Comfort of personal protective equipment*

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The degree of comfort of personal protective equipment (PPE) was investigated in an automobile encapsulating plant. Up to 96.2% of employees used one or a combination of PPE. Only 8% of the workers felt their respirators were comfortable, 30% tolerated their respirators, and 62% rated them as uncomfortable. The percentage of employees who rated their PPE (other than a respirator) as comfortable ranged from 32 to 52%. For comfort factor, coveralls/aprons rated 52%, safety glasses 51%, rubber gloves 42%, and hearing protectors 36%. PPE was tolerable (just acceptable) for about 30% of the employees. To increase the effectiveness and safety of PPE, the human-factor aspects of PPE design should be emphasized more and quality improvement should cover the wearability of PPE.

Keywords: personal protective equipment, protective clothing, comfort, subjective rating

The appropriate use of personal protective equipment (PPE) can reduce injuries and illnesses (Breisch, 1989; LaBar, 1990). A survey, based on 1986-88 United States Occupational Safety and Health Administration (OSHA) forms used to log occupational injuries and illnesses, revealed that the proper application of PPE could have prevented up to 37.6% of the occupational injuries and illnesses reported (LaBar, 1990). Indeed, according to OSHA statistics, about 12-14% of total disabling occupational injuries occur because workers do not wear the appropriate PPE (Breisch, 1989).

Enforcing the wearing of PPE may often be the best choice to protect the worker when other safety and industrial hygiene control methods are not feasible or able to protect workers fully. However, when it becomes necessary to furnish workers with PPE, workers will frequently oppose wearing these devices because of discomfort. Consequently, the devices are not used or are tempered with by the worker impairing the effectiveness of the equipment.

Several studies have focused on PPE including physiological tolerance or subjective responses to wearing respirators (Shimozaki et al., 1988), impermeable clothing (Nunneley, 1989; White et al., 1989), the mechanical and transport properties contributing to fabric comfort (Cowan et al., 1988), and safety helmets (Stroud and Rennie, 1982). While studies have examined the psychological problems due to PPE, very few have investigated the subjective reaction of a relatively large group of workers to a variety of PPE under real workplace conditions (Abeyesera and Shahnawaz, 1988). Therefore, a study was designed to investigate the degree of comfort of personal protective equipment in an automobile glass encapsulating plant.

Material and methods

Description of the plant

The plant encapsulates automobile glass, such as windshields, windows, and taillights. Most of the manufacturing is performed in five production areas:

- Pre-Assembly Department: raw glass is primed with solvent-based primer; some small parts are pre-assembled;
- Moulding Department: moulds are brushed, mould-releasing agent (isopropanol) and in-mould coating (urethane paint - hexamethylene diisocyanate) are sprayed, and windows are encapsulated using urethane moulding;
- Paint Department: windows are spray painted with urethane paint;
- Assembly Areas: windows are cleaned and scored with a razor blade; some windows are water tested;
- Hardware Shop: riveting operations are performed and metal guides are attached to the glass; no chemicals are used in this shop.

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Subjects

The plant employs a total of 475 workers, 51% female and 49% male, who work in three shifts. The average age of the workers was 29 years. A sample of 208 workers, a representative group of all workers using PPE, was included in this study. Up to 96.2% of these workers used one or a combination of safety glasses, safety shoes, gloves, respirators, hearing protectors, and coveralls/aprons.

Questionnaire

The data were collected through direct observation by an industrial hygienist, and workers were interviewed via the administration of a questionnaire. In addition to obtaining basic information such as personal and job characteristics, details about their use of PPE was also obtained. Subjective reactions of the workers to their PPE were sought in five categories: very comfortable, somewhat comfortable, no opinion or acceptable, somewhat uncomfortable, and very uncomfortable.

Personal protective equipment

Most of the PPE in this plant is available from the main supply crib. Employees normally check out their necessary protective devices at the beginning of their shift and return equipment at the conclusion of their shift. The company buys protective devices produced by various manufacturers to provide workers with a selection.

Several types of PPE are recommended or required at the plant:

- Side-shield safety glasses are required on the factory floor.
- Safety goggles are worn when cleaning the mould in the moulding department.
- Face-shields are worn while servicing lift-truck batteries or handling water treatment corrosive liquids.
- Leather shoes that cover the entire foot are required on the factory floor.

- Boot covers are recommended for painters and the workers who prime raw glass.
- Chemical-resistant gloves are worn when the workers are handling solvents and primers.
- Cut-resistant gloves are worn on the worker's non-dominant hand if a razor blade or utility knife is being used.
- Half-mask respirators with organic vapour cartridges are required when spraying the in-mould urethane coating.
- Hearing protection is mandatory in moulding and painting areas.
- Disposable coveralls are required when spray painting in the paint booth.
- Embossed polyurethane aprons are recommended when priming raw glass.
- Disposable sleeves are recommended for workers priming glass or spraying urethane paints in the moulding department.
- Sleeves also are available for workers using razor blades.
- Employees who have to lean against the metal frame of the clamp in the moulding department are advised to wear knee and elbow pads.

Results

The workers' reported comfort while wearing PPE is summarized in Table 1. Figure 1 shows the percentage of the workers who rated their individual PPE comfortable, acceptable, or uncomfortable. The PPE shown in the figure included half-mask respirators, safety shoes, hearing protectors, gloves, safety glasses and coveralls/aprons. In this figure, 'comfortable' is defined as the combination of ratings of 'very comfortable' and 'somewhat comfortable'; 'acceptable' is defined as 'no opinion or acceptable'; and 'uncomfortable' is the combination of 'somewhat uncomfortable' and 'very uncomfortable'.

Only 8% of the workers felt their respirators were comfortable, 30% tolerated their respirators, and 62%

<table>
<thead>
<tr>
<th>Personal protective equipment (PPE)</th>
<th>Number in PPE</th>
<th>Very comfortable</th>
<th>Somewhat comfortable</th>
<th>No opinion or acceptable</th>
<th>Somewhat uncomfortable</th>
<th>Very uncomfortable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Half-mask respirators</td>
<td>47</td>
<td>2</td>
<td>6</td>
<td>30</td>
<td>9</td>
<td>53</td>
</tr>
<tr>
<td>Safety shoes</td>
<td>154</td>
<td>18</td>
<td>14</td>
<td>23</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>Hearing protectors</td>
<td>145</td>
<td>16</td>
<td>70</td>
<td>24</td>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td>Gloves</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut resistance</td>
<td>156</td>
<td>29</td>
<td>18</td>
<td>30</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Rubber gloves</td>
<td>95</td>
<td>18</td>
<td>21</td>
<td>42</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Padded gloves</td>
<td>84</td>
<td>18</td>
<td>23</td>
<td>27</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Safety glasses</td>
<td>200</td>
<td>31</td>
<td>20</td>
<td>28</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Coverall/apron</td>
<td>79</td>
<td>24</td>
<td>28</td>
<td>33</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Knee pads</td>
<td>29</td>
<td>21</td>
<td>3</td>
<td>24</td>
<td>10</td>
<td>42</td>
</tr>
<tr>
<td>Elbow pads</td>
<td></td>
<td></td>
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<tr>
<td>Cotton gloves</td>
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<tr>
<td>Face shields</td>
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</tr>
</tbody>
</table>
Figure 1 Workers' reported comfort of personal protective equipment

rated them as uncomfortable. The percentage of employees who rated their PPE (other than respirators) as comfortable ranged from 32 to 52%. The safety glasses and coveralls/aprons were rated the highest for employees who rated their PPE (other than respirators) comfortable (51 and 52%) and gloves and hearing protectors scored 42% and 36% respectively. On the average, PPE was acceptable to about 30% of the employees. The percent of employees who rated their PPE as uncomfortable ranged from 15 to 35%; coveralls/aprons were indicated as uncomfortable by 15% of employees, and safety shoes by 35%.

Discussion

Comfort is a relative term, which is usually determined by a combination of physiological, psychological, and physical factors (Pontrelli, 1977). Improper fit, added weight, out-of-fashion style or colour make much PPE undesirable. Some types of PPE resist the passage of water vapour and barricade the air movement around the skin. This creates a humid microclimate, which will reduce the cooling effects of sweat evaporation. PPE may also increase the metabolic cost of performing a task by adding weight (Duggan, 1988) and limiting movements of the worker. Furthermore, PPE may restrict visual fields, limit communication, and reduce manual dexterity (Nunneley, 1989). Additional movements by the worker to compensate for these difficulties can aggravate an undesirable situation. These problems may also affect a worker's performance, and create hazards greater than those hazards against which the PPE is designed or expected to protect the worker. Worker unwillingness to use PPE can also be attributed to its becoming an obstacle to work, workers' perceptions that it is unnecessary or inadequate for protection, and workers' perception of bad smell or restricted senses (Abeyesera and Shahnavaz, 1988).

A study by Newill et al (1989) demonstrates that employees in a research institution, even those highly educated, failed to use their PPE. Lack of comfort was a major factor for this reported observation. The results of this study also demonstrate that workers perceive a relatively high degree of discomfort from the use of their PPE. It has been shown that the subjective responses under laboratory conditions are indicative of subjects' perceived relative degrees of physiologic strain (White et al, 1989). Therefore, it may be possible that the degree of discomfort perceived as expressed by workers reflects the extent of stress imposed by PPE. Discomfort from wearing PPE may be reduced, however, by the process of natural adaptation, which may include acclimatization to heat stress and metabolic demands, endurance training (Astrand and Rodhal, 1986), and repeated wearing of PPE (Abeyesera and Shahnavaz, 1990). Yet the optimum level of comfort in wearing PPE can only be achieved through ergonomic design and field research.

The comfort and fit of PPE can be considerably improved when employees actively participate in the selection and testing of PPE. The more the wearer knows about the equipment and its purpose, the greater the possibility that the correct device will be selected and worn consistently. Management should facilitate the process by soliciting employees' opinions about the desirable parameters in PPE. The responses to this inquiry can constitute the basis of decision, logic, and communication with vendors of PPE. Selected devices should be worn by a group of employees for a short trial and then by all employees for an extended time period before these devices are finally adopted for use in the workplace. The involvement of employees in the selection and testing of PPE helps them to understand the need for the equipment, and motivates them to use it with a lesser sense of discomfort.

In either case of trial or permanent use, each worker should be fitted individually. Individual fitting not only assures a good fit, but also gives a supervisory, health and safety professional, or manufacturer's representative an opportunity to explain to each employee how to wear, inspect, clean, and maintain the PPE. PPE that is not worn correctly, fits poorly, is not clean, or is improperly maintained will create discomfort and can present a serious hazard to the worker (OCA, 1992). The wearer should be encouraged to use, rather than be intimidated by, the PPE. Seminars, posters, bulletin boards, and safety meetings are all conceivable means for promoting a PPE programme.

Finally, it is necessary that a team that includes manufacturers, legislators, researchers, health and safety specialists, and other professionals works together to establish the parameters of performance, which include human-factor aspects of PPE design (Belkin, 1991). Expert systems are emerging to help employers with PPE selection. Such systems include computerized reference books with information including tests, ratings, and manufacturers' specifications. They permit a safety manager to scan large quantities of data and to focus on the best possible products to accomplish a particular safety task (OCA, 1991).

Conclusions

Despite all the enormous steps in the past decade in making PPE more appealing, light-weight or better fitting, about half of the workers surveyed did not accept their PPE as being comfortable. To make the workplace safer, we have to enhance the comfort, protective quantities and form or style of PPE, while
providing workers with adequate education and personal protection programmes.

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