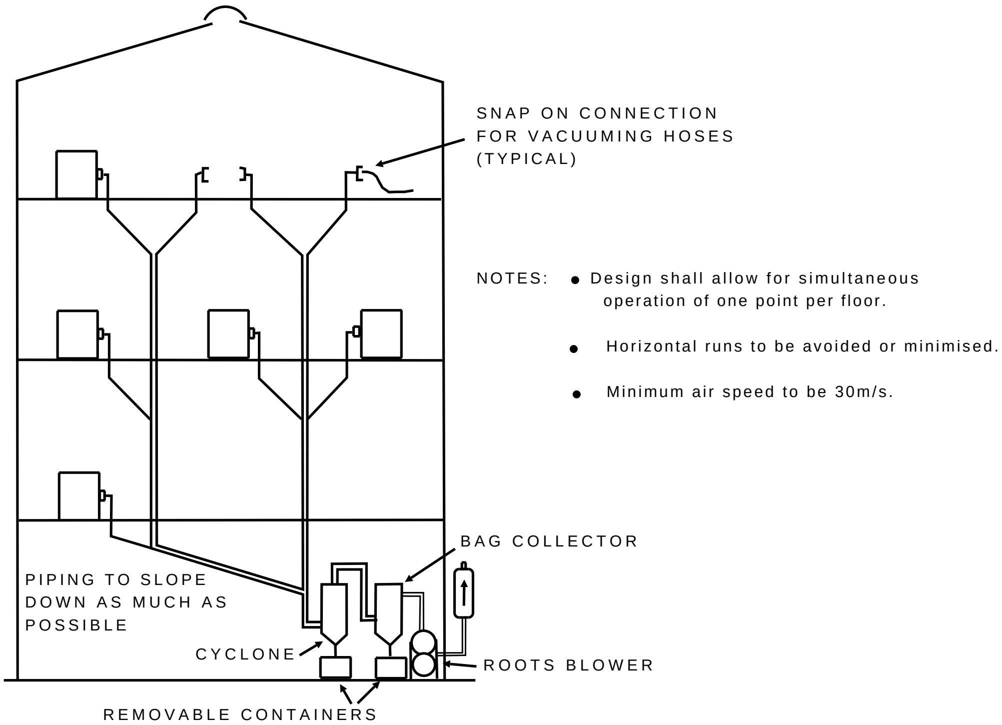


Figure 2.3.: Schematic arrangement of centralised vacuuming system.



2.5.4. Specific suggestions for engineering design

For success in implementation, the following suggestions must be preceded by a high level of competence, professional design, manufacture and installation. Illustrations of hood design for specific operations are shown in Figure A.1 on page 16 and Figure A.2 on page 17.

2.5.4.1. Mineral handling and conveyance

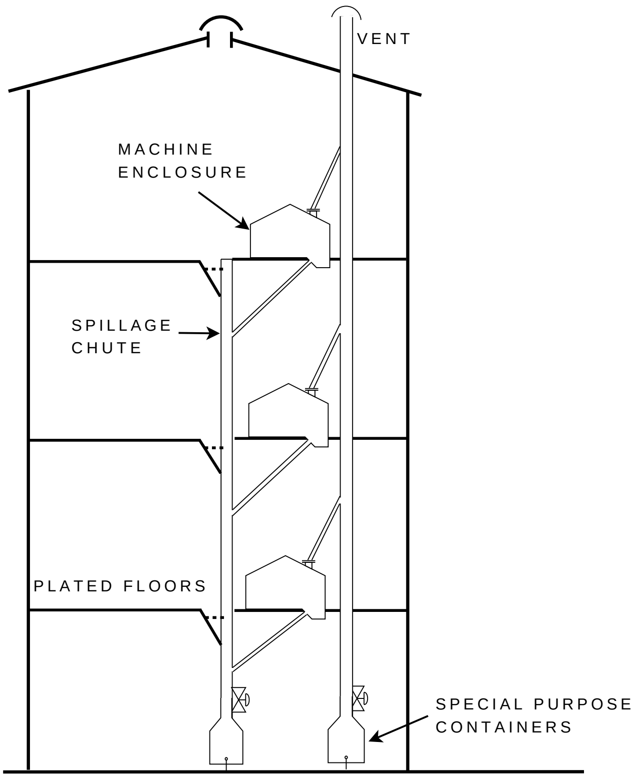
Where:

1. Mineral is discharged into feed boxes or onto conveyors, screens or other machinery, the transfer point should be enclosed and vented. Free falls of materials should be eliminated in detail design. Examples are given in Figure A.4 on page 19, Figure A.5 on page 20, and Figure A.6 on page 21.
2. Where possible, multiple feed points onto conveyors should be concentrated into a single, vented enclosure. Where process requirements demand the spread of the feed points along the conveyor, this entire section of the conveyor should be enclosed and vented.
3. Conveyor belts should be of generous width to allow running at low speeds which are less likely to generate airborne dust. Flat belts should be avoided and likely dust spillage points should be enclosed and vented. Where possible, conveyors should be fully enclosed and vented. An example is given in Figure 2.7 on page 14.

2.5.4.2. Electrostatic and magnetic separating equipment

The space and operational considerations of existing plants are recognised as substantial constraints on the practical implementation of recommendations for equipment enclosure. Nevertheless, enclosure of part or the whole of existing machines should be examined for implementation as follows:

Figure 2.4.: Schematic arrangement of dust collection chutes.



1. Visual inspection should be via viewing ports to eliminate the need to open doors.
2. Maintenance doors should be designed such that they are light, simple to open and whenever possible self-closing and dust tight.
3. The enclosure should be light, dust-proof and easily demountable for major maintenance.
4. The enclosure should be ventilated via an appropriate collection device.
5. The enclosure should be provided with bottom gravity drains connected to the collection or other convenient points to avoid internal accumulation of spilt material.
6. Where possible a vacuum connection point should be fitted to each enclosure.
7. Where operating practice requires the exchange or cleaning of components such as distribution feed slips or plates, an adequate area (e.g. fume cupboard) should be provided for the cleaning of such components.

2.5.4.3. Screening equipment

Several types of vibrating screens are used in industry; some of the screens are open and are sources of dust emissions. Where applicable, replacement of the open screens with fully enclosed units with connections for dust collection systems should be considered.

2.5.4.4. Air tables

The following is suggested for reducing the specific problems associated with air tables (see Figure 2.7 on page 14):

1. Where possible, clean outside air should be used.

Figure 2.5.: Schematic arrangement for venting feed boxes into main bins.

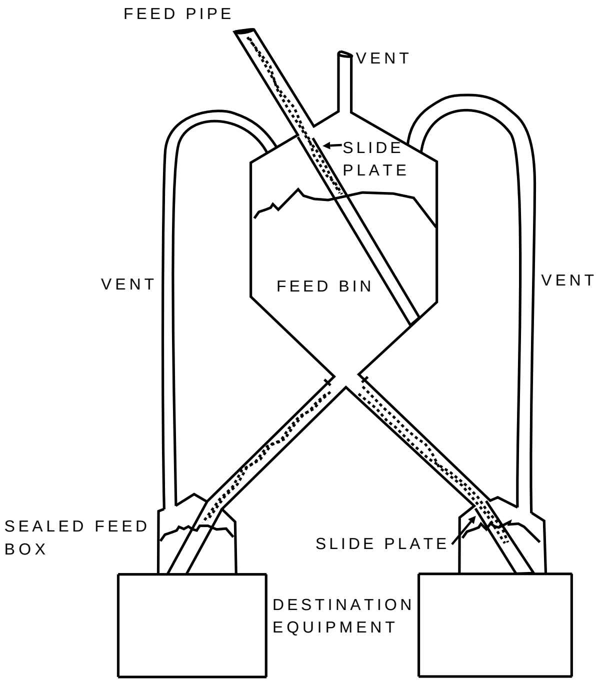


Figure 2.6.: Schematic arrangement for a typical machine enclosure/spillage chute arrangement.

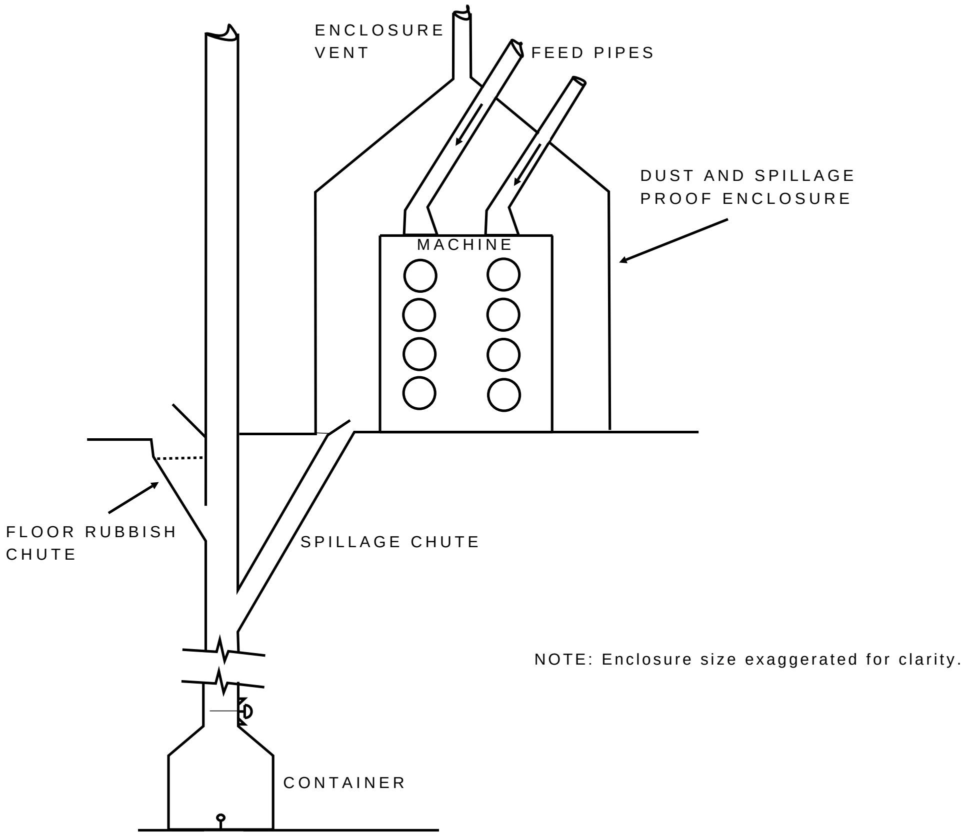
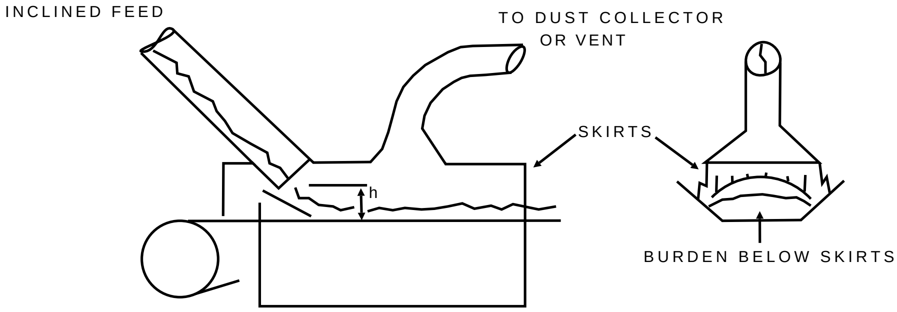


Figure 2.7.: Schematic arrangement for a typical machine enclosure/spillage chute arrangement.



2. A light hood with clear (transparent) side panels should be fitted over each table.
3. The hood should be fitted with self-closing openings.

2.5.4.5. Sample cutters and containers

The whole apparatus could be fully enclosed with provision for the discharge of spillage into the main flow stream. The sample container should be vented into the enclosure above.

2.5.5. Pre-treatment considerations

Coating of the coarser grains of mineral sands by slimes can provide a substantial source of dust in the dry plant. The degree to which this occurs is a function of both the geological nature of the deposit and the type of pre-treatment received during the primary separation process. The additional dry weight of residual slime expressed as a proportion of the total feed dry weight, which has the potential to be removed prior to dry processing, should be assessed and the decision on pre-treatment measures taken based on this determination.

Two types of pretreatment should be considered to reduce the slimes coating:

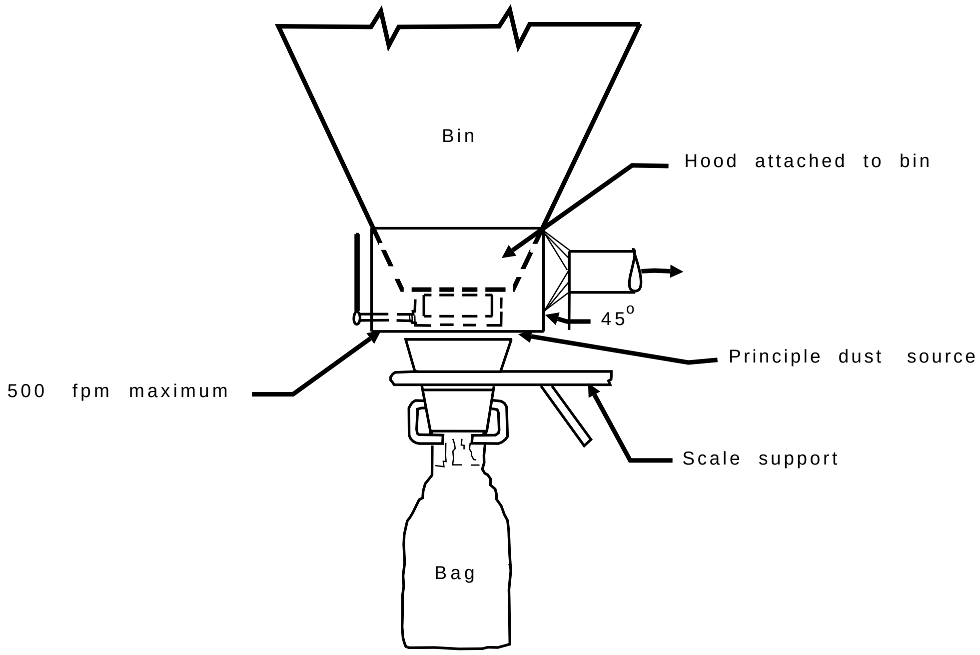
1. Scrubbing of mineral grains in wet attritioning circuits, with released coatings being removed in de-sliming circuits.
2. Wet classification (e.g. hydro-sizing) directed towards fines removal.

A. Appendix showing design illustrations

The following illustrations have been reprinted with permission from the American Conference of Governmental Industrial Hygienists publication, *Industrial Ventilation: A Manual of Recommended Practice*, 21st Edition, 1992 [6]. The illustrations are intended as guides for design purposes and apply to usual or typical operations. In most cases they are taken from designs used in actual installations of successful local exhaust ventilation systems.

A design engineer is referred to this publication for further details. The manual provides information on the general principles of ventilation, hood design, specific operations, design procedure, testing of ventilation systems and air cleaning (dust collection) devices.

Figure A.1.: Schematic arrangement for ventilation in bag filling.



Q = 400 - 500 cfm - non-toxic dust
1000 - 1500 cfm - toxic dust

Minimum duct velocity = 3500 fpm
h_e = 0.25 VP_d

Note: Care must be taken such that too much air is not used, as valuable product will be pulled into the exhaust system.

Reference : 10.15.2

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	*BAG FILLING*	
	DATE *1 – 91*	FIGURE VS – 15 – 02

From ACGIH®, *Industrial Ventilation: A Manual of Recommended Practice*, 21^{st} Edition. Copyright 1992. Reprinted with permission. [6]

Figure A.2.: Schematic arrangement for ventilation in barrel filling.

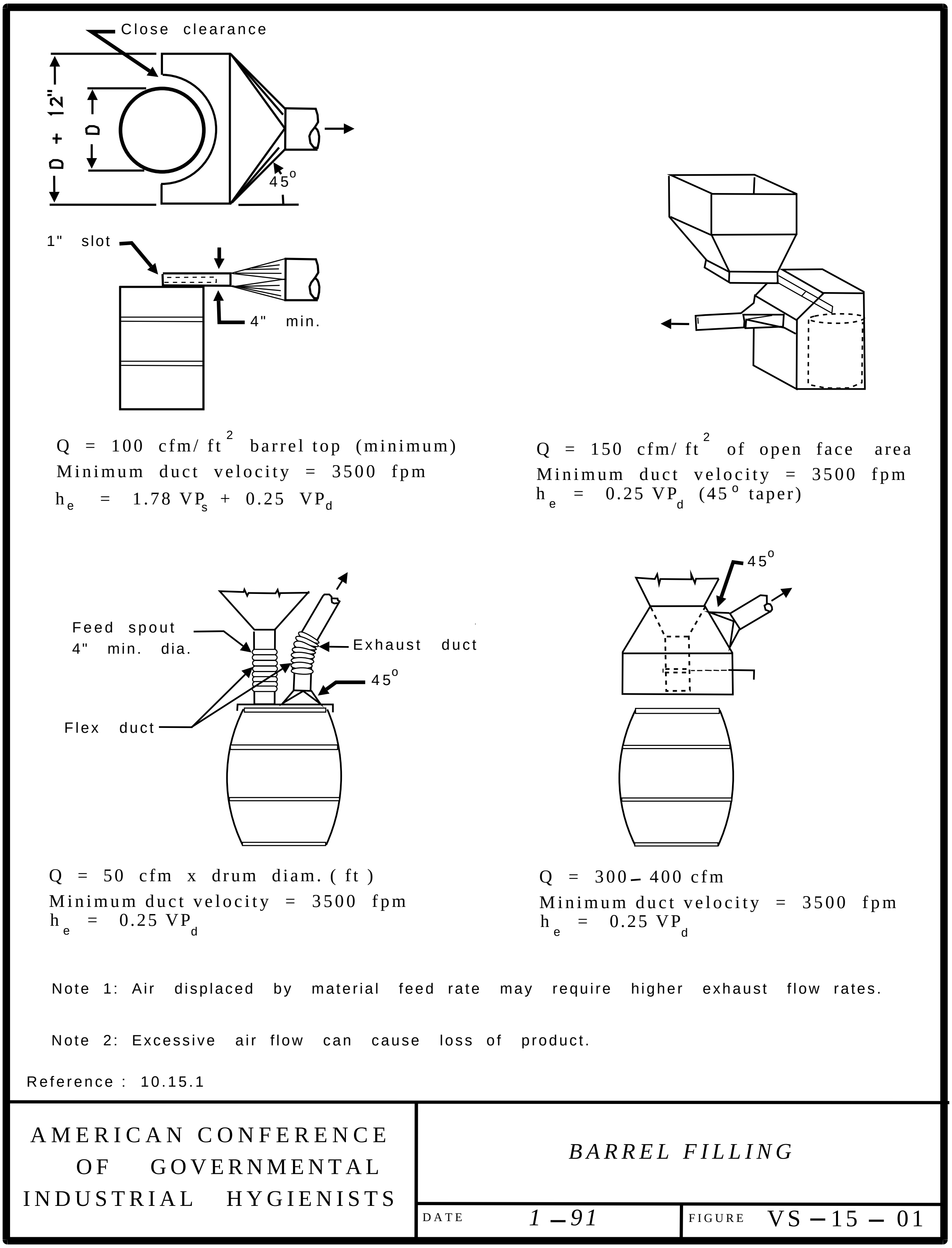


Figure A.3.: Schematic arrangement for ventilation in bins and hoppers.

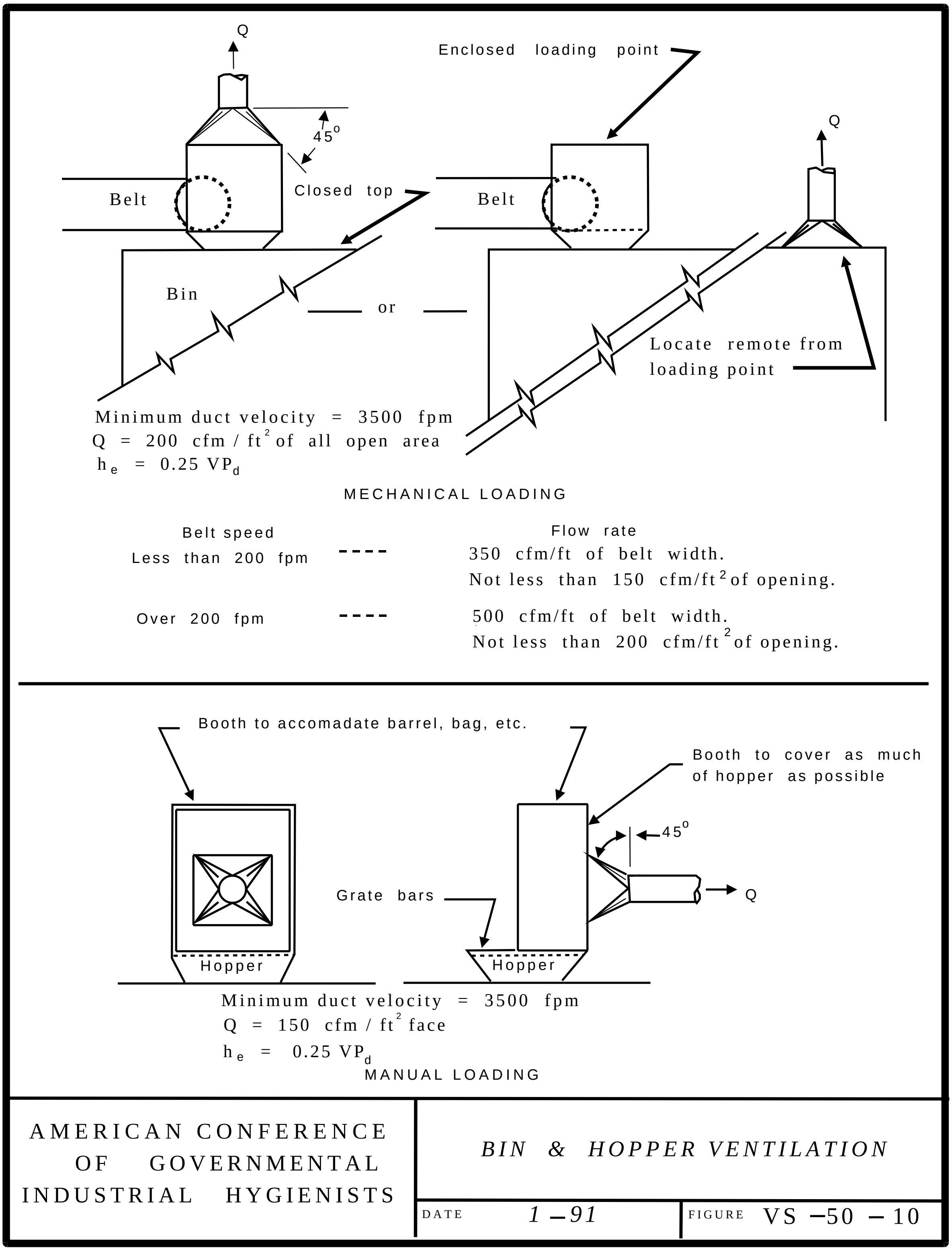
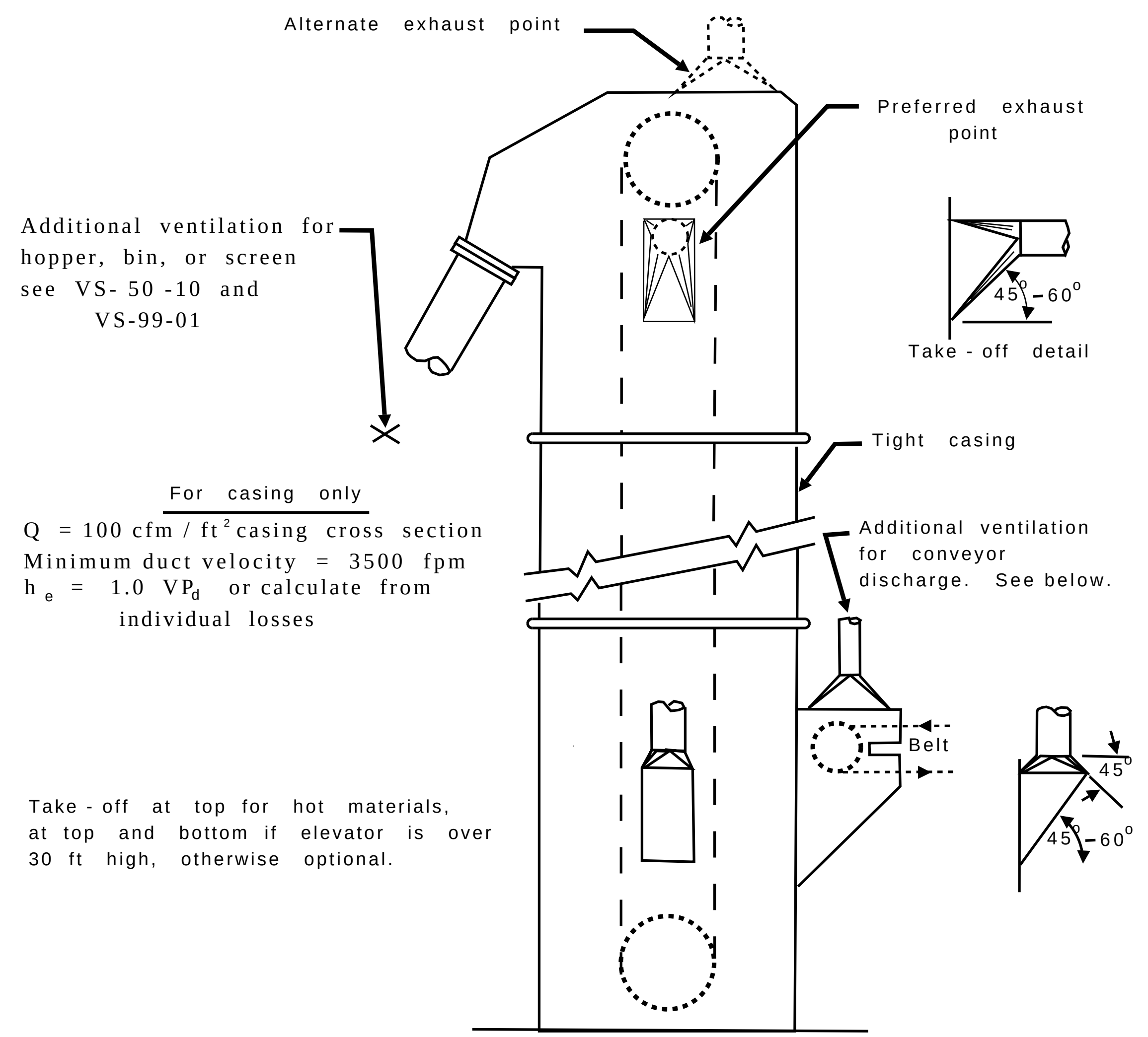


Figure A.4.: Schematic arrangement for ventilation in a bucket elevator.



CONVEYOR BELT DISCHARGE VENTILATION

BELT SPEED	FLOW RATE
Less than 200 fpm	350 cfm / ft of belt width. Not less than 150 cfm / ft² of opening.
Over 200 fpm	500 cfm / ft of belt width. Not less than 200 cfm / ft² of opening.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	*BUCKET ELEVATOR VENTILATION*
DATE *1 – 91*	FIGURE VS – 50 – 10

From ACGIH®, *Industrial Ventilation: A Manual of Recommended Practice*, 21^{st} Edition. Copyright 1992. Reprinted with permission. [6]

Figure A.5.: Schematic arrangement for ventilation with conveyor belts.

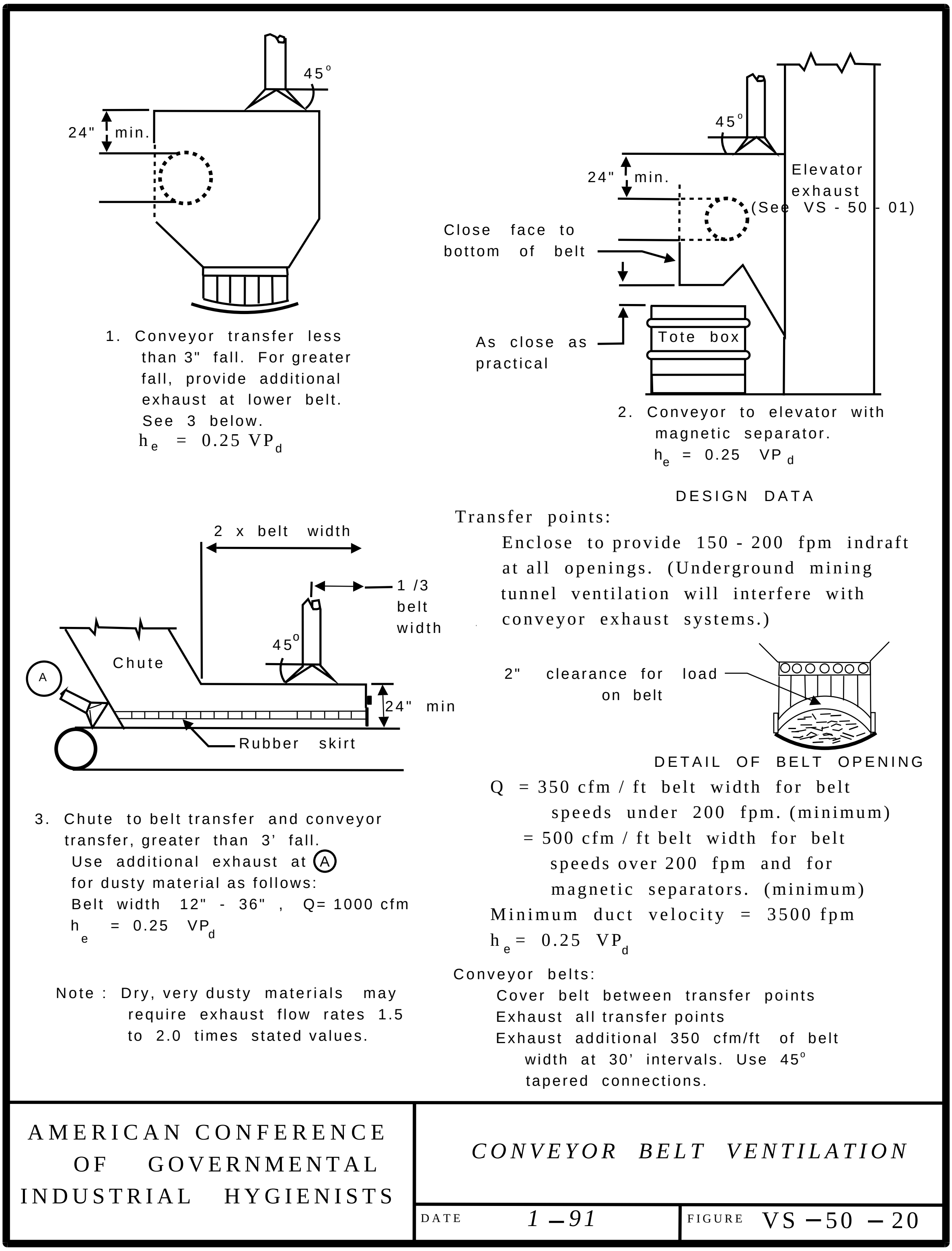
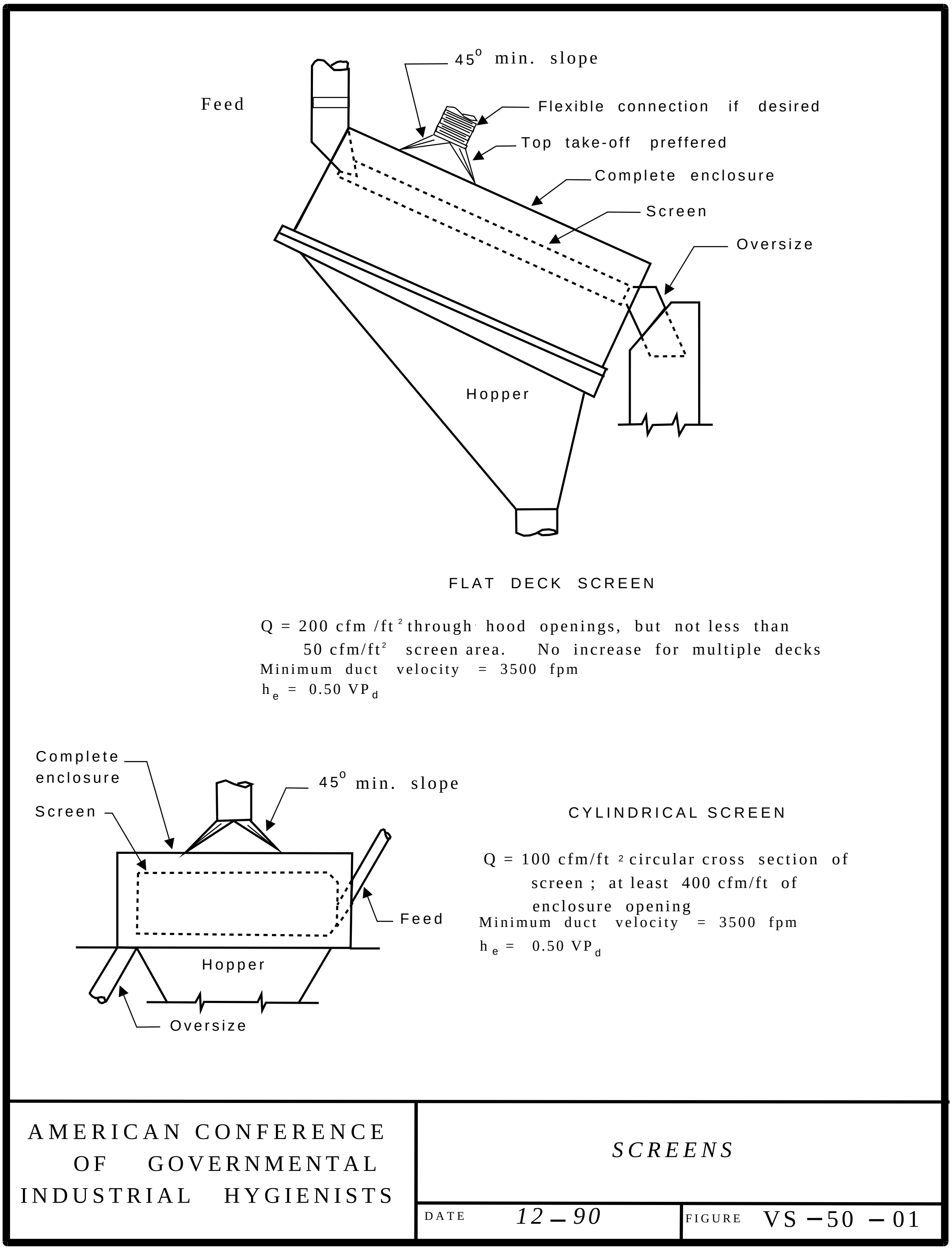


Figure A.6.: Schematic arrangement of dust collection chutes



From ACGIH®, *Industrial Ventilation: A Manual of Recommended Practice*, 21st Edition. Copyright 1992. Reprinted with permission. [6]

B. Appendix showing photographs

Figure B.1.: Interior of a plant with no dust control

Figure B.2.: Interior of a plant with dust control

Figure B.3.: Enclosed conveyor belt system

Figure B.4.: Enclosed drop-points on conveyor systems

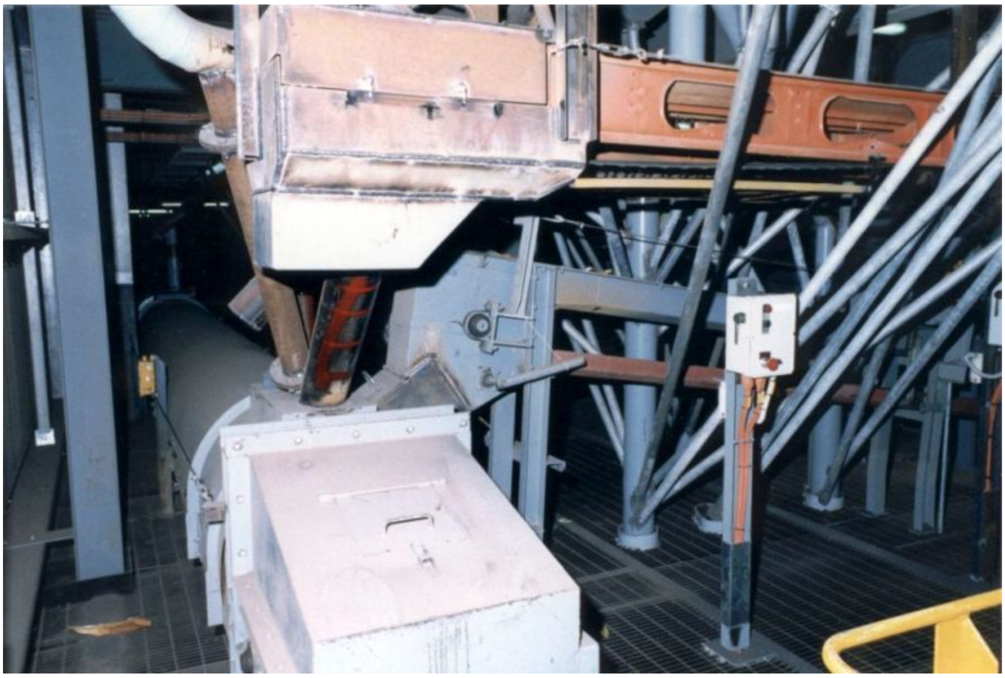


Figure B.5.: Enclosure around a HTR Separator, showing inspection door

Figure B.6.: Ventilated enclosures around an airtable and a kason screen

Figure B.7.: Feed distribution arrangement to HTRs – note enclosed feed hoppers, spillage collection hoppers and inspection doors

Figure B.8.: Test rig for determining optimum ventilation parameters – enclosed, ventilated drop box

Figure B.9.: Enclosures around bucket elevator feed points

Figure B.10.: Open mesh cable trays – minimises dust accumulation

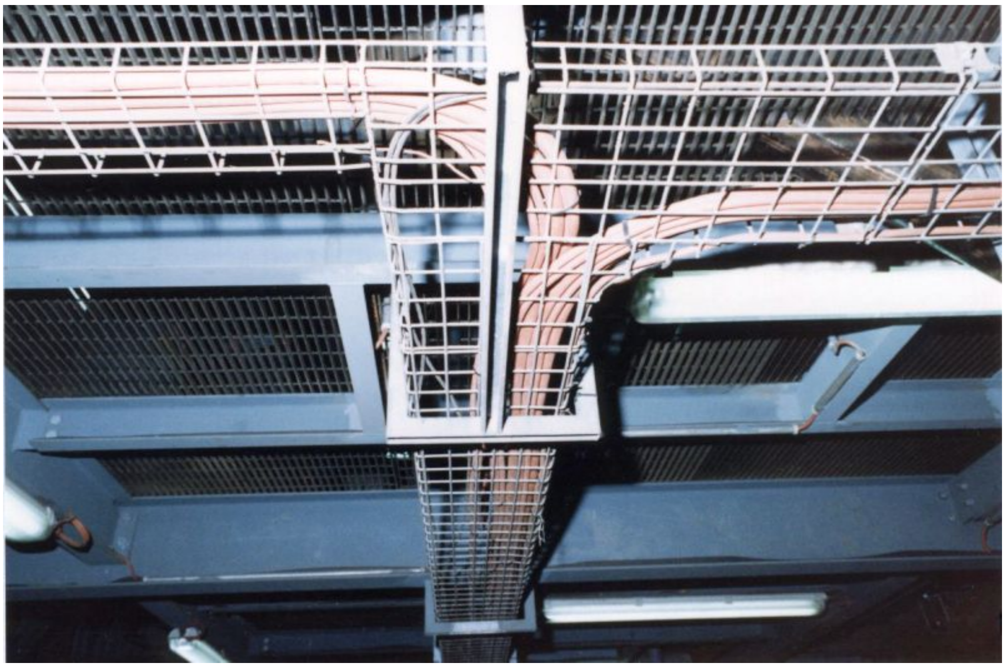


Figure B.11.: Extraction ventilation connection to bucket elevator heads

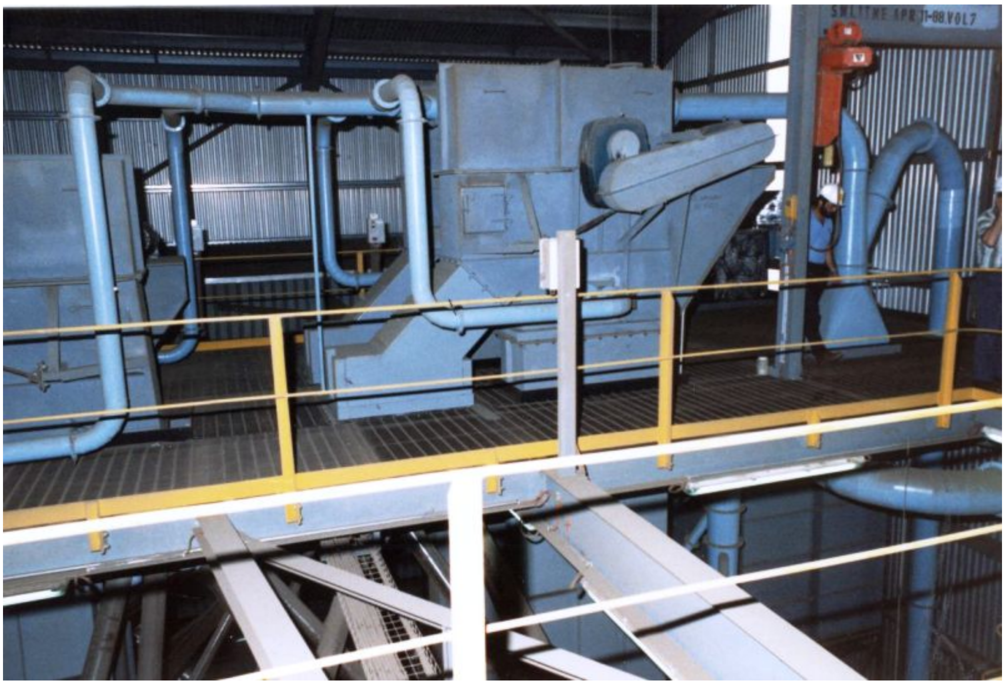


Figure B.12.: Insulation around gravity discharge pipes – assists in minimising thermal convections

Figure B.13.: Vacuum cleaning machine prior to maintenance work

C. Appendix showing respiratory protection

The information in this appendix outlines the requirements on the development of a formal respiratory protection program. Providing that all of the essential elements below are followed, it should be possible for a particular operation to seek approval to use a protection factor in determining a more realistic estimate of employee exposure to airborne radioactivity.

Compliance with exposure or dose limits via routine use of respiratory protection equipment (RPE) is not considered acceptable and a requirement for routine use of RPE is a clear indication of the inadequacy of existing engineering controls. There are, however, some circumstances in which the use of RPE may be regarded as a valid protection option:

1. During certain cleaning and maintenance operations (e.g. entering closed vessels).
2. During unplanned events or emergencies (e.g. when there is a failure of ventilation or dust control systems).
3. If airborne concentrations exceed specified action levels as determined by the appropriate authority, particularly in underground workplaces.

Respiratory protection use at exploration, mining and/or processing plants is generally confined to specific work tasks known to create or aggravate dust generation or to specific locations with elevated dust concentrations. With appropriate scheduling of work the time spent in mandatory respiratory protection use situations should be no more than a few hours per work shift.

C.1. Respiratory protection program (RPP)

When implementing a site RPP the following important considerations should always be considered:

1. Respiratory protection does not eliminate or rectify the conditions causing the hazard, and RPE can become ineffective without the knowledge of the wearer.
2. RPE can create a possibility of accidents and of stress by virtue of their interference with an employee's freedom of motion, communication and vision.
3. The full effectiveness of RPE is strongly dependent upon the active co-operation of the user.

Reliance on RPE for exposure control demands that strict attention be paid to auditing, training and written procedures to assure the correct selection, use and maintenance of RPE. Written standard operating procedures should be prepared for the site and these procedures should be readily available to managers, supervisors and employees. A site RPP should include documentation on the following key elements:

1. Site application
2. Selection
3. Fitting
4. Maintenance and storage
5. Training
6. Auditing

Specific details relating to these key RPP elements are outlined in the following sections. The selection, use and maintenance of RPE should always be in accordance with the requirements of Australian Standard [5]. The specification for the design, performance and testing of RPE is set out in Australian Standard [5].

C.1.1. Site application

A summary of work tasks and/or locations where employees must wear RPE and under what conditions (normal or emergency) should be prepared for each site. Particular work activities, processes or environments should be designated as requiring the use of RPE based on measured air contamination levels. In certain situations, where the air contamination level may not be precisely known, the site Radiation Safety Officer (RSO) will need to use his/her professional judgement. Mandatory respiratory protection use situations must be clearly identified and separated from optional use situations.

C.1.2. Selection

The selection of respiratory protection requires a thorough knowledge of all factors involved, including the nature and concentrations of contaminants, the types of duties to be performed by the worker, and an understanding of the design, scope and performance of the various types of respirators available.

There are four broad categories of respirators:

1. Filtered or purified air respirators (PAR) (e.g. common dust mask).
2. Hose-type supplied air (airline) respirators (SAR).
3. Self-contained breathing apparatus (SCBA).
4. Helmet–type respirators with filtered air supplied to the breathing zone through the helmet and between the face shield and the face (e.g. 'Airstream' helmet).

The PAR is the most common type of personal RPE used in mining and minerals processing. With the proper selection of the filter medium, these respirators provide effective protection against commonly encountered mineral dusts containing NORM. PARs are available in both half-face and full-face models, the former providing less protection than the latter but being more acceptable to workers because of greater comfort. A good fit between face and respirator is vital in achieving adequate protection.

Only approved certified RPE (as per [5]) should be used and the selection should be based on the potential exposure hazards. The types of filters, canisters and cartridges to be used in each mandatory RPE situation should be well documented. Where practical, individual respirator assignment should be undertaken. With regard to supply of RPE, it is essential that an operation has an adequate number of respirators and, where relevant, unexpired cartridges and canisters.

C.1.3. Fitting

Respirators should be selected with regard to the individual worker. Where practicable, respirators should be assigned to individual workers for their exclusive use. Correct fitting of the respirator to the worker is essential; in exceptional circumstances, special actions may be necessary to ensure that workers are adequately protected by RPE. For example, a worker with spectacles, a beard, dentures, or an unusually bony facial structure may not be able to obtain adequate protection from certain designs of RPE and special arrangements may need to be made. Such workers should be issued with

RPE on a personal basis. Workers with bronchial problems may not be able to wear those respirators that present a resistance to breathing.

Qualitative fit-testing using either saccharine or isoamyl acetate is recommended and such testing confirms that a good fit is obtained between the respirator face-piece and the face. A comprehensive training program and detailed procedures for performing qualitative fit tests are available in Appendix D of the Australian Standard [5]. Methods for fit-testing respirators should form part of the written standard operating procedures.

Respirator fit testing records must be kept until replaced by a more recent record. Records must include name, an identifying number, model(s) of respirators for which successfully fitted, appropriate remarks, and dates.

Type and extent of training should be indicated for each respirator user. Repeat fit-testing should be conducted at least annually, whenever the type/size of respirator is changed, and whenever there is a significant change in any facial characteristics, e.g. dentures, facial hair, etc, that might effect the respirator fit. The worker should be given a record of the respirator size or brand that fits him/her, unless the respirator is issued personally.

C.1.4. Maintenance and storage

Each employee individually assigned a respirator should maintain it in a clean and sanitary condition. In some cases, periodically wiping the interior surface with a sanitising tissue or solution may be sufficient. At least monthly (more often where conditions warrant), individually assigned masks that have been used during this month should be disassembled, inspected, repaired (if necessary), thoroughly washed and disinfected by a trained individual. Where more than a few masks are involved, it is advisable to have personnel at a centralised facility perform this function to limit the training program.

Respirators used by more than one worker should be thoroughly cleaned and disinfected after each use. A suitably equipped station (preferably centralised for a plant or an area) should be provided. The use of an alcohol-base sanitiser is not recommended as it may cause premature deterioration of respirator rubber components. If an alcohol-based sanitiser is used, saturating the respirator, i.e. dipping or spraying, should be avoided. Procedures for cleaning, sanitising, inspecting and repairing respirators should also be documented. Such procedures should generally be in accordance with Australian Standard [5].

When respirators are not in use, they should be stored so they are kept clean and protected from heat, direct sunlight, dust, chemicals and other agents that may cause deformation. Respirators should not be left in the work zone where they might become contaminated with dust and other substances. Preferably, they should be stored so they can be readily inspected — in a clear, plastic dedicated container, rather than stored loose in the worker's personal locker. Respirator storage locations should be clearly identified and brought to the attention of employees.

C.1.5. Training

A qualified person should give all employees expected to wear RPE initial training in its correct use. This training should cover the following points:

1. Mandatory site respiratory protection tasks/locations.
2. Description of the equipment, its mode of operation, function and limitations.
3. Proper care, cleaning, sanitising and storage.
4. Instruction on how to put on the equipment and adjust the face piece.

5. Explanation of when and how to replace filters, cartridges, canisters and cylinders.
6. Details on location of RPE and RPE requisition procedures.

The training program and the training and retraining schedules for new and experienced employees should be documented. Refresher training on at least an annual basis is recommended. People with responsibility for auditing the site RPP may need additional detailed instructions on individual program elements.

C.1.6. Auditing

There should be regular (at least annual) inspections and evaluations to determine the continued effectiveness of the site RPP. Auditing should be directed at all program elements (application, selection, fitting, maintenance and storage, and training). An important aspect of auditing is to verify the adequacy of employee job training policies and procedures by observing work practices. Regular monitoring of work areas for airborne radioactivity levels should be routinely carried out to ensure correct respirator selection. Program reviews should indicate if the application of the site RPP needs to be maintained, reduced or increased.

C.1.7. Records management

In order to maintain surveillance over, and control of the site RPP, the following sets of records are recommended:

1. Radiation and airborne contaminant monitoring data (contained in the 'Boswell' database).
2. Justification for selection of particular RPE.
3. Details of fit testing of RPE for each relevant employee.
4. Job assignment and medical surveillance data.
5. Training records.
6. RPE care and maintenance records.

C.2. Protection factors (PF)

The protection factors (PF) should not be applied to exposure measurement results without the written consent of the appropriate authority. Any proposal to invoke PF should be first put forward to the appropriate authority for consideration and approval if found acceptable.

C.2.1. Administrative requirements

Any proposal to use PF in the internal dose assessment should include appropriate administrative records that indicate the schemes of work, exposure periods and RPE usage for which exposure modification is sought. The proposal should also outline the site RPP and provide sufficient information so that the efficiency of this program can be satisfactorily demonstrated (e.g. strict supervision, proper fit testing procedures, adequate respirator maintenance and audit programs, etc). If these administrative requirements are met and the site RPP follows requirements of this guideline, the use of program protection factors may be acceptable to the appropriate authority.

The recorded intake for the worker(s) would then be lower than that calculated on the basis of the ambient airborne contamination assuming no use of RPE. However, because of the difficulties in ensuring that the correct RPE is used effectively for the requisite time, it should not be automatically assumed that the nominal PF specified in a particular respirator technical data can be applied in exposure assessment and reporting of such assessments.

The concept of Personal Protection Factor (PPF) is introduced to take into account intermittent respirator usage by incorporating the time a respirator is worn during the work cycle compared to the time it is not worn. The PPF is a function of exposure conditions, worker activities and RPE use regimes and, therefore, is a measure of the effectiveness of the complete respiratory protection program. It is prudent to use the lower limit of the nominal PF specified for the particular RPE, with an additional safety factor, as advised by the appropriate authority. Ideally, the PPF should be determined for a particular operation, as described below.

C.2.2. Determination of personal protection factor (PPF)

Surveys to determine PPF require the quantification of dust or activity concentrations under two conditions while the worker is:

- wearing a respirator; and
- not wearing a respirator.

The following protocol may be used:

1. The worker is issued with two dust sampling heads (filter cassettes) and instructed to use one only during respirator use periods and to the other one only during respirator non-use periods.
2. The PPF is calculated as follows:

Assuming no protection

$$A = \frac{((T1 \times D1) + (T2 \times D2))}{(T1 + T2)}$$

Assuming protection

$$B = \left(\frac{(T1 \times D1) + \left(T2 \times \left[\frac{D2}{PF}\right]\right)}{(T1 + T2)} \right)$$

$$PPF = \frac{A}{B}$$

where:

$T1$ – Time respirator not worn
$T2$ – Time respirator worn
Dl – Dust or activity concentration during respirator non-use periods
$D2$ – Dust or activity concentration during respirator use periods
PF – Protection factor of respirator

In the absence of quantitative fit testing data to provide PF on an individual basis, the PF chosen would usually correspond to the lower limit of the nominal PF specified for the particular RPE used.

It is important that any survey used to determine the PF is documented in detail and repeated at the intervals specified by an appropriate authority.

C.3. Conclusion

Without a clearly defined chain of supervision, there is no assurance that the procedures and requirements of respiratory protection program (RPP) will be followed. The responsibility for the entire site RPP should be assigned to one person. The person selected to head the respiratory protection program for the exploration/mining/mineral processing site should be adequately trained in all aspects of respiratory protection, and have the ability to administer the program in its entirety.

Bibliography

[1] Part 16 – Radiation Safety, Mines Safety & Inspection Regulations, 1995.

[2] *Mines Safety & Inspection Act, 1994.*

[3] AS 3640: 2004. Workplace atmospheres – Method for sampling and gravimetric determination of inhalable dust, 2004.

[4] AS 1715: 1994. Selection, use and maintenance of respiratory protective devices, 1994.

[5] AS 1716: 2003. Respiratory protective devices, 2003.

[6] Industrial Ventilation – A Manual of Recommended Practice, 21^{st} Edition, American Conference of Governmental Industrial Hygienists, 1992.

Index