Evaluating mechanised track maintenance machinery in terms of procurement principles for high traffic density lines

The Transnet Infrastructure Plan (TIP) 2011 forecast a growth in the national total freight (all forms of transport) from the current 750 mtpa (million tons per annum) to around 1 800 mtpa in 2040. In the Rail Development Plan section of the TIP, Transnet is preparing for this by putting in place strategies to move those commodities that are currently transported by road, but that are more suitable for rail, back onto rail. This will result in an increase in traffic beyond the current rail infrastructure traffic limit. The Transnet capital programme therefore relies on optimising the lines. In this regard efficient track maintenance will undoubtedly make a huge contribution.

AN INCREASE IN traffic on a railway line requires an exponential increase in the preventative track maintenance intervention frequency (shorter maintenance cycle) to ensure that the line remains reliable, available, maintainable and safe. However, the more trains there are in the system the less time there is to occupy the track for maintenance with mechanised machinery.

To maintain the required maintenance cycle for the increased traffic without uneconomically and impractically increasing the number of machines working on the line, maximum performance and durability of production are expected of the maintenance machines. High-production mechanised maintenance machines will reduce the time required for maintenance, the number of machines required and the total cost of maintenance.

This article consists of two parts: Part 1 examines the necessity of using high-production track maintenance machinery to contribute towards line optimisation and reduction in maintenance costs. Part 2 examines public procurement legislation, and the importance and challenges of specifying the required machine adequately in terms of the procurement scoring system to ensure that the machine will be contracted.

PART 1
HIGH-PRODUCTION MACHINES FOR HIGH TRAFFIC DENSITY LINES SAVE MONEY

The field of mechanised track maintenance is very complex, with a wide variety of machines available for nearly every track maintenance activity. Over the years the technology employed on all of these machines has improved vastly to increase the production and durability needed to keep up with the demands of ever-increasing traffic volumes, high speeds and high axle loading. The technology is available, and in most cases already in South Africa.

For example, lifting, levelling, lining and tamping of the track are the most frequently performed mechanised maintenance activities, and it is therefore not surprising that the advancements in this technology have been huge. Thirty years ago the Plasser 09-32 revolutionised main line tamping with the continuous action principle producing 39 sleepers per minute. Today the Plasser 09-4X produces in excess of 70 sleepers per minute! The fastest tamping machine in South Africa is the Plasser 09-3X, which produces a maximum of 60 sleepers per minute (Figure 1).

However, these main line tamping machines cannot tamp turnouts, due to
the restricted track around the switch blade, the diverging rails and the frog. Tamping machines were therefore equipped with specialised features to tamp both turnouts and main line, and became known as universal tamping machines, but were of relatively low production when tamping open track (around 15 to 21 sleepers per minute). As the demand for maximum production in short maintenance windows grew, universal tamping machines became too slow to keep up with production demands on high-capacity lines. The 09-24 Dyna-CAT (Figure 2) bridged the compromise between specialised high-production turnout tamping and high-production main line tamping by tamping the heavy and long concrete 1:20 turnout in one pass in less than 30 minutes, and up to 36 sleepers per minute on the open line.

Maximum production is, however, not the only important criterion for high-capacity lines. The durability of the production is also very important, since this will determine the tamping cycle. Despite the technology used on Plasser & Theurer machines (having been researched and proven to produce the maximum possible durability by independent academics), the durability is today further enhanced by the use of dynamic track stabilising, integrated as part of the tamping machine or working independently directly behind the tamping machine. Research in South Africa by the Transnet Track Testing Centre showed that an extension of up to 30% between the tamping cycles is possible if the track is stabilised immediately after tamping. Today dynamic track stabilising is non-negotiable on heavy-haul and main lines and has become an integral part of the tamping process.

Before the benefits of high-production machines can be quantified in monetary terms, it is necessary to explain the effect of track maintenance on train operations. Influencing factors would be traffic density, whether it is a single or double line, the number of turnouts, the number and radii of curves, the condition of the track material, etc. The variables are therefore vast, but the Sishen-Saldanha iron ore line will be used as a good example, due to its financial importance for Transnet and its unique characteristics in terms of it being a single line of 861 kilometres, with high traffic density (one train departing from either end at slightly over two-hour intervals), heavy axle loads (30 ton), 20 crossing loops at approximately 40 kilometre intervals, and high-value trains of up to 342 wagons.

With the current targeted 90 million gross tons of traffic on the ore line, the tamping cycle can be calculated at approximately five months, using empirical formulas. In other words, the 861 kilometre line must be tamped from top to bottom within five months before the next cycle must start again. With a 650 mm sleeper spacing, this means that 1 325 000 sleepers have to be tamped over this five-month period.

If, for example, one tamping machine with a nominal tamping rate of approximately 19 sleepers per minute is used, working for four hours per day during a 20-working-day month, an average of 91 200 sleepers per month would be tamped. One machine would therefore take 14.5 months to tamp the entire line. At a required five-month tamping cycle, three of these machines would be required, with three occupations along the line of at least six hours each to ensure a four-hour work period.

On busy lines such as the Sishen-Saldanha line, complicated further by it being a single line, occupations are created by using train-free slots to allow maintenance machines to occupy the line. This can be best illustrated using a typical train grid (see Figure 3).

The blue lines represent full trains leaving Sishen at two-hour intervals (rounded off for the sake of simplicity in this hypothetical example) and arriving in Saldanha 17 hours later. The red lines are the empty trains returning from Saldanha to Sishen, also at two-hour intervals, but they take 21 hours to reach Sishen, as they have to pause in the loops to allow the full trains to pass without stopping. At any point on the line a train (full or empty) will pass at just over one-hour intervals.

To create a train-free maintenance window (coloured green in Figure 3) for mechanised track maintenance, some of the slots in both directions must be occupied. Figure 3 shows a typical scenario: to create one maintenance window every day between 08:00 in the morning and 14:00 in the afternoon, slots F1 & F2, F13 & F14, and F25 & F26 in the full direction, and slots E9 & E10, E21 & E22, and E33 & E34 in the empty direction must be train-free for maintenance.

Figure 1: Plasser & Theurer 09-3X high-production mainline tamping machine with stabiliser behind

Figure 2: Plasser & Theurer 09-24 Dyna-CAT Universal tamping machine with integrated stabilising machine
As a result of the train-free slots, default windows appear (coloured lilac in Figure 3). This is, however, only one window per day (and one at night), and if the tamping machine described above is used, at least three of these windows will be required.

Tamping is not the only maintenance activity on the line. Other activities that cannot be done between passing trains, and for which occupations would also be required, are ballast cleaning, rail replacement, ballast offloading and regulating, rail destressing, overhead track equipment maintenance, etc. It is clear that maintenance windows have an adverse effect on train operations and the freight throughput on the line. This explains why an increase in traffic will exceed the traffic limit for this line if the infrastructure remains the same, and/or maintenance methods, machinery and strategies are not adapted to accommodate the increase.

This over-congestion of maintenance windows can be alleviated by the use of high-production machines. Similar to the calculation above: one high-production tamping machine with a nominal tamping rate of 55 sleepers per minute (as opposed to 19) can tamp 264 000 sleepers per month, or a tamping cycle of five months for this 861 kilometre line. Therefore only one of these machines would be required, as opposed to three slower machines.

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However, these high-production mainline tamping machines cannot tamp turnouts (turnouts were not considered in the above example). In practice at least one universal tamping machine would be required to tamp the turnouts. The mix of high-production universal tamping machines and high-production main line tamping machines will depend on the characteristics of a particular line.

The contract cost of high-production machines would be more than for low-production machines. However, the contract cost should not be considered in isolation. It is the total cost involved in an occupation for mechanised maintenance, of which the machine is but one component, that must be considered. These costs include the following, but will vary depending on the different types of maintenance activities:

- The cost of Transnet personnel: A permanent way inspector, track master, flagmen, overhead track equipment linesmen, a signalling technician, labour for each of these, vehicles and tools would be required for each occupation.
- Diesel locomotive, train driver, his assistant and a shunter: The combined cost of this can be conservatively estimated at R30 000 per day. For some types of maintenance activities more than one locomotive and other rolling stock may also be required.
- Loss of revenue due to the occupation: As higher traffic volumes are envisaged, loss of revenue will be a particular concern, as lost train slots will never be caught up again due to the congestion on busy lines. Every slot that is used for maintenance has the opportunity cost to the railway of the income generated by a train. A quick internet search revealed that the commodity value on the international market of each ore train can be R40 million on average (http://www.indexmundi.com/commodities). At a conservative estimate that the income for the Railways is only 10% of the commodity value, each occupation of two slots has an opportunity cost of R8 million! The loss to the South African economy is, however, R80 million. To put this into perspective, the contract cost of a typical low-production tamping machine package would be approximately R50 000 per day (occupation), and of a high-production tamping machine package around R80 000 per day. Should only the contract values be compared, without considering their production capacity, it is clear which machine would be contracted.

However, if the total cost to the client is considered, the higher cost of the high-production tamping machine is completely irrelevant.

Correctly specifying and evaluating the required machine during the procurement process is therefore of paramount importance in terms of the expected outcome of the contract. Contracting a machine which is not capable of the expected production, due to failure of the supply chain process during the evaluation of tenders, would have financial implications far exceeding the maintenance contract value itself.

The biggest challenge to getting the required machine, however, is related to the supply chain management process and the legislation that regulates it.

**PART 2**

**WHAT IS THE INFLUENCE OF LEGISLATION ON CONTRACTING THE MACHINE THAT IS REQUIRED?**

Various acts, regulations and guidelines prescribe the manner, format and content for the preparation and administration of procurement documents in organ-of-state tenders. The most important of these is the Preferential Procurement Policy Framework Act (PPPFA), which simply states that an organ of state must determine its preferential procurement policy and implement it within the framework of a preference point system based on the contract value. The point system is based on either 80 or 90 points allocated to specific goals, such as contracting with persons, or categories of persons, who had been historically disadvantaged by unfair discrimination on the basis of race, gender or disability. The contract must then be awarded to the tenderer who scores the highest points, unless objective criteria justify the award to another tenderer.

The 2011 Preferential Procurement Regulations (the Regulations), published in terms of the PPPFA, provide the criteria for evaluating tenders where the quality or functionality of the product or service, of which production or performance would be one, may have a decisive influence on the outcome of the contract. Clause 4 of the Regulations states that:

1. An organ of state must indicate in the invitation to submit a tender if that tender will be evaluated on functionality.
2. The evaluation criteria for measuring functionality must be objective.
3. When evaluating tenders on functionality, the evaluation criteria for measuring functionality must be clearly specified in the invitation to submit a tender.
4. No tender must be regarded as an acceptable tender if it fails to achieve the minimum qualifying score for functionality as indicated in the tender invitation.
5. Tenders that have achieved the minimum score for functionality must be evaluated further in terms of the preference point systems prescribed in regulations 5 and 6 [the 90/10 or 80/20 point system].

Quality or functionality can therefore be introduced in the procurement documentation as eligibility criteria (pre-qualification criteria) as a means of ‘gate-keeping’ to ensure that only those tenderers who are likely to deliver the required quality or functionality continue to compete for the award of the contract.

The scoring of functionality is therefore merely to establish that the tenderer is capable of providing the service, and to reject the tender submissions of those who fail to attain the threshold score. Thereafter the tender offers can be evaluated on the basis of price and preference alone. The points scored for functionality will therefore not contribute towards establishing the successful tenderer in terms of price and preference evaluation.

The result is that a cheaper lower-production and/or substandard machine can make it through the eligibility process (‘gate’) and score the highest points due to its lower price, unless technology and speed are specified as non-negotiable. The tender board will then have to contract this machine according to the PPPFA without any discretion (performance or production can be law not be used again as objective criteria to award the tender to a bidder who did not score the highest points). Referring back to Part 1 above, the
Higher-production machine may be more expensive in terms of the contract value, but if the overall cost of maintenance is considered, the lower-production machine’s so-called saving will be negligible, due to it requiring longer or more train slots to achieve the same output as the high-production machine. This can be illustrated at the hand of the following hypothetical example:

The Railways advertises an invitation to tender for a tamping machine to tamp an 800 kilometre single line at a six-month tamping cycle. The tamping machine must therefore be capable of tamping 1 600 km (2 461 000 sleepers) in a 230-working-day year. Train slots are two hours apart and provision is made for two slots per day for tamping, providing an effective four-hour working day (refer again to Figure 3). It is an ore line and the income to the railway is approximately R4 million per train. Calculations by the Railways showed that a tamping machine with a minimum tamping production of 45 sleepers per minute would be required (45 slp/min x 60 min x 4 hrs/day = 10 800 slp/day x 230 days = 2 484 000 slp/year > 2 461 000 slp/year required). The tender documentation is advertised as such and two tenders are received, as illustrated in Table 1.

In terms of the PPPFA, even if Tenderer B received the full 10 points for preference (equity) and Tenderer A does not, the contract must still be awarded to Tenderer A if the price component is purely based on the contract value, since Tenderer A will achieve the highest points. However, as explained in Part 1 above, the lower-production machine would require more occupations than a higher-production machine at the expense of the opportunity costs of income generating trains, as illustrated in Table 2.

Therefore, despite Tenderer B’s contract price being R3.5 million more expensive per annum, this is insignificant compared with the saving of R448 million per annum brought about by the fewer occupations required by Tenderer B’s higher production machine and the resulting more trains that can be run. This does not even include other occupations costs, as discussed in Part 1.

High-speed technology is only cost-effective if the benefits that it provides are factored into the evaluation. This article therefore calls on the Railways to consider a different approach to calculating the price component of tenders while still remaining within the framework of the PPPFA. This would require the price component to be calculated considering the overall cost to the railway per occupation, and the production achieved, as opposed to a contract value alone. This article will not at this stage propose a formula for such a calculation, since the variables are vast, but to find the best value for money and to optimise line availability, this concept requires further investigation.

This article recognises that not all lines have a traffic density where production would make such a large difference in terms of opportunity costs, but the other costs mentioned in Part 1, such as personnel costs and locomotive requirements, should still be considered.

### Table 1

<table>
<thead>
<tr>
<th>Tenderer A</th>
<th>Tenderer B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine production offered</td>
<td>45 sleepers/min</td>
</tr>
<tr>
<td>Contract price (per annum)</td>
<td>R14 900 000</td>
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</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Tenderer A</th>
<th>Tenderer B</th>
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</thead>
<tbody>
<tr>
<td>Required production per year</td>
<td>2 461 000 sleepers</td>
</tr>
<tr>
<td>Production in four hours per day</td>
<td>10 800 sleepers</td>
</tr>
<tr>
<td>Production in 230 days per year</td>
<td>2 484 000 sleepers</td>
</tr>
<tr>
<td>No of days/occupations required¹</td>
<td>227 occupations</td>
</tr>
<tr>
<td>Opportunity cost of maintenance²</td>
<td>R1 816 million</td>
</tr>
</tbody>
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¹ No of days/occupations required = Required production per year ÷ production capability in a four-hour day
² Opportunity cost of maintenance = Number of occupations required x R4 mil/train x two trains per four-hour occupation
Source: