



AVIATION



HIGHWAY



MARINE



RAILROAD



PIPELINE

Issued: September 23, 2024

Railroad Investigation Report: RIR-24-09

# Norfolk Southern Railway Train Derailment

Anniston, Alabama

March 9, 2023

## 1 Factual Information

### 1.1 Accident Description

On March 9, 2023, about 6:19 a.m. local time, westbound Norfolk Southern Railway (NS) freight train 245A109 derailed 2 locomotives and 37 railcars on the Alabama East End District of its Gulf Division near Anniston, Alabama.<sup>1</sup> The derailment involved two sections of the train, resulting in two derailment sites. The first derailment site was located at the front of the train and where 2 locomotives and 29 railcars derailed. At the second site, located near the rear of the train, eight railcars derailed. Three of the cars that derailed were tank cars carrying hazardous materials. These tank cars remained intact and did not release hazardous materials. There were no reported fatalities or injuries. NS estimated damages to equipment, track, and signal infrastructure to be about \$2.9 million. At the time of the accident, visibility conditions were clear with early morning daylight; the weather was 57°F with no precipitation. Figure 1 shows the accident scenes.

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<sup>1</sup> (a) All times in this report are local time unless otherwise noted. (b) Visit [www.nts.gov](http://www.nts.gov) to find additional information in the public docket for this National Transportation Safety Board (NTSB) accident investigation (case RRD23LR008). Use the [CAROL Query](#) to search safety recommendations and investigations.



**Figure 1.** Aerial view of the first derailment site (left) and the second derailment site (right). (Courtesy of NS.)

The crew of train 245A109 consisted of one engineer and one conductor. The train was composed of 6 coupled locomotives at the head end of the train and 108 railcars; 34 railcars were loaded, 74 were empty, and 2 of the locomotives were being transported as revenue waybill locomotives from Bluffton, Indiana, to Mobile, Alabama.<sup>2</sup> The revenue waybill locomotives, RMEX 06 and 08, were not equipped with alignment control couplers, which resist lateral coupler movement under compressive in-train forces. NS operating rule L-212 prohibits coupling together locomotives without alignment control couplers. The revenue waybill locomotives were coupled together and picked up from Bluffton, Indiana, on February 24, 2023.<sup>3</sup> An NS inspection performed before the first movement involving the coupled revenue waybill locomotives did not identify the absence of alignment control couplers.

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<sup>2</sup> These locomotives were being moved as a revenue-producing move for a customer. They are often called *dead-in-tow* locomotives, meaning that they are not used for tractive power or braking and the cabs are locked.

<sup>3</sup> The revenue waybill locomotives were moved by four other trains before being added to train 245A109 on the day of the derailment.

## 1.2 Accident Location

Train 245A109 was operating westbound on the Alabama East End District near milepost 721.3 when the derailment occurred. At the time of the derailment, the train was negotiating 10 curves varying from 7.1° to 3.8°. The point of derailment, at the west end derailment site, was located on tangent track at the exit of a 3.8° right turn just before a 4.2° left turn. The track gradient changes to a constant 1.29 percent descending grade at milepost 719.6. The train had negotiated this grade change and was entirely on the descending grade when the accident occurred.

## 1.3 Locomotive Consist

The first four locomotives in the consist were high-horsepower locomotives owned by NS and Union Pacific Railroad. Two of these locomotives were producing tractive and dynamic braking effort and the other two were isolated and not producing tractive or dynamic braking effort. RMEX 06 and 08 were the fifth and sixth locomotives in the consist and were not used for tractive power or braking.<sup>4</sup>

### 1.3.1 Locomotive Interchange Inspection and Clearance

NS arranged for the inspection of the RMEX 06 and 08 before being moved for the customer. An NS mechanical employee conducted an inspection of RMEX 06 on January 18, 2023, and of the RMEX 08 on February 2, 2023. Both inspections were performed in Bluffton, Indiana, by the same mechanical employee. As part of this inspection, the mechanical employee performing the inspection must identify the type of couplers installed on the locomotive. In both inspections, the locomotives were misidentified as being equipped with alignment control couplers on the In Tow Unit Inspection form, NS Form ME-925.

The completed In Tow Unit Inspection forms were emailed to the NS clearance desk and the units were identified in the NS system as having alignment control couplers. Using this information, clearance notices and waybills were produced for the locomotives and sent to field personnel. Clearance notices contain information about the locomotives but also function as the only warning to field personnel about conditions found on the locomotive, such as nonalignment control couplers. This information is needed by field employees when assembling consists and preparing a train. Any

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<sup>4</sup> According to the CSX Railroad Dictionary, *dynamic braking* is a method of retarding the locomotive and train by using the locomotive traction motors as generators. The current generated by the motors is dissipated through fan-cooled grids.

warnings of abnormal conditions would be listed on the top of the clearance notice in red lettering.

The clearance notices and waybills for the RMEX locomotives contained the information provided from the mechanical inspection. The locomotives were listed as having alignment control couplers and, therefore, there were no warnings present.

### **1.3.2 Locomotive Couplers**

Locomotive couplers are manufactured with a pivot point at one end of the device that allows it to attach to the locomotive. If a line is drawn down the center of the drawbar through this pivot, the amount of coupler movement from side to side is measured as an angle in degrees. This angle or lateral movement of the coupler varies depending upon the type of coupler installed on a locomotive. Under normal conditions this pivoting motion gives the coupler assembly some freedom of movement from side to side to allow operations through curves and turnouts. When the pivoting motion of the coupler is not limited (allowed to rotate freely) and coupler angles increase during train movement, the amount of lateral force present increases.

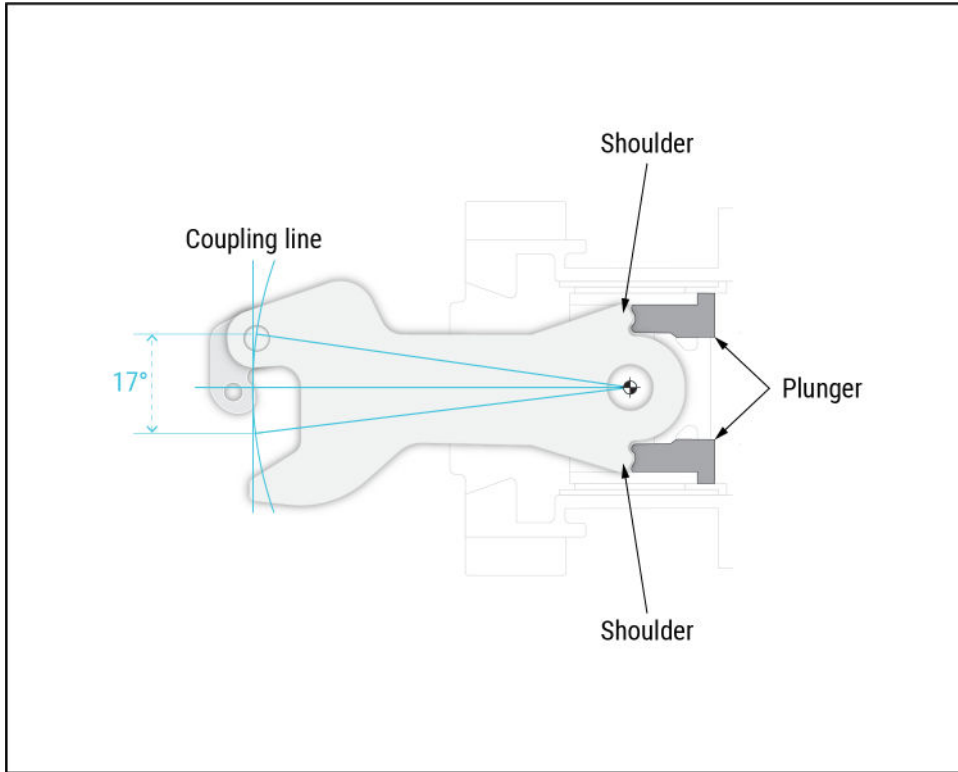
These lateral forces start at the coupler pocket with a coupler that is jackknifed or pressed up against the coupler pocket wall, exerting forces into the coupler pocket. Those forces are transmitted through the frame of the locomotive to the trucks and wheels of the locomotive, ultimately exerting high lateral loads against the rail. When these lateral forces exceed the vertical forces exerted on the rail by the weight of the locomotive, the rail will roll over, causing a derailment.

The first four locomotives in the consist were classified as modern locomotives, meaning, among other things, that they were equipped with alignment control couplers.<sup>5</sup> Alignment control couplers are manufactured with "shoulders" at the rear of the drawbar portion of the coupler and plungers designed to engage with the shoulders and draft gear when the train experiences compressive, or "buff" forces. These buff

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<sup>5</sup> *Alignment control couplers*, installed on most locomotives, will allow only limited lateral movement when longitudinal in-train forces are compressed. This reduces lateral forces on the track, transformed from longitudinal forces, and, therefore, reduces the possibility of derailment. Manufacturers' specifications indicate that alignment control couplers, under compressed conditions, can limit the total drawbar swing angle to about 17°, while the nonalignment control couplers permit a total drawbar swing angle as large as 38°, creating increased coupler offsets between locomotives and cars.

forces activate the draft gear and the plungers provide a centering torque to the coupler, limiting drawbar angles and centering the coupler in the coupler pocket. (See figure 2.)<sup>6</sup>



**Figure 2.** Alignment control coupler with plungers.

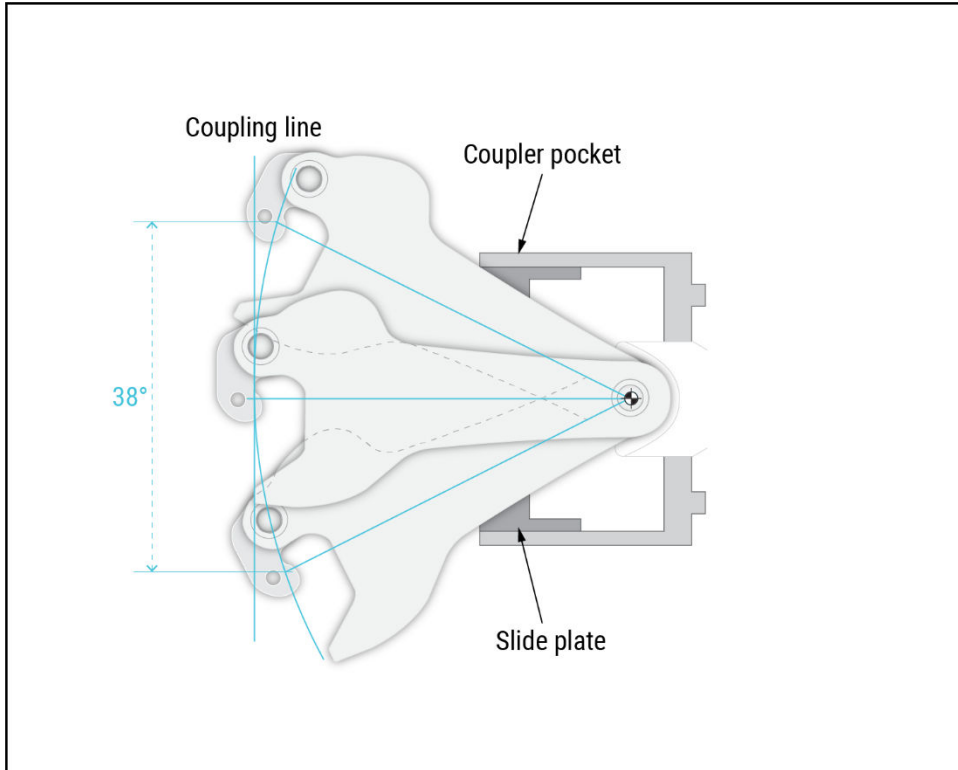
Locomotives used extensively to switch railcars, like the RMEX 08 and RMEX 06, may be equipped with nonalignment control couplers. (See figure 3.) These couplers lack the shoulders and are not equipped with the draft gear-engaging plungers. The coupler head is free to pivot to a larger degree without resistance, even when the train is in a compressed slack state.<sup>7</sup> These nonalignment control coupler-equipped

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<sup>6</sup> *Draft gear* is a term that describes a shock-absorbing unit which forms the connection between the connection between the coupler and center sill, which is the longitudinal structural member of a car underframe, often constructed as a large box section or hat section. The center sill receives all the buff and draft forces created in train handling and switching.

<sup>7</sup> *Slack* is the general term for movement of the draft system components. There are three types of slack: free slack, controlled slack, and uncontrolled slack. *Free slack* is the loose fit of mechanical components due to wear or maintenance requirements. *Controlled slack* is the design stroke of the draft system during its functional travel. *Uncontrolled slack* is movement within the design stroke, but beyond the unit's limit of control.

locomotives are not common, NS owns about 2,600 locomotives and only 3 of those locomotives are equipped with nonalignment control couplers.



**Figure 3.** Coupler without alignment control.

Railroads sometimes place a block in nonalignment control couplers between the coupler pocket and the side of the coupler to limit drawbar angles. These blocks, often known as stop blocks, can be either made of rubber and removable, or welded in steel. The application of stop blocks does not serve the same effect as an alignment control coupler. The stop blocks resist the rotation of the coupler, but without the shoulders and plungers found in alignment control draft gears, the coupler is not centered when compressive forces are applied, resulting in higher drawbar angles. The RMEX locomotives were equipped with these stop blocks.

The RMEX 08 had welded-in-steel stop blocks that showed signs of heavy lateral forces having been applied to them. The coupler pocket was bulged out on the left rear side with rust, wear, and moss found inside the broken welds of the coupler pocket consistent with a preexisting break.<sup>8</sup> This bulging of the coupler pocket reduced the effectiveness of the stop blocks allowing higher drawbar angles to be produced.

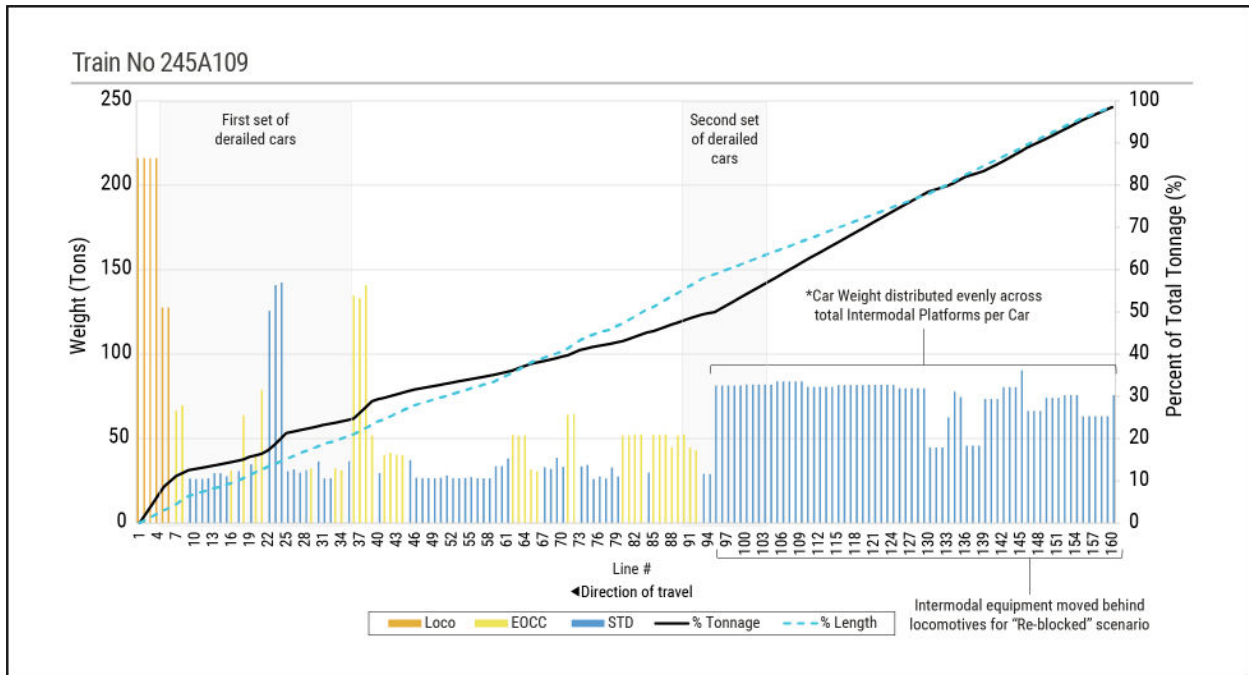
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<sup>8</sup> A coupler pocket is the recess in which the coupler is installed.

The RMEX 06 had rubber stop blocks applied to the coupler pocket. These stop blocks are manufactured to be temporarily installed on the locomotive with a securement chain bolted to the end of metal vertical tabs. The vertical tabs of the blocks on the RMEX 06 had been welded to the coupler pocket. The National Transportation Safety Board (NTSB) contacted the manufacturer via email to ask about the proper installation of the coupler stop blocks. In the email, the manufacturer stated that they have never seen the blocks welded to the coupler carrier in this manner and that this did not follow the manufacturer’s method of application. In the postderailment investigation, the NTSB noted that the right rear coupler stop block was missing on the RMEX 06. An NTSB metallurgist examined a photograph of the remaining bracket that held the missing rubber stop in place and noted that it had features consistent with fracture in overstress, from outward bending.

### 1.4 Train Consist Information

Train 245A109 consisted of 108 railcars behind the locomotive consist, weighed 9,175 tons, and was 9,769 feet long. The train consist had two distinct parts, a manifest portion, and an intermodal portion. (See figure 4.)



**Figure 4.** Graphical depiction of the train consist. Note the 20 intermodal cars on the rear of the train have been broken down into their individual segments.

The manifest portion was located directly behind the locomotive consist and contained 88 railcars—12 loaded and 76 empty railcars. The head portion of the train

contained a solid block of 32 empty railcars.<sup>9</sup> Mixed in the manifest portion were 38 railcars equipped with end-of-car cushioning (EOCC) devices.<sup>10</sup>

The 89th railcar in the train started a solid block of loaded intermodal railcars which contained eight five-well double-stack intermodal railcars.<sup>11</sup> This block was listed on the crew's paperwork as 20 railcars but when broken down into individual segments, this portion of the train equated to 65 loaded railcars. The intermodal block of railcars weighed 4,914 tons.

### 1.4.1 In-Train Forces

Railcars are designed with free space or slack in the coupling apparatus of each end of a railcar, this slack allows railcars to be coupled or uncoupled and helps with starting trains. The slack designed into couplers can vary depending on the type of coupler used on the railcar. Standard draft gears average about 12 inches of travel (slack), while EOCC devices may contain as much as 30 inches of slack. In a train, the amount of slack in the draft system of each railcar is cumulative, increasing with the number of railcars in the train.

As a train traverses the vertical undulations of a territory, individual railcars travel at slightly different speeds. One example of this would be a train going downhill and dynamic brakes are used to control the train speed. As brakes are applied to the head end of the train, the rear railcars will be traveling faster than the front of the train and the draft gear and EOCCs will compress. The resulting force is referred to as compressive "slack action" or buff forces. This compressive force is the same as described above and is used by alignment control couplers to provide a centering force.

Another way to think about draft gear and EOCC is being like a spring. As the train begins to move, the spring stretches until all railcars are moving. The heavy intermodal railcars on the rear of train 245A109 can be imagined as a heavy weight attached to that spring. When operated in a controlled manner, the locomotives can stretch the spring and pull the rear of the train uphill without problems. However, when

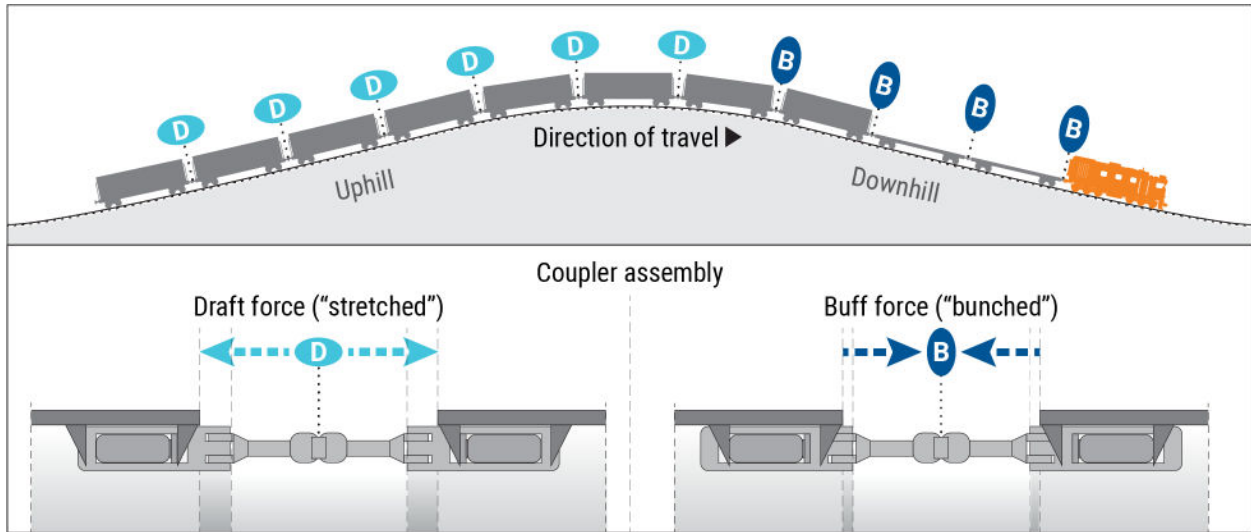
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<sup>9</sup> A *solid block* of railcars is an uninterrupted segment of railcars of the same type.

<sup>10</sup> EOCC devices are installed in railcars to absorb the shock of coupling during switching and reduce forces on the railcar while in operation. Railcars equipped with EOCCs have more slack or free movement than railcars with normal draft gear. This extra slack acts like a spring when the slack is compressed or pulled out.

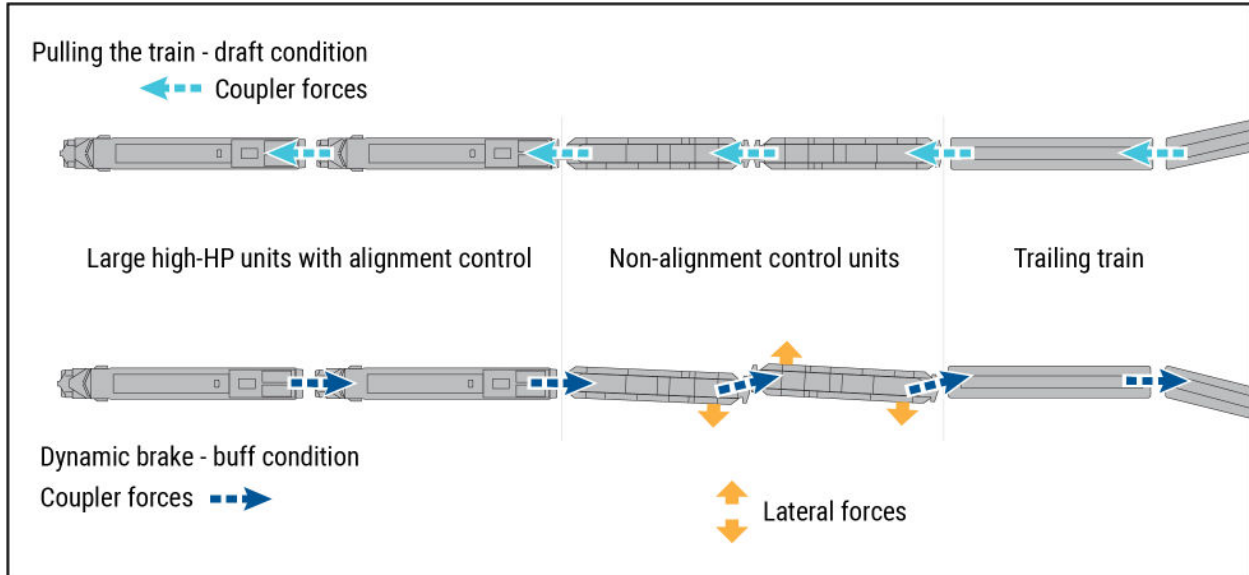
<sup>11</sup> *Intermodal* railcars are railcars equipped to carry intermodal shipping containers. Each well that holds a container is a segment of the multiplatform railcar. Multiplatform, intermodal railcars come in three-well and five-well configurations.

the train crests a grade and begins traveling downhill, the heavy rear railcars begin descending more quickly than the front of the train and compress the spring. (See figure 5.)



**Figure 5.** Train dynamics over the crest of a hill.

When a train is operating through curved track, or a railcar or locomotive is not steering properly, in-train forces tend to be exerted laterally (perpendicular to the direction of travel) and apply pressure against the rails below the train. These lateral forces increase when drawbars jackknife, long and short railcars are coupled together, or when dynamic braking is used. When lateral forces exerted on the rail exceed the vertical forces on the rail from the weight of the railcar, there is an increased risk for the rail to roll over beneath the train or for light railcars to climb up the rail. Figure 6 illustrates the transition to lateral forces and jackknifing couplers.



**Figure 6.** NTSB depiction of a *Railway Age* graphic showing the differences in how a train is pulled in draft condition as compared with buff condition.

## 1.5 Rules and Policies

Rules pertaining to the inspection and movement of revenue waybill locomotives moved on train 245A109 are contained in the NS-1 rulebook and Locomotive Department Inspection (LDI) procedure NS LDI 1-21. Equipment restriction rules (train assembly) for NS trains are contained in System Timetable Number 1.

### 1.5.1 Tow Locomotives Inspection Rule NS-1 L-214 (c)

The process for inspecting and evaluating revenue waybill locomotives is initiated in NS-1 rule L-214 (c). The rule states that before a revenue waybill locomotive can be accepted or moved, the NS mechanical department must perform an inspection, inform the train crew that the inspection was performed, and the NS clearance group must document any restrictions necessary for the safe movement of the locomotive on a clearance notice provided to the train crew.

### 1.5.2 Alignment Control Draft Gear NS-1 L-212 (b)

NS-1 rule L-212 (b) states that two locomotives without an alignment control draft gear must not be coupled together when moving dead in tow.<sup>12</sup>

<sup>12</sup> NS uses the term "dead-in-tow" to refer to revenue waybill locomotives.

### **1.5.3 NS Tariff 8002A Item 6275**

NS publishes Accessorial Services Rules and Charges on its public website for special movements such as diversions, overloaded railcars, use of cranes, and storage in tariff NS 8002-A (effective August 1, 2020). Item 6275 in this tariff addresses revenue waybill locomotives, which was applicable to the movement of RMEX 08 and RMEX 06. The tariff states that NS will move locomotives not equipped with alignment control draft gear, but equipped with stop blocks, in special train service only.<sup>13</sup> NS will not move locomotives on their own wheels if they are not equipped with either alignment control draft gear or stop blocks. The rule requires an NS mechanical department inspection and provides costs for the inspection and movement of these locomotives.

### **1.5.4 Equipment Restriction Rules**

Railroads publish instructions or rules to their personnel guiding them on how to assemble trains. NS equipment restriction rules in effect at the time that train 245A109 was built were contained in System Timetable Number 1. Two of the rules that applied to this train are EQ-09 and -11. Below are excerpts from the NS timetable, effective January 1, 2019.

- EQ-09 - Train Placement of 5 Well Equipment - When practicable, such equipment must be handled in the head 25 percent of the consist.
- EQ-11 - Blocks of Empty and Loaded Cars - (a) Blocks of empty cars - Blocks of 30 or more empty cars must be handled on the rear of trains whenever practicable.

## **1.6 Postaccident Safety Actions**

Following the derailment, NS implemented changes to prevent improper locomotive placement and circumvention of equipment restriction rules.

### **1.6.1 In-Tow Locomotive Inspections**

On April 12, 2023, NS revised NS LDI 1-21 to better assist field personnel conducting proper inspections of wayside revenue locomotives. In NS LDI 1-21, an appendix was added to provide field personnel with contact information for NS resources which can provide additional guidance or responses to technical questions. It also instructs the employee to ensure that all data recorded on the train's In-tow unit

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<sup>13</sup> *Special train service* is dedicated freight train service for the movement of equipment not permitted in normal train service.

inspection form, ME-925, is from the physical inspection, without reliance on information gathered from other systems. The instruction stresses the importance of determining whether the locomotive is equipped with alignment control couplers.

To further inform and assist the inspector, NS added a section to NS LDI 1-21 containing an additional four pages of text, photographs, and diagrams related to the proper identification of alignment control couplers. The new section points out that stop blocks are not a substitute for alignment control couplers.

### **1.6.2 Equipment Restriction Rule Changes**

Before this accident, NS had an ongoing data-driven project to make changes to their equipment restriction rules. These changes were being promulgated across the entire system. The day before this accident, NS issued the new equipment restriction rules in Operations Bulletin 7, OB-7. These changes were scheduled to go into effect the Monday following the accident. This bulletin contained rules changes removing the “when practicable” language from equipment restriction rules. Under the new equipment restriction rules, loaded articulated intermodal railcars would be required to be on the head end of the train and solid blocks of empty railcars would be required to be on the rear.

## **2 Analysis**

### **2.1 Introduction**

On March 9, 2023, Norfolk Southern train 245A109 derailed 2 locomotives and 37 railcars near Anniston, Alabama. There were no injuries or hazardous materials released as a result of the derailment. The analysis will discuss the following safety issues:

- The coupling of locomotives RMEX-06 and -08, both equipped with nonalignment control couplers in violation of NS rules, exacerbated by these improper couplers not being identified during mechanical inspections.
- Train build rules that allowed the train to be built in a manner that excessively increased in-train forces on the head end of the train and locomotive consist.

### **2.2 Nonalignment Control Couplers**

An NS mechanical department employee conducted in-tow locomotive inspections in Bluffton, Indiana. NS LDI 1-21 provides instructions and guidance to the mechanical department employees for completing this inspection. The mechanical

employee completed the In Tow Unit Inspection Form (NS Form ME-925), as required by NS LDI 1-21. In both cases, the mechanical employee checked the box “Yes” for the question, “Is unit equipped with alignment control draft gear?”. The follow-up question, “Are stop blocks applied?” was also checked yes. The presence of the stop blocks could have alerted the mechanical employee to the fact that the couplers on the locomotives were not alignment control couplers; however, it did not. In a postaccident interview with the Federal Railroad Administration (FRA), the mechanical employee stated that he did not know what an alignment control coupler was at the time of the inspection. Had the mechanical employee been equipped with job aids in the field, support contacts for technical questions, references to the correct applicable NS rules, and information related to the risks associated with the use of nonalignment control couplers, the inspection and clearance of the locomotives could have been more accurate, and the pair of locomotives would have been moved in a special train or been uncoupled and moved in separate trains.<sup>14</sup>

After the mechanical inspections were complete on the RMEX locomotives, the inspection forms were submitted by email to the NS clearance desk. Clearance desk employees questioned field mechanical leadership in Bluffton, Indiana, concerning both boxes being marked “Yes” for alignment control couplers and stop blocks being installed on the RMEX-08 form. NS officials at the clearance desk asked if the mechanical employee who conducted the inspection had verified the presence of alignment control couplers and stop blocks. Further conversations between the clearance desk and field mechanical leadership gave the impression that stop blocks had been applied to the locomotive and the moves were approved without clarifying why both boxes were marked “yes”.

The email communications between NS officials at the clearance desk and the mechanical department represented an opportunity for the railroad to catch the mistakes on the ME-925 forms, namely, that the locomotives were not equipped with alignment control couplers, despite the indications on the forms that they were present. Despite their awareness that something was not correct on the forms (both boxes should not be checked yes), NS did not hold movement of the train until verification of the type of couplers present occurred and the application of appropriate remedies applied (such as removing one or both locomotives from the train consist). It is not sufficient to simply state that the locomotive has stop blocks in place, as the stop blocks do not provide a centering force to the couplers in the same way an alignment control coupler. Even with the stop blocks applied, the movement of the two locomotives together was prohibited

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<sup>14</sup> *Job aids* are digital or printed handouts that contain written instructions and graphics to assist employees in completing a task. They remind employees of the correct way to complete a task and reduce mistakes in the work environment when used.

by NS rules. Therefore, the two locomotives coupled together could still be at risk to jackknife, leading to a rail-rollover event. (See figure 6.)

Had NS provided mechanical job aids that clearly stated that coupler stop blocks are not a replacement for alignment control couplers, and that the revenue waybilled locomotives must still comply with NS rule L-212, the locomotives would not have been coupled together in a train and the derailment may have been prevented.

With the RMEX locomotives incorrectly identified as having alignment control couplers, the clearance notice did not include the warning language printed in red at the top of the notice to warn and provide guidance to employees in the field.

### **2.3 Effects of Train Make Up on In-Train Forces**

With the placement of a block of 32 empty railcars in the head portion of the train and the loaded intermodal equipment that contained 5 well intermodal railcars on the rear, train 245A109 was not in compliance with NS's equipment restriction rules. However, the inclusion of the phrase "when practicable" in these equipment restriction rules allowed NS the ability to prioritize railcar placement in the train for destination blocking and in a manner that did not comply with equipment restriction rules.<sup>15</sup>

Postaccident, NS performed modeling of in-train forces on train 245A109 to evaluate how train make up affected them. The train was modeled exactly as it was built on the day of the accident and another model was created with the railcars repositioned. In the second model, the heavy intermodal railcars were moved from the rear of the train to directly behind the locomotive consist, as required by NS's standard equipment restriction rules. Both models used the same train handling the engineer used on the day of the accident to recreate the forces present in the train.

The first model, with the train built the same as the day of the accident, showed high compressed forces in excess of 225,000 pounds present at the location of the derailment. As the train started to increase speed on the downhill grade the engineer used the dynamic braking system on the locomotive consist to control the speed. This braking of the locomotive consist, as well as a recent application of the train braking system, caused the slack to run in toward the locomotives when the intermodal block of railcars on the rear of the train came over the crest of the grade. (See figure 5.) The wave of in-train forces peaked in the locomotive consist and the railcars directly behind the locomotives. The high levels of in-train forces generated could cause the damage to stop blocks described in section 1.3.2 and lead to a derailment. The derailment occurred in a

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<sup>15</sup> *Destination blocking* is the process of putting railcars in a train together according to where they are destined and placing them in the train in a certain order.

brief section of tangent track as the train exited a sharp curve. With this scenario, the in-train forces transitioning from longitudinal force to lateral force was exaggerated by the nonalignment control couplers on the revenue waybill locomotives and exceeded the amount of force the rail under these locomotives could withstand.

In the second scenario, the heavy intermodal block was moved from the rear of the train and positioned directly behind the locomotives at the front of the train—as is prescribed in NS rules for making up a train. This scenario resulted in a substantial reduction of the in-train forces, bringing the forces below 150,000 pounds. Had NS built the train as modeled in the second scenario, the in-train forces would have been reduced, lowering the likelihood of derailment.

The postaccident modeling showed how train build alone changes the amount of in-train forces. The modeling demonstrated a significant reduction in in-train forces, to the extent that had the train been built in compliance with NS's equipment restriction rules instead of destination blocking, the derailment would have likely been prevented. The equipment restriction changes that NS put in place immediately after the accident require the train to be built similar to the second scenario, eliminating the "when practical" language for empty blocks and loaded intermodal equipment.

### **3 Probable Cause**

The National Transportation Safety Board determines that the probable cause of this accident was the combination of the coupling together of two revenue waybill locomotives without alignment control couplers, in violation of Norfolk Southern Railroad rules, and excessive in-train forces created due to the build of the train. Contributing to the accident was the misidentification of couplers without alignment control during the Norfolk Southern Railroad inspection process.

The NTSB is an independent federal agency charged by Congress with investigating every civil aviation accident in the United States and significant events in the other modes of transportation—railroad, transit, highway, marine, pipeline, and commercial space. We determine the probable causes of the accidents and events we investigate and issue safety recommendations aimed at preventing future occurrences. In addition, we conduct transportation safety research studies and offer information and other assistance to family members and survivors for each accident or event we investigate. We also serve as the appellate authority for enforcement actions involving aviation and mariner certificates issued by the Federal Aviation Administration (FAA) and US Coast Guard, and we adjudicate appeals of civil penalty actions taken by the FAA.

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For more detailed background information on this report, visit the [NTSB Case Analysis and Reporting Online \(CAROL\) website](#) and search for NTSB accident ID [RRD23LR008]. Recent publications are available in their entirety on the [NTSB website](#). Other information about available publications also may be obtained from the website or by contacting –

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