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**BOOKLET OF INSTRUCTIONS FOR**  
**IMPLEMENTATION OF**  
**STANDARD DEVIATION BASED**  
**ASSESSMENT OF TRACK GEOMETRY**  
**USING TRACK GEOMETRY INDEX**

**TECHNICAL REPORT No. TM-11**

For official use only



GOVERNMENT OF INDIA  
MINISTRY OF RAILWAYS  
RESEARCH DESIGNS AND STANDARDS ORGANISATION  
LUCKNOW

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IMPLEMENTATION OF  
STANDARD DEVIATION BASED  
ASSESSMENT OF TRACK GEOMETRY  
USING TRACK GEOMETRY INDEX**

TECHNICAL REPORT NO. TM-11

TRACK MACHINES & MONITORING DIRECTORATE

MARCH 1997

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# STANDARD DEVIATION BASED ASSESSMENT

## OF TRACK GEOMETRY BY

### TRACK GEOMETRY INDEX (TGI)

#### 1. INTRODUCTION

1.1 The measurement of track geometry on the various routes is done periodically by Track Recording Cars at the specified frequencies. The purpose is to assess the riding quality of track and identify the stretches of track requiring maintenance attention for improving track geometry. The parameters of track geometry which are measured by TRCs are Unevenness and Alignment of left and right rails, twist and gauge. These parameters (except gauge) are measured on two sets of chords, the short chord and the long chord. The short chord is pertinent for four wheelers and bogie freight wagons, while the defects on the long chord are important for passengers coaches and locomotives. The values of these chords are as follows:

Parameters	Short chord	Long chord
Unevenness	3.6 m	9.6 m
Twist	3.6 m	4.8 m
Alignment	7.2 m	9.6 m

#### 1.2 Assessment of Track Quality using CTR:

- Assessment of the quality of track geometry on Indian Railways has traditionally been done using peak based formula which take into account the number of peaks exceeding a specified set of limits. Till recently, the following index, called Composite Track Record (CTR), was being used.

$$CTR = 100 - (U_A + T_A + G_A + A_B)$$

Where,

$U_A$  = Total number of peaks per km. of more than 6 mm (A limit) for Unevenness parameter on 3.6 m chord for left and right rails.

$T_A$  = Total number of peaks per km. of more than 5 mm (A limit) for twist parameter on 3.6 m base

$G_A$  = Total number of peaks per km. of more than 3 mm (A limit) for gauge parameter.

$A_B$  = Total number of peaks per km. of more than 5 mm (B limit) for alignment parameter on 7.2 m chord for left and right rails.

This peak based formula does not give a good indication of the actual riding quality or maintenance need on a stretch of track. The CTR formula has following limitations:

- No direct correlation with the riding quality
- Very sensitive to minor changes in track quality i.e. many times shows drastic improvement or deterioration between two successive recordings. Therefore, it is very difficult to make actual assessment of improvement or deterioration in track.
- The range of CTR values obtained is very large, from 100 for a kilometer of well maintained track to upto ~500 for a kilometer of poorly maintained track.

1.3 A need was, therefore, felt for evolving an Index based on the standard deviation values various track geometry parameters. During 1991 RDSO evolved standard deviation based formula called Track Quality Index (TQI). The formula is as follows:

$$TQI = 8 * (U + 2 * T + G + A)$$

Where,

U - Average of the S.D. values of Unevenness of left and right rails on 9.6 m chord

T - S.D. value of Twist at 3.6 m base

G - S.D. value of Gauge

A - Average of the S.D. values of Alignment of left and right rails on 7.2 m chord

Unlike the CTR index, TQI gives higher value for inferior track and lower values for good track because the value of the index goes down with reduction in the SD values. The formula was eventually not accepted and 66<sup>th</sup> Track Standard Committee asked RDSO to evolve a fresh formula. In pursuance of this, study was conducted by RDSO in 1995 and a new index called Track Geometry Index (TGI) was evolved by RDSO.

1.4 This formula contained in RDSO's report No.TM-1, was reviewed by a Committee appointed by the Railway Board comprising of Chief Engineers of four Zonal Railways (Western, South Central, Eastern and Northern Railway), ED/Track(MC), Railway Board, and EDTM/RDSO. After deliberation, the Committee submitted its report to the Railway Board. Railway Board vide their letter No. 94/Track-III/TK/23 dated 25/31-8-1995 instructed that formula should be implemented on NEW DELHI-HOWRAH and MATHURA JN-MUMBAI CENTRAL Rajdhani route and NEW DELHI-BHOPAL Shatabdi Route. On the basis of experience and comments of the Railways, a report on the application of TGI formula was sent by RDSO to Railway Board vide letter No. TM/IM/TRC/Tech(Vol.II) dated 18.9.96. The Railway Board have conveyed their approval for general adoption of the formula vide their letter No. 94/Track-III/TK/23 dated 30.12.96 (Annexure-I).

## 2.0 TRACK GEOMETRY INDEX

2.1 The formula for Track Geometry Index (TGI) is as under:-

$$TGI = \frac{2UI+TI+6AI+GI}{10}$$

Where :

$$UI \text{ (Unevenness Index)} = 100 * e^{-[(SDU_M - SDU_R) \vee (SDU_{UR} - SDU_R)]}$$

$$TI \text{ (Twist Index)} = 100 * e^{-[(SDT_M - SDT_R) \vee (SDT_{UR} - SDT_R)]}$$

$$GI \text{ (Gauge Index)} = 100 * e^{-[(SDG_M - SDG_R) \vee (SDG_{UR} - SDG_R)]}$$

$$AI \text{ (Alignment Index)} = 100 * e^{-[(SDA_M - SDA_R) \vee (SDA_{UR} - SDA_R)]}$$

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$$SDU_M = (SDU_{2L} + SDU_{2R})/2$$

$SDU_{2L}$  = Measured value of SD of Unevenness of left rail at 9.6 m chord.

$SDU_{2R}$  = Measured value of SD of Unevenness of right rail at 9.6 m

$SDT_M$  = Measured value of SD of twist at base of 3.6 m

$SDT_{UR}$  = SD prescribed for maintenance for twist at base of 3.6 m

$SDT_R$  = SD prescribed for newly laid track for twist at base of 3.6 m

$SDG_M$  = Measured value of SD of gauge

$SDG_{UR}$  = SD prescribed for maintenance for gauge

$$SDA_M = (SDA_{1L} + SDA_{1R})/2$$

$SDA_{1L}$  = Measured value of SD of alignment of left rail at 7.2 m chord

$SDA_{1R}$  = Measured value of SD of alignment of right rail at 7.2 m chord

$SDU_{UR}$  = SD prescribed for maintenance for unevenness at 9.6 m chord

$SDU_R$  = SD prescribed for newly laid track for unevenness at 9.6 m chord

$SDA_{UR}$  = SD prescribed for maintenance for alignment at 7.2 m chord

$SDA_R$  = SD prescribed for newly laid track for alignment at 7.2 m chord

2.2 This formula has the following features:

- a) TGI values are not susceptible to drastic variation due to minor improvement or deterioration in track quality as TGI is standard deviation based and SD value is a measure of the variation of all the sample sizes (sampling distance 0.4 m) in a length of track from the average value of the sample size.
- b) The index for the individual parameters gives quality rating to the measured standard deviation values by relating the measured SD values with the SD values prescribed for

newly laid track and the SD value for urgent maintenance on the set of chords through an exponential function.

- c) Track Geometry Index (TGI) is the composite index for assessing the overall quality of maintenance of track geometry. SD Values of unevenness, alignment, twist and gauge parameters are given weightages of 2,6,1 and 1 respectively.
- d) Because TGI is an exponential function with -ve sign of the exponent, the rate of change in the value of the index will reduce with the increase in the absolute value of the exponent. Therefore, the variation in the TGI value will be faster for good track with changes in the SD value than for a track in run-down condition.

**2.3 SD values for maintenance for routes having maximum speed more than 105 kmph and for routes having maximum speed less than 105 kmph and SD limits for newly laid track shall be as under -**

Parameters	Chord length	SD values for newly laid track	SD values for maintenance for routes with max. speed more than 105 kmph	SD values for maintenance for routes with max. speed less than 105 kmph
Unevenness	9.6 m	2.50	6.20	7.20
Twist	3.6 m	1.75	3.8	4.20
Gauge	-	1.00	3.6	3.60
Alignment	7.2 m	1.50	3.0	3.00

2.4 TGI will be calculated for a block of 200m length of track and the measured values of different parameters will be for the block. TGI for a km shall be taken as the average value of the TGI of all the blocks in the kilometer as under:

$$TGI = \frac{\text{Sum of TGI of all the blocks in km}}{\text{No. of blocks in the km}}$$

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### 3.0 INTERPRETATION OF INDICES FOR THE INDIVIDUAL PARAMETERS AND TGI

#### 3.1 INDICES FOR THE INDIVIDUAL PARAMETER

- a) The value of the index for the individual parameter will vary from 36 for track which has reached urgent maintenance limit to 100 for the track having SD value equal to the SD value prescribed for newly laid track. If the track is maintained to SD value superior to the value prescribed for newly laid track, the index value shall exceed 100.
- b) If index value for any of the parameters is 36 or less, it indicates that the measured SD value is equal to or greater than the SD value specified for urgent maintenance.
- c) The value of the index is equal to or less than 45 but more than 36 then the measured SD value on the set of chords is greater than the SD value for planned maintenance but less than the value prescribed for urgent maintenance.

#### 3.2 TRACK GEOMETRY INDEX (TGI)

- a) The results of the recordings have shown that the value of TGI will normally vary from 125 for a very well maintained track to 20 for very poorly maintained track.
- b) In a SD-based index, the changes in the value of the index are not large and a variation of more than 10 in the value of TGI indicates significant improvement or deterioration in the track quality. Results of successive runs on a typical routes are shown in Annexure-II
- c) TGI value is not a direct measure of the maintenance requirement of track although an increase or reduction in the value of the index indicates a general improvement or deterioration in the quality of track geometry. Track needing urgent maintenance can have a high TGI value upto 70 or more. This is because TGI takes the average value of all parameters on a particular set of chords after assigning weightages. The averaging can neutralize low value of a parameter if other parameters have high values. The maintenance requirement is governed by the SD value of the individual parameters i.e

even if one parameter exceeds the tolerance value for urgent/planned maintenance on the short chord or the long chord, the track needs maintenance.

- d) The TGI value should be used for making assessment of the overall quality of track geometry rather than for assessing the maintenance needs, for which SD values of individual parameter should be considered as explained in the next para.

#### ASSESSMENT OF THE MAINTENANCE REQUIREMENTS OF TRACK

- a) The SD value reflects the general quality of track in a block of 200 m. Decision regarding through packing, manually or with machines, should be based on the SD value. If SD value of any one of the parameter exceeds the urgent maintenance value, either on the short chord or long chord, then the track should be attended promptly. For attention to isolated defects in stretches of track otherwise maintenance well, as indicated by a lower value of SD, the peak size of individual defects should be considered. The TRC gives in the real time digital printout the sizes and location of the eight largest peaks in each km.
- b) In the digital printout the blocks where SD value for urgent maintenance is exceeded are identified with a three star marking (\*\*\*) , and block where the limit for planned maintenance is exceeded are identified with two stars (\*\*). See note at the end of para 4.
- c) Prioritising of maintenance of the various stretches (200 m blocks), should be done on the basis of the normalised value of the measured SD values. The normalised SD value ( $\sigma_n$ ) of a parameter is the measured SD value ( $\sigma_m$ ) divided by the urgent maintenance SD value ( $\sigma_u$ ) of that parameter and thus indicates the measured value relative to the urgent value.

$$\sigma_n = \frac{\sigma_m}{\sigma_u}$$

A value of less than 1 of the normalised value indicates that the urgent maintenance value is not exceeded and a value greater than 1 indicate that the urgent value has been exceeded. If the urgent maintenance SD value is exceeded for more than one parameter in a block, then the higher normalised value shall be reckoned deciding priority. In a

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stretch, the block having the highest normalised value should be given the highest priority for maintenance.

d) A software has been developed by RDSO for preparing an exception report by off-line processing giving list of all blocks in which the value specified for planned maintenance is exceeded for any one or more parameters. A copy of the exception report shall be given to the Railways during recordings by off-line processing. The listing shall be in the descending order and the block having highest normalised value shall be at the top. Because at present the limiting SD values for both the sets of chord are available for speed more than 105 kmph only, so this methodology shall presently be applied on routes maintained to C&M1 tolerances.

e) It should be noted that track maintenance requirements can not be assessed merely on the basis of track geometry values. The condition of the track components and fitting, the ballast bed and other local factors should be taken into account while assigning priority for maintenance. For planned maintenance, the rate of deterioration is a important factor. The rate of deterioration can be assest by building up historical record of successive recordings.

Note :- The following sets of SD values have been taken as the limiting values for urgent and planned maintenance on the basis of studies conducted by RDSO in the 1980s.

Parameter	URGENT MAINTENANCE		PLANNED MAINTENANCE	
	Short Chord	Long Chord	Short Chord	Long Chord
UN	3.6	6.2	3.0	5.5
TW	3.8	4.5	3.4	3.7
AL	3.0	5.0	2.8	4.0
G	3.6		2.9	

## 5.0 REPORTING OF RESULTS :

5.1 Reporting of results during recording run: The print-out of results given in real-time by the TRCs shall include the following information:

i) In Real Time Digital Printout:

- Individual index values (UI, TLAI & GI) for each block of 200 m length shall be given in the space at right-side of the long chord SD values and TGI value of individual blocks shall be given where TGI value is give at present, TGI shall be discontinued.
- The average TGI value for each Km shall be given in the place of CTR value

A copy of the revised format for the digital printout is kept at Annexure-III.

If the speed of recording in one or more blocks is less than the minimum speed of recording, the average TGI value for the km shall not be calculated and "NR" (Not Recorded) shall be printed in the space provided for TGI. However, for working out the average TGI value for longer stretches i.e CPWL, AEN, DEN/Sr.DEN sections etc, the TGI value of all blocks where speed is within the recording speed band shall be considered. The size and location of eight largest peaks in a Kilometer for each parameter shall continue to be reported unchanged as at present.

ii) Exception Reports by off-line Processing

The following two exception reports shall be given to the Railway officials accompanying the run.

- I. The listing of blocks where SD value of any one or more of the parameters exceeds the specified limits for planned maintenance. The blocks shall be listed in the descending order of the highest normalised value of each block. A sample copy is enclosed as Annexure-IV.
- II. The listing of all location where the peak sizes are in excess of the B limits for unevenness, alignment, gauge and twist values specified in report C&M Vol. I. A sample output is kept at Annexure-V.

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III. The software for taking out the above exception reports shall be given to the Railways so that they may also produce the reports from the recorded data which is given to the Railways on floppy. The software should be given by the Railways to all Divisions as well as AENs who are provided with a PC. This will enable them to quickly make out exception report for their section and also maintain a database of successive recordings.

5.2 Monthly Report on track monitoring: In the monthly report on track monitoring sent by RDSO to Railway Board and CEs/Zonal Rlys, following information on the track recording results shall be given.

- Average TGI value and the average value of the individual indices (UI, TLGI & AI), for the full length of a route falling on a railway, and for the various nominated sections of the routes as done at present for giving average CTR value.
- The number of Kms and percentage recorded length requiring urgent maintenance.
- Number of Kms and percentage recorded length requiring planned maintenance.

The proforma for reporting results is kept as Annexure-VI.

5.3 Analysis of Results by the Railways: The Railways shall work-out the above results for each PWL, AEN, DEN/Sr.DEN sections on the recorded route as well as for the total length of the route falling on each division of the Railway and the total route length on the Railway. A software has been prepared by RDSO for working out these results with the recorded data using an office PC. The software shall be supplied to the Railways and officials from each Railways shall be trained by RDSO for doing analysis with the software. Result have been worked out as aforesaid for one route (NDLS-BPL shatabdi Route) and are kept at Annexure VII.

### Scope of implementation of TGI and review in future:

6.1 The TGI formula shall be used on the Gr.A and B routes which are recorded by the upgraded microprocessor based TRCs (TRC Nos. 225 and 2500). In the other

microprocessor based TRCs, it is not possible to make changes in the software implementing TGI because the source code of software is not available with RDSO. However efforts are being made to decipher the software so that alterations can be made in these TRCs also. On routes which are not recorded by the upgraded micro-processor based TRCs, the existing CTR index shall continue to be used.

6.2 The limiting SD values for urgent and planned maintenance adopted in TGI formula and for working out blocks requiring urgent and planned maintenance are based on the studies done by RDSO in the 1980s. RDSO has undertaken a study, in collaboration with TRANSMARK of UK for fixing threshold values for track parameters upto 160 km/h. The study is in an advanced stage and is likely to be finalised in the near future. The formula for TGI will, thereafter, have to be reviewed in the light of the validated studies by RDSO. Once the SD value and peak size tolerances for the various speed bands are available maintenance planning as per methodology brought out in this report can be extended to all the routes.

### QUERRIES RAISED BY THE RAILWAYS

Comments on TGI were invited from Chief Engineers (Central, Eastern, Northern, Western and South Eastern Railways). Comments received from the railways along with RDSO's clarifications is given in Annexure-VIII which were sent to the Board vide RDSO's letter no TM/EM/TRC/TECH Vol (II) dt. 18.9.96.

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Government of India  
Ministry of Railways  
(Railway Board)

No. 94/Track-III/TK/23

New Delhi, dated 30.12.96

Exec. Director/IHM,  
R.D.S.O.,  
Lucknow.

श्री मंत्रालय  
Ministry of Railway Sub  
म. र. बो. वि., मंत्रालय-11  
र. डी. सी. लखनऊ 11

Adoption of Standard Deviation Base Index  
for monitoring quality of maintenance of  
track.

Ref: Your office letters No. IH/IH/TRC/IGI dated  
7.11.96 and IH/IH/TRC/Tech. (Vol. II) dated  
18.9.96.

The recommendations made in your letter dated 18.9.96 re-  
ferred to above for adoption of the IGI formula have been accepted  
by the Board with the following modifications:

In para 2.4, the grading of the track would be as follows:

Band Width of IGI	Maintenance Requirement of the track
IGI Value 80 and above	No maintenance required
50 to 80	Need based maintenance
36 to 50	Planned maintenance
Below 36	Urgent maintenance

Within each band, the individual parameters should be exam-  
ined and studied. From repeated recordings, trends in deteriora-  
tion should be studied to pre-plan the action before entering the  
band width between 50 and 36 & 36 and below. This study will  
lead us to "predictive need based track maintenance."

The final accepted recommendations (as modified above)  
should be advised to all the railways and a date for switch over  
to the new system should be fixed, which should not be later than  
31.3.97. The RDSO should plan an intensive education programme  
for the proper implementation of the new system to ensure ade-  
quate appreciation and acceptance of the new formula by the zonal  
railways, all the way down to the level of P.Way Supervisors.  
For this purpose, RDSO should make out a small pocket book cover-  
ing all the aspects of clarification, as contained in your letter  
dated 18.9.96.

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The Railway Board may kindly be kept advised about implementation through your Monthly PCDO.

(Harjinder Singh)  
Director, Track (HC)  
Railway Board



## SHATABDI ROUTE

TRACK RECORDING RESULTS  
CTR vis TGI VALUES

RAILY SECTION	TRD LENGTH DIR UP	MONTH OF RUN	TRCHD	HRZ	CTR VALUES	PEAKS				KM	TGI VALUES			
						LM	GA	TN	AL		UMI	GAU	TNI	ALI
CR TKD-BPL	SHT 683 UP	02/01/97	2500	19.83	32.110	5.63	25.36	11.90	-	77.00	76.00	81.00	-	-
CR TKD-BPL	SHT 683 UP	10/01/96	2500	9.81	29.16	6.90	21.84	10.97	31.11	76.71	78.17	85.34	52.44	66.1
CR TKD-BPL	SHT 683 UP	07/01/96	2500	24.45	20.34	9.67	19.10	11.87	37.79	47.57	76.57	40.47	55.85	55.1
CR BPL-TKD	SHT 683 DN	02/01/97	2500	23.57	39.22	4.65	24.75	0.84	22.54	92.00	77.00	90.00	60.00	74.0
CR BPL-TKD	SHT 683 DN	12/01/96	2500	10.48	31.85	5.68	23.42	10.70	29.14	79.46	77.03	87.03	67.00	70.0
CR BPL-TKD	SHT 683 DN	05/01/96	225	17.72	37.77	8.76	17.66	9.97	23.02	77.00	82.00	90.00	67.00	73.0

Recorded Raw Data, Printed on 21/03/97

Date of Recording : 22/1/1997 Run No : D EASTERN RAILWAY  
 Route Code : 0000 Sec : JAJ-HUR Division : ASH  
 Directorate (TM) R.U.S.O./PEP Meerut Software Version 1.40H

Section Speed : 100 KMPH (For calculating TGI)

Parameter Settings  
 Sampling Distance = 0.405 (M) (For chord calculation)  
 Tacho Factor = 0.4050 (M) (For route tape)

	UN1	UN2	AL1	AL2	TU1	TU2	GAGE	VACC	LACC
Chord (M)	3.6	9.6	7.2	9.6	3.6	9.6	ABS	ABS	ABS
SD Maint Limits(mm)Urgent	3.5	6.1	3.0	5.0	3.7	4.5	3.5		***
SD Maint Limits(mm) Plan	3.0	5.5	2.7	4.0	3.4	3.7	2.9		**
PK Limits (LOW)	10	10	7	7	10	10	6	0.10	0.10
PK Limits (HIGH)	15	15	10	10	15	15	10	0.20	0.20
GRAPHICS CHANNEL	0	1	2	3	4	5	6	7	
	UN1L	UN1R	AL1L	AL1R	G	CANT	TU1	LACC	

Long chord peak distribution bands

Band	Lower limit (mm)
X	5
Y	10
Z	15

TWIST CALCULATED FROM DYNAMIC CROSS LEVEL

Route Code : 0000 Date : 22/1/1997 Run No : D KM 0181 TO 0190

LOC	UN1L	UN1R	TU1	GAGE	AL1L	AL1R	RI	V	RI	L	GF/TGI	SPD	MI	UN2L	UN2R	AL2L	AL2R	TU2	MI	UN1	UN2	AL1	AL2
DLK1	2.0	1.7	3.7	2.0	2.9	2.7	2.61	2.23	51	49	***	3.9	3.6	4.3	3.9	5.1	7A	7A	85	87	82	82	
DLK2	1.9	1.8	2.6	1.5	2.1	2.0	2.83	2.45	71	54		4.6	3.8	2.6	2.6	3.2	7H	7H	82	70	82	70	
DLK3	1.7	1.6	2.4	1.5	2.3	2.4	2.67	2.46	65	56		4.0	3.1	2.9	2.0	2.9	8H	7H	81	56			
DLK4	1.8	1.7	2.9	1.7	1.6	1.7	3.29	2.57	80	60		5.1	4.0	1.8	2.1	3.1	6A	6A	62	77	69		
DLK5	2.3	2.5	4.1	2.0	3.2	3.0	3.79	2.88	41	62	***	5.9	5.8	4.2	3.9	4.2	49	1H	6H	15			
DLK6	1.2	1.7	2.6	2.2	2.3	3.6	2.47	2.60	50	62	***	3.7	4.1	3.0	4.2	3.6	7A	69	6A	17			

PEAK DISTRIBUTION

A	7	7	34	32	62	59								1>X	89	64	33	29	35				
B	7	2	11	1	18	20								1>Y	14	13	6	4	3				
C	1	0	4	0	0	0								1>Z	4	2	0	0	2				

CATE A1 A2 C11 B1 C18 C20 TGI 59 Speed 56 KMPH

Worst Peak Information

UN1L	17/2	8/417	8/885	8/935	8/973	7/228	7/745	6/159
UN1R	11/922	11/935	9/966	9/992	8/971	7/261	7/973	6/264
TU1	21/4	18/12	13/923	12/998	10/885	10/927	10/992	9/845
G	7/1023	6/23	6/799	6/930	5/6	5/41	5/173	5/189
AL1L	12/4	11/42	11/989	10/11	10/984	9/914	8/414	7/23
AL1R	12/1021	9/451	9/1017	8/49	8/455	8/922	8/963	8/969
UN2L	24/805	22/5	18/891	17/879	14/360	14/365	13/658	12/674
UN2R	17/919	17/925	15/884	15/993	14/878	13/890	13/936	13/971
AL2L	15/4	15/60	15/991	13/24	11/915	11/983	10/909	9/883
AL2R	12/49	12/970	11/991	11/1023	10/3	10/451	9/14	9/374
TU2	26/17	21/10	13/934	10/442	10/1002	9/51	9/94	9/222
VACC	22/893	25/905	23/881	22/917	22/940	21/900	20/928	20/888
LACC	10/924	10/998	10/919	10/907				

III - JYK3MM

Exception Report for blocks Requiring planned or urgent maintenance.

DN BLOCK#	SPEED	Normalized value of SD on short chord				Normalized value of SD on long chord				VAL VALUE				
		UJ	WI	54	AL1	AR1	UJ2	UR2	AL2		AR2	WJ2		
1201 BLOCK#	80	0.42	0.44	0.63	0.94	1.17	0.80	0.55	0.73	0.78	0.58	0.58	47.59	1.17
1204 BLOCK#	99	0.33	0.36	0.58	0.61	0.43	0.58	0.48	0.65	0.36	0.40	0.27	93.73	0.87
210 BLOCK#	43	0.42	0.50	0.73	0.69	1.07	1.07	0.55	0.61	0.84	0.86	1.00	45.23	1.07
1210 BLOCK#	47	0.42	0.53	0.66	0.64	0.78	0.98	0.53	0.68	0.64	0.64	0.67	54.23	0.98
211 BLOCK#	42	0.42	0.58	0.74	0.72	1.10	1.10	0.55	0.74	0.81	0.89	0.76	42.60	1.10
215 BLOCK#	101	0.36	0.42	0.61	0.33	0.43	0.47	0.66	0.73	0.36	0.38	0.84	55.51	0.94
217 BLOCK#	99	0.44	0.50	0.58	0.31	0.37	0.50	0.76	0.89	0.26	0.34	0.78	54.31	0.94
218 BLOCK#	98	0.36	0.44	0.63	0.36	0.43	0.53	0.56	0.74	0.32	0.42	0.87	51.33	0.87
20 BLOCK#	95	0.47	0.44	0.71	0.94	0.77	0.83	0.68	0.81	0.62	0.62	0.87	54.55	0.94
21 BLOCK#	96	0.53	0.56	0.82	0.69	0.87	1.13	0.65	0.87	0.68	0.82	0.73	43.37	1.13
11 BLOCK#	96	0.50	0.61	0.61	0.89	0.80	1.17	0.53	0.76	0.58	0.84	0.82	46.27	1.17
22 BLOCK#	97	0.61	0.67	0.58	0.39	0.47	0.53	0.81	0.98	0.36	0.40	0.62	25.57	0.72
0 BLOCK#	97	0.53	0.56	0.71	0.47	0.63	0.77	0.69	0.90	0.50	0.62	0.82	64.45	0.90
1 BLOCK#	100	0.47	0.47	0.61	0.47	0.63	0.70	0.58	0.68	0.46	0.60	0.78	65.11	0.90
1 BLOCK#	100	0.42	0.42	0.66	0.67	0.98	1.07	0.56	0.73	0.67	0.82	0.76	51.37	1.07
1 BLOCK#	97	0.47	0.47	0.71	0.56	0.78	0.98	0.58	0.85	0.52	0.62	0.80	57.27	0.98
1 BLOCK#	95	0.58	0.64	0.76	0.58	0.67	0.80	0.63	0.92	0.52	0.68	0.78	61.42	0.92
1 BLOCK#	93	0.58	0.53	0.74	0.69	0.67	1.17	0.58	0.90	0.50	0.86	0.89	43.82	1.17
1 BLOCK#	100	0.28	0.28	0.61	0.33	0.37	0.43	0.55	0.66	0.32	0.34	0.93	124.45	0.73
1 BLOCK#	99	0.39	0.41	0.68	0.64	0.78	0.87	0.58	0.53	0.58	0.62	0.84	62.85	0.87
1 BLOCK#	98	0.61	0.72	0.45	0.28	0.37	0.37	0.77	0.89	0.28	0.26	0.51	100.34	0.89
1 BLOCK#	96	0.69	0.67	0.61	0.31	0.43	0.47	0.98	0.87	0.28	0.30	0.51	74.87	0.87
1 BLOCK#	82	0.58	0.53	0.71	0.28	0.49	0.47	0.98	0.97	0.38	0.34	0.71	94.82	0.97
1 BLOCK#	73	0.58	0.67	0.84	0.31	0.58	0.43	0.76	0.85	0.32	0.34	0.82	95.53	0.85
1 BLOCK#	71	0.61	0.72	0.97	0.36	0.58	0.53	0.77	1.34	0.38	0.34	0.67	105.67	1.34
1 BLOCK#	68	0.53	0.56	0.74	0.26	0.43	0.57	0.63	0.97	0.34	0.42	0.87	71.58	1.34
1 BLOCK#	51	0.67	0.75	0.84	0.39	0.47	0.60	0.81	1.11	0.34	0.47	0.62	85.32	1.11
1 BLOCK#	48	0.61	0.67	0.79	0.58	0.63	0.77	0.66	0.85	0.58	0.56	0.67	100.34	0.85



161 PW/AEM/DEN/DIV WISE

JURISDICTION	RLY GROUP	DIR	DATE OF RUN	TRC NO	RFR	INTD	INDICES OF THE INDIVIDUAL PARAMETER					LAGE	LEMSIN	REQUIR
							INDEX UN	INDEX B	INDEX TW	INDEX AL	INDEX TGI			
KD-BPL	CR	SHT	UP	10/96	2500	1517	839	73	79	84	59	66	24	9
IB-SECTION														
D-AGC	CR	SHT	UP	10/96	2500	1517	1343	78	74	91	51	61	34	8
HC-JHS	CR	SHT	UP	10/96	2500	1343	1128	68	73	77	56	62	35	12
S-BINA	CR	SHT	UP	10/96	2500	1128	977	88	84	92	72	77	9	5
KA-BPL	CR	SHT	UP	10/96	2500	977	839	76	87	88	62	67	11	8
L-TXD	CR	SHT	DN	12/96	2500	835	1515	76	77	85	65	70	21	7
SUB-SECTION														
BPL-BINA	CR	SHT	DN	12/96	2500	835	977	77	82	79	73	75	9	4
BINA-JHS	CR	SHT	DN	12/96	2500	977	1129	88	82	92	78	82	5	4
JHS-AGC	CR	SHT	DN	12/96	2500	1128	1343	74	76	87	64	69	22	9
AGC-TXD	CR	SHT	DN	12/96	2500	1343	1515	65	71	88	44	55	44	13

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THE PNT/PER/SEN/BS/WISE

INDIVIDUAL

DIR/DIRECTION	FLY GROUP	DIR	DATE OF FLY	TRC NO	JSPR	LATO	INDICES OF THE <u>INDEXED</u> PARAMETER					TREE LENGTH RESERVE	
							INDEX ON	INDEX 6	INDEX 10	INDEX 14	INDEX 15	DIFFERENTIAL	PERCENT
PNT/BPL(N)	CR	SHT	DN	12/21/96	2588	835	855	88	88	82	74	77	14
PNT/BHS(S)	CR	SHT	DN	12/21/96	2588	855	871	79	77	78	71	74	14
ACK/BPL(N)	CR	SHT	DN	12/21/96	2588	835	871	79	79	88	72	75	11
DEN/BPL(HD)	CR	SHT	DN	12/21/96	2588	835	871	79	79	88	72	75	11
PNT/BHS(N)	CR	SHT	DN	12/21/96	2588	891	933	76	81	82	78	79	7
PNT/BAO	ER	SHT	DN	12/21/96	2588	933	977	75	81	75	78	75	9
ACK/BKA	CR	SHT	DN	12/21/96	2588	831	977	75	83	79	74	76	8
DEN/BPL(C)	CR	SHT	DN	12/21/96	2588	871	977	75	83	79	74	76	8
DIV/BPL(D)	CR	SHT	DN	12/21/96	2588	835	977	77	82	79	73	75	9
PNT/LAR(S)	CR	SHT	DN	12/21/96	2588	977	1037	82	87	91	82	83	5
PNT/LAR(N)	CR	SHT	DN	12/21/96	2588	1037	1082	94	79	93	76	82	1
PNT/JHS(S)	CR	SHT	DN	12/21/96	2588	1082	1129	89	78	93	76	81	7
ACK/JHS(N)	CR	SHT	DN	12/21/96	2588	977	1129	82	82	92	78	82	5
DEN/JHS(S)	CR	SHT	DN	12/21/96	2588	977	1129	88	82	92	78	82	5
PNT/JHS(N)	CR	SHT	DN	12/21/96	2588	1129	1172	98	83	94	76	82	6
PNT/DPA	CR	SHT	DN	12/22/96	2588	1172	1215	81	81	92	72	77	13
ACK/GWL(M)	CR	SHT	DN	12/22/96	2588	1129	1215	85	82	93	74	77	13
PNT/GWL(M)	CR	SHT	DN	12/22/96	2588	1261	1284	59	57	85	51	57	25
PNT/AGC(S)	CR	SHT	DN	12/22/96	2588	1324	1345	78	77	94	54	52	28
PNT/AGC(N)	CR	SHT	DN	12/22/96	2588	1345	1386	53	57	88	47	54	16
ACK/AGC(N)	CR	SHT	DN	12/22/96	2588	1261	1326	65	68	87	58	58	25
PNT/MTJ	CR	SHT	DN	12/22/96	2588	1386	1413	74	74	97	47	59	20
PNT/ISV	CR	SHT	DN	12/22/96	2588	1413	1462	53	72	72	49	44	17
PNT/FML	CR	SHT	DN	12/22/96	2588	1452	1494	67	72	82	41	51	14
PNT/PEB	CR	SHT	DN	12/22/96	2588	1494	1515	52	57	82	47	57	12
ACK/MTJ	CR	SHT	DN	12/22/96	2588	1386	1515	67	72	82	43	58	14
PNT/AGB	CR	SHT	DN	12/22/96	2588	977	1515	75	78	87	62	64	2
FLY	CR	SHT	DN	12/23/96	2588	835	1515	75	77	85	65	72	21

END

The Secretary(Track Machines),  
Railway Board,  
Rail Bhawan, New Delhi.

( Kind attn. Shri Rakesh Chopra, EDTK(MC) )

Sub: Adoption of standard deviation based index for  
monitoring quality of maintenance of track.

Ref: RDSO'S letter of even no. dated 26/2/96 addressed  
to Chief Engineers of Central, Eastern, Northern,  
South-Eastern and Western Railways and Copy to  
EDCE (P), Railway Board. New Delhi.

.....

Results of the last two track recordings on NDLS-HWH  
and MTJ-MCT Rajdhani Routes, NDLs-BPL Shatabdi Route, and HWH-NGP  
and KYN-MBCST sections in terms of the new standard deviation  
based indices (TGI and the indices for the individual parameters  
UI, TI, GI and AI) were sent to Chief Engineers of Central,  
Eastern, Northern, South-Eastern and Western Rlys for their  
comments vide TM Dte.'s letter under reference. Comments have  
been received from all the Railways except Central Railway. The  
comments have been examined. Remarks on the comments received  
from the various Railways are placed at Annexure-I.

2. Following recommendations are made regarding adoption  
of the TGI formula:-

.1 INDICES FOR THE INDIVIDUAL PARAMETER:

(i) The index for the individual parameters gives  
quality rating to the measured standard deviation values  
by relating them with the standard deviation values pre-  
scribed for newly laid track and the standard deviation  
value for urgent maintenance through an exponential  
function. The value of the index for the individual  
parameter will mostly vary from 36 for track which has  
reached urgent maintenance limit to 100 for the track  
having SD value equal to the SD value prescribed for  
newly laid track. From the index values recorded during  
track recording in the past 6 months, it has, however,  
been observed that the value of individual parameters  
for exceptionally well maintained track may be upto 140  
and for poorly maintained track upto 15.

(ii) If index value for a parameter is 36 or less, it  
indicates that the track requires urgent maintenance.  
Similarly, if the index value is equal to or less than  
45 but more than 36 the track should be kept under watch  
and attended early.

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r/rU. All blocks having the index value for any one or more of the parameters as 36 or lower should be listed in the descending order of the normalised SD value. The block having the highest normalised value should be given the highest priority for maintenance. RDSO will make a software for listing of all stretches of track needing urgent or planned maintenance in the descending order of priority by off-line processing of recorded data. This exception list will be given to the Railways at the end of each day's recording.

.4 GRADING OF TRACK ON THE BASIS OF TGI VALUE:

The TGI value normally ranges from 20 to 125. For putting the value of TGI in proper perspective and guidance of the field officers, following grading of quality of track on the basis of TGI is recommended. This has been arrived at by analysing results of randomly selected stretches of track on various routes. The TGI values of four such stretches of track in the various ranges of TGI values are shown in Annexure-II.

<u>Classification</u>	<u>Rajdhani and Shatabdi Routes</u>	<u>Other Routes</u>
Very Good	> 95	> 80
Good	80 - 95	70 - 80
Fair	60 - 80	50 - 70
Poor	< 60	< 50

.5 REPORTING OF RESULTS :

(i) Reporting of results during recording run: The print-out of results given in real-time by the IRCs during recording runs shall be modified as follows to include values of SD based indices:

(a) Standard Deviation values for each parameter are being given at present for each block of 200 meters. In addition to the SD values, the individual index values (UI, TI, AI & GI) for each block shall be given.

(b) The information regarding the number of peaks exceeding A, B, C & D limits shall be discontinued. Similarly, CTR value shall not be given and in its place TGI value for each Km shall be given.

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(c) The size and location of eight largest potholes in a kilometer for each parameter shall continue to be reported as these are required for spot maintenance.

(ii) Monthly Report on track monitoring: In the monthly report on track monitoring sent by RDSO to Railway Board and CEs/Zonal Rlys, following information on the track recording results shall be given.

(a) TGI value and value of the indices for each of the Track Geometry parameter (UI, TI, GI & AI), for the full length a route falling on a railway, and for the various nominated sub-stations.

(b) Number of Kms and percentage recorded length having index value for the individual parameters equal to or less than 36.

(c) Number of Kms and percentage recorded length having index value for the individual parameter equal to or less than 45 but more than 36.

Proposed proforma for reporting results is kept as Annexure-III.

(iii) Analysis of Results by the Railways: The Railways shall work-out the above results for each PWI, AEN, DEN/Sr. DEN of sections, and Divisions using recorded data given by RDSO to Rlys during recording run. A software for working out these results using PC shall be supplied by RDSO to the Rlys.

#### .6 SCOPE OF IMPLEMENTATION OF TGI

The TGI formula be adopted on all Group A, B, C and D routes. On the Group E routes, the revised CTR formula should be implemented because on the Group E routes the permissible speed limits are much lower than 105 kmph.

DA: As above.  
(Annexure-I, II & III)

( A.P. Mishra )  
for Director General/TM

ANNEXURE-1

RAILWAY	POINTS RAISED BY THE RAILWAY	COMMENTS OF RDSO
Northern Letter No. 219-W/28/ Policy dt. 12.7.96	Besides TGI for the whole km, one is required to see the values of TGI, UI, GI, TI & AI for all the blocks in that km for planning maintenance inputs to track. It is quite likely that TRC print out may not be analysed in that details by PWI.	Covered under para 2.3. and 2.5
B.E. Letter No. TC/TRC/TGI/ 2592 dt. 20.4.96	1. From comparison sheet of TGI and CTR values, it is seen that at same km <u>TGI values have come less</u> in case of the CTR value (which would have been more) & more TGI value in case of -ve CTR value (which would have been less).	Because the limiting peak sizes for the various parameters in the CIR formula are small, the CIR value is liable to fluctuate widely, particularly on run-down track. Further, SD value is more suited for assessing quality of longer stretches of track as compared to peak size which is more suited for measuring isolated defects.
	2. Results of TGI values is essential as per <u>Divisional jurisdictionwise.</u>	TGI values should be calculated for FWI, AEN and DEN/Sr. DEN sections as well as for the Division by the Railways. For this software shall be provided by RDSO.
	3. TGI & values of individual indices (UI, GI, TI and Alignment Index) separately <u>less than 45 &amp; more than 45</u> is essentially required after each run which will indicate clearly that the track of that block requires attention in r/o that particular parameter even though overall TGI may be more than 45.	Covered under para 2.5
	4. <u>A sample calculation</u> for finding out TGI value may be sent for guidance.	TGI formula is not amenable to manual calculations. Software shall be provided to the railways by RDSO for computerised analysis.

Note : The para nos referred in the "comments of RDSO" column are of the covering letter to this Annexure.

III ER  
Letter No.  
4.632/24/7  
dt.14.5.96

1. Kms having higher CTR values (less peaks) are showing a lower TGI and Km with lower CTR values (more peaks) are categorised on higher TGI which is likely to confused field supervisors at the initial stage. Thus the comparison of track on CTR values may be totally eliminated to provide uniformity.
2. The concept of TGI based on 60/block of 200m should be taught at various training institutions for P. Way supervisors and officers so that the officials are through with the new system of track monitoring.
3. E. Railway HWH-STN-MGS via PNBE (Gr 'R') section is also a Rajdhani Route and efforts are on for increasing the max. permissible speed to 120 kmph in the near future. Therefore RDSO may add this route for recording with TRCs provided with TGI system.

Once switchover to TGI is completed, comparison on CTR basis shall be stopped.

RDSO shall organise a training course for the P/ Way instructors of Railway ITSS so that the instructors can carry out wider dissemination of concepts regarding SI basis appraisal of track quality.  
Covered under para 2.6

JR  
Letter No.  
W 627/29  
(BG) dated  
22.4.96

1. Based on the recorded SD for 9.6m base for unevenness, 3.6m base for twist & 7.2m base for alignment by microprocessor based TRC then individual indices designated as UI, GI, TI and AI are to be calculated as per new formula. This is to be done for every 200m of recording.
2. A value of about 45 will be obtained for every individual parameter when the recorded SD of individual parameter reaches the limit prescribed for maintenance plan.
3. When the SD value prescribed for urgent Maintenance is reached, the individual index will be 36, i.e. the exponentiation to E will be -1.

No Comments

-do-

-do-

Note: The para nos referred in the "Comments of RDSO" column are of the covering letter to this Annexure.

- |   |  |
|---|--|
| <p>4. It is observed from the data sent by RDSO for last two recording (viz. MTJ-KTT-NAD-GDA, GDA-ST &amp; ST-BCT) <u>that on none of the sec for any of the parameter the threshold value of 45 for maintenance planning has been reached.</u> It is bound to happen since sub section selected are too long to indicate areas with indices lower than 45 or 36.</p> | <p>For maintenance planning SD value of individual parameters each block should be considered separately. See para 2.1 and 2.</p>                  |
| <p>5. There would be several stretches (200m long) where recorded values of these indices will <u>be below 36</u> indicating that existing SD of the parameter is lower than the stipulated value for Maintenance. The output sent by RDSO do not give any indication on them.</p>  | <p>The outputs sent by RDSO of km-wise results were of TGI value only.</p>   |
| <p>6. Instead of giving peak exceedences in the table enclosed with RDSO letter, <u>it might have been better to give the SDs of individual parameters for better appreciation of state of track geometry.</u></p>  | <p>See para 2.5</p>  |
| <p>7. It may be advisable <u>to give data on % of track (in 200m blocks) where the individual parameters have fallen below 45 and 36.</u></p>   | <p>See para 2.5</p>  |
| <p>8. In the prevalent conditions of track <u>what are the highest achievable and lowest possible</u> values of individual parameters to give an idea about the possible variation and the state of existing track maintenance.</p>   | <p>See para 2.1 &amp; 2.2</p>  |
| <p>9. The SD values given for <u>newly laid track appear to be unrealistic for new track</u> being laid, rather they should be called as SDs for ideal track.</p>   | <p>On the other hand this value appears to be rather slack for the Gr. A routes since large number of kms are found to be having TGI &gt; 100.</p> |

Note : The para nos referred in the "Comments of RDSO" column are of the covering letter to this Annexure.

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## ACKNOWLEDGEMENT

This booklet has been prepared under the guidance of Shri A.P. Mishra EDTM by the team of following officers and staff :

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