QUALITY AND WORK RISK PREVENTION. APPLICATION TO THE DESIGN OF GLAZING AND SORTING WORKSTATIONS IN TILE MANUFACTURING COMPANIES

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ABSTRACT

This paper presents a study undertaken by the Instituto de Biomecánica de Valencia and the Unión de Mutuas (Medical Care Fund), aimed at improving working conditions in the glazing and sorting workstations at ceramic floor and wall tile manufacturing companies. In the study, representative companies from the sector were visited, compiling the most relevant data from an ergonomic point of view at the glazing and sorting stations, and interviews were held at specialised machinery builders and distributors for the ceramic branch. After analysing the compiled data, a series of design recommendations and proposals was advanced for these two workstations, focussing mainly on working postures, the dimensions of the workstation, lighting conditions and organisation of the task. The results allow improvement of the quality of the work by diminishing the risk of muscular-skeletal injury for the worker, yielding greater output and efficiency in carrying out the work.

INTRODUCTION

Ergonomics is a field of multidisciplinary knowledge, which studies the characteristics, needs, capabilities and abilities of human beings, analysing the features that affect product design or production processes. All the applications have a common purpose: the attempt to adapt products, tasks, space and the general environment to the capabilities and needs of consumers, users or workers (García-Molina et al, 1997). The ergonomic approach may appear to be more expensive in the short term, but when a long-term balance is drawn up, this is shown not to be the case; improvements of an ergonomic type in the design of working systems are economically profitable in terms of output and lower production costs, including the costs associated with sick leave (Pheasant, 1991). Ergonomics also helps maintain quality systems in which to develop quality products and services (Getty, 1999).

OBJECTIVES OF THE STUDY

The objective of this study was the **ergonomic analysis** of two typical workstations in ceramic floor and wall tile manufacturing companies: **the glazing or screen printing workstation** and the **sorting workstation.**

It was aimed to develop a set of design recommendations and proposals to eliminate the most characteristic ergonomic risk factors of these two jobs, enabling the quality of the work to be improved by reducing the risk of a muscular-skeletal type of injury for the worker, raising output and efficiency in performing the work, associated with a greater general satisfaction of the worker at his post, and enhanced production quality. The study integrates the typical activities involved in work risk prevention in company quality management tasks by considering features such as machinery purchasing criteria, worker training and information on working conditions or the general improvement of the quality of the work and working conditions.

MATERIAL AND METHODS

An action plan was designed to conduct the study, which consisted of three main stages:

a) Compiling data

Typical sorting and glazing workstations were selected at 13 representative ceramic floor tile manufacturers of the sector, members of the Unión de Mutuas (Medical Care Fund), obtaining the following data for each station (Figure 1):

- √ Relevant dimensional data from an ergonomic point of view.
- √ Information on the task and workstation.
- √ Worker's opinion.
- √ Videotaping the activity of the worker at his station.

Figure 1. Compiling data on the studied workstations.

Contacts were also established with specialised machinery builders and distributors for the ceramic sector, obtaining information of interest on the studied workstations.

b) Analysis of the compiled data

The information compiled was analysed by a functional and dimensional analysis of the workstations, including a general description of the work and an assessment of working postures, of work organisation, lighting conditions, etc. (Kroemer and Grandjean, 1997; Pheasant, 1986 and 1991). An evaluation was also performed of the ergonomic risk of the workstations by the Ergo/IBV method (García-Molina et al., 1997) (Figure 2).

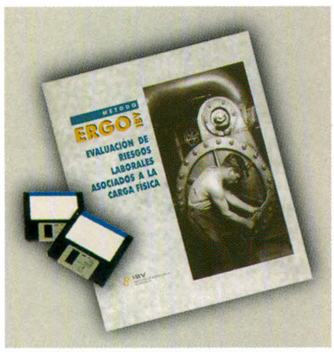

Figure 2. Ergo/IBV method for evaluating work risks associated with physical loads.

c) Design recommendations and proposals.

After detecting the main ergonomic problems and most important factors that produce these, design recommendations were advanced for both workstations. The recommendations focussed on working postures, workstation dimensions, lighting conditions and task organisation (Clark y Corlett, 1984; Helander, 1995; Konz, 1995).

RESULTS OF THE STUDY

Sorting workstation

At a sorting workstation, the task involves visually inspecting ceramic tiles as they move, selecting the ones that differ in quality or colour. Three types of workstations were detected in the study, in terms of the movement of the floor tiles and the selecting system:

- √ Discontinuous tile feed or carpet of tiles, with selection by a fluorescent fibre-tip pen (Figure 3).
- √ Continuous tile feed, with selection by a fluorescent fibre-tip pen (Figure 4).
- √ Continuous tile feed, with selection by a mobile keyboard or mouse (Figure 5).

Figure 3. *Discontinuous tile feed or carpet of tiles.*

Figure 4. *Continuous tile feed, with selection by a fluorescent fibre-tip pen.*

Figura 5. *Continuous tile feed, with selection by a mobile keyboard or mouse.*

The results of the study indicate that the worker devotes between 70% and 95% of the total work time to visually controlling the flow of tiles. The remaining time is spent in selecting the item, making repetitive arm movements with an average frequency of 6 repetitions/min. As a general rule, the worker devotes two hours at a stretch to sorting, and usually then switches to palletising tasks in the same selection line.

At 58% of the analysed workstations, there was a long-term risk of injury of a muscular-skeletal type in the neck-shoulder area. The main causes for this risk are as follows:

√ Benches with an excessive work depth (Figure 6).
√ Horizontal working planes.
√ Elements of the bench that hinder reaching the tiles (Figure 7).
√ Unsuitable seating from an ergonomic viewpoint (Figure 8).
√ Low working heights (Figure 9).
√ High selection frequencies.

Figure 6. *Benches with an excessive work depth.*

Figure 7. *Elements of the bench that hinder reaching the tiles.*

Figura 8. *Unsuitable seating from an ergonomic viewpoint.*

Figura 9. *Sorting bench with low working height.*

This activity involves high visual demands so that lighting conditions and tile feed rate are essential characteristics of the task. 75% of the lighting levels found were over 1000 lux, thus exceeding the minimum requirement. However at 80% of the benches a non-uniform light distribution was observed; cases of direct glaring light were also detected caused by light sources located below worker eye-level.

Screen printing workstation

One of the activities carried out in the glazing line of a ceramic tile manufacturer is the surface decoration of floor and wall tiles. The study detected two types of machines for performing this work: flat screen printing heads and rotating printing machines.

The flat screen printing heads form the most traditional decorating system, and are implemented at 100% of the companies.

At a traditional printing head workstation, the worker is in charge of the maintenance of the machines under his charge (an average of 3 machines), generally for 8-hour shifts, and performs the following tasks:

√ Visual inspection of the tiles that exit the head.
√ Manually feeding the screen printing pastes.
√ Screen cleaning (the average time devoted to screen cleaning is 7 seconds).

At 75% of the analysed workstations, unsuitable postures are found associated with the task of screen cleaning. These physical positions are particularly incorrect at heads with large screens, low working heights (Figure 10) and narrow opening angles (Figure 11), and particularly with printing head control panels that make reaching the innermost parts of the machine very difficult (Figure 12).

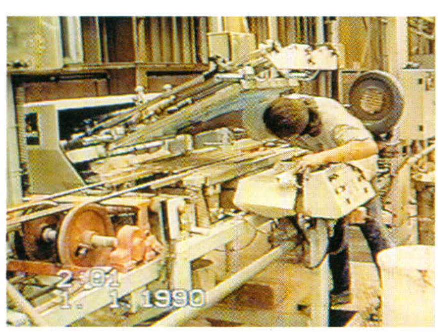

Figure 10. *Printing screen imposing a low height.*

The average level of lighting at the printing head output is 685 lux; however, about 45% of the analysed workstations had a level below the recommended minimum (500 lux) for the visual requirements of this type of task. The lighting systems are direct and are distributed at the head output or uniformly over the length of the whole line.

Rotating printing machines were found at 40% of the companies involved in this study, together with the flat screen printing heads. Their minimum and easy maintenance avoids inappropriate postures associated with flat screen cleaning, making them more suitable from an ergonomic standpoint.

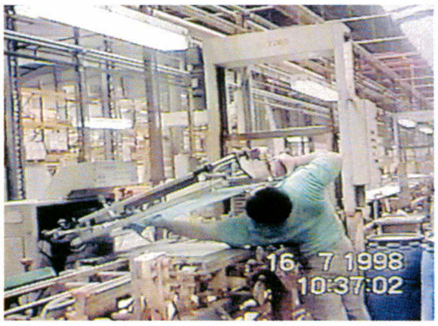

Figure 11. *Printing screen with a narrow opening angle.*

Figure 12. *Printing screen with an excessive front reach imposed by the control panel.*

DESIGN RECOMMENDATIONS AND PROPOSALS

Sorting worstation

The worker should be able to alternate (rotate) with other types of work every two hours.

A lighting level exceeding 750 lux is recommended, and should never be below 500 lux.

Carpets of tiles with selection by a fluorescent fibre-tip pen

It is recommended that the work be performed standing up, with the possibility of using a semi-seating type of chair, which allows relieving part of the body weight when this is required (Figures 13 and 14). To adapt the workstation to workers of smaller height, a 10-cm-high raised platform needs to be installed, which can be moved aside and easily placed at the workstation. Table 1 indicates the recommended dimensions for this workstation.

It is recommended to use lighting systems with screens and diffusers that distribute the light uniformly over the tile feed, avoiding low light fixtures with light glaring into the worker's eyes.

From an ergonomic point of view, this type of sorting workstation is the least recommendable of the three in this study.

Working plane centre point height	107 cm
Bench horizontal plane height	96 cm
Bench thickness	< 10 cm
Working depth	< 80 cm
Bench width	< 110 cm
Free depth under the bench	> 25 cm
Height of the raised platform	10 cm
Height of the semi-seating chair	adjustable between 70 and 90 cm
Slope of the working plane	> 15°

Table 1. *Recommended dimensions for discontinuous tile feed or carpet of tiles.*

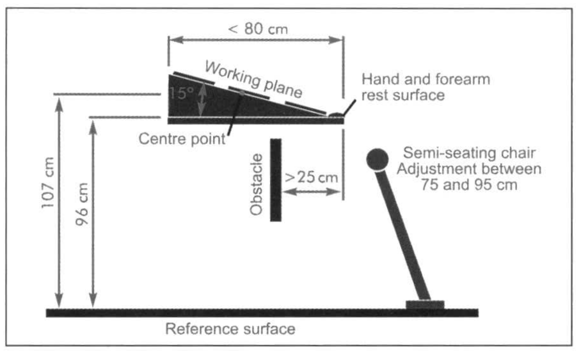

Figure 13. *Recommended workstation design for discontinuous tile feed or carpet of tiles.*

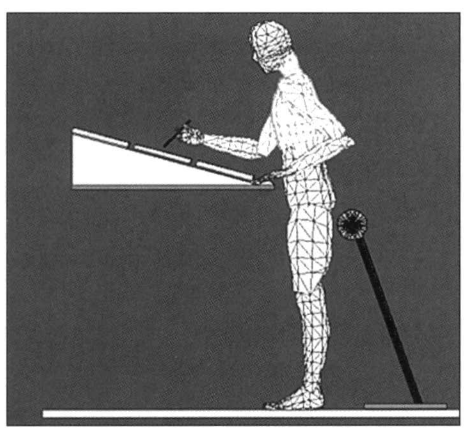

Figure 14. *Recommended workstation design for discontinuous tile feed or carpet of tiles.*

<u>*Continuous tile feed with selection by fluorescent fibre tip pen*</u>

It is recommended that the activity be performed seated, although the workstation design should allow the worker to change to an upright position. The workstation should therefore contain a chair with an adjustable height with a back and armrests, and an easily adjustable footrest (Figures 15 and 16). To adapt the station to workers of smaller height when they are working standing up, there should be a 10-cm-high raised platform, which can be easily set aside and placed in the workstation. Table 2 sets out the recommended dimensions for this workstation.

Working plane centre point height	107 cm
Bench horizontal plane height	100 cm
Bench thickness	< 4 cm
Working depth	< 68 cm
Slope of the working plane	> 15°
Height of the raised platform	10 cm
Free depth under the bench	> 41 cm
Chair height	adjustable between 72 and 82 cm
Height of the footrest	adjustable between 27 and 44 cm

Table 2. *Recommended dimensions for discontinuous tile feed with selection by fluorescent fibre-tip pen.*

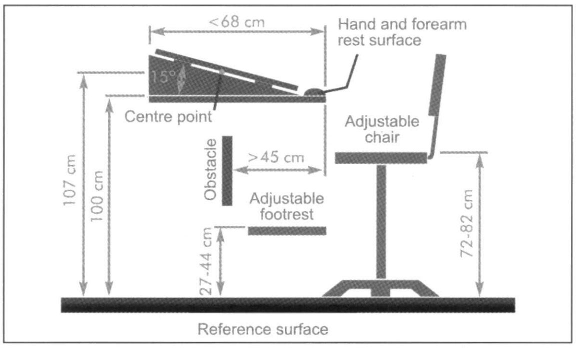

Figure 15. *Recommended workstation design for continuous tile feed with selection by fluorescent fibre-tip pen.*

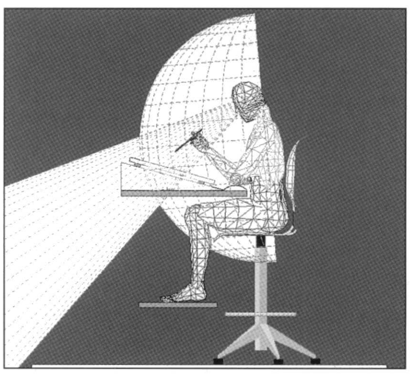

Figure 16. *Recommended workstation design for continuous tile feed with selection by fluorescent fibre-tip pen.*

<u>*Continuous tile feed with selection by mouse or mobile keyboard*</u>

From an ergonomic viewpoint, this is the most recommendable sorting workstation design. The task should be performed seated, with an adjustable chair and footrest (Figures 17 and 18). Table 3 presents the proposed dimensions for these types of benches.

Screen printing workstation

√ It is recommended that, whenever possible, the screen should be side opening.
√ The control panel should not increase the working depth.

Bench horizontal plane height	100 cm
Working depth	< 80 cm
Bench width	< 110 cm
Slope of the working plane	> 15°
Bench thickness	< 9 cm
Free depth under the bench	> 45 cm
Chair height	adjustable between 63 and 72 cm
Height of the footrest	adjustable between 17 and 34 cm
Height of the mouse with regard to the bench	< 10 cm

Table 3. *Recommended dimensions for discontinuous tile feed with selection by mouse or mobile keyboard.*

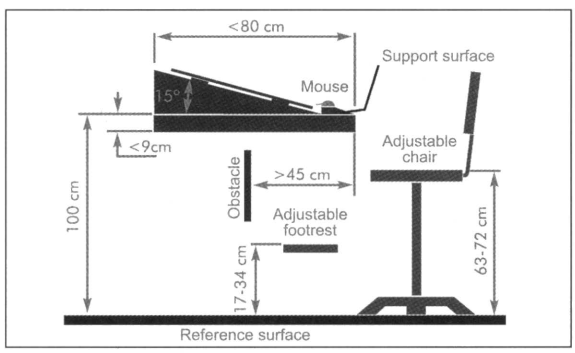

Figure 17. *Recommended workstation design for continuous tile feed with selection by mouse or mobile keyboard.*

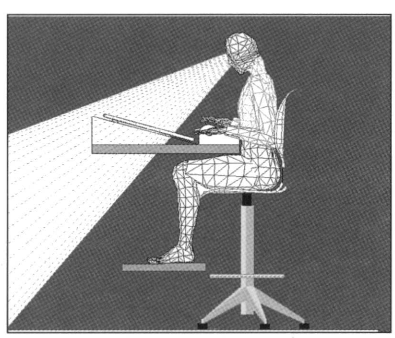

Figure 18. *Recommended workstation design for continuous tile feed with selection by mouse or mobile keyboard.*

- √ There should be a cleaning frequency of less than 22 cleanings/hour.
- √ Manual screen fastening force of less than 14.24 Nm.
- √ Lighting level exceeding 500 lux.
- √ If there is front opening (Figures 19 and 20), the dimensions set out in Table 4 are recommended.

Working depth	< 70 cm
Printing head horizontal plane height	103 cm
Screen opening angle	Continuous adjustment 0 – 52°
Free depth under the printing head	> 15 cm

Table 4. *Recommended screen printing workstation dimensions with a front-opening screen..*

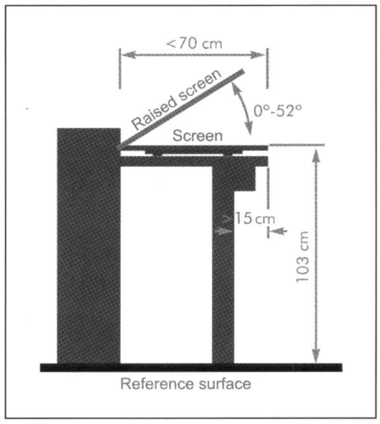

Figure 19. Recommended screen printing workstation design with a front-opening screen.

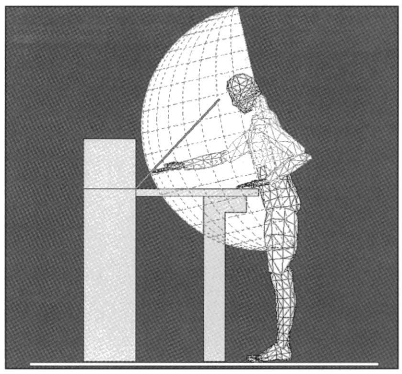

Figure 20. Recommended screen printing workstation design with a front-opening screen..

CONCLUSIONS

In this study the redesign of two typical workstations at ceramic floor and wall tile manufacturing companies is proposed, which eliminates the main ergonomic risk factors of these two tasks. After implementing the redesign, a quantitative assessment will be made of the improvements in the associated output. Based on similar ergonomic studies (Corlett, 1988; Pheasant, 1991), an improved quality of work (detection of errors and/or faults in the tiles) can be estimated of up to 20%.

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