



# Standard Specification for Selectorized Strength Equipment<sup>1</sup>

This standard is issued under the fixed designation F2216; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## INTRODUCTION

The goal of this specification is to promote proper design and manufacturing practices for selectorized strength equipment. Through these specifications, this specification aims to assist designers and manufacturers in producing functional, safe machines under proper operations. The equipment user must recognize, however, that a standard alone will not necessarily prevent injuries. Like other physical activities, exercise involving selectorized strength training equipment involves the risk of injury, particularly if the equipment is used improperly.

## 1. Scope

1.1 This specification establishes guidelines for the design and manufacture of selectorized strength equipment as defined in 3.1.6, 3.1.16, and 3.1.29.

1.2 It is the intent of this specification to specify products for use by individuals age 12 and above.

1.3 This specification shall be used with its accompanying test method, Test Method F2277.

1.4 The values stated in SI units are to be regarded as the standard. The values in parentheses are for information only.

1.5 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

F1749 Specification for Fitness Equipment and Fitness Facility Safety Signage and Labels

F2277 Test Methods for Evaluating Design and Performance Characteristics of Selectorized Strength Equipment

### 2.2 ANSI Standard:<sup>3</sup>

B29.1 Precision Power Transmission Roller Chains, Attach-

ments and Sprockets

### 2.3 European Standards:<sup>4</sup>

EN 957-1 Stationary Training Equipment—Part 1: General Safety Requirements and Test Methods

EN 957-2 Stationary Training Equipment—Part 2: Strength Training Equipment, Additional Specific Safety Requirements and Test Methods

## 3. Terminology

### 3.1 Definitions:

3.1.1 *accessible area—exposed, n*—area within reach of the user or third party when the machine is engaged during entrance, use and termination of the exercise movement.

3.1.2 *accessible area—obscured, n*—area inaccessible to the user of the machine but accessible to technicians or service personnel.

3.1.3 *assist means, n*—mechanism that the user engages on the machine to assist them in getting into and out of the loaded starting position.

3.1.4 *cam, n*—rotational component controlling the resistance to the user.

3.1.5 *catch point, n*—location at which edges, protrusions or surfaces allow a body part to become injured.

3.1.6 *consumer selectorized strength equipment, n*—selectorized strength equipment intended for home use or for use in a home environment.

3.1.6.1 *Discussion*—Since significant differences can arise between consumer and institutional selectorized strength equipment, the products must be clearly identified as not for commercial use.

3.1.7 *corner, n*—intersection of three planes or surfaces on a single component.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

<sup>4</sup> Available from CEN Management Centre, 36 rue de Stassart, B-1050, Brussels, Belgium.

3.1.8 *edge, n*—intersection of two planes or surfaces on a single component.

3.1.9 *extrinsic loading, n*—all loads applied to the machine or user means in addition to the users body weight.

3.1.10 *facility safety sign, n*—sign meeting the guidelines set forth in Specification **F1749** alerting facility users to the potential hazards associated with institutional fitness equipment.

3.1.11 *field of view, n*—field of view of the user defined by an arc of 150°. Seventy five degrees on each side of the median plane.

3.1.12 *fitness equipment, n*—machine or bench designed for use in exercising specific or multiple muscles of the body.

3.1.13 *foot support, n*—machine component(s) contacting the user's feet during operation, entry, and exit from the machine.

3.1.14 *general warning label, n*—label designed within the scope of this specification and Specification **F1749** which is affixed to a portion of the strength equipment and draws attention to potential hazards associated with use of that equipment.

3.1.15 *guard, n*—cover or enclosure that prevents access, without the use of tools, into an otherwise accessible area.

3.1.16 *institutional strength equipment, n*—strength equipment intended for use by numerous persons in a commercial or institutional facility, as opposed to home environment.

3.1.17 *integral handgrip, n*—location grasped by the user during performance of the exercise that is contained within another component(s) of the machine.

3.1.18 *intrinsic loading, n*—loads applied to the machine due only to the body weight of the user.

3.1.19 *maximum specified load, n*—maximum working load for the machine as set forth by the manufacturer.

3.1.20 *maximum tension developed, n*—maximum static tensile load experienced by a connector, fitting, rope, belt, or chain during use of the machine at the maximum specified load for the machine including all extrinsic loads.

3.1.21 *median plane, n*—plane of reference that divides the midline of the body of the user into equal right and left halves.

3.1.22 *pinch point, n*—location between two moving components or the location between a moving and fixed component that, when entered, causes a portion of the body to become entrapped.

3.1.23 *pulley, n*—component that guides, ropes, or belts and redirects forces from the resistance device to the cam or user means, or both.

3.1.24 *pull-in point, n*—location between two moving or rotating components, or the location between a moving or rotating and fixed component that, when entered, causes a portion of the body to be pulled into and trapped between the components.

3.1.25 *range of movement, n*—space in which the user or part of the user is moving when using the machine in accordance to the instructions supplied by the manufacturer.

3.1.26 *resistance means, n*—for the purpose of this specification, the device or system that, when varied by the user, increases or decreases the force encountered by the user through the user means. For the purpose of this specification,

such means include: weights, pneumatic cylinders, or electronic systems and their controls.

3.1.27 *rope, n*—for the purpose of this specification, a cord comprised of intertwisted synthetic or natural fibers or steel wires used for the transmittal of load from the resistance means to the user means.

3.1.28 *selector pin, n*—the component used to select resistance on weight based selectorized strength equipment.

3.1.29 *selectorized strength equipment, n*—strength equipment where the resistance means is an integral part of the machine and may be varied easily by the user.

3.1.30 *shear point, n*—location at which parts move past one another or past a fixed point in such a manner that when entered, causes a portion of the body to become caught in a scissors action between the components.

3.1.31 *site specific label, n*—label designed within the scope of this specification and Specification **F1749** which is affixed to a portion of the strength equipment and draws attention to a potential hazard in the immediate area of the label.

3.1.32 *strength equipment, n*—fitness equipment designed to strengthen one or more groups of muscles anaerobically.

3.1.33 *third party, n*—someone other than the user who is in the immediate area of the machine.

3.1.34 *training envelope, n*—maximum space through which the user and the machine components traverse when the machine is operated in accordance with the instructions.

3.1.35 *user means, n*—movable component or assembly that the user contacts to perform the exercise.

3.1.36 *user support means, n*—portion of the machine (seat, platform, etc.) that supports the user while the user is performing the exercise.

#### 4. General Requirements

4.1 *Stability*—Selectorized strength training equipment shall be stable in the unloaded, intrinsically, and extrinsically loaded conditions.

4.2 *Construction:*

4.2.1 *Edges and Corners:*

4.2.1.1 *Edges*—All edges in accessible areas shall be free of burrs and lack sharpness.

4.2.1.2 *Corners*—All corners in accessible areas shall be radiused or chamfered.

4.2.2 *Tube Ends and Open Holes*—Tube ends and open holes in the exposed accessible areas shall be closed off either by other components or by plugs. Openings smaller than 9.5 mm (0.37 in.) or holes that are required for the adjustment of the machine into and out of a use position are exempt from this requirement.

4.2.3 *Weights*—Weights shall move only when displaced intentionally. Weights shall move freely along their guide means and return to the resting point. The travel of the weights shall be controlled by the user such that no uncontrolled pendulum swing shall occur.

4.2.4 *Weight Selection Pin*—Weight selection pins shall be fitted with a positive retention means.

4.2.5 *Adjustment and Locking Means*—All adjustment and locking means shall function securely. The possibility of

inadvertent disengagement shall be reduced by spring retention, clamps or other means. Adjustment knobs and levers shall not interfere with the user's range of movement.

#### 4.2.6 Handgrips:

4.2.6.1 *Integral Handgrips*—Integral handgrips, if required for proper use as defined by the manufacturer, shall be conspicuous and shall reduce slippage during normal use.

4.2.6.2 *Applied Handgrips*—Applied handgrips shall be of a material that reduces slippage and shall withstand an applied pulling force of 90 N (20.2 lb) without movement in the direction of the applied pulling force.

4.2.6.3 *Rotating Handgrips*—Rotating handgrips shall be constrained against lateral movement along their rotational axis and be constructed of a material that reduces slippage.

4.2.7 *Machine Ingress and Egress*—If the user cannot (after adjusting the machine according to the manufacturer's instructions) attain the loaded starting position for the machine, then the machine shall be provided with an assist means.

4.2.8 *Foot Support*—Bars or plates designed to support the user's feet during exercise or to assist in ingress/egress from the machine shall be fitted with or be of a material or surface type or configuration that reduces slippage.

#### 4.2.9 Ropes, Belts, Chains, or Other Means:

4.2.9.1 *General*—Ropes, belts, chains, and other means, including all attachment devices (links, shackles, end fittings, and termination means) shall not fail with a load equal to six times the maximum static tension developed by the machine during operation and shall pass the endurance guidelines set forth in 4.5.3. All end terminations shall not be subjected to cyclic bending under normal machine operation as defined by the manufacturer.

4.2.9.2 *Chains*—Chains for selectorized strength equipment shall meet the general requirements of ANSI B29.1.

4.2.10 *Pulleys*—Pulleys for rope/belt drive machines shall rotate freely under all extrinsic loads.

4.2.10.1 *Wire Rope Pulleys*—The groove radius,  $r$ , of the pulley for wire rope driven machines shall meet the wire rope manufacturer's guidelines, allow for passing of the endurance guidelines set forth in 4.5.3 or lie within the range given by the following equation, or both:

$$\frac{C_d}{2} + 5\% \text{ to } \frac{C_d}{2} + 15\% \quad (1)$$

with  $C_d/2 + 10\%$  being the optimum.  $C_d$  is defined as the nominal wire rope diameter including coating. The tread diameter,  $d$ , of the pulley shall be a minimum of 18 times greater than the bare wire rope diameter (without coating).

4.2.10.2 *Belt Pulleys*—The diameter of the pulley shall be of sufficient size to yield a belt life meeting the parameters specified in 4.5.3. Belt pulleys shall be designed to prevent disengagement.

4.2.11 *Rope/Belt Guards*—Disengagement of ropes/belts shall be prevented by the provision of adequate retention guards or enclosures.

#### 4.3 Entrapment Points:

4.3.1 *General Comments*—Unlike other machinery, selectorized strength equipment is fully controlled by the user of the equipment. It is therefore assumed that the user shall take responsibility for his/her actions while using the machine and

can prevent the inadvertent contact with machine components within the user's field of view by the user or a third party by stopping the exercise or movement of the machine. For this reason, the discussion of entrapment points is broken down into "within" and "outside" the field of view of the user. Wherever possible, the design of movable components shall avoid catch, shear or pull-in points.

4.3.1.1 In general, the fingers are the body components most likely to be injured. The primary exception to this is weight stacks where feet or hands, or both, could also be injured. Weight stacks shall be spaced less than 9.5 mm (0.375 in.) or greater than 25 mm (0.98 in.) from any fixed frame member. This spacing shall remain constant through the travel range of the weight stack. Weight stacks shall be spaced at least 25 mm (0.98 in.) from the base frame of the machine. Strength equipment that includes weight stack enclosures designed in accordance with 4.4 as a permanent feature of the machine are exempt from this requirement, provided that the enclosure extends past the rest position of the bottom weight plate.

4.3.1.2 The user means or other moving components, or both, shall not pass within 60 mm (2.36 in.) of the moving weight stack during the normal operation of the machine, as defined in the instructions provided by the manufacturer. Mechanical stops are generally provided at one or both extremes of the user means range of travel. Since the user means will contact the stops at these locations, they are excluded from the clearance requirements. However, if the stop is physically part of the moving user means, then it shall pass no closer than 25 mm (0.98 in.) to any fixed frame members throughout its range of travel.

4.3.1.3 If the machine framework or the user's body placement, while using the machine in accordance with the manufacturer's instructions, prevents the uncontrolled access of a third party into the area of concern, then guarding is not required. The user's body shall prevent access throughout the entire exercise range of motion.

4.3.2 *Outside the Field of View*—To a height of 1800 mm (70.8 in.), the distance between movable components or between a movable and fixed component shall be at least 60 mm (2.36 in.) when other than the fingers are at risk. This dimension may be reduced to no less than 25 mm (0.98 in.) when only the fingers are at risk. If the spacing between moving components or between fixed and moving components remains constant throughout the range of motion of the machine, then the spacing shall be greater than 25 mm (0.98 in.) or less than 9.5 mm (0.375 in.). Guarding shall be provided if the design does not allow the above dimensions to be met.

4.3.3 *Within the Field of View and Within Reach of the User*—If distances do not conform to those specified in 4.3.2, the components shall be guarded or enclosed.

4.3.4 *Within the Field of View and Outside the Reach of the User*—Pinch and shear points within the user's field of view but accessible only to a third party shall not be located within 25 mm (0.98 in.) of a stationary component. Alternatively, such points can be less than 9.5 mm (0.375 in.) from a stationary component if the spacing between the components remains constant throughout the range of movement of the machine.

4.3.5 *Pull-in Points*—Finger pull-in occurs when the spacing between the fixed and rotating component is less than 25 mm (0.98 in.) or when the angle between the fixed guard and the belt or rope is less than 50°, or both (see Fig. 2). For ropes and pulleys or ropes and cams, pull-in will occur during the portion of the exercise stroke that the rope wraps onto the rotating element or passes into the guard. This can occur on both sides of a pulley or guard as shown in Fig. 2 and Fig. 3. Fig. 4 illustrates a circular pulley or cam guard. To achieve a pull-in angle greater than 50°, the guard radius  $G_r$  shall be calculated using the following equation:

$$G_r > \frac{d}{2} + \frac{C_d}{2} / \cos 50^\circ \quad (2)$$

where  $d$  and  $C_d$  have been defined in 4.2.10.1 and 4.2.10.2.

4.3.5.1 *Outside the Field of View*—Pull-in points up to a height of 1800 mm (70.8 in.) shall be guarded or spaced greater than 25 mm (0.98 in.) so that the user’s or third party’s fingers, when extended, cannot be caught between the components (see Fig. 2). Rope, belt or rope driven machines where the pressure between the rope/belt and the cam or pulley is less than 90 N/cm<sup>2</sup>(131 psi) are excluded from this requirement.

4.3.5.2 *Within the Field of View*—Pull-in points shall be guarded so that the user’s fingers, when extended from the exercise position, cannot be caught between the components. Pull-in points within the field of view of the user, during the entire range of motion of the exercise being performed, but accessible only to a third party, need not be guarded because the user can control the motion of the machine and thus prevent any inadvertent contact with a third party. A site specific label shall be present in the immediate location of the pull-in point, alerting the user or a third party to the potential for injury and to stay clear of the area. Rope or belt driven machines where

the pressure between the rope/belt and the cam or pulley is less than 90 N/cm<sup>2</sup> (131 psi) are excluded from the requirements of 4.3.5.1 and 4.3.5.2.

4.3.5.3 *Chain Drive or Gear Driven Machines*—Pull-in points on these machines shall be guarded in accordance with ANSI B29.1.

4.4 *Weight Stack Enclosures:*

4.4.1 *General*—Unlike other fitness equipment, selectorized strength equipment is fully controlled by the user. Stopping the exercise or the machine’s movement permits the user to prevent inadvertent contact with weight stacks within the field of view of the user. Weight stack enclosures may assist in preventing uncontrolled access by third parties outside this field of view. Weight stack enclosures shall be made available as an additional option by the manufacturer to the purchaser of institutional selectorized strength equipment. Weight stack enclosures shall be designed in accordance with the parameters outlined in 4.4.2-4.4.4. For consumer selectorized strength equipment, the manufacturer shall provide either weight stack enclosures designed to the parameters detailed in 4.4.2-4.4.4 or provide a lock out mechanism to secure the weight stack and prevent inadvertent use by children. Instructions and warnings shall state that this mechanism must be secured after use of the machine.

4.4.1.1 *Discussion*—The dimensions specified in 4.4.2-4.4.4 shall allow for free travel of the weights and insertion of the selector pin. Compliance with these specifications, however, may not necessarily prevent children from being injured by moving weights. In addition, an enclosure may block the user’s field of view of third parties including children. As specified in 4.7.1, manufacturers shall affix warnings to the machine alerting to keep children away. Multiple weight stack machines do not require guarding on the three sides furthest from the user, provided that there is sufficient framework on these sides to prevent the inadvertent access by third parties. On the side adjacent to the user enclosures shall be designed in accordance with 4.4.2-4.4.4. Fig. 5 depicts the placement possibilities of the weight stacks on selectorized strength equipment with respect to the user and a plane of reference through the top surface of the seat back pad.

4.4.2 *Weight Stack in Front of User*—When the weight stack is in front of the user (see Fig. 6), and it is always within the user’s field of view throughout the entire exercise movement, the weights need not be enclosed. The user shall face the weights at all times during the exercise and this shall be specified in the instructions supplied by the manufacturer.

4.4.3 *Weight Stack Behind the User*—When the weight stack is positioned behind the user (see Fig. 7) the weights shall be completely enclosed up to a height of 60 mm (2.36 in.) beyond the furthest possible travel of the weight stack as determined by use of the machine in accordance with instructions supplied by the manufacturer. The enclosure shall extend past the rest position of the bottom weight plate. The only opening shall be a slot no greater than 75 mm (2.95 in.) wide for the insertion and operation of the weight selector pin. The horizontal spacing between the open edges of the enclosure and the weights shall be less than 9.5 mm (0.375 in.) or greater than 25 mm (0.98 in.).

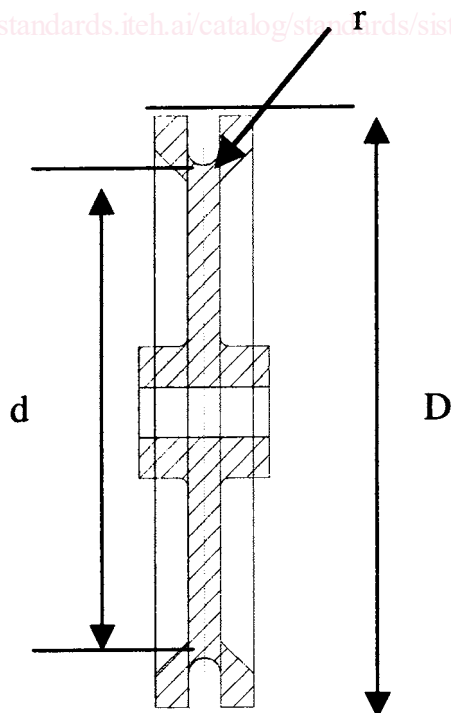


FIG. 1 Wire Rope Pulley Profile

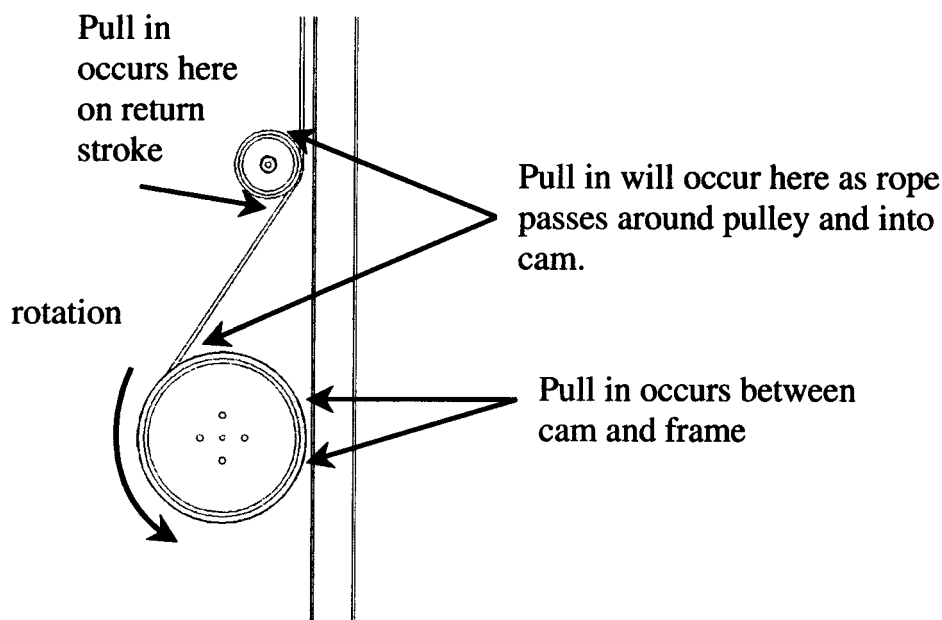


FIG. 2 Guarding of Pull-In Points—Unguarded

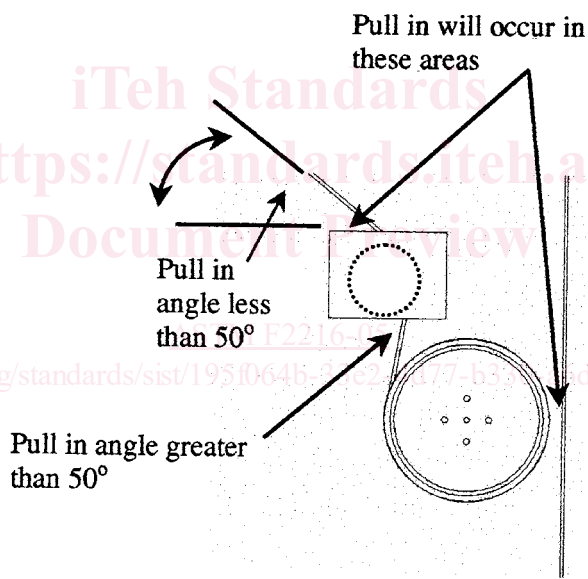


FIG. 3 Guarding of Pull-In Points—Pulley Guarding

4.4.4 *Weight Stack to the Side of the User*—When the weight stack is positioned to the side of the user (see Fig. 8), the amount of enclosure shall be dependent on the placement of the weight stack relative to the user’s field of view and the pad reference plane. Weight stacks that are located to the side of the user and extend beyond any portion of the pad reference plane either at rest, or during the execution of the exercise (see Fig. 8-Part A), shall be enclosed in accordance with 4.4.3. When encased only on three sides (Fig. 8-Part B), the enclosure shall meet the height guidelines of 4.4.3, and at a minimum, be flush with the front of the weights with the spacing being less than 9.5 mm (0.375 in.) or greater than 25 mm (0.98 in.) as shown in Fig. 9. Encasement of the weights is not required when the

weight stack is within the field of view of the user (Fig. 8-Part C) and it does not become obscured by the user or the machine during the performance of the exercise.

4.5 *Loading:*

4.5.1 *Intrinsic Loading*—All user supporting surfaces for consumer and institutional selectorized strength equipment shall be able to withstand a single static load application equal to a loading factor times the greater of 135 kg (300 lb) or the maximum specified user weight, as set forth by the manufacturer, at the point of user contact without breakage. The loading factor stated above shall be 2.5 for consumer selectorized strength equipment and 4 for institutional selectorized strength equipment.

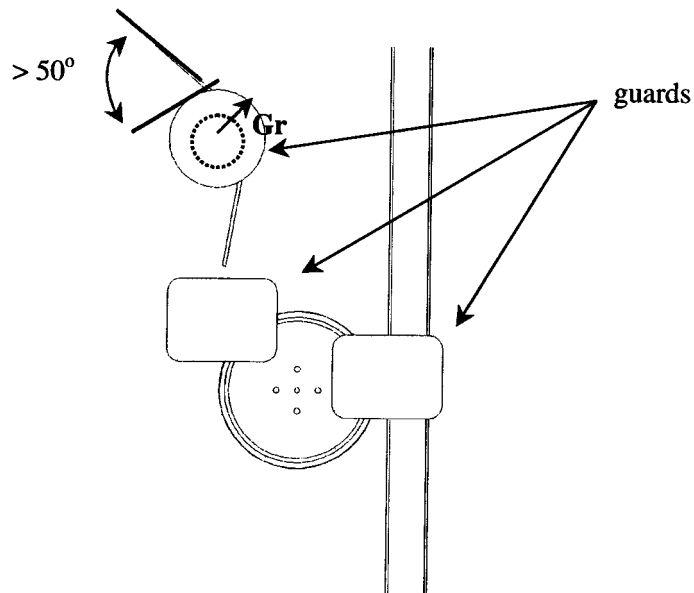


FIG. 4 Guarding of Pull-In Points—Guarded

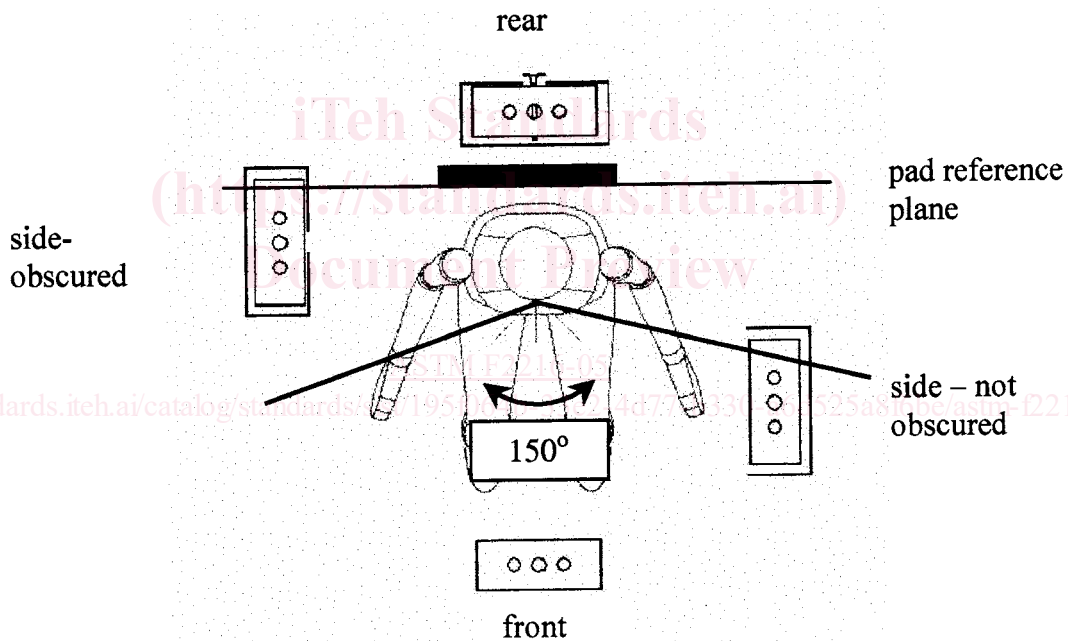


FIG. 5 Possible Weight Stack Placement

4.5.2 *Extrinsic Loading*—Selectorized strength equipment shall withstand the extrinsic loads applied to the machine by the user during the operation of the machine including the loads applied from his/her body mass. The machine or com-

ponents being tested shall not break. The load to be applied for this test is specified by the following equation:

$$F_{test} = [W_p + 1.5F_a] S \quad (3)$$