Radiological assessment of small pneumoconiotic opacities

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ABSTRACT Problems in the assessment of small opacities, within the *ILO U/C International Classification of Radiographs of the Pneumoconioses* (International Labour Office, 1972), are discussed in the light of readings by three experts of a group of films in which both rounded and irregular small opacities frequently coexisted. There was considerable disagreement on whether opacities were rounded or irregular, but reasonable agreement on type (diameter or thickness). As expected, rounded opacities were more commonly recorded in upper zones of the lung, and irregular opacities in lower zones. However, determination of which zones were affected left much to be desired. Perhaps as a result, major problems arose over the assessment of combined profusion.

Van Mechelen and McLaughlin (1962) have described the development up to 1958 of radiological classifications of the pneumoconioses. Because these did not allow for the grading of appearances associated with exposure to asbestos, a meeting was held at McGill University early in 1967 to prepare proposals which were considered later that year by a committee of the Union Internationale Contre le Cancer (UICC), and assembled into the UICC/Cincinnati classification (Bohlig *et al.*, 1970). Considerable experience was gained in the use of the UICC/Cincinnati classification, which was provisionally adopted in 1968 by the International Labour Office (ILO), amended slightly by UICC, and finally adopted by ILO as the *ILO U/C International Classification of Radiographs of the Pneumoconioses 1971*; its history is described in a report edited by Jacobson and Lainhart (1972), which also describes the classification fully, although the official version was published, with standard films, by the International Labour Office (1972).

The *ILO U/C International Classification 1971* provided a means of recording the appearance not only of small rounded opacities and large opacities but also of small irregular opacities, pleural thickening and calcification, the diaphragm and cardiac outline, and other conditions to be recorded as 'sym-

bols'. This paper is concerned solely with the assessment of small opacities.

The term irregular opacities was introduced to describe features that previously had been called linear, reticular, fibrotic, network, honeycomb or blotchy, including those classified in the 1958 ILO classification as L and some formerly read as Z, but not further graded (Jacobson and Lainhart, 1972). The classification demands that rounded and irregular small opacities be recorded separately, and that for each such form* of opacity a note be made of the predominant type (that is, size of rounded opacity or thickness of irregular opacity), of the profusion (that is, concentration, defined as the number of opacities per lung zone), and of the extent (that is, in which of six zones of the lung—upper, middle, lower; right, left—the opacities appear). The sizes (p: punctiform; q, formerly m: micronodular; r, formerly n: nodular) of rounded opacities were defined in terms of diameters. However, thickness (s, t, u) of irregular opacities was defined only in terms of standard films.

A major change was in the recording of profusion. In the 1958 ILO scheme, both profusion (opacities per unit area) and extent (number of rib spaces affected) were used in the definitions of categories of small opacities. This was criticised because it made difficult the classification of films with definite but sparse small opacities in several rib spaces (International Labour Office, 1972, p. 22). The current scheme defines the categories on profusion only: 'the category of profusion . . . is determined by averaging

*The term 'form' is used in this paper, because 'type' is used in the classification itself not only in this sense but also as an indication of size or thickness.

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Fig. 1 The short and complete classifications, and notional scale of abnormality.

the profusion in the affected zones'. The notes in the *ILO U/C International Classification 1971* go on to state that 'it is not thought this change of definition will materially alter the level of reading . . .' (International Labour Office, 1972, p. 22). However, it also stated that 'where there is marked difference in profusion in different zones of the lung, the zones predominantly affected are the ones over which averaging is made' and that 'the method used for averaging should be stated in publications using the classification' (International Labour Office, 1972, p. 9).

Because both rounded and irregular small opacities may coexist, the profusion and extent of each are recorded separately. However, this can lead to the assignment of a lower category of profusion of each form (particularly when both are present in the same lung zone) than the category of total profusion of all the small opacities when both forms coexist (Jacobson and Lainhart, 1972).

Another major international innovation was the use of the 12-point scale of profusion developed by the British National Coal Board (NCB) (Liddell, 1963, 1972; Liddell and Lindars, 1969). This had been designed to be fully compatible with the ILO 1958 scheme of categorisation; this compatibility had been demonstrated in the course of full testing of what became known as the NCB elaboration (Fig. 1).

Jacobson and Gilson (1972) discussed some of the problems arising in the use of the new classification, particularly in the averaging of profusion over affected zones, and reported that the problems had not been resolved at a meeting at Penarth in April 1971. These and related problems in the assessment of small opacities are discussed in the current paper which is based on a comparatively small film reading

trial, but the findings delineate some important principles.

Materials and methods

For a review* of a classification used in Ontario, 269 postero-anterior chest radiographs of male workers in Ontario were assembled. In conformity with accepted practice (Weill and Jones, 1975) 61 of these men had had no recorded exposure to dust hazards. Included in the series were 35 pairs of films of the same men, the intervals between the pairs varying up to nine years. A total of 173 men (138 with single films, and the 35 with pairs) were known to have been exposed. Most were hardrock miners in Ontario where copper, gold, nickel, and uranium are among the main products. Others were pipe and shingle makers who had been exposed to asbestos and/or silica.

The 269 films were placed in a single series, in random sequence (yet ensuring that pairs were separated), and read into the *ILO U/C International Classification 1971* (unmodified), by three readers, working separately and blind to the subjects' histories. Each reader, on a later occasion, read the film pairs, which had been assembled in a fresh sequence; in this reading, the earlier film was classified before the later film was made available to the reader. The 35 earlier films are referred to as the subset; their classification on two occasions provided some measure of intraobserver variation. (The assessment of radiographical progression will be reported separately.)

The readers were Dr J. C. Gilson, Dr J. C. McDonald, and Dr W. K. C. Morgan. The first two were leading participants in the discussions of the UICC in the late 1960s, and again in those of the ILO which produced the current classification used in this investigation. All three are experienced readers, having used the *ILO U/C International*

*Carried out at McGill University, on behalf of the Royal Commission on the Health and Safety of Workers in Mines (Ontario), and reported on, privately, to the Commission by the author.

Fig. 2 Calculation of combined average profusion (CAP): Film no. 69.

*Figures in square brackets are profusions on the notional scale of Fig. 1.

Classification 1971, and its immediate predecessors for the assessment of many thousands of films. Only one was equally familiar with both rounded and irregular opacities. The experience of another was predominantly with rounded opacities, and of the third with irregular opacities.

In what follows we make frequent use of the commonly used maximum small profusion, or more correctly *maximum profusion of small opacities*: the greater of the two possible recorded profusions, of rounded and of irregular opacities. Figure 2 gives its value for the assessments of one film (no. 69) from the subset. The *median maximum profusion* can then be determined for each film; for film no. 69, it was 1/1 on the first occasion and 1/0 on the second. Although the median is easily found (and can be determinate in certain cases of missing readings) and is less dependent on scale and on the frequency distribution, it has inferior mathematical tractability and certain other drawbacks (see for example, the comments below on Fig. 4). For some purposes therefore we have used the *mean maximum profusion* for a film. This was obtained by transforming each reader's assessments on to the notional scale (Fig. 1) introduced by Liddell and May (1966) (see items in square brackets in Fig. 2) and then taking the arithmetic mean.

We also calculated the *combined average profusion* over all six lung zones. To do so we converted the assessments of profusion of either form of opacity on to the notional scale, weighted by the number of zones recorded as affected by the specific form, and divided by six (the total number of zones). The calculations for film no. 69 on the first occasion (see Fig. 2) were as follows:

$$A: (4 \times 6 + 3 \times 6)/6 = (42)/6 = 7.00$$

$$B: (0 \times 0 + 1 \times 2)/6 = (2)/6 = 0.33$$

$$C: (1 \times 2 + 3 \times 6)/6 = (20)/6 = 3.33$$

There is strong evidence, both theoretical and practical, that the choice of scale would make little difference to findings based on these last two measures.

Findings

Table 1 gives the distributions of readings of maximum profusion. Only 242 (30.0%) of 806 were 0/0 or less; indeed, for only 45 films (16.8%) of 268 were readings of 0/0 or less agreed by all readers. However, these 45 included 36 (59.0%) of the 61 cases without recorded exposure to dust hazards. Of the 183 readings of these films for unexposed workers, 153 (83.6%) were 0/0 or less. None of the 61 was assessed by all three readers as showing change,

Table 1 *Distributions of maximum profusion, by reader*

Maximum profusion*	Reader A	Reader B	Reader C	All Readers
0/-	3	6	—	9
0/0	81	100	52	233
0/1	10	37	24	71
Category 0	94 (34.9)	143 (53.2)	76 (28.4)	313 (38.8)
1/0	17	25	33	75
1/1	45	23	40	108
1/2	24	20	25	69
Category 1	86 (32.0)	68 (25.3)	98 (36.6)	252 (31.3)
2/1	34	18	23	75
2/2	26	15	31	72
2/3	5	9	7	21
Category 2	65 (24.2)	42 (15.6)	61 (22.8)	168 (20.8)
3/2	5	10	18	33
3/3	16	4	11	31
3/4	3	2	4	9
Category 3	24 (8.9)	16 (5.9)	33 (12.3)	73 (9.1)
All categories	269 (100)	269 (100)	268† (100)	806† (100)

*See text for definition.

†One film considered unreadable.

Percentages are given in parentheses.

Table 2 *Interobserver variation in three studies*

Percentage 1/0 or more	This trial	(a) Eyssen (1975)	(b) Rossiter (1972)		
			Rounded	Irregular	Combined
Mean	61.2	26.8	13.6	43.2	50.9
Standard deviation	12.9	12.3	5.8	17.7	15.5
Coefficient of variation (%)	21.0	34.5	42.8	40.9	30.4

although two readers saw change in five cases (8.2%). Combined average profusion for this group had a mean value of 0.12, compared with a mean of 3.57 for the other films.

In the complete series, the proportions of films for which maximum profusion was scored 1/0 or higher were 65.1%, 46.8%, and 71.6% (see Table 1). This interobserver variation can be compared with that in two other studies, (a) where four readers assessed maximum profusion in 283 films of asbestos workers (Eyssen, 1975), and (b) where 12 readers assessed the profusions of rounded opacities, irregular opacities, and their combination in 100 films in which abnormalities were typical of asbestos exposure (Rossiter, 1972). The means, between-readers standard deviations, and coefficients of variation are given in Table 2.

Table 3 illustrates what Morgan *et al.* (1974) have called the middling tendency, that is, the tendency to use the central zones (0/0, 1/1, 2/2, 3/3) at the expense of the marginal zones. Within short categories 1, 2, and 3 the central zones were used for 43% of readings. Reader A exhibited the greatest middling tendency; Reader B had virtually eliminated it. Within category 0, however, the middling tendency was strong for all readers, because 0/- was seldom used.

Table 3 *The middling tendency (films placed in central zones 0/0; 1/1; 2/2; 3/3)*

Maximum profusion in short classification	Reader A	Reader B	Reader C	All Readers
Category 0	81/94 (86.2)	100/143 (69.9)	52/76 (68.4)	233/313 (74.4)
Category 1	45/86 (52.3)	23/68 (33.8)	40/98 (40.8)	108/252 (42.9)
Category 2	26/65 (40.0)	15/42 (35.7)	31/61 (50.8)	72/168 (42.9)
Category 3	16/24 (66.7)	4/16 (25.0)	11/33 (33.3)	31/73 (42.5)

Percentages are given in parentheses.

The subset of 35 films did not include any of unexposed workers, and there were no readings of 0/-. However, the distribution of readings into the short classification was similar to that for all 269 films.

As was to have been expected from the provenance of the subjects, both forms of small opacity occurred together frequently, in about a quarter of all cases. Often the different forms were not recorded in the same zones of the lung. However, among zones considered to be affected by small opacities, both forms were recorded in about 15%. In the reading and re-reading of the subset, readers recorded small

opacities on both occasions a total of 87 times, in 67 of which (77%) the same form was noted as predominant.

Interobserver variation in the assessment of form is difficult to quantify. In the subset of the 25 cases where all readers recorded small opacities, agreement on form was achieved in only 11 (44%), rounded agreed in 5, and irregular in 6. In the other 14 cases, Reader A thought that rounded opacities predominated more frequently (in 13 films), while Readers B and C felt that irregular opacities predominated more commonly (in 10 and 8 films, respectively).

The size of rounded opacities was most commonly assessed as q and the thickness of irregular opacities as t. Table 4 shows that the type (regardless of form) was similar on the two occasions in 64 out of 87 cases (74%). For Readers A, B, and C respectively, similar assessments were recorded in 26 out of 32 cases (81%), 18 out of 21 (86%), and 20 out of 34 (59%). On the subset, the individual readers agreed with the median in 58 of 75 cases (77%).

Figure 3 illustrates the spatial distribution of small opacities. When rounded opacities were not extensive, that is, were recorded in no more than four of the six zones of the lung, there was a tendency for them to be recorded in the upper and middle zones to the almost complete exclusion of the lower zones. There was no clear preference for side. When only one lung zone was unaffected, it tended to be the left lower zone. The patterns were similar for all readers. With irregular opacities the patterns were quite different with the upper zones the least affected, but this varied between readers. Readers A and C tended to see opacities on the right of the lung rather than on the left. For Reader A, the lower zones were most frequently affected, while for Reader C it was the

Table 4 Assessment of type (size or thickness) of opacities (35 films in subset)

(a) Intraobserver variation		Second assessment			
First assessment		p or s	q or t	r or u	Total
Either p or s	5	1	—	6	
Either q or t	6	45	7	58	
Either r or u	2	7	14	23	
Total	13	53	21	87*	

(b) Interobserver variation		Individual reader's assessments			
Median assessment		p or s	q or t	r or u	Total
Either p or s	4	2	—	6	
Either q or t	2	39	7	48	
Either r or u	—	6	15	21	
Total	6	47	22	75†	

*Excluding 18 pairs of assessments when at least one assessment was 0/0 or 0/—.
†Excluding 30 films for which at least one reader did not record type of opacity.

middle zones in which opacities were most often seen. The pattern for Reader B was less clear-cut.

Table 5 deals with observer variation in the count of lung zones affected by small opacities, of either or both forms. Despite some polarisation, particularly towards all zones being affected, the repeatability was low. Readers agreed with themselves in only 44% of cases (46 out of 105). The percentages of agreement were 60% for Reader A (21 out of 35), 46% for Reader B (16 out of 35), and 26% for Reader C (9 out of 35). The readers agreed with the median count in only 56% of cases (59 out of 105). Two of the worst disagreements were as follows. On the first occasion of assessing film no. 19, one reader recorded profusion 0/1 of form t in one zone

Fig. 3 Spatial distributions of opacities. Proportions of cases in which the indicated zones were affected.

Table 5 Number of lung zones in which opacities appear (35 films in subset)

(a) Intraobserver variation		Count on 2nd reading						
Count on 1st reading		0	1	2	3	4	5	6
0	10	—	3	1	—	—	—	14
1	—	1	—	—	—	1	—	2
2	1	—	6	1	4	2	—	14
3	1	1	1	2	3	2	4	14
4	2	1	2	—	5	6	6	22
5	—	—	—	—	2	—	4	6
6	—	—	1	3	6	1	22	33
Total	14	3	13	7	20	12	36	105

(b) Interobserver variation		Individual count						
Median		0	1	2	3	4	5	6
0	7	—	—	2	—	—	—	9
1	1	1	—	—	1	—	—	3
2	2	1	3	—	1	1	—	9
3	1	—	5	10	2	—	3	21
4	—	—	2	2	12	2	3	21
5	1	—	1	1	—	3	3	9
6	2	—	3	1	4	—	23	33
Total	14	2	14	16	20	6	33	105

(RM); on the second occasion, he recorded *t* opacities, profusion 1/1, in that zone and in two others (RL, LL), together with form *p* (of profusion 1/0) in the other two zones on the left. When another reader first assessed film no. 426, he recorded *t* opacities (profusion 1/1) in all six zones, but on the second saw opacities (of the same form) of profusion 0/1 in only two zones. There were also situations when the *counts* of affected zones were the same on the two occasions, but agreement in detail was by no means achieved.

Profusion (concentration per affected zone) and extent (number of zones affected) are to be recorded separately. However it seems not unlikely that progression will often take the form of concomitant increases in concentration and extent. This would show in the cross-section by a positive association between these two measures. Table 6 shows that profusion of 0/1 and 1/0 was usually recorded in no more than three zones. In just half the cases where profusion was 1/1 or more, it was reported as extending over all six zones. Reader A considered that all six zones were affected wherever profusion was 2/1 or greater. The main finding is very similar to that of Eyssen (1975) on irregular small opacities in a much larger series of films.

The classification 'strongly recommends' the recording of combined profusion when both forms of small opacity are present. The instructions are: 'assume that all the small opacities are either rounded or irregular and record their combined

Table 6 Profusion and extent of small opacities (35 films in subset)

Maximum profusion	No. of zones in which opacities* were seen						
	0	1	2	3	4	5	6
0/-	—	—	—	—	—	—	—
0/0	14	—	—	—	—	—	—
0/1	—	1	12	2	3	—	—
1/0	—	1	4	8	3	—	—
1/1	—	—	1	1	6	2	10
1/2	—	—	—	2	3	1	5
2/1	—	—	—	1	2	1	4
2/2	—	—	—	—	7	—	3
2/3	—	—	—	—	—	—	2
3/2	—	—	—	—	—	—	4
3/3	—	—	—	1	—	—	1
3/4	—	—	—	—	—	—	—

*Of the form with maximum profusion.

profusion as though they were all of this one [form]' (International Labour Office, 1972, p. 10). Only one of the readers attempted this, but his recordings were inconsistent with my interpretation of the instructions. For example, consider film no. 30, in which this reader recorded rounded opacities of profusion 2/1 in the four upper lung zones and irregular opacities of profusion 0/1 in the other two zones. Because coexistence within zones was not recorded, the average over the six zones would seem to lie *between* 2/1 and 0/1, perhaps around 1/2 (or 4 on the notional scale). Combined average profusion (as defined above) was 3.67. However, the reader's actual record of combined profusion was 2/2 (6 on the notional scale). Overstatement, in this sense, of combined profusion was the rule for this reader rather than the exception.

We have therefore calculated combined average profusion and compared it with maximum profusion in Table 7 (for individual assessments) and Table 8 (for cases averaged over readers). Entries on the diagonal (italic figures) arose mainly where only one form of opacity was present and extended over all or most of the lungs. In Tables 7 and 8 there were 50 and 154 such entries (47.6% and 58.1%). Entries below the diagonal arose where the opacities did not extend over all six lung zones. Those above the diagonal were because both forms of opacity were recorded in the same lung zones. The former were more frequent than the latter (48 and 72 entries compared with 7 and 39, in Tables 7 and 8, respectively). As expected from Table 6, the former were mainly where profusion was less than short category 2; the latter were mainly associated with higher degrees of profusion. Figure 4 gives the readings for film no. 386, the case lying furthest from the diagonal of Table 8. The main reason for the discrepancy was that maximum profusion of 1/2 for Reader A did not reflect the coexistence of rounded and irregular

Table 7 Combined profusion, averaged over all lung zones (individual assessments by three readers of 35 films in subset)

Maximum profusion	Combined average profusion*												Total
	-1	0	1	2	3	4	5	6	7	8	9	10	
0/-	—												—
0/0		14											14
0/1		12											19
1/0		1	12	2									15
1/1			1	6	13								20
1/2				2	3	1	1	2	2				11
2/1					2	1	4	1	—				8
2/2						5	2	2	1				10
2/3								—	2				2
3/2								—	—	4			4
3/3								1	—	—	1		2
3/4												—	—
	—	27	20	10	18	7	7	6	5	4	1	—	105

*See text for definition.

Table 8 Combined profusion, averaged over all lung zones (panel assessments of 265 films, excluding four where comparison was impossible†)

Median maximum profusion	Combined average profusion												Total
	-1	0	1	2	3	4	5	6	7	8	9	10	
0/-	—												—
0/0		75	5										80
0/1		8	10										18
1/0			12	11	2								25
1/1			1	15	8	1							40
1/2				3	8	8	5	2					26
2/1					3	12	7	7	2	1			32
2/2						2	4	11	2	1			20
2/3								3	—	3			6
3/2								1	—	7			8
3/3											8		8
3/4												2	2
	—	83	28	29	28	30	17	24	4	12	8	2	265

†One film was considered unreadable by Reader C (see Table 1). In three other cases, affected zones were not recorded by Reader A twice, and Reader B once.

	Combined average profusion		Maximum profusion	
Reader A	q	✓ ✓	f	✓ ✓
	1	✓ ✓	1	✓ ✓
	2	✓ ✓	2	✓ ✓
			8.00	1/2 [4] **
Reader B			u	✓ ✓
	3	✓ ✓	3	✓ ✓
	3	✓ ✓	3	✓ ✓
			9.00	3/3 [9]
Reader C	q	✓	u	✓ ✓
	1	✓	2	✓ ✓
	1	✓	1	✓ ✓
			5.67	2/1 [5]
	Median:		2/1	[5]
	Mean:	7.56		6.00

Fig. 4 Combined profusion: Film no. 386.

**See Fig. 2.

opacities in all zones, and was less than the 2/1 recorded by Reader C, which then became the median. This also illustrates a major shortcoming in the use of the median: the mean maximum profusion was 6.00, in closer accord with the combined average profusion of 7.56.

Figure 5 shows how intraobserver differences can be reduced by the use of combined average profusion, instead of maximum profusion. With the former measure, differences between occasions are 0.17, 0.33, and 0.67 steps while with the latter they were two steps for each film. The opposite effect was also observed (see for example film no. 69, Fig. 2), and the use of combined average profusion was not generally found to reduce intraobserver error.

The more complex phenomenon of interobserver variation is examined in Table 9. Mean differences were small at the extremes of the continuum, but for Readers A and B were large in the middle. The differences averaged over all films give little indica-

Fig. 5 Observer variation reduced in combined average profusion (CAP).

Table 9 Interobserver variation in assessment of individual films. Each reader's assessments of 230 films* compared with average, in terms of combined average profusion and maximum small profusion on the notional scale

(a) Mean differences

Average reading†	No. of films	Combined average profusion			Maximum profusion		
		Reader A	Reader B	Reader C	Reader A	Reader B	Reader C
0	60	-0.02	-0.08	0.09	-0.07	-0.13	0.20
1	30	-0.18	-0.44	0.62	-0.39	-0.69	1.08
2	20	0.87	-1.02	0.15	0.52	-1.23	0.72
3	24	1.11	-1.33	0.22	0.71	-0.96	0.25
4	28	1.19	-1.62	0.42	0.39	-0.93	0.54
5	26	0.96	-1.47	0.51	0.24	-1.14	0.90
6, 7	26	0.44	-0.52	0.08	-0.19	-0.23	0.42
8-10	16	0.05	-0.60	0.55	0.21	-0.54	0.33
All	230	0.47	-0.77	0.30	0.12	-0.64	0.52

(b) Standard deviations (RMS averages over all three readers)

Average reading†	No. of films	Combined average profusion	Maximum profusion
0	60	0.19	0.26
1	30	0.71	0.90
2	20	1.03	0.78
3	24	1.20	1.30
4	28	1.45	1.23
5	26	1.38	1.31
6, 7	26	1.48	1.40
8-10	16	0.89	0.65
All	230	1.12	1.04

*The original 269, less the 35 in the subset, less 4 incomplete for the purposes of this table (see footnote to Table 8)

†Of maximum small profusion on the notional scale, rounded to the nearest scale point.

tion of the true patterns. Standard deviations, which were fairly similar for all readers were small at the extremes, particularly when the average reading was zero on the notional scale. All this makes it difficult to assess the effect of averaging on interobserver variation, but there was no evidence of major improvement in general.

Discussion

The few films studied contained so much abnormality that more information was obtained than might have been possible from many more films. In particular both rounded and irregular opacities existed together in a substantial proportion of cases,

while rounded small opacities of the largest size (r) were more common than in most investigations. In fact, there were more than twice as many films as in the series on which the introduction of the NCB elaboration was based, and more subjects were involved than in the main investigations leading to the adoption of a method of assessing radiological progression in the NCB (Liddell and May, 1966).

Interobserver variability in the assessment of maximum profusion was shown by normal readings (0/1 or less) in 28.4% of films (Reader A) to 53.2% (Reader B see Table 1). It can be evaluated by the between-reader standard deviation of 12.9, that this was fairly similar to that achieved in other studies. However, in the light of the high degree of abnormality and the fact that the films tended to be of soft technique with low contrast levels, this degree of variability appears quite acceptable. Indeed, when evaluated in terms of coefficients of variation it compares favourably with earlier findings (Table 2).

The middling tendency has been apparent since 1959, when a 12-point scale was first introduced (Liddell, 1963). By appeal to a principle enunciated by Newton (1642-1727), or to algebra based on the theory of communication (Shannon, 1948), it can be shown that the most efficient use of the elaboration occurs when all three zones within each category are used equally, that is, when the middling tendency is eliminated. That it can be reduced in certain readers has been shown by Liddell and Lindars (1969). In the present trial, it was quite small in short categories 1, 2, and 3 averaging 43% (compared with the ideal of 33%) suggesting that efficiency remained high, or that little information was lost. Where it was virtually eliminated (Reader B), the number of films placed in each subcategory from 0/0 through 3/4 was in monotonic descending sequence, with one exception. This is the form of distribution to be expected in a naturally-occurring population of men exposed to dust. Within short category 0, however, the heavy predominance of 0/0 and the shortfall of 0/- indicates efficiency of only about 60%. Reluctance to record profusion as 0/- is well known, but in deceased coalminers whose films shortly before death were assessed as 'barndoor' normal there was on average a lower index of pathology in the lung than in those whose films were read 0/0 (Liddell, 1972). There would therefore appear to be grounds for encouraging the more frequent use of 0/-.

Although even these readers disagreed frequently with one another on whether opacities were rounded or irregular, they were reasonably self-consistent. In view of the different definitions of type (in terms of diameter and thickness), the correspondences between p and s, between q and t, and between r and u were acceptable. Undoubtedly, the inclusion of the

full categorisation of irregular opacities, exactly corresponding to that of rounded opacities, has been fully justified.

The tendency to find rounded opacities in upper zones of the lung and irregular opacities in lower zones, was to be expected (International Labour Office, 1972, pp. 7 and 9). It is however important to recognise the possible circularity. It could be that when small opacities are seen in only a few zones they are treated as one form or the other depending on their location.

The determination of the extent to which opacities affect the lung zones left much to be desired. This aspect of the classification, probably given least attention by readers, is also difficult for recording clerks. Steps should be taken to improve these procedures.

When both forms of small opacity coexist, and as long as it remains difficult to disentangle information about either form, it is clearly important to obtain some assessment of the profusion of all opacities combined. Indeed, it was to have been expected that such assessment would be more consistent than an assessment of each separately, or of the maximum profusion. That this was not so in this investigation may have been due to the difficulties in determining the extent (count of affected zones). Another possibility is that one or more of the readers may have overcompensated the tendency (noted by Jacobson and Lainhart, 1972) for 'assignment of a lower category of profusion of each [form] . . . when both are present in the same lung zone'. It is also possible that in more usual film series with much less abnormality, the benefits of averaging would outweigh the disadvantages.

There remains a clear need for guidance to readers on the recording of combined profusion. The one reader who essayed this recording did not seem to follow the averaging rules; a second said that he left assessment of combined profusion to the statisticians; the third that he could not make such assessments without fuller guidance. Although both forms of opacity are to be assessed without distinction, it is not clear how their profusions can be treated as commensurate. Dr J. C. McDonald, a reader, pointed out that *counting* opacities is a possible concept when they are rounded but impossible when they are irregular. He suggests that it might be better to assess degree of opacity (corresponding to lack of translucence), which, with a description of the appearance of the responsible opacities, would enable large opacities to be put on the same continuum. Emphysema would remain a problem, as it is now; so would decisions as to which zones are to be considered affected by combined profusion.

Some at least of the difficulty might be overcome

by recording additionally profusion averaged over all lung zones, that is, by assessing the concentration of opacities over the complete film. Where only one form of opacity is present, this would allow an immediate check of the consistency of the classification of the specific form averaged over affected zones, the number of zones affected, and of the average over all zones. When both forms are present, a corresponding check would quickly reveal problem areas.

Another possibility, unlikely to recommend itself to readers, would be for each lung zone to be treated separately for purposes of categorisation. This would probably require, firstly, scrutiny of the film to aid identification of the changes seen zone by zone. Thereafter, it should be possible to record, for each zone, whether opacities exist, if so of what form(s), and then their type(s) and profusion(s), with a final assessment of how much of the zone is affected *in toto*.

Finally, it is important to emphasise that the assessment of radiographic progression of small opacities can be misleading when based only on maximum profusion. Progression may often take the form of increase in both profusion and extent. However, there may be an increase of extent, without increase (or even occasionally with decrease) of profusion, yet increasing the total number of opacities visible. Or, again, the form of opacities which predominated in the earlier film may not have changed, but the other form may have progressed noticeably without becoming predominant in the later film. In such a case, maximum profusion would be unchanged, despite the increase in the number of opacities visible. That these are not simply academic problems was shown in the study of change in the subset.

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