



Application Guide for Manual Material-Handling Requirements in SEMI S8

**International SEMATECH Manufacturing Initiative
Technology Transfer #09095029A-ENG**

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Abstract: This document describes the correct use of methods to assess manual material-handling (MMH) tasks to determine their compliance with SEMI S8, Safety Guidelines for Ergonomics Engineering of Semiconductor Manufacturing Equipment. The three commonly accepted methods addressed are the 1991 NIOSH equation, 3D biomechanical analysis, and psychophysical assessment.

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1 EXECUTIVE SUMMARY

Manual material handling (MMH) tasks to operate, maintain, and service semiconductor manufacturing equipment frequently exceed the capability of the end-user population. The ability to accurately assess these tasks is critical to the completion of quality assessments that comply with SEMI S8, Safety Guidelines for Ergonomics Engineering of Semiconductor Manufacturing Equipment. This document describes the correct use of three commonly accepted methods of assessing manual material-handling tasks: the 1991 NIOSH equation, 3D biomechanical analysis, and psychophysical assessment.

These assessment methods pertain to all MMH activities that are required to demonstrate compliance to the latest version of SEMI S8. MMH activities that are to be performed by end-user employees or by field service engineers employed by the equipment supplier should be assessed. Assessments should include the handling of not only the item(s) being maintained or serviced, but also any item(s) that must be handled to provide access to the item(s) being maintained or serviced. Any hoists, jigs, or fixtures used to facilitate MMH activities must be available for evaluation whether the supplier provides them with the equipment or recommends that the end user purchases them.

2 TERMINOLOGY

- **Administrative controls**

A method to modify the way in which a job is performed without involving equipment design. These controls include job rotation, job enlargement, work-rest scheduling, micro-breaks, and stretching exercises. Risk mitigation through equipment design is preferred over administrative controls.

- **Biomechanical modeling**

A computer model used to calculate static strength requirements and spinal compression forces resulting from manual material handling.

- **Lifting index (LI)**

The ratio of actual weight (or force required) to recommended maximum weight (or force) resulting from an assessment using either the NIOSH model or psychophysical data.

- **Maintenance**

Planned or unplanned activities intended to keep equipment in good working order.

- **Manual material handling (MMH)**

Any lifting, pushing, pulling, or carrying activity.

- **Service**

Unplanned activities intended to return equipment that has failed to good working order.

3 REFERENCED STANDARDS

SEMI S8 – Safety Guidelines for Ergonomics Engineering of Semiconductor Manufacturing Equipment

4 REQUIRED DOCUMENTATION – TASK DESCRIPTION

For every task necessary to operate, maintain, and/or service the assessed equipment, the following documentation is required:

1. Name of task as described in equipment operation and service manuals.
2. Brief description of the task.
3. Expected frequency that the task is performed.
4. Expected length of time needed to complete the task.
5. Listing of all tooling and fixtures needed to complete the task.
6. Listing of all parts and components that are handled or moved manually.
7. Listing of weights and/or measured forces for all parts and components that are handled or moved manually that
 - Weigh more than 5 lbs. and are expected to be handled at least once every 5 minutes or weigh more than 10 lbs.
 - Require more than 5 lbs. of force and are expected to be handled at least once every 5 minutes or require more than 10 lbs. of force.

5 REQUIRED DOCUMENTATION – TASK ASSESSMENT

For each task for which parts or components are handled (lifted, lowered, pushed, pulled or carried), the following manual material handling analysis documentation is required.

Note: If material handling devices are used to handle or move materials, parts, or components, then the use of the device (i.e., positioning and handling the device) should be assessed and documented as follows:

1. Name of part/component/material that is handled
2. Associated maintenance or operational task during which part/object is handled
3. Input variables and measurements used for manual material handling analyses
 - Lifting/Lowering Task
 - Part weight
 - Horizontal location at origin of lift
 - Horizontal location at destination of lift
 - Vertical location at origin of lift
 - Vertical location at end of lift
 - Angle of asymmetry at origin of the lift
 - Angle of asymmetry at end of lift
 - Coupling selection (including rationale for a coupling rating that is not designated as “Poor”)
 - Frequency of lifting task in lifts per minute

- Duration of lifting task
- Rating of load placement clearance (used in psychophysical lift/lower analysis)
- Rating of load asymmetry (used in psychophysical lift/lower analysis)
- Rating of available headroom (used in psychophysical lift/lower analysis)
- Posture angles for all body segments used in biomechanics analysis (if applicable)

Note: If a task is designated as a two-person activity, then input variables for each person involved must be documented.

- Pushing/Pulling Task
 - Height of hands where force is applied
 - Distance over which force is applied
 - Frequency of pushing/pulling task
 - Required force to initiate the object in motion
 - Required force to sustain the object in motion
 - Description of flooring on which the analysis is conducted
 - Posture angles for all body segments used in biomechanics analysis (if applicable)
- Other Manual Material Handling Task (e.g., carrying, lifting in non-standard postures, opening/closing hinged components, application of torque, etc.)
 - Description and values of key measurements used to conduct analysis
 - Description and values of success criteria used to conduct analysis
 - Reference source of analysis methodology

4. Results from each manual material handling analyses method:

- NIOSH-recommended weight limit
- NIOSH lifting index
- Psychophysical recommended weight/force limit
- Psychophysical weight/force index
- Population strength capability for all body segments when the 5th percentile female is modeled (biomechanics analysis)
- Disk compression when the 95th percentile male and the 5th percentile female anthropometries are modeled (biomechanical analysis)
- Resulting risk ranking of analysis according to *ISMI Manual Material Handling Risk Characterization Guideline* (Technology Transfer #08064933A-ENG)

Note: If a task is designated as a two-person activity, analysis results for each person must be documented.

5. Description of solution recommended to mitigate identified risks, including step-by-step instructions to conduct the task with the solution implemented:
- If a material handling device is recommended to reduce identified risks, then an analysis of how the device is used (i.e., handling and positioning of the device) to complete the task and documentation as stated above (step #3 and step #4) is required.
 - If administrative controls (i.e., two-person lifting) are recommended, then an analysis of how the task is performed following the administrative control and documentation as stated above (step #3 and step #4) is required.

6 ANALYSIS TOOL SELECTION

Table 1 shows the three MMH evaluation tools: the NIOSH (1991) lifting equation, 3D biomechanical model, and psychophysical capacity analysis. A checkmark in the NIOSH, biomechanical or psychophysical column indicates that that analysis method is appropriate for the task type and task conditions. When multiple models are appropriate, apply each method and use the most conservative result as the design guideline.

Table 1 Criteria to Determine Appropriate MMH Analysis Tool(s)

MMH Task Type	Task Conditions	NIOSH	Biomechanical	Psychophysical
Two-handed lift/lower	Infrequent lifting/lowering tasks (less than once per five minutes)	✓	✓	✓
	Frequent lifting/lowering (more than once per five minutes)	✓		✓
	Extra considerations involved: <ul style="list-style-type: none"> • Work area has limited headroom • Load asymmetry is an issue 		✓	✓
Single-handed lift/lower	Infrequent lifting/lowering tasks (less than once per five minutes)		✓	✓
	Frequent lifting/lowering tasks (more than once per five minutes)			✓
Lift/lower in non-standard postures	Sitting and kneeling		✓	✓
	Lying tasks			✓
Carrying	Carrying tasks			✓
Pushing and pulling	Infrequent and short distance <ul style="list-style-type: none"> • Distances up to 2.1 m (7 feet) • Frequency less than once per five minutes 		✓	✓
	Other push/pull tasks			✓

7 NIOSH EQUATION 1991

The 1991 NIOSH equation considers load weight, lift dimensions, hand/container coupling, task frequency, and body position (asymmetry) while executing a lift. A Recommended Weight of Lift (RWL) is calculated based on the data entered into the equations. The RWL represents the maximum weight that can be safely handled by about 90% of the North American adult working population. The equation for calculating the RWL uses a multiplicative model that gives a weight to each task variable. The weightings are expressed as coefficients that are used in the model to decrease the recommended load constant (i.e., maximum load weight to be lifted).

Table 2 NIOSH 1991 Equation Multipliers

Multiplier	Equation U.S. Standard	Equation Metric
Load Constant (LC)	51 lbs	23 kg
Horizontal Multiplier (HM)	$(10/H)$	$(25/H)$
Vertical Multiplier (VM)	$(1 - (.0075 V-30))$	$(1 - (.003 V-75))$
Distance Multiplier (DM)	$(.82 + (1.8/D))$	$(.82 + (4.5/D))$
Asymmetric Multiplier (AM)	$(1 - (.0032 \times A))$	$(1 - (.0032 \times A))$
Frequency Multiplier (FM)	FM from Table 4	FM from Table 4
Coupling Multiplier (CM)	CM from Table 5	CM from Table 5
RWL = LC × HM × VM × DM × AM × FM × CM		

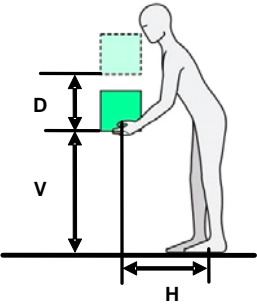


Figure 1 NIOSH (1991) Equation Variables H, V, and D

Horizontal Distance (H): Horizontal Location of Hands from Midpoint Between the Ankles

Measure the large knuckle at the base of the third finger to the ankle midpoint, as shown in Figure 1. H can range from 25 to 63 cm (10 to 25 inches). If H is 25 cm or less, HM = 1. If H is greater than 63 cm, HM = 0. If the lift task has a precision component (i.e., the weight of the lifted object must be held or supported at the end of the lift due to its fragile nature or close tolerance of placement), measure H at both the start and end of the lift. The larger of the two measurements is then used as the H variable in the equation. If the task does not have a precision component, use the measurement at the origin of the lift as the H variable. If a measurement of H is not available, estimate as follows, where W = the object width in the sagittal plane.

Table 3 Estimates for Horizontal Reach

Metric		US Standard	
If V =	Then H =	If V =	Then H =
<25 cm	$25 + W/2$	<10 inches	$10 + W/2$
>25 cm	$20 + W/2$	>10 inches	$8 + W/2$

Note: The estimates assume that H is a function of object width (W) and body depth (20 or 25 cm). If H includes additional factors beyond these, they should be added into the equation (general form: H = body depth + (object width/2) + additional reach).

Vertical Location (V): Vertical Location of the Hands from the Floor

Measure at the origin of the lift. V can range from 0 to 175 cm (0 to 70 inches). If $V > 175$ cm, $VM = 0$.

Vertical Travel Distance (D): Vertical Travel Distance Between the Origin and the Destination of the Lift

Subtract vertical measurements at the origin from the end of the lift. D can range from 25–175 cm (10–70 inches). If measured D is < 25 cm (10 in), $DM = 1$. If $D > 175$ cm (70 in), $DM = 0$.

Asymmetry (A): Angle of Asymmetry: Angular Displacement of the Load from the Sagittal Plane

Measure the angle at the start and end of the lift in terms of degrees from the sagittal plane of the body as shown in Figure 2. If the lift has a precision component (i.e., the weight of the lifted object must be held or supported at the end of the lift due to its fragile nature or close tolerance of placement), use the larger value of A. Otherwise use the start position A value. A can range from 0 to 135° . If A is greater than 135° , $AM = 0$.

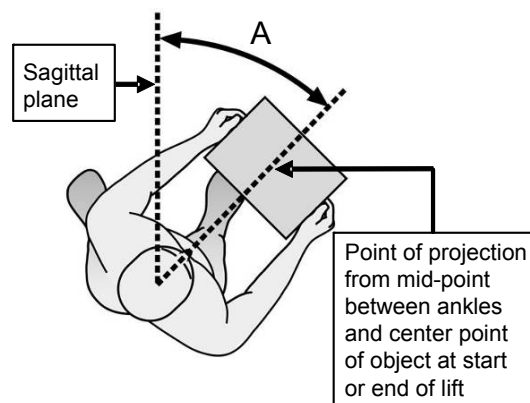


Figure 2 Determining Angle of Asymmetry (A) for NIOSH Lifting Equation

Frequency (F): Average Frequency Rate of Lifting

Frequency is based on three input variables: lifts per minute, vertical start of lift (V), and continuous task duration. Lifting frequency is defined as the mean number of lifts occurring in a 15-minute period. If the lifting is not continuous, add up the number of lifts occurring in the 15-minute period and divide by 15.

Duration is defined as one of three categories: ≤ 1 hour, ≤ 2 hours, or ≤ 8 hours assuming appropriate recovery allowances. The equation is not applicable for tasks lasting > 8 hours. Use the algorithms below to help determine the appropriate duration category for the task:

- Duration ≤ 1 hour: 0.001 to 1 hour with recovery time at least 1.2 times the work length
- Duration ≤ 2 hour: > 1 hour to 2 hours with recovery time at least 0.3 times the work length
- Duration ≤ 8 hour: > 2 hours to 8 hours with no recovery time other than scheduled work breaks

Recovery time is defined as resting or light work in which no lifting occurs. If a task does not meet the recovery criterion, omit the recovery time and add the work times together. As noted in Table 4, “maximum” acceptable frequencies (i.e., RWL defaults to 0) are present ranging from 9 to 15 lifts per minute, depending on task conditions.

Table 4 Frequency Multiplier (FM) Table

Frequency	Work Duration (Continuous)					
	≤8 HRS		≤2 HRS		≤1 HR	
	V <76 cm/ (30 in)	V ≥76 cm/ (30 in)	V <76 cm/ (30 in)	V ≥76 cm/ (30 in)	V <76 cm/ (30 in)	V ≥76 cm/ (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	0.00	0.15	0.30	0.30	0.52	0.52
10	0.00	0.13	0.26	0.26	0.45	0.45
11	0.00	0.00	0.00	0.23	0.41	0.41
12	0.00	0.00	0.00	0.21	0.37	0.37
13	0.00	0.00	0.00	0.00	0.00	0.34
14	0.00	0.00	0.00	0.00	0.00	0.31
15	0.00	0.00	0.00	0.00	0.00	0.28
>15	0.00	0.00	0.00	0.00	0.00	0.00

Note: F = Frequency in lifts/minute, V = Vertical start point of lift (cm/inches)

Coupling (C): Coupling Multiplier: Adjustment Factor Based on Quality of Handles on the Object Being Lifted

Coupling is based on one of three classifications: good, fair, or poor. If there is any doubt about classifying a particular coupling design, select the more stressful classification. Anytime tight-fitting elastic cleanroom-type gloves are worn, the next lower classification should be used. If bulky gloves are worn, the assessor should consider a more significant decrement based on available research. Table 5 shows which multiplier to apply for each classification. Table 6 and Table 7 explain how to classify coupling designs.

Table 5 Coupling Multiplier

Coupling	V <76 cm (30")	V >76 cm (30")
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

If tight fitting elastic cleanroom-type gloves are worn, the quality of the coupling should be decremented to the next lower classification than would be used if no gloves were worn.

In general, a good coupling reduces the maximum grasp forces required and increases the acceptable weight for lifting. A poor coupling will require higher maximum grasp forces and decrease the acceptable weight for lifting.

Table 6 Hand-to-Container Coupling Classification

Hand-to-Object Coupling Classification	Part/Container Description	Definition/Reference Note
Good	Containers of optimal design, such as some boxes, crates, etc. Loose parts or irregular objects which are not usually containerized, such as castings, stock, supply materials, etc.	A comfortable grip in which the hand can be easily wrapped around the object.
Fair	Containers of optimal design. Containers of optimal design with no handles or hand-hold cut-outs. Loose parts or irregular objects.	Handles or hand-hold cut-outs of less than optimal design. A grip in which the hand can be flexed about 90 degrees.
Poor	Containers of less than optimal design with no handles or hand-hold cut-outs. Loose parts or irregular objects that are bulky or hard to handle.	

Table 7 Description of Handle Design Classifications

Feature	Characteristics
Optimal handle design	1.9–3.8 cm (.75–1.5 inch) diameter ≥11.5 cm (4.5 inches) length 5 cm (2 inches) in clearance cylindrical shape smooth, non-slip surface
Optimal hand-hold cut-out	≥3.8 cm (1.5 inches) height 11.5 cm (4.5 inches) length semi-oval shape ≥5 cm (2 inches) clearance smooth, non-slip surface ≥0.60 cm (0.25 inches) container thickness
Optimal container design	≤40 cm (16 inches) frontal length ≤30 cm (12 inches) height smooth, non-slip surface
Finger hold	A worker should be capable of clamping the fingers at nearly 90 degrees under the container, such as required when lifting a cardboard box from the floor.
Less than optimal container design	≥40 cm (16 inches) frontal length ≥30 cm (12 inches) height rough or slippery surface sharp edges asymmetric center of mass unstable contents requires gloves
Wrist deviation/awkward posture/force	A worker should be able to comfortably wrap the hand around the object without causing excessive wrist deviations or awkward postures. The grip should not require excessive force.

The Lifting Index

The lifting index (LI) provides a simple estimate of the hazard of overexertion injury for a manual lifting job.

$$LI = \text{Load Weight} \div \text{RWL}$$

Two-Person Lifting

Two-person lifting can be assessed with either the 1991 NIOSH equation or psychophysical lifting data. A separate analysis should be performed for each person if any of the parameters of the analysis model (e.g., horizontal reach, vertical location, etc.) are different. Each person in a two-person lift can lift only 90% of the amount each could lift in a similar posture lifting alone.

$$\text{RWL}_{\text{Adjusted}} = 0.90 \times \text{RWL}_{\text{Calculated}}$$

Also, a lifting index should be calculated for the RWL for each person:

$$LI_{\text{Person 1}} = (\frac{1}{2} \text{ actual weight}) \div (0.90 \times \text{RWL}_{\text{Person 1}})$$

$$LI_{\text{Person 2}} = (\frac{1}{2} \text{ actual weight}) \div (0.90 \times \text{RWL}_{\text{Person 2}})$$

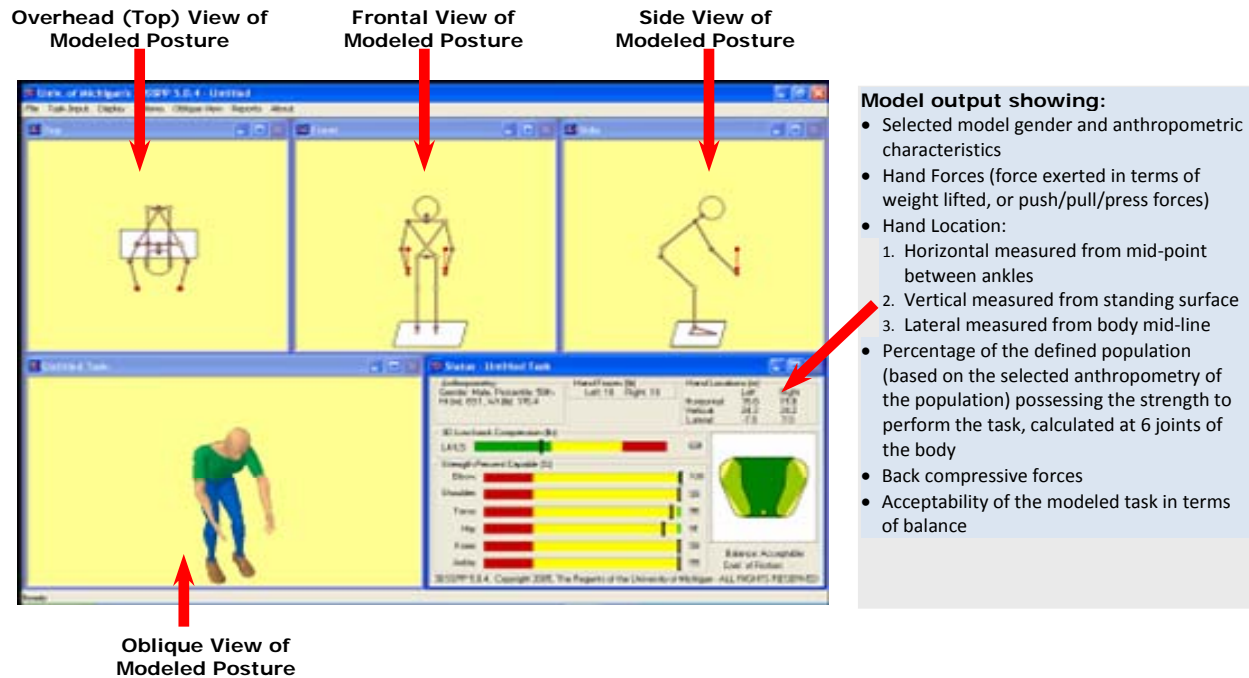
The acceptability of the task should be based on the larger of the two lifting indices. Risk characterization for the task is the same as single person lifting using the larger of the two lifting indices.

Conformance with SEMI S8

Any task with a lifting index greater than 1.0 presents an increased risk of injury and does not meet the expectation set in SEMI S8. The risk associated with any task with a lifting index greater than 1.0 should be determined according to *ISMI Manual Material Handling Risk Characterization Guideline* (Technology Transfer #08064933A-ENG).

8 BIOMECHANICAL MODELS: UNIVERSITY OF MICHIGAN 3D STATIC STRENGTH PREDICTION PROGRAM (3DSSPP)

Several biomechanical models of different types are commercially available. One example of these models is the University of Michigan 3D Static Strength Prediction Program (3DSSPP; available through the University of Michigan Center for Ergonomics). Figure 3 displays the output screen depicting the task parameters, worker characteristics (anthropometry), and posture that are entered into the model, and some calculations such as low back compressive forces and percentage of the specified population with the strength to perform the task. Changes to the model parameters (hand forces, posture, etc.) are typically made by the user. Posture is most typically entered using some variation of videotape analysis (redesign scenario) or the creation of a reasonable posture based on known work area/task dimensions (design scenario). In some biomechanical models (the 3DSSPP being an example), postures may be predicted based on user-defined hand location using inverse kinematics algorithms.



Note: Illustration provided with permission of the Regents of the University of Michigan. Website www.engin.umich.edu/dept/ioe/3DSSPP/.

Figure 3 3DSSPP Output Screens

Table 8 Description of the 3DSSPP Variables

Limit	Characteristic
Strength Design Limit (SDL)	Tasks that can be safely performed by 75% of females do not exceed the SDL
Back Compression Design Limit (BCDL)	Back compression above 350 kg (770 lbs) exceeds the BCDL (up to a threefold increase risk of injury)

Conformance with SEMI S8

Any task with requirements that exceed the SDL for the 25th percentile female or that compress the low back more than the BCDL of 350 kg (770 lbs) presents an increased risk of injury and does not meet the expectation set in SEMI S8. The risk associated with any task exceeding the SDL or BCDL should be determined according to *ISMI Manual Material Handling Risk Characterization Guideline* (Technology Transfer #08064933A-ENG).

Note: For any questions about the use of different biomechanical modeling software, contact the software publisher.

9 PSYCHOPHYSICAL CAPACITY DATA – TWO-HANDED LIFT/LOWER DATA

To explain the use of psychophysical data, *A Guide to Manual Materials Handling*, Mital et al., 1997, will be used, but other peer-reviewed sources of psychophysical data can also be used. If using other sources, data should accommodate 75% of the female population.

Metric (kg, cm)

The data in Table 9 represent the maximum acceptable weight that 75% of the female workforce can be expected to handle without increased injury risk under various task conditions. To conduct the analysis,

- Determine the vertical location of the hands at the start of the lift; use the appropriate data table that corresponds with this initial position (below 80 cm, between 80–132 cm, between 132–183 cm).
- Determine the horizontal distance to the object as measured from the large knuckle at the end of the third finger to the ankle. Select the appropriate column for the measured horizontal distance (25–42 cm, 42–50 cm, or 50–63 cm). Body thickness is assumed to be 25 cm, aligning horizontal distance ranges with assumptions made in the NIOSH lifting equation).
- Determine the vertical location of the hands at the end of the lift (below 80 cm, below 132 cm, above 132 cm).
- Determine the lifting task frequency. The recommended weight limit is the intersection of the lifting task frequency and the vertical location at the end of lift.
- Values between different lifting frequencies can be interpolated.

Table 9 Recommended Weight of Lift (kg) for Two-Handed Symmetrical Lifting for an 8-hour Shift

Vertical Location @ Start of Lift: Below 80 cm	Horizontal Distance [cm]								
	25 to 42 cm			42 to 50 cm			50 to 63 cm		
	Vertical Location @ End of Lift			Vertical Location @ End of Lift			Vertical Location @ End of Lift		
Frequency of Lift	<80 cm	<132 cm	≥132 cm	<80 cm	<132 cm	≥132 cm	<80 cm	<132 cm	≥132 cm
1 lift every 8 hours	19	16	14	16	13	12	14	12	11
1 lift every 30 minutes	14	12	10	12	10	9	11	9	8
1 lift every 5 minutes	13	11	10	10	8	7	10	8	7
1 lift per minute	12	10	9	10	8	7	9	8	7
4 lifts per minute	11	9	8	9	8	7	9	8	7
8 lifts per minute	9	8	7	8	7	6	8	7	6
12 lifts per minute	8	7	6	7	6	5	7	6	5
16 lifts per minute	7	6	5	6	5	5	6	5	5
Vertical Location @ Start of Lift: Between 80 cm and 132 cm	Horizontal Distance [cm]								
	25 to 42 cm			42 to 50 cm			50 to 63 cm		
	Vertical Location @ End of Lift			Vertical Location @ End of Lift			Vertical Location @ End of Lift		
Frequency of Lift	<80 cm	<132 cm	≥132 cm	<80 cm	<132 cm	≥132 cm	<80 cm	<132 cm	≥132 cm
1 lift every 8 hours	16	17	15	13	15	13	12	15	13
1 lift every 30 minutes	12	14	12	10	13	11	9	13	11
1 lift every 5 minutes	11	13	11	8	12	11	8	12	11
1 lift per minute	10	12	11	8	11	10	8	11	10
4 lifts per minute	9	11	10	8	9	8	8	9	8
8 lifts per minute	8	9	8	7	7	6	7	7	6
12 lifts per minute	7	9	8	6	7	6	6	7	6
16 lifts per minute	6	8	7	5	6	5	5	6	5
Vertical Location @ Start of Lift: Between 132 cm and 183 cm	Horizontal Distance [cm]								
	25 to 42 cm			42 to 50 cm			50 to 63 cm		
	Vertical Location @ End of Lift			Vertical Location @ End of Lift			Vertical Location @ End of Lift		
Frequency of Lift	<80 cm	<132 cm	≥132 cm	<80 cm	<132 cm	≥132 cm	<80 cm	<132 cm	≥132 cm
1 lift every 8 hours	14	15	14	12	12	13	11	13	11
1 lift every 30 minutes	10	12	12	9	10	11	8	11	9
1 lift every 5 minutes	10	11	11	7	9	11	7	11	9
1 lift per minute	9	11	11	7	9	10	7	10	8
4 lifts per minute	8	10	9	7	8	8	7	8	8
8 lifts per minute	7	8	7	6	6	6	6	6	6
12 lifts per minute	6	8	7	5	5	6	5	6	5
16 lifts per minute	5	7	7	5	4	5	5	5	4

U.S. Standard (lbs, inches)

The data in Table 10 represent the maximum acceptable weight that 75% of the female workforce can be expected to handle without increased injury risk under various task conditions. To conduct the analysis,

- Determine the vertical location of the hands at the start of the lift; use the appropriate data table that corresponds with this initial position (below 31.5 inches, between 31.5–52 inches, between 52–72 inches).
- Determine the horizontal distance to the object as measured from the large knuckle at the end of the third finger to the ankle. Select the appropriate column for the measured horizontal distance (10–16.5 inches, 16.5–20 inches, or 20–25 inches. Body thickness is assumed to be 10 inches, aligning horizontal distance ranges with assumptions made in the NIOSH lifting equation).
- Determine the vertical location of the hands at the end of the lift (below 31.5 inches, below 52 inches, above 52 inches).
- Determine the lifting task frequency. The recommended weight limit is the intersection of the lifting task frequency and the vertical location at the end of lift.
- Values between different lifting frequencies can be interpolated.

Table 10 Recommended Weight of Lift (lbs) for Two-Handed Symmetrical Lifting for an 8-hour Shift

Vertical Location @ Start of Lift: Below 31.5 Inches	Horizontal Distance (Front of Body to Hands) [in]								
	10 to 16.5 Inches			16.5 to 20 Inches			20 to 25 Inches		
	Vertical Location @ End of Lift			Vertical Location @ End of Lift			Vertical Location @ End of Lift		
Frequency of Lift	<31.5 in	<52 in	≥52 in	<31.5 in	<52 in	≥52 in	<31.5 in	<52 in	≥52 in
1 lift every 8 hours	42	35	31	35	29	26	31	26	24
1 lift every 30 minutes	31	25	22	26	22	20	24	20	18
1 lift every 5 minutes	29	24	22	22	18	15	22	18	15
1 lift per minute	26	22	20	22	18	15	20	17	15
4 lifts per minute	24	20	18	20	17	15	20	17	15
8 lifts per minute	20	18	15	18	14	13	18	14	13
12 lifts per minute	18	14	13	15	13	11	15	13	11
16 lifts per minute	15	12	11	13	11	10	13	11	10
Vertical Location @ Start of Lift: Between 31.5 and 52 Inches	Horizontal Distance (Front of Body to Hands) [in]								
	10 to 16.5 Inches			16.5 to 20 Inches			20 to 25 Inches		
	Vertical Location @ End of Lift			Vertical Location @ End of Lift			Vertical Location @ End of Lift		
Frequency of Lift	<31.5 in	<52 in	≥52 in	<31.5 in	<52 in	≥52 in	<31.5 in	<52 in	≥52 in
1 lift every 8 hours	35	37	33	29	33	29	26	33	29
1 lift every 30 minutes	25	31	26	22	29	24	20	29	24
1 lift every 5 minutes	24	29	24	18	26	23	18	26	23
1 lift per minute	22	26	23	18	24	21	17	24	21
4 lifts per minute	20	24	22	17	20	18	17	20	18
8 lifts per minute	18	19	17	14	15	13	14	15	13
12 lifts per minute	14	19	17	13	15	13	13	15	13
16 lifts per minute	12	18	15	11	13	11	11	13	11
Vertical Location @ Start of Lift: Between 52 and 72 Inches	Horizontal Distance (Front of Body to Hands) [in]								
	10 to 16.5 Inches			16.5 to 20 Inches			20 to 25 Inches		
	Vertical Location @ End of Lift			Vertical Location @ End of Lift			Vertical Location @ End of Lift		
Frequency of Lift	<31.5 in	<52 in	≥52 in	<31.5 in	<52 in	≥52 in	<31.5 in	<52 in	≥52 in
1 lift every 8 hours	31	33	31	26	26	29	24	29	24
1 lift every 30 minutes	22	26	26	20	22	24	18	24	20
1 lift every 5 minutes	22	24	24	15	20	23	15	23	20
1 lift per minute	20	23	24	15	20	21	15	21	18
4 lifts per minute	18	22	20	15	18	18	15	18	18
8 lifts per minute	15	17	15	13	13	13	13	13	13
12 lifts per minute	13	17	15	11	11	13	11	13	11
16 lifts per minute	11	15	15	10	9	11	10	11	9

Use of Psychophysical Multipliers

Other circumstances of the lift may affect the amount of weight the worker should lift. Common factors are listed in Table 11 with instructions for determining multipliers for each condition. The RWL is multiplied by each of the multipliers to determine the Final RWL (RWL). Less than optimal conditions result in a multiplier less than 1, which reduces the FRWL. Factors are listed below with the associated abbreviation and a brief description:

1. Work Duration (WD) is the number of hours the task will be performed in a workers shift.
2. Limited Headroom (LH) is a measure of how cramped a worker's posture is because of low overhead clearance.
3. Asymmetrical Lifting (AL) indicates twisting with a suspended load.
4. Coupling (CP) indicates how well the hands connect with the load.
5. Load Placement Clearance (LPC) is a determination of how precisely the load must be handled because of clearances at the destination of the load.

Table 11 Multipliers for Psychophysical Data

Multiplier Description	Duration (Hours)			
Working Duration (Hours) Not all MMH tasks are performed across the entire duration of the shift, and shift lengths differ. Use the multipliers below to adjust for this. Interpolate as required. The working duration multiplier should not be used if you are dealing with a lift/lower that occurs only once per 8 hours.	1	4	8	12
Limited Headroom Multiplier (Applies to two hand lifting only) If the work environment does not permit the worker to assume an upright posture during handling, use the limited headroom multipliers. Interpolate as required. Note that the limited headroom multiplier would be applied only for situations where the lift would permit the worker to stand upright if there was not a headroom restriction. <div data-bbox="467 600 781 856" style="text-align: center;"> </div>	% Upright	Height cm (in)	Multiplier	
Asymmetrical Lifting (Twisting) Multiplier (Applies to two hand lifting only) If twisting occurs, use the adjustment factors. The following assumptions apply: <ul style="list-style-type: none"> • Angle of twist measured from straight line drawn between the ankles to the midpoint of the container. Start and end points of lift must be considered. • The 30–90 adjustment factor assumes feet do not move and may be too high if feet move. • The “Above 90” adjustment factor assumes people move their feet. <div data-bbox="459 1073 781 1346" style="text-align: center;"> </div>	Angle of Turn (Degrees)		Multiplier	
Coupling Multiplier The RWL data assume that good quality handles are provided for the user's hands to couple with the load. If that is not the case, the appropriate multiplier should be used. If there is any question about the appropriate classification, use the lesser of the classifications in question. If tight-fitting elastic cleanroom type gloves are worn, the quality of the coupling should be decremented to the next lower classification than would be used if no gloves were worn.	Coupling (Handles)		Multiplier	
Load Placement Clearance Multiplier (Applies to two hand lifting only) If a load has to be positioned in a location where the clearance around the object is limited, a precision component is added to the task that effectively reduces capacity. A clearance of (e.g.) 1.5 cm refers to the clearance on both sides of the object handled. Interpolate for intermediate values.	Load Clearance in cm (Inches)		Multiplier	
Load Asymmetry Multiplier (Applies to two hand lifting and carrying only) Adjustment for loads where the center of mass is not centered in the object (i.e., a different load in each hand). The center of gravity shift is measured from physical midpoint of the object being lifted. Interpolate for intermediate values.	Load Asymmetry in cm (Inches)		Multiplier	

Calculation of the Final RWL

A simple equation describes how each of these multipliers is used to get the FRWL:

$$RWL \times WD \times LH \times AL \times CP = FRWL$$

Lifting Index

The lifting index (LI) provides a simple estimate of the hazard of overexertion injury for a manual lifting job.

$$LI = \text{Load Weight} \div FRWL$$

Two-person Lifting

Two-person lifting can be assessed with either the 1991 NIOSH equation or psychophysical lifting data. A separate analysis should be performed for each person if any of the parameters of the analysis model (e.g., horizontal reach, vertical location, etc.) are different. Each person in a two-person lift can lift only 90% of the amount that person could lift in a similar posture lifting alone.

$$FRWL_{\text{Adjusted}} = 0.90 \times FRWL_{\text{Calculated}}$$

Also, a lifting index should be calculated for the FRWL for each person:

$$LI_{\text{Person 1}} = (\frac{1}{2} \text{ actual weight}) \div (0.90 \times FRWL_{\text{Person 1}})$$

$$LI_{\text{Person 2}} = (\frac{1}{2} \text{ actual weight}) \div (0.90 \times FRWL_{\text{Person 2}})$$

The acceptability of the task should be based on the larger of the two lifting indices. Risk characterization for the task is the same as single-person lifting using the larger of the two lifting indices.

Conformance with SEMI S8

Any task with a lifting index greater than 1.0 presents an increased risk of injury and does not meet the expectation set in SEMI S8. The risk associated with any task with a lifting index greater than 1.0 should be determined according to *ISMI Manual Material Handling Risk Characterization Guideline* (Technology Transfer #08064933A-ENG).

10 PSYCHOPHYSICAL CAPACITY DATA – ONE-HAND LIFT DATA

The one-hand lift forces shown in Table 12 and Table 13 take into account the worker's posture (stand/squat/sit/kneel), reach distance (shoulder-grip distance, handling frequency (F greater than or less than 1 lift per minute), and age. These forces can be applied when the arm is in front of the body in the horizontal plane of the shoulder and when the arm is held to the side of the body. The forces are for the preferred hand; for the non-dominant hand, reduce the values by 10%. The data are for the 5th percentile female.

Table 12 One-Hand Lift Data Infrequent Lifts (F <1 lift per minute)

Position	Shoulder – Grip Distance	RWL
Standing/Squatting	65 cm (25.6 in)	5.9 kg (12.9 lbs)
	60 (23.6)	7.2 (15.7)
	50 (19.7)	8.5 (18.6)
	35 (13.8)	11.7 (25.7)
	20 (7.9)	14.3 (31.5)
	5 (2.0)	17.6 (38.6)
Sitting	65 (25.6)	5.2 (11.4)
	50 (19.7)	7.8 (17.2)
	40 (15.7)	10.4 (22.9)
	30 (11.8)	13 (28.6)
	15 (5.9)	15.6 (34.3)
	5 (2.0)	18.2 (40)
Kneeling on One Knee	65 (25.6)	5.9 (12.9)
	60 (23.6)	7.2 (15.7)
	55 (21.6)	7.8 (17.2)
	30 (11.8)	9.8 (21.5)
	25 (9.8)	11.7 (25.7)
	15 (5.9)	14.3 (31.5)

Note: Lifting forces in kg (lbs) for one-handed lift with arm in the front of the body in the horizontal plane of the shoulder.

Table 13 One-Hand Lift Data Frequent Lifts (F >1 lift per minute)

Position	Shoulder – Grip Distance	RWL
Standing/Squatting	65 cm (25.6 in)	4.1 kg (9 lbs)
	60 (23.6)	5 (11)
	50 (19.7)	5.9 (12.9)
	35 (13.8)	8.2 (18)
	20 (7.9)	10 (22)
	5 (2.0)	12.3 (27)
Sitting	65 (25.6)	3.6 (8)
	50 (19.7)	5.5 (12)
	40 (15.7)	7.3 (16)
	30 (11.8)	9.1 (20)
	15 (5.9)	11.1 (24.3)
	5 (2.0)	12.7 (28)
Kneeling on One Knee	65 (25.6)	4.1 (9)
	60 (23.6)	5 (11)
	55 (21.6)	5.5 (12)
	30 (11.8)	6.8 (15)
	25 (9.8)	8.2 (18)
	15 (5.9)	10 (22)

Note: Lifting Forces in kg (lbs) for one-handed lift with arm in the front of the body in the horizontal plane of the shoulder.

11 PSYCHOPHYSICAL CAPACITY DATA – TWO-HAND PULL DATA

Table 14 presents the maximum initial and sustained forces that can be exerted by 75% of the female population based on the task characteristics. Each cell gives two values: 1) the maximum acceptable initial pull force that can be exerted and 2) the sustained force that can be acceptably maintained across the distance/duration (number in parentheses). Initial force is defined as the force to get the object in motion; sustained force is defined as the force to maintain the object in motion. If the pull distances are not known, the evaluator should measure and document the required pull force and determine the maximum acceptable pull distance based on frequency.

The variables include the following:

- Pull distance 2.1 to 61 meters (7 feet to 200 feet)
- Frequency of pull (once every 6 seconds to once per 8-hour period)
- Floor-to-hand height (knee level, elbow level, shoulder level)
- Initial vs. sustained forces

Note: If cleanroom gloves are worn, the table values should be reduced by 15% for pull tasks only.

Table 14 Maximum Acceptable Two-Hand Pull Forces, Initial (Sustained) Forces

Floor-to-Hand Height	Pull Distance (Meters)	Frequency: One Pull Every... (Metric – Meters, kg)						
		6 sec	12 sec	1 min	2 min	5 min	30 min	8 hr
Shoulder Level	2.1	16(7)	19(10)	20(13)	21(14)	24(15)	25(16)	26(20)
	7.6	X	X	19(12)	19(12)	21(13)	22(14)	24(18)
	15.2	X	X	16(9)	16(10)	18(11)	19(12)	20(15)
	30.5	X	X	14(7)	16(9)	17(10)	18(10)	20(14)
	45.7	X	X	14(6)	16(9)	17(9)	18(9)	20(12)
	61	X	X	X	14(6)	15(7)	16(7)	18(10)
Elbow Level	2.1	16(7)	19(10)	21(13)	22(13)	25(15)	26(16)	27(19)
	7.6	X	X	19(11)	20(12)	22(13)	23(14)	25(17)
	15.2	X	X	17(9)	17(10)	19(11)	20(12)	21(14)
	30.5	X	X	15(7)	16(9)	18(9)	19(10)	21(13)
	45.7	X	X	15(6)	16(8)	18(9)	19(9)	21(12)
	61	X	X	X	15(5)	16(7)	17(7)	19(9)
Knee Level	2.1	17(6)	20(9)	22(12)	23(12)	26(13)	27(14)	28(18)
	7.6	X	X	20(11)	21(11)	23(12)	24(13)	26(16)
	15.2	X	X	17(8)	18(9)	20(10)	21(11)	22(13)
	30.5	X	X	16(6)	17(8)	18(9)	20(9)	22(12)
	45.7	X	X	16(6)	17(8)	18(8)	20(8)	22(11)
	61	X	X	X	15(5)	16(6)	18(6)	20(9)
Floor-to-Hand Height	Pull Distance (Feet)	Frequency: One Pull Every... (U.S. Standard – Feet, lbs)						
		6 sec	12 sec	1 min	2 min	5 min	30 min	8 hr
Shoulder Level	7	35(15)	42(22)	44(29)	46(31)	53(33)	55(35)	57(44)
	25	X	X	42(26)	42(26)	46(29)	48(31)	53(40)
	50	X	X	35(20)	35(22)	40(24)	42(26)	44(33)
	100	X	X	31(15)	35(20)	37(22)	40(22)	44(31)
	150	X	X	31(13)	35(20)	37(20)	40(20)	44(26)
	200	X	X	X	31(13)	33(15)	35(15)	40(22)
Elbow Level	7	35(15)	42(22)	46(29)	48(29)	55(33)	57(35)	59(42)
	25	X	X	42(24)	44(26)	48(29)	51(31)	55(37)
	50	X	X	37(20)	37(22)	42(24)	44(26)	46(31)
	100	X	X	33(15)	35(20)	40(20)	42(22)	46(29)
	150	X	X	33(13)	35(18)	40(20)	42(20)	46(26)
	200	X	X	X	33(11)	35(15)	37(15)	42(20)
Knee Level	7	37(13)	44(20)	48(26)	51(26)	57(29)	59(31)	62(40)
	25	X	X	44(24)	46(24)	51(26)	53(29)	57(35)
	50	X	X	37(18)	40(20)	44(22)	46(24)	48(29)
	100	X	X	35(13)	37(18)	40(20)	44(20)	48(26)
	150	X	X	35(13)	37(18)	40(18)	44(18)	48(24)
	200	X	X	X	33(11)	35(13)	40(13)	44(20)

Note: An “X” in a cell indicates the pull distance cannot be performed for the frequency pull.

12 PSYCHOPHYSICAL CAPACITY DATA–TWO-HAND PUSH DATA

Table 15 and Table 16 present the maximum initial and sustained forces that can be exerted by 75% of the female population based on the task characteristics. Each cell gives two values: 1) the maximum acceptable initial pull force that can be exerted and 2) the sustained force that can be acceptably maintained across the distance/duration (number in parentheses). Initial force is defined as the force to get the object in motion; sustained force is defined as force to maintain motion. If the push distances are not known, the evaluator should measure and document the required push force and determine the maximum acceptable push distance based on frequency.

The variables include the following:

- Push distance 2.1 to 61 meters (7 feet to 200 feet)
- Frequency of push (once every 6 seconds to once every 8-hour period)
- Floor-to-hand height (knee level, elbow level, shoulder level)

Table 15 Maximum Acceptable Two-Hand Push Forces Initial (Sustained) Forces

Floor-to-Hand Height	Push Distance (Meters)	Frequency: One Push Every... (Metric – Meters, kg)						
		6 sec	12 sec	1 min	2 min	5 min	30 min	8 hr
Shoulder Level	2.1	17(8)	18(10)	21(14)	22(14)	24(16)	25(17)	27(21)
	7.6	X	X	19(11)	20(11)	22(12)	23(13)	24(16)
	15.2	X	X	17(8)	17(9)	19(10)	20(11)	21(13)
	30.5	X	X	15(6)	16(8)	17(9)	19(9)	21(12)
	45.7	X	X	15(6)	16(8)	17(8)	19(8)	21(11)
	61	X	X	X	14(4)	15(6)	17(6)	19(9)
	91.4	X	X	X	X	15(5)	16(6)	19(7)
	121.9	X	X	X	X	14(4)	16(5)	18(6)
	152.4	X	X	X	X	13(3)	15(5)	17(6)
	228.6	X	X	X	X	X	15(5)	16(5)
	304.8	X	X	X	X	X	14(4)	16(5)
	381	X	X	X	X	X	13(4)	15(4)
	457.2	X	X	X	X	X	13(4)	15(4)
	533.4	X	X	X	X	X	12(4)	15(4)
609.6	X	X	X	X	X	12(3)	15(4)	
Elbow Level	2.1	17(7)	18(9)	21(13)	22(13)	24(15)	25(16)	27(19)
	7.6	X	X	20(11)	20(11)	22(13)	23(13)	25(17)
	15.2	X	X	17(8)	17(10)	19(11)	20(11)	21(14)
	30.5	X	X	15(7)	16(9)	18(9)	19(10)	21(13)
	45.7	X	X	15(6)	16(8)	18(8)	19(9)	21(12)
	61	X	X	X	15(4)	16(6)	17(7)	19(9)
	91.4	X	X	X	X	15(5)	16(7)	19(8)
	121.9	X	X	X	X	15(4)	16(6)	18(7)
	152.4	X	X	X	X	15(3)	15(5)	17(7)
	228.6	X	X	X	X	X	15(5)	16(6)
	304.8	X	X	X	X	X	14(4)	16(4)
	381	X	X	X	X	X	13(3)	15(3)
	457.2	X	X	X	X	X	13(3)	15(3)
Knee Level	2.1	14(6)	15(8)	17(11)	17(11)	19(13)	20(14)	21(17)
	7.6	X	X	17(10)	17(11)	19(12)	20(12)	21(15)
	15.2	X	X	14(8)	15(9)	16(10)	17(10)	18(13)
	30.5	X	X	13(6)	14(8)	15(8)	16(9)	18(12)
	45.7	X	X	13(6)	14(7)	15(8)	16(8)	18(11)
	61	X	X	X	12(4)	13(6)	14(6)	16(8)

Note: An “X” in a cell indicates the pull distance cannot be performed for the frequency push. Continuous pushing beyond the distances listed in the table is not recommended.

Table 16 Maximum Acceptable Two-Hand Push Forces Initial (Sustained) Forces

Floor-to-Hand Height	Push Distance (feet)	Frequency: One Push Every... (US Standard – feet, lbs)						
		6 sec	12 sec	1 min	2 min	5 min	30 min	8 hr
Shoulder Level	7	37(18)	40(22)	46(31)	48(31)	53(35)	55(37)	59(46)
	25	X	X	42(24)	44(24)	48(26)	51(29)	53(35)
	50	X	X	37(18)	37(20)	42(22)	44(24)	46(29)
	100	X	X	33(13)	35(18)	37(20)	42(20)	46(26)
	150	X	X	33(13)	35(18)	37(18)	42(18)	46(24)
	200	X	X	X	31(9)	33(13)	37(13)	42(20)
	300	X	X	X	X	32(10)	36(13)	41(15)
	400	X	X	X	X	30(9)	35(12)	39(14)
	500	X	X	X	X	28(6)	34(11)	38(13)
	750	X	X	X	X	X	32(10)	36(11)
	1000	X	X	X	X	X	30(9)	35(10)
	1250	X	X	X	X	X	29(8)	34(8)
	1500	X	X	X	X	X	28(8)	33(8)
	1750	X	X	X	X	X	27(8)	32(8)
2000	X	X	X	X	X	27(7)	32(8)	
Elbow Level	7	37(15)	40(20)	46(29)	48(29)	53(33)	55(35)	59(42)
	25	X	X	44(24)	44(24)	48(29)	51(29)	55(37)
	50	X	X	37(18)	37(22)	42(24)	44(24)	46(31)
	100	X	X	33(15)	35(20)	40(20)	42(22)	46(29)
	150	X	X	33(13)	35(18)	40(18)	42(20)	46(26)
	200	X	X	X	33(9)	35(13)	37(15)	42(20)
	300	X	X	X	X	34(11)	36(15)	41(18)
	400	X	X	X	X	33(9)	35(13)	39(16)
	500	X	X	X	X	32(6)	34(12)	38(15)
	750	X	X	X	X	X	32(10)	36(13)
	1000	X	X	X	X	X	30(9)	35(9)
	1250	X	X	X	X	X	29(7)	34(7)
	1500	X	X	X	X	X	28(7)	33(7)
	Knee Level	7	31(13)	33(18)	37(24)	37(24)	42(29)	44(31)
25		X	X	37(22)	37(24)	42(26)	44(26)	46(33)
50		X	X	31(18)	33(20)	35(22)	37(22)	40(29)
100		X	X	29(13)	31(18)	33(18)	35(20)	40(26)
150		X	X	29(13)	31(15)	33(18)	35(18)	40(24)
200		X	X	X	26(9)	29(13)	31(13)	35(18)

Note: An “X” in a cell indicates the pull distance cannot be performed for the frequency push. Continuous pushing beyond the distances listed in the table is not recommended.

13 PSYCHOPHYSICAL CAPACITY DATA – ONE-HAND PUSH/PULL FORCES

The capacity data below assume the following:

- The worker is standing.
- The dominant (stronger) hand is being used. If the non-dominant hand is used, reduce the values by 10%.

One-hand Push

- If the push force is exerted less than once per minute, the recommended value is 11 kg (24 lbs).
- If the push force is exerted more frequently than once per minute, the recommended value is 7.5 kg (16.5 lbs).

One-hand Pull

- If the pull force is exerted less than once per minute, the recommended value is 10 kg (22 lb).
- If the pull force is exerted more frequently than once per minute, the recommended value is 7 kg (15 lb).

Note: If cleanroom gloves are worn, reduce the above values by 15% for pull tasks only.

14 PSYCHOPHYSICAL CAPACITY DATA – KNEELING TASKS

The recommended weight of lift is based on the lifting capacity of 75% of the female population. Table 17 summarizes the recommended weight of lift for kneeling tasks. The assessor should select the activity description that best represents the actual task parameters being assessed.

Table 17 Recommended Weight Limit (RWL) for Kneeling Tasks

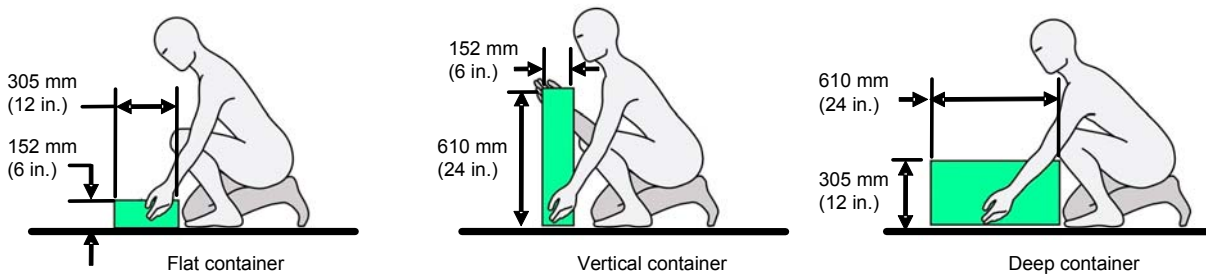
Task Description	RWL – kg (lb)
<p>1. Lift kneeling on 2 knees floor to 0.6 m (24 inches)¹</p> <p>The subject was positioned on both knees between the box and the shelf. The subject twisted 90° to the left, picked up the box, twisted 180° to the right, and lifted the box onto the shelf. Frequency of lift was 6 lifts per minute.</p>	7.7 (17.2)
<p>2. Lift kneeling on 1 knee floor to 0.6 m (24 inches)¹</p> <p>The subject was positioned in a kneeling posture (left knee on the floor) between the box and the shelf. The subject twisted 90° to the left, picked up the box, twisted 180° to the right, and lifted the box onto the shelf. Frequency of lift was 6 lifts per minute.</p>	7.6 (17.0)
<p>3. Horizontal transfer kneeling on 2 knees¹</p> <p>Subject knelt on both knees, twisted 90° to the left, picked the box up from the floor, twisted 180° to the right, and lowered the box back onto the floor. Frequency of lift was 6 lifts per minute.</p>	8.0 (17.9)
<p>4. Lower kneeling on 2 knees 0.6 m (24 inches) to floor¹ (Reverse of #1 above)</p>	8.6 (19)
<p>5. Kneeling 1 knee, 2 hands lift floor to:</p> <p>35% Functional Reach² flat container 61×30.5×15 cm (24×12×6 inches)²</p> <p>60% Functional Reach</p> <p>85% Functional Reach</p> <p>35% Functional Reach vertical container 30.5×15×61 cm (12×6×24 inches)²</p> <p>60% Functional Reach</p> <p>85% Functional Reach</p> <p>35% Functional Reach deep container 15×61×30.5 cm (6×25×12 inches)²</p> <p>60% Functional Reach</p> <p>85% Functional Reach</p> <p>The subject was instructed to kneel with the left knee on the floor and the right knee up. The subject bent over, grasped the handle of the box, picked the box up off the floor, lifted the box, and placed it on a shelf adjusted in height to 35, 60, and 85% of the subject's kneeling vertical reach. The subject was required to place precisely the box on the shelf without touching the clearance guides. The box size was 61×30.5×15 cm (24×12×6 inches), and lift was repeated for each possible box orientations. Frequency is 1 lift/8 hours.</p>	<p>20 (44.0)</p> <p>15.9 (35.6)</p> <p>13.6 (30.5)</p> <p>20 (44.0)</p> <p>15.9 (35.6)</p> <p>12 (26.9)</p> <p>20 (44.0)</p> <p>18.1 (40.5)</p> <p>13.6 (30.5)</p>
<p>6. Kneeling 2 knees, 2 hands lift floor to:</p> <p>35% Functional Reach flat container 61×30.5×15 cm (24×12×6 inches)²</p> <p>60% Functional Reach</p> <p>85% Functional Reach</p> <p>35% Functional Reach vertical container 30.5×15×61 cm (12×6×24 inches)²</p> <p>60% Functional Reach</p> <p>85% Functional Reach</p> <p>35% Functional Reach deep container 15×61×30.5 cm (6×24×12 inches)²</p> <p>60% Functional Reach</p> <p>85% Functional Reach</p> <p>The subject was instructed to kneel with both knees on the floor. The box was located in front of the subject with the box as close to the knees as was comfortable to the subject. The subject bent over, picked the box up off the floor, lifted the box, and placed it on a shelf adjusted in height to 35, 60, and 85% of the subject's kneeling vertical reach. The subject was required to place the box precisely on the shelf without touching the clearance guides. The box size was 61×30.5×15 cm (24×12×6 inches), and the lift was repeated for each of the three possible box orientations. Frequency is 1 lift per 8 hours.</p>	<p>20 (44.0)</p> <p>16 (35.2)</p> <p>13.6 (30.5)</p> <p>18.1 (40.5)</p> <p>15.9 (35.6)</p> <p>12.2 (27.3)</p> <p>20 (44.0)</p> <p>18.1 (40.5)</p> <p>13.6 (30.5)</p>

¹ Frequency = 6 lifts per minute ² Frequency = 1 lift every 8 hours

Table 17 Recommended Weight Limit (RWL) for Kneeling Tasks (continued)

Task Description	RWL – kg (lb)
<p>7. Kneeling 1 knee, 1 hand lift floor to: ²</p> <p>35% Functional Reach 60% Functional Reach 85% Functional Reach</p> <p>The subject was instructed to kneel with the left knee on the floor and the right knee up. The subject bent over, grasped the handle of the box with one hand, picked the box up off the floor, lifted the box, and placed it on a shelf adjusted in height to 35, 60, and 85% of the subject's kneeling vertical reach. The subject was required to place the box precisely on the shelf without touching the clearance guides. Frequency is 1 lift per 8 hours.</p>	<p>6 (13.0) 6 (13.0) 6 (13.0)</p>
<p>8. Kneeling 2 knees, 1 hand lift floor to: ²</p> <p>35% Functional Reach 60% Functional Reach 85% Functional Reach</p> <p>The subject was instructed to kneel with both the knees on the floor. The subject bent over, grasped the handle of the box with one hand, picked the box up off the floor, lifted the box, and placed it on a shelf that was adjusted in height to 35, 60, and 85% of the subject's kneeling vertical reach. The subject was required to precisely place the box on the shelf without touching the clearance guides. Frequency of lift was 1 lift per 8 hours.</p>	<p>6 (13.0) 6 (13.0) 6 (13.0)</p>

¹ Frequency = 6 lifts per minute ² Frequency = 1 lift every 8 hours



Note: Referenced in Table 17

Figure 4 Description of Container Orientations (Flat, Vertical, Deep)

15 PSYCHOPHYSICAL CAPACITY DATA – SEATED TASKS

The recommended weight of lift is based on the lifting capacity of 75% of the female population. Table 18 summarizes the recommended weight of lift for sitting tasks. Unless a handle is specifically mentioned, it should be assumed that handles are unavailable. The assessor should select the activity description that best represents the actual task parameters being assessed.

Table 18 Recommended Weight of Lifts for Sitting Tasks

Task Description	RWL – kg (lb)
<p>1. Horizontal transfer seated¹</p> <p>The subjects sat on the floor with legs extended straight in front of him or her, twisted 90° to the left, picked the box up off the floor, twisted 180 degrees to the right, and placed the box back onto the floor. Frequency is 6 lifts per minute.</p>	7.4 (16.6)
<p>2. Sitting 2 hands lift floor to:</p> <p>35% Functional Reach flat container 61×30.5×15 cm (24×12×6 inches)²</p> <p>60% Functional Reach</p> <p>85% Functional Reach</p> <p>35% Functional Reach vertical container 30.5×15×61 cm (12×6×24 inches)²</p> <p>60% Functional Reach</p> <p>85% Functional Reach</p> <p>35% Functional Reach deep container 15×61×30.5 cm (6×24×12 inches)²</p> <p>60% Functional Reach</p> <p>85% Functional Reach</p> <p>The subject was instructed to sit on a 30.5 cm (12 inches) high surface. The subject bent over, picked the box up off the floor, lifted the box, and placed it on a shelf adjusted in height to 35, 60, and 85% of the subject's sitting vertical reach. The subject was required to place the box precisely on the shelf without touching the clearance guides. The box size was 61×30.5×15 cm (24×12×6 inches), and the lift was repeated for each of the three possible box orientations. Frequency of lift was one lift per 8 hours.</p>	<p>20.0 (44.0)</p> <p>15.9 (35.6)</p> <p>13.6 (30.5)</p> <p>18.1 (40.5)</p> <p>13.6 (30.5)</p> <p>10.9 (24.4)</p> <p>18.1 (40.5)</p> <p>15.9 (35.6)</p> <p>13.6 (30.5)</p>
<p>3. Sitting 1 hand lift floor to 35%, 60%, or 85% Functional Reach²</p> <p>The subject was instructed to sit on a 30.5 cm (12 inches) high surface. The subject bent over, grasped the handle of the box with their right hand, picked the box up off the floor, lifted the box, and placed it on a shelf that was adjusted in height to 35, 60, and 85% of the subject's sitting vertical reach. The subject was required to place the box precisely on the shelf without touching the clearance guides. Frequency of lift was one lift per 8 hours.</p>	6.0 (13.0)

¹ Frequency = 6 lifts per minute ² Frequency = 1 lift every 8 hours

16 PSYCHOPHYSICAL CAPACITY DATA – LYING TASKS

The recommended weight of lift is based on the lifting capacity of 75% of the female population. Table 19 summarizes the recommended weight of lift for lying tasks. Unless a handle is specifically mentioned, it should be assumed that handles are unavailable. Recommended forces are based on symmetric distribution of weight about the handle. The assessor should select the activity description that best represents the actual task parameters being assessed.

Table 19 Recommended Weight Limit (RWL) for Lying Tasks

Task Description	RWL – kg (lb)
<p>1. Lying face down, lift with one hand: Lift with left hand Lift with right hand The subject lay prone on a 122 cm (48 inches) high platform and extends his or her arm through a 35.6×35.6 cm (14×14 inches) opening in the platform. With the arm fully extended, the subject grasped the pipe handle of a 25.4×25.4 cm (10×10 inches) box (30.5 cm (1 inch) high) and lifted it through the opening and placed it on the platform. The container with the pipe handle was similar to a small tool box or tray with a handle extending the full width of the container. The subject was allowed to prop up his or her body using the forearms. The task was repeated for both the left and right arm.</p>	<p>7.5 (16.8) 7.5 (16.8)</p>
<p>2. One hand lying side lift: Close Far The subject was instructed to lay on his or her left side on the floor with the body parallel to a 52.4 cm (1 inch) high platform. The distance between the platform and the subject was defined as the functional reach of the subject. Using the right hand, the subject grasped the handle of a 35.6×20×12.7 cm (14×8×5 inches) box and lifted it onto the platform. Two starting positions for the box were used, designated as close and far. For the close position, the rear edge of the box was placed against the body of the subject. For the far position, the subject extended his or her right hand so that the elbow could be located. The box was positioned such that the rear edge of the box was in line with the elbow.</p>	<p>5.4 (12.1) 5.7 (12.8)</p>
<p>3. Two hands lying side lift: Close Far The subject was instructed to lie on his or her left side with the body parallel to a 25.4 cm (1 inch) high platform. The distance between the platform and the subject was defined as the functional reach of the subject. Using both hands, the subject grasped a 20.3×20.3×20.3 cm (8×8×8 inches) box and lifted it onto the platform. Two starting positions for the box were used, designated as close and far. For the close position, the rear edge of the box was placed against the body of the subject. For the far position, the subject extended his or her right hand so that the elbow could be located. The box was positioned such that the rear edge of the box was in line with the elbow.</p>	<p>6.6 (14.8) 7.5 (16.8)</p>
<p>4. One hand lying face up lift: Close Far The subject was asked to lie flat on his or her back on an exercise bench. The subject placed the palm of his or her hand on the bottom of a 25.4×25.4×20.3 cm (10×10×8 inches) box suspended over the right shoulder of the subject. The subject lifted the box until the arm was fully extended. Two starting positions for the box were used, designated as close and far. For the close position, the box was suspended approximately 10 cm (4 inches) above the subject's right shoulder. For the far position, the subject extended the right arm so that the elbow could be located. The box was suspended such that the bottom of the box was at the height of the elbow.</p>	<p>7.5 (16.8) 10.4 (23.3)</p>
<p>5. Two hands lying face up lift: Close Far The subject was asked to lie flat on his or her back on an exercise bench. The subject placed his or her hands on the bottom of a 45.7×30.5×25.4 cm (18×12×10 inches) box suspended over the chest of the subject. The subject lifted the box until the arms were fully extended. Two starting positions for the box were used, designated as close and far. For the close position, the box was suspended as close to the subject's chest as possible, still allowing the subject to grasp the bottom edge of the box. For the far position, the subject extended the right arm so that the elbow could be located. The box was suspended such that the bottom of the box was at the height of the elbow.</p>	<p>20.9 (46.8) 26.1 (58.5)</p>

Note: Frequency for all tasks = 1 lift/8 hours

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