Patterns of Injury in Oil Refinery Construction and Maintenance Workers*

By

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FROM THE ESSO PETROLEUM COMPANY

THIS PAPER IS BASED ON an analysis of over 18,500 consecutive injuries which occurred to workmen and were treated by me during the construction of the Esso Refinery at Fawley during the early 1950s.

A quick study of the pattern of injuries by anatomical location showed: hands 42·5 per cent and eyes 27·2 per cent, accounting jointly for nearly 70 per cent of the total.

As hand injuries were so common, they were broken down by type of injury. (Table I.)

It will be observed that 54·8 per cent of the hand injuries are abrasions and contused wounds, and that fractures, sprains, dislocations and perforating wounds account together for only 1·1 per cent. If we now look at all hand injuries and time-losing hand injuries, broken down into types of injury (Figure 1), another picture emerges. Abrasions, although the commonest injury, have a small percentage of time-losing. Fractures, on the other hand, are uncommon but have a high percentage of time-losing.

The difference in time-losing between punctured wounds and foreign bodies is interesting—punctured wounds having twice as many time-losers (11·5 per cent) as foreign bodies (5·7 per cent). The reason for this is probably that nearly all F.B. cases are seen at the time, for removal. Punctured wounds may be neglected at the time, and not reported until they are septic.

In order to stress the differences in time-losing in each type of injury, the "time-losing potential" of each type of injury has been calculated, by dividing the percentage of time-losing injuries by the percentage of non-time-losing injuries. (Table II.)

If we look at the pattern of time-losing in all injuries and in hand injuries (Table III) we find that hand injuries have less time-losers than all injuries. "Reportable" (that is losing three days or over) accidents are just over half of the time-losing injuries in each case.

By occupations, the number of hand injuries per year varies widely. (Figure 2.) Eye injuries, by occupation, show a similar difference from one job to another. (Figure 3.) Eye injuries, it will be recalled, account for 27·2 per cent of all injuries. Definite injury was diagnosed in 90·9 per cent of cases, and this total comprised: foreign bodies 62 per cent, arc eye 21·4 per cent (mainly welders), burns 4·4 per cent, and others 3·1 per cent. The cornea was involved in one case in every eight.

By occupations, the overall distribution by upper limbs (including hands), eyes and others is shown in Figure 4.

By now it will be clear to readers that hand

*Read at a meeting of the Association on 29th March, 1957.
Table II

TIME-LOSING POTENTIAL

<table>
<thead>
<tr>
<th>INJURY</th>
<th>FACTOR</th>
<th>REMARKS</th>
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<tr>
<td>Incised wound</td>
<td>0.174</td>
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<tr>
<td>Abrasion</td>
<td>0.189</td>
<td></td>
</tr>
<tr>
<td>Contused wound</td>
<td>0.626</td>
<td></td>
</tr>
<tr>
<td>Contusion</td>
<td>0.713</td>
<td></td>
</tr>
<tr>
<td>F.B.</td>
<td>0.877</td>
<td></td>
</tr>
<tr>
<td>Lacerated wound</td>
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<td></td>
</tr>
<tr>
<td>Punctured wound</td>
<td>2.45</td>
<td></td>
</tr>
<tr>
<td>Dislocation</td>
<td>3.12</td>
<td></td>
</tr>
<tr>
<td>Fracture</td>
<td>25.6</td>
<td>Time-losing potential high</td>
</tr>
</tbody>
</table>

and eye injuries account for the major part of the total of all injuries.

In order to examine further all injuries except eye injuries and burns, the coloured diagrams appearing on the centre pages of this issue of the Transactions have been prepared. A scale will be observed at the top right corner of each picture, starting from white and progressing through yellow and orange to red. The deeper the colour, the greater the number of injuries to the part so coloured on the diagrams. The title appearing under the colour-scale on each page relates to the sub-headings under which more detailed data are given in the remainder of this paper.*

Abrasions
Abrasions account for 27.1 per cent of all injuries (excluding eye injuries and burns). Most abrasions (86.5 per cent) occur in the upper limb, particularly in the hands (79.5 per cent).

Hand
The right hand is injured more often than the left. The backs of the hands are affected mainly. Digits 1 and 2 are most affected. The middle knuckle areas have a high incidence of injury. The pattern of abrasions is one which affects mainly the backs of the hands, the fingers and, to a slight extent, the finger tips on the front.

Contusions
Contusions account for 12.4 per cent of all injuries (excluding eye injuries and burns). The pattern of injury shows a more generalized distribution than that of contused wounds which follows. The hands and the feet are the areas most affected.

Hand
The left hand is injured much more often than the right (L. 60 per cent, R. 40-0 per cent). This is due to the left hand being a holding hand, tools being used in the right. The backs of the hands suffer much more than the fronts (back 77.6 per cent, front 21-5 per cent).

Table III

INJURIES AND ABSENCE FROM WORK

<table>
<thead>
<tr>
<th>Absence from Work</th>
<th>% Hand injuries</th>
<th>% All injuries (incl. hands)</th>
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<tbody>
<tr>
<td>Non-time-losing</td>
<td>99.3</td>
<td>98.7</td>
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<tr>
<td>Time-losing</td>
<td>0.75</td>
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<td>Time-losing less than 3 days</td>
<td>46.2</td>
<td>42.7</td>
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<tr>
<td>Time-losing 3 days and over</td>
<td>53.8</td>
<td>57.3</td>
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* In these diagrams, it will be noted that the %age figures for injuries on the back and front of any hand do not total the figure given above for the whole hand. This discrepancy represents the small area allowed for as "side of hand". 

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NUMBER OF EYE INJURIES PER PERSON PER YEAR

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<td>7</td>
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<td>6</td>
<td>7</td>
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</tbody>
</table>

Figure 3

Punctured Wounds
These account for 6.45 per cent of all injuries excluding eye injuries and burns. With the exception of the face, which has less than 1 per cent of the injuries, the distribution of the injuries is in the limbs and the greatest number of injuries falls on the distal parts. Hand injuries account for 51.5 per cent of all the punctured wounds, and in the lower limb most of the injuries are to the soles of the feet.

Hand
The left hand is more affected, and the fronts of the hands are injured more often than the backs. The finger tips on the front of both first digits are the areas most frequently injured.

The interesting thing to note is the similarity of pattern between punctured wounds and foreign bodies. In both cases the fronts of the hands suffer heavily compared with the backs.

Foreign Bodies
Foreign bodies account for 4.85 per cent of all injuries excluding eye injuries and burns. The pattern is striking in its simplicity; 96.5 per cent of injuries occur in the upper limb, 95.5 per cent being hand injuries.

Hand
The right hand suffers very slightly more than the left. The fronts of the hands are most affected, and the tips of digits 1, 2, and 3 show most injuries. The pattern is "heavy" on the fronts and finger tips.

Lacerated Wounds
These injuries occur mainly in the upper limb (94.0 per cent) and hand (89.6 per cent) with only small numbers of injuries occurring elsewhere. The protective value of clothing is shown.

Hand
The left hand is more affected than the right. The injuries show a general distribution over the hands, the backs being slightly more affected.

Incised Wounds
The pattern here is of injuries mainly to the hands (92.4 per cent) and upper limb (95.7 per cent) with a few injuries to the head and neck. Normally exposed areas are the areas which are injured—again the protective effect of clothing is shown.

Hand
The fronts of the hands are most affected, particularly the finger tips of 1st and 2nd digits. On the back of the hands, the injuries are confined to the digits, particularly to an area bounded by an imaginary line drawn from the base of the nail of the 4th digit to the metacarpophalangeal joint of the 1st digit. This line is in the axis of use of cutting tools, the "holding" hand being the injured one.

Abrasions, Contusions and Contused Wounds
These are all usually caused by striking or by being struck. In view of the common causation they have been put together. Upper limb injury accounts for three-quarters of the total (74.9 per cent).

Hand
The backs of the hands are much more frequently injured than the fronts: 80 per cent backs to 20 per cent fronts. The areas most injured are the backs of the left thumb tip (probably by being struck) and the second knuckle of the index finger of the right hand (probably by striking against).

Foreign Bodies and Punctured Wounds
As there is often a similar causation in foreign bodies and punctured wounds, these have been put on to one diagram. The pattern of injury shows that the areas most affected are the hands.
and the soles of the feet. Very few of these injuries occur in other situations.

**Hands**

The fronts are more frequently affected—74 per cent fronts to 26 per cent backs.

<table>
<thead>
<tr>
<th></th>
<th>Backs</th>
<th>Fronts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrasions, Contusions, Contused wounds</td>
<td>80%</td>
<td>20%</td>
</tr>
<tr>
<td>Punctured wounds and Foreign bodies</td>
<td>26%</td>
<td>74%</td>
</tr>
</tbody>
</table>

**ALL HAND INJURIES**

52-6 per cent of all hand injuries occur in 19-9 per cent of the total hand area; that is to say just over half of all hand injuries occur in one-fifth of the total area.

**Occupations**

The remaining pages of coloured plates show the patterns of injury in various occupations. The circle to the right of the head is coloured for eye injuries.

From a knowledge of the basic patterns (which you have just seen) it is possible to look at the pattern of injury in an occupation and deduce the kind of injuries sustained—and possibly their cause.

**Boilermakers**

Injuries, apart from eye and hand injuries, account for only 15 per cent of the total. The hand injuries show a pattern characteristic of contusions of the left hand in the areas which would be struck when a chisel is missed, and of palmar surface finger tip injuries, due to handling rough edges on metal. Eye injuries are due mainly to foreign bodies and to occasional arc eyes.

**Bricklayers**

The high percentage of eye injuries may come as a surprise—52-8 per cent of all injuries among bricklayers. This is due almost exclusively to brick-dust in the eye. It could undoubtedly be prevented by goggles. The pattern of injury on the hands shows a very interesting distribution of injury in the left palm of the hand to the areas which are in contact with a brick grasped in the hand; i.e. the "heel" of the hand and the finger tips. The contusion pattern is shown on the left back. The right hand shows the typical pattern of abrasions with a hand grasping a tool (i.e. the trowel).

**Carpenters**

Carpenters show a very high percentage (70 per cent) of upper limb injuries, which are mainly hand injuries. The backs of the hands are injured mostly by abrasions and contusions, the fronts by punctured and incised wounds and by foreign bodies. The use of gloves, or even one glove on the holding hand, would assist greatly in cutting down the number of these injuries.

**Electricians**

Electricians show a high incidence of upper limb injuries—62 per cent, most of which are on the hands. The commonest type of hand injury is to the tip of the thumb and is incurred in stripping cable.

**Painters**

The proportion of eye injuries is higher than one would anticipate. This is due to foreign bodies in the eye, arising from descaling and preparation of surfaces prior to application of paint. For some of this work a mechanical rotating brush is used. Wire hand brushes and scrapers are also used. Goggles should prevent this type of injury.

In hand injuries, the right hand (which usually holds the brush) shows a characteristic pattern of abrasions and contusions on the index finger and thumb. The middle knuckle of the left middle finger has a large number of abrasions and contused wounds. On the backs of the hands, more punctured wounds and foreign bodies are found than in any other trade under review. This is probably due to striking against snags in metal, wood, etc. If gloves could be worn, it is likely that the incidence of injury would be lower.

**Pipefitters**

Injuries to the upper limbs (mainly the hands) account for 55-8 per cent of all injuries. The areas which are most injured on the hands are the areas which are struck in mistake for the chisel. Finger-tip injuries, due to metal snags, and knuckle abrasions are noted. Eye injuries are due mainly to metallic foreign bodies and to scale and grit. Again, gloves and goggles would reduce the total incidence of injury.

**Riggers**

The distribution of injuries in riggers shows a high incidence of upper limb (particularly hand) injuries. The hand injuries are generalized and are due to abrasions, contusions and punctured wounds from handling wire. Riggers sustain a very large number of punctured wounds of the hands. Gloves, which are worn by some riggers, could, if more generally used, cut down the number of injuries. Eye injury is due mainly to loose foreign bodies.

**Welders**

The outstanding area injured in welders is the eye, and the commonest eye injury is due to a foreign body in the eye or to a burn of the eye by a hot piece of slag from the weld. Welders working in close proximity to each other may sustain arc eyes. Prevention of the foreign body type of injury could be achieved by ensuring that the welder's eyes were at all times covered by glass—i.e. he should never have a "naked eye". This can be achieved by the type of welding hood which incorporates two glasses—one tinted for welding and one clear. Alternatively, clear glasses
can be worn under the welding helmet.

In the hands, the left hand is injured very much more frequently than the right and the commonest injury is due to striking the hand instead of the chisel. Education of the welder to use the "palmar hold" on the chisel would help to prevent these injuries as, if the hammer misses in this hold, the hammer will strike the soft palmar tissues without, in many cases, much resultant injury.

Conclusion
Having seen these diagrams, you may now be asking "What use can be made of this approach to the problem of industrial injuries?"

I would suggest the following answers.
1. The method of presentation allows a clear picture to be formed of the pattern of injuries in any occupation—and some surprises will probably emerge—for example the high incidence of eye injuries in bricklayers.

The diagram can be used in many ways—to educate management, the Safety Department, foremen and workers in the pattern of industrial injuries as, if the hammer misses in this hold, the hammer will strike the soft palmar tissues without, in many cases, much resultant injury.

Acknowledgements
I wish gratefully to acknowledge the invaluable help given in the preparation of the material, tables and diagrams, by A. J. Alexander, S. R. Chamberlain, K. Clark, L. G. Lewis and E. P. Reynolds.

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DISCUSSION

DR. J. R. GLOVER (Westinghouse Brake and Signal Co. Ltd.): May I congratulate the speaker on his excellently presented paper, especially in the time available? Two queries. Bricklayers—presumably you are counting just dust as foreign body, and I suggest that is not a terribly dangerous injury and is far less dangerous than putting on goggles to men on scaffolding, and that also applies of course to painters chipping off rust and paint. The only question I really want to know is about your arc welders. Do the flashes occur mostly amongst the welders themselves or from those near them?

DR. WARD GARDNER: In answer to these two questions I agree that the brick dust is not very dangerous in the eye. On the other hand, I think you can wear goggles when you are up a scaffold if you use the panorama type, rather than the typical industrial type. With us, welders suffer more than others. This is mainly because of the type of work on which they are employed. Very often they work inside towers and other types of enclosed spaces where they are in very close proximity to each other. Just as one man is about to weld one of his colleagues may strike an arc close by him and before he has got his goggles up.

DR. J. C. GILSON (Pneumoconiosis Research Unit, Cardiff): Has Dr. Ward Gardner anything to add to the actual use of gloves? Obviously they have the merit of providing protection, but they may also increase clumsiness in certain jobs and hence increase accidents. Is there any evidence for this in his very comprehensive statistics?

DR. WARD GARDNER: That is a very difficult question to answer. The difficulty one encounters is the prejudice of the workers; they don't like wearing gloves. Secondly, they say they can't do the job when wearing gloves. Very often if you have a foreman who will make them try they find they can do it and I feel quite convinced that a more extensive use of gloves and of goggles of a simple type would substantially reduce the number of injuries. We are at present trying to do that; we try to sell this idea but I can't measure the success of it yet.

DR. O. McGIRR (B.O.A.C.): I presume that your relatively low incidence of industrial back injuries is possibly accounted for by the fact that there was a high degree of mechanization in the building of this refinery. Would that be correct, because it is rather different from the usual pattern of industrial accidents?

DR. WARD GARDNER: I think that the answer is yes.

DR. O. P. EDMONDS (N.C.B.): If the distribution by the site of the accidents which do not give rise to loss of time is studied, do they correspond by site to the accidents which do give rise to lost time?

DR. WARD GARDNER: I just can't answer that.

DR. EDMONDS: One other question, do the people who have a lot of trivial accidents also have the serious accidents?

DR. WARD GARDNER: We did not study that. The question of accident proneness I think has been debated for a long while and I have no particular views on the subject.