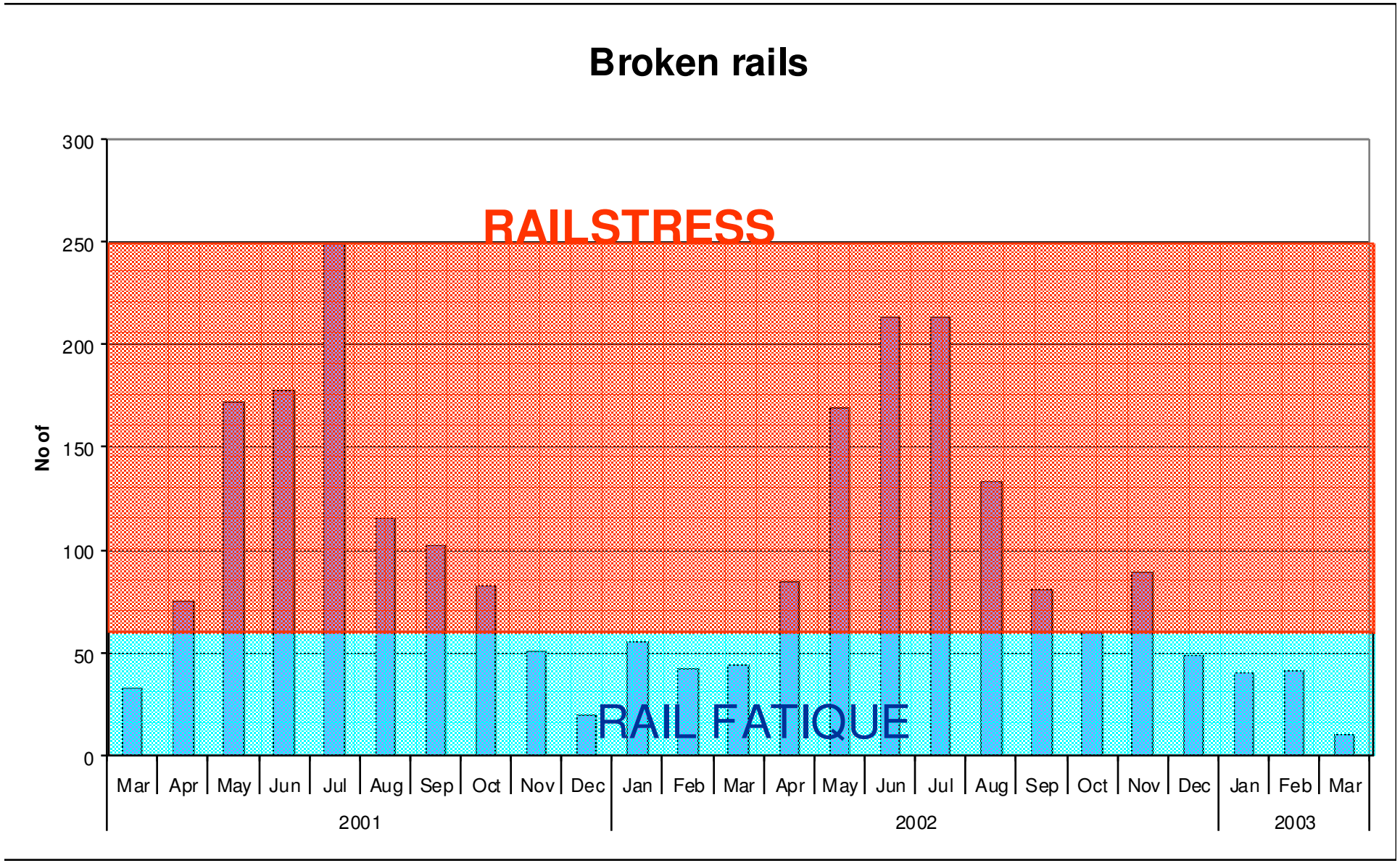
SPOORNET

SAICE : RAIL STRESS : OVERVIEW

IS RAILSTRESS VISIBLE IN TIME ?

Figure 1.1 Typical kickout


Broken rails
300
250
200
150
100
50
0
No of
RAILSTRESS
RAIL FATIQUE
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
2001
2002
2003

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SAICE : RAILSTRESS PRESENTATION

SAFE PASSAGE OF TRAINS

KICK OUTS = VERY DANGEROUS

RAILBREAKS = DANGEROUS

RAIL STRESS = VERY IMPORTANT

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SAICE : RAILSTRESS PRESENTATION

KICKOUTS : TYPICAL THREE FACTORS +

1. HIGH AMBIENT TEMPERATURE
2. WORK PERFORMED ON TRACK
3. SKEW BOGIES

SAICE : RAILSTRESS PRESENTATION

KICKOUTS : OTHER FACTORS

4. BALLAST STANDARD

5. FASTENINGS

6. VERSINE OFF SETS

7. CRITICAL PLACES

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SAICE : RAILSTRESS PRESENTATION

RAILSTRESS : CRITICAL PLACES

1. SIGNALS
2. STEEP GRADIENTS
3. TAMPING OF CURVES
4. TURNOUTS ON TIMBER

RAILSTRESS : CRITICAL PLACES (CONT.)

5. LONGSPAN CONCRETE BRIDGES
6. CHANGE IN FASTENING SYSTEMS
7. PEDESTRIAN CROSSINGS
8. LOW TRAFFIC VOLUME

SAICE : RAILSTRESS PRESENTATION

PERWAY TRADITIONAL FOCUS AREAS

VERTICAL FORCES

- VISIBLE

LATERAL FORCES

- NOT VISIBLE - UNTIL TOO LATE

SPOORNET

SAICE : RAILSTRESS PRESENTATION

ΔT_{CR} ABOVE $T_{NEUTRAL}$ BEFORE KICKOUT

57KG : PY/FY@700mm : B. PROFILE

HOR : R200 - 500 : ΔT_{CR} = 19 - 37 ºC

VERT. CURVES : ΔT_{CR} = 79 - 87 ºC

FS = 1.4 ; ALF = 20mm

SPOORNET

SAICE : RAILSTRESS PRESENTATION

RE-FOCUS REQUIRED

TRACK STABILITY DUE TO ΔT

LATERAL CRITICAL

LATERAL FORCES INVISIBLE

MEASUREMENT + MANAGEMENT

SPOORNET

SAICE : RAILSTRESS PRESENTATION

- RAIL TEMPERATURE RANGES

AIR TEMPERATURES IN R.S.A.: 50+ YEAR HISTORY

$T_{RAIL\ MAX} = T_{AIR\ MAX} + 23ºC$

$T_{RAIL\ MIN} = T_{AIR\ MIN} - 4ºC$

BIGGEST DIFFERENCE MAX-MIN RAIL TEMP. = 80 ºC

SMALLEST DIFFERENCE MAX-MIN RAIL TEMP. = 65 ºC

INTL. NORM : MAX $\Delta T\uparrow$ ABOVE $T_{NEUTRAL}$ = 35 - 45 ºC

INTL. NORM : MAX $\Delta T\downarrow$ BELOW $T_{NEUTRAL}$ = 45 - 55 ºC

SPOORNET NORM : MAX $\Delta T \downarrow$ = 50 ºC ; $\Delta T \uparrow$ = 40 ºC

SPOORNET

SAICE : RAILSTRESS PRESENTATION

- MAXIMUM RAIL TEMPERATURES

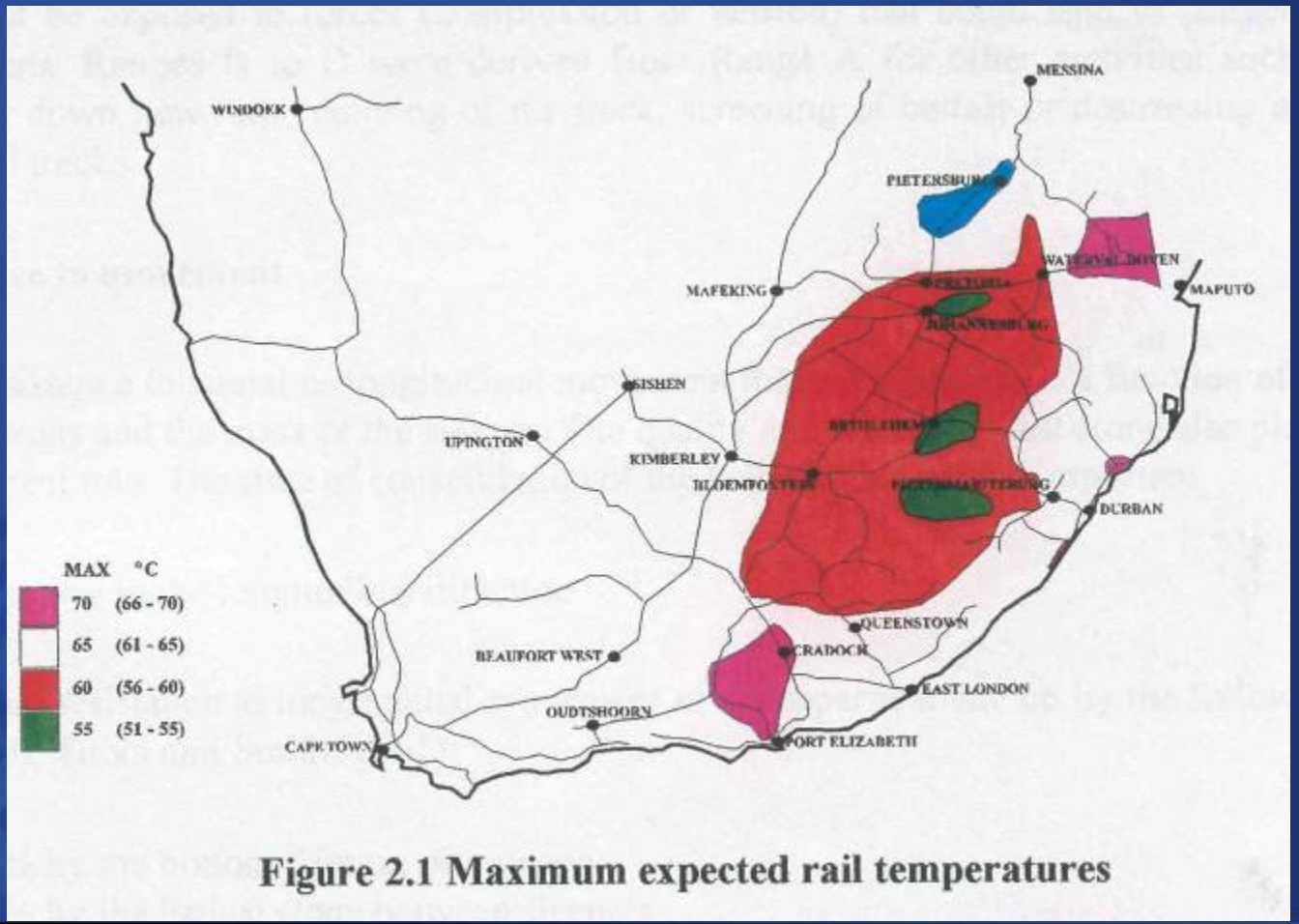


Figure 2.1 Maximum expected rail temperatures

SPOORNET

SAICE : RAILSTRESS PRESENTATION

- MINIMUM RAIL TEMPERATURES

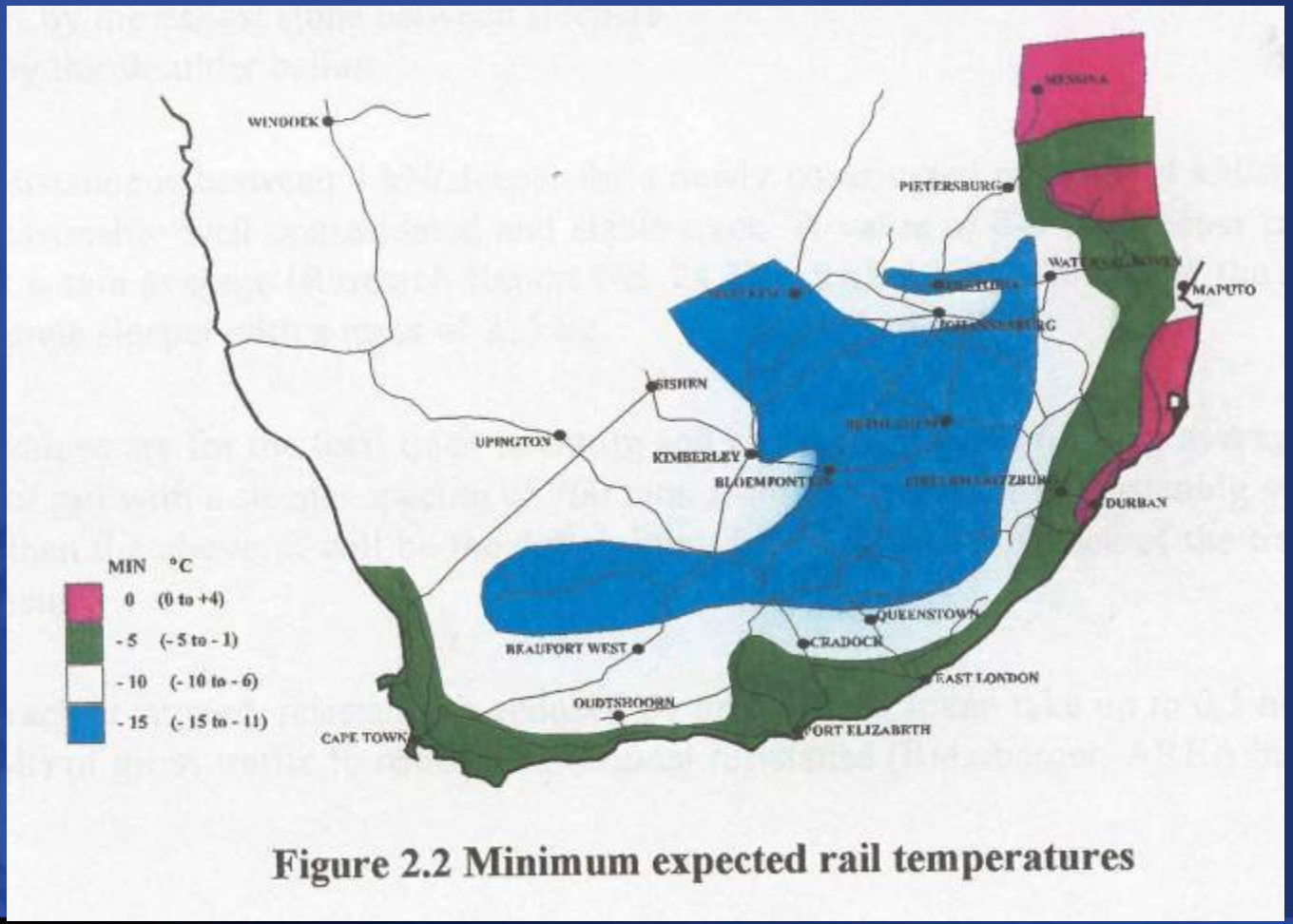
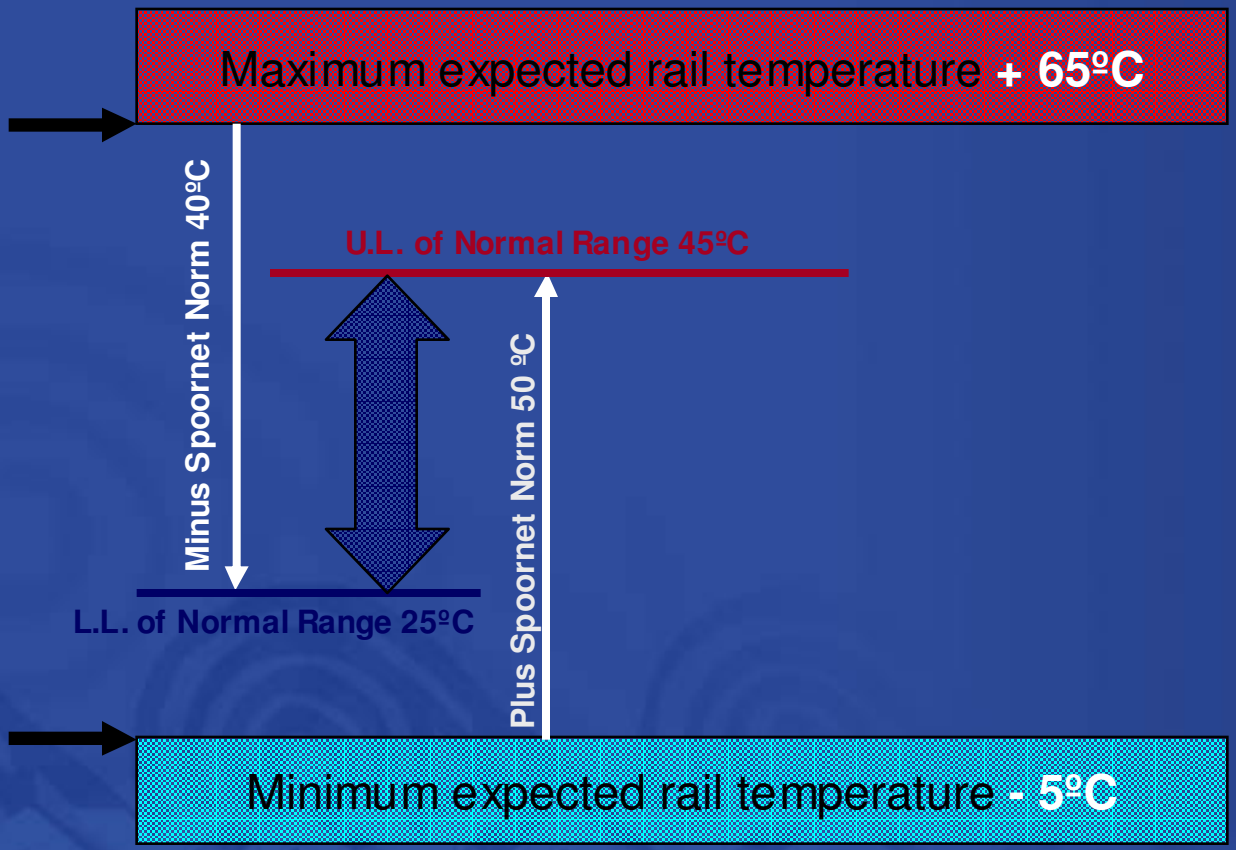


Figure 2.2 Minimum expected rail temperatures

SPOORNET

SAICE : RAILSTRESS PRESENTATION

Destressing Ranges-Tangent Track and Mild Curves



SAICE : RAILSTRESS PRESENTATION

- RAIL DESTRESSING TEMPERATURE RANGES (CONT.)

EXAMPLE : **BELLVILLE - WORCESTER**

TEMP. HISTORY => $T_{RAIL\ MAX}$ = + 65 ºC

TEMP. HISTORY => $T_{RAIL\ MIN}$ = - 5ºC

$T_{RAIL\ MAX}$ - $\Delta T\uparrow$ = 65 ºC - 40 ºC = 25 ºC

$T_{RAIL\ MIN}$ + $\Delta T\downarrow$ = - 5 ºC + 50 ºC = 45 ºC

MTM (2000), ANNEXURE 16 SHEET 3/5

LOWER LIMIT OF A - RANGE = 25 ºC

UPPER LIMIT OF A - RANGE = 45 ºC

SAICE : RAILSTRESS PRESENTATION

ANNEXURE 16
SHEET 3 of 5
AMENDMENT

DESTRESSING AND WORKING TEMPERATURE RANGES

SECTION	DESTRESSING RANGES		WORKING RANGES FOR RAIL LAYING	
	THROUGH LINES	YARD TRACKS		
	A	D	B	C
CAPE TOWN – BELLVILLE	20 – 50	25 – 45	15 – 55	15 – 60
* BELLVILLE – WORCESTER	25 – 45	30 – 40	20 – 50	20 – 60
* WORCESTER – DE AAR	25 – 40	25 – 35	20 – 50	20 – 55
HUTCHINSON – CALVINIA	25 – 35	25 – 30	20 – 40	20 – 50
KOOTJIESKOLK – SAKRIVIER	25 – 35	25 – 30	20 – 40	20 – 50
KRAAIFONTEIN – BITTERFONTEIN	25 – 45	30 – 40	20 – 50	20 – 60
KALBASKRAAL – SALDANHA	25 – 45	30 – 40	20 – 50	20 – 60
HERMON – PORTERVILLE	25 – 45	30 – 40	20 – 50	20 – 60
WOLSELEY – PRINCE ALFRED HAMLET	25 – 45	30 – 40	20 – 50	20 – 60
PAARL – FRANCHHOEK	25 – 45	30 – 40	20 – 50	20 – 60
EERSTERIVIER – BREDASDORP	25 – 45	30 – 40	20 – 50	20 – 60
VAN DER STEL – STRAND	25 – 45	30 – 40	20 – 50	20 – 60
KLIPDALE – PROTEM	25 – 45	30 – 40	20 – 50	20 – 60
EERSTERIVIER – MULDERSVLEI	25 – 45	30 – 40	20 – 50	20 – 60
* WORCESTER – RIVERSDALE	25 – 40	30 – 35	20 – 45	20 – 55
KENTEMADE – ATLANTIS	25 – 45	30 – 40	20 – 50	20 – 60
TABLE BAY HARBOUR – SIMONSTOWN	20 – 50	25 – 45	15 – 55	15 – 60
CAPE TOWN CENTRAL METRO AREA	20 – 50	25 – 45	15 – 55	15 – 60

SAICE : RAILSTRESS PRESENTATION

- TEMPERATURE FORCES IN RAIL

$$P = \alpha \Delta T E A$$

BIGGEST DIFFERENCE BETWEEN MIN-MAX = 80 ºC

↓ SMALLEST DIFFERENCE BETWEEN MIN-MAX = 65 ºC

$P_{80ºC}$ = 141 ton

$P_{65ºC}$ = 115 ton

SPOORNET NORM : MAX $\Delta T\downarrow$ = 50 ºC ; $\Delta T\uparrow$ = 40 ºC

$P\downarrow_{50ºC}$ = 88 ton

$P\uparrow_{40ºC}$ = 70 ton

SPOORNET

SAICE : RAILSTRESS PRESENTATION

- **LONGITUDINAL** RESISTANCE OF TRACK

  30 - 40%: FRICTION BETWEEN BALLAST EN SLEEPER BOTTOM

  60 - 70%: FRICTION OF BALLAST IN BOXES

  0 - 5%: FRICTION OF SHOULDER BALLAST

  SLPR RESISTANCE : 0.4t TO 1.4t PER SLPR (P2/F4 @ 700mm)

  FASTENINGS RESISTANCE : AVERAGE 0.6t/m RAIL (P2/F4 @ 700mm)

  TAMPED TRACK : RESISTANCE Δ BY 40%

  REQUIRE 0.5 MGT TO RESTORE TO ORIGINAL RESISTANCE

  FUNCTION OF SLEEPER, TYPE AND QUANTITY OF BALLAST

SPOORNET

SAICE : RAILSTRESS PRESENTATION

- **LATERAL** RESISTANCE OF TRACK

30 - 60%: FRICTION BETWEEN BALLAST EN SLEEPER BOTTOM

20 - 40%: FRICTION OF BALLAST IN BOXES

10 - 40%: FRICTION OF SHOULDER BALLAST

TRACK RESISTANCE : AVERAGE 0.7 - 1.0t /m (P2/F4 @ 700mm)

SHOULDER BALLAST CRITICAL : e.g. LIFT WAVE LIFT 10 SLPRS

SHOULDER BALLAST MAX 450MM : MORE ? : NO PURPOSE

HEAPED SHOULDER BALLAST : RESISTANCE Δ BY 15 - 20%

TAMPING Δ RESISTANCE 40 - 50% : TAKES 0.5MGT TO RESTORE

SPOORNET

SAICE : RAILSTRESS PRESENTATION

- **FISHPLATE AND SPLICE JOINTS**

  $\Delta T \uparrow$ OF 20ºC AFTER CLOSE OF GAP = KICKOUT

  $\Delta T \downarrow$ OF 30 ºC AFTER FULLY OPENED GAP = BROKEN FISH BOLTS

  GOOD FASTENINGS TO PREVENT CREEP

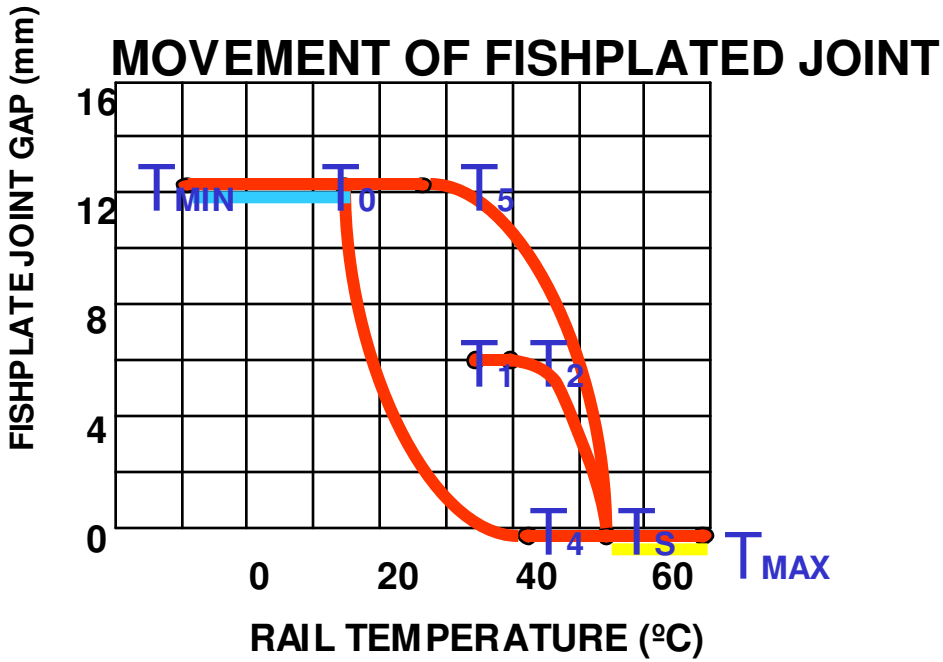
  GAP SET CORRECTLY AT CORRECT TEMPERATURE

  RESISTANCE OF FISHPLATE JOINT = 10 ton

  HEAPED SHOULDER BALLAST : RESISTANCE Δ BY 15 - 20%

  TAMPING Δ RESISTANCE 40 - 50% : TAKES 0.5MGT TO RESTORE

  SPLICE JOINTS : MTM(2000) CLAUSE 6.8.3



T_1 - T_2 = No movement in Gap, Joint resistance overcome

T_2 - T_S = Gap closes, each railend moves 0.5s, 6.25mm

T_S - T_{MAX} = Gap closed, compression force develops in rails

T_{MAX} - T_S = Compression force reduces to 0 at T_S

T_S - T_4 = Friction in joint is overcome, no movement in gap

T_4 - T_0 = Gap opens until fully opened at T_0, 12.5mm

T_0 - T_{MIN} = Tension develops in joint

SAICE : RAILSTRESS PRESENTATION

- ΔT_{cr} ºC = CRITICAL RAIL TEMPERATURE INCREASE ABOVE NEUTRAL TEMPERATURE : LOMBARD, 1978

MOMENT OF ENERTIA OF TRACK AROUND VERTICAL AXIS

MASS OF TRACK PER METER LENGHT

SECTIONAL AREA OF RAIL

ALIGNMENT FAULT

RADIUS OF HORIZONTAL CURVE

SHOULDER BALLAST RESISTANCE

SAICE : RAILSTRESS PRESENTATION

- ΔT_{cr} ºC = CRITICAL RAIL TEMPERATURE INCREASE ABOVE NEUTRAL TEMPERATURE : LOMBARD, 1978

$$\Delta T_{cr}\,^{o}C = \sqrt{\left[\frac{4 \times Jy}{f \times R}\right]^{2} + \frac{4 \times Jy \times q}{\alpha^{2} \times A^{2} \times E \times f} - \left[\frac{4 \times Jy}{\alpha^{2} \times A^{2} \times E \times f}\right]}$$

Jy = Equivalent moment of inertia of the track around vertical axis (m^4)

f = Alignment fault (m)

R = Radius of the curve (m)

A = Sectional area of the rail (m^2)

α = Temperature coefficient for rail steel (11.5×10^{-6} / ºC)

q = Ballast resistance (kN/m)

E = Young's modulus for rail steel (205 Gpa)

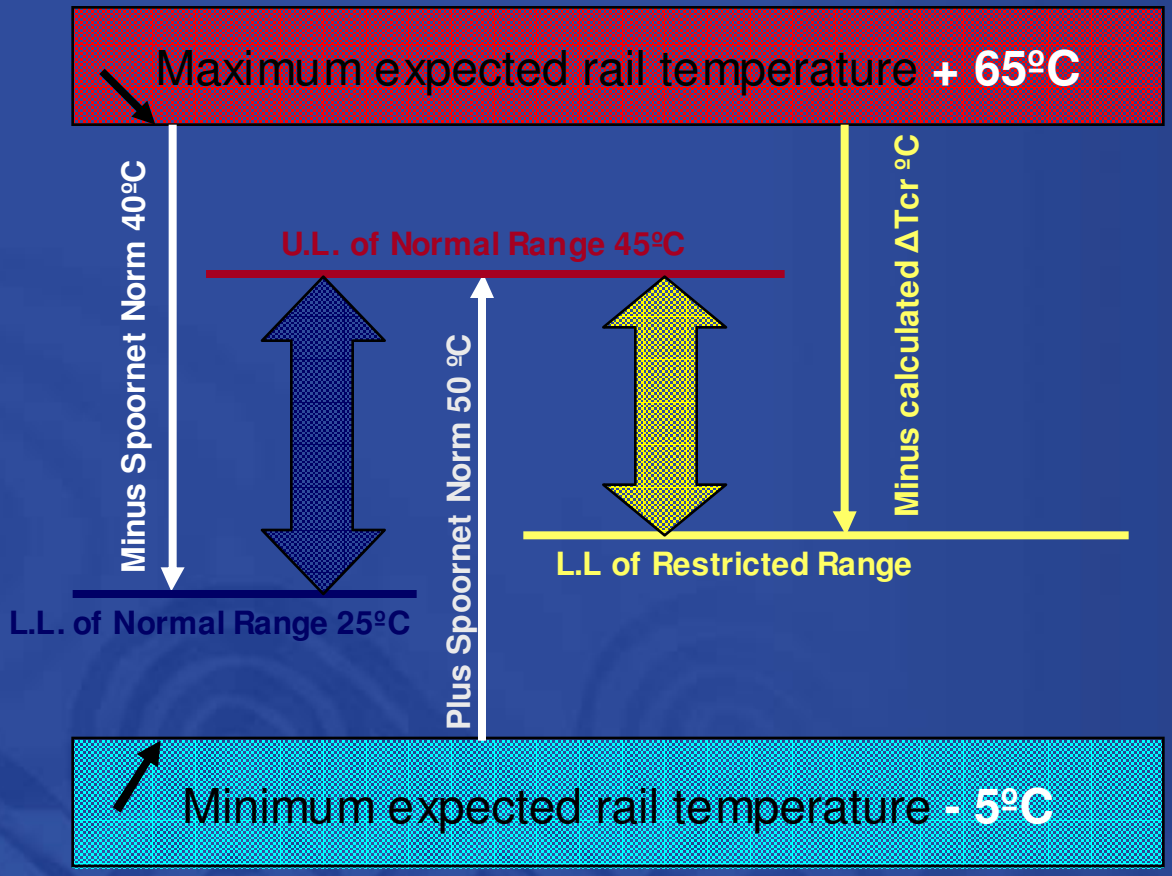
P_{cr}

R_{cr}

SPOORNET

SAICE : RAILSTRESS PRESENTATION

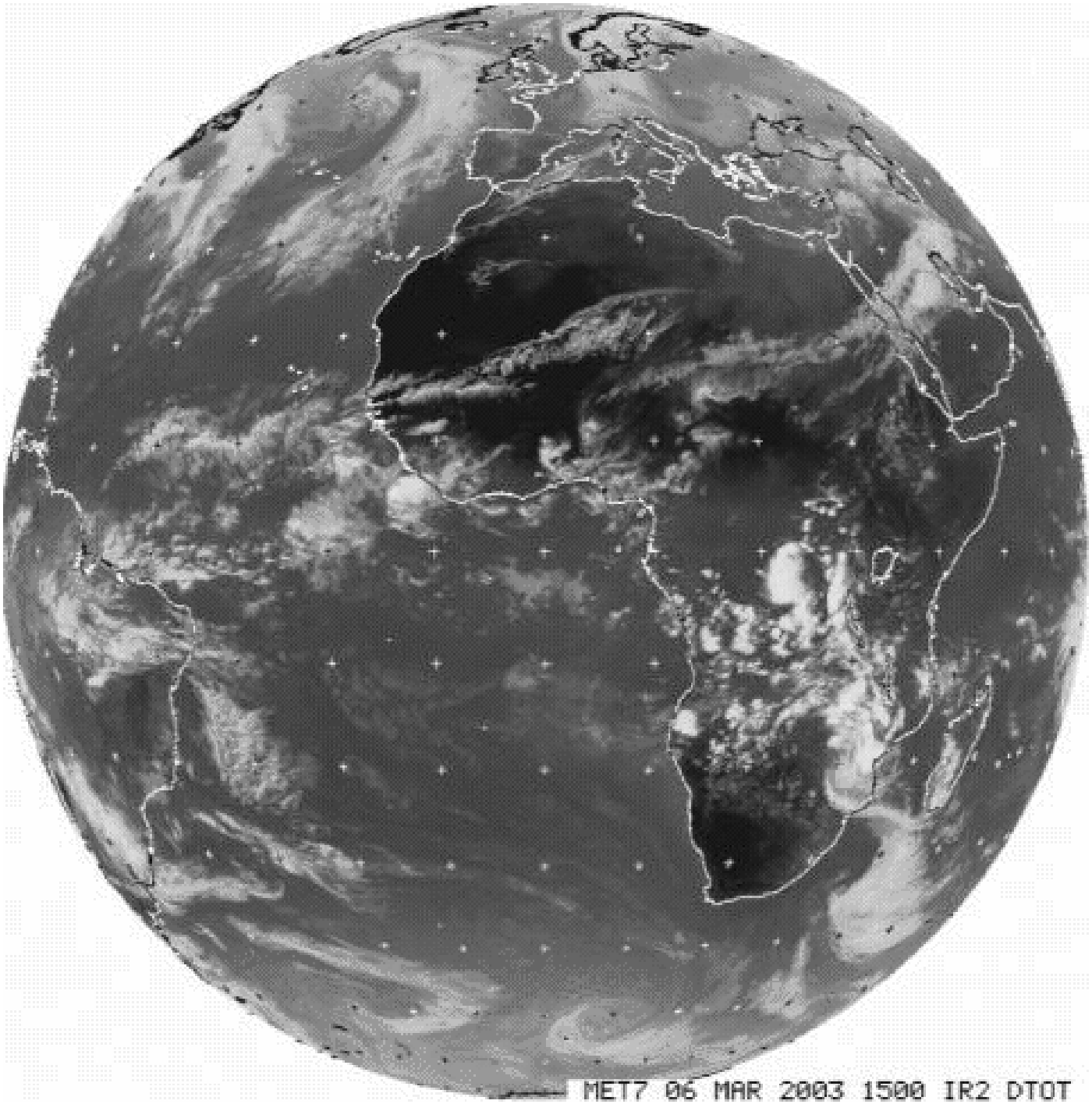
Destressing Ranges-Tight Curves



SAICE : RAILSTRESS PRESENTATION

- ΔT_{cr} ºC = CRITICAL RAIL TEMPERATURE INCREASE ABOVE NEUTRAL TEMPERATURE : LOMBARD, 1978

R605m - R200m				
Valid Temperature Ranges				
	40kg	48kg	57kg	60kg
A-Range_Upper L	45	45	45	45
Tcr ºC (P2/F4)	36-19	38-18	35-16	36-16
A-Range_Bottom L	29-46	27-47	30-49	29-49
Tcr ºC (PY/FY)	41-23	45-22	42-20	43-19
A-Range_Bottom	24-42	20-43	23-45	22-46
Tcr ºC (@600mm)	45-26	49-25	46-22	47-22
A-Range_Bottom	20-39	16-40	19-43	18-43
Tcr ºC (350mm)	38-21	41-20	38-17	39-17
A-Range_Bottom	27-44	24-45	27-48	26-48


MET7 06 MAR 2003 1500 IR2 DTOT

EXPECTED MINIMUM AND MAXIMUM TEMPERATURES FOR TODAY : 2003-03-07.
ISSUED AT 04:00 SAST BY THE SOUTH AFRICAN WEATHER SERVICE.
THIS FORECAST WILL BE UPDATED AT 16:00 SAST.

		MIN	MAX
1.	GAUTENG:		
	Pretoria	17	30
	Johannesburg	15	29
	Vereeniging	15	29
2.	MPUMALANGA:		
	Nelspruit	18	28
	Ermelo	16	25
	Witbank	14	28
	Standerton	13	27
	Skukuza	21	31
3.	LIMPOPO PROVINCE:		
	Polokwane	21	29
	Phalaborwa	22	31
	Tzaneen	20	27
	Musina	22	29
	Lephalale	23	35
	Mokopane	20	33
4.	NORTH WEST:		
	Klerksdorp	15	31
	Potchefstroom	16	32
	Mafikeng	18	33
	Rustenburg	18	31
5.	FREE STATE:		
	Bloemfontein	15	32
	Welkom	17	33
	Bethlehem	14	28
6.	NORTHERN CAPE:		
	Upington	21	36
	Kimberley	18	34
	De Aar	17	33
	Springbok	14	29
	Calvinia	11	32
	Sutherland	04	28
7.	WESTERN CAPE:		
	Cape Town	18	27
	Vredendal	13	29
	Riversdale	14	27
	George	14	24
	Worcester	17	35
	Beaufort West	14	31
	Oudtshoorn	14	29
8.	EASTERN CAPE:		
	Port Elizabeth	16	28
	Grahamstown	15	28
	Cradock	14	33
	East London	19	28
	Port St Johns	20	28
	Umtata	16	29
	Queenstown	13	27
	King Williams Town	15	27

SAICE : RAILSTRESS PRESENTATION

- QUESTIONS