



CGA P-61—2023

ERGONOMIC GUIDELINE FOR THE COMPRESSED AND CRYOGENIC GAS INDUSTRY

THIRD EDITION

This document licensed for the sole use of the purchaser. It may not be shared with any other person or used after the expiration date without the express written permission of the CGA. Any unauthorized use, reproduction, distribution, or modification of this printed page will result in a \$5,000 liquidated damages fee plus loss of access to CGA publications for one year for your company.

Full document details: CGA P-61-2023



Documents
Document Sharing Hub

PLEASE NOTE:

The information contained in this document was obtained from sources believed to be reliable and is based on technical information and experience currently available from members of the Compressed Gas Association, Inc. and others. However, the Association or its members, jointly or severally, make no guarantee of the results and assume no liability or responsibility in connection with the information or suggestions herein contained. Moreover, it should not be assumed that every acceptable commodity grade, test or safety procedure or method, precaution, equipment or device is contained within, or that abnormal or unusual circumstances may not warrant or suggest further requirements or additional procedure.

This document is subject to periodic review, and users are cautioned to obtain the latest edition. The Association invites comments and suggestions for consideration. In connection with such review, any such comments or suggestions will be fully reviewed by the Association after giving the party, upon request, a reasonable opportunity to be heard. Proposed changes may be submitted via the Internet at our website, www.cganet.com.

This document should not be confused with federal, state, provincial, or municipal specifications or regulations; insurance requirements; or national safety codes. While the Association recommends reference to or use of this document by government agencies and others, this document is purely voluntary and not binding unless adopted by reference in regulations.

A listing of all publications, audiovisual programs, safety and technical bulletins, and safety posters is available via the Internet at our website at www.cganet.com. For more information contact CGA at Phone: 703-788-2700, ext. 799. E-mail: customerservice@cganet.com.

Work Item 21-066
Safety and Health Committee

NOTE—Technical changes from the previous edition are underlined.

NOTE—Appendices A, B, C, D, and E (Informative) are for information only.

THIRD EDITION: 2023
SECOND EDITION: 2016
FIRST EDITION: 2009

© 2023 The Compressed Gas Association, Inc. All rights reserved.

All materials contained in this work are protected by United States and international copyright laws. No part of this work may be reproduced or transmitted in any form or by any means, electronic or mechanical including photocopying, recording, or any information storage and retrieval system without permission in writing from The Compressed Gas Association, Inc. All requests for permission to reproduce material from this work should be directed to The Compressed Gas Association, Inc., 8484 Vestmark Drive, Suite 220, McLean, VA 22102. You may not alter or remove any trademark, copyright or other notice from this work.

 **Documents**
Document Sharing Hub

Contents	Page
1 Introduction.....	1
2 Scope	1
3 Definitions.....	1
4 Work-related musculoskeletal disorder risk factors	2
5 Good body mechanics.....	3
6 Developing an ergonomics program	3
6.1 Ergonomics program elements.....	3
6.2 Management leadership	4
6.3 Employee participation	4
6.4 Recognizing and evaluating risk factors	6
6.5 Controlling risk factors	6
6.6 Training.....	7
6.7 Health care management	8
6.8 Program evaluation	8
7 References	9

Tables

Table 1—Examples of potential MSD risk factors	2
Table 2—ABCs of good body mechanics	3

Appendices

Appendix A—Plant and customer service environment (Informative).....	10
Appendix B—Warehousing environment (Informative).....	36
Appendix C—Office environment (Informative).....	40
Appendix D—Retail environment (Informative).....	63
Appendix E—Distribution (Informative)	66

1 Introduction

Ergonomics is the science of fitting workplace conditions and job demands to the capabilities of the working population.

Ergonomics attempts to develop equipment, tools, work practices, and machine technology that will improve overall employee health, comfort, and performance, as well as provide a safer working environment. Ergonomics places the emphasis on the human subject and how systems, processes, and everyday job tasks should be performed in an environment more adaptive to the worker, rather than the worker trying to adapt to the environment.

One type of injury that can be avoided by eliminating risk factors in the work environment is a work-related musculoskeletal disorder (MSD) or cumulative trauma disorder (CTD). MSDs refer to disorders of the soft tissues and are associated with repeated exertions or movements of the body, awkward postures, and extreme force.

MSD risk factors can be found in activities both on and off the job and can lead to muscle fatigue. Fatigue commonly leads to discomfort and to a reduction in endurance, strength, and muscle control.

The differentiating factor between a MSD and another type of injury is the acuteness of the injury. Acute trauma refers to injuries that occur immediately, such as cuts, bruises, and falls. Some cumulative trauma injuries appear to be sudden but can be the result of chronic exposure to MSD risk factors over time.

This publication heavily references the National Institute for Occupational Safety and Health's (NIOSH) publication, *Elements of Ergonomics Programs: A Primer Based on Workplace Evaluations of Musculoskeletal Disorders* [1].¹

2 Scope

This guideline describes the recommended generic parts of an ergonomic program for the compressed and cryogenic gas industry. It addresses recommendations for ergonomic practices related to the products, equipment, and activities of the compressed and cryogenic gas producers, manufacturers, distributors, and users.

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

¹ References are shown by bracketed numbers and are listed in order of appearance in the reference section.

3.2 **Technical definitions**

3.2.1 **Administrative controls**

Methods of controlling employee exposures by work rotation, work assignment, time periods away from the hazard, or training in specific work practices designed to reduce the exposure [2].

3.2.2 **Body mechanics**

Use of proper body movement in daily activities, to the prevention and correction of problems associated with posture, and to the enhancement of coordination and endurance [3].

3.2.3 **Cumulative trauma disorders (CTDs)**

Disorders or injuries to soft tissues such as muscles, tendons, ligaments, cartilage and spinal discs as well as joints and nerves that develop gradually over periods of time [4].

NOTE—Exposure to physical work activities that involve repetition, force, awkward posture, or other risk factors can cause or contribute to CTDs. Examples of CTDs include carpal tunnel syndrome, rotator cuff syndrome, De Quervain's disease, trigger finger, sciatica, epicondylitis, tendonitis, Raynaud's phenomenon, and carpet layer's knee. CTDs are also known as musculoskeletal disorders (MSDs).

3.2.4 **Engineering controls**

Methods of controlling employee exposures by modifying the source [2].

NOTE—Examples of engineering controls are changing the workstation layout, providing a mechanical lifting device, or changing the design of tools.

3.2.5 **Neutral posture**

When joints are not bent and the spine is aligned and not twisted [5].

NOTE—Working in neutral postures is preferable to working while twisting the back or bending the wrists.

4 **Work-related musculoskeletal disorder risk factors**

Musculoskeletal disorders that can be related or attributed to the work environment and/or the performance of work are known as work-related musculoskeletal disorders (MSDs). The development of MSDs is related to the exposure to identified MSD risk factors. MSDs risk factors are not necessarily causative of MSDs, but there exists an association or relationship between them. The greater the exposure to MSD risk factors the greater the likelihood of developing an MSD.

See Table 1 for examples of potential MSD risk factors.

Table 1—Examples of potential MSD risk factors

MSD risk factors	Description
Static posture	Maintaining a stationary position for extended periods of time, such as standing in place or holding the arm away from the body.
Awkward posture	Any fixed or constrained body positions other than neutral alignment. Neutral posture occurs when the natural tensions of the muscles are relaxed. If an extreme posture is sustained or combined with high forces, it can place a person at a greater risk of injury.
Repetition	High numbers of similar body part movements. Repetitive motion can combine with fatigue, force, and posture to increase the risk of injury.
Forceful exertion	Excessive force or strength used to perform a job, as in gripping or lifting. Force can be applied by an object to a body part or internally within the body such as compression of the discs of the back.
Contact stress	Long-term pressure on soft tissue and underlying nerves, such as the palm or forearm.
Excessive vibration	Vibrations are most commonly transmitted to workers through tools, controls, or contact with vibrating work surfaces. Vibration primarily affects circulation and nerve function.

MSD risk factors	Description
Extreme cold temperatures	Cold is typically transmitted to the person from tools, work surfaces, and the environment. The primary effect of cold is that it triggers the body's natural response to reduce circulation to the affected area.
Work structure	A person's work structure is defined by job factors, such as organization design, job design, incentive systems, and management policies and styles. Research has shown that these variables can affect the incidence of MSDs.
Nonoccupational activities	Nonoccupational activities can sometimes expose a person to many of the risk factors described in this table.
Individual factors	Certain medical conditions and anatomical differences are known to increase an individual's risk of developing a MSD.

5 Good body mechanics

Ergonomic-related injuries can be reduced by using our own bodies as effectively and efficiently as possible through the use of the principles of good body mechanics. Table 2 provides some general tips on good body mechanics.

It can be difficult to adhere completely to every principle every time. However, by keeping these principles in mind, you have the ability to set up each situation using as many principles as possible to enhance your safety.

Table 2—ABCs of good body mechanics

B ~ Back	• Maintain the natural curve of your back/spine; and • Pay particular attention to the normal inward curve of your lower back (the lumbar region).
A ~ Arms	• Keep your arms as close to your body as possible; • Hold the weight close to your body and at waist height; and • Remember to keep elbows in and thumbs up (or in neutral) to stabilize the shoulder joint.
T ~ Twisting	• Avoid trunk twisting; • Move your feet by pivoting or sidestepping; and • Keep in mind that your trunk is twisted if your shoulders are not positioned in the same plane as your hips.
B ~ Base of support	• Place your feet shoulder width apart and staggered (one slightly in front of the other).
L ~ Legs	• Use the large muscles of your legs and buttocks to generate the force for movement; use your own body weight as a counterweight.
E ~ Evaluate	• Think before you act; and • Evaluate your load and the environment.

6 Developing an ergonomics program

An ergonomic program enables employers to detect MSD risk factors and develop solutions to anticipate and prevent MSD problems.

6.1 Ergonomics program elements

An ergonomics program contains several common elements. These elements typically include the following:

- management leadership;
- employee participation;

- recognizing and evaluating risk factors;
- controlling risk factors;
- training;
- health care management; and
- program evaluation.

Each element is discussed in more detail in the following sections. Compressed gas companies are encouraged to utilize these elements and modify them as needed to meet the goals of their respective organizations.

Additional information on developing an ergonomics program in the United States and Canada can be found in NIOSH's Ergonomics and Musculoskeletal Disorders; the U.S. Occupational Safety and Health Administration's *Ergonomics Overview*; the Canadian Centre for Occupational Health and Safety's OSH Answers Fact Sheet on ergonomics; and the Association of Canadian Ergonomists² [6, 7, 8].

6.2 Management leadership

Management should take responsibility for the overall coordination of the company's ergonomics program. Managers shall show visible leadership and commitment to the program in terms of time and resources. Management commitment can be demonstrated by any of the following actions:

- establishing an ergonomics strategy plan with clear goals and objectives;
- assigning responsibility for coordinating the program and carrying out a number of tasks;
- promoting the ergonomics program and its efforts to make the workplace safer;
- ensuring responsibilities and accountabilities are defined as part of each employee's evaluation;
- being visible in the workplace promoting the program while demonstrating their level of commitment;
- empowering all employees; and
- establishing a clear ergonomics policy.

Creating ergonomic teams to develop, implement, and maintain the ergonomic program demonstrates management's commitment to ensuring an effective program. The team should have a purpose, and everyone on the team should have a role. An effective ergonomics team needs to:

- meet regularly;
- coordinate activities;
- establish procedures for conducting employee evaluations and making engineering changes;
- identify important tasks, setting target dates, and establishing who is responsible for follow-up; and
- document activities for record keeping.

A team with well-defined goals that follows through will be successful in bringing beneficial ergonomic changes to the company.

6.3 Employee participation

Employee participation is an integral part of an effective ergonomics program. Positive results can be achieved when employees actively participate. Benefits of employee involvement include:

- enhanced worker motivation and job satisfaction;

² The Association of Canadian Ergonomists. <https://ergonomicscanada.ca>

- added problem-solving capabilities;
- greater acceptance of change; and
- greater knowledge of their work environment and organization.

Participation methods vary according to the size, labor status, department structure, knowledge base, and geographical distribution of the workforce. Therefore, a company shall establish techniques to empower employees and obtain their participation, choosing from a variety of options:

- create an employee suggestion system;
- interview individual employees when their work area is being evaluated;
- perform an employee survey;
- create department-specific ergonomics teams involving employees and focusing only on their work area;
- conduct small group discussions by company work area; or
- make ergonomics an important part of the company's employee evaluations.

Team membership varies depending upon the company and the goals of the particular group and may include:

- safety and industrial hygiene personnel;
- health care providers;
- human resources;
- engineering personnel;
- facilities and maintenance personnel;
- ergonomics specialists;
- front-line personnel;
- management; and
- labor representatives, if applicable.

The team members should receive basic instructions on the following topics before beginning their efforts:

- goals and expectations of the team and its members;
- hazard recognition and control as it applies to ergonomics;
- basic problem-solving principles; and
- any limitations the team is working under (i.e., budget, schedules, etc.).

All employees should be encouraged to participate in ergonomics programs by reporting unsafe conditions as well as reporting any signs and symptoms of health problems in the workplace. Employees are expected to follow all work instructions and best operating practices as outlined by their employer. Employees should not only be concerned for their own safety, but for the safety of those who work around them.

These measures can help ensure employee participation by demonstrating to employees that the company is taking the proper steps to improve their safety and wellbeing while at work.

6.4 Recognizing and evaluating risk factors

Jobs or job functions that pose a possible risk shall first be identified and evaluated before implementing ergonomic solutions. Ergonomic risk factors are further discussed in Appendices A, B, C, D, and E. Sources and methods for gathering this data can include:

- reviewing injury reports and trend analysis, worker's compensation claims, and symptom surveys;
- logged worker complaints regarding certain jobs, tools, or workstations that create pain and discomfort;
- worker and supervisor interviews;
- findings from walk-through inspections and surveys; and
- risk assessments such as job function analysis and job safety analysis or ergonomic risk assessments.

The risk assessment is a critical component of the overall ergonomics program. The risk assessment is an exercise whereby each step of the work task process is examined, measured, and quantified according to the risk factor inherent in the step. The analysis further identifies the conditions that contribute to the risk factor. The risk assessment should focus on work procedures, exercises, and explicit work areas that cause MSDs or create an opportunity of causing them. Tasks are typically categorized as:

- tools, equipment, and materials used to perform the job;
- workstation layout and physical environment; and
- task demands.

Each task is further examined where the specific risk factor(s) that could occur are identified. Data is gathered by:

- measuring workstation designs (height, reach surfaces, materials);
- measuring the size, weight, vibration, etc., of tools;
- measuring exposures to heat, cold, body vibrations, etc.;
- measuring body forces required to lift, push, pull, etc.;
- evaluating work surfaces for hardness, slip resistance, edges, instability, etc.;
- observing, photographing, and/or videotaping employees as they perform their job function tasks; and
- taking photos to illustrate work posture, workstation layouts, tools, etc.

Intelligence gained from the risk assessment as well as from other sources should be further evaluated, prioritized, and implemented into a strategy plan to control hazards.

6.5 Controlling risk factors

Measures should be taken to create safety controls and/or alternative processes in terms of work-related MSDs. A variety of approaches can help control these ergonomic risk factors including:

- Engineering controls—Reducing or eliminating risk factors in work areas by:
 - Purchasing new equipment and materials (power tools in place of manual tools, lighter weight materials in the work process, mechanical lifts to hold/transport materials, etc.)
 - Changing the workstation (adjust seat height, work surface heights, reach distances, adding keyboard trays, etc.)
 - Eliminating or reducing sources of vibration;

- Administrative controls—Management implementing company work practices as a form of control such as:
 - Reducing shift lengths with more scheduled breaks
 - Reducing the work pace
 - Rotating workers from jobs with high risk factors to low risk factors
 - Training employees to identify risk factors and steps to avoid or report
 - Requiring two persons for heavy lifting
 - Training employees on exercise and stretching techniques appropriate to their job tasks. Before instituting an exercise program, consult with a licensed health care professional; and
- Safeguard controls—Wearing personal protective equipment.

A description of control methods relating specifically to the compressed and cryogenic gas industry can be found in the Job Function sections in the Appendices.

Developing controls is not enough; there shall be a plan to put them into action. There are many ways to do this including:

- trials of the proposed solution to the problem;
- making modifications to a work area;
- testing a number of different methods to see which best comparatively reduces the risk; and
- closely evaluating control effectiveness.

Evaluating the effectiveness of controls is essential to ensure that the controls have reduced or eliminated the ergonomic risk factors and that new risk factors do not occur. Employees that perform the job task can provide useful input into the testing process. Worker acceptance of the changes put into place is important to the overall success of the solution as well.

6.6 Training

Employee training is necessary to deal with workplace safety problems, including those concentrating on ergonomic risk hazards. Ergonomics training can vary to account for all employees doing a wide variety of work tasks. Training can range from employee awareness training, especially employees in suspected problem jobs, to more specific, rigorous training for employees expected to take on job analyzing and problem-solving tasks.

It is generally recommended that all employees receive basic ergonomics awareness training that may include any or all of the following topics:

- how to recognize ergonomic risk factors both on and off the job;
- how to recognize signs and symptoms of MSDs that are related to the work environment;
- the organization's procedures for reporting job-related risk factors; and
- general principles for controlling ergonomic risk factors (e.g., proper postures, lifting technique, etc.).

In addition to basic awareness training, employees who are involved in evaluating jobs for risk factors and recommending and implementing control measures should be provided more extensive training in such topics as:

- ergonomic principles and identification of risk factors;
- methods for performing job hazard analyses;
- types of engineering controls that are applicable to the job;

- types of administrative controls that are applicable to the job;
- problem-solving procedures; and
- team-building techniques.

The effectiveness of training greatly depends on the way it is designed and delivered to the target audience. The following steps are provided to assist in this effort:

- a) Determine if training is needed. If the evidence gathered from checking health records and the results of the job analysis indicates a need to control ergonomic risk factors, then employees shall be provided with the training necessary for them to gain the knowledge to implement control measures;
- b) Identify training needs. As already mentioned, different categories of employees require different kinds of ergonomics instruction;
- c) Identify goals and objectives. Goals and objectives for training shall be defined in clear, directly observable, action-oriented terms;
- d) Develop learning activities. Whatever the mode of training—live lectures, demonstrations, interactive video programs, use of varied instructional aids—learning activities should be developed to help employees demonstrate that they have acquired the desired knowledge or skill;
- e) Conduct training. Training should take into account the language and educational level of the employees involved. Trainees should be encouraged to ask questions that address their particular job concerns, and hands-on learning opportunities should be encouraged;
- f) Evaluate training effectiveness. A common tool for training evaluations is the use of questions to determine whether they found the instruction interesting and useful to their jobs and if they would recommend it to others. However, more important are the measures of knowledge gained or improvements in skills specified in course objectives. Knowledge quizzes, performance tests, and behavioral observations may be used for this purpose; and
- g) Improving the program. If the evaluations indicate that the objectives of the training were not achieved, a review of the elements of the training plan would be in order. Revisions should be made to correct shortcomings.

6.7 Health care management

Health care management and health care providers can be an important component of a comprehensive ergonomics program. Health care management is useful in promoting early detection and prompt appropriate intervention and treatment of work-related injuries. In general, the earlier that symptoms are identified and treated, the less likely a more serious disorder can develop. The health care provider should work closely with the employer and be familiar with the operation as they can help to achieve these goals. Responsibilities of the health care provider may include:

- promptly evaluating employees who report signs and symptoms of MSDs;
- recommending appropriate treatment for employees diagnosed with MSDs;
- determining work restrictions for injured employees;
- assisting with workplace accommodations for disabled employees;
- ensuring the privacy of medical information as required by law; and
- assisting in the evaluation of control measures for ergonomic risk factors.

6.8 Program evaluation

Ergonomics programs should be reviewed and evaluated periodically to determine if they are achieving the desired goals. Some of the factors evaluated during an overall ergonomics program review include:

- number of employees reporting signs and symptoms of MSDs;
- number of employees diagnosed with work-related MSDs;
- severity of work-related MSDs;
- changes in productivity for particular jobs; and
- review of employee suggestions.

When program deficiencies are identified by the review process, appropriate measures should be implemented to correct any problems or enhance program effectiveness. In addition, when specific control measures are implemented, a follow-up evaluation should be conducted to determine the effectiveness of the controls. One of the goals of a successful ergonomics program should be to strive for continuous improvement.

7 References

Unless otherwise specified, the latest edition shall apply.

[1] *Elements of Ergonomics Programs: A Primer Based on Workplace Evaluations of Musculoskeletal Disorders* (NIOSH Publication No. 97-117), National Institute for Occupational Safety and Health.

www.cdc.gov/niosh

[2] Plog, B and Quilan P, *Fundamentals of Industrial Hygiene Fifth Edition*, National Safety Council.

www.nsc.org

[3] Rodts, M, McLaughlin M editor, *Ergonomics: The Human Body and Injury Prevention*, Ergonomic Standards. Spineuniverse.com

[4] *Cumulative Trauma Disorders in the Workplace* (NIOSH Publication 95-119), National Institute for Occupational Safety and Health. www.cdc.gov/niosh

[5] *Ergonomics eTool: Solutions for Electrical Contractors – Glossary*, U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov

[6] *Ergonomics and Musculoskeletal Disorders*, National Institute for Occupational Safety and Health. www.cdc.gov/niosh

[7] *Ergonomics Overview*, U.S. Department of Labor, Occupational Safety and Health Administration. www.osha.gov

[8] *OSH Answers Fact Sheets*, Canadian Centre for Occupational Health and Safety. www.ccohs.ca

Appendix A—Plant and customer service environment (Informative)



A1 – Job function: using power tools

Description of work environment

An employee's job function involves using various power-assisted hand tools. In these tasks, the employee can use tools, such as a hammer rotary drill, hand-held electronic drills, lead cutters, impact wrenches, etc. These tools are powered by several methods such as pneumatics, hydraulics, gasoline, or electrical sources. Power tools can be used in various locations such as at a customer's facility as well as at a production, retail, or warehouse facility.

The weight of the tool varies according to its size. Power tools can be used during most weather conditions.



Employee using drill



Employee using rotary hammer drill

Risk factors	Body segment	Contributing factors
Unbalanced tools	Hand/Arm/Tendon/ Shoulder	Unbalanced tools can put stress on the small muscles and tendons in the arms and hands. These unbalanced tools also stress the shoulders if used above chest height.
Vibrating tools	Hand/Arm/Tendon/ Shoulder	Vibrating tools reduce blood flow by constricting blood vessels and cause motion and torque, which require a firmer grip. Certain frequencies can cause nerve damage.
Excessive torque	Hand/Arm/Tendon/ Shoulder	Shock and impact to hands and arms from using power hammer drills.
Grip force requirements	Hand	Forceful tool grip.
Cold temperatures	Hand	Cold temperatures reduce blood flow by constricting blood vessels.
Awkward posture	Wrists/Elbow/ Shoulder	Tools that don't allow neutral postures can reduce circulation and require greater forces.

Recommended solution strategy—short term

- Make available gloves with vibration-damping materials in palms and fingers.
- Be sure tools are well maintained. They should be kept sharp, lubricated, and tuned.
- Train employees on proper use of equipment, safety precautions, the effects of vibration, and methods for reducing exposure.
- Select tools with comfortable grips that allow use with neutral posture.
- Allow the tool to do the work by using a grip light enough to maintain sufficient control.
- Take rest breaks as needed.

Recommended solution strategy—long term

- Purchase power tools that are well balanced, have vibration-reducing features, and have handles that are smooth but not slippery.
- Power tools should be made available with torque converters to reduce the chance of sudden stops.

A2 – Job function: using hand tools

Description of work environment

This job function involves an employee using various hand tools. In this task, the employee can use tools such as hammers, pliers, screwdrivers, saws, wrenches, cutters, pry bars, chisels, clamps, etc. The tools are used to tighten, loosen, cut, open, close, pinch, and adjust. Hand tools can be used in various locations and most weather conditions. The weight of the tool varies according to its size.

Risk factors	Body segment	Contributing factors
Awkward posture	Hand/Forearm/ Elbow/Shoulder	Awkward posture can occur when an employee positions his or her body too high or too low in relationship to the work that needs to be performed.
Force	Hand	Forceful exertion occurs when the tool is poorly maintained, contributing to the forces people apply while using the tool. In addition, some forceful exertion is observed in the hand opposite of the hand manipulating the tool. Often times, the opposite hand is used to provide leverage or tension while performing the job tasks, thus leading to forceful exertion of the opposing hand.
Repetition		The number of tasks/functions performed in a day varies depending on the workload. Some days the load can be very high, increasing the repetitive movement.
Unbalanced tools	Hand/Arm/Tendon/ Shoulder	Unbalanced tools can put stress on the small muscles and tendons in the arms and hands. These unbalanced tools also stress the shoulders if used above chest height.
Excessive torque	Hand/Arm/Tendon/ Shoulder	Shock and impact to hands and arms from using hammers.
Grip force requirements	Hand	Forceful tool grip.
Cold temperatures	Hand	Cold temperatures reduce blood flow by constricting blood vessels.

Recommended solution strategy—short term

- Positioning your body properly as it relates to the work is very important. Locate the work as close to your body as possible to reduce excessive reaches.
- Tool maintenance is very important to reduce the amount of force used when performing a task. Ensure that a tool maintenance program is in place and encourage employees to report defective or malfunctioning tools. Tools should be kept sharp, lubricated, and tuned.
- Consider purchasing hand tools with cushioned handles. These tools should be tested for application prior to implementation.
- Make available gloves with vibration-damping materials in palms and fingers. Make sure that they fit.
- Train employees on the proper use of equipment, safety precautions, the effects of improper use, and methods for reducing exposure, such as:
 - Maintain straight wrists. Avoid bending or rotating the wrists;
 - Avoid static muscle loading. Reduce both the weight and size of the tool. Do not raise or extend elbows when working with heavy tools. Provide counter-balanced support devices for larger, heavier tools;
 - Avoid stress on soft tissues. Stress concentrations result from poorly designed tools that exert pressure on the palms or fingers. Examples include short-handled pliers and tools with finger grooves that do not fit the employee's hand;

- Reduce grip force requirements. The greater the effort to maintain control of a hand tool, the higher the potential for injury. A compressible gripping surface rather than a hard plastic surface can alleviate this problem;
- Whenever possible, select tools that use a full-hand power grip, rather than a precision finger grip;
- Maintain optimal grip span. Optimum grip spans for pliers or cutters, measured from the fingers to the base of the thumb, ranges from 2.4 in to 3.5 in (6 cm to 9 cm). The handle diameters for circular handle tools such as screwdrivers are 1.2 in to 2 in (3 cm to 5 cm) when a power grip is required and 0.3 in to 0.6 in (0.75 cm to 1.5 cm) when a precision finger grip is needed;
- Avoid sharp edges and pinch points. Select tools that do not cut or pinch the hands, even when gloves are not worn;
- Avoid repetitive trigger-finger actions. Select tools with large switches that can be operated with all four fingers; and
- Isolate hands from heat, cold, and vibration. Heat and cold can cause loss of manual dexterity and increased grip strength requirements. Excessive torque/squeezing can cause reduced blood circulation in the hands.
- Take rest breaks as needed.

Recommended solution strategy—long term

- Reduce the number of repetitions per shift.
- Maintain neutral (handshake) wrist positions:
 - Design jobs and select tools to reduce extreme flexion or deviation of the wrist; and
 - Avoid inward and outward rotation of the forearm when the wrist is bent.
- Reduce the force or pressure on the wrists and hands:
 - Whenever possible, reduce the weight and size of objects that must be handled repeatedly;
 - Avoid tools that create pressure on the base of the palm;
 - Avoid using the hands as a hammer; and
 - Avoid repetitive, forceful pressing with the fingertips.
- Design tasks so that a power, rather than a finger-pinch, grip can be used to grasp materials.
- Minimize reaching:
 - Avoid reaching more than 15 in (38 cm) in front of the body for materials;
 - Avoid reaching above shoulder height, below waist level, or behind the body; and
 - Avoid repetitive work that requires full arm extension (i.e., the elbow held straight and the arm extended).
- Provide support devices when awkward body postures (elevated hands or elbows and extended arms) must be maintained. Use fixtures to relieve stressful hand/arm positions.
- Provide for protection of the hands if working in a cold environment. Furnish a selection of glove sizes and sensitize users to problems of forceful over-gripping when worn.
- Select and use properly designed hand tools (e.g., grip size of tool handles should accommodate a majority of employees).
- Consider substituting power tools for hand tools when possible.

A3 – Job function: kneeling while working

Description of work environment

Kneeling while working on equipment is a common occurrence. The employee often has very little control over the placement of the equipment. This means that, at times, the work can be situated between the ground and 30 in (78 cm) in height, thus requiring the employee to work on his or her knees.



Employee using kneeling pad while repairing equipment

Risk factors	Body segment	Contributing factors
Contact pressure	Knee/Ankle/Foot	- Weight of the individual contributes to the contact pressure. - Type of surface on which the knees rest.
Time	Knee/Ankle/Foot/Back	The amount of time spent on the knees.
Cold temperatures	Knee/Ankle/Foot	Cold temperatures reduce blood flow by constricting blood vessels.

Recommended solution strategy—short term

- Use good body mechanics whenever possible.
- Provide training on the proper way to move into and out of a kneeling position.
- Use kneepads or a kneeling mat to kneel on, especially if the duration of the task is more than a few minutes.
- Limit the amount of time kneeling on a hard surface, if possible.
- Sit down, instead of kneeling, if the work requires a long period of time in a kneeling position.

Recommended solution strategy—long term

Work with management to position equipment at a height that would allow the worker to either sit or stand.

A4 – Job function: handling and storing compressed gas cylinders in service vehicles

Description of work environment

This job function involves an employee loading, unloading, and transporting compressed gas cylinders from a vehicle to a work or storage location. Pressurized gas cylinders are heavy unstable objects and can present considerable danger to those handling them. The gross weight of a 224 ft³ (6.3 m³) (51 in [1.3 m]) cylinder can be up to 155 lb (70 kg). For short distances, the cylinder is typically tilted on its edge and rolled slowly with one hand on top of the cap while pushing the bottom of the cylinder with the opposite foot. For longer distances, a cylinder trolley is used with the cylinder secured in place. This task is normally performed outdoors and can be affected by environmental conditions such as rain, ice, and/or snow.



Rolling a compressed gas cylinder a short distance



Moving a compressed gas cylinder a long distance

Risk factors	Body segment	Contributing factors
Awkward postures	Hand/Wrist/Arm/ Shoulder/Lower Back	- Length and weight of the cylinder can contribute to awkward handling of the cylinder. - Position of the cylinder in a vehicle can contribute to additional awkward postures.
Force	Hand/Wrist/Arm/ Shoulder/Lower Back	- Coordination of hand and leg movements together with the shifting of one's body weight while maintaining stability as the employee safely maneuvers compressed gas cylinder (i.e., loading, unloading, transporting, and placing). - Compressed gas cylinders can often weigh between 150 lb to 293 lb (68 kg to 133 kg), adding to additional forces on the body. - The smooth outer surface of the cylinder can make the cylinder harder to grip and can contribute to the forceful exertion required to move the compressed gas cylinder.

Recommended solution strategy—short term

- Cylinder loading/unloading, storage, and filling areas should be designed to keep travel distances to a minimum.
- For longer distances, use a lightweight cart or trolley to transport cylinders.
- When unloading or loading the container from a truck, use a hand truck, lift gate, or parallel loading dock.
- Always have assistance if the cylinder is too heavy or awkward (two-person job).

Recommended solution strategy—long term

- Utilize mechanical lifting devices (i.e., hydraulic lift, mechanical hoist), if possible.



- Filling locations should be designed so that loading/unloading, filling, staging, and processing areas keep cylinder loading to an absolute minimum.

A5 – Job function: rolling compressed gas cylinders

Description of work environment

This job function involves an employee loading, unloading, and transporting compressed gas cylinders from a vehicle to a work or storage location. Pressurized gas cylinders are heavy unstable objects and can present considerable danger to those handling them. The gross weight of a 224 ft³ (6.3 m³) (51 in [1.3 m]) cylinder can be up to 155 lb (70 kg). For short distances, the cylinder is typically tilted on its edge and rolled slowly with one hand on top of the cap while pushing the bottom of the cylinder with the opposite foot. For longer distances, a cylinder trolley is used with the cylinder secured in place. These tasks can be performed indoors and outdoors and can be affected by environmental conditions such as rain, ice and/or snow.



Moving compressed gas cylinder with assistance



Rolling compressed gas cylinder a short distance

Risk factors	Body segment	Contributing factors
Awkward postures	Hand/Wrist/Arm/ Shoulder/Lower Back	- Length of cylinder can contribute to awkward handling of the cylinder. - Weight and position of the cylinder while rolling can contribute to additional awkward postures.
Force	Hand/Wrist/Arm/ Shoulder/Lower Back	- Coordination of hand and leg movements together with the shifting of one's body weight while maintaining stability as the employee safely rolls compressed gas cylinder (i.e., loading, unloading, transporting, and placing). - Compressed gas cylinders can often weigh between 150 lb to 293 lb (68 kg to 133 kg), adding to additional forces on the body. - The smooth outer surface of the cylinder can make the cylinder harder to grip and can contribute to the forceful exertion required to move the compressed gas cylinder.

Recommended solution strategy—short term

- Cylinder loading/unloading, storage, and filling areas should be designed to keep the travel distances to a minimum.
- For long distances, use a lightweight cart or trolley to transport cylinders.
- When unloading or loading the cylinder from a truck, use a hand truck, lift gate, or parallel loading dock.
- Always have assistance if the cylinder is too heavy or awkward.

Recommended solution strategy—long term

Filling locations should be designed so that loading/unloading, filling, staging, and processing areas keep cylinder loading to an absolute minimum.

A6 – Job function: handling extension ladders

Description of work environment

This job function includes all aspects of working with and carrying extension ladders. Specifics include: carrying the ladder to the job site; extension and placement of the ladder for work; collapsing the ladder; and returning the ladder to its storage area. This function can be performed inside or outside in various types of terrain and weather conditions.



Carrying ladder to and from job site



Extending and collapsing ladder

Risk factors	Body segment	Contributing factors
Forces on the spine	Back	Weight of ladder. A typical 24 ft (7.3 m) fiberglass ladder, with rung and cable hooks, weighs approximately 60 lb (27 kg); a 28 ft (8.5 m), 300 lb (136 kg) rated ladder weighs approximately 67 lb (30 kg).
Awkward postures	Shoulder	- Icy, slippery conditions, unknown terrain, windy conditions. - Methods of carrying the ladder.
Contact stress	Head/Shoulder	Hard or sharp edges of the ladder can press on shoulders or fingers.
Forceful exertion	Hand	Pulling rope and placing ladder into position.

Recommended solution strategy—short term

- Use a two-person carry method for ladders over 28 ft (8.5 m).
- Use a hand line to raise and lower ladder on windy days.
- Always have assistance if the ladder is too heavy or awkward (two-person job).
- Use a pad on the shoulder to keep sharp edges from contacting soft tissues.
- Place indicator on ladder to show the center of balance to the employee.
- Suitcase handles on the side of ladder.

Recommended solution strategy—long term

- Provide lighter-weight ladders.
- Use a ladder trolley or ladder dolly where terrain or conditions permit.

A7 – Job function: handling liquid containers—carts**Description of work environment**

Handling liquid containers involves loading and unloading them from filling and staging areas onto the back of a truck or onto a trailer. This task involves moving heavy containers. Sometimes, one container must be moved manually to access another. Moving liquid containers is often required of the employee during filling, staging, and loading/unloading.



Securing a liquid container to a cart



Pushing a liquid container



Maneuvering a liquid container on a cart

Risk factors	Body segment	Contributing factors
Heavy pushing forces (60 lb to 70 lb [27 kg to 32 kg] or higher)	Back/Neck/Leg	Weight of the container. Some containers can weigh as much as a few hundred pounds. Types of terrain can contribute to more force.
Twisting of lower back and shoulders	Back/Shoulder	• Securing portable cart to the container. • Requirement of manually maneuvering containers. • Pulling backwards on the cart. • Balancing the container against the backrest.
High speed/jerking movements	Lower Limb	• Arrangement of containers in staging area. • Pedestrian and motorized traffic. • Uneven surfaces, dock plates, loading platforms, etc.
Forward bending	Back	• Must bend at the waist to handle smaller containers.

Recommended solution strategy—short term

- Use proper body mechanics and safe handling procedures when performing manual pushing tasks involving containers. Emphasize that containers should not be pulled because of safety issues. Research materials: <http://www.osha.gov>
- Use two people to move a heavy container.
- Investigate rearranging and/or redesigning the staging areas so that the trucks can back up to the desired containers without having to move them a great distance to the truck.

Recommended solution strategy—long term

- Investigate the use of powered mechanical equipment, such as a forklift or pallet mover, to transfer containers.
- Only lift container by its lifting brackets when using a mechanical lifting device or crane.

A8 – Job function: handling liquid containers—wheel base

Description of work environment

Handling liquid containers involves loading and unloading them from filling and staging areas onto the back of a truck or onto a trailer. This task involves moving heavy containers. Sometimes, one container must be moved manually to access another. Moving liquid containers is often required of the employee during filling, staging, and loading/unloading.



Pushing a large liquid container



Maneuvering a liquid container



Liquid containers in storage area



Pushing a small liquid container

Risk factors	Body segment	Contributing factors
Heavy pushing forces (60 lb to 70 lb [27 kg to 32 kg] or higher)	Back/Neck/Leg	Weight of the container. Some containers can weigh as much as a few hundred pounds. Types of terrain can contribute to more force.
Twisting of lower back and shoulders	Back/Shoulder	• Securing portable cart to the container. • Requirement of manually maneuvering containers. • Pulling backwards on the cart. • Balancing the container against the backrest.
High speed/jerking movements	Lower limb	• Arrangement of containers in staging area. • Pedestrian and motorized traffic. • Uneven surfaces, dock plates, loading platforms, etc.
Forward bending	Back	Must bend at the waist to handle smaller containers.