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Drywall Finishing Industry: Macroergonomic Evaluation and Intervention Design

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Abstract. A macroergonomic evaluation of the drywall finishing work system was conducted for the purpose of developing intervention alternatives to reduce worker exposure to dust. Findings from three studies of the subsystems of the drywall finishing work system were used as inputs into the Systems Analysis Tool (SAT). A Problem Factor Tree (PFT), Objectives/Activities Tree (OAT), and Input-Output Flow Diagram were developed to describe the barriers inherent to the current drywall finishing industry use of dust control technologies. Educational, health promotion, tool redesign, and regulatory interventions are proposed as strategies to improve dust control and worker protection in this industry.

Keywords. macroergonomics, drywall, dust, construction work, usability, dust control

1. Introduction

Respiratory disease among construction workers in general, and plasterers and wall finishers in particular, is a major public health concern. Workers in these trades suffer from disproportionately high rates of respiratory disease and disability (Wang, 1999). Drywall finishing operations have been associated with worker over-exposure to dust that contains known particulate respiratory health hazards, such as silica, talc, and mica (NIOSH, 1997). Despite the existence of engineering and work-practice control technologies for the mitigation of this hazard, worker exposures persist in the construction industry (Carlton *et al.*, 2003).

Three studies were conducted as distinct parts of a collective project concept that employed a macroergonomic framework to evaluate the drywall finishing work system with the intent of designing interventions to improve industry-wide dust control. The main findings of each were employed as inputs in this macroergonomic system analysis.

The macroergonomic approach defines a work system as one in which two or more people work together in interaction with technology within an organizational context (Kleiner, 2006). This definition identifies three key subsystems of any work system: personnel, technological, and organizational. The organizational subsystem can be further described as having internal and external influences: physical, cultural, legal and political.

According to the macroergonomic approach, all subsystems should be included in system analysis, design, and improvement (Hendrick, 2001). In the drywall finishing work system, it can therefore be assumed that organizational, human, and technological factors are important considerations when planning work designs to improve worker health. Therefore, all three subsystems were evaluated for potential barriers to the control of dust in drywall finishing operations. To perform the macroergonomic evaluation, three studies were designed to solicit information about barriers inherent to each of the major subsystems. Information regarding these identified barriers is them employed in the System Analysis Tool (SAT), to develop recommended alternatives for system improvement

1.1 Study 1

An evaluation of the organizational subsystem was performed in this study of drywall finishing firm owner perspectives. A telephone survey was administered to a target sample 1000 drywall-finishing contractor firms listed in the two major trade organizations in that field. This survey was constructed to measure the frequency of use of four primary and contemporary dust control technologies and respiratory protection. For each technology, firms were asked about barriers to implementation.

1.2 Study 2

In this study, problems inherent to the technological subsystem, especially the technology-user interface was examined. In a laboratory setting, participants performed simulated drywall finishing tasks using each of the four most common methods: plain sanding block, pole sander, wet method, and vacuum sander. Resulting dust concentrations and usability metrics were the outcomes of interest. Barriers to use associated with usability metrics were identified.

1.3 Study 3

The personnel subsystem was evaluated in the third study of worker perspectives on drywall dust control technologies. Drywall finishing worker attitudes toward the four technologies were explored through in-depth personal interviews. Attitudes and perceptions toward the technologies were solicited, and emergent themes were explored. Workers described perceived barriers to the adoption of the various dust control technologies.

2. Methods and Results

The Systems Analysis Tool (SAT) is the macroergonomics work system assessment methodology employed in this study. The SAT has roots in systems engineering theory (Robertson, 2005) and a system analysis framework for policy decision making (Mosard, 1982). It is restated as a formal tool in the Handbook of Human Factors and Ergonomics Methods (Stanton *et al*, 2005). This tool consists of a seven step process for identifying work system problems and causal factors and developing strategic solutions:

1. Define the problem: create a problem factor tree (PFT)

2. Develop an objectives/activities tree (OAT)
3. Model alternatives: the input-output flow diagram (IOFD)
4. Evaluate alternatives: evaluation scorecard table (EST)
5. Select an alternative: decision criteria table (DCT)
6. Plan for implementation: scheduling and management of project flow
7. Evaluation, feedback, and modification process

The current research employed the first three steps of this process to analyze the diverse problem factors associated with the drywall finishing industry low usage of dust control measures and develop several intervention alternatives.

From the system performance data collected in the three described studies, the problem factor tree (PFT) was constructed to assess problems and causal factors of the breakdown in use of drywall sanding operations dust control technologies (Figure 1). This tool incorporated inputs from the three main subsystems of the drywall finishing industry: organizational, technological and personnel. Additionally, external environmental and interface factors were included in the analysis.

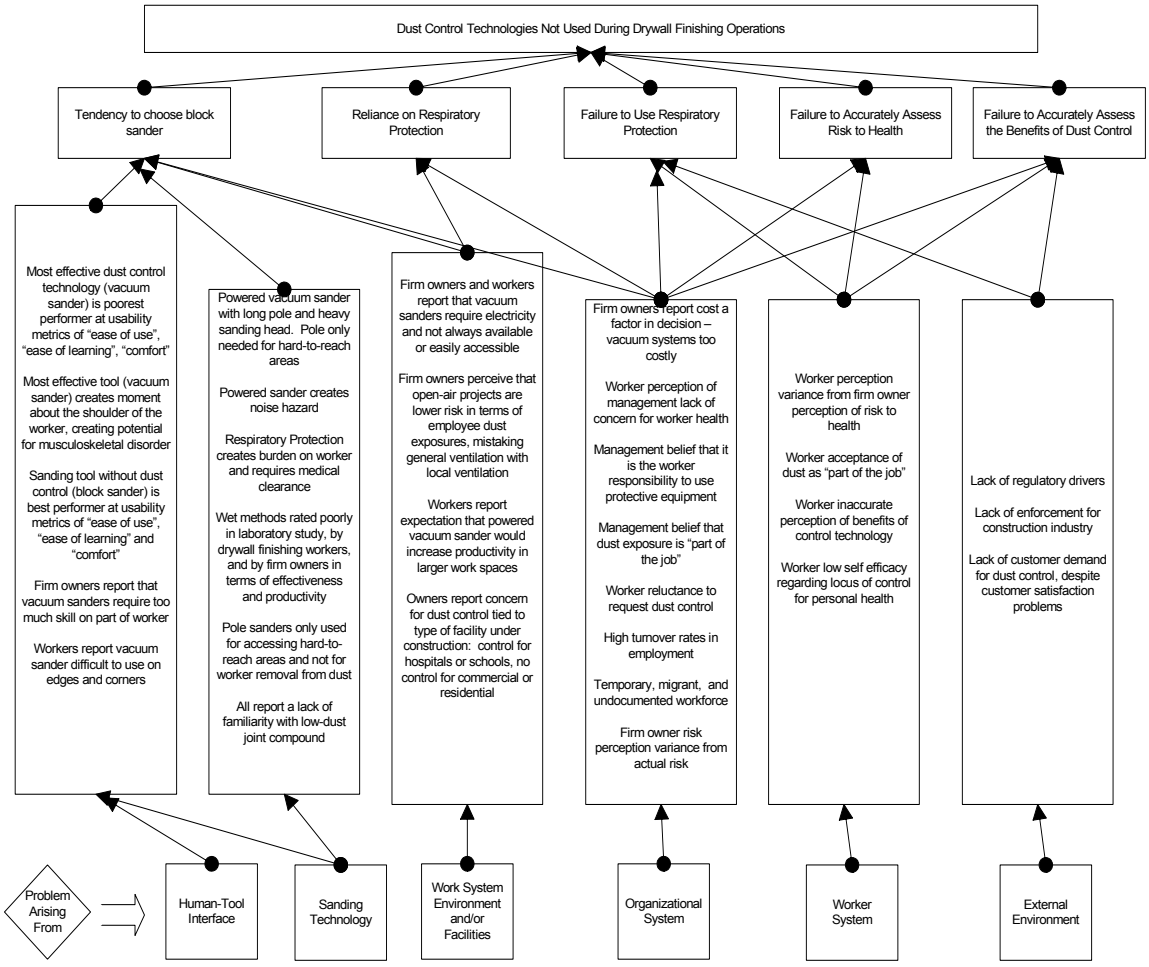

Figure 28: Problem Factor Tree

The problem under consideration in this study is the fact that dust control technologies are not being used during drywall finishing operations. Root causal factors contributing to this problem were identified as arising from the technology, the interface between the technology and the human users, the work environment, the organizational system, the worker system, and the external environment and are shown across the base of the PFT diagram. Studies of each of these subsystems found the main themes identified and are shown as problem factors in the body of the PFT. These are the main problem elements, constraints, and barriers that contribute to the sub-problem elements: tendency to choose sub-optimal sanding technology, reliance on personal protective equipment as a means of control, failure to use respiratory protection when it is provided, failure of the workers and managers to accurately assess the risk to human health associated with drywall dust, and failure of the workers and managers to accurately assess the benefits that would be derived from the use of dust control technologies.

The second step in the SAT is to set objectives and develop evaluation criteria, in an Objectives/Activities Tree (OAT). This is accomplished by identifying major needs, goals, objectives and sub-objectives associated with the identified problem (Figure 2). For the problem at hand, the major goal is a reduction of worker dust exposure in the drywall finishing industry. One objective would be an increased use of ventilated sanders and low-dust joint compound, as these are the methods have emerged from these combined project as the optimal solutions, based on firm owner, worker, and usability study outcomes. A second objective would be a diminished reliance on respiratory protection as a means of protecting workers. Intermediary objectives that would need to be addressed in order to achieve the goal would include changes to tool design to address usability issues, a change in worker perception of risk and susceptibility and a change in firm owner perception of locus of responsibility for dust control: shifting the burden from the worker to the owner.

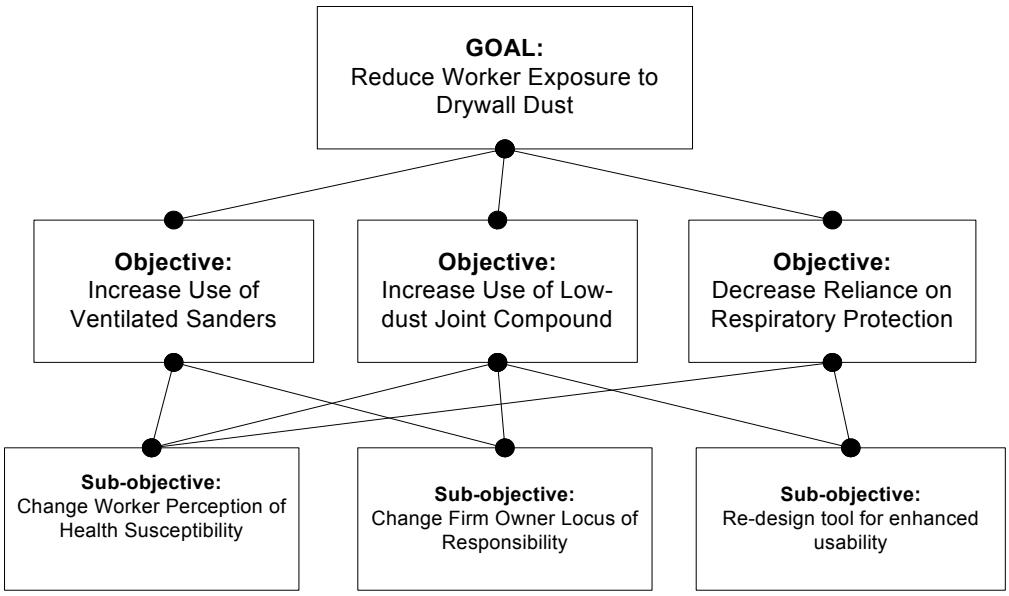

Figure 2: Objectives/Activities Tree (OAT)

An Input-Output Flow Diagram (Figure 3) was constructed to depict the key work system elements and barriers.

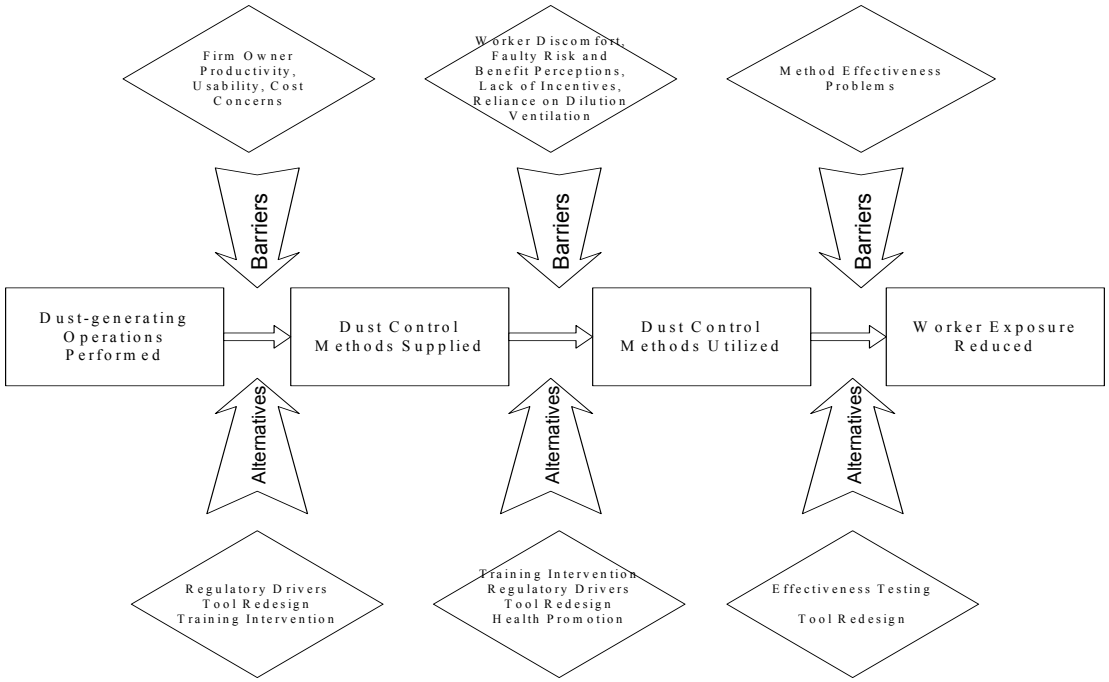

Figure 3: Input-Output Flow Diagram

4. Discussion and Conclusion

Technologies exist to effectively reduce worker exposure to known and regulated health hazards associated with drywall finishing operations, however usage rates are low across the industry. Barriers to the adoption of protective controls exist in the organizational, technological, and personnel subsystem, as well as the interfaces among them. The Systems Analysis Tool was employed to analyze the results of previous scans of the work system and develop three alternatives for system improvement. From the key barriers identified in this process, three primary intervention types have been selected for additional research: enhanced drivers for organizational subsystem, technology redesign to improve human-tool interface, and educational interventions to reduce barriers in personnel subsystem.

The first three steps of the Systems Analysis Tool were used to identify key barriers to dust control in the three subsystems of the drywall finishing operations work system. Future research is being developed to design and evaluate interventions that target these key barriers, with the aim of improving the use of dust control systems in this industry.

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