Case of Freight Train Derailment on a 153 m Radius Turnout

October 23, 2025

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Ministry of Land, Infrastructure and Transport

Aviation and Railway Accident Investigation Board (ARAIB)

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Ministry of Land, Infrastructure and Transport

I Introduction

Myself

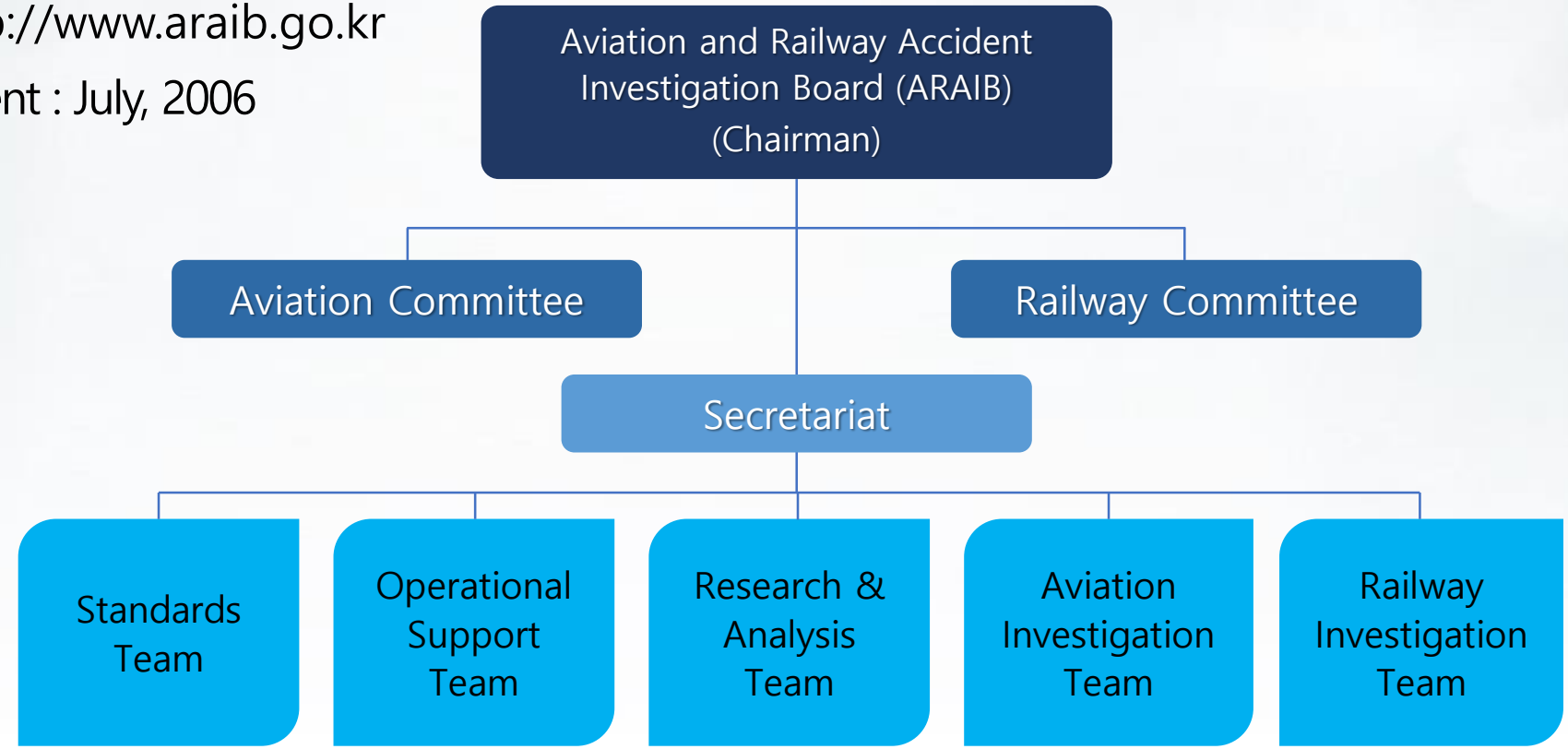
- My name : Injae Kim (e-mail : injaero1@korea.kr)
- Licensed : PE and Ph.D (Civil)
- My career

Duration	Workplace	Position	Remarks
2022.10.17-Present	ARAIB	Investigator	Public
201812.1-2022.10.17	Western Metro co., Ltd	Director	Private
2015.12.1-2018.11.30	ARAIB	Investigator	Public
1992.4.29-2014.12.10	Korea Rail Network Authority	Leader of the team	Public
1983.12.23-1992.4.28	Office of Railroads	Staff	Public

- Main Projects
  - Gyengbu and Honam High Speed Railway Line
  - **Daegok**-Sosa Line (BTL)

Organization

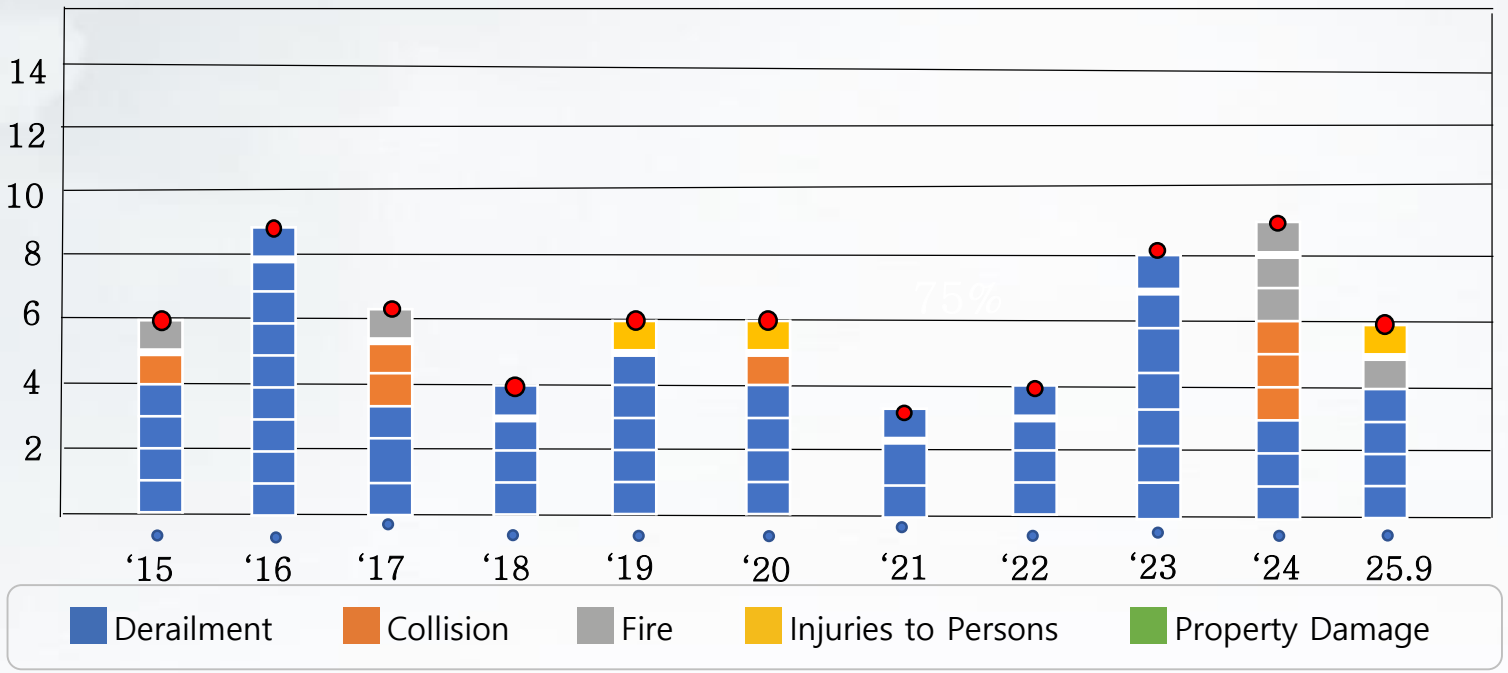
- Name : "Aviation and Railway Accident Investigation Board (ARAIB)"
  http://www.araib.go.kr
- Establishment : July, 2006

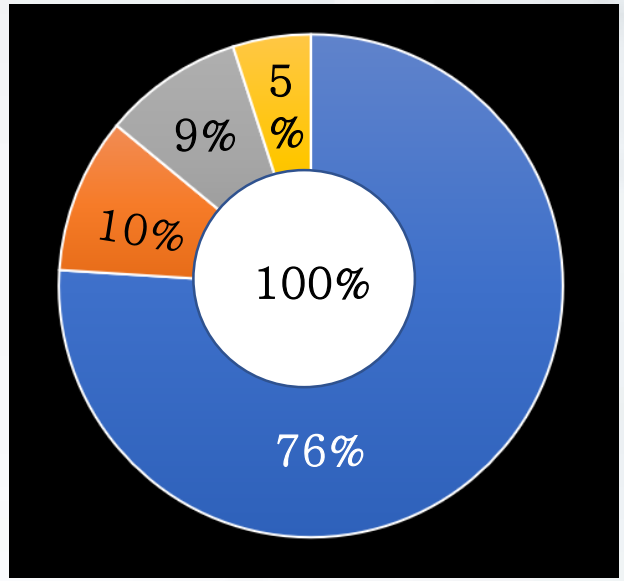


Scope of Railway Accident Investigation

- Train collision or derailment
- Fire on rolling stock or a train that halts an operation
- 3 or more casualties concerning rolling stock or a train operation
- 50 million won or more property damage regarding rolling stock or a train operation

Annual Railway Accident Statistics



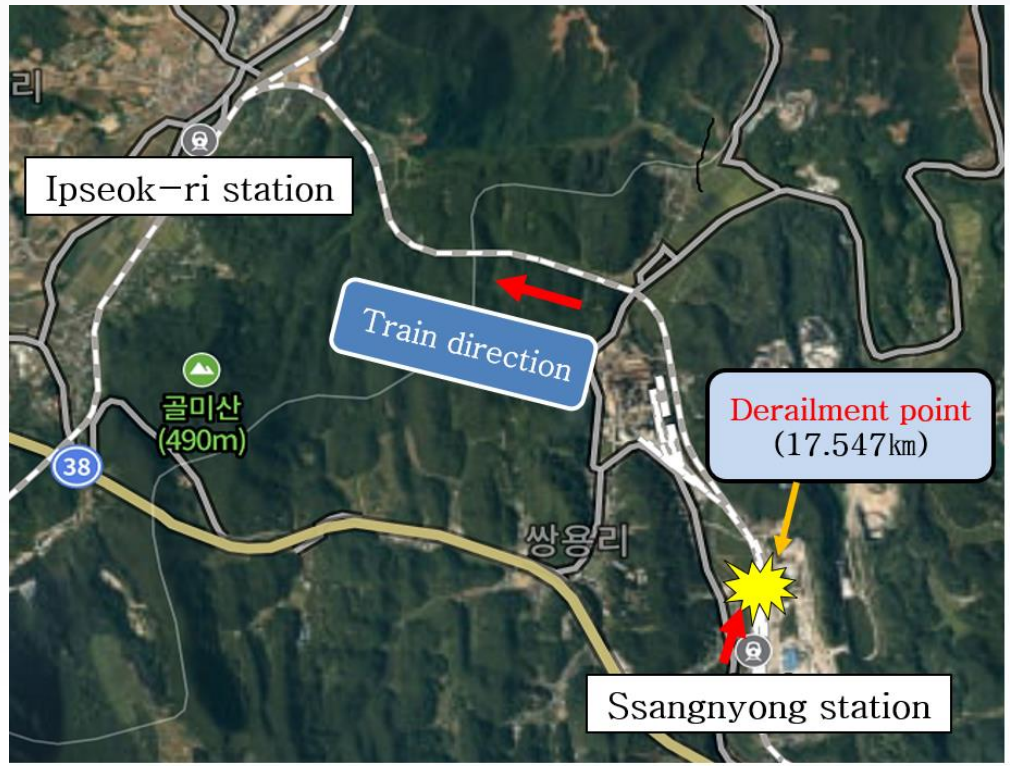


- For 11 years, there have been an average of 6.1 accidents annually.

II Cause of freight train derailment on a 153 m radius turnout

1 Overview of the accident

- Date and time of accident : Sunday, August 18, 2024, at 16:32
- Accident type : Freight train derailment



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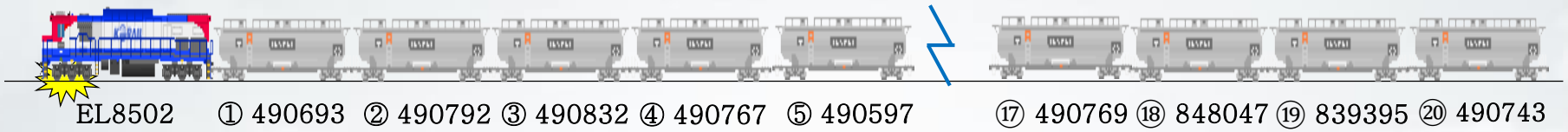

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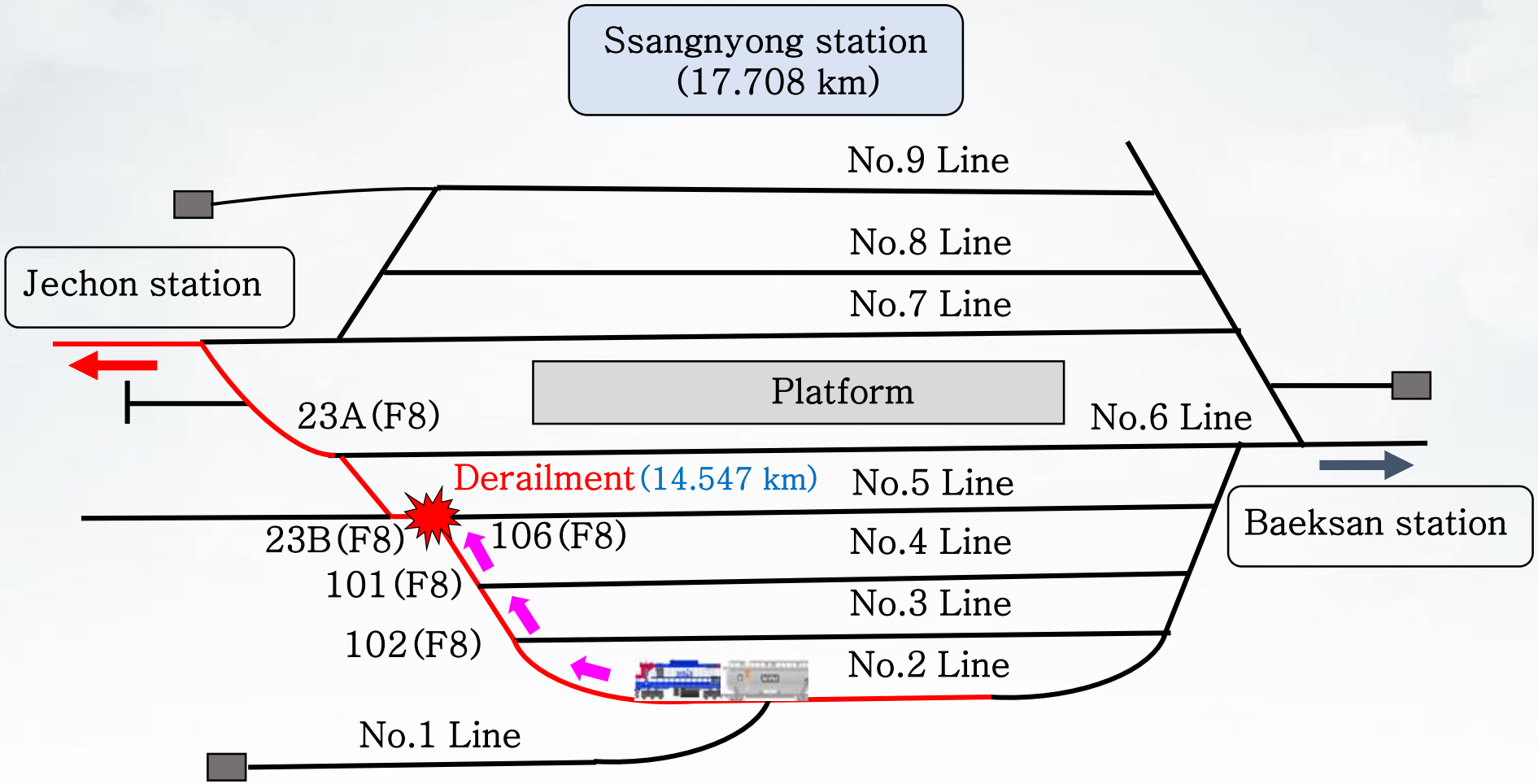

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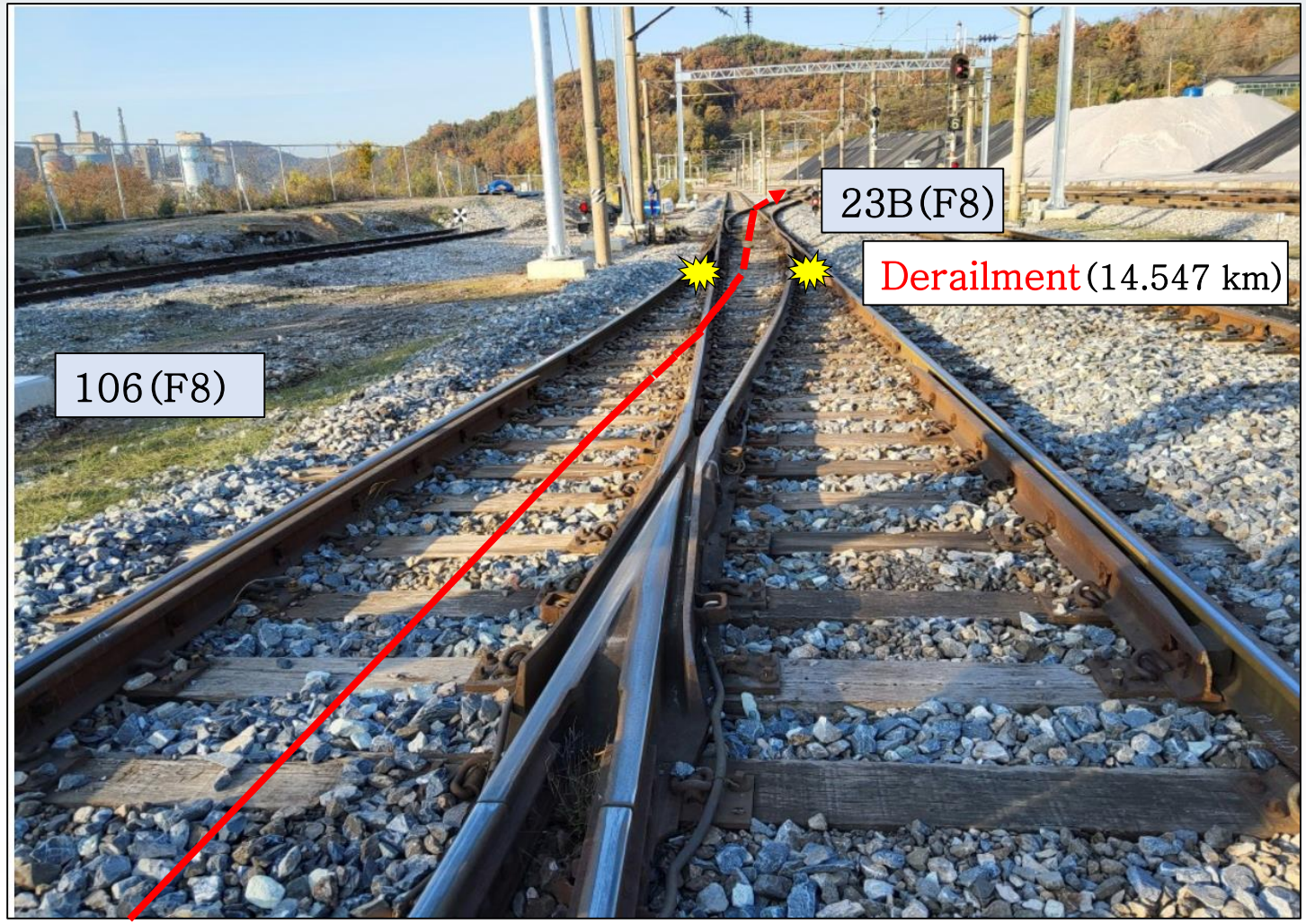

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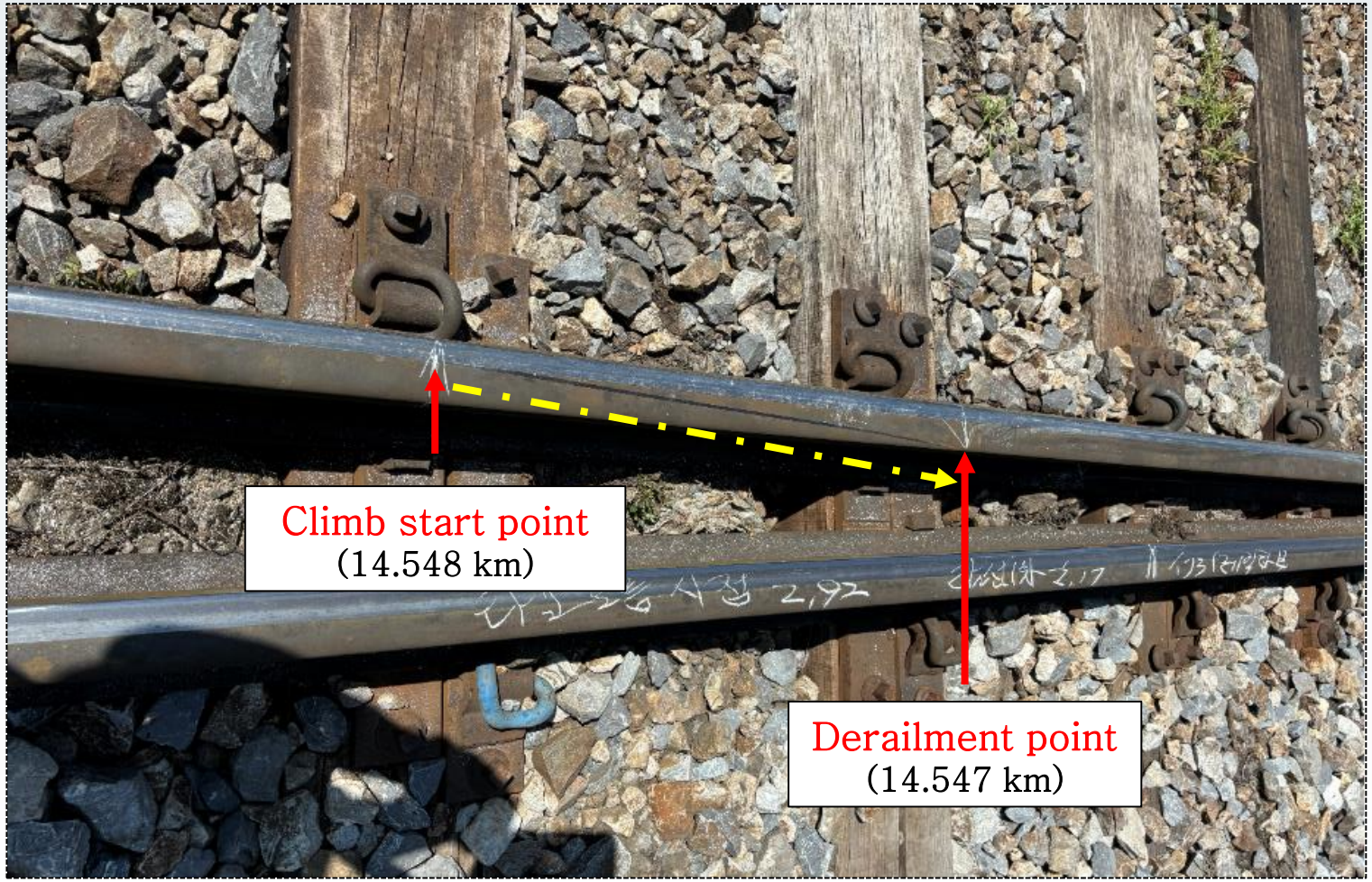

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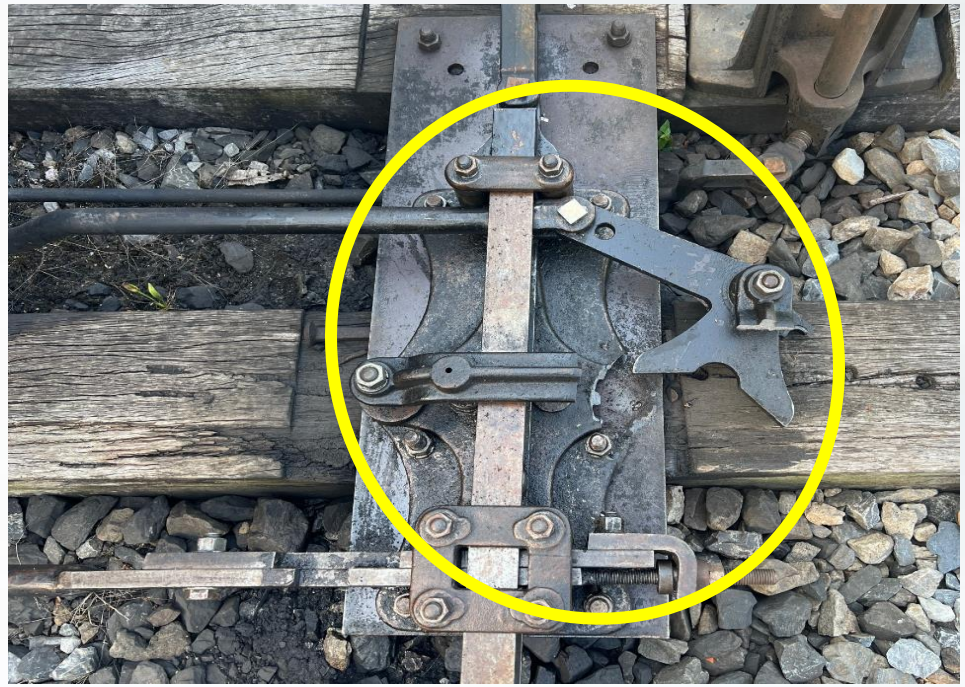


- Damage: The vehicles, track, and signal were damaged

2 Consideration of the causes of derailment

Review of technical specifications for vehicle manufacturing

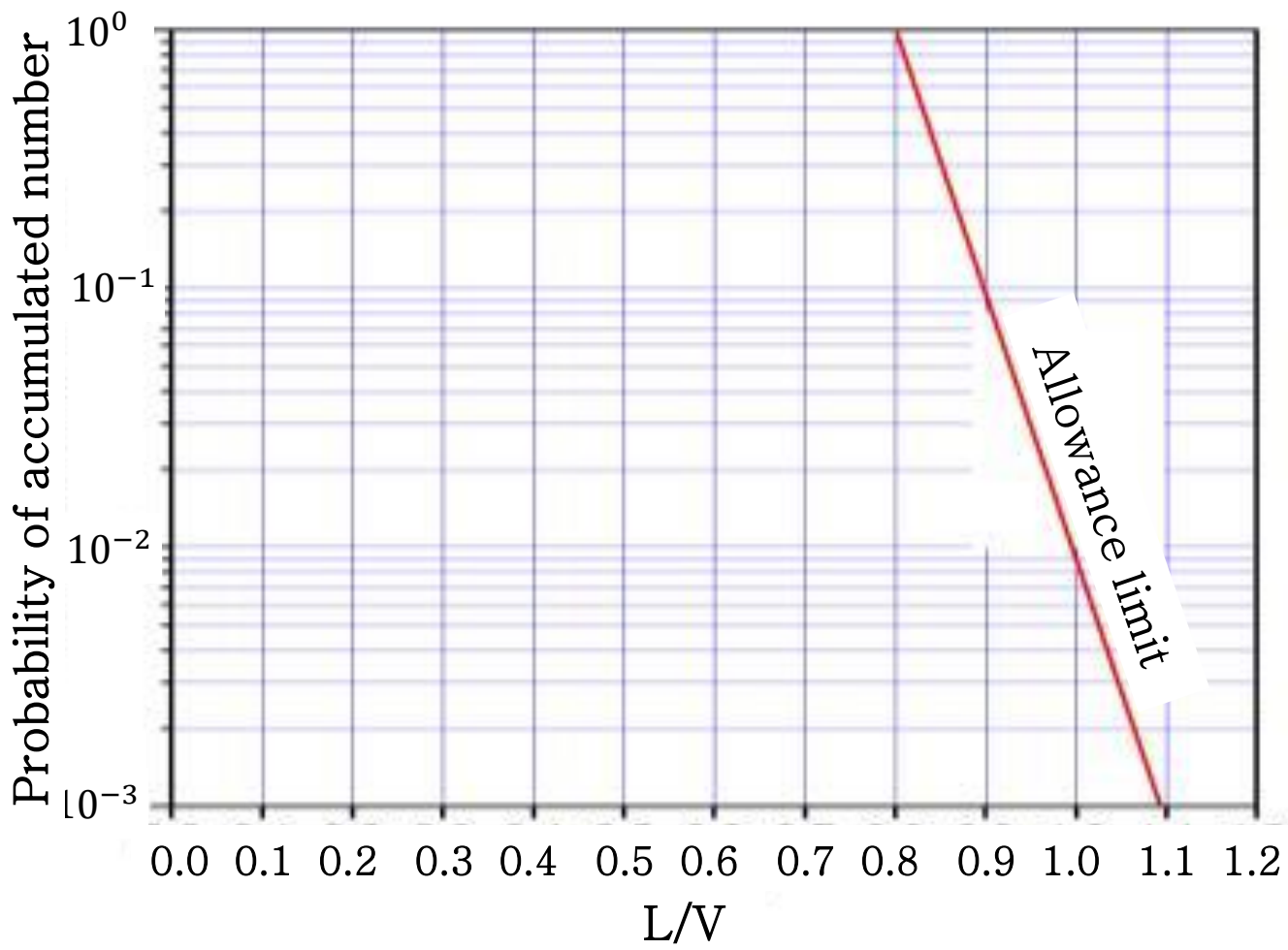
- Operational safety requirements under **the railway vehicle technical standards**

> The derailment coefficient in a rail section with 250 m or more curve radius is defined as follows: ① when the probability of occurrence for one vehicle reaches **100%, values up to 0.8** are permissible, ② For a probability of **0.1%, values up to 1.1** are permissible, ③ The **maximum allowable value is 1.2**

- **Track conditions** to be considered in vehicle design

> ① Track gauge : 1,435 ㎜
> ② Maximum gradient : 35 ‰
> ③ Minimum curve radius in operation **: 250 m**

II Cause of freight train derailment on a 153 m radius turnout



II Cause of freight train derailment on a 153 m radius turnout

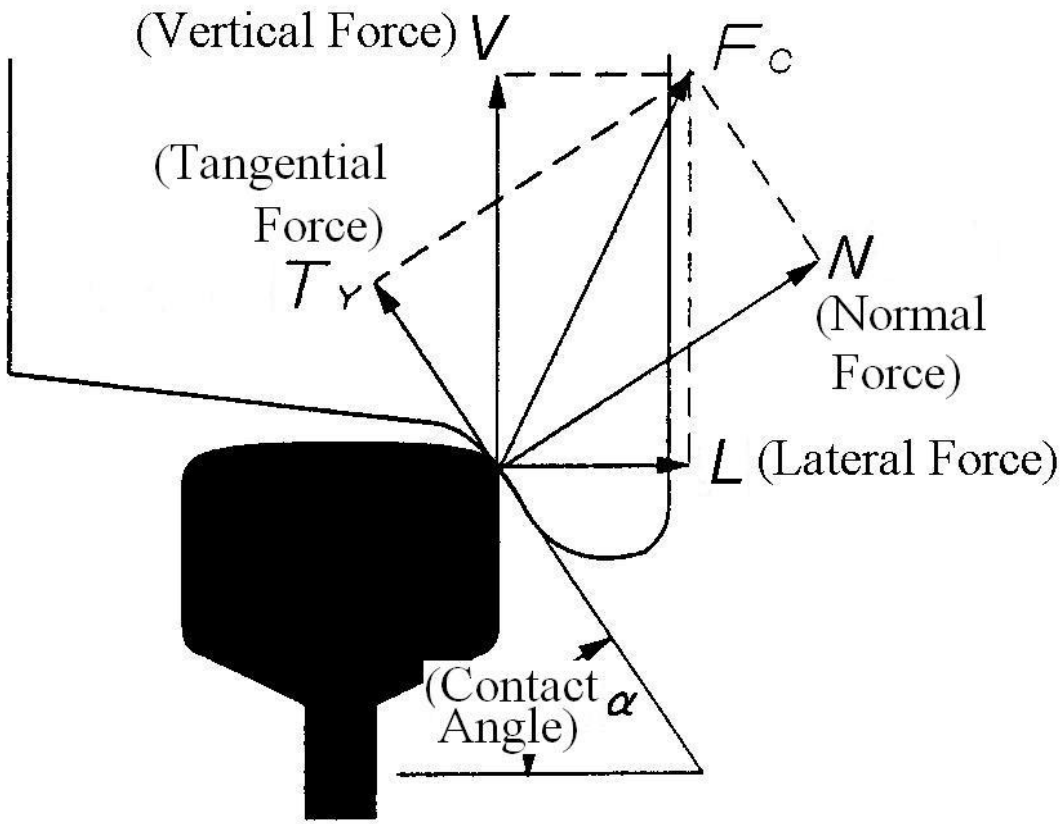
- **The railway vehicle technical standards**

When the **flange angle** is taken as **α=60˚** and the friction coefficient μ=0.3 is applied to the formula, the derailment coefficient becomes **0.94.** Applying a safety factor k=0.85, the calculated value becomes 0.8. Thus, the standard is **0.8.**

- **The derailment coefficient of the EN14363**

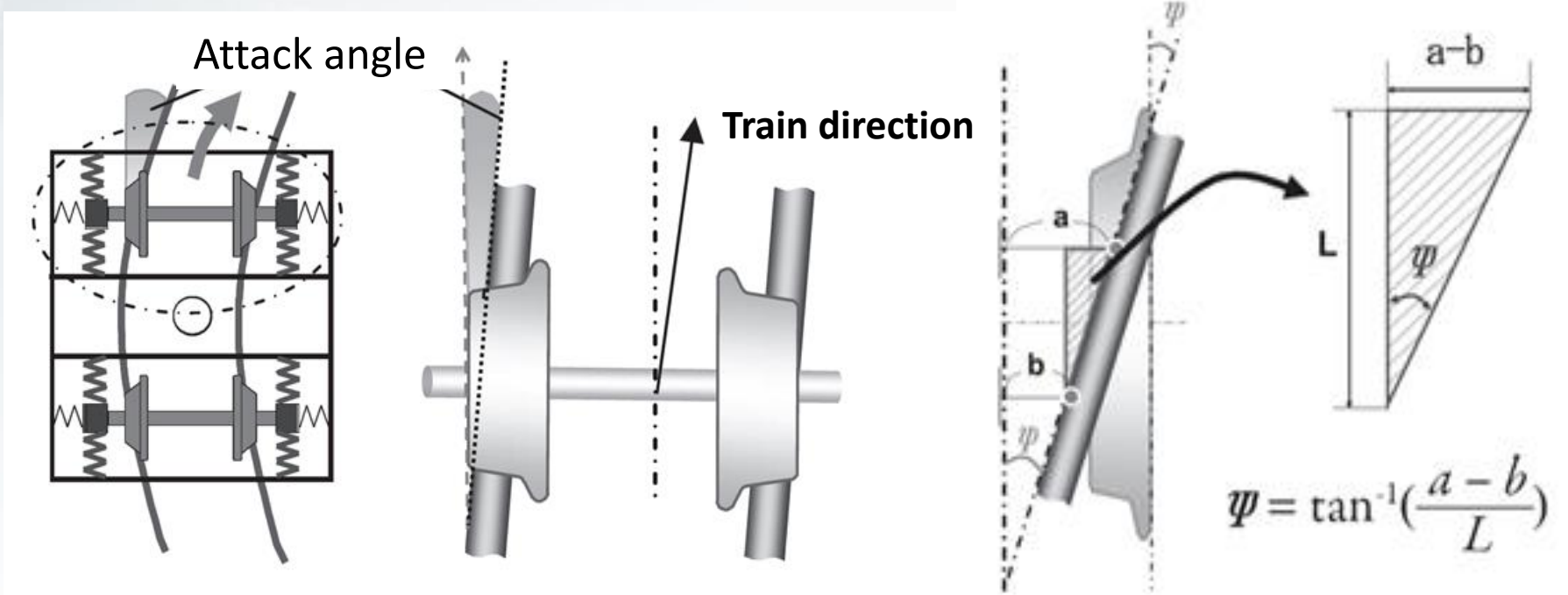
Classification	Derailment coefficient	Remarks
General case	0.8	
Wheel rise 5 mm within a curve radius of 150 m, When **friction coefficient 0.4** and **flange angle 70˚**	1.1	
When **friction coefficient 0.36** and **flange angle 70˚**	1.2	

II Cause of freight train derailment on a 153 m radius turnout



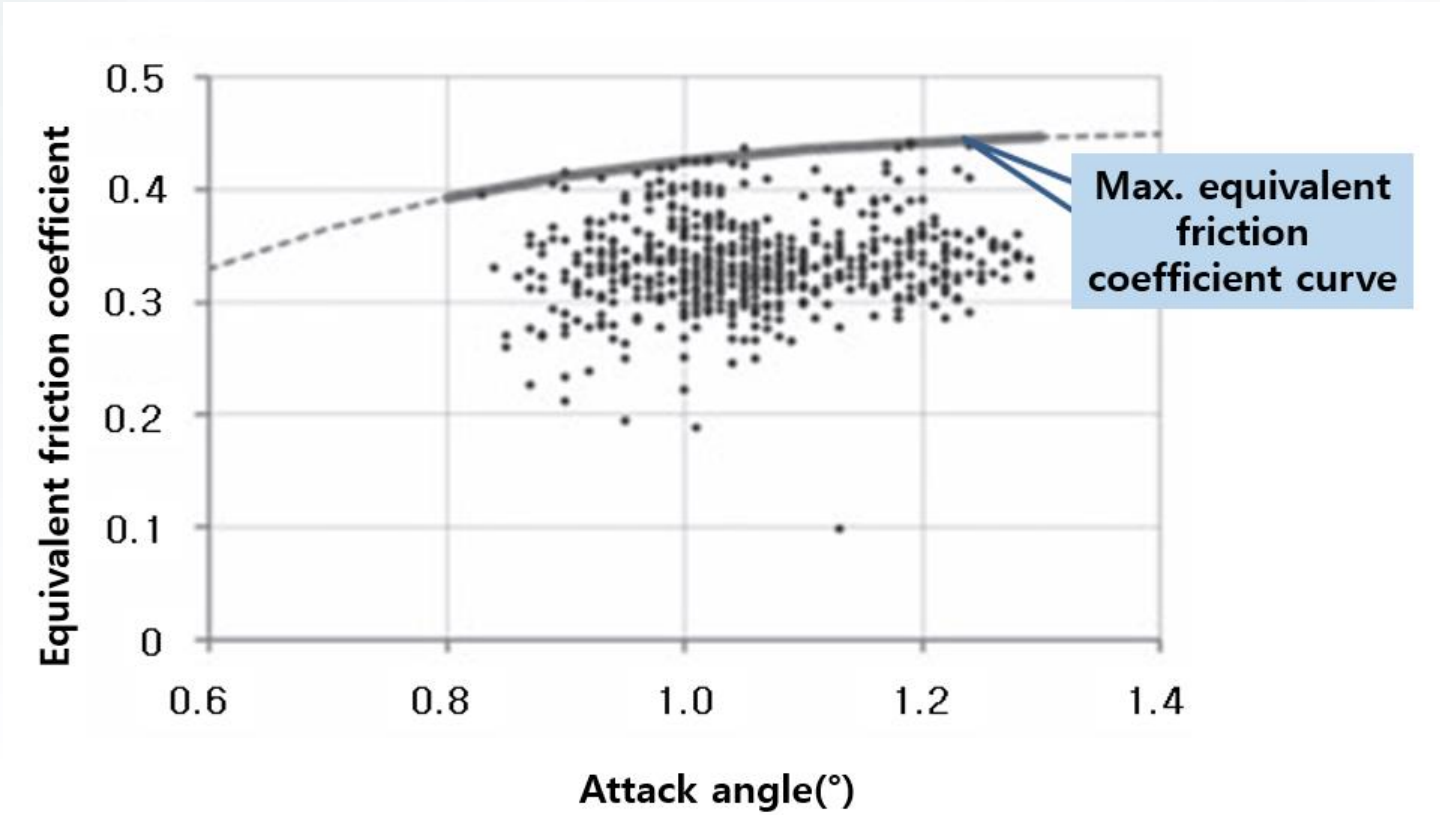
$$L = N \sin \alpha - T_Y \cos \alpha$$
$$V = N \cos \alpha + T_Y \sin \alpha \quad T_Y \leqq \mu N$$

II Cause of freight train derailment on a 153 m radius turnout



II Cause of freight train derailment on a 153 m radius turnout

- JR EAST Technical Review-No.30 "A Study on the Prevention of Wheel-Climb Derailment at Low Speed Ranges"



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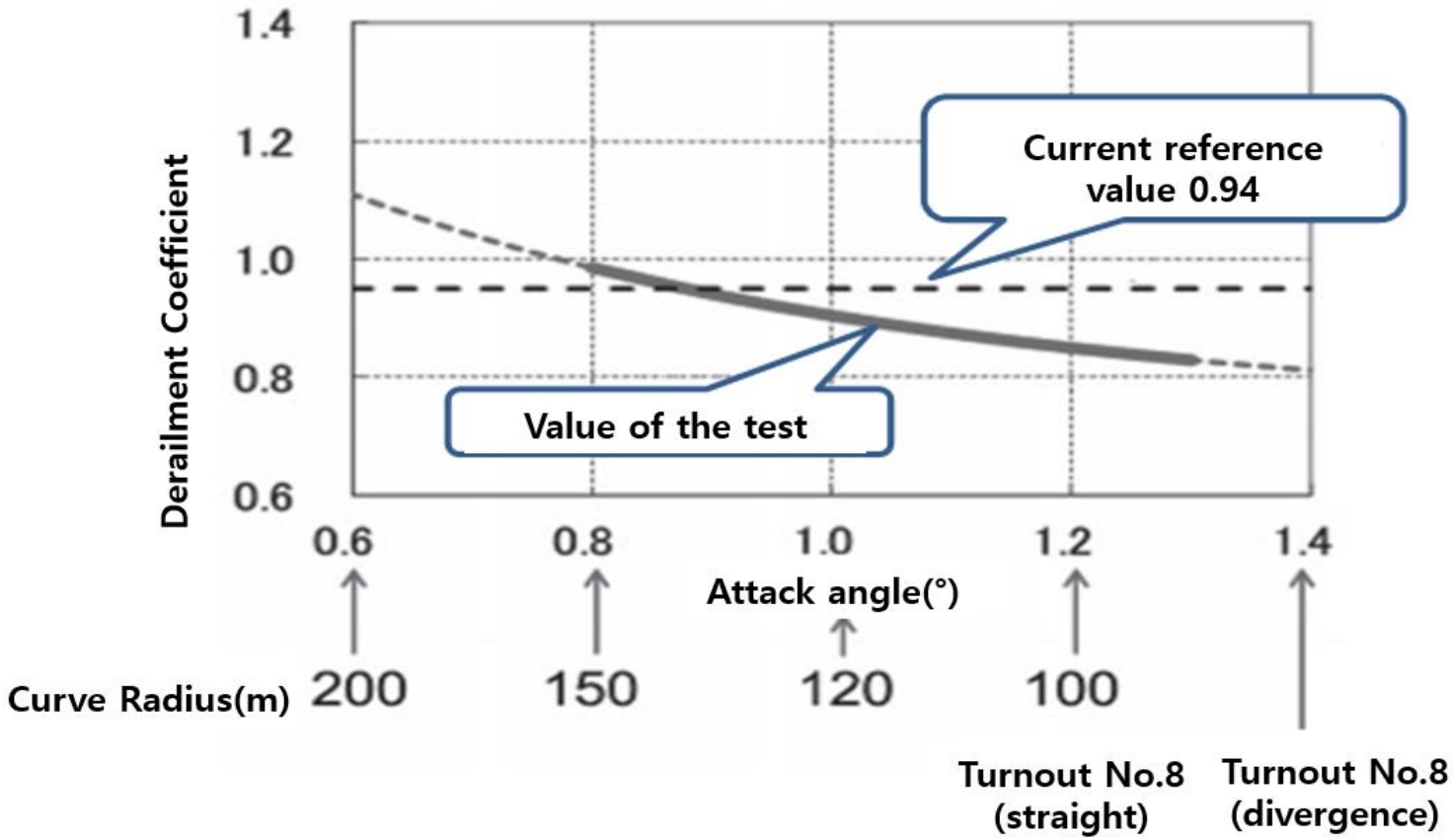


II Cause of freight train derailment on a 153 m radius turnout

- Limit derailment coefficient considering equivalent friction coefficient

Classification/curve radius		250 m	200 m	150 m	120 m	100 m (including F8 turnout)
Attack angle (°)			0.6	0.8	1.0	1.2
Equivalent friction coefficient		0.3	0.33	0.40	0.42	0.44
Derailment coefficient	Flange angle 60° ( ) values consider a safety factor of 0.85	0.94 **(0.80)**	0.89 **(0.76)**	0.79 **(0.67)**	0.76 **(0.65)**	0.73 **(0.62)**
	Flange angle 65° ( ) values consider a safety factor of 0.85	1.12 **(0.95)**	1.06 **(0.9)**	0.94 **(0.8)**	0.91 **(0.77)**	0.88 **(0.75)**
	Flange angle 70° ( ) values consider a safety factor of 0.85	1.34 (1**.14)**	1.27 (1**.08)**	1.12 **(0.95)**	1.08 **(0.92)**	1.04 **(0.88)**

3 Safety assessment of a 3-axle bogie on sharp curves

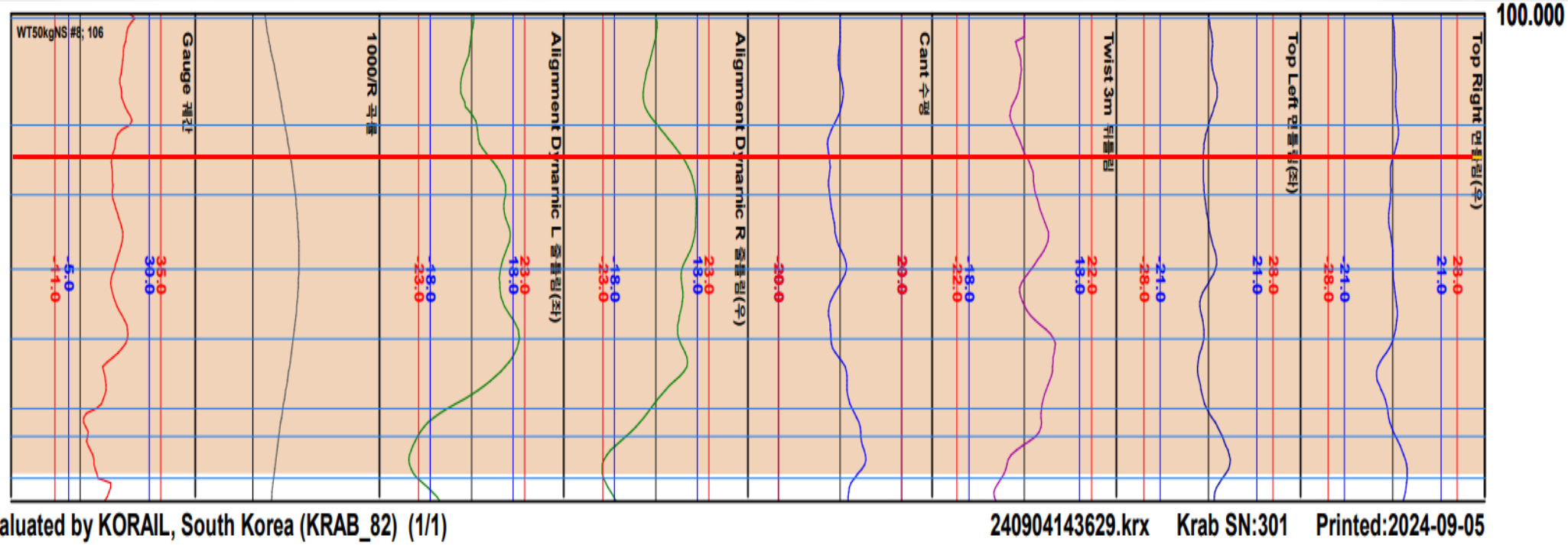
- Track Measurement Results

Point part

Heel part

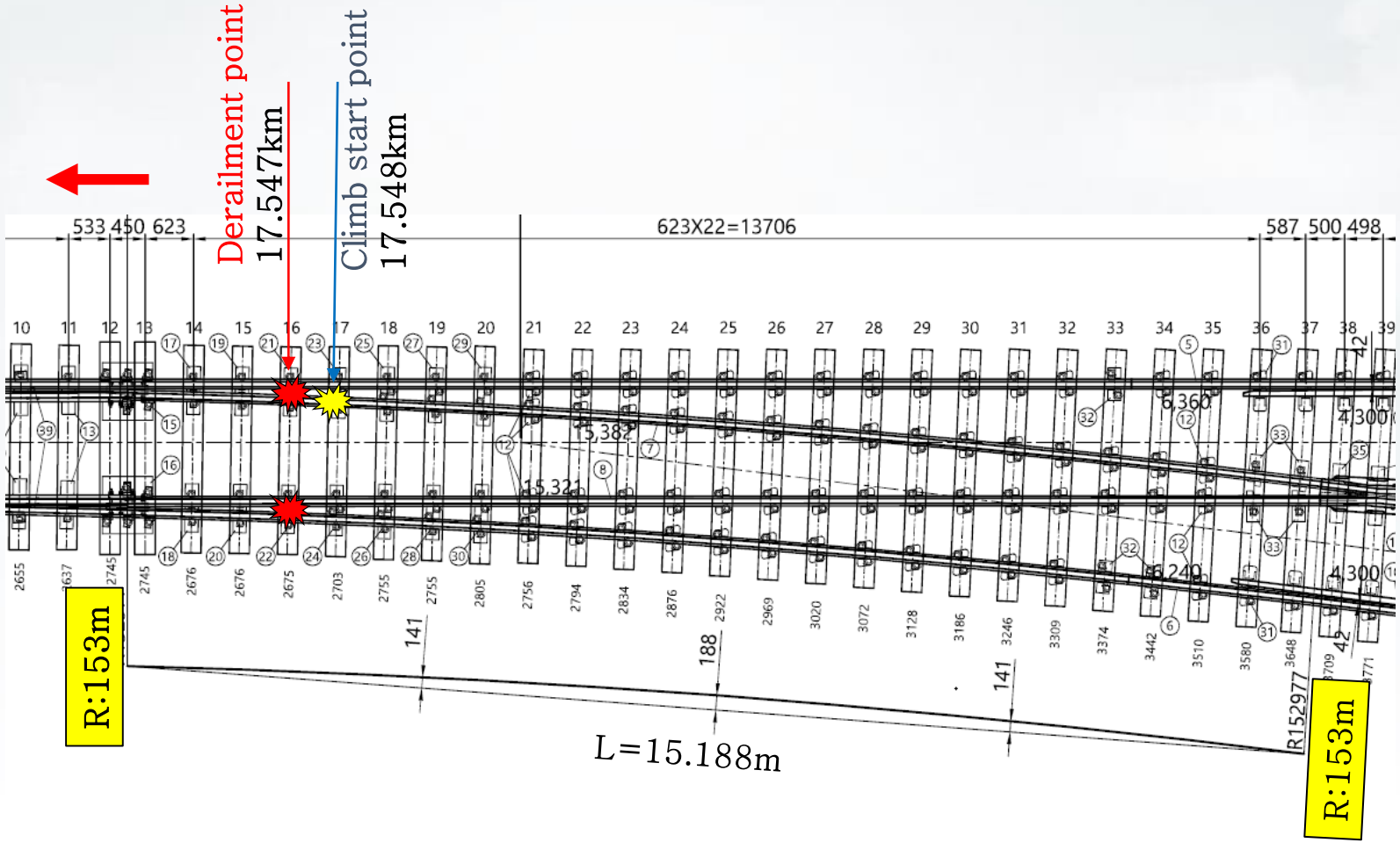
Derailment point

Crossing part



II Cause of freight train derailment on a 153 m radius turnout

- Layout of the turnout



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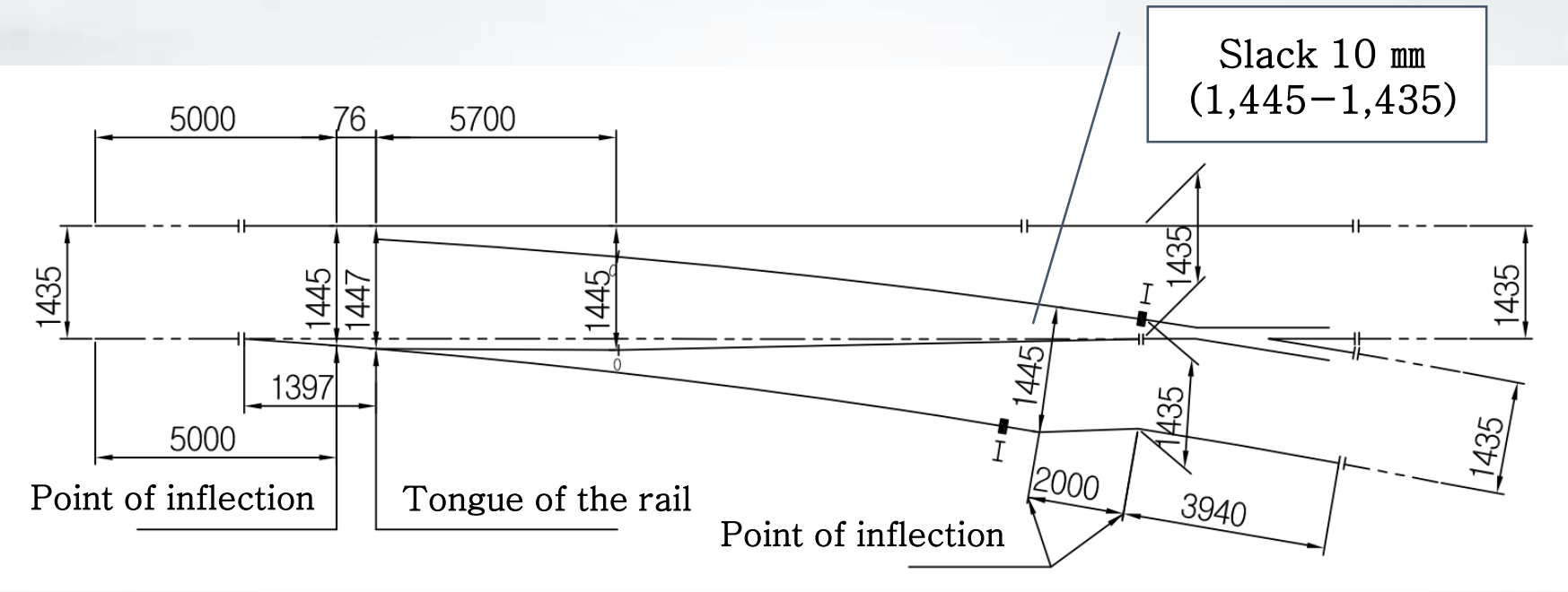
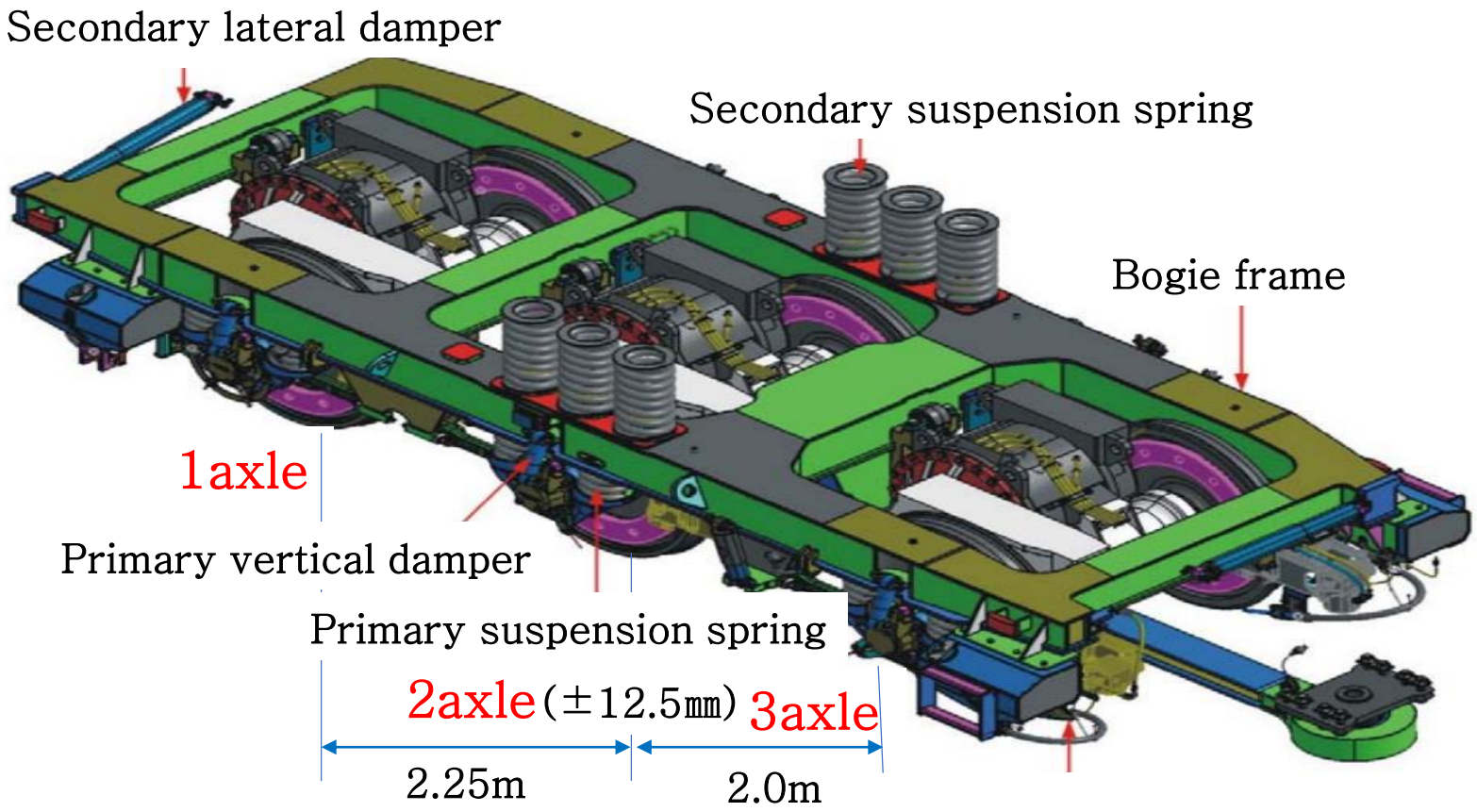


※ 50 kgN WT NS F8

Unit : ㎜

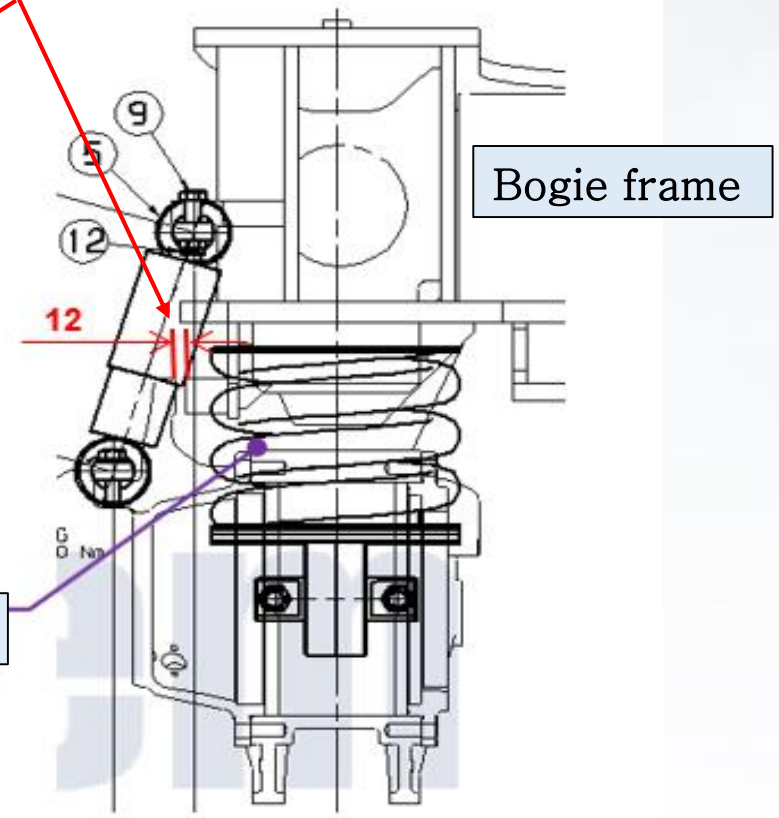
II Cause of freight train derailment on a 153 m radius turnout

- Locomotive structure



II Cause of freight train derailment on a 153 m radius turnout

Lateral displacement between axle and bogie frame : 12㎜



Bogie frame

Primary suspension spring

- Clearance between the inner wheel and rail of the 2axle (δ_{2u})

$\delta_{2u} > 0$

$\delta_{2u}(R:151) = \delta - f - 0.5 \times \delta_s$ = 28.5-15-0.5×25=0.5㎜

δ_{2u} : Clearance between the inner wheel and rail of the 2axle

δ : Lateral clearance between wheel and rail

f : Clearance between the outer wheel and rail of the 2axle

δ_s : Clearance between the flange of the outer wheel and the outer rail(max 25㎜) of the 3axle

$\delta_{2u}(R:151)$=0.5㎜ > 0

※ Assessment of derailment influence from increased friction caused by wheel griending day before the accident

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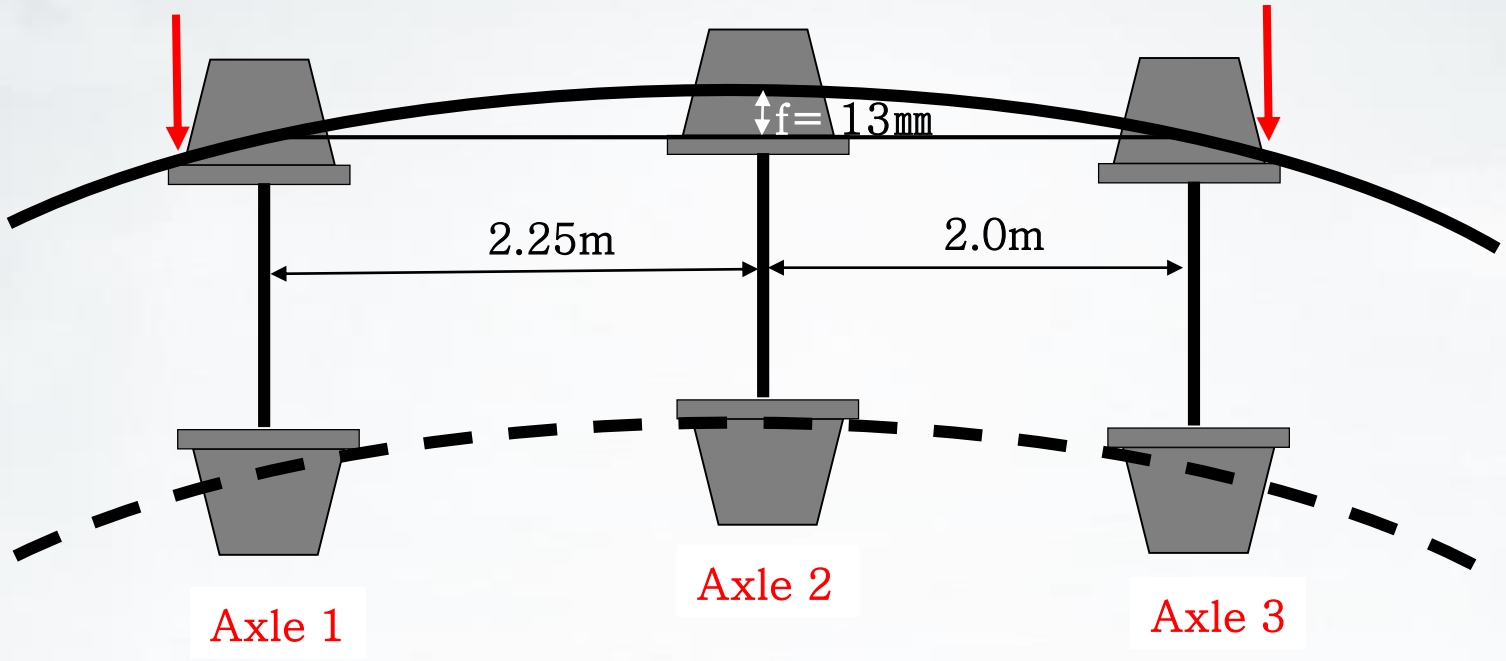

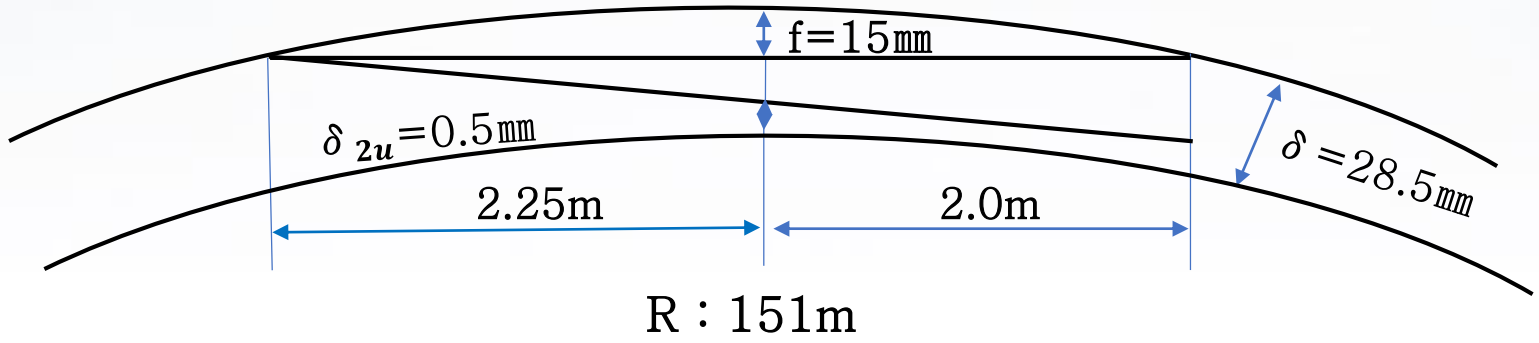

R : 151m

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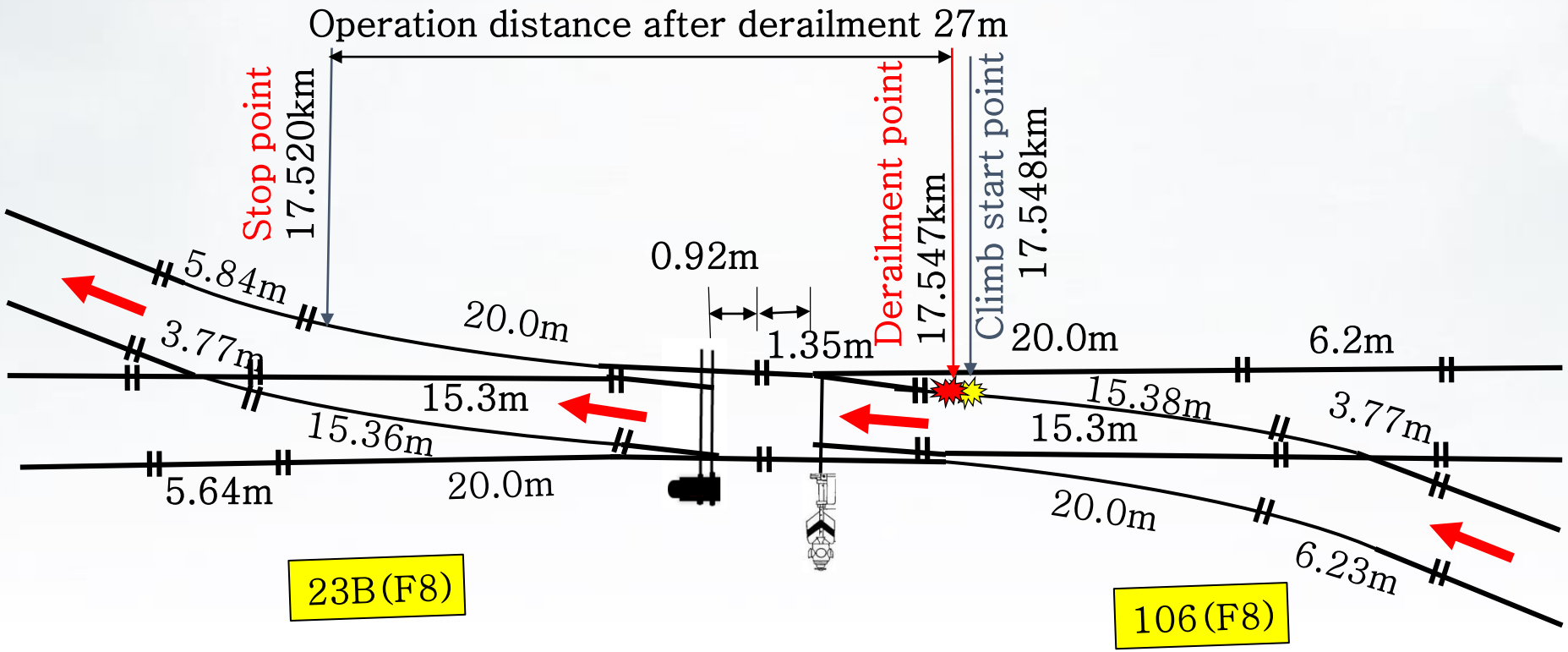
4 The specified distance ≥ 5 m between turnouts does not comply with the Railway Design Manual.



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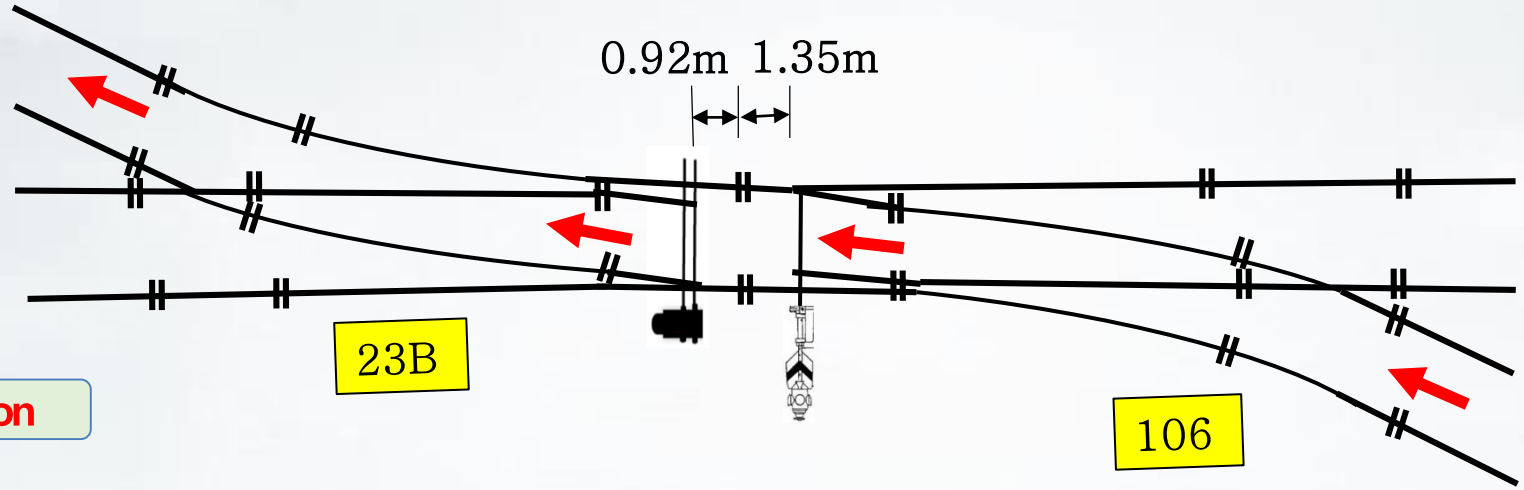
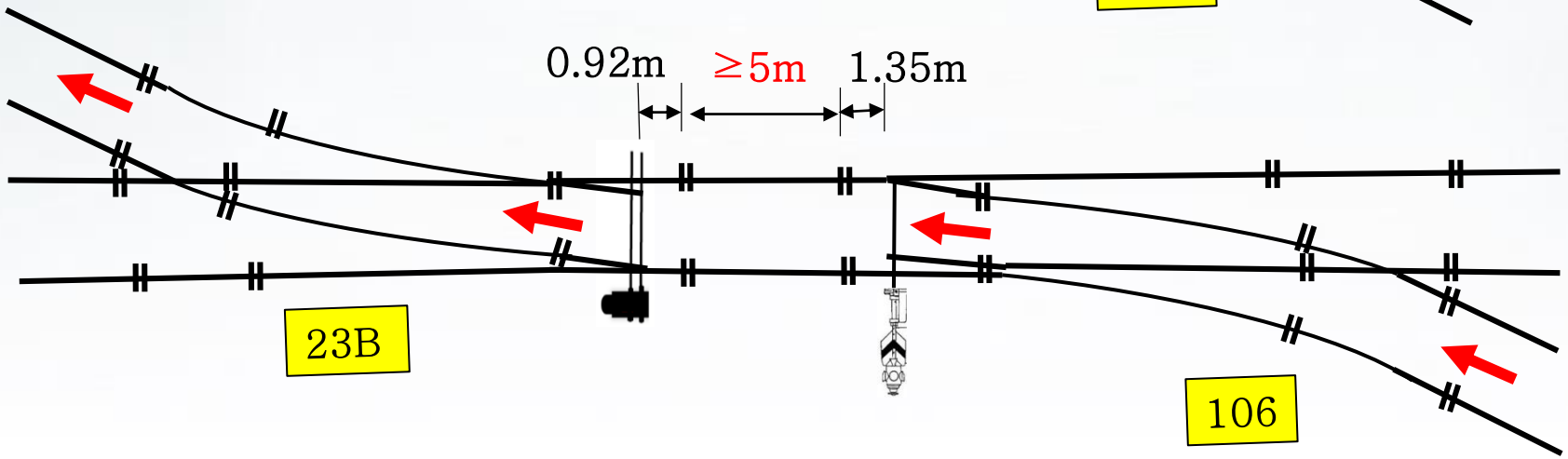
Current status



Regulation



5 The primary cause of the derailment

- **The cause of the freight train derailment**: "excessive lateral force exerted on the three-axle bogie while negotiating a turnout with a radius significantly tighter (153 m) than the vehicle's specified minimum curve radius (250 m)."

- **The contributing factor**: The locomotive was manufactured according to the manufacturer's specification requiring a minimum curve radius of 250 m, but was operated on track sections with a curve radius of 153 m.

6 Safety recommendations

- Review and, if necessary, revise the derailment coefficient criteria prescribed in the Railway Vehicle Technical Standards to ensure they reflect appropriate vehicle and track interaction limits.
- Develop measures for operating trains on turnouts with radii smaller than those permitted by the rolling stock's technical specifications, as such non-compliance increases derailment risk.
- Improvement measures shall be implemented at locations where the turnout spacing specified in the Railway Design Manual is insufficient.

1 Accident prevention activities

- Proper design and construction of the railway
- Regular track inspection and maintenance
- Rolling stock safety checks
- Signal and communication system monitoring
- Safety training and awareness programs for the employees
- Implementation of advanced safety technologies
- Emergency preparedness and response drills

2 Expected improvements

- Enhanced operational safety
- Reduction of accidents and incidents
- Increased reliability of railway services
- Improved passenger and worker confidence
- Cost reduction from fewer disruptions
- Stronger safety culture across the organization

Ⅳ Conclusion(How can we make a railway safer?)

- Establishment Railway Safety Management System(2004)
  - Introduction of the **SMS**(Safety Management System)
  - Introduction of the RAMS(Reliability, Availability, Maintainability, Safety) technique
  - Introduction of the System Engineering

+

- Measures of the accident prevention
  - Vehicle improvement
  - Facility improvement
  - Strengthening of employee education and training
  - System improvement
  - Research and development
  - Risk assessment

Ⅳ Conclusion(How can we make a railway safer?)

- Make a good facility
- Suitable raw, rule, manual
- Well-trained worker
- Continuous research and development

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Thank you.

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