



U.S. Department
of Transportation

Federal Highway
Administration

U.S. DOT Gulf Coast Study, Phase 2

Engineering Case Study 10: Continuous Welded Rail Exposure to Temperature Changes

This is one of 11 engineering case studies conducted under the Gulf Coast, Phase 2 Project. This case study investigated whether continuous welded rail (CWR) in Mobile could be vulnerable to projected increases in temperature.

Description of the Site and Facility

This study considered the potential impacts of higher temperatures on a hypothetical segment of CWR in Mobile.

Steel rail will expand with heat, possibly resulting in a track displacement called a sun kink. In extreme cold weather, the contracting rail can literally pull itself apart, usually at the joints or the welds. Therefore, when laying rail tracks, engineers take into account the anticipated exposure to temperature to help ensure that excess expansion or contraction will not occur. If rail temperature is not properly considered in the laying of track, the track structure can be damaged during periods of extreme heat or cold, requiring maintenance expenditures, causing train delays, and leading to a heightened risk of derailments. If the maximum or minimum temperatures to which the rail is exposed changes, then the current practices for laying rail may no longer be adequate.



Figure 1: Example of a Hot Weather Sun Kink

Climate Stressors and Scenarios Evaluated and Impacts on the Facility

This analysis considered two specific temperature scenarios for the 21st century; a “Warmer” narrative and a “Hotter” narrative.¹ The “Warmer” narrative represents the 5th percentile (mean-1.6 SD) of all the climate model outputs under the range of climate scenarios considered, whereas the “Hotter” narrative represents the 95th percentile outputs (mean+1.6 SD).

Within these scenarios, the key environmental variables used in this case study were the absolute expected maximum and minimum air temperatures over the lifespan of the rail installation. These temperature variables were selected because they are used to calculate the appropriate “neutral temperature” for laying rail.² Neutral temperature is the temperature at which zero thermal stress would occur. The desired neutral temperature is determined by the temperature of the rail (not the ambient temperature) at the time of its installation and fixing to the ties.³ There is an optimal range at which to set the neutral temperature that is based on the expected temperature patterns at the installation site; installing a rail at too high a neutral temperature might result in a higher risk of pull-aparts in cold temperatures and installing it at a temperature too low may result in greater risk of sun kinks during warm temperatures.

¹ For more information on the climate information referenced here, please refer to Climate Variability in Change in Mobile, AL (USDOT, 2012) and Screening for Vulnerability (USDOT, 2014).

² Although engineers typically consider the temperature of the rail itself, ambient air temperatures impact rail temperatures. This case study used the Federal Railroad Administration (FRA) guidance that states that rail temperature shall be considered 30°F higher than ambient temperatures in hot weather and equal to ambient air temperature in cold weather. See Federal Railroad Administration (FRA), Office of Safety Analysis, 2013. Continuous Welded Rail (CWR) Generic Plan: Procedures for the Installation, Adjustment, Maintenance and Inspection of CWR as Required by 49 CFR 213.118. <http://safetydata.fra.dot.gov/OfficeofSafety/publicsite/cwr/>.

³ The rail temperature at the time of installation is influenced by the ambient temperature but can be adjusted in the field as needed using specialized equipment so that the desired neutral temperature can be achieved regardless of weather conditions at the time of installation.

Table 1 summarizes the projected changes to the relevant temperature variables under both the “Warmer” and “Hotter” narrative.

Maintenance Activity	Observed (Model Baseline) ⁴ 1980-2009	“Warmer Narrative”			“Hotter Narrative”		
		2010-2039	2040-2069	2070-2099	2010-2039	2040-2069	2070-2099
Maximum Annual Highest Maximum Temperature (°F)	103	102	103	103	106	109	113
1st Percentile Coldest Day (°F)	4	-1	0	1	15	18	20

Table 1: Projected Changes to Maximum and Minimum Temperatures in Mobile, Alabama

These projected temperatures were used to calculate the acceptable range of neutral temperature in Mobile under the Warmer and Hotter narratives, for the near term, medium term, and end of century timeframes. Table 2 summarizes the acceptable ranges of neutral temperature under these climate narratives.

	Current Range	Projected 2010-2039	Projected 2040-2069	Projected 2070-2099
“Warmer” Narrative	110-115+/-5	98 to 113+/-5	99 to 114+/-5	99 to 114+/-5
“Hotter” Narrative		106 to 121+/-5	109 to 124+/-5	112 to 127+/-5

Table 2: Acceptable Rail Neutral Temperature Ranges (°F) in Mobile Considering Climate Projections

Mobile’s Class I railroads currently use 100°F (37.8°C) as the neutral temperature on all of their CWR tracks in the Mobile region. This temperature is in the acceptable range of neutral temperature for the less extreme, Warmer scenario through the end of the century. However, under the Hotter scenario, this neutral temperature would be outside the acceptable range.

Identification and Evaluation of Adaptation Options

For new rail, an appropriate adaptation option would be to use a higher neutral rail temperature to lay new tracks as the climate warms. For existing rail, a comprehensive track maintenance program could include the removal and reinstallation of rail at a higher neutral temperature.

Another adaptation option, for both new and existing rail, would be to ensure that ballasted tracks have shoulders that are at least one foot (0.3 meter) wide to provide lateral support to the ties. A fully ballasted track section with maintained shoulders can resist the lateral forces experienced during extreme high temperatures, reducing the risk for rail damage.

⁴ The observed values represent calibrated statistical values derived from climate models as opposed to actual historical observations. Use of the model baseline allows for a more consistent comparison of past and projected future climate conditions.

Potential Course of Action

Because action would need to be taken only under the Hotter scenario, the recommendation is to monitor temperature over time. If temperatures appear to be moving toward the extremes in the Hotter scenario, then adaptive action should be taken.

Lessons Learned

Monitoring temperature trends, and keeping track of buckling or kinking incidents, may help alert track managers to the appropriate time to take proactive adaptation measures.

For More Information

Resources:

Gulf Coast Study:

[Engineering Assessments of Climate Change Impacts and Adaptation Measures](#)

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