**Prevention of accidents due to explosions underground in coal mines**

ILO Codes of Practice

# Prevention of accidents due to explosions underground in coal mines

International Labour Office Geneva

ISBN 92-2-101062-7

*First published 1974*



Printed by Atar, Geneva, Switzerland

# Contents

# Introduction

This code of practice, although couched in the language of a set of rules, has no binding force and is not intended to supersede national laws or regulations or accepted standards; it is merely a body of practical advice for the use of all those, in both the public and the private sector, who have responsibility for safety in coal mines. The value of the code lies in the fact that it embodies the knowledge and experience of many countries. It has been drawn up to provide guidance for persons who may be framing provisions on this subject, particularly in government, in management and on safety committees, including persons planning new mines or engaged in the alteration or extension of existing mines.

The explosion hazard in mines arises from many causes and is erratic in its incidence.[1] Research into the underlying problems of the mine environment itself and into the prevention of initiation of explosions has provided a fund of knowledge which can contribute largely to a reduction of such occurrences. Other important factors are the human element and the effects of mechanisation and new methods of production. All these factors demand that an ample margin of safety be allowed in planning and that continual vigilance be maintained in all mining operations if explosions are to be prevented.

The International Labour Organisation has for many years promoted higher standards of safety and health in underground

[1] Among the points that have come to light during the preparation of this code is the question of gassy or non-gassy mines. The classification of mines into these two groups is controversial; however, all coal mines are potentially gassy and this fact should be taken into account both when planning and when operating such mines. Attention is also drawn to the fact that a number of mines other than coal mines in different parts of the world are known to be also subject to firedamp emissions, and that many of the provisions of this code are therefore equally applicable in such cases.

mining, especially for coal. In particular, it published in 1950 a *Model code of safety regulations for underground work in coal mines, for the guidance of governments and of the coal-mining industry.* Two codes of practice, on the prevention of accidents due to fires and electricity underground in coal mines, were published in 1959 after the Office had consulted a number of experts and had come to the conclusion that it should deal successively with selected branches of mine safety rather than once again endeavour to cover the whole subject in a single comprehensive set of rules.

The present code of practice has been prepared in the light of the above-mentioned conclusion. A preliminary draft prepared by the International Labour Office was submitted for comments and observations to the 28 members of an ILO panel of consultants on safety in mines. This panel is composed of consultants specialising in the various aspects of the subject and includes persons from different countries who reflect the views and experience of governments and of employers' organisations and trade unions in the mining industry. Their observations and comments were embodied in a second draft which was also submitted to the panel, and the present consolidated text has been prepared in the light of that second consultation. This document was approved for publication by the Governing Body of the International Labour Office at its 189th Session (February-March 1973).

# 1. General

## 1.1. Definitions

1.1.1. In this code of practice—

*(a)* the term "competent authority" means a minister, government department or other public authority having powers to issue regulations, orders, decrees or other instructions having the force of law in respect of safety in coal mines, or an authority entrusted with the enforcement of such regulations or instructions;

*(b)* the term "manager" means a duly qualified and appointed person legally responsible for the management and technical direction of the mine, whether he is the mine operator or a person appointed by him;

*(c)* the term "supervisory official" means a person appointed by the manager to supervise or perform certain work, or to supervise the operation of certain machinery, plant, or equipment, and who is competent and responsible for the duties so assigned to him, and has been provided by the manager with the necessary instructions and facilities for their proper performance;

*(d)* the term "authorised person" means a person appointed or selected by the manager to carry out special duties and competent and responsible for the work he has been directed to perform;

*(e)* the term "shot-firer" means a person authorised to fire shots under conditions specified in national laws or regulations;

*(f)* the term "face" means the moving front of any working place, entry, slope or drift;

*(g)* the term "firedamp" means any flammable gas, chiefly methane, given off from the coal or other strata in a mine; and

*(h)* the term "auxiliary fan" means a fan the use of which is confined to the ventilation of a localised stagnant zone such as a heading, drift or blind end.

## 1.2. General principle of present code

1.2.1. In the planning and operation of a coal mine, or any part of such a mine, all practicable precautions should be taken not only to prevent explosions of flammable gas and coal dust but also, in the event of an explosion, to limit its extension or spread.

## 1.3. Other applicable provisions

1.3.1. Shot-firing, if practised, should be carried on in compliance with the statutory regulations in force at the time in the country concerned, with the relevant requirements of the ILO Model Code of Safety Regulations for Underground Work in Coal Mines [1] (hereinafter called the Model Code), or requirements at least equally strict.

1.3.2. If electrical apparatus is installed, it should be used in accordance with—

*(a)* the statutory regulations in force at the time in the country concerned;

*(b)* the relevant provisions of the Model Code; and

*(c)* the provisions of the code of practice on the prevention of accidents due to electricity underground in coal mines [2], or requirements at least equally strict.

---

[1] ILO: *Model code of safety regulations for underground work in coal mines, for the guidance of governments and of the coal-mining industry* (Geneva, 1950).

[2] Idem: *Prevention of accidents due to electricity underground in coal mines* (Geneva, 1959).

1.3.3. Precautions against firedamp should comply with—

*(a)* the statutory regulations in force at the time in the country concerned;

*(b)* the relevant provisions of the Model Code;

*(c)* the provisions of the code of practice on the prevention of accidents due to fires underground in coal mines [1], or requirements at least equally strict; and

*(d)* the relevant provisions of this code of practice.

1.3.4. Precautions against coal dust should comply with—

*(a)* the statutory regulations in force at the time in the country concerned;

*(b)* the relevant requirements of the Model Code;

*(c)* the relevant recommendations [2] of the ILO meetings of experts on the prevention and suppression of dust in mining, tunnelling and quarrying or requirements at least equally strict;

*(d)* the relevant recommendations and advice to be found in the *Guide to the prevention and suppression of dust in mining, tunnelling and quarrying* [3];

*(e)* the relevant provisions of this code of practice.

---

[1] ILO: *Prevention of accidents due to fires underground in coal mines* (Geneva, 1959).

[2] Reproduced in *Occupational Safety and Health* (Geneva, ILO). Vol. 3, No. 1, Jan.-Mar. 1953, pp. 9-12, ibid., Vol. 6, No. 2, Apr.-June 1956, pp. 78-80.

[3] ILO: *Guide to the prevention and suppression of dust in mining, tunelling and quarrying* (Geneva, 1965).

# 2. Ventilation

## 2.1. General principles

2.1.1. (1) Full consideration should be given to problems of ventilation that may arise during the life of a mine.

(2) Adequate provision should be made at the planning stage for all foreseeable conditions that may be encountered, bearing in mind that all coal mines are potentially gassy.

2.1.2. The ventilation of any mine or part of a mine should be such that in the normal course of events the system possesses adequate reserves for exceptional requirements.

2.1.3. (1) Under the responsibility of the mine manager, a single authorised person should take charge of the ventilation of a mine.

(2) If the workings of two or more mines are unavoidably connected and thus have part of their ventilation circuit in common, this arrangement should be subject to the approval of the competent authority, and one authorised person should be designated as being responsible for the ventilation of both or all the mines in so far as the joint circuits are concerned.

2.1.4. Where two or more mines are interconnected but maintain separate ventilation systems, a positive and effective means of separation should be provided, making use of fireproof and explosion-proof doors or stoppings.

2.1.5. (1) When planning the method of working of a mine, it should be divided into independent ventilating districts in order to limit the consequences of an explosion or a fire.

(2) Each district should have an independent intake commencing from a main intake air course and an independent return airway terminating at a main return air course.

(3) A figure should be set for the maximum number of persons normally permitted to be in each independent ventilating

district at any one time. This figure should be restricted to a minimum.

2.1.6. The main ventilation of every coal mine should be ensured by a fan, or fans, electrically or mechanically operated, sited on the surface and kept in continuous operation.

2.1.7. (1) Main fans should be so constructed and sited as to reduce the possibility of damage due to an explosion, and should be installed in fireproof housings.

(2) A stand-by fan should be installed, and the power supply to the main fans should be separate from and independent of the main mine circuit.

(3) Fan installations should be inspected daily and a record of inspections and performance maintained.

2.1.8. (1) Initially, the over-all capacity of the fan or fans and the main features of the ventilation layout should be determined so as to correspond to the maximum requirements during the life of the mine.

(2) The characteristics of large fans should be checked *in situ*, since in practice they may differ from the theoretical curves supplied by the manufacturer.

2.1.9. In determining the ventilation layout, consideration should be given to—

*(a)* the desirability of ensuring that main haulages are situated in intake air; and

*(b)* the need to avoid high air velocities in conveyor belt haulages.

## 2.2. Ventilation plans

2.2.1. Ventilation plans covering the operation as well as the proposed development of each colliery should include details of the ventilation arrangements to be adopted at each stage of development, as well as the scheduled date for each change.

2.2.2. (1) Each plan on which ventilation details are given should be approved by the manager of the mine and, where applicable, by the specialist engineer or authorised person who is responsible for advising the manager on ventilation matters.

(2) The plans should be available if required for inspection by the competent authority.

2.2.3. A ventilation system that has been approved should not subsequently be altered in any major respect without the prior agreement of the manager.

2.2.4. (1) The statutory ventilation plan for the colliery should—

*(a)* show the main ventilation circuits and indicate the measured air quantities within them; and

*(b)* show the position and give essential particulars of the main items of ventilation equipment, including ventilating doors, auxiliary fans, air crossings, and stoppings.

(2) The plan should be brought up to date at intervals agreed by the competent authority.

(3) The plan should be kept at the mine office.

2.2.5. (1) Supervisory officials who have any responsibility in connection with the ventilation of the mine should be familiar with the ventilation plans and with the ventilation system for the mine as a whole.

(2) Supervisory officials in charge of districts should be familiar with and responsible for the correct operation of the parts of the system that ventilate the section of the mine to which they are assigned.

2.2.6. (1) All supervisory officials concerned should be promptly informed of proposed changes in the ventilation system in any part of the mine, and should be made aware of the likely effects of such changes on any part of the mine with which they are concerned.

(2) The person responsible for the preparation and maintenance of the statutory ventilation plan should also be promptly informed of any proposed changes, to enable him to keep the plan up to date.

## 2.3. Supervision of ventilation systems and equipment

2.3.1. Specialist advice in ventilation matters should be available to a mine manager, who should take advantage of such advice whenever ventilation problems are likely to be encountered, as in the case of new interconnections among workings, as well as in relation to the selection and use of ventilation equipment.

2.3.2. Ventilation systems, including all equipment and arrangements for directing the air current into the various districts, roadways and places that require to be ventilated, should be visited regularly by a specialist ventilation engineer or other authorised person in order—

*(a)* to make sure that the system is functioning in accordance with the ventilation plan;

*(b)* to make sure that airways are free of falls and debris; and

*(c)* to take note of changing circumstances that might call for a revision of the existing arrangements.

2.3.3. Consideration should be given to the use of a computer for solving ventilation network problems in large mines, as well as for predicting the effect of major alterations to the ventilation system.

2.3.4. The services of a qualified ventilation engineer such as is generally employed in the larger mines should be made available to smaller mines by means of a group arrangement.

2.3.5. Arrangements should be made for each mine so that information relating to air measurements, firedamp percentages and air leakage determinations is promptly transmitted to the ventilation engineer, who should make regular and continuous

appraisals of the ventilation conditions for the information of the manager.

## 2.4. Ventilating fans below ground

2.4.1. (1) Care should be taken in the selection and installation of auxiliary fans to ensure that they are of an appropriate type having regard both to the duty they will be called upon to fulfil and to the conditions that may be found at the site of installation.

(2) Particular attention should be given to the siting of the inlet and of the outlet to the column, so as to avoid all possibility of recirculation of air.

2.4.2. (1) The ventilation of a localised vulnerable point should be ensured by making use of special mechanical means, such as an auxiliary fan.

(2) In exceptional cases, consideration may be given to the efficacy and practicability of diverting an adequate part of the normal ventilating airstream by means of flame-resistant bratticing or tubing to ventilate the point in question.

2.4.3. Where the ventilation of a heading or other localised working place is ensured by an electrically operated auxiliary fan, special provision or arrangements should be made so that—

*(a)* the fan is so placed or operated that it will be running in fresh air uncontaminated by firedamp;

*(b)* the power supply to the fan is maintained in the event of a shut-down of any or all other plant in the working place;

*(c)* electricity can be supplied to the working place only when the auxiliary fan is running; and

*(d)* on restarting the fan after a prolonged shut-down, sufficient time is allowed to elapse to clear any accumulation of gas or foul air before the supply of electricity to the working place is re-established.

2.4.4. Where the ventilation of any system of underground workings is ensured by an auxiliary fan driven by compressed air, arrangements corresponding to those mentioned in paragraph 2.4.3 *(a)*, *(b)* and *(c)* should be made.

2.4.5. An interruption to the ventilation arrangements for working places envisaged in paragraphs 2.4.3 and 2.4.4 for reasons other than a fan breakdown (e.g. damage to the ventilation column) should also be foreseen; whatever the cause of the interruption, such conditions should be corrected with the least possible delay, and in cases of imminent danger all persons should be withdrawn from the area affected, with the exception of those required to rectify the situation, who should be provided with appropriate protective equipment.

2.4.6. Where an auxiliary fan is kept running continuously to prevent the accumulation of gas in a heading, provision should be made for a suitable warning device to be actuated if any excessive heating or other fault arises at the fan motor.

## 2.5. Gas emission and ventilation requirements

2.5.1. In all parts of a mine which are not sealed off, the ventilation should be such that it will—

*(a)* continuously dilute, render harmless and remove flammable and noxious gases;

*(b)* provide air containing sufficient oxygen; and

*(c)* maintain reasonable working conditions with respect to temperature, humidity and the amount of airborne dust.

2.5.2. (1) For the effective prevention of explosions of firedamp in any part of a mine where a dangerous amount of firedamp is likely to be found, the ventilation should satisfy the requirements of subparagraphs (2) to (5) below.

(2) The volume of air passing through that part of the mine

should be sufficient to dilute the firedamp given off to a value regarded as insignificant and hence permissible.[1]

(3) The air speed should be such as to sweep away the issuing firedamp and prevent it from remaining or moving in layers against the roof owing to its low density by comparison with that of air.

(4) In wastes or abandoned areas where firedamp is present and which are not stopped off or stowed, there should be maintained adequate ventilation as mentioned in paragraph 2.5.1, or, if that cannot be done, steps should be taken to minimise dangerous emissions of firedamp and to maintain the zone of flammable fringe well back from the working place at all times and under all conditions of barometric pressure. However, where there exists a risk of spontaneous combustion in such areas, care should be taken to ensure that any ventilation current flowing across the wastes is arrested or reduced to a minimum.[2]

(5) In working faces other than longwall faces and not subject to heating, an adequate flow of ventilation should be ensured from the working area across the gob area. The location of the connections to the return airway should be such that air movement is induced throughout the gob area, leaving no part unventilated. Special attention should be given to roof control to ensure that these connections remain open.

2.5.3. (1) Determinations should be made of the firedamp content in the air current circulating in the various independent ventilation districts of a mine, and also in the main intake and return airways.[3]

(2) Measuring points and time intervals for making these determinations should be stipulated with a view to determining—

---

[1] It should be borne in mind that there is always a stage at which the gas, during its dilution, must pass more or less quickly through the explosive range.

[2] See also ILO: *Prevention of accidents due to fires underground in coal mines*, op. cit., Part II (pp. 42-46).

[3] See paragraphs 4.4.1-4.4.8.

*(a)* the normal rate and pattern of the outflow of gas from the workings in each ventilating district, and in the mine as a whole; and

*(b)* the pattern and extent of variations in the normal rate of emission.

2.5.4. (1) Limiting values for the percentage volume of firedamp in the air of the general ventilation at a working place should be established.

(2) The limits should take into account the danger of ignition from various sources, particularly that represented by the use of electrical equipment. They may comprise an upper limit at which all workers are withdrawn from the affected area, and a lower limit at which the electric power supply to that area is cut off.[1]

2.5.5. Records should be kept of all measurements taken of gas emission into and ventilation of workings.

2.5.6. In making provision for ventilation requirements, a sufficient margin should always be provided to meet the typical mining contingencies that experience has shown may conceivably arise, such as—

*(a)* a sudden or additional firedamp emission due to a fall of roof in a waste containing firedamp, or resulting from the intersection of a blower or from a sudden outburst of gas; or

*(b)* an outflow of gas, following a fall in barometric pressure, from a firedamp-filled waste or from a fissure leading to large cavities or to bed separation (which may not necessarily be found immediately adjacent to the seam being worked).

2.5.7. In certain cases, in view of the danger of gas outflows from the wastes into the workings[2], it may be necessary to supplement the ventilation by—

---

[1] Values that have been set for this purpose by various authorities range from 1 per cent for the lower limit to 2 per cent for the upper.

[2] Often resulting from excessive or abnormal roof movements or from falls of ground.

*(a)* firedamp drainage;
*(b)* improvement in strata control for the district as a whole; and
*(c)* improvement in the support of the roof at the working face, including a strengthening of waste edge supports.

2.5.8. (1) Consideration should be given, particularly in retreating longwall faces, to bleeder or other methane drainage systems.

(2) In shaft sinking, special precautions should be taken to guard against the danger from emissions of firedamp when the shaft is approaching or is passing through coal-bearing strata.

## 2.6. Stagnant zones and vulnerable places

2.6.1. All places in the mine where the flammable gas hazard tends to be greater should be noted, and should be given special attention by the supervisory officials and by all other persons concerned with the maintenance of efficient ventilation and the detection of gas; in particular, special detection and ventilation measures should be taken in respect of—

*(a)* all stagnant zones;
*(b)* headings and dead ends;
*(c)* gate roads or cross-cuts where the ventilation may be unstable;
*(d)* ripping lips (top brushings);
*(e)* roadway roof cavities;
*(f)* the highest points of roadways;
*(g)* the upper zone of large roadways, especially those where air velocities are low;
*(h)* fast ends of a longwall face;
*(i)* waste edges;
*(j)* buttocks and such areas as the underside of conveyors on mechanised longwall faces;

*(k)* machine stable holes;

*(l)* machine undercuts;

*(m)* the highest point of steeply inclined faces, the face of raises or headings advancing to the rise, and the underside of shelters, recesses and ledges; and

*(n)* the vicinity of geological faults.

2.6.2. (1) Continuing positive action designed to suit the particular circumstances should be taken to prevent accumulations of flammable gas in places listed in paragraph 2.6.1.

(2) The action taken should be kept continuously under review.

2.6.3. In machine undercuts, where it is not always possible to ensure the elimination of a source of ignition due to frictional sparking, care should be taken—

*(a)* as far as is possible, to avoid cutting in the spark-producing horizon;

*(b)* to provide positive means (such as venturi devices, compressed air blowers, etc.) to prevent accumulations of firedamp; and

*(c)* to arrange for a continuous flow of water over the cutter picks.

2.6.4. Increased firedamp emission should also be anticipated, and appropriate steps taken to meet it, in parts of the mine where—

*(a)* the strata are faulted or heavily broken;

*(b)* excessive ground movement occurs, or is likely to occur, as when a new longwall face moves off the solid and passes through the critical period of first weighting;

*(c)* there is excessive and more or less sudden degradation of the coal, owing to shot-firing off the solid, or for any other reason; or

*(d)* the rate of mining undergoes a significant increase.

2.6.5. Steps should be taken not only to deflect the ventilating

current at adequate speed into the ripping lip [1], but also to strengthen the support system with a view to preventing bed separation and roof breaks connecting with the bed separation cavities.

## 2.7. Ventilation of stable holes

2.7.1. To prevent stagnant conditions in machine stable holes, which should always be kept as small as possible, an airstream should be directed over the surface of the coal in the stable at a velocity at least equal to that along the rest of the face and in sufficient quantity to dilute firedamp and disperse airborne dust to within safe limits.

2.7.2. In cases in which no special measures are employed to remove firedamp, and in which caving will tend to cause the gas to accumulate towards the return end of the waste in a longwall face and to be discharged into the airstream at that point, positive precautions should be taken to ensure that this firedamp-laden air does not find its way into a machine stable.

2.7.3. If advance headings are used on longwall faces to eliminate the need for stable holes, and if the face of the advance heading may be in a region subject to emission of gas, sufficient positive ventilation should be provided at the face of the heading to neutralise such emissions.

## 2.8. Interruption in firedamp drainage system

2.8.1. (1) In mines where firedamp drainage is practised, the mine manager should take every precaution against an interruption of drainage or damage to the system.

---

[1] The likelihood of a firedamp explosion in a ripping lip is greatly increased when shots are fired in ripping where the standard of roof control and support is poor, and where gas layering occurs next to the roof near the ripping lip, because of the inadequate speed of the air reaching the lip.

(2) The effect of a rapid increase of the firedamp concentration in the mine atmosphere should be considered not only in relation to the district in question but in relation to the mine as a whole. Standing arrangements should be made to ensure that all supervisory officials concerned receive timely notification of such an occurrence and are familiar with the steps to be taken.

# 3. Emission of firedamp

## 3.1. Rapidly advancing faces [1]

3.1.1. (1) Although the effect of increasing firedamp emissions may be moderated by increasing the quantity of air passing along the face, the limitations of this practice, mainly in regard to the ventilation velocity that can be accepted, should not be overlooked.

(2) Unless and until other means can be used to prevent an excessive increase of the firedamp concentration in the ventilating air, it may be necessary to stabilise the firedamp emission rate by avoiding any further increase in the rate of mining the coal and in its degradation.

## 3.2. Strata control

3.2.1. (1) Good strata control should be ensured.[2]

(2) Close liaison should be maintained between ventilation and strata control engineers.

(3) The mine manager should be able to call for the advice of a specialist strata control engineer whenever required.

---

[1] It should be noted that although the effect of firedamp drainage is to remove much of the gas from the surrounding strata, thereby keeping the explosive fringe well clear of the waste edge, it will have little influence on the emission of firedamp from the working face. On a rapidly advancing face in a gassy seam a marked increase in firedamp emission can take place towards the end of a working week. Similarly, the emission can become higher towards the end of a continuous series of strips. In addition, the quantity of firedamp released in any given period is related to the rate of face advance and to the degree of degradation caused in getting the coal.

[2] Strata control is an important factor in reducing the explosion risk. Excessive and abnormal roof movements often lead to falls of ground sufficient to displace the firedamp and to upset the normal flow of ventilation, thereby reducing the usual margin of safety.

3.2.2. (1) In commencing a new longwall face, special precautions should be taken to limit the effects of first weighting in order to reduce the danger from emissions of firedamp often associated with it.

(2) The measures required will vary with the circumstances:

*(a)* in the early stages of advance of the face, the ordinary support system should be strengthened along the working face and at the waste edge;

*(b)* in exceptional circumstances the provision of solid or strip packing, or of a solid pack against the rib sides, may have to be considered.

3.2.3. (1) Roadside packs, and intermediate packs where these are built as part of the normal system of roof control, should be well constructed and systematically advanced as close to the coal face as possible so as to facilitate regular control of the strata and to prevent undue fracturing of the beds.

(2) If these packs are sealed, account should be taken of the possibility that firedamp may accumulate behind them.

## 3.3. Cavities

3.3.1. Care should be taken, through good strata control practice and the prompt setting of roadway supports with a high degree of stability, to prevent the formation of roadway cavities.

3.3.2. If a roadway cavity is formed as a result of a roof collapse, appropriate steps should be promptly taken to support it in such a way as will prevent its extension.

3.3.3. (1) Roadway cavities should be filled as soon as possible.

(2) Until this can be done, the roadway should be provided with adequate ventilation so as to prevent firedamp from accumulating within roadway cavities.

3.3.4. It should not be overlooked that a fall of roof from a gas-filled cavity can bring the gas down and cause it to mix with the air current in the roadway, and so give rise to a firedamp atmosphere within the flammable range near the floor of the roadway.

## 3.4. Formation and dispersion of thin gas layers

3.4.1. Positive measures should be taken to prevent the formation of a thin layer of gas next to the roof in mine workings and roadways, and to disperse any layer that may have formed.

3.4.2. (1) The main action taken to prevent the formation of gas layers should be the maintenance of the speed of the general ventilating air current at a level sufficient to dilute the gas as it is given off from the strata.

(2) Where such action is not practicable, measures should be taken to increase the air speed in the area covered by the layering.

3.4.3. The attention of all supervisory mine officials should be drawn to the fact that a layer of gas may be found close to the roof of mine roadways and working faces and that it may move against the direction of the air current.[1]

[1] Indeed, in an inclined roadway, even when the ventilating flow is downhill, the firedamp may steadily flow uphill unless the speed of the air near the roof is sufficient to prevent it from doing so. In addition, it should be noted that standard safety lamps will not detect such roof layers.

# 4. Detection of gas

## 4.1. Inspection

4.1.1. Pre-shift examinations of the working places and regular determination of the firedamp content in the mine air should be made in accordance with the requirements of national laws and regulations.

4.1.2. (1) Supervisory officials and other personnel of the mine who are directed to make inspections or examinations for gas and of the state of the ventilation should be given a clear understanding of the parts of the mine for which they are responsible.

(2) As new roads or workings are started and old ones finished, the supervisory officials should be informed in good time by their superiors of any changes in the inspection arrangements.

(3) Any changes in the ventilation arrangements that may affect their section of the mine should also be brought to their notice.

(4) They should also be informed of any other type of gas that may be expected to occur in the mine and of the steps to be taken in the event of its being detected.

4.1.3. Any person whose duty it is to test for methane should be thorough and conscientious in his work and should at all times guard against the false sense of security that is engendered by the assumption that because a place has been habitually free of gas in the past it will always remain so.

4.1.4. After inspecting for gas and the state of the ventilation, the person concerned should record in his report the presence of firedamp and any unusual incidents or abnormalities affecting the efficiency of the ventilation system and likely to endanger safety, i.e.—

*(a)* the percentages and location of any gas encountered;

*(b)* the stoppage of any auxiliary fan;

*(c)* the development of potentially dangerous conditions in the roof and sides of a roadway likely to result in a fall of ground; or

*(d)* any other factor that could block or impede the ventilation.

4.1.5. (1) The importance should be stressed of testing for firedamp not only in the general body of the air but also in such places as those listed in paragraph 2.6.1.

(2) In longwall workings firedamp determinations should be made along the face and in the return road to establish the pick-up of gas in the district.

(3) Tests should be made wherever there is a concentrated outflow from the gob into the workings, and also at such places as the junction of old ventilation headings or cross headings, even at some distance from the longwall face, since gas emission from a pillar area may continue at a substantial rate for some time.

4.1.6. (1) When making determinations of the firedamp content in the air in working faces other than longwall faces, suitable sampling points should be fixed, due account being taken of the distribution of the ventilation currents in the area.

(2) In the case of bleeder ventilation systems, the official making the inspection should report on the physical condition of the bleeder entries and their effectiveness in removing firedamp from the gob.

4.1.7. When the waste is not solid-stowed, it may be necessary to sample the atmosphere within it to establish whether there are likely to be dangerous outflows of firedamp into the face working or the roads. Should such sampling be found necessary, it should not be carried out by individuals; the management should arrange for remote sampling.

## 4.2. Exceptional conditions

4.2.1. If the tests indicate that there is a likelihood of dangerous outflows of firedamp from the waste, the relevant provisions

of Chapters 2 and 3 above should be put into effect. Regular testing should be continued in order to monitor the effectiveness of the measures taken.

4.2.2. Before making any intentional roof fall in pillar workings, the firedamp content in the area should be determined. If the gas is present in dangerous amounts, the work should not be proceeded with until appropriate changes have been made in the ventilation to reduce the gas concentration to a safe level.

## 4.3. Gas plug in roadway

4.3.1. Underground supervisory officials and other persons concerned with gas detection and inspections should be warned against the dangers that will result if an accumulation or plug of gas is for any reason caused to move through the workings.[1]

4.3.2. If gas plugs are present, precautions against ignition should be taken, such as—

*(a)* moving men from workings likely to be in the path of the gas plug;

*(b)* switching off the electric power; and

*(c)* checking gas concentrations before work is restarted.

## 4.4. Gas testing and air sampling

4.4.1. Even if the results of tests for firedamp content—made in accordance with the statutory regulations of the country concerned and the ILO Model Code—show that gas emission is very

[1] The condition described in paragraph 4.3.1 can arise as the result of a gas outburst. It should also be expected in certain cases after an interruption or irregularity of the normal ventilation, causing stagnant conditions during a period in which gas can accumulate. When normal ventilation conditions are re-established, this accumulated gas may be moved through the workings as a plug.

low and that the gas is well diluted, testing for gas at places outside the main airstream, such as those mentioned in paragraph 2.6.1, should continue to be carried out with the same frequency and care as previously.

4.4.2. (1) If the results of analysis of successive routine samples show a tendency for the gas content to increase, careful investigation should be made to ascertain the source and cause of the increase.

(2) The significance of even the smallest increase should not be overlooked, in that the local effects of such a variation may be extremely important.

4.4.3. (1) Information should be secured on the variations in gas emission, and a record kept thereof, in all mines where firedamp is a recognised hazard.

(2) Where large emissions of gas are encountered, consideration should be given to the installation of continuous recording methanometers.

4.4.4. (1) Where circumstances permit, consideration should be given to the installation of a "firedamp detection centre" which can continuously receive and record information on methane content from the monitoring devices located at key points throughout the mine.

(2) Arrangements may also be made for the electric power to be automatically cut off if the firedamp concentrations exceed a predetermined level.

(3) The centre may also be used to receive information on undesirable changes that might occur in the ventilation system.

4.4.5. (1) Whenever appropriate, consideration should be given to continuous monitoring of firedamp during coal-getting operations, by means of a monitoring instrument which may be mounted on certain types of coal-getting machines such as continuous miners.

(2) Such instruments may be set to warn the operator of the presence of firedamp, and to cut off the power supply to the machine should the firedamp accumulation approach the danger level.

4.4.6. All mine supervisory officials and other persons whose duties and responsibilities include testing for gas should receive adequate and detailed instruction in the correct use of the flame safety lamp as well as other instruments for the detection of firedamp. A check should be carried out from time to time, and fresh instruction given if necessary.

4.4.7. (1) Persons who are required to test for gas, especially with flame safety lamps, should be provided with and have readily available to them a suitable means of reaching any places to be tested that are normally difficult of access.

(2) For detecting layers of gas near the roof of a roadway, use may be made of a probe with a rubber bulb for feeding the gas into the methane-testing instrument.

4.4.8. When making underground visits, senior officials of the mine should always have at their disposal an approved methane-testing instrument and a flame safety lamp.

# 5. Sources of ignition

## 5.1. General

5.1.1. All reasonable practicable steps should be taken to eliminate the known sources of ignition.[1]

5.1.2. Where a source of ignition may possibly be present, as in the firing of shots, or where heavy falls of quartzitic or pyritic rock may occur in wastes, or where there is a danger that the packs of a coal-cutting machine may strike quartzitic or pyritic material in an undercut, special care should always be taken to ensure that the atmosphere at and in close proximity to it is, as far as possible, not flammable.

## 5.2. Restrictions on use of light alloy equipment

5.2.1. (1) Because a particularly dangerous form of incendive friction may arise from contact between rusty steel and light alloys of magnesium and aluminium, the use of equipment containing such light alloys in parts of a mine where there is a firedamp hazard should be prohibited.

(2) If for practical reasons the use of equipment containing such light alloys becomes necessary, the design should include

---

[1] The most important sources of ignitions fall into six main classes—

*(a)* electrical apparatus—by sparking (switching or short circuit), and by heating of outer surfaces;

*(b)* electrostatic spark discharge;

*(c)* hot surfaces or sparks caused by the impact or frictional rubbing of pieces of metal or rock;

*(d)* incendive products from the discharge of explosives;

*(e)* underground fires and heating; and

*(f)* use of open or naked lights, and of contraband (i.e. illegal smoking) underground.

protective features such as a layer of zinc [1] or a covering of sheet metal or a suitable plastic material.

5.2.2. It should be prohibited to introduce metal foil likely to give rise to a thermite reaction [2] into a mine where there is a firedamp hazard.

## 5.3. Shot-firing

5.3.1. Scrupulous compliance should be ensured with the provisions on the safe use of explosives for shot-firing usually set out in great detail in mining countries, as well as with supplementary provisions relating to mines classified as fiery or gassy and the relevant provisions in the ILO Model Code.

5.3.2. (1) In mines classified as fiery or gassy, only approved or permitted explosives, detonators or accessories should be introduced.

(2) They should be used in accordance with the instructions of the competent authority and the manufacturer, and should be carefully selected in accordance with the work to be done.

(3) Approved materials should be used for stemming boreholes.

5.3.3. Shot-firing and all related operations should be entrusted only to competent and duly certificated shot-firers. Before a shot is fired the shot-firer should ensure by means of an approved testing device that no flammable gas is present.

5.3.4. Strict control should be exercised over the issue and return of unused explosives, and precautions should be taken to ensure that there is no jettisoning or concealment of explosives or detonators underground.

---

[1] Of a thickness of 0.2 to 0.3 mm.

[2] A thermite reaction capable of igniting firedamp may result when a glancing blow is struck on a piece of metal foil, such as is commonly used in wrappings, when in contact with rusty steel.

## 5.4. Electrical apparatus

5.4.1. In addition to strict compliance with the requirements relating to the use of electricity underground as laid down in the relevant statutory regulations in force and in the provisions of the ILO Model Code and the ILO code of practice on the prevention of accidents due to electricity underground in coal mines, special attention should be directed to ensuring that in the choice of electrical apparatus, as regards its design and manufacture, and in the choice of site for its use underground, proper regard is paid not only to the dangers arising from the presence of flammable gas but also to the risk of damage from falls of ground and from the rough treatment to which the apparatus may be subjected in the course of underground operations.

5.4.2. Positive steps should be taken to protect, during transport and installation as well as when in position, all electrical apparatus or cables which, if damaged, would be capable of producing incendive sparking.

5.4.3. (1) Special care should be taken to ensure that effective support is given to the roof and sides of the roadway or working place in the immediate vicinity of electrical apparatus.

(2) Care should also be taken to avoid all possibility of pressure on the apparatus from the strata or from the supports.

5.4.4. Consideration should also be given to affording additional protection, where geological or mining conditions warrant it, by the provision of specially designed canopies for certain items of the apparatus or its auxiliary equipment.

5.4.5. To guard against the firedamp hazard, the manager should ensure that as far as practicable, having regard to the importance of keeping its size and weight within reasonable limits, the design of the apparatus is such that—

*(a)* it is suitably protected mechanically against damage by falls and other sources of material damage; and

*(b)* it is provided with suitable electrical protection to reduce the danger from incendive sparking if it should sustain mechanical damage.

5.4.6. (1) Special attention should be paid to providing systematic and suitable protection for electric cables or equipment, especially in places where shots are to be fired.

(2) Makeshift arrangements should not be employed, and whatever method is adopted should have been specifically designed to suit the particular circumstances.

5.4.7. In addition to the requirements referred to in paragraph 5.4.1, special attention should be paid to trailing cables for use underground in coal mines; in particular—

*(a)* they should comply with the requirements of the responsible authority as regards their nature and use;

*(b)* they should be mechanically fixed to machinery in such a way as to prevent strain on the electrical connections;

*(c)* they should not be connected or disconnected under load; and

*(d)* the use of damaged cables that could give rise to sparking or heating should be prohibited.

## 5.5. Fires

5.5.1. (1) The requirements of the relevant statutory regulations and the provisions in the ILO Model Code and codes of practice [1], as well as any directives that may have been issued on the subject, should be taken into account at the commencement of all mining operations with a view to establishing the best possible plan or scheme for fighting or controlling an outbreak of fire, as well as the necessary facilities.

(2) To meet the cases in which direct methods of combating a fire or heating prove unsuccessful, previous study and practical

[1] See paragraphs 1.3.1, 1.3.2 and 1.3.3.

experiments should be initiated in each mine to gain an understanding of the effects of alterations to the ventilation arrangements and any possible reversals of the airflow due to fire or other causes.

(3) A decision to seal off an area or otherwise alter the ventilation arrangements may then be taken with the least possible delay, and with a full appreciation of the factors governing the accumulation or movement of firedamp that would be related to a possible explosion.

5.5.2. Wherever there is the likelihood of an accumulation of flammable gas near the fire—whether due to migration of firedamp to the seat of the fire, the emission of gas from the strata in the vicinity of the fire or any other cause [1]—and unless there are valid reasons to the contrary—

*(a)* the main fan or fans should continue in normal operation; and

*(b)* the ventilation should be maintained as nearly as possible at its normal rate until such time as explosion-proof seals or stoppings have been erected.

5.5.3. (1) If it is found necessary to reduce the flow of ventilation, for reasons such as the erection of seals or of stoppings to delay the progress of the fire, or to help in fire fighting, the reduction in flow should be maintained under strict control.

(2) The degree of reduction can be determined only from a sound knowledge of the rate of emission of gas within the district, supported by on-the-spot appraisals of the changing nature of the atmosphere throughout the district.

---

[1] With few exceptions, the explosion hazard arising from mine fires is due to the accumulation of firedamp, or, very occasionally, of flammable gases produced by the fire itself, after the normal ventilation has been stopped or seriously reduced.

## 5.6. Flammable materials

5.6.1. As far as is practicable, the flammability of all materials to be used underground should be controlled. This applies in particular to materials such as brattice cloth, ventilation tubing, belting and sealing materials.

## 5.7. Flammable liquids

5.7.1. Only fire-resistant hydraulic fluids should be used underground for the transmission of power.

5.7.2. The immediate vicinity of any place where flammable oil or another flammable liquid is used or stored should be enclosed with or constructed of either fireproof materials or materials that have been rendered fire resistant.

5.7.3. Whenever flammable liquids are used underground, their quantities should be restricted to the minimum amount required.

5.7.4. Means of extinguishing outbreaks of fire in flammable liquids should be provided and kept readily available.

5.7.5. Precautions should be taken to minimise the possibility that hydraulic fluid may come into contact with hot surfaces or electrical apparatus as a result of the rupture of a flexible pipe or some other fragile component of a machine.

5.7.6. Appropriate precautions should be taken to prevent ignition of vapour from insulating oils for electrical equipment. The provisions of paragraphs 62-68 of the ILO code of practice on the prevention of accidents due to electricity underground in coal mines should be taken into account in this connection.

## 5.8. Open or naked lights

5.8.1. (1) Since no coal mine should be regarded as free from emissions of gas or immune from the risk of explosions of fire-

damp, the best interests of safety will be served by prohibiting the use of naked lights underground.

(2) Where an open flame is required for certain operations (e.g. welding), this should be subject to special permission, given under arrangements which should be specified.

## 5.9. Contraband

5.9.1. (1) The introduction of smoking materials, tobacco for smoking, cigarette papers, matches, lighters, metal foil or other material that could contribute to the ignition of firedamp should be strictly prohibited.

(2) To assist in enforcing this rule, a checking system should be introduced, such as selecting a percentage of the men entering the mine on each shift for search, or to otherwise show proof that they are not in possession of such materials.

5.9.2. Any person found smoking or in possession of contraband underground should be liable to such sanction as may be determined by the competent authority.

## 5.10. Inspection

5.10.1 (1) In the case of mines classified as being liable to self-heating, particular attention should be given to the provisions contained in paragraphs 202-205 and 223-224 of the ILO code of practice on the prevention of accidents due to fires underground in coal mines and relating to underground inspections and to carbon monoxide control respectively.

(2) To facilitate a continuous watch, the use of continuously recording gas-monitoring devices should be taken into consideration.

# 6. Coal dust

## 6.1. General

6.1.1. (1) The formation of coal dust should be prevented as far as possible.

(2) Underground roadways including airways should be kept free of accumulations of coal dust, and deposited coal dust should be removed or rendered harmless.[1]

6.1.2. (1) To prevent or restrict the spread of explosions, approved [2] stone dust should be applied to the roof, floor and sides of roadways at frequent intervals, and regular sampling of the incombustible content of the combined material should be performed.

(2) Judicious use should be made of suitable explosion barriers, which should be properly installed and maintained in an efficient state.

## 6.2. Application of water

6.2.1. The application of water should be recommended as a means of controlling dust at source and preventing it from becoming airborne, by the use of atomisers, water curtains, etc., and as a means of ensuring the cleanliness of workings by regular hosing down and by whitewashing.

6.2.2. (1) Water should be applied at transfer points and other places where dust is released.

---

[1] In coal mines other than anthracite mines (or coal mines in which tests have proved that the danger does not exist) freedom from risk of coal dust explosions depends on maintaining a high standard of cleanliness at all times.

[2] For silica content.

(2) Regular washing down of conveyor structures and surroundings should be practised wherever possible.

## 6.3. Stone dust or water barriers

6.3.1. (1) The erection of stone dust or water barriers should be regarded as an essential factor in preventing the spread of an explosion in coal conveyor roads.

(2) The design, construction and siting of such barriers should be based on careful research and practical testing having regard to the conditions under which they will be used.

(3) They should be maintained so that they will function as intended.

6.3.2. (1) Stone dust or water barriers should be the subject of regulations or approved directives in which detailed specifications should be laid down concerning the nature and construction of the barrier and the quantites of stone dust or water to be used.

(2) They should be inspected regularly and maintained in accordance with the foregoing requirements.

6.3.3. (1) The siting of stone dust or water barriers, both for longwall and for bord and pillar workings, should be specified by the manager and based on the relevant directives and on specialist advice.

(2) Their position should be indicated on the ventilation or other plan of the mine.

## 6.4. Stone dusting at roadheads of conveyor roadways

6.4.1. (1) In all mines where there is a risk of coal dust explosions, particular attention should be paid to conveyor systems.

(2) To reduce the likelihood that a firedamp explosion near a coal face may develop into a coal dust explosion, stone dust in

specified quantities should be spread systematically in all conveyor roadways and appropriate roadheads.

(3) Spillage from the conveyor should be minimised.

## 6.5. Use of hygroscopic salts

6.5.1. Hygroscopic salts in the form of pastes or solutions being effective in consolidating roadway dust and in rendering it less dispersible, their use where practicable is recommended.

## 6.6. Treatment of coal dust in wet conditions

6.6.1. In workings that are naturally wet or damp, protective measures against explosions should be based on the use of water. However, the use or presence of water on its own to render coal dust harmless from the point of view of propagating an explosion involves certain residual hazards which should be taken into consideration.

6.6.2. In no case should coal dust, even if wet or in the form of sludge, be permitted to accumulate in roadways.[1]

6.6.3. To meet the possibility of propagation of explosions, suitable precautions should be taken by spreading a quantity of an effectively waterproofed stone dust sufficient to ensure compliance with the standards required for other roads.

6.6.4. (1) Sampling of road dust in appropriate lengths of road should be carried out in wet or damp environmental conditions as well as in dry conditions.

(2) As far as possible, the samples should be representative of the more dispersible surface layer.

---

[1] Although the risk that thoroughly wetted coal dust will propagate an explosion is certainly not high, such a hazard may arise in certain circumstances.

# 7. Human factors

7.0.1. (1) Stress should be laid at all times on the importance of the human element in the prevention of explosions.

(2) Steps should be taken to ensure that all workers, supervisory officials and management gain an understanding of the different aspects of the mine explosion hazard and the preventive methods employed, and seek to co-operate on the widest basis to ensure the most effective application of these methods in the interests of the safe operation of the mine.

7.0.2. Although the safety of a mine depends very largely upon the extent to which the individuals in it—management and workers alike—want it to be safe and are prepared to exert themselves to make it safe, the lead in this respect should be seen to come from management.

7.0.3. Everyone should take care for his own safety and that of his own working place and should also have continually in mind the safety of others; everyone should endeavour to ensure that anything happening in the course of his work that might adversely affect safety is put right.

7.0.4. The statutory requirements in relation to safety should not be looked upon as a catalogue of imperatives and penalties, but rather as a code of good practice which everyone willingly accepts and is at pains to observe, a code every departure from which will at once be challenged.

7.0.5. Every effort should be made, through education and training, including regular instruction in basic safety rules, to develop and encourage in each individual the growth of a personal feeling of responsibility for safety.

7.0.6. (1) Constant stress should be laid on the value of joint action by management and workers.

(2) The maximum effort should be made at meetings of consultative and safety committees at colliery level to ensure that the knowledge and experience of workers in relation to safety and good mining practice is used to the best advantage, and to assist in creating the necessary spirit of co-operation.

(3) The competent authority should associate itself with these efforts in a spirit of co-operation, and should devote its efforts not only to the enforcement of statutory requirements but also to the eradication of hazardous conditions, the promotion of safety research and the training and enlightenment of personnel.