6.2 Designing equipment for handling

The purpose in designing equipment for handling is to increase the efficiency of the maintainer and to reduce the likelihood of injury to the maintainer or damage to the equipment. The topics covered in this section include (1) the weight, size, and shape of the equipment, (2) the provision of handles and grasp areas, (3) the provision of stands, rests, and alignment aids, (4) designing for remote handling, and (5) designing for the use of hoists, jacks, and cranes.

6.2.1 General

- **6.2.1.1 Maintainer efficiency and safety.** Units of equipment shall be designed, located, and protected so that they maximize the efficiency of the maintainer and minimize the likelihood of injury to the maintainer and damage to the equipment. (See paragraph 12.4.1.18 for safety aspects of electrical utilization equipment as required by OSHA.)

- **6.2.1.2 Prevention of damage.** Units of equipment shall be designed, located, and protected so that they will not be damaged when they are stored, shipped, handled, installed, operated, or maintained. Susceptibility to damage shall be clearly identified. Procedural guidance and suitable warning labels shall be provided to help prevent such damage.

- **6.2.1.3 Minimal number of maintainers.** Units of equipment shall be designed, placed, and mounted so that they can be

installed and removed by a minimum number of people wearing clothing appropriate to the environment.

6.2.2 Weight

The weight limits provided in this section assume that they will be lifted by able-bodied people not by those covered by the Americans with Disabilities Act.

- **6.2.2.1 Maximum weight of units of equipment to be lifted by one person.** If a unit of equipment is designed to be lifted by a single person, its weight shall not exceed the value in exhibit 6.2.2.1 that is appropriate for the height to which it is to be lifted and the size of the unit as it affects the distance between the body and the grip.

Exhibit 6.2.2.1 Maximum weight limits for objects lifted by one person using both hands; data are for a male or female

Height to which lifted	Distance between body and grip 150 mm (6 in)	300 mm (12 in)	460 mm (18 in)	610 mm (24 in)
.9 m (3 ft)	20.2 kg (44 lb)	13.3 kg (29.3 lb)	10.1 kg (22 lb)	6.6 kg (14.7 lb)
1.5 m (5 ft)	16.8 kg (37 lb)	11.2 kg (24.7 lb)	8.4 kg (18.5 lb)	5.6 kg (12.3 lb)

- **6.2.2.2 Lifting in the presence of obstacles.** The values given in exhibit 6.2.2.1 assume that there are no obstacles between the person lifting and the surface onto which the object is to be placed. If there is an obstacle, such as a lower shelf, the weight limit shall be reduced by 33 percent for an obstacle protruding 300 mm (12 in), 50 percent for an obstacle protruding 460 mm (18 in), and 66 percent for an obstacle protruding 610 mm (24 in). No lift shall be performed at a reach distance greater than 635 mm (25 in). If the allowable weight must be reduced by both size (distance between body and grip) and obstacle considerations, only the more restrictive single value shall apply, that is, two reductions shall not be applied.

- **6.2.2.3 Maximum weight of units of equipment to be lifted by two people.** If a unit of equipment is designed to be lifted by two people, the weight lifted by either one of them shall not exceed the appropriate value given in exhibit 6.2.2.1; thus, if the weight of the unit is distributed uniformly, the maximum weight is twice that for a single person.

- **6.2.2.4 Maximum weight of units of equipment to be lifted by three or more people.** If a unit of equipment is designed to be lifted by three or more people, the weight lifted by any one of them shall not exceed the appropriate value given in exhibit 6.2.2.1. The maximum weight of the unit may be increased by three-fourths of the single person value for each person in addition to the first. Thus the maximum weight shall not exceed

$$X + 0.75(N-1)X$$

where X is the appropriate value from exhibit 6.2.2.1, and N is the number of people lifting. This increase assumes that the unit is large enough that the people lifting do not interfere with each other.

- **6.2.2.5 Maximum weight of units of equipment to be carried by one person.** The weight of a unit of equipment designed to be carried by one person shall not exceed 16 kg (35 lb). This limit applies to carrying distances up to 10 m (33 ft).

- **6.2.2.6 Maximum weight of units of equipment to be carried by more than one person.** If a unit of equipment is designed to be carried by two people, the weight carried by either one of them shall not exceed 19 kg (42 lb); thus, if the weight of the unit is distributed uniformly, the maximum weight of the unit is 38 kg (84 lb). This limit applies to carrying distances up to 10 m (33 ft).

- **6.2.2.7 Maximum weight of units of equipment to be carried by more than two people.** If a unit of equipment is designed to be carried by more than two people, the total weight shall not exceed 19 kg (42 lb) plus 14.3 kg (31.5 lb) for each person carrying in addition to the first. This increase in weight assumes that the unit is large enough that the people carrying do not interfere with each other. This limit applies to carrying distances up to 10 m (33 ft).

- **6.2.2.8 Lifting eyes or jacking points.** Units of equipment weighing more than 68 kg (150 lb) shall have lifting eyes or jacking points (same as paragraph 6.2.10.1).

- **6.2.2.9 Reducing weight by removing parts.** Heavy pieces of equipment should be made more manageable by designing them with removable parts.

- **6.2.2.10 Labeling heavy units.** Weight and center of gravity caution placards shall be placed on any unit of equipment to be moved for maintenance if it's weight exceeds 13.6 kg (30 lbs). Any unit of equipment designed to be lifted or carried by more than one person shall be labeled prominently with its weight and the number of people recommended to lift or carry it (see paragraph 6.3.5.1.3).

6.2.3 Size

The size of a unit of equipment affects its weight limits; a large unit intended to be handled by one person cannot weigh as much as a smaller one, as can be seen in exhibit 6.2.2.1. Similarly, a unit intended to be handled by two or more people that is so small that the people interfere with each other cannot weigh as much as a unit that is large enough to avoid such interference.

- **6.2.3.1 Desirable size.** Each unit of equipment should be small enough for one person to lift or carry.

- **6.2.3.2 Reducing size by removing parts.** Units of equipment that are too large to be handled by one person should be designed with removable parts to reduce their size.

6.2.4 Shape

- **6.2.4.1 Avoiding protuberances.** Equipment shall be designed with a minimum number of bulges or extensions that might interfere with handling.

- **6.2.4.2 Removing protuberances.** If a unit of equipment includes irregular bulges or extensions that make handling difficult, the bulges or extensions shall be easily removable by hand or with common hand tools.

6.2.5 Handles

A handle is a permanent part of a unit of equipment that is designed to be grasped by the hand. Handles may extend out from the unit so that the fingers wrap around them, or they may be recessed areas so that the fingers fit inside an opening. Extended handles may be rigid or folding.

The size, number, and location of handles depend upon: (1) the weight and center of gravity of the unit, (2) the number of people lifting or carrying the unit, (3) the type of clothing worn and whether or not gloves are worn, (4) the position of the unit before handling and its final position, (5) the frequency with which the unit is handled, and (6) any additional uses the handles may serve.

6.2.5.1 When handles are needed

- **6.2.5.1.1 Units of equipment designed for carrying.** Units of equipment intended to be carried shall have handles or grasp areas.

- **6.2.5.1.2 Units of equipment weighing less than 4.5 kg (10 lb).** Units of equipment weighing less than 4.5 kg (10 lb) shall have handles if they would otherwise be difficult to grasp, remove, or carry.

- **6.2.5.1.3 Units of equipment weighing between 4.5 and 18 kg (10 to 40 lb).** Units of equipment weighing between 4.5 kg (10 lb) and 18 kg (40 lb) shall have one or more handles that permit easy handling of the unit by one person. If the unit is bulky or if its weight is unevenly distributed, the handles shall permit easy handling by two people.

- **6.2.5.1.4 Units of equipment weighing between 18 and 68 kg (40 to 150 lb).** Units of equipment weighing between 18 kg (40 lb) and 68 kg (150 lb) shall have handles that provide easy handling of the unit by two or more people. If the unit is very large, it shall have lifting eyes (see paragraph 6.2.10.1).

- **6.2.5.1.5 Force limits.** The force exerted pulling or pushing a handle or grasp area shall not exceed the values given in exhibit 6.2.5.1.5 for the appropriate elbow angle. The values provided in the exhibit shall be reduced by 30% if the work is performed in excess of 30 minutes. The values given are projected to a

mixed male and female population by taking two-thirds of the values for a male population. For a more detailed coverage of pulling and pushing limits, see Snook & Ciriello (1991).

Exhibit 6.2.5.1.5 Maximum force limits for pulling and pushing units of equipment using handles or grasp areas

Degree of elbow flexion °	Pulling		Pushing	
	Left arm N (lbf)	Right arm N (lbf)	Left arm N (lbf)	Right arm N (lbf)
180	148 (33)	154 (35)	125 (28)	148 (33)
150	125 (28)	166 (37)	89 (20)	125 (28)
120	101 (23)	125 (28)	77 (17)	107 (24)
90	95 (21)	110 (25)	65 (15)	107 (24)
60	77 (17)	71 (16)	65 (15)	101 (23)