

Stepping Surface Testing Method for Medium and Heavy Duty Vocational Trucks

James Roger Lackore
Oshkosh Corporation

Kevin Voss
Oshkosh Defense

ABSTRACT

Access method design for entry and egress of medium and heavy duty truck cabs and bodies is a critical aspect of vehicle design. Occupational injuries due to entering or exiting the truck cab, or climbing onto and off of the truck body, can be a significant percentage of a fleet's lost-time incident rate. Many vocational trucks operate in both off-road and on-road conditions, and the slip resistance of the stepping surface is an important design aspect.

Examples of vocational vehicles that involve off-road operation include dump, refuse, utility, tree-trimming, and concrete trucks. Stepping surfaces in these applications must provide a balance between traction and the ability to shed water, snow, and mud. While there are a few methods and devices for measuring walking surface slip resistance, they are either complicated, or not well suited to measuring aggressive surfaces. This SAE paper will explore the pros and cons of currently accepted walking surface test methods and suggest a new testing method more conducive to the types of aggressive surfaces commonly used on vocational truck steps.

CITATION: Lackore, J. and Voss, K., "Stepping Surface Testing Method for Medium and Heavy Duty Vocational Trucks," *SAE Int. J. Commer. Veh.* 8(2):2015, doi:10.4271/2015-01-2834.

INTRODUCTION

An access system includes all the components of a vehicle that allow personnel to enter or exit a cab, or climb onto or off of a vehicle. Common components of an access system include steps, platforms, ladders, handrails, and railings. A good access system provides a means for personnel of any body shape or size to enter or exit while maintaining three points of contact (one hand and two feet, or two hands and one foot) at all times.

A key aspect of proper access system design is the ability of the stepping surface to provide a high coefficient of friction under as many environmental conditions as possible. Selection of the optimum surface for varying design applications necessitates some means of measuring this coefficient of friction.

Currently, there are very few standards regarding measurement of slip resistance in vehicular applications. While there are standards for slip resistance for flooring or walkway surfaces, very little has been done to develop an applicable standard for automotive applications. No governing or standards agency, including OSHA, ISO, or SAE, has released standards regarding slip resistance in an automotive application.

This paper presents the need for access system design, reviews the current access system standards and slip resistance testing methods, and concludes with a proposal for a new method of measurement. The ability to accurately compare the performance of various stepping surfaces is key to optimizing the effectiveness of the stepping surface.

IMPORTANCE OF TRUCK ACCESS DESIGN

In 2013, the US Bureau of Labor Statistics (BLS) reported that slips, trips, and falls (STF) were the second leading cause of nonfatal occupational injuries requiring days away from work. In the United States alone, nearly 250,000 cases of STF related injuries were reported for 2013, including 724 fatal occupational injuries as a result of STFs [1]. Additionally, the incidence rate of STFs in occupations utilizing heavy duty vocational vehicles was higher than the national average. Heavy and tractor-trailer truck drivers had incidence rates (per 10,000 full time workers) of 32.8 for falls to a lower level and 47.4 for falls on the same level, compared to the national average of 5.4 and 17.4 respectively. Light truck and delivery drivers had incidence rates of 19.1 for falls to a lower level and 48.6 for falls on the same level [1].

Design of access systems on vocational vehicles is especially important as users are often working at elevated heights. Operators routinely are required to step, walk, or operate at heights greater than the OSHA height requirement for fall protection in general industry [2]. This elevated height greatly increases the potential consequences of falls. A study by the University of Florida - Institute of Food and Agricultural Services found that in 1999, 25% of elevated falls reported in the Florida agriculture sector were from vehicles or other mobile equipment.

While same level STFs are more common, falls to a lower level generally result both in more major injuries and in more lost work time [3]. This increased risk due to height, combined with the variable operating environments of these vehicles (water, mud, snow, and ice) means a design which balances high slip resistance and an ability to shed debris is of the utmost importance.

COMMON AGGRESSIVE STEP MATERIALS

Heavy truck designers employ a wide variety of stepping surface materials. Most are fabricated from steel, stainless steel or aluminum, which can be cast, stamped, punched, formed, or welded. Presented below are examples of common step configurations currently employed in the heavy truck industry.

Step Types

Cab Access Steps

Conventional cab access steps typically consist of two exterior steps or stairs, with the step being the interior floor of the cab. They may be integrated into a stylized fairing, attached to fuel tanks or battery boxes, or simply hung beneath the cab.

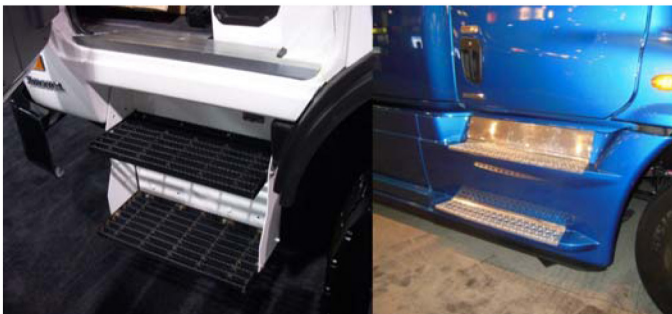


Figure 1. Examples of a traditional cab access step utilized on most over the road vehicles.

Cab Access Stirrup Steps

Stirrup steps are often used in vocational applications where a conventional truck has been modified to raise the frame, typically due to the addition of a front drive axle. Stirrup steps, as their name implies, hang down below the standard steps like the stirrup of a horse's saddle.



Figure 2. Examples of stirrup style access step utilized on US military vehicles.

Body Access Ladders

Vocational vehicles often include fixed or deployable ladders to access features on the body. These may be areas that are only accessed occasionally for service, maintenance or cleaning, or they may be for access to working areas of the truck.



Figure 3. Examples of cab or body access step ladders employed on over the road and off highway vehicles.

Surface Construction

Truck designers use a wide variety of shapes, features, and construction methods to produce aggressive slip-resistant stepping surfaces. Some examples of various constructions are presented below.

Punched

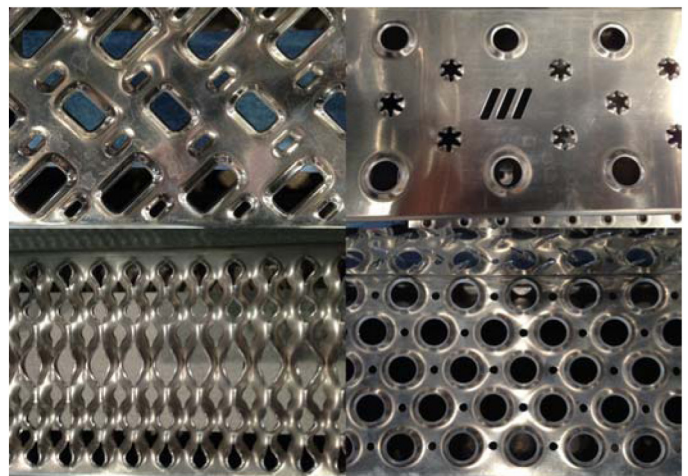


Figure 4. Examples of punched steel or aluminum step designs commonly utilized in the heavy truck market.

Expanded



Figure 5. Example of expanded metal grate on US military vehicle.

Machined



Figure 6. Example of machined step design.

Rolled



Figure 7. Example of rolled diamond plate steel in a cab access step application.

Coatings

Slip resistant coatings either with or without grit materials can be applied either to smooth or aggressive surfaces. The same surface may be either raw or painted.



Figure 8. Example of slip resistant coating, 3M safety walk general purpose adhesive-backed applique installed on a front discharge cement mixer.

COMMON MEASUREMENT METHODS INAPPROPRIATE

Common Devices

Slip resistance of stepping, standing and walking surfaces is a complex topic because of the great variability in both the stepping surface and footwear materials. Additionally, the human gait is a complex motion that differs between persons. The vast majority of human stepping and walking occurs on surfaces in buildings or on sidewalks and streets. As such, most testing machines and methods have focused on homogenous hard surfaces.

There are five common approaches to slip resistance measurement:

- Pendulum
- Angular Force
- Inclined Plane Dolly
- Crawler
- Drag Sled

Pendulum Devices

The pendulum device is typically used for measuring road surfaces such as concrete or asphalt. This device utilizes a friction pad mounted to the end of a pendulum. The device is leveled and adjusted so that the pad will rub the surface for a set distance as it swings past the surface. The friction of the surface is determined by measuring the difference in swing distance (angle) from the free-swinging condition.

Angular Force Devices

The articulated strut and variable incidence tribometer are examples of devices that use various means to direct a force onto a pad that rests on the horizontal test surface. The angle of the force is changed from vertical toward horizontal until the pad slips off the surface. These devices measure strictly the static friction, and the