HEALTH AND ENVIRONMENTAL CONDITIONS IN BRICKWORKS

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This survey is based on experience gained at three of the four brickworks of the Butterley Company Limited, in which altogether 144 persons are employed. At three of these works the "stiff plastic" process of manufacture is employed, but at the fourth the "wirecut" or "fully plastic" method is used. Since the workers employed are, at best, semi-skilled and tend frequently to change from one job to another, it is not possible to classify their occupations in an entirely satisfactory manner, but a rough list has been attempted as follows:

clay-getting
grinding and screening
brickmaking
tramming to kilns
setting
fitting and maintenance
burning
drawing
labouring (i.e., kiln cleaning and reloading from stock)

The works owned by the Company are typical of a large number of brick-producing units which together yield a high proportion of the total bricks manufactured in England. The buildings and general environment are of a kind usually met with in the industry, and for this reason it is felt that conclusions based on the results of this survey can claim to give a fair picture of a considerable section of the brickmaking industry.

The Clays and the Processes

The so-called "clays" from which bricks are made in this country are mixtures of complex compounds of alumina and silica in widely varying proportions, together with impurities in the form of free silica, iron oxide, lime, magnesia, alkalis, and a certain amount of decomposed organic matter. Of these impurities, the most important

from the brickmaker's point of view is iron oxide. In the rare instances where little or none occurs the finished brick is a white or pale yellow colour. Three to 5 per cent. of iron causes a yellow to buff colour, and a higher proportion, up to 12 per cent., gives varying shades from salmon-pink to deep red. Even higher iron contents are occasionally met with, and such clays, if otherwise suitable, can be used for the manufacture of blue bricks. All the bricks produced at the works under review have an average iron content and burn to a red colour. The chemical constitution of the clay or shales from which such bricks are made is of the range given in Table 1.

TABLE 1
CHEMICAL CONSTITUTION OF CLAY OR SHALE USED FOR
BRICKS AT BUTTERLEY COMPANY WORKS

	Percentage	
	Minimum	Maximum
Alumina	17.8	24.5
Total silica	43.0	60.7
Iron oxide	3.6	7.4
Calcium carbonate	Trace	
Magnesium carbonate	1.6	1.8
Organic matter and carbon	5.9	8.9
Other constituents (calcium sulphate, sodium chloride, etc.)	5.4	18.4
Moisture content	1.4	2.4
"Free silica" *	12.4	29.1

* By chemical analysis.

In three cases, the supply of material comes from a "clay hole" or quarry, adjoining the brickworks, but in the fourth it takes the form of shale from a nearby colliery.

Stiff Plastic Brickmaking.—In the case of bricks made by the stiff plastic process, the shale or clay is brought down from the quarry face by excavators and loaded directly into wagons which are trans-

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ported to the works by an endless chain or rope haulage system. It is then reduced to a fine powder in grinding pans. These pans have perforated bottoms, and as they revolve the material is crushed under heavy rollers; when fine enough it passes through the perforations into a pit, from which it is collected by a bucket elevator and delivered to the screening chamber. This is situated on the top floor of the building. In this chamber the ground material passes over sieves formed by a series of parallel wires, which take out the particles too coarse for brickmaking. Such particles gravitate back to the grinding pans. The material which passes through the sieves falls on to a stock-heap from which the brick machines are fed through holes in the floor. The brickmaking machine consists of a mixer, where sufficient water is added to form a stiff paste, and a pugmill or compression machine, which fills a series of moulds. The "clots" thus formed, are then automatically pressed into bricks. All machines of the stiff plastic type demand copious lubrication, both of the moulds and of the press dies, to prevent the adhesion of the clay paste to the metal. A continuous spray of oil is used for this purpose. The bricks are taken off the machine by hand and loaded on to trolleys. Having a moisture content of only about 18 per

cent., they are stiff enough to be set directly into the kiln.

Wirecut or Plastic Brickmaking.—Here again the material is taken from the clay face by mechanical excavator and transported to the works by endless-chain haulage. The wagons are emptied into a feeder, from which the clay passes into a wet pan where water is added and the whole is milled into a plastic mass. The clay is squeezed through a series of slots in the bottom of the pan, after which it passes through several pairs of finely set crushing rollers and is delivered into a pugmill. From this machine it is extruded in a continuous column of very plastic clay, the cross-section of which is that of a green brick. This column is divided into three-foot lengths, which are then passed on to a removable pallet at right angles through a frame supporting parallel wires which cut the column into nine or ten bricks. The pallets are then loaded on to trolleys designed to carry about sixty bricks. Wirecut bricks at this stage of manufacture are too soft to permit being set directly into the kilns and they therefore spend a period of two or three days either on a heated drying floor or in some form of drying chamber, after which they are transported to the kiln.

TABLE 2

SHOWING THE COOLING POWER AS ASSESSED BY MEANS OF THE KATA THERMOMETER AND THE AIR TEMPERATURE IN DEGREES FAHRENHEIT FOR WET AND DRY BULBS (THE AIR VELOCITY IN FEET PER MINUTE IS ALSO OBTAINED FROM THESE READINGS)

Process	Date of reading	Hour of reading	Temperature assessed by whirling psychrometer		Relative humidity	Cooling power assessed by Kata thermometer		Air velocity in ft. per minute
			Dry-bulb	Wet-bulb		Dry-bulb	Wet-bulb	
Brick setting (chamber empty) ..	April 3	12.00	73	—	—	9.00	—	250
Brick setting (chamber quarter full)	April 4	10.00	78	63	42%	6.25	—	—
Cleaning out	April 3	10.30	98	72	27%	1.00	11.5	10
Brick drawing (chamber nearly empty)	April 4	10.30	75	63	51%	6.00	—	70
Brick drawing (chamber nearly full)	April 3	11.15	75	68	70%	5.25	—	50
Space against chamber tapped same morning*	April 3	12.30	95	72	58%	2.00	—	450
Cleaning flue hole in empty chamber	April 4	12.30	89	68	35%	2.50	25.0	190
<i>Kiln No. 1 :</i>								
Above chambers								
Hot end	April 4	11.00	94	68	25%	5.50	15.0	320
Cool end	April 4	11.30	83	63	31%	5.00	12.5	220

* This space was too hot to allow readings to be taken on arrival, but the figures given here were obtained some two hours later, that is, some five or six hours after tapping.

FIG. 1.—The excavator deposits clay into a wagon, which is moved by rope haulage up an inclined plane where the clay is transferred to a conveyor belt which carries it to the brickworks.

FIG. 2.—A view from above, showing the heavy rollers and grinding pans which reduce the clay to a fine powder.

FIG. 3.—The fine dust is raised by elevators from the grinding pans to the screens, one of which is seen in this picture. The workman is directing the flow of ground clay into the aperture through which it passes to the presses on the floor below.

Firing.—Brick kilns nowadays are generally of the continuous type which are constructed in a series of sixteen to twenty or more, so as to form a continuous tunnel. These kilns or chambers are set with bricks from floor to roof at the rate of about six to eight chambers per week. The bricks remain stationary in the kiln, but a body of fire circulates through the whole eighteen kilns in about three weeks.

During this time a chamber of bricks, after being set and the entrance to the kiln bricked up, undergoes a period of approximately three days' drying, six or seven days' pre-heating, three days during

which actual firing takes place, followed by five to six days' cooling, after which the bricks are drawn and the chamber is cleaned out ready for refilling. The firing is done from the roof of the kilns, which are provided with small openings known as firing holes, to enable the coal to be introduced from above. Combustion takes place among the bricks.

Environmental Studies

Atmospheric Conditions.—The environmental studies were carried out at a stiff plastic brickworks.

FIG. 4.—The process of taking the bricks off the press is done by hand. Note the careful guarding of a dangerous machine. Taking off the bricks brings the hands of those engaged on this work into contact with oil.

FIG. 5.—The bricks are stacked on a trolley and are then taken to the kiln.

FIG. 6.—The trolley is pushed by hand to the kiln along a covered way which, however, is open to the weather on one side.

FIG. 7.—The green bricks are stacked by hand from floor to roof of the kiln.

FIG. 8.—Firing is done from above the kilns. The brick-burner is a highly-skilled person.

FIG. 9.—The bricks, having been fired and allowed to cool, are drawn off by hand.

FIG. 10.—The barrows are wheeled direct onto the waiting lorries, where the bricks are again stacked by hand. In the background can be seen the inclined plane by which the wagons reach the brickworks.

Table 2, shows the results obtained with the Kata thermometer and the sling psychrometer. The temperature readings are high, ranging from 73° F. to 78° F., but such a state of affairs is inherent in the nature of the processes. As might be expected, the cooling power is rather low; in the case of brick-drawing the relative humidity is high when the chamber is full.

Dust Hazards.—The estimation of the dust risk was determined according to a technique similar to that previously described by us (Keatinge and Potter, 1945) and amplified subsequently in greater detail by one of us (Potter, 1946).

The Mass Concentration of Air-borne Dust.—Twenty determinations of the dust hazard were under-

TABLE 3
SUMMARIZED OBSERVATIONS

Sample No.	Operation and location	Mass concentration (g. per 1,000 cu. ft.)		No. of particles per c.cm. 5.5 microns 0.9 microns	Sulphur-dioxide, parts per hundred million of air
		Below 5.5 microns	Whole dust		
		(1)	(2)	(3)	(4)
<i>Kilns :</i>					
10	Brick-drawing kiln 1 : chambers 8, 9, and 10	—	1.2	—	—
2	Brick-drawing kiln 2 : chamber 11	—	0.5*	—	28
13	Brick-drawing kiln 1 : chamber 11 (windy)	—	4.6	—	17
18	Brick-drawing kiln 1 : chamber 4 (very windy) ..	0.12	4.9	326	—
1	Brick-drawing and cleaning-out kiln 1 : chambers 8, 9, and 10	—	7.2	—	—
19	Cleaning-out kiln 1 : chamber 3	0.12	2.7	340	—
24	Chamber ready for cleaning out, open three days ..	—	—	—	76
25	Firing floor above kiln 2	—	—	—	41
8	Stacking green bricks kiln 2 : chamber 2	—	0.1	—	40
14	Stacking green bricks kiln 2 : chamber 3	—	0.3	—	—
20	Stacking green bricks kiln 2 : chamber 4	0.008	—	17	—
<i>Dust Mills :</i>					
6, 17	General body on ground floor near presses	0.008	0.2	31	—
7	Top floor, outer room to screen B	—	0.9	—	15
15	Top floor, outer room to screen B	0.06	2.0	169	—
3	Top floor, screen B	—	4.6	—	—
21	Top floor, screen B	0.16	3.5	601	—
11	Top floor, screen B	—	3.7	—	—
4	Top floor, screen A	—	4.6	—	—
16	Top floor, screen A	0.15	4.8	455	—
22	Top floor, screen A	0.08	4.2	257	—
5, 12	Top floor, screen A	—	1.2	—	—
23	Top floor, screen A	0.02	1.4†	105	—

* This sample was a continuous one. Normally samples were discontinued when the kiln was not occupied.

† This sample represented a place where the worker stood out of the dust when not needed at the screen.

taken. These were carried out when workers were in the environment, each sample being taken by means of a hand pump attached to a filter. Eight of these were taken actually in the kilns, and the remaining twelve in the environment of the dust screen which feeds the crushed shale to the mixer. These were considered to be the dustiest occupations.

The cycle of operations in the kilns is (1) loading the green bricks; (2) unloading the fired bricks out of the kiln; (3) cleaning out the coke and ashes from the kiln. Operations 2 and 3 may occur simultaneously.

At these times the highest mass concentration of dust was observed. The maximum concentration was 7.2 g. per 1,000 cu. ft.

The mass concentration of dust during emptying the kilns depends on outside conditions and whether the bricks are being removed from the mouth of the kiln or from the interior. The range was from 1.2 to 4.9 g. per 1,000 cu. ft. The dust is lodged on the tops of the bricks and is largely the ash from the coal which is fired from the top. When the brick is removed the ash is dislodged, and in windy weather the dust can cause physical discomfort.

There is very little dust associated with the stacking of the kilns with green bricks. An average concentration amounted to only 0.2 g. per 1,000 cu. ft.

To deal with the ground shale there are two screens in separate rooms each serving different moulding machines. In each room a worker is

maintained to keep the feed constant. Here again, conditions are variable depending on the position of the operator, ventilation, and the dryness of the powder. Both rooms are very dusty. In one room a belt carries part of the dust to an outer room where it is delivered again to a hole in the floor. Owing to the open nature of this room and the small feed, the dust concentration affecting the operator is much lower than is the case for the other two workers.

The mass concentration near screen (A) varied from 1.2 to 4.8 g. per 1,000 cu. ft., an average value being 3.2. The operator will tend to be in the lower concentration when he is standing away from the screen.

Near screen (B) the concentration varied from 3.5 to 4.6 g. per 1,000 cu. ft. and the average is 3.9.

In the outer room adjoining screen (B) the concentration is not greater than 2 g. per 1,000 cu. ft. with a mean value of 1.4 g.

Downstairs below the screens where the shale is being ground and the presses are working the average dust concentration is only 0.2 g.

Numerical Concentration of Dust Particles.—Nine of the above samples were selected as generally representative, and the air borne dust was examined in order to assess the number of particles present in each cubic centimetre of air of a size which may be regarded as a potential hazard to health. Dust particles larger than 5.5 microns have been ignored

TABLE 4
PARTICLE FREQUENCY DISTRIBUTION OF AIR BORNE DUSTS*

Description	Drawing bricks (very windy)	Cleaning out a chamber	Setting green bricks	Dust screen A	Dust screen A	Dust screen A, out of main dust	Dust screen B	Outer room to screen B	General body, ground floor
Sample number	18	19	20	16	22	23	21	15	17
5.5 microns	19	15	1	23	15	4	24	8	1
4.4 microns	25	24	2	24	11	2	16	12	2
3.5 microns	23	31	1	36	13	4	37	14	1
2 microns	40	52	4	52	28	15	85	22	3
1.8 microns	56	82	6	122	72	27	160	46	7
0.9 microns	163	136	3	198	118	53	279	67	17
Total (5.5 to 0.9)	326	340	17	455	257	105	601	169	31
Grammes per 1,000 cu. ft. calculated	0.12	0.12	0.008	0.15	0.081	0.024	0.156	0.060	0.008
Weight % of total dust ..	2.4	4.4	4	3.1	5.8	1.7	4.5	3	4

* The mass concentration of the —5.5 micron dust is calculated from the specific gravity and the volume constant.

as have those smaller than 0.9 microns. (Normally the count would have been to include particles down to 0.5 microns, but the refractive index of the shale particles made examination in oil very unreliable.) A full count down to 0.5 microns would probably double the numbers given below, which are, of course, comparable with one another.

The highest number of particles was near to screen (B) when 600 particles per c.cm. were recorded. In the room adjoining screen (B) the concentrations were much lower with 169 particles per c.cm. In the vicinity of screen (A) the lowest particle number recorded was 105 and the highest 455, corresponding to the observed changes in mass concentration.

In the kilns the highest number was obtained during cleaning out, namely 340 particles per c.cm. Unloading kilns showed a high count, with 326 particles per c.cm., but the number was probably increased by windy conditions.

During the loading of a chamber with green bricks the number dropped to 17 particles per c.cm. This is comparable with conditions in the general body of the dust mill near the presses, where the number of particles per c.cm. was 31.

Extent of Risk.—Although some of the dust concentrations are high, the chemical constitution of the dust is such that the danger from the inhalation of free silica in these brickworks cannot be great. Nevertheless the practice of water suppression as in use at one of the brickworks could well be extended, although it may be recalled that alumina has been shown to inhibit the fibrosis-forming properties of free silica on the lung (Gardner and others, 1944). The process of manufacture of wire-cut bricks limits the risk of inhalation of dust to work in the kilns, where the hazard is comparable with that encountered in the firing of stiff plastic bricks.

Fumes.—During the cooling and cleaning of the chambers there appeared to be a considerable amount of fume present. This was tested for sulphur dioxide, hydrogen sulphide, and carbon monoxide, traces being found of the two first mentioned.

Sulphur Dioxide Concentrations.—Six measurements of the concentration of sulphur dioxide were made, five in the chambers and a sixth on top of the kilns where the coal was being fired. A seventh test was carried out in the outside air. The measurements were all made after a week-end and in clear windy weather so that our recorded concentrations are probably somewhat lower than normal. Qualitative tests were made with the starch-iodate-

iodine stain (Department of Scientific and Industrial Research, 1943) and quantitative measurement by means of the volumetric method, that is to say absorption of a known volume of air in dilute hydrogen peroxide solution, the sulphuric acid thus formed being titrated with $\frac{N}{250}$ alkali. The concentrations are all expressed in parts per 100 million.

Above the kiln the concentration was 41. Coal is fed at intervals through the small opening by means of a hand shovel, the whole top floor is very open and only one man is employed at each shift. It was noticed that fumes were emitted from the top of the lids after firing.

A chamber which was ready for cleaning out, having been open for three days, gave the highest concentration—of 76. This was on the windward side. Two chambers being unloaded, one on either side of the kiln, gave concentrations of 28 and 17 respectively. In a chamber that was being loaded with green bricks the concentration was rather high at 40.

The normal air external to the brickworks was exceptionally free from sulphur dioxide, and certainly did not exceed 5. This is very low indeed, and indicates that mixing conditions in the atmosphere were very good.

Carbon Monoxide Concentration.—The palladium chloride reaction was the method used for the estimation of carbon monoxide. (Department of Scientific and Industrial Research, 1943.)

Tests were carried out above the kilns (from where the stoking is done) and in the chambers during cleaning out. No reactions whatever were noted for concentrations of 1 in 12,000 or less. Concentrations of 1 in 10,000 or less are regarded as harmless for practical purposes.

Hydrogen Sulphide Concentrations.—The Lead-acetate test was used for the estimation of this gas (Department of Scientific and Industrial Research, 1943).

Tests were carried out above the kilns, at the entrance to a chamber just tapped, and in a chamber during cleaning out. All three positions gave positive results, but the concentrations were very low, namely considerably less than one part per 1,000,000 in the first two positions and less than one part per 500,000 in the chamber during cleaning out.

Mineral Oil.—Although it has not been possible to find out the country of origin of the oil, it has a specific gravity of 849 and its refractivity is within the range of 5,540 to 5,500, so that on the basis of these findings its carcinogenic properties should not be high (Twort and Lyth, 1933).

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Health Studies

A study of the occupational mortality figures in the Registrar General's Decennial Supplement (1931) relating to "makers of bricks, unglazed tiles, kiln and oven men not making earthenware, china or terra cotta," although apt to be misleading in some respects, nevertheless shows the low ratio of eighty-seven in each of the above groups expressed as a standardized mortality rate.

One hundred and forty-four men are employed, and of these one hundred have been submitted to medical examination, while radiography of the chest was carried out in seventy-three cases. Two of the brickworks have recently been re-opened and all those starting work in them—thirty-seven persons—have been examined. The remaining sixty-three have all been employed at a larger brickworks and were examined on a routine survey, which included all save three of the workers.

The average length of employment in the brickworks industry was 7.88 years per worker. The results of the investigation are given in Tables 5, 6, and 7, and it will be noted that the physical condition of those examined was on the whole satisfactory. These findings therefore afford confirmatory evidence of the good standard of health of the brickworkers; nevertheless it must be borne

TABLE 6

SHOWING LUNG CHANGES IN SEVENTY-THREE MEN X-RAYED AT FOUR BRICKWORKS OF THE BUTTERLEY COMPANY LIMITED

Age group (years)	Class				
	I	II	III	IV	V
14-25	16	10	—	—	—
26-35	5	24	1	—	—
36-45	1	10	—	—	—
46 and over ..	—	5	—	—	1

Class I, normal lung;
Class II, increased markings but not beyond normal limits for a town dweller;
Class III, early reticulation;
Class IV, first-stage silicosis;
Class V, second-stage silicosis.

in mind that the vast majority examined were young men whose physical condition might be expected to be good. The radiographic appearances of the lungs were singularly free from changes due to dust, although in only two cases had there been a dust hazard of any magnitude. These were both young men, aged 25 and 22, who had been working in the dust mill for a considerable time; but even in them the changes due to dust were minimal.

One new entrant to the brick-making industry, a man aged 49, showed radiographic appearances indistinguishable from classical silicosis. He had previously been a bricklayer's labourer, and the changes seen in the lung therefore remain unexplained, although we have from time to time observed early dust changes in the lungs of bricklayers and their labourers.

Two cases showing keratotic changes in the skin were seen in men aged 46 and 36, who had been exposed to mineral oil for a long time; biopsy, however, showed no evidence of malignant changes. The occurrence of skin effects following the use of mineral oil in brickworkers has been noted previously (Henry, 1946) but needs to be stressed.

Only one compensatable accident took place during the twelve months in which this survey was being conducted. This was a case of amputation of the terminal portions of the distal phalanges of the third and fourth fingers of the right hand in a boy aged fifteen years who was operating a brick press.

Discussion

The possible hazards of brickworkers are: (1) dermatitis and keratotic changes in the skin associated with the use of mineral oil; (2) the inhalation of dust in those working in the mills;

TABLE 5

SHOWING PHYSICAL DEFECTS FOUND IN ONE HUNDRED PERSONS EXAMINED AT FOUR BRICKWORKS OF THE BUTTERLEY COMPANY LIMITED

Physical defects found	Number of persons in each age group (years) showing such defects			
	14-25	26-35	36-45	Over 46
No physical defect noted	10	11	3	1
Respiratory conditions	1	3	1	2
Enlarged tonsils ..	9	—	—	—
Dental conditions ..	6	4	4	2
Reduced vision ..	2	4	2	7
Low mental grade ..	1	1	—	1
Defects of cardiovascular system	—	1	5	—
Defects of central nervous system	3	1	1	1
Hernia and weakness in inguinal rings	2	2	1	2
Skin	7	4	1	1
Miscellaneous ..	7	6	12	1
Total	48	37	30	18

TABLE 7

OCCUPATIONAL HISTORY AND PHYSICAL DEFECTS FOUND ON EXAMINATION OF WORKERS EMPLOYED AT FOUR BRICKWORKS OF THE BUTTERLEY COMPANY LIMITED

No.	Age	Period in brick-works	Present occupation and how long	Principal occupation while employed in brickworks	Previous employment and how long	Defects	X-ray class
1	14	6 mth.	On the press	On the press	None	Cannot read	..
2	14	Few weeks	Taking off, few weeks	Taking off	None	None	I
3	14	3 mth.	Tramming, 3 mth.	Tramming	None	None	I
4	14	3 mth.	Tramming, 3 mth.	Tramming	Cinema operator, 6 mth.	Oral hygiene poor	II
5	14	3 mth.	Labourer, 3 mth.	Labourer	None	Oral hygiene poor	I
6	14	2 mth.	Labourer, 2 mth.	Labourer	None	None	I+
7	15	2 mth.	Labourer, 2 mth.	Labourer	Farm labourer, 12 mth.	Ununited fracture left ulna styloid; tonsils plus; dry skin; carious teeth	I
8	15	3 mth.	Labouring	Labouring	None	None	I
9	15	1 yr.	Taking off, 12 mth.	Taking off	None	Carious teeth	I
10	15	1 yr.	Labourer, 12 mth.	Labourer	None	None	I
11	15	1 yr.	Taking off, 12 mth.	Taking off	None	None	II
12	15	1 mth.	Cleaning up	Cleaning up	Blacking fireplaces, 6 mth. Making boxes, 10 mth.	Operation for hernia at 5 yr.	I
13	15	4 mth.	On the press	On the press	None	Tonsils plus	I
14	15	1 mth.	Wheeling	Wheeling	Trimming in a shoe factory, 2 yr.; cutting at crisp factory, 1 mth.	..	..
15	15	10 mth.	Brickmaking, 10 mth.	Brickmaking	Iron works, constructional dept., riveter, 5 mth., drawing off, 13 mth.	Carious teeth; tonsils plus	I
16	16	3 mth.	Mixing and dust room, 3 mth.	Mixing and dust room	At home 12 mth.; colliery 12 mth.; farm labourer 3 mth.	Vision R. 6/36, L. 6/24, B. 6/36; oral hygiene poor	..
17	16	2 yr.	Labourer, 24 mth.	Labourer	None	Gums infected with carious teeth	..
18	16	3 mth.	Labourer, 3 mth.	Labourer	Cinema operator, 24 mth.	Teeth carious; bilateral pes cavus	II
19	17	1 mth.	Dust room, 1 mth.	Dust room	Laundry boy 12 mth.; woodyard 24 mth.	Acne of face	..
20	17	6 mth.	Taking off, 6 mth.	Taking off	Dye worker 3 yr.	Tonsils plus; left varicocele	I
21	17	8 mth.	Taking off, 8 mth.	Taking off	Foundry 3 yr.	..	II
22	17	6 mth.	Labourer, 6 mth.	Labourer	Foundry labourer 2 yr.; market gardens; labourer 1 yr.	Nil	I
23	17	2 yr.	Tramming, 3 mth.	Mixing	Hair cutting assistant 6 mth.	Tonsils plus	II
24	18	2 yr.	..	..	Box-making 18 mth.; building 6 mth.	Dry skin	..
25	18	4 yr.	Tramming, 48 mth.	Tramming	Nil	Dry skin; some weakness of inguinal rings; suffers from frequent colds; tonsils plus; vision; near 7+ 1. 1., distant 6/24. 6/6. 6/5.	I
26	20	5 yr.	Tramming, 2 yr.	Taking off	Core-making in foundry 1 yr.	Dry skin; knee-jerks plus	..
27	21	4 yr.	Labouring, 54 mth.	Labourer	Shop assistant 6 mth.; Army 4 yr.	Tonsils plus	II
28	22	8 yr.	Tramming, 96 mth.	Tramming	Nil	Left tonsil plus	I
29	22	1 mth.	Labouring, 1 mth.	..	Messenger boy 1 yr.; shipyard labouring 2 yr.; rope works labouring 1 yr.; engineering labouring; G.P.O. laying cables; timber merchant labouring 1 yr.; Navy, home service and North Atlantic 3 yr.	Nil	..
30	22	4 yr.	Labourer, 1 mth.	Labouring and drawing	Foundry labourer, few weeks; Army, England and Singapore 2½ yr.	Dry skin	II
31	23	3 mth.	Labouring, 3 mth.	Labouring	Colliery haulage and coal face 7 yr.; sawing trees, 3 mth.	Tonsils plus; emotionally unstable	..
32	23	4 yr.	Fitter's mate, 54 mth.	Fitter's mate	Foundry core-maker 6 mth.; Army 4 yr.	Nil	I
33	24	6 yr.	Machine attendant	Machine attendant	Fettler in foundry 6 mth.; Army 4 yr.	Nil	II

(Continued on next page)

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TABLE 7—(continued)

No.	Age	Period in brick-works	Present occupation and how long	Principal occupation while employed in brickworks	Previous employment and how long	Defects	X-ray class
34	24	3 mth.	Labourer, 3 mth.	Labourer	Colliery haulage 2 yr.; boot and shoe repair 2½ yr.; building trade 1 yr.; Army, N. Africa, Sicily, Italy, Austria, Home Service 4 yr.; aircraft dump 6 mth.; unemployed 6 mth.	States that he suffers from "shell shock"	..
35	24	1 yr.	Setting a week or two	..	Boot and shoe factory 2 yr.; Army, Home Service, N. Africa, Sicily, Italy, 4 yr.; packing 1 yr. 8 mth.	Operation for "brain tumour." Gets occasional blackouts when cycling	..
36	25	5 yr.	Foreman	..	Engineering works 12 mth.; Army, Home Service, Germany, France, Belgium, and Holland 5 yr.	Epidermophytosis	..
37	25	3 yr. (approx.)	Labourer	..	Pottery 1 yr.; engineering 1 yr.; farm 2 yr.; Army, France, and Home Service, 4 yr.	Appendicectomy	II
38	25	6 yr.	In dust room	Taking off, wheeling	Lorry driver's mate 2 yr.; Army, N. Africa, Sicily, Italy, and Egypt, 4 yr.	Amputation of left leg few inches below the knee. Near vision, R.J. 7, L.J. 7, B.J. 7	II
39	25	5 yr.	General work now	..	Colliery 6 weeks; Navy, foreign service, round the world, and home waters, 5 yr.	Dry skin; psoriasis left leg	..
40	26	1 mth.	General work 1 mth.	General work	Engineering apprentice 11 yr.; estate work 1 yr.	Infected gums	II
41	26	5 mth.	Clay hole; tramming	Clay hole; tramming	Fruit seller 6 mth.; colliery haulage 9½ yr.; driver's mate coal lorries 9 mth.	Mitral stenosis well compensated	II
42	27	5 mth.	Brick setter	Brick setter	Farm labourer 2½ yr.; ironworks raming up on pipes and on the conveyor 2½ yr.; Army, France, Germany, Holland, Belgium, Italy, Egypt, and S. Africa, 5½ yr.	Scabies	I+ Tenting right dome of diaphragm
43	27	2 weeks	Clay pit	Clay pit	Concrete works 6½ yr.; Army, Home Service, Burma, 6 yr.; county council road works ½ yr.	Meniscotomy right knee	..
44	27	1 mth.	Clay pit	Clay pit	Shoe trade 3 yr.; Navy, Mediterranean and Home waters 9 yr.; building trade 1½ yr.	Nil	II
45	27	6 yr.	Labourer 6 yr.	Labourer	Army 7 yr.	Left varicocele	II
46	27	6 yr.	Haulage 6 yr.	Haulage	Army 7 yr.	Nil	II
47	28	1 yr. 3 mth.	Labourer one week	Moulding	Forestry 6½ yr.; Army, N. Africa and Italy, 6½ yr.	Malaria B.T. and B.W.	I. Calcified glands, hilar region
48	28	1 mth.	Drawing	Drawing	Farm work 6 yr.; Army, United Kingdom, Europe, 7 yr.	Nil	II
49	29	8 yr.	Slag wheeling	Slag wheeling	Army, Egypt, Italy, and Austria, 6 yr.	..	I+
50	29	11 yr.	Machine hand, 11 yr.	Machine hand	Army 4 yr.	Nil	II
51	30	9 yr.	Navy driving, 2 yr.	Loading and shot firing	Rolls Royce; milling machine, 4 yr.	Nil	II. Ill-defined shadow right upper zone, calcified glands right lower zone
52	30	13 yr.	Brick burning, 9 yr.	Brick burning	Army 3 yr.	Nil	II
53	31	4 yr.	Labourer, 4 yr.	Labourer	Navy 13 yr.	..	II
54	31	11 yr.	Labourer, 11 yr.	Labourer	Army 6 yr.	Occasional rhonchi both lungs	II
55	31	6 mth. ½ yr.	Labourer, ½ yr.	Labourer	Colliery ganging 6 yr.; Army 11 yr. (P.O.W. 3½ yr. Burma)	Retro-bulbar neuritis, vision, N.L. None, R. and B.7; distant, L. None, R. 6/18, B. 6/18	II
56	32	12 yr.	Setting, 6 yr.	Labourer	Army 6 yr.	Right varicocele	II
57	32	14 yr.	Taking off, 6 yr.	Drawing	Army 4 yr.	Near vision J. 5, J. 5, J. 4; distant vision, 6/12, 6/12, 6/12	II
58	32	12 yr.	Brick burning, 10 yr.	Brick burning	Army 6 yr.	Right inguinal hernia controlled by a truss	II
59	33	8 yr.	Setter, 6 weeks	Brick wheeler	Army, S. Africa, N. Africa, Italy, and Austria, 7 yr.	Cannot read; right chronic otitis media; dysentery at 28 and a few tropical sores	II. Calcified glands hilar region, in right lower zone

(Continued on next page)

TABLE 7—(continued)

No.	Age	Period in brick-works	Present occupation and how long	Principal occupation while employed in brickworks	Previous employment-and how long	Defects	X-ray class
60	33	4 mth.	Stoker	Stoker	Colliery haulage and coal face 5 yr.; Army, India, N. Ireland, and Home Service 13 yr.; lorry driver $\frac{1}{2}$ yr.; Air Ministry constabulary 3 mth.	All teeth carious	Occa- sional rhonchi
61	33	2 mth.	Packing, 2 mth.	Packing	Colliery (roads 7 yr., coal face 1 yr.); Army 9 yr.	Nil	II
62	33	19 yr.	Brick burning, 8 yr.	Labouring	Nil	Chronic bronchitis and asthma; pruritus ani	II
63	33	2 mth.	Labourer, 2 mth.	Labourer	Gardening 2 yr.; porter in shop 5 yr.; celanese-spinner $\frac{1}{2}$ yr.; colliery banksman $5\frac{1}{2}$ yr.; Army 6 yr.	Near vision J. 7, J. 1, J. 1; distant vision 6/24, 6/5, 6/5	II
64	33	8 yr.	Labourer, 8 yr.	Tramming	Celanese, winder 1 yr.	..	II
65	34	8 yr.	Labourer in clay hole, 8 yr.	Labourer in clay hole	Colliery surface 1 yr.; woodyard labourer $2\frac{1}{2}$ yr.; bus conductor 2 yr.; unem- ployed 7 yr.	Weak inguinal rings	I
66	35	2 mth.	Labourer, 2 mth.	Labourer	Rivet heater $1\frac{1}{2}$ yr.; chemical works $8\frac{1}{2}$ yr.; Army 11 yr.	Nil	II
67	35	19 yr.	Kiln work, 2 yr.	Labourer	Farm labourer 1 yr.; railway winding $1\frac{1}{2}$ yr.; colliery labourer 2 yr.	Carious teeth; distant vision left eye 6/18	I
68	35	2 mth.	Labourer, 2 mth.	Labourer	Rivet heater $1\frac{1}{2}$ yr.; chemical works $8\frac{1}{2}$ yr.; Army 11 yr.	Nil	II
69	35	22 yr.	Grinding pans, 3 yr.	Stock chamber, 16 yr.	Nil	Traumatic amputation of right forearm; carious teeth	III
70	35	18 yr.	Taking off, 18 yr.	Taking off	Army 3 yr.	Nil	II
71	35	18 yr.	Drawing, 17 yr.	Drawing	Army 3 yr.	Nil	II+
72	36	22 yr.	Fitter, 15 yr.	Fitter	Nil	Varicose veins; keratosis right leg	I. Numer- ous cal- cified glands both hilar region
73	36	21 yr.	Setter, 18 yr.	Setter	Shop assistant 1 yr.; colliery, knocking clips off, 1 yr.	Carious teeth; distant vision R. 6/12, L. 6/9, B. 6/6	..
74	36	21 yr.	Brick burning, 21 yr.	Brick burning	Colour works 1 yr.	Nil	II
75	36	20 yr.	Clay hole, 18 yr.	Clay hole	Nil	Deaf and dumb; enlarged cervical glands	II
76	36	5 mth.	Labourer, 5 mth.	Labourer	Farm labourer 4 yr.; oil fields labourer $2\frac{1}{2}$ yr.; railway porter 2 yr.; odd jobs 4 yr.; butcher $\frac{1}{2}$ yr.; threshing 1 yr.; Army	Cataract right eye; very highly arched palate; varicose veins left leg	II
77	37	9 yr. 8 mth.	..	In the mill	Biscuit factory 1 yr.; electrician's labourer $\frac{1}{2}$ yr.; Army, India, Palestine, Egypt $9\frac{1}{2}$ yr.; abrasive machines $\frac{1}{2}$ yr.	Manipulation of feet in Army	..
78	39	25 yr.	Foreman	Wheeling and setting	Nil	Fractured right arm; move- ment of elbow limited; pleurodynia each year, 1937-1942	..
79	40	26 yr.	Labouring	..	Forge	Operation for right inguinal hernia at 36 yr.	..
80	40	1 mth.	Burner	Burner	Cowman $\frac{1}{2}$ yr.	Carious teeth	..
81	41	23 yr.	Bricklayer and plasterer 2 yr.	Brick setting 11 yr.	Farm labourer 4 yr.	Nil	II
82	41	6 yr.	Labourer, 6 yr.	Labourer	Colliery surface 12 yr.; celanese 4 yr.; painter 1 yr.	Blood pressure 167/102; ? old tuberculous hip, leg shortened by approx. 6 in.; no bruits but slight enlargement	II
83	41	22 yr.	Labourer in clay hole, 18 yr.	Labourer	Carter 2 yr.; farm labourer $\frac{1}{2}$ yr.; engin- eering $1\frac{1}{2}$ yr.	Bilateral pes cavus	II
84	43	24 yr.	Brick burning, 11 yr. 12 yr.	Clay pit, 12 yr.	At home 2 yr.; gardening 3 yr.	Nil	II+
85	43	28 yr.	Brick burning, 28 yr.	Brick burning	Army 1 yr.	Enlarged heart; blood pressure 168/118	II
86	43	6 yr.	Labouring	Watchman	Colliery underground 21 yr.; unemployed 2 yr.	Bilateral hernia; scoliosis; deformity of chest	..
87	44	20 yr.	Pans $\frac{1}{2}$ yr.	Pan feeder	Colliery road 8 yrs.; county council labourer 2 yr.; Army, India 5 yr.	Nil	II
88	44	1 yr.	Slack wheeling and kilns	Slack wheeling and kilns	Colliery screens 2 yr.; wool factory 3 yr.; foundry labourer 1 yr.; unemployed 1 yr.; laying pipes 1 yr.; Army (England) (A satisfactory occupational history was impossible to obtain in this case)	Bilateral varicose veins lower third pes cavus; chronic rhinitis	II

(Continued on next page)

CONDITIONS IN BRICKWORKS

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TABLE 7—(continued)

No.	Age	Period in brickworks	Present occupation and how long	Principal occupation while employed in brickworks	Previous employment and how long	Defects	X ray class
89	45	3 mth.	Labouring, 3 mth.	..	Gentleman's service 9 mth.; Army, Home Service, Middle East, N. Africa, Italy, lorry driver 7½ yr.; machinist and inspector 1 yr.	Deafness left ear; dry skin	..
90	46	24 yr.	Fitter, 24 yr.	Fitter	Machine shop, fitter 8 yr.	Emphysema both bases; keratosis right hand	II
91	46	7 yr.	Quarry labourer, 7 yr.	Quarry labourer	Colliery ganging 7 yr.; colliery coal face 15 yr.; erector 3 yr.	..	II+
92	49	1 mth.	Labourer	Labourer	Colliery trapping driving 3 yr.; Navy 4 yr.; bricklayer's labourer 5 yr.; engineering works, labourer 2 yr.	Near vision, J. 7, J. 7, J. 7, J. 7; oral hygiene noted	V. Old rhonchi noted
93	51	23 yr.	Labourer, 23 yr.	Labourer	Woodyard labourer 2 yr.; colliery loading	Near vision (with glasses) J. 3, J. 8, J. 3; distant vision (without glasses) 6/36, 6/36, 6/36	II
94	51	8 yr.	Drawing	Drawing	Colliery screens 3 yr.; underground and surface and firing; odd jobs 1 yr.	Bilateral varicose veins; infected gums; occasional rhonchi	II+
95	54	2 yr. 6 mth.	Setting	..	Ginger beer factory 18 mth.; railway signal man 14 yr.; motor mechanic 2 yr.; agriculture 1 yr.	Nil	..
96	61	7 mth.	Kiln cleaner	..	Printing trade 6 yr.; public house 1 yr.; colliery surface 20 yr.; building trade 10 yr.; odd jobs	Left inguinal hernia; skin dry; low I.Q.; near vision (without glasses) J. 8, J. 8, J. 8; distant vision 6/18, 6/18, 6/18	..
97	63	29 yr.	Mixing	..	Shoe making 7 yr.; concrete sheds 9 yr.; Army, France, Home Service, 5 yr.	Bilateral inguinal hernia; exercise tolerance somewhat reduced	..
98	64	6 yr.	Labourer, 6 yr.	Labourer	Woodyard labourer 3 yr.; colliery banksmen 9 yr.; colliery labourer 6 yr.; general labourer 13 yr.	Vision left eye near, J. 8; left eye distant 6/60	II
99	66	53 yr.	Burning	..	Army, N. Africa, Italy, Greece	Vision (without glasses) near J. 8, J. 8, J. 8; distant 6/36, 6/36, 6/36 (wears glasses)	..
100	66	53 yr.	Burning	Burning	..	Vision (wears glasses for reading) near J. 8, J. 8, J. 8; distant 6/36, 6/36, 6/36	..

(3) the effect of undue changes of atmosphere and of noxious fumes among those working in the kilns and engaged in the cleaning of flues; (4) the possibility of ill health due to the arduous nature of the work.

Only fitters and workers engaged in taking green bricks off the press come into contact with mineral oil, while continuous work in a very dusty atmosphere is restricted to those operatives who maintain the flow of ground dust from the screens to the mixers. It is true that cleaning out the kilns and unloading them may also be dusty, especially in windy weather when the work may give rise to physical discomfort, but the workers do not stay in the kilns for many minutes at a time.

In the same way the exposure to sulphur dioxide given off in the kilns is intermittent. The only workers who are continuously exposed to sulphur dioxide are the men setting the green bricks. Our tests were carried out under favourable conditions and in no case did the concentrations reach one part in a million, a figure not substantially higher than is common in the atmosphere of industrial towns. We do not think that the concentration

of sulphur dioxide is likely to exceed a few parts per million even in adverse circumstances.

The most striking features of these brickworks are (a) the absence of all forms of mechanized help in the operation of the kilns, and (b) the extreme changes of atmosphere which is the habit of workers in and out of the kilns.

From the time that the stiff plastic brick leaves the press it is handled four times before it leaves the brickworks. The green bricks are transported to the kilns by trolley and then stacked by hand at the rate of about 1,000 per hour. During unloading of the fired bricks these are stacked in fifties on a wheelbarrow and wheeled across the loading bay to waiting lorries. A man employed on this work averages 15,000 bricks per day: he thus makes 300 journeys per day, and each brick is handled twice. Wirecut plastic bricks are handled no less than six times, as they require to be dried before burning can take place.

Men are continually employed both in the hot chambers and out in the open air at regular intervals, and in winter weather extremes of temperature are considerable. The principal risks to health are the

monotonous and arduous nature of the work, as well as exposure to extremes of temperature.

An assessment of the physical condition of those entering the industry should therefore be carried out, and to do this a comprehensive medical examination is required. Candidates for employment giving a history of recurrent bronchitis and all those who admit to previous respiratory disease, whatever its nature, should be submitted to x-ray examination of the chest before a decision is reached as to their fitness for this type of work. Evidence of tuberculosis of the lungs, active or quiescent, must be regarded as a contraindication to employment.

People with a previous history of skin disease or actually suffering from dermatoses should be excluded if they are likely to come into contact with mineral oil, and attention should also be paid to the type of skin of such persons (Peters, 1944).

The placement examination is paramount in importance, but periodic examination of those exposed to the risk of skin affections should be undertaken every three months, and there should be annual x-ray examination of the chest in workers engaged in dusty operations of a continuous nature. As contact with mineral oil seems unavoidable in those taking green bricks off the presses, adequate washing facilities and the provision of a suitable barrier cream are essential to prevent the occurrence of dermatitis and keratotic changes in the skin.

The information about the environment and health of the brickmaker gained as a result of this survey serves to support, and in certain respects to amplify, that published in the Reports of the Committee on Amenities in the Brick Industry (1947). It also indicates the urgent necessity for implementing without delay the recommendations contained in that report.

Summary

A brief description is given of modern brick-making methods.

Environmental studies were carried out in a brickworks employing sixty-five workers.

These studies included a survey of atmospheric conditions, the dust hazards, the risk from exposure to fumes, and an investigation into the nature of the mineral oil in use.

In this survey it is shown that the dust hazard is not excessive; chemical analysis indicates that the material consists mainly of combined silica and alumina.

Traces of sulphur dioxide and hydrogen sulphide were found.

The carcinogenic properties of the mineral oil in use appeared to be low.

The general health of the workers was good. Seventy-three men had chest x-ray examinations; "dust changes" in the lungs were noted in two cases.

Two cases of keratotic changes in the skin were seen in workers who had been exposed to contact with mineral oil.

The number of accidents causing injury was very low.

Brick-making does not involve excessive occupational hazards, but it requires considerable physical effort and exposure to extremes of temperature is frequent.

Placement examination is essential to exclude those physically unfit for this work.

Periodic medical examination of certain workers is needed.

The recommendations in the Report of the Committee on Amenities in the Brick Industry should be implemented without delay.

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