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Railroad Hand Switch Stand Operation—An Update

George B. Page, MSE, CPE[1]; Steve Fleming, BSE, MBA, CPE[1]; Greg G. Weames, M.Sc., CPE, CCPE, CRSP[2]; John Vanderpool, BSE[1]

[1]Page Engineering, Inc.
Jackson, MI 49201
Corresponding author's e-mail: george@pageengineering.net

[2]Page Engineering, Inc.
Georgetown, Ontario L7G 3E5

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Abstract: Railroad hand switch stand operation was studied from an ergonomics and biomechanics perspective in the 1990s and early 2000s. At that time, operating methods that optimized safe operation of contemporary hand switch stands were developed and demonstrated. Since the early 2000s, new, "ergonomic" switch stand designs have been developed and implemented across the North American railroad system. We undertook a study to identify the optimal safe operating methods for the latest hand switch stand design, using biomechanical modeling to demonstrate the safety and capability of the best operating methods. The study affirms principles identified in the past for safe hand switch stand operation, such as: getting close to the load, not twisting the torso, and exerting upon the switch stand handle in a slow and smooth manner. The study also demonstrates additional principles to apply for the last half of hand switch stand lever movement that increase safe force-producing capability.

Keywords: railroad switch stand, biomechanics, design

1. Introduction

Railroad hand switch stands have been a fixture of the rail industry for over a century. A switch stand allows for train traffic to be diverted from one set of tracks to another. A manual switch stand is a switch stand that is operated by hand—most commonly found in railroad yards and industry sidings.

An original assessment of the manner in which switch stands were operated, from a biomechanical perspective, was conducted more than 25 years ago (McMahan, 1984; Chaffin et al. 1988; Page and McMahan, 1990; Page and McMahan, 1993). Along with studying and prescribing the best operating methods per biomechanical criteria, Page and McMahan (1990) also assessed the effects of various maintenance procedures and possible design improvements. Subsequent to these studies, hand switch-stand manufacturers developed new, ergonomic, switch stand designs aimed at improving the safety and ease-of-use of hand switch stand operation. These new designs included longer handles, longer and elevated handles, bow-shaped handles—both elevated and not elevated, which were among the most common new designs. Meanwhile, North American railroads improved their switch stand operating rules to incorporate biomechanical principles—improving performance and reducing loading upon the back and primary joints of the body. Of noteworthy importance, most North American railroads empowered railroad employees to stop the operation of hand switch stands when said switch stands become difficult to operate—requiring more than slow, smooth, quasi-static exertion to complete the operation of the switch stand.

This paper aims to perform an update of the best biomechanical-based methods to operate the most common, new, hand switch stand design on the market: the bow-handle hand switch stand.

2. Methods

Commonly observed methods by which to operate the bow-handle switch stand were observed by the authors over the last decade. The methods were categorized by the three phases of switch stand operation: the beginning, the middle, and the end of handle movement. Together, these phases of movement represent approximately 110 degrees of range-of-motion in the vertical plane, in total. Figure 1 shows a picture of the bow-handle switch stand from the perspective of the operator facing the switch stand. These observed methods have embraced the basic biomechanical tenants laid out by Page and McMahan (1990, 1993). These include standing close to the handle, repositioning one's feet as the handle proceeds through its range-of-motion, not jerking on the handle, and not twisting the torso while exerting hand forces upon the handle. The initial phase of operation is considered inconsequential, since only half the weight of the handle is being lifted during this phase—about 25 pounds. The second and third phases of operation are the focus of the biomechanical modeling and assessment. In these two phases, given the mechanics of the switch stand, the operator moves the weight of the handle and, also, moves the switch points—the rails that are connected to the switch stand. Thus the forces acting upon the hands needed to move the bow handle through its range-of-motion are greatest through these two phases of movement.

Figure 1: The Bow-Handle Switch Stand

The operating methods (postures) assessed in this paper include: pulling the bow handle through its second phase of movement, pushing and pulling the bow handle through its third phase of movement, and pushing the bow handle through its third phase of movement with assistance from the outside foot. See Figure 2. The University of Michigan's Three-Dimensional Static Strength Prediction Program™ (2017) was used to assess each of these three postures. Each posture was assessed by incrementing the amount of hand force exerted by the two hands until body balance could no longer be maintained. This is considered the maximum hand force possible for each posture. Moreover, a 95th percentile man's anthropometry was assessed to determine the worst-case scenario in terms of low-back loading. Figure 2 also shows a 95th percentile male operating the bow handle switch stand in the three assessed postures.

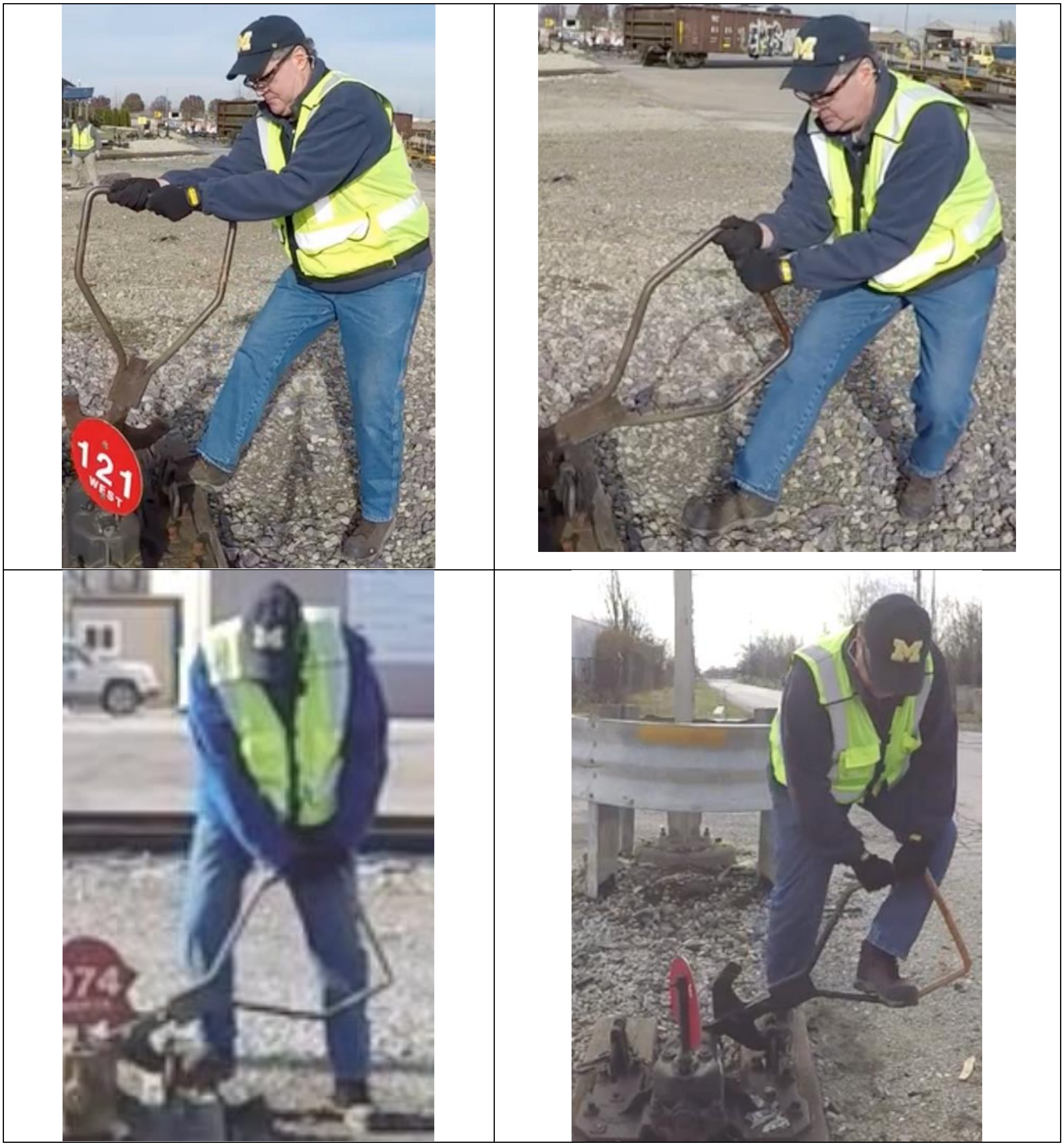

Figure 2: Operating Methods (Postures) For the Second and Third Phases of Operation

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3. Results

Figure 3 shows the results of the biomechanical analysis of the four postures shown in Figure 2. On the top of Figure 3, the maximum hand forces capable of being exerted by a 95th percentile male are shown. On the bottom of Figure 3, the associated back compression levels for each of the four postures is presented.

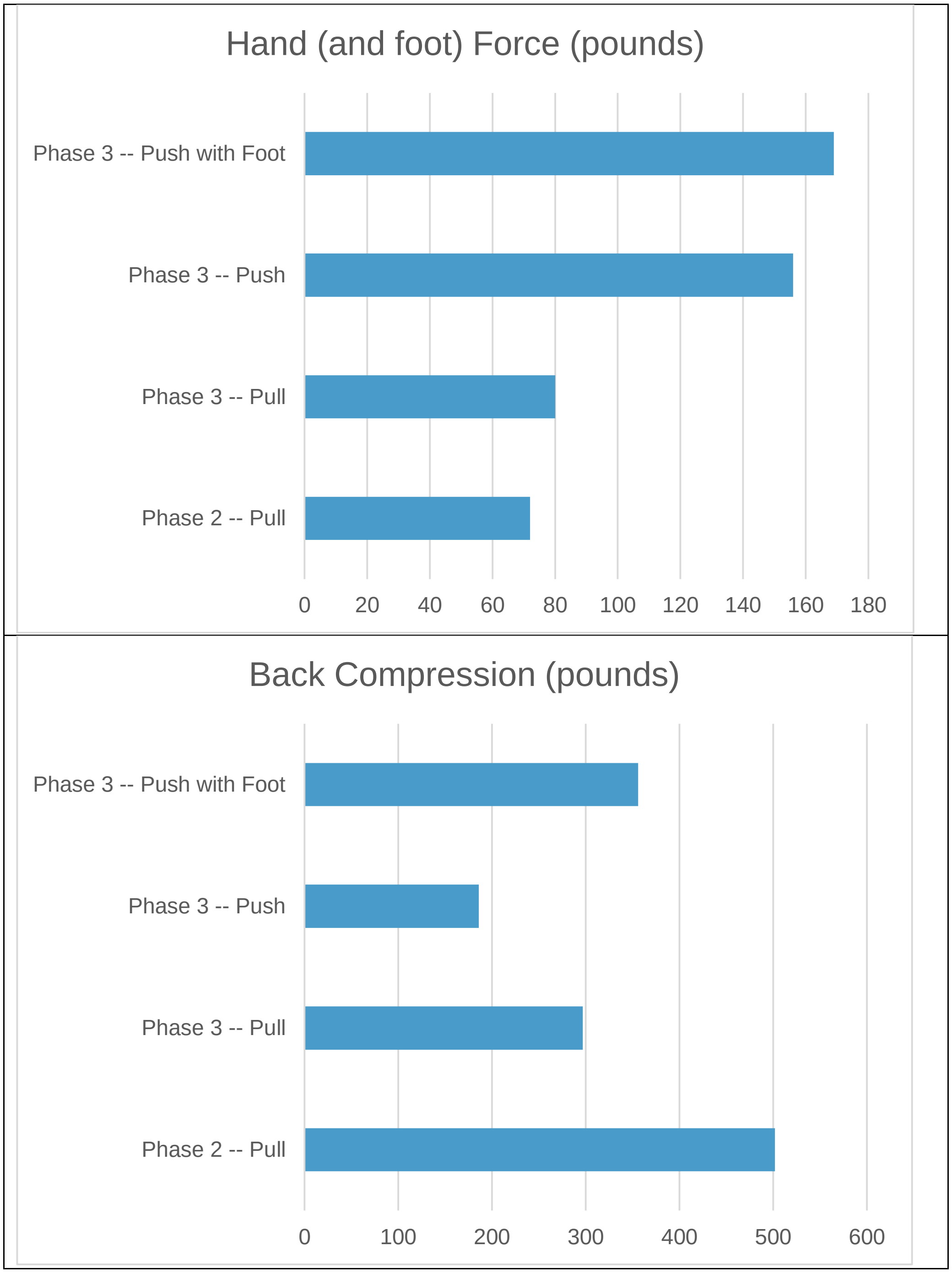

Figure 3: Hand (and foot) Forces and Back Compression by Method (Posture)

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Figure 3 shows, for the Phase 2—Pull posture, 72 pounds can be exerted before body balance is compromised. The associated back compression is 502 pounds. For Phase 3, the Push with foot assistance exerts the greatest force—169 pounds. The associated back compression is 356 pounds. Phase 3—Push, without foot assistance, exerts 156 pounds, with a back compression of 186 pounds. Phase 3—Pull exerts 80 pounds, with a back compression of 297 pounds.

4. Discussion

Operating the bow-handle switch stand can be performed with back compression levels well below the NIOSH (1981) Action Limit for back compression of 770 pounds. Notably the Phase 3—Push and Phase 3—Push with foot assistance exert the greatest amount of force upon the switch stand handle, namely due to the application of the individual's body weight. The effect of the push-down aspect of this task using these methods (postures) is to unload the low back, hence the low back compression values. The foot-assisted method is only used where conditions permit doing so, i.e., dry surfaces with the handle close to its end of range-of-motion and the other foot firmly positioned on the ground.

5. References

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