WORK SAFETY AND HEALTH PROTECTION IN MAINTENANCE AND REPAIR

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Abstract: *Based on current stress situations in the repair section of a big German truck and bus company procedures for force measuring have been developed, methods for risk assessment are selected and applied and proposals for improvement of the work performance are discussed. In addition to the technical component of the force measurement with a specially designed device and the organizational component in a project with representatives of various disciplines the specific differences between service and production are to be respected. Most of the approved assessment tools like COBRA, KIM (LMM) or EAWS for physical work situations with critical body and spine loads can just be applied with restrictions. By use of a special documentation systematic the results of risk analysis of selected activities are evaluated and solutions developed according to the TOP principle with respect to economical, technical and organisational feasibility. Effort and practical acceptance of the project are mainly determined by the multidisciplinary staffed working group.*

Keywords: ERGONOMIC ASSESSMENT, LOAD HANDLING, LOAD MEASUREMENT, WORK DESIGN

1. Introduction

Apart from communication and internet of things the third global megatrend is services. However the ergonomic methods for work design are primarily focussed on production. This discrepancy appears particularly on machines and vehicles with respect to many repetitive processes in production and high process variety in maintenance. So the approved assessment tools for physical work situations with critical body and spine loads like COBRA, KIM (LMM) or EAWS can just be applied with restrictions. For example the valuation of the necessary muscle force during mounting of heavy spare parts, to be lifted completely or even partly, is difficult and mathematical simulations are not available. To find solutions for the worker's situations in the garages and workshops, to improve the work perfomance and to select matching work supporting tools the joint venture project with a big bus and truck company (MAN) has been conducted especially for the repair and maintenance section.

2. Methods

With the goal to analyze the working conditions in the service department of heavy load vehicles and to improve work place ergonomics in the context of demographic change, the company composed a team with following participants:

- corporate management representatives
- employee representation
- experienced staff from the service area
- skilled personnel for the assessment of activities (e.g. by occupational physicians, specialists for occupational safety as well as for integration management)
- deputies of occupation cooperative and health assurance (e.g. physiotherapist)
- ergonomics expertise of Munich University of Applied Sciences.

2.1 Work Analyses

First the main activities were analyzed with respect to their frequency and significance to assess the conditions in the service department. It was shown on the part of the company that, despite the variety of the tasks in this service sector, some tasks have a high share in the daily working time. It was therefore decided to analyze these frequent activities in detail. As part of the analysis, it turned out that particular attention must be paid to the strain on the back and spine during the maintenance and repair of vehicles. Stretched or flexed postures as well as high action forces due to the heavy vehicle parts were identified as main risk factors.

2.2 Force Measurement and Posture Analysis

For analysis of body postures the CUELA measurement system (Ellegast et al. 2010) was used by representatives of occupation cooparative of wood and metal. At the beginning of each test series the worker was equipped with the CUELA system. To establish standardized conditions and to obtain objective data, the activities have been carried out strictly in accordance with the repair instruction manual.

For the analysis of the reaction forces occurring, a measuring system for use in the field has been developed. The application of the system and the interpretation of the measurement data should be as simple as possible. It should be ensured that the reaction forces can be properly assessed, for example when pressing or holding and when lifting heavy parts. Finally, the measurement device itself should not influence the result or the work performance too much. After evaluation of the prototype the force measuring device (see. Fig.1) was integrated into a glove (Mujic 2014). The unit can measure axial forces up to 300 N per hand with an accuracy of ±3 N, transverse forces are suppressed by the measurement system. In the tests the force measurement was carried out only in simplified operations, in which a component weight with exceeding 5 kg occurred. For this, the activity was temporarily suspended in order to apply the force measuring system. In addition, heavier parts were measured with separate hand scales.

For later analysis, the activities were documented by video recording so that a clear assignment of forces and postures was possible.

Fig. 1: *Force measuring unit and evaluation with various load situations.*

2.3 Risk Assessment

In the service section occur different strains with quick sequence, making it difficult to assess by means of key indicator methode of BAuA (=LMM: lifting, holding, carrying), which is used actually nearly as a standard. At least to get a strain indicator of lifting and carrying and pulling and pushing the multiple loads tool of the KoBRA project (Kugler et al . 2010) has been used and the corresponding results were tabulated.

3. Results

In addition to the measured values of the hand forces a particular focus was in the assessment of body postures. The CUELA analysis allowed on the one hand a differentiated presentation of critical body postures over time (the results are not shown here) on the other hand, it was possible to assess the classifications of the posture with the multiple loads tool and to discuss the registered data with the specialists the occupation cooperative.

The main stress activities were identified as (Fig. 2):

- huge action forces combined with unfavorable body postures
- head inclination towards the rear (by overhead work under the vehicle)
- static postures with body bending and twist (due to bad accessibility of the work area and cramped conditions)
- inflected torso (work in a bent position)

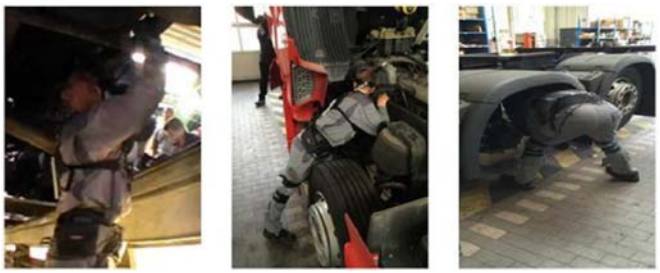

Fig. 2: *Selected work situations during service activities (with CUELA system)..*

In addition to daily exposures also singular activities could be analyzed in more detail. Figure 3 shows an example of a part replacement, which weighs 13.5 kg and has to be helt in an unfavorable posture for about 46 s.

Weight/kg:	**13,8**
Duration:	104 sec
Body posture:	6
Working conditions:	3

Fig. 3: *Work assessment according to KoBRA multiple loads tool.*

After the analysis the collected ideas of the participants were registered in a standard form, which has been developed for the team work, and are categorized according to the TOP-principle, thus differentiated by technical (lifting aid), organizational (help from a second person) and personal action (improving posture or appropriate physiotherapy exercises). At the end of the standard form the possible activities are valuated with respect to their contribution to reduce the strain and the corresponding risk indicator (Fig. 4). Very promising are primarily:

- suitable headroom adjustment in the pit
- posture supports in worse accessible sections and for fine motor skills
- optimization of the used tools and their accessibility
- organizational and physiotherapeutic action
- use of lifts

Following the principle of cost and benefit first action are prioritized and recommended for implementation.

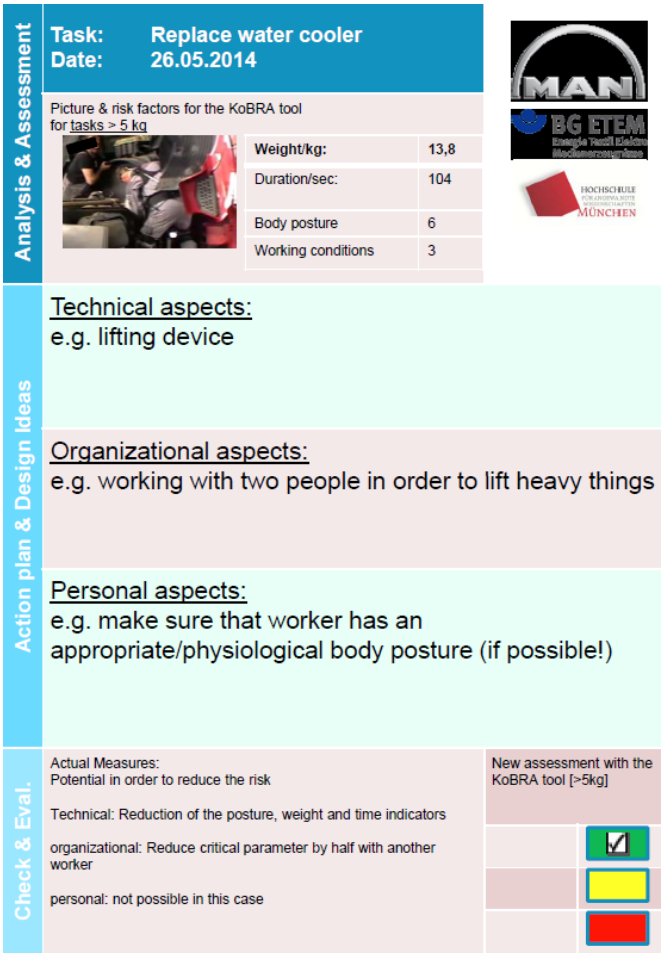

Fig. 4: *Standardized documentation sheet for categorization, assessment and prioritized actions with evaluation of effects on strain reduction.*

4. Discussion

The assessment of working conditions in the production compared to the service department is often simpler, because there are many repetitive procedures, which can be optimized with economical advantages. However, the one-sidedness and the combined monotony are often established as disadvantages of synchronized work. In the service section the work activities show a high variety. Although the postures are often very unfavourable,the worker takes often "almost automatically" the corresponding compensation posture, which is favored by physiotherapy to reduce possible risks by one-sided loads.

When applying the risk assessment by use of the multiple loads tool, it is implicitly assumed that a bad attitude in load handling (like holding a distal load of high posture rating points), which must always be taken recurrently, is synonymous to different but always unfavorable body postures (e.g. overstretching the backward bending, lateral twisting of the spine in bad accessible sections or deep bending when removing heavy parts). This assumption, however, is at least questionable, because a general, physically different stressing activity cannot be compared to a one-sided and repetitive work. At least synchronization and frequent load changes can be respected like in then key indicator method (LMM) for assessment of manual activities (Steinberg, et al. 2012). However, this method should be used only at forces less than 50 N.

A particularly positive aspect of the project is that the workers were able to take part in the team meetings. In addition to the theoretical and metrological findings could thus be ensured that the findings of the investigation were reflected also in the subjective experience of the employees. Here, for example, an extreme posture, e.g. to reach a few cm more or to produce the necessary force to solve a corroded screw, which were already conspicuous in the objective analysis, is confirmed by the subjective perception of employees.

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