INTERNATIONAL CLASSIFICATION OF RADIOGRAPHS OF PNEUMOCONIOSES (REVISED, 1968)
Contents

Introduction ............................................. 1
International classification of radiographs
of pneumoconioses ..................................... 3
Notes on the use of the classification ............ 11
Radiological technique ................................. 21
Introduction

At the end of 1958 a meeting of experts convened by the International Labour Office examined the question of the classification of radiographs of pneumoconioses with a view to arriving at an international agreement on this matter. They adopted the "International classification of persistent radiological opacities in the lung field provoked by the inhalation of mineral dusts" (Geneva classification, 1958). This classification was illustrated by a set of fourteen radiographs and has since been applied widely throughout the world. Over 900 sets of standard radiographs illustrating the international classification were sold in fifty-five countries.

After ten years the ILO has carried out an inquiry among the users of the international classification in order to find out what difficulties if any were encountered in the application of the international classification. It appeared that symbols S and I were not easily identified and it was suggested to combine them in one symbol of "suspect cases"; the distinction between categories 2 and 3 did not appear sufficiently clear; the order of the symbols was questioned and certain films illustrating the classification were criticised. Requests for a "normal" film in the set of standards were also received.

A working group was set up to assist the Office in the revision of the international classification. It was composed of Dr. Gilson (United Kingdom), Dr. Jarry (France), Professor Vigliani (Italy) and Professor Worth (Federal Republic of Germany). 1

In order to finalise this preparatory work, done in consultation with the Commission of the European Communities (Coal and Steel Community), the following experts were convened in Geneva from 16 to 20 December 1968:

Mr. W.G. Clarke, MSR, ARPS, 28 Southcourt Road, Penylan, Cardiff, CF3, FDB, United Kingdom.

Dr. J.C. Gilson, FRCP, Director, Pneumoconiosis Research Unit, Llandough Hospital, Penarth, CF6, IXW, United Kingdom.

Dr. G. Guerra, Casilla 2114, La Paz, Bolivia.

1 Dr. Jarry and Professor Worth are also members of the working group for radiological classification established by the Coal and Steel Community (CECA).
Representative of the Commission of the European Communities:

Dr. Hents, Communauté du Charbon et de l'Acier (CECA), Direction générale du travail, assainissement et reconversion, Luxembourg.

Secretariat:

Dr. L. Parmeggiani, Chief, Occupational Safety and Health Branch.

Dr. A. Annoni and Dr. N. Gavrilescu, Occupational Safety and Health Branch.

Professor A.A. Letavet could not attend. During the course of the meeting, Dr. J.J. Jarry had to leave and was replaced by Dr. C. Amoudru, médecin-chef, Houillères du Bassin du Nord et Pas-de-Calais (France).

The meeting appointed Dr. J.J. Jarry and Professor E.C. Vigliani Chairman and Vice-Chairman respectively. Dr. G. Jacobson was appointed Rapporteur.

The meeting took note of the considerable preparatory work already carried out by the ILO, the CECA and the consultants and defined the aim of its work as follows:

To revise, clarify and bring up to date the 1958 ILO international classification of radiographs of pneumoconioses. To accomplish this it was decided to:

(1) provide an improved version of the 1958 ILO classification to be used primarily for clinical purposes, this to be designated as "short classification";

(2) to provide an extended classification to be used for epidemiological and other studies of the pneumoconioses due to all mineral dusts, including, for example, asbestos and beryllium, this to be designated as "extended classification";

(3) to provide clear instruction for the use of the classification.
International classification of radiographs of pneumoconioses

Scope of the classification

International classification of persistent radiological opacities in the lung fields provoked by the inhalation of mineral dusts, including coal and carbon.

Object of the classification

The objects of the classification are to codify the radiological appearances of pneumoconioses in a simple reproducible manner. The classification does not define pathological entities, or take into account working capacity. The classification does not imply legal definitions of pneumoconiosis for compensation purposes, nor sets or implies a level at which compensation is payable. However, the scheme can be of value in reporting the types and extent of pneumoconiosis in those receiving compensation, and hence international comparability of pneumoconiosis statistics.
SHORT CLASSIFICATION

Symbol 0

No radiographic evidence of pneumoconiosis but not necessarily a normal radiograph.

Symbol Z

Abnormal lung or hilar shadows the nature of which is uncertain and which may or may not represent a stage of pneumoconiosis. This stage, which is not sufficiently indicative of pneumoconioses, has been introduced as a warning stage, which could be used in any particular industry for the purpose of prevention.

Small rounded opacities

In the 1958 classification there was an implied relationship between extent and profusion of small opacities (see previous definition of category 1). This has been a cause of ambiguity. In the revised (short) version only "profusion" is to be recorded. 2

Small opacities are to be graded in three categories of increasing profusion. When the distribution of small opacities is markedly uneven, as for instance when large opacities, emphysema or other diseases are also present, the film is classified on an over-all assessment.

Category 1. Small rounded opacities are definitely present but are relatively few in number. In this category small rounded opacities are commonly seen in the upper and middle zones of both lungs, but rarely may they be seen only in one lung.

Category 2. Small rounded opacities are numerous in both lungs.

Category 3. Small rounded opacities are very numerous in both lungs. In this category, the normal lung markings are usually obscured.

1 Profusion is defined as the number of opacities per unit area.

2 In the extended classification provision is made for recording "profusion" (as in the short version) and "extent" by the number of zones in the lung affected, "upper", "middle", and "lower", "right" and/or "left".

3 One of the experts wished to add "and sometimes in the lower zones", because in some kinds of pneumoconioses (i.e. graphitosis, arc welders' pneumoconiosis, etc.) small rounded opacities are seen in the lower zones of both lungs.
Types of small rounded opacities

The symbols "p", "m" and "n" are retained. However, because of difficulty in phonetically distinguishing the symbols "m" and "n", when desired the symbols "q" and "r" may be substituted. Therefore, in the classification "q" and "r" are given in brackets opposite "m" and "n" respectively. In addition to overcoming the phonetic problem, this is done to ensure continuity of understanding and comparability in studies and publications in which these symbols have been used.

The small rounded opacities are classified according to the greatest diameter of the predominant opacities and are denoted by the following symbols:

- **p** - small rounded opacities up to about 1.5 mm in diameter.
- **m (q)** - small rounded opacities exceeding about 1.5 mm to about 3 mm in diameter.
- **n (r)** - small rounded opacities exceeding about 3 mm to about 10 mm in diameter.

### Large opacities

- **Category A.** An opacity having a greatest diameter of between 1 and 5 cm, or several opacities each greater than 1 cm, the sum of whose greatest diameters does not exceed 5 cm.

- **Category B.** One or more opacities, larger or more numerous than those in category A, whose combined area does not exceed one-third of the right lung field.

- **Category C.** One or more large opacities, whose combined area exceeds one-third of the right lung field.

The background of small rounded opacities shall be specified if possible.

### Recommended additional symbols

In the 1958 classification a number of symbols were suggested, all of which were optional. In the revised "short" classification the recommended symbols are divided into two groups, those which should always be recorded as present or absent - obligatory symbols, and a second group which may be used optionally. The obligatory group lists those features which are especially associated with pneumoconioses. Some of the obligatory symbols also cover features which in the extended classification are recorded in greater detail.
Obligatory symbols

plc - calcified pleural plaques.
pl - significant pleural abnormalities.
co - abnormalities of the cardiac size and shape.
es - eggshell calcifications of lymph nodes.
tba - opacities suggestive of active tuberculosis.
ca - suspect neoplasm.
od - other significant diseases not covered by one of the other obligatory or optional symbols. (In each case this should be described briefly under Remarks.)

Optional symbols

ax - suspect coalescence of small rounded opacities.
on - calcification in small rounded opacities.
cp - cor pulmonale.
cv - cavity.
di - significant displacement or distortion of the thoracic structure.
em - significant emphysema including large bullae.
hi - significant enlargement of the hilar shadows.
ho - honeycombing
px - Pneumo thorax.
rl - pneumoconiosis modified by the rheumatoid process.
tb - opacities suggestive of inactive tuberculosis, excluding the calcified primary complex.
K - Kerley lines.

Miniature films

When mini-films are used it is of the greatest importance that they be of good quality. The same criteria for classification are to be applied. However, it must be recognised that with these films there may be some reduction in accuracy particularly in the identification of early pneumoconiosis, e.g. category 1. Mini-films are unsuitable for use with the extended classification.
EXTENDED CLASSIFICATION

This classification is designed to apply to the radiographic changes provoked in the thorax by the inhalation of all the mineral dusts including coal, carbon, asbestos and beryllium and to provide a means of recording more information about these radiographic changes than can be done in the short version of the 1968 ILO classification. Both classifications are entirely compatible, as can be seen in table 1.

The extended classification is based on the UICC/Cincinnati classification (which embodied the 12-point scale elaboration of the ILO classification, developed by the National Coal Board, United Kingdom) with some modifications. Details of the classification are given in the "Notes on the use of the classifications", page 11.

SELECTION OF STANDARD FILMS

A set of standard films has been selected to illustrate the short classification. In the case of small rounded opacities, these films represent the middle of each category. Most of these films were taken with a low kilovoltage technique.

FUTURE ACTION

It is recommended that the ILO make provision for the selection of additional standard films, particularly for asbestosis.

It is also recommended that ILO consider making appropriate revisions of both classifications when there has been sufficient experience with them.
<table>
<thead>
<tr>
<th>FEATURE</th>
<th>SHORT</th>
<th>EXTENDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>No pneumoconiosis</td>
<td>0</td>
<td>(Rounded 0/- 0/0 0/1)</td>
</tr>
<tr>
<td>Suspect pneumoconiosis</td>
<td>Z</td>
<td>(Irregular 0/- 0/0 0/1)</td>
</tr>
</tbody>
</table>

### PNEUMOCONIOSIS

#### SMALL OPACITIES

- **Rounded**
  - Profusion
    - Type: p,m(q)
    - Extent: n(r)
  - Extent: zones 1-6

- **Irregular**
  - Profusion
    - Type: -
    - Extent: -

#### LARGE OPACITIES

- **Size**: A, B, C
- **Type**: wd (well defined) id (ill defined)

### SYMBOLS, OBLIGATORY

<table>
<thead>
<tr>
<th>YES/NO</th>
<th>Site</th>
<th>Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleural calcific.</td>
<td>plc diaph. wall others</td>
<td>0,1,2,3</td>
</tr>
<tr>
<td>Flaveral thickening (significant)</td>
<td>pl costophrenic lower limit</td>
<td>0,1,2,3</td>
</tr>
<tr>
<td>Cardiac outline</td>
<td>co (ill defined)</td>
<td>0,1,2,3</td>
</tr>
<tr>
<td>Brachial calcific.</td>
<td>es</td>
<td>-</td>
</tr>
<tr>
<td>Active tuberculosis</td>
<td>tba</td>
<td>-</td>
</tr>
<tr>
<td>Carcinoma</td>
<td>ca</td>
<td>-</td>
</tr>
<tr>
<td>Other signific. disease</td>
<td>od</td>
<td>-</td>
</tr>
</tbody>
</table>

### SYMBOLS, OPTIONAL

<table>
<thead>
<tr>
<th>ax</th>
<th>cv</th>
<th>hi</th>
<th>rl</th>
</tr>
</thead>
<tbody>
<tr>
<td>on</td>
<td>di</td>
<td>ho</td>
<td>tb</td>
</tr>
<tr>
<td>cp</td>
<td>em</td>
<td>px</td>
<td>K</td>
</tr>
<tr>
<td>Category (according to profusion)</td>
<td>Symbol (according to the greatest diameter of opacities)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1: a small number of opacities</td>
<td>p: diameter up to about 1.5 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2: opacities are more numerous</td>
<td>m (q): diameter exceeding 1.5 mm up to about 3 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3: opacities are very numerous</td>
<td>n (r): diameter exceeding 3 mm up to about 10 mm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DESCRIPTION**

**No pneumoconiosis**

O: No radiographic evidence of pneumoconiosis

Suspect

Z: Abnormal lung or hilar shadows the nature of which is uncertain and which may or may not represent a stage of pneumoconiosis.

**PNEUMOCONIOSIS**

**Small opacities**

- 1: a small number of opacities
- 2: opacities are more numerous
- 3: opacities are very numerous

**Large opacities**

- A: An opacity having a greatest diameter of between 1 and 5 cm, or several opacities each greater than 1 cm, the sum of whose greatest diameters does not exceed 5 cm.
- B: One or more opacities larger or more numerous than those in category A, whose combined area does not exceed one-third of the right lung field.
- C: One or more large opacities, whose combined area exceeds one-third of the right lung field.

**ADDITIONAL SYMBOLS**

**Obligatory**

- plc - calcified pleural plaques.
- pl - significant pleural abnormalities.
- co - abnormalities of the cardiac size and shape.
- es - eggshell calcifications of lymph nodes.
- tba - opacities suggestive of active tuberculosis.
- ca - suspect neoplasm.
- od - other significant diseases not covered by one of the other obligatory or optional symbols. (In each case this should be described briefly under Remarks.)

**Optional**

- ax - suspect coglescence of small rounded opacities.
- cm - calcification in small rounded opacities.
- cp - cor pulmonale.
- cv - cavity.
- di - significant displacement or distortion of the thoracic structure.
- em - significant emphysema including large bullae.
- hi - significant enlargement of the hilar shadows.
- ho - honeycombing.
- px - pneumothorax.
- ri - pneumoconiosis modified by the rheumatoid process.
- tb - opacities suggestive of inactive tuberculosis, excluding the calcified primary complex.
- K - Kerley lines.
Notes on the use of the classification
(prepared with the assistance of Dr. J.C. Gilsc)

Background

The chest radiograph remains the most specific means of diagnosis of pneumoconiosis. It is, therefore, desirable that there is an international system of classification of the radiographs of pneumoconiosis so that statistics of incidence of pneumoconiosis in different countries and industries can be compared and trends of improvement or deterioration detected. The ILO has for twenty years taken a lead in assisting in the establishment of an international classification. The classification recommended in 1950 was intended for use in coalworkers' pneumoconiosis and silicosis. A revision in 1958 covered a wider range of types of pneumoconiosis and some features not classified in the 1950 scheme. But this classification still did not cover asbestosis and certain other types of pneumoconioses. Recently the incidence of silicosis and coalworkers' pneumoconiosis has declined in many countries; more attention is being paid to other types of pneumoconiosis and especially asbestosis. In December 1968 a group of experts again reviewed the classification in the light of developments since 1958 and the comments on the 1958 scheme received from many countries; 900 sets of the 1958 standard films have been distributed to fifty-five countries by the ILO.

The group of experts recognised that the wide use of the 1958 scheme was a powerful reason for maintaining this classification with as few modifications as practicable. But there was the need to make use of new developments in classifications to cover a wider range of pneumoconiosis, especially asbestosis. There was also evidence that the 1958 scheme, with improved methods of assessing the films, could provide a finer grading of abnormality than was originally thought possible.

The short and extended 1968 classifications

The group of experts in December 1968 saw that it was possible to meet the apparently conflicting requirements by two schemes which were mutually compatible. First, a short classification would be the 1968 scheme slightly simplified in the light of criticisms and
intended primarily for clinical purposes and for the types of pneu-
moconiosis adequately described by the 1958 system. Secondly, a
new extended classification based on the UICC/Cincinnati scheme,
which would cover all types of pneumoconiosis and in more detail;
with more grades which epidemiological studies had shown to be use-
ful. Thus, the short and extended classifications together are
likely to meet the needs, both of clinicians concerned with the
assessment of the severity of pneumoconiosis in the individual and
of epidemiologists more concerned with the differences between
groups of workers, and in the lesser degrees of abnormality.

As the two schemes are closely linked, it is possible to use
parts of either according to the circumstances - for example, for
pneumoconiosis where pleural changes are rare but both rounded and
irregular small opacities occur, it may be useful to classify the
films using the categories of small opacities in the extended
scheme and the symbols of the short scheme.

DIFFERENCES BETWEEN 1958 AND
SHORT 1968 CLASSIFICATIONS

Category L (Linear opacities)

This has been omitted in the short 1968 classification. The
standard 1968 film of linear opacities was not thought satisfactory
by many users; and there was no grading of the profusion or extent
of the linear opacities. However, that linear opacities did occur,
at least in asbestosis, was agreed and provision therefore made for
their classification and grading in the extended scheme.

Category Z (Suspect pneumoconiosis)

This was retained to describe those films which were thought
for any reason - small opacities less than required for category 1;
enlarged hilar glands; or small linear shadows or pleural
thickening - might be pneumoconiosis. This category provides the
clinician with a place for "suspect" pneumoconiosis, i.e. those cases
which are below the levels required in the 1968 short classification.
It is not recommended for use by epidemiologists because films so
classified are likely to be at the lower end of categories of
several different features, for example one or both types of small
opacities as well as pleural changes, and the means of classifying
many of them are better provided in the extended scheme.

Small opacities

The 1958 category 1 had been criticised as being too low by
some users of the classification. The experts recognised there may
be some conflict between the needs of the clinician who wants a
category 1 film which was indisputably pneumoconiosis and those of
the epidemiologist who would prefer a lower limit standard which
would be on the borderline between categories 0 and 1 and would,
therefore, be read as category 1 by only half the readers. A
decision was taken to select a mid-category film which is slightly
further up the scale than the 1958 standard. Categories 2 and 3
are retained at about their previous level and should be regarded as mid-category films.

In the 1958 scheme the size of the small opacities, "p", "m", and "n" is put before the category 1, 2, 3. This was a change from the 1950 recommendation and seemed to have no merit as the category relates better than the size of opacity to past dust exposure and the amount of dust in the lungs. The 1968 recommendation, therefore, reverts to the 1950 proposal and puts the category first (category 2p, etc.).

The definitions of the types "p", "m", and "n" are retained with small alterations. First, a recognition of the uncertainty of the sizing is made by the word "about" 1.5 and 3 mm, etc. Secondly, "q" and "r" are suggested as alternatives to "m" and "n" because of phonetic and scriptural errors when using "m" and "n", but the definitions of "q" and "r" are identical to "m" and "n" respectively.

In the 1958 scheme both profusion (opacities per unit area) and extent (number of rib spaces affected) are used in the definitions of the categories of small opacities. This has been criticised because it makes difficult the classification of films with definite but very sparse small opacities in several rib spaces. The 1968 scheme, therefore, defines the categories on profusion only. It is not thought that this change of definition will materially alter the level of reading because many observers probably have been using a convention of this type and not sticking quite strictly to the 1958 definition of category 1. No provision is made for recording the extent of the small round opacities in the short classification, but this can be done in the extended scheme.

Large opacities

No changes are recommended here, with the exception of the small alteration of the words "longest diameter" to "greatest diameter". This was done to make it clear that the diameter does not have to be measured with any particular relation to the axes of the lung.

Symbols

These were introduced in the 1958 scheme to call attention to other features of the radiograph which might be relevant but were not in the main classification. At that time the experts said, "The classification would be incomplete without a mention of the complications of pneumoconiosis or the other abnormalities seen in the radiographs... It was also difficult to fix the lower limits of the complications which did deserve mention. For these reasons it was decided that the use of additional symbols should remain optional, but was strongly recommended because, in particular, useful statistical comparisons could be made." Experience since 1958 has shown the value of the symbols. These were extended in number in the US Public Health Service modification of the 1958 ILO scheme. The experts in 1968 went a stage further in recommending an obligatory and optional list of symbols. An advantage of doing this is seen in table 1. Some of the symbols in the obligatory lists in the short classification refer to features which are classified in greater detail in the extended scheme - for example, pleural calcification, pleural thickening; thus, the short and extended schemes are brought closer together.
THE EXTENDED 1968 CLASSIFICATION

The way in which this is an extension of the short classification is seen in table 1. There are four main reasons for recommending an extended scheme:

(1) the abnormal appearances seen in the lung parenchyma in asbestosis and some other types of pneumoconiosis are not adequately covered by the small round opacities section of the 1958 and short 1968 schemes;

(2) pleural thickening, both calcified and uncalcified, are features induced by exposure to asbestos and some other minerals. The pleural thickening may occur with or without changes in the parenchyma. There is a need, therefore, to classify and grade the pleural changes separately from those in the parenchyma. The calcified and uncalcified pleural changes are recorded separately because there is evidence that the calcification is related both to the type of mineral dust inhaled and to the age of the subject.

(3) the "shaggy" heart has long been recognised as a feature of asbestosis; but whether this appearance and a similar one over the diaphragm is caused by thickening of the pleural surface or superimposition of these outlines against an abnormal pattern in the lung parenchyma is not certain. The changes are, therefore, classified and graded separately from pleural thickening as "ill defined cardiac or diaphragm outline";

(4) advances in statistical and epidemiological techniques since the 1958 classification have shown that more information can be obtained if films are allocated into subdivisions within the formal categories 0-3 in the small opacities section. A method of doing this without the need for extra standard films has been developed and extensively tested. It was, therefore, decided to introduce this scheme as an optional extra into the extended scheme as this would be used more often for epidemiological purposes than the short scheme.

The extended classification is based on the UICC/Cincinnati classification (table 3), which embodies the 12-point scale elaboration of the ILO classification, formulated by the National Coal Board, United Kingdom, and which was developed as an extension of the ILO 1958 scheme to cover a wider range of pneumoconioses, and especially the appearances seen in asbestos-exposed workers.

---

1 This is a wider definition than asbestosis. Workers exposed to asbestos are often also exposed to other types of mineral mixed with asbestos. In addition, there is at present uncertainty whether films showing only pleural thickening believed to be caused by inhalation of asbestos should be classified as asbestosis.
Small "rounded" and "irregular" opacities

The classification and grading of features as diverse as those seen in the films of pneumoconiosis must inevitably involve a degree of over-simplification and formalisation of the pattern which may appear rather different to different observers. The small round opacities have long been recognised as a feature of certain pneumoconioses, especially silicosis and coalworkers' pneumoconiosis. The size of the opacities in fact varies quite widely in a single film and not all opacities are equally well rounded, but the use of the term "round" and an approximate size of the opacities by the symbols "p", "m" ("q"), and "n" ("r") is widely used. Much research has now established the relationships between the type and category of round opacities and mortality, morbidity, changes of lung function, and duration of exposure to dust, and dust content and composition in the lung.

Starting with this well established ILO scheme, the UIIO/Cincinnati classification recommended the addition of a complementary category of small "irregular" opacities to describe these radiographs in which the rib spaces contained shadows which were small but linear or curved rather than round. The shadows so classified are not the normal vascular and bronchial markings which contributed to the normal architecture of the lung. They are shadows which are additional to or replacements of the normal pattern. On account of the variation in size and shape of these irregular opacities they cannot be defined verbally as precisely as the rounded opacities. Inspection of the standard films of category 2 "rounded" and "irregular" opacities shows the marked difference of appearance. In deciding the category of small irregular opacities a decision has to be made on how much of the whole pattern is likely to be the normal lung architecture and how much the "abnormality" to be classified as irregular small opacities. A mental concept of the normal lung pattern is, therefore, necessary. The features included in this group, "irregular small opacities", are those described in other classifications as "linear", "reticular", "honeycomb", "fibrosis", etc. The choice of the term "irregular small opacities" was to contrast them on the one hand with the "rounded opacities" in shape, and on the other hand with the "large opacities" for size.

The irregular small opacity group provides a means of classifying films seen in asbestos workers and in other types of pneumoconiosis where the opacities cannot well be described as "round". Films of this type are also seen in silicosis, mixed dust pneumoconioses, occasionally in coalminers' pneumoconiosis, and diatomite pneumoconiosis, and other types. The relationship of the severity and extent of these linear shadows and dust exposure, lung function, and mortality is much less well established than in the case of round opacities, and this was recognised at the time of the 1958 revision, but once a scheme of classification is available information will build up. Some has already been published on asbestos workers.

The extended classification, by providing parallel categories of profusion of rounded and irregular small opacities, should assist in epidemiological studies of both types and reveal the degree to which they occur together in different types of pneumoconiosis. In some circumstances it may be justifiable to group the round and irregular opacities together. But, as the round opacities tend to occur in the upper zones of the lung and the irregular in the lower zones, strict comparability of profusion is not possible. The extent of the opacities can be recorded by noting the number of zones - upper, middle, and lower - in which they can be seen in each lung.
To use the elaborated 12-point scale of small rounded and irregular opacities is a simple procedure. The instructions are "classify the film in the usual way into one of the four categories 0-3 by comparing with the standard film and, if during this process a neighbouring category is considered a serious alternative, record this after the formal category". Thus, if the film well matches the standard film (which are mid-categories), it will be read as 1/1, 2/2, 3/3. But if the film is decided to be a category 2 but category 1 was considered a serious alternative, the film is recorded as 2/1. There is not good evidence that this procedure does not alter the reading into the formal categories, but does provide more information and reduces the variation in readings between different observers. In practice, the 12-point scale takes no longer to record than the formal categories, and many readers find it easier, as an appropriate place for films on the borderline is provided. It has also been shown that for rounded and irregular opacities the extended scale can be used within category 0. The category 0/0 film is one with no opacities; 0/1 is a film which is less than category 1 but in which category 1 was considered as a serious alternative. 0/- are the not very common films where there is exceptional clarity (but not exaggeration) of the normal lung architecture. Such films occur especially, though not exclusively, in young people. The subcategories 0/1 and 1/0 provide for recording those films which are "suspect" pneumoconiosis by placing them in the most appropriate continuum of abnormality. An essential feature of the classification not always appreciated is that they express a continuum from an exceptionally "normal" film at one end to an advanced category 3 at the other. The concept that films are either normal or show pneumoconiosis, and that there is a sharply defined boundary at this point, is not supported by the extensive epidemiological research into the relation of the categories of round opacities to past dust exposure, dust content in the lungs, or the variations in the readings between skilled observers. All this research has shown the essential continuum of the scale. Arbitrary points on the scale are for convenience chosen as the boundaries between the categories.

Large opacities

The large opacities seen in pneumoconiosis vary in sharpness of outline. No provision is made for recording this in the 1958 scheme. The large opacities seen in asbestosis and in some other types of pneumoconiosis have much less well defined edges than those which are characteristically seen in silicosis and coalworkers' pneumoconiosis. The extended classification makes provision for recording the outline of the shadow by the symbols "id" (ill defined), "wd" (well defined) after the category. It is possible that the sharpness of the outline may be related to the rate of progression of the shadows; further research on this is needed.

Pleural thickening

Costophrenic angle. The filling of the costophrenic angle is a common sight of pleural thickening and the least specifically related to pneumoconiosis. For this reason the extended classification records this separately from pleural thickening in other sites. A lower limit is provided but no upper limit, and the degree is not graded. If the thickening extends appreciably further up the chest
wall, the film is then classified as costophrenic angle and pleural thickening. "Leafing" of the diaphragm should not be recorded as "cpa" even though it leads to obscuration of the costophrenic angle.

Chest walls. Asbestos-exposed workers may develop highly characteristic though not entirely specific thickening along the chest wall. In addition, plaques fairly uniform in radio-opacity with well defined edges are occasionally present. They may occur on the chest wall where they may have a characteristic shape. The diffuse type of pleural thickening is given three grades. As the small areas of pleural thickening are difficult to detect with certainty and may be confused with the "companion shadows" of the ribs, grade 1 pleural thickening is intentionally set at a fairly high level where there is an unmistakable shadow of pleural thickening. (In practice, it may be possible to detect with a fair degree of certainty changes less than grade 1.) The pleural changes associated with pneumoconiosis tend to be bilateral, hence provision is made in the extended scheme for recording whether they are on the right and/or left lung. When the diffuse pleural changes are widespread but not thick, the "ground-glass" appearance is produced.

Ill-defined cardiac border

The shaggy appearance of the mediastinal shadow is highly characteristic of asbestosis when well marked. Less marked changes, affecting especially the left cardiac border, are also seen and may be the only abnormality detected in the films of some asbestos workers. A separate recording of this feature from pleural thickening was introduced in the extended classification to cover the shaggy heart of asbestosis. The grade 1 is set fairly high to exclude the not infrequent poor definition of the extreme tip of the left cardiac border from other causes, such as cardiac fat pads.

Ill-defined diaphragm

A lack of definition of the diaphragm is common from many causes, such as movement, single adhesions, scolloping, marked leafing, etc. For this reason the lower limit for recording an ill-defined diaphragm has to exceed one-third of one side.

Further research is needed to validate the usefulness of classifying separately the contour of the cardiac and diaphragm outline in this way.

Pleural calcification

There are three main causes of pleural calcification - post traumatic, old infections, and exposure to asbestos, tremolite, talc, and some other minerals. The mineral dusts tend to produce bilateral changes. The calcification varies from just detectable speculates a few millimetres long to large areas covering nearly the whole lung. The calcified plaques due to asbestos tend to lie along the ribs where they may be missed. They are often more clearly seen on the surface of the diaphragm and pericardium. The large plaques have "rolled" edges of greater radio-opacity and have been likened in appearance to holly leaves or candlewax.
Pleural calcification has been separated from pleural thickening and graded independently because the calcified and uncalcified pleural changes do not always run parallel and there is evidence that pleural calcification may be related to particular types of asbestos or associated minerals. Calcification is graded on the length of the greatest diameter of the shadows and adding the diameters of the shadows as is done for "large opacities".

Calcification within the wall of the aorta should not be recorded in this classification.

GENERAL INSTRUCTIONS FOR THE USE OF THE CLASSIFICATION

There are no absolutely specific individual features of a film which are uniquely the result of dust exposure, but in deciding whether a film is to be classified within the scheme the following recommendations are made:

1. decide if any of the changes seen in the pleura or the parenchyma are sufficiently characteristic of pneumoconiosis to be recorded in the classification. If so, proceed with the classification;

2. if it is probable that all the changes seen are the result of some other aetiology, do not classify but record opinion using appropriate symbols and comments;

3. if changes might be due to pneumoconiosis, record the features of the classification, but make a note that other aetiology is thought possible.

Viewing screens

To apply the classification satisfactorily requires at least two viewing boxes with uniform illumination and well matched for colour and intensity.¹ The standard film against which the comparison is being made is put up on one box, the film for classification on the other. In practice it is often more convenient to use a much larger screen so that four or five standard films most used can be displayed round the film for classification. The films should be viewed both from not more than about 30 cm in order to look for

¹ Viewing boxes should have a brightness of at least that obtainable with two 15 W fluorescent tubes. Variable illumination is not a necessity. Kodak cold light series 11 meets this requirement.
small opacities which may be 1 mm or less in diameter, as well as from at least twice this distance to obtain a general impression of the film and the degree in which the normal architecture is altered. The viewing of the films should proceed methodically and preferably in the order in which the features to be recorded are listed in the reading sheet, so that the final assessment includes all the features as well as the symbols. When the classifications are being used for epidemiological purposes on groups of films where the total abnormality rate may be about 30 per cent, it will be found practicable to classify 200-500 films a day using the extended classification.
<table>
<thead>
<tr>
<th>Compensate</th>
<th>Symbols</th>
<th>Type</th>
<th>IRREGULAR DIAPHRAGM</th>
<th>IRREGULAR CARDIAC BORDER</th>
<th>THERMIC</th>
<th>SMALL OPACITIES</th>
<th>LARGE OPACITIES</th>
<th>ROUNDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>C.P.</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>None</td>
<td>None</td>
<td>C.P.</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>None</td>
<td>None</td>
<td>C.P.</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Ulcc Cincinnati classification of radiographic appearance of pneumoconioses

Page 3
Radiological technique

(prepared with the assistance of Professor G. Jacobson)

Essentials of chest radiography

The most desirable chest radiograph for the study of the pneumoconioses or other pulmonary disease is one in which the lung is shown in greatest detail. While it is helpful to visualise the mediastinal structures as well, this is of secondary importance. Thus, a film in which the vertebral bodies are faintly visible through the heart shadow will ordinarily be adequate for the study of pulmonary detail.

The maximum information can be obtained from radiographs which have a broad range of contrast, i.e. a long gray scale. High contrast radiographs should be avoided.

Two types of technique for chest radiography are commonly employed. With a proper balancing of the exposure factors and careful attention to all detail, under ideal conditions good radiographs can be produced by either method. In one, the kilovoltage used ranges from 60 to 80 kV. In order to deliver sufficient radiation to produce a radiograph of adequate density, the exposure time must be relatively long, 0.05-0.08 s. In the other, the kilovoltage used ranges from 110 to 140 kV and the exposure time is comparatively short, 1/60-1/30 s (0.017-0.032 s). With this technique, a grid of air-gap is required to reduce secondary radiation.

There are several advantages to the high kilovoltage technique. First, the low kilovoltage technique does not permit the use of short exposure times, e.g. less than 1/30 s, except when using generators of considerably higher capacity than 300 mA or the patients are quite small. Secondly, with larger patients, or when using more than 75 kV, secondary radiation increases rapidly, decreasing radiographic detail. The reduction of radiographically effective radiation resulting from the interposition of a grid or air-gap between the

---

patient and the film to eliminate this secondary radiation must be compensated for by either increasing the exposure time, which is already relatively long, or increasing the kilovoltage. Thirdly, the higher the kilovoltage employed, the smaller is the effect of any drop in line voltage, poorly functioning phototimer, and selection of wrong exposure factors by the technician. It is for these reasons that the technique used should be a combination of as high a range of kilovolts and as low a range of milliamperes-seconds as permitted by the available equipment. This produces radiographs of maximum detail; variations in density and contrast are minimised, so that the radiographs are consistent in quality and the number of unsatisfactory examinations is markedly reduced. The latter is probably the outstanding feature of the high kilovoltage technique. Moreover, the higher the kilovoltage, the smaller is the radiation dose to the patient.

However, the high kilovoltage technique requires modern and costly X-ray equipment and an adequate electrical supply, which are not usually available in screening centres or in field work. At present, low kilovoltage technique is commonly used, and, when properly applied, provides suitable results for detecting lung changes due to dust exposure.

Equipment

The installation and maintenance of the radiographic equipment is of the greatest importance. The electric power source should be independent of other users. It must be of adequate capacity, for example having a resistance of not more than 0.1Ω, and should be subject to no more than 5% fluctuation. The voltage drop between the main supply and the X-ray unit when the unit is at its maximum output should not exceed 10%. The radiographic unit must be carefully calibrated at the time of installation and should be recalibrated periodically. Preventive maintenance at regular intervals is strongly recommended.

The generator should have a minimum capacity of 300 mA at 125 kV. A generator with a capacity of 150 kV is strongly recommended. The generator must be full-wave rectified. It should be equipped with an accurate timer (± 1%) capable of minimum exposure of no more than 10 ms.

A rotating anode tube is essential. It should have as small a focal spot as feasible for the anticipated load, but in no instance should this exceed 2 mm in diameter.

The total filtration, added and inherent, of the primary X-ray beam shall be the equivalent of 2 mm of aluminium.

The radiation shall be confined by means of a collimator to the portion of the subject to be examined. This will not only decrease radiation hazard, but also will improve detail by reducing scattered radiation. The collimator should have adjustable diaphragms, a light beam for centering, and be designed so that the projected field cannot exceed the size of the film. Evidence of collimation should be visible at the edges of the film as "cone cuts".
Medium speed (par speed) intensifying screens should be used. They provide the best compromise between sharp definition and short exposure. The cassettes in use should contain screens of the same speed. Both films and screens should be tested and matched for speed, and cassettes should be checked periodically for screen cleanliness, contact and defects.

The X-ray film should be of a general-purpose type and of medium sensitivity. High speed film is not recommended. To improve collimation, the film should be no larger than needed to cover both lungs, including the costophrenic angles.

When using kilovoltages of 80 and above, reduction of secondary radiation by a grid or other means is essential. A 10:1, 100-line per inch fixed grid or an air-gap of 8 in with an 8 ft focal-spot film distance may be used.

Automatic processing should be employed whenever possible. If only manual processing is available, a constant time-temperature technique must be followed meticulously. An improper exposure cannot be corrected by improper processing.

Further improvement in radiographic quality may be expected with the use of a three-phase generator or other means of increasing the effective photon energy, high-speed rotating anode tubes, smaller focal spots, finer grain film, etc.

**Technique**

Correct centering of the X-ray tube and careful positioning of the subject are of great importance for the proper visualisation of anatomic structures and comparison of serial examinations. For the PA projection, the X-ray tube should be centered to the centre of the film and the X-ray beam directed horizontally. The shoulders should be positioned so that the scapulae are outside the lung fields. The exposure should be made at full inspiration and immediately after this has been reached, to avoid the valsalva effect. It is desirable, but not essential, that all the clothes above the waist be removed.

The focal spot-film distance should be fixed at 6 ft (1.8 m) and should not be less than 5 ft (1.5 m).

For the reasons given above, a variable high kilovoltage, constant milliampere-second technique is recommended. Exposure factors employed may vary somewhat with each generator and tube. The highest range of kilovoltage and shortest range of milliampere-seconds obtainable should be used. For the average subject, with an AP chest diameter between 21 and 23 cm, the usual exposure factors will be 5 mAs at approximately 125 kV. The recommended exposure time is 1/60 (0.017) s. It should not exceed 1/30 (0.32) s.

---

1 Based on 60 Hz current. For 50 Hz current, exposure times are 1/50 (0.02) and 1/25 (0.04) s respectively.
With larger diameters of the chest, additional exposure is obtained by increasing the kilovoltage. The milliampere-second product is increased only when the kilovoltage required to give a proper exposure exceeds the capability of the generator or X-ray tube. With focal spot-film distances of less than 6 ft (1.8 m), the technique should be adjusted by decreasing the milliampere-second product.

When using a low kilovoltage technique, the exposure factors for an average subject will be approximately 300 mA, 0.05 s (15 mAs) at 75 kV. For larger subjects, greater amounts of radiation are obtained by increasing either the milliampere-second product or the kilovoltage.

Phototimers are inaccurate with exposures of less than 0.03 s and are not recommended with the high kilovoltage technique since films of variable density and contrast result. Phototiming can be very useful with exposures of longer duration.
OTHER TITLES IN THE OCCUPATIONAL SAFETY AND HEALTH SERIES

1. Occupational Health Problems in Agriculture.
2. Medical Inspection of Labour.
4. Man at Work. Studies on the application of physiology to working conditions in a sub-tropical country by E. H. Christensen.
5. Maximum Permissible Weight to be Carried by one Worker.
7. Organisation of Occupational Health Services in Developing Countries.
8. Course on Dust Prevention in Industry.
11. Course on Radiation Protection in Industry.

These publications may be obtained free of charge from:
International Labour Office,
Occupational Safety and Health Branch,
CH 1211 GENEVA 22.