CSA STANDARDS

Z1004-12

Workplace ergonomics — A management and implementation Standard

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Contents

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Preface

This is the first edition of CSA Z1004, *Workplace ergonomics — A management and implementation Standard*.

This Standard sets out requirements and provides guidance for the systematic application of ergonomics to the development, design, use, management, and improvement of work systems through the implementation of an Ergonomics Process. The objective of this Standard is to enable an organization to enhance worker health, safety, and well-being and optimize system performance to prevent occupational injuries, illnesses, and fatalities and/or reduce the severity of harm related to occupational activities and work environments.

To facilitate its use and adoption, this Standard is aligned with the Plan-Do-Check-Act (PDCA) continuous improvement model found in occupational health and safety management systems (OHSMS), such as CAN/CSA-Z1000.

This Standard was prepared by the Technical Committee on Workplace Ergonomics under the jurisdiction of the Strategic Steering Committee on Occupational Health and Safety, and has been formally approved by the Technical Committee.

March 2012

Notes:

(1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*

(2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*

(3) *This publication was developed by consensus, which is defined by* CSA Policy governing standardization — Code of good practice for standardization *as "substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity". It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this publication.*

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(b) provide an explanation of circumstances surrounding the actual field condition; and
(c) where possible, phrase the request in such a way that a specific "yes" or "no" answer will address the issue.
Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization *and are published in CSA's periodical* Info Update*, which is available on the CSA website at* ***http://standardsactivities.csa.ca****.*

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(c) wording of the proposed change; and
(d) rationale for the change.

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Z1004-12
Workplace ergonomics — A management and implementation Standard

0 Introduction

0.1 General

Ergonomics (or human factors) is the discipline concerned with the understanding of interactions among humans and other elements of a system, and the application of theory, principles, data, and methods of design to enhance worker health, safety, and well-being and optimize system performance. For the purposes of this Standard, the term "Ergonomics" is being used interchangeably with the term "human factors".

The science and Application of Ergonomics can be used to improve many aspects of the interactions of people with jobs, systems, products, and environments. This Standard describes how ergonomics is integrated into occupational health and safety and design using an Ergonomics Process to improve occupational health and safety outcomes and to optimize work system design.

This Standard is structured for use with an occupational health and safety management system (OHSMS), such as CAN/CSA-Z1000; however, it may also be used independently or with other health and safety activities as it employs an identification, elimination, assessment, and control structure. This Standard is compatible with the Plan-Do-Check-Act (PDCA) model found in CAN/CSA-Z1000. This Standard provides an overall framework for addressing preventive and protective measures, worker participation, training, design, procurement issues, documentation, and legal and other requirements.

See Figure 1.

0.2 Principles of an effective Ergonomics Process

Within the scope of this Standard, the following principles form an integral part of an effective Ergonomics Process to enhance worker health, safety, and well-being, and optimize system performance:

(a) Worker health, safety, and well-being and system performance are enhanced through the use of ergonomics, by considering interactions between people and the components of the work system, such as tasks, equipment, workspace, work organization, and the environment.

(b) Ergonomics has its greatest benefit when used early in the design of a work system rather than being used to solve problems after the design is complete. Ergonomics is also beneficial in the redesign of an existing work system.

(c) The user-centred approach is a key attribute of ergonomics and ensures that a broad range of worker characteristics and requirements are accommodated.

(d) Worker participation is an essential aspect of the Ergonomics Process in the organization. Workers and their representatives provide valuable knowledge in work system design when they are involved.

(e) A workplace Ergonomics Process operates effectively when it is integrated within the organization's OHSMS.

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0.3 Using this Standard

0.3.1 General

The Ergonomics Process consists of the commitment, leadership, planning, implementation, and continual improvement necessary to identify and eliminate hazards and to assess and control risks using ergonomics principles. It operates within the OHSMS, where one exists, to enhance worker health, safety, and well-being and optimize system performance.

The implementation element of the Ergonomics Process includes the Application of Ergonomics, to identify and eliminate hazards, and to assess and control risks in a work system to enhance worker health, safety, and well-being and optimize system performance. This occurs at each stage of design and operation of a work system. Design occurs during any project or undertaking where changes are being introduced. The Application of Ergonomics emphasizes prevention of injuries, illnesses, and errors in the workplace; it is further described in detail in Clause 7.

Many organizations first develop awareness of the use of ergonomics in a reactive mode, when problems arise with worker health and safety. The emphasis should be on the proactive use of ergonomics to design improved processes, systems, or work organization. This Standard requires the Ergonomics Process to be applied in both types of conditions (i.e., proactive and reactive).

The implementation of this Standard should be customized by each organization based upon the nature of their work and the size and location of their operations. This Standard applies to all types and sizes of organizations, regardless of whether or not a formal OHSMS is in place.

0.3.2 Structure of this Standard

The informative guidance material (see Annex A) is intended to assist users in complying with the Standard. In Annex A, the provisions, which are reproduced from the Standard, are included in text boxes. The guidance information is given below the text boxes to which it applies.

Annex B provides information and examples of evidence-based tools and checklists. The content included in Annex B is not intended to be exhaustive and other such tools and checklists demonstrated to be equally effective through professional use, best practice, or citations in the scientific literature may also be used where applicable. The application of such evidence-based tools and checklists will enable organizations to meet the objectives of this Standard.

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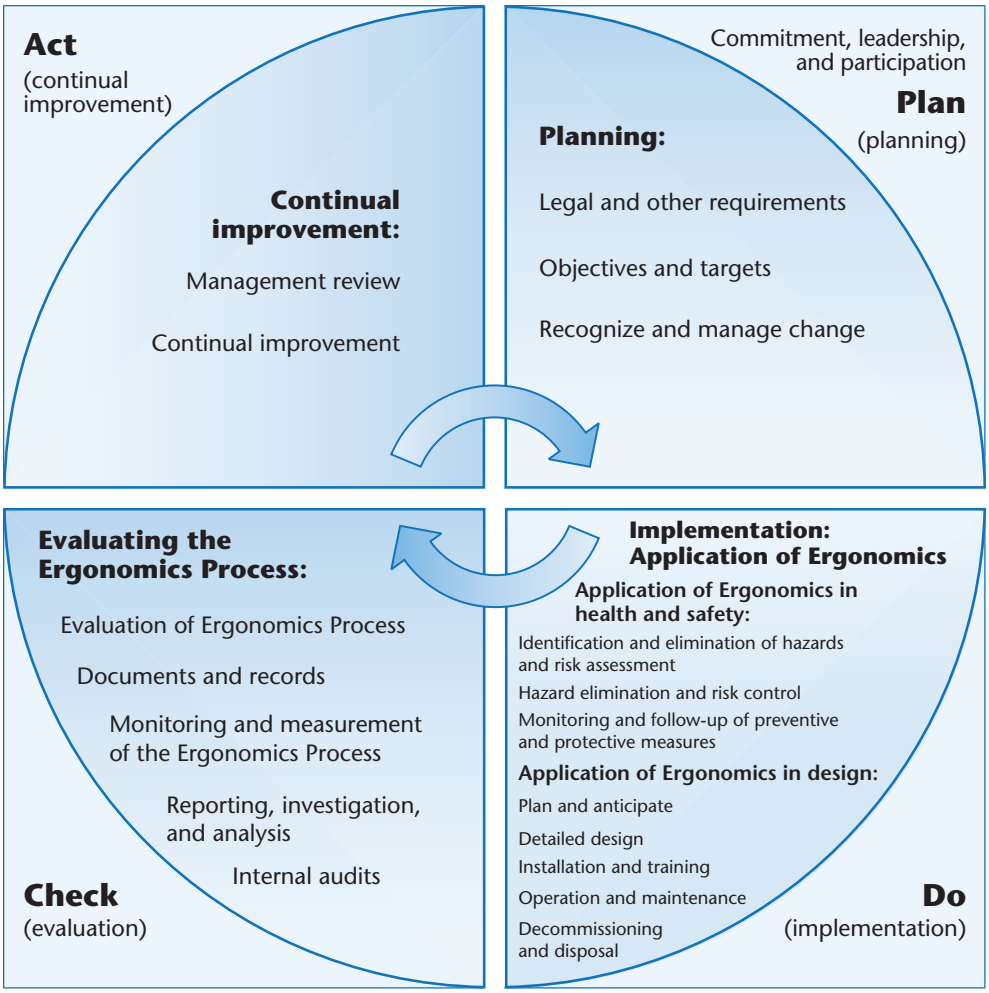

Figure 1
Elements of an OHSMS and the Ergonomics Process
(See Clause 0.1.)

1 Scope and objective

1.1 Scope

1.1.1
This Standard specifies requirements and provides guidance for the systematic Application of Ergonomics to the development, design, use, management, and improvement of work systems through the implementation of an Ergonomics Process.

1.1.2
This Standard does not apply to medical management programs or to aspects that could be considered part of a medical management program, such as therapeutic or clinical interventions.

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1.2 Objective

The objective of this Standard is to enable an organization to enhance worker health, safety, and well-being and optimize system performance to prevent occupational injuries, illnesses, and fatalities and/or reduce the severity of harm related to occupational activities and work environments through the systematic Application of Ergonomics.

Prevention strategies proactively identify hazards and eliminate them where possible. Where elimination is not possible, prevention can be achieved through appropriate risk assessment and control techniques.

1.3 Terminology

In CSA standards, "shall" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; "should" is used to express a recommendation or that which is advised but not required; and "may" is used to express an option or that which is permissible within the limits of the standard.

Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.

Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

2 Reference publications

This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below.

CSA (Canadian Standards Association)
CAN/CSA-ISO 19011-03 (R2007)
Guidelines for quality and/or environmental management systems auditing

CAN/CSA-Z1000-06 (R2011)
Occupational health and safety management

ACGIH (American Conference of Governmental Industrial Hygienists)
TLVs and BEIs (2011)

ASHRAE (American Society of Heating, Refrigerating and Air-conditioning Engineers)
ANSI/ASHRAE 55-2010
Thermal Environmental Conditions for Human Occupancy

IES (Illuminating Engineering Society)
The Lighting Handbook, 10th edition (2011)

INPO (Institute of Nuclear Power Operationist)
06-003 (2006)
Human Performance Reference Manual

ISO (International Organization for Standardization)
ISO 6385:2004
Ergonomic principles in the design of work systems

NIOSH (National Institute for Occupational Safety and Health)
NIOSH Lifting Equation (1991)

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US Department of Defense
MIL-STD-1472 (1999)
Department of Defense Design Criteria Standard — Human Engineering

Other Publications
Eastman Kodak Company. 2003. *Kodak's Ergonomic Design for People at Work*. 2nd edition.

Gordon, C. C.; Churchill, T.; Clauser, C. E.; Bradtmiller, B.; and McConville, J. T. 1988
Anthropometric Survey of U.S. Army Personnel; Methods and Summary Statistics. Yellow Springs, OH.

Mital, A.; Nicholson, A.S.; and Ayoub, M.M. 1997. *A Guide to Manual Materials Handling*. London: Tylor & Francis. 2nd edition.

Reason, James. 2008. *The Human Contribution: Unsafe Acts, Accidents and Heroic Recoveries*. Ashgate.

SAFE Work Manitoba. 2008. *Seeing the Workplace with New Eyes.* New Eyes Project.

3 Definitions

The following definitions shall apply in this Standard:

Anthropometry — the study of the size and shape of the human body.
Note: *Anthropometric data are one of the basic criterion used to design workspaces/tools/equipment to a range of body sizes and shapes.*

Application of Ergonomics — the use of ergonomics principles to identify and eliminate hazards and assess and control risks at each stage of design of any work system to enhance worker health, safety, and well-being and optimize system performance. It is an element of the Ergonomic Process.

Audit — the systematic and documented process for obtaining evidence and evaluating it objectively to determine the extent to which the specified criteria are fulfilled.

Cognitive — related to "cognition", which is
(a) the process people use for remembering, awareness, perception, reasoning, understanding, and using judgment; and
(b) the ability to think and make sense out of what is seen, heard, felt, and experienced in order to take appropriate actions.

Cognitive demands — stressors associated with cognitive aspects of tasks being performed (see **Cognitive**).

Competence — demonstrated ability to apply ergonomics knowledge and skills to a work system design and operation.

Competent person — a person who is knowledgeable of ergonomics by reason of education, training, experience, or a combination thereof, and has a demonstrated ability to apply this knowledge to the design and operation of work systems.

Continual improvement — the process of enhancing the Ergonomics Process to achieve ongoing improvement in overall OHS performance.

Design — the process of changing existing or developing new work systems, encompassing individual tasks through to complex systems.

Document — a medium containing information related to the Ergonomics Process.

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Ergonomics — the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to enhance human well-being and optimize overall system performance.
Note: *Also referred to as "human factors".*

Ergonomics Process — the commitment, leadership, planning, implementation, and continuous improvement necessary to identify and eliminate hazards and to assess and control risks using ergonomics principles. It operates within the OHMS, where one exists, and in the design and operation of new or existing work systems.

Ergonomist — an individual whose knowledge and skills concern the analysis of human-system interaction and the design of the system in order to enhance human well-being and optimize overall system performance.

Evidence-based — derived from a systematic process of identifying, appraising, and using research findings and workplace experience as the basis for decision making.

Hazard — a source of potential harm to a worker.

Human factors — see **Ergonomics**.

Lagging indicators — a measurable factor, such as lost time injuries, that changes after health or safety has already begun to follow a particular pattern or trend.
Note: *Lagging indicators confirm long-term trends, but they do not predict them.*

Leading indicators — a measurable factor, such as preventive measures to eliminate hazards that changes before the incident, injury, or disorders occur and start to follow a particular pattern or trend.
Note: *Leading indicators can be used to predict changes in disorders and injuries, but are not always accurate.*

Legal requirements — requirements of applicable laws and, where applicable, provisions of the organization's collective agreements that relate to occupational health and safety.

Management system — a system governing the overall performance expectations within the work environment.

Mock-up — a sample that emulates a final product or layout.
Note: *It can be a full-sized or smaller-scale model and it is used for evaluation, demonstration, study, testing, and other purposes.*

Musculoskeletal disorders (or injuries) — injuries and disorders of the musculoskeletal system (the muscles, tendons, tendon sheaths, nerves, bursa, blood vessels, bones, joints/spinal disks, and ligaments) that can be caused or aggravated by various hazards or risk factors in the workplace.
Note: *Musculoskeletal disorders is an umbrella term used to describe a number of diagnoses including strains, sprains, carpal tunnel syndrome, repetitive strain injury, tendonitis, etc.*

Occupational health and safety management system (OHSMS) — part of the overall management of the organization that addresses OHS hazards and risks associated with its activities.
Note: *CAN/CSA-Z1000 is an example of an OHSMS.*

Organization — a company, operation, undertaking, establishment, enterprise, institution, or association, or a part or combination thereof, that has its own management.
Note: *An organization can be incorporated or unincorporated, public or private.*

Other requirements — other occupational health and safety provisions to which an organization subscribes.

Procedure — a documented process to carry out an activity.

Process — a set of interrelated or interacting activities, which transforms inputs into outputs.

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Record — a document that states results achieved or provides evidence of activities performed.

Residual risk — the risk remaining after protective measures have been implemented.

Risk — a combination of the likelihood of the occurrence of harm and the severity of that harm.

System — a set of interrelated or interacting elements.

System design — the human-centred design of work organization, processes, equipment, tools, and their interactions to optimize worker well-being and overall system performance.

Trial — the test of an item or a set of circumstances with the purpose of evaluating its effectiveness or usefulness and for other purposes.
Note: *One type of trial is the use of a "mock-up" (see **Mock-up**).*

User-centred — a type of approach to designing or developing products, systems, layouts (and other items) that seeks to use information from users who are affected by the process.
Note: *This approach is used rather than forcing the users to change how they work to accommodate the developers' approach.*

Work organization — the manner in which work is structured, supervised, and carried out.

Work system — a system comprising one or more workers and work equipment acting together to perform the system function in the work environment, under the conditions imposed by the work tasks.

Worker — a person employed by an organization or a person under the day-to-day control of an organization.

Worker representative — a non-managerial worker who
(a) represents workers in accordance with the requirements of law or collective agreements; or
(b) is otherwise selected by non-managerial workers.

Workplace parties — managers (including supervisors), workers, and worker representatives.

Workspace — any locations where a person's work is performed and the components within these locations.

4 Ergonomics in occupational health and safety

4.1 Occupational health and safety

An occupational health and safety management system (OHSMS) shall use a set of interrelated elements in the workplace to support the development and implementation of an effective OHS program. These elements shall include
(a) management commitment;
(b) leadership;
(c) planning;
(d) implementation;
(e) evaluation; and
(f) continual improvement.
Note: *Each of these elements and their development are described in detail in the CAN/CSA-Z1000. They are reviewed only briefly in this Standard as requirements to provide a foundation for the Ergonomics Process.*

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4.2 Ergonomics Process — Introduction

The organization shall establish, implement, and maintain an Ergonomics Process within the OHSMS, if such a system exists, and in the design and operation of new and/or existing work systems in order to prevent injuries, enhance worker health, safety, and well-being and optimize system performance in accordance with the requirements of this Standard.

The Ergonomics Process includes the Application of Ergonomics to identify, assess, and control hazards and risks at each stage of design and operation of new or existing systems. Ergonomics shall be applied in the planning, designing, installing, training, operating, maintaining, decommissioning, and disposing of systems, equipment, products, tools, facilities, and the organization and performance of work.

Persons competent in ergonomics shall be involved in these activities.

4.3 The Application of Ergonomics in the design and operation of a work system

The Application of Ergonomics is an integral part of the overall Ergonomics Process. The components of the Application of Ergonomics (identification and elimination of hazards and assessment and control of risks using ergonomics principles) is described in Clause 7.

Ergonomics is applied to the design stages and to the operation of work processes. The design stages are

(a) plan and anticipate changes in the workplace;
(b) detailed design of all components of work and the workplace and the organization of work;
(c) installation and training;
(d) operation and maintenance of an existing work system; and
(e) decommissioning and disposal.

Evidence-based tools, methods, checklists, and standards shall be used in the development of the proposed workplace changes. Annex B provides information and examples of evidence-based tools and checklists. The content included in Annex B is not intended to be exhaustive and other such tools and checklists demonstrated to be equally effective may also be used where applicable.

Figure 2 emphasizes that the Application of Ergonomics is essential at each of the stages in design and in the operation of work systems to prevent injuries, enhance worker health, safety, and well-being and optimize system performance. The earlier in the design stages that ergonomics is applied, the more likely it is that the system will effectively meet the needs of workers and that injuries or concerns can be prevented. Since work performance can change with the introduction of new people, equipment, tools, products, or services, the task of monitoring to identify and eliminate new hazards and assess and control risks shall be an ongoing and repeated process as indicated by Figure 2.

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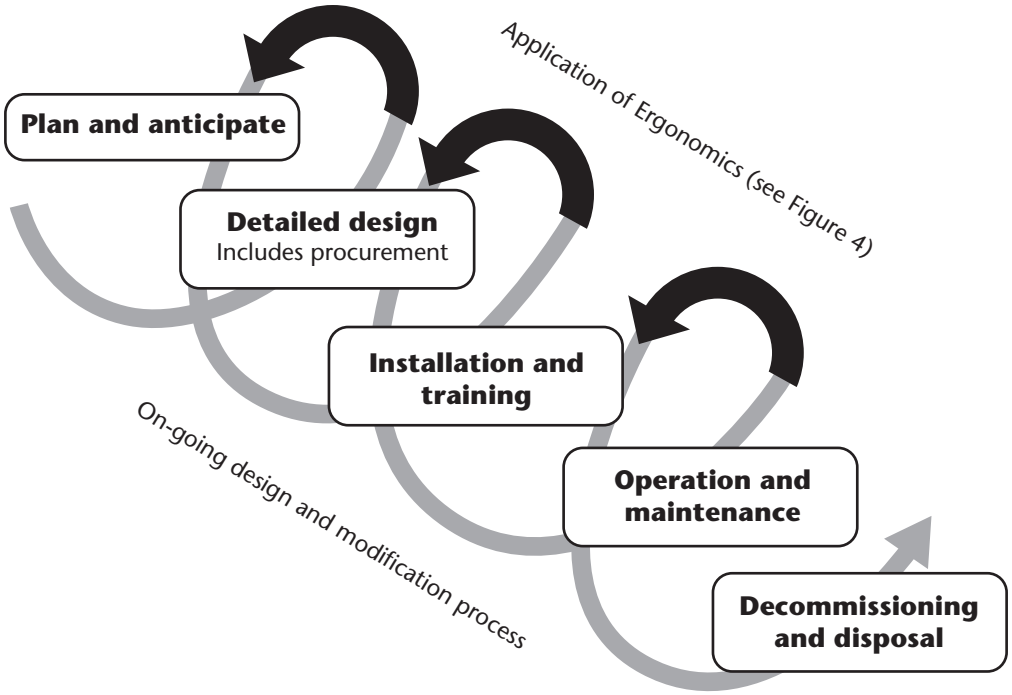

Figure 2
Application of Ergonomics in the design and operation of a work system
(See Clauses 4.3, A.4.3, and A.7.1.)

5 Commitment, leadership, and participation

5.1 General

Commitment, leadership, and effective participation are essential for the successful implementation of this Standard.

5.2 Resource requirements

The organization shall determine, provide, and maintain the infrastructure and resources needed to achieve conformity to this Standard, including the appropriate financial, human, and organizational resources. The organization shall have access to persons competent to implement this Standard.

5.3 Management commitment and leadership

5.3.1 Responsibility, accountability, and authority

Senior management shall provide leadership and ensure that the Ergonomics Process is established. This responsibility shall ensure that

(a) the Ergonomics Process is promoted, maintained, and reviewed for continual improvement;
(b) appropriate financial, human, and organizational resources are provided;
(c) measurable objectives and targets are determined and adopted;
(d) the organization's performance is reviewed against the objectives and targets at planned intervals;
(e) roles are defined, responsibilities are assigned, accountability is established, and appropriate authority is delegated; and
(f) workers and worker representatives are consulted and provided with opportunities to participate in the Ergonomics Process.

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5.3.2 Management direction

Senior management shall establish and document their commitment, leadership, and participation for the development, implementation, and maintenance of an effective Ergonomics Process, as described in this Standard.

5.3.3 Management representatives

Senior management shall designate one or more representatives of management who, irrespective of other responsibilities, have defined roles, responsibilities, accountability, and authority for ensuring that an Ergonomics Process is established, maintained, and reviewed in accordance with this Standard.

5.4 Worker participation

Worker participation is an essential aspect of the Ergonomics Process in the organization. The organization shall

(a) provide workers and worker representatives with time and resources to participate effectively in the development, planning, implementation, training, evaluation, and corrective action related to the Ergonomics Process;
(b) encourage worker participation by providing mechanisms that identify and remove barriers to participation; and
(c) ensure that workers and worker representatives are informed, consulted on, and given the opportunity to participate in the aspects of the Ergonomics Process associated with their work or the workplace which they represent.

5.5 Communication

The organization shall establish and maintain procedures to

(a) communicate information about its commitment to, and development of, the Ergonomics Process and the progress of the implementation plan to all affected levels of the organization;
(b) receive, document, and respond appropriately to internal and external communications related to the Ergonomics Process;
(c) promptly provide reports of workplace injuries, illnesses, incidents, hazards, and risks;
(d) ensure that the concerns, ideas, and inputs of workers and worker representatives regarding ergonomics are received, considered, and responded to in a timely fashion; and
(e) use workplace OHS committees or worker representatives as a forum for communication.

5.6 Awareness and training

5.6.1

Persons competent in ergonomics shall be involved in the design and redesign of work systems with attention to providing optimal working conditions for human well-being, safety, and health. This might require the enhancement of existing skills and development of new skills, while taking into account technological and economic effectiveness and efficiency.

The organization shall

(a) ensure that its workers have a general awareness of hazards and risks that can be addressed through the use of an Ergonomics Process;
(b) define the training requirements for addressing hazards and risks inherent in each job classification, including those associated with the introduction of changes in the workplace;
(c) provide training to its workers in the safe use of tools/equipment and safe work procedures applicable to their job; and
(d) ensure that its workers are aware of the importance of compliance with the applicable procedures, legal requirements, and other requirements, and the potential consequences of non-compliance.

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5.6.2
Awareness and training activities shall
(a) be conducted by competent persons;
(b) include participation of workers or their representatives;
(c) include timely refresher or re-training sessions;
(d) include participants' evaluation of the training activity;
(e) be evaluated and modified as necessary to ensure relevance and effectiveness; and
(f) be documented appropriately.

6 Planning

6.1 General
The organization shall develop a plan to identify resource requirements, current legal requirements, and other requirements and to consider ergonomics in the design of systems and procurement of materials, in management of change, and in the setting of objectives and targets. Planning provides information to support systematic identification and elimination of hazards and assessment and control of risks. The plan shall include the designation of responsibility for implementing preventive and protective control measures as well as the implementation time frame.

6.2 Legal and other requirements
The organization shall
(a) identify and ensure access to applicable legal and other requirements;
(b) ensure that these requirements are satisfied by the Ergonomics Process; and
(c) plan for periodic evaluation of compliance to these requirements.

6.3 Objectives and targets
The organization shall establish and document measurable objectives and targets to demonstrate that the Ergonomics Process is established and utilized effectively.

Objectives and targets shall be determined by considering legal and other requirements, plans for change (such as new processes or equipment), technological options, the organization's operational and business requirements, hazards and risks identified in the Application of Ergonomics (see Clause 7), and incidents and injuries. Objectives and targets shall be reviewed on a regular basis and modified according to changing information and conditions, as appropriate.

The organization shall establish and maintain a plan for achieving its objectives and targets. The plan should include the
(a) designation of responsibility for achieving objectives and targets; and
(b) identification of the means and time frame within which the objectives and targets are to be achieved.

6.4 Recognizing and managing change
The organization shall identify changes that have the potential to affect worker health and well-being and system performance. This includes
(a) the design of new work processes or operations;
(b) significant changes to work procedures, organizational structure, staffing, products, services, or suppliers;
(c) advancements in knowledge and technology; and
(d) changes to legal requirements, collective agreements, or other requirements.

The organization shall use the Ergonomics Process to identify any hazard and assess risks associated with the change before any workplace modification is implemented.

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7 Implementation

7.1 General

In order to identify and eliminate hazards and to assess and control risks, the organization shall utilize the Application of Ergonomics in the design and operation of a work system. The Application of Ergonomics is a part of the implementation of the Ergonomics Process and is in the "Do" section of the "Plan-Do-Check-Act" approach followed in this Standard (see Figure 3). The Application of Ergonomics shall take place at all stages of design and wherever the operating work system could have the potential to cause harm.

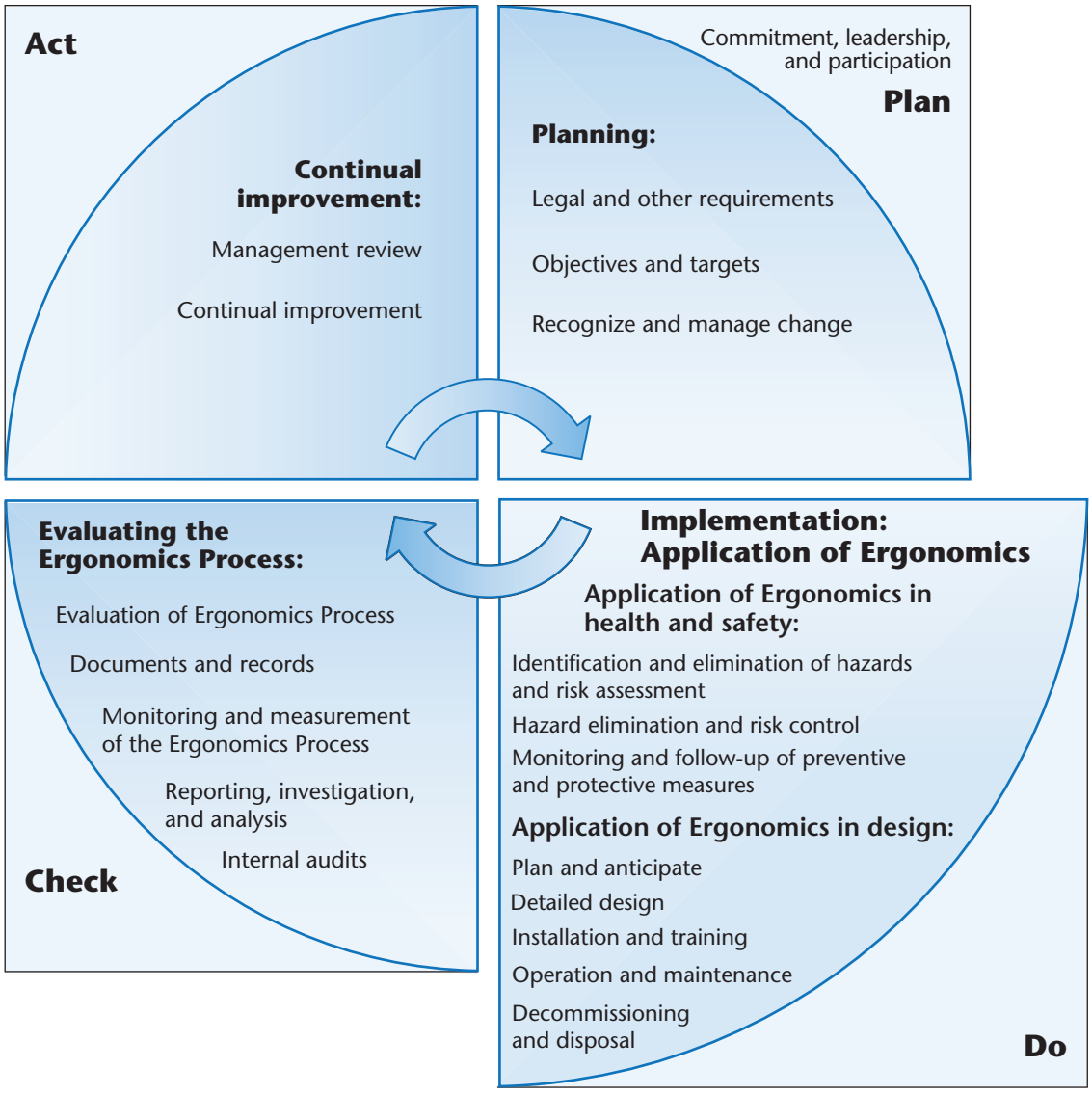

Figure 3
Ergonomics Process — How it fits within the OHSMS
(See Clause 7.1.)

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7.2 Application of Ergonomics

7.2.1 Identification and elimination of hazards and risk assessment

Note: *See Figure 4.*

7.2.1.1 General

The organization shall systematically identify and assess the physical, cognitive, and organizational hazards that work systems can impose on workers. However, where there is an occurrence of an injury or where there are signs or symptoms of an injury attributable to workplace hazards, immediate interim preventive and protective measures shall be implemented before the completion of the risk assessment.

7.2.1.2 Hazard identification and risk assessment

The hazard identification and risk assessment shall

(a) be conducted by competent persons;
(b) include participation by workers and worker representatives;
(c) include use of leading and lagging indicators; and
(d) include infrequently performed tasks and tasks performed only in emergency response situations.

Where there is a recognized hazard or an injury, or where there are signs or symptoms of an injury attributable to workplace hazards, immediate interim preventive and protective measures shall be implemented before the completion of the risk assessment.

7.2.1.3 Performing hazard identification, elimination, and risk assessment

Hazard identification, elimination, and risk assessment should include the following activities:

(a) defining the worker population;
(b) performing a task analysis incorporating worker participation;
(c) identifying the root cause of hazards;
(d) eliminating hazards to the extent possible;
(e) identifying the ergonomics data;
(f) assessing the level of residual risk; and
(g) prioritizing.

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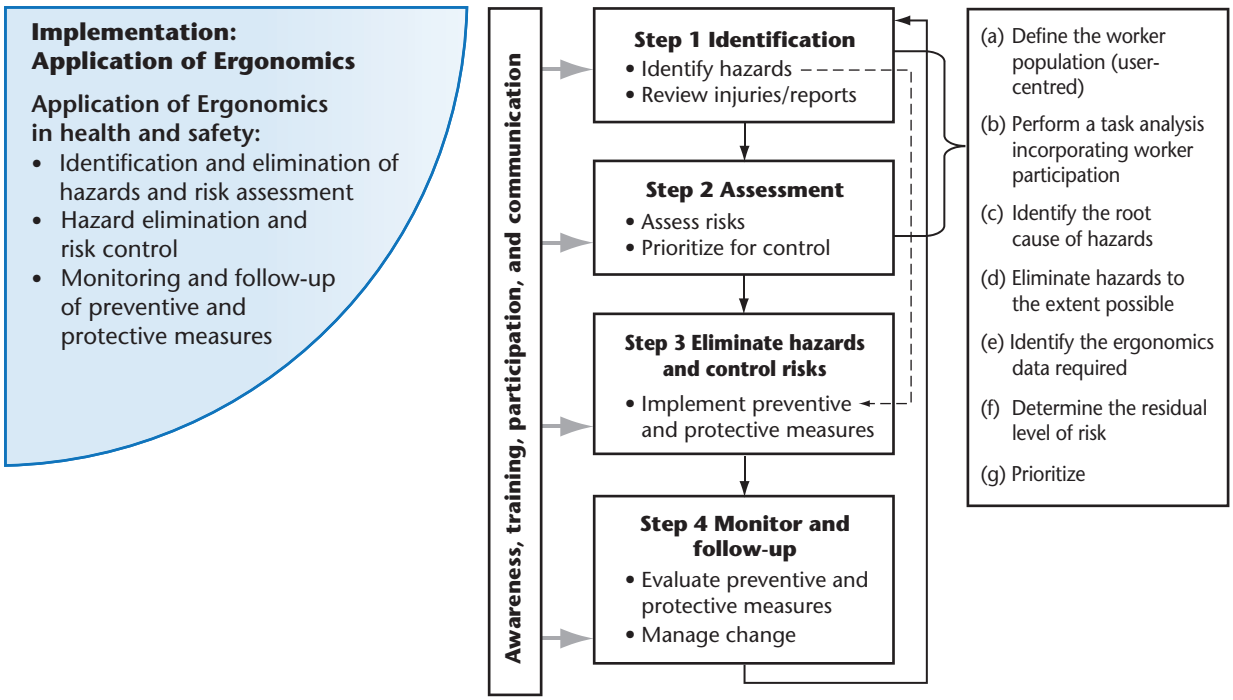

Figure 4
Application of Ergonomics in health and safety
(See Clauses 7.2.1 and 7.2.2 and Figures 2 and 5.)

7.2.2 Hazard elimination and risk control

The organization shall implement preventive and protective measures to eliminate the hazards or control the risks identified during the Application of Ergonomics in order to promote physical, cognitive, and organizational well-being.

Preventive and protective measures shall be designed to eliminate hazards where possible (this is illustrated by the dotted line in Figure 4). Where hazards cannot be eliminated, risks should be controlled (minimized) as far as is capable. In determining hazard elimination and risk control measures, the organization in consultation with workers and worker representatives shall take into account the following:

(a) the causes, nature, and extent of the hazards and risks identified;
(b) the degree of risk control required;
(c) applicable legal and other requirements;
(d) applicable standards, codes, guidelines, and best practices, such as those referenced in Annex B;
(e) the availability of suitable technology; and
(f) opportunities to improve design of work systems.

7.2.3 Hierarchy of preventive and protective measures

Elimination or control of hazards and risks shall be achieved by designing preventive and protective measures in the following priority:

(a) elimination or substitution, where either the hazard is removed from the workplace or the source of the hazard is replaced by a safer alternative;
(b) engineering measures representing change to the arrangement and design of equipment, tools, machinery, materials, or processes;
(c) administrative measures, such as those that affect the performance, duration, or organization of the tasks; and
(d) personal protective equipment of known effectiveness, such as padding for a part of the body.

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7.2.4 Monitoring and follow-up of preventive and protective measures

The organization shall

(a) evaluate the effectiveness of the preventive and protective measures implemented;
(b) identify any newly created hazards resulting from the preventive and protective measures implemented;
(c) expedite action on inadequately controlled risks; and
(d) track actions taken to ensure their effective implementation.

7.3 Application of Ergonomics in design

7.3.1 General

The Application of Ergonomics shall be applied to all stages of design, including plan and anticipate, detailed design, installation and training, operation and maintenance, and decommissioning and disposal (see Figure 5).

Persons competent in ergonomics shall be involved in these activities.

To effectively eliminate hazards or control risks and to enhance human health and well-being and optimize system performance, the application of evidence-based tools, methods, checklists, and standards shall be used. These shall be employed in conjunction with data, which shall be collected through consultation with worker groups or operators of other similar systems, where necessary.

Note: *Some evidence-based tools and checklists are provided in Annex B; however, Annex B is not intended to be exhaustive and other such tools and checklists demonstrated to be equally effective may also be used where applicable.*

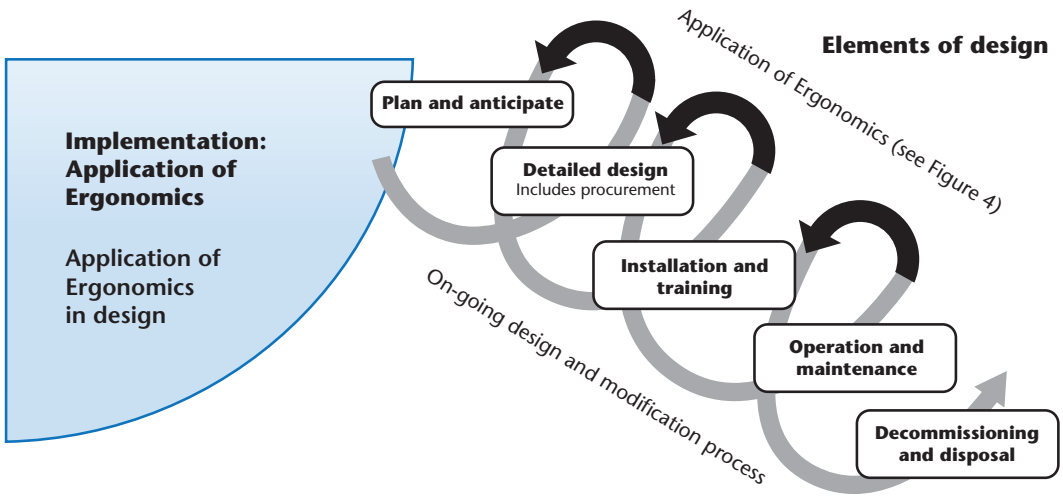

Figure 5
Application of Ergonomics in design
(See Clause 7.3.1.)

7.3.2 Plan and anticipate

During the plan and anticipate stage, each aspect of the workplace or work process to be created or modified, and its interactions with workers should be defined. System specifications shall be identified at this stage and shall take into account the anticipated health and well-being and performance of workers who will be a part of the system being designed or modified. Ergonomics shall be applied in the earliest stages of design or redesign of a work system, including workspace, equipment, layout, facility design, work organization, and environment.

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7.3.3 Detailed design

During the detailed design stage, the major interactions between one or more people and components of the work system shall be identified and assessed.

While taking into account technological and economic effectiveness and efficiency, the design of optimal working conditions shall take into account the anticipated health and well-being of workers who will be a part of the system being designed or modified as well as the optimal system performance.

The Application of Ergonomics shall be applied to the design of the work system, including tasks, equipment, the workspace, work organization, and environment.

As far as is practical, work systems shall be designed to

(a) accommodate a broad range of the population;
(b) prevent adverse effects on workers, promote health and well-being, and facilitate optimal task performance;
(c) allow for workers' postural stability and mobility;
(d) consider body dimensions, posture, muscular strength, and movement; and
(e) consider both the cognitive and physical demands related to equipment and the interface design.

7.3.4 Procurement

The organization shall establish a process to evaluate products, supplies, equipment, tools, furniture, and raw materials to be procured in order to identify and eliminate potential hazards or to control risk before they are brought into the workplace and to prevent injuries, enhance worker health, safety, and well-being, and optimize system performance.

The organization shall

(a) develop ergonomics specifications to be used during procurement that take physical, cognitive, and work organization demands into consideration;
(b) include a user-centred approach in the development of procurement specifications;
(c) ensure that procured goods conform to established specifications and that suppliers are made aware of these specifications when required; and
(d) include worker participation in the development of specifications and in the evaluation of procured goods, as appropriate.

7.3.5 Installation and training

During the installation and training stage, installation of new workspaces, equipment, machinery, or work processes takes place and training on safe and effective use is provided.

During installation, the predicted interactions between people (the installers and the users) and the components of the work affected by the installation shall be documented in order to identify and eliminate hazards wherever possible, or assess and control risks.

Trials to verify design specifications shall be performed prior to final permanent installation of new work components.

Workers shall be trained in the safe and effective use of new workspaces, tools, equipment, machinery, or work processes and procedures. Workers shall be informed of the importance of compliance with applicable procedures and legal requirements and of the potential consequences of non-compliance.

7.3.6 Operation and maintenance

During the operation and maintenance stage, the interactions between people and the components of their work shall be monitored regularly and documented to enhance worker health and well-being and optimize system performance.

The Application of Ergonomics shall take place in the operation of existing and newly designed work systems to ensure that hazards are identified and eliminated and risks are assessed and controlled.

The Application of Ergonomics shall take into consideration physical, cognitive, and work organizational demands. It shall include a review of

(a) objectives and targets for a work system;
(b) workplace inspections;
(c) incident and accident investigations; and
(d) analyses of incident and injury reports.

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Further opportunities for gathering worker input for review include the results of worker surveys, physical demands analyses, and cognitive demands analyses. Any defects in a component of a work system shall be reported and addressed through the Ergonomics Process.

7.3.7 Decommissioning and disposal

During the planning and carrying out of the decommissioning and disposal stage, the interactions between people and the components of their work shall be reviewed and documented to enhance worker health, safety, and well-being and optimize system performance.

The Application of Ergonomics shall take place when planning and carrying out decommissioning and disposal to identify and eliminate potential hazards and to assess and control risks.

As part of the Application of Ergonomics, a safe work plan shall be reviewed with the workers involved in the decommissioning and disposal prior to beginning work.

8 Evaluating the Ergonomics Process

8.1 Evaluation

The organization shall, in conjunction with worker representatives, regularly evaluate its Ergonomics Process to

(a) determine the extent to which the objectives and targets are met;
(b) determine that appropriate preventive and protective measures are taken and to assess their effectiveness; and
(c) enable continual improvement.

The organization shall use the documents and records required in Clause 8.2 to evaluate the Ergonomics Process.

8.2 Documents and records

8.2.1

The organization shall create and maintain the following documents and records:

(a) the objectives and targets required by Clause 6.3;
(b) the assignment of duties and responsibilities as required by Clauses 5.3.1, 5.3.3, 6.1, 6.3 and 9.1;
(c) the procedures required by Clauses 5.5 and 8.4;
(d) the high level direction required by Clause 5.3.2;
(e) the documents required by Clause 8.5, if the organization chooses to conduct internal audits;
(f) records of internal and external communications required by Clause 5.5;
(g) records of training required by Clause 7.3.5;
(h) supporting documents and records required by the organization to ensure the effective planning, implementation, operation, and control of the Ergonomics Process; and
(i) other documents and records required to assess compliance with legal and other requirements.

8.2.2

The organization shall establish and maintain legible, readily identifiable, and retrievable records. Records may include

(a) reports of related injuries and illnesses;
(b) records arising from legal requirements;
(c) assessments performed as part of the Application of Ergonomics and comparison of findings with standards and guidelines;
(d) records of worker concerns;
(e) records of changes or improvements made to eliminate hazards and control risks;
(f) calibration records for monitoring and measurement equipment; and
(g) records of job accommodations or modified work.

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8.2.3
Workers and their representatives shall have access to documents and records relevant to the Ergonomics Process, while respecting the need for confidentiality.

8.3 Monitoring and measurement

8.3.1
Measures for monitoring the Ergonomics Process shall be developed. These shall
(a) be appropriate to the needs, size, and nature of the organization;
(b) be developed in consultation with workers and worker representatives;
(c) include both qualitative and quantitative measures; and
(d) be used as input to the process review.

8.3.2
Monitoring and measurement activities shall be recorded. Examples of these activities include reviews of
(a) general inspections addressing ergonomics considerations in work design and arrangement, tasks, facilities, and equipment;
(b) number and results of hazard identification and elimination and of risk assessment and control investigations;
(c) preventive and protective measures implemented;
(d) injury and illness trends;
(e) accident and injury investigations and implementation of corrective actions;
(f) use of physical demands analyses; and
(g) worker input and concerns.

8.4 Reporting, investigation, and analysis
The organization shall establish and maintain a procedure for reporting and investigating incidents, concerns of unsafe conditions, and hazardous physical, cognitive, or organizational job demands. The procedure shall
(a) establish roles and responsibilities, including those of workers and worker representatives, for reporting, investigating, and analyzing incidents and concerns;
(b) specify that investigations be carried out by competent persons;
(c) require analysis of the concerns;
(d) include consideration of preventive and protective measures recommendations; and
(e) require assessment of effectiveness of any measures implemented.

When an investigation occurs, the analysis of the findings can result in recommendations. Recommendations, along with investigation findings, shall be communicated to the workplace parties. These recommendations shall form a basis for any preventive and protective measures to be implemented. Corrective actions resulting from the reporting, investigation, and analysis procedures shall be implemented within an established time frame.

8.5 Internal audits
Audits conducted at planned intervals can be used to determine whether the Ergonomics Process conforms to the requirements of this Standard and if it is effectively implemented and maintained.

If the organization chooses to use internal audits, the organization shall determine and document the criteria for auditor competency, the audit scope, frequency of audits, the audit methodology, and reporting mechanisms.

Note: *See CAN/CSA-Z1000 and CAN/CSA-ISO 19011 for information on conducting internal audits.*

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9 Continual improvement

9.1 Management review

The organization should continually improve the effectiveness of the Ergonomics Process. Senior management shall review the organization's Ergonomics Process at planned intervals to ensure its continuing suitability, adequacy, and effectiveness. The management review shall include an assessment of opportunities for continual improvement.

9.2 Review input

Inputs to the management review of the Ergonomics Process shall include

(a) results of the overall evaluation of the Ergonomics Process, including monitoring and measurement;
(b) the extent to which objectives and targets have been met (see Clause 6.3);
(c) communication with workers and worker representatives;
(d) follow-up actions from previous management reviews;
(e) information concerning changing circumstances;
(f) communication from external agencies and organizations; and
(g) results of audits (if conducted).

9.3 Review output

The output of the management review shall include any decisions and actions related to

(a) revising objectives and targets;
(b) improving the effectiveness of the Ergonomics Process; and
(c) allocating resources.

Action plans with appropriate timelines and designated responsibility shall be developed from the management review. The organization shall use findings and conclusions to develop action plans based on the review. Action plans shall be communicated to the persons responsible for action and to any workers, or worker representatives, who might be impacted.

9.4 Continual improvement

The organization shall have an ongoing process to assess opportunities for continual improvement, including the reduction of residual risk. This shall include

(a) review of current control strategies;
(b) review of best available methods, technologies, and procedures to address residual risks; and
(c) implementation strategy to ensure continual improvement.

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Annex A (informative)
Guidance on the use of CSA Z1004-12

Notes:
(1) *This Annex is not a mandatory part of this Standard.*
(2) *This Annex is structured as follows: Normative clauses, which are reproduced from the Standard, are included in text boxes. These are requirements that organizations might need to demonstrate conformance with this Standard. The informative guidance material, developed by the Technical Committee on Workplace Ergonomics, to assist users in meeting the normative requirements is provided below the text boxes. This guidance material does not contain normative requirements of the Standard.*

0 Introduction

0.1 General

Ergonomics (or human factors) is the discipline concerned with the understanding of interactions among humans and other elements of a system, and the application of theory, principles, data, and methods of design to enhance worker health, safety, and well-being and optimize system performance. For the purposes of this Standard, the term "Ergonomics" is being used interchangeably with the term "human factors".

The science and Application of Ergonomics can be used to improve many aspects of the interactions of people with jobs, systems, products, and environments. This Standard describes how ergonomics is integrated into occupational health and safety and design using an Ergonomics Process to improve occupational health and safety outcomes and to optimize work system design.

This Standard is structured for use with an occupational health and safety management system (OHSMS), such as CAN/CSA-Z1000; however, it may also be used independently or with other health and safety activities as it employs an identification, elimination, assessment, and control structure. This Standard is compatible with the Plan-Do-Check-Act (PDCA) model found in CAN/CSA-Z1000. This Standard provides an overall framework for addressing preventive and protective measures, worker participation, training, design, procurement issues, documentation, and legal and other requirements.

See Figure 1.

0.2 Principles of an effective Ergonomics Process

Within the scope of this Standard, the following principles form an integral part of an effective Ergonomics Process to enhance worker health, safety, and well-being, and optimize system performance:

(a) Worker health, safety, and well-being and system performance are enhanced through the use of ergonomics, by considering interactions between people and the components of the work system, such as tasks, equipment, workspace, work organization, and the environment.
(b) Ergonomics has its greatest benefit when used early in the design of a work system rather than being used to solve problems after the design is complete. Ergonomics is also beneficial in the redesign of an existing work system.
(c) The user-centred approach is a key attribute of ergonomics and ensures that a broad range of worker characteristics and requirements are accommodated.
(d) Worker participation is an essential aspect of the Ergonomics Process in the organization. Workers and their representatives provide valuable knowledge in work system design when they are involved.
(e) A workplace Ergonomics Process operates effectively when it is integrated within the organization's OHSMS.

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0.3 Using this Standard

0.3.1 General

The Ergonomics Process consists of the commitment, leadership, planning, implementation, and continual improvement necessary to identify and eliminate hazards and to assess and control risks using ergonomics principles. It operates within the OHSMS, where one exists, to enhance worker health, safety, and well-being and optimize system performance.

The implementation element of the Ergonomics Process includes the Application of Ergonomics, to identify and eliminate hazards, and to assess and control risks in a work system to enhance worker health, safety, and well-being and optimize system performance. This occurs at each stage of design and operation of a work system. Design occurs during any project or undertaking where changes are being introduced. The Application of Ergonomics emphasizes prevention of injuries, illnesses, and errors in the workplace; it is further described in detail in Clause 7.

Many organizations first develop awareness of the use of ergonomics in a reactive mode, when problems arise with worker health and safety. The emphasis should be on the proactive use of ergonomics to design improved processes, systems, or work organization. This Standard requires the Ergonomics Process to be applied in both types of conditions (i.e., proactive and reactive).

The implementation of this Standard should be customized by each organization based upon their nature of the work and the size and location of their operations. This Standard applies to all types and sizes of organizations, regardless of whether or not a formal OHSMS is in place.

0.3.2 Structure of this Standard

The informative guidance material (see Annex A) is intended to assist users in complying with the Standard. In Annex A, the provisions, which are reproduced from the Standard, are included in text boxes. The guidance information is given below the text boxes to which it applies.

Annex B provides information and examples of evidence-based tools and checklists. The content included in Annex B is not intended to be exhaustive and other such tools and checklists demonstrated to be equally effective through professional use, best practice, or citations in the scientific literature may also be used where applicable. The application of such evidence-based tools and checklists will enable organizations to meet the objectives of this Standard.

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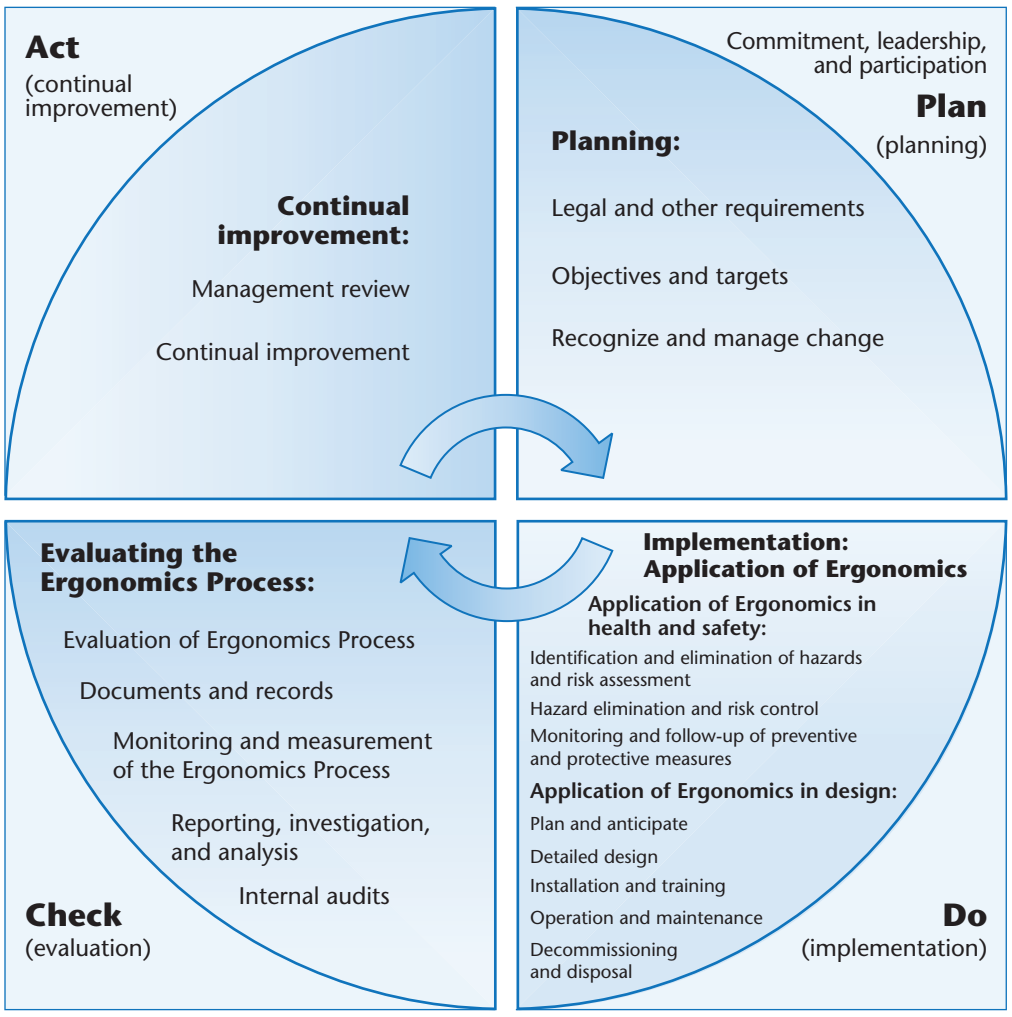

Figure 1
Elements of an OHSMS and the Ergonomics Process
(See Clause 0.1.)

A.0 Guidance on ergonomics: a broad overview

Ergonomics (or human factors) is the discipline concerned with the understanding of interactions among humans and other elements of a system, and the application of theory, principles, data, and methods to design in order to enhance human well-being and optimize overall system performance. Applying ergonomics effectively can benefit an organization, work team, and/or individual.

There are three main domains in the field of ergonomics:

- Physical ergonomics is concerned with human anatomical, anthropometric, physiological, and biomechanical characteristics as they relate to physical activity. Relevant topics include working postures, materials handling, repetitive movements, work related musculoskeletal disorders, and workspace layout and design.
- Cognitive ergonomics is concerned with mental processes, such as perception, memory, reasoning, and sensory-motor response (e.g., reaction time) as they affect interactions among humans and other elements of a system. Relevant topics include cognitive workload, decision-making, skilled performance, human-computer interaction, and human error.

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- Organizational ergonomics is concerned with aspects of the work output (i.e., work standards), work process (i.e., how the work is carried out), work cycle (i.e., work/rest regimen), the psychosocial structure, and the nature of supervision. Relevant topics include systems design process, communication, management support, and commitment to safety, manager/supervisor/worker relationships, job content, work systems (e.g., job rotation, remote work), training, work schedules, teamwork, and organizational culture.

1 Scope and objective

1.1 Scope

1.1.1
This Standard specifies requirements and provides guidance for the systematic Application of Ergonomics to the development, design, use, management, and improvement of work systems through the implementation of an Ergonomics Process.

1.1.2
This Standard does not apply to medical management programs or to aspects that could be considered part of a medical management program, such as therapeutic or clinical interventions.

1.2 Objective
The objective of this Standard is to enable an organization to enhance worker health, safety, and well-being and optimize system performance to prevent occupational injuries, illnesses, and fatalities and/or reduce the severity of harm related to occupational activities and work environments through the systematic Application of Ergonomics.

Prevention strategies proactively identify hazards and eliminate them where possible. Where elimination is not possible, prevention can be achieved through appropriate risk assessment and control techniques.

1.3 Terminology
In CSA standards, "shall" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; "should" is used to express a recommendation or that which is advised but not required; and "may" is used to express an option or that which is permissible within the limits of the standard.

Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.

Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

2 Reference publications
This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below.

CSA (Canadian Standards Association)
CAN/CSA-ISO 19011-03 (R2007)
Guidelines for quality and/or environmental management systems auditing

CAN/CSA-Z1000-06 (R2011)
Occupational health and safety management

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ACGIH (American Conference of Governmental Industrial Hygienists)
TLUs and BEIs (2011)

ASHRAE (American Society of Heating, Refrigerating and Air-conditioning Engineers)
ANSI/ASHRAE 55-2010
Thermal Environmental Conditions for Human Occupancy

IES (Illuminating Engineering Society)
The Lighting Handbook, 10th edition (2011)

INPO (Institute of Nuclear Power Operationist)
06-003 (2006)
Human Performance Reference Manual

ISO (International Organization for Standardization)
ISO 6385:2004
Ergonomic principles in the design of work systems

ISO (International Organization for Standardization)
ISO 6385:2004
Ergonomic principles in the design of work systems

NIOSH (National Institute for Occupational Safety and Health)
NIOSH Lifting Equation (1991)

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3 Definitions

The following definitions shall apply in this Standard:

Anthropometry — the study of the size and shape of the human body.
Note: *Anthropometric data are one of the basic criterion used to design workspaces/tools/equipment to a range of body sizes and shapes.*

Application of Ergonomics — the use of ergonomics principles to identify and eliminate hazards and assess and control risks at each stage of design of any work system to enhance worker health, safety, and well-being and optimize system performance. It is an element of the Ergonomics Process.

Audit — the systematic and documented process for obtaining evidence and evaluating it objectively to determine the extent to which the specified criteria are fulfilled.

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Cognitive — related to "cognition", which is
(a) the process people use for remembering, awareness, perception, reasoning, understanding, and using judgment; and
(b) the ability to think and make sense out of what is seen, heard, felt, and experienced in order to take appropriate actions.

Cognitive demands — stressors associated with cognitive aspects of tasks being performed (see **Cognitive**).

Competence — demonstrated ability to apply ergonomics knowledge and skills to a work system design and operation.

Competent person — a person who is knowledgeable of ergonomics by reason of education, training, experience, or a combination thereof, and has a demonstrated ability to apply this knowledge to the design and operation of work systems.

Continual improvement — the process of enhancing the Ergonomics Process to achieve ongoing improvement in overall OHS performance.

Design — the process of changing existing or developing new work systems, encompassing individual tasks through to complex systems.

Document — a medium containing information related to the Ergonomics Process.

Ergonomics — the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to enhance human well-being and optimize overall system performance.
Note: *Also referred to as "human factors".*

Ergonomics Process — the commitment, leadership, planning, implementation, and continuous improvement necessary to identify and eliminate hazards and to assess and control risks using ergonomics principles. It operates within the OHMS, where one exists, and in the design and operation of new or existing work systems.

Ergonomist — an individual whose knowledge and skills concern the analysis of human-system interaction and the design of the system in order to enhance human well-being and optimize overall system performance.

Evidence-based — derived from a systematic process of identifying, appraising, and using research findings and workplace experience as the basis for decision making.

Hazard — a source of potential harm to a worker.

Human factors — see **Ergonomics**.

Lagging indicators — a measurable factor, such as lost time injuries, that changes after health or safety has already begun to follow a particular pattern or trend.
Note: *Lagging indicators confirm long-term trends, but they do not predict them.*

Leading indicators — a measurable factor, such as preventive measures to eliminate hazards that changes before the incident, injury, or disorders occur and start to follow a particular pattern or trend.
Note: *Leading indicators can be used to predict changes in disorders and injuries, but are not always accurate.*

Legal requirements — requirements of applicable laws and, where applicable, provisions of the organization's collective agreements that relate to occupational health and safety.

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Management system — a system governing the overall performance expectations within the work environment.

Mock-up — a sample that emulates a final product or layout.
Note: *It can be a full-sized or smaller-scale model and it is used for evaluation, demonstration, study, testing, and other purposes.*

Musculoskeletal disorders (or injuries) — injuries and disorders of the musculoskeletal system (the muscles, tendons, tendon sheaths, nerves, bursa, blood vessels, bones, joints/spinal disks, and ligaments) that can be caused or aggravated by various hazards or risk factors in the workplace.
Note: *Musculoskeletal disorders is an umbrella term used to describe a number of diagnoses including strains, sprains, carpal tunnel syndrome, repetitive strain injury, tendonitis, etc.*

Occupational health and safety management system (OHSMS) — part of the overall management of the organization that addresses OHS hazards and risks associated with its activities.
Note: *CAN/CSA-Z1000 is an example of an OHSMS.*

Organization — a company, operation, undertaking, establishment, enterprise, institution, or association, or a part or combination thereof, that has its own management.
Note: *An organization can be incorporated or unincorporated, public or private.*

Other requirements — other occupational health and safety provisions to which an organization subscribes.

Procedure — a documented process to carry out an activity.

Process — a set of interrelated or interacting activities, which transforms inputs into outputs.

Record — a document that states results achieved or provides evidence of activities performed.

Residual risk — the risk remaining after protective measures have been implemented.

Risk — a combination of the likelihood of the occurrence of harm and the severity of that harm.

System — a set of interrelated or interacting elements.

System design — the human-centred design of work organization, processes, equipment, tools, and their interactions to optimize worker well-being and overall system performance.

Trial — the test of an item or a set of circumstances with the purpose of evaluating its effectiveness or usefulness and for other purposes.
Note: *One type of trial is the use of a "mock-up" (see **Mock-up**).*

User-centred — a type of approach to designing or developing products, systems, layouts (and other items) that seeks to use information from users who are affected by the process.
Note: *This approach is used rather than forcing the users to change how they work to accommodate the developers' approach.*

Work organization — the manner in which work is structured, supervised, and carried out.

Work system — a system comprising one or more workers and work equipment acting together to perform the system function in the work environment, under the conditions imposed by the work tasks.

Worker — a person employed by an organization or a person under the day-to-day control of an organization.

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Worker representative — a non-managerial worker who
(a) represents workers in accordance with the requirements of law or collective agreements; or
(b) is otherwise selected by non-managerial workers.

Workplace parties — managers (including supervisors), workers, and worker representatives.

Workspace — any locations where a person's work is performed and the components within these locations.

4 Ergonomics in occupational health and safety

4.1 Occupational health and safety

An occupational health and safety management system (OHSMS) shall use a set of interrelated elements in the workplace to support the development and implementation of an effective OHS program. These elements shall include
(a) management commitment;
(b) leadership;
(c) planning;
(d) implementation;
(e) evaluation; and
(f) continual improvement.

Note: *Each of these elements and their development are described in detail in the CAN/CSA-Z1000. They are reviewed only briefly in this Standard as requirements to provide a foundation for the Ergonomics Process.*

A.4.1 Guidance on integrating ergonomics into an OHSMS

Using the Ergonomics Process to enhance human health and well-being and system performance is one of the ways to eliminate and minimize hazards and improve work. This Standard helps to explain the management system components that need to be in place for the successful implementation of an Ergonomics Process. They include management commitment, leadership, and worker participation, planning, implementation, evaluation, and continual improvement to the Ergonomics Process. There are several opportunities to apply the Ergonomics Process within an organization that should be planned for, such as

- changes in law;
- new designs;
- procurement;
- incident investigations/analysis;
- improving efficiency and productivity; and
- addressing worker concerns.

The Ergonomics Process is integrated into the activities of existing OHS committees, depending on the size and nature of the organization. Organizations may also form project-based committees that incorporate ergonomics into a specifically defined project, such as the planning of a new facility, process, equipment, or workspace or procurement activities (new materials, tools, etc.).

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4.2 Ergonomics Process — Introduction

The organization shall establish, implement, and maintain an Ergonomics Process within the OHSMS, if such a system exists, and in the design and operation of new and/or existing work systems in order to prevent injuries, enhance worker health, safety, and well-being and optimize system performance in accordance with the requirements of this Standard.

The Ergonomics Process includes the Application of Ergonomics to identify, assess, and control hazards and risks at each stage of design and operation of new or existing systems. Ergonomics shall be applied in the planning, designing, installing, training, operating, maintaining, decommissioning, and disposing of systems, equipment, products, tools, facilities, and the organization and performance of work.

Persons competent in ergonomics shall be involved in these activities.

A.4.2 Guidance on the work system

The term "work system" is used to indicate a large range of situations involving people and equipment within a given space and environment and the interactions between these within a work organization. Examples of work systems include

- a single person and machine;
- an assembly line;
- a processing plant;
- a facility, such as a hospital;
- an outdoor environment;
- a computer-based interactive system;
- an emergency response system; and
- a maintenance task.

4.3 The Application of Ergonomics in the design and operation of a work system

The Application of Ergonomics is an integral part of the overall Ergonomics Process. The components of the Application of Ergonomics (identification and elimination of hazards and assessment and control of risks using ergonomics principles) is described in Clause 7.

Ergonomics is applied to the design stages and to the operation of work processes. The design stages are

(a) plan and anticipate changes in the workplace;
(b) detailed design of all components of work and the workplace and the organization of work;
(c) installation and training;
(d) operation and maintenance of an existing work system; and
(e) decommissioning and disposal.

Evidence-based tools, methods, checklists and standards shall be used in the development of the proposed workplace changes. Annex B provides information and examples of evidence-based tools and checklists. The content included in Annex B is not intended to be exhaustive and other such tools and checklists demonstrated to be equally effective may also be used where applicable.

Figure 2 emphasizes that the Application of Ergonomics is essential at each of the stages in design and in the operation of work systems to prevent injuries, enhance worker health, safety, and well-being and optimize system performance. The earlier in the design stages that ergonomics is applied, the more likely it is that the system will effectively meet the needs of workers and that injuries or concerns can be prevented. Since work performance can change with the introduction of new people, equipment, tools, products, or services, the task of monitoring to identify and eliminate new hazards and assess and control risks shall be an ongoing and repeated process as indicated by Figure 2.

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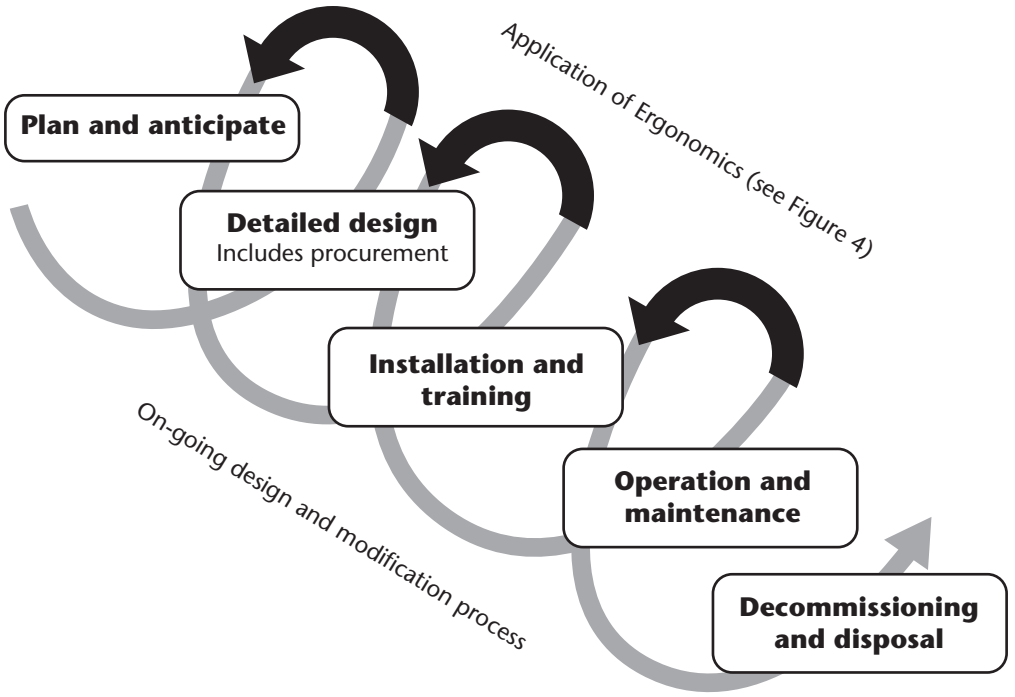

Figure 2
Application of Ergonomics in the design and operation of a work system
(See Clauses 4.3, A.4.3, and A.7.1.)

A.4.3 Guidance on the Application of Ergonomics in the design and operation of a work system

Ergonomics is used most effectively when it is applied at every stage of design, including the earliest stages, to help avoid the introduction of hazards and to identify possible risks of injury, illness, or poor work design. Figure 2 shows that design proceeds from "Plan and anticipate" to "Detailed design", "Installation and training" to "Operation and maintenance", and ultimately to "Decommissioning and disposal". The process is repeated often and is cyclical in nature.

Design does not occur only when a new facility is being considered. Rather, it occurs during any project or undertaking where changes are being introduced, even to an existing workplace or system. For example, a new workspace can be designed for a new position in an existing workplace. The process of designing that workspace progresses through all of the same steps as the larger process of designing a new facility. The difference is that the types of considerations at each stage of designing the individual workspace are different than those needed to design a new facility. It is important to use ergonomics at the earliest stages of design in any project (large or small), since hazards that are inadvertently designed into a workspace or work process can be difficult and expensive to address later when the workplace is already in operation.

The bold arrows in Figure 2 indicate that the task of identifying and eliminating hazards and assessing and controlling risks occurs at each stage of design. In this Standard, this activity is referred to as the "Application of Ergonomics", where the goal is to design a work system that performs well and with minimal risk for injury or error. Modifications can be made to the design of equipment, machinery, or tools or changes can be made to how equipment is installed or how work is planned. For example, during "shut down", a company refers to the hazards identified during the "operation and maintenance" stage of an existing assembly line and then considers them during the "plan and anticipate" and "detailed design" stages that take place prior to the installation or redesign of a new assembly line.

The Application of Ergonomics at each stage of design has a different character:

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- At the "plan and anticipate" stage, the new design is still at the conceptual stage. In some cases there might not be a physical example to evaluate and the Application of Ergonomics at this point will therefore use a different approach than for an existing workplace. Pre-existing data on human performance and anthropometry (human measurements), legislative requirements, and the experience of workers, OHS specialists, engineers, architects, ergonomists, and others with relevant knowledge can be called upon based on the complexity of the new design or project.
- At the "detailed design" stage, all components of work and the workplace and the organization of work can be reviewed. In some cases, there might not be a physical example to evaluate and hazard identification will therefore use the results of prototypes, mock-ups, or computer simulations.
- At the "operation and maintenance" stage, the workplace exists, the work is being performed and can be observed, and worker input can be obtained. Identification and elimination of hazards and assessment and control of risks in an operating workplace can be facilitated through inspections, worker feedback and other means. Clause 7 (and the Guidance) gives a more detailed description of each of the design stages and the nature of the Application of Ergonomics that is performed at each stage.

5 Commitment, leadership, and participation

5.1 General

Commitment, leadership, and effective participation are essential for the successful implementation of this Standard.

5.2 Resource requirements

The organization shall determine, provide, and maintain the infrastructure and resources needed to achieve conformity to this Standard, including the appropriate financial, human, and organizational resources. The organization shall have access to persons competent to implement this Standard.

A.5.2 Guidance on access to ergonomics information and resources

The organization can ensure competency by evaluating the education, training, and experience that enable a person to apply ergonomics to a given situation to optimize workers' well-being and system performance. To ensure that the organization has access both to persons competent in the Application of Ergonomics to implement this Standard and to ergonomics information and resources, the following are considered:

- availability of persons in-house with suitable education and training in ergonomics;
- need for more training in ergonomics;
- access to ergonomics-related standards, guidelines, assessment tools, and other information;
- access to ergonomics-related information specific to the organization's type of business (e.g., health care, process control, manufacturing, office, etc.);
- need for assistance by persons in ergonomics from outside the organization who can assist with the development of the organization's Ergonomics Process, perform hazard and risk identification and assessment, develop and conduct training, assist with job modifications, and participate in setting procurement standards).

  Note: *A person competent in ergonomics can be expected to have expert knowledge, skill, and ability to enhance human health and well-being and system performance by*
  - *evaluating interactions between people and the components of a work system such as tasks, equipment, work space, work organization, and the environment;*
  - *designing work systems and in the redesign of existing work systems;*
  - *applying user-centred approach by ensuring that a broad range of worker characteristics and requirements are recognized and accommodated; and*
  - *utilizing a participatory process.*

Those involved directly in implementing and participating in the Ergonomics Process, including worker representatives, require education and training in several aspects of ergonomics and in the Ergonomics Process, such as

- basic ergonomics skills and knowledge of physical, cognitive, and organizational factors;

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- identifying and assessing hazards and risks pertaining to physical, cognitive, and organizational factors;
- gathering background information and concerns about a job, process, equipment, or design;
- analyzing incident and injury trends;
- developing effective hazard elimination and risk control options;
- managing change;
- implementing and evaluating preventive and protective measures; and
- training in effective group work, communication skills, and problem-solving.

Depending on the size of the organization and the objectives and targets for the Ergonomics Process, there can be others who would benefit from awareness and training in ergonomics.

The responsibilities of those involved directly in implementing and participating in ergonomics include the following:

- managers/supervisors:
  - overview of the legal and other requirements pertaining to ergonomics;
  - the need, importance, and ways to demonstrate management commitment to the Ergonomics Process;
  - the importance of minimizing hazards and risks;
  - appropriate ergonomics skills and knowledge of physical, cognitive, and organizational factors;
  - factors to be considered in designing work methods and tasks to minimize hazards and risks to workers;
  - the importance and methods for involving workers in ergonomics and techniques for making workers' involvement as effective as possible;
  - opportunities for implementing the Ergonomics Process (e.g., during new designs or procurement, when hazards are identified, during inspections or investigations, etc.);
  - managing change; and
  - understanding ergonomic assessment methods;
- engineers, purchasers, and facilities managers:
  - legal and other requirements pertaining to ergonomics;
  - appropriate ergonomics skills and knowledge of physical, cognitive, and organizational factors;
  - the importance of designing and procuring equipment, facilities, workspaces, tools, and products to minimize hazards and risks to workers;
  - techniques for evaluating the potential impact of hazards and risks on workers (e.g., CAD systems, prototyping, design decision groups, etc.);
  - ergonomics specifications, related to their particular industry;
  - techniques for involving workers in design, procurement, and evaluation of new equipment, facilities, machinery, tools, products, etc.;
  - factors to be considered in designing work methods and tasks to minimize hazards and risks to workers;
  - ergonomics factors to consider in installation, layout, and implementation of new designs, equipment, or tools;
  - managing change; and
  - understanding ergonomic assessment methods; and
- workers:
  - identification of hazards and risks associated with poor ergonomic design and control strategies;
  - the importance of identifying and reporting problems, early signs, and symptoms;
  - understanding the importance of and mechanisms for participating in an Ergonomics Process including hazard identification, risk assessments, and job redesign;
  - how and why injuries related to poor ergonomic design occur;
  - how to apply ergonomics skills and knowledge of physical, cognitive, and organizational factors to their work in order to prevent injuries or discomfort;
  - the benefits of applying this Standard, and legal and other requirements;
  - options for preventive and protective measures (i.e., elimination, engineering controls, administrative controls, and PPE);

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- qualitative and quantitative evaluation strategies to assess the effectiveness of ergonomic interventions; and
- understanding ergonomic assessment methods.

5.3 Management commitment and leadership

5.3.1 Responsibility, accountability, and authority

Senior management shall provide leadership and ensure that the Ergonomics Process is established. This responsibility shall ensure that

(a) the Ergonomics Process is promoted, maintained, and reviewed for continual improvement;
(b) appropriate financial, human, and organizational resources are provided;
(c) measurable objectives and targets are determined and adopted;
(d) the organization's performance is reviewed against the objectives and targets at planned intervals;
(e) roles are defined, responsibilities are assigned, accountability is established, and appropriate authority is delegated; and
(f) workers and worker representatives are consulted and provided with opportunities to participate in the Ergonomics Process.

5.3.2 Management direction

Senior management shall establish and document their commitment, leadership, and participation for the development, implementation, and maintenance of an effective Ergonomics Process, as described in this Standard.

5.3.3 Management representatives

Senior management shall designate one or more representatives of management who, irrespective of other responsibilities, have defined roles, responsibilities, accountability, and authority for ensuring that an Ergonomics Process is established, maintained, and reviewed in accordance with this Standard.

A.5.3 Guidance on management commitment and leadership

Using ergonomics in an organization is most effective when senior management shows active commitment to the process. Senior management's commitment to the Ergonomics Process can be integrated within an OHS policy or program, where one exists. Senior management provides visible commitment and leadership by

- including ergonomics and OHS in the organization's business planning;
- defining the intervals at which the organizations performance is reviewed against the objectives and targets (e.g., annually);
- encouraging, facilitating, and supporting participation and worker engagement;
- defining roles, assigning responsibilities, establishing accountability, and delegating authority to implement the Ergonomics Process;
- committing time and resources to the Ergonomics Process;
- visibly participating in "shop floor" discussions regarding ergonomics; and
- implementing, reviewing, and improving the Ergonomics Process.

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5.4 Worker participation

Worker participation is an essential aspect of the Ergonomics Process in the organization. The organization shall

(a) provide workers and worker representatives with time and resources to participate effectively in the development, planning, implementation, training, evaluation, and corrective action related to the Ergonomics Process;

(b) encourage worker participation by providing mechanisms that identify and remove barriers to participation; and

(c) ensure that workers and worker representatives are informed, consulted on, and given the opportunity to participate in the aspects of the Ergonomics Process associated with their work or the workplace which they represent.

A.5.4 Guidance on worker participation

Organizations with successful Ergonomics Processes realize the importance of participation by workers and worker representatives in various roles at both the organizational and individual levels.

Worker representatives are involved with ergonomics within the overall OHSMS, as well as during each component of the Ergonomics Process.

Participation means the involvement of workers in planning and controlling a significant amount of their own work activities, with sufficient knowledge and ability to influence both processes and outcomes in order to optimize health and well-being.

To improve the overall human health, well-being and system performance in an organization, the scope of worker participation in an organization includes

- reporting symptoms, injuries, near-misses, concerns, and other incidents related to the workplace;
- reporting concerns with design, use, and maintenance of tools and equipment;
- suggesting solutions that would improve the human health and well-being and system performance in the organization;
- using new equipment, tools, designs, or best practices that result from the Ergonomics Process; and
- providing feedback on new equipment, tools, and designs.

Existing OHS committees already include worker representatives. Depending on the organization's size and the nature of its operations, the Ergonomics Process may become part of the OHS program. In this way, the roles of participants in the OHS program are broadened to include ergonomics issues. Other organizations may convene a separate committee to address ergonomics. Like the OHS committee, this separate committee is expected to have worker representation. Worker representatives provide input from the workers whom they represent and are therefore the voice of the larger workforce.

There might also be circumstances where direct involvement of a group of workers is beneficial, such as during procurement of a new piece of equipment or the redesign of a workspace or job. In these circumstances, the workers using the equipment or performing the job can contribute valuable information about concerns and solutions to the Ergonomics Process.

While many workers might not have direct involvement in the Application of Ergonomics, they still have a role and responsibilities within the broader occupational safety and health issues and Ergonomics Process. The scope of worker participation in an organization can include

- worker representatives on the OHS or ergonomics committee;
- workers who are consulted during a defined project within the Ergonomics Process; or
- all workers in the organization.

Relevant awareness and training is an important component for those participating in the Ergonomics Process, which is discussed in Clauses A.5.2 and A.5.6.

The role of worker representatives

The role of the worker representative is to consult with workers who are familiar with work tasks and the operation and seek their advice regarding concerns and suggestions of an ergonomics nature. Some suggested roles for worker representatives within the Ergonomics Process include assisting in

- collecting information from workers about discomfort, injuries, errors induced by poor ergonomics, or concerns about a particular job or piece of equipment;

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- hazard identification and elimination and risk assessment and control;
- investigation of adverse outcomes;
- setting priorities for the new equipment/design/workspace;
- providing advice on the new equipment/design/workspace;
- communicating change to other workers (e.g., new technology, best practices);
- assessment and implementation of the new equipment/design/workspace;
- training for new equipment/design/workspace; and
- collecting evaluations from workers and assisting with follow-up of concerns after implementation.

Worker consultation for defined projects in an Ergonomics Process

During a project (e.g., when buying a new piece of equipment, or redesigning a workspace or a job), an appropriate worker group should be convened early in the process to provide information and suggestions concerning the current situation and potential ideas for improvements.

Roles could include

- communicating concerns and participating in discussions with designers or manufacturers;
- evaluating new equipment, designs, or layouts and providing input; and
- participating in a mock-up or prototype of a new design and providing feedback.

Workers with direct knowledge of the concerns, symptoms, or injuries associated with the current equipment or workspace should be involved. A representative sample of workers should consider the gender, age, experience, size, techniques, etc.

5.5 Communication

The organization shall establish and maintain procedures to

(a) communicate information about its commitment to, and development of, the Ergonomics Process and the progress of the implementation plan to all affected levels of the organization;
(b) receive, document, and respond appropriately to internal and external communications related to the Ergonomics Process;
(c) promptly provide reports of workplace injuries, illnesses, incidents, hazards, and risks;
(d) ensure that the concerns, ideas, and inputs of workers and worker representatives regarding ergonomics are received, considered, and responded to in a timely fashion; and
(e) use workplace OHS committees or worker representatives as a forum for communication.

5.6 Awareness and Training

5.6.1

Persons competent in ergonomics shall be involved in the design and redesign of work systems with attention to providing optimal working conditions for human well-being, safety, and health. This might require the enhancement of existing skills and development of new skills, while taking into account technological and economic effectiveness and efficiency.

The organization shall

(a) ensure that its workers have a general awareness of hazards and risks that can be addressed through the use of an Ergonomics Process;
(b) define the training requirements for addressing hazards and risks inherent in each job classification, including those associated with the introduction of changes in the workplace;
(c) provide training to its workers in the safe use of tools/equipment and safe work procedures applicable to their job; and
(d) ensure that its workers are aware of the importance of compliance with the applicable procedures, legal requirements, and other requirements, and the potential consequences of non-compliance.

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5.6.2
Awareness and training activities shall
(a) be conducted by competent persons;
(b) include participation of workers or their representatives;
(c) include timely refresher or re-training sessions;
(d) include participants' evaluation of the training activity;
(e) be evaluated and modified as necessary to ensure relevance and effectiveness; and
(f) be documented appropriately.

A.5.6 Guidance on awareness and training

Worker representatives should be involved in designing and evaluating awareness and training in the organization.

The organization needs to ensure that all workers are aware of

- legal and other requirements pertaining to their job;
- hazards and risks pertaining to their job;
- early recognition of the effects of poor physical, cognitive, or organizational ergonomics in their job (e.g., signs and symptoms of musculoskeletal injury, declining health and well-being, headaches, errors, and visual fatigue);
- how to report concerns;
- safe and efficient use of equipment, tools, and materials in their job to minimize hazards and risks;
- work methods, techniques, and best practices (proper procedures) that minimize hazards and risks; and
- potential consequences of non-compliance with proper procedures.

In addition, workers should be trained to use the preventive and protective measures introduced as part of the Ergonomics Process.

Workers who are involved in an ergonomics project (e.g., redesign of a workspace or procurement of new equipment) might require additional awareness and training, such as

- basic understanding of physical, cognitive, and organizational risk factors;
- the Ergonomics Process and its application (hazard identification and elimination and risk assessment and control, and follow-up, including education and training);
- information about their roles and responsibilities within the ergonomics project or process;
- training in effective group work, privacy concerns, communication skills, and problem-solving; and
- the design process and their role in that process.

Training activities should be provided during working hours and at no cost to participants.

6 Planning

6.1 General

The organization shall develop a plan to identify resource requirements, current legal requirements, and other requirements and to consider ergonomics in the design of systems and procurement of materials, in management of change, and in the setting of objectives and targets. Planning provides information to support systematic identification and elimination of hazards and assessment and control of risks. The plan shall include the designation of responsibility for implementing preventive and protective control measures as well as the implementation time frame.

A.6.1 Guidance on identification of resource requirements

Consideration of time and financial commitments should form part of the planning for implementation and management of the Ergonomics Process in order to ensure that the organization's ergonomics objectives and targets can be achieved and that the process is a success. The time and financial resource requirements should consider

- time and facilities for meetings;
- time for consultation with workers;

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- time to research options and identify and implement solutions;
- time to modify designs or workspaces;
- operational downtime as changes are implemented;
- access to internal expertise (e.g., worker representatives, OHS specialists, engineers, mechanics, purchasers);
- resources to contract for outside expertise;
- time and facilities to mock-up, prototype, or trial new equipment or designs;
- money for the purchase of new tools, equipment, software, and furniture;
- time for training on new tools, procedures, software, equipment, or workspaces;
- time for workers to become familiar with new tasks, procedures, and protocols;
- time to evaluate and follow-up on changes; and
- time and resources to make additional changes made necessary by follow-up evaluations.

6.2 Legal and other requirements

The organization shall

(a) identify and ensure access to applicable legal and other requirements;
(b) ensure that these requirements are satisfied by the Ergonomics Process; and
(c) plan for periodic evaluation of compliance to these requirements.

A.6.2 Guidance on legal and other requirements

Examples of legal requirements include

- *Canada Labour Code* (Part II) and Regulations;
- Provincial and Territorial workplace or OHS Acts and Regulations;
- standards that might have been adopted as law (e.g., the American Conference of Government Industrial Hygienists' *TLVs and BEIs* booklet); and
- provisions of collective agreements that affect the health and safety of workers in the workplace.

Examples of other requirements adopted by the organization can include

- memoranda of understanding, guidelines, and similar documents;
- equipment and systems standards developed by standards development organizations (e.g., the Canadian Standards Association and the International Organization for Standardization);
- industry and trade association codes of practice or "best practices"; and
- guidelines and bulletins issued by government agencies, labour organizations, and safety and professional associations (e.g., the Association of Canadian Ergonomists and the Canadian Centre for Occupational Health and Safety).

6.3 Objectives and targets

The organization shall establish and document measurable objectives and targets to demonstrate that the Ergonomics Process is established and utilized effectively.

Objectives and targets shall be determined by considering legal and other requirements, plans for change (such as new processes or equipment), technological options, the organization's operational and business requirements, hazards and risks identified in the Application of Ergonomics (see Clause 7), and incidents and injuries. Objectives and targets shall be reviewed on a regular basis and modified according to changing information and conditions, as appropriate.

The organization shall establish and maintain a plan for achieving its objectives and targets. The plan should include the

(a) designation of responsibility for achieving objectives and targets; and
(b) identification of the means and time frame within which the objectives and targets are to be achieved.

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A.6.3 Guidance on objectives and targets

Objectives and targets and the plan for achieving them may be developed under the organization's OHSMS or as part of the Ergonomics Process. For example, one objective can be to reduce musculoskeletal disorders or injuries in a particular department job by 20% over the next two years. This objective would lead to designating responsibility to certain individual(s) or committees (e.g., an ergonomics committee) a work plan to achieve the objective, and more details about the time frame of each step in the work plan. Another objective can be to upgrade equipment over the next three years. Achieving this objective could involve the designation of responsibility to various individuals and groups where applicable, (e.g., procurement staff, management, and workers and their representatives). Responsibilities would include working together to create a plan to research and develop ergonomics specifications, evaluate alternative options, and conduct user trials and evaluations.

The Ergonomics Process works within a system of continual improvement (see Clause 9). When new problems are identified or objectives and targets have not been met, then the objectives and targets should be revisited.

6.4 Recognizing and managing change

The organization shall identify changes that have the potential to affect worker health and well-being and system performance. This includes

(a) the design of new work processes or operations;
(b) significant changes to work procedures, organizational structure, staffing, products, services, or suppliers;
(c) advancements in knowledge and technology; and
(d) changes to legal requirements, collective agreements, or other requirements.

The organization shall use the Ergonomics Process to identify any hazard and assess risks associated with the change before any workplace modification is implemented.

7 Implementation

7.1 General

In order to identify and eliminate hazards and to assess and control risks, the organization shall utilize the Application of Ergonomics in the design and operation of a work system. The Application of Ergonomics is a part of the implementation of the Ergonomics Process and is in the "Do" section of the "Plan-Do-Check-Act" approach followed in this Standard (see Figure 3). The Application of Ergonomics shall take place at all stages of design and wherever the operating work system could have the potential to cause harm.

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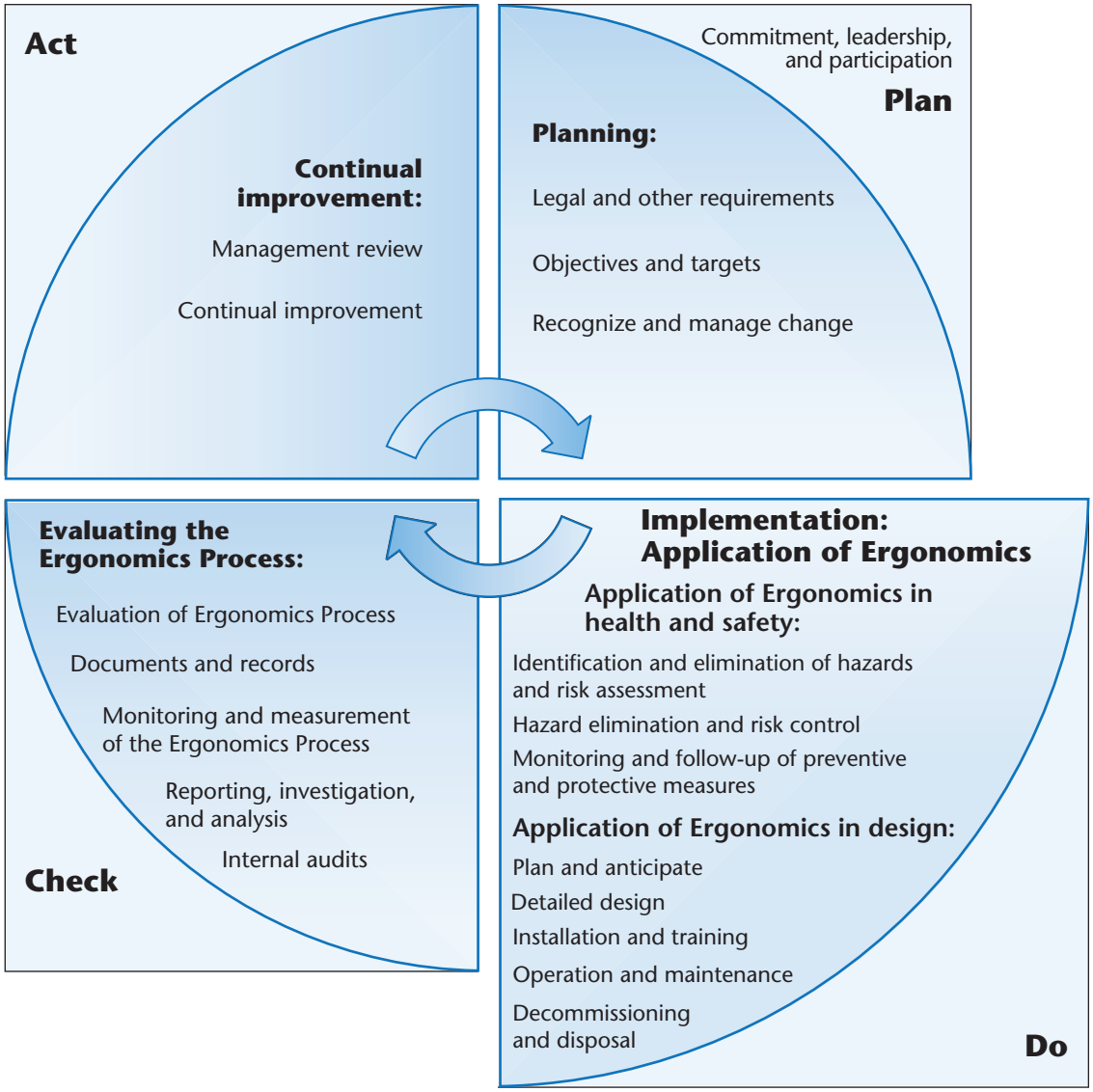

Figure 3
Ergonomics Process — How it fits within the OHSMS
(See Clause 7.1.)

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A.7.1 Guidance on implementation — Application of Ergonomics

Figure 2 provides an overview of the stages in design and emphasizes that the Application of Ergonomics occurs at each stage of the design cycle (e.g., in the design of a workplace or work process or where modifications take place to an existing workspace or work process). The Application of Ergonomics occurs throughout the identification and elimination of hazards or, if this is not possible, by assessing and controlling risks on an ongoing basis.

The general steps involved in the Application of Ergonomics are outlined in Figure A.1.

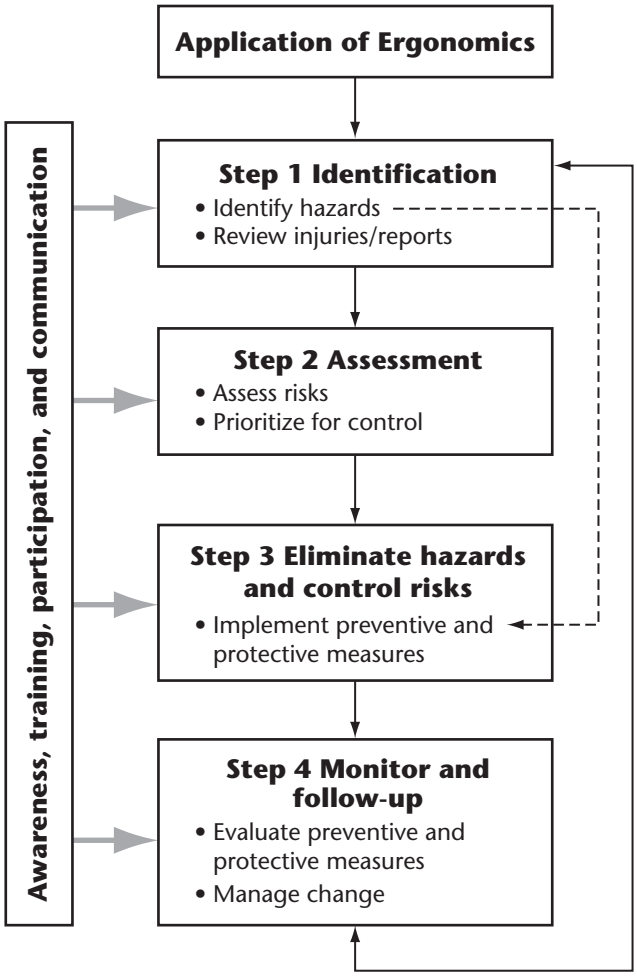

Figure A.1
General steps of the Application of Ergonomics
(See Clause A.7.1.)

The general steps are as follows:

- Step 1: Identify hazards in the workplace before incidents, injury, or illness occur. In addition, monitor for the occurrence of injury, signs or symptoms of incidents, injuries and disorders, or other concerns reported by workers. Where there is an occurrence of an injury or where there are signs or symptoms of an injury attributable to workplace hazards, immediate interim preventive and protective measures are to be implemented (see dotted line Step 3).
- Step 2: Assess each of the risks presented by the hazards that have not already been eliminated. This information is then used to prioritize risks for the implementation of remaining preventive and protective measures.

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- Step 3: Develop and implement preventive and protective measures that will eliminate the remaining hazards or, if this is not possible, to control the risks.
- Step 4: Follow-up activity (monitoring and review) takes place to ensure the effectiveness of all of the preventive and protective measures.

These steps are each identified in Figure A.1. This Figure also illustrates communication taking place with workers throughout the Application of Ergonomics. This communication ensures that the workers have input into the identification and elimination of hazards and the assessment and control of risks, and that they are aware of changes in their workplaces and how they will be affected.

These steps are cyclical and occur on an ongoing basis throughout the design or redesign of work systems and processes, as well as during their actual operation.

Some of the tools for the identification of hazards and assessment of risks are referenced in Annex B.

Clause 7 describes how the Application of Ergonomics in Figure A.1 is used in the workplace at each stage of design in order to identify and eliminate hazards or, if this is not possible, to assess and control risks. More detailed information on hazard identification and elimination and on risk assessment and control is found in CAN/CSA-Z1000.

7.2 Application of Ergonomics

7.2.1 Identification and elimination of hazards and risk assessment

Note: *See Figure 4.*

7.2.1.1 General

The organization shall systematically identify and assess the physical, cognitive, and organizational hazards that work systems can impose on workers. However, where there is an occurrence of an injury or where there are signs or symptoms of an injury attributable to workplace hazards, immediate interim preventive and protective measures shall be implemented before the completion of the risk assessment.

7.2.1.2 Hazard identification and risk assessment

The hazard identification and risk assessment shall

(a) be conducted by competent persons;
(b) include participation by workers and worker representatives;
(c) include use of leading and lagging indicators; and
(d) include infrequently performed tasks and tasks performed only in emergency response situations.

Where there is a recognized hazard or an injury, or where there are signs or symptoms of an injury attributable to workplace hazards, immediate interim preventive and protective measures shall be implemented before the completion of a risk assessment.

7.2.1.3 Performing hazard identification, elimination, and risk assessment

Hazard identification, elimination, and risk assessment should include the following activities:

(a) defining the worker population;
(b) performing a task analysis incorporating worker participation;
(c) identifying the root cause of hazards;
(d) eliminating hazards to the extent possible;
(e) identifying the ergonomics data;
(f) assessing the level of residual risk; and
(g) prioritizing.

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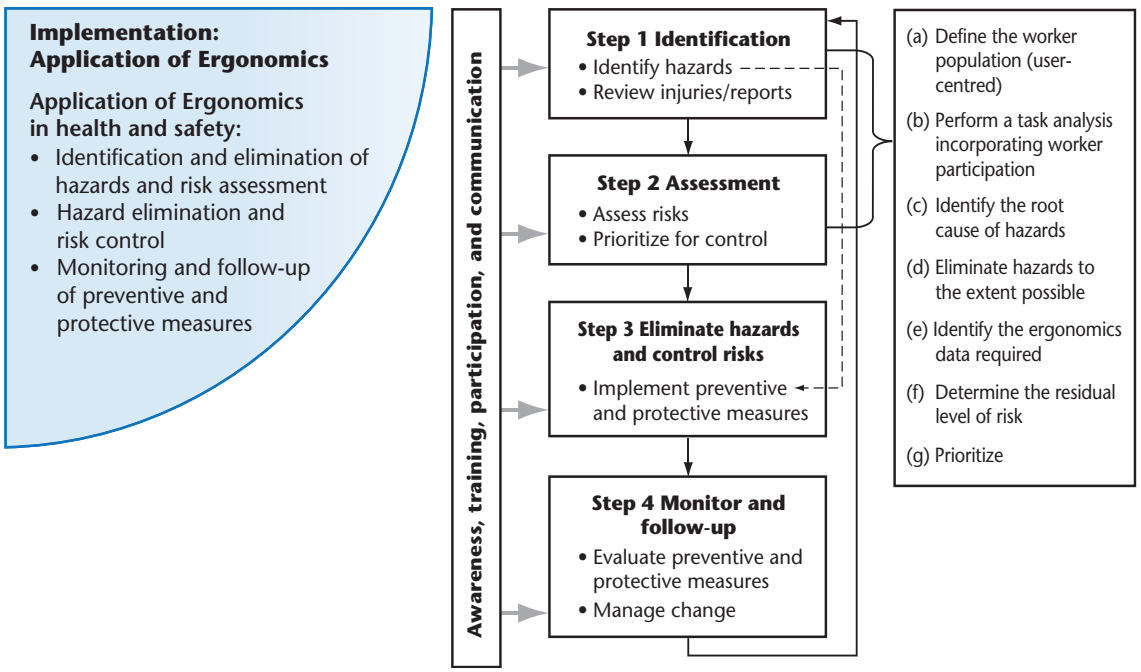

Figure 4
Application of Ergonomics in health and safety
(See Clauses 7.2.1 and 7.2.2 and Figures 2 and 5.)

A.7.2.1.1 Guidance on hazard identification and risk assessment

Hazard identification and risk assessment are commonly performed in organizations in order to work towards improving occupational health and safety performance. Hazard identification and risk assessment constitute the first step in the Application of Ergonomics. If physical, cognitive, and organizational hazards cannot be immediately eliminated or prevented, decisions on how to do so should be based on an assessment of their associated risks.

The first step in the Application of Ergonomics is to identify physical, cognitive, and organizational hazards in a work system that detract from the objective of health promotion and could result in injuries and illnesses, or performance concerns. This step should aim to

- eliminate the hazards;
- control risks by means of preventive and protective measures (see Clauses 7.2.2, 7.2.3, and 7.2.4);
- create hazard awareness for workers (see Clause 5.6); and
- set organizational objectives and targets (see Clause 6.3).

Using leading and lagging indicators

The identification of hazards may be approached by two complementary routes:

- monitor lagging indicators that document incidents, injuries, illnesses, errors, or near misses that have already occurred. Such lagging indicators might indicate that hazards are present in the work system; and
- use leading indicators during all stages of design and before incidents, injury, and illness occur.

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Lagging indicators
Monitoring of incidents, injuries, illnesses, and other concerns can be accomplished using administrative data that the organization regularly collects, such as first aid (sometimes called passive surveillance or monitoring) or using new information collected specifically for the purpose (sometimes called active surveillance or monitoring). Indicators such as the incidence of musculoskeletal disorders or reported concerns from workers might indicate that hazards are present in the work system.

Leading indicators
Hazards should be identified and eliminated at the earliest stages of design before incidents, injuries, illnesses, and other concerns occur when it is usually easiest and cheapest to do so. Clause 7.3 addresses how the Application of Ergonomics is used at each stage of design.

Hazards may be identified, for example, by

- asking individual workers about their concerns;
- inspecting the workplace during the operation and maintenance phase;
- applying ergonomics at the "detailed design" stage of design (e.g., identifying and eliminating the need to use excessive force to complete a task based upon documented strength data); or
- researching other similar work systems in separate locations during the planning and anticipation phase regarding their reports of injuries, illnesses, and errors.

Note: *See Annex B for useful tools to help identify leading indicators.*

A.7.2.1.3 Performing hazard identification and elimination and risk assessment

The following activities for hazard identification and risk assessment are similar whether designing a new system, redesigning one to address an existing problem, or performing ongoing monitoring of an existing work system. The Application of Ergonomics uses this approach at each stage of design. For more detail on how each stage of design is addressed, see Clause 7.3.

(a) Defining the worker populations
Any undertaking to identify hazards at any stage of design, including modifying existing workplaces, should include an effort to understand who the workers are, or defining the worker population. Workplaces or workspaces are used by a wide range of people. There is typically turnover of workers and, potentially, workers could belong to a wide population range. Therefore, designs for new workspaces or modifications to existing ones should be based on populations that form current and anticipated workforce. Where possible, design of workspaces should not be restricted to meet only the characteristics of the people present at the current time. Nonetheless, the current work force, where one exists, is an excellent starting point for defining the worker population. The various characteristics of the workers who currently perform the task/job, such as gender, size, age, skills, knowledge, training, and experience, need to be determined. This will also be helpful in choosing which workers to work with or to interview in the task analysis step [see Item (b)].

Consideration should also be given to users or workers who come in contact with the task/job/equipment infrequently (e.g., cleaning staff, information technology personnel, and people who maintain equipment).

Anthropometrics is the study of the size and shape of the human body. Examples of measures include standing and sitting height, forward reach, elbow height, seated knee height, and hand breadth. Poor design that does not take this information into account can result in the poor fit of an individual into a workspace, the inability to safely reach controls or see displays, or the accidental access to moving parts of a machine.

Anthropometric data are available on many national populations, usually broken down by gender but sometimes including specific age ranges, children, youths, older adults, and sub-populations such as military personnel or persons with mobility restrictions. This data is considered to be one of the types of ergonomic data referred to in Item (e).

A common mistake is to design for the average user. In general, a design should allow for the smallest person to be able to reach and for the largest person to be able to fit. Four strategies can be used to apply anthropometry in design:

- custom fit each person as in special circumstances (e.g., space suits);

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- provide a fully adjustable setting (e.g., office chair), typically between the 5th and 95th percentile value. For the 10% of people not covered by this range, special arrangements will need to be made;
- provide a number of sizes (e.g., gloves); or
- provide a fixed value that allows for the best fit for the largest number of people (e.g., counter height). This need not be the average value.

(b) Performing a task analysis incorporating worker participation

Task analysis is a basic first step in ergonomics describe and understand work. It involves, in its simplest form, a list of all tasks that a person, a couple of people, or a group of people might be expected to perform. It also includes the interactions between people and equipment, systems, and other people. The tasks that a worker performs, or will perform, are identified and broken down into their components. The task analysis should first identify the sequence of activities within a task or tasks. Knowing and understanding the sequence of activities and tasks in a job allows the analyst to prepare for interviews and observations. The task analysis helps to identify the interactions within the environment in a systematic way. This helps in identifying the physical, cognitive, and organizational demands and their associated hazards at the task level. These can include frequency and duration demands as well as visual, force, memory, and communication demands. The task analysis will identify hazards and possibly the need for further assessment of risk.

The task analysis is typically based upon observing the work, videotaping, performing interviews, and reviewing documents. As a result, pre-planning the performance of the task analysis is critical (e.g., which tasks to observe, when, what, etc.). Although reviewing documentation is important, it should be remembered that work is often more complex than described in documentation. The work is an addition of coping strategies and adaptation to differences and variability in the material, technology, conditions, and changing circumstances in which the job is being done.

Work can be performed differently by different workers depending on factors such as gender, size, age, skills, knowledge, training, and experience. The number of people to be observed and interviewed should encompass as large a range as possible. The inclusion of workers with previous injury among those to be observed is often helpful. Where possible, workers who do not regularly perform the task or who are from different enterprises (e.g., contractors, suppliers) but who work in the same workplace should be included in the task analysis.

Tasks and their performance can change on an hourly or a monthly basis. Tasks that are performed differently through time should be captured by the task analysis. For example, a task can be performed quite differently in the summer as opposed to the winter or when a plant is starting up on a Monday morning as opposed to later in the week. It is also important to identify all tasks performed in the work system, including maintenance, emergency response, and infrequent tasks.

(c) Identifying the root cause of the hazards

In order to determine effective preventive and protective measures (means of eliminating the hazards), a root cause analysis of the hazards is necessary. This analysis is performed in order to determine why the hazards are present in the job before looking for methods to control them. The process for analyzing a hazard's root cause or causes involves asking "why" several times until a dead end is reached. For example a worker identifies that she is leaning "too far". Asking why she leans too far to do the work, she might answer that the equipment she works at provides no leg room for access, that the printed material she needs to see is very small, and that the design of the hand tool being used requires reaching due to its size. Now, asking "why" to each of these elements (i.e., why is there no leg room, why is the printing so small, why does the tool have to be so short), will lead to further possible root causes that when controlled, will help to eliminate the over-reaching hazard. This process is referred to as moving up the chain of underlying causes. This analysis requires the participation of the workers who perform the task. The analysis might require the input from other workers who might be affected indirectly, such as supervisors, maintenance personnel, and others

(d) Eliminating hazards to the extent possible

Wherever possible, hazards should be eliminated once they have been identified. Implementation of preventative and protective measures should be accomplished based on the outcome of the analysis for their root causes, in order to be most successful. The best opportunity for hazard elimination is at the

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design stage of a work process or work system, including the early application of ergonomic considerations in workplace design specifications, work design standards, work procedures, and work practices.

(e) Identifying the ergonomics data

Once the hazards are identified and analyzed for their root causes they should be eliminated wherever possible. If some hazards still remain, their associated risk will need to be assessed. To assess the risk, ergonomics methods and data are chosen based on the type of demands and hazards identified in the task analysis (e.g., postural, force, information processing, etc.).

Because of the many types of activities that workers perform and the wide range of available data sources and methods, it is essential that the appropriate ergonomics methods or data are used for the particular task demands and worker population (see Annex B for assessment resources). The identification of appropriate ergonomics methods and data might require the assistance of a person competent in ergonomics in order to be effective.

(f) Assessing the residual level of risk

The goal is to compare information about the workers capabilities and needs [see Item (a)] and the task demands or hazards [identified in Item (b)] against known information from ergonomics data or measurement tools [identified in Item (e)]. An example of known information about a job task can include its lifting demands; these demands should then be compared to acceptable lifting limits taking into consideration the worker population characteristics or the specific worker capabilities and needs in question. Lifting limits should not be exceeded as they are a minimum standard used to protect the majority of a workforce. Changing demographics can result in the need to reduce lifting limits further due to symptoms of injury, aging workforce, or increased production demands. Accommodation of the workforce with specific restrictions must also be addressed.

(g) Prioritizing

Hazards that have not yet been eliminated after the task analysis and root cause analysis have been completed should be prioritized in order to systematically eliminate or control unacceptable physical, cognitive, or organizational demands that could cause injury, illness, or errors. Prioritizing hazards and risks should result in the development of a plan for the implementation of preventive and protective measures. Issues to be taken into consideration when prioritizing the order in which preventive and protective measures are to be implemented include

- severity of risk;
- urgency based on leading and lagging indicators (hazards causing or aggravating symptoms of injury must be immediately addressed); and
- available resources (time, financial, equipment, expertise, physical layout changes).

7.2.2 Hazard elimination and risk control

The organization shall implement preventive and protective measures to eliminate the hazards or control the risks identified during the Application of Ergonomics in order to promote physical, cognitive, and organizational well-being.

Preventive and protective measures shall be designed to eliminate hazards where possible (this is illustrated by the dotted line in Figure 4). Where hazards cannot be eliminated, risks should be controlled (minimized) as far as is capable. In determining hazard elimination and risk control measures, the organization in consultation with workers and worker representatives shall take into account the following:

(a) the causes, nature, and extent of the hazards and risks identified;
(b) the degree of risk control required;
(c) applicable legal and other requirements;
(d) applicable standards, codes, guidelines, and best practices such as those referenced in Annex B;
(e) the availability of suitable technology; and
(f) opportunities to improve design of work systems.

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A.7.2.2 Guidance on hazard elimination and risk control

Some preventive and protective measures might require time to be designed, budgeted, purchased, and implemented. For example, redesigning a control booth can take time to plan, obtain operator input, develop mock-ups, and build. In some cases, the installation needs to occur during a regularly scheduled shut-down period. In the interim, risk should be reduced as much as possible with administrative controls.

When determining preventive and protective measures,

- involve as many workers as possible since they often have ideas for solutions, especially those who have been injured or have concerns with the job;
- involve supervisors and maintenance personnel who might have other perspectives on how to solve the problem;
- focus on the high-risk tasks first, and eliminate or reduce risk factors as much as possible;
- use brainstorming or focus group methods to encourage innovative ideas and solutions;
- seek ideas from other industries with similar hazards, visit other organizations to observe their preventive and protective measures, and find out more about them;
- consider building the preventive and protective measures in-house if it is not available commercially;
- prototype, mock-up, and perform user-trials to evaluate the preventive and protective measures before they are implemented;
- evaluate the preventive and protective measures using up-to-date ergonomics standards and guidelines to ensure risks are controlled; and
- be prepared to modify the design or preventive and protective measures based on feedback from workers and based on monitoring and follow-up activities (see Clause 7.2.4).

This process should take into account best practices appropriate to the industry. Considerations include practicability, the organization's internal standards, rules, procedures, and the special needs of workers, including workers with disabilities. Industry associations and unions can also be a source of best practices specific to the organization. Procurement is an important aspect for consideration when designing preventive and protective measures and is described in further detail in Clause 7.3.4.

7.2.3 Hierarchy of preventive and protective measures

Elimination or control of hazards and risks shall be achieved by designing preventive and protective measures in the following priority:

(a) elimination or substitution, where either the hazard is removed from the workplace or the source of the hazard is replaced by a safer alternative;
(b) engineering measures representing change to the arrangement and design of equipment, tools, machinery, materials, or processes;
(c) administrative measures, such as those that affect the performance, duration, or organization of the tasks; and
(d) personal protective equipment of known effectiveness, such as padding for a part of the body.

A.7.2.3 Guidance on hierarchy of preventive and protective measures

Consideration must be given to the hierarchy of preventive and protective measures. The hierarchy falls under the order of elimination or substitution measures, engineering measures, administrative measures, and personal protective equipment.

Elimination or substitution involves design changes or substitution of other materials, processes, or equipment. Some hazards can be eliminated, especially in the early stages of design and during procurement, by appropriate choice of equipment, tools, workspaces, machinery, products, processes, and design of tasks and jobs. Using machinery or equipment to perform repetitive, forceful, awkward, or heavy functions can eliminate risk to workers.

Where hazard elimination or substitution is not feasible, engineering controls should be implemented since they represent changes, often permanent, in the arrangement and design of processes, equipment, tools, machinery, or materials and do not rely on changing human behaviour to reduce risk. Examples of engineering solutions that would benefit all workers performing the task include providing an adjustable height workspace, a mechanical lift for patient handling, or a lighter-weight tool with reduced vibration.

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Administrative controls are changes that affect the performance, duration, or organization of a task. Administrative controls generally do not eliminate hazards, but instead reduce the extent or duration of an individual's exposure to the risk. Examples of administrative measures include

- increased staffing during heavy periods of the day;
- increased variety in a job by introducing job rotation between different tasks, recognizing that implementing a basic job rotation scheme can expose more workers to particular risk factors and increase the overall level of risk for that group of workers, and addressing inherent hazards;
- providing opportunities for workers to control the pace and order of tasks in their job; and
- conducting technique training to control risk by altering how a task is performed by a worker (e.g., training in safe lifting techniques).

In some cases, complimentary engineering and administrative measures are required. For example, where a hazard cannot be eliminated or the risk controlled through engineering, devices that detect a hazardous condition and produce an adequate warning signal to alert personnel can be considered. Passive warning measures, such as signs, labels, and constantly flashing lights as well as training and written procedures can increase the likelihood of personnel taking correct actions in response to the warnings.

Depending upon the situation, there can be a combination of elimination, substitution, engineering, and administration measures taken. For example, an overall objective and target to reduce manual materials handling injuries due to baggage handling by airport check-in staff can involve a combination of

- elimination (requiring passengers to place their own baggage on conveyor belt);
- engineering controls (lowering the conveyors or aligning conveyors to eliminate a transfer between check-in and main conveyors); and
- administrative controls (scheduling of extra staff during peak periods and training workers in proper handling).

Personal protective equipment (PPE) generally does not eliminate hazards, but can help to control risk (e.g., knee pads to reduce contact stress from kneeling and gloves to keep hands warm). Some types of personal aids or equipment, such as back belts, have been shown to be ineffective or to possibly increase the risk of injury.

7.2.4 Monitoring and follow-up of preventive and protective measures

The organization shall

(a) evaluate the effectiveness of the preventive and protective measures implemented;
(b) identify any newly created hazards resulting from the preventive and protective measures implemented;
(c) expedite action on inadequately controlled risks; and
(d) track actions taken to ensure their effective implementation.

A.7.2.4 Guidance on monitoring and follow-up of preventive and protective measures

Following implementation of preventive and protective measures, follow-up is required to ensure that new hazards and risks are not introduced or left unaddressed. This takes place following the identification and immediate elimination of hazards and after the implementation of protective and preventive measures to control risks. Monitoring and follow-up of preventive and protective measures should involve workers who are directly affected by the changes that have been made.

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7.3 Application of Ergonomics in design

7.3.1 General

The Application of Ergonomics shall be applied to all stages of design, including plan and anticipate, detailed design, installation and training, operation and maintenance, and decommissioning and disposal (see Figure 5).

Persons competent in ergonomics shall be involved in these activities.

To effectively eliminate hazards or control risks and to enhance human health and well-being and optimize system performance, the application of evidence-based tools, methods, checklists, and standards shall be used. These shall be employed in conjunction with data, which shall be collected through consultation with worker groups or operators of other similar systems, where necessary.

Note: *Some evidence-based tools and checklists are provided in Annex B; however, Annex B is not intended to be exhaustive and other such tools and checklists demonstrated to be equally effective may also be used where applicable.*

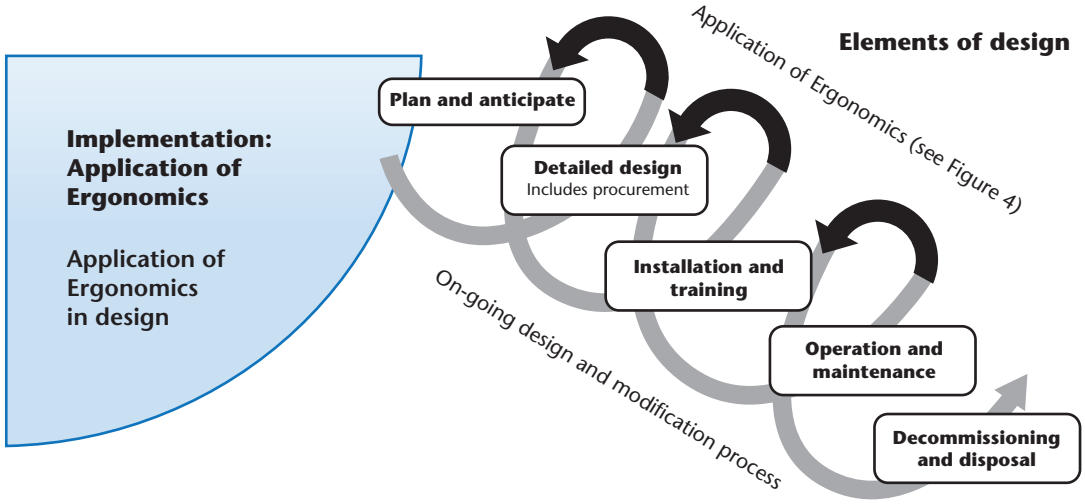

Figure 5
Application of Ergonomics in design
(See Clause 7.3.1.)

A.7.3 Guidance on ergonomics in design

A.7.3.1 General

The Application of Ergonomics at each stage of design helps to identify the physical, cognitive, and organizational demands that will be placed on workers. This allows optimization of system performance as well as the identification and elimination of potential hazards. Where hazards cannot be eliminated, the risk must be assessed and then controlled by implementing the appropriate preventive and protective measures. The implementation of preventive and protective measures must be monitored and followed-up to ensure their effectiveness. Where they are not effective, or in the circumstances where new unforeseen hazards are introduced as a result of their implementation, further changes must be made. In Clause 7.2, the elements of the Application of Ergonomics are described in terms of hazard identification and elimination, and risk assessment and control. In the Application of Ergonomics in design (Clause 7.3), the same steps are taken at each stage of design as described in Clause 7.2; however, the information at each stage of design is gained from different sources depending on which stage of design is being considered. For example, the information available to perform a task analysis at the plan and anticipate stage will differ from the type of information available at the detailed design stage.

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7.3.2 Plan and anticipate

During the plan and anticipate stage, each aspect of the workplace or work process to be created or modified, and its interactions with workers should be defined. System specifications shall be identified at this stage and shall take into account the anticipated health and well-being and performance of workers who will be a part of the system being designed or modified. Ergonomics shall be applied in the earliest stages of design or redesign of a work system, including workspace, equipment, layout, facility design, work organization, and environment.

A.7.3.2 Guidance on ergonomics considerations in the plan and anticipate stage

The plan and anticipate stage is the earliest stage of design. It represents the formalization of the decision to design or redesign a system, workspace, or other aspect of the workplace or how work is done. At this stage, system specifications are created which have implications for the health and well-being of workers as well as the technical performance requirements of the new system. Choices are made regarding how large an investment will be made and what the objectives and core criteria are for the design. If ergonomics is not considered at this stage, then ergonomics-related improvements at later stages will be more difficult and therefore less likely to be successful. At this early stage in design, the basic format of the changes are established. For example, the work system outputs/products are defined, the users of the work system are identified, the production model (e.g., cellular manufacturing, assembly line, or teleworking) are established, the automation level are chosen, and the human operations are clarified.

In keeping with the activities outlined in Clause 7.2.1.3, the worker population must be defined. Through consultation with worker representatives and end users of the proposed system (or of existing systems), information is collected that is used to develop a new system or improve an existing one. A task analysis on each critical operation should then be done with the goal of identifying physical, cognitive, and organizational demands and possible associated hazards. In the plan and anticipate stage, only a very general idea of possible tasks might be available. It might be known, for example, that parts will need to be transported between two departments, but at this stage the details of frequency, personnel requirements, the mode of transportation, etc. are not available. These specifications are developed in the next stage of design (detailed design).

If a similar work system already exists elsewhere, the task analysis of that system could provide a valuable basis on which to create the task analysis of the new design. The existing system can also provide valuable information on job demands and hazards that have been identified and injuries that have occurred. In addition, standards, guidelines, best practices, or legal and other requirements that are applicable to the system should be considered (e.g., decision-making or error performance models, labour agreements, and anthropometric models).

Tasks demands and their potential hazards, identified above, should be assessed for worker health, safety, and well-being and optimal system performance. For example, the transporting of heavy parts implies the presence of a hazard due to heavy lifting and possible work organization issues. With the identification of a possible hazard and work organizational issues, a decision to eliminate the task demand up front could be made at this stage (e.g., decision to provide mechanical lifting equipment).

Exposure assessment can be difficult at this stage because there might not be an existing system to work with. However, some knowledge of previous or existing work systems (weights, forces, types of decisions that workers have to make, what tools can be used to help make decisions, etc.) together with anticipated changes give indications of where special attention is needed.

Changes of a general nature should be developed to eliminate the hazards at source where possible. It is typically easier and cheaper to eliminate hazards at this early stage of the design. If elimination is not possible, then a preliminary hazard assessment, based upon the limited knowledge available, might need to be performed.

Such potential hazards are flagged, together with possible solutions, and forwarded to the detailed design phase. If the same hazards are predicted for multiple tasks or operations, a general solution for the entire workplace (e.g., installing a plant-wide materials conveyance system for heavy parts) might be better than implementing a number of changes of a piecemeal nature.

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7.3.3 Detailed design

During the detailed design stage, the major interactions between one or more people and components of the work system shall be identified and assessed.

While taking into account technological and economic effectiveness and efficiency, the design of optimal working conditions shall take into account the anticipated health and well-being of workers who will be a part of the system being designed or modified as well as the optimal system performance.

The Application of Ergonomics shall be applied to the design of the work system, including tasks, equipment, the workspace, work organization, and environment.

As far as is practical, work systems shall be designed to

(a) accommodate a broad range of the population;
(b) prevent adverse effects on workers, promote health and well-being, and facilitate optimal task performance;
(c) allow for workers' postural stability and mobility;
(d) consider body dimensions, posture, muscular strength, and movement; and
(e) consider both the cognitive and physical demands related to equipment and the interface design.

A.7.3.3 Guidance on ergonomics considerations in the detailed design stage

At the detailed design stage, the process has moved beyond planning to a point where more in depth information is available and decisions have been made about the new design. The information at this stage is used to assess all interactions between one or more people and components of the work system. The goal of the Application of Ergonomics at the detailed design stage is to avoid the introduction of hazards and risks into the new or modified system and to enhance system performance.

By gathering more detailed information on the working population, the system being designed will be able to accommodate a broad range of workers by accommodating their various characteristics and needs, including those of people with special requirements. This approach will minimize the need to develop special solutions for individuals.

At the detailed design stage, tasks to be performed by people become more clearly defined. A task analysis at this stage provides more detailed information about the interactions between the workers and the components of the work system, as well as possible hazards. The use of mock-ups or computer simulations is possible for the hazard identification and risk assessment. Body templates or computer mannequins can be used to simulate tasks and to estimate risk. Fitting trials and user trials of prototypes of machinery, workstations, or tasks done with workers performing scenarios based upon the task analysis should be considered at this stage of design.

Identifying the ergonomics data required for risk assessment, such as worker posture information, generally needed for an ergonomic (biomechanical) analysis becomes more readily available at this stage. If the workforce is not present however, the specific postures are inferred based on assumed body sizes and postural strategies adopted in the performance of the task. Simple models that require only task information (and not workforce information) can be applied (see Annex B for examples). Anthropometric and strength capability data can provide useful inputs for layout teams trying to optimize their designs.

If the design causes unacceptable demands and hazards are identified, they should be eliminated from the design or an assessment of risk needs to be completed and redesign might be warranted. For example, a decision in the plan and anticipate stage to not install lift assists might be reconsidered in the detailed design stage when the level of risk is determined to be unacceptable.

The following considerations are important at the detailed design stage to ensure that the interaction between workers, equipment, and the elements of the system being designed is as safe and effective as possible. These elements include

- work environment;
- job design and work organization;
- workspace design; and
- work signals, displays, and controls (hardware and software).

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Design of the work environment

In addition to ensuring that environmental conditions remain within recognized limits for controlling health hazards (e.g., limits for physical and chemical exposures), attention should also be given to the design of the work environment to facilitate worker well-being and system performance. For example, appropriate lighting to optimize the environment in which visual inspection tasks take place and appropriate noise reduction to minimize distractions that can impact upon concentration. Wherever possible, workers should be able to influence the conditions in their work environment (e.g., lighting, temperature, and noise levels).

Equipment might also affect the work environment by contributing to noise levels, temperature changes, and other environmental effects.

Job design and work organization

The design of jobs and subsequent physical, cognitive, and work organizational demands depends on the combination of work tasks within a job, the content and repetitiveness of operations, and the workers' level of control over the work process.

The effects of the physical demands required by individual tasks need to be considered:

- Avoid unnecessary or excessive strain on the musculoskeletal, respiratory, and circulatory systems.
- Ensure that power and work demands are compatible with the physical capabilities of the worker taking into account the effects of strength, frequency of exertion, posture, and fatigue.
- Avoid the need for high muscular strength for movements requiring accuracy.
- Consider the extent to which various work systems create constraints and pressures on other work systems. For example, deadlines in one department can have a negative effect on work organization in another department.
- Consider the effect of work organization on scheduling of workers (e.g., will workers be required to work the night shift? Will workers be required to work alone?).
- Provide training on required job skills including safe and effective operation of equipment.
- Recognize the experience and capabilities of the working population.
- Provide opportunities for the development of existing skills and the acquisition of new skills:
  - change of activities, such as by job rotation, where appropriate;
  - having one person perform several different tasks belonging to the same job rather than several people each performing one specific task of that job (job enlargement); and
  - having one person perform successive tasks belonging to different functions (job enrichment).
- Provide people with an appropriate degree of control in deciding priority, pace, and procedure.
- Ensure that the worker makes a significant contribution to the total work system, which can be understood by the people involved, rather than contributing to only a fragment of the work.
- Provide sufficient, meaningful feedback to those performing the work task.
- Avoid overload as well as underload of the worker, which can lead to unnecessary or excessive strain, fatigue, or errors.
- Avoid high repetitiveness, which may lead to work strain as well as sensations of monotony, boredom, or dissatisfaction.
- Avoid working alone without opportunities for social and functional contacts.
- Plan for adequate breaks, both scheduled and unscheduled.

Design of workspace

In designing an effective workspace for optimal performance, the following should be considered:

- The design of the workspace must allow for postural stability and postural mobility, taking into account body dimensions, posture, muscular strength, and movement.
- Workspace must be sufficient to accommodate the wide range of sizes of the working population such that workers who are on the small end of the size spectrum (5^{th} percentile) as well as workers on the large end of the spectrum (95^{th} percentile) can all reach, fit, and see
- Workspace should be designed to consider space constraints imposed by the body dimensions together with any clothing or other necessary items.
- Workspace should provide the space needed for the worker to maintain body joints in neutral or optimal postures.

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- Prolonged tasks should permit alternation between sitting and standing, where possible.
- Crouching or kneeling postures should be avoided for prolonged tasks.
- A good balance should be established among body movements to avoid excessive movement or prolonged immobility.
- Equipment can impact upon a worker's personal workspace (e.g., the orientation and placement of the equipment can put a worker in an awkward posture and the cab of mobile equipment can require excessive neck flexion to view the operation being performed).

Design of work signals, displays, and controls

The design of signals, displays, and controls should optimize decision-making, information transfer, and communication:

- signals, displays, and controls should
  - provide enough information to allow a rapid overview, as well as providing information concerning detailed parameters;
  - work in a way likely to reduce human error;
  - be selected, designed, and laid out in a manner compatible with human perception and the task to be performed; and
  - be organized such that the most needed displays can be easily seen;
- controls should be
  - selected, designed, and laid out in such a way as to be compatible with the characteristics (especially movement) of that part of the body that uses them, considering skill, accuracy, speed, and strength requirements;
  - compatible with population characteristics, the dynamics of the control process, and its spatial representation;
  - close enough to facilitate correct operation where they are to be operated simultaneously or in quick succession, but not so close as to create a risk of inadvertent operation; and
  - organized such that the most needed controls can be easily reached and operated; and
- computer software and hardware (human computer interaction) should allow the end users to perform their job efficiently.

7.3.4 Procurement

The organization shall establish a process to evaluate products, supplies, equipment, tools, furniture, and raw materials to be procured in order to identify and eliminate potential hazards or to control risk before they are brought into the workplace and to prevent injuries, enhance worker health, safety, and well-being, and optimize system performance.

The organization shall

(a) develop ergonomics specifications to be used during procurement that take physical, cognitive, and work organization demands into consideration;
(b) include a user-centered approach in the development of procurement specifications;
(c) ensure that procured goods conform to established specifications and that suppliers are made aware of these specifications when required; and
(d) include worker participation in the development of specifications and in the evaluation of procured goods, as appropriate.

A.7.3.4 Guidance on ergonomics considerations in procurement

The Application of Ergonomics in procurement identifies mismatches between items being considered for procurement and the workers who will use them, so that hazards and risks are not introduced into the workplace.

During the procurement process, there should be consultation with an appropriate group of workers, as outlined in Clause 5.4. Workers, supervisors, and procurement personnel should work together to identify relevant issues with current items (products, supplies, equipment, etc.). Competent persons should be consulted to help develop ergonomics specifications to be applied to procured goods. This can take the form of design requirements or a checklist (see Annex B for examples).

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The specifications should ensure that procured goods conform to ergonomics considerations in Clause A.7.3. This will help ensure that their design and use minimizes adverse effects on workers and optimizes the work system.

Procured goods can then be compared between manufacturers as to their compliance with the ergonomics specifications and the final "fit" within the workplace. An appropriate group of workers should also provide input to the final options prior to procurement. This can involve any of the following activities:

- consulting organizations that have the equipment/item to evaluate the features;
- participating in a trial of the new equipment/item;
- collecting feedback from other workers during implementation of the new equipment/item; and
- providing feedback on the ergonomics specifications.

Products, supplies, and raw materials brought into the organization can be associated with an identified risk to the workers who are to assemble, move, handle, use, operate, maintain, or disassemble them. An example is the supply of flour to a bakery in 40 kg bags. Consideration should be given to aspects of these products, supplies, and raw materials, such as

- procurement of supplies/materials of lower weight if they are to be handled manually;
- availability of lifting devices or mechanization to move the products, supplies, and materials;
- labelling of product weight;
- availability of good handles if handled manually;
- ease of use or disassembly;
- storage requirements; and
- disassembly and handling requirements of packaging.

By working with suppliers to identify, eliminate, and control hazards and risks prior to procurement, injuries and illnesses can be minimized for all workers.

7.3.5 Installation and training

During the installation and training stage, installation of new workspaces, equipment, machinery, or work processes takes place and training on safe and effective use is provided.

During installation, the predicted interactions between people (the installers and the users) and the components of the work affected by the installation shall be documented in order to identify and eliminate hazards wherever possible, or assess and control risks.

Trials to verify design specifications shall be performed prior to final permanent installation of new work components.

Workers shall be trained in the safe and effective use of new workspaces, tools, equipment, machinery, or work processes and procedures. Workers shall be informed of the importance of compliance with applicable procedures and legal requirements and of the potential consequences of non-compliance.

A.7.3.5 Guidance on ergonomics considerations in installation and training

As in all other design stages, this stage is not only relevant to the installation of large systems or equipment in an industrial setting; it can also be applied to the installation of a new computer system at a workspace or the installation of a new coffee maker in a coffee shop.

The installation of new workspaces, equipment, machinery, or work processes must be safe for those workers performing the installation and working in the vicinity of the new work components. This can include consideration for how the new equipment or parts are to be transported into the facility for assembly, as well as how the items are to be transported within the facility. Installation should be planned out ahead of time to ensure that the workers who are installing the new equipment are not put at risk of injury and are able to effectively perform the task within the scheduled time. Workers in the workspace of the installation should also be made aware of what is taking place.

Careful attention at this stage of design is important as it will provide another opportunity for potential problems in the new system to be identified and corrected before final installation. This stage can also identify possible hazards related to the installation itself. The Application of Ergonomics uses methods (e.g., pilot builds, user trials, and pre-start health and safety reviews) to enhance worker health, safety, and

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well-being and optimize system performance related to the installation. It is also advantageous to identify possible issues related to future decommissioning and disposal of the equipment and systems being installed (see Clause 7.3.7).

The Application of Ergonomics at the installation and training stage provides a final opportunity to evaluate the "fit" of new installations with workers who will be performing tasks in these workspaces. These trials (e.g., using prototypes, mock-ups, or computer simulations), which occur prior to final permanent installation of work components, verify the design specifications outlined at the detailed design stage. Adjustments to design specifications at this stage are less costly than modifications that occur after a system is operational.

Training of the workers who install components is important to their understanding of the possible hazards of the work and how to perform it safely. This can include informing contractors of hazards in the workplace, with which they might be otherwise unfamiliar. Workers who will be using the newly designed or redesigned system must have training on how to do so in the safest and most effective manner. Training might be needed to understand how best to integrate the changed aspect of their jobs with other parts of the job.

7.3.6 Operation and maintenance

During the operation and maintenance stage, the interactions between people and the components of their work shall be monitored regularly and documented to enhance worker health and well-being and optimize system performance.

The Application of Ergonomics shall take place in the operation of existing and newly designed work systems to ensure that hazards are identified and eliminated and risks are assessed and controlled.

The Application of Ergonomics shall take into consideration physical, cognitive, and work organizational demands. It shall include a review of

(a) objectives and targets for a work system;
(b) workplace inspections;
(c) incident and accident investigations; and
(d) analyses of incident and injury reports.

Further opportunities for gathering worker input for review include the results of worker surveys, physical demands analyses, and cognitive demands analyses. Any defects in a component of a work system shall be reported and addressed through the Ergonomics Process.

A.7.3.6 Guidance on ergonomics considerations in operation and maintenance

In the operation and maintenance stage, the workplace is active and work is being performed. At this stage, the process of identifying and eliminating hazards and assessing and controlling risks, through modifications and follow-up, continues to take place. This is an ongoing process that should take place as a routine part of work. This can be done using a variety of methods and should take place in existing and new work systems. It should include participation of the workers and worker representatives as outlined in Clause 5.4.

In an operating system where work is actively being performed, the Application of Ergonomics can include observations of people working, measurements of forces exerted, postures adopted, and a collection of direct feedback. Checklists, observational methods, or more specialized tools may be used. Annex B provides examples of tools that may be used for this type of work. The goal is to ensure that work currently being performed is designed as well as possible to prevent injuries and to enhance worker health, safety, and well-being and optimize system performance.

In the operation and maintenance phase, there will typically be people to observe and interview; however, for highly irregular tasks, observation might not be possible and the information can be gained by interview only.

In the operation and maintenance phase, it is possible to perform detailed evaluation of many aspects of the job. The task analysis of the work will have identified both tasks and people whose demands should be captured. The evaluation will therefore include a representative sample of workers and consideration

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should be given to the characteristics of future worker populations where possible (e.g., a predominately female workforce that might include more males in the future might have an impact on workspace design due to the differences in body dimensions).

The Application of Ergonomics at the operation and maintenance stage may be achieved by

- reviewing the following:
  - Objectives and targets — Repeated failure of the work system, or repeated incidents or injuries, can suggest that the objectives and targets set for a specific work system are not realistic.
  - Workplace inspections — Ongoing inspections of the work systems, equipment, tools, and work organization should take place followed by the elimination of hazards, where possible, and risk assessment and control.
  - Incident investigations — Investigations of incidents will identify the root causes of the incident.
  - Trends analysis of incident reports — When incidents or hazardous work conditions are being regularly reported, these reports should be monitored for trends. Where trends are forming, improving the ergonomics of a work system might be required to prevent incidents and poorly designed work systems from reoccurring or remaining. An immediate response is required to correct hazardous work conditions or to investigate incidents in the workplace.
- conducting the following:
  - Worker surveys — Worker surveys can be used to establish whether workers are experiencing early signs and symptoms of musculoskeletal disorders (i.e., injuries) or if they are experiencing problems with work system design or work organization. These surveys can then be used to monitor preventive and protective measures once they have been implemented to ensure their effectiveness.
  - Physical demands analyses — This type of analysis can help to identify the types of physical demands required of workers who perform certain tasks. If physical hazards are identified, they should be eliminated or their risk assessed and controlled.
  - Cognitive demands analysis — This type of analysis can help to identify the cognitive demands of the job (e.g., remembering, awareness, perception, reasoning, using judgement, decision making).

7.3.7 Decommissioning and disposal

During the planning and carrying out of the decommissioning and disposal stage, the interactions between people and the components of their work shall be reviewed and documented to enhance worker health, safety, and well-being and optimize system performance.

The Application of Ergonomics shall take place when planning and carrying out decommissioning and disposal to identify and eliminate potential hazards and to assess and control risks.

As part of the Application of Ergonomics, a safe work plan shall be reviewed with the workers involved in the decommissioning and disposal prior to beginning work.

A.7.3.7 Guidance on ergonomics considerations in decommission and disposal

Performing the Application of Ergonomics during the decommissioning and disposal stage helps to optimize the safety and effectiveness of the work by considering physical, cognitive, and work organizational demands.

When equipment or facilities are decommissioned and then dismantled or disposed of, many interactions take place between workers and the equipment or the facility. The interactions need to be well planned to prevent hazards. Some of this planning will have taken place well in advance during the detailed design stage; however, it must be re-visited when preparations for decommissioning and disposal activities are being made.

At this stage, the worker population that will be affected by decommissioning and disposal tasks need to be identified as a part of the Application of Ergonomics. Examples of interactions between workers and decommissioning and disposal tasks are the dismantling of equipment, the storage of equipment until it is disposed of, and the actual task of disposing of equipment and parts. The interaction can affect those who perform the tasks, as well as those who routinely use the equipment or facility. This is especially important

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where equipment or layout is being altered or replaced while work is continuing in the area. In addition, there are important considerations for the people that work in the area around the decommissioning and disposal of equipment.

The details needed for a task analysis at this stage might be known as well, in terms of when and how the removal or disposal of equipment and systems will occur, and any physical, cognitive, or organizational hazards associated with this activity. These need to be identified through task analysis and eliminated wherever possible. New equipment that is needed to perform the decommissioning and disposal can be introduced to the work area, which could cause congestion and production issues and safety hazards that must be eliminated or their risks controlled. Workers in the immediate area need to be made aware of the hazards and risks related to the decommissioning and disposal activities in their area of work.

The ergonomics data and resources to be used at this stage for a risk assessment include many of the same resources used during the detailed design stage, since much of the information at this stage is likely to be available for use. Those resources can be used to perform the risk assessment during the Application of Ergonomics at this stage of design, coupled with information such as equipment specifications, worker population characteristics (as outlined above), and work environment characteristics, wherein the decommissioning and disposal will take place.

8 Evaluating the Ergonomics Process

8.1 Evaluation

The organization shall, in conjunction with worker representatives, regularly evaluate its Ergonomics Process to

(a) determine the extent to which the objectives and targets are met;
(b) determine that appropriate preventive and protective measures are taken and to assess their effectiveness; and
(c) enable continual improvement.

The organization shall use the documents and records required in Clause 8.2 to evaluate the Ergonomics Process.

8.2 Documents and records

8.2.1

The organization shall create and maintain the following documents and records:

(a) the objectives and targets required by Clause 6.3;
(b) the assignment of duties and responsibilities as required by Clauses 5.3.1, 5.3.3, 6.1, 6.3, 8.4 and 9.1;
(c) the procedures required by Clauses 5.5 and 8.4;
(d) the high level direction required by Clause 5.3.2;
(e) the documents required by Clause 8.5, if the organization chooses to conduct internal audits;
(f) records of internal and external communications required by Clause 5.5;
(g) records of training required by Clause 7.3.5;
(h) supporting documents and records required by the organization to ensure the effective planning, implementation, operation, and control of the Ergonomics Process; and
(i) other documents and records required to assess compliance with legal and other requirements.

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8.2.2
The organization shall establish and maintain legible, readily identifiable, and retrievable records. Records may include
(a) reports of related injuries and illnesses;
(b) records arising from legal requirements;
(c) assessments performed as part of the Application of Ergonomics and comparison of findings with standards and guidelines;
(d) records of worker concerns;
(e) records of changes or improvements made to eliminate hazards and control risks;
(f) calibration records for monitoring and measurement equipment; and
(g) records of job accommodations or modified work.

8.2.3
Workers and their representatives shall have access to documents and records relevant to the Ergonomics Process, while respecting the need for confidentiality.

8.3 Monitoring and measurement

8.3.1
Measures for monitoring the Ergonomics Process shall be developed. These shall
(a) be appropriate to the needs, size, and nature of the organization;
(b) be developed in consultation with workers and worker representatives;
(c) include both qualitative and quantitative measures; and
(d) be used as input to the process review.

8.3.2
Monitoring and measurement activities shall be recorded. Examples of these activities include reviews of
(a) general inspections addressing ergonomics considerations in work design and arrangement, tasks, facilities, and equipment;
(b) number and results of hazard identification and elimination and of risk assessment and control investigations;
(c) preventive and protective measures implemented;
(d) injury and illness trends;
(e) accident and injury investigations and implementation of corrective actions;
(f) use of physical demands analyses; and
(g) worker input and concerns.

A.8.3 Guidance on monitoring and measurement
Monitoring and measuring indicators and activities associated with the Ergonomics Process facilitates evaluation and promotes continuous improvement. By making use of leading indicators, the organization can evaluate the effectiveness of the steps taken to prevent workplace injuries and illnesses, and not rely solely on the lagging or trailing indicators whereby failures or deficiencies are counted in the way of concerns, complaints, injuries, or illnesses.

Examples of leading indicators include
- the number of workplace inspections conducted and the corrective action taken on inspection findings that prevented injury or illness;
- identification of and corrective action taken on near-misses or errors;
- the instances of proactive consideration of ergonomics in new design or procurement;
- audit findings verifying the incorporation of ergonomics into all aspects of the OHS management systems;
- the number of task analyses conducted to identify the physical, cognitive, and organizational demands in tasks or jobs;

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- awareness training provided to workers to encourage the recognition and reporting of ergonomics-related concerns prior to the development of injuries of illnesses;
- the results of surveys evaluating the organization's safety culture, safety attitudes, and beliefs and the readiness for change; and
- investment in ergonomics in the workplace to prevent hazards.

Examples of lagging or trailing indicators include

- reports of nonconformance, noncompliance, or other Ergonomics Process deficiencies;
- occupational accident or injury incidents and trends;
- the number of accident and injury investigations;
- the modifications to workspaces or jobs where task analysis identified problems related to physical, cognitive, and organizational demands mismatched to worker capabilities but before an injury has occurred;
- ergonomics related corrective actions;
- the number of worker concerns or complaints of hazards;
- directives or orders resulting from a failure to meet legal requirements to eliminate or reduce risk; and
- direct and indirect costs associated with correcting poor ergonomics after the initial stages of design.

8.4 Reporting, investigation, and analysis

The organization shall establish and maintain a procedure for reporting and investigating incidents, concerns of unsafe conditions, and hazardous physical, cognitive, or organizational job demands. The procedure shall

(a) establish roles and responsibilities, including those of workers and worker representatives, for reporting, investigating, and analyzing incidents and concerns;
(b) specify that investigations be carried out by competent persons;
(c) require analysis of the concerns;
(d) include consideration of preventive and protective measures recommendations; and
(e) require assessment of effectiveness of any measures implemented.

When an investigation occurs, the analysis of the findings can result in recommendations. Recommendations, along with investigation findings, shall be communicated to the workplace parties. These recommendations shall form a basis for any preventive and protective measures to be implemented. Corrective actions resulting from the reporting, investigation, and analysis procedures shall be implemented within an established time frame.

8.5 Internal audits

Audits conducted at planned intervals can be used to determine whether the Ergonomics Process conforms to the requirements of this Standard and if it is effectively implemented and maintained.

If the organization chooses to use internal audits, the organization shall determine and document the criteria for auditor competency, the audit scope, frequency of audits, the audit methodology, and reporting mechanisms.

Note: *See CAN/CSA-Z1000 and CAN/CSA-ISO 19011 for information on conducting internal audits.*

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9 Continual improvement

9.1 Management review

The organization should continually improve the effectiveness of the Ergonomics Process. Senior management shall review the organization's Ergonomics Process at planned intervals to ensure its continuing suitability, adequacy, and effectiveness. The management review shall include an assessment of opportunities for continual improvement.

9.2 Review input

Inputs to the management review of the Ergonomics Process shall include

(a) results of the overall evaluation of the Ergonomics Process, including monitoring and measurement;
(b) the extent to which objectives and targets have been met (see Clause 6.3);
(c) communication with workers and worker representatives;
(d) follow-up actions from previous management reviews;
(e) information concerning changing circumstances;
(f) communication from external agencies and organizations; and
(g) results of audits (if conducted).

9.3 Review output

The output of the management review shall include any decisions and actions related to

(a) revising objectives and targets;
(b) improving the effectiveness of the Ergonomics Process; and
(c) allocating resources.

Action plans with appropriate timelines and designated responsibility shall be developed from the management review. The organization shall use findings and conclusions to develop action plans based on the review. Action plans shall be communicated to the persons responsible for action and to any workers, or worker representatives, who might be impacted.

9.4 Continual improvement

The organization shall have an ongoing process to assess opportunities for continual improvement, including the reduction of residual risk. This shall include

(a) review of current control strategies;
(b) review of best available methods, technologies, and procedures to address residual risks; and
(c) implementation strategy to ensure continual improvement.

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Annex B (informative)
Reference tools

Notes:
(1) *This Annex is not a mandatory part of this Standard.*
(2) *The publication,* Seeing the Workplace with New Eyes*, was referenced if the development of this Annex.*

B.1 Introduction

B.1.1 General

An occupational health and safety management system (OHSMS) as it applies to the Ergonomics Process can be divided into four stages of a continual improvement process, specifically "Plan" (planning), "Do" (implementation), "Check" (evaluation), and "Act" (continual improvement)(see Figure B.1). Annex B provides resources for use in the "Do" stage of the Ergonomics Process. The purpose of this Annex is to present information and examples of evidence-based tools and checklists that can be used when applying ergonomics principles to help meet the objectives of this Standard.

Annex B provides examples of ergonomics checklists and observation tools, with an emphasis on hazard identification through observation and worker participation, and subsequent hazard elimination or risk control. The tools emphasize qualitative observation and evaluation, but with some quantitative analytical tools for those issues that require further study.

The content included in this Annex is not intended to be exhaustive.

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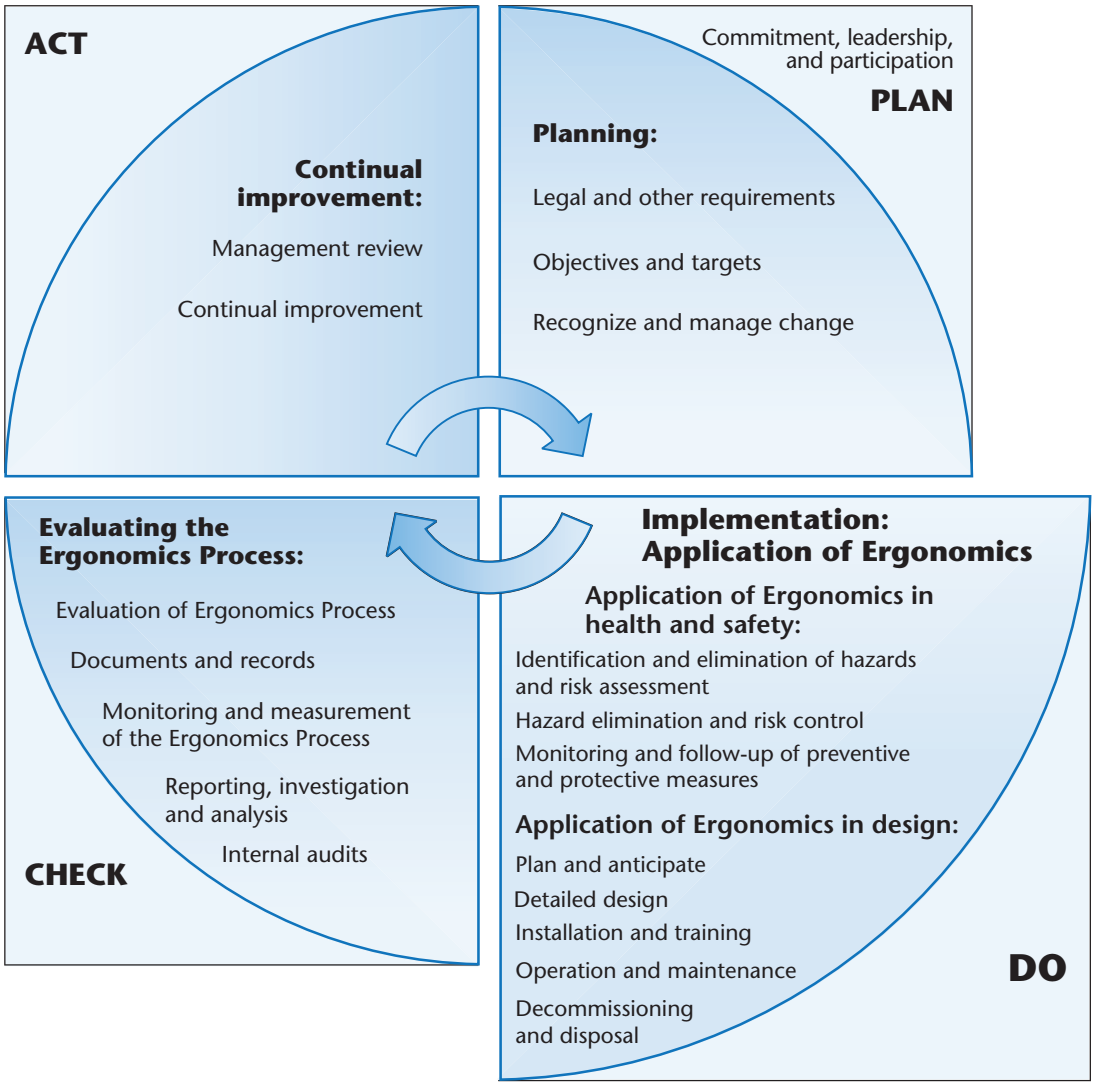

Figure B.1
Application of ergonomics and how it fits in the ergonomics process
(See Clause B.1.1.)

B.1.2 Use of the ergonomics checklists and observation tools

Clauses 7.2.1 and 7.2.2 require the organization to systematically identify and eliminate physical, cognitive, and organizational hazards in a work system, and to assess and control risk to workers who are exposed to them (see Annex A).

This Annex provides ergonomics checklists and observation tools that begin the process of examining the workplace. The checklists and tools have been divided into three broad categories: physical ergonomics, work organization, and cognitive ergonomics (as defined by this Standard). These tools assist the user to identify hazards that could be present in the workplace. Some tools provide guidance values to aid in the design and modification of work systems. Meeting these guidelines, where they are provided, will assist in minimizing incidents, worker injury, reducing errors, and enhancing worker health, safety and well-being and optimizing system performance by addressing physical, cognitive, and organizational hazards in the workplace, including MSD hazards. Any guidance values must be interpreted in light of the particular context and population of interest.

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In order to assist in hazard identification in the workplace, where physical, cognitive, and organizational demands are concerned, this Annex provides a number of tools organized into checklists and charts for observation of the workplace. This stage of the hazard identification process ("Application of Ergonomics") utilizes basic questions to help the user consider all aspects of the work environment covering physical, work organization, and cognitive demands (see Annex A).

Table B.1 is designed to serve as a leading indicator tool for the user to conduct an initial hazard identification. Figures B.2 and B.3 are designed to serve as lagging indicator tools based on the signs and symptoms already being experienced by workers. Used together or separately, the tools in Table B.1 and Figures B.2 and B.3 will help to lead discussion and activity working towards the elimination of hazards in a workplace once they have been identified. Once hazards have been identified, they should be eliminated. If this is not possible, steps must be taken to minimize the hazard. Residual risk should be assessed in order to prioritize and plan additional control measures. The hazard identification, elimination, or control, as well as risk assessment, can be approached using the ergonomics observation and recommendation tools (Tools 1 to 24), each of which addresses a possible hazard in the workplace and which also includes a component of hazard identification as a part of the process.

Tools 1 to 24 are observational tools with some recommendations and guidance values for hazards that have been identified. Each tool is divided into two tables: Table "a" is a hazard identification form based on observation and Table "b" provides recommendations and guidance to eliminate or minimize hazards identified or to control any residual risk. Information in Table "b" is relevant during both the observation (for identification of hazards) and the risk assessment and in the development of elimination or control activities.

Where applicable, evidence-based quantitative guidance to eliminate hazards or control risk is provided. Meeting these guidance values will assist employers in minimizing incidents, worker injury, reducing errors, and optimizing human well-being and overall system performance. Table B.4 is provided at the end of this Annex for the user's convenience in order to summarize observations. It provides a table format for recording comments regarding each of the possible hazards from the Tools 1 to 24 in terms of action that has been taken as a result of the Application of Ergonomics and what actions might need to be undertaken in the future.

B.2 Hazard identification for ergonomics related issues

B.2.1 General

Table B.1 will help identify potential work design problems at the workplace. This Table has been designed to highlight potential issues by asking a number of generic questions about the workplace. If an element is identified as "applicable" in this Table, see the appropriate observation and recommendation tool number in this Annex for further assistance or information. This Table is divided into broad categories (physical, organizational, cognitive) and further divided to specific subgroups. Users should use the entire Table to help determine where potential ergonomics issues exist.

Note: *The tools in this Annex are not exhaustive.*

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Table B.1
Workplace screening checklist for ergonomics related hazard identification

(See Clauses B.1.2 and B.2.1.)

Element	Applicable	Not applicable	Comment
1. Workstation: design and layout			
What do you observe in terms of the • extent to which the workstation accommodates the worker population who use it; • ability of people to change postures while working; • ability for people to adjust the workstation and whether they been trained to do so; • ability for people to reach comfortably; • frequency of which different tools or items are used; • sequence in which tools and materials are used; • presence of obstructions at the work station; • presence of obstructions under the work surface; and • stability of the work surface?			
2. Posture: sitting			
What do you see in terms of • work surface position in relation to the worker; • the quality of the chair; • the effectiveness of back support; • the effectiveness of the arm rests; • how the seat height is adjusted; • are the workers legs properly supported; • how frequently does the person change postures;			

(Continued)

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Table B.1 (Continued)

Element	Applicable	Not applicable	Comment
• type of casters; and • the ability for people to adjust the chair and whether they been trained to do so?			
3. Posture: working while standing			
What do you see in terms of the • height of the work surface; • amount of time spent standing; • type of work surface workers are standing on; and • supports for knees, hips, trunk, arms, etc.?			
4. Posture: neck, shoulders, and back			
What do you see in terms of the • position of the neck; • position of the shoulders; and • position of the back?			
5. Posture: elbows, forearms, hands, and wrists			
What do you see in terms of the • position of the elbows and forearms; • position of the hands and wrists; and • wrist and hand strain/effort?			
6. Posture: other positions/postures			
What do you see in terms of • a twisted posture/position; • prolonged (i.e., static) posture/position; and • other postures/positions: kneeling, squatting, lying down?			
7. Repetition			
What do you notice about highly repetitive motions?			
8. Displays, equipment, and tools			
What do you observe in terms of • displays; • controls; • distance required to reach;			

(Continued)

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Table B.1 (Continued)

Element	Applicable	Not applicable	Comment
• how suitable/appropriate the tools are for the work and workers; • handle shape; • weight; and • vibration and noise?			
9. Force: lifting			
What do you observe in terms of • the lift preparation; • the horizontal distance for grasping the load; • heights when grasping or putting down the load; • frequency of lifting; • weight being lifted; • handles/hand holds of the object being lifted; • awkwardness of the load; and • edges that can cut rough surfaces, etc.?			
10. Force: carrying			
What do you observe in terms of • characteristics of the task; • distance; • frequency; • weight; • characteristics of the load; and • whether the carrying task is one handed?			
11. Force: pushing/pulling			
What do you observe in terms of • the characteristics of the task; • the characteristics of the cart/equipment; • the type of environment (indoor or outdoor, including stores dock areas, rough ground); • the distance items are being moved; • whether the pushing/pulling is one handed; and • obstruction of line of sight?			

(Continued)

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Table B.1 (Continued)

Element	Applicable	Not applicable	Comment
12. Force: vibration			
Are hand tools emitting vibration?			
Is the user exposed to whole body vibration?			
13. Work environment: effects of noise on performance			
What do you hear or notice in terms of • speech comprehension; and • performance?			
14. Work environment: temperature			
What do you feel or notice in terms of • temperature; • drafts; • humidity; and • the number of breaks given?			
15. Work environment: lighting			
What do you observe in terms of • reflection; • glare; and • intensity relative to the activity being performed?			
16. Personal protective clothing and equipment			
Is the choice of personal protective clothing and equipment made considering • the individual requirements of the worker to ensure fit and comfort (anthropometrics); • the task performed by the worker (including the requirements of vision, mobility and reach, dexterity, and communication); • its suitability for actual work situations (physical task performance); • the environmental conditions in which the work task is performed (temperature and humidity, lighting, noise); and • the potential to contribute to ergonomic stressors (increasing use extreme postures or excessive forces)?			

(Continued)

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Table B.1.1 (Continued)

Element	Applicable	Not applicable	Comment
Does the use of protective clothing and equipment • produce discomfort when worn (e.g., elevated body temperature, increased perspiration, breathing resistance); • require increased exertion of energy because of its weight; • interfere with movement or dexterity required for the performance of tasks; • interfere with use of tools; • restrict the field of vision; and • interfere with necessary interpersonal communication? Has training been provided for proper use of personal protective clothing and equipment?			
17. Computer or monitor work			
Consider the following questions: • How is the workstation organized or laid out? • Where is the monitor currently located? • Does the worker stare at the monitor for long lengths of time? • Does the worker use multiple monitors?			
18. Work organization/stressors: time issues			
What do you observe about • time constraints; • breaks/rest periods; • overtime; • production bonuses; • monotony or repetitive nature of the work; and • shift work?			
19. Work organization/work demands and employee control			
What do you observe about • the demands of the jobs; • employee, control, and autonomy; • management of unacceptable workplace behaviours; • worker input during change and execution of work;			

(Continued)

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Table B.1 (Continued)

Element	Applicable	Not applicable	Comment
• performance accountability; and			
• management error reporting?			
20. Cognitive considerations			
Consider the following questions:			
• What are the workplace objectives and are they clear to all?			
• Has the system been standardized?			
• Has a fail safe design been used?			
• Has system interactions been considered?			
• What safety considerations have been made?			
• Is there automation?			
21. Cognitive considerations for tools and displays			
Does your organization have			
• instrumentation or equipment that is out of service;			
• non-functioning warning systems;			
• nuisance alarms giving false negative indications;			
• hidden system responses that prevent the distribution of critical information;			
• unexpected equipment conditions;			
• identical and/or adjacent displays and controls that lead to errors;			
• poorly designed (confusing) displays or controls that;			
• overly sensitive equipment that could lead to system errors through inadvertent actions; and			
• functional use of colour?			
22. Cognitive ergonomics program			
Does your organization have			
• an operating experience (lessons learned) program;			
• an effective training programs for new workers or new tasks;			
• a self-assessment and corrective action programs; and			
• a simple, effective process for managing work?			

(Continued)

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Table B.1 (Concluded)

Element	Applicable	Not applicable	Comment
Are the workers • lacking familiarity and knowledge with the task, process, or system; • required to use techniques not used before or only infrequently used; • aware of critical parameters; and • supported by appropriate accommodations with respect to physical and cognitive demands?			
23. Organizational performance factors			
Does your organization suffer from any of the following negative performance factors: • limited perspective; • factors affecting decision making; and • organizational factors that contribute to stress?			
24. Cognitive task demands			
Does your organization have the following: • time pressure imposed on workers; • high workloads or high memory requirements; • simultaneous/multiple tasks that have to be performed; • excessive communication requirements; • confusing procedures or vague guidance on how to use procedures; • repetitive actions or monotonous work; • delays or excessive idle time associated with the work; • a complex work, process, or system with high information flow demand; • a long-term monitoring task; and • tasks that workers need to spend excessive time?			

B.2.2 Symptom screening checklist

B.2.2.1

Figure B.2 is an example of a checklist that can be used to determine if workers are experiencing musculoskeletal symptoms that might be a result of their work. The follow-up questions can help to determine the cause of the discomfort, as frequently the worker will know what activities cause the pain. This form may be used to gather information for individuals or may be compiled to produce summary data for a workgroup.

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Step 1:	
Workplace:	Name of department:
Work station/job:	Date of discussion: With (person filling in form):
Summarize here: For details, use the following body maps (Step 2).	

Step 2: Shade in the area where pain is felt. Indicate side by shading the appropriate side. Use the space provided to elaborate on the type of pain you feel:

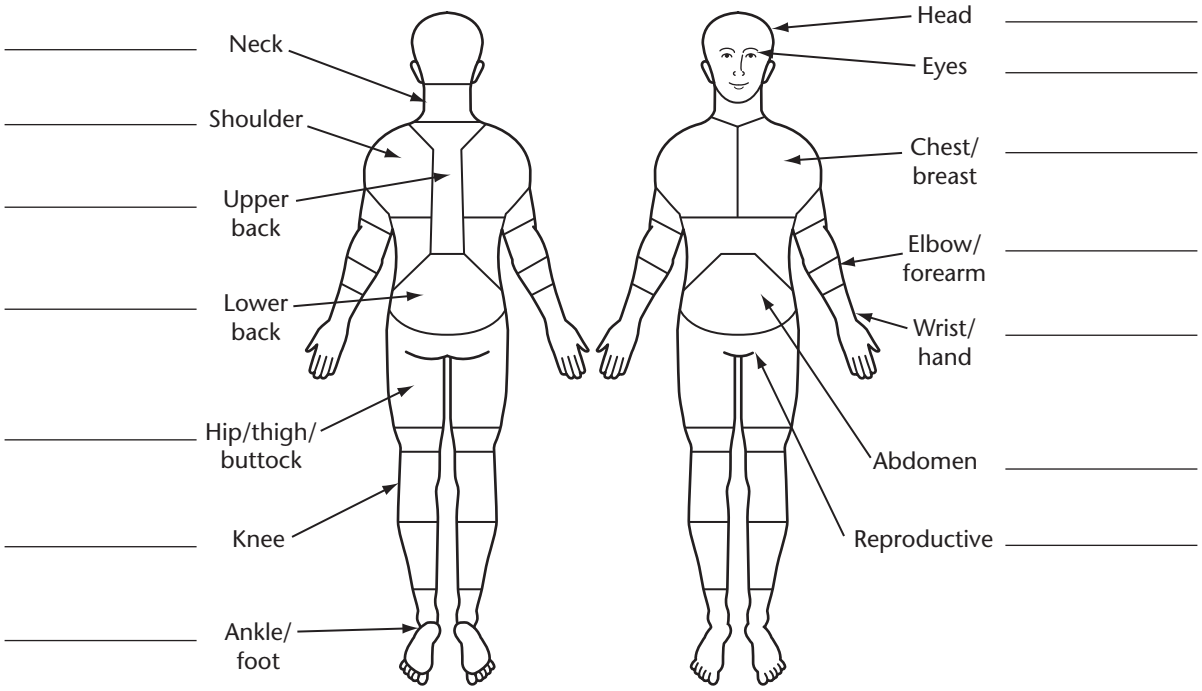

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Figure B.2
Symptom screening — Checklist 1
(See Clauses B.1.2 and B.2.2.1.)

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Figure B.2 (Concluded)

Step 3:
1. How long does each bout of the discomfort last?
2. How long has this discomfort persisted?
3. Is the pain felt at work, after work, or both?
4. What do you think caused the discomfort?
5. Please comment on what you think would help to reduce your level of discomfort.
6. Have you received medical treatment (doctor, chiropractor, physiotherapist, massage therapist, or other health care practitioner) for your discomfort? ❑ Yes ❑ No

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B.2.2.2

If the form in Figure B.2 is used to compile data within departments or across the workplace, the form in Figure B.3 can be useful.

Workplace(s):		Name of department(s):
Work station(s)/job(s)		Date:
Number of people in work area/department:		Notes:
Region	Total # of workers identified	
Head		
Neck		
Shoulders		
Back		
Elbows and arms		
Legs		
Wrists and hands		
Knees		
Feet		

Figure B.3
Symptom screening — Checklist 2
(See Clauses B.1.2 and B.2.2.2.)

B.3 Ergonomics observation and recommendation tools

B.3.1 General

In a system where work is being performed, the application of ergonomics can include observations and analysis of work areas, tasks, and new designs. Observations of people working may address postures adopted, forces exerted, vibration experienced, cognitive factors involved, displays and controls used, and work organization. Collection of worker feedback is necessary. Tools 1 to 24 may be used. The goal is to ensure that work is designed and performed as well as possible, thus minimizing incidents, worker injury, reducing errors, and optimizing human well-being and overall system performance.

B.3.2 Observation

A plan of what, when, and who to observe should be developed before any observation commences. Observation must be planned so as to include all relevant tasks and the person or persons to be observed need to be selected. For currently operating systems or processes, it is desirable to obtain, as far as is possible, a representative sample of workstations and workers, i.e., persons of different sizes, skill levels, and gender. This might require multiple observations to accommodate schedules of different people and to see infrequent tasks, such as those associated with emergency situations or maintenance. Issues of consent and privacy should be addressed before embarking on observation.

Tools 1 to 17 predominantly cover physical ergonomics issues, Tools 18 to 19 cover work organizational issues, and Tools 20 to 24 cover cognitive issues.

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B.3.3 Ergonomics observation and recommendation Tools 1 to 17 — Physical ergonomics issues

B.3.3.1 General

Tools 1 to 17 deal with physical ergonomics issues.

Tool 1a. Workstation — Design and layout

What do you observe in terms of

- the extent to which the workstation accommodates the worker population who use it;
- the ability for people to change postures while working;
- the ability for people to adjust the workstation (and have they been trained);
- the ability for people to reach comfortably;
- the frequency with which different tools or items are used;
- the sequence in which tools and materials are used;
- the presence of obstructions at the work station;
- the presence of obstructions under the work surface; and
- stability of the work surface?

The workstation design and layout:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the workstation design, layout, or proposed solutions be examined in more detail?	No: end here	Yes: see Tool 1b

Note: *For background information, see Tool 1b.*

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Tool 1b. Workstation — Design and layout

Design factor	Why be concerned (consequences)	Recommendations
Accommodate the worker population the ability to change postures	Poor fit can lead to poor postures and can lead to both musculoskeletal injuries and reduction of effective work being performed: • awkward postures (extended arms and shoulders, bent back); • tendon and joint problems; and • local and general muscle fatigue back and neck pain.	Determine the user population (intended users). Determine if the workstation is designed for only one person, or if further adjustability is needed. Determine which body measurements are relevant. Look up values in Table B.2 or measure the required body dimensions on the workers being designed for. Consider whether protective measures such as whether boots and/or gloves are worn and their effect on the body dimensions. Consider the additional movements associated with the tasks (e.g., if reaching a lever is the first step, can the user reach to the end of the lever's range?).
The ability for users to adjust the workstation	A workstation that is used by numerous workers must be easily adjustable. Otherwise, poor fit, awkward postures, muscle pain, and fatigue can result.	Build in adjustability where possible to best optimize the workers' ability to fit in the workstation. Train workers on how to make the proper adjustments to their workstation and the reasons why.
The ability for people to reach	If tasks that involve excess reaching must be performed frequently or for long durations, the risk of shoulder and back injury is increased. Awkward postures will reduce the forces that people can exert.	Organize tasks and arrange the workstation so that the worker can maintain comfortable seated postures with the elbow fairly close to the body for most of the work time. Place items required for task that are of highest priority, highest frequency, or longest duration, and that involve large force requirements or high speed accuracy (such as in an emergency), closest to the worker. Design the workstation so that movement is made around the elbow, not the shoulder. Prevent the need to reach behind. Use Figure B.4 to determine recommended distances for workstation layout.
Frequency of use	Frequently over reaching can cause pain and injuries in the shoulder	Place most frequently used components in the most convenient locations.
Sequence of use	Poorly designed layout can reduce the efficiency of work and increase fatigue.	Locate components used in sequence next to each other, in the order they are to be used. Where repetitive tasks are performed (i.e., manufacturing), design the workstation so that arm movements can be continuous and curved, not random and jerky.

(Continued)

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Tool 1b. (Concluded)

Obstructions in the workstation	If the workstation is obstructed, the result can lead to • poor work postures; • fatigue and muscle pain; • less precise moves/control; and • increased risk of hitting something or being injured.	Maintain a sufficient clear access path that is at least 80 cm wide (consider that more space might be required for equipment or materials). Provide sufficient clearance space for worker movement. Provide sufficient and adequate storage space. Keep work station and work surfaces clean and tidy.
Obstructions under the work surface	If the work surface is obstructed, the result can lead to • static posture of feet and legs; • fatigue; and • poor seated posture (e.g., twisting while sitting).	Provide sufficient leg and foot clearance to accommodate the work being performed and varied postures. Do not store work materials under the work surface.
Stability	If the work surface is not sufficiently stable, the work pace will be limited and errors will increase.	Ensure that the work surface is significantly stable to perform the required work.

Notes:
(1) *Figure B.4 provides additional information for reach dimensions.*
(2) *Additional information regarding how to use anthropometric data has been provided in Clause B.3.3.3.*

B.3.3.2 Reach dimensions

Figure B.4 illustrates work reach dimensions for primary, secondary, and tertiary zones, sometimes referred to as “frequent”, “infrequent”, and “occasional” reaches. Dimensions on the right are measured from the work surface edge and dimensions on the left are measured from the centre of the shoulder. If awkward postures are observed, adjustments should be made.

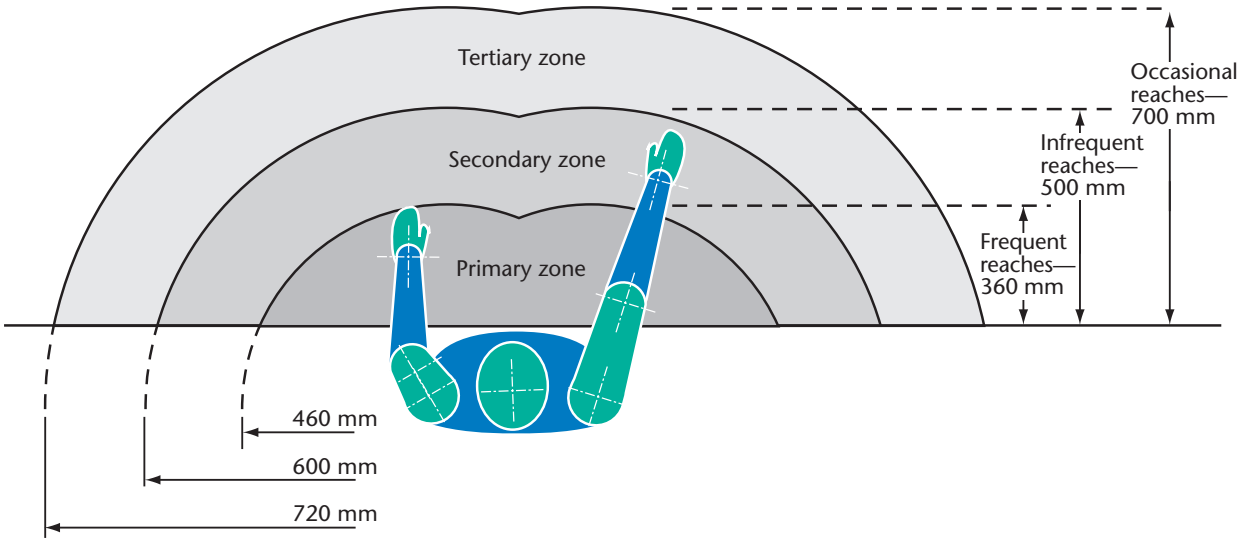

Figure B.4
Reach dimensions
(See Clause B.3.3.2.)

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B.3.3.3 Using anthropometric data in workstation design

For an introductory note to anthropometric data, see Clause A.7.2.1.1.

The steps in using anthropometric data are as follows (to understand the more complicated aspects such as statistics in calculating and using percentiles, consult a competent person):

(a) **Determine the user population:** When designing a workstation, one must consider who the intended users (current and future) will be. For example, is this a workstation that will be used by one person exclusively or will there be multiple users. Where there are multiple users, greater adjustability might be required.

(b) **Determine what percentage of the population is to be accommodated:** Determine what level of design is being implemented. Has the workstation been designed for extremes (everyone can fit and everyone can reach), adjustability (so the greatest number of people can be accommodated comfortably), or average, where most are able to use the system, but extremes will have a difficult time.

(c) **Determine which body measurements are relevant:** Determine which body dimensions are relevant. For example, if the end user must reach controls or peddles then the limb length will be important.

(d) **Lookup the appropriate anthropometric data:** Refer to anthropometric databases or charts where available, that represent the population being designed for. An example of anthropometric data is presented in Table B.2. Other anthropometric data may be consulted.

(e) **Adjust data:** Adjustments must be made to accommodate added factors such as weight, girth, or loss of dexterity that might be affected by use of personal protective equipment or clothing.

(f) **Consider the tasks being performed and make additional corrections:** For example, reaching to push a button – add the displacement of the button

(g) **Use mock-ups or simulations to test design:** See Clause A.7.3.3

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Table B.2
Anthropometric data for use in workstation design, cm

(See Clause B.3.3.3.)

Measurement	Percentile		
	5th	50th	95th
	Male/Female	Male/Female	Male/Female
Stature	**162/150**	**174/161**	**186/171**
Standing			
Eye height	152/140	163/150	174/161
Shoulder	132/122	142/131	154/140
Elbow	100/93	109/100	118/108
Hip	84/74	92/81	100/88
Knuckle	69/66	76/72	82/78
Sitting (above seat height)			
Sitting height	85/80	91/85	96/91
Shoulder height	54/50	60/56	64/61
Elbow height	20/18	24/24	30/28
Thigh thickness	14/12	16/16	18/18
Buttock-to-knee length	54/52	60/57	64/62
Buttock-to-popliteal length	44/44	50/48	55/53
Knee height, sitting	49/46	54/50	60/54
Popliteal height, sitting	40/36	44/40	49/44

Source: *Kodak's Ergonomic Design for People at Work*, 2nd Edition, Table 1.7.

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Tool 2a. Posture — Sitting

What do you see in terms of

- the position of the work surface in relation to the worker;
- the quality of the chair;
- the effectiveness of back support;
- the effectiveness of the arm rests;
- how the seat height is adjusted;
- are the workers legs properly supported;
- how frequently does the person change postures; and
- type of casters?

The sitting posture:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	

Should the sitting posture be further analyzed or the proposed solutions be examined in more detail?	No: end here	Yes: See Tool 2b

Note: *For background information, see Tool 2b.*

Tool 2b. Posture - Sitting

Design factor	Why be concerned (consequences)	Recommendations
Position of the work surface	Poor fit leads to poor postures and can both lead to cumulative trauma injuries and reduce the effectiveness of the work being performed. Prolonged or repetitive awkward postures, raised or dropped shoulders, rounded back can lead to • difficult movements; • local and general muscle fatigue; and • local muscle pain.	Adjust the work surface depending on the task: • support forearms: a few cm above elbows; • industrial work that requires free arm movements; • computer or typing work: keyboard positioned to maintain a neutral wrist posture; • allow for the work surface height to be adjusted; and • allow for the work surface to tilt when needed. Where workstation adjustability is not present, consider other changes that will eliminate or minimize the effect of the work surface positions (for example awkward postures).
Chair quality	Using a poor quality chair can lead to • poor postures; • compression of thighs or behind the knees; • poor stability; and • difficult movements.	Choose a chair with the following features: • adjustable height and back; • seat pan wide enough to allow movement; • seat pan depth appropriate or adjustable; • seat pan slightly tilted towards the front or adjustable; • able to rotate to accommodate needs of the job; • chair with five casters; and • adequate seat and back padding.

(Continued)

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Tool 2b. (Concluded)

Design factor	Why be concerned (consequences)	Recommendations
Back support	If there is no back support or poor support is present, the spine is not supported, which could lead to back problems.	Provide a chair with lumbar support (fit "the small of the back"), which can be used for the task being performed, so the normal spinal curvature can be maintained.
Armrest	Lack of armrests can increase the stress on the shoulders, neck, and back.	Ensure that arm rests • are appropriate for the task; and • are at the proper height for the worker, so that they are neither causing the user to slump, nor to elevate the shoulders (arm rests might need to be height adjustable to achieve this). Do the arms fall in between the armrests? If they do, the arm rests are too far apart for the user, and may need to be width adjustable. Where multiple users exist for one chair, the arm rests should be height and width adjustable.
Seat height adjustment	If too high or too low, can lead to poor postures and can lead to both cumulative trauma injuries and reduction of effective work being performed: • awkward postures, raised or dropped shoulders, rounded back, difficult movements; • local and general muscle fatigue; and • local muscle pain.	Adjust the height of the chair to maintain a horizontal hip knee alignment that maximized contact between the chair and the legs and buttocks to avoid pressure points feet flat on the floor or supported (see "foot support").
Worker leg and foot support	If the full foot is not supported on either the floor or a foot support, this could lead to compression of the thigh muscles and blood vessels. Muscle discomfort can result.	Foot support should • be of sufficient size to support both feet; • may be flat, at a fixed angle, or adjustable; and • should not slide on the floor while in use.
Time in seated position	If there is no regular opportunity to change postures or to move from the chair, muscle fatigue and pain could occur.	Organize work to allow getting up and/or alternating between standing and sitting positions. Workers should stand and stretch frequently, such as once every 15 min.
Casters	Improper casters will limit a worker's mobility.	Use chair with five casters. Use hard caster on soft surface (e.g., carpet) and soft (rubber) on a hard surface (e.g., concrete).

Note: *For a complete diagram showing all aspects of a recommended seat setup, including reference values, see Figure B.5.*

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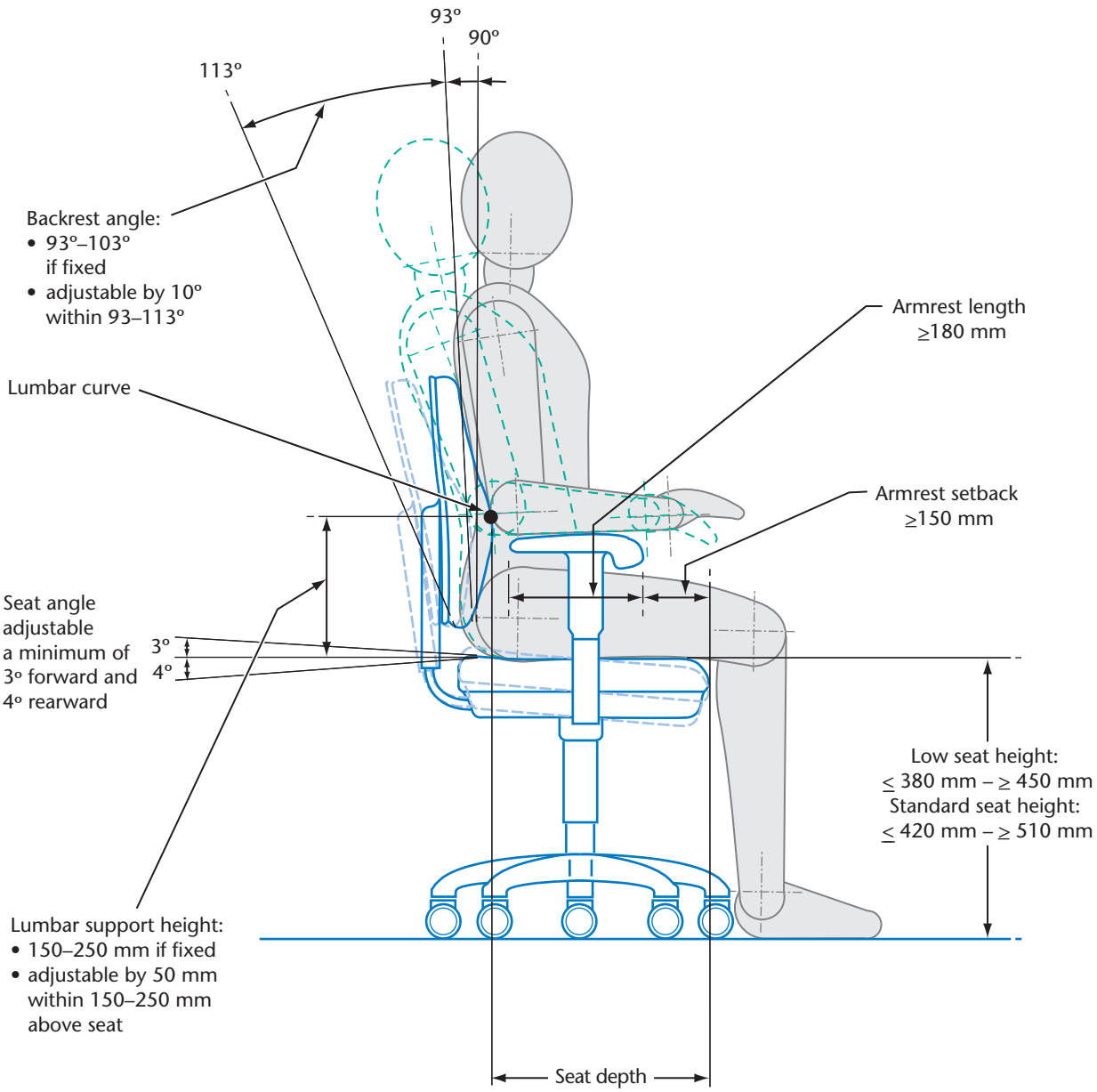

Note: *Based on accommodating 5th percentile female body dimensions to 95th percentile male body dimensions using the Natick* 1988 Anthropometric Survey of US Army Personnel *(Gordon* et al.*)*

Figure B.5
Chair dimensions (side view)

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Tool 3a. Posture — Working while standing

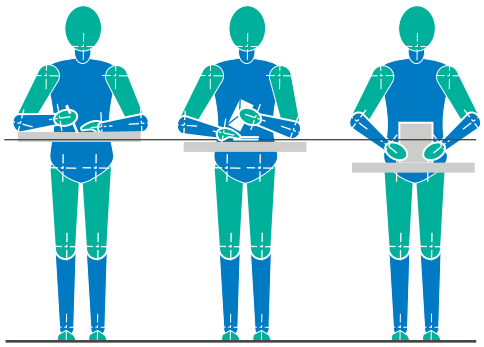
What do you see in terms of

- the height of the work surface;
- the amount of time spent standing;
- the type of surface workers are standing on; and
- supports for knees, hips, trunk, arms, etc.?

The work while standing:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should standing work be further analyzed or the proposed solutions be examined in more detail?	No: end here	Yes: see Tool 3b

Note: *For background information, see Tool 3b.*

Tool 3b. Posture — Working while standing

Design factor	Why be concerned (consequences)	Recommendations
Height of the work surface	Poor if • raised shoulders, bent back, or neck; and • general and local fatigue.	Adjust the working height of the hands according to the position of the hands during work:  **Precise work:** 4–6 cm above elbow height **Light work:** 5–10 cm below elbow height **Heavy work:** 20–40 cm below elbow height
Amount of time spent standing	Prolonged standing can lead to • swelling of the legs and varicose veins; and • back and neck fatigue and pain.	Provide a sit-stand (sit-lean) stool, with room for knees and feet to fit under the work station/surface. Allow for work periods where workers can walk and sit down. Use anti- fatigue mats to avoid problems associated with prolonged standing on very hard surfaces such as concrete or tiles.

(Continued)

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Tool 3b. (Concluded)

Design factor	Why be concerned (consequences)	Recommendations
Type of surface workers are standing on	Standing on a hard surface can lead to • swelling of the legs and varicose veins; and • back muscle fatigue. Standing on uneven, sloped or slippery surfaces can lead to falls and muscle strain.	Where possible, consider alternate type of flooring. Where floor changes are not feasible, consider use of appropriate footwear (e.g. cushioning, insoles) or anti-fatigue mats.
Supports for knees, hips, trunk, arms	Local supports can reduce • muscular strain; and • leg and back pain.	Put a hip rest at the edge of the work surface. Position a hand grip where workers can hold onto it with one hand for high working surfaces. Vary working positions to avoid constant leaning. Remove sharp edges in a work area that workers are likely to lean against while performing their work.

Tool 4a. Posture — Neck, shoulders, and back

What do you see in terms of

- the position of the neck;
- the position of the shoulders; and
- the position of the back?

The neck and shoulders and back postures:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the posture of the neck, back, and shoulders be further analyzed or the proposed solutions be examined in more detail?	No: end here	Yes: see Tool 4b

Note: *For background information, see Tool 4b.*

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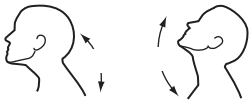
Tool 4b. Posture — Neck, shoulders, and back

Design factor	Why be concerned (consequences)	Recommendations
Neck position	If neck is rotated, bent forward (flexed), back (extended), or to either side repeatedly or for prolonged periods of time, workers can experience • muscle fatigue/soreness; • tendon and muscle strain; and • pain and stiffness/tight feeling.	Workstations should allow the workers to • rotate the chair to the direction required by the user to complete their work task; • have the work surface at a height so that they can work with their neck in a neutral (natural) alignment; and • use the document holder/reader placed next to, or in line with, the screen/monitor. Work organization should allow the workers to • take regular short breaks; and • change posture and relax the neck regularly. Maintain neck posture as close to neutral as possible. Avoid repetitive or prolonged use of the following awkward neck postures: • Working with the neck bent forward or to the side:  • Working with the neck rotated either direction:  • Working with the neck bent forward/back: 
Shoulder position	If the shoulders are rotated or are raised repetitively or for prolonged periods, workers can experience • muscle fatigue/soreness; • tendon and muscle strain; • pain in the shoulders and arms; and • joint and tendon injuries. If the arms are raised away from the body repeatedly or for prolonged periods of time, workers can experience • pain and discomfort in the back, neck, shoulders, and/or hands; and • less precise control.	Prevent repetitive and prolonged activities where • arms are extended forward without support; • arms are spread apart; and • shoulders are rotated. Have enough space so people can move their feet to turn, rather than reaching. Place materials, products, tools being used etc., within easy reach of the hands. Provide a platform or stool that is light, safe, and stable and easy to move if it is necessary to reach for something that is high. Support forearms should whenever possible during repetitive static work.

(Continued)

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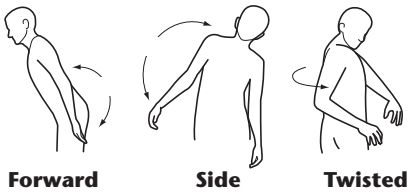
Tool 4b. (Concluded)

Design factor	Why be concerned (consequences)	Recommendations
		Maintain shoulder posture as close to neutral as possible. Avoid repetitive or prolonged use of the following awkward shoulder postures: • Working with the hands(s) at or above the head:  • Working with the elbow(s) at or above the shoulder: 
Back position	Bending the back forwards, backwards, or from side-to-side or twisting repeatedly or for prolonged periods of time can lead to • back muscle fatigue; • compressed discs in the spine; and • back, neck, and/or leg pain.	Position controls, tools, equipment within easy reach of the worker. Provide space for legs and feet at the base of the work surface so the worker can get close to what they are working on. Locate loads that have to be routinely handled, between average knuckle and shoulder height. See Table B.2. Maintain back posture as close to neutral as possible. Avoid repetitive or prolonged use of the following awkward back postures: • Working while sitting or standing with the back bent forward, sideways, or twisted:  **Forward** **Side** **Twisted** • Working while sitting or standing with the back bent, and with no support for the back:  **Backward**

Note: *Workers should avoid working in awkward postures repetitively or for prolonged periods of time.*

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Tool 5a. Posture — Elbows, forearms, hands, and wrists

What do you see in terms of

- the position of the elbows and forearms;
- the position of the hands and wrists; and
- wrist and hand strain/effort?

The elbows, forearms, hands, and wrists postures:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the position of the elbows, forearms, hands, and wrists be further analyzed or the proposed solutions be examined in more detail?	No: end here	Yes: see Tool 5b

Note: *For background information, see Tool 5b.*

Tool 5b. Posture — Elbows, forearms, hands, and wrists

Design factor	Why be concerned (consequences)	Recommendations
Position of the elbows and forearms	If the position of the arms results in them being pressed against a surface or a sharp edge in a workstation or if workers frequently rotate the forearms, they can experience • compression of the nerves and tendons; • pain and tingling; and • inflammation of the tendons.	Provide support for the forearms when doing work that involves computer or prolonged precise works. Recognize and control tasks that force the forearms to rotate (maintain a neutral "handshake" wrist position). Round off edges of workstations if people are resting elbows and forearms on them.
Position of the hands and wrists	If the hands or wrists are in an awkward posture (not in a neutral position) repeatedly or for prolonged periods, or rest against a sharp edge, it can lead to • friction of the nerves and tendons; • possibly decreased strength; • fatigue and difficulty performing the task; and • pain and tingling.	Avoid repetitive or prolonged use of the following awkward postures:  Locate materials and tools closer to the worker. Choose tools that allow the wrists to be straight when in use (e.g., bent or straight handles; keyboard wrist rest or split keyboard). Put the task on an angle. Provide support for the wrists, to avoid wrist extension. Round the edges of work surfaces. Design task so that a power grip can be used instead of a pinch grip.

(Continued)

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Tool 5b. (Concluded)

Strain in the wrist and hand	When force exerted is high (tightening, squeezing, etc.) or low but sustained (keyboard, mouse, etc.), it can lead to • fatigue; and • joint tendon, nerve, or muscle problems. When the heel of the hand is used as a hammer or for squeezing, it can lead to • compressed tendons, nerves, blood vessels; and • carpal tunnel syndrome.	Reduce the following to a minimum: • tightening and squeezing; • exerting sudden force; • fine grasping with the fingers (pinch grip); • using the heel of the hand as a hammer. Assess the need to tighten "to the max" (avoid as best as possible). Provide tools with long enough handles. Provide hydraulic or electric tools. Carry objects (files) in containers with handles to avoid pinching the fingers. Use pliers or failing that, the whole hand, to grasp small objects, rather than the fingers which can only grip them. Provide regular breaks, even when minor effort is sustained.

Tool 6a. Posture — Other positions/postures

What do you see in terms of:

- a twisted posture/position;
- prolonged (i.e., static) posture/position; and
- other postures/positions: kneeling, squatting, lying down?

The other postures:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the postures be further analyzed or the proposed solutions be examined in more detail?	No: end here	Yes: see Tool 6b

Note: *For background information, see Tool 6b.*

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Tool 6b. Posture — Other positions/postures

Design factor	Why be concerned (consequences)	Recommendations
Twisted posture or position	If the back or trunk is twisted, it can lead to • muscle fatigue; and • back problems.	Use rotating and moveable chairs. Products/objects and orders facing the person. Use pivoting conveyors or tables whenever the product or object changes direction.
Prolonged (i.e., static) postures or positions	A prolonged and fixed or static posture involves • fatigue for the contracted muscles (static load); and • overloading joints and tendons.	Alternate with tasks allowing movement. Reduce continuous muscular efforts (static positions). Provide elbow supports, padded to level of the chair. Avoid keeping arms in the air or the body leaning forward.
Other postures or positions	• Tired legs; • Problems for hips, knees, ankles; and • Losing balance and chance of falling.	Keep materials, products, and tools within easy reach. Organize the work area so there is both seated or standing. Layout loads so they can be handled at a height that lies around waist height. Foresee/be aware of stable support points.

Tool 7a. Repetition

What do you notice about highly repetitive motions?

The repetition:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	

Should the highly repetitive work be further analyzed or the proposed solutions be examined in more detail?	No: end here	Yes: see Tool 7b

Note: *For background information, see Tool 7b.*

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Tool 7b. Repetition

Design factor	Why be concerned (consequences)	Recommendations
Repetition	No recovery time for repetitive tasks can lead to • a build-up of muscle and tendon strain and fatigue; • a loss of precision; and • a drop in alertness, increasing the risk of incidents causing injury and damage.	Redesign product or production process to minimize work and repetition. Reduce the work pace whenever possible. Design the job so that workers can alternate between using the right and left hand to work. Arrange for frequent rotations between workstations that require different postures and effort (see Clause A.7.2.3 for more information on job rotation). Arrange for short, frequent breaks from the job as required by the repetitive nature. Provide mechanical aids that require minimal force to operate (e.g., pneumatic tools, electric stapler) for the most repetitive tasks. Avoid repetitive fine grasping with the fingers (pinch grip), especially with high force.

Note: *The repetition referred to in Tools 7a and 7b means doing the same motions or using the same muscles repeatedly with minimal opportunity for rest and recovery. The appropriate work rest cycle should be based on the speed of the work, variety of the task, force required to work, posture while working, and the body region being used to perform the tasks.*

The following descriptors can help in determining hand activity level:

- *low — consistent, conspicuous long pauses; or very slow motions;*
- *medium — slow steady motion or exertion; frequent brief pauses; and*
- *high — rapid steady motions or exertions; no regular pauses.*

These descriptors may also apply to the motions or exertions of other body parts.

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Tool 8a. Displays, equipment, and tools

What do you observe in terms of

- displays;
- controls;
- distance required to reach;
- how suitable/appropriate the tools are for the work and workers;
- handle shape;
- weight; and
- vibration and noise?

The equipment and tools:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the equipment and tools be further analyzed or the proposed solutions be examined in more detail?	No: end here	Yes: see Tool 8b

Note: *For background information, see Tool 8b.*

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Tool 8b. Displays, equipment, and tools

Design factor	Why be concerned (consequences)	Recommendations
Displays	Position of gauge, meters, screens, etc. determines • eye movement; • head posture; and • trunk posture.	Position displays in front of the operator, especially when • they are referred to or used frequently; and • they are important for safety and production quality.
Controls	If controls are poorly designed, workers can be exposed to • awkward posture; • overexertion and fatigue; and • increased risk of error.	Provide controls that are • easy to operate without stress for the fingers, hands, or wrists (e.g., do not require over-tightening); • not too sensitive; • able to be used by left-handed people; and • not positioned so that they can be accidentally activated. Locate controls that have related function near each other. Design controls that can be easily identified through the use of shape, colour, or location. Design hand controls for fast or precise movements and foot controls for large or continuous force applications. Use hand tools with switches and stops that • allow for more than one finger to operate (i.e., strip trigger rather than a single-finger trigger); and • avoid tools requiring sustained trigger force unless keeping the trigger activated is a safety requirement.
Distance required to reach	If overreaching repeatedly or for prolonged periods of time for equipment or tools, workers can be exposed to • awkward postures; • over exertion; and • muscle pain and fatigue.	Review Tool 1a on workstation design and layout.
Suitable or appropriate tools for the work and workers	If tools are poorly chosen, workers can experience • awkward postures (shoulder, elbow, forearm, and wrist problems); and • hand injuries, blisters, tendonitis, etc.	Choose the tool that is best suited for the job (e.g., specialized tools, tools that are grasped with the whole hand rather than using just the fingertips, using a hammer rather than the heel/palm of the hand, using a jig to support an item being worked on rather than grasping the item with one hand). Minimize the number of different tools needed to repair or service the equipment. Provide tools that are suitable to a wide range of the working population (e.g., women, men, left-handed people).

(Continued)

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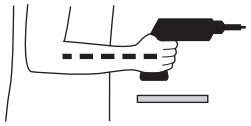
Tool 8b. (Concluded)

Design factor	Why be concerned (consequences)	Recommendations
		Tool choice can depend on • whether it is powered or manually operated (powered is the preferred choice); • weight of the tool (see "Weight" section below); • balance of tool (centre of gravity of the tool); • whether it is a one-handed or two-handed operation; and • handle characteristics (see "Handle shape" section below).
Handle shape	If poorly matched to function, workers can experience • awkward arm postures (e.g., raised, stretched, twisted; twisted wrist) • contact stress of hands and fingers if too small or sharp-edged; and • over exertion (more strength required).	Use tools with handles that • can be used by both left-handed and right-handed people; • are shaped so the wrist remains straight where possible (e.g., pistol shaped, or in-line handle);  • fit well in the hand: – not dig into the palm; – for use of strength use a power grip; and – for precision grip consider a tool with a pinch grip. Handle material allows safe use of the tool without slipping, cutting, or pressure points on the hands (wood or metal coated with rubber/plastic). Workers' hands must be protected from exposure to heat, cold, and vibration (see "Vibration" section below) generated by the tool. Handle length should have a smooth nonslip surface.
Weight	If tools are very heavy, workers can experience tired arms, cramps, tendonitis, and other musculoskeletal problems.	Tools used for work should be • 2 kg or less if used away from the body or above shoulder height; • supported if tool weighs more than 2 kg, and it is being used over-head; and • less than 0.4 kg when used for precision work. For use of heavier tools/special systems, provide counterbalanced support devices, elbow rests, etc.
Vibration, noise, and temperature	Using tools in cold or hot environments or tools and equipment that emit high levels of vibration or noise can expose workers to • occupational diseases related to vibration (hand/arm vibration or whole body vibration); and • hearing loss.	See Tool 12 for vibration issues, Tool 13 for noise, and Tool 14 for temperature issues. Preventative maintenance programs help to maintain tools and equipment operating within safe and healthy parameters.

Note: *The use of equipment and tools can pose hazards to workers, such as awkward postures, forces, temperature, and vibration exposures. It is important to recognize that both high forces (e.g., tightening, squeezing) and low, sustained forces (e.g., keyboard and mouse use, precision work) can be hazardous to workers.*

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Tool 9a. Force — Lifting

What do you observe in terms of

- the lift preparation;
- the horizontal distance for grasping the load;
- heights when grasping or putting down the load;
- frequency of lifting;
- weight being lifted;
- handles/hand holds of the object being lifted;
- awkwardness of the load; and
- edges that can cut, rough surfaces etc.?

The lifting in this task:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the lifting be further analyzed or the proposed solutions be examined in more detail?	No: end here	Yes: see Tool 9b

Note: *For background information, see Tool 9b.*

Tool 9b. Force — Lifting

Design factor	Why be concerned (consequences)	Recommendations
Lift preparation	Poor preparation for a lift can result in • excessive or unnecessary muscle force required; • overloaded joints and back; and • increased risk of incidents or injuries.	Plan the lift and assess the load. Remove all obstacles between object being lifted and the worker. For small, compact loads: • starting posture: comfortable, in position that allows holding the load close to the body; • place feet on both sides of the load, if possible, with one foot forward; • lift using leg muscles, if possible; and • lift in the range above knee height and below shoulders, if possible. For larger or bulkier loads: • reduce the size of the load or container in order to get the load closer to the body; and • use devices such as dollies, hand trucks, hoists, forklifts or find another person to assist/help.

(Continued)

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Tool 9b. (Continued)

Design factor	Why be concerned (consequences)	Recommendations
Horizontal distance for grasping the load	A load that is farther away from the body • requires more effort; • can cause arms and back fatigue; and • can cause back problems.	Hold load as close to body as possible. Reduce the size of the load or container in order to get the load closer to the body. Provide mechanized lifting equipment for handling very awkward or large objects.
Vertical distance for grasping or putting down the load	If the object is too high, workers will be exposed to awkward postures: • leaning backward with arms raised (balance problems); and • back and shoulder problems. An increased risk also occurs where the load must be placed or held in a specific position. If the object is too low, workers can be exposed to awkward postures: • bending down to the load; and • back and shoulder problems.	Design the lifting task to allow the starting and the ending point of the lift to be between the knuckle and shoulder height. Provision of adjustable height surfaces would allow for handling weights at preferred heights (e.g., lift table). Provide space to allow workers to turn their whole body or take a step, rather than to twist at the waist. Provide mechanized lifting equipment for objects placed above shoulder level. Arrange storage areas taking into account the information above.
Frequency of lifting	If frequent lifting is required, workers can experience • general fatigue; and • local muscle fatigue.	Limit lifting frequency based on the weight of the object, the range of the lift, and the horizontal distance of the object from the body. Arrange delivery schedules of items to allow for paced, less frequent lifting tasks in one shift. Provide mechanical aids if loads are lifted often.
Weight	If lift weights exceed recommended limits, workers can experience increased incidents and back or hand/arm injuries.	Recommended lift weight depends on lifting conditions — all the factors reviewed in this Annex. (See Tables B.3 and B.4(a) to (h) to determine recommended weights). Reduce the weight of an object being lifted by a worker by • limiting the capacity of the container; and • splitting the load into smaller containers. Provide mechanical lifting aids.
Handles / handhold	If there are no handles or poor handles, workers can experience • difficulty holding objects (more likely to drop them); • hand and wrist pain; • awkward postures (back, shoulders); and • localized muscle fatigue (from pinch grip or other less effective methods of gripping objects).	Provide a means for workers to grip an object safely whenever possible (e.g., handles, hand holds) rather than gripping the edge of an object (e.g., using pinch grip or palm grip). Handles: • should allow for good grip (i.e., not be too slippery); • should have a round/oval shape where possible (avoid sharp edges); and • should allow for space for gloves where applicable. Consider material that handles/grips are made of (plastic, rubber, or wood are good choices).

(Continued)

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Tool 9b. (Concluded)

Design factor	Why be concerned (consequences)	Recommendations
Awkward loads	If the load is awkward, it could • reduce field of vision; • cause awkward postures; • cause muscle strain; and • affect balance.	Limit load or object size or awkwardness to ensure safe worker movement when handling the load. Consider the load characteristics (e.g., temperature, sharpness, solid, or liquid). Consider having two people lift where space allows safe movement. Use mechanical aids for awkward or large loads.
Cutting edges, rough surfaces	If object has cutting edges or rough surfaces, • it can result in cuts and abrasions; and • the ability to grip properly is affected.	Remove edges that can cut or surfaces that are rough on the skin. Wrap/box/bag objects with cutting or rough edges or which are too hot, cold, or dirty. Provide handles as part of the wrapped/boxed/bagged object. Use protective gloves as a last resort.

Notes:

(1) *When determining the safety of a lift, many components must be taken into consideration, beyond the weight of the object being lifted. Other variables (characteristics) of the lift that need to be considered include the frequency of the lift, distance of the weight from the body, height to be lifted to, types of handles, etc. Users of this Standard may also want to consider the* NIOSH lifting equation *(1991).*

(2) *Tables B.3 and B.4 (a) to (h) are provided with recommended weights for simple lifting tasks [based on Mital et al. (1997), two-handed, symmetrical load lifts which safely accommodates 90% of the population] as well as multipliers (correction factors) that might be needed depending on the different lifting scenarios.*

(3) *For more complicated lifts, more advanced assessment tools should be utilized or a competent person who is knowledgeable in ergonomics should be contacted.*

B.3.3.4 Determining recommended lifting weights

The values in Table B.3 are designed to protect the 90th percentile of the worker population. Table B.4(a) to (h) consists of "multipliers", which are correction factors used against the weights being lifted, in order to adjust the recommended limit of the weight when variables such as asymmetry, heat stress, lack of headroom etc., are making the lift more difficult or less safe.

The Tables are used as follows:

(a) Choose the correct table:
  (i) If the task is performed while using both hands, use Table B.3 with correction factors [(Table B.4(a) to (g)].
  (ii) If the task is performed while using one hand, and is a horizontal lift, use Table B.4 (h).
  Note: *If the task is a vertical lift and it is performed while using one hand, the lift should not exceed 9 kg (standing) and 8kg (sitting) for males, and 6 kg (standing or sitting) for females. These weights will be too high if the lift is frequent or the lift is far away.*

(b) Determine whether the distance of the load from the body is near, medium, or far:
  (i) near – hands are horizontally 34 cm or less from the shoulders at all times during the lift;
  (ii) medium – hands are horizontally 35 cm to 49 cm from the shoulders at all times during the lift; or
  (iii) far – hands are horizontally 50 cm or more from the shoulders at any time during the lift.

(c) Determine the starting and ending height of the lift:
  (i) floor to 80 cm (knuckle height);
  (ii) 80 cm to 132 cm (knuckle to shoulder height); and
  (iii) 132 cm to 183 cm (shoulder to over head height).

(d) Determine the worker population. If the worker population is male only, use the male data. If the user population is female or mixed, use the female data.

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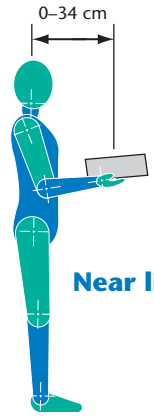
(e) Determine how often the object is lifted/lowered: once every 4 s, 5 s, 7.5 s, 15 s, 1 min, 30 min, or once in 8 h.
(f) Using the information from Items (a) to (e), determine the recommended weight using Table B.3.
(g) Determine if there are any additional factors that would affect the lift, and if so apply the correct multiplier from Table B.4(a) to (h):
  (i) limited headroom multiplier (the worker is working in a stooped posture);
  (ii) asymmetrical lifting multiplier (the worker must twist while lifting, without moving their feet);
  (iii) load asymmetry multiplier (load is unbalanced);
  (iv) heat stress multiplier (the worker is working in a warm/hot environment);
  (v) coupling multiplier (the object being lifted does not have good handholds);
  (vi) load clearance multiplier (load must be moved into a small space, i.e., a shelf); and
  (vii) work duration multiplier.
(h) Compare the final recommended weight derived from Items (a) to (g), to the actual weight of the object being lifted. If the actual weight of the object being lifted is heavier than the recommended weight, then controls should be put in place.

Table B.3
Recommended weight of lifts to safely accommodate the 90th percentile of the worker population, kg

(See Clause B.3.3.4.)



		Lifting Frequency								
	Lifting height	Gender	1 per 8 h	1 per 30 min	1 per 5 min	1 per 1 min	4 per min	8 per min	12 per min	15 per min
	80 to 132 cm	Male	22	20	18	17	14	7	6	5
		Female	14	12	11	10	9	7	6.5	6.5
	80 to 183 cm	Male	18	17	15	14	12	7	6	5
		Female	12	10.5	10	9	8	6	6	6
	132 to 183 cm	Male	20	18	17	16	13	7	6	5
		Female	12	11	10	9	8	6	6	6
	Floor to 80 cm	Male	23	19	19	15	11	7	7	6.5
		Female	15	11	10	9	9	8	7	6
	Floor to 132 cm	Male	22	18	18	14	11	6	6	5
		Female	12.5	9	8	7.5	7.5	6.5	6	5
	Floor to 183 cm	Male	20	16	16	13	9	6	6	4
		Female	11	8	7	7	7	6	5	4.5

(Continued)

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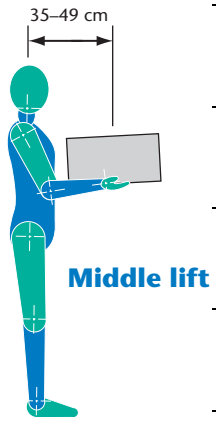
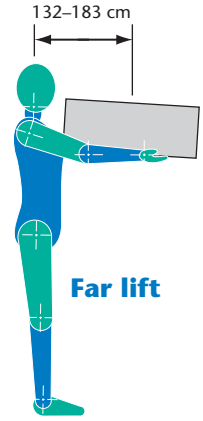
Table B.3 (Concluded)

	Lifting Height	Gender	Lifting Frequency 1 per 8 h	1 per 30 min	1 per 5 min	1 per 1 min	4 per min	8 per min	12 per min	15 per min
	80 to 132 cm	Male	19	18	16	15	13	7	6	5
		Female	13	11	10	9	8	6	6	5
	80 to 183 cm	Male	16	15	13	12	11	7	6	5
		Female	11	9.5	9	8	7	5	5	4.5
	132 to 183 cm	Male	18	16	14	14	11	7	7	5
		Female	10	9	8	7	7	5	4	3
	Floor to 80 cm	Male	20	17	16	13	10	7	7	6.5
		Female	13	9	8	8	8	7	6	5
	Floor to 132 cm	Male	18	16	15	12.5	9	6	6	5
		Female	11	7.5	6.5	6.5	6.5	6	5	4
	Floor to 183 cm	Male	17	15	14	11	9	6	6	4
		Female	10	7	6	6	6	5.5	4.5	3.5
	80 to 132 cm	Male	19	18	16	15	13	7	6	5
		Female	13	11	10	9	8	6	6	5
	80 to 183 cm	Male	16	15	13	12	11	7	6	5
		Female	11	9.5	9	8	7	5	5	4.5
	132 to 183 cm	Male	15	14	12	12	9	7	6	4
		Female	9	8	7	7	7	5	4	3
	Floor to 80 cm	Male	17	14	14	11	9	7	6	4.5
		Female	12	9	8	7	7	6	5	4
	Floor to 132 cm	Male	15	13	13	10	8	6	6	4
		Female	10	7.5	6.5	6	6	5	4	3
	Floor to 183 cm	Male	15	12	12	9.5	8	6	5	3
		Female	9	6	6	5	5	4.5	4	3

** Refer to Tables B.4(a) to (h) if lifting is to be performed with limited headroom, asymmetry, heat stress, and clearance or duration issues.*

Source: Mital *et al* (1997)

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B.3.3.5 Multiplier tables — Lifting

The following tables provide multipliers (correction factors) for when lifts are not straight forward, simple lifting tasks. Weights in the Table B.3 should be multiplied (reduced) by the correction factors when the ability to lift will be affected by any of the following conditions:

Table B.4 (a)
Limited headroom multiplier
(See Clause B.3.3.5.)

Stature	Multiplier*
Fully upright	1
95% upright	0.6
90% upright	0.4
85% upright	0.38
80% upright	0.36

*Interpolate for intermediate stature

Table B.4 (b)
Asymmetrical lifting multiplier
(See Clause B.3.3.5.)

Angle of turn, degree	Multiplier*
0-30	1
30-60	0.924
60-90	0.848
Above 90	0.8

*Interpolate for intermediate stature

Table B.4 (c)
Load asymmetry multiplier
(See Clause B.3.3.5.)

Load asymmetry	Multiplier*
0	1
10	0.96
20	0.89
30	0.84

*Interpolate for intermediate stature

Table B.4 (d)
Heat stress multiplier
(See Clause B.3.3.5.)

Heat stress (WBGT)	Multiplier*
Up to 27 °C	1
At 32 °C	0.88

*Interpolate for intermediate stature

Table B.4 (e)
Coupling multiplier
(See Clause B.3.3.5.)

Coupling	Multiplier*
Good and comfortable handles/firm hold to initiate lift	1
Poor quality handles/limited or slippery hold	0.925
No handles/holds to initiate the lift	0.85

*Interpolate for intermediate stature

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Table B.4 (f)
Load clearance multiplier
(See Clause B.3.3.5.)

Load clearance, mm	Multiplier*
Unlimited to 30	1
15	0.91
3	0.87

*Interpolate for intermediate stature

Table B.4 (g)
Work duration multiplier
(See Clause B.3.3.5.)

Time, h	Men	Women
1	1.238	1.140
4	1.136	1.080
8	1.000	1.000
12	0.864	0.920

Table B.4 (h)
Maximum frequency (cycles/min) acceptable for one handed horizontal lifting
(See Clause B.3.3.5.)

	Maximum frequency of lift											
Posture	Sitting						Standing					
Max Reach, cm	38			60			38			60		
Load, kg	2.3	4.5	6.8	2.3	4.5	6.8	2.3	4.5	6.8	2.3	4.5	6.8
Male	11	8	6	10	8	6	11	9	6	10	8	6
Female	9	7	—	7	5	—	9	5	—	8	5	—

Example: During a full 8 h work shift, in a room that is 32 °C, a female employee is lifting small boxes from the floor to a table, four times per minute, while rotating 75°.

Recommended weight (from table) = 9 kg

Adjustment = 9 kg × 1 × 0.88 × 0.848 = 6.7 kg

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Tool 10a. Force — Carrying

What do you observe in terms of • characteristics of the task; • distance; • frequency; • weight; • characteristics of the load; and • whether the carrying task is one handed?		
The carrying requirements:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the carrying requirements be further analyzed or the proposed solutions be examined in more detail?	No: end here	Yes: see Tool 10b

Note: *For background information, see Tool 10b.*

Tool 10b. Force — Carrying

Design factor	Why be concerned (consequences)	Recommendations
Characteristics of the task	Unsafe carrying tasks (heavy objects, very frequent, using awkward postures, on uneven ground) can expose workers to • muscular strain; • slipping; and • fatigue.	Remove all obstacles in the path of travel and where possible avoid travelling over changes in surface, e.g., • staircases; • changes in slopes; • cracks in the floor; • uneven ground; and • slippery/wet surfaces. Loads being carried should not block the worker's view of their path of travel.
Distance	The greater the distance, • the greater the muscle fatigue; and • the greater the risk of falling. Distances over which loads are carried should be as short as possible	Carry the load with both hands. Limit the carry distance based on the characteristics outlined in Table B.5. Use mechanized transport equipment (e.g., sliding tables, conveyors belts, ball casters) when recommended carrying values from Table B.5 are exceeded. Consider layout of the workplace to reduce the distance to be covered (e.g., bringing the stock area closer).

(Continued)

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Tool 10b. (Continued)

Design factor	Why be concerned (consequences)	Recommendations
Frequency	If carrying is frequent, workers can experience • general fatigue; and • local muscle fatigue.	Limit carrying frequency based on the weight of the object, the distance of the carry and the vertical height of the hands during the carry (see Table B.5 for recommended carrying weights) Additional considerations are • the dimensions of the load (awkwardness); • the characteristics of the load (e.g., temperature, sharpness, liquid); and • whether the handles or hand holds are adequate (or present). Provide mechanical aids if loads are carried often.
Weight	If lift weights exceed recommended limits, workers can experience increased incidents of back or hand/arm injuries.	Recommended carrying weight depends on carrying conditions (see Table B.5 to determine recommended weights). Reduce the weight of an object being carried by a worker by • limiting the capacity of the container; and • splitting the load into smaller containers. Provide mechanical aid for transportation of loads.
Characteristics of the load	If there are no handles or poor handles, workers can experience • difficulty holding objects (more likely to drop them); • hand and wrist pain; • awkward postures (back, shoulders); and • localized muscle fatigue (from pinch grip or other less effective methods of gripping objects).	Provide a means for workers to grip an object safely whenever possible (e.g., handles, hand holds) rather than gripping the edge of an object (e.g., using pinch grip or palm grip). Handles should • allow for good grip (i.e., not be too slippery); • have a round/oval shape where possible (avoid sharp edges); and • allow for space for gloves where applicable. Consider material that handles/grips are made of (plastic, rubber, or wood are good choices).
Characteristics of the load	If the load is large, • it reduces field of vision (likely to fall or run into things); and • it can create awkward postures, muscle strain.	Limit load or object size to ensure safe worker movement when handling the load: • should not impede full movement of the legs during the carrying; • consider having two people lift where space allows safe movement; and • use mechanical aids for awkward or large loads.
Characteristics of the load	If object has cutting edges or rough surfaces, • there is risk of getting local cuts and abrasions; and • ability to grip properly is affected.	Remove edges that can cut or surfaces that are rough on the skin: • wrap/box/bag objects with cutting or rough edges or which are too hot, cold, or dirty; • provide handles as part of the wrapped/boxed/bagged object; and • use protective gloves as a last resort.

(Continued)

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Tool 10b. (Concluded)

Design factor	Why be concerned (consequences)	Recommendations
Whether the carry is one-handed	One handed carrying tasks require the worker to assume awkward postures and exert forces asymmetrically. This can expose workers to • muscle fatigue; • muscle pain; and • decreased ability to carry items safely.	Consider whether the item or task can be redesigned to accommodate two-handed carrying.

Notes:

(1) *When determining the safety of a carry, many components must be taken into consideration, beyond the weight of the object being carried. Other variables (characteristics) of the carry that need to be considered include the distance and frequency of the carry as well as the load dimensions and type of object being carried. Table B.5 is provided with recommended weights for simple carrying tasks (based on Mital et al. (1997), two-handed, symmetrical load carries for the 90th percentile) as well as multipliers (correction factors) in Tables B.6(a) to (f) that might be needed depending on the different carrying scenarios.*

(2) *For more complicated carrying tasks, more advanced assessment tools should be utilized, or a competent person who is knowledgeable in ergonomics should be contacted.*

B.3.3.6 Determining recommended carrying weights

The values in Table B.5 are designed to protect the 90th percentile of the worker population. Tables B.6(a) to (f) consist of "multipliers", which are correction factors used against the weights being carried, in order to adjust the recommended limit of the weight when variables such as asymmetry, heat stress, lack of headroom etc., are making the carrying task more difficult or less safe.

The Tables are used as follows:

(a) Determine the height at which the object is being carried (from the floor).
(b) Determine how far the object is being carried.
(c) Determine how often the carrying task is performed.
(d) Based on the gender of the worker and the information from Items (a) to (c), locate the recommended carrying weight limit in the chart.
(e) Determine if there are any additional factors that would affect the carrying task, and if so apply the correct multiplier from Tables B.6(a) to (f):
    (i) limited headroom multiplier (the worker is working in a stooped posture);
    (ii) asymmetrical lifting multiplier (the worker must twist while lifting, without moving their feet);
    (iii) load asymmetry multiplier (load is unbalanced);
    (iv) heat stress multiplier (the worker is working in a warm/hot environment);
    (v) coupling multiplier (the object being lifted does not have good handholds); and
    (vi) work duration multiplier.
(f) Compare the final recommended weight derived from Items (a) to (e), to the actual weight of the object being carried. If the actual weight of the object being carried is heavier than the recommended weight, controls should be put in place.

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Table B.5
Recommended weights for two-handed carry to safely accommodate the 90th percentile of the worker population, kg

(See Clause B.3.7.)

Carrying height, cm	Carry distance, m	Gender	Frequency						
			1 per 8 h	1 per 5 min	1 per 1 min	3.3 per 1 min	5 per 1 min	6 per 1 min	10 per 1 min
105-111	2.1	Male	25	19	17	—	14	–	10
		Female	18	13	13	—	12	–	11
	4.3	Male	22	17	15	—	—	9	—
		Female	18	13	13	—	—	9	—
	8.5	Male	20	15	13	10	—	—	—
		Female	16	12	12	10	—	—	—
72-79	2.1	Male	27	23	21	—	17	—	13
		Female	20	16	16	—	14	—	11
	4.3	Male	27	21	18	—	—	11	—
		Female	20	14	14	—	—	10	—
	8.5	Male	26	20	17	13	—	—	—
		Female	19	14	14	10	—	—	—

Source: *Mital et al (1997).*

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B.3.3.7 Multiplier tables — Carrying

The following tables provide correction factors for when the characteristics of carrying tasks are not straight forward. Weights in Table B.5 should be multiplied (reduced) by the correction factors when the ability to lift is affected by any of the following conditions:

Table B.6 (a)
Limited headroom multiplier
(See Clause B.3.3.7.)

Stature	Multiplier*
Fully upright	1
95% upright	0.6
90% upright	0.4
85% upright	0.38
80% upright	0.36

*Interpolate for intermediate stature

Table B.6 (b)
Asymmetrical carrying multiplier
(See Clause B.3.3.7.)

Angle of turn, degree	Multiplier*
0-30	1
30-60	0.924
60-90	0.848
Above 90	0.8

*Interpolate for intermediate stature

Table B.6 (c)
Load asymmetry multiplier
(See Clause B.3.3.7.)

Load asymmetry, %	Multiplier*
0	1
10	0.96
20	0.89
30	0.84

*Interpolate for intermediate stature

Table B.6 (d)
Heat stress multiplier
(See Clause B.3.3.7.)

Heat stress (WBGT)	Multiplier*
Up to 27 °C	1
At 32 °C	0.88

*Interpolate for intermediate stature

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Table B.6 (e)
Coupling multiplier
(See Clause B.3.3.7.)

Coupling	Multiplier*
Good and comfortable handles/firm hold to initiate lift	1
Poor quality handles/limited or slippery hold	0.925
No handles/holds to initiate the lift	0.85

*Interpolate for intermediate stature

Table B.6 (f)
Work duration multiplier
(See Clause B.3.3.7.)

Time, h	Men	Women
1	1.238	1.140
4	1.136	1.080
8	1.000	1.000
12	0.864	0.920

Example: During a full 8 h work shift, in a room that is 32 °C, a female employee is carrying a box for a distance of 4.3 m at a height of 111 cm, once every 5 min. It is an unbalanced load with 20% of the weight on one side.

Recommended weight (from table) = 13 kg

Adjustment = 13 kg × 1× 0.88 × 0.89 = 9.6 kg

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Tool 11a. Force — Pushing/pulling

What do you observe in terms of

- the characteristics of the task;
- the characteristics of the cart/equipment;
- the type of environment (indoor or outdoor including stores dock areas, rough ground);
- distance items are being moved;
- whether the pushing/pulling is one handed; and
- obstruction of line of sight?

The pushing and pulling requirements:	Are acceptable ❑	Need improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the pushing and pulling requirements be further analyzed or the proposed solutions be examined in more detail?	No: end here	Yes: see Tool 11b

Note: *For background information, see Tool 11b.*

Tool 11b. Force — Pushing/pulling

Design factor	Why be concerned (consequences)	Recommendations
Characteristics of the task	Unsafe pushing and pulling tasks (heavy objects, very frequent, using awkward postures, on uneven ground) can expose workers to • muscular strain; • slipping; and • fatigue.	Consider the amount of force necessary to • start the push/pull (initial force); and • sustain the push/pull for a long time. Provide motorized carts or conveyers for heavy loads (see Table B.7) to be moved over long distances. Plan the route of the push/pull task. Consider the • amount of manoeuvring (cornering, moving around objects); and • distance of the route. If the hands are above shoulder or below waist level, the task should be redesigned. Redesign the task to eliminate or minimize these factors: • Reduce the load if it must be pushed or pulled with the hands above shoulder or below waist level, or when the object is not directly in front of the worker. • Wear non-slip shoes to provide better traction during pushing/pulling.

(Continued)

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Tool 11b. (Continued)

Design factor	Why be concerned (consequences)	Recommendations
Characteristics of the cart /equipment	Inappropriate design can lead to • overloading; • difficulty manoeuvring; • jarring movements; • muscle fatigue and injury; and • obstruction of line of sight.	When using carts, ensure that they are adequate for the tasks. Provide a handle at about elbow height for straight horizontal pushing or just above elbow height where manoeuvring of the cart or equipment is necessary. Use swivel casters on one end of the cart and • for manoeuvrability, ensure that the handle is at that end; and • for steer ability, ensure that the handle is at the opposite end from the swivel casters. Handles should have sufficient clearance for the gloved hand. Long and wide trucks or carts are difficult to manoeuvre in standard aisles. Hand and wheel/caster brakes should be provided on carts and trucks that are transported on sloped floors or have to be aligned with equipment. Optimally, install vertical handles to the carts that allow different grasping heights to accommodate a wide population. Reduce friction between cart castors and the floor surface. Provide four large-diameter, wide, low-friction wheels. Regular maintenance of the casters is important. When height obstructs line of sight, consider redesigning the cart.
Type of environment	The environment (floor surface, overall space) in which the task takes place (indoor or outdoor) could expose workers to • slipping; • jarring movements; • awkward postures; and • high forces.	Ensure that the floor is not slippery or uneven. Ensure adequate space to manoeuvre carts/equipment.
Move distance	Excessive movement of materials can lead to fatigue	Review the full process to determine if moving materials and equipment is necessary. Chose the right cart for the type of task (long distances versus tight corners and manoeuvring). Reduce the distance to be covered, for example, by bringing the stock area closer.
One-handed pushing and pulling	Pushing or pulling with one hand can lead to • awkward postures; and • muscle fatigue or injury.	Consider whether the task can be redesigned to accommodate two-handed pushing and pulling.

(Continued)

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Tool 11b. (Concluded)

Notes:

(1) *When determining the safety of a pushing/pulling task, many components must be taken into consideration, beyond the weight of the object being pushed/pulled. The weight of an item being pushed/pulled is not the same as the forces required to move it. Other variables (characteristics) of the push/pull that need to be considered include the handle height, distance, and frequency of the push/pull as well as the type of surface on which the push/pull takes place. When measuring push/pull forces, a push/pull strain gauge or dynamometer is required.*

(2) *Tables B.7 (a) to (d) are provided with recommended forces for simple push/pull tasks [based on Mital et al. (1997), two-handed, symmetrical load push/pull tasks for the 90th percentile] for initial forces and sustained forces. The values for the recommended maximum "initial force" required to get an object moving and the "sustained force" required to keep the object moving differ from one another.*

(3) *The preferred method for transporting carts or wheeled equipment is pushing because pulling is often done with one hand and with a twist in the trunk.*

(4) *For more complicated push/pull tasks, more advanced assessment tools should be utilized or a competent person who is knowledgeable in ergonomics should be contacted.*

B.3.3.8 Determining recommended push/pull forces

The values in Tables B.7 (a) to (d) are designed to protect the 90th percentile of the industrial worker population.

The Tables are used as follows:

(a) Determine the correct Table to use, based on whether the task is a pushing task or pulling task and whether the forces in question are for initial (getting the object moving) or sustained (keeping the object moving) forces:
- Table B.7 for initial push force;
- Table B.7 (b) for sustained push force;
- Table B.7 (c) for initial pull force; and
- Table B.7 (d) for sustained pull force.

(b) Determine the height of the handle on the cart being pushed/pulled.

(c) Determine how far the object is being pushed/pulled.

(d) Determine how often the object is pushed/pulled.

(e) Based on the gender of the worker, and the information from Items (a) to (d), locate the recommended push/pull forces in the chart.

(f) Using the push/pull strain gauge or dynamometer, measure the force needed to move the cart or equipment.

(g) Compare the force level from the table to the actual amount of force required to initiate or sustain the push/pull of the object. If the actual force required to push/pull the object is heavier than recommended by the Tables B.7 (a) to (d), then controls should be put in place to limit the actions or the forces required should be lowered.

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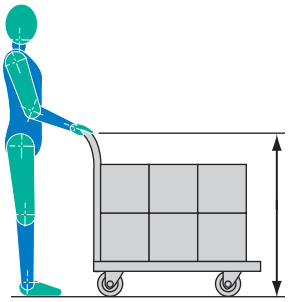
Table B.7 (a)
Recommended initial forces for two-handed push, kg, to safely accommodate the 90th percentile of the industrial worker population

(See Clause B.3.3.8.)



Handle height, cm	Push distance, m	Gender	1 per 8 h	1 per 5 min	1 per min	2.4 per min	4 per min	5 per min	10 per min
135 - 144	2.1	Male	31	26	25	—	—	22	20
		Female	22	20	17	—	—	15	14
	7.6	Male	26	22	21	—	15	—	—
		Female	20	18	16	—	15	—	—
	15.2	Male	25	20	19	16	—	—	—
		Female	17	15	14	12	—	—	—
	30.5	Male	24	19	15	—	—	—	—
		Female	17	14	12	—	—	—	—
	45.7	Male	20	16	13	—	—	—	—
		Female	17	14	12	—	—	—	—
	61	Male	18	14	12	—	—	—	—
		Female	15	13	12	—	—	—	—
89-95	2.1	Male	34	28	26	—	—	24	21
		Female	22	20	17	—	—	15	14
	7.6	Male	30	25	23	—	16	—	—
		Female	21	19	16	—	14	—	—
	15.2	Male	28	23	22	18	—	—	—
		Female	17	16	14	11	—	—	—
	30.5	Male	27	22	17	—	—	—	—
		Female	18	15	12	—	—	—	—
	45.7	Male	23	19	14	—	—	—	—
		Female	18	15	12	—	—	—	—
	61	Male	20	16	14	—	—	—	—
		Female	16	13	12	—	—	—	—

(Continued)

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Table B.7 (a) (Concluded)

Handle height, cm	Push distance, m	Gender	1 per 8 h	1 per 5 min	1 per min	2.4 per min	4 per min	5 per min	10 per min
57-64	2.1	Male	31	25	24	—	—	22	19
		Female	18	16	14	—	—	12	11
	7.6	Male	26	21	20	—	13	—	—
		Female	17	16	14	—	11	—	—
	15.2	Male	24	20	19	15	—	—	—
		Female	15	13	12	—	—	—	—
	30.5	Male	23	19	14	—	—	—	—
		Female	15	12	11	—	—	—	—
	45.7	Male	20	16	12	—	—	—	—
		Female	15	12	11	—	—	—	—
	61	Male	17	14	12	—	—	—	—
		Female	13	11	10	—	—	—	—

Source: *Mital et al. (1997).*

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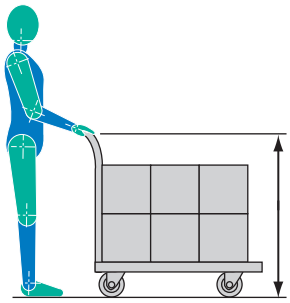
Table B.7 (b)
Recommended sustained forces for two-handed push, kg, to safely accommodate the 90th percentile of the industrial worker population

(See Clause B.3.3.8.)



Handle height, cm	Push distance, m	Gender	1 per 8 h	1 per 5 min	1 per min	2.4 per min	4 per min	5 per min	10 per min
135-144	2.1	Male	22	18	15	—	—	13	10
		Female	14	11	10	—	—	8	5
	7.6	Male	18	15	13	—	6	—	—
		Female	11	8	7	—	5	—	—
	15.2	Male	16	13	11	6	—	—	—
		Female	9	7	4	4	—	—	—
	30.5	Male	16	12	6	—	—	—	—
		Female	8	6	4	—	—	—	—
	45.7	Male	13	10	5	—	—	—	—
		Female	8	5	4	—	—	—	—
	61	Male	11	8	7	—	—	—	—
		Female	6	4	3	—	—	—	—
89-95	2.1	Male	23	19	16	—	—	13	10
		Female	13	10	9	—	—	7	5
	7.6	Male	18	15	13	—	6	—	—
		Female	11	9	8	—	5	—	—
	15.2	Male	16	13	11	6	—	—	—
		Female	10	7	4	4	—	—	—
	30.5	Male	16	12	6	—	—	—	—
		Female	9	6	4	—	—	—	—
	45.7	Male	13	9	5	—	—	—	—
		Female	8	6	4	—	—	—	—
	61	Male	11	8	7	—	—	—	—
		Female	6	4	3	—	—	—	—

(Continued)

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Table B.7 (b) (Concluded)

Handle height, cm	Push distance, m	Gender	1 per 8 h	1 per 5 min	1 per min	2.4 per min	4 per min	5 per min	10 per min
57–65	2.1	Male	23	18	16	—	—	13	10
		Female	12	9	8	—	—	6	4
	7.6	Male	18	14	12	—	—	—	—
		Female	11	8	7	—	—	—	—
	15.2	Male	15	12	11	6	—	—	—
		Female	9	7	4	4	—	—	—
	30.5	Male	15	11	6	—	—	—	—
		Female	8	6	4	—	—	—	—
	45.7	Male	13	9	5	—	—	—	—
		Female	7	5	4	—	—	—	—
	61	Male	10	8	7	—	—	—	—
		Female	6	4	3	—	—	—	—

Source: *Mital et al. (1997).*

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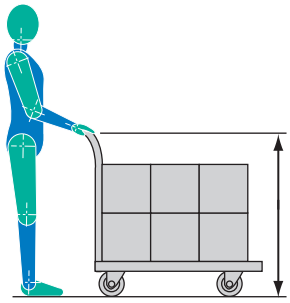
Table B.7 (c)
Recommended initial forces for two-handed pull, kg, to safely accommodate the 90th percentile of the industrial worker population

(See Clause B.3.3.8.)



Handle height, cm	Push distance, m	Gender	1 per 8 h	1 per 5 min	1 per min	2.4 per min	4 per min	5 per min	10 per min
135-144	2.1	Male	23	19	18	—	—	16	14
		Female	22	19	17	—	—	16	13
	7.6	Male	21	17	16	—	11	—	—
		Female	20	17	16	—	11	—	—
	15.2	Male	20	16	15	13	—	—	—
		Female	17	15	13	10	—	—	—
	30.5	Male	19	15	12	—	—	—	—
		Female	17	14	12	—	—	—	—
	45.7	Male	16	13	10	—	—	—	—
		Female	16	14	10	—	—	—	—
	61	Male	14	11	—	—	—	—	—
		Female	14	11	—	—	—	—	—
89-95	2.1	Male	32	27	25	—	—	22	19
		Female	23	21	18	—	—	16	14
	7.6	Male	29	24	23	—	15	—	—
		Female	21	19	16	—	14	—	—
	15.2	Male	28	23	21	18	—	—	—
		Female	18	16	14	10	—	—	—
	30.5	Male	26	21	16	—	—	—	—
		Female	18	15	13	—	—	—	—
	45.7	Male	23	18	14	—	—	—	—
		Female	18	15	13	—	—	—	—
	61	Male	19	16	13	—	—	—	—
		Female	16	13	12	—	—	—	—

(Continued)

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Table B.7 (c) (Concluded)

Handle height, cm	Push distance, m	Gender	1 per 8 h	1 per 5 min	1 per min	2.4 per min	4 per min	5 per min	10 per min
57-64	2.1	Male	36	30	28	—	—	25	22
		Female	24	22	19	—	—	17	15
	7.6	Male	33	27	26	—	18	—	—
		Female	22	20	17	—	15	—	—
	15.2	Male	31	26	24	20	—	—	—
		Female	19	17	15	11	—	—	—
	30.5	Male	30	24	18	—	—	—	—
		Female	19	15	13	—	—	—	—
	45.7	Male	26	21	16	—	—	—	—
		Female	19	15	13	—	—	—	—
	61	Male	22	18	15	—	—	—	—
		Female	17	14	13	—	—	—	—

Source: *Mital et al.* (1997).

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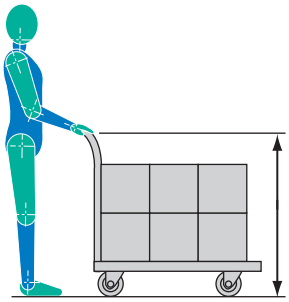
Table B.7 (d)
Recommended sustained forces for two-handed pull, kg, to safely accommodate the 90th percentile of the industrial worker population



Handle height, cm	Push distance, m	Gender	1 per 8 h	1 per 5 min	1 per min	2.4 per min	4 per min	5 per min	10 per min
135-144	2.1	Male	18	15	12	—	—	10	8
		Female	15	11	10	—	—	8	5
	7.6	Male	15	12	10	—	6	—	—
		Female	13	10	9	—	6	—	—
	15.2	Male	13	10	9	6	—	—	—
		Female	11	8	6	4	—	—	—
	30.5	Male	13	8	7	—	—	—	—
		Female	10	7	5	—	—	—	—
	45.7	Male	10	8	5	—	—	—	—
		Female	9	7	5	—	—	—	—
	61	Male	9	6	6	—	—	—	—
		Female	7	5	4	—	—	—	—
89-95	2.1	Male	24	19	16	—	—	13	10
		Female	14	11	10	—	—	8	5
	7.6	Male	19	16	13	—	6	—	—
		Female	13	10	9	—	6	—	—
	15.2	Male	17	14	12	7	—	—	—
		Female	11	8	6	4	—	—	—
	30.5	Male	17	12	7	—	—	—	—
		Female	10	7	5	—	—	—	—
	45.7	Male	14	10	6	—	—	—	—
		Female	9	6	4	—	—	—	—
	61	Male	12	9	7	—	—	—	—
		Female	7	5	4	—	—	—	—

(Continued)

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Table B.7 (d) (Concluded)

Handle height, cm	Push distance, m	Gender	1 per 8 h	1 per 5 min	1 per min	2.4 per min	4 per min	5 per min	10 per min
57-64	2.1	Male	25	20	17	—	—	14	11
		Female	13	10	9	—	—	8	4
	7.6	Male	20	17	14	7	—	—	—
		Female	12	9	8	5	—	—	—
	15.2	Male	18	15	12	7	—	—	—
		Female	10	7	6	4	—	—	—
	30.5	Male	18	13	7	—	—	—	—
		Female	9	6	5	—	—	—	—
	45.7	Male	15	11	6	—	—	—	—
		Female	8	6	4	—	—	—	—
	61	Male	12	9	8	—	—	—	—
		Female	6	5	3	—	—	—	—

Source: *Mital et al.* (1997).

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Tool 12a. Force — Vibration

Are hand tools emitting vibration? Is the user exposed to whole body vibration?		
The vibration issues:	Are acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the vibration issues be further analyzed or the proposed solutions be examined in more detail?	No: end here	Yes: see Tool 12b

Note: *For background information, see Tool 12b.*

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Tool 12b. Work environment — Vibration

Design factor	Why be concerned (consequences)	Recommendations
Vibrating tools (hand/arm vibration)	Workers using tools that emit vibration can be exposed to or experience • limited mobility and joint pain (hands, elbows) typical of impact hammers, pneumatic drills, power chisels etc.; • whitening of fingers when exposed to cold (a.k.a. Reynaud's disease or vibration white finger); and • tingling, numbness.	Use the machine or tool that is best suited for the task/job. Maintain machines or tools on a regular basis (e.g., sharpening, tune-ups). Handles: • provide anti-vibration handles; • coat contact surfaces with rubber, felt, cork, etc.; • hold the machine only by the handles; and • use gloves that fit the worker. Improve postures and reduce strain: • support the tool with a counterweight; • adjust the height of the work surface; • train the operator to make the best use of the tool, using as little grip force and pressure as possible; and • immobilize the items that are being tooled. Organize the work differently: • limit the time for using vibrating tools; • increase the number of rest periods; and • alternate work with non-vibrating tools.
Whole body vibration	Whole body vibration is transmitted through the body's supporting surfaces such as the legs when standing and the back and buttocks when sitting. It can lead to • mechanical injuries and disease of the spine and discs; • general feeling of discomfort, including headaches, nausea, motion sickness; and • muscle contractions with decreased performance in precise manipulation tasks.	Reduce the transmission of vibration to the worker by engineering the equipment or workplace more effectively. For example, • improving vehicle suspension; • altering the position of the seat within the vehicle; • mount equipment on springs or compression pads; • maintain equipment properly (i.e., balance and replace worn parts); • use materials that generate less vibration; and • in standing operations, provide a rubber or vinyl floor mat. Decrease the amount of vibration to which the driver is exposed by • reducing the speed of travel; • maintaining the surface over which the vehicle must travel; • minimizing the exposure period by alternating working tasks where vibration is present and those where it is negligible; and • increasing rest/recovery time between exposures.

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B.3.3.9 Guidance for hand-arm vibration

For hand-arm vibration,

(a) find the vibration value for the tool. Get it from the manufacturer.

(b) from Figure B.6, mark the point on the left side shown as vibration value.

(c) find out how many total hours per day the worker is using the tool and mark that point on the bottom of the chart below.

(d) Trace a line into the graph from each of these two points until they cross.

Note: *The caution limit curve (bottom) is based on an 8 h energy-equivalent frequency-weighted acceleration value of 2.5 m/s^2. The hazard limit curve (top) is based on an 8 h energy-equivalent frequency-weighted acceleration value of 5 m/s^2.*

(e) If the point lies in the crosshatched area above the upper curve, then a vibration hazard is considered to be present. If the point lies between the two curves, a vibration hazard can affect some workers. In both cases, refer to Tool 12 for guidance on hazard elimination or reduction.

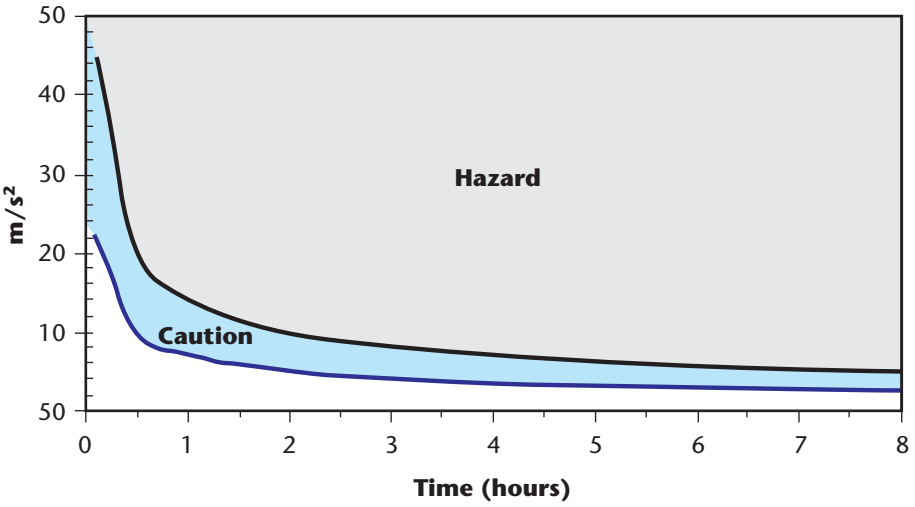

Figure B.6
Vibration value
(See Clause B.3.3.9.)

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Tool 13a. Work environment — Effects of noise on performance

What do you hear or notice in terms of

- speech comprehension; and
- performance?

The noise level :	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the noise issues be further analyzed or the proposed solutions be examined in more detail?	No: end here	Yes: see Tool 13b

Note: *For background information, see Tool 13b.*

Tool 13b. Work environment — Effects of noise on performance

Design factor	Why be concerned (consequences)	Recommendations
Speech comprehension	Instructions need to be communicated for effective work performance. Warning signals must be heard by all workers.	The ability to understand speech is influenced by both the volume of the background noise and that of the speaking voice. The average intensity of a human voice in a room at a distance of one metre lies within the following ranges: • conversation 60-65dB (A) • dictation 65-70dB (A) • calling out 80-85dB (A) If the sound of the voice is to be heard clearly, the background noise level must be at least 10dB(A) below these levels.
Performance	Noise can cause fatigue and a loss of concentration impacting on efficiency (a decrease in work output) and performance (an increase in the number of work errors). Work involving learning is more susceptible to disruption from noise than routine work.	Recommended noise levels: • executive offices, conference rooms: 30 dB • video conference rooms: 25 dB • private offices: 35 dB • open plan office: 40 dB • call centre, public circulation: 45 dB • industrial control room: 60 dB.

Notes:

(1) *The hazards of workplace noise are commonly linked to noise-induced hearing loss. Recommended noise levels in industry are specified in Occupational Health and Safety Acts and regulations, which are not covered in this Annex. There is also a concern for non-auditory health effects related to low-intensity noise emission exposure. These include effects of noise on human performance, interpersonal behaviour, and mental and physical health. There can be individual differences in reactions to noise, with the psychological effects ranging from annoyance to stress-related health effects. In addition to psychological effects, noise can interfere with verbal communication and reduce working efficiency.*

(2) *In order to measure noise levels, specific equipment such as noise dosimeters are used. For more assistance on the measurement of exposure to noise, a competent person who is knowledgeable in noise assessments should be contacted.*

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Tool 14a. Work environment — Temperature

What do you feel or notice in terms of

- temperature;
- drafts;
- humidity; and
- the number of breaks given?

The environmental temperature:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the temperature issues be further analyzed or the proposed solutions be examined in more detail?	No: end here	Yes: see Tool 14b

Note: *For background information, see Tool 14b.*

Tool 14b. Work environment — Temperature

Design factor	Why be concerned (consequences)	Recommendations
Temperatures	If working in temperatures that are too cold, workers can experience • decreased blood flow; • less strength capability, which results in greater muscle demand; • less co-ordination; and • greater discomfort. If working in temperatures that are too hot, workers can experience • increased blood flow; • increased demands on the cardiovascular system; • fatigue; and • slippery hands (excessive sweating).	Be aware of • personal parameters: – thermal insulation of clothing; and – activity level; and • environmental parameters: – air temperature; – mean radiant temperature; – air velocity; and – humidity. Reduce gain or loss of heat to outside. Unacceptable temperature differences can be caused by large cold or warm surfaces, such as badly insulated windows in winter, direct sunshine through windows in summer, or heated or cooled ceilings. Reduce internal gain or loss of heat: • caulk hot and cold surfaces (ducts, walls, etc.); • vent warm and humid gases at source; and • eliminate all water and vapour leaks. Adapt clothing to conditions. Observe comfort zones and ASRAE IAQ Design Criteria (ANSI/ASHRAE 55). Optimum temperature ranges: • summertime: 23–26°C at 50% relative humidity; and • wintertime: 20–23.5°C at 50% relative humidity.

(Continued)

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Tool 14b. (Concluded)

Design factor	Why be concerned (consequences)	Recommendations
Drafts	If drafts exist, workers can experience • local chills or general thermal sensation (feeling hotter or colder); and • muscle contractions, neuralgia.	Maintain consistent air velocity (minimize turbulence) and air temperature in internal work environments. The design of air conditioning or ventilating systems should consider that humans are most sensitive to draft around the ankle and neck regions. Limit air speeds to • 10 m/s for short-term exposure; • 3 m/s for intermittent work; • 1 m/s for prolonged standing or heavy work; • 0.5 m/s for prolonged sitting work. Eliminate all drafts on the face or neck.
Humidity	Increased humidity can give the perception of a higher temperature. If the humidity is too low (lower than 20%), there is a risk of dryness of the mucus membranes and static electricity build-up on the body	For air quality reasons humidity should be limited to 30 to 70%.
Breaks and the work/rest cycles	If work takes place where thermal stress is an issue, workers can experience over exposure to heat or to cold. This results in any of the noted conditions in this section.	When scheduling work, consider the temperatures in which workers must complete their work: • schedule heavy work during hours of the day with less extreme temperatures; • increase worker numbers to complete jobs where heavy or very heavy work must be performed; • mechanize work wherever possible if it must be performed in extreme temperatures; • provide warm or cool rest areas where appropriate, for workers to recover in; and • shorten work/rest cycles with increased exposure to temperatures (see Table B.8).

Notes:

(1) *Excessive exposure to heat is referred to as heat stress and excessive exposure to cold is referred to as cold stress.*

(2) *The ACGIH publication* 2011 TLVs and BEIs *(or the most current booklet), provides recommended screening criteria for worker exposure to thermal stress (cold and hot). This ACGIH publication should be consulted for more detailed information on these screening criteria, categories of work demands, and guidelines for limiting thermal strain.*

(3) *Table B.8 outlines simple definitions of task demand levels, as well as recommended Wet Bulb Globe Temperatures for work/rest cycles.*

(4) *In order to measure Wet Bulb Globe Temperatures and other aspects of thermal stress, specific equipment must be used. For more assistance on the measurement of exposure to thermal stress, contact a competent person who is knowledgeable in thermal stress management and thermal measurements.*

B.3.3.10 Determining work/rest cycles for WBGT in the workplace

Table B.8 provides information on screening criteria for heat stress exposure and includes recommended wet bulb globe temperatures for work/rest cycles. Wet Bulb Globe Temperature (WBGT) index is used to measure workplace conditions in industrial environments to prevent potential heat stress situations that can lead to heat stroke to employees. This method closely relates to the human body's response to heat. The WBGT measurement takes into account air temperature, air movement, radiant heat, and humidity and WBGT limits are usually prescribed in OHS regulations. For comfort aspects and to promote an optimal work environment relating to workers in office, retail and other non-industrial environments, the recommendations for temperature, draft, and humidity ranges found in Tool 14.b are more appropriate.

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Table B.8
ACGIH screening criteria for heat stress exposure for 8-hour work day 5-day work week with conventional breaks, WBGT values in °C

(See Clause B.3.3.10.)

Allocation of work in a work/rest cycle	Acclimatized				Action limit (unacclimatized)			
	Light	Moderate	Heavy	Very heavy	Light	Moderate	Heavy	Very heavy
75-100%	31.0	28.0	—	—	28.0	25.0	—	—
50-75%	31.0	29.0	27.5	—	28.5	26.0	24.0	—
25-50%	32.0	30.0	29.0	28.0	29.5	27.0	25.5	24.5
0-25%	32.5	31.5	30.5	30.0	30.0	29.0	28.0	27.0

Source: *Canadian Centre for Occupational Health and Safety (www.ccohs.ca).*

Notes:

(1) *This Table assumes 8-hour workdays in a 5-day work week with conventional breaks.*

(2) *TLVs assume that workers exposed to these conditions are adequately hydrated, are not taking medication, are wearing lightweight clothing, and are in generally good health.*

(3) *Examples of work loads include*

(a) rest — sitting (quietly or with moderate arm movements);

(b) light work — sitting or standing to control machines; performing light hand or arm work (e.g., using a table saw); occasional walking; driving;

(c) moderate work — walking about with moderate lifting and pushing or pulling; walking at moderate pace; e.g., scrubbing in a standing position;

(d) heavy work — pick and shovel work, digging, carrying, pushing/pulling heavy loads; walking at fast pace; e.g., carpenter sawing by hand; and

(e) very heavy — very intense activity at fast to maximum pace; e.g., shovelling wet sand.

Tool 15a. Work environment — Lighting

What do you observe in terms of

- reflection;
- glare; and
- intensity relative to the activity being performed?

The lighting:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	

Should the lighting be further analyzed or proposed solutions be examined in more detail?	No: end here	Yes: see Tool 15b

Note: *For background information, see Tool 15b.*

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Tool 15b. Work environment — Lighting

Design factor	Why be concerned (consequences)	Recommendations
Lighting: reflection and glare	Poor lighting leads to • poor vision; • reflection and glare; • poor work posture; • difficulty seeing dangerous objects/elements; and • higher chance of incidents causing injury and damage.	Provide lighting based on the degree of perception/visibility needed, the size and contrast of objects to be handled, tool detail, etc. Eliminate all shiny surfaces (e.g., polished metal, glass, plastic sheeting, etc.). Provide even lighting on work surfaces. Avoid major shadows and contrast. Increase lighting on dangerous objects and elements. Clean and maintain light fixtures on a regular basis.

Intensity — type of activity	Recommended range, Lx
Public area with dark surroundings	20-50*
Simple orientation for short temporary visits	50-100*
Working spaces where visual are performed only occasionally	100-200*
Performance of visual tasks of high contrast or large size: e.g., reading printed materials, typed originals handwriting in ink and good xerography; rough bench and machine work; ordinary inspection; rough assembly	200-500†
Performance of visual tasks of medium contrast or small size: e.g., reading medium-pencil handwriting, poorly printed or reproduced material; medium bench and machine work; difficult inspection; medium assembly	500-1000†
Performance of visual tasks of low contrast or very small size: e.g., reading handwriting in hard pencil on poor quality paper and very poorly reproduced material; highly difficult inspection	1000-2000†
Performance of visual tasks of low contrast and very small size over a prolonged period: e.g., fine assembly; very difficult inspection; fine bench and machine work	2000-5000‡
Performance of very prolonged and exacting visual tasks: e.g., the most difficult inspection; extra fine bench and machine work; extra fine assembly	5000-10 000‡
Performance of very special visual tasks of extremely low contrast and small sizes: e.g., surgical procedures	10 000-20 000‡

**General lighting throughout room.*
† *Illumination on task.*
‡*Illumination on task, obtained by a combination of general and local lighting.*
Note: *For further information, see IES* The Lighting Handbook.

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Tool 16a. Personal protective clothing and equipment

Is the choice of personal protective clothing and equipment made considering

- the individual requirements of the worker to ensure fit and comfort (anthropometrics);
- the task performed by the worker (including the requirements of vision, mobility and reach, dexterity, communication);
- its suitability for actual work situations (physical task performance);
- the environmental conditions in which the work task is performed (temperature and humidity, lighting, noise); and
- the potential to contribute to ergonomic stressors (increasing use extreme postures or excessive forces)?

Does the use of protective clothing and equipment

- produce discomfort when worn (e.g., elevated body temperature, increased perspiration, breathing resistance);
- require increased exertion of energy because of its weight;
- interfere with movement or dexterity required for the performance of tasks;
- interfere with use of tools;
- restrict the field of vision; and
- interfere with necessary interpersonal communication?

Has training been provided for proper use of personal protective clothing and equipment?

The personal protective clothing and equipment:	Are acceptable ❑	Need improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the workstation design, layout, or proposed solutions be examined in more detail?	No: end here	Yes: see Tool 16b

Note: *For background information, see Tool 16b.*

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Tool 16b. Personal protective clothing and equipment

Design factor	Why be concerned (consequences)	Recommendations
Clearance requirements	The type of clothing an individual wears can hinder safe work practices: e.g., tight clothing can restrict movements. Gloves can protect against hand injuries, such as abrasions and burns, but they will affect grip stability, dexterity, and strength.	When special clothing is required, such as uniform or personal protective equipment, it is important to evaluate the impact of these items on other hazards and risks.
Tool use	Gloves can affect the ability of a worker to use a tool or perform precision work.	When selecting tool, ensure that the controls are acceptable with the PPE required.
Training	Misuse of the PPE will often render it ineffective and will not provide the protection required.	Employees should have the knowledge and training required to perform tasks safely.
PPE interfering with the job	Poorly fitting PPE can lead to workers removing the items while working, increasing the likelihood that they will be exposed to hazards.	Ensure the type of work being performed is considered when selecting PPE.

Tool 17a. Computer or monitor work

- How is the workstation organized or laid out?
- Where is the monitor currently located?
- Does the worker stare at the monitor for long lengths of time?
- Does the worker use multiple monitors?

The computer or monitor layout:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the computer or monitor layout be further assessed or the proposed solutions be examined in more detail?	No: end here	Yes: see Tool 17b

Note: *For background information, see Tool 17b.*

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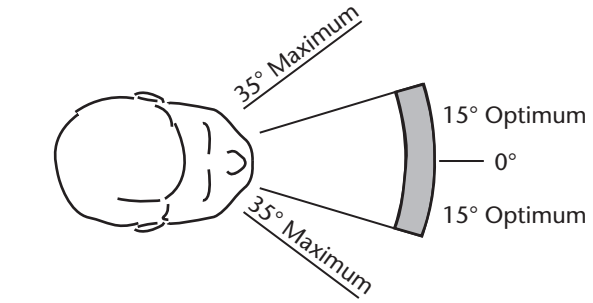
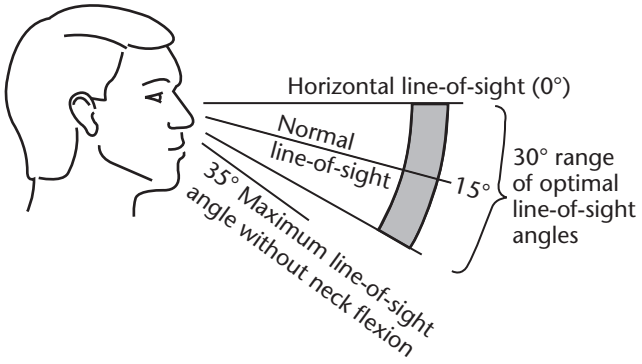
Tool 17b. Computer or monitor work

Design factor	Why be concerned (consequences)	Recommendations
Layout	If accessories (screen/monitor, keyboard, mouse, document holder) are poorly placed, the worker can experience poor posture, fatigue of muscles, and pain in the • nape of the neck shoulder and arms; and • wrists and hands.	Avoid glare – unless other anti-glare strategies have been implemented, the screen/monitor should not face a window or have one directly behind it. Choose furniture and equipment that allows the worker to work with their neck in neutral alignment upright, the shoulders relaxed, wrists in neutral position (straight), and elbows at a 90° or more. Place screen/monitor and document holder in proper line of sight. Place keyboard and mouse in location that optimizes position of the arms and hands and wrists. Adapt arrangement of materials for the task — document holder facing the person, to let them read the information (e.g., coding work).
Where is the monitor currently located?	 	
Does the worker stare at the monitor for long lengths of time?	Holding static postures can lead to the development of musculoskeletal injuries and/or eye strain.	Rearrange task to utilize changes in posture. Optimize lighting and avoid glare. Take frequent rest breaks. Encourage the use of tools (e.g., software) that will prompt workers to take frequent breaks.
Use of multiple monitors	Poorly designed layout of monitors can lead to • poor postures; and users missing important data.	When multiple monitors are used, place the monitor with the most relevant or frequently accessed information in direct line of sight, and less important data on monitors that the workers do not need to stare at for long lengths of time.

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B.3.4 Ergonomics observation and recommendation Tools 18 and 19 — Worker organizational issues

Working conditions affect worker well-being. The following work organizational factors are known to influence worker well-being:

(a) temporal factors such as shift work, quotas, deadlines, break sequences, and extended shift length;
(b) job design factors such as monotony, repetitiveness, variety, ability to learn, role clarity, autonomy, coherence and control; and
(c) psychosocial factors such as co-worker interactions and supervision.

The information presented in this section is intended to provide guidance on the topic of work organization. It is not intended to be comprehensive or exhaustive. If the initial assessment reveals areas for concern, this is an indication that further in-depth analysis might be required. Due to the complexity of this subject area, advice from competent person is recommended for in-depth analysis and understanding of the issues.

Tool 18a. Work organization/stressors — Time issues

What do you observe about

- time constraints (e.g., quotas, deadlines, machine pacing);
- breaks/rest periods;
- incentive systems (e.g., production bonuses, piece work);
- monotony or repetitive nature of the work; and
- hours of work (e.g., overtime, 12 h shifts, shift work)?

The work organization:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the workstation design, layout or proposed solutions be examined in more detail?	No: end here	Yes: see Tool 18b

Note: *For background information, see Tool 18b.*

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Tool 18b. Work organization/stressors — Time issues

Design factor	Why be concerned (consequences)	Recommendations
Time constraints	Time constraints, such as quotas, pacing, and deadlines lead to an increase likelihood of developing MSD because • local and general fatigue; • higher repetition; • work is often done without breaks; and • increase chance of error and incidents.	Adapt organization and technical procedures to limit the frequency of rush situations. Assign tasks so that help can be available in rush situations. Assign a set of tasks to a group of people. Avoid factors that increase the work pace, including • tight or frequently changing deadlines; and • electronic monitoring of productivity. Recognize effects of quotas, deadlines, and pacing and plan work accordingly.
Breaks/rest periods	Lack of regular breaks or rests leads to • local, visual, and general muscular fatigue; • reduced vigilance; • if sitting, poorer health; and • heat stroke in hot environments.	Shorter and more frequent breaks are preferred over long and infrequent breaks for highly repetitive work tasks. For heavy work, there should be mandatory breaks spread throughout the day, especially in hot environments. For moderate mental and physical effort, there should be a 10 to 15 min morning and afternoon break.
Incentive systems	Productivity incentives (e.g., piecework or production bonuses) can lead to • a faster pace of work; • increased fatigue; and • adverse work conditions, more injuries.	Eliminate production or risk-incentive bonuses. Give priority to health and safety, while respecting operators' interests and productivity constraints. If there are bonuses, integrate them permanently into the wages while minimizing the stressors.
Monotony and repetitive nature of work	A lack of variety in work can lead to • constant static posture, similar movements; • increase chance of error and incidents; and • decreased vigilance in performing the job.	Organize the work so that monotonous tasks are performed for less than an hour. This can be done by • job rotation: moving at predetermined times between different tasks; • job enlargement: adding different kinds of work to a job description; or • job enrichment: adding different kinds of work to the job description that allows for personal development. When possible, have workers perform more demanding jobs at the beginning of a shift. Ensure that workers are properly trained to perform all jobs in a job rotation. Job rotation is an administrative control that should not replace addressing the underlying hazards and their associated risks leading to increased fatigue and musculoskeletal disorders.

(Continued)

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Tool 18b. (Concluded)

Design Factor	Why be concerned (consequences)	Recommendations
Hours of work	Shift work can interfere with the body's circadian rhythms and can lead to • difficulty sleeping; • poor recovery from physical and mental exertions/demands; • increased reproductive health problems; • increased chance of error, incidents, and injuries; • adverse health effects; and • poor work life balance. Working excess overtime leads to • local and general fatigue; • increased effort; • slower reaction times; • poorer performance and productivity; and • increased chance of error, incidents, and injuries. The long term effects of working a lot of overtime can be • more injuries in general and MSDs in particular; • isolation from family and friends and poor life-work balance; • weight gain; and • job stress.	Planning: • Plan shifts in advance. • Reduce night work as much as possible. • Schedule the most demanding work early in the shift when workers are most alert. • Schedule shorter, more frequent breaks. • Avoid scheduling more than five shifts in a row. • Avoid excessive 12 h shifts. • Avoid excessive overtime. • Schedule time off over weekends. • Rotate shifts forward (day-afternoon-night). • Provide at least 48 h between shift changes to allow the body to adjust. • Avoid split shifts. • Evaluate shift schedule design such as length of breaks, start and finish times, etc. • Provide adequate illumination using ambient light when possible. Organizational: • Develop strategies for fatigue management. • Take advantage of individual differences and maximize worker autonomy to self-select shifts, or trade with coworkers to optimize their personal life schedule. • Provide alternative options for workers who can not perform shift work. • Train workers how to reduce the negative effects of shift work including stress management. • Have enough staff on hand to cover production or activity peaks. • Reduce overtime: – hire extra staff during extra busy production periods; and – modify the job design (e.g., going from 2 to 3 positions etc.). • Upon hiring, warn of the likelihood of overtime. • Give plenty of advance warning when overtime will be required.

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Tool 19a. Work organization — Work demands and worker control

What do you observe about

- the demands of the jobs;
- worker control and autonomy;
- management of unacceptable workplace behaviours;
- worker input during change and execution of work;
- emphasis on production;
- performance accountability; and
- management error reporting?

The workstation design and layout:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the proposed solutions be examined in more detail?	No: end here	Yes: see Tool 19b

Note: *For background information, see Tool 19b.*

Tool 19b. Work organization — Work demands and employee control

Design factor	Why be concerned (consequences)	Recommendations
Demands of the jobs	High demand jobs lead to • higher rates of employee turnover; • more workers requiring more sick days; • increased number of incidents; • increased absenteeism; • diminished productivity; and • higher direct medical, legal, and insurance costs.	Provide employees with adequate and achievable work requirements in relation to the agreed hours of work. Ensure that skills and abilities of the workers are matched to the job demands. Design jobs to be within the capabilities of employees and encourage worker input into the job design.
Employee, control, and autonomy	When workers have low control over how they perform work, there can be a negative impact on • physical and mental health; and • productivity.	Provide employees with control over the pace of their work where possible. Provide opportunities for employees to develop and use their skills and initiative. Provide flexibility for employee control regarding their work patterns such as breaks and task sequence.

(Continued)

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Tool 19b. (Concluded)

Design factor	Why be concerned (consequences)	Recommendations
Unacceptable behaviours	Bullying and harassment at the workplace can lead to • increased worker stress; • increased likelihood of violence; and • a negative impact on morale, physical and mental health, and productivity.	Promote positive behaviours at work to avoid conflict and ensure fairness. Develop policies and procedures to prevent or resolve unacceptable behaviour. Install systems to enable and encourage managers to deal with unacceptable behaviour. Install systems to enable and encourage employees to report unacceptable behaviour. Refer to legal and other requirements specific to violence and harassment.
Worker input during change and execution of work	Organizational changes can cause stress for workers who • worry about losing their jobs or being reassigned; and • have to learn new skills or take on new roles and responsibilities. A lack of worker input can lead to • unsafe and ineffective work procedures; • errors in performance; and • reduced learning opportunities for the organization.	Provide employees with timely information so they understand the reasons for proposed changes. Ensure adequate employee consultation on changes and provides opportunities for employees to influence proposals. Inform employees on the probable impact of any changes to their jobs. Inform employees of timetables for changes. Provide employees with access to relevant support during changes. Encourage ideas and creativity. Promote worker suggestions and ideas for improvement. Promote a learning culture.
Production emphasis	Production pressure can lead to poor decision making and increase risk of incidents.	Ensure that health and safety is not compromised in favour of production.
Performance accountability	Lack of accountability for actions can lead to complacency and unclear understanding of priorities.	Provide clear expectations on job/task requirements and responsibilities. Provide timely and constructive feedback on performance. Ensure that the promotion of health and well-being in the workplace is considered to be a key component of performance for the entire organization.
Error reporting	Fear of consequences can lead to • reduced reporting of errors and near misses; and • loss of opportunity for continuous improvement.	Develop a procedure for reporting incidents, errors, and near misses. Promote reporting of incidents, errors, and near misses.

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B.3.5 Ergonomics observation and recommendation Tools 20 to 24 — Cognitive ergonomics issues

Tools 20 to 24 are focused on those factors that can, and do, influence the decisions and actions of workers as a result of the impacts from the workplace on cognitive function. Setting the stage at the organizational level is vital to the success of any ergonomics improvement program.

Note: *For further information, see INPO 06-003 and Reason (2008).*

Tool 20a. Cognitive considerations

Consider the following questions when thinking of your workplace:

- what are the workplace objectives and are they clear to all;
- has the system been standardized;
- has a fail safe design been used;
- has system interactions been considered;
- what safety considerations have been made; and
- is there automation?

The workplace design and layout:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the workstation design, layout, or proposed solutions be examined in more detail?	No: end here	Yes: see Tool 20b

Note: *For background information, see Tool 20b.*

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Tool 20b. Cognitive considerations

Design factor	Why be concerned (consequences)	Recommendations
Objectives	Unclear system objectives lead to • decreases in system productivity; • wasted time; and • increased system waste.	Organization, systems, equipment, and facilities should provide work environments that • foster effective procedures, work patterns, and worker safety and health; • minimize factors that degrade human performance; • decrease error; • minimize requirements for operator workload, accuracy, mental processing, and communication that do not exceed operator capabilities; and • minimize personnel and training requirements.
Standardization	Non-standard equipment/controls lead to • increased error; • increased decision time; and • poor/incorrect decisions.	Ensure that controls, displays, marking, coding, labelling, and arrangement schemes (equipment and panel layout) are uniform for common functions of all equipment. Selecting "off-the-shelf" equipment should be based on the equipment conforming to identified standards.
Fail-safe design	Lack of a fails-safe design for critical systems can result in • injury to personnel; • catastrophic damage to equipment; and • inadvertent operation of critical equipment.	Provide a fail safe design in critical areas to prevent "run away" disasters that are the result of • incorrect system activation; • unforeseen events; and • natural disasters.
Interaction	Failure to consider personnel interactions in equipment design will result in loss of efficiency and potential for increase in error.	Design the system to reflect the interaction requirements of workers with equipment.
Safety	Lack of safety considerations increases the risk of an incident or injury.	Design applicable system to reflect personnel safety factors, including minimizing potential human error in the operation and maintenance of the system, particularly under the conditions of emergency or non-routine conditions.
Automation	Automation of process is not always the best option and can sometimes lead to new problems that did not previously exist.	Ensure that functions are automated only to attain greater overall effectiveness, efficiency, reliability, simplicity, economy, and system safety rather than relying on human performance alone. Ensure that the human operator is in control irrespective of the level of automation, and can be informed as to the status of automated functions.
Functional use of colour	In some systems, not distinguishing between similar object (displays, controls or equipment) could lead to • increased selection errors; and • increased waste.	Use colours for functional purposes (e.g., visual displays, controls, workspaces, equipment connections) where not in conflict with other legislative requirements. Accommodate users with colour deficient vision.

Source: *MIL-STD-1472.*

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Tool 21a. Cognitive considerations for tools and displays

Consider the following when thinking of your workplace:

- instrumentation or equipment that is out of service;
- non-functioning warning systems;
- nuisance alarms giving false negative indications;
- hidden system responses that prevent the distribution of critical information;
- unexpected equipment conditions;
- identical and/or adjacent displays and controls that lead to errors;
- poorly designed (confusing) displays or controls;
- overly sensitive equipment that could lead to system errors through inadvertent actions; and
- functional use of colour.

The workstation design and layout:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the workstation design, layout, or proposed solutions be examined in more detail?	No: end here	Yes: see Tool 21b

Note: *For background information, see Tool 21b.*

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Tool 21b. Cognitive considerations for tools and displays

Design factor	Why be concerned (consequences)	Recommendations
Out-of-service instrumentation or equipment	Uncorrected equipment deficiencies often lead to nonstandard actions in an attempt to comply with a requirement (often production) that can lead to • increases in errors, incidents, and injuries; and • decreased production.	Maintain and repair instrumentation and equipment that are essential to job performance on a priority basis. Identify appropriate workarounds and ensure the instrument or equipment is back into service as soon as practical.
Out-of-service warning systems	Lack of warning systems lead to • lack of key indicators in critical systems; • reduced workers to understanding equipment or system status; • indecision or incorrect decisions or behaviours resulting in system or personnel loss; and • increases in errors, incidents, and injuries.	Repair and verification of all warning systems should be on a priority basis.
Nuisance alarms	If allowed to persist, nuisance alarms can cause performers to ignore the alarm or adjust the alarm set point (cry wolf phenomenon).	Fix the underlying problem that is causing the alarm to trigger.
Hidden system responses	System responses that are invisible to individuals after input lead to • a lack of information conveyed to workers that previous action had any influence on the equipment or system; and • increased decision errors.	Provide system indicators where possible to remove hidden responses.
Unexpected equipment conditions	System or equipment status not normally encountered, creating an unfamiliar situation for the individual leading to • increases in errors, incidents, and injuries; and • wasted production.	Establish a clear protocol for unexpected equipment conditions such as "Stop and consult with management and/or system specialists to address the condition".
Identical and adjacent displays and controls	Depending on the design, identical adjacent displays can lead to an increase in error (e.g., an abnormal condition is present and the wrong system is identified).	Use shape and colour coding to distinguish displays and controls. Use human factors design principles to modify displays and controls to reduce error potential where this is practical.
Poor equipment sensitivity	Equipment that can be negatively impacted by inadvertent action can lead to • increases in errors, incidents, and injuries; • decrease production; and • increased production waste.	Use design solutions, such as guards and interlocks to prevent inadvertent operation.

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Tool 21b. (Concluded)

Design factor	Why be concerned (consequences)	Recommendations
Confusing displays or controls	Poorly designed displays and controls that are • missing or vague content (insufficient or irrelevant); • lack of indication of specific process parameter; • illogical organization and/or layout; and • insufficient identification of displayed process information can confuse or exceed the working memory capability of workers, leading to increases in errors, incidents, and injuries.	Use colour, shape, and labelling strategies to help reduce confusion. Re-organize displays and controls into logical groupings (e.g., displays and controls for a particular function should be grouped together). Fill in the gaps for missing information and provide clarification for any items that are vague.
Display design	When reading, responding to, and understanding displays is difficult, the risk of human error increases.	Digital displays should be used for readings that change with great frequency and/or where exact measurement is required. Analog displays are preferred for displaying trends (e.g., decelerating, rising, and falling). If immediate action is required, immediate auditory signalling should accompany visual display. A steady light represents a normal condition. A flashing light indicates a change. High priority displays are located at • horizontal level of the operator's eyes; and • slightly to the right or to the left of centre. Consider the contrast between the display text and its background (e.g., avoid blue or red background). Align dials so all pointers are positioned the same for "normal" conditions.

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Tool 22a. Cognitive ergonomics program

Does your organization have

- an operating experience (lessons learned) program;
- an effective training programs for new workers or new tasks;
- a self-assessment and corrective action programs; and
- a simple, effective process for managing work?

Are the workers

- familiar with the task, process, or system;
- required to use techniques not used before or only infrequently used;
- aware of critical parameters; and
- supported by appropriate accommodations with respect to physical and cognitive demands?

The workstation design and layout:	Is acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the workstation design, layout, or proposed solutions be examined in more detail?	No: end here	Yes: see Tool 22b

Note: *For background information, see Tool 22b.*

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Tool 22b. Cognitive ergonomics program

Design factor	Why be concerned (consequences)	Recommendations
Lessons learned program	Companies that do not take corrective steps after an incident will inevitably repeat them.	Distribute information about the event in a timely manner so corrective steps can begin. Task appropriate staff to determine how to prevent the incident from occurring again. Track safety metrics and add a best practices element to increase staff involvement in creating a safer, healthier work environment.
Effective training and retraining	Regardless of the perceived simplicity of a job, people cannot simply perform a job correctly and efficiently without training. Lack of training leads to increased errors, injures, and product waste.	Offer training, retaining, and refresher courses to prevent workers from developing bad habits that increase errors, injures, and product waste.
Self-assessment	Lack of formal, or informal, processes of identifying one's own opportunities for improvement by comparing present practices and results with desired goals, policies, expectations, and standards can lead to deterioration in performance.	Implement corrective actions that have been identified in event investigations, trend reviews, and other deficiency management processes to ensure that organizational performance is continuing to improve.
Work management	Lack of effective work management leads to misunderstandings, poor communication practices, workers making assumptions, and decisions on the fly, all of which lead to an increased potential for error.	Establish and use effective work management processes as outlined in this Standard, starting with the basic framework of Plan-Do-Check-Act.
Familiarity and knowledge	Knowledge is the combination of training received and experiences. Users facing new tasks, or new users who are not familiar with a task, will be less likely to perform the task, at an optimal level, which will increase errors, increase product waste, decrease production levels.	Ensure that all workers are fully qualified for the roles they are expected to perform. Use selection processes, training, and experience-based learning opportunities to ensure competence. Maintaining and increasing knowledge is necessary to achieve continual improvement. Provide problem solving training to extend knowledge and skill base and provide opportunities to practice problem solving in a non-threatening environment. Provide training and experience to increase competence and move the worker from knowledge-based performance to skill-based performance. Alternately, provide verbatim procedures to established rule-based behaviour when skill-based performance achievement is impractical. Teach effective problem solving strategies for cases where rule-based performance is impractical.

(Continued)

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Tool 22b. (Concluded)

Design factor	Why be concerned (consequences)	Recommendations
Frequency of use/rehearsal	Lack of frequency of use or lack of rehearsal with infrequently used processes will result in increased error.	Provide opportunities to rehearse infrequently used processes or provide step-by-step procedures and drills with place keeping strategies built in.
Critical parameters	Any equipment whose failure results in a plant shutdown, a loss of generation, a loss of an important safety function, or otherwise degrades the ability to monitor or control safety or generation functions.	Ensure critical parameters (critical components, systems, or processes) are well documented and understood by all. Establish detailed procedures with place-keeping steps clearly delineated. Train workers in the use of self-check tools.
Appropriate accommodations	A person's cognitive ability can be affected by sickness, disease, debilitating injury, lack of sufficient rest, or other life events that might need to be accommodated.	Where possible, modify job demands/design. Be sensitive to worker state of health and well-being. Ensure that workers take appropriate time and are given appropriate support for a full recovery before returning to full duties. Provide assistance to workers to help them recover from the event. Do not assign stressed worker to sensitive or error prone tasks until fully recovered.

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Tool 23a. Organizational performance factors

Does your organization suffer from any of the following negative performance factors:

- limited perspective;
- factors affecting decision making; and
- organizational factors that contribute to stress?

The performance factors:	Are acceptable ❑	Needs improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the workstation design, layout, or proposed solutions be examined in more detail?	No: end here	Yes: see Tool 23b

Note: *For background information, see Tool 23b.*

Tool 23b. Organizational performance factors

Design factor	Why be concerned (consequences)	Recommendations
Limited perspective	Limited-perspective bias is a human tendency to overestimate the completeness of what we know and to act on our own (limited) perspective of what is important. This bias contributes to ineffective decision-making.	Increase awareness associated with biases. Solicit input from independent sources to limit the bias affect.
Excessive cognitive demands	When workers simultaneously perform multiple tasks, they sometimes cannot • perform all the task adequately or correctly; • miss cues about their performance; and • detect other relevant information about their workplace.	Do not overload the workforce with complicated tasks. Make sure they use different mental faculties for tasks that must be combined (i.e., hearing combined with seeing, not two visual tasks). Complicated tasks that must be combined should be done when employees are the most rested. Ensure that if tasks are combined, employees know which are the most important tasks or components.
Excessive short-term memory demands	Short-term (or working) memory is severely limited and is degraded further in stressful situations. Working with similar data (i.e., two different set of numbers) will cause interference	Provide memory prompts to reduce the workload on the short term memory, especially in stressful situations. Develop training to allow workers the time to rehearse data that must be remembered to increase their ability to encode the information into long-term memory, where it can be retrieved when needed.

(Continued)

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Tool 23b. (Concluded)

Design factor	Why be concerned (consequences)	Recommendations
Factors affecting decision making	Situations that seem similar due to initial or common stimulus require drastically different responses. Similar layouts on different pieces of equipment can lead to incorrect choices. There is a tendency for people to give more weight to information received first. There is a tendency for people to favour information that confirms initial hypotheses regardless of whether the information is true. A tendency for the mind to seek out recognizable patterns in an attempt to quickly find a solution. Assumptions made without verification of facts, often based on perception of recent experience, or the challenge to perceive all facts pertinent to a decision often lead to an incorrect hypotheses or poor mental model selection.	Increase awareness regarding biases. Use colour coding, shape coding, and labelling to help correct this bias. Re-design the layout if other strategies do not work. Use a second party, independent verification strategy to help overcome this bias. Ensure the system is designed so that procedures are followed in the order intended (e.g., use checklists). Use independent verification process to counteract assumptions. Emphasize the need to stop and reconsider work patterns when assumptions cannot be supported by existing information.
Organizational factors that contribute to stress	Stress can involve anxiety, reduced attention, reduced working memory, poor decision-making, transition from accurate to fast; degree of stress reaction depends on an individual's experience with the task.	Recognize the factors that contribute to mental stress. Recognize the signs and symptoms of stress. Plan and organize work load to help reduce stress. Provide support, including recommending professional guidance to individuals who are suffering from stress.

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Tool 24a. Cognitive task demands

Does your organization have the following:

- time pressure imposed on workers;
- high workloads or high memory requirements;
- simultaneous/multiple tasks that have to be performed;
- excessive communication requirements;
- confusing procedures or vague guidance on how to use procedures;
- repetitive actions or monotonous work;
- delays or excessive idle time associated with the work;
- a complex work, process, or system with high information flow demand;
- a long-term monitoring task; and
- tasks on which workers need to spend excessive time?

The task demands:	Are acceptable ❑	Need improvement ❑
What *specific* improvements or remedial actions have been made?	What *specific* improvements still need to be made?	
Should the workstation design, layout, or proposed solutions be examined in more detail?	No: end here	Yes: see Tool 24b

Note: *For background information, see Tool 24b.*

Tool 24b. Cognitive task demands

Design factor	Why be concerned (consequences)	Recommendations
Time pressure	Urgency or excessive pace while performing actions or task with no spare time can lead to • increase stress on the worker; • shortcuts and a degradation in the quality of work; and • increase in production waste.	Plan and schedule work to ensure that there is sufficient time to complete tasks. Have an effective change management strategy to react to unexpected conditions that can lead to time pressure.
High workload high memory requirements	Mental demands on individual to maintain high levels of concentration such as scanning, interpreting, deciding, while requiring recall of excessive amounts of information (either from training or earlier in the task) can lead to a higher number of errors and forgetting.	Use work planning to reduce and balance work load. Use memory aids such as checklists to assist in completing complex tasks. Where high memory requirements cannot be changed, ensure system design uses error reducing strategies such as shape and colour coding.

(Continued)

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Tool 24b. (Concluded)

Design factor	Why be concerned (consequences)	Recommendations
Simultaneous / multiple tasks	The performance of two or more activities, either mentally or physically, results in divided attention, which can lead to mental overload or reduced vigilance on one or the other task.	Assign two workers where possible. Plan to ensure that tasks are divided where possible. Arrange tasks such that if a single worker must perform different tasks, they require different sensory modalities (i.e., hearing and seeing), and that the worker knows which of the tasks are more important.
Excessive communication requirements	When workers cannot process all information required, they are more likely to make errors or make incorrect decisions.	Use work planning to reduce communication load. Use communication protocols such as priority codes to assist in prioritization of communication load.
Confusing procedures or vague guidance on how to use procedures	Errors resulting from procedures that are not well written and are difficult to follow. Vague guidance refers to imprecise instruction or information exchange. This can be either written or verbal.	Identify, clarify, document, and communicate.
Repetitive actions or monotonous work	Repetitive actions or monotonous work can lead to an inadequate level of mental activity, which can lead to missed signals and decreased job vigilance.	Use job rotation and job sharing to break the task into segments. Encourage regular work breaks to help maintain vigilance when it is possible.
Delays or excessive idle time	The longer work is delayed, the greater the time between task instruction and task completion and thus the greater the potential for error.	Use work planning to fill in idle time with alternate work tasks. Use idle time between tasks for work planning, training, and practice.
Complex work, process or system, and high information flow demand	Mental demands on individuals to maintain high levels of concentration; (e.g., scanning, interpreting, deciding) while requiring recall of excessive amounts of information can increase the chances of errors and production waste.	Plan to reduce complexity. Provide tools to assist in dealing with complex tasks. Re-design the process or system to simplify if that is an option.
Long-term monitoring task	Long-term monitoring tasks can lead to boredom, static posture fatigue, and general lethargy (low level of alertness), which, in turn, can increase error potential.	Use job rotation and job sharing to break the task into segments. Encourage regular work breaks to help maintain vigilance when it is possible.
Spending excessive time on a task	Depending on the nature of the task, spending excessive time on a task can lead to fatigue, boredom, lethargy, or a drive to complete the task that possibly can lead to cutting corners or taking shortcuts.	Use job rotation and job sharing to break the task into segments. Encourage regular work breaks to help maintain vigilance when it is possible.

B.4 Summary

Table B.4 provides a tool to summarize observations.

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Table B.4
Summary of observations
(See Clauses B.1.2 and B.4.)

Work station/job: _____

Date: _____

	Item	Current situation			Future Actions	
Observation headings applicable	**Not Applicable**	**Acceptable**	**Actions taken**	**Needs improvement**	**Acceptable None req.**	**Needs more analysis**
1. Workstation — Design and layout						
2. Posture — Sitting						
3. Posture — Working while standing						
4. Posture — Neck, shoulders, and back						
5. Posture — Elbows, forearms, hands, and wrists						
6. Posture — Other positions/postures						
7. Repetition						
8. Displays, equipment, and tools						
9. Force — Lifting						
10. Force — Carrying						
11. Force — Pushing/pulling						
12. Force — Vibration						
13. Work environment — Effects of noise on performance						

(Continued)

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Table B.4.4 (Concluded)

	Item	Current situation			Future Actions	
Observation headings applicable	**Not Applicable**	**Acceptable**	**Actions taken**	**Needs improvement**	**Acceptable None req.**	**Needs more analysis**
14. Work environment — Temperature						
15. Work environment — Lighting						
16. Personal protective clothing and equipment						
17. Computer or monitor work						
18. Work organization/stressors — Time issues						
19. Work organization — Work demands and worker control						
20. Cognitive considerations						
21. Cognitive considerations for tools and displays						
22. Cognitive ergonomics program						
23. Organizational performance factors						
24. Cognitive task demands						

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