

Critical Human Factor Issues in Quality Inspection Tasks

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Abstract. This paper looks at the quality control task from human factors standpoint. It presents critical human factor issues which if considered can greatly enhance the health, safety and productivity of the inspector. Various planning issues pertaining to the quality inspector workstation design are also outlined. Since the human being plays a vital role in an inspection task and assuming that most workplaces are designed with the task in mind rather than the human, the capabilities and limitations of the human if not incorporated into the design, could lead to the acceptance of poor items and rejection of good ones. The possibility of physical injuries fatigue and boredom etc. will also be prevalent in these workplaces. Since it is well established that fatigue and poor postures result in injuries and slow work pace, any reduction in the above will improve productivity. This fact is highlighted with an example outlining the poor and improved features of a workstation.

Introduction

Inspection and test departments have the responsibility to appraise the quality of purchased and manufactured items and to report the results. The reports are used by other departments to take corrective action when needed. One of the major problems with inspection is the tendency to view the inspector as a person who has total responsibility for the potential error. This attitude can lead to both ineffective inspection and also a deterioration of product quality. Various planning issues pertaining to the quality inspector job assignments and supervision are critical in any workplace design. Also, more importantly, the human factor variable, which is often neglected by the industry, should be explicitly described.

Human factors engineering, which focuses on the human interaction with any system or component and looks at the design based on human capabilities and limita-

tions addresses the issue of inspection tasks in a very comprehensive fashion. The decision making in inspection tasks can be viewed as a case of signal detectability. Signal in this case, can be viewed as the defect, and the ability to detect this depends on several human factor variables including, illumination, workplace layout, inspector's sensory mechanism, inspector's vision, body size of the inspector with respect to the workplace etc. Since the decision making cannot be any better than the informational input, one of the more important ways to aid the inspector is to optimize the visual task. Sometimes the simple positioning of lights or changing a viewing angle can enhance a particular job. Colored lights have also proved to be helpful in color matching inspection.

In dealing with the human error, the selection and training of the inspector is a prime concern. Also, the design of equipment, procedures and environments can improve the performance of people.

Human factors engineering

Human factors or ergonomics aims at looking at things from the human angle. This may include the physical and psychological understanding of the human as these traits are applied in designing any system which has the human as its integral part. If these issues are incorporated in the design, than the likelihood of achieving a safe, healthy, efficient and comfortable workplace is very likely. The following section describes the designing of quality control workstation to achieve maximum human performance.

Ergonomic workstation design

A workstation lacking in proper consideration of human physical and psychological characteristics usually ends up being non-productive, inefficient and unhealthy. The workstation should be able to accommodate at least 90% of the population of users [1, 8] in relevant body dimensions for a particular workstation. Usually the designs for shorter people would include such situations as reach, strength, or any limiting value, whereas, the larger or taller people should be incorporated in the designs such as doorways, door heights or any situation in which the performance may be affected by the increased height or length of an individual or different body members. The user should be both physically and mentally satisfied with the work being done at the station, and this can only be achieved if the design has user in mind. The most critical issues in the workspace design itself include the reach or clearance and the positioning of the user with respect to various features of the workplace. These issues call for the proper height of the work area determined from the

body measurements, good static and dynamic fit with respect to the user population (to include 90%), i.e. both the body's non-moving and moving positions.

The static position would involve the actual anthropometric or body measurement of the user in a non-moving position, whereas, the dynamic or functional position requires that there is no interference between the body members and the workplace when they are moving or in motion. Appropriate tolerances can then be included in the physical dimensions of the workplace for e.g. there is generally clearance between the knee and the table top while seated. Some of the specific guidelines in designing an effective ergonomic workstation includes [2].

- i) Avoiding static loads and fixed work postures.
- ii) Reducing repetitive work to minimize cumulative trauma disorders.
- iii) Setting the work height at about 50 mm below the elbow.
- iv) Furnishing every employee with an adjustable chair.
- v) Using the feet as well as the hands.
- vi) Using gravity and not opposing it.
- vii) Conserving momentum i.e. avoiding unnecessary acceleration and deceleration.
- viii) It is preferable to make two hand motions rather than one hand motions.
- ix) Using parallel motions for eye control of two hand motions.
- x) Using rowing motions for two hand motions.
- xi) Pivoting motions about the elbow.
- xii) Using the preferred hand.
- xiii) Keeping arm motions in the normal work area.
- xiv) Letting the small woman reach and letting the large man fit.

The body posture plays an important role in the overall comfort of any workstation. Often extended reaches, bending of the body etc. result in muscle fatigue and potential musculo-skeletal injuries causing safety hazards. Much of this problem is caused as a result of poor seating. By incorporating adjustable seating the seat design can accommodate various segments of the population, this can be achieved. Inclined seating should be used whenever the work to be performed requires bending postures. Also a standing position should always be evaluated against the seating position for a particular application, this could also be assessed based on the frequency of standing and sitting.

Quality inspection tasks require extensive decision making from the inspectors.

Even though the decisions are generally simple, they may need to make a large number of decisions. As the inspector looks at every part, he or she has to decide if the required specifications are met and if the part should be accepted or rejected. There is good chance that the inspector may forget to look for a particular specification especially if the choices are many. This would result in the acceptance of defective items or rejection of non-defective items. If both of these are reduced then the inspection performance will improve. This will result in increased productivity, customer satisfaction, cost savings and better health and safety of inspector.

Several researchers (Drury; Nelson and Barany; Wallack and Adams and Bloomfield) [3, 4, 5, 6] have addressed human factors issues in quality inspection tasks. Ballon and Pazer [7] have addressed the costs associated with error in inspection tasks. Most of these researchers agree on the major issues which can influence the proper performance of the quality inspector. Time variable for inspection is a crucial variable since the inspection jobs are normally either paced or unpaced. In a paced line, the inspector needs to detect several types in a certain period of time resulting in various errors, especially if the line is not properly paced or the defects are too many or the workplace is not designed properly. A human system can only perform at a limited speed, which depends on the individuals maximum physical and mental capacity. Unpaced tasks may be non-productive or may cause unhealthy postures etc., therefore, a well designed workplace incorporating both the human abilities and limitations can improve the inspector's performance several folds.

Illumination is the amount of light striking a surface. Some of this light is absorbed while some of it is reflected. The light that is reflected from the surface of objects is what allows us to see objects. The amount of light leaving a surface is called luminance, lux is the unit of illuminance in SI systems and foot candles is used in U.S. customary system. The Illuminating Engineering Society (IES) recommends levels of 3000 lux for precise assembly work, 7500 for very precise machine tool work and 750 for general office work. The IES lighting hand book contains extensive tables listing various illumination levels for variety of tasks.

Improper lighting can make objects appear different, the light should preserve the color of objects especially for inspection type tasks, therefore the optimum amount of light falling on the work area or the workpiece is important in defect detectability, this light depends on light location, intensity, surface texture etc, also due to more energy cost consciousness the tendency to limit the illumination in factories can have serious effects on the inspection quality. Table 1 describes some recommended illumination levels for use in interior lighting design.

Table 1. Recommended illumination levels for use in interior lighting design

Category	Range illuminances, lx (foot candles)	Type of activity
A	20–30–50* (2–3–5)	Public areas with dark surroundings.
B	50–75–100* (5–7.5–10)*	Simple orientation for short temporary visits.
C	100–150–200* (10–15–20)	Working spaces where visual tasks are performed only occasionally.
D	200–300–500† (20–30–50)†	Performance of visual tasks of high contrast or large size: e.g., reading printed material, typed originals, handwriting in ink and good xerography; rough bench and machine work; ordinary inspection; rough assembly.
E	500–750–1000† (50–75–100)†	Performance of visual tasks of medium contrast or small size; e.g., reading medium-pencil handwriting, poorly printed or reproduced material; medium bench and machine work; difficult inspection; medium assembly.
F	1000–1500–2000† (100–150–200)†	Performance of visual tasks of low contrast or very small size: e.g., reading handwriting in hard pencil on poor-quality paper and very poorly reproduced material; highly difficult inspection.
G	2000–3000–5000‡ (200–300–500)‡	Performance of visual tasks of low contrast and very small size over a prolonged period: e.g., fine assembly; very difficult inspection; fine bench and machine work.
H	5000–7500–10,000‡ (500–750–1000)‡	Performance of very prolonged and exacting visual tasks; e.g., the most difficult inspection; extra fine bench and machine work; extra fine assembly.
I	10,000–15,000–20,000‡ (1000–1500–2000)‡	Performance of very special visual tasks of extremely low contrast and small size: e.g., surgical procedures.

* General lighting throughout room.

† Illuminance on task.

‡ Illuminance on task, obtained by a combination of general and local (supplementary) lighting.

The inspector's vision is probably the most important factor in his/her ability to detect a defect, the visual acuity varies between individuals and can be measured to categorize the inspector's ability to detect a defect.

A posture at the workplace that forces a person to take a poor posture because of improper table or chair heights, adjustments etc. can affect the performance as the long term effects of these postures can cause static muscle loading which results in excessive fatigue and hence increased errors and slower reaction times.

Example

Existing workplace is described in Fig. 1, the needed human factor considerations in the redesign of the existing workplace are outlined in Fig. 2. Both of these are described as follows:

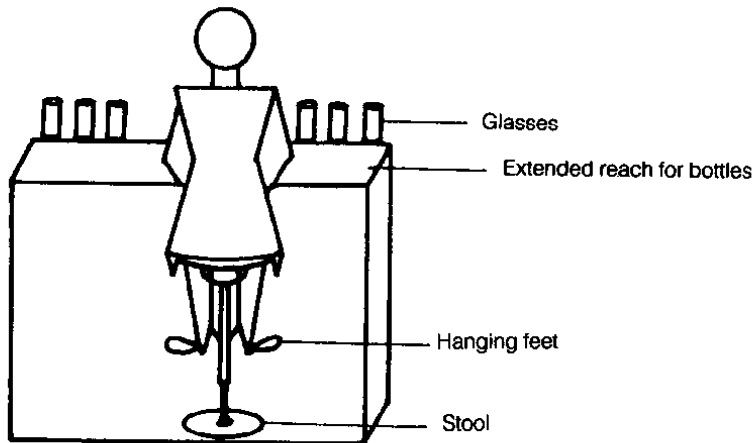


Fig. 1. Existing design of a glass/tumbler workplace inspection.

Present layout

The operator or inspector is seated on a stool, extends the body to get the inspection piece or glass and looks for relevant defects such as cracks, bubbles etc. and places the defectives in a bin, whereas the good ones are packed in a box.

It can be seen in Fig. 1 that the operator has to extend the body in order to get the workpiece, putting excessive static loading on the musculo-skeletal system. This loading can easily result in fatigue injuries etc. The feet of the inspector are hanging on the stool causing excessive pressure on the undersides of the thighs. This condition may cause swelling and tissue damage for extended periods of seating. The unnecessary holding postures for glass can cause muscle fatigue and cumulative

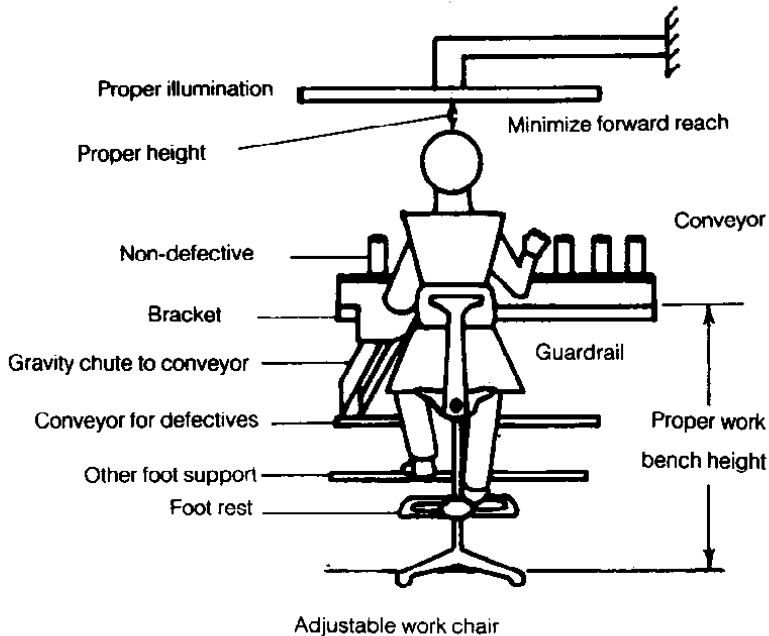


Fig. 2. Improved design with human factor considerations.

trauma disorders, such as carpal tunnel syndrome etc. Improper location or low intensity lighting in the present set up can cause eye strain.

Improved layout

The improved design takes into account the relevant human factor variables. It can be seen from Fig. 2 that an adjustable chair is provided to accommodate varying sitting heights, a backrest is provided to reduce strain on both lower and upper back. Extended body reach is reduced by providing a conveyor closer to the body and a gravity chute is introduced to minimize holding postures. This chute carries the defective part to the defective part conveyor. Proper illumination or lighting of about 2000 lux (Table 1) would be reasonable with good location would help reduce eye strain and improve the productivity. Guardrail is provided to reduce the accidental dropping, of the glasses on the ground. Footrests, both at the conveyor and the chair would give more freedom for foot comfort.

Since ergonomic design changes help in minimizing the operator fatigue, muscle sprains and strains, these features translate to productive operator. Substantial

experimental data in the field of ergonomics is available to prove the motion. The example given in the paper is a more generalized one identifying the bad features and pinpointing possible ergonomic changes to minimize fatigue and injury resulting in productivity gains. The physical fatigue causes various chemicals to build inside the muscles resulting in the need to take rest, this causes reduction in output e.g. reduced workpieces produced or assembled per/hour etc. It is evident from Fig. 2 that the use of human factor design principles can aid the workplace designer to improve the health and safety of the worker which transforms into efficiency and improved productivity.

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العوامل الإنسانية المهمة في مهام فحص الجودة

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ملخص البحث . يتناول هذا البحث موضوع ضبط الجودة من وجهة نظر العوامل الإنسانية، حيث يقدم العوامل الإنسانية المهمة التي لو أخذت في الاعتبار يكون لها تأثير في صحة مفتش الجودة وسلامته وإنتاجيته، هذا بالإضافة إلى تقديم عناصر أخرى مختلفة تتعلق بجودة تصميم مكان عمل مفتش الجودة. للعامل الإنساني دور مؤثر وفعال في مهمة التفتيش والفحص ومع ذلك لا يأخذ في الاعتبار عند تصميم أماكن العمل وهذه الأماكن تصمم معتمدة على عوامل أخرى، ولذا فإن تقييد إمكانيات العامل الإنساني بعدم أخذه في الاعتبار عند تصميم أماكن العمل، يؤدي إلى قبول عناصر رديئة ورفض عناصر جيدة، بالإضافة إلى ذلك انتشار السأم والإجهاد العصبي في أماكن الأعمال المفتقدة إلى تأثير العامل الإنساني في تصميمها.

إن الإعداد الجيد لأماكن الأعمال يؤدي إلى زيادة الإنتاجية كنتيجة لتقليل الإجهاد العصبي والحالة النفسية السيئة والتي تؤدي دائماً إلى الإصابات وبطء حركة العمل، ولذا فإن هذا البحث يركز على هذه الحقيقة مع عرض مثال للخصائص السيئة والمحسنة لموقع عمل.