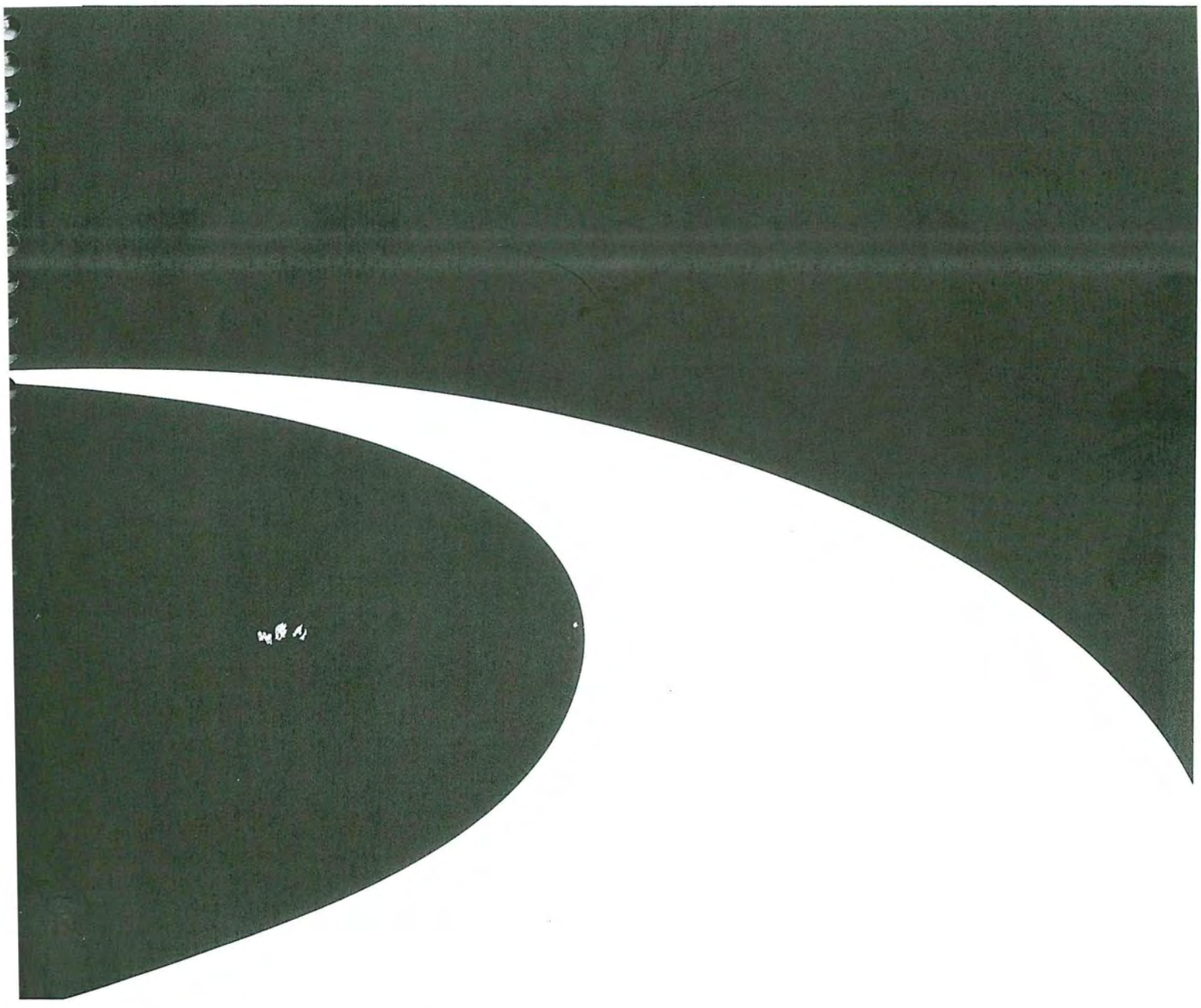
AIAG

Automotive Industry Action Group

OHS-5

Ergonomics Guidelines for Small Lot Delivery Systems



ABOUT AIAG

Purpose Statement

Founded in 1982, AIAG is a globally recognized organization where OEMs and suppliers unite to address and resolve issues affecting the worldwide automotive supply chain. AIAG's goals are to reduce cost and complexity through collaboration; improve product quality, health, safety, and the environment; and optimize speed to market throughout the supply chain.

AIAG Organization

AIAG is made up of a board of directors, an executive director, executives on loan from member companies, associate directors, a full-time staff, and volunteers serving on project teams. Directors, department managers and program managers plan, direct, and coordinate the association's activities under the direction of the executive director.

AIAG Projects

Volunteer committees focus on business processes or supporting technologies and methodologies. They conduct research and develop, publish, and provide training on standards, conventions, standard business practices, white papers, and guidelines in the areas of automatic identification, CAD/CAM, EDI/electronic commerce, continuous quality improvement, health focus, materials and project management, occupational health & safety, returnable containers and packaging systems, transportation/customs, and truck & heavy equipment.

AIAG PUBLICATIONS

An AIAG publication reflects a consensus of those substantially concerned with its scope and provisions. An AIAG publication is intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of an AIAG publication does not in any respect preclude anyone from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the publication.

CAUTIONARY NOTICE

AIAG publications are subject to periodic review and users are cautioned to obtain the latest editions.

MAINTENANCE PROCEDURE

Recognizing that this AIAG publication may not cover all circumstances, AIAG has established a maintenance procedure. Please refer to the Maintenance Request Form at the back of this document to submit a request.

Published by:
Automotive Industry Action Group
26200 Lahser Road, Suite 200
Southfield, Michigan 48033
Phone: (248) 358-3570 • Fax: (248) 358-3253

APPROVAL STATUS

The AIAG Safety, Health and Environmental Steering Committee and designated stakeholders approved this document for publication on March 14, 2007.

AIAG COPYRIGHT AND TRADEMARK NOTICE:

The contents of all published materials are copyrighted by the Automotive Industry Action Group unless otherwise indicated. Copyright is not claimed as to any part of an original work prepared by a U.S. or state government officer or employee as part of the person's official duties. All rights are preserved by AIAG, and content may not be altered or disseminated, published, or transferred in part of such content. The information is not to be sold in part or whole to anyone within your organization or to another company. Copyright infringement is a violation of federal law subject to criminal and civil penalties. AIAG and the Automotive Industry Action Group are registered service marks of the Automotive Industry Action Group.

© 2007 Automotive Industry Action Group

AIAG OCCUPATIONAL HEALTH & SAFETY DISCLAIMER

AIAG documents are developed through a consensus process. Consensus is established when substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered and that a concerted effort be made toward resolution. This process brings together volunteers and/or seeks out the views of persons who have an interest in the topic covered by this publication. While AIAG administers the process and establishes procedures to promote fairness in the development of consensus, it does not write the document and it does not independently test, evaluate, or verify the accuracy or completeness of any information or the soundness of any judgments contained in its standards or guidelines.

AIAG Guideline and Standard Documents are for voluntary use by the Automotive Industry; their existence does not in any respect preclude anyone, whether they have approved the Documents or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the Documents. However, users, distributors, regulatory bodies, certification agencies, and others concerned may apply AIAG Guidelines and Standards as mandatory requirements in commerce and industry.

AIAG makes no warranty, either expressed or implied, as to the fitness of merchantability or accuracy of the information contained within this document, and disclaims and makes no warranty that the information in this document will fulfill any of your particular purposes or needs. AIAG disclaims liability for any personal injury, property, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, application, or reliance on this document. AIAG does not undertake to guarantee the performance of any individual manufacturer's or seller's products or services by virtue of this standard or guide, nor does it take any position with respect to the validity of any patent rights asserted in connection with the items which are mentioned in or are the subject of this document, and AIAG disclaims liability for the infringement of any patent resulting from the use of or reliance on this document. Users of this document are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

In publishing or making this document available, AIAG is not undertaking to render professional or other services for or on behalf of any person or entity, nor is AIAG undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment, or as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

AIAG has no power nor does it undertake to police or enforce conformance to the requirements of this document. AIAG does not certify, test, or inspect products, designs, or installations for safety or health purposes. Any certification or other statement of conformance to any health- or safety-related information in this document shall not be attributable to AIAG and is solely the responsibility of the certifier or maker of the statement.

FOREWORD

With the advent of lean manufacturing and small lot delivery systems, material handling has evolved from a mechanized system to a primarily manual system for many in the automotive industry. As a result, there are increased physical demands imposed on material handlers.

In response, auto industry manufacturers are interested in applying sound ergonomic practices and principles to their material handling system designs. A common goal is to minimize ergonomics-related occupational risk factors and maximize system productivity.

The intent of this document is to assist manufacturers in achieving these goals. The recommendations relate to material handling system design, task design, and task ergonomic risk analysis.

Application of these guidelines should result in improved safety, performance, and productivity when properly administered.

Users of this guideline may include packaging engineers, industrial engineers, ergonomists, ergonomics coordinators, material handlers, supervisors, operators, and worker representatives.

Each AIAG member or SLDS Document User must assess their situation and determine the applicability of this document. Most will find it to be of significant benefit when designing small lot delivery systems. While the document may also serve as a useful tool to assess existing situations, things like pending model change, technology and cost issues, etc will all have to be decided by the using company.

ACKNOWLEDGEMENTS

Irv Chmielewski
Senior Consultant
IWConsultants

Carolin Bart, CCPE
Manager, New Programs Industrial Engineering & Ergonomics
DaimlerChrysler
Work Group Co-Chair

Robert Fox, PhD, CPE
General Motors Technical Fellow
Manager, Global Ergonomics Support Activity
General Motors Corporation

Chris Freeman
Ergonomics Specialist/Project Manager
Human Engineering Solutions

Laura Hardy
Corporate Manager, Ergonomics
Delphi Corporation

Arnold Love
Corporate H&S Manager
Visteon Corporation

Jack Lu, PhD, CPE
U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health

Bruce MacGregor
Senior Industrial Engineer
General Motors Corporation
Work Group Recorder

Jeffrey Mans
VP of Technology and Development
Human Engineering Solutions

Wayne Maynard, CSP, CPE
Director, Ergonomics & Tribology, Loss Prevention Department
Liberty Mutual Research Institute for Safety

Jim Potvin, PhD
Department of Kinesiology
McMaster University

Tami Rozovics
Project Coordinator
AIAG

Darius D. Sivin, PhD
International Union, UAW
Health and Safety Dept.
Document Coordinator

Troy K. Uahinui
Safety Assistant Manager
Toyota Motor Manufacturing N.A., Inc.

Scott Vandenbergh, M.Eng, PE
PTO Division Ergonomist
Ford Motor Company
Work Group Co-Chair

Thomas Waters, PhD
U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health

TABLE OF CONTENTS

ABOUT AIAG 1

FOREWORD 3

TABLE OF CONTENTS 5

INTRODUCTION 7

DOCUMENT OVERVIEW 7

1 SMALL LOT DELIVERY SYSTEM (SLDS) 9

1.1 BACKGROUND AND DESCRIPTION 9
1.2 ROLES AND RESPONSIBILITIES 11

2 ERGONOMIC GUIDELINES / RECOMMENDATIONS 13

2.1 ROLLER RACKS AND SHELVES 13
2.2 HORIZONTAL REACHES 17
2.3 CONTAINER AND TOTE CHARACTERISTICS 17
2.4 TUGGER AND TRAILER CHARACTERISTICS 20
2.5 DEPALLETIZING STOCK 20
2.6 MANUAL MATERIAL HANDLING TECHNIQUES 21

3 ANALYZING THE RISK OF CUMULATIVE MUSCULOSKELETAL INJURY (OR DISORDER) 22

3.1 BASIC DATA 22
3.2 INTERPRETING THE CLI 28
3.3 MAKING CHANGES 29
3.4 PREVENTING MUSCULOSKELETAL INJURIES AND DISORDERS 29

4 APPENDIX 30

4.1 EXAMPLE RESULTS OF A NIOSH CLI VS. LIFTS/HOUR ANALYSIS 30
4.2 OVERSIZE LOADS 32
4.3 GLOSSARY OF TERMS 37

Table of Tables

TABLE 1: SUGGESTED LOAD CORRECTIONS FOR OVERSIZED LOADS 27
TABLE 2: INTERPRETATION OF CLI VALUES 28
TABLE 3: LEFT HAND LIMITS FOR LONG LOADS 33
TABLE 4: LEFT HAND LIMITS FOR WIDE LOADS 35

Table of Figures

FIGURE 1: ACTIVITY DIAGRAM FOR SMALL LOT DELIVERY DECOUPLED SYSTEM 10
FIGURE 2: RECOMMENDED HAND HEIGHT/CONTAINER WEIGHT RANGES FOR SMALL LOT DELIVERY LIFTING/LOWERING TASKS 14
FIGURE 3: CONTAINER CLEARANCE 15
FIGURE 4: ROLLER BARS AT PICK END OF ROLLER RACK 16
FIGURE 5: VERTICAL AND HORIZONTAL REACHES 17
FIGURE 6: CONTAINER DIMENSIONS 18
FIGURE 7: ASYMMETRY 23
FIGURE 8. SAMPLE SMALL LOT DELIVERY ANALYSIS MANUAL MATERIAL HANDLING ACTIVITY DATA GATHERING WORKSHEET. 24
FIGURE 9. SCREEN VIEW OF NIOSH LIFTING GUIDELINES – JOB ANALYSIS 25
FIGURE 8: ILLUSTRATION OF CONTAINER LENGTH AND WIDTH PARAMETERS 28
FIGURE 9: NIOSH CLI VS. LIFTS/HOUR 31
FIGURE 10: ANALYSIS OF LONG LOADS 34
FIGURE 11: ANALYSIS OF WIDE LOADS 36

INTRODUCTION

Document Overview

This easy-to-use guideline provides not only a systematic process for analyzing and evaluating musculoskeletal injury (or disorder) risk factors in Small Lot Delivery Systems (SLDS) but also recommendations for the design of material handling tasks and material handling systems. This guideline contains recommendations, not mandates, which are applicable during material handling system 'design' and 'redesign' activities.

The scope of this document includes the following:

- Analysis of lift, lower, and carry tasks of full and empty containers
- Assessment of manual material handling jobs involving a combination of multiple different manually handled containers (weight, type, size, location, frequency)
- Analysis of delivery points (lift/lower origins, height, reach, and clearance)
- Depalletization process
- Tugger and trailer selection

Section 1 provides a basic description of a small lot delivery system. Section 2 provides ergonomic guidelines and recommendations aimed at reducing the musculoskeletal injury (or disorder) risk factors associated with individual tasks. It discusses the following topics:

- Rack and shelf design
- Horizontal reaches
- Container and tote characteristics
- Tugger and trailer characteristics
- Depalletizing stock
- Manual material handling techniques

Even if conditions are designed to optimize each lift to the degree feasible, the cumulative impact of multiple lifts may pose a hazard. To address this issue, Section 3 discusses analysis of the ergonomics of the cumulative activity of material handlers.

The recommendations in this document are taken from a variety of existing sources including the *Applications Manual for the Revised NIOSH Lifting Equation* (http://www.cdc.gov/niosh/94-110.html). These guidelines are designed to accommodate the physical capacity of at least 75 percent of the female population (encompassing approximately 99 percent of the male population) and accommodate the anthropometry of all but the smallest 5 percent of women and the largest 5 percent of men. Anthropometric data used to generate these guidelines are derived from U.S.

populations[1]. (1 inch (2.5 cm) was added to all anthropometric data to account for industrial footwear.)

SLDS are characterized by many complexities, including:

- The non-cyclical nature of a material handler's job
- Tasks that combine two or more activities such as lifting, lowering, carrying, walking, driving, etc.
- Variation in the roles and responsibilities of material handlers
- Frequently changing delivery schedules and routes.

To account for these, other analyses may be useful in addition to the ones presented in this document.

[1] Pheasant, Stephen. (2001). *Bodyspace: Anthropometry, Ergonomics and the Design of Work* (Second Edition). Philadelphia: Taylor and Francis Inc.

1 SMALL LOT DELIVERY SYSTEM (SLDS)

1.1 Background and Description

The terms *Small Lot Delivery System*, *material pull-system*, *lean material system*, *Kanban*, *Just-In-Time,* and *Decanted Card Marketplace* all describe essentially the same type of material movement system. Each system involves a set of strategies for reducing inventory and delivering material to the point of production when it is needed. Each system also shares similar ergonomic concerns related to manual material handling.

For the purpose of this document, *Small Lot Delivery System (SLDS)* will be the term used to describe a manual material handling system. **SLDS** are defined as:

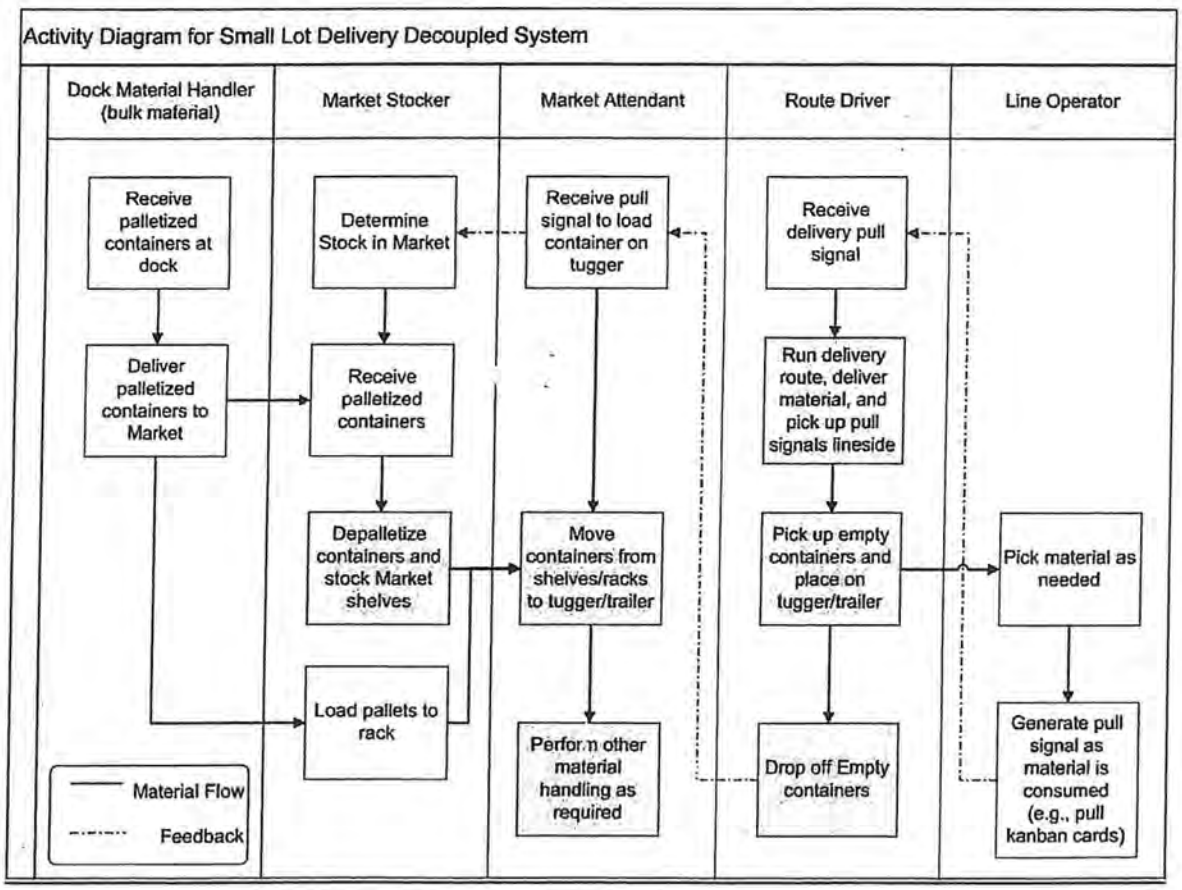
Systems in which stock handlers manually and repetitively load containers in small lots from a storage area (per pull signal or Kanban) and deliver to the appropriate locations via a tugger and trailers. The deliveries are made multiple times throughout an eight (8) hour shift.

The SLDS uses small containers that are manually handled by individuals and transported on a cart (tugger, dolly, etc.). An SLDS is designed to replace and/or supplement bulk-delivery of material in large containers transported by forklifts. Two fundamental elements of an SLDS in an industrial/manufacturing environment are:

1. A designated material storage area in the plant in which racks are used to present manually handled containers/totes to a route driver. (Note: The designated small lot material storage area can be located off-site. In this case, a pull signal prompts the shipment of the small lot containers/totes to a plant, where they are delivered to the point of use via a route driver.)
2. A route driver who is responsible to deliver containers/totes to the point of use.

A typical SLDS process is shown below.

Figure 1: Activity Diagram for Small Lot Delivery Decoupled System



1.2 Roles and Responsibilities

The following responsibilities exist in most SLDS. However, the names of the jobs may vary across employers.

Dock Material Handler:

This person is responsible for receiving incoming material (in the form of palletized containers) off the dock and delivering the pallets to the 'market stocker' located in the material storage area. Also, the *dock material handler* is responsible for loading trucks to return empty palletized containers to their supplier.

Market Stocker:

This is the person who receives the palletized containers (incoming material from the *dock material handler*) and depalletizes them by removing each container from the pallet and placing the containers onto the storage racks in the designated storage locations. Also, the *market stocker* is responsible for palletizing the empty containers to be returned to the dock.

Market Attendant:

The *market attendant* is responsible for loading full containers onto the trailer and unloading empty containers from the trailer.

Route Driver:

The *route driver* is responsible for driving the trailers to each stop along the designated route, placing full containers on lineside racks for the operator's use and, picking up the empty containers to return to the market.

An SLDS can be 'coupled' or 'decoupled.' (A decoupled SLDS is shown above in Figure 1.) In a decoupled SLDS, roles are exactly as described above. In a 'coupled' SLDS, the *market attendant* position does not exist and it becomes an additional responsibility of the *route driver* to pick and place the full containers for delivery onto the trailer and to remove the empty containers that are returned to the market place from the previous route.

2 ERGONOMIC GUIDELINES / RECOMMENDATIONS

This section provides ergonomic guidelines and recommendations aimed at reducing the musculoskeletal injury (or disorder) risk factors associated with individual (primarily lifting) tasks. It discusses the following topics:

- Roller Racks and Shelves
- Horizontal Reaches
- Container and Tote Characteristics
- Tugger and Trailer Characteristics
- Depalletizing Stock
- Manual Material Handling Techniques

2.1 Roller Racks and Shelves

Roller Rack Advantages

Most SLDS use shelves with roller units, called roller racks, for container storage. Roller racks have an ergonomic advantage over flat shelves in that they allow operators to pull containers more easily toward themselves before lifting them. This allows lifting to occur with minimized horizontal reach. An advantage of sloped roller racks is that they allow containers to flow by gravity to the picking operator, eliminating the need to pull/push the containers across the shelves. For ease of part retrieval, another option may include a tilt feature on the end of a roller rack.

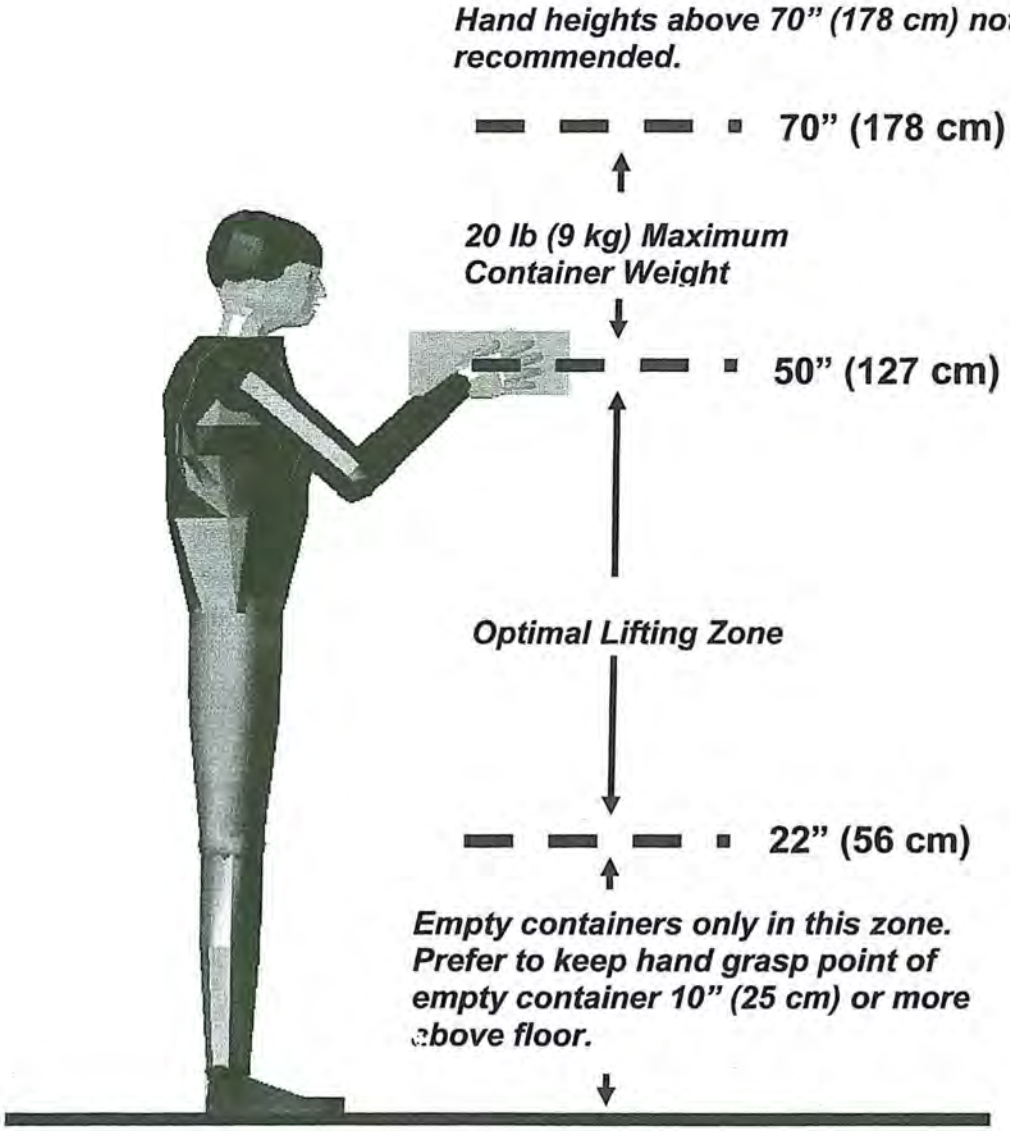
Rack and Shelf Height Design Considerations

Whether roller racks or flat shelves are used, one of the more important considerations in rack design and configuration is the height of the hands during lifting to/from the racks. In general, a person's material handling capacity is greatest when hand height is between the knees and shoulders. Lifting frequently to/from below knee height increases fatigue and may increase back and other physical complaints. Lifting above shoulder height reduces lift strength and increases the risk of losing control of the load. It is recommended that:

- Shelves be positioned to allow an operator to place all containers within an optimal *hand* height, *not shelf* height, of 22-50 inches (56-127 cm).
- If constraints do not allow all containers to be placed in the optimal range, it is recommended that the heaviest containers be given preference.
- Lighter containers, up to 20 lbs (9.1 kg), may be placed in the 50-70 inches (127-178 cm) hand height range. The frequency of lifts in this range should be minimized.
- Handling containers at a hand height greater than 70 inches (178 cm) is not recommended. Hand heights below 22 inches (56 cm) should be used only with empty containers.
- To avoid excessively low reaches, the grasp point of these empty containers should be 10 (25 cm) inches or higher from the standing surface.

Recommended hand height ranges are shown in Figure 2. Again, Figure 2 refers to *hand* height, *not shelf* height.[1]

Figure 2: Recommended Hand Height/Container Weight Ranges for Small Lot Delivery Lifting/Lowering Tasks



(Note: Hand heights, not shelf heights, are shown.)

[1] Hand height (height of the large middle knuckle of the hand) should be measured from the standing surface.

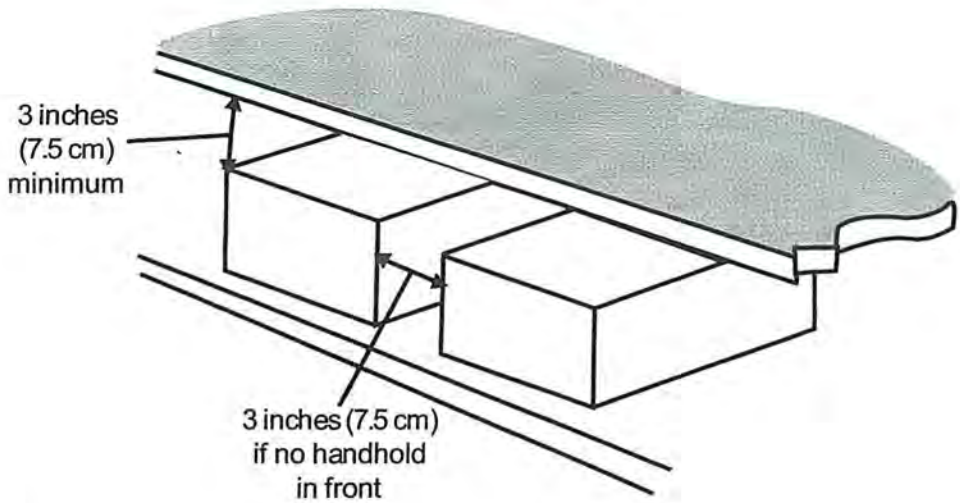
From Hand Height to Shelf Height

When calculating appropriate shelf heights, one should consider the container dimensions and placement of hand grips on the container. In addition, returnable and expendable containers each have specific considerations such as:

- Returnable containers typically have handles that, when grasped, place the hands 4-8 inches (10-20.5 cm) or more above shelf height.
- Expendable containers may lack handles or handholds of any sort and are lifted either with the hands at opposite corners or along the lower edges. Operators vary in their techniques, although handling by gripping the lower edges seems more common. In these cases, hand height would equal shelf height. If the container is grasped at opposite corners, one-half the height of the container may be taken as the hand height; usually in the range of 4-8 inches (10-20.5 cm) above the shelf height. Whenever possible, consult the operators as to how they do the job.

Recommended Clearances Around Containers Placed in Racks

Figure 3: Container Clearance



- Preferred container orientation: Place containers on shelves so that both handles can be grasped simultaneously. Allow at least 3.0 inches (7.5 cm) between containers.
- If the preferred container orientation is not feasible and there is a handhold in front, allow for at least 1.0 inch (2.5 cm) between containers.
- Allow at least 3.0 inches (7.5 cm) from the top of the container to the underside of the shelf above.
- Containers without handholds should be located for easy grasping of the opposite corners or from underneath the container.

Additional Rack/Shelf Design Guidelines

- Shelf slope should be sufficient to allow smooth controlled container movement in roller rack shelves. A 3-5° slope (approximately 1.0 inch (2.5 cm) rise to 12.0 inch (30.5 cm) run) will be appropriate for most loads.
- When designing a roller rack, review the expected container dimensions. A general guideline for smooth flow of containers is to size the roller spacing so that there will always be three rollers in contact with the bottom of the container.
- Features such as roller bars on the pull ends of shelves and shelf extensions may allow easier extraction of containers from the shelf. Make sure that such features make the task easier rather than adding to the reach or creating other hazards such as pinch points. See Figure 4.

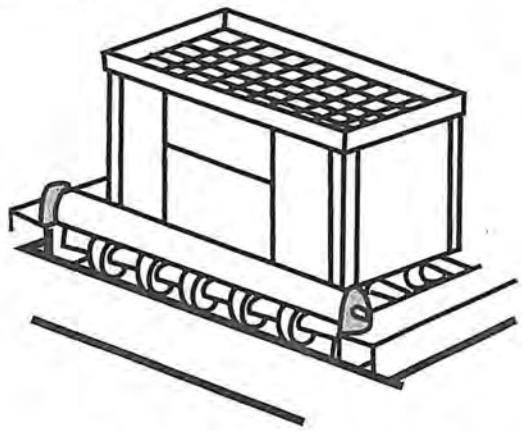


Figure 4: Roller Bars at Pick End of Roller Rack

2.2 Horizontal Reaches

Holding the load close to the body throughout a lifting exertion is a fundamental principle of reducing the risk of musculoskeletal injury (or disorder). As the horizontal distance of the hands from the body increases, an operator's lifting capacity falls off rapidly. Containers should be presented to the operator so that the maximum forward reach required to grasp the handles is 18 inches (45.5 cm) or less. Reach distance is measured from the midpoint between the ankles to the midpoint of the hand grasps (i.e., load center).
See Figure 5.

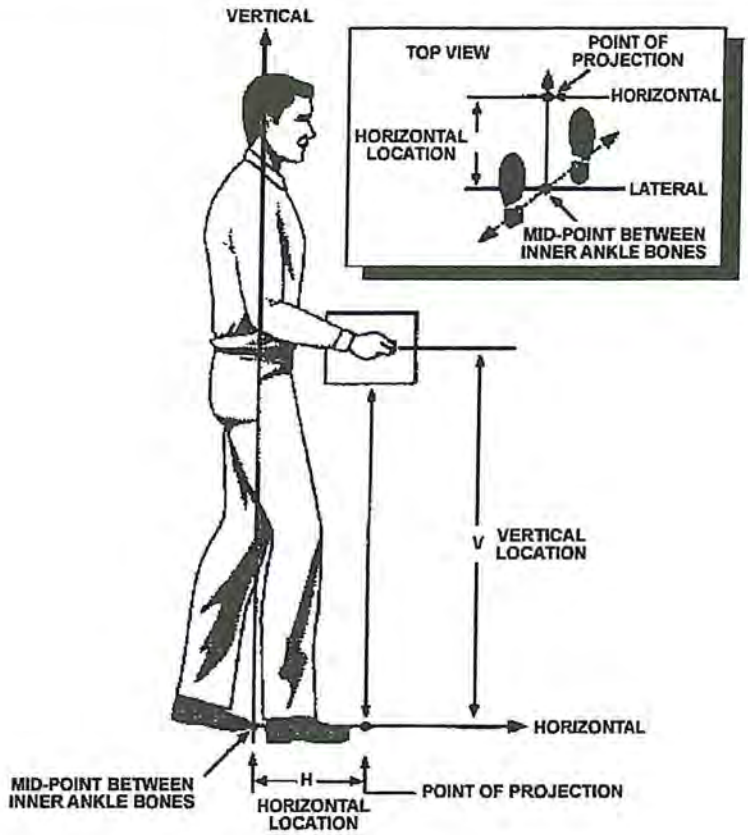


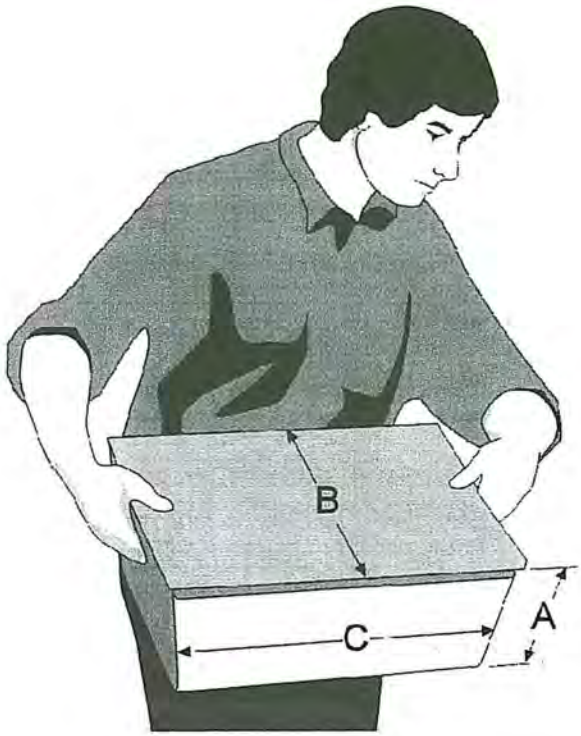
Figure 5: Vertical and Horizontal Reaches

2.3 Container and Tote Characteristics

- Container dimensions influence the risk of musculoskeletal injury (or disorder). See Figure 6 below. As width (Dimension B in Figure 6) increases, the distance of the center of the load from the low back increases, resulting in greater strain, increased muscle tension, and increased risk of back injury.
- Length (Dimension C) is important because an object will usually be grasped at the opposite ends of the longest side of a container.
- Height (Dimension A) may be subject to the most variation of the three dimensions. Dimension A should be chosen so as not interfere with leg movement or vision when the container is carried.
- For AIAG's recommendations on these dimensions, see *AIAG Guideline for Manually Handled Containers.*[1]

[1] (OHS-4) Section 1.0, p.7.

Figure 6: Container Dimensions



Returnable Containers

Considerations related to returnable containers include:

- Returnables typically have handholds, which may give a better grasp point than simply grasping corners or edges. However, re-grasping a returnable, which might be desirable for lifts above shoulder originating below shoulder, may not be easy due to its contours and surface features.
- Lifts and lowers of returnables to/from *hand* heights above the optimal range may put the arms and wrists in awkward postures.
- Provisions should be made for collecting and returning containers. It is not recommended that anyone handle stacks of returnable containers high enough to hinder visibility.
- Damaged returnables that present sharp edges or crushed handles should be removed from circulation immediately.

Container Size, Weight, and Handhold

Recommendations for container size, weight, and handhold can be found in the *AIAG Guideline for Manually Handled Containers*[1].

Container dimensions that fall outside these recommendations are likely to do so in length (Dimension C). When this is the case, the container generally cannot be lifted using a conventional two-hand symmetrical lift. The container is likely to be lifted and carried with one arm wrapped over the container and the long axis parallel to the direction of the carry. Containers that are very long or otherwise create a non-symmetric handhold generally should be handled with hands near elbow height. When it is not possible to avoid manually handling oversized containers, as many as possible of the following should apply:

- Oversized containers should be fewer than 30 percent of the containers handled.
- Two of the three container dimensions should be within the recommendations given in the *AIAG Guideline for Manually Handled Containers*[2].
- Handholds should be designed and located in a manner consistent with the *AIAG Guideline for Manually Handled Containers*[3].
- Contents should not project above the container when handholds are grasped across the container.
- For long containers, handholds should be spaced equally along the sides of the container, with two on each long side.
- It is recommended that containers exceeding 30 inches (76 cm) in length (Dimension C) be restricted to no more than 15 inches (38 cm) in width (Dimension B).
- If containers longer than recommended in the *AIAG Guideline for Manually Handled Containers* are used, it is recommended that a safe and acceptable handling method be devised along with assurances of good container presentation and placement.
- It is recommended that oversized containers be placed in the optimal lifting zone.

If oversized containers are particularly numerous on a route and/or are heavy with more than one dimension outside the *AIAG Guideline for Manually Handled Containers*[4], a separate analysis should be performed on their handling, with particular attention placed on locations and orientation at pick and delivery points.

---

[1] (OHS-4) Section 1.0, pp.7-12.

[2] *Ibid.* p.7.

[3] *Ibid.* Section 2.0, pp.8-11.

[4] *Ibid.* Section 1.0, p.7.

2.4 Tugger and Trailer Characteristics

Tugger/Trailer Load Floors

It is recommended that tugger and trailer load floors allow operator hand heights to fall within the vertical range shown in Figure 2. When loading multiple shelf trailers, consider the container weight restrictions shown in Figure 2. Other load floor features to consider include:

- Smooth load floor surfaces allow containers to be more easily pulled toward the operator before lifting. The load floor should also allow for adequate retention of containers while in motion.
- Rotating "Lazy Susan" type load floors may reduce the carry distance of operators delivering containers to a workstation.

Tugger Recommendations

A variety of tow tractors or tuggers of different designs and capacities are available from many different manufacturers. In SLDS operations, tuggers will generally be subjected to heavy use. It is important that the tugger design selected is appropriate for this level of use and for the requirements of the plant. Considerations include the following:

- Load, tow bar capacity;
- Sit, stand, or sit-stand capability and operator preference;
- Turn radius;
- Endurance/charge capacity;
- Maintenance support;
- Minimization of steering and other control forces;
- Operator vision;
- Vehicle visibility;
- Ease of ingress/egress.

2.5 Depalletizing Stock

Two principles to consider when depalletizing containers to roller racks are:

- Reducing the vertical distance that a container travels during a lift/lower task will conserve the worker's energy.
- Initiating lifts/lowers at a point below shoulder height allows a shoulder joint posture that reduces the risk of musculoskeletal injury (or disorder).

These principles can be applied to a depalletizing task by:

- Elevating the pallet so that the bottoms of the containers are slightly higher than the load end of the roller rack. This will reduce the amount of vertical travel in the lift/lower task and may allow the worker to slide the container directly onto the roller rack.

- Not elevating pallets so that the grasp point of a container is higher than 50 inches (127 cm). This will allow the shorter stature workers to initiate lift/lower tasks from below the shoulder.

Elevating the pallet may be accomplished with powered material handling vehicles, lift tables, or other methods.

2.6 Manual Material Handling Techniques

This document contains the basic equipment and task design recommendations for reducing musculoskeletal injury (or disorder) risk factors in a small lot delivery process. Understanding and using proper lifting techniques may further reduce the frequency of back and other injuries related to manual material handling.

A review of the literature on recommendations for safe lifting has shown that the following are commonly accepted and sound practices:

- Minimize the horizontal distance of the load from the body. Before lifting the object, bring it close to the body.
- Lift in smooth and well-coordinated motions. Do not jerk or throw the object.
- Lift with a posture that is most comfortable to you, taking into account the weight, size, and frequency of handling. This may be a squat, a stoop (bending forward at the waist with near straight legs), or a combination of these. Use a squat lift (lifting with the legs instead of the back) only if you are able to get the object between your knees and have no physical problems with your knees.
- Do not twist the body while lifting. When you must lift an object and turn to carry it away, do not twist during the lifting action. Complete the lifting action and then turn with the feet.
- Be particularly careful with wet or slippery objects and objects with poor handholds.

What about Back Belts?

Most authorities including the U.S. National Institute for Occupational Safety and Health (NIOSH) do not recommend the use of back belts as injury prevention devices. Research has found that back belt users may suffer de-conditioning of their back muscles and may be more prone to injury when the back belt is removed. There is no evidence in the scientific literature that they are preventive of low back pain but no evidence they do harm either. Back belts as described here do not include orthotic devices or back support devices as prescribed by physicians for people who have suffered injuries or chronic low back pain[1].

[1] Penrose KW, Chook K, Stump JL. Acute and chronic effects of pneumatic supports on muscular strength, flexibility and functional impairment index. *Sports Train Med Rehabil* 1991; 2: 121–129.

3 ANALYZING THE RISK OF CUMULATIVE MUSCULOSKELETAL INJURY (OR DISORDER)

Section 2 was largely devoted to the physical design of the fixed and moving elements of an SLDS. This section is devoted to analysis of the risk of musculoskeletal injury (or disorder) associated with a combination of tasks performed over the course of a workshift. Regardless of whether an SLDS is coupled or decoupled, each material handler performs a variety of lifts involving different origin and destination hand heights, horizontal reaches, and container weights. When the system is designed, an evaluation of the cumulative impact of these lifts over an eight hour shift is recommended.

It is further recommended that this be done using the 1991 revision of the NIOSH Lifting Equation (http://www.cdc.gov/niosh/94-110.html) to calculate a composite lifting index (CLI)[1]. Non-ergonomists can be trained to make measurements with sufficient accuracy to provide consistent recommended weight limit and lifting index values[2]. A number of websites provide Excel spreadsheets that can be used for the calculations. Two of them are:

http://personal.health.usf.edu/tbernard/ergotools/index.html
http://www.wvu.edu/~exten/depts/she/Niosh-Multitask.xls

The following is a brief description of data collection for calculating a CLI. The reader is advised not to attempt to undertake this calculation without first having consulted the *Applications Manual for the Revised NIOSH Lifting Equation* (http://www.cdc.gov/niosh/94-110.html).

3.1 Basic Data

To calculate a CLI, the following data are needed for each lifting and/or lowering task:

- Weight of each loaded container[3]. (Include returnables or dunnage weighing over 10 lbs (4.5 kg) and multiple items handled in one lift. Indicate what part types are so treated[4].)
- Lifts per hour for each loaded container (frequency).
- Horizontal and vertical hand location at starting (origin) and ending (destination) point. See Figure 5.

---

[1] Physiological, biomechanical, and psychophysical tools may be useful supplements to the NIOSH CLI analysis.

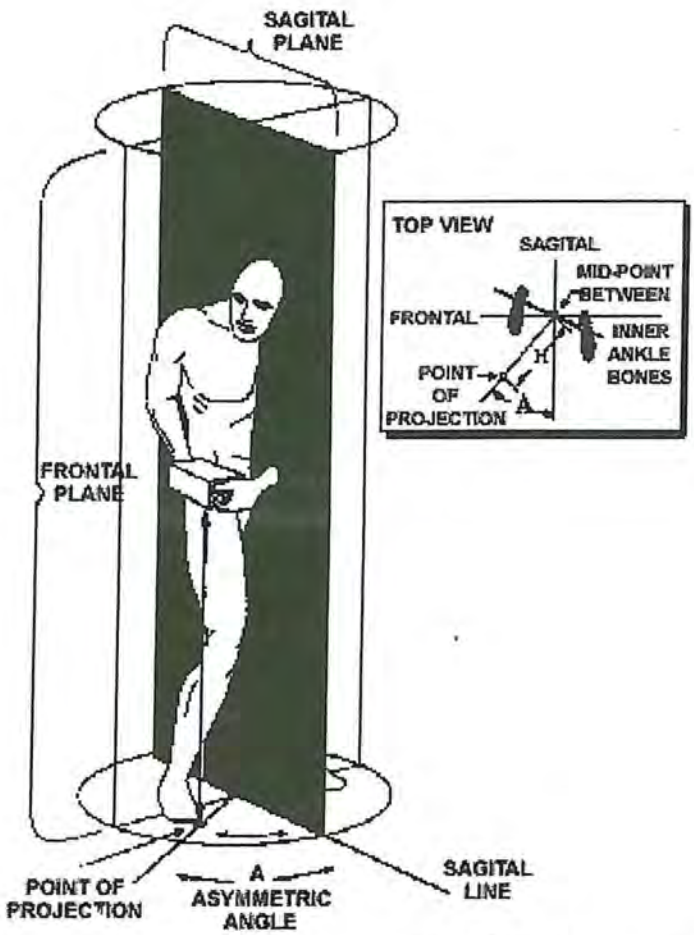
[2] Waters, T.R., Baron, S.L. & Kemmlert, K. 1998. Accuracy of measurements for the revised NIOSH lifting equation, *Applied Ergonomics*, 29 (6), 433-438.

[3] NOTE: All loaded containers, including those weighing less than 10 lbs. (4.5 kg), should be entered into the analysis.

[4] If there are more lifts than can be input into your computer program, aggregate similar lifts.

- Quality of the hand-to-object coupling. This is scored as a '1' for good coupling, a '2' for fair coupling, and a '3' for poor coupling. Good coupling situations will have good handholds, which will be the case with some of the returnables.
- Shift length (hours).
- Measure asymetry. See Figure 7.

Figure 7: Asymmetry



Record data on a data sheet (examples below). After data are collected, enter them into one of the 1991 NIOSH multiple-lift EXCEL-based programs indicated above. Compute the CLI.

Figure 8. Sample Small Lot Delivery Analysis Manual Material Handling Activity Data Gathering Worksheet.

Small Lot Delivery Analysis
Manual Material Handling Activity
Data Gathering Worksheet

Analysis Name: _____ Route Name: _____
Analysis Date: _____ Route Cycle Time (min.): _____
Routes per Shift: _____

Item #	Part #	Pcs./ Container	Demand pcs/hr.	Size of Container l x w x h inches			Weight of Container lbs.	# Cont./ Route	# Cont./ Shift	Weighted Average lbs.	Supermkt: Lift Origin (V) inches	Tugger/Cart: Lower Dest. (V) inches	Tugger/Cart: Lift Origin (V) inches	Delivery Pt.: Lower Dest. (V) inches	NIOSH Analysis Needed? Y or N
				l	w	h									
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															
21															
22															
23															
24															
25															
26															
27															
28															
29															
30															

Figure 9. Screen View of NIOSH Lifting Guidelines – Job Analysis

Web Site: http://personal.health.usf.edu/tbernard/ergotools/index.html

NIOSH Lifting Guidelines -- Job Analysis
Notes

Enter values in Yellow area.

Clear Data

For Composite Lifting Index (CLI) to be computed correctly, sort tasks in decreasing order based on LI-ave by pressing button.

Sort Tasks

Task No.	CLI = 0.0 1991 Guide RWL	LI-ave	LI-max	1981 Guide AL	MPL	Task Notation	Object Wt. (lbs) L (avg)	L (max	Hand Location (inches) Origin H	Origin V	Destination H	Destination V	Asymmetry (degrees) Orig	Dest	Freq (#/min) F	Handle C	Period (hours) P	
1	0.0	0.0	0.0	0.0	0.0													0.0
2	0.0	0.0	0.0	0.0	0.0													0.0
3	0.0	0.0	0.0	0.0	0.0													0.0
4	0.0	0.0	0.0	0.0	0.0													0.0
5	0.0	0.0	0.0	0.0	0.0													0.0
6	0.0	0.0	0.0	0.0	0.0													0.0
7	0.0	0.0	0.0	0.0	0.0													0.0
8	0.0	0.0	0.0	0.0	0.0													0.0
9	0.0	0.0	0.0	0.0	0.0													0.0
10	0.0	0.0	0.0	0.0	0.0													0.0

G or g
F off
P or p

Multipliers by Task (Lower multipliers indicate areas for attention.)

Task	HM	VM	DM	FM	AM	CM
0	1.00	0.78	1.00	1.00	1.00	#N/A
0	1.00	0.78	1.00	1.00	1.00	#N/A
0	1.00	0.78	1.00	1.00	1.00	#N/A
0	1.00	0.78	1.00	1.00	1.00	#N/A
0	1.00	0.78	1.00	1.00	1.00	#N/A
0	1.00	0.78	1.00	1.00	1.00	#N/A
0	1.00	0.78	1.00	1.00	1.00	#N/A
0	1.00	0.78	1.00	1.00	1.00	#N/A
0	1.00	0.78	1.00	1.00	1.00	#N/A
0	1.00	0.78	1.00	1.00	1.00	#N/A

Thomas E. Bernard
University of South Florida
College of Public Health
Tampa FL 33612-3805
www.health.usf.edu/~tbernard OR tbernard@health.usf.edu
v3.0 10/20/06 © 2006 Thomas E. Bernard
No Warranty: Explicit or Implicit

Originally developed by
Gary Herrin
University of Michigan

Support for this package development was provided by Ford Motor Company, AutoAlliance International, Inc. and USF.

Additional data that may be useful include:

- A listing of each part type (part number or name)
- Quantity of pieces per container
- Demand pieces used per shift
- Number of containers lifted per shift per part type
- Dimensions of container (Length x Width x Height)
- Average container weight based on frequency (known as weighted average[1]) should be calculated.

The following is an example of a weighted average for four types of parts:

Part no.	Containers/day	Weight/container
012234	1	35
218893	3	22
512234	2	17
344578	1.5	26

Computation of weighted average:

$$\frac{1 \text{ container} \times 35 \text{ lb.} + 3 \text{ containers} \times 22 \text{ lb.} + 2 \text{ containers} \times 17 \text{ lb.} + 1.5 \text{ containers} \times 26 \text{ lb.}}{1 \text{ container} + 3 \text{ containers} + 2 \text{ containers} + 1.5 \text{ containers}}$$

$$= \frac{(35 + 66 + 34 + 39) \text{ lb. container}}{7.5 \text{ containers}}$$

$$= 23.2 \text{ lb.}$$

[1] The significance of the weighted average is that it takes into account the number of times that a container of a given weight is handled in a day instead of being a straight average of the weights by part type.

When the part mix includes containers that exceed the recommended maxima for length or width indicated in the *AIAG Guideline for Manually Handled Containers*[1], multiply the actual weight by the number indicated in the 'Multiplier' column in Table 1.[2] If the container is oversized in both length and width, multiply the actual weight by both multipliers[3].

Table 1: Suggested Load Corrections for Oversized Loads

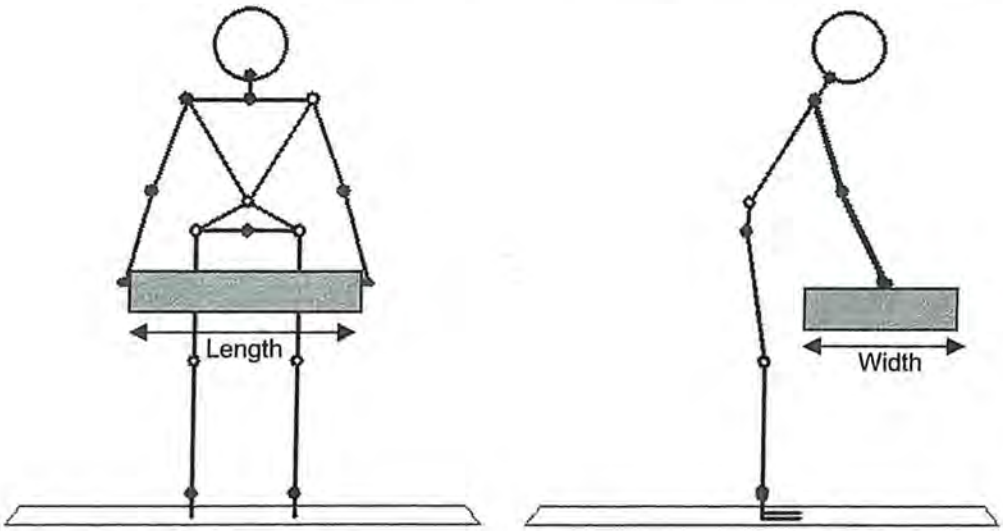
Long Containers		Wide Containers	
Container Length in inches (cm)	Multiplier	Container Width in inches (cm)	Multiplier
≤30 (≤76)	1.00	≤20 (≤51)	1.00
>30-35 (>76-89)	1.28	>20-25 (>51-63.5)	1.10
>35-40 (>89-101.5)	1.48	>25-30 (>63.5-76)	1.18
>40-45 (>101.5-114.5)	1.50	>30-35 (>76-89)	1.27
		>35-40 (>89-101.5)	1.43

[1] OHS-4, Section 1.0, p.7

[2] The derivation of the Multipliers found in Table 1 is shown in the Appendix, Section 4.2.

[3] In the above example, if part 512234 were in a container whose length was 32 inches and whose width was 22 inches, its penalized weight would be 17 × 1.28 × 1.1 = 23.94 lbs. This raises the weighted average to 25.05 lbs from 23.2 lbs.

Figure 8: Illustration of Container Length and Width Parameters



3.2 Interpreting the CLI

It is recommended that the NIOSH cumulative lifting index (CLI) be interpreted as follows:

Table 2: Interpretation of CLI Values[17]

CLI Value	Interpretation
1.5 or under	It is recommended that the CLI be kept within this range
1.5 to 2.0	It is recommended that the job be modified to lower the CLI, but not necessarily that the job be stopped pending modification.
Above 2.0	Above this point, it is recommended that the job should not be done until modifications lowering the CLI are complete.

[17] There was a statistically significant elevation in low back pain at a CLI of 2.0 and above (Odds Ratio = 2.45, 95% Confidence Interval = 1.29-4.85). (Waters TR, Baron SL, Piacitelli LA, Anderson VP, Skov T, Haring-Sweeney M, Wall DK, Fine LJ. Evaluation of the revised NIOSH lifting equation. A cross-sectional epidemiologic study. *Spine.* 1999 Feb 15;24(4):386-94; discussion 395.) The rationale for modifying jobs in the 1.5 -2.0 range is that there may be a risk (the Waters study lacked the statistical power to determine this) and that it is safer to keep the CLI some distance from the level at which increased risk has been shown scientifically. The rationale for not stopping jobs in the 1.5-2.0 CLI range before modifications are complete is that there do not, at present, exist hard data demonstrating risk in this range. In setting frequency limits for routes, an employer should take into account all relevant aspects of the route jobs and of the worker population.

3.3 Making Changes

The overall analysis of the data may indicate that modifications are recommended. When a lower CLI is sought, recommended modifications include:

1. Engineer the workplace and conditions so that lifts are within the recommended hand height and horizontal reach.

2. Reduce the frequency of containers handled.

3. Modify packaging to reduce container weight. (This may increase the frequency.)

3.4 Preventing Musculoskeletal Injuries and Disorders

Workplace engineering should be the core of any program addressing the reduction of musculoskeletal injuries (or disorders) and any concerns with manual material handling productivity. *Workplace engineering* involves the systematic design of equipment and tasks to engineer out risk factors of musculoskeletal injury (or disorder). Dr. Stover Snook of Liberty Mutual Insurance Company has estimated that two out of three occupational back injuries may be avoided through good task and workplace design[18]. In conjunction with workplace engineering, we recommend that workers be trained to recognize potential musculoskeletal injury (or disorder) risk factors and to participate in the process of reducing or eliminating those risk factors.

If **training in lifting or fitness** is conducted, it is recommended that such training not be a major program component. Research by Dr. Snook has indicated that, in most cases, training by itself is not effective in preventing musculoskeletal injuries (or disorders). In some circumstances, lift training that is appropriate and tailored to the specific workplace can be recommended as a *supplement* to a sound and comprehensive workplace engineering approach.

Selecting workers to match the physical demands of each job is not recommended. There are ongoing questions about the legality and ethics of such an approach for much industrial work.

[18] Snook, S,H., Campanelli, R.A., and Hart, J.W., A Study of Three Preventive Approaches to Low Back Injury. *J Occup. Med.*, 20(7):478-481 (1978).

4 APPENDIX

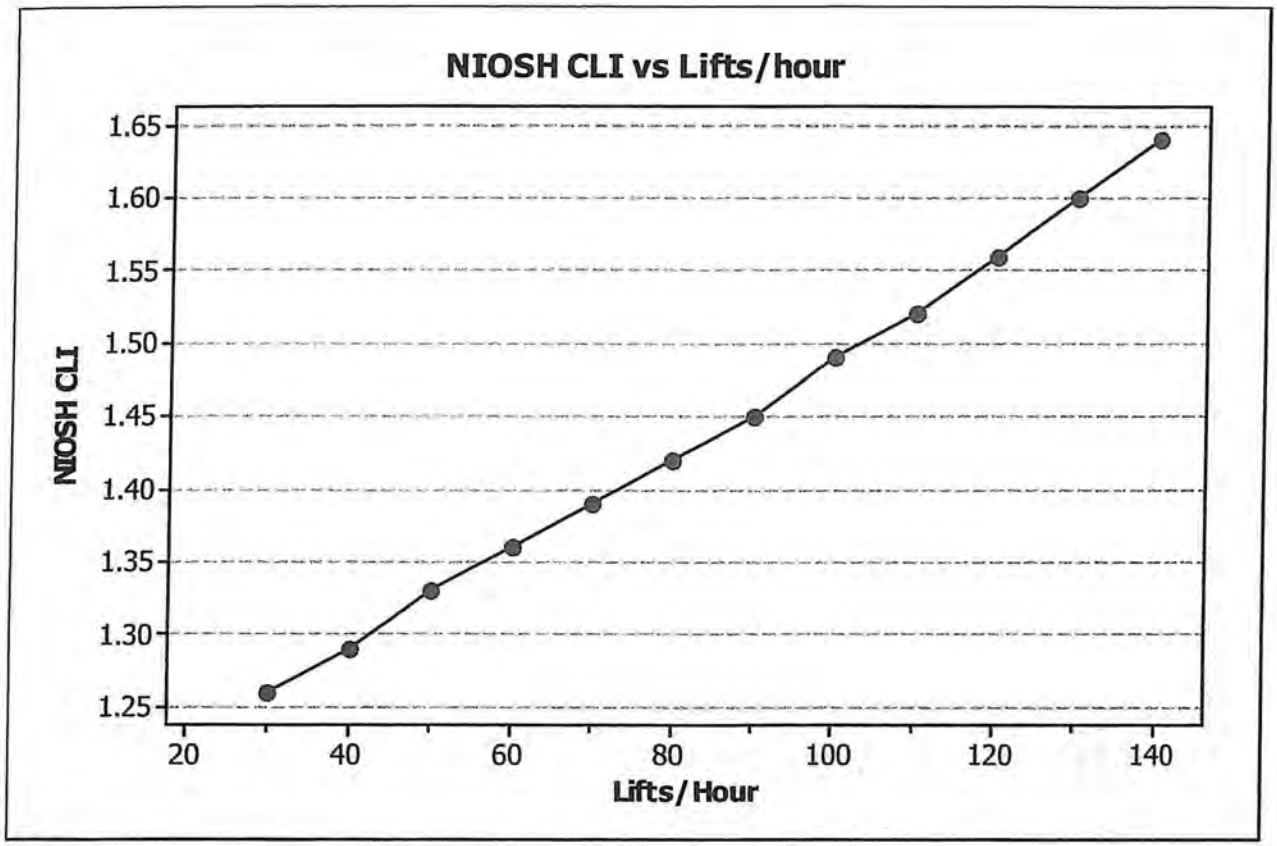
4.1 Example Results of a NIOSH CLI vs. Lifts/Hour Analysis

Following are the results of a NIOSH CLI vs. Lifts/Hour analysis for a specific job. Under certain circumstances detailed below, a CLI can be read from Figure 9 instead of being calculated in according to the procedure described in the *Applications Manual for the Revised NIOSH Lifting Equation* (http://www.cdc.gov/niosh/94-110.html).

The job whose CLI vs. Lifts/Hour is presented in Figure 9 has the following characteristics:

- The job consists of picking containers from a 3-shelf roller rack and placing them onto a trailer.
- 30 percent of the lifts start at a hand height of 66 inches (167.5 cm) (picking from the upper shelf of the roller rack) with a constant container weight of 20 lbs (9 kg).
- 40 percent of the lifts start at a hand height of 41 inches (104 cm) (picking from the middle shelf of the roller rack) with an average container weight of 32 lbs (14.5 kg) and a maximum container weight of 40 lbs (18 kg).
- 30 percent of the lifts start at a hand height of 22 inches (56 cm) (picking from the lower shelf of the roller rack) with a constant container weight of 30 lbs (13.5 kg).
- The horizontal distance of the hands away from the mid-point between the ankles at the start and end of all lifts is 15 inches (38 cm).
- The destination hand height of all lifts is 38 inches (96.5 cm).
- All lifts are symmetrical in front of the body.
- The maximum carry distance of any container is 10 feet (3 m) or less.
- The shift length is 8 hrs.
- The job is designed to be consistent with a predetermined time system for job design such as Methods-Time Measurement.

Figure 9: NIOSH CLI vs. Lifts/Hour



Application of results to another specific job

It is advisable to collect data and compute a NIOSH CLI for every job. However, if a specific job has characteristics relatively close to the example job above, the NIOSH CLI vs. Lifts/Hour graph shown can be used for a broad indication of the job's acceptability. To apply Figure 7 to a specific job, the job must also meet the following assumptions:

- No lifts require a hand height above 68 inches (173 cm).
- No more than 30 percent of the lifts require a hand height in the 50 - 68 inch (127 – 173 cm) range.
- No more than 30 percent of the lifts start at a hand height below 25 inches (63.5 cm).
- No lifts require a hand height below 22 inches (56 cm).
- Containers requiring hand heights above 50 inches (127 cm) weigh no more than 20 lbs (9 kg).
- The average container weight for lifts that maintain a hand height in the 22-50 inches (56-127 cm) range does not exceed 32 lbs (14.5 kg).
- The maximum container weight is 40 lbs (18 kg).

- The horizontal distance of the hands away from the mid-point between the ankles at the start and end of all lifts is no greater than 15 inches (38 cm).
- The destination hand height of all lifts is in the 28 - 44 inch range (71-112 cm).
- All lifts are symmetrical in front of the body.
- The maximum carry distance of any container is 10 feet (3 m) or less.
- The length of the shift is 8 hrs or less.
- The job is designed to be consistent with a predetermined time system for job design such as Methods-Time Measurement.

Unless all of the above characteristics apply to the specific job of interest, the graph above is not applicable. In this case it is recommended that data be collected and a NIOSH CLI be computed.

The effect of the number of lifts/hour on the calculated NIOSH CLI for this job is shown in Figure 9 above.

4.2 Oversize Loads

Long Loads (laterally)

The *AIAG Guideline for Manually Handled Containers*[19] indicates that the maximum recommended length for a container is 30 inches (76 cm). The University of Michigan 3D Static Strength Prediction Program™ (3D SSPP) was used to calculate a 75th percentile female left-hand load limit for a container of this length (= 17.7 lbs.(8.0 kg.). Left-hand load limits were then calculated with progressively larger lateral numbers[20]. The left-hand load limit for each given container length over 30 inches (76 cm) was divided by 17.7 lbs. (8.0 kg.) to calculate a percentage. The recommended multiplier to be used in calculating a weighted average container weight is the reciprocal of that percentage.

[19] OHS-4, Section 1.0, p.7

[20] The left arm has 90 percent of the strength of the right in 3DSSPP and thus the left shoulder would always be the limiting joint. The vertical was set at 40 inches (101.5 cm) and the horizontal reach was assumed to be 14 inches (35.5 cm). Handle depth was set at 2.5 inches (6.5 cm), based on the recommendation on page 9 of the *AIAG Guideline for Manually Handled Containers*. Thus, the distance between knuckles would be 5 inches (13 cm) larger than the container length.

Table 3: Left Hand Limits for Long Loads				
Container Length in Inches (cm)	Distance Between Knuckles in Inches (cm)	Left-Hand Load Limit in pounds (kg)	Percentage of Left-Hand Load Limit for a 30 inch (76 cm)-long Container	Multiplier
30 (76)	35 (89)	17.7 (8)	100%	100%
35 (89)	40 (101.5)	13.8 (6)	78%	128%
40 (101.5)	45 (114.5)	12 (5.5)	68%	148%
45 (114.5)	50 (127)	11.8 (5.5)	67%	150%

Figure 10: Analysis of Long Loads

Here is an example analysis: Lateral = 22.6 inches. The distance between the knuckles is 45.2 inches. The container is 40" long.

Task: Untitled Task
Gender: Female, Percentile: 50th
Ht (in): 63.9, Wt (Lb): 137.7
Hand Forces (Lb) Left: 12, Right: 11.1

Hand Location (in)	Left	Right	Trunk and Legs Locked
Horizontal:	13.9	-3.8	
Vertical:	40.0	29.5	
Lateral:	-22.6	7.2	

Strength Percent Capable

Elbow:	97	Hip:	98
Shoulder:	75	Knee:	99
Torso:	98	Ankle:	99

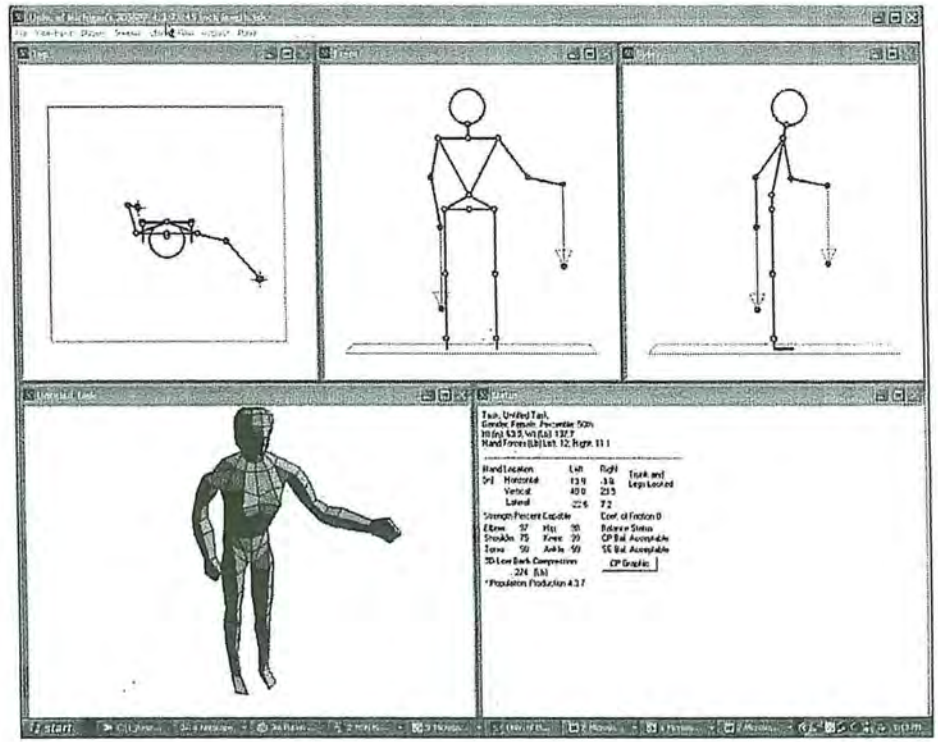
Coef. of Friction: 0

Balance Status
CP Bal: Acceptable
SE Bal: Acceptable

3D Low Back Compression:
224 (Lb)

CP Graphic

* Population: Production 4.3.7



Wide Loads (anterior)

The method for wide loads is parallel to that for long loads. The *AIAG Guideline for Manually Handled Containers*[21] indicates that the maximum recommended width for a container is 20 inches (51 cm). 3D Static Strength Prediction Program™ (3D SSPP) was used to calculate a 75th percentile female left-hand load limit for a container of this width (= 16.5 lbs. (7.5 kg)). Left-hand load limits were then calculated with progressively larger widths[22]. The left-hand load limit for each given container width over 20 inches (51 cm) was divided by 16.5 (7.5 kg.) to calculate a percentage. The recommended multiplier to be used in calculating weighted average container weights is the reciprocal of the percentage.

Table 4: Left Hand Limits for Wide Loads

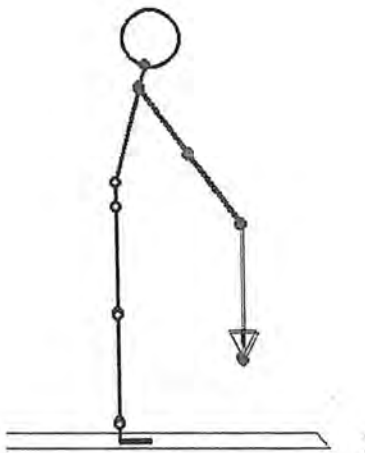
Container Width in Inches (cm)	Horizontal Distance in inches (cm)	Left-hand Load Limit in pounds (kg)	Percentage of Left-and Load Limit for a 20-inch (51 cm) - wide Container	Modifier
20 (51)	18 (46)	16.5 (7.5)	100%	100%
25 (63.5)	20.5 (52)	15 (7)	91%	110%
30 (76)	23 (58.5)	14 (6.5)	85%	118%
35 (89)	25.5 (65)	13 (6)	79%	127%
40 (101.5)	28 (71)	11.5 (5)	70%	143%

[21] OHS-4, Section 1.0, p.7.

[22] The legs were locked and the loads were assumed to be limited by the torso or shoulder strength. The horizontal reach (H) was assumed to be 8 inches (20.5 cm) plus half the container width.

Figure 11: Analysis of Wide Loads

20" container, H=18.0"
33 lbs



Task: Untitled Task
Gender: Female, Percentile: 50th
Ht (in): 63.9, Wt (Lb): 137.7
Hand Forces (Lb) Left: 16.5, Right: 16.5

Hand Location (in)		Left	Right	Legs Locked
	Horizontal:	18.1	18.1	
	Vertical:	31.6	31.6	
	Lateral:	-7.6	7.6	

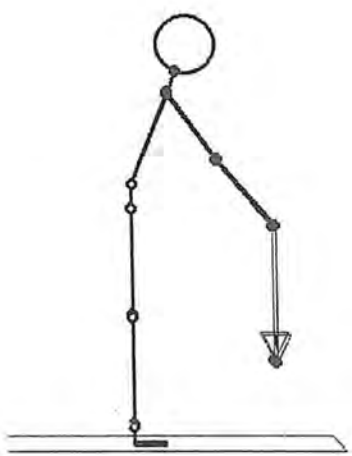
Strength Percent Capable — Coef. of Friction: 0

Elbow:	99	Hip:	90	Balance Status
Shoulder:	75	Knee:	90	CP Bal: Acceptable
Torso:	85	Ankle:	91	SE Bal: Acceptable

3D Low Back Compression: 462 (Lb) — CP Graphic

* Population: Production 4.3.7

25" container, H=20.5"
30 lbs



Task: Untitled Task
Gender: Female, Percentile: 50th
Ht (in): 63.9, Wt (Lb): 137.7
Hand Forces (Lb) Left: 15.5, Right: 15.5

Hand Location (in)		Left	Right	Legs Locke
	Horizontal:	20.5	20.5	
	Vertical:	31.6	31.6	
	Lateral:	-7.6	7.6	

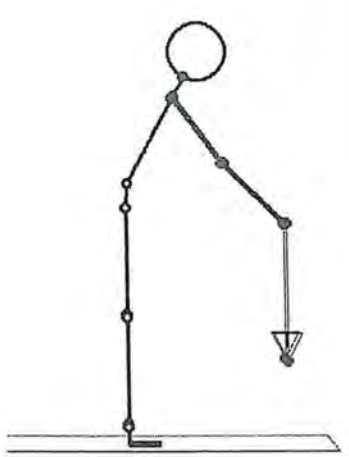
Strength Percent Capable — Coef. of Friction: 0

Elbow:	99	Hip:	86	Balance Status
Shoulder:	75	Knee:	84	CP Bal: Critical
Torso:	81	Ankle:	84	SE Bal: Acceptable

3D Low Back Compression: 512 (Lb) — CP Graphic

* Population: Production 4.3.7

30" container, H=23.0"
28 lbs



Task: Untitled Task
Gender: Female, Percentile: 50th
Ht (in): 63.9, Wt (Lb): 137.7
Hand Forces (Lb) Left: 14, Right: 14

Hand Location (in)		Left	Right	Legs Locked
	Horizontal:	23.0	23.0	
	Vertical:	31.7	31.7	
	Lateral:	-7.7	7.7	

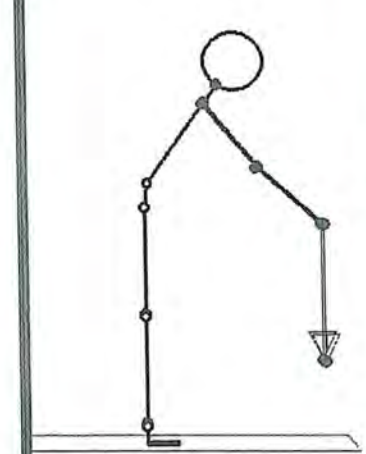
Strength Percent Capable — Coef. of Friction: 0

Elbow:	99	Hip:	82	Balance Status
Shoulder:	76	Knee:	78	CP Bal: Un-Acceptable
Torso:	79	Ankle:	76	SE Bal: Un-Acceptable

3D Low Back Compression: 547 (Lb) — CP Graphic

* Population: Production 4.3.7

35" container, H=25.5"
26 lbs



Task: Untitled Task
Gender: Female, Percentile: 50th
Ht (in): 63.9, Wt (Lb): 137.7
Hand Forces (Lb) Left: 13, Right: 13

Hand Location (in)		Left	Right	Legs Locked
	Horizontal:	25.5	25.5	
	Vertical:	31.7	31.7	
	Lateral:	-7.6	7.6	

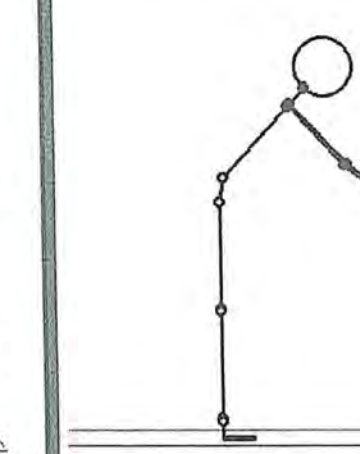
Strength Percent Capable — Coef. of Friction: 0

Elbow:	99	Hip:	78	Balance Status
Shoulder:	75	Knee:	71	CP Bal: Un-Acceptable
Torso:	77	Ankle:	66	SE Bal: Un-Acceptable

3D Low Back Compression: 583 (Lb) — CP Graphic

* Population: Production 4.3.7

40" container, H=28.0"
23 lbs



Task: Untitled Task
Gender: Female, Percentile: 50th
Ht (in): 63.9, Wt (Lb): 137.7
Hand Forces (Lb) Left: 11.5, Right: 11.5

Hand Location (in)		Left	Right	Legs Locked
	Horizontal:	28.1	28.1	
	Vertical:	31.8	31.8	
	Lateral:	-7.6	7.6	

Strength Percent Capable — Coef. of Friction: 0

Elbow:	99	Hip:	75	Balance Status
Shoulder:	76	Knee:	65	CP Bal: Un-Acceptable
Torso:	77	Ankle:	59	SE Bal: Un-Acceptable

3D Low Back Compression: 604 (Lb) — CP Graphic

* Population: Production 4.3.7

4.3 Glossary of Terms

Term	***Definition***
Container	*A receptacle for containing goods that is manually handled. Examples: tote, box, carton*
Coupled delivery	*Small lot operator picks and delivers containers to the production line via a designated delivery route. The container picking process is performed in an on-site small lot supermarket (CMA).*
Decoupled delivery	*Small lot operator delivers pre-picked containers to the production line via a designated delivery route. The container picking process can be either within the facility or at an outside supplier.*
Depalletize	*Remove containers from a palletized load. Also referred to as decanting.*
Dock Material Handler	*This person is responsible for receiving incoming material (in the form of palletized containers) off the dock and delivering the pallets to the 'market stocker' located in the material storage area.*
Kanban	*A pull signal replenishment system used to replace consumed materials.*
Line Operator	*Plant employee responsible for repetitive assembly line manual tasks.*
Market	*The location where containers are de-palletized and stored immediately before line side delivery. Also referred to as Supermarket.*
Market Attendant	*Plant employee responsible for loading the tugger.*
Market Shelves	*A rack consisting of shelves located in the market area.*
Market Stocker	*Plant employee responsible for de-palletizing containers and stocking the containers to the market shelves..*
Palletize	*Assembling of material on a pallet.*
Pull Signal	*A signal that is received as an indication that more material is required on the line. Signal methods include kanban cards, electronic signals, visual controls, etc.*
Rack	*A structure of shelves that may include rollers or flat shelves.*
Route Driver	*Plant employee responsible for operating a tugger and delivering material.*

Term	***Definition***
Small Lot Delivery System (SLDS)	*A system in which stock handlers manually load or unload containers to or from tuggers/trailers or pallets. Containers are delivered in small lots to the production line multiple times throughout the shift.*
Stock	*Items consumed during the production process.*
Tugger	*Powered industrial vehicle, operated by a route driver, that moves trailers or dollies of material to the line operator.*

MAINTENANCE REQUEST FORM

Name of Submitter: **Date:**

Company:

Company Address:

Phone: **Fax:** **E-mail:**

MAINTENANCE REQUEST

Page Number of Change:

Document Currently Reads:

Recommended Changes/Should Read:

Reason for Change (Use additional sheets if necessary):

Signature of Submitter:

DISPOSITION (AIAG USE ONLY)

Manager's Recommendation:

Final Disposition:

Comments:

Note: Complete form and return to the AIAG Publication Specialist for consideration.

Automotive Industry Action Group • 26200 Lahser Road • Suite 200 • Southfield, MI 48034
Telephone: (248) 358-3570 • Fax: (248) 358-3253
Web: www.aiag.org