

# Investigation of baseplate pad life on the London Underground Jubilee line extension

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## INTRODUCTION & HISTORICAL BACKGROUND

The Jubilee Line is the newest line in London Underground's network originally opening in 1979 and was named after the silver jubilee of Queen Elizabeth II. It took over part of the existing Bakerloo line with a new section being built to Charing Cross. The line was further extended in the 1990s with the so-called Jubilee Line Extension (JLE). This new section opened in 1999.

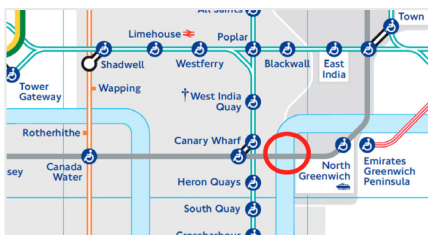


Image 1: Map of Jubilee Line Extension track / location in the network

The Jubilee Line Extension runs from Green Park to Stratford in east London with 10 intermediate stops. It greatly improved the access to public transport for the neighbourhoods along its route including the financial centre of Canary Wharf and the entertainment centre of North Greenwich. Today the line is the third busiest on the network with approximately 213 million passengers per year.

The London Underground engineers responsible for the design of the Jubilee Line Extension in the 1990s were aware of

the latest requirements for minimising the impact of structure-borne noise and vibration. London Underground found a suitable partner in Getzner Werkstoffe GmbH to support the design of a bespoke engineering solution. As a one of a kind project Getzner not only provided the elastic baseplate pads made of Sylomer®, but designed the whole rail fastening system in conjunction with London Underground.

The elastic baseplate pads (dimensions: 300x150x25mm) were designed with an asymmetric stiffness distribution in order to avoid rail head tilting, with the stiffer part of the pad facing outside of the track. The asymmetry was achieved through an elliptical cut which was positioned slightly off-centred. When producing the Sylomer® baseplate pads, a groove was moulded into the side in order to

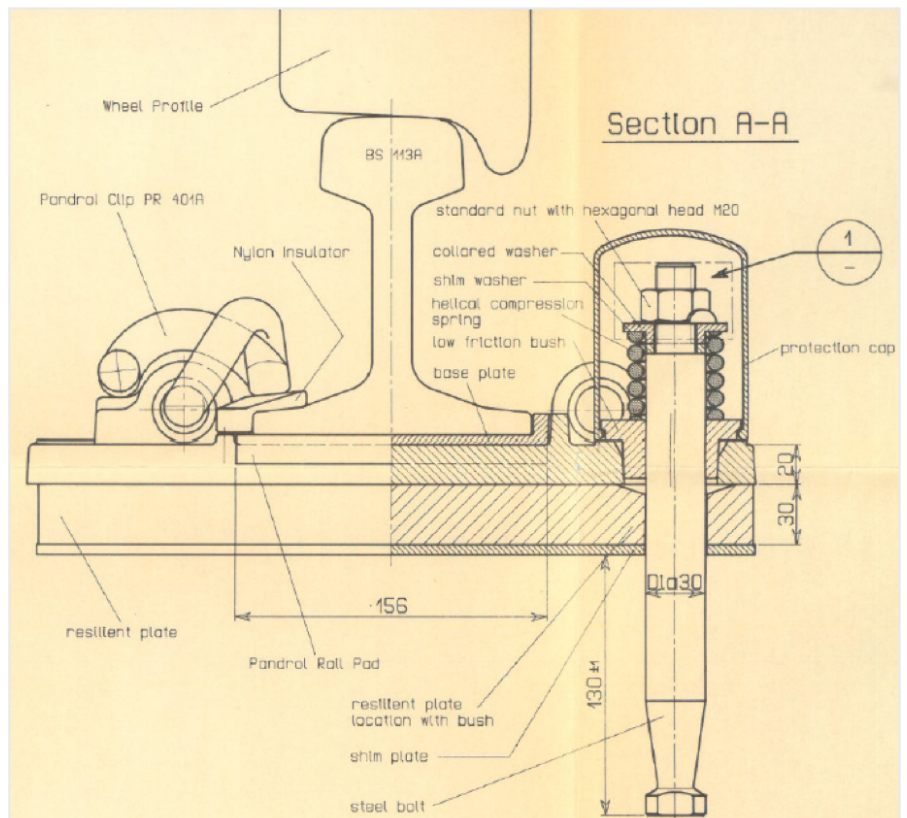


Image 2: Original design drawing of Jubilee Line Extension rail fastening system

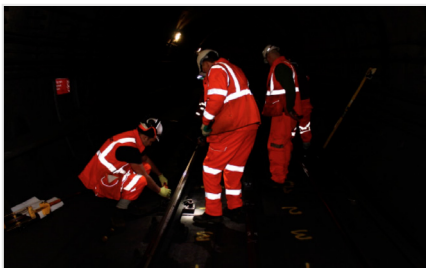


Image 3: Disassembly and removal of baseplate pads from the Jubilee Line track

facilitate the crucial identification of the inner side of the pad and thus enabling correct installation on site.

### REMOVAL OF BPP & SUBSEQUENT TESTING

After nearly 20 years of in-track operation, London Underground was interested in understanding how these pads were performing now. The main question to be answered being: for how much longer will the elastic pads remain fully functional? London Underground approached Getzner in November of 2015 with an enquiry to remove some of the baseplate pads originally installed in 1996 for testing purposes.

The project aimed at gaining insights into the long-term behaviour of elastic polyurethane baseplate pads, increasing the understanding and thus helping both London Underground as well as Getzner to better determine the possible realistic life cycle of baseplate pads. A testing programme was jointly developed

and agreed upon, including visual inspection, dimensional control against original drawings, stiffness tests (both static and dynamic) and tensile tests. London Underground defined the most important parameter being the dynamic to static stiffness ratio. Furthermore, the estimation of the remaining life span of the elastomer pads was key information to be assessed.

In the night from January 31 to February 1 2016, track engineers from London Underground accompanied by an expert from Getzner Werkstoffe GmbH removed ten pads from both a curved and a straight section, between the stations Canary Wharf and North Greenwich for testing purposes.

The first impressions when lifting the rails were very positive, since the majority of the pads had no visible damage at all. Besides some dirt from the track and conventional rust particles from the rails, the pads were found to be in very good condition. Besides the pads, also the other fastening system components were found to be in good condition.

After removal, the 20 pads were then brought to Getzner's testing facilities at its headquarters in Bürs, Austria to undergo the previously mentioned testing programme. All tests were done in accordance with the respective norms, original project specifications stemming from the year 1996 and under supervision of a London Underground representative. Quality assurance data collected during the original production phase served as a reference in order to compare original to current performance of the pads.

As the visual inspection had already yielded very promising results, the dimensional control also showed a positive outcome. In regards to the thickness, being an important indicator for creeping/permanent deformation of the material, the control showed excellent results: every pad was still within the thickness tolerance of +/- 1 mm.

Subsequently the samples underwent static and dynamic testing on an Instron PSB 250 hydropulse test rig. The tests were done pursuant to the original specifications. The samples from the track were tested at 30 Hz with evaluation points at different pre-loads.

The originally defined criteria for the ratio of dynamic to static stiffness was set to be smaller or equal to 2.75 at 30 Hz. The measured dynamic to static ratio of all pads was found to be still well below the originally specified ratio, with a mean value of 1.5, thus implying high performance.

### RESULTS

The baseplate pads taken from the Jubilee Line Extension tracks endured heavy use for 20 years. The data of London Underground shows that the pads were subjected to 77.4 million load cycles and 565 MGT (Million Gross Tonnes). The real loads are about 23% higher than the originally anticipated values calculated by the Technical University of Munich, due to rapidly increasing passenger numbers on the Jubilee Line.

A very good indicator that the pads are still good for further use is the thickness of the pad. All pads are still within original thickness tolerance. This, amongst other factors, indicates that the resilient pads still show full functionality.

Another important factor to be taken into account is the dynamic to static stiffness factor, indicating good performance during the passing of a train. The ratio is still well within original specified value, another strong sign that proper functionality and performance are still given.

After analysing the positive outcome of the tests and calculations with London Underground and the fact that during 20 years of operation not a single pad had to be exchanged, despite a tonnage of 565 MGT, it is very likely that the Jubilee Line Extension baseplate pads will remain fully functional for decades to come. Getzner and London Underground have agreed upon a follow-up pad removal and respective testing programme in 5 years in order to further observe the development of material properties of the Sylomer® baseplate pads.

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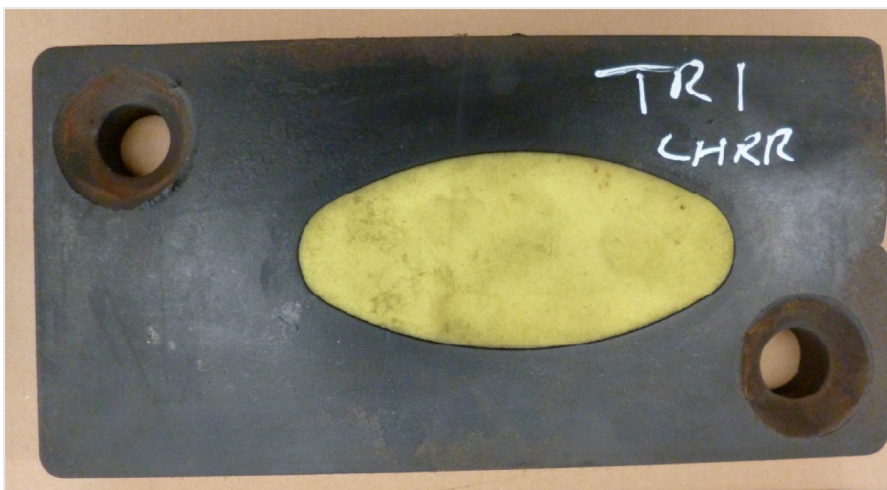


Image 4: Visual inspection of baseplate pads