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Ergonomic Risk Reduction and Labor Savings Involved with Manual Material Handling Reduction: A Case Study

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Abstract: Ergonomics can spark debate, especially when it comes to spending money on capital equipment. In manufacturing, some managers view ergonomics as a useful aspect to their business, while others view ergonomics as "nice to have, as long as it doesn't cost money". Many ergonomics projects do save money, while some ergonomics projects save significant financial impact. This paper describes one of these projects, and the resulting savings due to the implementation of the project. This paper will aid those safety professionals that need case study information to justify ergonomics as a cost-savings measure. The study of the ergonomic risks within the safety function leads to an even larger capital justification with very large labor savings.

Keywords: ROI, Ergonomic Risk Reduction, Project Justification

1. Introduction

A search of Google web hits for the terms "cost justification in ergonomics" equates to 435,000 hits. Using the search terms "ergonomics and ROI" yields 189,000 hits on Google. There's lots of information on the internet, some is more useful than others. Several authors have attempted to answer the question and suggest methods of cost justifying ergonomics. For example, Goggins, Spielholz, and Nothstein (2008) reviewed 250 case studies and suggested patterns of benefits from the ergonomic improvements. These benefits included less injuries, less lost work days, less workers 'compensation cost and increased productivity. Each case study suggested a pattern of decreased injury and injury costs and higher productivity. Each study in the collection had different numbers for a particular metric; say a range of lost time reduction from zero to 100 percent. Productivity changes could also range from zero to 80 percent. Nicholson, Smith and Mitchell (2006) prepared a summary of ergonomic studies which had productivity increases and injury reduction. The team was asked to find 25 case studies with financial payback as a result of ergonomics improvements in the UK. The authors found 21 such studies with another eight case studies with suggested cost savings, but no detail around the actual monies saved due to the project. The authors from the UK study concluded that there are probably four reasons for lack of cost-benefit analysis:

1. Cost-benefit analyses are difficult to conduct in the health and safety arena and it is very difficult to assign costs and benefits to ergonomics interventions.
2. Few organizations have the time to carry out such detailed measurements; they are more concerned with overcoming ergonomics problems and getting on with business, provided that the costs of so doing are within their budgets.
3. Few organizations study their operations in detail as long as they appear to be working satisfactorily.
4. Many organizations are unable to provide the necessary data, and in any case may be unwilling to support a thorough analysis of costs and benefits by an external body.

These and many other case studies are available on injury cost reduction and productivity gains from ergonomics improvements. Rick Goggins, an Ergonomist with Washington State Department of Labor & Industries and a member of the

Puget Sound Human Factors and Ergonomics Society, has gathered and detailed a listing of over 250 case studies on ergonomics cost savings. This listing, with the suggested savings can be downloaded from http://pshfes.org/cost-calculator.

2. Description of the Task

Manual material handling is a common task performed in all types of factories and distribution centers. Of course, some facilities have a lot less material handling than others. One common material handling job found in all types of facilities in the United States and other countries is palletizing. Employees will move a box or carton of a product from a conveyor, workstation to a pallet. Workers can also move product from one pallet to another or from a pallet to a shelf. Pallets are easy to move with powered industrial equipment and inexpensive to obtain. They are also interchangeable from supplier to customer, customer facility to distribution center, etc. In other words, pallets are everywhere. Pallets must be loaded and unloaded, which can involve manual material handling, which is the focus of ergonomic assessment and this paper.

In food processing plants, it can be common to use conveyors to move product from one area to another, and pallets may be useful to also move product within a facility. In Figure 1 below, a manual material handling task is illustrated. Totes of product weighing 60-80 pounds are moved from a conveyor to a pallet. When moving the totes, employees carry the totes to the pallet and stack them on the pallet. The employee will bend to place the first row of totes on the pallet and then build up the stack as totes are added. Depending on need, the totes are stacked to different heights and reaches up to shoulder level may result.

Figure 1. Existing handling method.

When analyzing this task from an ergonomics prospective, one must ask about potential improvements and the costs associated with those improvments. In manual material handling jobs, common improvement strategies include job rotation, using machancial cranes or other methods to move the tote to the pallet, or using some type of pallet lift, which is useful to raise the pallet and reduce the bending associated with loading the pallet. In food processing, each of these improvement strategies can be used to improve ergonomics. Each improvement strategy has an associated cost and each has a different level of injury risk reduction.

Is the particular task being described in need of ergonomic improvement? There are suggested methods of answering the question and for these type of repetitive manaul material handling tasks, the NIOSH lift equation can be useful. The NIOSH lift equation was developed in 1981 and suggests a relative risk for material handling tasks. The lift equation calculates the risk of strain on the back based on reaching, vertical lift range, lift frequency, coupling and twisting, resulting in a recommended weight limit (RWL) for the job. The RWL is the recommneded weight that a normal person should be able to lift under the measured conditions without sustaining a back injury. In addition, a Lifting Index (LI) is calculated based on these parameters and the resulting RWL. The LI is the actual product weight divided by the RWL and is a useful index for the actual versus recommended force or weight. For this particular task the following data was collected.

Table 1. NIOSH Lift Equation Data.

NIOSH Variables	Present State
Weight	70 pounds
Horizontal Reach	14 inches
Starting Load Height	32 inches
Travel Distance	26 inches
Lifting Frequency	2 boxes/minute
Twisting	0
Coupling	Good
Recommended Weight Limit (RWL)	20.7 pounds
Lifting Index (LI)	3.4

When using the NIOSH Lift Equation as a ergonomic assessment strategy, it is common to make judgements based on the RWL and it's corresponding LI. In this job, the RWL was less than the actual weight, and when the Weight divided by the RWL is computed, we get a LI of 3.4. NIOSH suggests that engineering or administrative improvements should be used to reduce the LI to 1.0. A score of 1.0 is considered safe for most employees.

Within this project, job rotation was considered. Job rotation will decrease the job exposure time and provide rest and recovery for the entire team of employees doing the job. Employee one will perform the job for one (1) to two (2) hours, then rotate to another job for the next two (2) hours that does not feature lifting. Job rotation is a very common ergonomics improvement strategy and provides rest and recovery from the lifting task. However; when changing the exposure time and recalculating the LI, the resultant score is lower, but not low enough. With an end goal of a LI of 1.0, or, practically speaking, at least a number close to 1.0, by limiting the exposure time or using a combination of job rotation and less exposure time will not yield the results.

Table 2. NIOSH Lift Equation Data.

NIOSH Data	Present State	Future State 1	Future State 2
Weight	70 pounds	70 pounds	70 pounds
Horizontal Reach	14 inches	14 inches	14 inches
Starting Load Height	32 inches	32 inches	32 inches
Travel Distance	26 inches	26 inches	26 inches
Lifting Frequency	2 boxes/minute	1 box/minute	1 box/minute
Twisting	0	0	0
Coupling	Good	Good	Good
Recommended Weight Limit (RWL)	20.7 pounds	23.9 pounds	28.1 pounds
Lifting Index (LI)	3.4	2.9	2.5

A safety team brainstormed other improvement possibilities. The entire use of totes was questioned, both from a safety and cost standpoint. The main focus was on using very basic lean concepts, and in this case, the same totes that are stacked on a pallet must be unstacked in a matter of hours or sometimes days. Once the whole idea of palletizing was questioned by the team, other ideas were formulated. The main focus quickly became tote usage. Instead of placing the product into totes and palletizing them, the idea of using a larger tote was brainstormed. The type and size tote is shown in Figure 2.

Figure 2. Suggested New Method.

By changing to a larger tote, the product can be conveyed and dropped directly into the tote, eliminating the manual material handling task. By eliminating the lifting task, the manual labor needed to move the totes was also not needed. By changing to the larger totes in several areas of the plant, the stacking and unstacking of the small totes was eliminated, both from an ergonomic risk standpoint and from a cost standpoint as well. Once the engineering details of the process flow were defined using the new method, cost savings were estimated. The team estimated that $100,000 was needed to add and change conveyors to make the change, and each of the affected employees could be moved to another department. The result of this project resulted in $723,360 less labor cost across all shifts in the plant. Once these two metrics were agreed upon, the resultant financial metrics could be estimated.

3. Financial Aspects of the Project

By applying the NPV method outlined in Stevens (1983), using the data estimated by the plant team, a Net Present Value (NPV) of $3,939,787 resulted from using input variables Capital Equipment Cost = $100,000, Minimum Attractive Rate of Return (MARR) = 0.04, and Labor Savings=$723,360, for an assumed six-year life of the project. The actual financial data is shown in Appendix 2, and is computed with an excel spreadsheet.

4. Conclusions

By changing the container from 70 pounds to over 1,000 pounds, less lifting and carrying are needed. The resultant cost savings makes this project a clear winner with labor savings of $723,360 USD per year. Too often, teams are rushed to get moving on the next project and do not spend appropriate time on savings metrics. Also, in this case, the ergonomics metrics used, namely the NIOSH Lift Equation, suggested that the manual method could not be improved to the point where the team deemed the risk sufficient for the organization. The lessons learned from this project should be clearly stated. Ergonomics metrics should be used in parallel with relevant financial models to achieve a two-pronged approach to benefits.

5. References

Goggins, R., Spielholz, P. & Nothstein, G. (2008). Estimating the effectiveness of ergonomics interventions through case studies: implications for predictive cost-benefit analysis. Journal of Safety Research 39. 339–344.

Hendrick, H., (2003) Determining the cost-benefits of ergonomics projects and factors that lead to their success, Applied Ergonomics. 2003 Sep;34(5):419-27.

Nicholson, A, Smith, C., Mitchell, A., (2006) Cost benefit studies that support tackling musculoskeletal disorders, HSE Report 491, St Clements House, 2-16 Colegate, Norwich NR3 1BQ.

Stevens, G.T., (1983) Engineering Economy, Reston Publishing Company, Reston, VA.

Goggins, R., (2012) Ergonomics Cost-Benefit Case Study Collection, Downloaded from http://pshfes.org/cost-calculator.

Appendix 1: NIOSH Lift Equation Calculation

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NIOSH Lifting Equation

Significant Control at Destination? ○ Yes ◉ No

Units: ◉ US Customary (in) ○ Metric (cm)

	Origin		
	Measurement		Multiplier
Horizontal Location: Distance from the midpoint between the ankles to the center of the load	14.0	in	0.71
Vertical Location: Distance from the floor to the mid-point between the hands	32.0	in	0.99
Vertical Travel Distance: Vertical distance between the start and end points of the lift	26.0	in	0.89
Asymmetric Angle: Angle between the asymetry line and the mid-sagittal line	0.0	deg	1.00
Duration: Length of continuous work time	8.0	hrs	
Frequency: Number of lifts per min	2.0	lifts/min	0.65
Coupling: Gripping method	Good		1.00
Weight: Observed weight of the load	70.0	lbs	
RWL: Recommended Weight Limit	20.7	lbs	
Lifting Index:	3.4		

Overall Lifting Index: 3.4   Clear

Recommendation: Engineering or Ergonomic redesign should be considered

Error Messages:

Lift Number: 3   Save

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Appendix 2: Financial Calculations

Cost Benefit Analysis of Ergonomic or Safety Improvements

Company Name:			
Location:			
Presented to:			
Description of ***problem being controlled***			
Description of ***controls being considered***			
Comments:			
Payback Period (in years):			**0.16**
Net Present Value (NPV):			**$3,939,787**
Internal Rate of Return (IRR):			**Initial Savings are greater than the initial investment**
Return on Investment (ROI):			**42.41**
Analysis performed by:	Richard Wyatt	**Date:**	3/9/16

Fill in all information in yellow and results will be calculated automatically

A =	Average current cost of incident being addressed (site specific if possible)		$ 0	
B =	Number of incidents that these controls are likely to prevent each year		1	
	Avoidable Costs:		**Per accident**	**Per year**
	Direct avoided costs (A X B = AB)		$ 0	$ 0
	Indirect avoided costs:			
	Productivity:			
	Productivity Loss of replacement worker			$ -
	Decreased productivity of an employee after an incident		$ -	$ -
	Time:			
	Increased supervisory attention to job			$ -
	Administrative time related to the incident (investigation, paperwork, etc.)		$ -	$ -
	Other:			
	Replacing workers (hiring, orientation, post offer testing)		$ 723,360	$ 723,360
	Overtime		$ -	$ -
	Number of hours employee is absent prior to Workers Compensation X Employees Wage /hr =		$ -	$ -
	Other (define)		$ -	$ -
	Other (define)		$ -	$ -
	Possible Savings (PER YEAR) as sum of possible costs avoided			$ 723,360
	Potential Savings assuming the recommended control allows for a 100% reduction in avoidable costs			$ 723,360
	Control Costs:			
	Total initial cost to implement controls			$ 100,000
	Capital	$ 100,000		
	Installation			
	Training			
	Other (define)			
	Initial productivity improvements as a result of process change			
	Net initial cost of controls			$ 100,000
	Annual cost of maintaining controls			$ -
	Maintenance			
	Training			
	Other (define)			
	Annual Productivity Improvements			
	Net annual cost of controls			$ -
	Residual value of controls at end of period			$ 1,000
	Life expectancy of controls in years		6	
i =	Expected average inflation rate during the life expectancy of the controls being considered in %		1%	
r =	Company minimum acceptable rate of return on an investment (i.e., "discount rate") in %		4%	

Disclaimer: The financial results presented above are an approximation of an outcome based on the data supplied the worksheet. This program does not guarantee these results will be achieved.

Notes:
1. Potential Savings (benefits) are treated as cash flows in the formulas used to calculate the Payback Period, NPV and ROI.
2. Both time value of money and inflation factors are involved in the calculations, including the Payback Period calculation.
3. No depreciation or tax consequences are involved in any of the calculations.
4. Costs and Benefits are both assumed to occur at the beginning of the period because costs are paid immediately and the benefits are potential savings (or money not spent on claims that can be directed towards other expenses during the year).
5. Claim savings are assumed to be constant and last for the expected life of the control.
6. IRR will not be calculated if there is not an initial Cash Outflow.

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