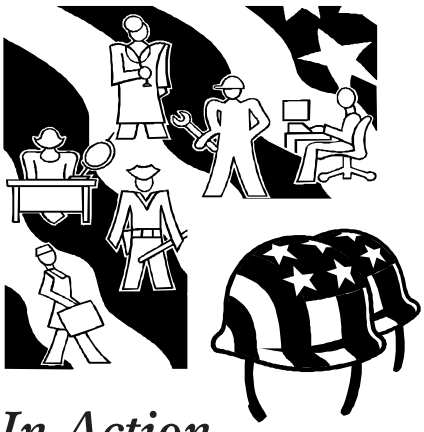
Ergonomics



In Action

Booklet II

Worksite Analysis

Worksite Analysis Overview

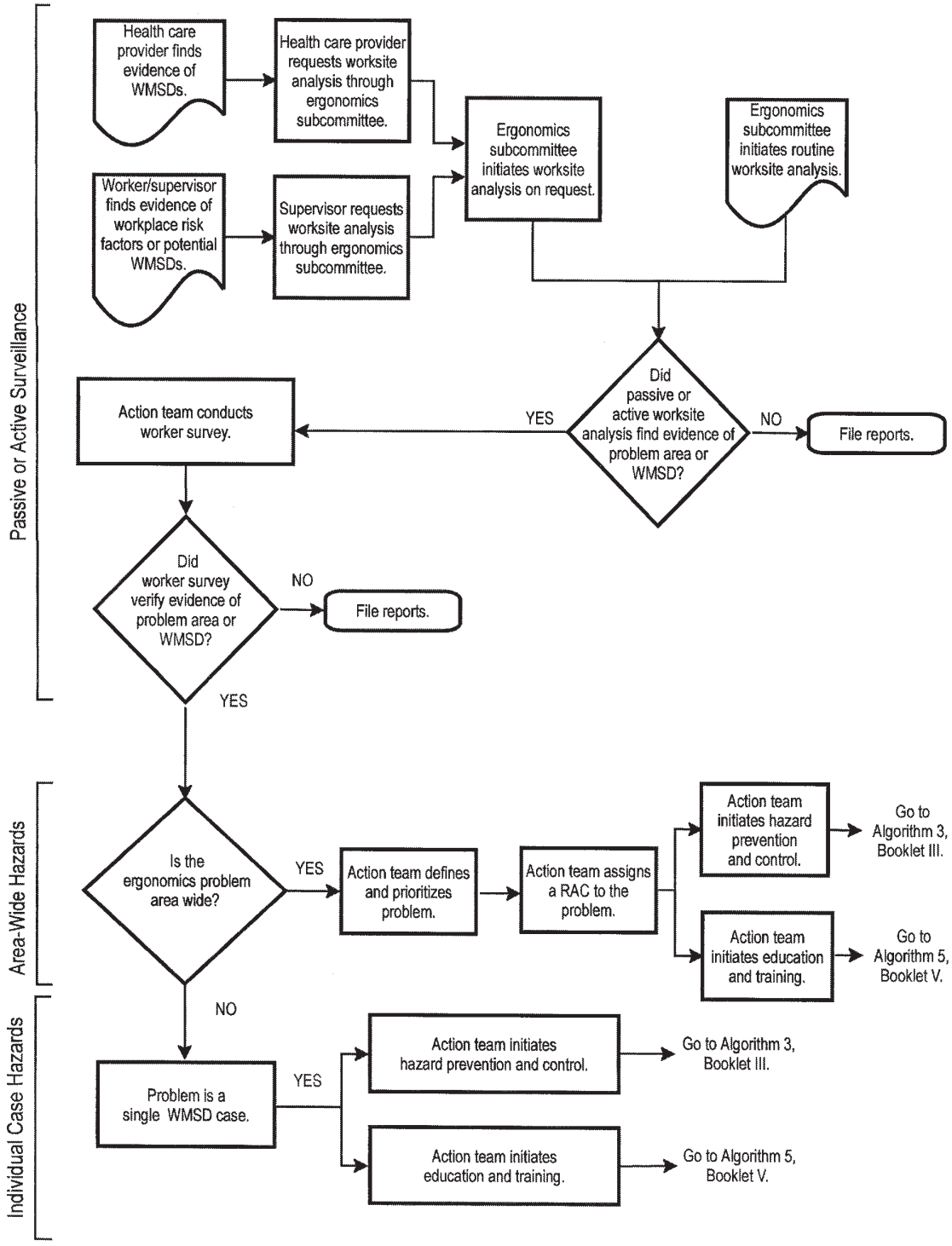
The key to successful ergonomics programs are organized, orderly, and guided analyses. Work-related musculoskeletal disorders (WMSDs) can be reduced and ultimately prevented with effective surveillance. Regardless of your installation's mission, you should implement worksite analysis using the information presented in this guide. The ergonomics subcommittee, an action team, health care providers, management, and employees must join forces to perform this analysis.

Conduct passive or active worksite surveillance
 	
Passive surveillance is the systematic analysis of data provided in existing reports and data sources such as routine injury reports, OSHA logs, medical and safety records, workforce reports, and employee suggestions.
 	
Active surveillance involves actively seeking information to target and assess problematic work areas, job series, and tasks.
	• There are three entry points to passive or active surveillance.
	  • Health care providers who are treating a worker with a suspected WMSD request analysis of the worksite through the ergonomics subcommittee.
	  • Supervisors who are concerned about possible workplace risk factors or potential WMSDs in their work area request analysis of the worksite through the ergonomics subcommittee. Supervisors may also contact the ergonomics subcommittee on behalf of workers who have similar concerns.
	  • The ergonomics subcommittee initiates routine worksite surveillance, either passive or active. Under either surveillance method--
	  • If no evidence of problem areas or WMSDs is found, a routine report is filed.
	  • If there is evidence of a potential problem area, or even one WMSD is found, the ergonomics subcommittee forms an action team to conduct a focused (in-depth) assessment of the work environment.
	• To complete assessment of the work environment and to verify if there is evidence of a problem area or WMSD, the action team conducts a worker survey (e.g., the Job Requirements and Physical Demands (JR/PD) Survey) to obtain information on current and past symptoms, including the anatomical location, duration, intensity, and frequency of symptoms.
	  • A worker's response to a body part discomfort survey may vary over time; however, when worker responses are grouped by work area or job series, the group's responses over time are usually stable.
	  • These surveys can also identify problem tasks, tools, or work areas, and can be used to assess the effect of ergonomic interventions.
	  • If no evidence of problem areas or WMSDs is found, a routine report is filed.
	• If there is evidence of a potential problem area, or even one WMSD is found, the action team should use the results of the JR/PD Survey to determine if the problem is limited to one individual case or is area-wide.

Assess area-wide hazards	If the ergonomics problem is area-wide, the action team—
	• Defines and prioritizes the problem by its severity or magnitude.
	• Assigns a risk assessment code (RAC) to the problem.
	  • The RAC describes the level of risk associated with an ergonomic hazard, and combines the hazard severity and mishap probability into a single numeral.
	  • The RAC, coupled with the costs associated with any given intervention method, establishes the priority of the problem area.
	• Initiates hazard prevention and control. See Algorithm 3 in Booklet III.
	• Initiates education and training, including job-specific training and an overview of interventions being implemented. See Algorithm 5 in Booklet V.

Assess individual case hazards	If the ergonomics problem is related to one individual case, the action team— • Focuses on the work task(s) causing the WMSD to determine if the task under normal stressors would cause the WMSD, or if the individual affected by the task has special needs (e.g., obesity, existing handicap, etc.), which the action team will also need to address. • Defines and prioritizes the immediacy of the problem by asking: "What costs does the WMSD present in terms of compensation, worker error, decreased productivity, and worker morale?" • Initiates hazard prevention and control. See Algorithm 3 in Booklet III. • Initiates education and training, including job-specific training and an overview of interventions being implemented. See Algorithm 5 in Booklet V.

Algorithm 2. Worksite Analysis



Contents

Booklet II prepares you for actual surveillance; discusses issues relevant to the analysis of the worksite, the task, and the tools and equipment; and offers tables, figures, and checklists to assist you in the analysis process.

Worksite Analysis

BOOKLET II

PART I: GENERAL

The key to successful ergonomics programs are organized, orderly, and guided analyses. Worksite surveillance is the ongoing systematic collection, analysis, and interpretation of health and exposure data used to identify, record, and track work-related musculoskeletal disorders (WMSDs). Effective surveillance can help reduce and prevent WMSDs if it is used to determine the need for action, and to plan, implement, and evaluate ergonomic interventions and programs.

Worksite analysis includes both passive and active surveillance. These analyses target problem work areas, job series, and tasks for in-depth assessment and intervention.

Passive Surveillance

Passive surveillance is the systematic analysis of data provided in existing reports and data sources such as routine injury reports, logs, summaries of occupational injuries and illnesses, Federal Employees Compensation Act (FECA) claims, medical and safety records, and workforce reports and suggestions. Some of the best sources of data for trend analyses and the identification of work-related problems include:

- Log of Federal Occupational Injuries and Illnesses (OSHA 200).
- Health clinic records.
- Workers' compensation records.
- Industrial hygiene/safety reports.
- Accident reports and insurance claims.

Supervisors, the ergonomics subcommittee, health care providers, and trained ergonomics personnel should collect and analyze these data routinely (e.g., quarterly), depending on the risk of injury. Classifying the WMSD according to the current International Classification of Disease (ICD) codes is common and allows comparisons among work areas, job series, and tasks.

ICD-9 codes are three-part codes that classify not only the activity at the time of injury, but also intent and location. An up-to-date list of ICD-9 codes associated with cumulative trauma and work-related conditions is available from USACHPPM, ATTN: MCHB-DC-OER, Stark Road, Bldg. E-1570, Aberdeen Proving Ground, MD 21010-5403. Or contact the Ergonomics Program Manager at DSN 584-3928; commercial 410-436-3928.

In the glossary:
- ✓ worksite analysis
- ✓ passive surveillance
- ✓ work-related musculoskeletal disorders

Incidence, prevalence, and severity rates are based on 100 worker-years per year. The rates should be calculated for all WMSDs. To target specific problem areas or jobs, categorize the rates by body part for each department, job series, work area, or process to target specific problem areas or jobs.

While the DOD recommends calculating rates monthly, the timeframe for calculating rates is a local decision.

Type	**Rate** (per 100 worker-years per year)	**Numerator/Denominator**
New Cases	Incidence	$\frac{\text{\# new cases during the past 12 months X 200,000 hours}}{\text{\# work hours during the past 12 months*}}$
All Cases During Period	Prevalence	$\frac{\text{total \# cases in the past 12 months X 200,000 hours}}{\text{\# work hours during the past 12 months*}}$
All Cases Resulting in Lost Workdays	Severity	$\frac{\text{\# of lost workdays during past 12 months X 200,000 hours}}{\text{\# work hours during the past 12 months*}}$
* If the specific number of work hours during the past 12 months is not available, multiply the number of full-time equivalent employees in each area by 2,000 hours to obtain the denominator.		

The following example illustrates the information presented in the above table:

- Work area Y has 30 full-time workers. Over the past 12 months, 4 workers have developed WMSDs, bringing the total number of workers with WMSDs to 7. There were a total of 45 lost workdays over the past year due to WMSD conditions.
- To calculate the incidence rate:

  $$\frac{\text{4 cases X 200,000 hours}}{\text{(30) X 2,000 hours}} = \text{13.3 cases per 100 workers}$$

- To calculate the prevalence rate:

  $$\frac{\text{7 cases X 200,000 hours}}{\text{(30) X 2,000 hours}} = \text{23.3 cases per 100 workers}$$

- To calculate the severity rate:

  $$\frac{\text{45 lost workdays X 200,000 hours}}{\text{(30) X 2,000 hours}} = \text{150 lost workdays per 100 workers}$$

In the glossary:
✓ incidence rate
✓ prevalence rate
✓ severity rate

Passive surveillance is limited by the quality of collected data. Data may be incomplete, inaccurate, or inconsistent. Data quality can be affected by management's attitudes, perceived or real disincentives to reporting, training provided to the personnel responsible for data input, different coding systems and differences in medical practitioners' diagnoses. Under-reporting of conditions can be a serious problem. Many workers delay seeking medical care and reporting conditions until the condition has become functionally limiting.

Active Surveillance

Active surveillance involves actively seeking information to target and assess problematic work areas, jobs series, and tasks. The advantage this method offers over passive surveillance is a greater degree of sensitivity, which can help identify symptoms that indicate early or developing WMSDs. Early intervention or prevention programs can be more focused and effective with active surveillance.

For example, the action team can use worker surveys to obtain information on current and past symptoms, including the anatomical location, duration, intensity, and frequency of symptoms. Worker surveys and questionnaires—

- Are generally easy and inexpensive to administer.
- Provide a quick way to identify workers' perceptions of discomfort and the sources of discomfort.
- Identify problems that otherwise might go unreported.

Refer to appendix A for a sample of the risk factor/ discomfort survey being used by the DOD.

Worker surveys should be conducted when—

- Passive surveillance indicates an increase in WMSDs.
- Before and after the initiation of new jobs, tasks, tools, or processes.
- When a worker is hired or transferred in order to establish a baseline.

Active surveillance worker surveys are limited by the workers' comprehension of the survey purpose and questions (including language barriers with some non-English-speaking workers) and the accuracy of the workers' responses. Researchers have found gender, age, and cultural biases in reporting symptoms in worker surveys. Questions have been raised about the effect of repeatedly using the same questionnaire for the same worker population; however, no controlled study addressing these questions has been conducted.

In the glossary:
✓ active surveillance
✓ work area

An individual worker's response to a body part discomfort survey may vary over time; however, when worker responses are grouped by work area or job series, the group's responses stabilize over time. These surveys can identify problem tasks, tools, or work areas and can be used to assess the effect of ergonomic interventions.

Risk Factors. Walk-through surveys to identify risk factors associated with WMSDs are another form of active surveillance. Researchers have identified risk factors that should trigger further assessment and intervention. The following are examples of risk factor triggers:

- Performance of repetitive motion or a motion pattern every few seconds for more than 2 hours at a time.
- Practice of fixed or awkward postures for more than a total of 2 hours during a work shift.
- Use of vibrating or impact tools or equipment for more than a total of 2 hours during a work shift.
- Use of forceful hand exertions for more than a total of 2 hours at a time.
- Unassisted frequent or heavy lifting (e.g., greater than 25 pounds) for more than a total of 1 hour.

PART II: PERFORMING THE ASSESSMENT

Getting Started

Effective surveillance can help reduce and prevent WMSDs if it is used to determine the need for action, and to plan, implement, and evaluate ergonomic interventions and programs.

Regardless of your installation's mission, there are three entry points to passive or active surveillance.

- Health care providers who are treating a worker with a suspected WMSD should request analysis of the worksite through the ergonomics subcommittee.
- Supervisors who are concerned about possible workplace risk factors or potential WMSDs in their work area should request analysis of the worksite through the ergonomics subcommittee. The supervisor may also contact the ergonomics subcommittee on behalf of a worker who has similar concerns.

If a private physician is examining/treating a worker with a suspected WMSD, refer to Booklet IV for detailed information on communicating with the Civilian Personnel Advisory Center (CPAC).

Figure 1 illustrates the what, who, how, and when for each surveillance or analysis method.

- The ergonomics subcommittee initiates routine worksite surveillance, either passive or active.

Setting Priorities

The presence of any risk factor(s) or even one WMSD requires further investigation, a detailed job analysis, and intervention. When prioritizing jobs or work areas for in-depth assessment and intervention, consider—

- The number of workers affected.
- High incidence or prevalence rates.
- Case severity.
- Exposure time of risk factors.
- Reported/unreported symptoms.

Jobs undergoing major changes in process or products, or where the interventions can be easily accomplished, should also receive priority consideration.

Symptoms of WMSDS are best measured by conducting a Job Requirements and Physical Demands (JR/PD) survey. Appendix A includes a sample of the DOD JR/PD survey that the action team can use to assess workers' job requirements and physical demands.

NOTE: If the work area poses no risk to the "typical" worker (e.g., someone who is not bothered by the normal physiological stress found in the work area), then the action team should manage the problem as a single WMSD case, and provide special accommodations for a worker whose tolerance capacity is below the level necessary for a specific work area (e.g., due to a previous injury, medical condition, or extreme anthropometric limitations).

Basic Work Area Information

The action team should initially collect descriptive work area information, including the demographics of the workers, the tasks performed in the work area, the products produced in the work area, and the specifics of the workstation.

- **Demographics**. Demographic information should include:
  - Number of workers assigned to the area or job series.
  - Age and gender distribution of the workers.
  - Length of the workday and daily break schedule.
  - Any special administrative arrangements such as job rotation plans or flex schedules.
  - Length of time at a particular task or job.

Figure 1. Analysis Process Factors

Variable	What	Who	How	When
Passive Surveillance	Existing data analysis	• Ergonomics subcommittee • Action team • Health care providers • Management • Employees	Data analysis • Incidence rates • Prevalence rates • Severity rates • OSHA 200 log • Compensation cases	Local decision (i.e., quarterly)
Active Surveillance	Worker surveys and questionnaires	• Ergonomics subcommittee • Action team • Management • Employees	Worker group targeted by job series, area, or task	Local decision • One WMSD, so survey to define the extent of the problem • Potential problem identified through complaint, supervisor report, or walk-through inspection • After training • With newly assigned personnel • With change in job, task, tools, or processes
	Identified workplace risk factor(s)	• Ergonomics subcommittee • Action team • Supervisor • Worker groups	• Direct observation • Checklist	Local decision • Periodically • With change of new process, equipment, or task
Prioritization and Problem Determination	• Prioritization of ergonomics concern for in-depth analysis and intervention • Determination of area/job series-wide problem *vs* individual WMSD case	• Ergonomics subcommittee • Action team • Health care providers • Management • Supervisor	Local criteria, such as: • Cost • Number of workers affected • Severity • RACs	Local decision • Within 1 week of problem determination
High-Risk Targeting (if needed)	Identification of high-risk components of complex jobs or work areas	• Ergonomics subcommittee • Action team • Supervisor • Worker (focus) groups	• Review of documents (job descriptions, safety reports) • Focus group discussions	Local decision • Based on prioritization, but not more than 2 weeks after prioritization
Assessment Method Determination and Investigation	Decision on method of assessment • Checklist • Risk factor assessment • In-depth survey	• Ergonomics subcommittee • Action team • Management • Supervisor	Local decision based on criteria, such as: • Complexity • Criticalness of problem	Local decision • Based on prioritization, but not more than 2 days after high-risk targeting

- **Tasks**. Task-related information should include:
  - Description of the task.
  - Task objective.
  - Percentage of the day spent performing the task.
  - Task pacing (e.g., continuous or intermittent, machine-paced, or self-paced).

- **Products**. If a specific product is produced, the action team should identify:
  - Weight and dimensions.
  - Cost of producing a unit.
  - Production rate and quotas.
  - Error rate and any error penalties for the workers.

Targeted Assessments

The action team should conduct an in-depth assessment of the work environment once problem areas or job series have been identified and prioritized. The four basic components of the work environment — the workstation and physical environment; specific tasks; tools, equipment, and containers used in performing the tasks; and employee characteristics — are outlined in the following table.

Workstation and Physical Environment Features	Task Features	Tools, Equipment, and Containers Features	Employee Characteristics
Benches Chairs Checkout stand Controls and displays Lighting Mats Noise level Shelves Stools Storage bins Tables Temperature Vehicle cab	Job content (simple, routine, or complex, variable) Level or amount of autonomy Pacing Training Work scheduling	Assembly parts Boxes Components Hand tools Keyboards Machines Power tools	Anthropometric dimensions Endurance Range of motion Strength Sensory status (visual, tactile, perception)

In the glossary:
- ✓ workstation
- ✓ task
- ✓ physical environment
- ✓ tools, equipment, and containers

Many methods are available for assessing the work environment. If the worker performs only a few distinct tasks daily, the assessment can be easily focused on these tasks. If the job is variable (i.e., there are a variety of tasks that may be performed by the worker), the action team must go through a high-risk task focusing process.

High-Risk Task Focusing. Many jobs require high-risk task focusing. For example, mechanics generally have a high rate of back injuries. However, assessing mechanics' jobs is problematic due to the random order of the wide variety of tasks they perform. These tasks are based on the repair needs of the vehicles or machinery and the variety of work techniques used among the workers. The task-focusing process uses information from the workers' job descriptions, injury report data, and the input of the workers. The process involves classifying and subclassifying workers to a level where most of the workers in the group are exposed to the same risk factors.

Data can be gathered by questionnaire for larger groups, but smaller focus groups are more effective when identifying high-risk tasks. Once the action team establishes similar exposure groups, a select number of "experts" from that group are chosen to identify the high-risk tasks. The size of the group depends on the size of the work force and the expertise of the workers.

The workers should be asked to identify major problem areas, physically demanding high-risk tasks, workstation design problems, and tool and equipment concerns. Focus the discussion by asking about specific elements of the job description (e.g., the requirement to occasionally lift 75 pounds) and injury histories. The workers' familiarity with the job is critical. The entire exposure group of workers should then receive training in the risk factors for WMSDs and typical workstation problems, concerns, and solutions.

Site Analysis

Once a small number of high-risk tasks, workstation design problems, or tool and equipment concerns have been identified, the assessment process becomes straightforward. All of the ergonomic assessment methods focus on the basic risk factors of awkward posture, repetition, duration/recovery time, mechanical compression, vibration, force, and temperature extremes. The risk for developing a WMSD increases as exposure to a single risk factor or a combination of risk factors increases.

Checklist Assessments

There are a variety of checklist assessments available for the action team. Checklists can be used in regular, periodic surveys, or to initially assess high-risk work areas and tasks. Most of these checklists address the basic recognized risk factors and have a scoring mechanism to quantify risk. Checklists are quick, easy-to-use assessments and require a minimum of training. However, checklists are limited by a narrow focus on common risk factors and do not cover the entire spectrum of risk factors that may be present at a specific worksite. Some of the checklists focus on a specific element of the work environment, such as a particular tool or the chair. Other checklists examine posture, repetition, and duration factors.

Refer to Appendix B for several sample checklists.

Refer to Booklet V for more information on training requirements under the ergonomics program.

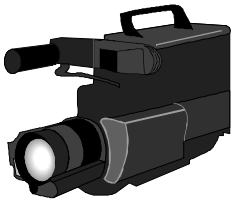
In the glossary:
✓ high-risk task focusing

USACHPPM has developed an inclusive survey form for use during detailed assessments. This form is available from the Ergonomics Program Manager at DSN 584-3928; commercial 410-436-3928; or by writing to USACHPPM, Attn: MCHB-DC-OER, Stark Road, Bldg. E-1570, APG, MD 21010-5403.

Detailed Assessments

The action team should have several tools available for the detailed assessment, including a—

- Video camera to record workers' postures and movements during specific tasks.
- Tape measure to capture workstation dimensions and reach distances.
- Timer or stopwatch to measure the duration of a specific task, subtask, or break from the task.
- Force gauge or spring scale to measure push or pull forces or the weight of tools, products, or objects.



The videotape is an essential tool in the assessment process. The tapes provide a permanent record of the activity and allow the ergonomist to assess motions and postures in slow motion. Videotapes also serve to enhance ergonomic training and demonstrations.

Conduct the following actions during the pre-survey:

- Check equipment.
- Obtain approvals and schedule taping.
- Verify presence of electrical outlets, if needed.
- Verify lighting conditions and bring lighting equipment, if needed.
- Use a tripod to support the camera, if needed.

Conduct the following actions during the survey:

- Identify the video segment on a piece of paper, and film this piece of paper for 3 seconds at the beginning of the video.
- Activate the time/date indicator if the camera has this feature.
- Select views that will maximize description of movement.
- Record the worker's whole body posture and entire work area initially.
- Select views 90° from each other.
- Film at least 10 cycles if the job is repetitive.

- If several people perform the job, film two to three employees doing the same job.

- Focus on overexertion or fatigue conditions.

- Frame each view with common reference points.

- If multiple tasks are involved in a process, tape the tasks in order.

Thorough planning before the site survey is critical. Action team members should be assigned specific tasks, including:

- Taking workplace measurements.

- Interviewing supervisors and workers.

- Sketching and note taking. Make sure to note the locations of equipment, fixtures, etc., on the sketch, and identify:
  - Dimensions of surfaces.
  - Reach distances.
  - Clearances.
  - Travel distances.

- Videotaping.

- Identifying and measuring risk factors.

Schedule the survey when the tasks of interest are being performed and subjects are available. Every effort must be made to minimize disruption to the workplace and record a representative "picture" of the tasks.

Sampling Strategies

The action team determines the most appropriate sampling strategy for the tasks of interest. Sampling strategies may be classified as:

- Random interval sampling, or observing/evaluating the worker(s) at randomly selected time intervals (e.g., 15-, 22-, and 61-minute intervals).

- Fixed interval sampling, or observing/evaluating the worker(s) at specific time intervals (e.g., every 30 minutes).

- Selected interval sampling, or observing/evaluating the worker(s) at a specific time during the day or during a specific task/subtask.

- Continuous sampling, or observing/evaluating entire work processes.

The type of work performed, the variability of subtasks, the objectives of the assessment, and methodological constraints determine the choice of sampling strategies. Continuous sampling is the most involved approach and requires sophisticated instrumentation and computer assistance. However, this approach provides the most accurate and meaningful data, including an estimate of the percentage of time the worker spends in an awkward posture, in a repetitive activity, applying force, exposed to vibration, or using a particular tool or piece of equipment. In most instances, fixed or selected interval sampling of target high-risk tasks will provide sufficient information for the worksite assessment.

Special Task Features

The action team should assess the special features of the task, including the use of hand tools, gloves, prolonged standing, prolonged sitting, and materials handling. Each is discussed below. These special features also include exposure to vibration and poor lighting conditions, which are discussed later as biomechanical/environmental risk factors.

Hand Tools. Hand tools are used in numerous jobs. Poorly designed tools that require the employee to assume awkward postures, apply excessive force, or perform the same motion repeatedly, can be particularly problematic. These tools can stress the entire upper extremity and contribute to WMSDs.

Gloves. Gloves are required in certain work areas to protect the hands from physical hazards including chemicals, temperatures, abrasives, and biological contaminants. Management should review each work area's personal protective equipment (PPE) hazard assessment document, which is an OSHA requirement established in 29 CFR 1910.132(d), to determine if gloves are required, and if so, what type.

Gloves reduce dexterity and tactile feedback, causing the worker to increase his or her grip force. Working with tight-fitting gloves or bulky gloves also increases the force applied. Proper fitting gloves in good repair that provide the required protection are critical. The action team should assess the function, condition, type, and fit of work gloves.

Prolonged Standing. Prolonged standing, especially on a hard surface, increases lower extremity and back discomfort. If prolonged standing is required, assess the standing surface, shoes, and activity. Antifatigue matting should be at least ½-inch thick and made of a firm, resilient material. There are a wide variety of mats available to accommodate specific workplace requirements (e.g., water drainage, antistatic, or chemical resistance). If standing and moving is required, assess the workers' shoes for cushioning.

Task requirements during standing should be noted, especially any requirement to operate foot pedals. Using foot pedals while standing causes extreme and awkward hip and back postures. The team should also note if a sit-stand stool would be feasible given the work situation and task requirements.

Prolonged Sitting. Prolonged sitting can lead to back and lower extremity problems, especially when the chair does not properly fit the worker or the type of work.

Appendix B contains a sample chair evaluation checklist.

Materials Handling. Materials handling problems can be assessed in a variety of ways. Generally, a combination of these methods provides a more complete picture of the problem. These methods include checklists and standardized assessments of the task and workstation. The critical factors in any assessment of a materials handling task include:

Appendix C presents a discussion of the NIOSH Lift Equation and the Lift Index.

- Distance of the load from the spine and distance of the load from the floor. As the load moves away from the spine and above or below the critical "strike zone" between the thighs and shoulders, the biomechanical stress on the worker increases greatly, also increasing the risk of injury.

- Twisting involved in the task. Any twisting decreases the stability of the spine, increasing the probability of injury.

- Frequency and duration of the task. As the frequency and duration of the task increase, there is less time for the tissues to recover from the physiologic stress, again, increasing the probability of injury.

Energy Expenditure

The action team should assess the energy requirements of the work and determine if recommended energy levels are exceeded, requiring increased rest periods to recover from the physiologic stress.

Recommended energy expenditure limits are based on the daily workload. This workload should not exceed 35 percent of a person's maximum aerobic power over an 8-hour day. This represents approximately 5 kilocalories (kcal)/min for men and 3.35 kcal/min for women. The heart rate should not exceed 115 beats/min for aerobic exercise, 112 beats/min for leg work, and 99 beats/min for arm work.

In the glossary:
✓ kilocalorie

The table below presents approximate energy expenditure rates for various types of work. The table estimates are based on an average-size worker and should be adjusted for the individual worker's weight. For every 10 pounds the worker is overweight or underweight, 0.1 kcal/min should be added/subtracted. The actual energy expenditure of the worker depends on his/her health, experience, conditioning, and age.

Type of Work	Typical Task	Energy Expenditure (kcal/min)
Light hand work, sitting	Writing	1.6
Moderate hand work, sitting	Soldering	2.2
Moderate arm work, sitting	Hammering	3.0
Moderate body work, walking	Pushing wheelbarrow	5.0
Heavy arm work, standing	Sawing wood	6.8
Heavy body work, walking	Pushing manual lawnmower	7.7
Very heavy body work, standing	Chopping tree with ax	8.0
Very heavy arm work, standing	Shoveling continuously	8.5

Source: Sanders and McCormick, 1992.

Task Analysis

Task analysis includes many assessment methods that observe human behavior in a task and record task elements and demands. These elements and demands are compared to human capabilities to determine if modification, redesign, controls, or automation are required. Task analysis methods include:

- Motion analysis, which identifies excessive repetitions, and awkward and static postures.
- Timed activity analysis.
- Time and motion analysis.

In the glossary:
✓ task analysis

Task analyses break tasks down into component elements and may subdivide the elements to the motion or micro-motion level. There are five types of information used in task analyses:

- Sequence of activities.
- Duration of activities.
- Frequency of activities.
- Fraction of time (of a person, machine, or work unit) exposed to specific workplace risk factors or activities.
- Spatial movements.

One of the most useful approaches to ergonomic assessment combines the task analysis methodology with the approach that researchers recommend for ergonomic job analysis. The task analysis records the job, task, work cycle time, and specific component steps in the task. These component steps are then examined for workplace risk factors by affected body part. Other questions the action team may ask during a task analysis include:

- What is the task's name?
- What is the task's objective or end result?
- How many workers perform this task?
- How much of the day is spent performing the task?
- Is the task continuous or intermittent?

Risk Factor Considerations

Considering risk factors as part of the overall ergonomics assessment requires some qualitative expert judgment as well as comparing observations to specific criteria (e.g., joint angles — elbows, wrists, etc.). The duration of exposure to risk factors may also affect how you assess or correct ergonomics problems. However, no specific guidelines exist on duration, though a number of scientifically validated thresholds and many expert opinions are available. Therefore, use your best professional judgment and remember:

- Duration is the amount of time a worker is exposed to the risk factor.
- Prolonged exposure increases local and generalized fatigue and tissue stress.
- As the duration of exposure increases, the required recovery period increases proportionally.

Workplace risk factors, as well as some environmental factors like temperature extremes and lighting conditions, are presented below.

Repetition. Repeated motions or tasks increase fatigue and muscle-tendon strain. Highly repetitive tasks often prevent adequate tissue recovery from the effects of awkward postures and force. A task is considered repetitive when the cycle time is less than 30 seconds or when one fundamental cycle constitutes more than 50 percent of the total cycle. The level of risk from repetition varies by body part.

Force. Forceful exertions increase the physiologic stress to muscles, tendons, and joints. Muscles fatigue faster as the force exerted increases. Force increases with—

- Object weight.
- Load distribution characteristics (shifting or bulky loads require more force exertion).
- Object friction (slippery objects or surfaces require more force).
- Awkward postures.
- Vibration (localized hand tool vibration increases grip forces).
- The type of grip (a pinch grip places three to four times more force on tendons than a power grip).

Figure 2 presents the optimal position and angle of various body parts during work activities. The figure also presents the angles at which body parts will experience minimum, moderate, and severe stress.

Posture. Awkward postures require increased muscle force; contribute to muscle fatigue, tendon fatigue, and joint soreness; and increase forces on the spine.

Mechanical Compression or Contact Stress. Mechanical compression, such as grasping a tool or using a pinch grip, creates pressure over a small area. Mechanical compression can be caused by hard or sharp objects, the sharp edge of the desk, and small diameter handles. This compression interferes with blood flow and nerve function.

Figure 2. Posture Positions and Angles

Joint and Position	Optimal	Minimal Stress	Moderate Stress	Severe Stress
Neck				
Forward Flexion	0-10°	11-15°	16-20°	21-30°
Extension	0-5°	6-10°	11-15°	16-20°
Rotation	0-15°	16-25°	26-35°	36-45°
Side bend (Lateral)	0°	1-5°	6-10°	11-15°
Back				
Twist	0°	1-5°	6-10°	11-15°
Forward Bend	0°	1-10°	11-20°	over 20°
Shoulders				
Side Reach	0-5°	6-15°	16-25°	over 26°
Forward Reach	0-25°	26-45°	46-90°	over 91°
Across Body Reach	0-10°	11-15°	16-20°	over 21°
Elbow Flexion	60-90°	91-105°	106-120°	121-135°
Forearm Rotation - Pronation/Supination	0°	1-20°	21-35°	36-50°
Wrist				
Extension	0°	1-20°	21-35°	over 36°
Flexion	0°	1-15°	16-35°	over 36°
Deviation	0°	1-10°	11-15°	over 16°
Hips				
Standing	0°	1-5°	6-10°	11-15°
Sitting	90°	91-100°	101-110°	over 110°
Knees				
Standing	0-95°	96-110°	111-130°	over 130°
Sitting	0-95°	96-110°	111-130°	over 130°
Ankles				
Upward Flexion	90°	89-85°	84-80°	79-75°
Downward Flexion	90-105°	106-115°	116-125°	126-135°

Vibration. Force and acceleration play an important role in ergonomics. Occupational vibration sources include motor vehicles (e.g., heavy equipment, buses) and various hand-held power tools that may contribute to worker discomfort and ultimately lead to worker injury. For practical purposes, just the presence of vibration in the workplace should be noted as a potential risk factor. Remember to consider the duration of exposure to the vibration in your observation.

If a detailed analysis is necessary, it should include force and tri-axial acceleration measurements to evaluate the occupational vibration components. When evaluating hand-arm vibration, surveyors should use the American National Standards Institute (ANSI) S3.34-1986 and the hand-arm vibration threshold limit values (TLVs®) of the American Conference of Governmental Industrial Hygienists (ACGIH). When evaluating whole-body vibration, surveyors should follow procedures in ANSI 3.18-1979 and the ACGIH TLVs for whole body vibrations.

Temperature. In their booklet on TLVs, the ACGIH (1996) recommends temperature limits for bare skin exposure by type of activity. Exposure to temperatures below these levels may—

- Reduce the dexterity and sensitivity of the hand.
- Increase grip force.
- Exacerbate the effects of localized vibration.

Prolonged contact between the bare hand and metal surfaces below 59°F (15°C) may impair dexterity, and contact with metal surfaces below 44.6°F (7°C) may induce numbness. The following table presents additional guidance on temperature exposure limits by activity.

Activity	Temperature Limits for Bare Skin Exposure
Sedentary work	60°F (15.5°C)
Light work	40°F (4.4°C)
Moderate work (fine manual dexterity not required)	20°F (-7.0°C)

Lighting. Inadequate lighting or direct or indirect glare can force the worker to assume awkward and fixed postures. Inadequate lighting during inspection tasks or video display terminal (VDT) work often leads to eye strain.

The lighting levels described below represent the minimum level for each activity. These levels do not indicate the level for maximum worker productivity. The amount of light needed for maximum visual efficiency varies with the worker's age (e.g., older workers require more light).

Type of Work	Examples	Recommended Light Level (lux)*
General	Storeroom	80-170
Moderately precise	Packing, simple assembly	200-250
Video display terminal	Data entry	500-600
Fine work	Reading, writing, bookkeeping, fine work on machines	500-700
Very fine to precise	Technical drawing, watchmaking, testing electrical equipment	1,000-2,000

* 1 lux = .0929 footcandle.

Figure 3a shows a sample task description, and in combination with Figure 3b, often helps the action team identify intervention strategies more easily.

Figure 3b presents a sample risk factor analysis and task description.

Figure 3c presents a sample survey summary table for the ergonomics subcommittee to use when summarizing the risks associated with specific tasks for upper management.

Use the information in Booklet III, *Hazard Prevention and Control*, as your guide for prescribing appropriate interventions.

Appendix D presents a model for estimating costs for ergonomics hazards based on the RACs.

Risk Factor and Body Part Analysis

The task components responsible for identified risk factor exposures are recorded by affected body part in an analysis table. For example, a mechanic's task of removing a tire requires the subtask of removing the lug nuts. This subtask involves the use of a pneumatic drill to remove the nuts. The subtask exposes the hand to vibration, the hand and arm to forceful exertions, the hand to mechanical compression (depending on the shape of the handle), and the hand, arm, and shoulder to awkward postures. These exposures are recorded in the analysis table by subtask number for each risk factor identified and body part affected. This analysis process allows the team to identify the subtasks responsible for high exposures to the risk factors and the body parts most frequently exposed to these risk factors. Often intervention strategies are easily identified after this focusing analysis is completed.

Risk Assessment Codes and Ergonomics

The bottom line for all preventive medicine programs is to reduce or avoid the costs of clinic visits, hospitalization, lost time, disability, rehabilitation, and death. The ergonomics program is no exception. Therefore, a model for estimating costs of ergonomics hazards was developed. This model quantifies the costs that prevention avoids. Risk assessment codes (RACs), in conjunction with the cost effectiveness index, are used to establish a priority listing of abatement projects.

If an area-wide ergonomics problem is discovered, the action team appointed to the surveillance of the area assigns a RAC to the problem to define its severity or magnitude. The RAC—

- Describes the level of risk associated with an ergonomics problem, and combines the hazard severity and accident probability into a single numeral.

- Coupled with the costs associated with any given intervention method, establishes the priority of the problem area.

One model for assigning RACs to ergonomics hazards is presented in Appendix D. This model should support the action team and the ergonomics subcommittee in quantifying the risk of ergonomics hazards, improving the understanding of a stated ergonomics risk, and assisting management in making intervention decisions.

Limitations of the Model. Since no clear thresholds exist for ergonomic hazards, the model and its components are presented as a starting point. The action team must use professional judgment in evaluating the hazard severity in terms of hazard intensity and exposure time.

Figure 3a. Sample Task Description

Mechanic's Task
The mechanic's task of removing a tire* requires the following subtasks:

1. Stabilize car (e.g., wheel blocks, hand brake).
2. Position car jack.
3. Remove hubcap (if present).
4. Loosen tire nuts with pneumatic wrench (not completely removed).
5. Raise car jack.
6. Remove nuts with pneumatic wrench.
7. Remove tire.

Once the task is broken down, the action team can analyze each subtask separately. By using the table in Figure 3b, and applying the number of the subtask to the affected body part and the encountered workplace risk factor, the action team can create a summary of the most stressful or highest risk portions of the overall task.

**Replacing the tire also needs to be considered in exposure to risk factors. It is similar to the task of lifting.*

Figure 3b. Sample Risk Factor and Body Part Analysis

Body Part	Workplace Risk Factors				
	Position	Force	Repetition	Mechanical Stress	Vibration
Neck					
Back	7	7			
Shoulder	4, 6, 7	4, 6, 7			4, 6
Arm	4, 6, 7	4, 6, 7		4, 6	4, 6
Hand/Wrist	6	7		4, 6	4, 6
Legs	7	7			
Feet					

By applying the number of each subtask outlined in Figure 3a to the table above, the action team can determine which body part is affected by which workplace risk factor during which subtask.

To summarize this example, the most stressful/highest risk portions of the mechanic's task of removing a tire are the nut loosening and removing, and the tire removal. The body parts primarily affected by these subtasks are the back and upper extremities.

Possible solutions to controlling or eliminating the workplace risk factors associated with changing a tire might be to add a—

- Mobile counterbalance to the pneumatic wrench.
- Second worker to assist the mechanic, especially during the most stressful, high-risk portions of the task.
- Support device or hand lift to support the weight of the tire and assist in removal.

Figure 3c. Sample Survey Results Summary

Body Part	Workplace Risk Factors					Risk Assessment
	Position	Force	Repetition	Mechanical Stress	Vibration	
Neck	○	○		○	○	○
Back	●	●		○	○	●
Shoulder	●	●		○	□	●
Arm	●	●		□	□	●
Hand/Wrist	●	●		●	●	●
Legs	□	□		○	○	□
Feet	○	○		○	○	○

● = High; □ = Medium; ○ = Low

When the action team completes their survey, and reports the results to the ergonomics subcommittee, the subcommittee must present the results to upper management.

Different formats are available for reporting survey results to upper management. One of the most effective formats is a table, like the sample above, which gives an at-a-glance summary of the amount of risk associated with a mechanic's task of changing a tire. To create a summary table, the ergonomics subcommittee refers to the risk factor and body part analysis survey results (like the ones presented in Figure 3b), and uses symbols to indicate the amount of exposure (e.g., high, medium, low) associated with the task.

Often a summary table like this one is very helpful to workers and upper management in understanding the problem and deciding on a future course of action.

Appendix A

RISK FACTOR/DISCOMFORT SURVEYS

Workplace risk factors contribute to WMSDs. Exposure to these risk factors can result in decreased blood flow to muscles, nerves, and joints; nerve compression; tendonitis; muscle strain; and joint damage. Prolonged exposure to the risk factors can lead to permanent damage and a debilitating condition.

Supervisors and workers need to be aware of the workplace risk factors, and should report their presence to the ergonomics subcommittee. Action team members can use Table A-1 to help supervisors and employees understand the workplace risk factors.

To facilitate a complete analysis, this appendix includes:

- A guide for action team members to use to administer the survey.

- A JR/PD survey to assess workers' job requirements and physical demands. The JR/PD survey was traditionally scored by hand. This method is time consuming and requires the evaluator to have basic knowledge of the Microsoft Excel application. In order to reduce time and improve accuracy during survey correction, the USACHPPM Ergonomics Program developed the JR/PD survey on mark sense forms. These forms are available by writing USACHPPM, Attn: MCHB-DC-OER, Stark Road, Bldg. E-1570, Aberdeen Proving Ground, MD 21010-5403; or by calling DSN 584-3928, commercial 410-436-3928. Individuals answer survey questions by filling in the appropriate "bubble" directly on the survey sheet. The completed surveys can be mailed back to the USACHPPM Ergonomics Program for quick scoring and report generation, or installations may request a copy of the scanner program and scan the surveys locally.

The JR/PD survey (hand-scored version only) and a macro that will help you score the survey and summarize the results are available electronically at *http://sg-www.satx.disa.mil/~hscoemo/index.htm*. At this site, look under "publications."

The DOD Ergonomics Working Group also maintains a web site on the Internet. For more information, access the DOD home page at *http://www.acq.osd.mil/ens/sh*, or contact the working group chair at DSN 584-3928 or commercial 410-436-3928.

Table A-1. Understanding Workplace Risk Factors

Workplace Risk Factor	Definition/Description/Effect	Method of Assessment
Repetition	Repeated motions or tasks increase fatigue and muscle-tendon strain. Highly repetitive tasks often prevent adequate tissue recovery from the effects of awkward postures and force.	• Observation • Comparison to standards
Force	Forceful exertions increase the physiologic stress to muscles, tendons, and joints. Muscles fatigue faster as the force exerted increases.	• NIOSH Lift Equation (See Appendix C of this booklet.) • Force gauge (comparisons to push/pull, lift/carry, etc.)
Posture	Awkward postures require increased muscle force; contribute to muscle fatigue, tendon fatigue, and joint soreness; and increase forces on the spine.	• Observation • Comparison to standards • Joint angle table (See Figure 2 of this booklet.)
Mechanical Compression or Contact Stress	Mechanical compression creates pressure over a small area. Mechanical compression can be caused by hard or sharp objects, the sharp edge of a desk, and small diameter handles. This compression interferes with blood flow and nerve function.	• Observation • Task modeling (psycho-physical)
Vibration	Localized vibration occurs when a part of the body contacts a vibrating object. Whole body vibration occurs when the entire body is in contact with a vibrating/moving body (e.g., when driving a forklift).	• Observation • ACGIH standards • ISO and ANSI standards
Temperature	Prolonged contact between the bare hand and metal surfaces below 59°F (15°C) may impair dexterity, and contact with metal surfaces below 44.6°F (7°C) may induce numbness.	• Observation and measurement • ACGIH standards
Lighting	Inadequate lighting or direct or indirect glare can force the worker to assume awkward and fixed postures.	• Observation • Recommended light levels (See page 19 of this booklet.)

Job Requirements and Physical Demands Survey C Administrative Script

NOTE: Industrial hygiene, safety, and health care personnel and technicians can administer this survey.

Welcome and Introduction

Welcome and thank you for taking the time to complete this occupational health survey. The survey will assess your job requirements and physical demands.

The purpose of the survey is to enable the ergonomics subcommittee to better understand and identify opportunities for improving work in shops and offices throughout the installation.

After you complete the survey, we will:

- Analyze the results for the entire work area.
- Determine a PRIORITY SCORE for the work area.
- Provide information to the ergonomics subcommittee.
- Decide on priorities for follow-up and work area improvement.

This is an anonymous survey. You will notice that we do not ask you to provide your name and there is no coding system. The survey is also voluntary. You are not required to take the survey; however, your participation is appreciated.

We are using the survey to obtain an overall assessment of the experiences in your work area as a whole. We are not looking specifically at you or your individual responses.

However, if you wish to request a follow-up visit by the ergonomics subcommittee, you may do so.

Overview of the Survey

The survey is divided into several parts.

I will give you a quick overview of each section, so follow along with me as I go through the form.

Page 1 asks for general information about yourself.

Turn to page 2.

Part I - Job Factors
A: Description of Work (Questions 1-38)

For this section, please provide a response to *all* questions.

This section allows you to describe certain job factors related to your work that occur on an approximately daily basis.

In Part III of this survey, you will have a chance to tell us about the work that you do less often, like seasonal work.

Turn to page 6.

Part I - Job Factors
B: Organizational Factors (Questions 39-44)

These questions ask about aspects of your job that may be sources of stress for you.

Part I - Job Factors
C: Physical Effort (Question 45)

This question asks about the physical effort required to do your job.

Turn to page 7.

Part II - Your Body's Response to Work Demands
D: Discomfort Factors (Questions 46-60)

This section enables you to identify how your body responds to demands of the job. For example, describing whether you are comfortable or experience fatigue or discomfort is one of the purposes of this part of the survey.

Again, we will make conclusions about the entire work area based on how all of you respond to the survey questions. We do not intend to focus on any one individual.

Turn to page 8.

Part II - Your Body's Response to Work Demands
Part E. General Questions (Questions 61-65)

These questions ask about medical care, medical conditions, and persistent pain and discomfort.

Turn to page 9.

Part III - Work Content (Questions 66-122)

This section allows you to list the tasks you perform in your work and how often you do them.

We will use this information to determine:

- **#** What the typical/routine tasks are for your work area.

- **#** The variety of tasks that are done by your work area, even if they are not done very often.

Turn to page 11.

Part IV - Process Improvement Opportunities (Questions 1-4)

The purpose of this section is to identify the tasks that you think place the greatest demands on your body.

For this section, consider your routine, non-routine, and seasonal tasks, and describe the tasks that you think are a problem.

We will need to know this information in order to help the ergonomics subcommittee decide which tasks may be good candidates for improvement.

Start the Survey Process

Turn back to page 1 and begin.

We expect that it will take you about 15-20 minutes to complete the survey. When you are finished with the entire survey, please turn it in to me. Thank you again for your participation.
(End of Instructions)

APPENDIX A

Job Requirements and Physical Demands Survey

JOB REQUIREMENTS AND PHYSICAL DEMANDS SURVEY

Job Requirements and Physical Demands Survey	Date (YYMMDD)	**Workplace Identifier:**	
(*use this space for mechanical imprint)*		Base	Organization
		Workplace	
		Bldg. No/Location	Room/Area
		AFSC/Job Series	
Gender:	Female ❍	Male ❍	
Work Group:	Civilian ❍ Grade:_____	Military ❍ Rank:_____	
Age Category:	20 and under ❍	21-30 ❍	31-40 ❍ over 40 ❍
Length of service at this base:	less than one year ❍	more than one year ❍	
Length of time in current shop:	less than one year ❍	more than one year ❍	
Have you completed this questionnaire before?	Yes ❍	No ❍	

Part I - Job Factors

This section enables you to describe what is involved in your job. Indicate how long you do this work on approximately a daily basis.

A. DESCRIPTION OF WORK

SHOULDER / NECK

	Never	0-2 hrs.	2-4 hrs.	4-8 hrs.
1. I work with my hands at or above chest level. ***(Figure A.)***	❍	❍	❍	❍

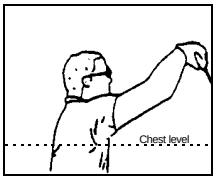


Figure A.

2. To get to or to do my work, I must lay on my back or side and work with my arms up.	❍	❍	❍	❍
3. I must hold or carry materials (or large stacks of files) during the course of my work.	❍	❍	❍	❍
4. I force or yank components or work objects in order to complete a task.	❍	❍	❍	❍
5. I reach or hold my arms in front of or behind my body (e.g., using a keyboard, filing, handling parts, performing inspection tasks, pushing or pulling carts, etc.). ***(Figures B.)***	❍	❍	❍	❍

Figure B.

6. My neck is tipped forward or backward when I work. (***Figure C.)***	❍	❍	❍	❍

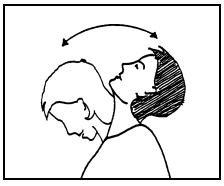


Figure C.

7. I cradle a phone or other device between my neck and shoulder. ***(Figure D.)***.....	❍	❍	❍	❍

Figure D.

Part I - Job Factors (continued)

HAND/WRIST/ARM

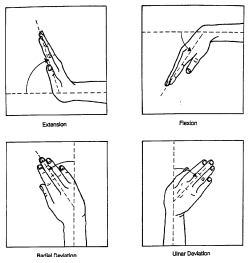


Figure E.

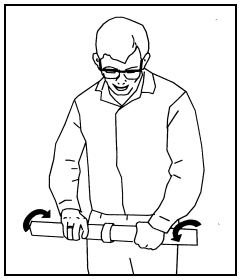


Figure F.

	Never	0-2 hrs.	2-4 hrs.	4-8 hrs.
8. My wrists are bent (up, down, to the thumb or little finger side) while I work. ***(Figure E.)***	❍	❍	❍	❍
9. I apply pressure or hold an item/material/tool (e.g., screw driver, spray gun, mouse, etc.) in my hand for longer than 10 seconds at a time.	❍	❍	❍	❍
10. My work requires me to use my hands in a way that is similar to wringing out clothes. ***(Figure F.)***	❍	❍	❍	❍
11. I perform a series of repetitive tasks or movements during the normal course of my work (e.g., using a keyboard, tightening fasteners, cutting meat, etc.).....	❍	❍	❍	❍
12. The work surface (e.g., desk, bench, etc.) or tool(s) that I use presses into my palm(s), wrist(s), or against the sides of my fingers leaving red marks on or beneath the skin.	❍	❍	❍	❍
13. I use my hand/palm like a hammer to do certain aspects of my work.	❍	❍	❍	❍
14. My hands and fingers are cold when I work.	❍	❍	❍	❍
15. I work at a fast pace to keep up with a machine production quota or performance incentive.	❍	❍	❍	❍
16. The tool(s) that I use vibrates and/or jerks my hand(s) and arms(s).	❍	❍	❍	❍
17. My work requires that I repeatedly throw or toss items.....	❍	❍	❍	❍
18. My work requires me to twist my forearms, such as turning a screwdriver.	❍	❍	❍	❍
19. I wear gloves that are bulky, or reduce my ability to grip.	❍	❍	❍	❍
20. I squeeze or pinch work objects with a force similar to that which is required to open a lid on a new jar.	❍	❍	❍	❍
21. I grip work objects or tools as if I am gripping tightly onto a pencil.	❍	❍	❍	❍

Part I - Job Factors (continued)

BACK/TORSO

	Never	0-2 hrs.	2-4 hrs.	4-8 hrs.
22. When I lift, move components, or do other aspects of my work, my hands are lower than my knees. ***(Figure G.)***	❍	❍	❍	❍

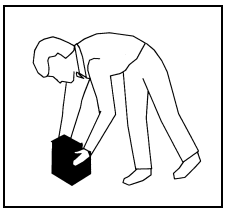


Figure G.

23. I lean forward continually when I work (e.g., when sitting, when standing, when pushing carts, etc.).	❍	❍	❍	❍
24. The personal protective equipment or clothing that I wear limits or restricts my movement.	❍	❍	❍	❍
25. I repeatedly bend my back (e.g., forward, backward, to the side, or twist) in the course of my work.	❍	❍	❍	❍
26. When I lift, my body is twisted and/or I lift quickly. ***(Figure H.)***	❍	❍	❍	❍

Figure H.

27. I can feel vibration through the surface that I stand on or through my seat.	❍	❍	❍	❍
28. I lift and/or carry items with one hand. ***(Figure I.)***	❍	❍	❍	❍

Figure I.

29. I lift or handle bulky items.	❍	❍	❍	❍
30. I lift materials that weigh more than 25 pounds.	❍	❍	❍	❍

Part I - Job Factors (continued)

LEGS / FEET

Figure J.

Figure K

	Never	0-2 hrs.	2-4 hrs.	4-8 hrs.
31. My work requires that I kneel or squat. ***(Figure J.)***	❍	❍	❍	❍
32. I must constantly move or apply pressure with one or both feet (e.g., using foot pedals, driving, etc.).	❍	❍	❍	❍
33. When I'm sitting, I cannot rest both feet flat on the floor. ***(Figure K.)***	❍	❍	❍	❍
34. I stand on hard surfaces.	❍	❍	❍	❍

HEAD / EYES

35. I can see glare on my computer screen or work surface.	❍	❍	❍	❍
36. It is difficult to hear a person on the phone or to concentrate because of other activity, voices, or noise in/near my work area.	❍	❍	❍	❍
37. I must look at the monitor screen constantly so that I do not miss important information (radar scope).	❍	❍	❍	❍
38. It is difficult to see what I am working with (monitor, paper, parts, etc.).	❍	❍	❍	❍

Part I - Job Factors (continued)

B. ORGANIZATIONAL FACTORS

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1	**2**	**3**	**4**	**5**
39. I often feel unclear on what the scope and responsibilities of my job are.	❍	❍	❍	❍	❍
40. I often feel that I have too heavy of a workload, one that I could not possibly finish during an ordinary workday.	❍	❍	❍	❍	❍
41. I often feel that I will not be able to satisfy the conflicting demands of various people around me.	❍	❍	❍	❍	❍
42. I often find myself unable to get information needed to carry out my job.	❍	❍	❍	❍	❍
43. I often do not know what my supervisor thinks of me, how he/she evaluates my performance.	❍	❍	❍	❍	❍
44. I often think that the amount of work I have to do interferes with how well it's done.	❍	❍	❍	❍	❍

C. PHYSICAL EFFORT

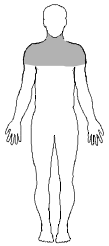
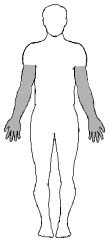
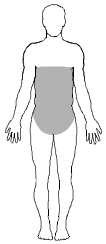
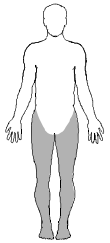
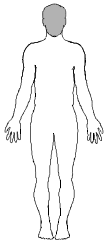
45. How would you describe the physical effort required of your job?

6	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
No exertion at all	Extremely light		Very light		Light		Somewhat hard		Hard		Very hard		Extremely hard	Maximal exertion
❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍

Part II - Your Body's Response to Work Demands

D. DISCOMFORT FACTORS

This section enables you to identify how your body responds to the demands of ***your job***. In each section, answer the first question. If the answer is "no" go to the next column.

Question	 **Shoulder/Neck**	 **Hands/Wrists/Arms**	 **Back/Torso**	 **Legs/Feet**	 **Head/Eyes**
• In the past 12 months, have you experienced <u>any</u> discomfort, fatigue, numbness, or pain that ***relates to your job***?	46. Yes ❍ No ❍ ***If "no", go to question 49***	49. Yes ❍ No ❍ ***If "no", go to question 52***	52. Yes ❍ No ❍ ***If "no", go to question 55***	55. Yes ❍ No ❍ ***If "no", go to question 58***	58. Yes ❍ No ❍ ***If "no", go to question 61***
• How often do you experience discomfort, fatigue, numbness, or pain in this region of the body?	47. Daily ❍ Weekly ❍ Monthly ❍	50. Daily ❍ Weekly ❍ Monthly ❍	53. Daily ❍ Weekly ❍ Monthly ❍	56. Daily ❍ Weekly ❍ Monthly ❍	59. Daily ❍ Weekly ❍ Monthly ❍
• On average, how severe is the discomfort, fatigue, numbness, or pain in this region of the body?	48. Mild ❍ Moderate ❍ Severe ❍	51. Mild ❍ Moderate ❍ Severe ❍	54. Mild ❍ Moderate ❍ Severe ❍	57. Mild ❍ Moderate ❍ Severe ❍	60. Mild ❍ Moderate ❍ Severe ❍

Part II - Your Body's Response to Work Demands (continued)

E. GENERAL QUESTIONS

61. In the past 12 months, have you seen a health care provider for any pain or discomfort that you think **relates to your job**? Yes ❍ No ❍

62. Do you experience any work-related pain or discomfort that does not improve when you are away from work overnight or over the weekend? Yes ❍ No ❍

63. In the past 12 months, has any work-related pain or discomfort caused you difficulty in carrying out normal activities (e.g., job, hobby, leisure, etc.)? Yes ❍ No ❍

64. Has a health care provider ever told you that you have any of the following conditions which you think might be **related to your work**? Yes ❍ No ❍

- Tendonitis/Tenosynovitis
- Epicondylitis (Tennis Elbow)
- Thoracic Outlet Syndrome
- Ganglion Cyst
- Bursitis
- Back Strain
- Trigger Finger
- Carpal Tunnel Syndrome
- Knee or Ankle Strain
- Overuse Syndrome

65. Do you have or have you ever had one or more of the following conditions? Yes ❍ No ❍

- Wrist Fracture
- Thyroid Disorder
- Rheumatoid Arthritis
- Hypertension
- Diabetes
- Kidney Disorders
- Gout

Part III - Work Content

The section below will enable you to describe the content of the work that you do in your current shop.

Fill in the box that describes how frequently you do the task listed, based on the following definitions:

- **Routine:** Performed on three or more days per week.
- **Non-routine:** Performed two days a week or less.
- **Seasonal:** Performed only during certain times of the year
- **Never/NA:** You do not perform this type of work.

No.	Type of Work	Work Frequency (Check one)			
		Routine	Non-Routine	Seasonal	Never/NA
66.	abrading	❍	❍	❍	❍
67.	baking	❍	❍	❍	❍
68.	bolting/screwing	❍	❍	❍	❍
69.	calling (telephone use)	❍	❍	❍	❍
70.	chipping	❍	❍	❍	❍
71.	cleaning by hand	❍	❍	❍	❍
72.	cleaning with high pressure equipment	❍	❍	❍	❍
73.	coating/immersing	❍	❍	❍	❍
74.	cooking	❍	❍	❍	❍
75.	copying	❍	❍	❍	❍
76.	crimping	❍	❍	❍	❍
77.	cutting/shearing	❍	❍	❍	❍
78.	drafting/CAD system use	❍	❍	❍	❍
79.	drilling	❍	❍	❍	❍
80.	driving (vehicles)	❍	❍	❍	❍
81.	excavating	❍	❍	❍	❍
82.	filing/general administrative	❍	❍	❍	❍
83.	flame cutting/arc cutting	❍	❍	❍	❍
84.	folding/fitting	❍	❍	❍	❍
85.	gluing/laminating	❍	❍	❍	❍
86.	grinding/buffing/polishing	❍	❍	❍	❍
87.	hammering	❍	❍	❍	❍
88.	lifting	❍	❍	❍	❍
89.	loading (pallets, trucks, carts, aircraft)	❍	❍	❍	❍
90.	lubricating	❍	❍	❍	❍

Part III - Work Content (Continued)

No.	Type of Work	Work Frequency (Check one)			
		Routine	Non-Routine	Seasonal	Never/NA
91.	machining	❍	❍	❍	❍
92.	masoning	❍	❍	❍	❍
93.	melting	❍	❍	❍	❍
94.	molding	❍	❍	❍	❍
95.	monitoring (visual displays)	❍	❍	❍	❍
96.	mousing (for computer work)	❍	❍	❍	❍
97.	nailing	❍	❍	❍	❍
98.	opening/closing heavy doors	❍	❍	❍	❍
99.	packing/packaging	❍	❍	❍	❍
100.	painting/spray painting	❍	❍	❍	❍
101.	paving	❍	❍	❍	❍
102.	pumping (by hand)	❍	❍	❍	❍
103.	riveting/bucking	❍	❍	❍	❍
104.	sanding	❍	❍	❍	❍
105.	sawing	❍	❍	❍	❍
106.	scanning (using bar code readers)	❍	❍	❍	❍
107.	sewing	❍	❍	❍	❍
108.	soldering/brazing	❍	❍	❍	❍
109.	stapling	❍	❍	❍	❍
110.	stripping/depainting by hand	❍	❍	❍	❍
111.	stripping/depainting mechanically	❍	❍	❍	❍
112.	transporting loads on non-powered carts	❍	❍	❍	❍
113.	turning valves	❍	❍	❍	❍
114.	tying/twisting/wrapping	❍	❍	❍	❍
115.	typing/keying	❍	❍	❍	❍
116.	welding	❍	❍	❍	❍
117.	wheeling loads	❍	❍	❍	❍
118.	wiring	❍	❍	❍	❍
119.	wrenching/ratcheting	❍	❍	❍	❍
120.	writing/illustrating	❍	❍	❍	❍
	(Write in others)				
121.	_____	❍	❍	❍	❍
122.	_____	❍	❍	❍	❍

Part IV - Process Improvement Opportunities

Think about your job as a whole, including routine, non-routine or seasonal work.

Read the questions listed below and **describe the activities** that you or your co-workers think place the greatest demands on your body.

1. Which tasks are the most awkward or require you to work in the most uncomfortable positions?

2. Which tasks take the most effort?

3. Are there any tools or pieces of equipment that are notoriously hard to work with? (If so, list them below)

4. If you could make any suggestions that would help you do your job more easily or faster or better, what would you suggest?

Appendix B

CHECKLISTS

Contents

Figure B-1. Ergonomic Analysis — Background Information/Demographics

THE WORK AREA

Survey Date: _____

Evaluation Team Members: _____

_____

Area(s) evaluated (division, building, room, department, etc.): _____

_____

Total number of employees in each area evaluated: _____

_____

What is the length of the workday? _____ Start Time: _____ End Time: _____

Number of Breaks: _____ Break Schedule: _____

Are breaks self-governed? ☐ Yes ☐ No Is a job rotation plan used? ☐ Yes ☐ No

If yes, describe the jobs rotated to: _____

_____

Employee Breakdown by Age and Gender						
	<20	20-29	30-39	40-49	50-59	60+
Male						
Female						

THE WORKER

Name: _____ ☐ Male ☐ Female

Height: _____ Age: _____ Hand Dominance: _____

Experience: _____

_____

_____

Previous jobs (last 5 years): _____

_____

Number of other workers at this job: _____

Figure B-2. Ergonomic Analysis — Injury/Workers' Compensation Data

Information Obtained (check all that apply): ☐ Medical Records ☐ OSHA 200 Log ☐ Other

Injury	Male or Female	Body Location	Type of Injury	Job Title	Lost Workdays	Restricted Workdays or Duty Days	Date Reported	TOTAL COSTS		
								Medical	Continuation of Pay	Compensation
#1										
#2										
#3										
#4										
#5										
#6										
#7										
#8										
#9										
#10										

Total number of new incidents (cases): _____

Total number of workers in the same risk group for which incidence rate will be calculated: _____

Total number of workers in entire facility: _____

Figure B-3: Ergonomic Analysis — Task/Production Information

THE TASK

Task Name: _____

Task Objective: _____

_____

Task Summary (2-3 sentences): *Note complete process, including motions, objects, and weights handled; tools; fixed equipment; non-fixed equipment; and personal protective equipment.*

_____

_____

_____

_____

How many workers perform this job? _____ How many hours are spent performing the task? _____

Is the task ... ☐ Continuous? ☐ Intermittent?

PRODUCTION

What is being produced? _____ What does each unit weigh? _____

What are the dimensions of each unit? _____

Sketch the unit being produced (if possible):

What cost is associated with producing each unit? _____

Is there a minimum production rate? ☐ Yes ☐ No If yes, what is it? _____

Do employees have difficulty reaching the productivity quota? If yes, explain: _____

_____

What is the average production rate per day? _____

How is production measured? _____

How is the error (or scrap/rework) rate measured? _____

Are employees penalized for errors? If yes, explain: _____

_____

_____

Figure B-4. Ergonomic Analysis — General Risk Factor Checklist

This checklist covers most potential ergonomic issues. Use this checklist as general guidance when performing worksite surveillance. Check the box (☐) if your answer is "yes" to the question. A "yes" response indicates that an ergonomic risk factor may be present, that requires further analysis.

MANUAL MATERIAL HANDLING *(See figure B-8 for a detailed materials handling checklist.)*

- ☐ Is there lifting of tools, loads, or parts?
- ☐ Is there lowering of tools, loads, or parts?
- ☐ Is there overhead reaching for tools, loads, or parts?
- ☐ Is there bending at the waist to handle tools, loads, or parts?
- ☐ Is there twisting at the waist to handle tools, loads, or parts?

PHYSICAL ENERGY DEMANDS *(See figure B-6 for a detailed fatigue assessment checklist.)*

- ☐ Do tools and parts weigh more than 10 pounds?
- ☐ Are reach distances greater than 20 inches?
- ☐ Is bending, stooping, or squatting a primary task activity?
- ☐ Is lifting or lowering loads a primary task activity?
- ☐ Is walking or carrying loads a primary task activity?
- ☐ Is stair or ladder climbing with loads a primary task activity?
- ☐ Is pushing or pulling loads a primary task activity?
- ☐ Is reaching overhead a primary task activity?
- ☐ Do any of the above tasks require five or more complete work cycles to be done within one minute?
- ☐ Do workers complain that rest breaks and fatigue allowances are insufficient?

OTHER MUSCULOSKELETAL DEMANDS

- ☐ Do manual jobs require frequent, repetitive motions?
- ☐ Do work postures require frequent bending of the neck, shoulder, elbow, wrist, or finger joints?
- ☐ For seated work, are reach distances for tools and materials more than 15 inches from the worker's position?
- ☐ Is the worker unable to change his or her position often?
- ☐ Does the work involve forceful, quick, or sudden motions?
- ☐ Does the work involve shock or rapid buildup of forces?
- ☐ Is finger-pinch gripping used?
- ☐ Do job postures involve sustained muscle contraction of any limb?
- ☐ Is vibration present? Source: _____
  (include manufacturer, model, and serial #)

COMPUTER WORKSTATION *(See figures B-5 and B-9 for detailed checklists related to the office environment.)*

- ☐ Do operators use computer workstations for more than 4 hours a day?
- ☐ Are there complaints of discomfort from those working at these stations?
- ☐ Is the chair or desk nonadjustable?
- ☐ Is the display monitor, keyboard, or document holder nonadjustable?
- ☐ Does the lighting cause glare or make the monitor screen hard to read?
- ☐ Is the room temperature too hot or too cold?
- ☐ Is there irritating vibration or noise?

Figure B-4. Ergonomic Analysis — General Risk Factor Checklist (continued)

ENVIRONMENT

- ☐ Is the temperature too hot or too cold? Actual temperature (^{o}F): _____
- ☐ Are the workers' hands exposed to temperatures less than 70^{o}?
- ☐ Is the workplace poorly lit? Light meter measurement: _____
  Refer to Figure 7 in Booklet III for recommended illumination levels.
- ☐ Is there glare?
- ☐ Is there excessive noise that is annoying, distracting, or producing hearing loss?
  Sound level reading: _____
- ☐ Is there upper extremity or whole-body vibration?
- ☐ Is air circulation too high or too low?

GENERAL WORKPLACE

- ☐ Are walkways uneven, slippery, or obstructed?
- ☐ Is housekeeping poor?
- ☐ Is there inadequate clearance or accessibility for performing tasks?
- ☐ Are stairs cluttered or lacking railings?
- ☐ Is proper footwear worn?

TOOLS *(See figure B-7 for a detailed hand tool evaluation.)*

- ☐ Is the handle too small or too large?
- ☐ Does the handle shape cause the operator to bend the wrist to use the tool?
- ☐ Is the tool hard to access?
- ☐ Does the tool weigh more than 10 pounds?
- ☐ Does the tool vibrate excessively?
- ☐ Does the tool cause excessive kickback to the operator?
- ☐ Does the tool become too hot or too cold?

GLOVES

- ☐ Do the gloves require the worker to use more force when performing job tasks?
- ☐ Do the gloves provide inadequate protection?
- ☐ Do the gloves present a hazard of catch points on the tool or in the workplace?

ADMINISTRATION

- ☐ Is there little worker control over the work process?
- ☐ Is the task highly repetitive and monotonous?
- ☐ Does the job involve critical tasks with high accountability and little or no tolerance for error?
- ☐ Are work hours and breaks poorly organized?

Figure B-5. Ergonomic Analysis — General Office Workplace Checklist

Use this checklist as general guidance when performing worksite surveillance in an office environment.

BODY POSTURE (e.g., sitting, standing, stooping)

Yes	No	N/A	
☐	☐	☐	Does this posture involve much static muscular (e.g., when the muscle does no work, but the tension within the muscle increases) effort?
☐	☐	☐	Is the working height correct?
☐	☐	☐	Is the range of movement of grips and handles anatomically correct?
☐	☐	☐	Is there enough room to move about?
☐	☐	☐	Can the work be seen clearly and any instruments read with the body in a neutral position?

SEATING

Yes	No	N/A	
☐	☐	☐	Is the seat correctly adjusted to the working height?
☐	☐	☐	Does the seat cause aches or pains?
☐	☐	☐	Is a footrest necessary?
☐	☐	☐	Is there adequate clearance for feet and calves under the chair?

VDT WORK

Yes	No	N/A	
☐	☐	☐	Is the line of sight 15^{o} below the horizon?
☐	☐	☐	Is the display within a circle 10^{o} to 15^{o} in radius around the normal line of sight?
☐	☐	☐	Is keyboard height (floor to home row) between 23 and 28 inches?
☐	☐	☐	Is keyboard angle between 5^{o} and 25^{o}?
☐	☐	☐	Is the angle between the upper arm and forearm approximately 90°?
☐	☐	☐	Are the hands in approximately a straight line with the forearm?
☐	☐	☐	Is screen height from floor between 24.4 and 35 inches?
☐	☐	☐	Is screen angle to vertical at least +/- 7^{o} (ideal is +/- 20^{o})?
☐	☐	☐	Does the desk provide ample space for operator?
☐	☐	☐	Is the eye-to-screen distance from 15 to 32 inches?

Figure B-6. Ergonomic Analysis — Fatigue Assessment Checklist

Use this checklist as general guidance when performing worksite surveillance.

Yes	No	N/A	
☐	☐	☐	Are operators required to apply near-maximum force capacities over many cycles and for long periods of time?
☐	☐	☐	Are there continuous, rapid, repetitive muscle contractions for long periods (e.g., pounding, tapping, cranking, or push-pull cycling)?
☐	☐	☐	Do operators have to “hold” some device in a fixed position for long periods without intermittent rest periods?
☐	☐	☐	Do operators have to maintain an upright posture for long periods without adequate body support (as in the case of a seat)?
☐	☐	☐	Do operators have to make very long reaches, frequently, and for extended periods of time?
☐	☐	☐	Do operators stand or sit in an awkward position and hold their arms above their heads for a long period of time?
☐	☐	☐	Do operators work in a “bent-over” or squatting position or in a position on their stomachs or backs, with the accompanying stress of holding the head and arms in a strained position?
☐	☐	☐	Are operators required to bend over and straighten up frequently and over a long period of time?
☐	☐	☐	Does the workplace layout require many steps, repeated again and again over a long period of time?
☐	☐	☐	Does the workplace layout require operators to sit “askew” (in a twisted position) in order to watch a display, and at the same time operate some control (especially a foot control)?
☐	☐	☐	Are operators required to hold one foot above a foot control (between pedal depressions) for long periods of time?
☐	☐	☐	Do the operators have to continuously move their heads from side to side, or up and down?
☐	☐	☐	Do the operators have to step up and down frequently for long periods?
☐	☐	☐	Are the job demands high, requiring increased rest to avoid excessive fatigue?
☐	☐	☐	Does the job involve continuous monitoring or inspection?
☐	☐	☐	Is the work performed in a hot environment?

Figure B-7. Ergonomic Analysis — Hand Tool Evaluation

Use this checklist as general guidance when performing worksite surveillance.

DEMOGRAPHICS

Manufacturer: _____
Model: _____
Serial #: _____

WEIGHT

Yes	No	
☐	☐	Is the tool used on a repetitive basis?

Rate of tool use: _____
Tool weight: _____

NOTE: If the tool weighs more than 25 pounds and is used repetitively, the tool is too heavy. Tools weighing 25 pounds or more should not be used more than once every 3 minutes.

SIZE

Yes	No	
☐	☐	Can the fingers wrap around the hand tool?
☐	☐	Are the handles located under the tool's center of gravity?
☐	☐	Are high forces needed to operate the tool?

NOTE: Trigger activation force for tools should not exceed 2.25 pounds of force.

Grip span of the tool handle (in inches): _____

NOTE: An effective grip span for handles is no more than 4.5 to 5 inches. If high grip forces are needed for a manually operated (squeezable) hand tool, the handle opening should be in the range of 2.5 to 3.5 inches.

SHAPE

Yes	No	
☐	☐	Can both hands easily grasp the tool when it is held?
☐	☐	Do sharp edges come in contact with the hands?
☐	☐	Does the use of the hand tool place the wrists in an awkward posture?
☐	☐	Does the use of the hand tool place the arm in an abducted posture?
☐	☐	Does the tool handle extend past the palm?
☐	☐	Does the user wear protective gloves?

NOTE: If the tool handle is too short, or has rough or sharp edges, mechanical trauma to the palms can occur. Gloves reduce mechanical trauma to the hands and often increase the coefficient of friction (for example, the torque exerted on a screwdriver); however, they decrease manual dexterity and grip strength. Gloves that are too large can significantly increase the force required to handle tools.

Figure B-7. Ergonomic Analysis — Hand Tool Evaluation (continued)

TEMPERATURE

Yes	No	
☐	☐	Is the hand tool used in a cold environment?
☐	☐	Is the tool handle conductive?

NOTE: If a hand tool is used in a cold environment, handles should be made or covered with a nonheat-conducting material (i.e., plastic or wood). Additionally, the handles should be designed to accommodate the wearing of gloves, thus requiring a reduced maximum span of about 4 inches where significant grip forces are required. Handles should be shaped to better retain the tool in the hand.

VIBRATION

Yes	No	
☐	☐	Is vibration exposure present when using the hand tool?
☐	☐	Is there antivibration padding on the hand tool?
☐	☐	Does the user wear vibration-dampening gloves?

NOTE: Leather gloves reportedly reduce vibration by 24 percent.
Sorbothane®-padded gloves reduce vibration by 45 percent.

Figure B-8. Ergonomic Analysis — Materials Handling Checklist

Use this checklist as general guidance when performing worksite surveillance.

DISTANCE AND POSITION

Yes	No	
☐	☐	Is the horizontal distance from the body to the hands greater than 4 inches?
☐	☐	Is the object lifted from the floor?
☐	☐	Is the object lifted above the shoulders?
☐	☐	Does the object have to be carried?
		If yes, how far? _____
☐	☐	Does the object have to be carried up or down stairs?
☐	☐	Is any twisting of the trunk involved?

OBJECT

Yes	No	
☐	☐	Is the object weight over 25 pounds?
☐	☐	Is the object stable (i.e., no shifting load)?
☐	☐	Are there good handholds?
☐	☐	Are mechanical aids available?
☐	☐	Is repeated lifting/lowering or pushing/pulling required?
		If yes, how often? _____
☐	☐	Is the work machine-paced or worker-paced?

WORK AREA

Yes	No	
☐	☐	Are there obstacles in the area?
☐	☐	Is the floor wet or slippery?
☐	☐	Is the work area well lit?

Figure B-9. Ergonomic Analysis — Chair Evaluation Checklist

Use this checklist as general guidance when performing worksite surveillance.

Yes	No	
☐	☐	If the seat is a fixed height, is the seat pan 18 to 19 inches high?
☐	☐	If the seat is adjustable, is the seat pan 16 to 20.5 inches high?
☐	☐	Does the seat pan adjust from an angle of 5^{o} to 15^{o} forward tilt to 5^{o} backward tilt and lock in place?
☐	☐	Is the seat 15 to 17 inches deep?
☐	☐	Is the seat 18.2 inches wide?
☐	☐	Does the seat have a rounded, waterfall front seat edge?
☐	☐	Does the amount of contouring support postures, distribute pressures, and provide freedom of movement?
☐	☐	Does the seat cushion thickness range from 1.5 to 2 inches?
☐	☐	Does the seat covering "give" and "breathe?"
☐	☐	Is the seat back angle a minimum of 90^{o} to 105^{o} (preferably up to 120^{o})?
☐	☐	Is the seat back width at least 12 inches in the lumbar region?
☐	☐	Is the seat back 15 to 20 inches high?
☐	☐	Does the lumbar support move upward relative to the lumber spine as the backrest reclines?
☐	☐	Is the lumbar support 6 to 9 inches in height and 12 inches wide?
☐	☐	Is the lumbar support positioned 6 to 10 inches above the seat?
☐	☐	Does the lumbar support protrude forward about 2 inches from the back of the seat?
☐	☐	Does the chair have a stable five-point base with casters?
☐	☐	Does the chair have adjustable armrests?
☐	☐	Are the armrests 9 to 12 inches in length and 8 to 9 inches above the seat?
☐	☐	Is the chair easily adjustable?
☐	☐	Can controls be easily reached and adjusted from the standard seated work position?
☐	☐	Do the controls provide immediate feedback?
☐	☐	Is the direction of operation of controls logical and consistent?
☐	☐	Do adjustments require the use of only one hand?
☐	☐	Does the chair pivot 360^{o}, allowing easy ingress/egress and access to various surfaces?

NOTE: Any question answered NO indicates a potential problem area.

Appendix C

NIOSH LIFT EQUATION AND LIFT INDEX

The most common standardized approach to materials handling lifting and lowering assessment is the NIOSH Lift Equation. The NIOSH Lift Equation was revised in 1991 and is based on studies of human capacities and endurance and biomechanical, physiological, psychophysical, and epidemiologic data. The equation calculates the recommended weight limit (RWL). The RWL represents the load that the majority of workers (90 percent of working men and 75 percent of working women) can safely lift, and should be calculated at the origin and destination of the lift and for all of the lifts required in the task. The equation consists of six multipliers and a lift constant of 51 pounds.

RWL = LC * HM * VM * DM * AM * FM * CM

LC (load constant) = **51 lbs**
(This represents the maximum load allowed under ideal circumstances.)

HM (horizontal multiplier) = **10/H**
H = The horizontal location of the hands from the midpoint between the ankles (in inches). If the horizontal distance is less than 10 inches, then set H at 10 inches.

VM (vertical multiplier) = **(1-(.0075|V-30|))**
V = Vertical location of the hands from the floor (in inches).

DM (distance multiplier) = **(0.82 + (1.8/D))**
D = The vertical travel distance between the origin and the destination of the lift (in inches). If the distance traveled is less than 10 inches, set D to 10 inches.

AM (asymmetric multiplier) = **(1-(.0032A))**
A = The angle of asymmetry minus the angular displacement of the load from the sagittal plane (in degrees). If the asymmetry angle is over 135°, then AM will equal 0, indicating the job must be redesigned.

FM (frequency multiplier) = Values from table D-1.
For lifting less frequently than once per 5 minutes, set F at < 0.2 lifts/minute.

CM (coupling multiplier) = Values from table D-2.

There are some limitations to the lift equation. It—

- Does not include safety factors to account for unpredicted conditions such as unexpectedly heavy loads, slips, or falls. Also, environmental conditions such as temperatures outside of the 66°F-to-79°F range or humidity outside of the 35 percent-to-65 percent range are not considered.

- Assumes other manual material handling activities and body motions such as holding, pushing, pulling, carrying, walking, or climbing represent less than 20 percent of the total work activity for the shift.

- Does not assess the hazards of one-handed lifting, lifting while seated or kneeling, or lifting in a constrained work space.

- Assumes a worker-floor surface coupling provides a static friction coefficient of at least 0.4 (preferably 0.5) between the shoe sole and the working surface. Firm footing is necessary when lifting and to control accidents and injuries resulting from foot slippage. A coefficient of static friction of 0.4 to 0.5 is comparable to the coefficient of friction between a smooth, dry floor and the sole of a clean, dry, nonslip leather work shoe.

- Is very conservative and does not consider the effect that gender, age, or conditioning would have on the load that could be safely lifted.

Table C-1. Frequency Multipliers

	Work Duration (Continuous)					
Frequency	**Long Duration (≤ 8 hours)**		**Moderate Duration (≤ 2 hours)**		**Short Duration (≤ 1 Hour)**	
Lifts/Min	**V< 30 in.**	**V ≥ 30 in.**	**V < 30 in.**	**V ≥ 30 in.**	**V < 30 in.**	**V ≥ 30 in.**
0.2	0.85	0.85	0.95	0.95	1.00	1.00
0.5	0.81	0.81	0.92	0.92	0.97	0.97
1	0.75	0.75	0.88	0.88	0.94	0.94
2	0.65	0.65	0.84	0.84	0.91	0.91
3	0.55	0.55	0.79	0.79	0.88	0.88
4	0.45	0.45	0.72	0.72	0.84	0.84
5	0.35	0.35	0.60	0.60	0.80	0.80
6	0.27	0.27	0.50	0.50	0.75	0.75
7	0.22	0.22	0.42	0.42	0.70	0.70
8	0.18	0.18	0.35	0.35	0.60	0.60
9	0	0.15	0.30	0.30	0.52	0.52
10	0	0.13	0.26	0.26	0.45	0.45
11	0	0	0	0.23	0.41	0.41
12	0	0	0	0.21	0.37	0.37
13	0	0	0	0	0	0.34
14	0	0	0	0	0	0.31
15	0	0	0	0	0	0.28
>15	0	0	0	0	0	0

Table C-2. Coupling Multipliers

	Good	Fair	Poor
Description	• For containers of optimal design, such as some boxes or crates, "good" couplings are handles or hand-hold cutouts of optimal design.[1, 2, 3] • For loose parts or irregular objects, such as castings, stock, or supply materials, "good" is a comfortable grip in which the hand can be easily wrapped around the object.[6]	• For containers of optimal design, "fair" couplings are handles or hand-hold cutouts of less than optimal design.[1, 2, 4] • For containers of optimal design with no handles or hand-hold cutouts or for loose parts or irregular objects, 'fair" is a grip in which the hand can be flexed about 90°.[4]	• Containers of less than optimal design with no handles or hand-hold cutouts or loose parts or irregular objects that are bulky or hard to handle.[5]
V < 30 in.	1.00	0.95	0.90
V ≥ 30 in.	1.00	1.00	0.90

1 An optimal handle design has a 0.75- to 1.5-inch diameter, is at least 4.5 inches long, has a 2-inch clearance, cylindrical shape, and a smooth, nonslip surface.
2 An optimal hand-hold cutout is at least 3 inches high; 4.5 inches long; has a semi-oval shape; at least a 2-inch clearance; a smooth nonslip surface; and at least a 0.43-inch container thickness.
3 An optimal container design has a frontal length of less than 16 inches; is less than 12 inches high; and has a smooth, nonslip surface.
4 A worker should be capable of clamping the fingers at nearly 90° under the container.
5 A less-than-optimal container has a frontal length of over 16 inches, is over 12 inches high, has rough or slippery surfaces, sharp edges, an asymmetric center of mass, unstable contents, or requires gloves.
6 A worker should be able to comfortably wrap the hand around the object without causing excessive wrist deviations or awkward postures, and the grip should not require excessive force.

Once the RWL is calculated, it is compared to the load actually being lifted in the lift index (LI) calculation. The LI is essentially a hazard index; as the LI value increases, the risk from the lift increases. The optimal value for the LI is 1.0 or less. An LI greater than 1.0 suggests the lifting task should be redesigned.

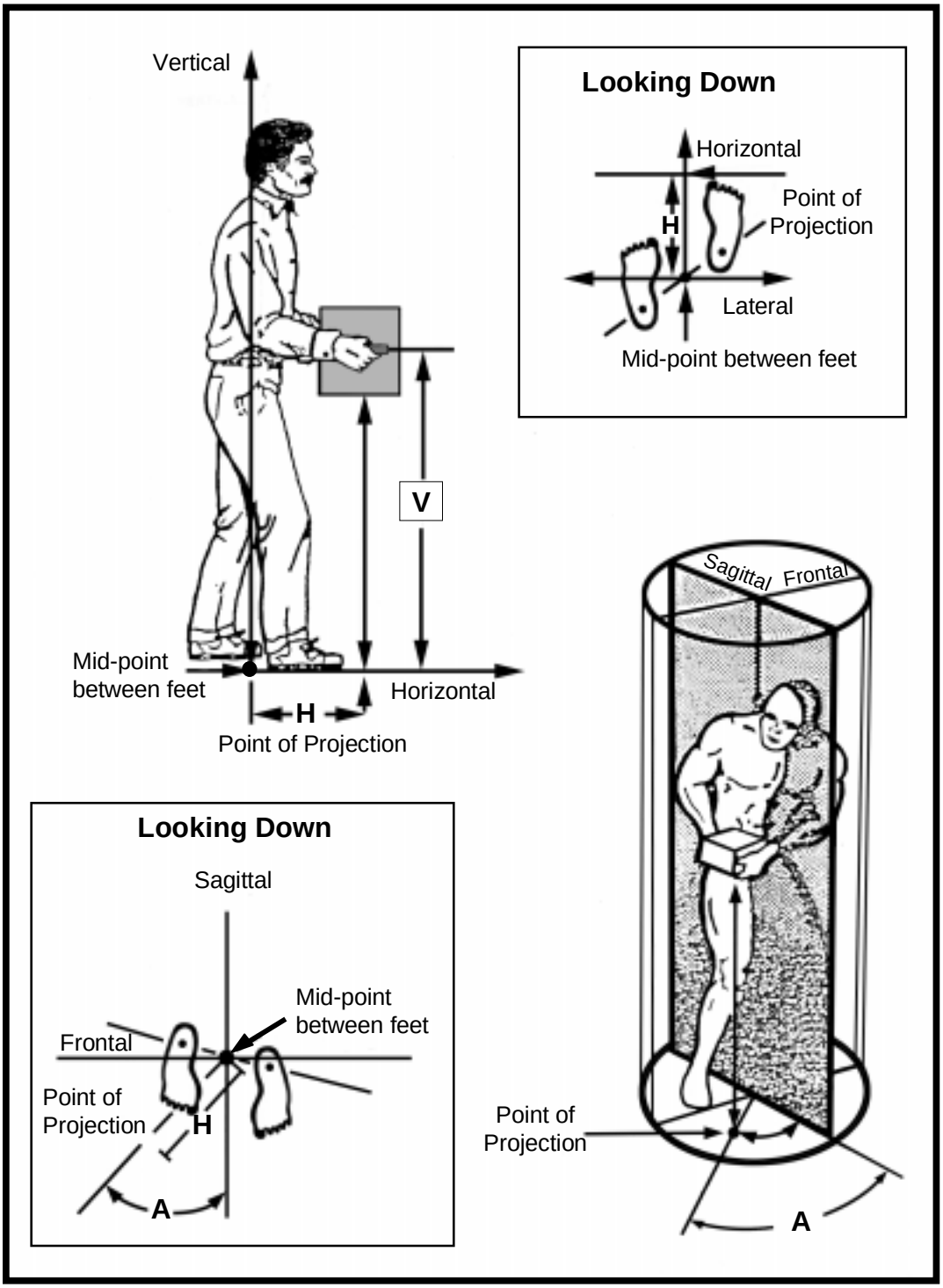
LI = L/RWL

L (load) = current load weight

RWL = recommended weight limit

Figure C-1. Graphic Representations of NIOSH Lift Equation Multipliers

Horizontal and Vertical Multipliers



Asymmetric Multipliers

Appendix D

RISK ASSESSMENT CODES AND ERGONOMICS

Background. RACs describe the level of risk associated with a hazard that combines the hazard severity and WMSD probability into a single numeral. RACs, in conjunction with the cost effectiveness index, are used to establish a priority listing of abatement projects. An abatement plan for a RAC 1 or 2 must be prepared within 30 days of RAC assignment, per DoDI 6055.1.

Hazard severity is an assessment of the expected consequence, derived by degree of WMSD or occupational illness that could occur from a hazard. When determining hazard severity, consider the following:

- Has a WMSD occurred that may be attributable to ergonomic hazards?
- What is the intensity of the hazard and exposure time to the hazard?

The four hazard severity categories are listed in the following table, which also describes the expected outcome of a musculoskeletal injury occuring as a result of an ergonomic hazard within that category.

Category	Outcome
I	■ Permanent total disability (i.e., permanent total back disability)
II	■ Permanent partial disability (i.e., permanent partial hand disability following ineffective carpal tunnel surgery) ■ Temporary total disability of 60 days or more (i.e., lost workdays following surgery for a back injury) ■ Temporary partial disability of 90 days or more (i.e., restricted duty for carpal tunnel syndrome)
III	■ Temporary total disability of less than 60 days ■ Temporary partial disability of less than 90 days ■ Claim for compensation filed
IV	■ Only first-aid or other minor supportive treatment (i.e., sprain/strain, minor discomfort, no disability, no medical evaluation required) ■ No claim for compensation filed

"WMSD probability" is an assessment of the likelihood that, given exposure to a hazard, a WMSD will result. The four WMSD probability levels are:

A — Likely to occur immediately.
B — Probably will occur in time.
C — Possible to occur in time.
D — Unlikely to occur.

RACs are based on the ergonomist's professional assessment of the hazard severity and WMSD probability. The resulting RAC may range from 1 (critical) to 5 (negligible), with 2 being serious, 3 being moderate, and 4 being minor. For example, an ergonomic hazard that could be expected to cause a musculoskeletal injury resulting in a permanent partial disability (or category II) with a WMSD assessed as probable (level B) has a serious overall risk (RAC = 2).

Risk Assessment Code Matrix				
Hazard Severity	**WMSD Probability**			
	A	**B**	**C**	**D**
I	1	1	2	4
II	1	2	3	4
III	2	3	4	5
IV	4	4	5	5

Determining the cost effectiveness index. The cost effectiveness index (CEI) is a measure that represents, in a single value, the ratio between the cost of an abatement project and the potential effectiveness (measured in terms of reduced frequency and severity of WMSDs) to be derived from implementing the abatement project. CEIs are calculated using the following method:

- **Severity/probability multiplier.** The severity/probability multiplier represents a proportional distribution of the annual cost and frequency of DOD WMSDs. They are derived from an analysis of actual DOD WMSD experiences. Find the severity/probability multiplier (SPM) in the matrix below. Record that number here: _____

Severity/Probability Matrix				
Hazard Severity	WMSD Probability			
	A	B	C	D
I	188	63	21	7
II	63	21	7	2
III	21	7	2	1
IV	7	2	1	0.26

- **Number exposed daily (NED).** Record the average or equivalent number of persons exposed daily to the hazard during the course of a year: _____

- **Compute the effectiveness index (EI)** by using the calculation below. Record that number here: _____

  (SPM) x (NED) = (EI)

- **Estimate the cost (EST)** of the abatement project: $_____

- **Compute the CEI** by using the calculation below. Record that number here: _____

  (EST)/(EI) = (CEI)

Abatement priority number. The abatement priority number (APN) is a two-part code that combines a RAC and CEI. It is written as APN RAC(CEI). For example, an APN 2(7) reflects a RAC of 2 and a CEI of 7. Abatement projects are rank-ordered by APN, grouped by RAC and by CEI in descending order within identical RACs. This order represents the intervention priorities. For example:

APN Rank Order
- 1(3)
- 1(5)
- 2(1.5)
- 2(4)
- 3(3)
- 3(5.2)