CHALMERS
UNIVERSITY OF TECHNOLOGY

RAILWAY OPERATIONS IN SWEDEN AND JAPAN

Similarities and differences with a particular focus on wheel/rail deterioration

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OUTLINE

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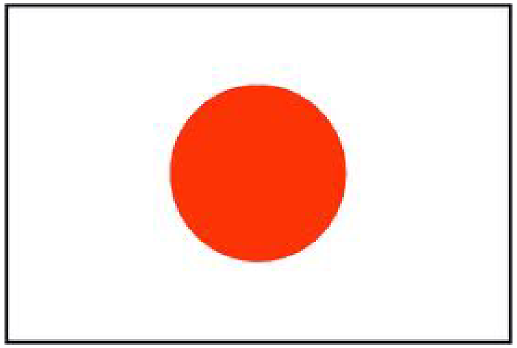
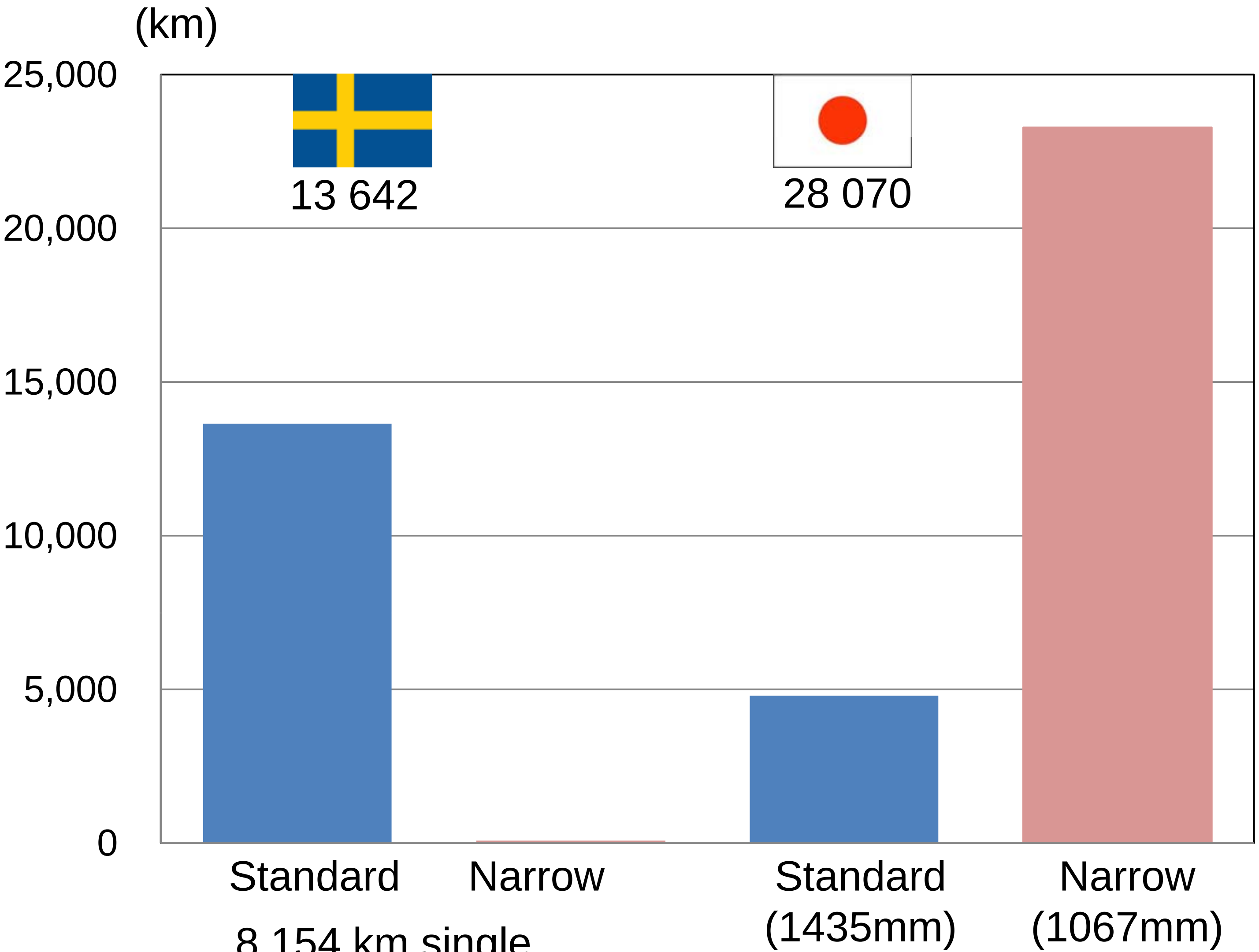
2. Comparison of rail / wheel specification
3. Comparison of rail / wheel deterioration
4. Comparison of mitigating actions
5. Conclusions
6. Brief introduction of RTRI

General comparison



	Sweden	Japan
Population (million)	9.5 (21 persons/km^2)	127.6 (338 persons/km^2)
Land area (thousand km^2)	450	378

Total length of tracks



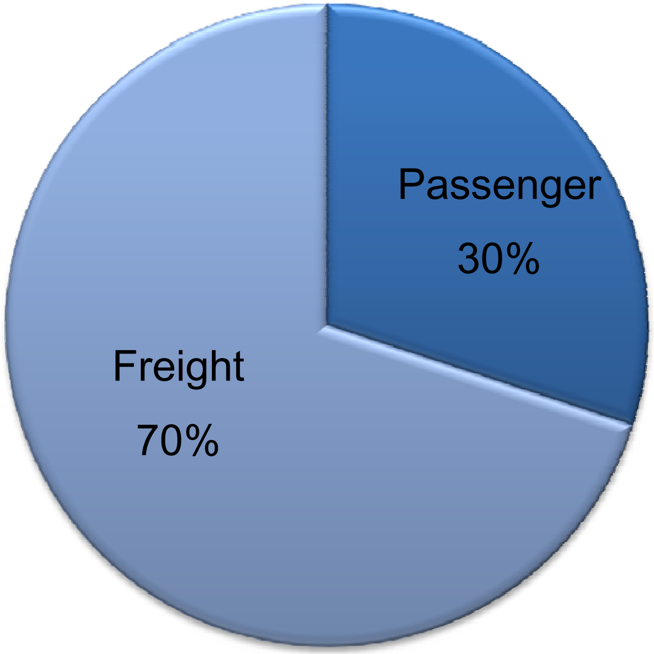
8 154 km single
9 780 km electrified

7 603 km single
20 257 km electrified

www.trafikverket.se
International railway statistics 2008 of UIC

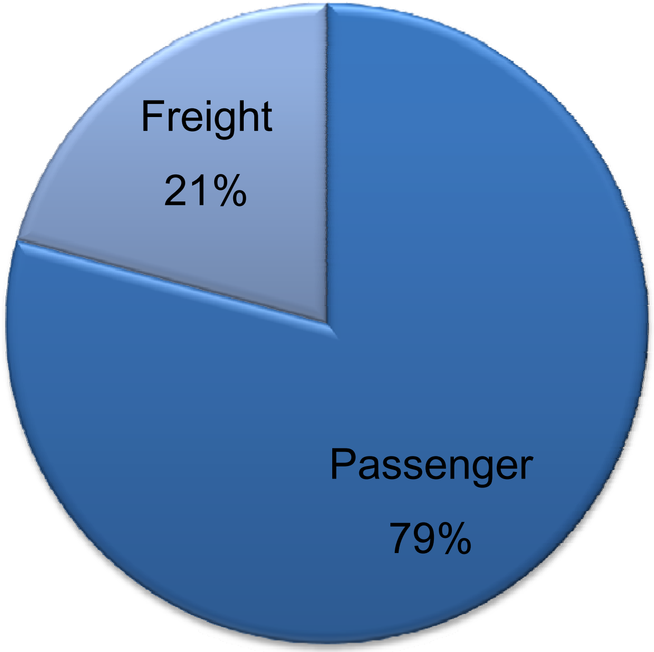
Gross hauled tonne-kilometres of trains running on the network 2008

Total : 65 488
(millions tonnes-kilometres)



max axle load 30t
max speed 200 km/h

Total : 285 991
(millions tonnes-kilometres)

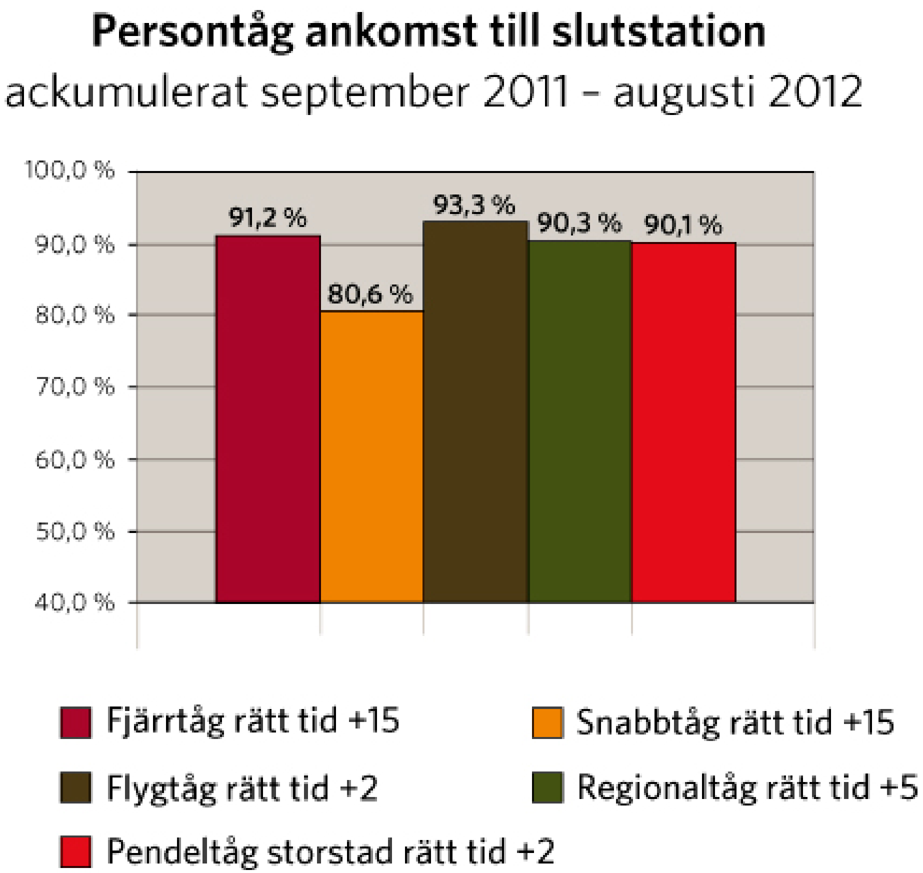


max axle load 18t (conventional)
max speed 300 km/h

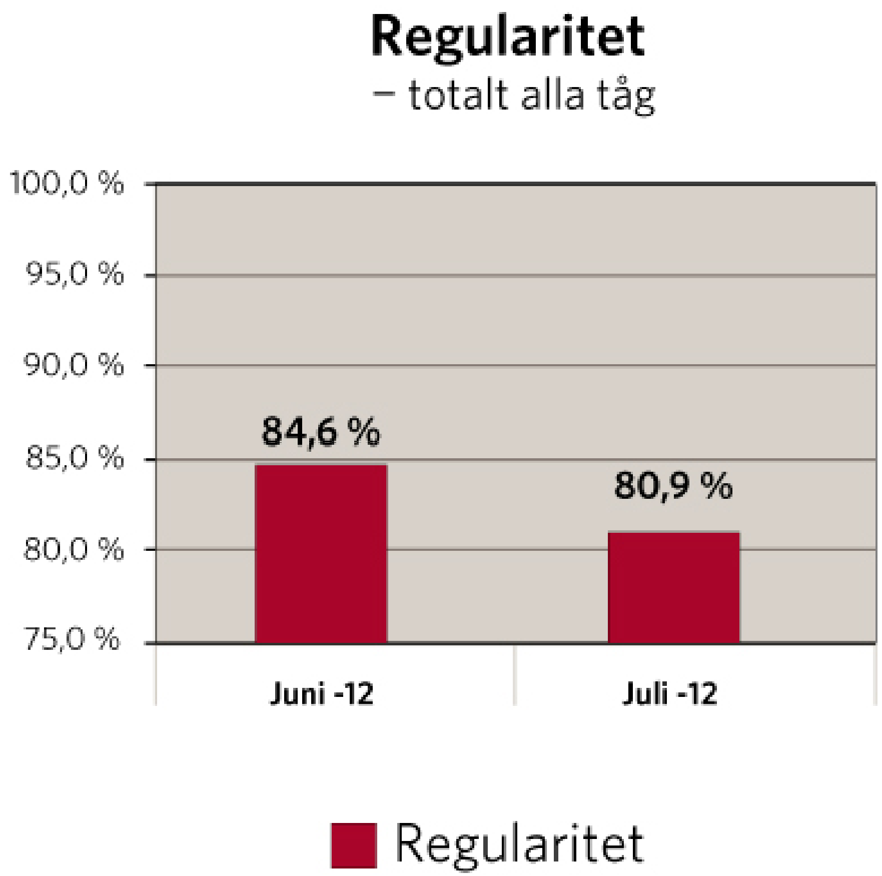
International railway statistics 2008 of the UIC

Punctuality – Sweden

Trains arriving within prescribed "allowed delays"



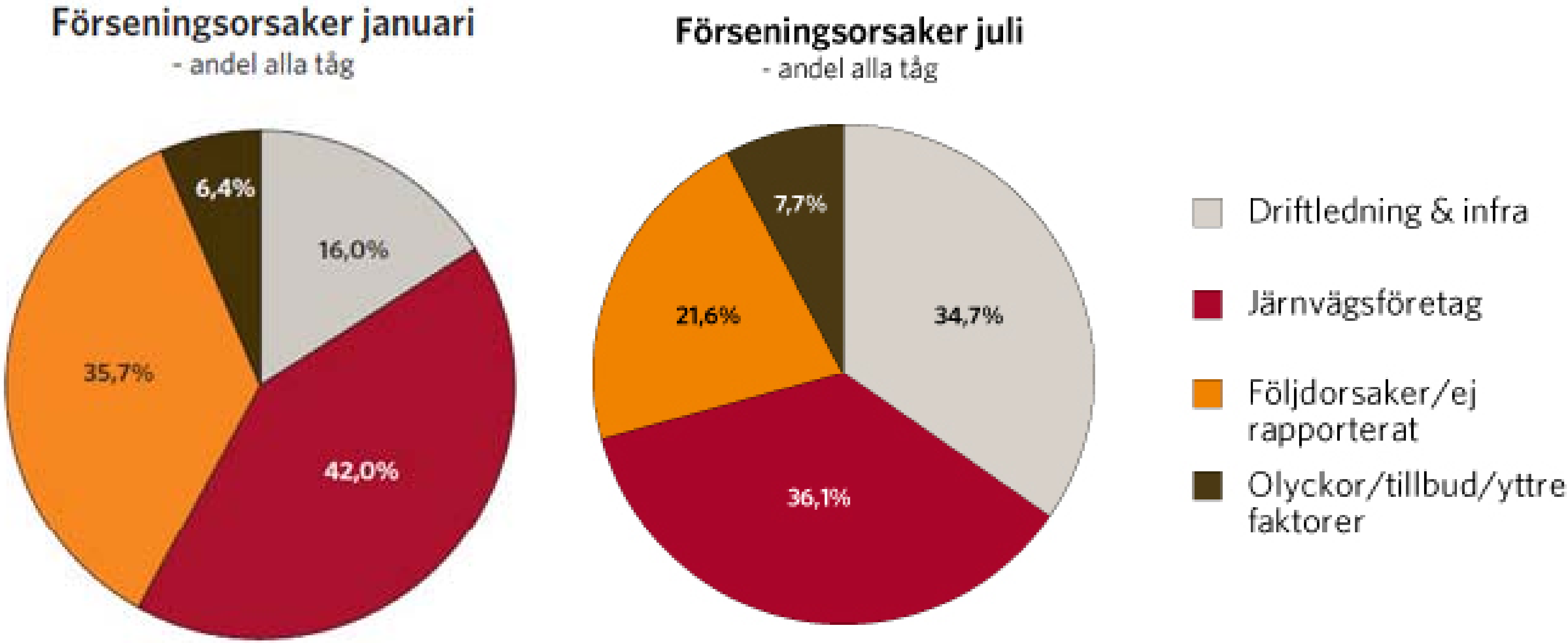
Percentage of trains operating all of the planned route



http://www.trafikverket.se/Om-Trafikverket/Trafikverket/Manatlig-trafikrapport/Transport-pa-jarnvag-i-ratt-tid/

Punctuality – Sweden

Causes of delays in January and July, 2012

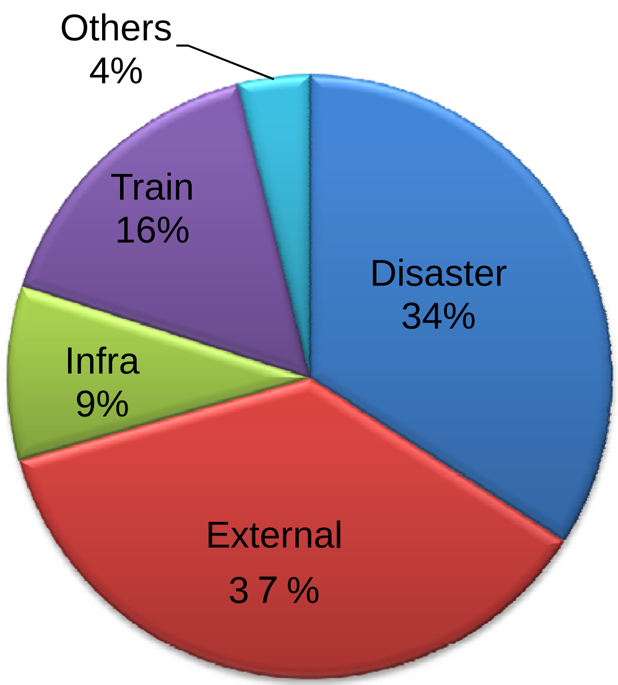


http://www.trafikverket.se/Om-Trafikverket/Trafikverket/Manatlig-trafikrapport/Transport-pa-jarnvag-i-ratt-tid/

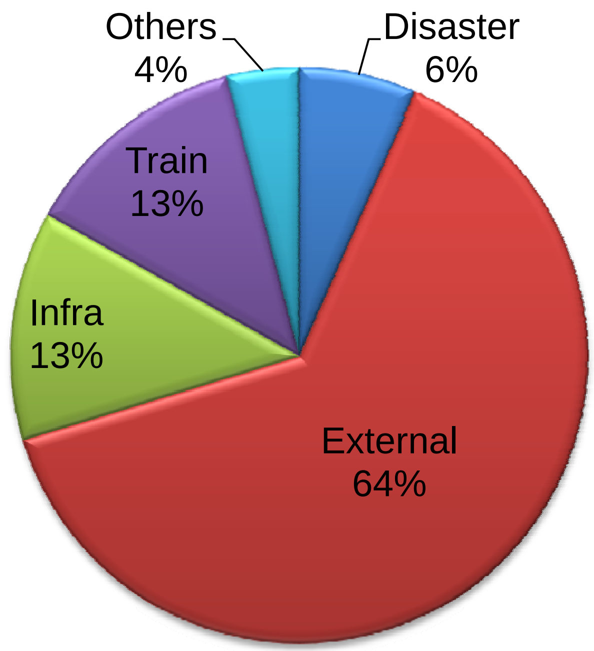
Punctuality – Japan

Causes of delays in 2009

Total



Metropolitan area
(Tokyo, Chiba, Saitama, Kanagawa)



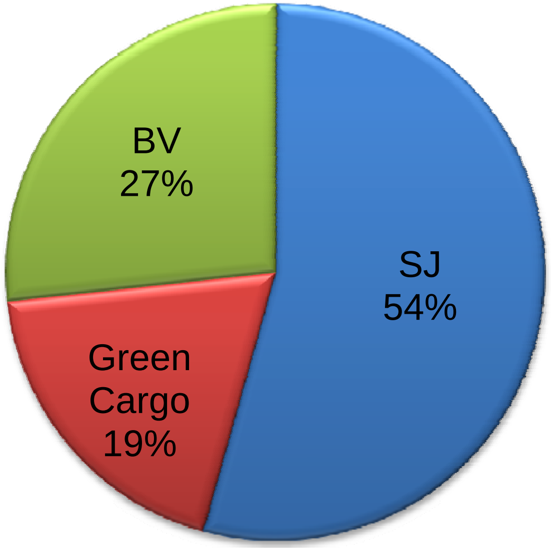
- Regulation -

Railway companies have to report to the government if the train is delayed over 30 min..

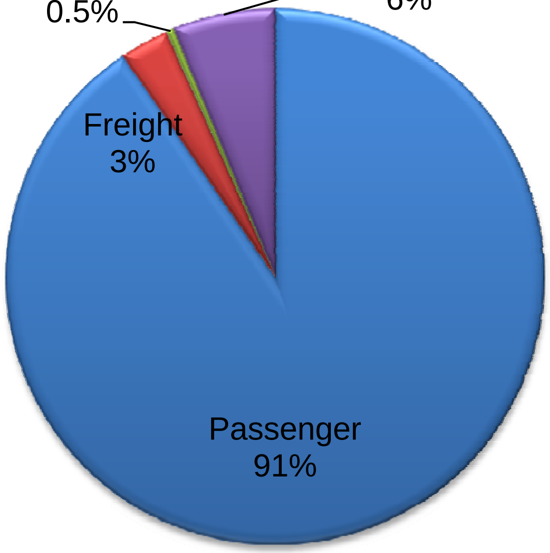
http://www.mlit.go.jp/common/000164410.pdf (in Japanese)

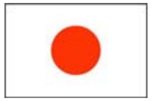
Turnover 2008

Total 1 728 millions euros



Total 29 658 millions euros





The portion of passenger traffic is quite large in Japan.

The portion of freight traffic in Sweden is large, compared with that of Japan.

International railway statistics 2008 of UIC

Comparison of rail / wheel specification

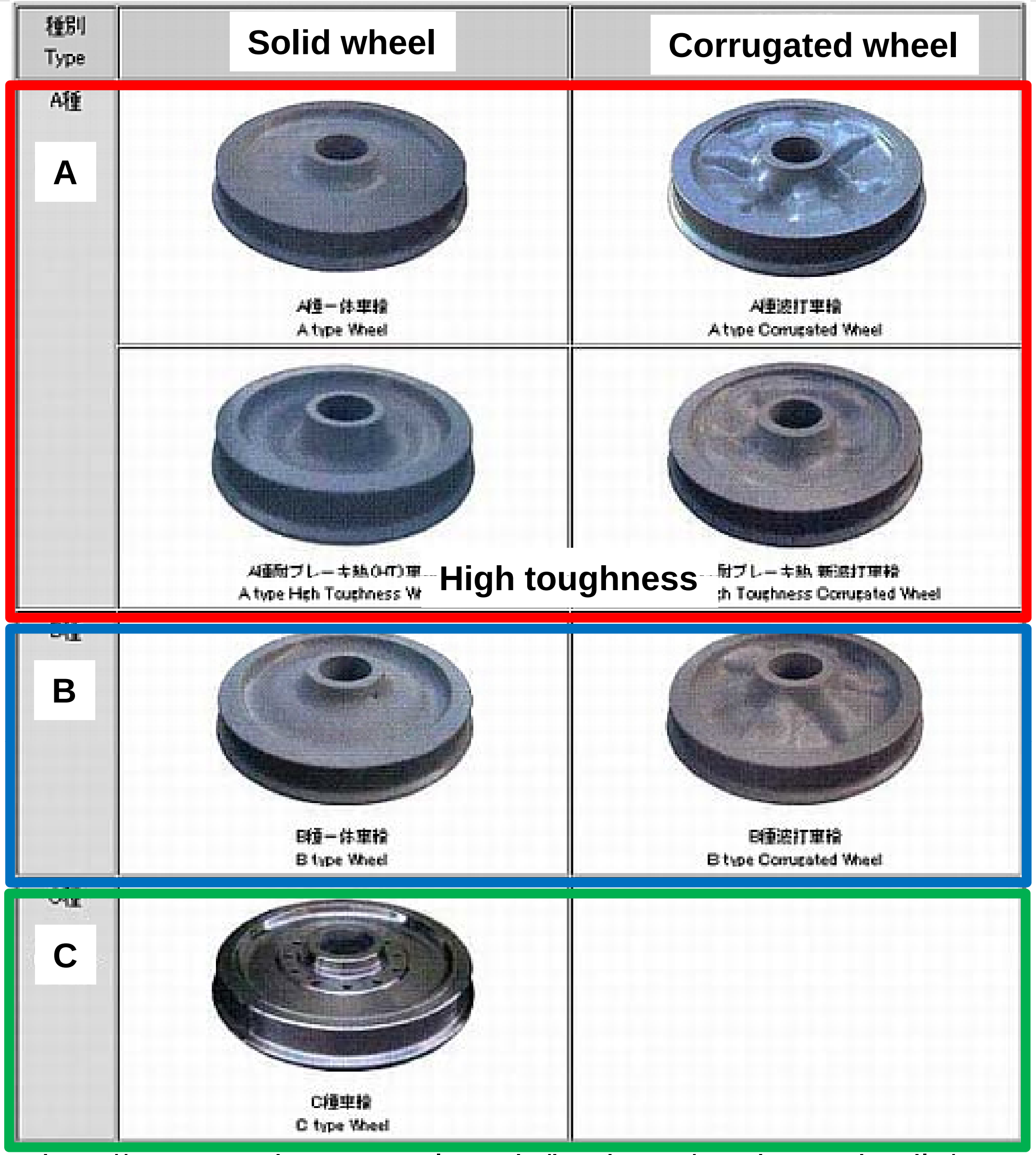
Wheel specification

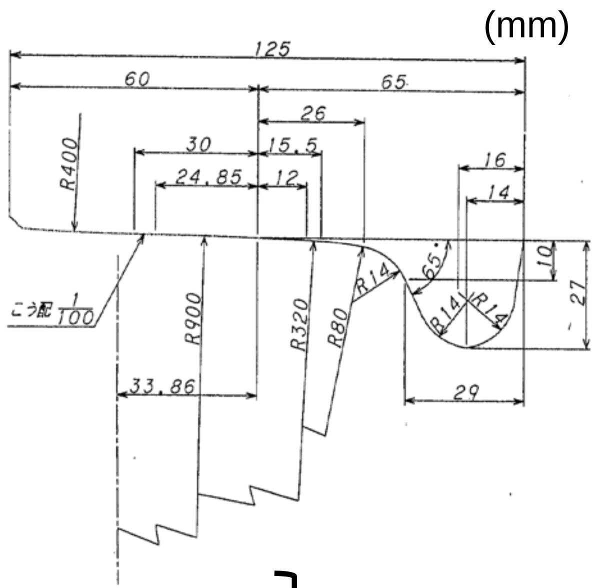
Europe	Cmax	Si max	Mn max	P max	S max	σ_t(MPa)
C46GT	0.46	0.38	1.15	0.035	0.035	600-720
C55GT	0.55	0.38	0.86	0.035	0.035	700-820
C57GT	0.57	0.38	1.05	0.035	0.035	750-880
C67GT	0.67	0.38	0.86	0.035	0.035	800-940
C77GT	0.77	0.38	0.86	0.035	0.035	1050-1200

Japan	C	Si	Mn	P max	S max	σ_t(MPa)
SSW-S	0.60-0.75	0.15-0.35	0.50-0.90	0.045	0.050	730-960
SSW-Q						860-1080

(-S and -Q denote the different thermal treatments), JIS E 5401

Comparison of rail / wheel specification





A type

B type for bogie with motor

Conventional

C type for Shinkansen

http://www.sumitomometals.co.jp/business/products_details/railway-automotive-machinery-parts/syarin/

Comparison of rail / wheel specification

Rail specification

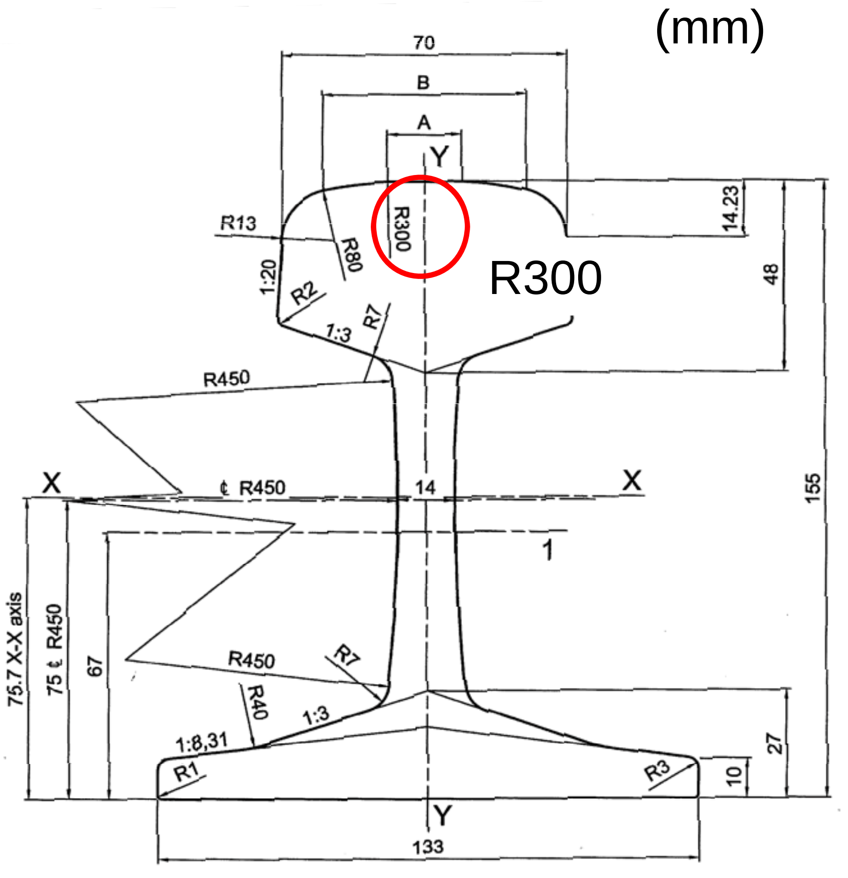
Europe SS-EN 13674-1	**C**	**Si**	**Mn**	**Cr max**	**P max**	**S max**	**σ_t(MPa) min**
R260	0.62-0.80	0.15-0.58	0.70-1.20	0.15	0.025	0.025	880
R350HT	0.72-0.80	0.15-0.58	0.70-1.20	0.15	0.020	0.025	1175
R370CrHT	0.70-0.82	0.40-1.00	0.70-1.20	0.40-0.60	0.020	0.020	1280
R400HT	0.90-1.05	0.20-0.60	1.00-1.30	0.30	0.020	0.020	1280

Japan JIS E1101 & E1120	**C**	**Si**	**Mn**	**Cr max**	**P max**	**S max**	**σ_t(MPa) min**
As-rolled	0.63-0.75	0.15-0.30	0.70-1.10	-	0.030	0.025	800
HH340 (Head Hardened)	0.72-0.82	0.10-0.55	0.70-1.10	0.20	0.030	0.020	1080

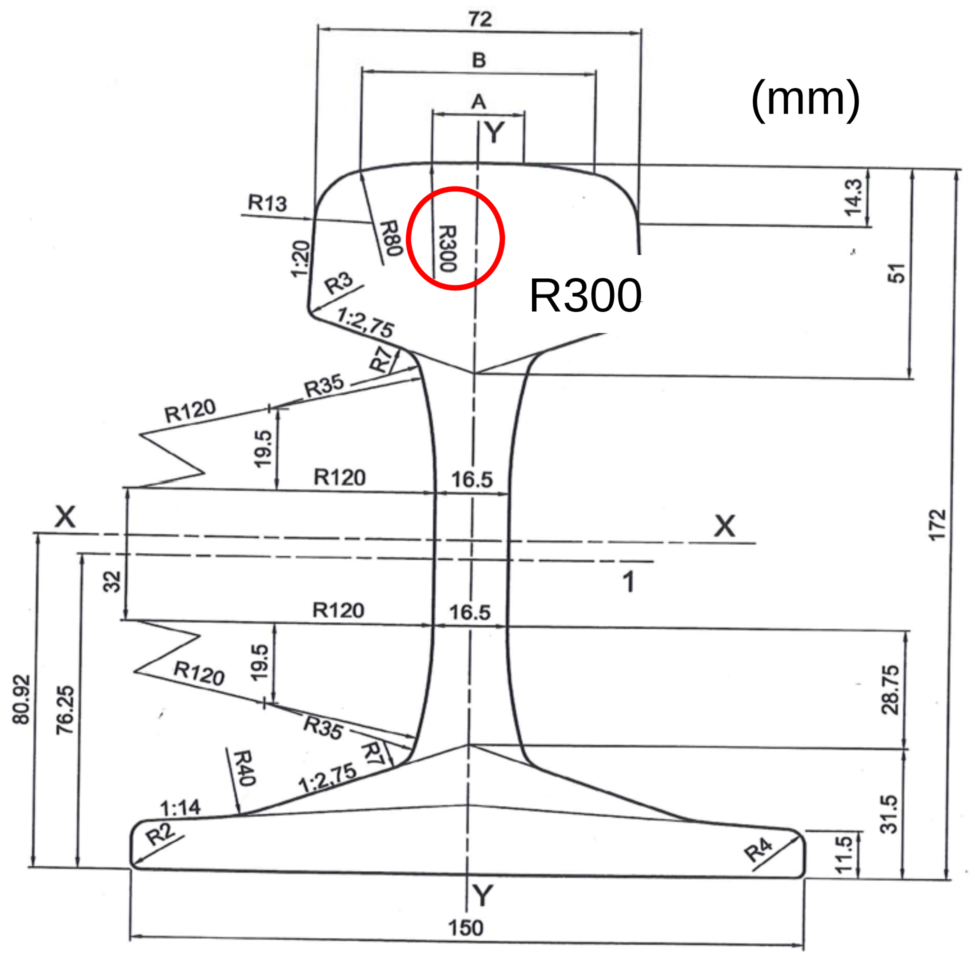
(As-rolled: 270HV, HH340: 380HV)

Comparison of rail / wheel specification

Swedish rail shape



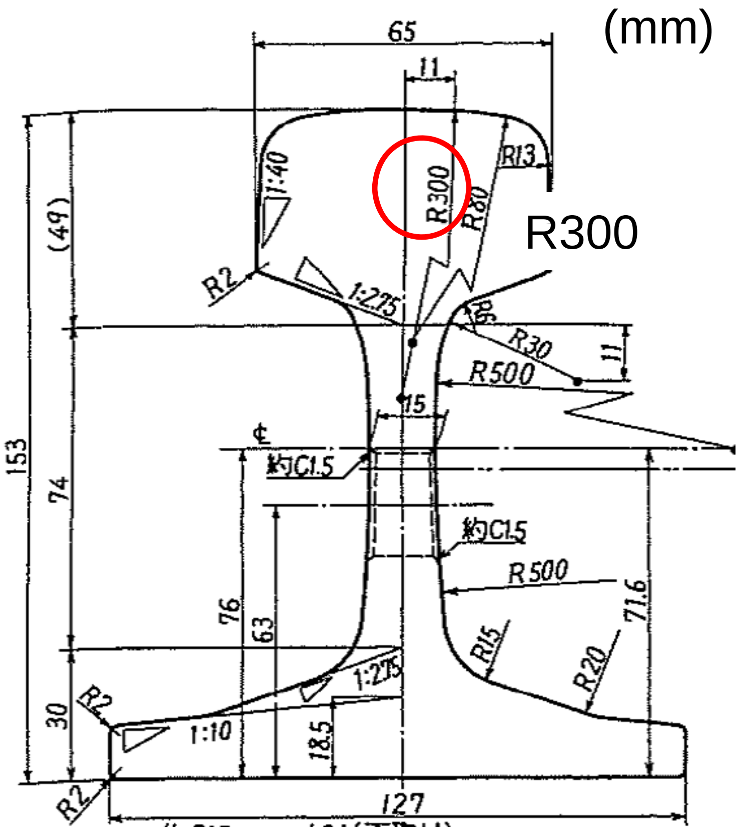
50kg



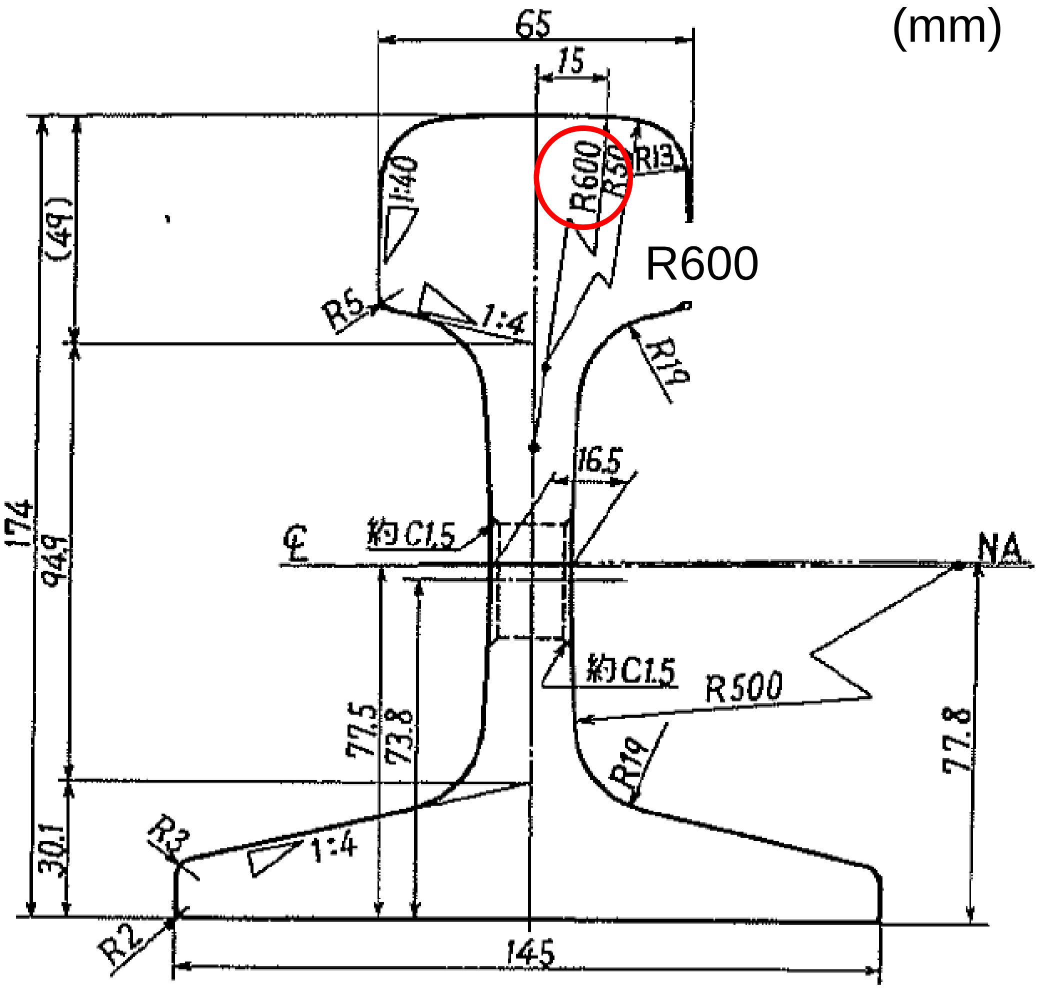
60kg

SS-EN 13674-1

Japanese rail shape



50kgN
(conventional)



60kg
(Shinkansen & conventional with high train density)

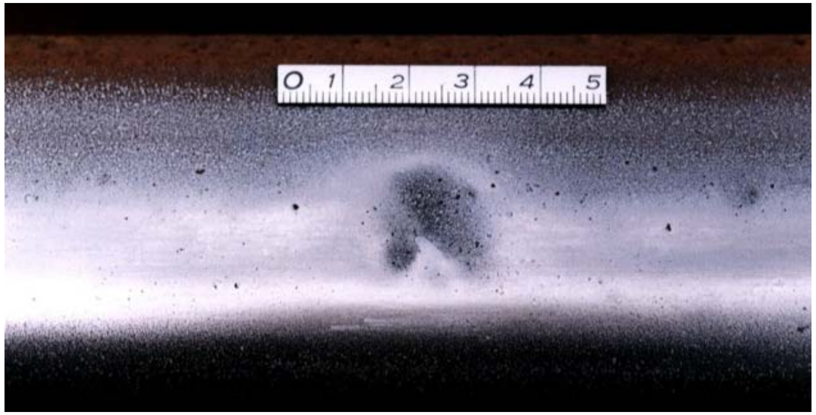
JIS E1101 & E1120

Damage situation in Japan

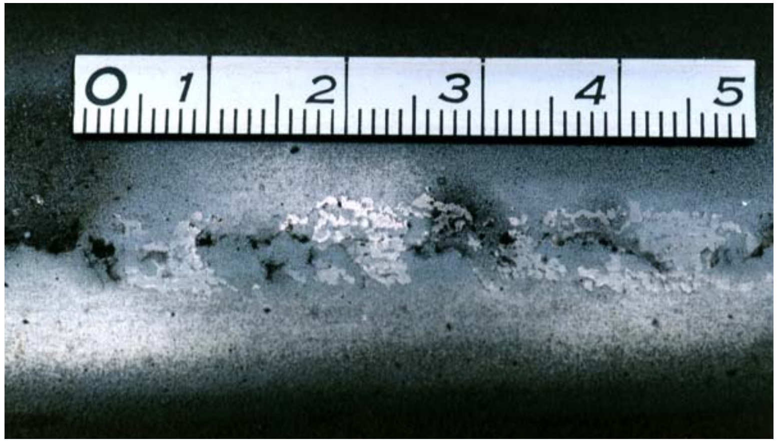
Squats arose at narrow gauge lines in 1950s

- **Steam locomotive (large lateral force)**
- **Water spray to reduce wear in curves**
- **Heat treated rail**
- **Modernization of traction : from Steam locomotives to Electric locomotives**
- **Stop water spray because of improvement of steering performance due to changing steam locomotives to electric locomotives**

Appearance of squats(tangent rail)



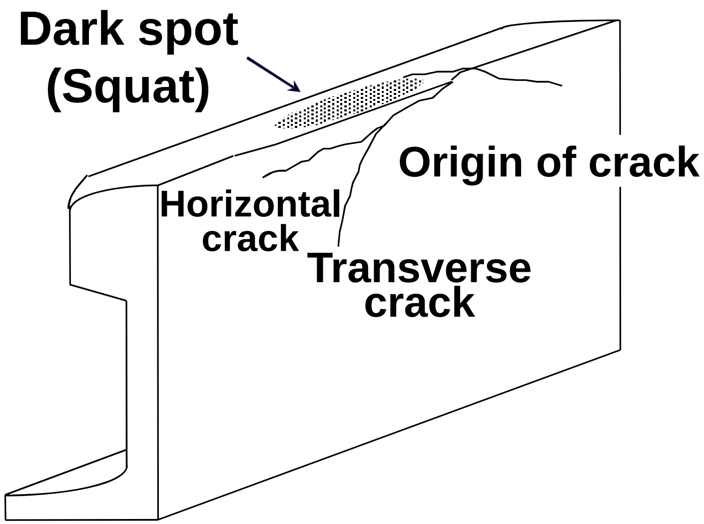
Single squat

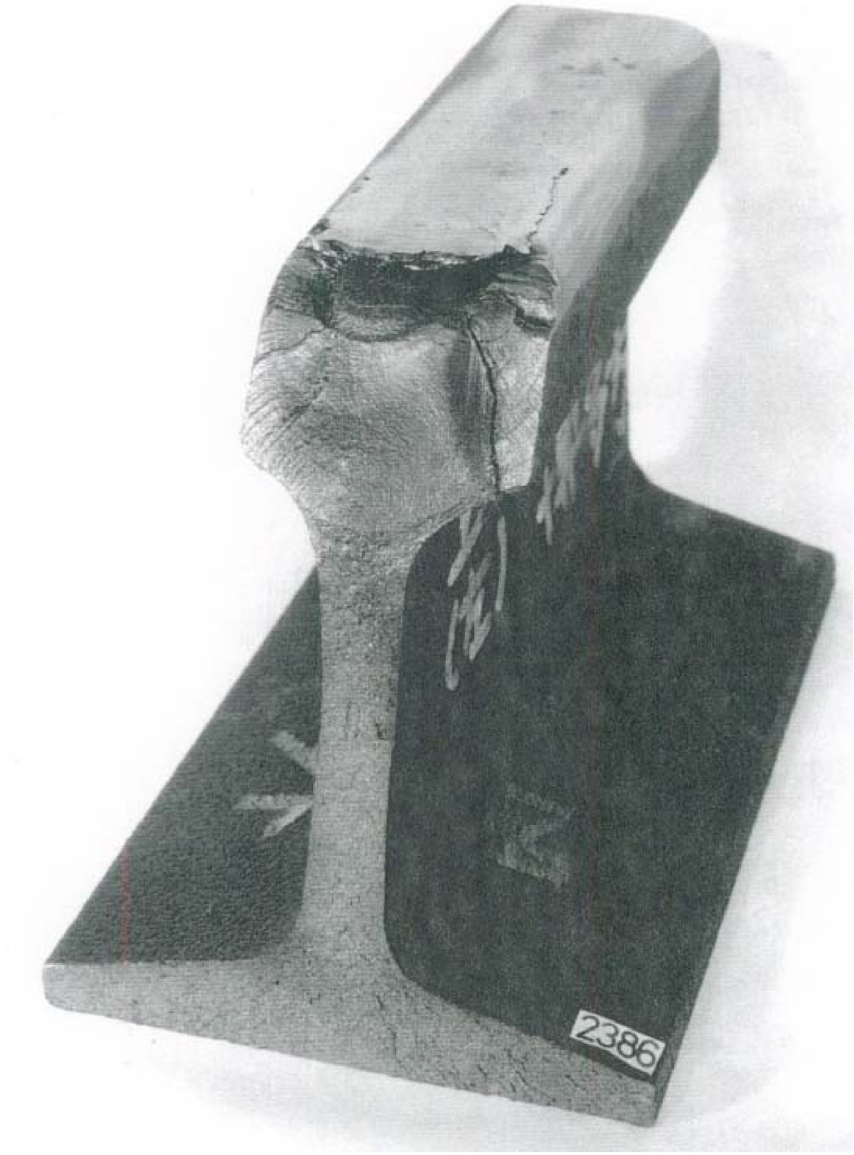


Squats due to WEL

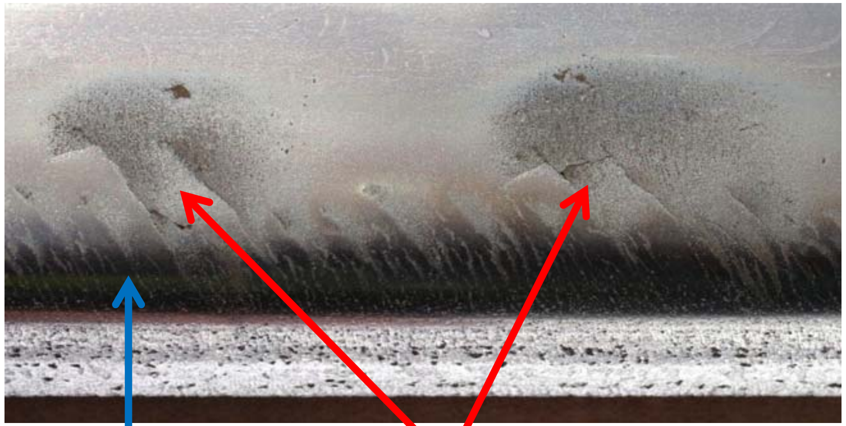
Multiple squats

Fracture surface of squat





Wear & other RCF damage



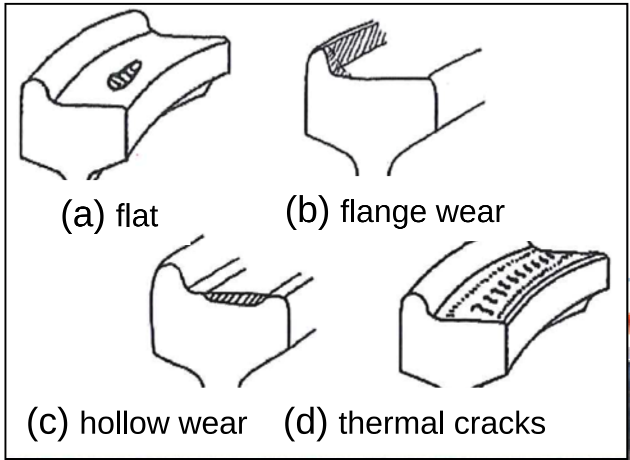
Head check & Gauge corner crack (squat)
(curve rail)

Head check & Flaking
(curve rail)

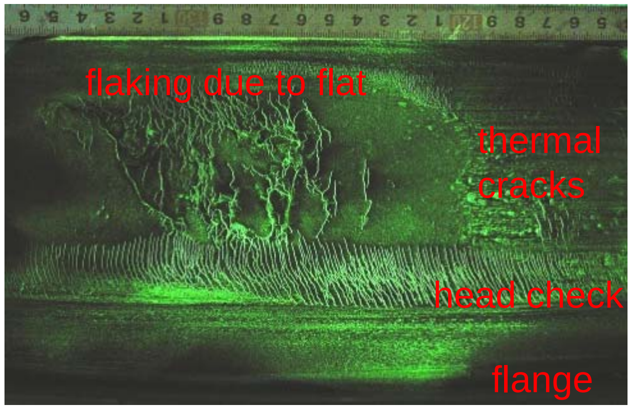
Head check (curve rail)

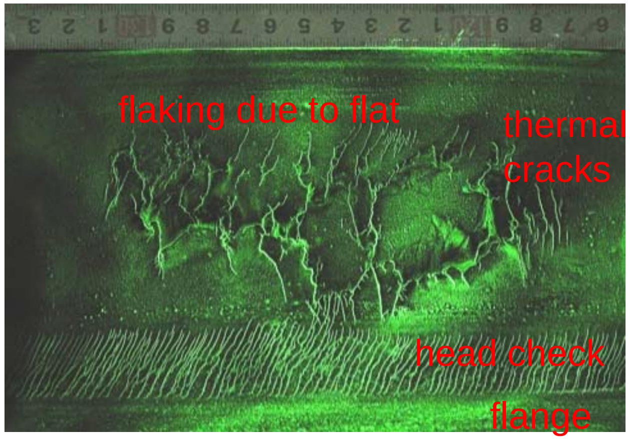
Corrugation (low rail)

Typical wheel damage of freight wagon



Flat and flange wear were dominant (flat is rare now).
Hollow wear and thermal cracks are common
(not very detrimental).





Mitigating actions in Japan

Rail

- Preventive grinding (grinding stones)
- Preventive milling (cutting tool)
- Lubrication on low and/or high rails (liquid & solid)
- Better control on running gear and infrastructure and preventive maintenance
- Monitoring of inspection cars (ultrasonic & on-board camera, etc..)
- Material approach (bainitic steel etc..)
- .....

Wheel

- Reprofiling (back to original shape)
- Monitoring (camera & sensor mounted in workshop, etc..)
- Flat detection sensor (vibration sensors mounted on the track)
- Better control on running gear (ABS etc..)
- Material approach (modification of wheel shape, corrugated wheel, lubrication on flange and tread, etc..)
- …..

Damage situation in Sweden

- Head checks and wheel RCF are dominating
- Sometimes (especially under winter conditions) fast growth of damage

- Squats and RCF clusters not very common, but increasing
- Wheel flats and thermal damage fairly common
- Very different damage patterns in different places (diversified operations)

Mitigating actions in Sweden

Rail

- Preventive grinding (grinding stones)
- Lubrication mainly liquid on high rails
- Inspection cars (geometry and rail head cracks)
- Head hardened rail in curves
- Profiles
- ...

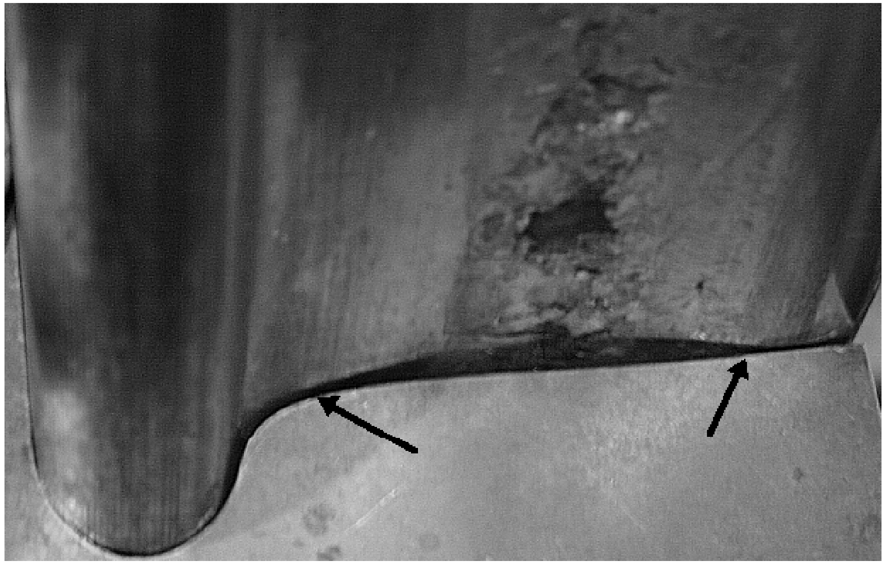
Wheel

- Reprofiling
- Ultrasonic inspection
- Wheel load and hot wheel / axle box detectors
- Calibration of braking (/ acceleration)
- Wheel profiles
- ...

General damage – wear and plastic deformation

- Distributed wear (hollow wear / flange wear / gauge corner wear)
  - sensitive in destroying contact geometry
  - in severe operations often in combination with plasticity

Rail corrugation *Photo Lennart Lundfeldt, Banverket*



Hollow wear of rather severely damaged Swedish freight wheel.

- Periodic wear (corrugation /out-of-roundness)
  - noise
  - risk of RCF

General damage – RCF

- Distributed RCF defects (head checks and wheel RCF)
  - curving and braking/acceleration
  - typically surface pits on wheels
  - risk of rail breaks

RCF-pattern of a Swedish heavy haul wheel

Rail break setting out from a headcheck crack

- Single RCF defects (squats and RCF clusters)
  - more random occurrence
  - risk of rail breaks
  - risk of axle box failures

Some concluding remarks

- Japan has about 13 times the population of Sweden. Sweden has about 20% larger area.
- Japan has about twice the railway network size of Sweden with about 4 times the transport volume and 17 times the turnover.
- Japan have higher max speeds, Sweden higher loads
- In Japan passenger transports dominate, in Sweden freight.
- In simplified terms the main focus in Japan is on punctuality and the main focus in Sweden on costs.
- Material specifications for wheel and rails in Japan and Sweden are comparable.
- Japan uses corrugated wheels and rails with more flat heads, which are not commonly used in Sweden.
- The same types of wheel and rail damage occur in Japan and Sweden, although with different emphasis, e.g.:
  - Japan has experience of squats since the 1950's
  - Sweden has more "heavy haul related" damage (headchecks and plastic flow/wear on rails, hollow and flange wear, RCF, thermal damage on wheels)

Introduction of RTRI
the rest of time

Conclusions

- Almost all the tracks are a standard gauge in Sweden. A lot of narrow gauge lines are in Japan (Shinkansen and conventional lines are completely divided.).

- In Sweden, the portion of freight is large. On the other hand, in Japan, the portion of passenger is large.

- There are more specifications in Europe than in Japan. Actual specifications of serviced wheels and rails are a little bit different from each other.

- Damage situations are common in both even though the focused damage to be solved is different in the case of wheel.(hollow wear, subsurface RCF…. in Sweden, flange wear, thermal cracks …. in Japan)

- Practical mitigating actions are similar in both.