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A Proposed Method for Improving Ergonomic Risk in Maintenance Jobs

Ted DesMarais[1], Richard Wyatt[2]

[1]Aon Casualty Risk Control,
Providence, Rhode Island USA

[2]Aon Casualty Risk Control,
Huntsville, Alabama USA

Corresponding author's Email: Ted.Desmarais@aon.com

Author Note: Ted DesMarais is a Director in Aon's Casualty Risk Control Practice in Providence, Rhode Island. Ted has a BS degree in Biomechanics from the University of Connecticut and a M.S. degree from the University of Massachusetts, Lowell and is a Certified Professional Ergonomist. He also is a Certified Safety Professional and has been in the field of safety and ergonomics for 22 years.

Richard Wyatt is a Senior Risk Control Consultant with Aon Casualty Risk Control in Huntsville, Alabama. Richard holds a Ph.D. in Industrial and Systems Engineering from the University of Alabama-Huntsville and is a registered Professional Engineer. He is a Certified Professional Ergonomist and a Certified Safety Professional and has over 30 years' experience in Industrial Engineering, Quality Engineering, and Ergonomics.

Abstract: In today's industrial setting, maintenance employees are expected to perform a wide variety of tasks. Maintenance functions change all the time and have a wide variety of physical requirements. Job descriptions and Physical Demands Analyses (PDAs) can describe and provide a general view of the physical nature of the job, but typically do not focus on the myriad of detailed physical job requirements required by maintenance employees. This paper describes a method to fill in the gaps of ergonomic risk factors that may not be detailed in the PDA and provide a job planning tool to anticipate and reduce MSD type risk factors in maintenance jobs or tasks.

Keywords: Ergonomics, Safety, Maintenance

1. Introduction

The term maintenance may have different meanings according to the business in which it is used. The same is true for the occupational label of maintenance personnel. In some instances, this may refer to the upkeep of grounds or outdoor environments. In another business it might refer to scheduled servicing and or repair of machinery. The label might also be applied to all skilled trade employees not actively involved in the building or installation of a system or structure. Whichever definition fits your experience there are several factors that all employees share within this occupational label.

Many of these workers perform job tasks that require a significant physical demand. A typical physical job demands assessment for maintenance will measure the average or maximum lifting, carrying and push/pull in the overall job, but the assessment does not detail the many postures used or account for age or physical conditioning of the employee. An additional important factor to consider is age. Many of these maintenance workers are older on average than the working population as whole. In 2012 fifty three percent of skilled trades workers were 45 or older compared to just forty four percent of the overall labor force (Wright, 2013). The skilled trades work group also has fewer members working at age sixty-five and over than the general labor force, 1.9 to 4.8 percent respectively (Wright, 2013). This data supports the concept that this work is physically demanding and contributes to employee attrition. Maintaining adequate employee levels in these positions is essential to many business functions. Maintenance jobs can require many different skills, and many organizations prefer employees that have multi-craft skills, meaning the employees can work in a variety of crafts, from electrical, plumbing, carpentry, hydraulic, and

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general mechanical repair. As the jobs become broader, the physical demands become broader, and the average age of the employee tends to be higher. A wider array of skills and experience takes longer to develop, thus adding to the age problem found in many maintenance departments.

2. Physical Job Demands in a Maintenance Environment

A well written Physical Job Demand Analysis (PDA) should document the essential duties of the job and the physical requirements of the job. The PDA should list the essential functions of the job (e.g., what types of activities is involved in the job?), and the physical effort needed to perform the essential function. There is no one set way of documenting physical job demands, but the two most important things to document is the essential tasks, and the amount of force and time that the task is performed. Now in a job where tasks regularly repeat, the essential task measurements can be very straightforward. For example, a scale operator in a food plant could add or subtract product so the product meets production weight standards. The frequency of the job task is known, and the weights/forces in the job are easily measured. But with a maintenance job, the job task list can be quite long, and vary from hour to hour. In most maintenance jobs, the required tasks or essential duties can be a long list.

The best way to explain this concept is to show a few examples. The authors Googled 'physical job demands for maintenance worker' and got back 158 million hits. Maintenance job descriptions are listed for schools and universities, and other county and local governments. In reviewing these documents, we were interested in the listing for 1) essential duties and 2) physical demands for those essential duties. The physical demands are listed as 'lift and maneuver items weighing up to 50 pounds (Livermore Parks and Recreation Department, 2017). This job description lists the required skills and knowledge needed to perform the job but does nothing about proactive suggestions to lower the risk associated with these tasks.

3. Suggestions for Filling the Gaps

To meet this need for skilled trade employees, companies may either hire younger workers or maintain the status of their existing workforce. Replenishing the workforce with younger employees may seem like a simple process until it is examined further. A shortage of skilled trade workers has been reported for the previous ten years. The Hudson Institute predicts the supply of skilled labor in the U.S. will not catch up to demand until 2050 (Kotlikoff and Burns, 2005). The Aon client interactions over the previous five years support this assessment. It is common to hear examples from human resource professionals regarding the difficulty to locate younger applicants for skilled trade positions. Stimulating participation in the skilled trades is a worthy endeavor. However, there will be significant latency between the efforts to improve these metrics and businesses recognizing a change in their hiring environment. For this reason and more it makes good business sense to protect the health of the existing workforce, especially those who are older and may begin to struggle with the physical demand required of the position. As these workers are challenged by job demands they may suffer overexertion injuries. These injuries create increased pain and suffering for the employee, financial uncertainty, increased insurance cost and reduced productivity for the employer.

Overexertion is a term used to describe a leading cause of injury in the workplace. Overexertion refers to the overburdening of the human anatomy, principally the musculoskeletal system. For insurance classification purposes this cause of injury category is defined by lifting, pushing, pulling, holding, and carrying activities that lead to a workplace injury. If the mechanism of injury is cumulative in nature that is building up over time as opposed to an acute one-time trauma to the body, then the term Musculoskeletal Disorder (MSD) is often used to describe the injury type.

In 2018 Liberty Mutual reported that the overexertion-cause category resulted in $13.7 billion in direct business costs (Liberty Mutual Insurance, 2018). This figure is based on non-fatal injuries resulting in five or more days away from work and represented 23.4% of the total national burden of direct business cost. Aon Casualty Laser is the flagship of our series of data analytics approaches. Launched in 2011, with industry specific metrics added in 2016, it provides benchmarks for Worker's Compensation cost performance based on more than $9 billion in injury costs. The Casualty Laser "All Industries" benchmark for MSD's is 31.6% of total claim count and 40.6% of the total incurred claim cost (Aon, 2019). "Ergonomic related injury" is greater in frequency and cost than any other category measured. This data suggests that MSD injuries result in significant worker's compensation costs to say nothing of the human toll paid by injured workers.

Due to the significant costs associated with MSD injuries it is logical to suggest that reducing the frequency (e.g., claims count) of these injuries would benefit employers and employees alike. Safety professionals try to achieve this reduction through the identification of risk factors, implementation of controls or workplace improvements, and the evaluation of progress towards injury reduction.

The identification of risk factors is a complex problem that often involves knowledge from several disciplines such as, industrial engineering, human anatomy and physiology, industrial psychology, and biomechanics. In some instances, risk identification can be pursued by professionals who train in these fields to build knowledge for the application of this information to the proper fit between worker and the work. These professionals are typically referred to as Ergonomists.

An Ergonomist might employ a variety of tools to identify and measure risk. It may be helpful to consider these tools organized in a continuum. To the left of the continuum are items such as checklists that require a minimal amount of instruction and offer the user the ability to screen for workplace factors that might be considered risky, like Ergonomic Assessment Checklist (OSHA, 2018). To the right of the continuum there are tools like objective based measurement of biomechanical forces and their proposed ability to predict injury, like the Static Strength Prediction Model, which was developed by the University of Michigan – Center for Ergonomics (2020). For more information on this analysis method, see University of Michigan – Center for Ergonomics (2020). Tools on the right of the continuum typically require significant time investment in their proper application, in addition to technology and equipment that might be prohibitive for some uses. In a perfect world the best tools would be used in every possible application to achieve the greatest possible results.

However, in the real world of risk identification and helping businesses improve worker health and financial performance, a compromise of sorts is required. Just as every job cannot be examined by a trained safety professional neither can the most elaborate tools be applied to all circumstances. One method for achieving a compromise is the use of a screening tool applied at manager and employee level. A screening tool has the advantage of being relatively easy to learn and thereby accessible to many users. Applying the screening activity at the employee/manager level creates a participatory approach that is widely recognized as more likely to produce sustainable effective results. Undoubtedly there will be occasions where a more sophisticated tool is beneficial, or a credentialed professional is required. It is the authors' opinion that over time businesses will benefit from more frequent discussions of ergonomic principles at any level of sophistication. As a result, the authors offer a proposed the Ergo-TEMP Check for Maintenance workers. This checklist is listed below in Figure One.

Ergo-TEMP Check Inventory Worksheet (Figure 1) is a screening process by which managers and maintenance staff may examine the physical demands a of work assignment for the purpose of identifying work factors that may lead to an increase risk of musculoskeletal disorders. It is not a risk prioritization or measurement tool, but rather a qualitative review intended to raise awareness and indicate opportunities for the reduction of ergonomic related risk factors: force, repetition, and posture.

The screening tool should be used by maintenance managers and their personnel to:

- recognize risk for MSD injury
- improve communication about safety within the manager and employee work group
- stimulate discussion on methods for reducing the risk of MSD injury
- raise employee awareness regarding safety in the workplace with specific emphasis on manual material handling tasks.

4. TEMP: Tools Equipment Materials & People

Ergonomics evaluates the review of job tasks for the purposes of identifying risk for strain or cumulative trauma disorders. These questions below can support the job hazard analysis process for Maintenance Supervisors reviewing common tasks or infrequent but physically demanding tasks. This process does not characterize or measure the risk. The intent of this document is to ask critical questions that will allow operations and safety personnel to see if there are common sense improvement opportunities for reducing the risk of ergonomic related injury. Some tasks may require further investigation to determine if the majority of the working population may perform the activity safely. The authors suggest that the following information be used to determine to determine strain and sprain injury risk on any maintenance or construction project. The

questions and Ideas for Improvement listed below are proposed by the authors to aid the user of this TEMP form that is listed in Figure One. The checklist in Figure One can be printed and used for individual maintenance projects to think about injury risks related to tools, equipment, materials and people, with the end goal of completing the work injury free.

TEMP Category	Critical Questions	Ideas for Improvement & Additional Questions
Tools	Do we have the correct tools for the job? 1. would a powered tool help? 2. would a lighter tool help? 3. would a longer or shorter tool help? 4. would a tool support help? 5. does the tool create vibration?	1. Power tools can reduce the force required to perform a physical task, e.g. battery powered drill v screwdriver; reciprocal saw v handsaw. 2. Lighter tools require less effort to manipulate and result in less fatigue for the user in many but not all applications. 3. Tool size can offer mechanical advantage; may improve posture by allowing the operator to remain more upright or work with hands below shoulder height. 4. A support can reduce the force required to manipulate or hold tools reducing the force required to perform a task 5. Vibration is a risk factor for MSD injury but may be appropriate and exposure can be reduced through administrative controls and personal protective equipment.
	How are we getting the tools to the job? 1. hand carry 2. transport with manual device 3. transport with powered device	1. Carrying tools should be reduced whenever practical using hand truck, cart, dolly, or rolling tool bag. When tools must be carried the preferred method is in a tool belt or backpack leaving both hands free to support walking or climbing. Hand carrying tools weighing 35lbs. or less is acceptable if the method of carry, distance, and terrain are reasonable and vision is not obstructed. See additional information on method of carry. Hand carrying tools weighing greater than 35lbs. should be reviewed by personnel to develop a best practice to eliminate or reduce this task to the minimum frequency possible. 2. Transporting with manual devices such as carts and hand trucks will generally reduce risk of MSD injury unless the weight of the tool(s) transported are more than 100's of pounds in weight. Job tasks that require near maximal exertion, for example moving a cart up an incline or pulling a heavily loaded hand truck upstairs, should be reviewed by personnel to develop a best practice to eliminate or reduce this task to the minimum frequency possible. 3. Transportation via powered device should not increase the risk of manual material handling related injury beyond the loading and the unloading of the tool to the transportation device. This activity should be reviewed as above. Powered equipment should be consistent with company guidelines with respect to operators and methods of use.
Equipment	Do we have the correct equipment?	The proper equipment can improve working postures. See additional information on strike zone. Activities should be

TEMP Category	Critical Questions	Ideas for Improvement & Additional Questions
	• ladder selection a-frame vs. extension • rolling work platform • mobile lift scissor or articulating boom How are we getting the equipment to the job? • hand carry 1p or 2p • transport with manual device • powered transportation	located between knee and shoulder height of the worker and at a horizontal distance that does not encourage reaching. Positioning devices such as ladders, scaffolding, scissor lifts, and articulating booms may improve working postures. Work located below knee height may lead to trunk bending and low back risk. Work positions such as kneeling, sitting, or laying down may be appropriate to improve working postures. These positions should be supported by mats, knee pads, work-stools, and creepers when these work positions exist for greater than 10 minutes of exposure per 1 hour of work duration or when their use would not interrupt the completion of other tasks performed during that time period. See previous information with respect to types of carrying tasks and use of transportation devices (Tools section).
Materials	What materials are needed to complete the job? 1. Are there individual items or items in the aggregate that weigh more than 35 lbs.?	1. Carrying materials should be reduced whenever practical using hand truck, cart, dolly, or other transport device. When materials must be carried the preferred method is in a tool belt or backpack leaving both hands free to support walking or climbing. Hand carrying materials weighing 35lbs. or less is acceptable if the method of carry, distance, and terrain are reasonable and vision is not obstructed. See additional information on method of carry. Hand carrying materials weighing greater than 35lbs. should be reviewed by personnel to develop a best practice to eliminate or reduce this task to the minimum frequency possible. 2. Transporting with manual devices such as carts and hand trucks will generally reduce risk of MSD injury unless the weight of the materials transported are more than 100's of pounds of weight. Job tasks that require near maximal exertion, for example moving a cart up an incline or pulling a heavily loaded hand truck upstairs, should be reviewed by personnel to develop a best practice to eliminate or reduce this task to the minimum frequency possible.
People	How do people interact with the work? 1. Is this a single person job? 2. Is the work performed below knee height? 3. Is the work performed from positioning equipment? 4. Will most of the work be performed in the strike zone? 5. What job tasks will require work to be performed overhead or below knee height? 6. Will work outside of the strike zone be repetitive, of a long duration, or require moderate force demands?	• The previous review process should indicate material handling requirements of the job task. Adding support personnel for a portion or all the task assignment may reduce the individual material handling force required by reducing the weight lifted (team lift) or by reducing the frequency of the lifts per person. Work assignments performed alone should be tracked by management staff to have a general knowledge of employee whereabouts during the workday and provide a method for communication with that employee in the event of an emergency such as cellphone or other communication device. • If the job task is performed below knee height and kneeling or crawling postures are anticipated

TEMP Category	Critical Questions	Ideas for Improvement & Additional Questions
	7. Is this job task something that the employee is conditioned to perform or is it an infrequent activity that is more physically demanding than common job assignments?	provide the proper PPE in form of knee pads and work gloves. Can the worker be supported by a small stool to alternate sitting and kneeling postures? • If positioning equipment is used review the ergonomic strike zone concept for proper work placement. See strike zone graphics. • Work outside of the strike zone should be recognized as more physically demanding. Personnel should be reminded to maintain a reasonable work rest cycle that allows a break from a difficult position to reduce musculoskeletal fatigue. 7. Very demanding jobs should be reviewed more specifically to identify the risk for MSD injury. If possible share this work among the work group to reduce repeated exposure to a small number of individuals. Consider restricting less fit employees from this work assignment or pairing with additional personnel to reduce the exposure to a single employee.
	How does the worker get to the jobsite? 1. Walking 2. Climbing stairs 3. Climbing ladders 4. Is the worker carrying TEM? 5. Riding in equipment 6. Operating equipment 7. Is terrain (uneven/slippery) a concern 8. Is visibility a concern while performing the work or operating equipment? What resources are available to provide additional light. 9. Is the work environment hot or cold?	1. Walking may be beneficial if TEM is not carried or heavy. 2. Climbing stairs should be performed with at least one hand free. 3. Climbing ladders should be performed with both hands free of TEM. 4. If the worker is carrying TEM could it be avoided by additional personal? Could this material be located in a belt or bag? 5. Three points of contact should be used entering and exiting the vehicle. Workers should not jump off truck beds, tailgates, or raised steps. Workers should only ride in approved vehicles with the proper restraint system in place. 6. Only authorized employees should operate equipment or vehicles. 7. Precondition areas that are likely to be slippery to reduce fall hazards. Review footwear requirements to determine if they meet the conditions anticipated. 8. Individual light sources such as temporary lighting, portable lanterns, headlamps, and magnetic flashlights can improve the lighting conditions of the work environment. Improving supplemental light and specific task lighting will benefit visual acuity, improve head and neck posture, and support a more productive work environment. 9. Does the work crew have sufficient water or other fluids to drink? 10. In cold temperatures, have proper clothing and PPE been considered?

Figure 1. Ergo TEMP Check Inventory Worksheet

Ergo TEMP Check Inventory Worksheet			
Manager/Reviewer:	**Routine Task:** ☐ **Non-Routine Task:** ☐		**Review Date:**
Tools: (List the tools that will likely be used to complete this assignment. Indicated any tools weighing greater than 35 lbs. that might present a risk of material handling injury during transportation to the work zone. Provide weights whenever possible)			
Equipment: (List all equipment that will likely be used to complete this assignment. Indicated any equipment greater than 35 lbs. that might present a risk of material handling injury during transportation to the work zone. Provides weights whenever possible. Indicate equipment that will function to better position the worker (locating work within the strike zone and what step of the task assignment it should be utilized)			
Materials: (List the materials that will likely be used to complete this assignment. Indicated any material weighing greater than 35 lbs. that might present a risk of material handling injury during transportation to the work zone. Provide weights whenever possible)			
People:	Check the box		Comments
Is this a single person job?	Yes	No	
Is the work performed below knee height?	Yes	No	
Is the work performed from positioning equipment? (Follow your organization's guidelines for fall protection.)	Yes	No	
Will most of the work be performed in the strike zone?	Yes	No	
What job tasks will require work to be performed overhead or below knee height?	Yes	No	
Will work outside of the strike zone be repetitive, of a long duration, or require moderate force demands?	Yes	No	
Is this job task something that the employee is conditioned to perform or is it an infrequent	Yes	No	

Ergo TEMP Check Inventory Worksheet		
activity that is more physically demanding than common job assignments?	Yes No	
How does the worker get to the jobsite? Walking?	Yes No	
Climbing stairs?	Yes No	
Climbing ladders?	Yes No	
Is the worker carrying TEM?	Yes No	
Riding in equipment?	Yes No	
Operating equipment?	Yes No	
Is terrain (uneven/slippery) a concern?	Yes No	
Is visibility a concern while performing the work or operating equipment?	Yes No	
What resources are available to provide additional light?		

5. Conclusions

The authors have proposed the Ergo TEMP Check Inventory Worksheet to fill a void in determining potential ergonomic risks in maintenance activities, as most ergonomic risk assessment methods assume a job is done the same way over time. Maintenance jobs are often one-time events, and this method gives a maintenance manager or project manager a roadmap of potential ergonomic-related injury risks and allows them to plan administrative or engineering solutions to lower those risks. This method may also have application in construction tasks and additional research is needed to apply this method to construction.

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