Working for Traffic Safety in Austria

DERAILMENTS OF FREIGHT WAGONS IN AUSTRIA

Interaction between vehicle test twist and track parameters (twist, track cant and curve radius); Version 2

BMVIT-795.136/-II/BAV/UUB/SCH/2010

This investigation has been carried out in compliance with the Federal Act setting up the Federal Accident Investigation Bureau and amending the Aviation Act, the Railways Act 1957, the Shipping Act and the Road Traffic Act 1967, which entered the statute book on 1 January 2006 (Accident Investigation Act, Federal Government Gazette I No. 123/2005), and on the basis of Directive 2004/49/EC of the European Parliament and of the Council of 29 April 2004. The sole purpose of the investigation is to establish the cause of the incident and to prevent such incidents in future, not to establish culpability or liability. References to persons shall be understood to apply to either sex.

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BUNDESANSTALT FÜR VERKEHR (FEDERAL OFFICE OF TRANSPORT)

Federal Accident Investigation Bureau – Rail Section

Further investigation with safety recommendations

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List of abbreviations

BMVIT	Federal Ministry of Transport, Innovation & Technology
DV	Service regulation
DB	Instruction
EN	European standard
ERA	European Rail Agency
HS	High speed
IM	Infrastructure manager (infrastructure operator)
NSB	National Safety Authority *(Eisenbahnsicherheitsbehörde)*
ÖBB	Austrian Railways *(Österreichische Bundesbahnen*)
ÖNORM	Austrian Standards Institute
ORE	UIC Office for Research and Experiments
RIV	Regulations governing the reciprocal use of wagons in international traffic *(Regolamento Internazionale Veicoli)*
TSI	Technical Specification for Interoperability
UUB	*Unfalluntersuchungsstelle des Bundes* (Federal Accident Investigation Bureau)
UIC	International Union of Railways *(Union Internationale des Chemins de Fer)*
VzG	List of locally permissible speeds
Z	Train
ZOV	Addendum to Track Specification

Symbols and abbreviations used

^{o}	index for track values
$^{+}$	index for bogie values
*	index for vehicle body values
$2a^{+}$	bogie wheelbase
$2a^{*}$	wheelbase, wagon bogie centre-to-centre distance
a_q	unbalanced lateral acceleration
g	twist
g^{*}	vehicle test twist
r	radius of curvature
D, u	track cant
lim	Limes (limits)
zul	permissible

Definitions

According to HS Infrastructure TSI (2008/217/EC), point 4.2.7, *track cant is the maximum difference in height between outer and inner rails, measured at the centre of the rail head surface (in mm). Value depends upon gauge if measured in mm; value is not dependent on gauge if measures in degrees.*

According to UIC Leaflet 530-2, Glossary, *a track twist occurs in junction curves comprising superelevated curves, as a design feature. Track twists are also caused by deviations from the rail geometry as per the design specification that are due to height errors. These differences in the opposing elevation of the rails affect the torsion of a track vehicle and result in changes in the distribution of wheel forces.*
UUB comment: The torsion stiffness of a vehicle must comply with the vehicle test twist.

1. General

There have been a number of freight wagon derailments on the Austrian Railways since 16 August 2008, the cause of which has not always been immediately apparent:

- Z 94435 on 16 August 2008 at Neulengbach Station
- Z 40667 on 6 September 2008 at Rosenbach Station
- Z 41186 on 8 April 2009 between Leithabrücke and Ebenfurth Station
- Z 48286 on 25 July 2009 between Villach Central Station and Förderlach Station
- Z 49581 on 1 September 2009 at Ebenfurth Station
- Z 47022 on 19 September 2009 between Semmering Station and Breitenstein Station
- Z 54599 on 25 September 2009 at Villach West Station

Previous derailments have been disregarded.

All the above derailments without exception occurred when the rails were dry.

Irrespective of the causes of the above derailments, Austrian Railways has analysed the regulative and technical correlations (vehicle test twist and track parameters such as track twist, track cant and radius of curvature). The results were sent to the BMVIT for verification under cover of its letter ref. BMVIT-795.136/0002-II/BAV/UUB/SCH/2009 dated 23 October 2009.

The basic finding was that the vehicle test twist as per the Freight Wagon TSI is smaller than the permissible track twist as per the High-Speed Infrastructure TSI and other standards. The vehicles and infrastructure comply with the regulations in force at the time. Further investigation into this matter was conducted by the ORE – B55 working party (final report OT B55/RP8 dated April 1983).

The findings from this analysis were sent to infrastructure operators and authorities as safety recommendations. They affect main lines and branch lines, secondary structures (traction locations and workshops), as well as feeder lines.

2. Analysis of vehicle regulations

Freight wagons are used in accordance with the following technical and operational regulations:

- RIV
- TEN
- TEN-RIV
- other freight wagons (per agreement)

2.1. Freight wagon TSI

According to section 4.2.3.4.2.2*, wagons are able to run on twisted tracks when (Y/Q) for stationary tests does not exceed the limit given in section 4.2.3.4.2.1 in a curve of radius R = 150 m and for a given twisted track:*

for a wheelbase of 1.3 m ≤ $2a^*$
— g lim = 7‰ for 2a + < 4m
— g lim = $20/2a^+$ + 2 for 2a + > 4m
— g lim = $20/2a^*$ + 2 for 2a* < 20m
— g lim = 3‰ for $2a^*$ > 20 m

The wheelbase $2a^*$ *represents the axle spacing for 2-axle wagons or the distance between the pivot centres of a bogie wagon. The wheelbase* $2a^+$ *represents the axle spacing for a bogie.*

According to section 6.2.3.2.1.4, *freight wagons are exempted from the stationary tests mentioned in section 4.2.3.4.2.1 if they comply with the requirements of UIC leaflet 530-2 (May 2006)* (Amendment 2009/107/EC).

UUB comment: UIC Leaflet 530-2 and the provision made to safeguard existing standards apply. Older wagons comply with the provisions of ORE B55/RP8, which stipulates a vehicle test twist of $g^* = 15/2^* + 2$**. The limit given in the TSI is greater than in the aforementioned ORE report.**

2.2. EN 14363

EN 14363 entered into force in October 2005. A great number of standard-gauge wagons in circulation today were approved before then under the provisions of UIC Leaflet 530-2 or ORE report B55/RP8.

According to section 4.1.2.2.3, vehicle test twist is defined as follows:

Bogie test twist (UUB comment: in ‰)*:*
$g^+_{lim} = 7$ *for* $2a^+ \leq 4$ *m wheel set difference in the bogie*
$g^+_{lim} = (20 / 2a^+) + 2.0$ *for* $2a^+ > 4$ *m wheel set difference in the bogie*

Vehicle body test twist (UUB comment: in ‰)*:*

$g^*_{lim} = 7$	*for* $2a^* < 4$ *m*
$g^*_{lim} = (20 / 2a^*) + 2.0$	*for* $4 \text{ m} < 2a^* \leq 20$ *m*
$g^*_{lim} = 3$	*for* $20 \text{ m} < 2a^* \leq 30$ *m*
$g^*_{lim} = 90 / 2a^*$	*for* $2a^* > 30$ *m*

2.3. UIC 530-2

According to Leaflet **UIC 530-2,** 2.1 – ***basic conditions*** *for freight wagons irrespective of coupling type, section 2.1.3, for the purpose of assessing the potential risk of derailment when newly built freight wagons are driven over track twists, the point in the diagrams in Annexes A, B and C above line A-A (limit curve for driving over track twists) that defines the design features of the wagon must lie within the permitted range. If there is/are no line(s) A-A in the diagram, then there is no limitation on torsional strength ct*.*
For freight wagons whose design features do not agree with those contained in Annexes A, B and C, the potential risk of derailment when driven over track twists must be assessed in accordance with the calculation and test procedures set out in Report B55/RP8.

In short, this means that the application of the diagrams contained in Annexes A, B and C of Leaflet UIC 530-2 represents a simplification of the proof that a vehicle is safe to drive over track twists; otherwise this proof must be provided according to Report B55/RP8.

2.4. ORE B55/RP8

According to ORE B55/RP8, *it seems that one possible cause of such derailments is the simultaneous occurrence of wheel force changes arising from large track superelevations and track twists in curves with tight radii of curvature, when driven over at low speed.*

The probability of a twist derailment is higher when

- *relatively large curve-induced guiding forces are applied in tight curves;*
- *in the case of empty or partially loaded vehicles with a low deadload weight, small wheel forces are acting;*
- *in torsion-resistant vehicles, the twist-induced wheel force change is encouraged;*
- *at a low speed, the forces are subjected to quasi-static conditions;*

- *the prevailing friction characteristics are unfavourable as the tracks are dry.*

With vehicle test twist constant as per ORE B55/RP8, Figure 6 ($g^* = 15/2a^* + 2$; 4.5 m $\leq 2a^* \leq$ 20 m), the following applies for the individual ranges:

Range 1: No restrictions, $\lim g_1° = (20/2a^*) + 3 \leq 7‰$
as $\text{zul } u_1 \leq (r - 100) / 2$

Range 2: Restricted track limit twist and limit on the permitted superelevation
$\lim g_2° = (20/2a^*) + 1.5$; $3.0‰ \leq \lim g_2° \leq 6.0‰$
as $\text{zul } u_2 > u > \text{zul } u_1$; $\text{zul } u_2 = (r - 50) / 2$

Range 3: Restricted track limit twist and limit on the permitted superelevation with additional measures
$\lim g_2° = (20/2a^*) + 1.5$; $3.0‰ \leq \lim g_2° \leq 6.0‰$
as $u \geq \text{zul } u_2$

Where u [mm] and r [m].
See also section 3.6
According to ORE B55/RP8, the twist that can be withstood by freight wagons (torsion resistance, test twist) may be smaller than the track twist of the track to be driven over as long as several unfavourable factors do not coincide (occurrence of wheel force changes due to big track superelevations and track twists in curves with tight radii of curvature that are driven over at low speed or due to off-centre loading).

The model is based on a statistical confidence coefficient of p = 95% with limited distribution tail on either side, as is generally used when solving technical problems. This results in a probability of error of a = 5%. Due to this model-induced uncertainty, a residual probability of twist derailments has to be expected even when the track/vehicle condition complies totally with specification. After extensive checking of results to verify that the model agrees with the actual frequency of twist derailments, it would appear that the chosen confidence coefficient is adequate.

As an additional safety precaution, ORE B55/RP8 mentions adding guard rails or rail-lubricating equipment.

3. Analysis of infrastructure regulations

3.1 HS Infrastructure TSI (2008/217/EC)

This TSI applies to the sections listed as high-speed sections on the BMVIT website (http://www.bmvit.gv.at/verkehr/eisenbahn/interoperabilitaet/arbeitsgruppe/20040623/beilage2.pdf)

Track twist — isolated defects — zero to peak value (section 4.2.10.4.1)*:*
Track twist is defined as the algebraic difference between two cross levels taken at a defined distance apart, usually expressed as a gradient between the two points at which the cross level is measured.

For standard gauge the measurement points are 1 500 mm apart.

The track twist limit is a function of the measurement base applied (l) according to the formula:

Limit twist = (20/l + 3)
— where l is the measurement base (in m), with 1,3 m ≤ l ≤ 20 m
— with a maximum value of:

— 7 mm/m for lines designed for speed ≤ 200 km/h
— 5 mm/m for lines designed for speed > 200 km/h.

The Infrastructure Manager shall set out in the maintenance plan the basis on which it will measure the track in order to check compliance with this requirement. The basis of measurement shall include a measurement base of 3 m.

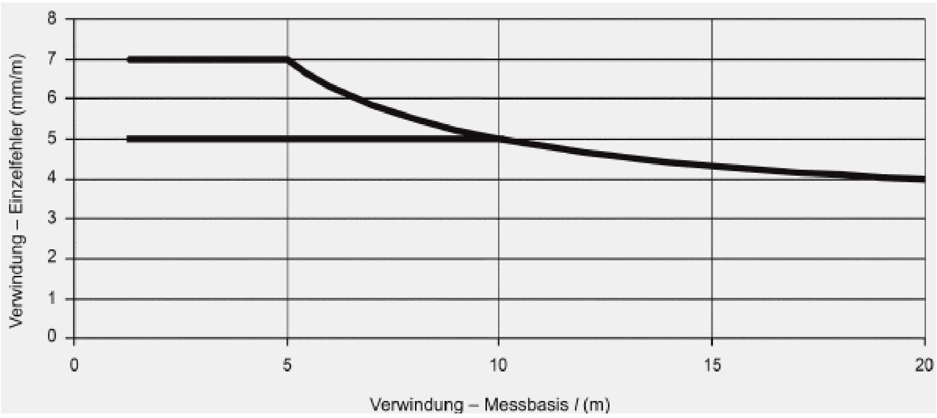


Diagram 1: Track twist as per HS Infrastructure TSI (2008/217/EC, section 4.2.10.4.1)

According to section 4.2.7, for *Lines of category I, II and III, the design cant on new HS stretches shall be limited to 180 mm. On tracks in operation, a maintenance tolerance of ± 20 mm is allowed, subject to a maximum cant of 190 mm; this design value may be raised to 200 mm maximum on tracks reserved for passenger traffic alone*.

ORE B55/RP8 does not limit cant in relation to radius of curvature.

3.2 EN 14363

According to section 4.1.2.2.2 of this EN, *the track limit twist takes into account the twist arising from the track alignment and the maximum permitted error of the opposing elevation (maintenance limit) and in European railways amounts to*

g_{lim} = min (7.0; 20/2a + 3.0)

with 2a as longitudinal base in m and g_{lim} in ‰. Applicability is limited to 2a ≤ 20 m.

3.3. EN 13803-1

According to section 5.2.2 of this EN, *superelevation D must be chosen, taking into account the following points:*

- *a big superelevation in curves of small radius increases the risk of derailment in freight wagons running at low speed. Here, the vertical wheel force acting on the outer track is significantly reduced, especially if the load on the wheel is also reduced by track twists (for further information, see [ORE B 55/RP8]);*

- *superelevations of more than 160 mm can cause the load to shift and constrain the ride comfort where trains come to an unplanned halt in a place where the superelevation is high. In addition, where superelevation is excessive, the stability of working rolling stock and unusual loads with a high centre of gravity may be endangered;*

- *a large superelevation magnifies the excess superelevation in curves, with a big difference between the speeds of fast and slower trains.*

To avoid the risk of derailment of torsionally rigid freight wagons in curves of relatively small radius, the superelevation should be limited to the following value (on this point see ORE B 55/Rp 5 and 8):

D_{lim} = (R-50) / 1.5 [mm]

UUB comment: this superelevation to be observed corresponds to the maximum superelevation mentioned in ORE B55/RP8 of zul u_2 = (r - 50) / 2 and accordingly is already in ORE B55/RP8 range 2, so limited twist limit values are needed (see section 3.6).

Section 5.2.5.1 specifies the change in superelevation over time dD/dt for trains of conventional design.

For superelevation ramps with a constant ramp inclination and a change in superelevation of amount ΔD, the following relationship applies:

$$\frac{dD}{dt} = \frac{\Delta D \cdot V_{max}}{3,6 \cdot L} \leq \left(\frac{dD}{dt}\right)_{lim} \qquad [mm/s]$$

Diagram 2 EN 13803-2 Superelevation ramp

where L is the length of the superelevation ramp [m]

According to ORE B55/RP8, the probability of a twist derailment is higher when the forces are subjected to quasi-static conditions at low speed (see section 3.6).

Annex I (informative) contains a summary of the working results of ORE Committee B 55 — Maximum permitted superelevation.

3.4. ÖBB DV B 50-2

The maximum permitted twist lies between 1.25 mm/m and 3.33 mm/m, depending on track grade and application.

According to ORE B55/RP8, for rolling stock with 2a* = 20 m, the track limit twists can be exceeded.

ORE B55/RP8 does not consider the possibility of limiting the permitted superelevation as a function of the radius of curvature (see section 3.6).

3.5. ZOV 54

The measurements on a 5 m basis (machine measurement, no direct manual measurements) as a function of the permitted speed are as follows:

Speed according to VzG [km/h]	> 120	80 to 120	< 80
Twist [mm]	3.0	4.0	5.0

Diagram 3: Table of twists according to ZOV 54

These measurements are taken under the load of the test vehicle. This is a lot lower than the wheel pressure forces of a loaded freight wagon.

The limits disregard the influence of the wheel pressure forces.

ORE B55/RP8 does not consider the possibility of limiting the permitted superelevation as a function of the radius of curvature (see section 3.6).

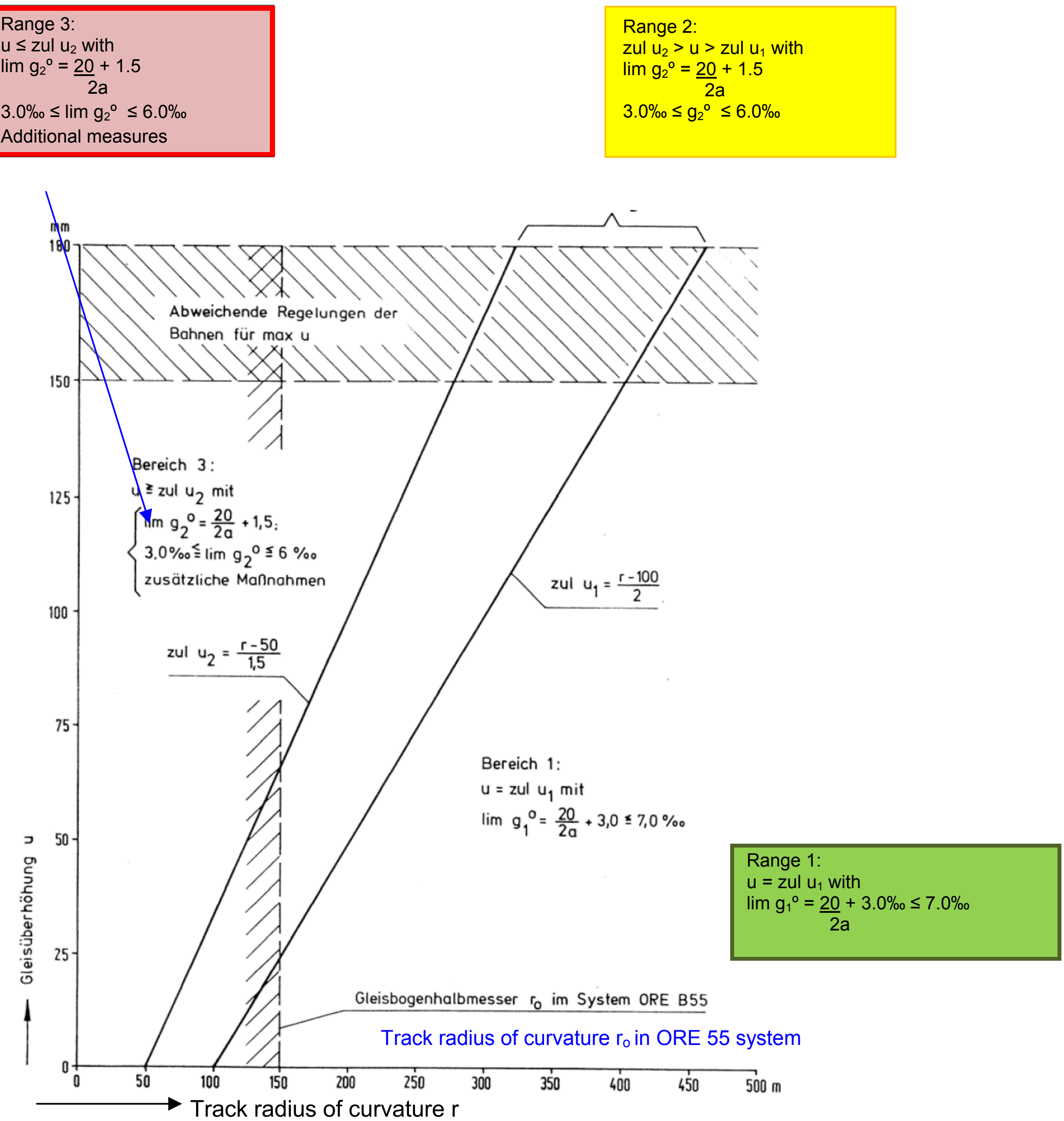
3.6. ORE B55/RP8

In ORE B55/RP8 - Figure 7 (next page), the track twist (g_n°) that a vehicle can withstand is shown as a function of the permitted track superelevation (u_n):

With vehicle test twist constant as per ORE B55/RP8, Figure 6 ($g^* = 15/2a^* + +2$; 4.5 m $\leq 2a^* \leq$ 20 m), the following applies for the individual ranges (see diagram 7):

Range 1:	Track limit twist as in current HS Infrastructure TSI, but permitted superelevation limited as function of radius of curvature lim $g_1° = (20/2a^*)+3 \leq 7‰$ since zul $u_1 \leq (r - 100) / 2$
Range 2:	**Restricted track limit twist and limit on the permitted superelevation** lim $g_2° = (20/2a^*)+1.5$; $3.0‰ \leq$ lim $g2° \leq 6.0‰$ since zul $u_2 > u >$ zul u_1; zul $u_2 = (r - 50) / 1.5$
Range 3:	**Restricted track limit twist and limit on the permitted superelevation with additional measures** lim $g_2° = (20/2a^*)+1.5$; $3.0‰ \leq$ lim $g_2° \leq 6.0‰$ since $u \geq$ zul u_2

where u [mm] and r [m] apply.



Gleisüberhöhung = Track superelevation u
Abweichende Regelungen der Bahnen für max u = Discrepancy in railway regulations for max. u

Diagram 4: RE B55/RP8 - Figure 7

As an additional safety precaution against derailment, ORE B55/RP8 (Diagram 7) mentions adding guide rails or rail-lubricating equipment for Range 3.

3.7. ÖBB DB IS 2

For the Immediate Action Limits (IALs) from the x-axis to the peak value, the following limit values must be observed for twist in machine measurement.

v_{max} [km/h]	3 m twist [mm/m]	9 m twist [mm/m]	16 m twist [mm/m]
≤ 160	6.0	4.0	2.5
> 160	5.0	3.6	2.2

Diagram 5: Table of twists according to ÖBB DB IS 2

According to ORE B55/RP8 (Range 2), the permitted track twist with high superelevation for the 9 m twist with v < 160 km/h (4.0 mm/m), is 3.72 mm/m (see section 3.6).

ORE B55/RP8 does not consider the possibility of limiting the permitted superelevation as a function of the radius of curvature (see section 3.6).

No relationship is given between twist, radius of curvature and permitted superelevation.

For the 5m twist, using manual measurement, the permitted superelevation is not considered as a function of radius of curvature.

4. Principles of vehicle dynamics

According to EN 14363, Figure A.1, the forces acting on the wheel flange [Spurkranzwinkel] at the beginning of a derailment are as follows:

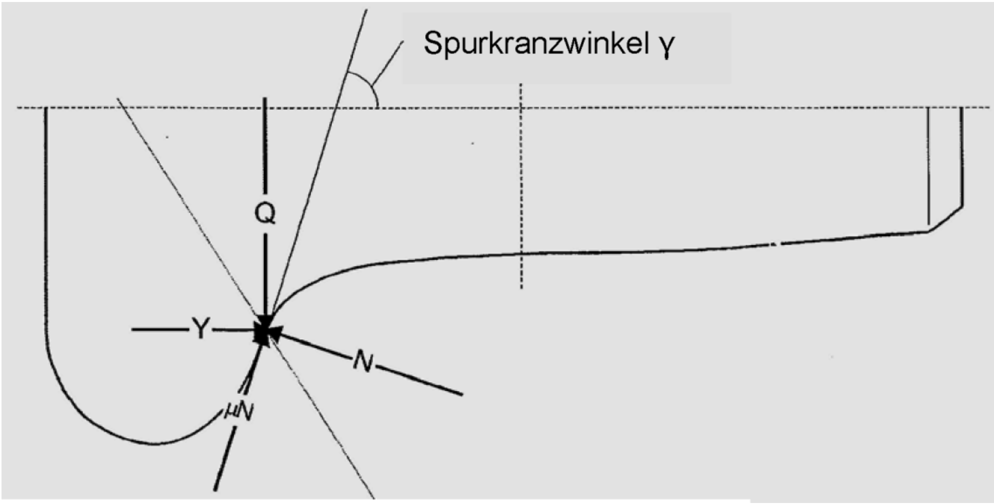


Diagram 6: Forces acting on the wheel flange according to EN 14363 –Figure A.1

A lateral force Y and a vertical force Q act on the wheel. At the point of contact, normal force N and frictional force µN exert an influence. An equilibrium of forces in the transverse and vertical directions produces the following equations:

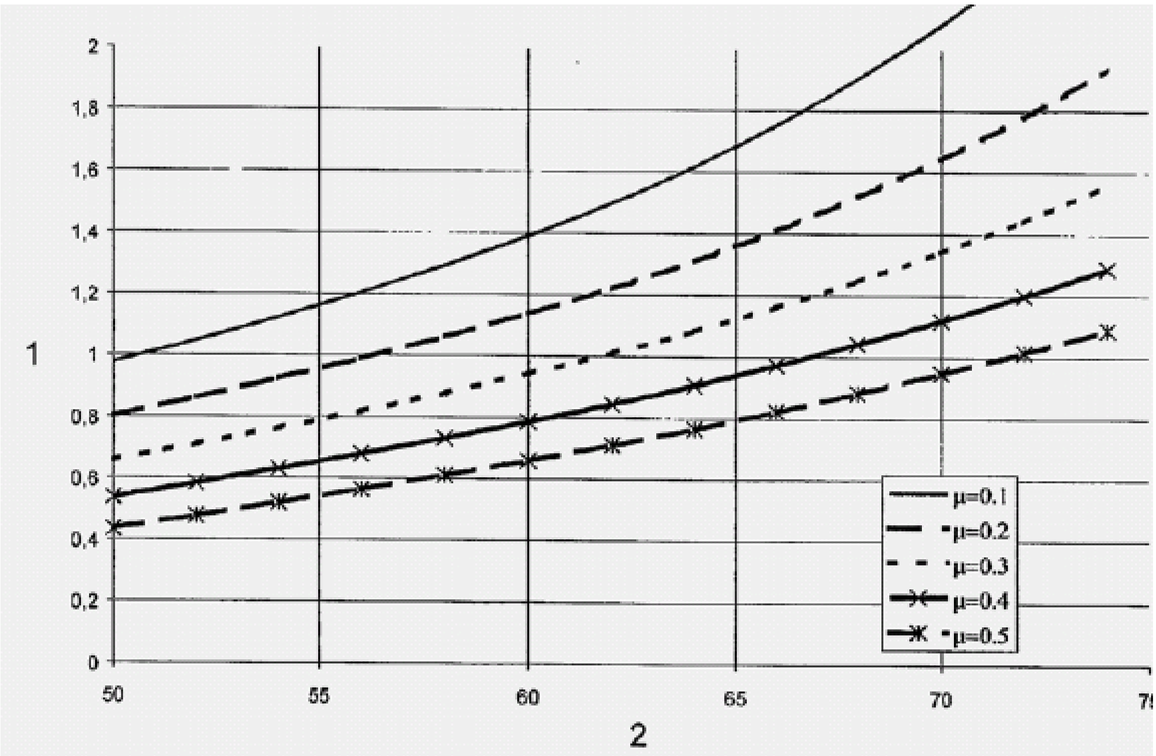
$Y = N\sin\gamma - \mu N\cos\gamma$
$Q = N\cos\gamma + \mu N\sin\gamma$

From this, it is possible to work out the equation for (Y/Q) (Nadal's equation):

$$\frac{Y}{Q} = \frac{\tan\gamma - \mu}{1 + \mu\tan\gamma}$$

Diagram 7: Nadal's equation as per EN 14363

The limit value (Y/Q) depends on wheel flange angle γ and the coefficient of friction at the wheel flange **µ**. Values for normal ranges of wheel flange angle and coefficient of friction are presented in EN 14363, Figure A.2:



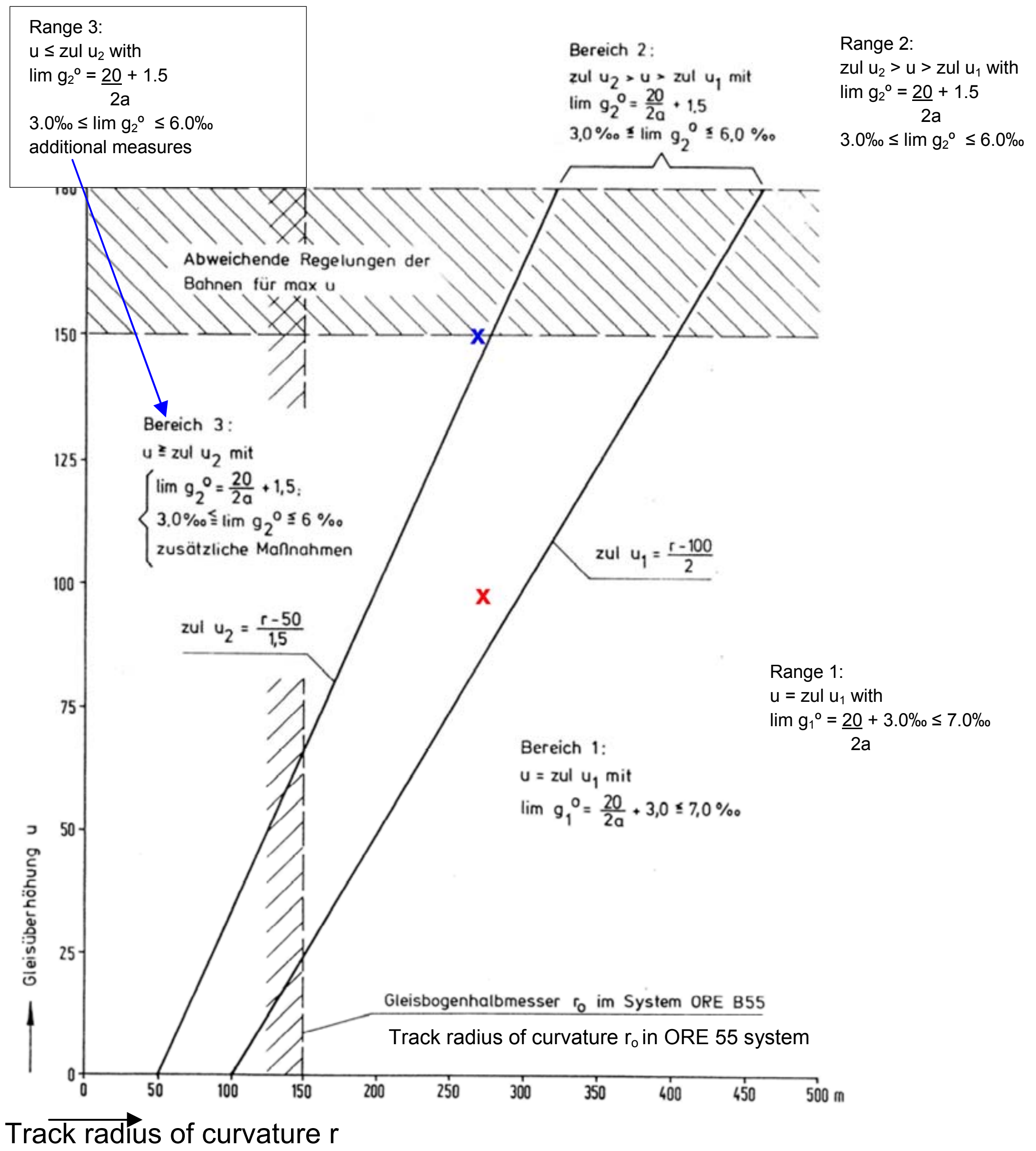
Legend: 1 … Limit value Y/Q 2 … Wheel flange angle γ [°]

Diagram 8: Interaction of Y/Q coefficient of friction μ according to EN 14363, Figure A.2

The diagram shows that the coefficient of friction at the wheel flange μ has a significant influence on the limit value (Y/Q).

- Fixed equipment for the lubrication of running edges and
- wheel flange lubrication equipment on the locomotive vehicle can be used as a means of keeping the coefficient of friction down.

5. Analysis of derailments



Gleisüberhöhung = Track superelevation u
Abweichende Regelungen der Bahnen für max u = Discrepancy in railway regulations for max. u

Diagram 9: Analysis of derailments (application of ORE B55/RP8, Figure 7)

X Derailment 6 September 2008 at Rosenbach station, r = 218.7 m, u = 150 mm, u_{soll} = 138 mm

This suggests a permitted track twist as per range 3, with additional measures needed. Other influencing factors are the speed of travel < 30 km/h due to a low speed point and the dry track running edge.

X Derailment 8 April 2009 Leithabrücke – Ebenfurth, r = 265 m, u = 90 mm, u_{soll} = 62 mm
This suggests a permitted track twist as per range 2. Other influencing factors are the speed of travel < 30 km/h (braking operation prior to “STOP” signal at the entrance to Ebenfurth station) and the dry track running edge.

6. Additional safety measures

Wheel flange lubrication equipment on modern locomotive vehicles (Taurus fleet of ÖBB Traktion GmbH) operates according to the following principles:

- 0-20 km/h: no wheel flange lubrication
- v > 20 km/h: normal wheel flange lubrication
- If v lies in the range 73-90 km/h for longer than 2 minutes:
  extra wheel flange lubrication (Hill 2 mode)
- If v lies in the range 30-72 km/h for longer than 3 minutes:
  a substantial amount of extra wheel flange lubrication (Hill 1 mode)

This means that the extra or substantial amount of extra wheel flange lubrication only becomes effective 2 to 3 minutes after the threshold speed value has been exceeded (by which time the vehicle will have travelled between 1,500 and 3,600 m).

At low speeds in tight curves with high superelevation (excess superelevation), due to a negatively unbalanced lateral acceleration,

$aq = v^2 / r – 9.81 \times u / 1500$

there is contact with the wheel flange on the inner track of the curve. As a result, at the outer track of the curve no lubricant is transferred from the wheel flange to the running edge for the wheel sets of the freight wagons behind.

By deliberate attachment of fixed equipment for lubrication of the running edge, such accidents could be avoided after twist derailments (e.g. at Salzburg Gnigl station and Spittal-Millstättersee station).
Moreover, the accompanying RoLa coaches were equipped with additional wheel flange lubrication equipment.

When laying new track and performing certain work on the track (e.g. grinding the rails), several trips with a locomotive vehicle are required to generate sufficient lubrication film on the running edge.

Reducing the speed in areas with excess superelevation does not promote safety.

7. Summary

Numerous European freight wagons comply in terms of their test twist with the provisions of UIC 530-2 based on ORE B55/RP8 – Figure 6 ($g^* = 15/2a^* + 2$) and the provisions of the Freight Wagon TSI and EN 14363 ($g_{lim} = 20/2a^* +2$ for $2a^* < 20$ m). This requires that the track complies with the permitted track twist lim $g_1° = (20/2a^*)+3 \leq 7$ in conjunction with the permitted superelevation zul $u_1 \leq (r - 100) / 2$).

For ORE B55/RP8 – Figure 7, range 2, a restricted track twist of lim $g_2° = (20/2a^*) + 1.5$; 3.0‰ ≤ lim $g_2°$ ≤ 6.0‰ applies, so the permitted track superelevation must be limited to zul $u_2 \leq (r - 50) / 1.5$.

For ORE B55/RP8 – Figure 7, range 3, the same provisions regarding vehicle test twist for track twist and superelevation apply as in ORE B55/RP8 – Figure 7, range 2; however, additional measures are necessary.

As an additional safety precaution against derailment, ORE B55/RP8 mentions adding guide rails or (running edge) rail-lubricating equipment.

The HS Infrastructure TSI sets a limit value in keeping with the limit set for Range 1 in ORE B55/RP8. ORE B55/RP8 does not consider the possibility of limiting the permitted superelevation as a function of the radius of curvature.

The permitted superelevation of $D_{lim} = (R – 50)/1.5$; [mm] specified in EN 13803-1 is a lot higher than the superelevation allowed in ORE B55/RP8 – Figure 7, Ranges 1 and 2, of $g_1° = (r - 100) / 2$.

This suggests that freight wagons that comply with European regulations for rolling stock could derail due to over-liberal interpretation of regulations governing infrastructure. In addition, slow speeds (e.g. leading up to a "STOP" signal) and/or off-centre loading (albeit compliant with standards) can also trigger twist derailments.

The following further parameters can also have an adverse effect on derailment safety (list not exhaustive):

- Off-centre loading: definition according to RIV, Load Tariff, volume 1 Principles, section 3.3 Load Distribution
- The lubrication state of the buffer heads

8. Additional safety measures

According to EU Directive 49/2004, Article 25(2), recommendations shall be addressed to the safety authority and, where needed by reason of the character of the recommendation, to other bodies or authorities in the Member State or to other Member States. Member States and their safety authorities shall take the necessary measures to ensure that the safety recommendations issued by the investigating bodies are duly taken into consideration, and, where appropriate, acted upon.

On the basis of the above information, the UUB of the Federal Office of Transport issues the following safety recommendations in accordance with the *Unfalluntersuchungsgesetz* [Accident Investigation Act] (Federal Law Gazette I, no. 123, Section 16(2)):

No.	Safety recommendation	**Directed at**
1	Investigate whether freight wagons per Freight Wagon TSI or RIV and freight wagons per agreement can use sections in accordance with the HS Infrastructure TSI without complying with ORE B55/RP8. Rationale: non-compliance with findings of ORE B55/RP8	**NSA** **ERA**
2	Investigate whether track regulations (e.g. ÖBB-DB 50-2) need to be revised so that superelevation is limited as a function of radius. Rationale: non-compliance with provisions of ORE B55/RP8.	**IM**
3	Investigate if it would be expedient to reduce the current superelevation on certain sections (e.g. Semmering section) Rationale: Compliance with superelevation per ORE B55/RP8, Range 1, does not mean limit values for track twist need to be limited.	**IM**
4	Review maintenance regulations (e.g. ÖBB-DB IS 2) with regard to the permitted maintenance parameters (Action Limits and Immediate Action Limits) for permitted track twist in conjunction with track superelevation. Rationale: the IALs used do not comply with the provisions of ORE B55/RP8.	**IM**
5	Attach fixed equipment for the lubrication of running	**IM**

	edges, especially in front of exposed sections of track (tight radii of curvature and large superelevations and also on the approach to certain stations with special track alignment parameters). Rationale: need to reduce coefficient of friction on wheel flange **μ** in order to keep the limit value (Y/Q) low (EN 14363, Figure A.2).	
6	Ensure that after work on the track (e.g. new track laid, rail polishing etc.) that adequate basic lubrication of the running edge is available before the operational go-ahead is given. Rationale: it takes several locomotive vehicle trips to achieve an adequate lubrication film as basic lubrication.	**IM**
7	The TSI infrastructure needs to take into account not only the permitted twists but also superelevation as a function of the radius of curvature. Rationale: compliance with the provisions of ORE B55/RP8 and hence also with the provisions of the Freight Wagon TSI	**NSA** **ERA**
8	Review EN 13803-1 in relation to twist and permitted superelevation as a function of the radius of curvature. Rationale: if no account is taken of superelevation and the radius of curvature as per ORE B55/RP8, the values specified for track twist could cause derailments.	**NSA** **ERA** **ÖNORM**

The companies affected are requested to advise the safety authorities of the sections affected and measures taken.

The safety authority and other authorities or bodies or, when appropriate, other Member States to which the recommendations have been addressed, shall report back at least annually to the investigating body on measures that have been taken or are planned as a consequence of the recommendation (EU Directive 49/2004, Article 25(3)).

These safety recommendations should be distributed to:

Company/office	Function
Bundesministerium für Verkehr, Innovation und Technologie	Authority (AT)
European Rail Agency	Authority (EU)
ÖNORM – Österreichisches Normeninstitut	Standards Institute
AG der Wiener Lokalbahnen	IM
Cargo Center Graz Betriebsgesellschaft m.b.H.&CoKG	IM
Graz-Köflacher Bahn- und Busbetrieb GmbH	IM
Linzer Lokalbahn AG	IM
Montafoner Bahn AG	IM
ÖBB Infrastruktur AG	IM
Raab-Oedenburg-Ebenfurter Eisenbahn AG Neusiedler Seebahn AG	IM
Salzburg AG für Energie, Verkehr und Telekommunikation – Salzburger Lokalbahn	IM
Steiermärkische Landesbahnen GmbH	IM
Stern und Hafferl Verkehrsgesellschaft mbH	IM

and for information to:

Company/office	Function
Regional Commissioner of Burgenland	Authority
Regional Commissioner of Carinthia	Authority
Regional Commissioner of Lower Austria	Authority
Regional Commission of Upper Austria	Authority
Regional Commissioner of Salzburg	Authority
Regional Commissioner of Styria	Authority
Regional Commissioner of Tyrol	Authority
Regional Commissioner of Vorarlberg	Authority
Regional Commissioner of Vienna	Authority

with the request they pass them to the relevant district authorities

Vienna, 18 January 2010

Investigation leader:

Engineer Johannes Piringer