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## Ergonomics Technical Note

### Excalibur Screwbolt

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**Author:** Dr Elizabeth de Mello, Senior  
Ergonomics Specialist

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## 1. INTRODUCTION

The aim of this document is to set out ergonomics observations following a site inspection to look at the ergonomic implications of using the Excalibur screwbolt. The inspection took place at Southampton University on 14.08.18. at the request of Dr. Ian Coleman, Principal Engineer, Network Rail.

## 2. PURPOSE & SCOPE

The purpose of ergonomics involvement was to assess the musculoskeletal and other stresses and demands (i.e. general usability issues) of attaching AS rail chairs to (hardwood) sleepers using two different methods:

1. The traditional method – the AS rail screw spike, which has been used for this purpose for many years. These are driven in using a petrol powered Bance impact wrench
2. The new method - the Excalibur screwbolt, a new type of bolt which is inserted using a battery powered Milwaukee M18 High-Torque Impact Wrench

Three fixings are required to attach each AS rail chair to the sleeper. Although there are various Regulations and Standards which cover ergonomics, I will not list them here but can provide more information if required.

## 3. RESULTS

According to Excalibur staff, the screwbolt is precisely inserted to the required torque, whereas the AS rail screw spike is simply inserted until it protrudes a certain amount above the chair i.e. it is done by 'look and feel' and there is no precise torque.

Excalibur staff also stated that inserting the Excalibur screwbolt requires 1/3 of the effort of the old method. No data was provided to substantiate this from the user's perspective, and it is possible this assertion refers to the torque levels required i.e. this considers the mechanical perspective of the tool/equipment interface, not the user perspective.

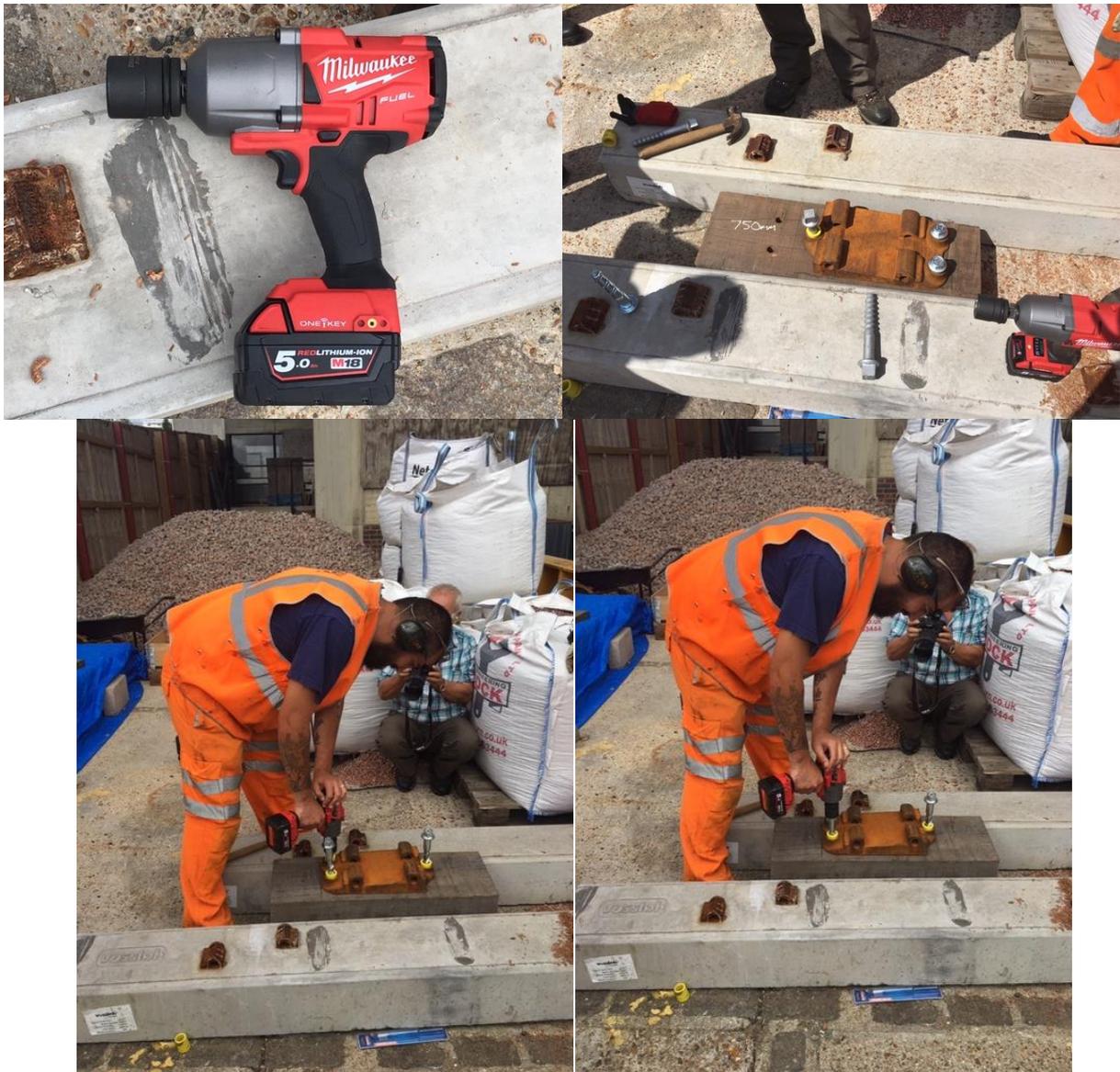
### 3.1. Observations on attaching rail chairs using AS rail screw spikes and the Bance impact wrench

1. A Bance impact wrench weighs in the region of 19 – 20 kg (depending on model). Its weight is poorly balanced, the machine is not well designed from an ergonomic point of view, and there is, from SMIS data, a known history of musculoskeletal injury when using/handling it. From an ergonomics/health and safety point of view, decreasing staff exposure to this tool would be welcomed, providing any alternative meets engineering/performance requirements.
2. There are issues of quality control with this method. The operator is unable to see what they are doing – they rely on a colleague to tell them when to stop inserting the AS rail screw spike since they cannot know themselves (the visual distance to the spike and its obscuration by the Bance both lead to this problem). As there is no predefined torque I assume there will be occasions where the operators have to revisit the fixings since they may prove not to be satisfactory. There could be inter- and intra - operator variability in the standard of fixing achieved.

3. This is a two person technique with the operator using the Bance placed under physical stress. The Bance operator is slightly stooped over and slightly twisted to the left. To insert the rail screw spike they push down firmly, and constantly, with their arms and the weight of their upper body throughout. They continually bear the weight and vibratory impact of the Bance whilst inserting the AS rail screw spike. Their colleague guides their work.
4. Postures are shown below. The operators informed me that after about 5 – 10 minutes of using the Bance they have lower back pain. I observed the operator using the Bance was using a lot of muscular force and got hot and sweaty on the job, even though the time on task was relatively short. There may also be issues with fumes, noise, and HAVS, although none of these were measured or examined.



### 3.2. Observations on attaching rail chairs using the Excalibur screwbolt and the Milwaukee torque wrench



1. The Milwaukee M18 weighs 3.3 kg including battery pack.
2. As this tool has not, to my knowledge, historically been used on the rail network, there is no past history of injury to consult. However, given the weight of the tool and the fact it is battery operated, it is likely to pose less risk in terms of overall weight, HAVS, noise and fumes than the Bance.
3. There are likely to be fewer issues of quality control with this method. The operator can see what they are doing as they are closer to the tool and it does not obscure their view, and in any event they fix to a predetermined torque. All these factors, aside from rail safety, indicate the operators are less likely to need to revisit their work and repeat the fixing operations. Consequently I would assume staff workload could decrease with this option.
4. The fixing can be achieved with one operator alone as there is no need for a second person to guide them (for the reasons explained in (2) above).

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5. However, the strongly negative postural effects of fixing Excalibur screwbolts with the Milwaukee can be seen on the previous page. All three operators who tried this method showed extreme stooping postures. Such extreme stooping can mean up to 60% of the weight of the body may be borne by the spine. This is not an ideal working posture. It is known that stooping places stresses on the spine since the spine bears the weight of the superincumbent body parts whilst in a position of mechanical disadvantage. In addition, epidemiological studies have demonstrated a link between repeated/prolonged stooping and incidence of lower back pain. Operator weight/size has an effect on this matter too - the greater the abdominal depth, the greater the spinal stresses)
6. I am not able to say why the operators all adopted this working stance but the following three possibilities spring to mind:
  - a. Because of the design of the tool (short handle, close to the ground)
  - b. Due to the need to exert downwards pressure with a straight arm from the shoulder (combined with tool design)
  - c. They are used to working like this with the Bance so didn't try kneeling and doing the job

This would need further examination, as would the possibility of providing a jig for the tool so the operators could use it with a more upright posture, or extended handles, either of which would be an acceptable option. However, just how much of a problem this would be in the field would be determined by task exposure – how many of these chairs are inserted at a stretch, and for how long over a shift. If they are only doing this task for 10 - 15 minutes in their shift and the rest of the time doing other tasks with different postures then I would not be overly concerned, particularly given the tool weight advantage over the Bance. However, if they were doing this for more than 30 – 40 minutes without rest or movement to other activity then this would be a concern. We would not want to introduce additional, although different, risks into the work when installing Excalibur screwbolts.

7. From a usability perspective, it would be good to know the length of time the Milwaukee battery would last during these operations, and the time to recharge. None of this information is available to me at the time of writing
8. Nevertheless, the operators all found this task/tool combination far easier than the traditional method described in 3.1 above for the short time they did this task, and the following comments were recorded –
  - “So much better than the Bance”
  - “A lot easier”.

I noted none of the three operators who tried the new method got t hot and sweaty, as had all three operators who used the traditional method.

### 3.3. Borg Rating of Perceived Exertion

Immediately following fixing the rail chairs using the two different methods, the operators were asked to report on the level of effort taken using the Borg CR10 Rating of Perceived Exertion (RPE) scale. This is a method for measuring physical activity intensity level.

Perceived exertion is how hard a person feels their body is working and is based on the physical sensations they experience during physical activity including increased heart rate, increased respiration or breathing rate, and increased sweating and muscle fatigue. It has been shown to be reliable in a number of industrial contexts, and has previously been used by the Health and Safety Laboratory for assessing railways tasks/tools. The Borg scale ranges from 0 to 10 where 0 means no exertion at all and 10 means maximal exertion. The lower the number given by the operator, the less exertion they perceived when doing the task.

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Three operators rated each rail chair fixing method (repeated measures). One operator also rated inserting the AS rail screw spike (traditional bolt) with the Milwaukee impact wrench (new tool). The purpose of this was to ascertain whether or not it would be possible to insert the traditional AS rail screw spike using the Milwaukee i.e. whether the forces required to insert the AS rail screw spike were greater than those required to insert the Excalibur screwbolt. The results are shown in Table 1 below:

<b>Fixing Method</b>	<b>Operator</b>	<b>Borg Scale response</b>
AS rail screw spike/Bance	1	6
	2	4
	3	4
Excalibur Screwbolt/Milwaukee	1	1
	2	1
	3	1
AS rail screw spike/ Milwaukee	1	9 - 10 <sup>1</sup>

**Table 1: Borg scale results**

It is clear from these results that the new method imposes significantly less physical stresses on the operators than the old method. However, I must also refer the reader to the matters noted above about the extreme stooping postures evinced. A more extended comparative trial, fixing several rail chairs, would be advisable, just to be sure we are not introducing new stresses on the operators which could lead to low back pain/injury.

### 3.4. Time on Task

The times to insert the AS rail screw spike and Excalibur screwbolt were taken by both myself and Excalibur staff. I have seen the videos sent by Excalibur which show three rail chairs fixed by the traditional method, and two by the new Excalibur method. There is also a video of the failed AS rail screw spike insertion using the Milwaukee.

Using the traditional method takes approx. 40 – 72 seconds to install a rail chair. Using Excalibur was timed at between approx. 15.6 and 42.6 seconds. However, it must be said

<sup>1</sup> Operator unable to complete task due to stresses of the work.

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that the longer of these two times appeared to be related to the operator idling the tool on the screwbolt, and the shorter of the times is likely to be more representative of the time on task.

These results demonstrate a potentially greater productivity with Excalibur installations, and a shorter exposure time to the stresses of the work. It is likely that the shorter time on task also contributed to the lower Borg scores for the Excalibur screwbolt insertion.

## 4. SUMMARY

1. The Excalibur screwbolt:
  - a. Is faster to insert than the AS rail screw spike
  - b. Imposes less perceived physical exertion on the operators during installation than the AS screw spike
2. The increased speed of installing rail chairs with Excalibur is likely to lead to:
  - a. Greater *potential* for productivity gains
  - b. Lower levels of operator fatigue

When operators become fatigued they can be at greater risk of injury, including musculoskeletal injury (but also other types of injury e.g. slip, trip, fall, & etc.) and so this method could have potential for some reduction of injury risk. It would also have the advantage of decreasing exposure to the Bance impact wrench, which is known to be demanding and linked to musculoskeletal injury.

3. However, there remains a potential risk of musculoskeletal strain due to the extreme stooping postures to use the Milwaukee when installing Excalibur screwbolts. The level of this risk will be determined by matters related to task exposure such as:
  - a. How long screwbolts are inserted at a stretch without a break
  - b. How long in total is spent on this task over a shift

Given this, it would be advisable to consider these matters further and obtain information on exposure to this task over the shift, if only to exclude this as a potential new risk.

4. A more extended comparative trial, fixing several rail chairs, would also be advisable, just to be sure we are not introducing new stresses on the operators which could lead to low back pain/injury. If we were to find we were, any risk of extreme stooping could be reduced by providing extended handles or a jig for the Milwaukee.

## 5. APPENDICES

1. Attendees
  - a. Jim Clement - Excalibur Screwbolts
  - b. Joh Stevens - Excalibur Screwbolts
  - c. Duncan Crump - Southampton University
  - d. Wendall Bailey - Southampton University
  - e. David Milne - Southampton University
  - f. Ian Coleman – Network Rail
  - g. Elizabeth de Mello – Network Rail
  - h. Three person pway team – Network Rail