

ADDRESSING ERGONOMIC AND SAFETY CONCERNS ON A LOCAL MANUFACTURING PRODUCTION LINE WITH INCREASED PRODUCTIVITY DEMANDS

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ABSTRACT

The AvaLung™ is a personal protective device designed and manufactured by Black Diamond of Salt Lake City, Utah. The product is used by back country skiers and other winter sports enthusiasts to decrease the probability of suffocation in the event of being buried in an avalanche. The product has been sold for close to a decade, and has evolved over the years. The production line, however, has evolved very little and has not advanced sufficiently to accommodate the demand, nor to address occupational safety and ergonomic issues associated with its manufacture. While traditionally it has been manufactured in batch orders with no dedicated assembly area or specialized production equipment, this is no longer sufficient to support the manufacture of the product at its current demand. The purpose of this project is to investigate the production line for the AvaLung™ in terms of ergonomics, safety, production efficiency, and worker comfort. The line was broken down into specific tasks, jobs, or “manned stations” and each one was evaluated in the areas discussed. Recommendations were made to Black Diamond, specifically for each task. These recommendations covered all reasonable abatements from a low-level / immediate action to higher level / future abatements that may require planning both in terms of engineering and economics.

INTRODUCTION

Anticipating increased production demands, a local company desired to address a production line in it’s facility in terms of safety and ergonomic factors, and to incorporate any reasonable safety procedures into the line as production needs increase. The goals of the project team were to investigate issues in regard to occupational safety and health, propose methods to resolve these issues, and ensure that the suggestions meet the goals of production output.

METHODS

Job Hazard Analysis

Each task on the production line was observed and entered into a Job Hazard Analysis (JHA) worksheet. The hazards or potential hazards were listed for each task, along with suggestions for eliminating or reducing the hazards. As a slight modification to the JHA, a priority rating was

given to each task (high, medium, low) to indicate the attention that should be given to that job task. Any task that received a ‘high’ priority rating was then selected as a Target Task.

Moore-Garg Strain Index

The target tasks were then analyzed using the Moore-Garg strain index for both current method and improved method, giving a reasonable idea of the effectiveness of the suggested hazard abatements.

	Task	Priority	Concerns	Proposed Solutions	Pros	Cons
1	Weld valve box	High	Pinch / crush hazard from horn coming down, excessive high frequency noise	1: enclose sonic welder to isolate noise and eliminate pinch hazard to neighboring workers 2: surround contact points with an interlock system 3: place shields (such as lexan) on either side of sonic welder to prevent neighboring workers from accessing pinch points	noise hazard/irritation removed from general work area; compliance with guarding regulations further protection for worker; eliminates hazard for neighboring workers; compliance with guarding regulations compliance with guarding regulations; relatively inexpensive; quick/immediate abatement; able to manufacture in house	cost; obstacle to one piece flow design—requires forethought expense; may not be able to be manufactured in house noise hazard not eliminated
2	Air flow test	High	Pinch / crush hazard from test machine closing	1: place shields (such as lexan) on either side of sonic welder to prevent neighboring workers from accessing pinch points	compliance with guarding regulations; relatively inexpensive; quick/immediate abatement; able to manufacture in house	no foreseen cons
3	Placing tube inside a tube: "intake assembly" (particularly piercing tubing with "hook" manually)	High	Punctures, blunt force trauma to hand / fingers, fine motor movements with force	1: Update standard work instructions 2: redesign a tool to aid in threading of tube (alligator clip on a long handle) 3: replace tubing with a more structurally robust tubing (such as one with a wire mesh embedded)	reduce confusion; eliminate "hook of death"	none foreseen none foreseen costs associated with replacing tubing; possible need to recertify design
			Standard work instructions do not match what is currently done	4: update standard work instructions or retrain workers	ensures consistency, avoids confusion	none foreseen
4	Avalung Valve Box Connection (including Align and Fasten Clamps)	High*	Awkward ergonomic posture, high force trauma, UECTD, pinch / crush from crimper; "hanging" crimper is in the way	1: provide a tool/fixture to hold the valve box so worker has two hands to attach tubing to valve box 2: design tool to push tubing onto valve box 3: move crimper from hanging position and anchor to table 4: guard all pinch points	 elimination of shoulder stress from reaching; crimper is no longer swinging and in the way compliance with guarding regulations; increased safety to worker	 loss of table space (may not actually be a problem) none foreseen

Figure 1: JHA for Target Tasks

RESULTS

As can be seen from the JHA, there were four Target Tasks:

1. Welding the valve box
2. Testing the valve box
3. Constructing the intake assembly
4. Assembling the valve box connection

Weld valve box

Two clam-shell plastic pieces are welded together using a sonic welding machine to create what is called the valve box. The concern is the noise produced during the welding process, and radiates both near the production line and also through the facility creating an uncomfortable workplace as well as a hearing injury potential. There is also a second concern regarding the sonic welding machine due to the lack of guarding around the horn as it clamps down on the part. Although there is a two-hand control for the machine, it is near to other workstations along the line and a neighboring worker is at risk for a pinch / crush injury. The following suggestions were made to reduce or eliminate the hazards:

- Explore the feasibility of replacing the welding process with glue.
- Install a guard system around the welder to minimize the access to moving parts.
- Consider redesigning the valve box: perhaps a snap together clam shell could work. (Explore options)
- Improve the sound isolation of the machine.

Test valve box

The valve box is placed in a machine for testing. This presents a hazard due to the lack of guarding around moving parts. Once again, a two-hand control is implemented on the machine, but neighboring workers are at risk for the injury. Suggested hazard abatements:

- Build a box to guard moving parts. Box is open at the bottom to allow the operator access, but greatly reduces the risk to near by workers.
- Install shielding or light curtain to protect adjacent workers.

Construct intake assembly

The intake assembly presents a cut or puncture hazard. The process involves placing one tube inside another tube in order to achieve more robustness. This is done by piercing one tube with a makeshift hook, then fishing the pierced tube through the outer tube using a wire attached to the hook. This process also exposes the worker to Work Related Muscular Skeletal Disorders (WRMSDs). Suggested hazard abatements:

- To eliminate the puncture hazard, replace the hook with an alligator clip or similar tool.
- Consider eliminating the current tube design and search for an alternative that achieves the goal of robustness, thus eliminating this task altogether.

Valve box connection

The valve box is connected to the intake assembly by sliding the tube over a tightly fitting attachment port on the box. This is done manually with no tooling, creating very high forces on the hands and arms. The workers often use awkward postures in order to achieve the forces necessary to achieve this job. Suggested hazard abatements:

- Provide (build of necessary) tooling to reduce the forces necessary to attach the tubing to the box. Ensure that the worker has both hands available to do the task.

- Investigate the possibility of tooling which attaches the tube to the box, eliminating the worker from this task.
- Consider redesigning the valve box at the attachment points.

Evaluation of Target Tasks using the Moore-Garg Strain Index

Two of the four target tasks (intake assembly process and making the valve box connection) were high risk for work-related musculoskeletal disorders (WRMSDs). Therefore, an evaluation of the proposed changes to these jobs was done by applying the Moore-Garg Strain Index to the pre-abatement tasks (as they are now) and also to the tasks assuming the suggested hazard abatements are applied.

The Moore-Garg Strain Index is a tool used to assess job risk in terms of WRMSDs of the distal upper extremities by applying six variables to a task in order to attain the SI score. Simply put, these variables are intensity of exertion, duration of effort, rate of exertion, posture, speed of work, and total daily exposure. The tasks are scored using these variables and compared to a standard scale to achieve a multiplier for each variable. The SI score is then the product of the multipliers. For a thorough treatise on the SI method, see “The Strain Index: a proposed method to analyze jobs for risk of distal upper extremity disorders” (Moore and Garg, 1995).

The SI score for the two WRMSD tasks indicates that the recommendations will in fact decrease the exposure to injury. The SI score for the intake assembly task was reduced from a score of 6.75 to 2.25, while the valve box connection showed a reduction from 6.0 to 1.69.

DISCUSSION

This production line has been in operation for a few years and with the anticipated increase in demand, there now exists an advantageous window of opportunity to improve the line making it safer and more efficient. The simple improvements suggested have a large payoff for small effort and will be a good start to a continual monitoring and improvement process for the line. The results show that there are several areas along this line that give opportunity for improvement in terms of general safety as well as ergonomic improvements to prevent time related injuries. Along with simple improvements in housekeeping and line design, the suggested improvements will help reduce injuries, increase productivity, and improve the work environment.

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