



GUIDELINES FOR WORKING OF RAIL GRINDING MACHINE (FOR INDIAN RAILWAYS)



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FOREWORD

Rail Grinding is an important technological solution to reduce the damage to rails and wheels by re-profiling the railhead so as to make rail wheel interaction favourable. The technology has given rich dividends on several railway systems in terms of increase in the life of rails and wheels, reduction in rail/weld failures, enhancing reliability and safety, reduction in fuel consumption etc. The technique has been adopted as a regular maintenance practice on several rail networks.

On Indian Railways, two high productivity rail grinding machines have been commissioned recently. Maximising benefits of rail grinding, proper understanding of target profiles and monitoring of rail grinding programme are essential

Prof. P. K. Garg picked up the subject while working in Track Machine Directorate of RDSO. He attended the training courses organized by National Research Council, Canada in India and USA. The present document is based upon the literature survey, undergoing training programme and visits to rail grinding sites. The document covers salient features of the rail grinding machine and the various aspects necessary for monitoring and decision making. Needless to emphasise that the real understanding of the issues will require the involvement of the field engineers to grasp the new technology.

I convey my sincere thanks to Mr. Peter Sroba of National Research Council, Canada to have helped IR personnel concerned with Rail Grinding programme and Prof. P.K. Garg to have prepared this document for the help of field organizations.

The document will need revisions based on experience of working on Indian Railways system. I hope that it will be found greatly useful by Permanent Way Engineers involved in Rail Grinding Programme in particular and others in general

Pune
March 2012

C. P. Tayal
Director, IRICEN

ACKNOWLEDGEMENT

Rail Grinding has proved itself as an important technology for increasing the life of rails and wheels by way of reduction of damage due to rail wheel interaction. Rail wheel interaction is made favourable by re-profiling the railhead taking into consideration the profile of the wheel so as to increase the rail wheel contact area and removal of fatigued metal layer from rail top. The technology has helped to enhance the reliability and safety performance of rails & wheels in particular and other track components in general, reduction in fuel consumption, enhancement of reliability of defects during ultrasonic testing of rails etc. The increase in the life of the rails has generally been found to be 60-100%.

Indian Railways has taken the first step for rail grinding by commissioning two high productivity rail grinding machines manufactured by M/S Loram Way of Maintenance, USA. The technology requires proper understanding of the subject and systematic monitoring for implementation of the rail grinding programme. The document covers the issues related to the implementation of rail grinding programme for the guidance of field engineers along with the salient features of the rail grinding machine.

I picked up some of the basics of this technology while working in Track Machines & Monitoring Directorate of RDSO. I was also one of few officers who attended the training courses organized by National Research Council, Canada in India and USA. The present document is based upon the literature study, the training imparted to me and my subsequent visits to rail grinding sites.

It is important to note that the document provides only the basic guidelines and the monitoring techniques necessary for rail grinding but the success of the grinding programme calls for the involvement of the field engineers for accuracy of the grinding by way of selection of the correct pattern, analyzing the changes in the condition of rail along with the changes in the rail-wheel interaction etc. The reviewing and modifying the grinding strategy is very important in initial few cycles of grinding. The key to success is learning by experience. The day-to-day monitoring is to be done by the field supervisors but the broad monitoring and the guidance to the field engineers is to be given by the divisional and headquarter officers for the success of the technology. The document will need revision after gaining the experience of working on Indian Railways system. The theory of rail grinding and its benefits have not been covered in this booklet and I intend to publish another document for the same.

I wish to convey my sincere thanks to the engineers from National Research Council, Canada especially Mr. Peter Sroba, one of the stalwarts in this field. I also convey my sincere thanks to Shri C. P Tayal Director/IRICEN for his encouragement and guidance. I am also thankful to Shri Ganesh Srinivasan, PS for his help in prompt typing work.

I hope that the document will be useful to Permanent Way Engineers for implementation, monitoring and decision making for the success of Rail Grinding Programme on Indian Railways.

Pune
March 2012

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RAIL GRINDING

1.0 General

Rail Grinding is an important maintenance tool, which helps in reducing the damage to the rail, wheel and other track components, thereby increasing their life and safety in operations. Indian Railways has purchased two Rail Grinding Machines from M/s Loram Maintenance of Way, USA. The contract includes operation and maintenance of the machines for two years after supply and commissioning. The operation and maintenance of the machines is being carried out by M/s Vandana International Pvt. Ltd. (VIPL), the Indian agent of M/s Loram. As a part of this contract, training and technical support is being provided by National Research Council (NRC), Canada. The approximate cost of each machine is ₹55 crores and the cost of operation and maintenance for 2 years is about ₹20 crores. Indian Railways has already commissioned these Rail Grinding Machines, one on South Central Railway and the other on North Central Railway in Feb'2011 and July'2011 respectively. Machine on South Central Railway will cover the southern part of the network while North Central Railway machine will cover the northern part of the rail network. The route for grinding has been planned in such a way that the machine should come back for the second cycle for grinding as per the pre-decided grinding interval. Locations with severe corrosion such as Vijaywada division of SCR have not been planned for grinding as the grinding will not help for improvement in corrosive conditions.

2.0 Working of Rail Grinding Machine

- 2.1 Rail Grinding Machines procured by Indian Railways are high productivity grinders consisting of 72 stones, i.e. 36 stones for the left side and 36 stones for the right side rail.
- 2.2 Each stone is rotated by an independent electric motor of 30 HP. The speed of rotation is 3600 RPM.
- 2.3 Each motor can be tilted at a desired angle in isolation from +70° (towards gauge face side) to -30° (towards field side).
- 2.4 The machine is capable of grinding through 10° curves (after removal of check rails) and up to 3% gradients.
- 2.5 The machine will work in **traffic block**, but no power block is required during the grinding operation.
- 2.6 Grinding can be done in either direction without the need for reversing the machine.
- 2.7 The machine **can grind plain as well as curved track (without check rails)**, track in tunnels, track on bridges (guard rails on bridges are not an obstruction), glued joints, fish-plated joints. However, level crossings, points & crossings, SEJs and axle counters create **obstructions** and are to be skipped by raising the grinding stones while grinding. It has also been observed that joggled fish plates provided on high rail of sharp curves also create an obstruction and should be removed before grinding as far as possible.
- 2.8 The machine is capable of grinding at a speed ranging from 2.4 km/h to 24 km/h. However the **speed is kept between 8 and 20 km/h during grinding**. The

traveling speed of the machine without grinding is 80 km/h by design. However, RDSO has issued provisional speed certificate for this machine at 50 km/h at present.

- 2.9** The **grinding stones** are having 250 mm outer dia and 150 mm inner dia with 75 mm thickness. There is fiberglass wrapping around the stone so as to contain the debris within the wrapping area in case of breakage of stone. The new grinding stone and the worn out grinding stone is shown in Fig. 1. The grinding stones consist of Abrasive Grain Particles for cutting the rail and bonding material for holding the abrasive particles. The technology is very complex and patented and we need to purchase the stone from the manufacturer in the present scenario. The **life of the stone** is found to be 8-10 hours of grinding.



Fig. 1: New Grinding Stone

Worn Out Grinding Stone

- 2.10** The machine can remove 0.2mm of metal on an average while grinding at 10 kmph.
- 2.11** As per the experience gained so far, the average **diesel consumption** is found to be 85 litres per km and average **water consumption** is 1100 litres per km.
- 2.12** There is no need of any **speed restriction** on the track after grinding or on the adjacent track during grinding. However, as a precaution, trains carrying inflammable materials like Naphtha etc. should not be run on the adjacent track during grinding operation.
- 2.13** During the grinding operation, it is ensured that metal deformation does not take place and the **temperature** should not rise beyond 350°C so that there are no metallurgical changes in the rail.
- 2.14** **Water** is not required for grinding operation but water is sprinkled on to the sleepers and on cess with the help of tie sprays and ditch sprays respectively to make the area wet to avoid cases of fire due to sparks generated while grinding.
- 2.15** The grinding strategy adopted on Indian Railways is '**Preventive Gradual**', wherein we will move to the 'Preventive' grinding regime gradually. In corrective grinding, we remove the defects in one go, by giving more number of passes at slow speed while the metal removal in preventive grinding is very less but more frequently. The metal removal in preventive gradual strategy will be more as compared to preventive grinding but less as compared to corrective grinding.
- 2.16** It has been decided to give a **single pass at 15 kmph for the straight track** and **three passes at 18 kmph for curve track**. In fact, the speeds for the second and

the third pass will be given by GDMS software as explained in clause 4.5 of this document.

3.0 Salient Features of Rail Grinding Machine

- 3.1** The Rail Grinding Machine is not a single vehicle but it consists of a formation of 6 vehicles, namely, one control car, 3 grinding cars, one water wagon and one camp coach as shown in Fig. 2. It means that during every grinding operation this formation of 6 vehicles will go in the block as a unit.

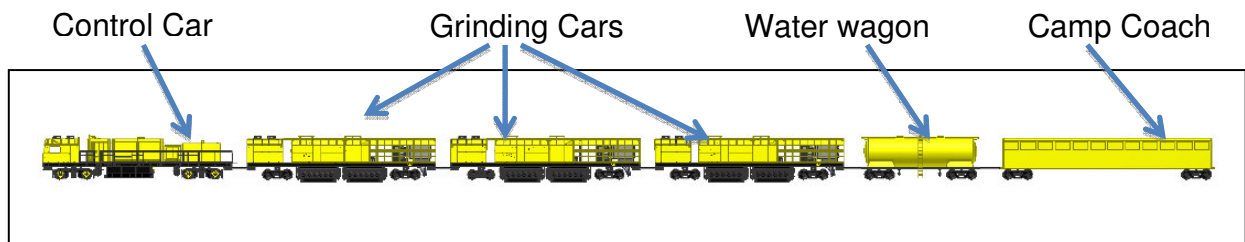


Fig. 2: Rail Grinding Machine

- 3.2** Front Control Car or FCC is provided with driving controls as well as all the grinding controls as shown in Fig. 3. The camp coach is also having driving controls known as Rear Control Car or RCC.



Fig. 3: Front Control Car

- 3.3** Each grinding car consists of two grind carriages and each carriage is having 12 grinding motors –6 on each side as shown in Fig. 4 & Fig. 5 respectively.



Grind Carriages

Fig. 4: Grind Car



Fig. 5: Grinding Motors on a Buggy

- 3.4** The grind carriages known as buggies are provided with separate wheels (Fig. 6) and the buggies are kept in raised and locked position during idle running of the machine.

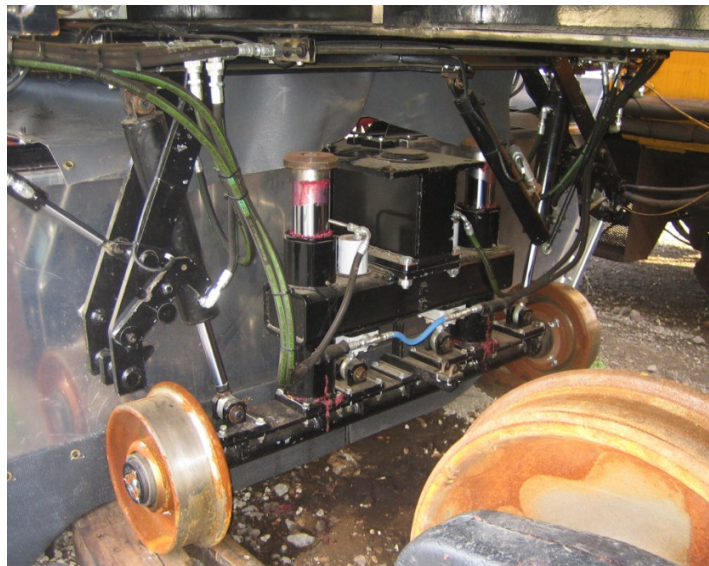


Fig. 6: A Buggy or Grinding Carriage

- 3.5** The grinding motors can be in up or down position when the buggies are down and running on the track. The grinding motors are raised only in case of obstruction while the buggies keep running on track.
- 3.6** The buggies should be lowered on straight track only to ensure that the buggy wheels sit properly on rails. In case of curve, due to different wheelbase of the buggy as compared to the wagon, the wheels will go off the rail on lowering. For the same reason, the raising of the buggies is also done on straight track only.
- 3.7** There is a water tank attached to Rail Grinding Machine to ensure sufficient availability of water to take care of fire hazards. About 75,000 litres of water is available on Rail Grinding Machine, when full. Wooden sleepers in track, dry

grass in track/ on cess is susceptible to catch fire due to heavy sparks generated during grinding operation. Water is sprinkled through 'Tie Sprays' and 'Ditch Sprays' before the grinding operation to prevent fire. These are provided on Grind car no. 1 & 3 as shown in Fig. 7.

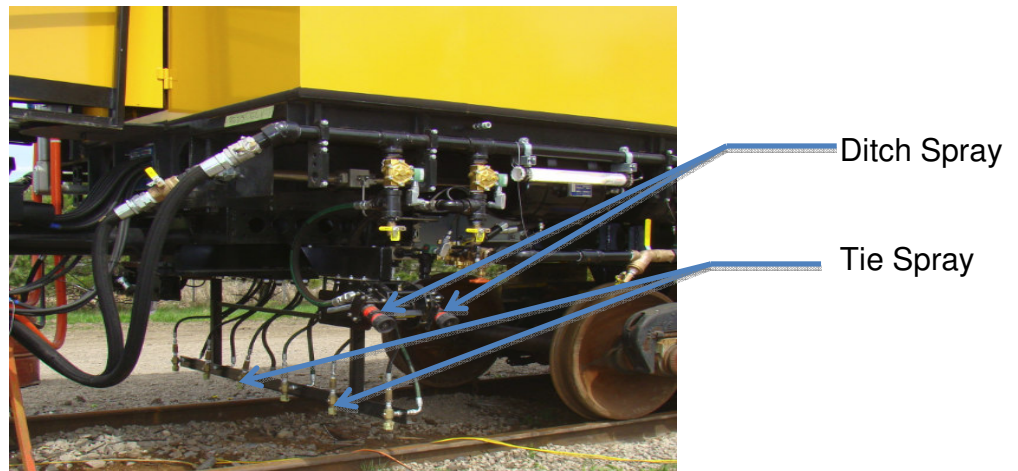


Fig. 7: Tie Spray & Ditch Spray

- 3.8** The machine is equipped with 30 HP pump, water cannons, fire hoses, fire extinguishers and fire detection system to take care of fire hazards.



Fig. 8: Water Pump & Water Tank

- 3.9** The fuel consumption on Rail Grinding Machine is quite high and to cater to this demand, the capacity of the fuel tank on the machine is about 21000litres. Railway Board has issued a letter for supply of diesel to Rail Grinding Machine through Railway Consumption Depots (RCDs). RCDs are located at a distance of 250 to 400 km and timely filling of fuel from RCDs is to be planned. In addition to this, an imprest of Rs.5 lakhs is to be created to supply diesel in emergency and for purchase of urgent spares to avoid idling of the machine.
- 3.10** Rail Grinding Machine is equipped with a Rail Corrugation Analyzer (RCA) from Stuart Grassie mounted on front axle of rear drive truck (Fig. 9). This measures the rail corrugation while running of the machine and gives an idea of the level of corrugations present in the track for facilitating decision for depth of cut.

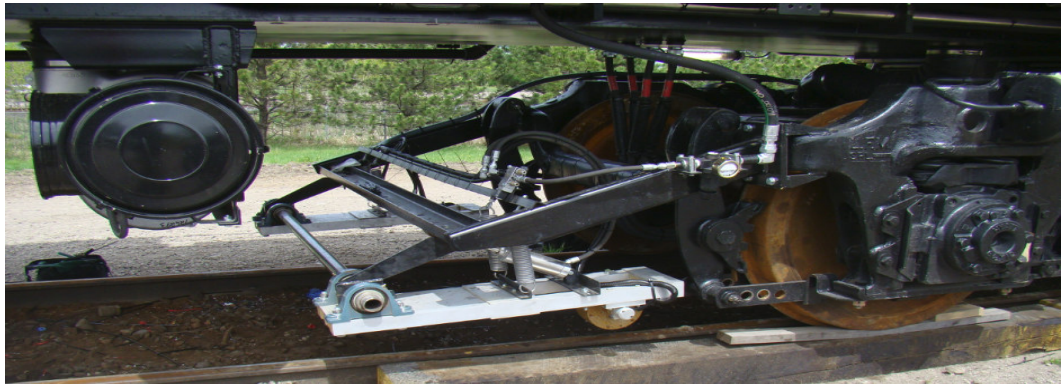


Fig. 9: Rail Corrugation Analyser(RCA)

- 3.11** The machine is also provided with an obstacle detection system, which gives a warning to the operator in case of any obstruction found in the track. The operator can take appropriate action on getting a signal.



Fig. 10: Obstruction Detection Device

- 3.12** A 'Dust collection system' is provided in the machine (Fig. 11) to suck the iron particles generated during grinding to take them to a chamber so that the iron filings will not cause any damage to human beings (specially eyes) and to protect the environment. The dust collection chambers can be emptied as per convenience. The present practice is to empty them in a bag and put the iron filings in a ditch near to track safely. Sometimes, grind dust also gets accumulated on to the machine and forms a lump, which drops down on the track under its own weight as shown in Fig. 12.

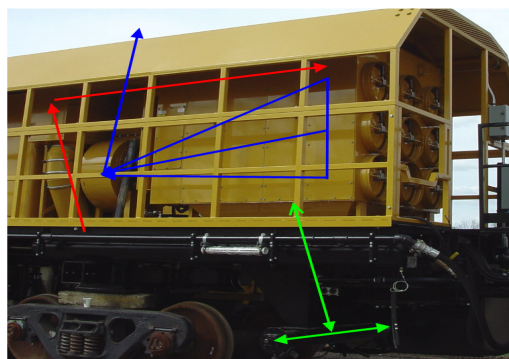


Fig. 11: Dust Collection System



Fig. 12: Accumulated Rail Dust Lump

- 3.13** The machine is having a well-furnished air-conditioned camp coach for accommodating 14 people. The coach is provided with a kitchen, dining area, bathrooms, etc. The coach is also having driving controls for the machine on one end. Hence, this also called Rear Control Car or RCC.
- 3.14** Cameras are mounted on RCC overlooking the track in the rear and this image is displayed on a monitor in FCC (Fig. 13). This will help in sequencing the motors up and down as well as looking for any obstructions on the rear side of the train while carrying out grinding in reverse direction.



Fig. 13: Travel Cameras & Sequencing Monitor

- 3.15** The machine is provided with safety devices to bring all machine operations to a halt by pressing one emergency stop button. "Hot Rail" switches are provided on each console and on each ladder in the train. On pressing this switch, a loud hooter is blown and flashes blue strobes to warn the personnel on the machine of a passing train on the adjacent track.

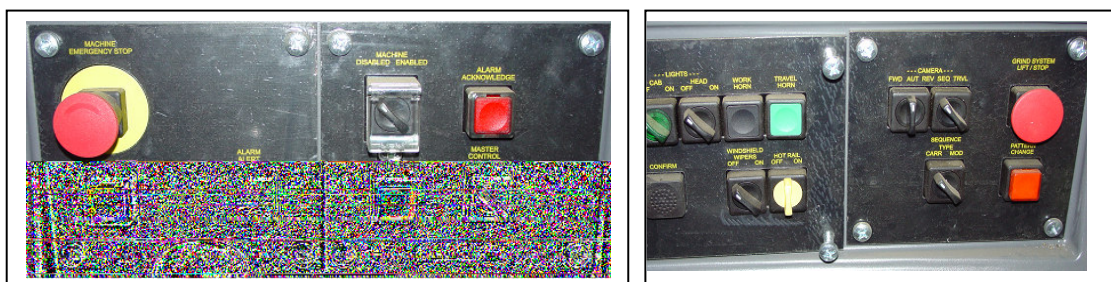


Fig. 14: Emergency Stop & Other Safety Buttons

- 3.16** For all grinding operations, the machine is having 2 touch screen consoles (Fig. 15) known as HMI (Human Machine Interface) consoles. These consoles are used for various settings, selection of patterns, viewing machine working, etc.



Fig. 15: HMI Monitors

- 3.17** The machine is having two laser based rail profile measurement systems (known as KLD) to measure the railhead profile before and after the grinding (Fig. 16). The after ground profile is compared with the target rail profile by the machine software and an index known as GQI (Grind Quality Index) is displayed during the run. GQI gives an indication as to how close or away we are from the target rail profile. GQI value of 100 means that we have achieved the target profile within the specified tolerances. A lower value indicates the deviation. GQI value of 80 or above can be considered as OK. However, we may not achieve it during the first cycle since in the beginning, existing rail profile may be much deviated from the target and we may be able to achieve the target after 2 or 3 cycles only.



Fig. 16: KLD System

4.0 Patterns and Pattern Selection

- 4.1** Metal removal from the rail head will depend upon the number of grinding stones working on a rail, the power of the motors, speed of grinding and number of passes. The amount of metal removal will also vary depending upon the hardness of the rail and position of the grinding stones. To achieve the target rail profiles from the existing rail profile at any location, the metal to be removed will

vary from point to point across the rail head and therefore, the grinding stones are to be positioned differently (at different angles) across the rail head (Fig. 17). Arrangement of the stones is known as “Pattern”. The position of a stone is characterized by the angle of the rotation axis from the vertical and depending upon the angle, the location of the grinding across the rail head will vary. This means that zero degree stone will have vertical axis of rotation of 30° from the vertical. The stones working on gauge face side are given positive angles and the stones working on the field side are given negative angles. Thus a pattern will define the angle and power of each motor working on the railhead.

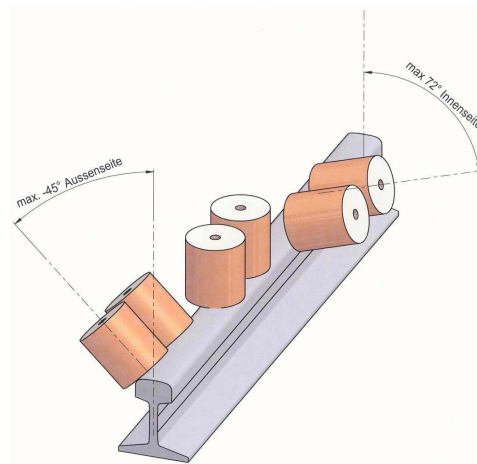


Fig. 17: Stones at Different Angles on Rail

- 4.2 The Grinding Supervisor (the in-charge SSE/P.Way in our case) has to select one or more of the designed patterns for grinding at a particular location so as to achieve the target rail profile from the existing rail profile in one or more passes. M/s Loram has designed 49 patterns for Indian Railways in consultation with NRC Canada for the first cycle of grinding (Fig. 18). Since the target rail profile changes from straight to a curved track and will also be different for the high rail and the low rail of curved track, the pattern to be selected will also be different for all such situations.
- 4.3 A pattern shown in the sheet is highlighting the area across the railhead from where the metal will be removed, if that pattern is selected. The blackened portion over the railhead is showing the location of the metal removal and high points are indicative of more metal removal from that particular point. Thus we can see that some of the patterns are of generic nature such as pattern 39 or pattern 24 which remove the metal from whole head width of rail while some of the patterns such as pattern no. 10 or 14 are very aggressive on gauge face of rail. So depending upon the requirement of metal removal from different parts on the railhead, one or more patterns are to be chosen in one or more passes.
- 4.4 Indian Railways does not have enough experience and expertise for selection of the patterns. Hence based on the experience and field trials, NRC has suggested the patterns to be selected in the first pass of grinding in the first cycle as given in Table 1. The selection of pattern also varies with the type of rail, viz. 60 kg or 52 kg, new rail or old rail etc. The rail can be considered to be new if it has carried approx. upto 80 - 100GMT of traffic. A particular pattern specifies the angle and power (amperage) for each of the 36 motors working on a rail.



Fig. 18: Patterns Designed by Loram for First Cycle

Table 1: Patterns Suggested by NRC for Different Track Conditions

NRC Recommendation for Preventive Gradual Grinding Edit 6 Sep 6th, 2011								
Template	Track	Patterns		Speed Kph	Wrong Direction in GDMS 3 Pass Patterns			All Passes Speed Kph
		First Pass Aggressive	First Pass Generic		Pass 1	Pass 2	Pass 3	
HS	UP/Down	14	45	18	14	27	15	18
HS NEW RAIL	UP/Down	2	45	18	2	47	23	18
HM	UP/Down	10	45	18	10	43	27	18
HM NEW RAIL	UP/Down	2	45	18	2	47	x	18
LS-CPF	UP/Down	20	47	18	20	23	27	18
LS-CPF NEW RAIL	UP/Down	24	47	18	24	23	23	18
LM-CPC	UP/Down	39	39	18	39	42	39	18
LM-CPC NEW RAIL	UP/Down	17	41	18	39	46	x	18
TCPF	UP	24	24	15				
TCPF New rail	UP	24	24	15				
TCPC	DN	39	39	15				
TCPC NEW RAIL	DN	39	39	15				
TCPC 52 Kg RAIL	UP/Down	39	39	15				
LS-CPC 52 Kg RAIL	UP/Down	39	39	18	39	42	39	18
LM-CPC 52 Kg RAIL	UP/Down	39	39	18	39	42	39	18

- 4.5** In case of grinding on a curve, it has been decided to give 3 passes, the first pass of grinding will be selected from the table as recommended by NRC. The pattern and speed of the second and third pass will be recommended by the machine software i.e. Grind Data Management System (GDMS). GDMS is having the facility of recommending one of the pre-fed patterns to get target rail profile from the existing rail profile to the extent possible. There is a laser based rail profile management system available in the front as well as on the rear of the grinding machine. After the first pass on the curve, the rail profile after grinding has already been picked up by the system. The target rail profile to be achieved is also known to the system since the track alignment, i.e. straight or curve, degree of curve, direction of the curve (RH/LH) is already incorporated into the system. After knowing the existing rail profile and the target rail profile, GDMS recommends patterns and speeds to get the most efficient results (Fig. 20). In GDMS, the direction of curve is to be taken in the direction of increasing kilometers only and not in the direction of movement of traffic.
- 4.6** It has been observed during grinding that in some cases direction of the curves incorporated in the system is reverse to as existing in the field. In such a case, the system will recommend the profile to be given to high rail, for the low rail and vice versa. Hence we cannot use the patterns as recommended by the GDMS and the patterns for all the three passes should be selected manually as given on the right side of the table. However, it should be ensured that once the mistake in the curve direction is noticed, the same should be got rectified for future.

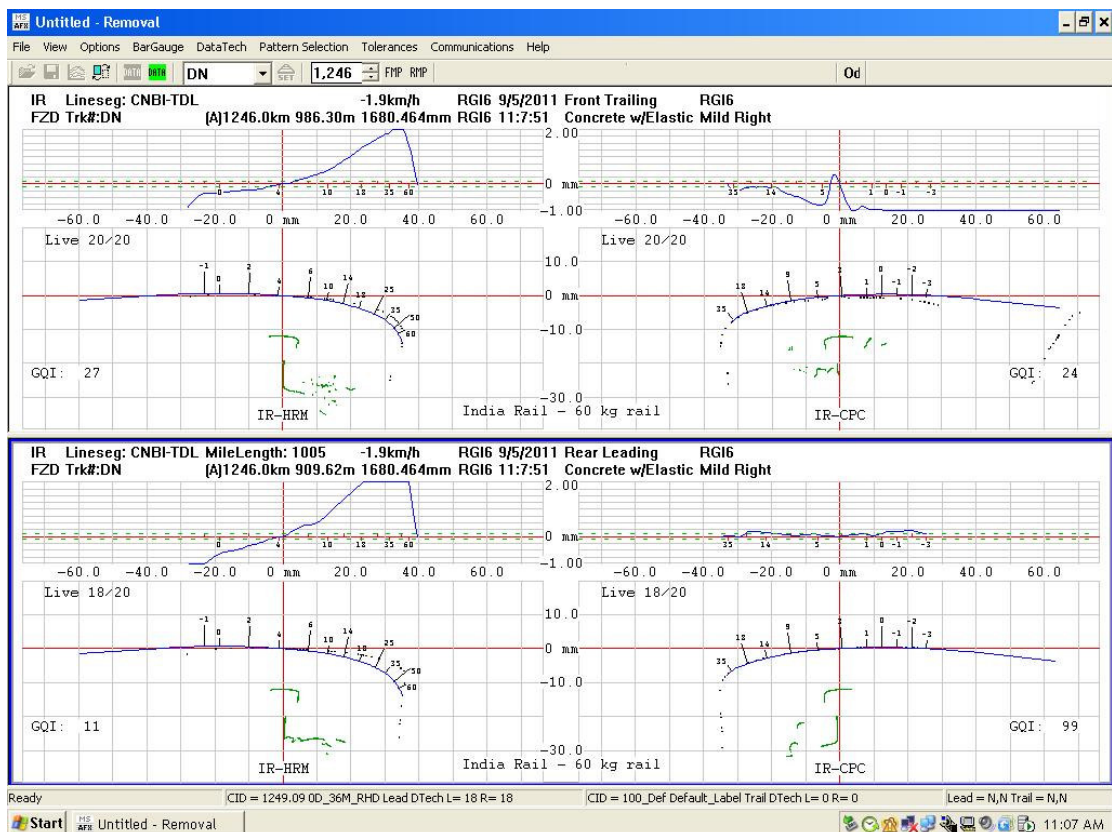


Fig. 19: Sample Screen Shot for GDMS Monitor

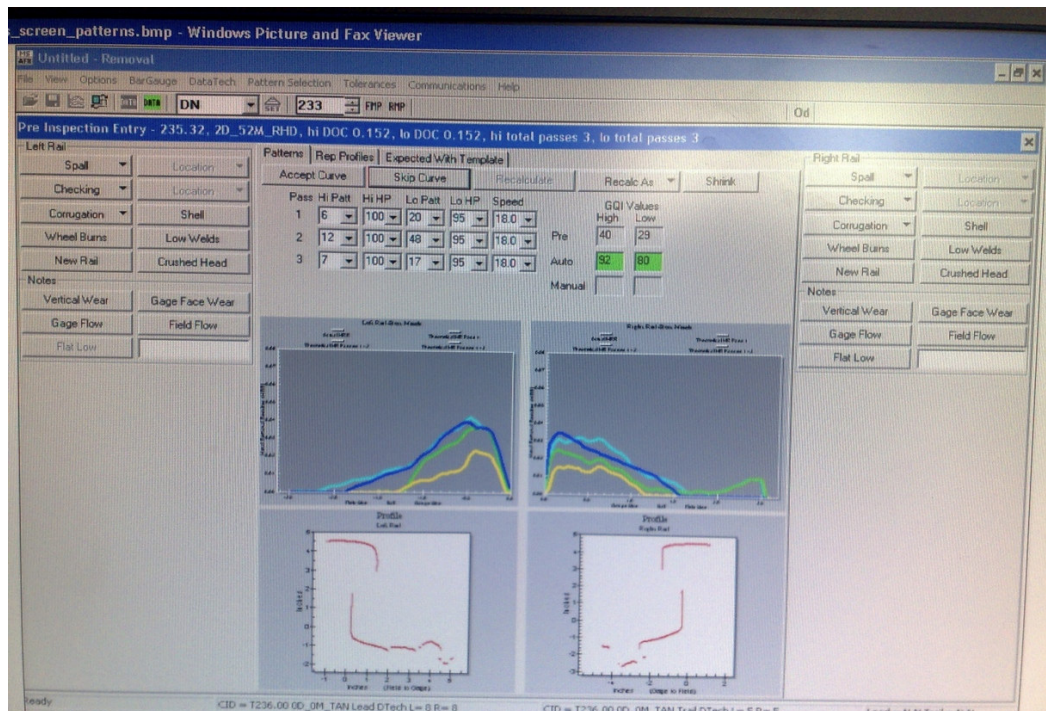


Fig. 20: Sample Patterns Suggested by GDMS for Curve

- 4.7** The pattern sheet shown in given figure will hold good only in the first cycle of grinding since the metal to be removed in the first cycle is more. However, the new patterns need to be designed for the subsequent cycles since the rail has already been reshaped towards the target profile during the first cycle. These new patterns will be designed by LORAM and we have to carry out field trials for deciding about the patterns for different situations.

5.0 Target Rail Profiles

- 5.1** One of the main purposes of rail grinding is to make Rail Wheel Interaction favourable so as to have the optimum area of contact between wheel and rail to reduce stress. Since Rail Wheel interaction will change from straight to curved track, from mild to sharp curve, from high rail to low rail – the target rail profile also need to change for these situations. NRC Canada has designed four target rail profiles/template for Indian Railways, namely Contact Point Central (CPC), Contact Point Field (CPF), High Sharp (HS) and High Mild (HM). As the name suggests, in CPF profile the contact of the wheel on the rail will shift towards the field side while in CPC the wheel will make the contact with the rail in the centre.
- 5.2** CPC and CPF profiles will be used for straight track while HS profile is for high rail of a sharp curve and HM for high rail of a mild curve. For the low rail of a sharp curve, CPF profile will be used and for low rail with mild curve, CPC profile will be used.
- 5.3** A curve is said to be sharp if it is more than 1.25 degrees.

TABLE 2: Target Rail Profiles Templates for Different Tracks

Location	Track	Rail Type	TemplateUsage
Tangent	UP	60 kg	CPF
Tangent	Down	60 kg	CPC
Tangent Hunting	Down	60 kg	CPF
Tangent Single - alternate CPF and CPC	Single	60 kg	CPF / CPC
High Sharp	> 1.25 deg	60 kg/52kg	HRS
High Mild	≤ 1.25 deg	60 kg/52kg	HRM
Low Sharp	> 1.25 deg	60 kg	CPF
Low Mild	≤ 1.25 deg	60 kg	CPC
Tangent	Up/Down	52 kg	CPC
Low Sharp & Mild	Up/Down	52 kg	CPC

5.4 For the straight track, 2 profiles have been designed. CPC would be used on 'Down' track and CPF will be used for 'UP' track. The idea is to have half of the straight track with CPC and the balance with CPF. In case of long stretches of single line track, half of it will be demarcated for CPC and the other half for CPF. In case we have only one profile say CPC for the straight track, the wheels through their journey will mostly be making contact on the centre of the rail, thereby wearing out more at a particular location. This will result into development of hollowness/stress raiser in the wheel causing high stress concentration during Rail Wheel interaction. To even out the wear of the wheel, the contact is shifted from the central portion of the rail towards the field side for half of the track.

5.5 The process of designing of target rail profile is known as "**Pummeling**". For the design, the sample wheel profiles for a number of wheels from coaching stock as well as freight stock are collected with the help of "MINIPROF" (for wheels). These wheels are made to run on a proposed target rail profile in simulation mode in a software known as "Pummeling" software and the stress pattern generated by these wheels on the surface of the rail is studied. This exercise is repeated for number of proposed target rail profiles and the rail profile giving the least stress concentration on the rail is selected as target rail profile.

6.0 Monitoring Equipments for Rail Grinding

6.1 MINIPROF

MINIPROF is an equipment to measure the profile of the rail head very accurately. The accuracy of the MINIPROF equipment is .054 mm. The equipment is shown in the photograph below. It consists of the main equipment with magnetic base for fixing on the railhead and a telescopic bar to be supported on the head of the other rail. It is having two lugs which should be touching the rail gauge face so as to ensure rail profile is perpendicular to rail axis. The equipment is attached to a

laptop/PDA. The stylus of the equipment is rotated across the railhead in a specific sequence and the rail profile gets recorded in the laptop/PDA electronically. One such typical profile is shown in the figure below. The MINIPROF data is useful for knowing the wear of rail due to traffic and wear of the rail due to grinding. The total wear of the rail should be commensurate with the growth of cracks over the rail top. The MINIPROF data is also used to compare the after-grinding profile with the targeted profile. The MINIPROF profile records the details such as date, the track, i.e. UP/DN, the rail i.e. left/right and gauge etc. as shown in Fig. 21.



Fig. 21: MINIPROF Equipment

6.2 Bar Gauge

Bar Gauge is an instrument to measure the deviation of rail profile from the target rail profile quickly. The equipment is shown in the figure below. Since there are four target profiles, there are four templates provided on the bar gauge also i.e. CPC, CPF, HS and HM (Fig. 22). The relevant template is kept on the rail with 45^0 point of the gauge touching and pressing against the gauge corner and the gap at 0^0 point is measured with the feeler gauge. This will indicate the deviation from template.



Fig. 22: BAR GAUGE Having Four Templates



Fig. 23: Measurement Using BAR GAUGE

6.3 Star Gauge

Star Gauge is an instrument for measuring the rail top radius. It is a pentagon having different radii on its different sides (Fig. 24). By matching the radius of the rail top with one of the side, the approximate radius of the rail top is determined. The rail top radius will be flatter due to wear etc. before grinding but should reach to 250mm after grinding.



Fig. 24: STAR GAUGE

6.4 Digital Inclinator

This equipment is used to get the angle of a particular point on the rail top i.e. the angle for the motor, which will be grinding that particular location of the rail. On keeping the instrument on any point on the rail, it will directly give the angle in digital form as shown in Fig. 25.



Fig. 25: DIGITAL INCLINOMETER

6.5 Surface Roughness Measuring Gauge

The rail surface after the grinding is quite rough due to the grinding marks left by the stones on the rail. If the grinding quality is poor due to any problem, the roughness level could become unacceptable (beyond 12microns). The roughness is measured by a calibrated roughness measuring gauge as shown Fig. 26 below.



Fig. 26: Roughness Measuring Gauge

6.6 Rail Hardness Measuring Gauge

The hardness of the rail plays an important role in the metal being cut, frequency of grinding etc. Rail hardness should also be measured to make sure that the work hardened layer of steel is not removed from the rail top, thereby reducing the hardness appreciably. Since on Indian Railways, generally the rails are 90UTS and we are not cutting too much metal during grinding, this item is not critical for us. The equipment is shown in Fig. 27.



Fig. 27: Hardness Measuring Gauge

6.7 Other Equipments

In addition to above, we need **a good quality digital camera, 1m straight edge, a taper gauge, one steel scale, feeler gauge**, black marker pens, cotton waste also. Dye Penetration Test is also carried out at site for which we will need the relevant solutions i.e. cleaner, dye & penetrant.

7.0 Works to be done before grinding

7.1 Arranging Infrastructure

- 7.1.1** Rail Grinding Machine will need proper infrastructure for its maintenance and operation. The length of the machine is 130m. Construct stabling sidings of 300 m each or two spurs of 1150 m each at a distance of about 50 kms.
- 7.1.2** The machine carries about 75000 liters of water and the consumption will vary from section to section. The average consumption so far has been about 1100 lit/km of grinding. Arrange for regular water supply to the machine.
- 7.1.3** The machine is having storage for about 21000 liters of diesel. The consumption so far is about 85 lit/km of grinding (including idle running of engine). The diesel supply is to be given through RCDs, which may be located at a distance of 250 kms or so. Plan in advance for diesel filling pending upon the distance etc.
- 7.1.4** An imprest of Rs. 5 lacs should be created to take care of urgent repairs, fuel etc to avoid idling of the machine.
- 7.1.5** Proper planning for the block should be done in advance in co-ordination with the traffic department.

7.2 Marking Obstructions in Grinding

Few locations in the track are to be left while grinding and the grinding motors need to be lifted on these locations to avoid damage to track structure. These are turnouts, SEJs, level crossings, curves with check rails and axle counters. These locations are to be marked with paint prominently on the track for the guidance of grinding operator. The start and end of the curve should also be marked with paint on the sleepers prominently where a different pattern has to be selected. Similarly, SEJ locations should also be marked.

7.3 Collecting Track Details

The chainages of the start and end of the curves, turnouts on main line, SEJs, level crossings, axle counters and degree and direction of curves should be collected in advance since these data needs to be incorporated in GDMS to help in grinding. **The direction of the curve is always seen in the direction of increasing kilometers and not in the direction of movement of traffic.** We should also compile the history of rail/weld failures, USFD defects in rail/welds, rail replaced for any other reasons, etc. The track stretches, which will be skipped during the grinding should be identified. These stretches may consist of the locations with rails due for renewal or where corrosion of the rails is very high.

7.4 Establishing Test Sites

Test sites are the locations, which are established in the track as a representative track where intense monitoring and measurement will be done before and after grinding. With the help of monitoring at these locations one should be able to decide the appropriateness of the metal being removed from the rail surface vis-à-vis growth of RCF cracks, the effectiveness of the grinding pattern to achieve the target rail profile and to control the grinding cycles to optimum frequency. The test sites are established to represent the track in a typical curvature and a typical rail type. It means there should be separate test sites for 52 kg and 60 kg rails, separate test sites for straight and curved track and in curves also separate sites for mild and sharp curves. The test sites can be representative of 10-20 or 50 kms of track depending upon the broad changes in the traffic pattern, age of rail and damage on rail surface. Typically we may have one test location in each SSE/P.Way section for straight track, mild curve and sharp curve each. The test site should have easy access by road so that one is not dependent on train/trolley to go or reach these locations. The rail should not be planned for replacement in the near future, say within the next 3-4 years so that the effect of rail grinding can be studied for a longer period. The test site should have typical traffic and speed potential and should be away from weld location, signals, Level crossings, yards, bridge approaches, etc. The history of defects, failures, rail surface damage etc should be established at test sites to the extent possible.

8.0 Monitoring Rail Grinding

8.1 Rail grinding operation requires systematic monitoring to judge and get the maximum advantages of it. Rail Grinding is a very costly operation and monitoring is also necessary for the cost-benefit analysis. The decisions regarding the suitability of the target profiles to reduce the damage optimally, frequency of the

grinding, amount of the metal to be cut and proper pattern selection are all dependent on the systematic monitoring of the grinding process. Thus, the efficacy of the Rail Grinding operations and subsequent review and decision-making is possible only after the proper monitoring.

- 8.2** The benefits of the grinding will accrue in the form of reduced wear of rails, reduction in USFD defects as well as failures of rails and welds in the track, reduction in the damage on the surface of the rail and reduced weld dip with the passage of the traffic. Hence the history as well as the present data of the rail wear, USFD defects, Rail/weld fractures etc need to be studied in the sections where grinding has been started. One easier way of monitoring could be to have about a km of track ungrounded in the section and compare these parameters on ground rails and non-ground rails. Apart from these aspects, various monitoring issues are discussed below.

8.3 Test Sites

A typical test site is represented in the Fig. 28 below. It consists of 3 sleeper spacing - one for measuring rail profile by MINIPROF (Marked as MP), second for taking surface photographs and the third for doing Dye Penetration Test and taking photograph. In fact, we will have 3 such spots at the interval of 80 to 100 m apart to constitute one test site. Since we are going to take important decisions based on the measurements being at these locations, it is a better idea to monitor three spots instead of one for better reliability. Also in case the rail at one of the locations gets changed due to rail fracture etc, the other two spots will be available for further monitoring. The measurements at the test sites are to be taken within 15 days before and after grinding.



Fig. 28: A Typical Test Site on SCR

- 8.4** A separate file should be made for each test site location and the data should be recorded chronologically for all the items discussed here so that it can be readily seen as to how the rail condition has been changing with the grinding.

8.5 Miniprof Measurement

The first spacing of the test site is marked as 'MP' and an arrow is painted here. This is the location where rail profile will be measured every time before and after grinding. A typical rail profile measured by Miniprof is given in Fig. 29.

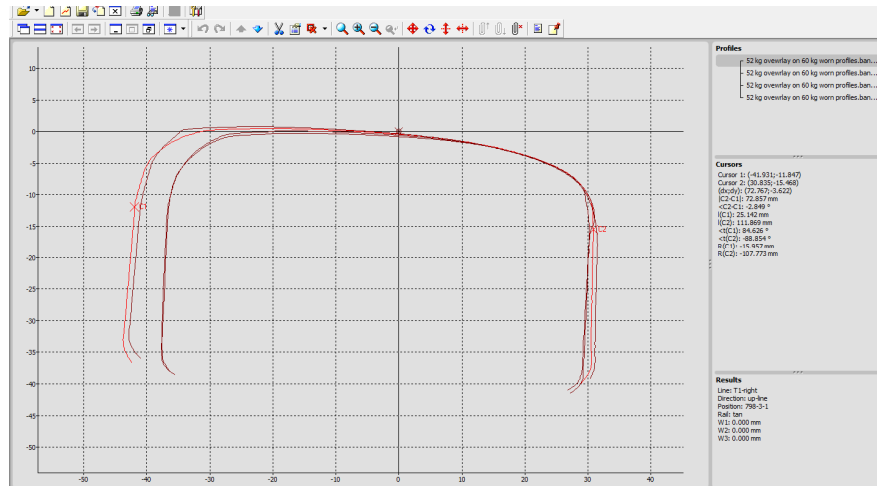


Fig. 29: Rail Profiles Measured by MINIPROF

8.6 Dye Penetration Test

At the second spacing of the test site, dye penetration test is done so that the damage on the rail surface including the cracks will become prominent. The dye penetration test uses 3 step process, viz. application of cleaner, application of dye penetrant and application of developer. After the test, details such as date, location, tangent or curved track (degree also), left/right rail or inner/outer rail, GMT carried, rolling year of rail, length of RCF cracks etc are written with a marker pen as shown in the figure and a photograph is taken with a digital camera (Fig. 30). The gauge face side and direction of traffic is marked by arrows on the rail head as shown. Dye penetration test is carried out before and after grinding. After the grinding, the test should be done only when the rail surface has become smooth, i.e. 10-15 days after grinding.

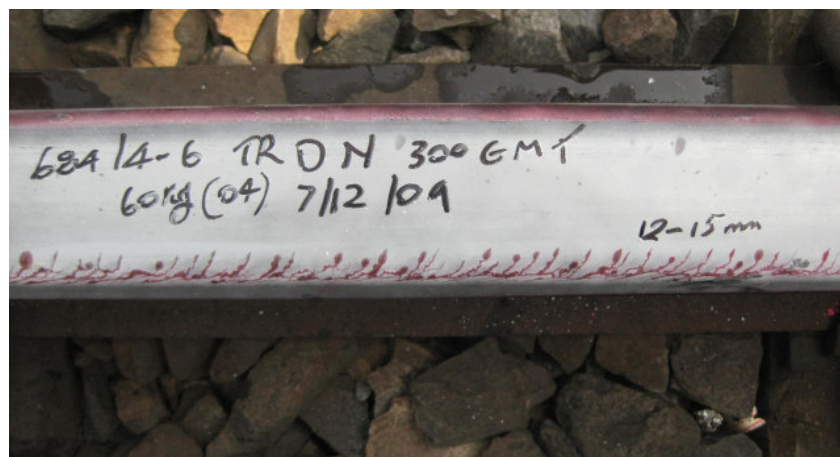


Fig. 30: Photograph Taken after DPT

8.7 Surface Photograph

In the third sleeper spacing at the test site, the railhead is cleaned and the fixed details as given above in the dye penetration test process are written with the marker pen and a photograph taken with a digital camera (Fig. 31) before as well as after grinding.

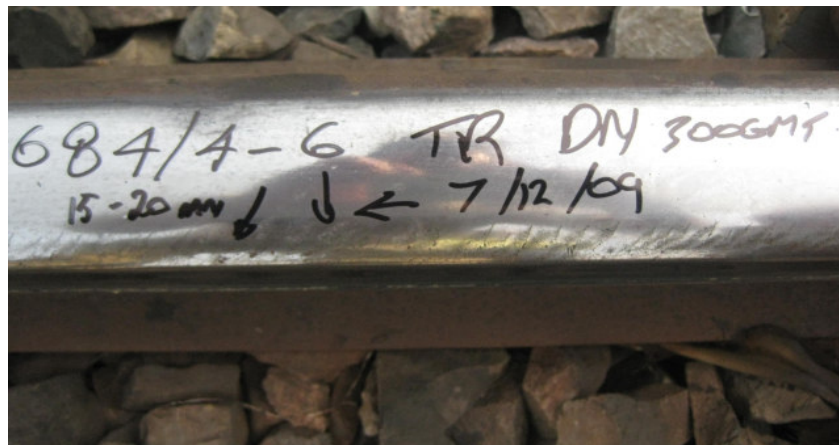


Fig. 31: Surface Photograph

8.8 Deviation from Target Rail Profile

The closer is the profile of the rail to the target after the grinding, the more will be the benefits accruing from it. So we need to monitor the deviation of the after grounded profile with the target profile. This will also help in decision making in choosing the pattern etc. for the future.

TABLE 3: Tolerances to templates				
Template	Lower Gauge Corner (+60 to +16 ⁰) mm	Mid gauge (+16 to +6 ⁰) mm	Field (0 ⁰) mm	Far Field > 0 ⁰
HS	+0 to - 0.6	+0 to - 0.6	+0.3 to - 0.3	+0.3 to - 0.3
HM	+0 to - 0.6	+0 to - 0.6	+0.3 to - 0.3	+0.3 to - 0.3
LS-CPF	+0.3 to - 0.3	+0.3 to - 0.3	+0.3 to - 0.3	+0.3 to - 0.3
LM-CPC	+0.3 to - 0.3	+0.3 to - 0.3	+0.3 to - 0.3	+0.3 to - 0.3
T-CPC	+0.3 to - 0.3	+0.3 to - 0.3	+0.3 to - 0.3	+0.3 to - 0.3
T-CPF	+0.3 to - 0.3	+0.3 to - 0.3	+0.3 to - 0.3	+0.3 to - 0.3

The deviation is measured with the help of the relevant template on the bar gauge and the gap is measured by a tapered or a feeler gauge. The prescribed tolerances are given in the table.

8.9 Monitoring Rail Crown Radius

The rail crown radius should be measured with the help of star gauge before and after the grinding.

8.10 Monitoring Contact Band

At present, the wheels are contacting the rail surface arbitrarily and the whole rail top is shining since different wheels are making a contact with the rail at different locations. The contact of the wheel on the rail should change after the grinding. Most of the wheels should make a contact on rail within a defined band. So a clear change in contact band should be visible. The contact band is to be monitored at isolated locations in curve and on straight track before and after grinding. It can be done by spraying the paint or chalk marks on rail surface and allow a freight train pass over it. Write down the details of location, date, width of contact band, distance from gauge face etc. and take a photograph. Figure 32 shows a contact band photograph after passage of a goods train after the grinding.



Fig. 32: Photograph Showing Contact Band Details after Grinding

8.11 Rail Surface Finish after Grinding

The condition of the rail top after grinding gives a lot of clues about the quality of grinding. A good finish should have regular grind marks of the wheels (these are known as facets) with silver finish. A bad finish will have irregular marks or skipped grinding at regular interval or blue colour on rails at certain location (known as blueing defect) or irregular facet width etc. The facet width (the width of the marks left by grinding wheels) should be about 10mm in the center of the rail and 4mm at the corners. Figures 33 to 38 illustrate different rail surface finishes.

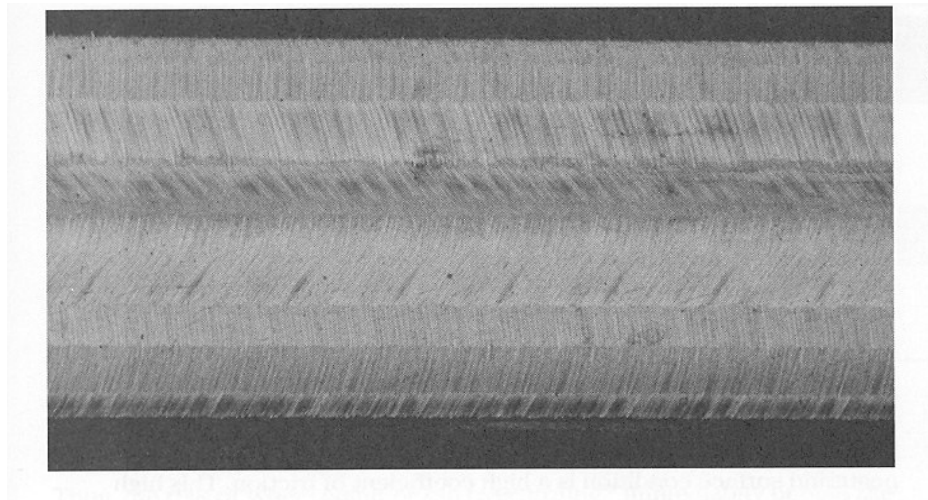


Fig. 33: A Good Surface Finish after Grinding

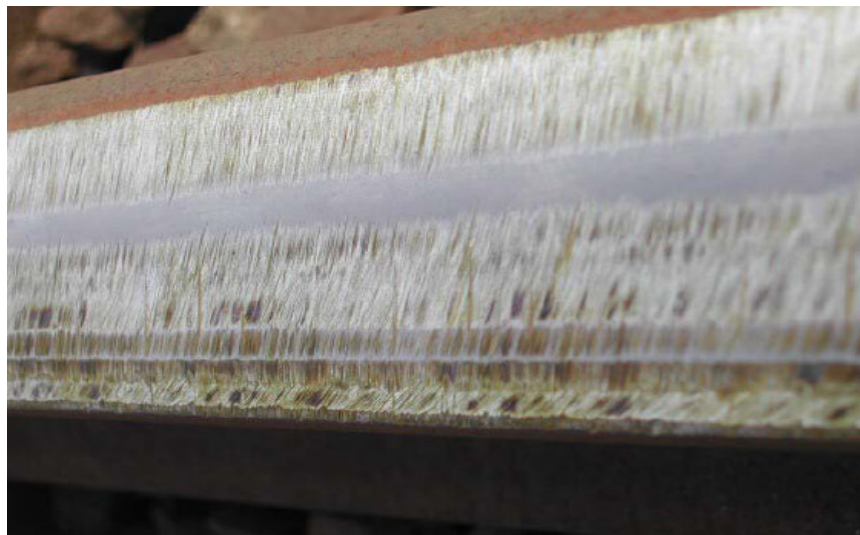
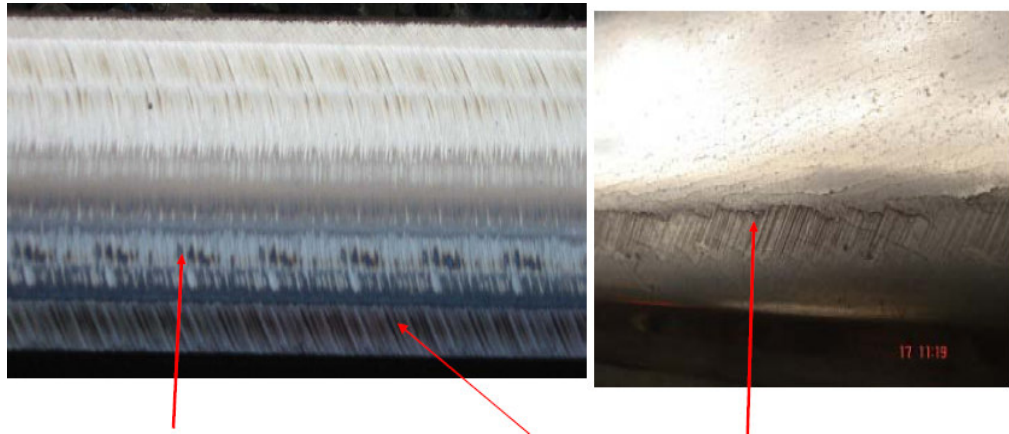


Fig. 34: Poor Surface Finish after Grinding



Fig. 35: Skipped Grinding & Blueing of Rail



Bluing

Large grinding facets

Fig. 36: Poor Surface Finish with Large Facets



Fig. 37: Poor Surface Finish



Fig. 38: Very Poor Surface Finish

8.12 Surface Roughness after Grinding

The rail surface should not become too rough after the grinding. NRC has prescribed that the surface roughness level should not go beyond 12 microns after grinding. So the surface roughness should be measured at isolated locations especially where the finish is poor.

8.13 GQI before & after Grinding

GQI stands for Grind Quality Index, which is a measure of the efficacy of the grinding with respect to the target rail profile. The GQI value 100 indicates that the target profile has been achieved fully. The lower the value, the more is the deviation from the target profile. During the run, GDMS screen displays GQI for both the rails before and after grinding separately. So at a glance, one can see the improvement in the profile.

8.14 Filling-up RDSO Proforma for Grinding

RDSO has issued a proforma (copy attached as annexure 'A') to be filled-up by the field units for monitoring of the Rail Grinding. The items given in the proforma are similar to those discussed above. The proforma needs to be filled every time before and after grinding and a copy (soft as well as hard) should be sent to RDSO for studying, decision making and issuing necessary guidelines to the field.

8.15 Monitoring Fire Hazards

Due to lot of sparks generated during the grinding, cases of fire may take place in the section. This should be taken care of by proper watch and taking necessary action.

8.16 Watch Grinding History

The grinding machine produces the history of the work done during the day giving the details of the track km, location, pattern used for each pass, speed of grinding and GQI before and after grinding for both the rails. This should be studied and see that the parameters selected were alright and GQI has improved after grinding in general. At isolated locations, GQI may reduce marginally, may be due to the error of measurement etc. A sample grind history sheet is attached as Annexure 'C'.

- 9.0** Rail Grinding has proved to be a very useful maintenance tool for reduction in damage of the rail, wheels and other track components and increasing their life substantially. The safety performance and the maintenance requirements of the infrastructure get reduced due to lesser damage and failures. It is therefore, necessary for the field engineers to understand the grinding technique and procedure properly and take the necessary action at their level to reap its benefits. For the benefits of the field staff, a DOs list is attached as annexure 'B' for a quick check.

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RAIL GRINDING MONITORING PROFORMA
(Details of Test Locations)

Rly..... Divn Section Km/TP

Rail Section/UTS Type of Sleeper Sleeper Density Ballast cushion.....

Tangent/Curved track Degree of curve Line (UP/DN) Axle Load

Total GMT carried GMT (Current) Date of Grinding Gauge (in mm)

Engineered Rail Profile Template used

S.No	Item	Observations on Left Rail		Observations on Right Rail		Remarks
		Before Grinding	After Grinding	Before Grinding	After Grinding	
A	Visual Inspection (severity be indicated)*					
	1. Gauge corner chipping					
	2. Flow of rail top / Burring					
	3. Rolling Contact Fatigue (Visual inspection & Dye Penetration test)					
	a) Gauge face (65 to 16 deg) (Y/N)					
	b) Shoulder of Rail (16 to 6 deg) (Y/N)					
	c) Crown of Rail (6 to -4 deg.) (Y/N)					
	d) Pitch of fatigue cracks (mm)					
	e) Length of fatigue crack (mm)					
	4. Wheel burns and Scabbing					
B	5. Any other defect observed					
	Corrugation					
	1. Wavelength (in mm)					
C	2. Length of track (in metre)					
	Hunting					
D	1. Wavelength (in metre)					
	Track Geometry (in mm)					
	1. Gauge					
	2. Cross level					
	3. Unevenness (3.6m/7.2m chord length)					
	4. Alignment (7.2m/9.6m chord length)					

*Hard & soft copies of Photographs of the test locations before and after grinding, after Dye Penetration Test indicating condition of rail (size of defect, location in Km, Line, indication of gauge face, direction of traffic) be sent.

Date :

(Signature of Inspecting official
With Name/Designation)

S.No	Item	Observations on Left Rail		Observations on Right Rail		Remarks
		Before Grinding	After Grinding	Before Grinding	After Grinding	
E	Type of contact of wheel on Rail					
	1. One point contact					
	a) Contact Bandwidth (mm)					
	b) Position (Centre line) from gauge face side (mm)					
	2. Two point contact					
	a) Contact Bandwidth (mm)					
	b) Position (Centre line) from gauge face side (mm)					
	3. Multiple point contact					
	a) Contact Bandwidth (mm)					
	b) Position (Centre line) from gauge face side (mm)					
F	Wear of rail (in mm)					To be measured by MiniProf Rail Profile measuring equipment and hard & soft copies of rail profiles be sent.
	1. Gauge face					
	2. Top table					
G	Metal removal in grinding					
	a) Crown (mm)					
	b) Gauge face (mm)					
H	Surface Hardness (in BHN)					
I	Weld dip (in mm)					
J	Roughness (Microns) – immediately after grinding					

Date :

(Signature of Inspecting official
With Name/Designation)

RAIL GRINDING MONITORING PROFORMA
(Route Specific Details)

Railway Divn Major Section From Km/TP To Km/TP Line (UP/DN/Single)
 Rail Section and UTS Rolling mark of rails Type of sleeper Sleeper density Ballast cushion
 Start Date of Grinding cycle for major section Date of last TRC run Total GMT carried Annual GMT Axle Load
 Completion Date of Grinding cycle for major section

S.No.	Item	Tangent Track		Curved Track			Remarks
		Left Rail	Right Rail	Degree of curve	Outer rail	Inner rail	
A	Full details of locations before grinding -						Details to be enclosed as per the format location wise (Line & Km details)
	1. Rolling Contact Fatigue (Head checks)						
	2. Corrugation						
	3. Hunting						
	4. Other defects (specify type)						
B	USFD Testing details of last grinding interval						
	1. No. of IMR defects in rail						
	2. No. of OBS defects in rail						
	3. No. of IMRW defects in weld						
	4. No. of OBSW defects in weld						
	5. Defect generation rate (DGR) of rails (Nos./km/GMT)						
	6. Defect generation rate (DGR) of welds (Nos./km/GMT)						
C	No. of fractures of last grinding interval						
	1. Rail						
	2. AT weld						
	3. FB weld						
D	Track Geometry before grinding						
	1. Average TGI of Gauge						
	2. Average TGI of Cross level						
	3. Average TGI of Unevenness						
	4. Average TGI of Alignment						
	5. Overall TGI						
E	Wear Pattern of Wheels before grinding	To be measured by MiniProf Wheel Profile measuring equipment and hard & soft copies of wheel profiles be sent.					

Note : The above details be provided for the period between two successive grinding cycles.

Date :

(Signature of Inspecting official
With Name/Designation)

DOs for the Guidelines of Field Engineers

DOs

1. General

- Arrange for proper stabling facilities for the machine at about 50 km distance.
- Identify the RCDs and plan for timely supply of diesel to the machine.
- Ensure that diesel does not spill onto the rubberized spark guards to avoid fire during grinding.
- Make the arrangements for supply of water to the machine.
- Plan for the adequate traffic blocks for the machine working.
- Arrange for all the equipments for taking the required measurements.
- Collect the track data for feeding in GDMS software installed in the machine. Note down chainages of the level crossings, SEJs, Points & Xings, Axle Counters, start and end of Curves. Curve direction should be taken in the direction of increasing km irrespective of direction of movement of traffic.
- Find out history of the rail wear, surface damage on the rail, USFD defects, rail/weld failures etc in the section where grinding is being done and study the change in these parameters as the grinding is done.
- Identify the stretches of the track which will be skipped during grinding like rails planned for renewal in next two years, rails having severe corrosion and liner bite corrosion etc.
- Establish test sites.
- Open a separate file for each test site in your section. Take measurements at the test sites as per RDSO proforma and keep in file.
- Open a register on the machine where all the observations/ defects noticed by the P. Way supervisors and the officers will be recorded and the action taken with date should be mentioned by the machine maintenance supervisor.

2. Before the Block

- Paint the sleeper prominently on either side of the SEJs and at the start and end of the curve.
- Arrange for a pilot for the machine working.
- Ensure effective communication between FCC, RCC and on the ground.
- Counsel the staff and gatemen to keep everyone away from the machine during its working to avoid injury.

- Counsel the staff to use safety gadgets such as helmet, goggles, reflective jackets, shoes etc on the track as well as on the machine during machine working.
- Measure the rail profile with miniprof, carry out DPT and take surface photograph at each test site before grinding (say within 15 days). Keep these details in the file chronologically.
- If the machine is to come back to the yard for the second pass as in case of a curve, co-ordinate with the station master for proper setting of the point to avoid accident.

2. During Block on Track

- Go on a motor trolley behind the grinding machine and look for the fire in track or on cess, if any.
- Check for the quality of surface finish visually for any irregular grinding, blueing of the rail, skipped grinding etc.
- See the facet width is about 4mm at the corners and about 10mm at the centre of the rail.
- Check the surface roughness at bad location and see that it is not exceeding 12 microns.
- Check the profile at few places on straight and in curves after grinding with bar gauge and see how close or away we are from the target profile. See whether the profiles are within prescribed tolerances or not.
- Check the rail crown radius with the star gauge and see that the radius after grinding is about 250mm.
- Check the contact band in straight and curve track at one or two locations before and after grinding. Take a photograph and keep for record.
- See that the dust collection system is working properly.
- Inform any irregularity noticed to the machine operator and get it rectified.
- See that a train with inflammable material is not passed by the controller on adjacent track.

3. During Block on Machine

- Check whether the motor angles, calibration of tachometer and calibration of KLD has been done by the operator as per the schedule. Check yourself before the block once a while.
- Check the proper functioning of the water pump and water cannons etc.

- Check that all the motor are working properly. The indication comes on HMI panel.
- Make a chart in advance for the pattern to be selected during the first pass of the grinding.
- Synchronize the chainage of the track on the machine.
- See whether the patterns being selected by the operator are correct.
- See that the grinding speed is correct.
- Check that the operator sequences the motors up and down correctly and promptly on the obstruction.
- Check whether the direction of the curve in GDMS software is same as existing on the ground. Do not use GDMS suggested patterns for the second and the third pass of the curve in case the direction is wrong.
- Make sure to get the GDMS data corrected if the direction of curve is found to be wrong so that the similar problem is not faced during the next cycle.
- See that the patterns are changed promptly on entry and exit of the curves.
- Check the GQI before and after grinding and see that generally, there is improvement in GQI after the grinding.
- Learn the working of GDMS software including recommendation for the pattern and speed for the I and II pass on a curve.
- Check the GQI before & after Grinding.
- Check the active pattern selected in real time on the monitor.
- Look for any alarm on HMI of the machine and see that corrective action is taken promptly by the operator.

4. After Grinding

- Take rail profile after grinding within 15 days at the test sites.
- Carry-out DPT test at test site 10-15 days after grinding and take a photograph. Keep in file.
- Take a surface photo at test site 10-15 days after grinding and keep in file.
- Preserve the soft copies of miniprof measurements and photographs.
- Overlay and Analyseminiprof reading i.e. rail profile before grinding, after grinding and target profile. Calculate the metal cut and deviation from target profile.
- Ensure safe disposal of the grind dust in a yard.

- Clean the grind dust from the glued joints.
- Check for the stone grind marks on the joggle fish plates.
- Notice the change in contact band and analyse.
- Fill-up RDSO proforma and send to track directorate.
- Ensure that the machine engines are not unnecessarily kept running by the machine staff. ENERGY SAVED IS ENERGY PRODUCED.

Please feel free to contact the author, in case of suggestions/ clarifications -
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Progress of Rail Grinding

Grinding Record Table												
MP Range: 1249.0 to 1252.0	Track#: 1	TDL-ALD	9/2/2011 to 9/2/2011									
Date	Time	CurveID	Start	End	Length	Curve Desc	Pass #	Hi\Lo Pattern#	Speed	GQI Pre (Hi\Lo)	GQI Post (Hi\Lo)	Avg Gauge
9/2/2011	16:23:16	1249.09	1249.17	1250.28	1060	0°40' R	1	10 \ 39	18	40 \ 75	41 \ 81	1677.88
9/2/2011	16:31:12	1249.09	1250.28	1249.29	1006	0°40' R	2	6 \ 37	-12.7	42 \ 81	73 \ 91	1677.29
9/2/2011	16:36:02	1249.09	1249.36	1250.28	878	0°40' R	3	40 \ 41	12.4	74 \ 90	69 \ 90	1678.14
9/2/2011	16:37:24	1250.41	1250.47	1250.65	177	1°7' R	1	10 \ 39	15.6	50 \ 77	66 \ 78	1677.70
9/2/2011	16:40:45	1250.41	1250.65	1250.47	178	1°7' R	2	6 \ 20	-15.3	66 \ 76	72 \ 90	1677.39
9/2/2011	16:43:18	1250.41	1250.47	1250.65	177	1°7' R	3	40 \ 36	16	74 \ 93	78 \ 92	1677.87
9/2/2011	16:44:59	1250.71	1250.8	1251.15	348	0°38' R	1	10 \ 39	18.8	48 \ 75	55 \ 80	1677.36
9/2/2011	16:48:16	1250.71	1251.14	1250.8	352	0°38' R	2	6 \ 31	-15.6	54 \ 80	76 \ 90	1676.39
9/2/2011	16:52:10	1250.71	1250.8	1251.15	347	0°38' R	3	7 \ 41	15	74 \ 90	78 \ 89	1677.52
9/2/2011	16:52:29	T1251.24	1251.24	1251.24	6		1	10 \ 39	17.9	86 \ 39	88 \ 42	1677.8
9/2/2011	16:56:19	T1251.24	1251.24	1251.24	6		2	4 \ 38	-17.6	83 \ 50	82 \ 78	1677.16
9/2/2011	16:58:45	T1251.24	1251.24	1251.24	5		3	3 \ 41	18.3	82 \ 69	89 \ 62	1678.09
9/2/2011	16:53:14	1251.24	1251.34	1251.45	118	1°3' R	1	10 \ 39	17.6	54 \ 77	80 \ 81	1676.41
9/2/2011	16:55:59	1251.24	1251.45	1251.33	119	1°3' R	2	4 \ 38	-18.4	79 \ 79	82 \ 93	1677.00
9/2/2011	16:59:28	1251.24	1251.34	1251.45	118	1°3' R	3	3 \ 41	18.1	84 \ 91	83 \ 92	1676.65