# Derailment Case Studies Caused by Poor Management of the Wheel-Rail Interface

Presented by:

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Walter Rosenberger – Norfolk Southern Railway

George Fowler – Transportation Safety Board Canada

# The Common Belief…

- Wheel – Rail interface management is all about maintenance issues:
  - Rolling contact fatigue (RCF)
  - Excessive Rail Wear
  - Excessive Wheel Wear
  - Degradation of the tie and fastening systems
  - Increased fuel consumption

# But the reality is…

- **Improper Wheel – Rail interface management can be the root cause of serious rail accidents due to:**
  - **Poor lubrication practices (or lack or lubrication )**
    - **Gage Face and Top of Rail (TOR)**
  - **Improper wheel/rail profiles and contact geometry (lack of rail grinding and lack of wheel profile maintenance)**
    - **Two point contact, lack of steering**
    - **Field side rail contact, rail rollover**
    - **Hollow worn wheels, rail roll and lack of steering; truck hunting at high speeds**
    - **Worn gage face, wheel climb (exceed Nadal)**
  - **Rail Cant**
  - **RCF and growth of fatigue cracks**
    - **Broken Rail derailments**
    - **Interference with Ultrasonic Testing**

# A Couple of Wake-up Calls

- 22 Unexplained derailments of 125 ton doublestack cars between 1988 and 1992
- CSX Clinchfield Subdivision rail rollover derailments in early 90's
- Other rail rollover derailments occurring immediately after rail grinding (BN, BCR, SP)

# 125 ton Doublestack Derailments

## 25 Unexplained low rail rollover in 1-2 year period

- Low rail rollover
- Wood tie track, cut spikes
- Dry rail conditions
- Moderate curvature (3-7 degree)
- Running under balance speed
- Canted Rail
- Loaded 125 ton DS cars
- Low drawbar force

*Trains* October 2017 Issue provides detailed summary of the Doublestack phenomenon.

# INTERMODAL MYSTERY

## HOW SCIENCE SAVED THE DOUBLE-STACK TRAIN

BY DAVID IBATA

Few things are more representative of 21st century railroading than a big oceangoing container ship in port, at Savannah, Ga., or Long Beach, Calif., with massive overhead cranes shuttling thousands of steel boxes to double-stack container rail cars. But if not for crisis-driven research a quarter-century ago, that scene might never have come to pass.

To this day, no academic paper has been published, and no government report has been issued to chronicle the unexplained derailments that almost killed the double-stack container business — or how America's rail industry responded to the emergency. Those in the know were instructed at the time not to talk about it, but they believe that the story can now be told.

What was at stake? Nothing less than the future of North American railroading.

The double-stack container train "really transformed the whole transportation network," says Gary Wolf, president of Wolf Railway Consulting LLC in Atlanta. "Before, intermodal was sometimes a loss leader. But with the ability to double-stack containers, you could cut train length in half. This really mushroomed the business."

Powered by a colorful 1990s consist that includes Cotton Belt, CSX, and Santa Fe power, a Southern Pacific container train climbs east out of the San Bernardino Valley in October 1994. Elrond Lawrence

# After the first 5-6 derailments, the largest shipper threatened to pull all containers off the doublestack fleet if problem not fixed quickly!

The future of the entire intermodal business segment was at risk

WOLF

**DOUBLE STACK DYNAMICS TASK FORCE**
**Participants**

- A. Stucki Company
- American President Lines, Ltd.
- American Steel Foundries
- Association of American Railroads
- Atchison Topeka & Santa Fe Railway Co.
- Burlington Northern Railroad
- Cardwell Westinghouse Co.
- Gunderson, Inc.
- Miner Enterprises, Inc.
- National Castings, Inc.
- Norfolk Southern Corp.
- Rail Sciences Inc.
- Southern Pacific Lines
- Standard Car Truck Company
- Thrall Car Manufacturing Company
- TTX Company
- Transportation Test Center
- Trinity Industries
- Union Pacific Railroad

DDTF Formed in 1989/1990
Leadership from BN, ATSF, and UP

18 Voting Members

AAR TTC Non-voting member
Rail Sciences Inc. – Project Consultant

We Moved at Warp Speed!!!



WOLF Railway Consulting

WRI 2018

# DDTF Process



- A systems approach was used to evaluate every component in the doublestack system
  - Lading and containers
  - Car body
  - Trucks and articulated connectors
  - Track
    - Fasteners, grinding, rail cant, lubrication, rail profile, geometry (Gage, Xlevel, Align, Elevation)

# DDTF Testing and Research

- Truck Turning moment
- Truck warp characteristics
- Side bearing characteristics
- Truck curving performance
- Simulation modeling of system
- Rail deflection testing
- Teardown inspections
- Centerplate lubrication
- Wayside testing at Cajon Pass
- Torsional stiffness of car body


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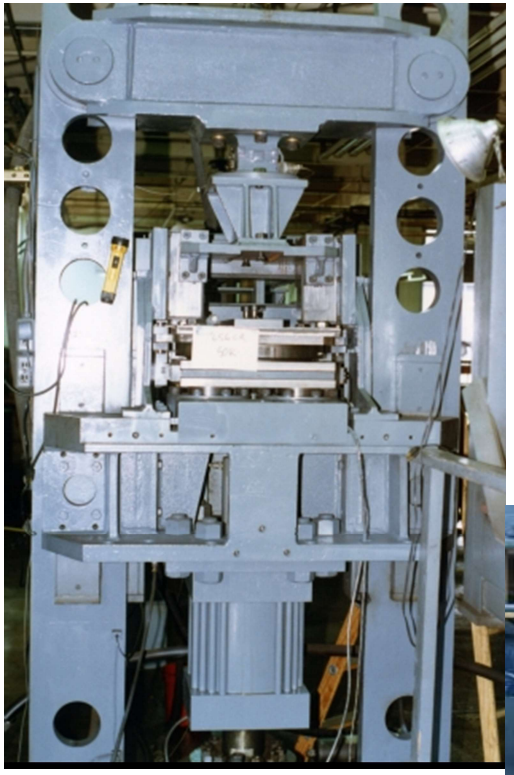
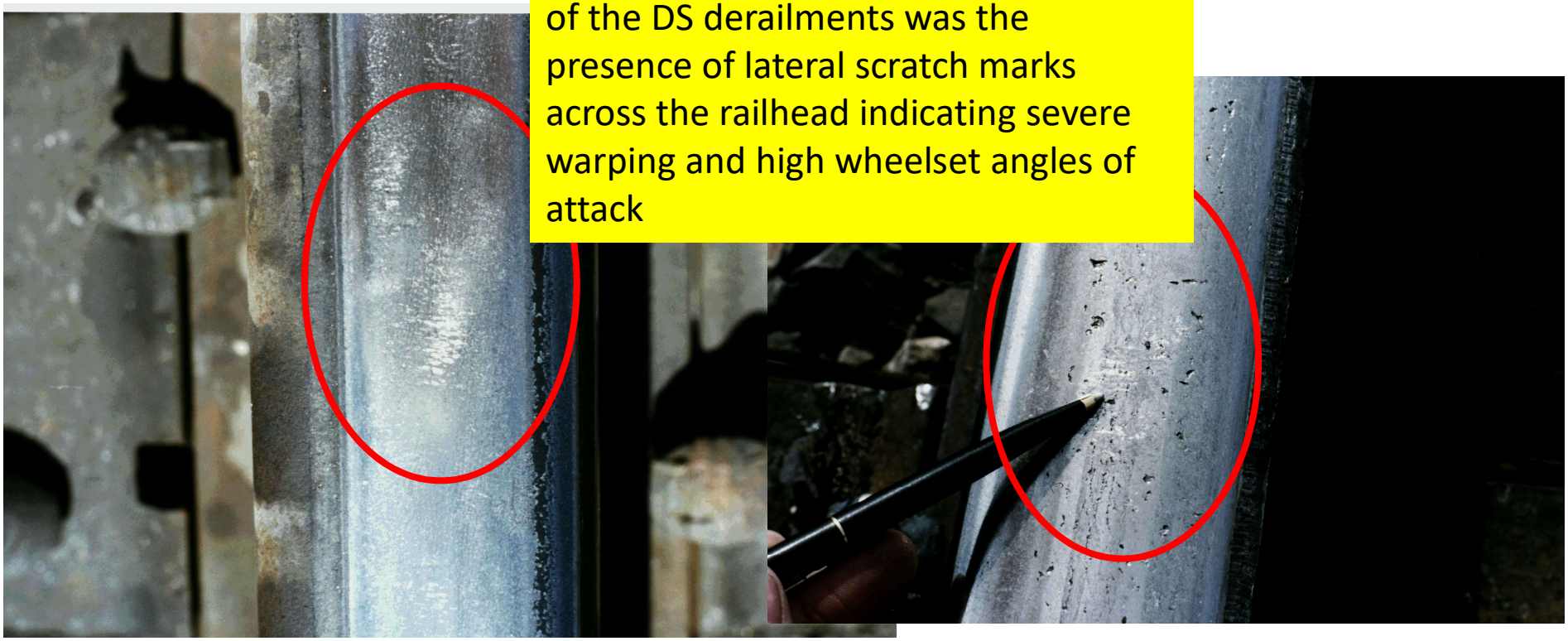
DO NOT HUMP

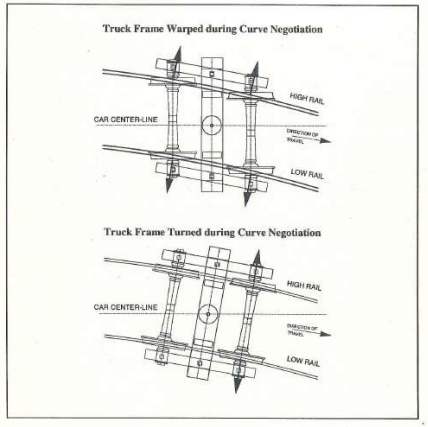


A common characteristic linking many of the DS derailments was the presence of lateral scratch marks across the railhead indicating severe warping and high wheelset angles of attack



125-Ton Double Stack Derailment Prevention
NUCARS Modeling of 125-Ton Double Stack Curving Performance
CONFIDENTIAL

Contractor: Transportation Test Center, Pueblo, Colorado




TTC Report No. P-93-104
March 1993

DOUBLE STACK DYNAMICS TASK FORCE (DDTF)

125-Ton Double Stack Derailment Prevention
Double Stack Car Curving and High Speed Stability Test
CONFIDENTIAL

Contractor: Transportation Test Center, Pueblo, Colorado

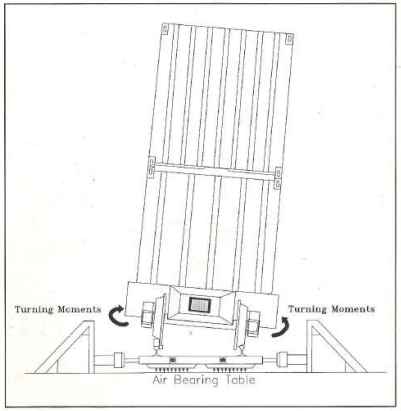

TTC Report No. 93-105
April 1993

DOUBLE STACK DYNAMICS TASK FORCE (DDTF)

W o L F, G. P.

125-Ton Double Stack Derailment Prevention
Truck Turning Moment Test Results

Contractor: Transportation Test Center, Pueblo, Colorado

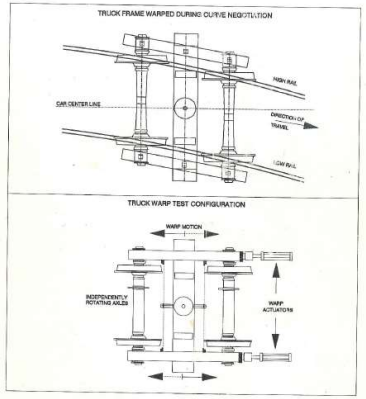



TTC Report No. P-91-101
June 1, 1991

DOUBLE STACK DYNAMICS TASK FORCE (DDTF)

125-Ton Double Stack Derailment Prevention
Truck Warp Test Results
CONFIDENTIAL

Contractor: Transportation Test Center, Pueblo, Colorado



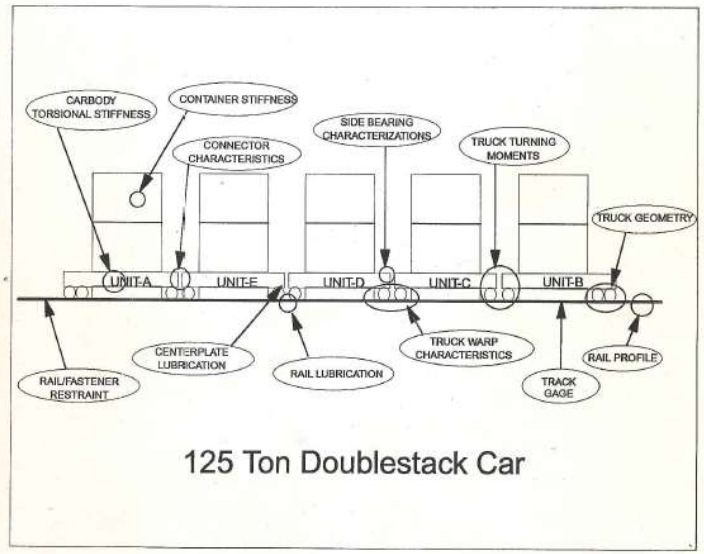

TTC Report No. P-91-106
December 1991

DOUBLE STACK DYNAMICS TASK FORCE (DDTF)

WOLF, G.P.

FINAL REPORT
TESTING, EVALUATION & RECOMMENDATIONS
CURVING PERFORMANCE OF 125T DS CARS

Contractor: Rail Sciences Inc., Atlanta, GA

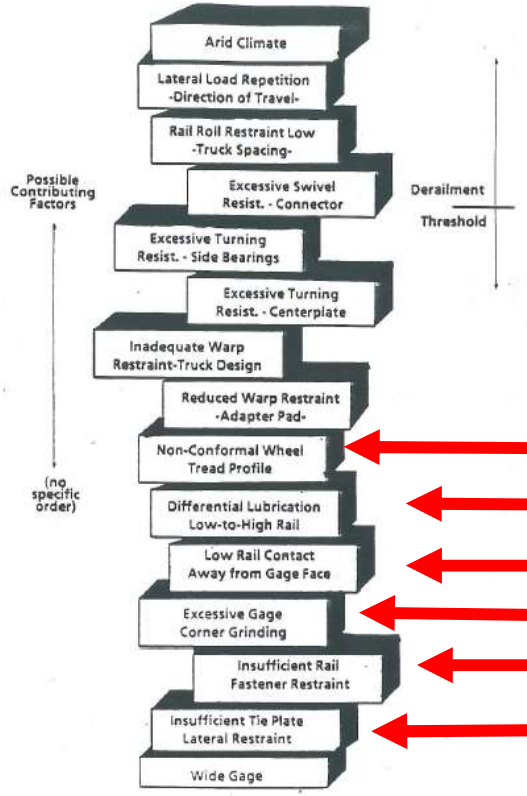



125 Ton Doublestack Car

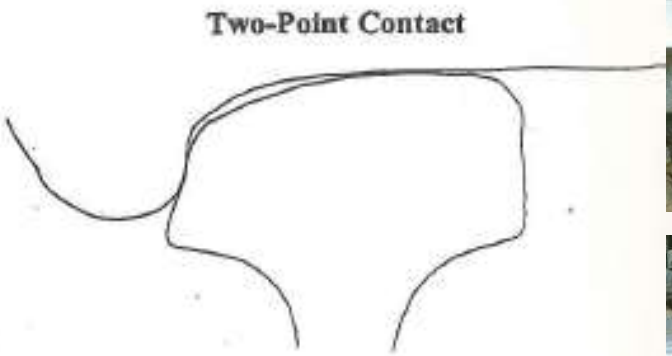
RSI Report No. RSI - DDTF - 2
February 12, 1993

DOUBLE STACK DYNAMICS TASK FORCE (DDTF)

## CONTRIBUTING FACTORS VS. DERAILMENT THRESHOLD

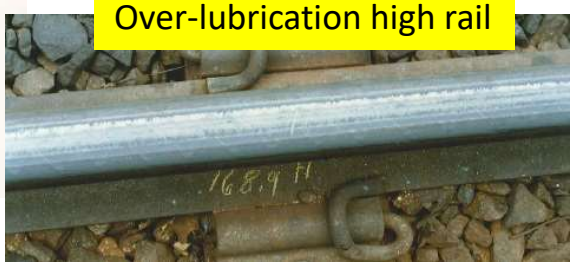



Factors dealing with Wheel-Rail Interface



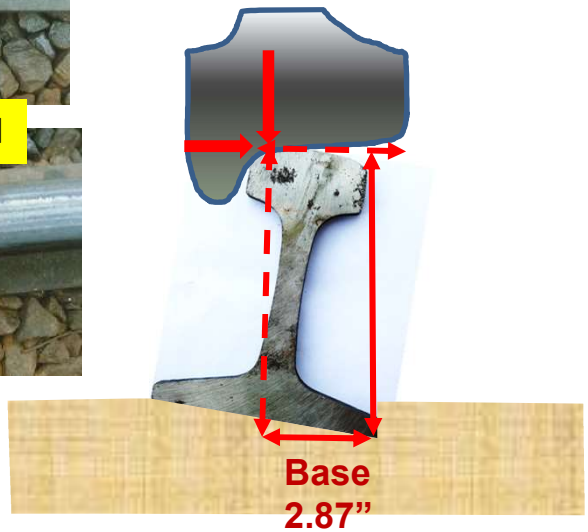

Two-point contact

Dry low rail

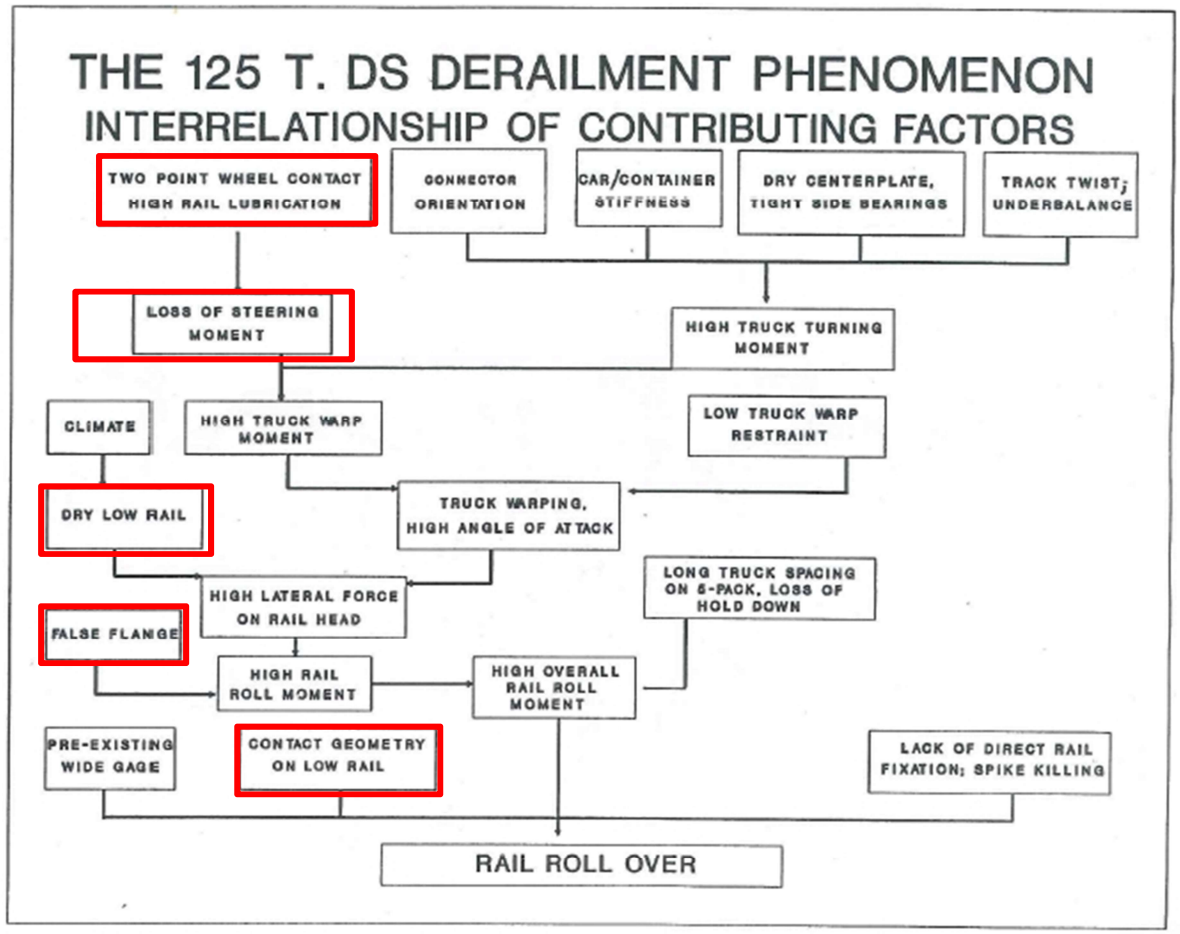


Over-lubrication high rail

Field side contact low rail

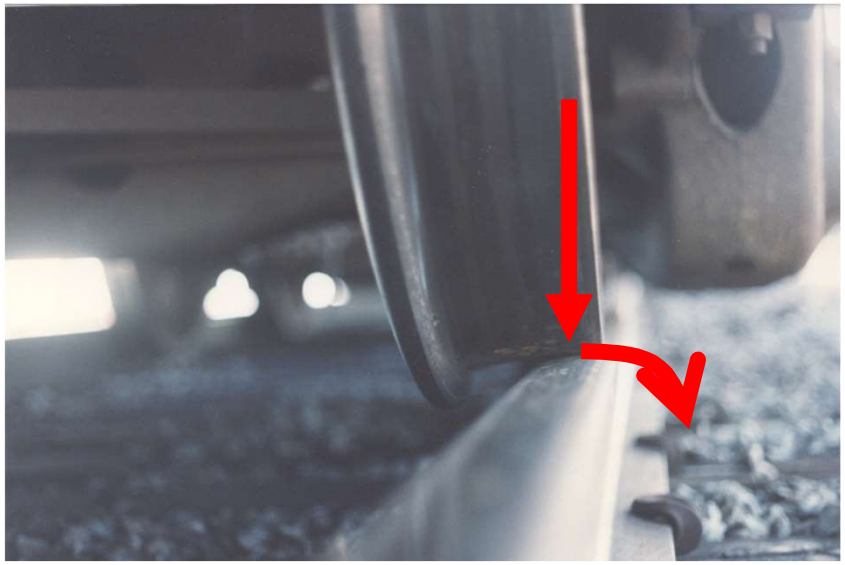


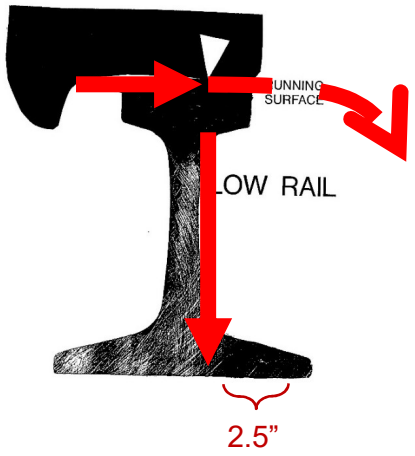

Rail Cant


THE 125 T. DS DERAILMENT PHENOMENON
INTERRELATIONSHIP OF CONTRIBUTING FACTORS
TWO POINT WHEEL CONTACT HIGH RAIL LUBRICATION
CONNECTOR ORIENTATION
CAR/CONTAINER STIFFNESS
DRY CENTERPLATE, TIGHT SIDE BEARINGS
TRACK TWIST; UNDERBALANCE
LOSS OF STEERING MOMENT
HIGH TRUCK TURNING MOMENT
CLIMATE
HIGH TRUCK WARP MOMENT
LOW TRUCK WARP RESTRAINT
DRY LOW RAIL
TRUCK WARPING, HIGH ANGLE OF ATTACK
LONG TRUCK SPACING ON 6-PACK, LOSS OF HOLD DOWN
HIGH LATERAL FORCE ON RAIL HEAD
FALSE FLANGE
HIGH RAIL ROLL MOMENT
HIGH OVERALL RAIL ROLL MOMENT
PRE-EXISTING WIDE GAGE
CONTACT GEOMETRY ON LOW RAIL
LACK OF DIRECT RAIL FIXATION; SPIKE KILLING
RAIL ROLL OVER

# DDTF Conclusions

- Loss of steering moment due to:
  - Two-point contact on high rail
  - Differential lubrication (dry low rail, lubed top of high rail)
- High lateral creep forces on head of low rail due to dry low rail (arid)
- High truck turning moments
- Warping of sideframe to bolster
- Insufficient low rail rollover resistance
  - In adequate fastening on low rail, spike kill, rail cant
  - Vertical weight positioned toward field side of low rail (cant involved)






**Why Low Rail is More Prone to Rail Rollover Especially with Hollow worn wheels**

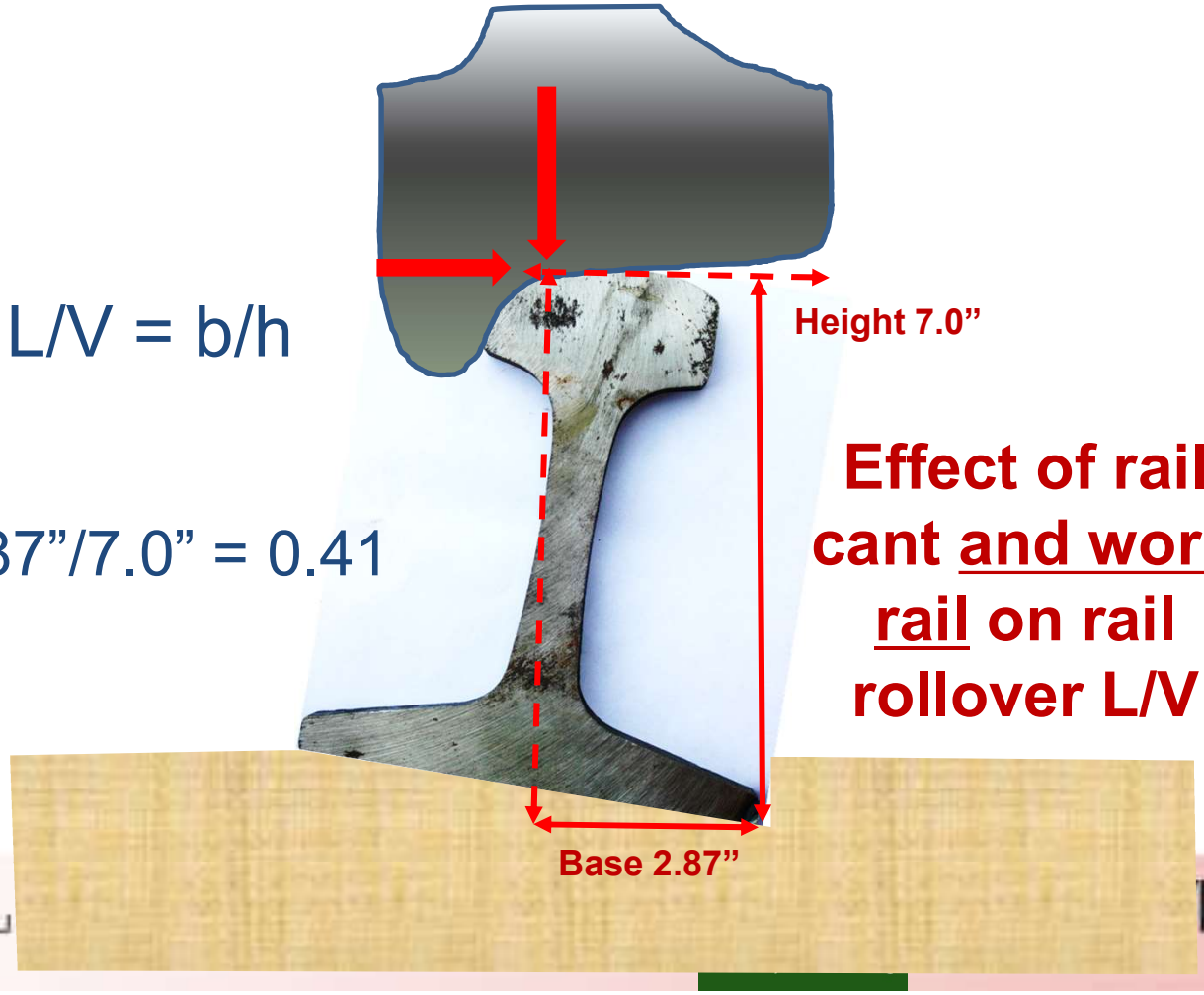
B/h Ratio

2.5”/7.0”

L//V for rollover = 0.35

L/V = b/h

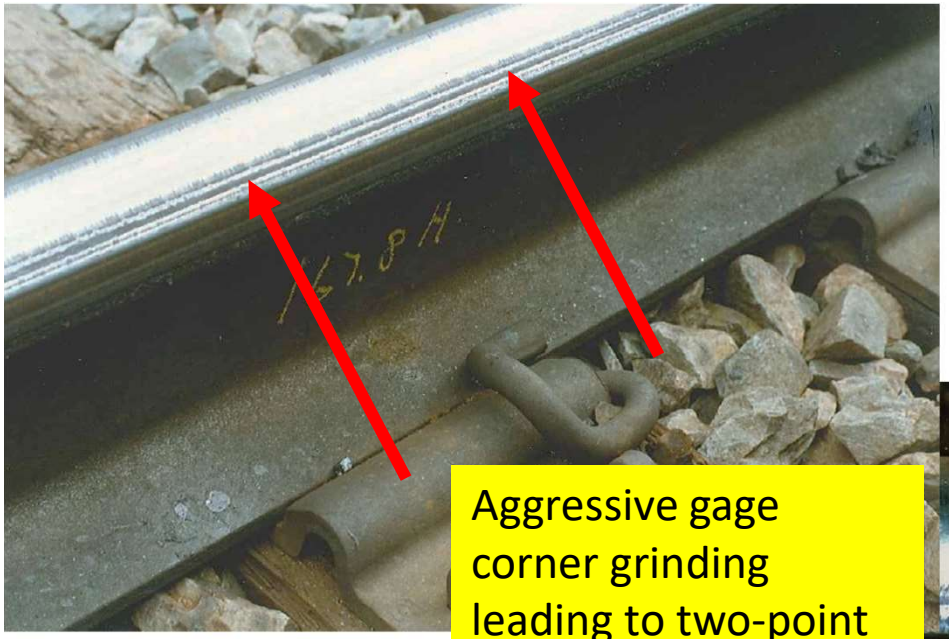
2.87”/7.0” = 0.41

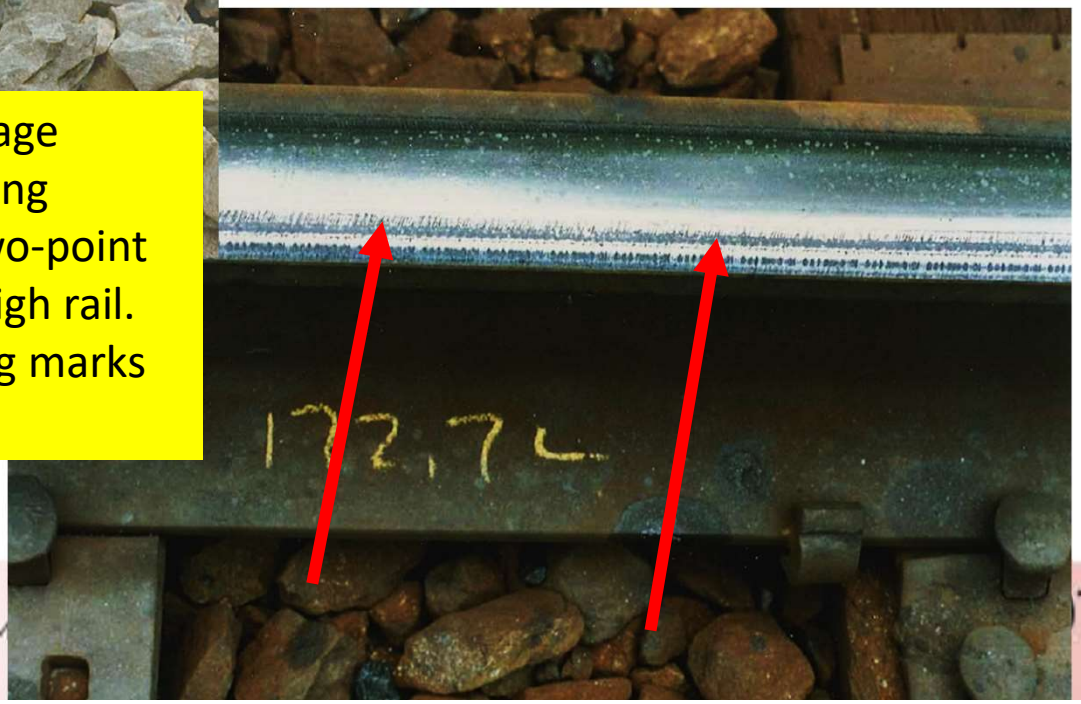



**Effect of rail cant and worn rail on rail rollover L/V**

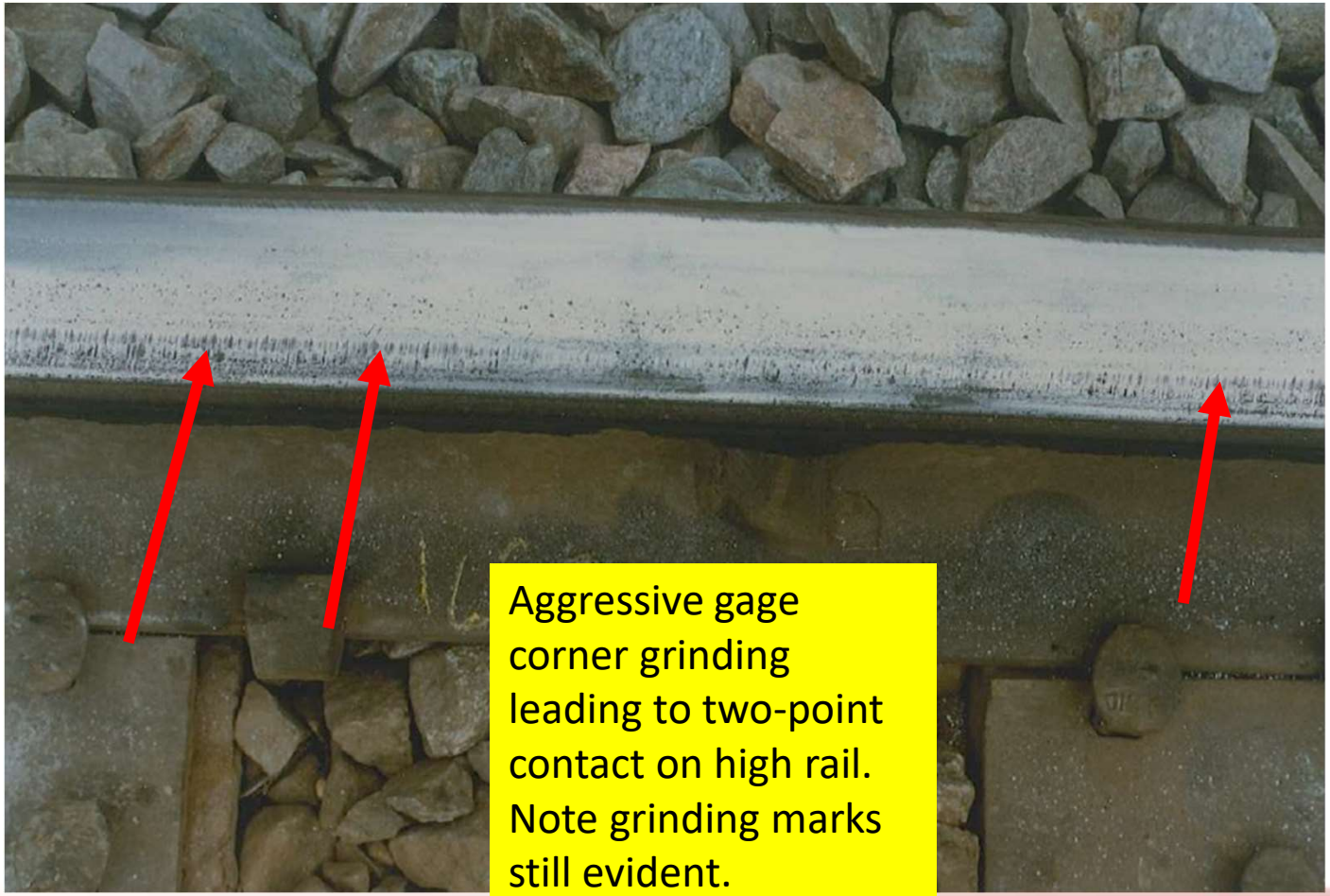

Clinchfield Route Rail Rollover

- ✓ Early 1990's
- ✓ Heavy Haul coal route
- ✓ Heavy Grades (~1.8%)
- ✓ Sharp Curves (10 degree)
- ✓ Several Rail Rollover derailments on well maintained track
- ✓ Derailments occurred after recent rail grinding





Aggressive gage corner grinding leading to two-point contact on high rail. Note grinding marks still evident.



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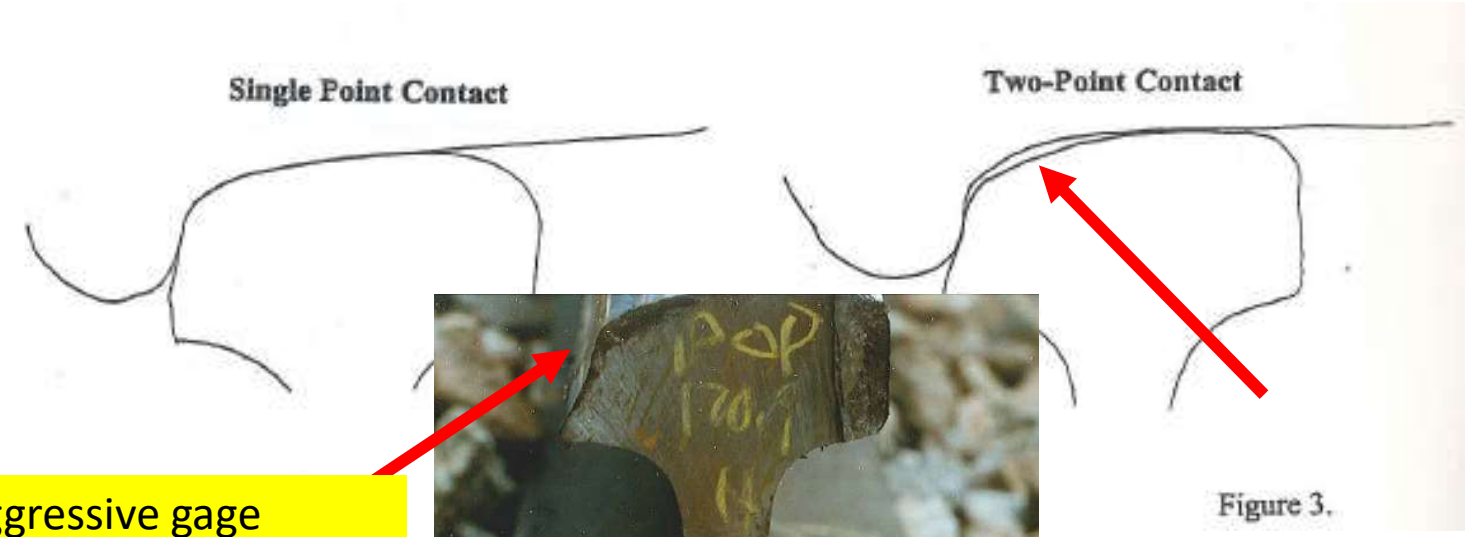


Figure 3.

Aggressive gage corner grinding leading to two-point contact on high rail.

# Case Study Conclusions

- These two case studies from the early 1990's ushered in the need to better understand wheel – rail contact and rail lubrication from the standpoint of accident causation.
- It also taught us a lesson on the law of unintended consequences:
  - Changing truck parameters without understanding the effect on wheelset steering
  - Changing the rail profile without understanding the effect on wheelset steering

**This is why Gordon's Seminar is now called WRI!**