TRAIN DERAILMENTS AND RAILROAD SAFETY

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No railroad wants to suffer a derailment, and even a minor derailment (which is, fortunately, what the majority are) can be costly. These accidents can lead to service interruptions, delaying or re-routing of passengers and cargo, and economic loss. More serious derailments can result in the release of hazardous materials or pollutants and/or personal injuries.

This paper will examine some common causes of derailments, preventive measures, and ways to minimize risks for future incidents.

The basics: what is a derailment and how does it occur?

At the most basic level, a derailment means a train leaves the track due to unintended circumstances.

These accidents usually occur in one of three ways.

- Wheel Climb is pretty straightforward: this is when a wheel climbs up and over the rail.
- Gage Spreading / Rail Rollover whereby the distance between the rails widens too much (spread gage) and/or one or both rails tip over (rail roll) resulting in wheels dropping down between the rails.
- A Catastrophic Event such as a track washout, a collision, a broken rail or wheel, or a burnt off journal (axle housing).

Many factors, including track conditions, mechanical defects, train make-up, human error, or even weather and environmental conditions could be the root cause of a derailment. Quite often, derailments occur from a combination of factors rather than just one singular condition. The following is not an exhaustive list of derailment causation elements, but are some of the more-often factors of significance:

Track conditions

- Broken rail – examples include metallurgical defects (e.g. spalling, shelling, fissures, improperly formed steel), repeated impacts at joints, and separation of the rail due to improper Rail Neutral Temperature (RNT).

- Crosslevel – the relative height between the two rails. On straight (tangent) track, this should be 0 inches, while in curves, the outside rail is typically elevated higher than the inside rail to better balance vertical and lateral wheel forces (same principle as curve-banking on a race track). If the difference in crosslevel is improper for the train speeds or is inconsistent, derailment can occur. Excessive dips and bumps can be problematic as well (even on tangent track). When tracks begin to develop subgrade and ballast issues—these are the types of materials or soils that form the railbed—it can be expensive to fix, but is absolutely necessary, as a shifting or improperly supported ground structure can be some of the most significant threats to track stability.

- Track buckle / sun kink – rail expansion from very hot temperatures in summer months can cause tracks to warp or sway out of their intended path as shown in the figure below. Too low a RNT, inadequate ballasting due to sudden weather erosion, unseen issues in need of maintenance, or recent track work, etc. could also lead to buckling.

The RNT is the engineering design temperature at which the rail is in neither tension nor compression. For example, a RNT setting of 90° F means that if a properly de-stressed section of rail were un-spiked and cut out from the track, it would not lengthen or shrink if the rail temperature were 90° F. The RNT is set higher in warmer weather regions and lower in colder regions. Since cold makes metal contract, extremely cold temperatures in the winter months can cause rail separation problems if the RNT is not properly set and/or managed for the region.

- Gage and rail restraint (loaded and unloaded) - refers to the distance (gage) between the rails and the ability of the ties, tie plates, and fasteners to hold the rails at the proper width under loaded and unloaded conditions.

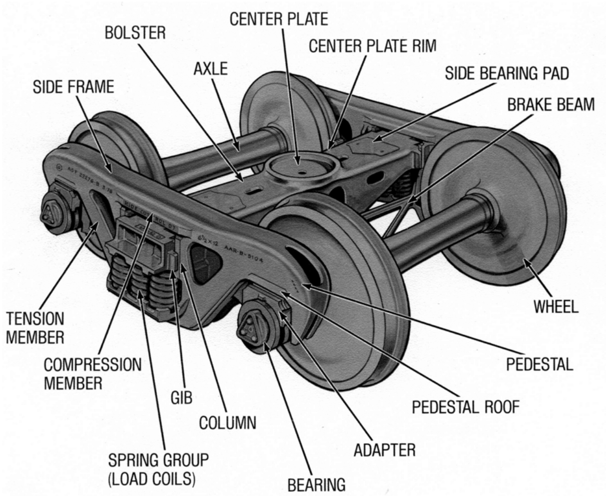
- Alignment/curvature - If the curvature is inconsistent or the rails get out of alignment with one another, problems and derailments can occur.

- Rail profile – curve worn rail shifts vertical forces outward which can cause the outer rail of a curve to get pushed out and allow wheels to drop inside and/or roll the rail.

- Lubrication - A fine balance of rail lubrication must be maintained, particularly in curves. Under-lubricating curves can inhibit proper railcar steering and heighten the risk for wheel climb (as well as exacerbate rail/wheel wear) and over-lubricating can lead to overly-slick rails which may cause locomotive traction issues.

Mechanical (railcar) factors

The assembly beneath a railcar body which includes the wheels, axles, structural members, and key braking components is called a "truck". There are typically two trucks on a conventional freight or passenger car and each truck swivels independently beneath the car body to allow the car to steer through curves. The diagram below shows the primary components of a common three-piece freight car truck. Passenger car trucks are more complex due (mostly) to the addition of supplemental suspension components to enhance passenger ride quality (particularly at higher speeds). Locomotive trucks are also more complex to accommodate and structurally support power assemblies, air sources, electronics, and crew members.



Excessively-worn or damaged truck components can heighten derailment risk, particularly if those components negatively affect proper truck steering and/or braking.

Mechanical components of particular significance include:

- Friction wedges – wedges which reside in the bolster pocket/ side frame interface that help keep the side frames square to the truck bolster as well as provide secondary suspension.

- Side bearings – load bearings that are mounted towards the outer edges of the bolster to prevent the car body from tipping excessively. Proper side bearing clearances must be maintained to allow the railcar to steer correctly and keep the car body balanced above the trucks.

- The center bowl/center plate interface – this is the primary contact surface between the carbody and truck. Binding in the center bowl can prevent the truck from properly steering if it is hindered from rotating freely beneath the carbody.

- Wheel profiles – the shape of the wheels (as well as the rail) is paramount as this is the where the railcar interfaces with the track (where the rubber meets the road, so to speak!)

External factors such as the ones listed below can also play a role

- Human errors: excessive speed, poor train handling, incorrectly lined switches, distracted operators (cell phone use, texting, etc.), improper train routing/dispatching, etc.
- Train Make-Up: excessive tonnage, improper car placements, incorrect locomotive utilization, etc.
- Weather: wind, flooding/washout, extreme temperatures, etc.
- Obstructions: fallen trees, rock slides, motor vehicle on the track, etc.
- Signal failure
- Shifted or improper loading

A derailment can result from one or more of the factors noted above. The risk for derailment increases as more items deviate from their optimum conditions - a derailment is still possible even in the absence of an FRA defect (minimum operating standards set forth by the Federal Railroad Association) if the "perfect storm" situation arises.

Inspections: The Key to a Safer Railroad

It should go without saying that routine inspections of both the railcars themselves and the tracks that carry them are the first lines of defense in assuring a safe day on the railroad. The FRA dictates how often inspections must occur depending upon the commodity being carried, the speed of operations, and other factors. Federal law and railroad operating rules typically dictate tighter operating tolerances and more frequent inspections for passenger services, operations involving hazmat, and higher train speeds.

Inspecting railcars for safety

Cars that are interchanged are inspected constantly along the route both visually and with technology. Specially trained car inspectors visually inspect railcars inbound and outbound from rail-yards. When a train is stopped on a main line or siding for a "meet" to allow another train to pass, the crew on board gets down from their stopped train to do a "roll-by" inspection of the passing train to look for potential problems such as dragging equipment, stuck brakes, or an improperly rolling railcar.

In addition to visual inspection by inspectors and train crews, Hot Box Detectors, high-speed scanners equipped with specialized sensors such as infrared cameras, look for hot axle bearings in a train as it passes en route, even at higher speeds. These detectors then automatically radio the crew on the inspected train to inform them of any defects detected. Some train yards have cameras and laser-based inspection equipment at entry and exit points. Other types of mechanical inspection equipment include dragging equipment detectors that look for hanging air hoses and other dangling equipment hazards and Wheel Impact Load Detector (WILD) systems that detect higher than normal rail impacts typically caused by "flat" wheels (wheels with a flat spot resulting from a wheel slide or other causes).

When mechanical problems are detected, cars with defects exceeding prescribed limits are "Bad Ordered" and set out and repaired at certified shops to specified settings. The car owner is charged for the repairs at industry agreed upon billing rates. This is an ongoing process; cars in service are repaired routinely and regularly, but not typically on a daily or mileage-based service interval. Locomotives, on the other hand, have 90-day service inspection intervals in addition to their operational visual inspections before use. In general, federal law limits freight cars to a 50 year service life (there are some further restrictions and exceptions).

Track Geometry Inspection

The tracks in service are categorized by "Class." The lower the track class, the lower the maximum allowable train speed. Track Classes 1-5 are most applicable to freight and lower-speed passenger service while Classes 6 and above are for speeds of greater than 80 mph for freight and 90+ mph for passenger service. Classes 7 and 8 are reserved for the highest-speed trains, such as the Amtrak Acela, and are currently found only in the Northeast Corridor between Boston and Washington, D.C.

Inspection intervals of main line track depend on the track class. Higher class tracks have tighter tolerances to accommodate the higher train speeds. Generally speaking, main track is visually inspected by qualified inspectors on a weekly basis for track Classes 1-3 and twice a week for track Classes 4 and 5. There are additional caveats in that regard, but that is the typical schedule for track that is used on a regular basis. It is not uncommon for many of the larger railroads to conduct these inspections more frequently than mandated by law. Tracks used for passenger service such as those in the heavily trafficked Northeast Corridor are inspected on a daily basis.

Automated track geometry cars are designed and utilized to monitor gage, alignment, rail profile, and other parameters with a variety of ultrasonic, induction, and other tools. Geometry car inspections are mandated once or twice per year, for example, for track Classes 3-5, depending on the amount of tonnage hauled and/or if passenger service operates over the track. If a segment of track does not meet all of the requirements for its intended class, it is reclassified to the next lowest class for which it meets all minimum standards and the maximum allowable train speed is lowered accordingly.

Supplemental to visual inspection, specially equipped ultrasonic cars are used to look for internal as well as external defects that can cause rail failure from things such as localized metallurgical inclusions that occurred when the rail was manufactured, impact loading due to flat wheels, and normal rail wear. Repeated impacts (rail batter) at a mismatched joint or switch could cause breakage. These issues are routinely caught by sharp-eyed inspectors and/or rail inspection cars.

Other Derailment FAQtors (or, common questions)

Q: Is it more dangerous to use a track that doesn't see much traffic?

- No, not necessarily. The condition of the track—not the age or the amount of traffic on the track—is what's important. Factors such as rail wear, tie condition, track gage, alignment and crosslevel conditions, ballast quality, and subgrade stability are just some of the factors that must be quantified for the intended operations. There are documented instances of newly-constructed track that was not fit for operations and required remediation before use. Conversely, it is not uncommon for track that was installed decades ago to pass all inspections and be suitable for use, having been properly maintained to the appropriate standards.

- Track class also comes into play, as lower track classes have more lenient specification tolerances. For instance, standard track gage in the US is nominally 56 ½". Class 1 track, which is limited to 10 mph or lower for freight trains, allows for track gage to vary between 56-58" whereas Class 4 track, which limits freight trains to less than 60 mph, only allows for variance from 56-57 ½".

Q: What about the recent accidents involving trains overturning in curves?

- Curves on mainline tracks are typically super-elevated (the outside rail higher than the inside rail) to better balance railcar centrifugal forces and distribute them more evenly to the high and low rails. This lessens the risk for overturning as well as better manages rail wear. Since centrifugal and overturning forces increase with speed, yard tracks are not typically super-elevated as the operations in yards are typically slow speeds (10-15 mph or less). Engineering formulas based on the degree of curvature and train speed are used to set the design elevation for a curve.

- Overturning accidents are quite rare and most often stem from human error when an engineer fails to properly slow the train to the designated curve speed limit. The forthcoming implementation of Positive Train Control (PTC) is intended to make such events nearly nonexistent as PTC will track the train's location via GPS in real-time and automatically employ penalty braking to slow or stop the train prior to the occurrence of an excessive over-speed event.

Q: Are concrete ties better than wood?

- Not necessarily. Both can provide excellent service with proper installation and fastening systems (spikes, clips, etc.). While wood ties rot over time, they have preservatives that delay rot significantly; concrete ties are susceptible to freeze/thaw cracking and catastrophic failure from impacts (dragging equipment, damage from track gangs, derailments, etc.). Wood tie use/replacement is far more economical and can be just as structurally sound when properly installed and maintained.

Q: What derailment risks are associated with weather?

- While such incidents are uncommon, derailments have resulted from heavy rains that caused flooding and/or track washouts and from high winds that toppled railcars - particularly intermodal cars which often have stacked containers with large surface areas and higher centers of gravity.

- Railroads have weather services and policies in place to continually monitor conditions, alert crews of potential hazards, revise operating speeds in high-heat and extreme-cold conditions, move and park trains to avoid water and wind hazards, etc. Railroads are very conscious of the weather conditions and are highly proactive in derailment prevention regarding such factors.

Q: Is there an argument to be made that oil cars could be causing more problems due to weight or uniformity of cargo imparting forces that mixed cargo trains don't create?

- No real increased derailment risk is present – a tanker car of milk rolls on the rails and loads the track structure very similarly to a tanker car full of crude oil.

- Obviously there is a greater risk of fire if a tanker of oil derails and puncture occurs but there are many other commodities hauled by rail that are also flammable and/or toxic if product is released. Tank car standards are under constant review and improvements are continually evolving to lessen the risk for puncture. Significant consideration is also given to routing oil trains away from and around high-population-density areas.

- Even though some crude oil is denser than some other liquids, the gross weight of a crude oil car is not heavier than many other railcars which operate on a regular basis. For instance, there are many unit trains operating daily that generate similar heavy, repeated loading to the track (coal trains, ore trains, grain trains, etc.).

- Simply put, more unit crude oil trains are being operated to carry the large volumes being requested for consumer and economic reasons than a decade ago. Conversely, there are far fewer coal trains in operation today.

Minimizing Derailment Risks

Along with rules compliance and employee training, minimizing derailment risk requires the proper maintenance of the tracks, railcars, locomotives, and other infrastructure involved in everyday operations. This encompasses utilizing the inspection methods available and the involvement of trained personnel to repair or address issues as quickly as possible. Training and keeping personnel up-to-date on the latest safety developments is critical to this. An employee cannot report on a defect if he is unable to identify it, so continual education is paramount.

Oversight by others (supervisors, crew members, outside agencies, etc.) helps to maintain safety and keep people accountable. Human error can oftentimes be caught before becoming a catastrophic issue, and even the simple act of assuring crew members are alert, attentive, and properly rested for their duties can prevent incidents.

The soon to be fully-implemented PTC technology and the continued development of other new technologies will help to reduce derailment numbers as well. PTC was mandated by Congress in 2008 in response to the collision of a Metrolink passenger train in California and was once again brought into the national spotlight after the recent Amtrak train derailment outside of Philadelphia was found to have been caused by engineer distraction resulting in excessive train speed around a curve. PTC, with its minimum train separation controls and speed enforcement logic was designed to prevent train collision and over-speed accidents due to human error.

Finally, learning from investigations, inspections, and incident reports adds to the collected data about derailment causes and effects. Root causes are discovered and allow railroads, states, and federal regulators to implement corrective actions and additional rules or tighter standards (track, equipment, etc.), guidelines, and safety measures (locally & industry-wide).

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