Improving Stability with Leather Boots

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Abstract

A firefighter's boots play a crucial role in his/her ability to work safely and effectively. W. L. Gore & Associates supported efforts at Auburn University and the University of Mississippi to evaluate the impact of rubber versus leather boot construction in the stability of firefighters. Professional firefighters participated in simulations of typical firefighting activities while wearing leather boots and rubber boots. Based on the results of this study, leather boots reduced the likelihood of slipping and/or falling while performing normal firefighting activities — with firefighters four times more likely to have a hazardous slip when wearing rubber boots.

Introduction

Although non-fatal injuries have declined in the last several years, the National Fire Protection Agency (NFPA) estimates that 70,090 injuries occurred in the line of duty in 2011, with 30,505 of these occurring during fireground operations. Slips and falls are the second highest cause of firefighter injuries, comprising 21 percent of fireground-related injuries.[1]

To reduce injuries resulting from fireground hazards, the National Fire Protection Association (NFPA) has developed standards for the gear used by firefighters, with NFPA 1971 containing requirements for footwear and boots worn with protective clothing. Footwear certified to this standard is available in both rubber and leather constructions. However, the nature of these materials results in significantly different footwear designs.

W. L. Gore & Associates collaborated with Chip Wade, Ph.D., from Auburn University's Department of Industrial and Systems Engineering and with John Garner, Ph.D., from the University of Mississippi's Department of Health, Exercise Science and Recreational Management, as they studied the impact of different footwear types on the severity of slips and falls while working in fireground activities.

Test Process

Thirty full-time firefighters were tested in separate sessions — in some instances wearing rubber boots and others wearing leather boots (Table 1).

Table 1: Firefighter Characteristics by Boot Type

Statistic	Rubber Boot	Leather Boot
Age range (years)	18 – 46	18 – 46
Average weight (lb)	204	203
Height (in)	67	67.5
Boot size range	8.5 — 12.5	8.5 – 12
Average boot size	10	10
Average boot weight	1.6	1.4

All tested boots met NFPA 1971 requirements. During each session, the firefighters wore the turnout gear, mask, and helmet issued by their department. The test area was set up to record the firefighters' stability while walking through a simulated fireground environment, including:

- an 8.5 meter, vinyl-tiled walkway containing a force plate that measured the force exerted by the heel and toe as the firefighter stepped on the plate
- a motion measurement system that recorded three-dimensional data about the firefighter's stride
- a harness system that was used to catch the firefighter in the event he/she lost balance during the walking session

All of the firefighters followed the same protocol for each session:

- While wearing his/her gear, the firefighter walked on a CPAT stepmill for approximately three minutes, beginning with 50 steps per minute and increasing to 60 steps per minute.
- After one minute, the firefighter began walking across the vinyl-tiled walkway. He/she was asked to walk as naturally as possible while visually focusing on a target placed at eye-level on the far wall.
- After several practice walks, a diluted glycerol solution (75% glycerol, 25% water) was applied to the force plate without the firefighter's knowledge, and the firefighter walked across the path again.
- Two variables were measured to determine the severity of any slip:
  - the vertical and horizontal velocity of the heel hitting the force plate
  - the distance the foot travelled once it hit the floor

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Test Results

A hazardous slip was defined as any slip in which either the foot exceeded the distance of the contaminated force plate or the firefighter relied upon the harness to regain his/her balance. While the slip velocity and slip distance varied among the boots, these values were substantially higher for rubber boots (Figures 1 and 2).

Statistically the results showed that a firefighter wearing rubber boots is 4 times more likely to slip and fall when encountering a slick surface than if he/she is wearing leather boots (Figure 3).

Conclusion

This study examined the differences between slip characteristics of rubber and leather boots commonly worn by structural firefighters. Summarizing the data comparing rubber boots to all leather boots, the study showed that firefighters are approximately four times more likely to slip or fall when wearing rubber boots.[2]

The findings of this study suggest that the type of boot a firefighter wears has a direct impact of his/her stability during fireground activities, and leather boots provided a more stable interface between the foot and the floor. Because slip-and-fall accidents are the second leading cause of work-related firefighter injuries, it is important to select the boots that provide the most stability, which this study indicates are leather boots.

Figure 1: Peak Slip Velocity by Boot Type

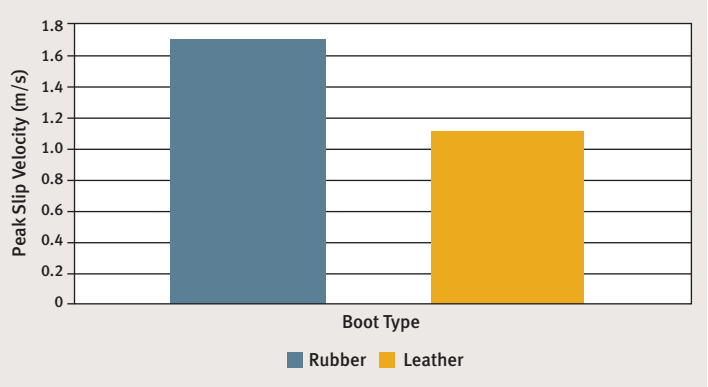


Figure 2: Slip Distance by Boot Type

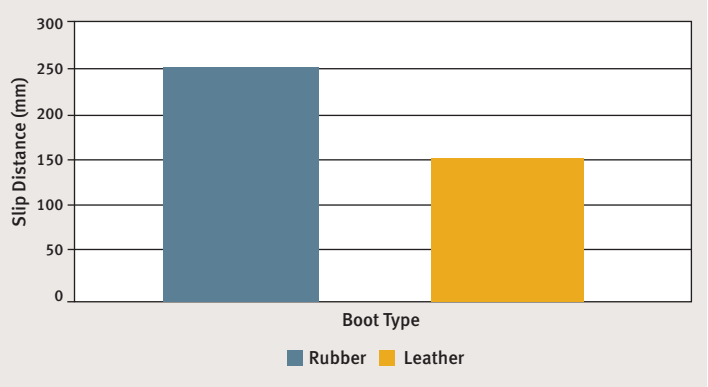
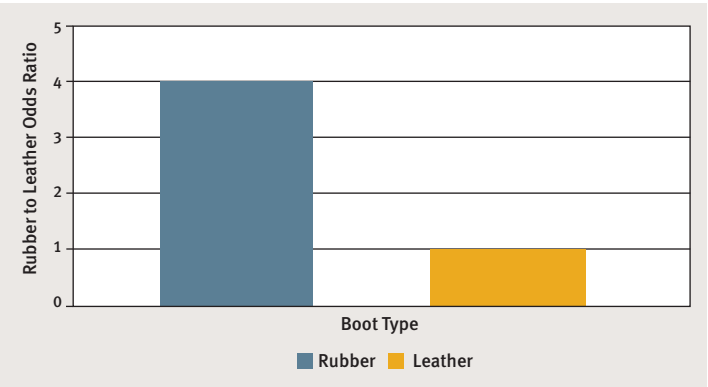


Figure 3: Odds of Hazardous Slip When Wearing Rubber versus Leather



[1] Karter, Jr., Michael J. and Joseph L. Molis, "U. S. Firefighter Injuries – 2011," National Fire Protection Association, October 2012.

[2] Chip Wade, Ph.D., CPE (2013) "Slip Outcomes in Firefighters: A Comparison of Rubber and Leather Boots" working paper, Auburn University, Department of Industrial and Systems Engineering, cwade1@auburn.edu.

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