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Title: 2005 ACGIH Lifting TLV: Employee-Friendly Presentation and Guidance for Professional Judgment

Author(s): Splittstoesser, Riley
O'Farrell, Daniel Edward
Hill, John
McMahon, Terrence
Sastry, Nikhil
Tiemeier, Mark

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2005 ACGIH Lifting TLV: Employee-Friendly Presentation and Guidance for Professional Judgment

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Prepared by:

Energy Facility Contractor's Group (EFCOG)
Industrial Hygiene and Safety Task Group's
Ergonomics Project Team

Riley Splittstoesser[1], Dan O'Farrell[1], John Hill[2], Terrence McMahon[3], Nikhil Sastry[3], Mark Tiemeier[3]

[1] Los Alamos National Laboratory
[2] Savannah River Site
[3] SLAC National Accelerator Laboratory

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Abstract

The American Council of Governmental Industrial Hygienists (ACGIH) Lifting Threshold Limit Values (TLVs) provide a tool to reduce incidence of low back and shoulder injuries. However, application of the TLV is too complicated for floor-level workers and relies on professional judgment to assess commonly encountered tasks. This paper presents an Employee-Friendly Simplified Format of the TLV that has been adapted from Table 1 of the Lifting TLV presented in the 2005 TLVs and BEIs Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices. This simplified format can be employed by floor-level workers to self-assess lifting tasks. The Ergonomics Project Team also provides research-based guidance for applying professional judgment consistent with standard industry practice: Extended Work Shifts – Reduce weight by 20% for shifts lasting 8 to 12 hours; Constrained Lower Body Posture – Reduce weight by 25% when lifting in such postures; Infrequently Performed Lifts – Lift up to 15 lbs. ≤3 lifts per hour within the zones marked “No safe limit for repetitive lifting” in the TLVs Table 1; Asymmetry beyond 30° – Reduce weight by 10 lbs. for lifts with up to 60° asymmetry from sagittal plane.

Introduction

In the modern workforce, low back pain (LBP) and/or shoulder pain is common and extremely costly with incidences related to work activities (Bernard 1997; Liberty Mutual 2016). The 2005 ACGIH Lifting TLV is the primary tool used to assess lifting tasks governed by 10 CFR 851. The TLVs are based on biomechanical, psychophysical and epidemiologic studies and recommends lifting conditions under which it is believed nearly all workers may be repeatedly exposed without developing work-related low-back and shoulder disorders related to repetitive lifting (ACGIH 2005). While the 2005 ACGIH Lifting TLVs compare well to other lift assessment tools (Russell et al. 2007), the TLV still requires 1) a trained professional to properly apply it, and 2) relies on professional judgment for situations commonly encountered in Department of Energy (DOE) laboratory facilities. These two issues limit our ability to train workers to identify unsafe lifting conditions and create challenges for safety professionals seeking to consistently apply the TLV to create safe lifting scenarios. In this paper, the Ergonomics Project Team presents research-based guidance for an Employee-Friendly Simplified Format lifting assessment that accommodates the TLV and is useable by all workers, as well as provide recommendations to safety professionals who can use it to consistently apply professional judgment.

Discussion

Problem Statement #1

Despite the effectiveness of the ACGIH Lifting TLV at reducing Injury Risk, its complexity prevents the workforce from using it to identify increased risk jobs.

The ACGIH Lifting TLV is intended for use by trained safety professionals such as Ergonomists, Industrial Hygienists and Safety Specialists rather than by floor-level employees. Unfortunately, safety professionals are only able to evaluate a small percentage of daily lifts in most facilities. Floor-level employees are often relied upon to decide whether to request an evaluation based on their safety training or "common sense" rules such as a single arbitrarily determined safe weight for lifting. An Employee-Friendly Simplified Format assessment tool is needed that remains within TLV guidelines and that workers can use to self-identify lifting tasks that may exceed the TLV. This will allow safety professionals to focus their time on lifting tasks that require their increased level of expertise to properly assess. Such an assessment tool should be simple for workers to remember, easy for them to apply and provide a conservative estimate so they correctly identify tasks they are able to perform within the guidelines of the TLV.

Problem Statement #2

The ACGIH Lifting TLV recommends professional judgment be used to reduce weight limits below those recommended in the TLVs in the presence of specific factors or working conditions.

Safety professionals are accustomed to exercising professional judgment when working conditions exist that may present risk to the workforce, yet are not specifically covered by existing rules. Generally, safety professionals attempt to use evidence-based guidelines and standard industry practice to inform their decisions in these situations. The Ergonomics Project Team attempted to compile such evidence-based guidelines and standard industry practices to provide guidance to safety professionals evaluating working conditions that involve infrequently performed lifts within zones the TLV labels, "No known safe limit for repetitive lifting," extended work shifts, asymmetric lifting and constrained lower body postures.

Recommendations

Employee-Friendly Simplified Format adapted from the 2005 ACGIH Lifting TLVs

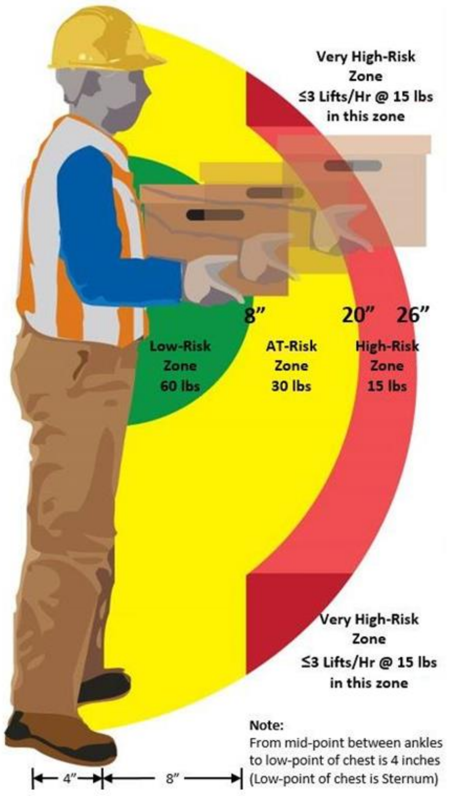
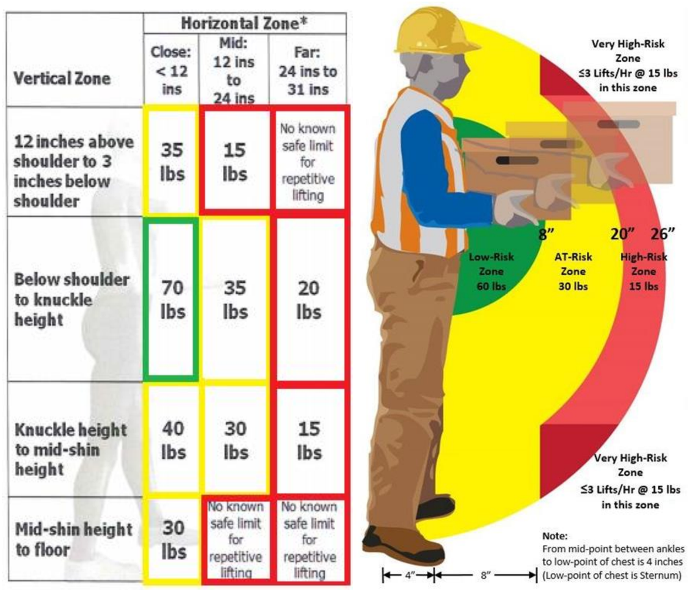


Figure 1. Simplified format of 2005 ACGIH lifting TLVs Table 1.

The Ergonomics Project Team concluded that the majority of lifting that take place in DOE facilities falls within the repetition boundaries of the ACGIH Lifting TLVs Table 1. Therefore, an Employee-Friendly Simplified Format of Table 1 was created (Figure 1). The Ergonomics Project Team recommends teaching floor-level employees to apply the methodology below for lifting tasks: $\leq$ 2 hours per day with $\leq$ 60 lifts per hour, OR > 2 hours per day with ≤ 12 lifts per hour, that otherwise do not contain any of the factors or working conditions in which the ACGIH lifting TLV calls for professional judgment.

The Simplified Format employs a three-arc color-coded lifting zone graphic shown in Figure 2 that delineates the vertical and horizontal ranges for each colored lifting zone.

The Simplified Format attempts to use existing safety formats to present information in a way most likely to be familiar to floor-level workers. The three standardized lifting zone arcs are commonly used by safety and health professionals to teach employees about load positioning during lifting. The three colors are used as standard representations created by lifting within that arc relative to the body – Low-Risk (Green), Moderate-Risk or At-Risk (Yellow) and High-Risk (Red). It is important to note that acceptably safe lifts can be performed in each arc provided they are below the weight limit for that zone. The term "Risk" is used here to cause increasing scrutiny of lifts with rapidly decreasing acceptable weight due to their increased "Risk" zones. Each zone arc is assigned an easy to remember weight limit at or below the corresponding lifting limit on Table 1 of the TLV. Figure 2 shows a side-by-side view demonstrating how the color-coded lifting zone arcs of the Simplified Format on the right align with the TLV Table 1 lifting zones on the left using a color-coded overlay. Note that the weight limits on the Simplified Format are at or below the weight limits on TLV Table 1.



Vertical Zone	Horizontal Zone* Close: < 12 ins	Mid: 12 ins to 24 ins	Far: 24 ins to 31 ins
12 inches above shoulder to 3 inches below shoulder	35 lbs	15 lbs	No known safe limit for repetitive lifting
Below shoulder to knuckle height	70 lbs	35 lbs	20 lbs
Knuckle height to mid-shin height	40 lbs	30 lbs	15 lbs
Mid-shin height to floor	30 lbs	No known safe limit for repetitive lifting	No known safe limit for repetitive lifting

Figure 2. Comparison of the data from the ACGIH lifting TLV's Table 1 and the Simplified Format (adapted from ACGIH (2007))

Lifts performed in the Low-Risk (green) zone have a 60-lb. lift limit, the Moderate-Risk/At-Risk (yellow) zone lift limit is half the green zone limit, and the High-Risk (red) zone lift limit is half the yellow zone limit. By using this method, employees only need to remember one lifting limit and perform simple division to remember the other two lifting zone limits.

Anatomical markers were used to make the Simplified Format consistent with the TLV. As shown at the bottom of Figure 1, the anatomical marker to determine the distance away from the body that the load is positioned is the low-point of the chest at the sternum (xyphoid process) rather than the mid-point between the ankles. The low-point of the sternum is easier for employees to judge distance between the body and the center of the load between the hands. When lifting in many postures it is difficult to judge the distance from the mid-point between the ankles to the center of gravity for the load because the load and the body visually block the mid-point between the ankles. In the Simplified Format it is assumed an average distance of approximately 4 inches from the center of the spine's L5/S1 intervertebral disc to the front of the body at the xyphoid process as an adjustment for a 95th percentile mixed gender population. This allows the Simplified Format arcs to be constructed by subtracting 4 inches from each of the horizontal zone distances on the TLV to arrive at an adjusted horizontal distance. As shown in Figure 2, 12 inches on the TLV table from the mid-point between the ankles to the endpoint of the Low-Risk (green) zone corresponds to an 8-inch distance from the low-point of the chest to the end of the green zone in the Simplified Format.

Figure 2 also contains two "Very High-Risk" zones, which use the same weight limit as the High Risk zones with lower permitted lifting frequency. The rationale for these zones are explained in more detail in the Professional Judgment section below.

Finally, the ACGIH TLV recommends applying professional judgment to lifting limits if lifting more than 30° away from the sagittal plane. As estimating asymmetry is a challenging task even for safety professionals, the Ergonomics Project Team recommends employees be trained to subtract 10 lbs. from the Simplified Format lifting limit if their torso is "noticeably twisted" during lifting. Additional discussion is in the Asymmetry Beyond 30° section below.

Professional Judgment in Applying the TLV

The original 2005 TLVs and BEIs Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices presents recommend workplace lifting conditions under which it is believed nearly all workers may be repeatedly exposed, day after day, without developing work-related low back and shoulder disorders. These TLVs are limited to two-handed, mono-lifting tasks within 30° of the sagittal plane, performed for up to 8 hours per day. However, there are a number of situations where the authors of the TLV call upon the professional judgment of the safety professional applying the lifting TLV to reduce the TLV weight limits below those listed in the TLV tables. In this section, we present guidance based on research and standard industry practice for adapting the TLV to account for Extended Work Shifts, Constrained Lower Body Posture, Infrequently Performed Lifts, and Asymmetry Beyond 30º.

Extended Work Shifts

Many DOE facilities offer work schedules involving 9- or 10-hour workdays. The ACGIH TLV calls for professional judgment in applying Table 1 to work shifts that extend beyond 8 hours. There is limited information on the effects of extended work shifts on manual material handling capacity (Caruso et al. 2004). Using the maximum acceptable weight of lift and energy expenditure data from Mital (1984)'s psychophysical comparison of 8- and 12-hour shift lengths, the Ergonomics Project Team recommends reducing the ACGIH lifting TLV weight by 20% for shifts lasting 8 to 12 hours.

Constrained Lower Body Posture

Many worksites have lifting tasks that involve constrained lower body postures, such as stooping, squatting, sitting and kneeling, due to loads not being directly accessible in front of an individual at waist level. Constrained lower body postures during lifting often cause substitution patterns in muscle activation where fewer large muscle groups are activated (e.g., glutes, hamstrings, quadriceps). This results in increased muscle load on the remaining major muscle groups, increased activation by smaller, less effective muscle groups, and increased spinal loading (Gallagher et al. 1988; Potvin et. al. 1991; Gallagher et al. 2002). A review of the research outlined in Appendix 1 – Research Into Constrained Lower Body Posture, suggests reducing the ACGIH TLV recommended lifting weight by 25% when lifting in a constrained lower body posture.

Infrequently Performed Lifts

An adjustment to the Simplified Format involving professional judgment guidance is the addition of two “Very High-Risk” zones. The TLV does not list weight limits for these areas stating instead: “No known safe limit for repetitive lifting.” The TLV indicates routine lifting tasks should not be performed in these areas and recommends professional judgment be used to determine if infrequent lifts of light weights is acceptable (ACGIH 2005). The psychophysical literature suggested weight limits of approximately 15 lbs. in the similar zones to the “No known safe limit for repetitive lifting” zones from the TLVs in Table 1 (Snook et al. 1991). The Ergonomics Project Team further applied a 75% safety factor to the frequency limits in adjacent zones within the TLV and in similar zones found within the psychophysical literature. Therefore, the lifting limits used on the Simplified Format for the High-Risk and Very High-Risk (red) zones are set to 15 lbs. with the High-Risk zone using 12 lifts per hour as the frequency, and the Very High-Risk zones using the adjusted frequency of ≤3 lifts per hour as shown on the right side of Figure 2.

Asymmetry Beyond 30°

Asymmetric lifts beyond 30° away from the sagittal plane occur in DOE facilities. While the preferred intervention is to alter the workplace layout to reduce this asymmetry, often these asymmetries cannot be reduced below 30°. The Ergonomics Project Team investigated the Asymmetric Multiplier employed in the Revised NIOSH Lift equation as well as the workplace design guidelines employed by the Ohio Bureau of Worker’s Compensation in asymmetric situations beyond 30° (Waters et. al. 1994; Marras et. al. 1999; Ferguson et al. 2005). Both tools would reduce the maximum ACGIH TLV limit to approximately 50 lbs. from a maximum of 60 lbs. Therefore, the Ergonomics Project Team recommends a conservative reduction of 10 lbs. from the ACGIH TLV for lifts with up to 60° asymmetry from the sagittal plane.

Call for Additional Research Investigation

The Ergonomics Project Team was unable to investigate all factors and working conditions that require professional judgment in application of the ACGIH Lifting TLV. In particular, the Team noted the following factors and working conditions occur frequently in DOE facilities and warrant priority for future investigation: One-Handed Lifting, Team Lifting, Poor Hand Coupling, Unstable Footing and Lifting During High Heat and Humidity.

Conclusions

A Simplified Format is presented herein that floor-level workers can use to self-assess some lifting tasks and prioritize other tasks for Safety Professionals to perform a full evaluation upon using the ACGIH Lifting TLV. In addition, the Ergonomics Project Team provides the following guidance for applying professional judgment in the following areas:

- Extended Work Shifts – Reduce ACGIH Lifting TLV weight by 20% for shifts lasting 8 to 12 hours.
- Constrained Lower Body Posture – Reduce ACGIH lifting TLV weight by 25% when lifting in a constrained lower body posture.
- Infrequently Performed Lifts – Lift up to 15 lbs. at ≤3 lifts per hour within the zones marked, "No safe limit for repetitive lifting," in the ACGIH Lifting TLVs Table 1.
- Asymmetry Beyond 30° - Reduce ACGIH lifting TLV weight by 10 lbs. for lifts performed >30° and up to 60° asymmetry from the sagittal plane.

Appendix 1 – Research Into Constrained Lower Body Posture

A brief summary of the research investigated for lifting in constrained lower body postures is presented below.

Gallagher Sean, William S. Marras, and Thomas G. Bobick. "Lifting in stooped and kneeling postures: effects on lifting capacity, metabolic costs, and electromyography of eight trunk muscles." International Journal of Industrial Ergonomics 3.1 (1988): 65-76.

- Stooped posture substantially increases the force experienced by the intervertebral discs of the spine.
- Kneeling posture often results in a twisting motion of the trunk to accomplish a lift.
- Three approaches have traditionally been used to determine the stresses imposed on workers performing manual materials handling (MMH) tasks: psychophysical, psychological, and biomechanical.
- Majority of subjects were able to handle more weight stooped compared to kneeling.
- Despite the fact that less weight was lifted in the kneeling posture, the physiological demands of lifting in this posture were higher than in the stooped posture.
- Psychophysical lifting capacity is reduced in kneeling posture compared to the stooped position.
- The difference in lifting capacity may be due to the fact that fewer muscles can be recruited to perform the lift when kneeling. It is apparent that the large, powerful muscle groups of the legs are not able to contribute a great deal of useful force when lifting in the kneeling posture. This means the work of lifting must be performed primarily by the muscles of the upper body, particularly shoulder and arm muscles and muscles associated with extension of the vertebral column. The back muscles would be expected to provide a substantial increase in force output to execute the lift.
- Analysis of the integrated electromyographic activity of the trunk muscles appears to confirm the erectors spinae are called upon to provide a larger component of the lifting force in the kneeling posture than when lifting in the stooped position. This finding leads one to speculate the compressive load on the spine due to contraction of these muscles may be considerably higher when kneeling.
- The acceptable weight of lift for the stooped posture for this sample of healthy underground miners is 25.7 kg (56.6 lbs.) while the acceptable weight of lift for the kneeling posture is 20.4 kg (45 lbs.).

Yates, J. W., and W. Karwowski. "An electromyographic analysis of seated and standing lifting tasks." Ergonomics 35.7-8 (1992): 889-898. Sitting lifting results in greater stress in the low back, upper back, and shoulders than does lifting while standing.

- Data presented suggest lifting tasks performed in a sitting position result in more muscle activity, hence more stress, than those performed in a standing position.

- Using the psychophysical method of determining the maximum acceptable weight of lift, subjects selected 1-4 kg less weight during sitting lifting when compared to the standing lifting at a frequency of one lift per min.

Yates, J. W., and W. Karwowski. "Maximum acceptable lifting loads during seated and standing work positions." Applied Ergonomics 18.3 (1987): 239-243.

- When sitting, subjects lifted 8-25% less than when in standing positions (average difference of 16%).

Fathallah, F. A., J. M. Meyers, and I. Janowitz. "Stooped and Squatting Postures in the Workplace Conference Proceedings." University of California Center for Occupational and Environmental Health, Oakland, California (2004). Downloaded August 2016 from *http://nasdonline.org/1917/d001873/stooped-and-squatting-postures-in-the-workplace-july.html.*

Gallagher, Sean, and Christopher A. Hamrick. "Acceptable workloads for three common mining materials." Ergonomics 35.9 (1992): 1013-1031.

Gallagher, Sean, et al., "Torso flexion loads and the fatigue failure of human lumbosacral motion segments." Spine 30.20 (2005): 2265-2273.

Gallagher, Sean, et al. "Effects of posture on dynamic back loading during a cable lifting task." Ergonomics 45.5 (2002): 380-398.

- Sean Gallagher of NIOSH also presented research on the effects of MMH in stooped, squatting and kneeling postures in vertically-restricted spaces on spinal load and on worker performance. Such postures predominate in workspaces such as low-seam coal mines, airplane cargo holds, and utility tunnels. Research on lifting in kneeling yielded decreased lifting ability compared to stooped and standing postures. Psychophysical studies have shown there is a 10-20% reduction in lifting capacity when kneeling as compared to either stooping or standing erect, which were comparable to one another. A study of trunk extension strength when kneeling showed a decrease of 18% compared to standing, due to the loss of lower leg assistance when lifting in the kneeling posture. Moderate vertical space restrictions cause workers to stoop or squat, which increases the torque on the spine compared to standing. Further vertical restriction forces workers into a kneeling posture, which also produces much higher spine loads than standing. The results of these studies indicate all three awkward postures (stooped, squatting, and kneeling) increase the load on the spine.

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