TECHNOLOGY DIGEST

TD-13-030

©NOVEMBER 2013

TIMELY TECHNOLOGY TRANSFER

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Establishment of a Heavy Axle Load Northern Mega Site

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Summary

Canadian National Railway Company (CN) and Transportation Technology Center, Inc. (TTCI) have established a northern mega site to study the effects of cold climates on 286,000-pound car heavy axle load (HAL) operations. The site is located near Winnipeg, Manitoba, Canada, on main lines of the CN system. The climate is typical for midcontinent conditions on the CN main line.

Tests to be established at the northern mega site include:

- Rail flaw growth experiment — This test will document the growth of transverse railhead flaws over time. The data will be used to determine the potential value of prioritizing rail flaws for removal.
- Tie plate size experiment — This test will compare performance of track with 14-inch and 16-inch tie plates on hardwood crosstie service life.
- Rail wear experiment — This test will compare the performance of premium rails in moderate 4- to 6-degree curves.
- Insulated joint performance experiment — This test will compare the performance of premium insulated joints to standard joints in mainline track.
- Ballast performance experiment — This test will compare the performance of ballasts over expansive soils.

The new test site will allow a wider range of weather and operating conditions for evaluating the performance of trains and infrastructure under HAL service. While the northern mega site focus is on cold weather effects, it also will supplement the HAL research and development work being done at the Facility for Accelerated Service Testing and the HAL testing being done at companion eastern and western mega sites.

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INTRODUCTION AND BACKGROUND

The results from the ongoing HAL research program, funded by Association of American Railroads (AAR) and Federal Railroad Administration (FRA), have contributed to the implementation of 36-ton axle loads (286,000-pound gross weight vehicles) by North American railroads over the past decade. The HAL research has been carried out primarily at a dedicated facility and at two revenue service mega sites. The Facility for Accelerated Service Testing (FAST), Pueblo, Colorado, is used to test track and structures at axle loads above 36 tons. It is also used to test novel components and maintenance methods where failure modes may not be fully understood.

In 2003, the Heavy Axle Load Research Committee (HALRC), which oversees the HAL Strategic Research Initiatives (SRI) Program, and the Railway Technology Working Committee (RTWC), which oversees the entire AAR SRI Program, decided that the existing revenue service testing efforts needed to be expanded to meet the industry needs. Under the direction of HALRC and RTWC, a technical advisory group (TAG) consisting of TTCI, railroad, and FRA representatives, was formed in August 2003 to determine future FAST and revenue service test needs. One of the main recommendations from this TAG was the creation of the "mega test site" concept.

In 2004, two mega sites were selected, each 10 to 30 miles long: one in the east on the Norfolk Southern (NS) mainline from Narrows to Bluefield, West Virginia, the other in the west on the Union Pacific (UP) mainline, South Morrill Subdivision, Nebraska. Both sites are in coal routes with predominately loaded 286,000-pound traffic.

It was decided that most revenue service experiments should be consolidated to these two mega sites in order to improve experiment design and capabilities, to foster cost-efficiency, and to simplify the coordination and communication between the host railroads and TTCI. The following main objectives of the revenue service testing remain the same:

- Determine the effects of HAL on track infrastructure and mechanical components by supplementing and complementing the FAST program with a wider range of curvatures, train speeds, foundation conditions, and climatic conditions than those found at FAST.
- Advise stakeholders of potential safety problem areas.
- Provide data for refined economic analysis of HAL operation.

Northern Railway Issues

There are significant operating and engineering issues involved with HAL operations in cold climates. In addition to discussions with the mega site host railway, a literature review was conducted to document current problems and potential solutions.

From the literature review conducted,[1] the following issues were identified:

- Rail defect growth and broken rail in cold weather
- Frozen switches
- Thermal force issues for continuously welded rail (CWR) and CWR-bridge interaction in cold weather
- Rail lubrication and friction control in cold weather
- Change of track modulus/track stiffness in cold weather
- Identification and remediation of frost heave locations (use of ground penetrating radar)
- Frost susceptibility of ballast, subballast, and subgrade
- Effect of freeze/thaw on gage strength of wood tie track

Mega Sites

Table 1 lists the main characteristics of the new northern mega site and the existing mega sites. As Table 1 shows, the mega sites have distinctive characteristics in track components, track geometry, and train operation speeds. Of the two existing sites, the eastern mega site typically has higher lateral wheel loads, while the western mega site typically has higher vertical wheel loads. Additionally, the eastern mega site is exposed to more rain and lower temperatures than the western mega site.

Table 1. Mega Site Characteristics

	Eastern	Western	Northern
Track Structure	Timber ties and cut spikes, Premium rail, Standard turnouts with fixed point frogs, Open deck steel bridges, Variable subgrade	Concrete ties, Premium rail, Premium turnouts w/spring or movable point frogs, Ballast deck concrete bridges, Variable ballast and subgrade	Timber ties and cut spikes, Premium rail, Premium and standard turnouts with fixed point frogs, Open deck steel bridges, Variable subgrade
Annual Tonnage	≈ 60 MGT	>200 MGT	70 MGT
286-k Traffic	50%	80%	40%
Speeds	20–40 mph	50–60 mph	20–60 mph
Track Geometry	Curvature up to 12 degrees	1–2-degree curves	2–6-degree curves
Cant Deficiency	2 inches (3 inches for intermodal and passenger)	1 inch	2 inches
Grade	0.5–1.4% downhill	Less than 0.5%	Less than 0.5%
Elevation (feet above mean sea level)	2,657 feet	3,264 feet	784 feet
Average Monthly Temperature Range	24–79°F	12–91°F	-6–78°F
Annual Precipitation	39.2 inches	18.8 inches	20.2 inches

The northern mega site adds a wider range of climate conditions with colder average and minimum temperatures and a slightly wider range of temperatures. The HAL traffic at this site differs in that there are more varieties of commodities, e.g., coal, grain, and intermodal. The operating speeds are generally higher than at the other two mega sites.

Establishment of Northern Mega Site

After reviewing the desired mega site characteristics and the requirements of the initial experiments, CN selected the eastern end of the Rivers Subdivision near Winnipeg, Manitoba, Canada, for the mega site. Figure 1 shows the location in relation to the other mega sites.

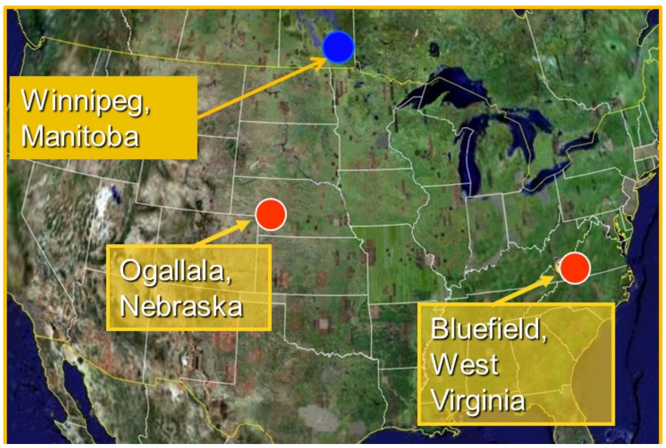

Figure 1. HAL Mega Site Locations

Proposed Experiments

Table 2 lists the proposed experiments for the northern mega site. The list was developed by CN and TTCI engineers involved with the mega site. The list matches well the literature search for northern railway issues.

Table 2. Proposed Northern Mega Site Experiments

Experiment	Test Variables	Comments
Rail Flaw Growth (2013)	Flaw location	Document rail flaw growth behavior
Tie Plate Size (2014)	Tie plate size	Determine effect on tie life, track performance
Rail Performance (2014)	Rail metallurgy	Determine performance of rails in mainline curve and cold climate conditions
Insulated Joints (2014)	Design	Determine performance of premium and standard insulated joints in cold climate
Ballast (2014)	Gradation, source	Measure performance on expansive soils

Rail Flaw Growth Experiment

The rail flaw growth experiment is intended to document the range of growth rates for railhead flaws under HAL traffic in a cold climate. It is expected that the rates of rail flaw growth can be higher under HAL traffic in northern climates due to higher dynamic loading from frozen track and wheel defects. Wheel defect occurrence rates are known to be higher in cold seasons.

The study will document the behavior of transverse railhead flaws with time and tonnage. Current practice and regulations require that virtually all rail flaws be removed when found. However, it is well documented from other industries that cracks in metal components can become dormant.

Also, as inspection technology improves, smaller flaws can be detected. Some of these flaws will not become fatigue cracks during the service life of the rail. Others may grow very slowly before reaching a critical size. The proposed experiment will gather the data needed to determine whether rail crack growth rates are correlated with climate, operating, and track features. This will help in determining if railhead flaws can be managed to reduce overall safety risk under HAL service.

Tie Plate Size Experiment

Background: Many railways install longer (i.e., 16-inch) tie plates when they replace rail. This practice is based on experience that using large tie plates results in longer crosstie life. The amount of life extension varies with several factors related to climate and traffic characteristics. This experience has been codified into a best practice for heavy haul railways, which recommends 16-inch tie plates for mainline curves.[2] Additionally, theoretical studies suggest a potentially significant increase in crosstie service life for 16-inch tie plates (versus 14-inch tie plates).

For test planning, a study of tie plate size was conducted using the Railway Track Life Model (RTLM™).[3] RTLM predicts track component failures and maintenance costs for an input route and operation. For the potential northern mega site test conditions, the expected increase in crosstie service life ranges from 15 to 21 percent. Table 3 shows RTLM results for a range of train speeds, two tie species, and two track curvatures.

Table 3. 2013 North Mega Site Tie Plate Study

Tonnage Rate: 70 MGT/year

Train Type	Speed (mph)	Curvature (degrees)	Superelevation (inches)	Tie Type	Predicted Average Tie Life 14-inch plates (years)	16-inch plates (years)	Improvement for 16-inch plates (years)	(percent)
286K unit	45	0	0	Hardwood	29	37	8	28
286K unit	50	0	0	Hardwood	28	37	9	32
286K unit	60	0	0	Hardwood	26	37	11	42
286K unit	25	4	4.5	Hardwood	20	23	3	15
286K unit	35	4	4.5	Hardwood	20	23	3	15
286K unit	45	4	4.5	Hardwood	19	23	4	21
286K unit	45	0	0	Softwood	17	26	9	53
286K unit	50	0	0	Softwood	16	26	10	63
286K unit	60	0	0	Softwood	15	26	11	73
286K unit	25	4	4.5	Softwood	12	12	0	0
286K unit	35	4	4.5	Softwood	11	12	1	9
286K unit	45	4	4.5	Softwood	10	12	2	20

Figure 2 shows the predicted tie plate service life for each case in the parametric study. Note that the larger 16-inch tie plates suppress lateral force related failures in the model. Thus, environmental failure modes dominate. This is why train speed has no effect on tie life for 16-inch plates shown in the figure.

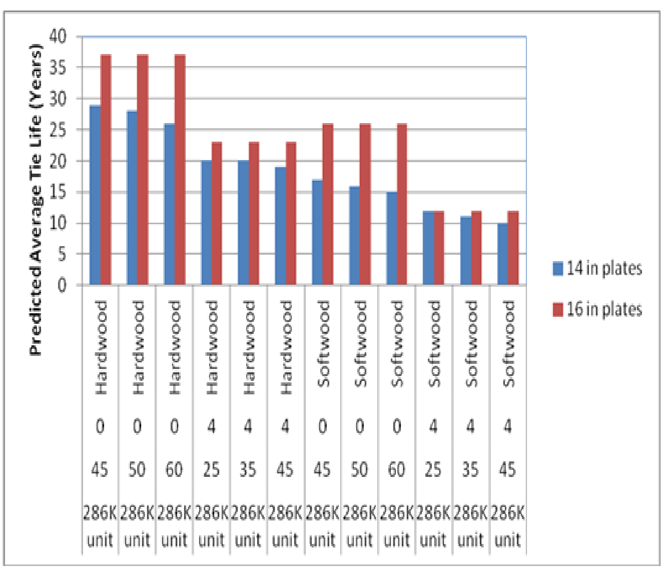

Figure 2. Predicted Tie Life vs. Tie Plate Size

Additional Experiments

Experiments on rail performance, insulated joints, and ballast are in the planning stage. The rail performance experiment will supplement the tests at the eastern and western mega sites with similar premium rails on 5- and 6-degree curves. Cold climate effects may include larger variations in friction levels. The insulated joint test will evaluate the effects of cold climate on premium designs. These effects are expected to include large variations in dynamic loading. The ballast/subgrade test will evaluate the ability of track foundations to perform over expansive soils.

SUMMARY

A northern mega site has been established by CN for documenting the effects of cold climate on the performance of trains and infrastructure under HAL traffic. The selected site is on the Rivers Subdivision of CN near Winnipeg, Manitoba, Canada. The line carries about 70 MGT/year of mixed freight, intermodal, and unit trains.

One experiment is underway in 2013. The rail flaw growth experiment will document the performance of transverse railhead flaws left in track to grow with time and tonnage.

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