# Fall Protection for the Heavier Worker

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## Introduction

You don't have to go very far to find statistics to prove that the North American worker is getting larger. Because of this growing trend and consumer pressure, the traditional 310-pound capacity for most fall protection equipment is being pushed higher and higher. As a result, equipment rated for workers weighing up to 440 pounds is now readily available to consumers.

This paper examines the risks associated with heavier workers and explores how well fall arrest systems designed for heavier workers protect these individuals in the event of a fall.

## Obesity

With few exceptions, workers weighing more than 310 pounds fall within the extreme weight categories.

Obesity is defined according to the amount of excess body fat at which the individual's health risks begin to rise. Clinicians commonly use the body mass index (BMI) to classify body weight among adults. BMI is calculated by dividing weight in kilograms by height in meters squared. It should be noted that BMI does not directly measure percent body fat and does not take into account body fat composition or fat distribution. Table 1 shows the cut-off points for BMI categories established by the World Health Organization (WHO 2006).

| **BMI ($kg/m^2$)** | **Classification** |
|---|---|
| Less than 18.5 | Underweight |
| 18.5-24.9 | Normal Weight |
| 25.0-29.9 | Overweight |
| 30-34.9 | Class I Obesity |
| 35.0-39.9 | Class II Obesity |
| More than 40.0 | Class III Obesity |

**Table 1. Adapted from WHO, 2006, this table shows the classification of adult underweight, overweight and obesity according to BMI.**

Assuming the average US adult male has a height of 5’9”, at 210 pounds that individual meets the clinical definition of obese (BMI = 31). At 270 pounds, that same individual is now classified as morbidly obese (BMI = 40). In 2005 and 2006, more than one-third of US adults were obese (Ogden et al. 2007).

If BMI classifications are accepted indicators of risk, allowance is not the only issue. The argument begins with the user’s overall health. The heavier worker demographic is in a high-risk category for health issues which are compounded by occupational injuries related to weight. Even more serious is morbid obesity, indicated by a BMI of 40 or higher. Approximately 75 percent of the adults with class III obesity have at least two or more health conditions (Must et al 1999). Health conditions associated with a high body mass index include hypertension, heart disease, stroke, osteoarthritis, asthma and some cancers to name a few (CDC 2008).

## Capacity

The ANSI Z359 Accredited Standards Committee (ASC) prescribes a capacity range of 130 pounds to 310 pounds (59 – 140 kg). Capacity refers to the weight a component, system or subsystem is designed to hold (ANSI 2007). The 310-pound maximum represents the total weight of a fully equipped worker. This includes tools, clothes, and other user-borne items. Components, systems or subsystems designed to hold more than 310 pounds fall outside the scope of the ANSI Z359 standard.

Since 1992, ANSI’s criteria for defining capacity have remained constant. Although there has been discussion by the Z359 ASC about going beyond 310 pounds, there is limited data to support an increase at this time. The U.S. Department of Labor’s Occupational Safety and Health Administration (OSHA), however, addresses increased capacities in its non-mandatory testing requirements for employers in which it states that employees having a combined tool and body weight of more than 310 pounds are considered to be in compliance “provided that the criteria and protocols are modified appropriately to provide proper protection for such heavier weights” (OSHA 1996).

Fall protection equipment manufacturers are producing harnesses, personal energy absorbers and other equipment with an increased capacity range. Each manufacturer has determined a different target weight. Capacities among manufacturers vary and range from 360 to as high 440 pounds. Some of this equipment is even labeled ANSI-compliant. While ANSI is not the law, those employers who choose to comply with ANSI standards must understand that once you exceed the 310-pound capacity range, you are no longer working with ANSI-compliant equipment.

## Conversion Factor

During dynamic performance testing of personal fall arrest equipment, a multiplier of 1.4 is used to relate a steel weight to the human body, which was historically assumed to absorb some of the acquired energy. Manufacturers, in essence, use a 220-pound rigid test weight to represent a 310-pound person.

In recent years, the 1.4 multiplier has come into question. Tests conducted by Gravitec Systems, Inc., and others have shown that a multiplier of 1.1 multiplier may be more accurate for systems utilizing a full-body harness, assuming a 6-foot freefall distance (Gravitec Systems, Inc., 2007). When the 200-pound test weight is multiplied by a conversion factor of 1.1, the result is 242 pounds. ANSI has recognized and adopted the 1.1 conversion factor. New ANSI standards will prescribe a 282-pound weight be used, resulting in more rigorous qualification testing for personal energy absorbers.

## Maximum Arrest Force (MAF)

The law states and ANSI agrees that the maximum arrest force (MAF) on the employee can be no greater than 1,800 pounds (8kN). To address workers with weights greater than 310 pounds, manufacturers add to the rigid test weight until OSHA's maximum arrest force of 1,800 pounds is realized. Once the maximum test weight is determined, it is then multiplied by a conversion factor of 1.4 to get the maximum capacity.

As the user mass is increased, the MAF is increasingly limited to the tearing threshold or complete deployment of the shock absorber, intentionally loading the secondary webbing. MAF increases when the energy absorber has been fully deployed. Energy absorbers designed at the 4kN maximum are more likely to fully deploy and transition to the secondary webbing, causing a spike in arrest forces. Assuming a freefall distance of six feet, heavier workers are subjected to MAFs closer to, if not exceeding, the OSHA limit of 1,800 pounds (8kN). However, these reactions are dependent on the manufacturer and type of energy absorber used. Workers with higher body weights are recommended to use energy absorbers of the 6kN or 8kN maximum (Crawford, 2003).

It is predicted that the level of stress tolerated by a morbidly obese individual would be considerably less than that of the physically-fit individual. Increasing the arrest forces becomes especially problematic in these circumstances. Given a constant free fall distance and user mass, the reduction of force experienced during the arrest of a fall can only be achieved by increasing the deceleration distance.

## Harness Fit and Suspension

Suspension trauma or harness-induced pathology, a well-documented phenomenon, occurs when a person is suspended upright and motionless. Harness straps exert pressure on the leg veins, restricting flow back to the heart in what is termed as venous pooling, and circulatory problems arise from prolonged immobility (Seddon, 2002).

Tolerance appears to vary between individuals. Previous research has demonstrated the influence of body weight, fitness levels, comfort and ability to self-adjust in suspension tolerance, but nothing was found examining the physiological response of users weighing more than 310 pounds. A previous study conducted by the National Institute for Occupational Safety and Health (NIOSH) found body weight had a statistically significant effect on suspension time during back D-ring attachment tests; the heaviest weight tested was 270 pounds (Turner et al. 2008).

For management of suspension trauma, the harness chosen should be appropriate for type of work to be undertaken and should be of good anatomic fit and adjustability allowing adequate comfort of the user. Final positioning of the sub-pelvic strap below the buttocks has been identified as crucial element to the prolonged suspension tolerance as it provides maximum support of the human frame.

## Method

For a maximum duration of 15 minutes, static suspension tests were performed on six volunteers with weights ranging from 308 to 575 pounds. Tests were conducted to assess harness design, upper-body support, sub-pelvic support, the ability to self rescue, suspension trauma and harness adjustability.

Subjects were properly fitted with full-body harnesses and hoisted approximately six inches from the ground by the dorsal D-ring of the harness, as shown in Exhibit 1.

**Exhibit 1. Volunteers were fitted with full-body harnesses and suspended 6" from the ground.**

Prior to suspension, participants were asked to complete a medical history and underwent an orthostatic intolerance test.

Volunteers were continuously monitored using a Lifepack 12, which measured blood pressure, heart rate, O2 levels and respiration rate. User comfort level was also subjectively monitored. No dynamic forces were exerted on the body; only static suspension was performed. Volunteers retained the right to terminate the test at any time.

Three EMTs and a standby ambulance equipped to monitor heart rates, pulse and blood pressure, were present during the tests as shown in Exhibit 2.

**Exhibit 2: The volunteers' heart rates, pulse and blood pressure were monitored by EMTs.**

## Results

Half of the tests were terminated for medical reasons. The increase in weight exaggerated conditions related to suspension. Volunteers experienced nausea, increased heart rate, increased blood pressure, diaphoresis and loss of sensation.

Of the six full-body harnesses with "high capacities" that were purchased, only two models could be adjusted to accommodate the user's body shape. All test subjects experienced discomfort, were diaphoretic and could not readjust to an upright position. The average suspension time was 9 minutes.

## Conclusion

The purpose of this study was to provide preliminary information to employers considering use of personal fall arrest systems with capacities in excess of 310 pounds. Through fitting and suspension, it became apparent that little, if any, modifications were made for this atypical user. Other than increased webbing length, harnesses for heavier workers displayed no differences than conventional harnesses; no extra padding or increased width was provided. The subpelvic straps did not accommodate the larger pelvic region of test subjects, causing the strap to ride up between the legs. Additionally, several of the harnesses would not fit and encroached on the neck as shown in Exhibit 3.

**Exhibit 3. Several of the harnesses encroached on the neck.**

Volunteers exhibited an earlier onset of physical effects due to suspension. Rescue of heavier workers, illustrated in Exhibit 4, was also more difficult, increasing suspension time or resulting in a failed rescue.

**Exhibit 4. Rescuing a heavy worker is more difficult, increasing suspension time or resulting in a failed rescue.**

It is clear that further study is needed before we can be confident of these excess-weight systems.

## Discussion

The entire demographic that these systems are designed to protect is in a high health risk group, and the equipment being used falls outside of the scope of a nationally-recognized standard. Product capacity determinations utilize an inaccurate conversion factor and arrest forces are higher than they should be. Furthermore, there is no evidence to suggest that manufacturers have taken body shape and dimensions of heavier workers into consideration.

Even if the fall arrest system supports the increased weight of a heavier worker in the event of a fall, the individual's health is still jeopardized because he/she has a lower tolerance to suspension. This is worsened by the difficulty of and increased time required for rescue.

Impact forces may be higher than those experienced by the workers of recommended weights in the event of a fall. Fall arrest systems with increased capacities intentionally load the secondary webbing in an energy absorber. As a result, workers may be exposed to forces closer to 1,350 pounds (6kN) or the OSHA limit of 1,800 pounds (8kN), if not more. The accuracy of MAF determinations are compromised because a conversion factor of 1.4 is currently used when testing equipment. Deceleration distances are higher and greater clearance is required for workers using a 6 kN energy absorbers, which will be addressed in the new ANSI Z359.13-20xx standard.

Specialty equipment is needed. The harness in particular must have more padding, be of adequate fit and dimension to accommodate the heavier worker's body shape, provide increased support in the sub-pelvic region and offer a greater range of adjustability. Specialized energy absorbers are also recommended.

It is recommended that other protection methods be evaluated first. Guardrails, fall restraint, or covers may be substituted for fall arrest systems. Ultimately, it is the employer's responsibility to ensure the safety and health of their workers at height.

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