Energy and Forces within a Train Consist

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Two Derailment Case Studies

Estimated Length: *10 minutes (19 slides)*

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Root Causes and Draft System Comparison

Estimated Length: *20 minutes (27 slides)*

Two derailments illustrate the power of in-train forces

1) Train 18N, Altoona, PA, 2014
2) Train 22Q, Pell City, AL, 2018

Hydraulic End-Of-Car Cushion Units

An EOCC unit absorbs energy by compressing a hydraulic piston. Car type determines stroke and preload.

Equipped car types include multi-level, coil steel, auto parts box, and center beam & bulkhead flats (where impact could shift or damage lading)

	Auto	Other
Preload	50,000 lbs	100,000 lbs
Stroke	10”	15”

EOCC units on multi-levels, unloaded & compressed

Unloaded EOCCs
50” car separation

Fully-compressed EOCCs
30” car separation (each coupler compressed 10”)

1) Train 18N descending the East Slope into Altoona, PA

Train 18N – 107 multi-levels (similar to train in photo)

Descending grade 1.5% - 2%

Q: *If the head-end of a train is traveling at 21 mph, what is the speed of the rear end?*

Train 18N consist details

107 multi-levels equipped with EOCCs

Length - 10,331 feet

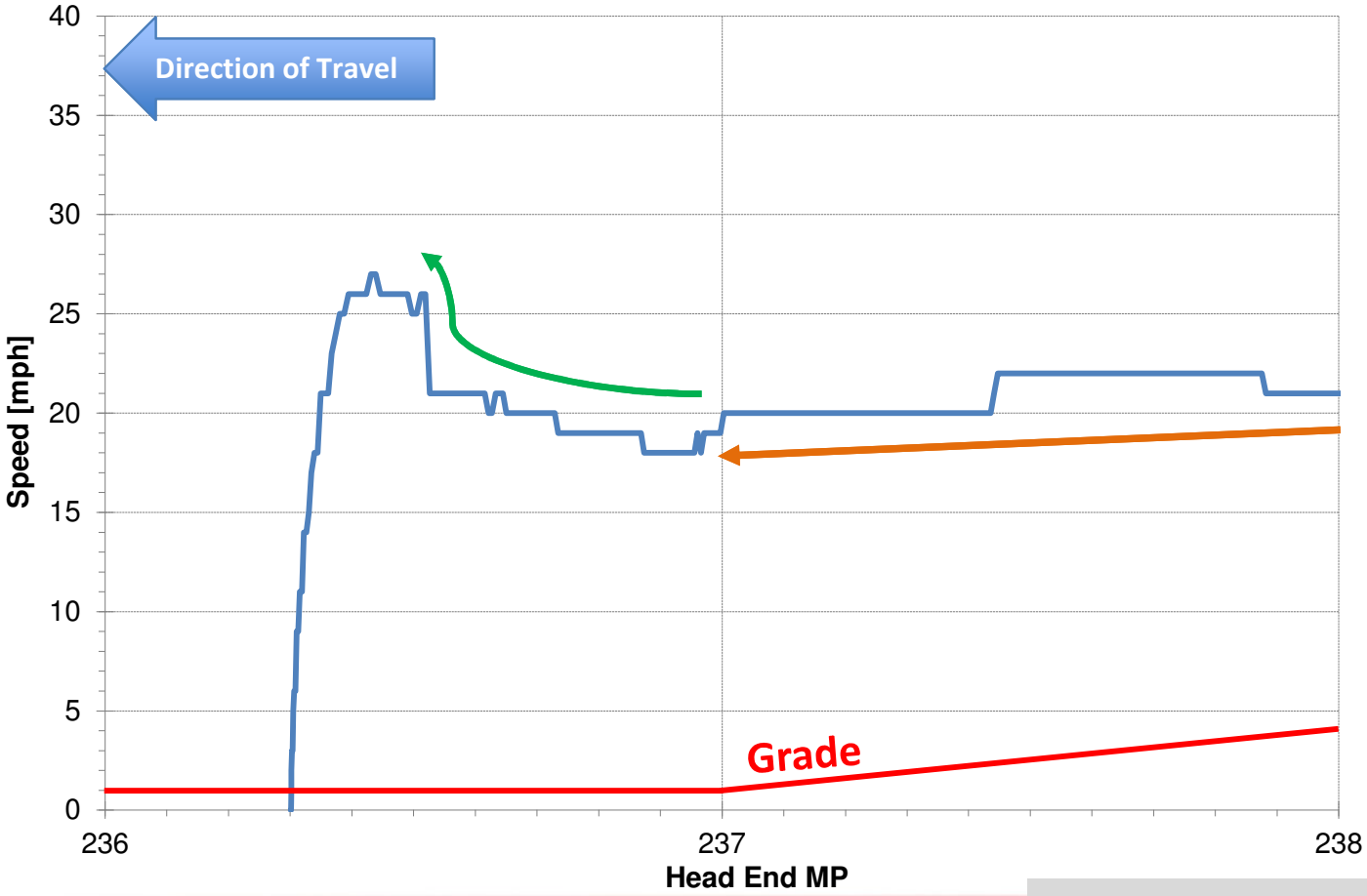
Weight - 7866 tons

Slack - 10” per EOCC unit

**Not including mechanical free slack*

Total EOCC slack - 107 x 20” = 178 feet

Speed, lead locomotive, at bottom of grade



Speed is displayed in full mph increments

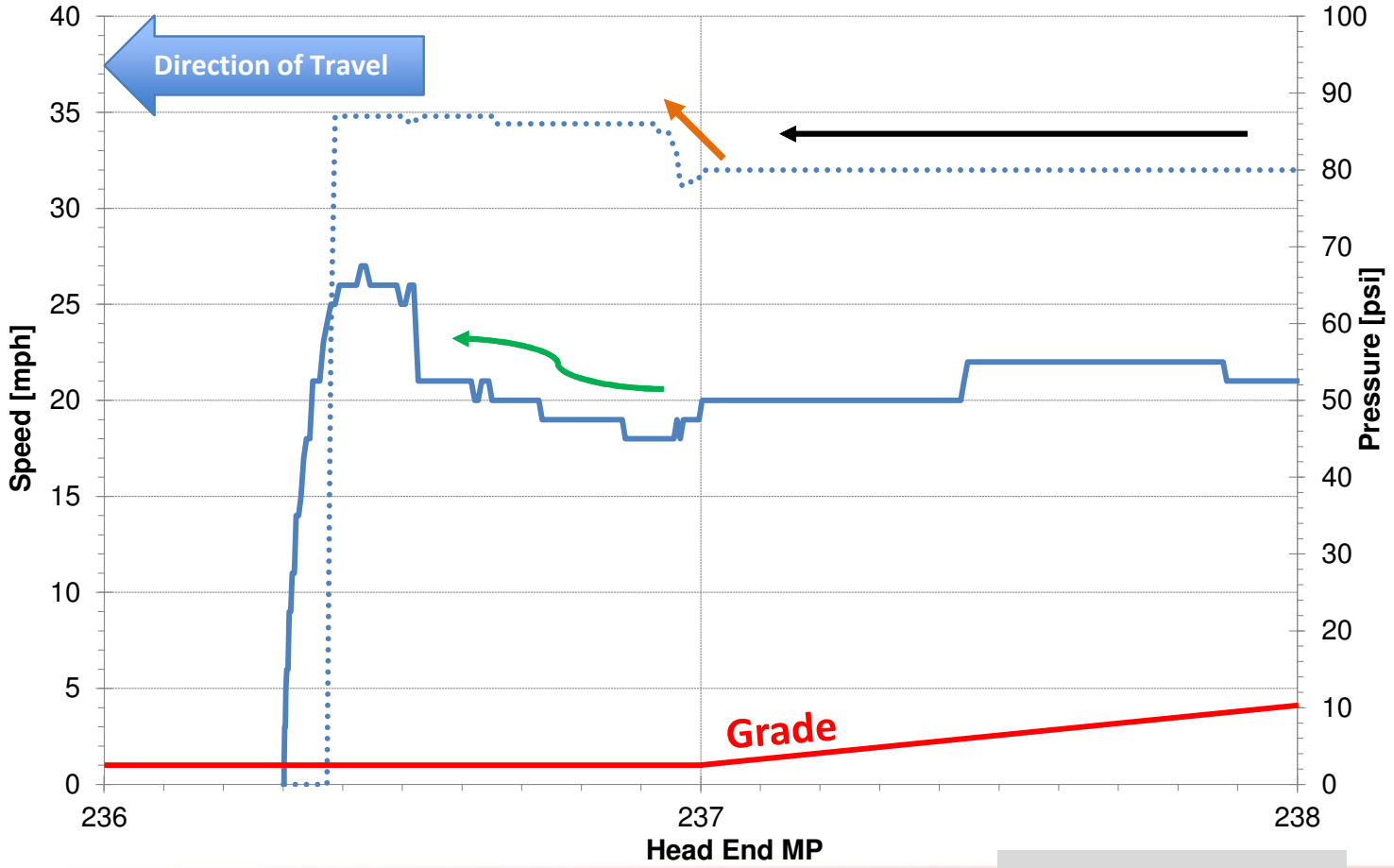
MP 237 - bottom of 1.8% grade

Between MP 238 & 237, speed changes from 21 to 22 to 20 mph

Beyond MP 237, speed drops to 18 mph, increases gradually to 21 mph, then spikes suddenly to 26 mph

Graph: NS derailment report P-7185, 9-20-14

Add brake pipe pressure, lead locomotive



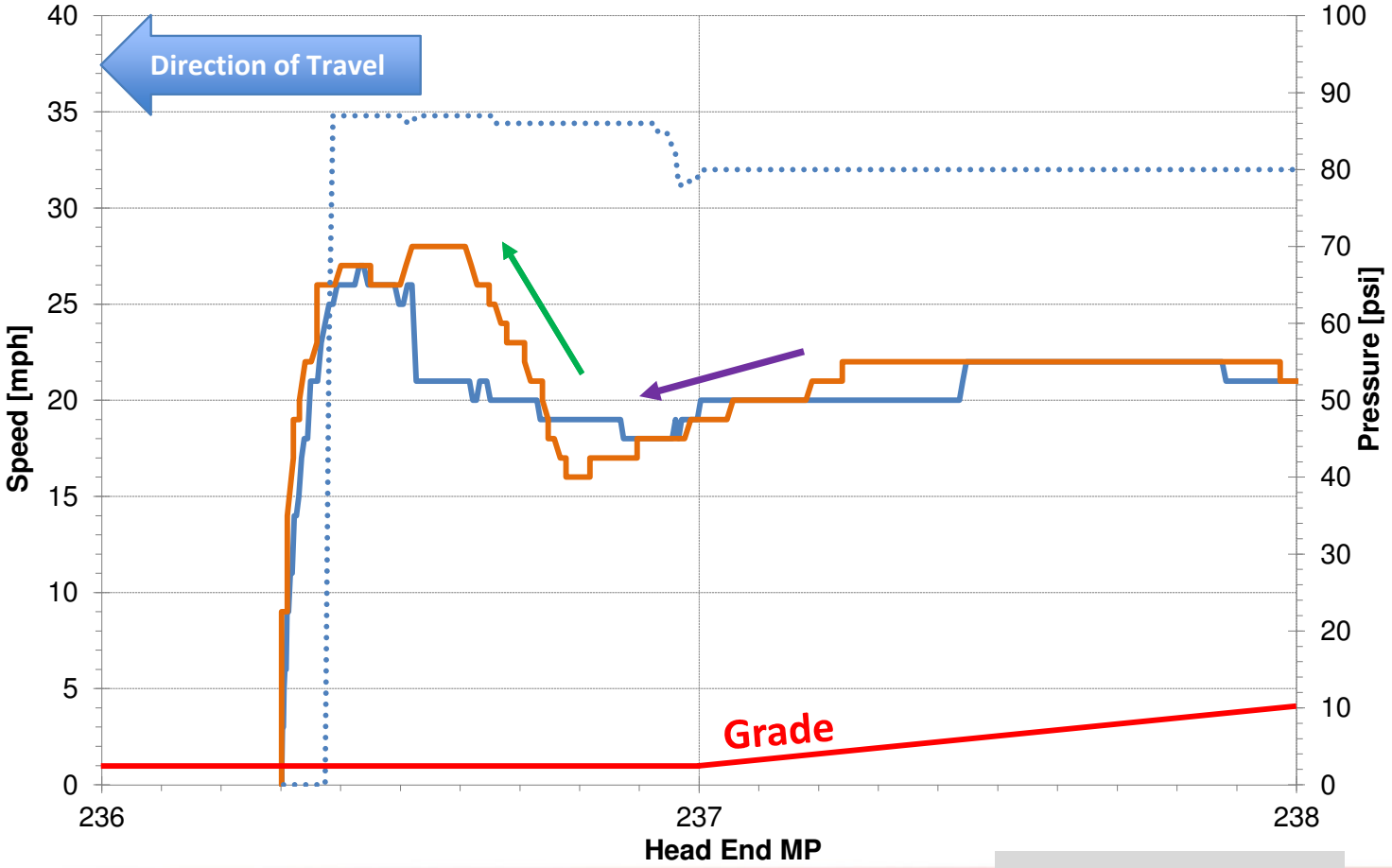
MP 238-237: Brakes are applied; brake pipe is 80 lbs. (10-lb. reduction)

When head end gets to bottom of grade, the engineer releases his air brakes (brake pipe increases from 80 to 88-90 lbs.)

Brake release results in a gradual increase in head end speed

Graph: NS derailment report P-7185, 9-20-14

Add speed, helper locomotive



NS 9912 Speed
NS 9912 ABRK
NS 6304 Speed

Solid orange line is speed of the rear-end helper (event recorders are time-synced)

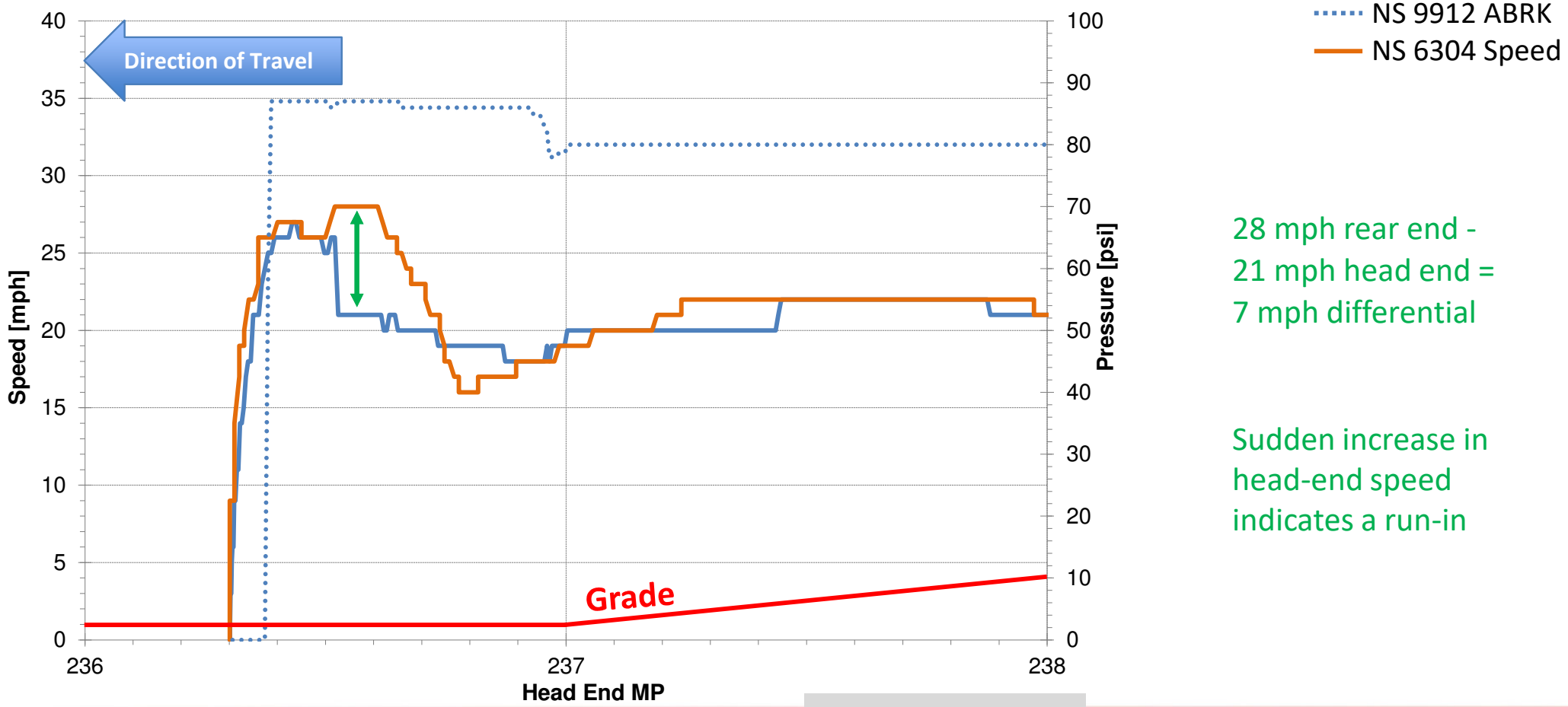
After brakes were released at the head end, rear end continues to slow

Why? Service brake pipe pressure changes travel at 600 fps; for a 2-mile train, that's 17 seconds!

When the rear end finally releases, speed increases to 28 mph

Graph: NS derailment report P-7185, 9-20-14

If the head end is traveling at 21 mph, what is…..?



28 mph rear end -
21 mph head end =
7 mph differential

Sudden increase in head-end speed indicates a run-in

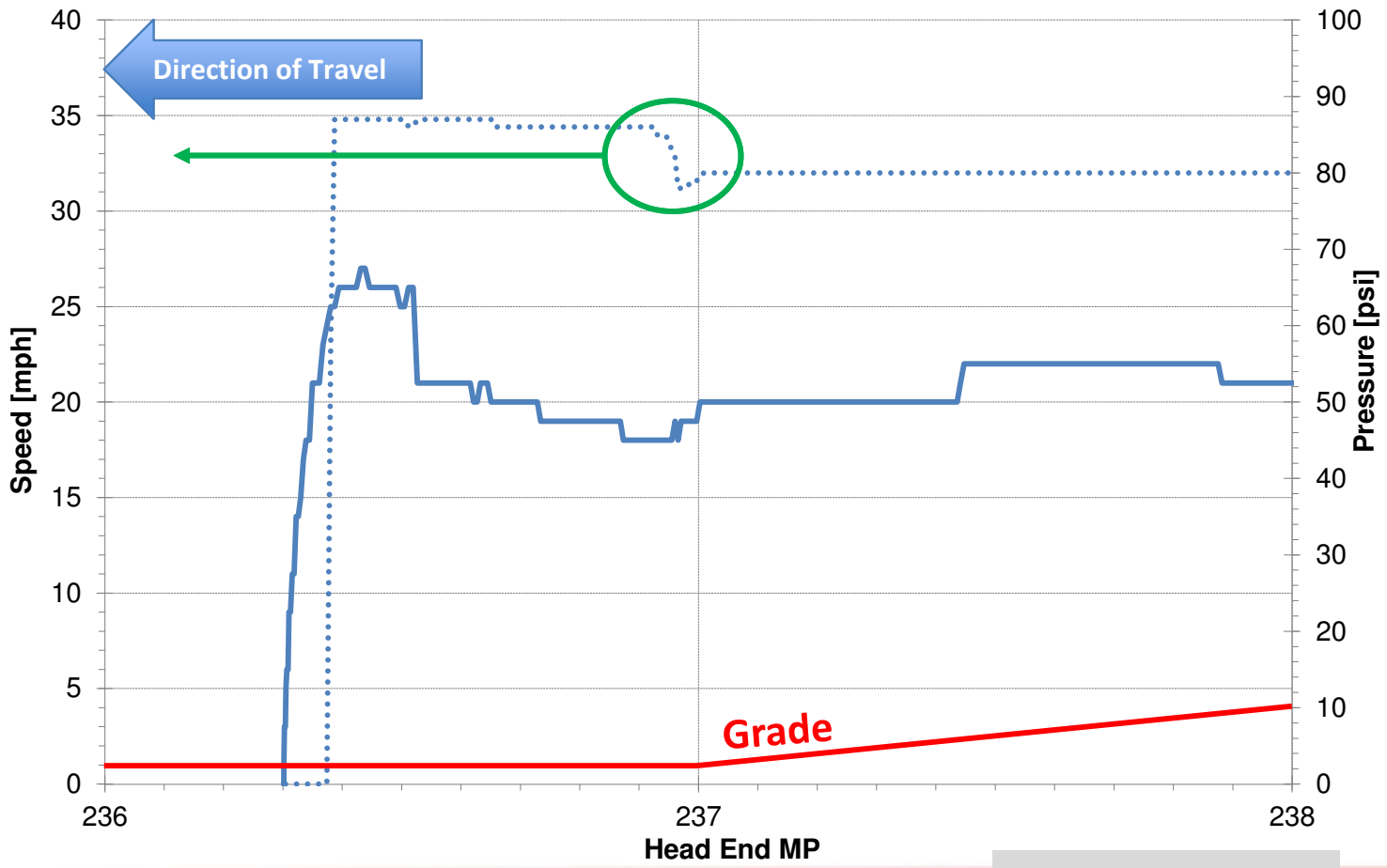
Graph: NS derailment report P-7185, 9-20-14

And quite the run-in it was!

NS derailment file P-7185

Cause: Improper release of the air brakes on a descending grade allowing the stretched train to run in.

The solution – delay the air brake release



Delay release of air brakes until half the train is off the descending grade

For a two-mile long train, release brakes when the head end reaches MP 236

Graph: NS derailment report P-7185, 9-20-14

2) Train 22Q, Pell City, AL on an undulating grade

NS derailment file P-7728

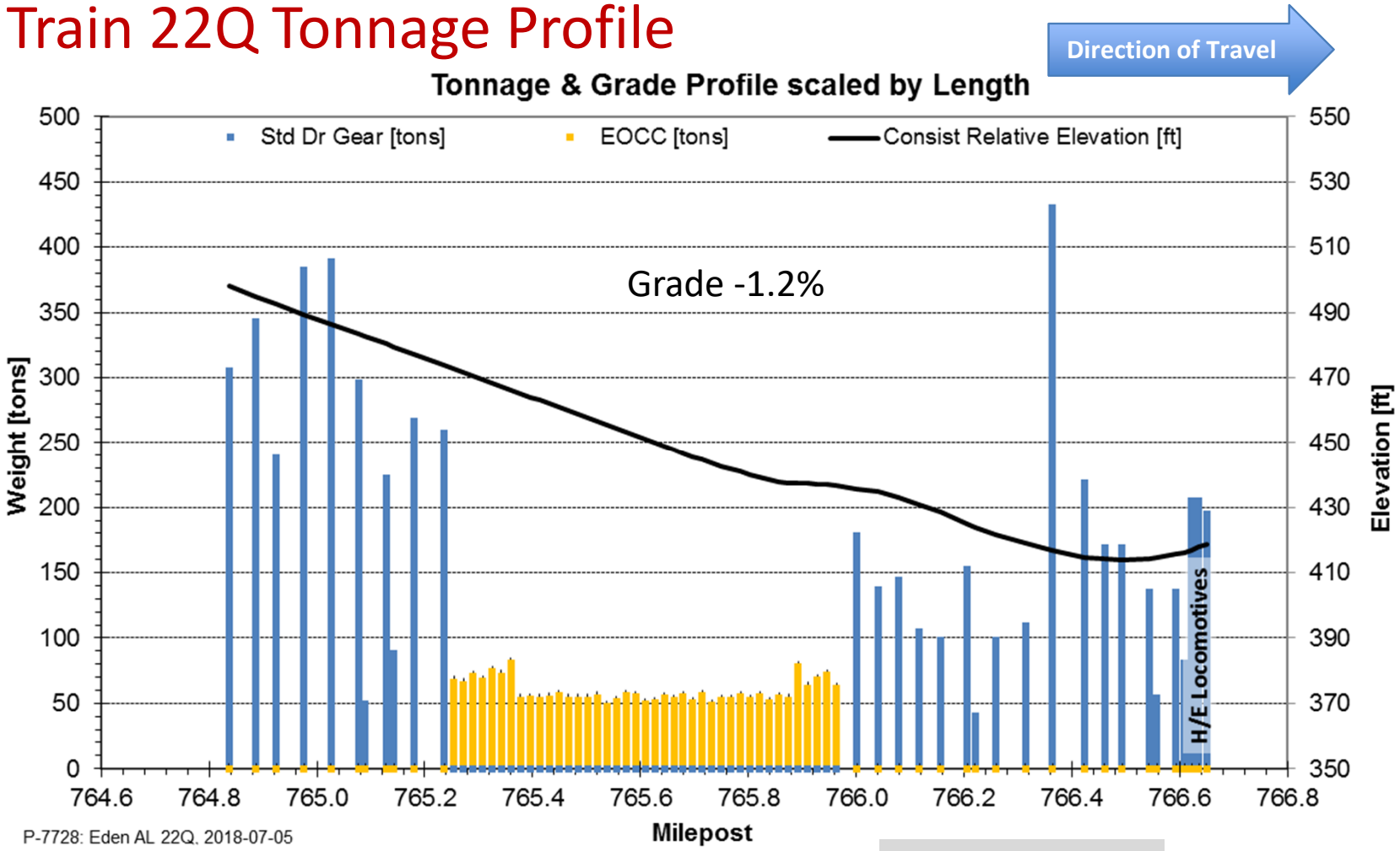
Consist details

3 locos on head end

70 cars - a combination of loaded double-stacks and loaded & empty multi-levels

8631 tons, 10,194 feet

Train 22Q Tonnage Profile



17 doublestacks
(55 platforms)
2527 tons

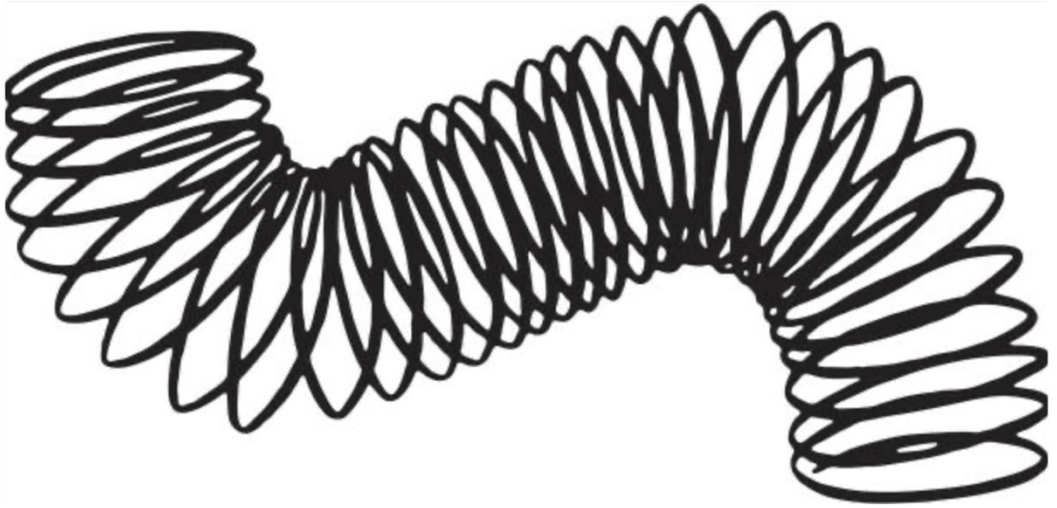
41 multi-levels
2357 tons
68 ft EOCC slack

12 doublestacks
(46 platforms)
3347 tons

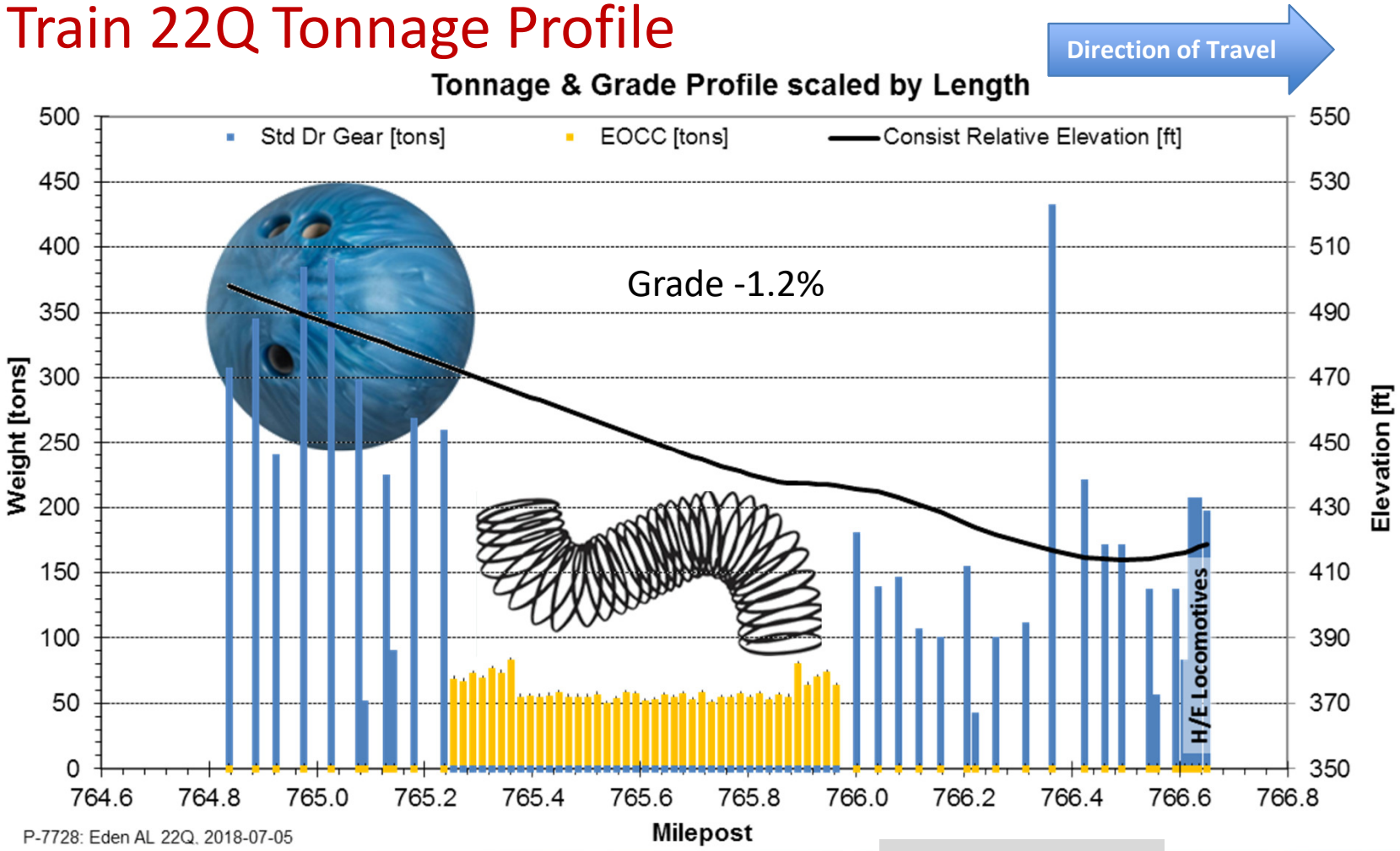
NS derailment report
P-7728, 8-27-18

This analogy has been used for multi-levels & doublestacks

Q: Which is the more controllable arrangement: a slinky pulling the bowling ball, or the bowling ball pulling the slinky?



Train 22Q Tonnage Profile



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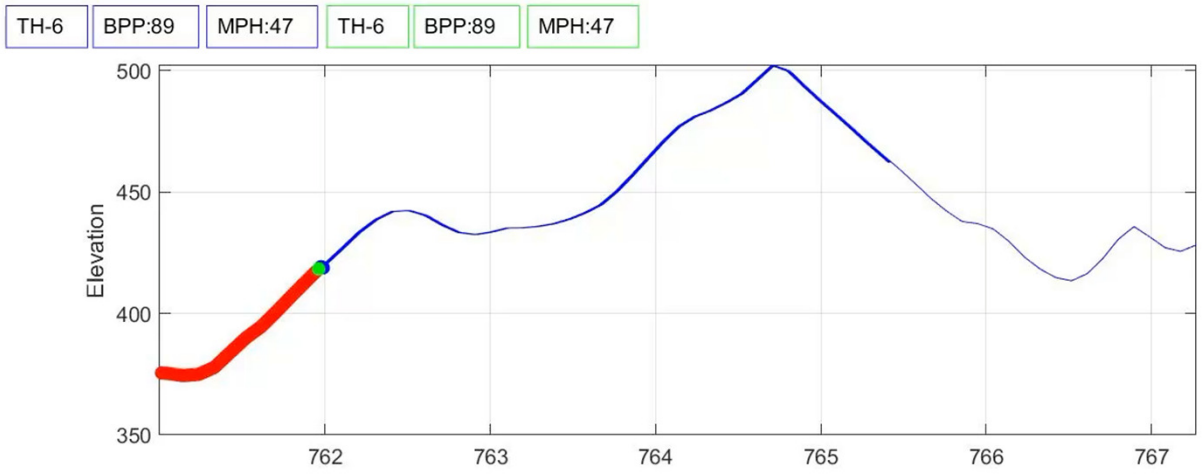
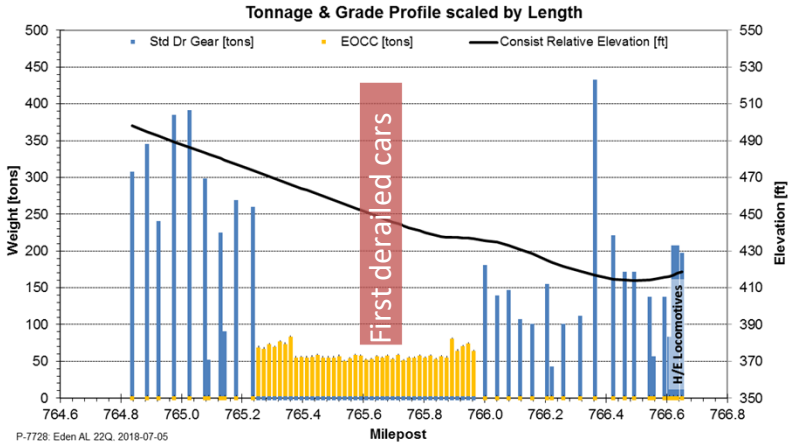
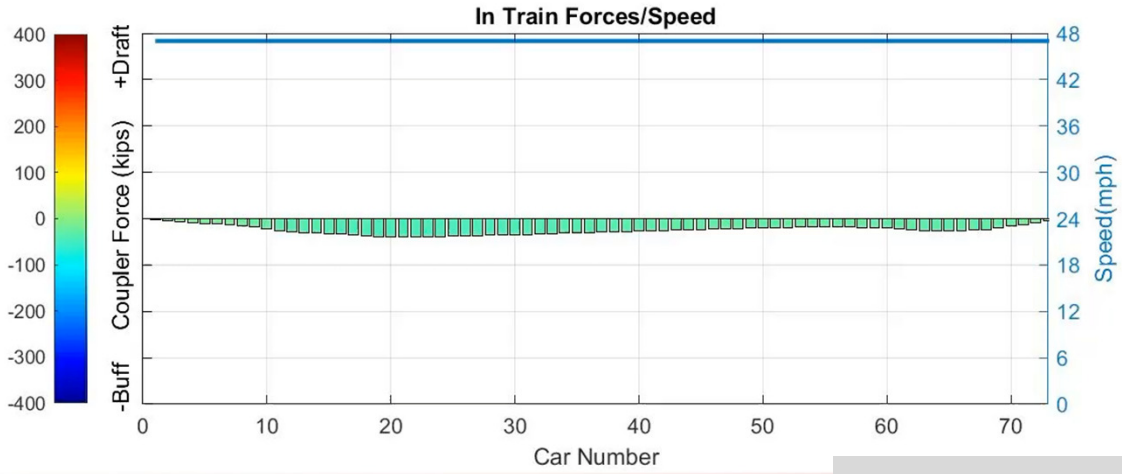
NS derailment report
P-7728, 8-27-18







TOES simulation displayed in video format

Bar graph – coupler force, left margin (+ draft, - compression)

Blue line – vehicle speed, right margin

Engineer was in DB-4 at bottom of grade

Video clips by Brent Ballew, NS Research Engineer
P-7728 derailment file

Destined to derail

Description: When the rear doublestack block, weight 3347 tons, crested, it caused a run-in force of -315 kips compressing the slack in 41 EOCC-equipped multi-levels and rupturing gage under the 39th-43rd head cars.

Cause: Train makeup

TOES modeling showed that no train handling that complied with the rules and generally acceptable train handling practices could have prevented a causative level run-in.

Train make-up: things to consider

1. EOCC-equipped cars – number and placement
2. Tonnage trailing a block of EOCC-equipped cars
3. Grade
4. Use of air & dynamic brakes
5. Tonnage trailing empty cars
6. Distributed power placement & operation