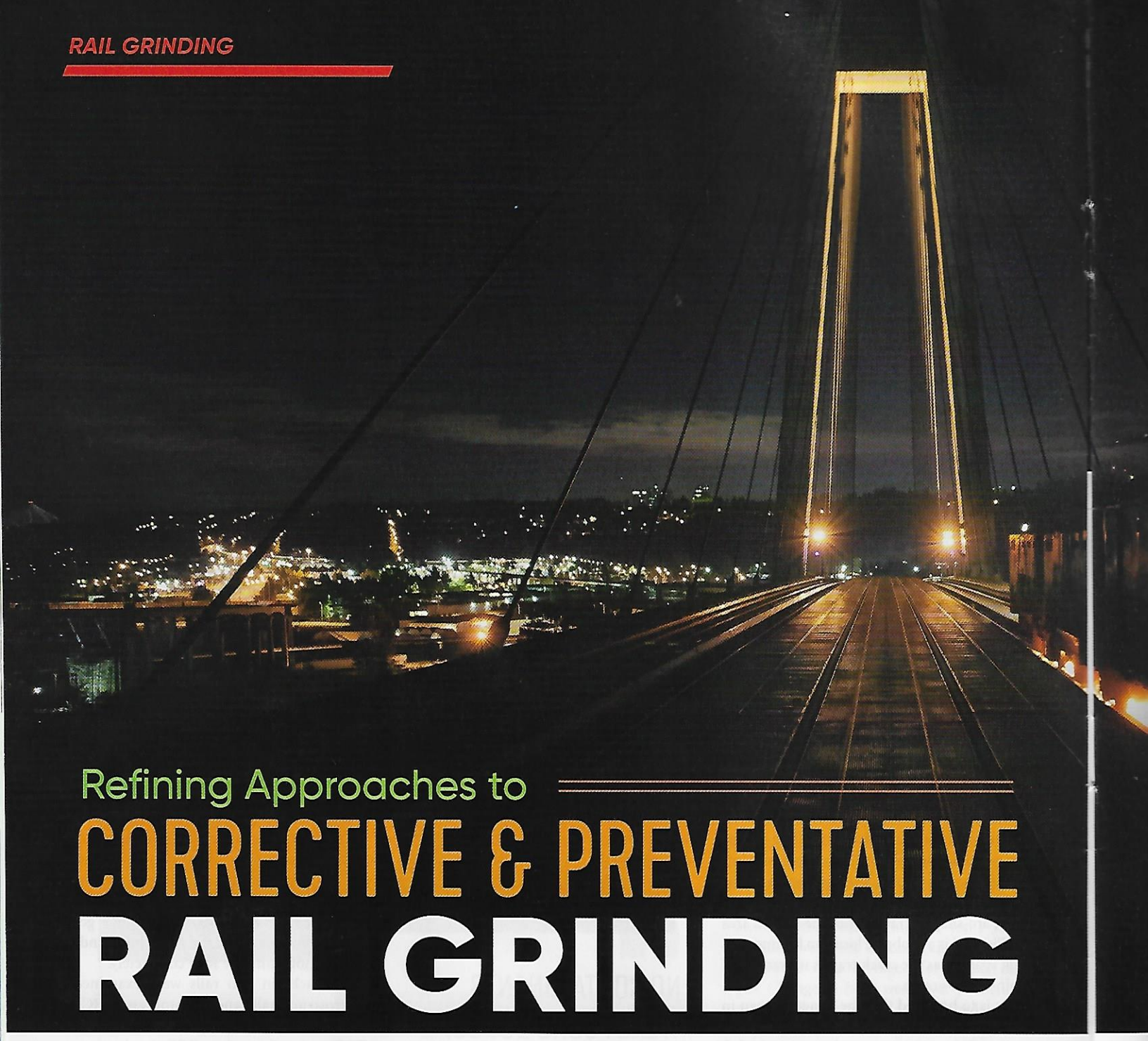


Refining Approaches to

CORRECTIVE & PREVENTATIVE RAIL GRINDING

When it comes to correcting or maintaining the profile and surface condition of rail on North American railroads, there is one primary method: rail grinding. Rail milling, an established method in other parts of the world was recently introduced in a transit application in Canada (see p. 16), but at present, rail grinding is the method of choice.

Freight railroads grind for two primary reasons: to maintain or manage rail shape (a fundamental aspect of wheel/rail interaction) and to minimize surface-initiated fatigue cracks that interfere with ultrasonic testing and can ultimately lead to rail defects. Transit systems grind for the same reasons, but also to control wheel/rail noise induced by rail corrugation. So, the goals of most grinding programs are to correct or maintain the desired rail profile; to remove surface damage, such rolling contact fatigue (RCF) and shells, spalls and corrugation (SSCs), which interfere with the ability of ultrasonic rail flaw detection systems to inspect the rail for internal defects.

While there are shades of gray between them, the two primary approaches have been corrective and preventive grinding. Corrective grinding typically implies the application of multiple passes with heavy metal removal at lower speeds to restore the rail shape and/or surface to acceptable conditions; preventive grinding typically implies the application of fewer passes with less metal removal at higher grinding speeds to catch degrading surface and/or profile conditions on a more frequent basis *before* significant damage is done.

Most grinding programs are tonnage based, with intervals determined by a range of factors, such as the hardness and cleanliness of the rail, the extent of SSCs, the existing versus desired profile, among others. While every railroad puts its own spin on grinding requirements, recommended practices for preventive grinding programs are in the range of:

Photo Credit: Jack Lindquist

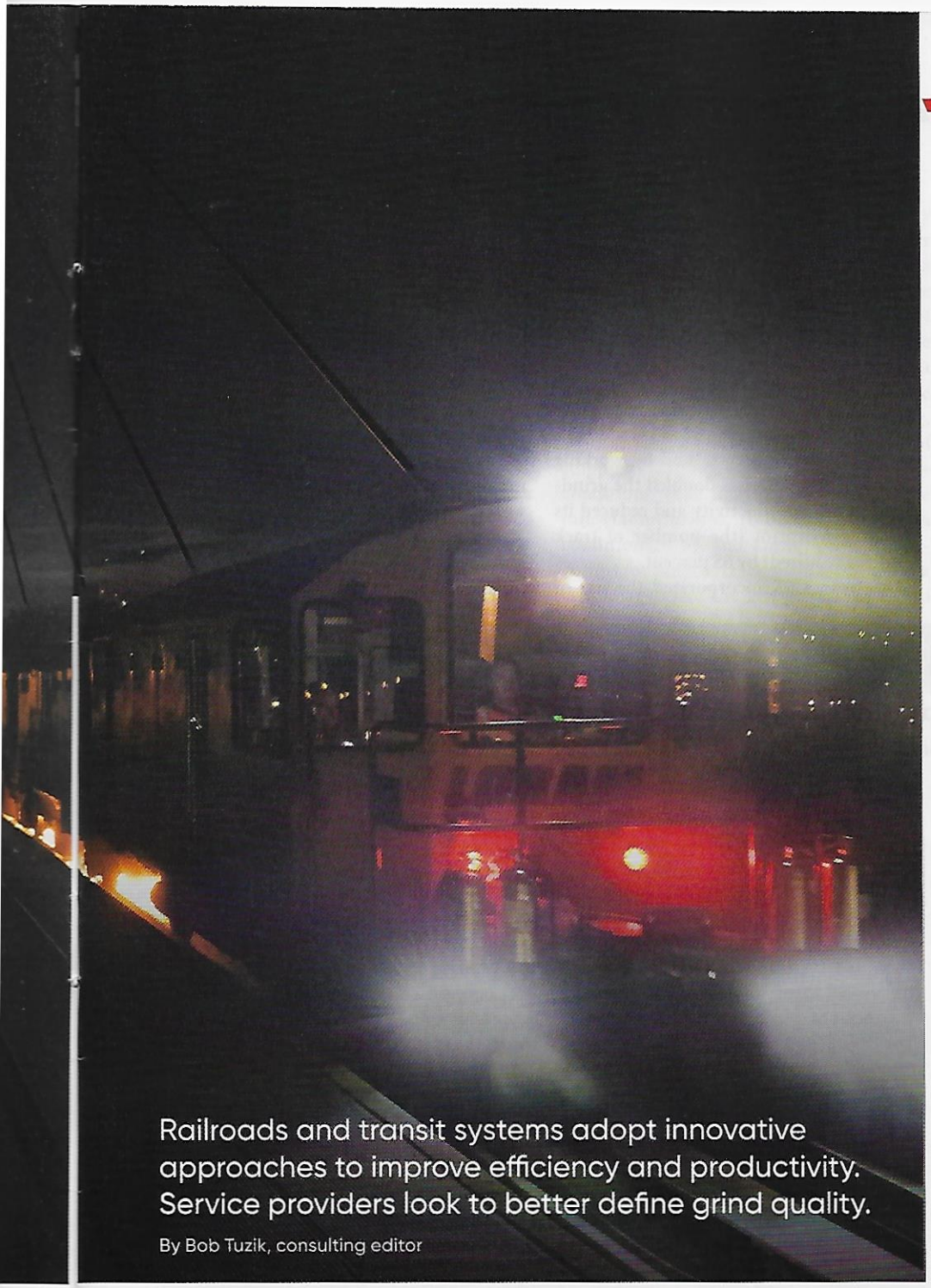


Photo Credit: Jack Lindquist

Railroads and transit systems adopt innovative approaches to improve efficiency and productivity. Service providers look to better define grind quality.

By Bob Tuzik, consulting editor

- 15 – 25 MGT in sharp curves (3 degrees or greater) with rail hardness of 340 to 420 BHN;
- 30 – 50 MGT in mild curves (less than 3 degrees) and 320 to 340 BHN;
- 50 – 60 MGT in tangent track with 320 to 340 BHN, and 100 MGT with 340 to 420 BHN.

While every railroad aspires to be in a preventive grinding mode, it's essential to perform corrective grinding when rail conditions call for it. "By focusing too much on maintaining a preventive grinding mode, you can miss deeper defects," Wolfgang Scheoch, former Director of External Affairs, Speno International SA, told members of the International Collaborative Research Initiative during a panel discussion on rail grinding at the ICRI meeting in Vancouver, BC, in 2017. Preventive grinding, which typically results in very little surface material removal, only works if the rail is in a defect-free state. But defects can be missed, they can be larger than expected, develop faster than expected, and can change position over time, Schoech said.

Brad Kerchof, Director of Research and Tests at Norfolk Southern, reported on an NS study in which a number of grinding passes on an apparently clean rail section uncovered both significant RCF and a nearly 0.21-inch deep spall that was effectively invisible to ultrasonic testing due to interference from RCF at or near the rail surface. "There might be a lot of RCF out there that's invisible until you begin to grind," Kerchof said. And that RCF could be effectively concealing even bigger issues. The take away, he said, is that an effective grinding plan must include RCF removal wherever it impacts rail testing,

The goal of preventive grinding is to treat rail at regular intervals with few passes (ideally one pass) to maintain the target profile and acceptable rail surface conditions with minimal metal removal. Corrective grinding becomes necessary when RCF, SSCs or other surface conditions interfere with the ability of ultrasonic rail flaw detection systems to detect internal defects. Experience and tests have shown that corrective grinding is effective at cleaning and potentially "saving" rail.

In one test, the Transportation Technology Center Inc., analyzed five rails with surface conditions that interfered with UT testing. Optical microscopy showed that the maximum depth of 90 percent of the cracks and spalls measured in the sample rails did not exceed 0.040 inch. "This is well within the range of corrective grinding with a large production grinder," TTCI Engineer Scott Cummings reported in *Testability and Corrective Grinding Depth of Rails with Poor Surface Condition* (Technology Digest 18-027) last year.

Comparison of pre- and post-grind rail profiles shows that a large production grinder can remove as much as 0.014 inch per pass at slow speeds and 0.006 to 0.008 inch per pass at more typical speeds, Cummings said. "Based on these values, three to five grinder passes could have completely eliminated the majority of cracks and spalls in the five test rails and substantially reduced the depth of any remaining surface damage, thus resulting in improved UT confidence."

Other grinding-related research is in the offing in the near future, as well. The TTCI plans to:

- Evaluate rail grinding templates; especially, field-side relief.
- Survey grinding practices and results at switches and crossings.
- Create, evaluate and model rail profile template(s) designed specifically for turnouts.

The fact that these topics are on the TTCI's research docket is a clear indication that Class 1s are looking for ways to improve their grinding programs. CSX is one of the Class 1s that has been honing its grinding

program over the past couple years, taking an innovative approach to how it utilizes grinding equipment.

Reducing the operational footprint

CSX has initiated a joint grinding program in which it operates a 120-stone production unit followed by a 24-stone switch and crossing (S&C) grinder within the same window. The production grinder handles the bulk of the work on standard track, while the S&C machine handles specialty assets and hot spots that may need additional passes, freeing the production machine to continue operating at maximum efficiency. CSX utilizes two joint grinding teams to cover the network.

Prior to the joint grinding program, begun in 2016, CSX used a standalone S&C grinder for six months per year. Since it required its own work window and support staff the standalone S&C grinder was less effective and costlier to operate.

By operating in the wake of a production grinder, which gets high priority because of its cost to operate, the S&C grinder gets the same priority access. And by working them together, CSX has doubled the grinding program's productivity and reduced its operating footprint (the number of track windows required) by 65 percent.

Last year, CSX incorporated the use of Loram's Rail Inspection Vehicle (RIV), which collects rail profile and surface condition data prior to production grinding, to also inspect switches and crossings. By inspecting rail to be addressed by the production *and* S&C grinders, Loram is able to generate grinding plans for the out-of-face *and* specialty grinds with one inspection, rather than the multiple inspections / track occupations required in the past.

Prior to using the RIV, CSX performed manual inspections at specialty assets with a star gauge, then used standard patterns to grind to a standard 8-inch radius—the same shape as new rail. Using information collected by the RIV, CSX is now able

TORONTO ADDS MILLING TO THE RAIL MAINTENANCE MIX

The Toronto Transit Commission looks to European technology to meet its maintenance and service needs.

THERE HAS BEEN talk for years about if and when rail milling technology would be coming to America. Well, the talking is over. A milling machine, the product of a joint venture between two Austrian companies, landed on these shores and began work in December of last year at the Toronto Transit Commission (TTC).

The deployment, the culmination of several years of speculation and planning, is the start of a three-year service contract to address rail shape and surface conditions in the heavy rail TTC subway lines. The joint venture, formed by LINMAG, a global provider of rail milling services and Rhomberg Sersa, which provides rail grinding, ballast undercutting and project management services (in North America), will operate as Rhomberg Sersa North America.

In order to meet requirements to commence milling work in 2018, Rhomberg Sersa leased a SF02W-FS hi-rail milling machine from Austrian manufacturer LINSINGER. The diesel-hydraulic hi-rail unit, which has one cutting head per rail, will be used to complete the first year of the contract. Rhomberg Sersa North America purchased a higher-capacity diesel-electric railbound machine (SF02T-FS) that will be built by LINSINGER and delivered later this year to fulfill the subsequent years of the TTC contract. The SF02T-FS, which will be able to remove as little as 0.1mm and as much as 1.5mm of metal from the top of rail in one pass, will provide extended chip storage capacity that will enable the machine to work continuously for up to 6 hours at a maximum processing speed of 840 meters per hour. The machine will also be equipped with state-of-the-art measurement technology to provide electronic documentation of metal removal, profiles (transversal and longitudinal), and crack conditions on the rail surface.

A Rhomberg Sersa-leased LINSINGER SF02W-FS hi-rail milling machine is being used to complete the first year of the TTC contract.

Milling work in year one of the TTC contract will focus on damage removal and profile restoration on portions of the Line 2 Bloor-Danforth heavy rail subway line. "We are focusing on areas that have not been ground over the past few years—areas where there is surface damage, such as corrugation or RCF, and areas in which we are too far from the target profiles," said Mostafa Nouri, Sr. Engineer, Noise and Vibration – Maintenance Engineering for TTC's subway lines.

The TTC, which has used contract grinding services for the past 10 years, elected to incorporate milling into its rail maintenance programs after observing spark- and smoke-free milling operations in Europe. Like most transit systems, the TTC is sensitive to any whiff of smoke. The TTC sometimes encountered service delays addressing reports of smoke or potential fires from the traveling public on the mornings after grinding. With milling, there's only light grinding with a fine polishing stone following the milling operation; with no sparks, there is no smoke or fire (or related passenger complaints) to deal with. Impressions after the first half dozen shifts in December are favorable. "The machine is quiet, there are no sparks, there's not much dust, and there's not much smoke," Nouri said.

Nor is there much heat. LINSINGER has observed low rail temperatures during milling under test conditions. "Since the rail has such a large volume, the heat is taken directly from the surface, leaving it warm to the touch right after milling," said Richard Stock, Milling Technology Manager at LINSINGER.

The first year of the TTC's milling program essentially replaces what a corrective grinding program would do to remove surface damage and restore the desired profile. The TTC worked with the National Research Council of Canada to reduce the number of target profiles from five used in its grinding

is to develop a custom grinding plan with the precise patterns and number of passes needed for each specialty asset. "By going directly to our NRC-designated custom rail profile, which better matches the typical worn wheel profiles, we're reducing the contact stresses by 50 to 70 percent," said Dan Hampton, CSX manager of contract services. This reduction in contact stress should result in similar rail life extension for these high-cost specialty assets.

The CSX grinding program uses a tonnage-based frequency with a weighted average for different segment lengths. The grinding frequency for individual curves varies, depending on the degree of curvature; tangent segments are typically ground half as frequently, or every other cycle. But rather than just skipping tangents every other cycle, all track segments are inspected every cycle. There are tangent segments with higher demands than the tonnage rule of thumb would indicate that need to be ground every cycle because of operational conditions, such as grade, signals, yard leads, etc., that cause a lot of stopping / starting, accelerating / braking—conditions that increase damage to the rail, Hampton said. To better address such conditions, CSX and Loram created algorithms for tangent track segments that look at tonnage since the last grind, the Grind Quality Index (GQI) of the rail profiles, and any surface conditions. If all three condition thresholds—accumulated tonnage, profile GQI exceeding a specific threshold, and no surface conditions found during the inspection—are met, the planning software has an automated rule to skip it.

The Operations Research team in CSX Technology also developed a scheduling optimizer that assigns priority to high-tonnage, passenger and hazmat routes to ensure that segments are ground as close to the optimum cycle as possible while minimizing non-productive travel. "By using the scheduling optimizer, we cut more than 10 travel days, which represents hundreds

TORONTO ADDS MILLING *cont.*

program to two for the milling program. Unlike grinding machines which can change the orientation of the grinding stones to generate multiple rail profiles, each cutting head on a milling machine produces only one, albeit very precise, profile; multiple profiles require multiple cutting heads. And since changing cutting heads during milling operations takes time out of the TTC's scant 60- to 90-minute nightly work window, the TTC opted to use only two profiles for milling on the system—one biased toward the center and one biased toward the field side of the rail—regardless of the degree of curvature.

The milling work is being done in a one-pass operation. "TTC requires an average metal removal of 0.8mm of metal per pass at the top of rail, allowing about 450m of finished track per hour with the SF02W-FS hi-rail milling machine," Stock said. The cutting head can accommodate the 100- and 115-pound rail sections in the subway.

While it was not one of TTC's requirements, the very smooth surface finish that milling leaves on the rail is a welcome byproduct. Expectations are that surface finish will become more important and will work its way into specifications on rail transit systems.

The TTC's three-year contract includes 60 milling shifts per year. The program is designed to obtain the highest potential production during the initial stages. Beginning next year, TTC expects to direct milling efforts to corrective work. It will also incorporate a traditional grinding program to address localized areas with corrugation, which drives noise- and vibration-related complaints.

Working with milling equipment will be a learning experience, TTC's Mostafa Nouri said. "It took us a decade to really understand rail grinding; we're starting anew with milling."

THE ANATOMY OF A CUTTING HEAD

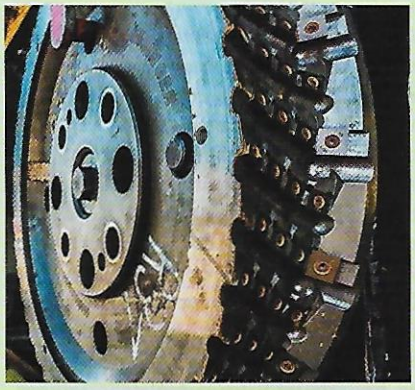
RAIL MILLING IS a spark- and dust-free rotational cutting process. Each cutter head consists of 140 to 220 carbide inserts, depending on the diameter (400mm or 600mm) of the cutting head. Depending on the type of machine, rail milling can remove as little as 0.1mm (0.004 in.) or as much as 5mm (0.2 in.) per pass at speeds up to 1.3 mph.

Heat from the milling process is transferred from the rail to the milling tool and the metal chips, which are collected on board the milling machine for recycling afterwards. The low heat generated by the milling process prevents bluing or the generation of martensite, an unwanted by product of heat-related material transformation at the surface of the rail.

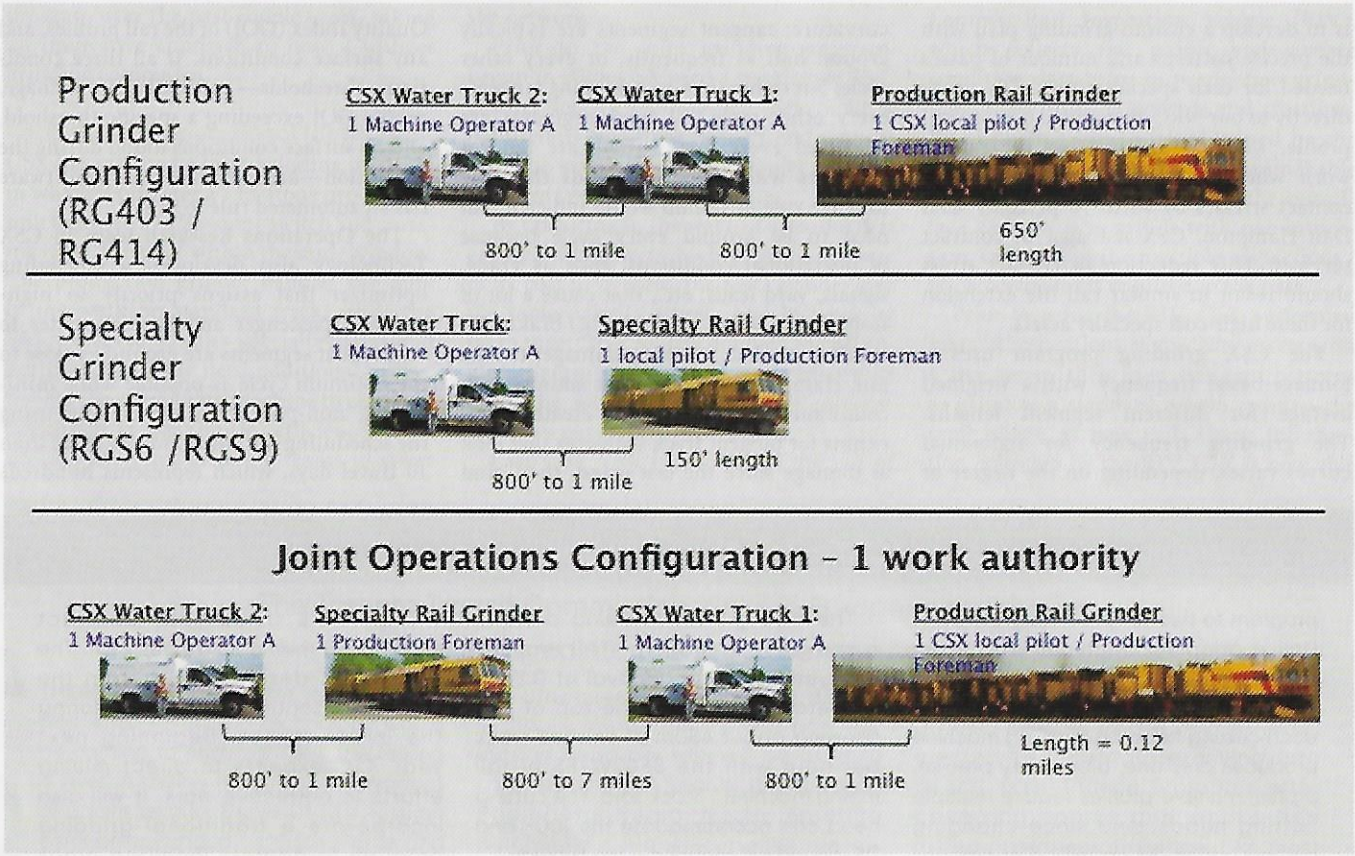
The carbide inserts can be turned up to 7 times before they're recycled. Depending on rail conditions and metal-removal depth, the carbide inserts can stand up to 2 km of cutting rail before they must be turned or exchanged. If cutting inserts are worn or damaged, cutting heads are changed on track to best utilize the available track time.

The shape of the high-precision cutting head determines the resulting shape of the rail profile. Any pre-defined rail profile can be produced by the milling process. Multiple profiles can also be produced by changing cutting heads, which can be done on the fly or within a few minutes, depending on the number of milling units on the milling train.

The milling trains incorporate a polishing unit that includes a completely enclosed circumferential grinding wheel with a small off-set angle in order to produce a finished surface roughness of Ra < 5µm and a smooth longitudinal profile that meets the most stringent noise standards.



LINSINGER rail milling cutter-head showing the carbide inserts.



CSX reduced manpower and equipment requirements by moving from independent operations for a production grinder [configuration (RG403 / RG414)] and a switch & crossing grinder [Specialty Grinder Configuration (RGS6 /RGS9)] to joint operations configuration, effectively shrinking its operational footprint and reducing the number of required work windows.

of thousands of dollars, from the grinding plan," Hampton said.

While grinding to address rail surface conditions—RCF and SSCs—is a bigger driver than profile correction, CSX has found that profile conditions are a good guide to overall rail conditions. "We tend to find poor surface conditions wherever the profile is out," Hampton said. "But we also find poor surface conditions in locations where the profile is fine."

A lot of SSCs occur in the approaches to switches and crossings, an area in which production grinders generally pick up the stones to prevent damage to specialty assets. S&C grinders are used to handle this. CSX determined that a minimum of 10 passes with an S&C grinder (two five-pass series consisting of two passes to gauge, two to field, one at the top) is required to remove enough metal for an inspector to determine if the SSCs were removed. An additional five to 10 passes (one or two five-pass series) may be required to completely remove them; then an additional one to three passes will be required correct the profile.

To better target SSCs, Loram, at the request of CSX, developed the NavPro application, which uploads data to the grinders and displays the length and GPS coordinates of SSCs on digital track charts. "With this information, we're able to roll right up to the spot and grind it out. If it's more than 250 feet, we hit it with the big production grinder, then follow up with the specialty grinder with as many passes as needed to clean it," Hampton said. "It's much more efficient than the previous approach."

SSCs also occur on bridges. And like most railroads, CSX is wary of grinding on bridges—especially timber bridges. As a result, the railroad expanded the NavPro app to include the locations and types of bridges, whether they can be ground, and the requirements for fire protection. When the grinder operator sees a bridge coming up on the digital map, he knows what type of bridge it is and whether to grind it. And the support crew knows the fire-protection plan. "We don't grind anything with a wood substructure, for example, but we treat a concrete ballast deck bridge just like any other right of way," Hampton said. "Using this approach, we went from grinding bridges by exception to now grinding the vast majority of our bridges." Along with the effectiveness of its joint grinding program, CSX has reduced the number of SSC on the property by 60 percent per year for the past three years, Hampton said.

The next piece of the puzzle is dynamic track segmentation, which will allow the grinders to change patterns wherever the rail profile changes, based on pre-inspection reports and analysis. CSX is also looking into ways to correlate GQI values with rail life extension. "Will a GQI score of 80 provide the same rail life extension as a score of 90?" Hampton said. "Better understanding of the relationship between rail profile and rail life extension will allow us to make better decisions, to optimize the program and maximize safety and efficiency."

Rail Transit

"With the instrumentation that's available, it's possible to monitor and manage

CSX Transportation

grinding with greater rigor," said Eric Magel, Principal Engineer at the National Research Council of Canada. Comprehensive measurement of profile shape, rail surface condition, corrugation and wheel/rail-related noise is being done on a few transit systems. Bay Area Rapid Transit (BART) , for example, regularly measures rail profile, surface cracks with eddy current measurement and corrugation with a Corrugation Analyzer Trolley (CAT). With this information to work with BART and its consultants are moving beyond a typical GQI assessment.

"The current approach to GQI is limited because it set limits based only on what the grinder is capable of achieving, not on whether the profiles are actually meeting a performance requirement," Magel said. The idea behind the GQI is to put a reasonable tolerance around the shape you're trying to achieve. As it stands, 100 percent means it's within ±0.25 millimeters of the described shape. But if you're high by 0.2 mm in one spot and low at another, you can generate very different contact conditions. We'd like to tighten the tolerances to indicate you're at 100 percent if you're spot on; short of that, you might be at 80 or 70 percent".

The NRC, in collaboration with the University of Manitoba and Advanced Rail Management Corp., has begun a project to evaluate how to better determine when rail shape associated with the GQI is good enough, and whether there's a reasonable return on investment to improve it from a 70 to an 80, or better. The consortium is looking to migrate away from the standard GQI toward three related indices: a profile quality index, a surface quality index (which could be called an RCF index), and a corrugation index.

Magel and Kevin Oldknow, Associate Dean - Faculty of Applied Sciences at Simon Fraser University, laid out their ideas on "Quality Indices for Managing Rail Through Grinding" at the 11th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems, in September of last year. They proposed three related indices in place of the current GQI:

1. Profile Quality Index (PQI), which replaces the former GQI, to measure and evaluate efforts to move the rail profile toward the shapes prescribed by the rail grinding templates.

2. Surface Damage Index (SDI) to measure a grinding program's effectiveness in:

- immediately or progressively removing rail surface damage and expose clean material beneath;
- minimizing the probability of an RCF-caused broken rail;
- facilitating reliable ultrasonic testing.

3. Rail Corrugation Index (RCI), which measures the program's effectiveness at removing corrugation that contributes to noise, vibration and track deterioration. RCI will apply chiefly to rail transit systems.

Together, the PQI, SDI, and RCI indices can provide the basis for an equivalent grinding index (EGI), which in addition to the three indices would also take tonnage, track geometry, rail metallurgy and friction conditions into account, they said. Initial efforts will focus on transit, since a few of them are already collecting the necessary rail profile, surface and corrugation data to support all three indices. Acoustic data is also proving to be a useful variable in identifying the presence of corrugation and the effectiveness of grinding programs to remove it.

> BY FOCUSING TOO MUCH ON MAINTAINING A PREVENTIVE GRINDING MODE, YOU CAN MISS DEEPER DEFECTS
>
> -WOLFGANG SCHEOCH, SPENO INTERNATIONAL SA

The Bay Area Rapid Transit (BART) system is a pioneer in using acoustic data to guide its corrective grinding program. BART combines acoustic data, which is collected by microphones on the trailing ends of revenue trains, with data from a Corrugation Analyzer Trolley to pinpoint locations that need to be ground. BART uses CoreTracker, a proprietary software used by ATS Consulting, BART's acoustics consultant, to look at noise data in a graphical form, and to generates reports that identify priorities based on the decibel level.

"We tend to see roaring corrugation at frequencies between 400 and 600 Hertz," said Greg Shivy, BART's principal track engineer – maintenance and engineering. Noise levels, along with complaints from passengers and nearby residents, increase in tunnels and aerial structures, and at speeds above 50 mph.

Like most transit systems, BART gets precious little time for maintenance – about 90 minutes during the week and up to 4 hours on weekends. Near term, much of the grinding effort is spent chasing corrugation. But it has been effective. "We saw a 73 percent reduction in customer noise complaints, last year," Shivy said.

But addressing hot spots is only one driver of the grinding plan. BART only recently completed a migration of its fleet from a cylindrical wheel shape to a conical BT3 wheel profile. New "interim" rail profiles have been designed and applied to correspond with the changing wheel shapes. Using a pair of 12-stone in-house transit grinders, BART plans to grind nearly 4,000 pass miles across the 125-route-mile system to achieve the desired rail profile over a four-year period.

About 1,000 pass miles were completed last year. And by the end of this year, BART will have completed the interim rail profile across the system. It will then go back and install the final profile.

With all the wheels converted to the new cylindrical profile as of January of this year, BART start with a clean slate. "We're going to look closely at corrugation growth rates to see how they correlate to curve radius, speed and track types," Shivy said. "It will be interesting to see how corrugation growth rates change with the new wheel and rail profiles over time."

And with the corrugation issues on the run, BART will be able to get its grinders over the system more quickly with less metal removal to address RCF and other surface conditions. A more efficient grinding program coupled with comprehensive pre- and post-grind measurement of surface conditions will go a long way toward improving conditions at BART and educating the industry, overall.

"The ability to measure rail profile, wear, surface cracks, and corrugation is enabling us to take a more scientific approach to rail grinding," said Gordon Bachinsky, president of Advanced Rail Management Corp., which manages BART's rail measurement and grinding programs. Monitoring noise levels, as is done at BART, will not only identify problem areas, but verify that they've been addressed, he said. "These improvements, along with more rigorous requirements for surface finish, will push grinding, and possibly milling, into an exciting new era."

CSX Transportation

EQUIPMENT PROVIDERS BUILD ON CORE COMPETENCIES

RAIL GRINDING remains the tried-and-true approach to rail maintenance. Freight, passenger and urban transit systems around the world employ high-speed, corrective and specialty grinding to control rail shape and remove the inevitable damage that traffic and tonnage inflict on the rail surface. Until recently, grinding was the only option in North America. But as of this year, there's a new kid in town. One service provider has begun rail milling operations in Toronto; another provider plans to add rail milling to its North American portfolio later this year. Here's a look at what the major players in the market are up to.

Harsco Rail's line of rail grinders serves all segments of the North American and global markets. Improvement to the rail grinding product lines is an ongoing process at Harsco, where grinding machines utilize a common control system that allows for different configurations, depending on the customer's needs. Ongoing development of its Jupiter control system allows the company to respond to custom specifications and global requirements.

Harsco's C model grinders have been improved to the point that the life of high wear parts, such as grinding motors, exceed 5 years; head actuator life exceeds 10 years. A new, higher horsepower grinding motor, which has increased metal removal rates at higher grinding speeds on its larger grinders, has a 3 to 5 times longer life than the previous grinding motors.

Harsco - 96 stone production rail grinder.

Linsinger's MG11 transit milling machine demonstrated its capabilities in New York.

Since obtaining track time is always a challenge, Harsco takes the following into account when designing equipment: grinding machines must consistently perform at a high level. They must be dependable, easy to operate; operators must be able to quickly identify and repair problems.

Factors driving equipment development vary, depending on the part of the world in which they operate. In heavy-haul operations, increased grinding speeds is a primary requirement. In Europe and Southeast Asia, equipment configuration and surface finish are more important. The flexibility of Harsco's Jupiter control system allows the company to achieve high metal-removal rates and high speed when needed and provides the ability to achieve EN-standard surface finishes when required.

Stone life is also a consideration. Longer-lasting stones typically remove less metal, impact surface finish, and increase overall cost. Years ago, development of grinding stones was a necessity. While Harsco continues to test and improve grinding stones, the advanced control system on the latest grinders can better control stone positioning and behavior to obtain a high metal removal rate from one type of grinding stone, then use the same stone to meet a stringent surface finish requirement. "We can also introduce slightly different head lateral shifts independently, which helps control acoustic noise on light rail metros or transit systems," the company said.

Performance and efficiency are essential, but safety is the most important factor to consider, the company said. Over the years Harsco has improved spark-containment, fire-detection, fire-extinguishing, dust-collection, and operator-safety systems, along with systems that are easier to operate and troubleshoot, overall. "We have designed to some of the most demanding EN and SEA standards," the company said. Most of the grinding equipment use sealed cabins that control dust and hold noise to 68 dBa.

LINSINGER offers a selection of rail milling machines that accommodate tight clearances on transit systems and high-capacity requirements on heavy-haul mainlines. In addition to treating mainline rail, LINSINGER milling machines can also treat switches and crossings (if equipped with the switch kit); no dedicated switch treatment machine is required. Turnouts can be milled in approximately 45-60 minutes with a one-pass operation.

As a dust- and spark-free process, milling can be used in tunnels, stations, on timber bridges and other areas with fire restrictions, without special precautions; fire crews and fire suppression measures such as water tank cars are not required. While rail milling operates at a slower speed than rail grinding, the length of finished and completely regenerated track per shift can be significantly higher due to the variable metal-removal capabilities of the process. LINSINGER machines are also equipped with state-of-the-art measurement technology to determine transversal profile, achieved metal removal rates, longitudinal profile and surface crack condition.

In August 2018, LINSINGER demonstrated the MG11 transit milling machine to several U.S. Transit systems at a yard in New York. The MG11 is specifically designed for flexible deployment (delivered in a 40-foot container), small clearance envelopes, and short operational shutdowns.

LINSINGER also offers several types / sizes of machines for heavy-haul applications. Typically, such machines have higher metal-removal capabilities and higher process speeds as compared to transit milling machines. Machines like the MG31, which is the most efficient milling train currently available, can be equipped with multiple cutter heads per rail. All LINSINGER rail milling machines are self-propelled and meet the North American environmental standards.

EQUIPMENT PROVIDERS *cont.*

Rhomberg Sersa and LINMAG have been operating transit and mainline milling machines in Europe and the Asia Pacific region over the past 10 years, performing cyclic-preventive work for profile restoration and corrective work on mainline track and switches to remove surface damage, such as RCF, corrugation, wheel burns, and dipped welds. Services also include milling of newly installed rails and switches to remove mill scale, correct profile tolerances, and remove surface damage caused by track construction activities.

In December 2018, Rhomberg Sersa Canada Ltd., a consortium between Rhomberg Sersa and LINMAG, delivered a hi-rail LINSINGER milling machine (SF02W-FS Truck) to begin work on a three-year contract with the Toronto Transit Commission (see *Toronto adds Milling to the Rail Maintenance Mix p. 16*). LINSINGER is currently building a high-capacity railbound milling machine (SF02T-FS) for the consortium, which incorporates diesel-electric driven milling units that can remove 0.1mm to 1.5mm of metal at the top of rail in one pass, and chip storage capacity that allows up to 6 hours of operation at speeds of up to 840 meters per hour.

The SF02T-FS, which will fit within most North American transit and Class 1 tunnel clearance envelopes, is scheduled to arrive in North America by the end of 2019. Rhomberg Sersa expects the SF02T-FS to be available for contract work in North America in April 2020. It will focus on transit and passenger systems but will also be available for demonstrations and spot milling activities, such as switches, crossings, bridges, heavily damaged curves, etc., on freight railroads.

Rail grinding is one of **Loram Maintenance of Way**, Inc.'s core competencies. Loram's expertise and wide range of products, which include the 400-series production grinders and specialty rail grinders, serve all segments of the U.S. and global market.

As the leading rail grinding services company in North America, Loram has directed development of its grinding fleet to meet the industry's need for speed, performance, and reliability. Whether performing a preventive or corrective grinding program, proper inspection, scheduling, machine selection, grind stone selection and performance monitoring, are keys to maximizing a railroad's return on investment.

While all customer requirements are demanding, transit customers require a unique configuration of grinding stones to achieve the desired post-grind finish. "Longer lasting stones and superior metal removal continue to be at the forefront of development," said Brandon Riddering, Loram's director of marketing. "Breakthroughs in technology allow Loram to achieve superior grind quality despite the challenge of decreasing dedicated track time." And while all market segments can realize economic savings by harvesting data at a more granular level, adjustments made according to specific needs in any area of track on transit systems and metro lines, in particular, can result in the most efficient rail grinding program.

Orgo-Thermit, Inc. has been performing rail grinding services with its VM8000 on/off track rail grinding vehicle on shortlines, passenger railroads and rail transit systems over the past seven years.

The VM8000 is used to remove rust and mill scale on new track construction. On the maintenance side, it is used to restore the desired profile and remove corrugation, head checks, squats, and wheel burns. The company's grinding programs help extend the life cycle of the rail and reduce noise, leaving a 3- to 5-micron surface finish upon completion. With four-wheel steering, the VM8000 can be set on or off track within minutes at crossings closest to the work locations, reducing travel time and increasing the time available for grinding.

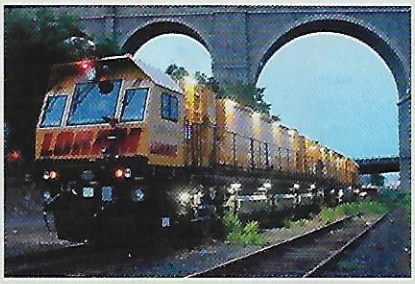
To accommodate increased business, Orgo-Thermit introduced a second VM8000 grinding vehicle. The new machine is equipped with a pre- and post-grind measurement system..

Orgo-Thermit, Inc. also introduced the RailShape Eco, a mobile grinding unit for use in difficult areas, such as switches, and for re-profiling and deburring rails, and removing defects on the running edge of the rail that can lead to narrow gauge.

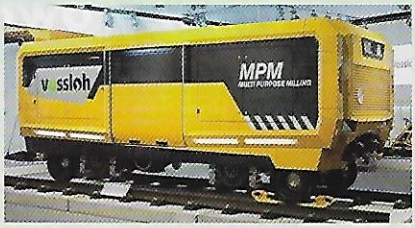
RailWorks, with its equipment provider Harsco, utilizes a 20-stone switch & crossing grinder to perform mainline and S&C rail grinding services to Class Is, shortlines, and transit agencies. "Our combined offering provides up-to-date information to help keep the railroads operating safely and effectively," the company said.

RailWorks, which averages 230 days of grinding per machine per year, is expanding its grinding services to include inspection, analysis, grind planning, and evaluation to create a comprehensive turnkey grinding solution, this year.

The transit market represents a potential growth area. Increased ridership is generating higher traffic frequencies, which increase rail wear and surface damage. This is driving the need to address rail conditions on a more frequent and consistent basis. RailWorks reports that it was recently awarded a multi-year contract for corrective grinding and maintenance services at a major transit system. The contract provides an opportunity



Loram's RGS15 high-production rail grinder.



Vossloh's truckable milling machine will be available in North America in 2019.

EQUIPMENT PROVIDERS *cont.*

to further data collection and grind planning, the company said.

Freight railroads continue to increase the number of grinding cycles to address rail wear and fatigue damage caused by heavy axle loads. Balancing MOW outages to allow for repairs and maintenance against the need to run revenue trains remains the single biggest opportunity to improve upon. "We're ensuring that our equipment is running at optimal levels and our crews are available for every track time opportunity," the company said.

Vossloh's maintenance products and services cover multiple railway markets. From a worldwide perspective, the current focus is on main corridors (often with mixed traffic), high-speed lines and urban transit systems, which correspond to Class 1 and rail transit systems in the U.S.

Examples of optimized technologies are Vossloh's High Speed Grinding (HSG) trains, which by removing a thin layer of material at operating speeds up to 80 km/h (50 mph) is well suited to preventive grinding. Vossloh's milling trains, on the other hand, normally operate at a walking pace with a continuous metal removal rate of up to 3mm (0.12 in).

"As a global rail maintenance supplier, we have observed over the years that different markets have developed in different ways with different needs," said Brett Urquhart, vice president – sales & marketing for Vossloh, North America.

At Vossloh, equipment development is driven by the need for speed and performance without jeopardizing quality. "Introducing too much energy into the rail steel or leaving a rough surface finish can set up a breeding ground for new rail flaws," Urquhart said. That's why Vossloh advocates the use of different technologies for different conditions, rather than trying to extend the use of one type of equipment to address conditions it was not designed for.

Vossloh used its HSG train to perform a non-stop preventive grinding program through the Swiss Federal Railway's approximately 37-mile Gotthard tunnel (the world's longest railway tunnel) without disturbing traffic. In China, it used an HSG train to grind approximately 249 miles of a high-speed line in one shift.

Vossloh, which recently acquired STRABAG Rail GmbH's rail milling business, introduced the Multi-purpose

EQUIPMENT PROVIDERS *cont.*

Milling Machine (MMM), a compact multifunction milling machine at Innotrans in 2018. The MMM, which is able to address track and turnouts in freight or transit applications, is slated to be available in Europe and in North America in the second half of the year.

Designed to remove damage to rail and turnout hotspots on commuter and transit systems and in confined spaces, the MMM removes as much as 2 mm of material per machining run and can operate on either ballasted or slab tracks and on standard or grooved rails. With its adjustable wheel gauge, it can be used on all common track gauges. Its compact size and light weight make it easy to transport.

The MMM employs up-cut milling, in which the milling wheel rotates counter to the direction of travel. This transmits more milling power into the rail. Milling quality is enhanced by the use of rubber tires on the drive wheels. MMM doesn't use water, produce sparks or generate grinding dust. The milling chips are extracted during the process and stored in a chip bunker for disposal.

The covered operator's console at the back of the vehicle is equipped with two 15-inch touch screens, a control panel and two camera monitors. The operator can also control the MMM remotely by means of a wireless panel, which provides access to all of the machine's important functions and provides a good view of the track at the same time.

Though currently not scheduled for work in North America, Vossloh's equipment portfolio also includes the High Performance Milling (HPM) machine, which can generate up to 3mm (0.12 in) of continuous metal removal at speeds up to 3km/h (1.86 mph).

An increasing number of customers in various markets have realized the advantages of deploying a variety of rail machining technologies side by side, such as conventional grinding, milling and high-speed grinding, rather than sticking to one type of technology. For example, railways may use high-speed grinding for preventive measures, conventional grinding trains to reprofile the rail, and milling to address RCF.

Rail grinding and milling operations have been shown to extend the asset life of rail to its maximum value. "As a result, our customers today compare the cost/value of rail grinding or milling with the cost of rail replacement," Urquhart said. "This was not the case 10 years ago."