NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

January 20, 2015

MATERIALS LABORATORY FACTUAL REPORT — Report No. 15-007

A. ACCIDENT INFORMATION

Place	:	Lynchburg, Virginia
Date	:	April 30, 2014
Vehicle	:	CSX train KO8227
NTSB No.	:	DCA14FR008
Investigator	:	Richard Hipskind, RPH-10

B. COMPONENTS EXAMINED

Rail pieces 10N, 11N, 12N, 13N, 14N-A, 1S-B, and a joint bar piece.

C. DETAILS OF THE EXAMINATION

The pieces examined for this report were located within a right-hand curve (in the eastbound direction of travel) in the vicinity of the point of derailment (POD). The track timetable orientation was east-west, and the train that derailed was traveling eastbound. For this report, all compass orientations will be referenced to the timetable direction.

Pieces were examined from the north rail (high rail, or outside of the curve) and the south rail (low rail, or inside of the curve). Mating fractures were identified on the recovered rail and joint bar pieces, and the broken rail was reconstructed on-scene as shown in figures 1 and 2 by placing mating fractures in close proximity to each other. The reconstructed pieces from the north and south rail were independently numbered from west to east, and a suffix N or S was added to the number to indicate the north or south rail, respectively.

Rail brands and heat stamps were used in the reconstruction of the recovered rail pieces to help identify mating fractures and identify missing segments. In addition, distances between rail features such as joint bar holes and signal pins were compared to rail inspection data to quantify the length of missing pieces. A field weld with bolt holes at either side of the weld was present at the location of the fracture between pieces 7N and 8N, and a service fracture with applied joint bars was located between pieces 11N and 12N. Based on the distance between these features as measured from records of the last rail inspection, an approximately 1-foot length of rail was missing between pieces 8N and 10N. No pieces were missing from the south rail in the reconstruction from the west torch cut end until a location east of the POD.

After work on scene was completed, pieces 14N and 1S were cut at the locations shown in figure 1. Then pieces 10N, 11N, 12N, 13N, the segment of 14N west of the cut (labeled 14N-A), the segment of 1S east of the cut (piece labeled 1S-B), and the joint bar piece that mated to the piece attached to 12N were shipped to the NTSB Materials Laboratory for further examination.

Group examinations of the rail pieces at the NTSB Materials Laboratory were conducted on June 26, 2014, and again on September 10 and 11, 2014. Participants in the group examination included representatives from CSX Transportation and the Federal Railroad Administration.

Rail identification marks were observed on the segment of the north rail that was comprised of pieces 10N, 11N, 12N, and 13N. The brand and heat stamp for these pieces was “132 RE VT NIPPON STEEL 1990 I” and “DH37 T59569 V1B,” respectively. Piece 8N also had the same brand, but no heat stamp markings were observed within the length of the piece.

During the on-scene work and first group examination, wheel contact marks were identified on the low rail in the vicinity of the POD as shown in figures 3 and 4. At a location 101.5 inches west of the fracture in piece 1S-B, the flow lip at the gage corner was deformed (see arrow in figure 3). Further east on piece 1S-B, wheel marks were observed angled across the running surface to the gage corner (see arrows in figure 4). The wheel marks intersected the gage corner in piece 1S-B approximately 63 inches and 75 inches west of the fracture, respectively. Another angled wheel mark was observed intersecting the gage corner at a location 37 inches west of the fracture. Center spalling was observed on the running surface on piece 1S-B and appeared most prominent in the vicinity of the deformed flow lip.

A visual examination of fracture surfaces was completed on-scene and during the group examination. On the south rail, the fracture between 1S and 2S had uniform rough features on the fracture faces consistent with overstress fracture. On the north rail, the fracture at the west end of piece 10N and the fracture between 10N and 11N also showed uniform rough features on the fracture faces consistent with overstress fracture. No evidence of end batter was observed on these fractures in the north and south rails.

Views of the east and west faces of the fracture between pieces 11N and 12N (barred service failure) are shown in figure 5. A dashed line in figure 5 indicates the boundary of a detail fracture observed on the fracture surface. The detail fracture extended across approximately 5 percent of the remaining head area. Slight flow of the running surface over the fracture face was observed on the west face of the fracture. The area of the detail fracture on the east face (on piece 12N) was partially obliterated by receiving batter.

The joint bar on the field side of piece 12N was separated from piece 11N, and the west end of the field joint bar was bent toward the gage direction relative to the centerline of the rail. The joint bar on the gage side of piece 12N was fractured near the middle the span. The west face of the joint bar fracture (mating side of the fracture face shown in figure 5) is shown in figure 6. Smooth fracture features with a dark oxide and a curving boundary were observed consistent with fatigue cracking. The fatigue features emanated from an origin at the upper side of the joint bar (see the bracket in figure 6) where it contacted the underside of the rail head. A dashed line in figure 6 indicates the extent of fatigue crack propagation to a depth of approximately 0.16 inch from the upper surface of the joint bar.

Views of the fracture between pieces 12N and 13N are shown in figure 7. A reverse detail fracture was observed at the lower corner on the gage side of the head. Dashed lines in figure 7 indicate the extent of propagation of the reverse detail fracture, and arrows indicate the origin located at a flow lip at the lower corner of the head. An oblique view of the fracture showing the underside of the head and the flow lip is shown in the lower left image in figure 7. The reverse detail fracture extended across approximately 3 percent of the remaining head area. On the west side of the fracture, flow was observed at the running surface consistent with leaving batter. On the east side of the fracture, the lower corner on the gage side showed post fracture damage, and material at the running surface was deformed over the fracture surface. Sliding contact marks were observed on the running surface at the west end of piece 13N consistent with contact with sliding equipment.

Views of the fracture between pieces 13N and 14N are shown in figure 8. The fracture occurred adjacent to the field weld east of the weld. A detail fracture was observed covering approximately 26 percent of the remaining head area. Dashed lines in figure 8 indicate the extent of propagation of the detail fracture. No rail end batter was observed on either of the fracture faces.

Transverse cuts were made through rail the rail near the west end of 12N and the east end of 14N to reveal the existing cross-section of the rail. Views of the cross-sections at the cut locations are shown in figure 9. Black lines in figure 9 show the outline of a new 132-pound rail cross-section for comparison. The percent remaining head area was calculated by measuring the area of the remaining head relative to the head area of the new rail profile in the images shown in figure 9. The remaining head area for both the 12N and 14N samples was 78 percent of the new head area.

The rail height and head width was measured on the two cross-sections shown in figure 9. The pieces were placed on a granite table, and the rail heights were measured with a vernier caliper at the rail centerline. The rail heights were 6.681 inches and 6.710 inches for the pieces from 12N and 14N, respectively. The head width on each piece was measured with a vernier caliper at a location approximately 5/8 inch below the running surface. The head widths were 2.680 inches and 2.770 inches for pieces from 12N and 14N, respectively.

Results of the rail measurements were compared to the dimensions of a new 132-pound rail to determine the extent of vertical and side wear. The vertical wear was

0.44 inch and 0.42 inch for the pieces from 12N and 14N, respectively. The side wear was 0.32 inch and 0.23 inch for the pieces from 12N and 14N, respectively. According to the track owner's maintenance of way instructions for main line track, 132-pound RE rail is to be scheduled for replacement when the vertical wear reaches 0.438 inch (7/16 inch) or when the side wear reaches 0.625 inch (5/8 inch).

Cross-secitons of the rail head from pieces 12N and 14N were polished and then etched using 2 percent nital.[1] Overall views of the as-polished cross-sections are shown in the lower images in figures 10 and 11, and closer views of the gage corner after etching are shown in the upper images. As indicated with arrows in figures 10 and 11, cracks consistent with head checking, a form of rolling contact fatigue damage, were observed in the gage corner of each of the cross-sections.

The rail heads from pieces 12N and 14N showed fully pearlitic microstructures in both polished and etched cross-sections. A micrograph from head piece 12N showing features typical of the two etched cross-sections is shown in figure 12.

Hardness measurements were conducted on the rail head samples from pieces 12N and 14N using a Rockwell hardness tester. According to a diagram provided by the rail manufacturer, hardness properties of a new 132-pound rail head manufactured in 1990 were determined from indents at 5 locations around the rail head. Three of the 5 indent locations were in areas that were worn away on the accident rail. The remaining two indent locations were 0.87 inch below the top of a new rail head and 0.55 inch away from each side. Hardness tests were conducted on 12N and 14N at these two remaining available indent locations. Hardness of 12N was 38.3 HRC and 36.6 HRC at the indent locations on the gage side and field side of the head, respectively, resulting in an average of 37.5 HRC from the two measurements. Hardness of 14N was 35.6 HRC and 36.3 HRC at the locations on the gage and field sides of the head, respectively, resulting in an average of 36.0 HRC from the two measurements.

The rail manufacturer provided typical hardness values for 132-pound DH370 deep head hardened rail measured at the 5 locations around the head profile. Hardness values measured on pieces 12N and 14N were within the range of typical values provided by the manufacturer.

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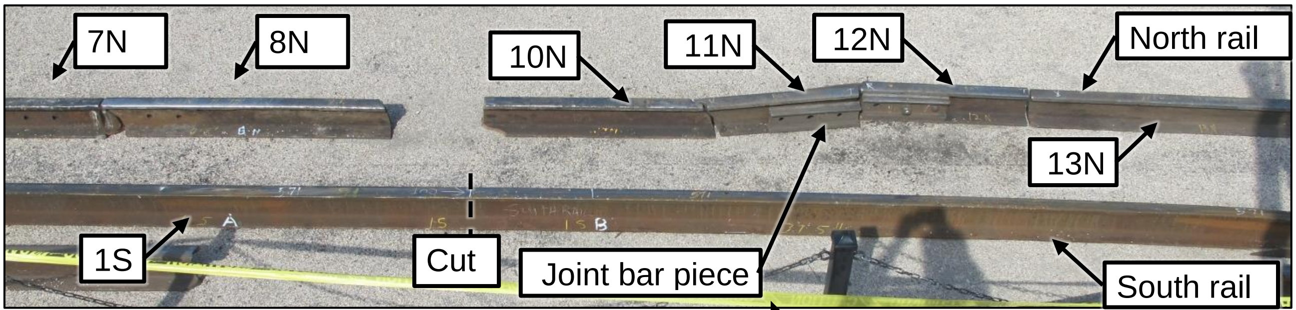
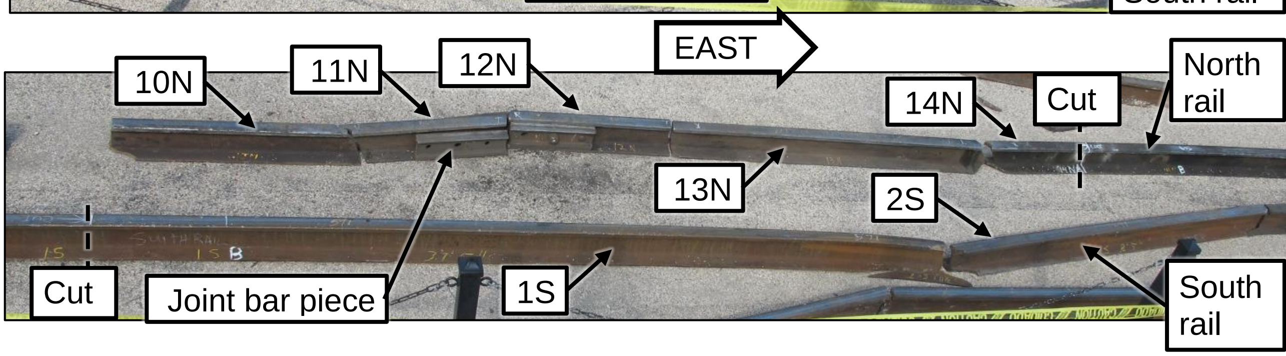
Senior Materials Engineer

[1] Two percent nital is a mixture of two percent by volume nitric acid in methanol used to reveal microstructural features in steel.





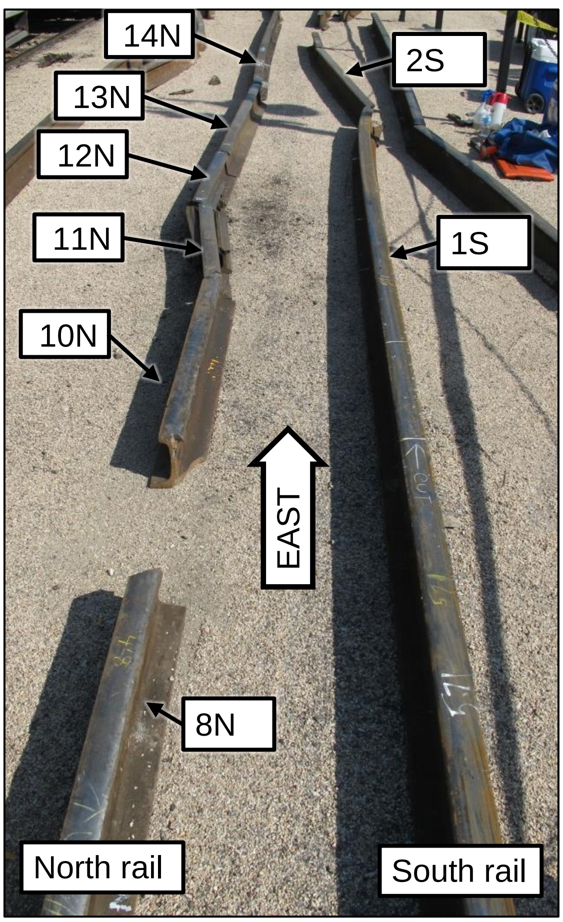


Figure 1. Overall views of the rail reconstruction at the point of derailment.

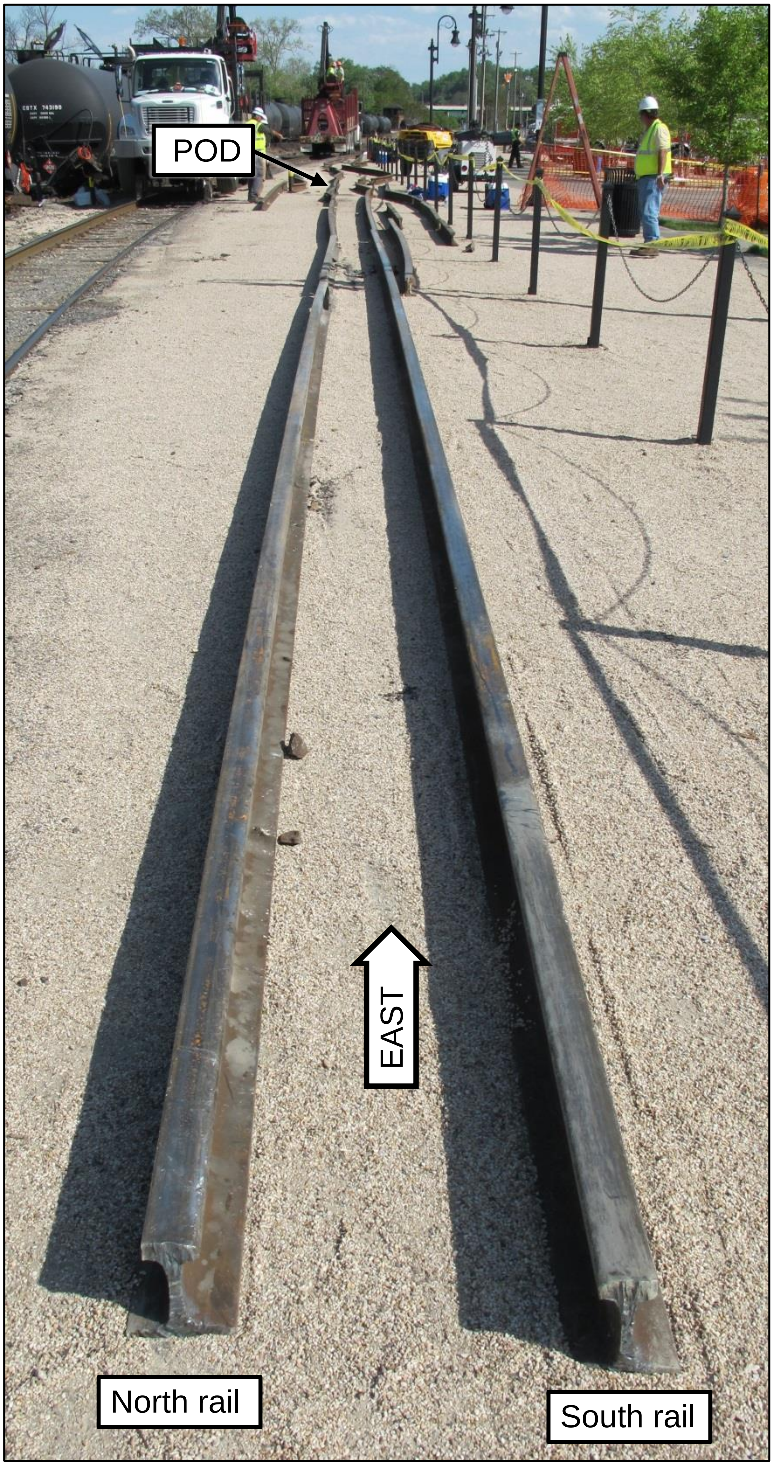


Figure 2. Another view of the rail reconstruction as viewed from torch-cut ends at the west end where the rails were cut from intact track.

Figure 3. Gage side of the low rail showing a disturbance of the flow lip at the gage corner of the head as indicated with an arrow.

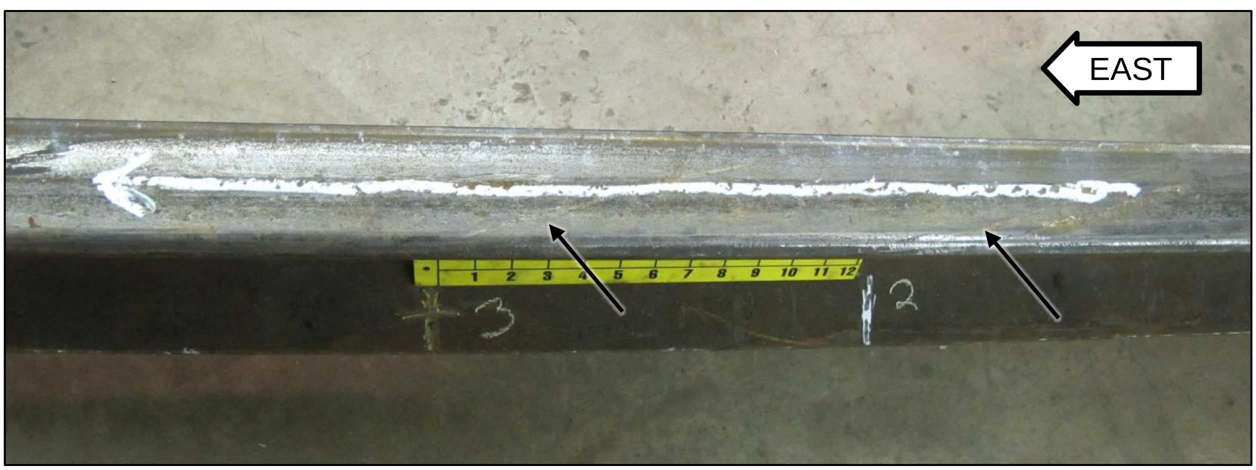


Figure 4. View of the head of the low rail showing wheel marks going across the head to the gage corner (indicated with arrows).

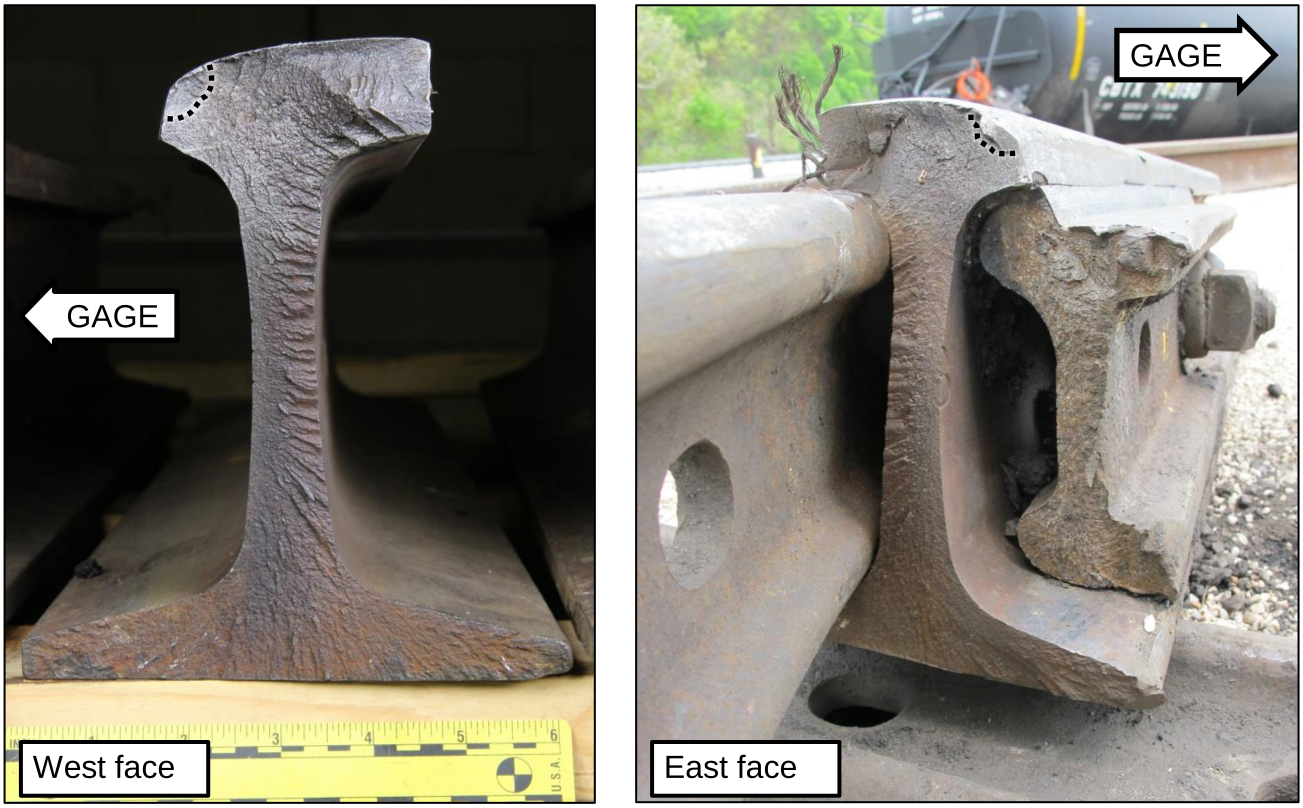
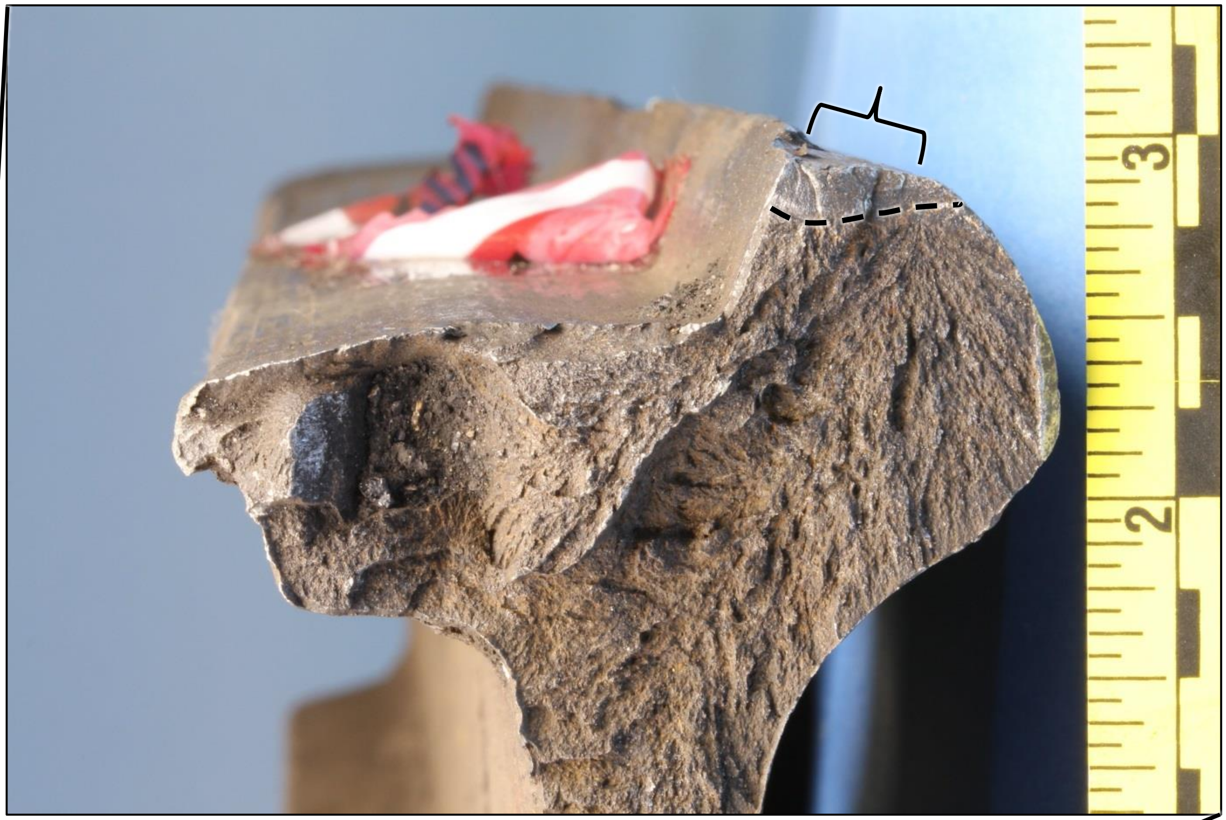


Figure 5. Overall views of the barred serivce failure. The south joint bar (on the gage side of the rail) was fractured, and bolts attaching the joint bars to piece 11N were missing. Dashed lines indicate the boundary of a detail fracture on the fracture surface.



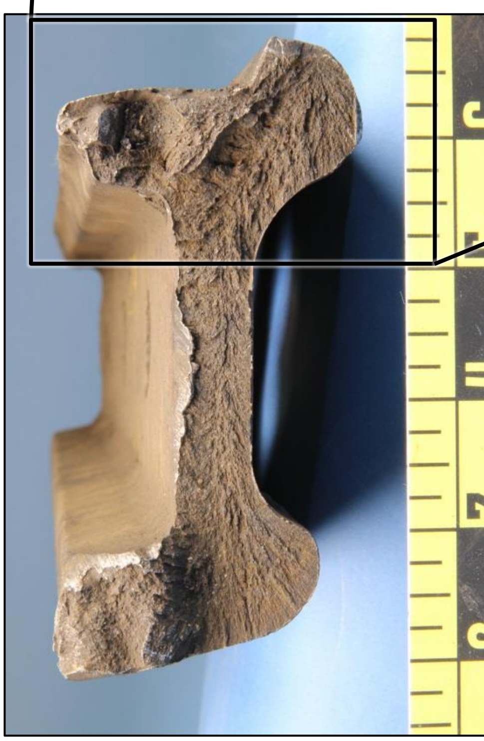
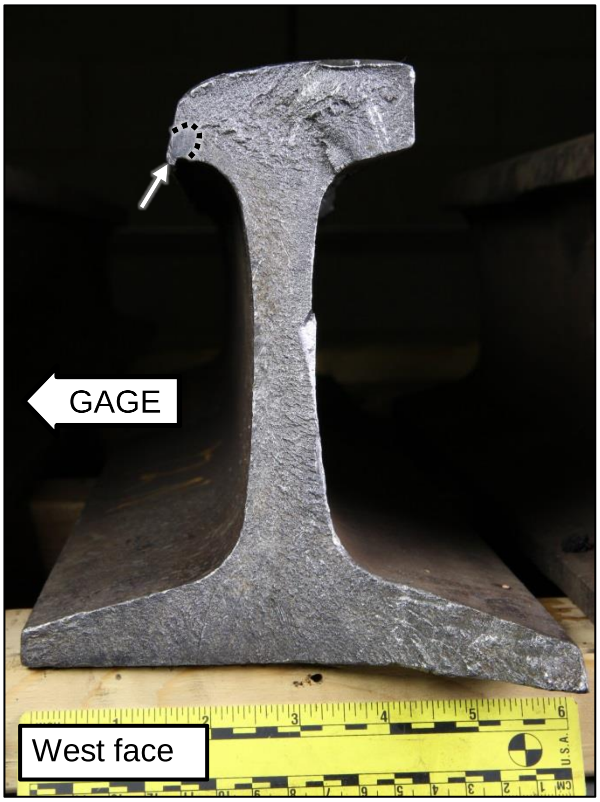
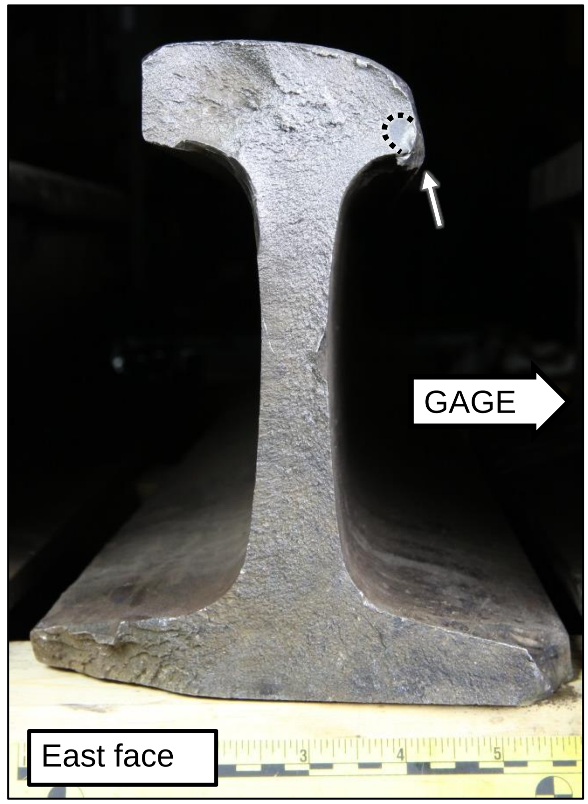


Figure 6. Views of the fracture surface on the south joint bar showing the west side of the fracture. A bracket in the upper image indicates the fatigue origin area, and a dashed line indicates the fatigue boundary.





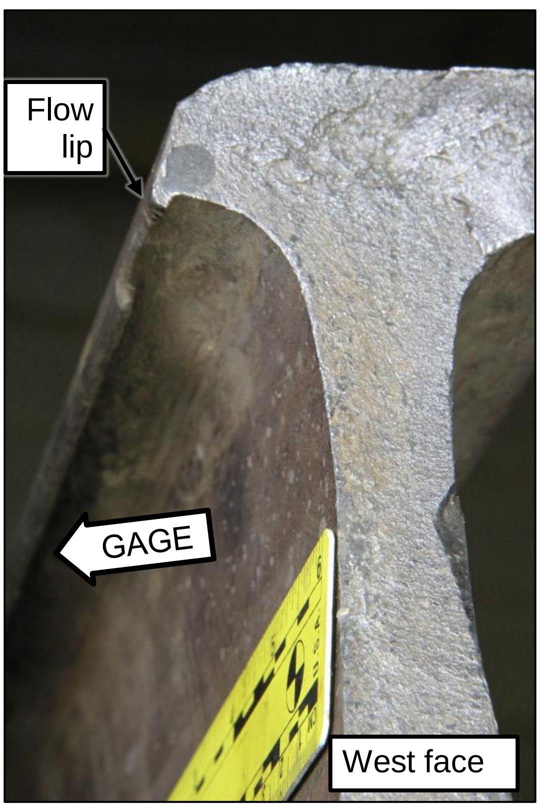


Figure 7. Views of the fracture between pieces 12N and 13N showing the east and west mating surfaces and an oblique view of the west surface. In the upper images, arrows point to the origin of the reverse detail defect, and dashed lines indicated the boundary.

Figure 8. Views of the east and west faces of the fracture between pieces 13N and 14N. A dashed line indicates the boundary of the detail fracture.

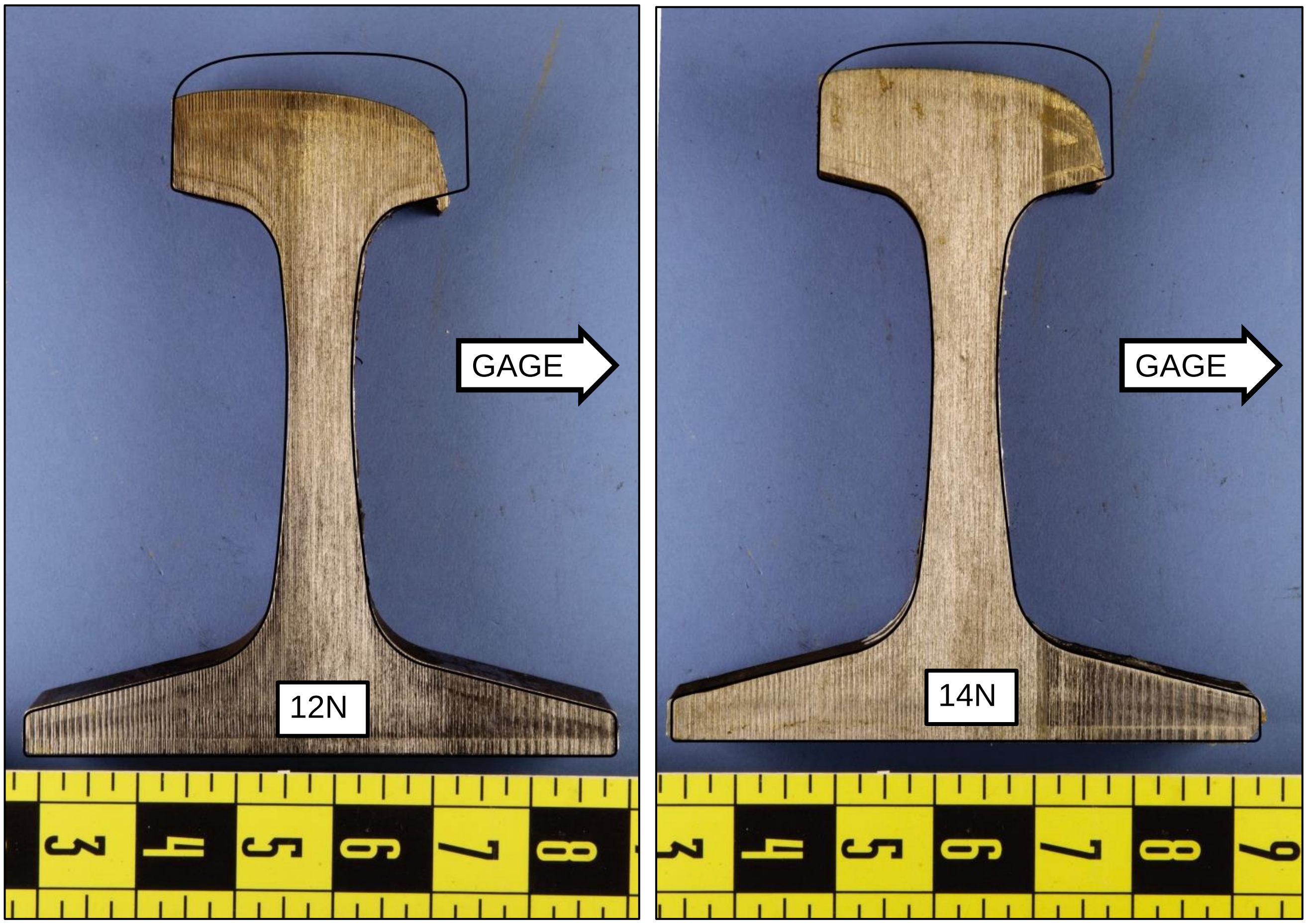
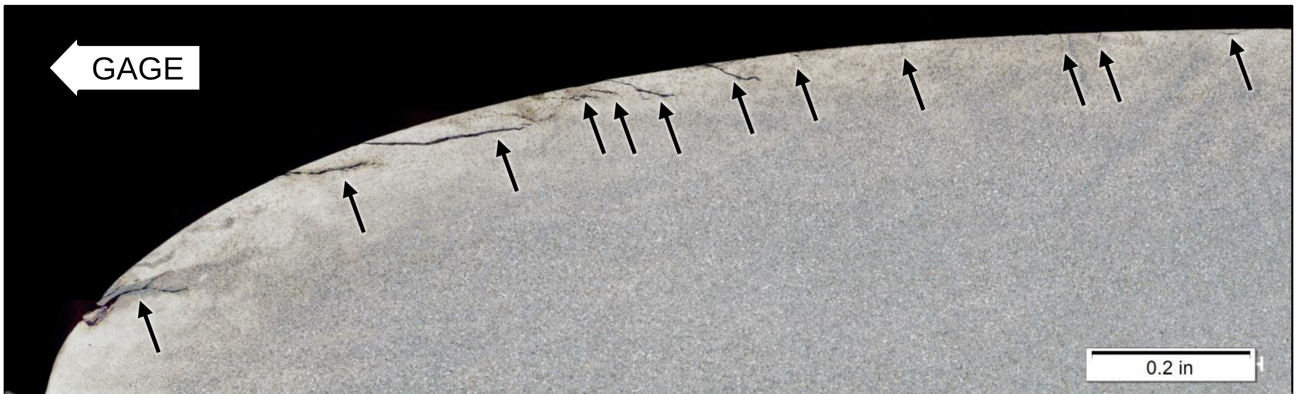


Figure 9. Cross-sections through pieces 12N and 14N. A black outline in each image shows the profile of a new 132-pound rail for reference.



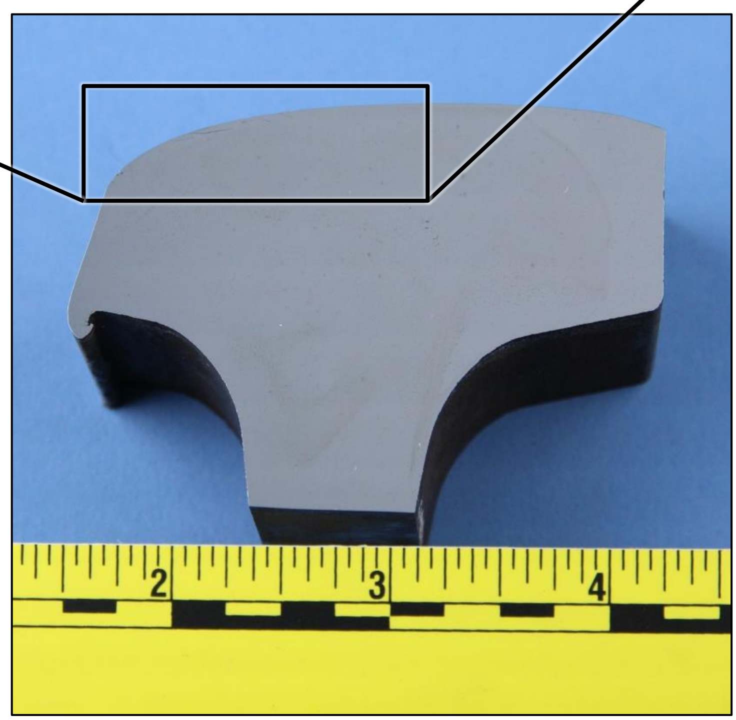
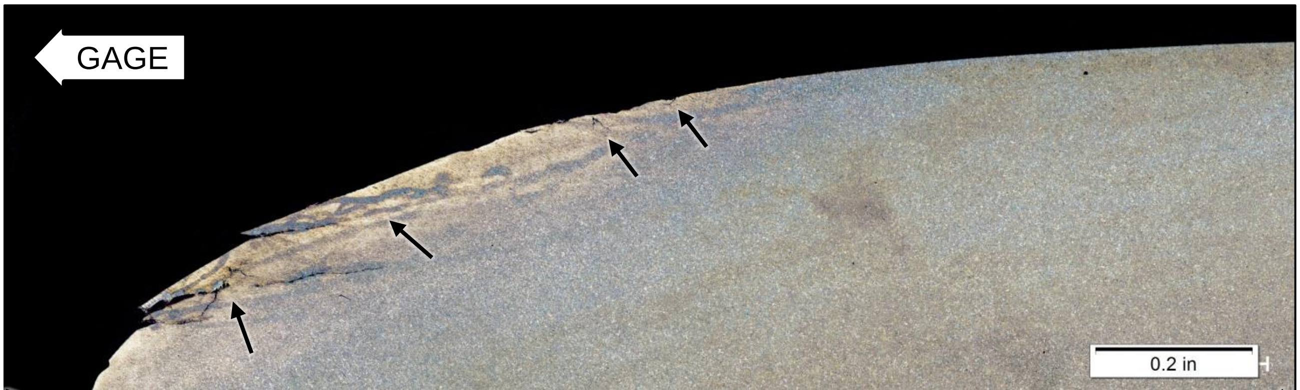


Figure 10. Overall view of as-polished cross-section of the rail head from piece 12N (image to the right) with a closer view of the gage corner after etching with nital (upper image). Head checks (cracks) at the gage corner are indicated with arrows.



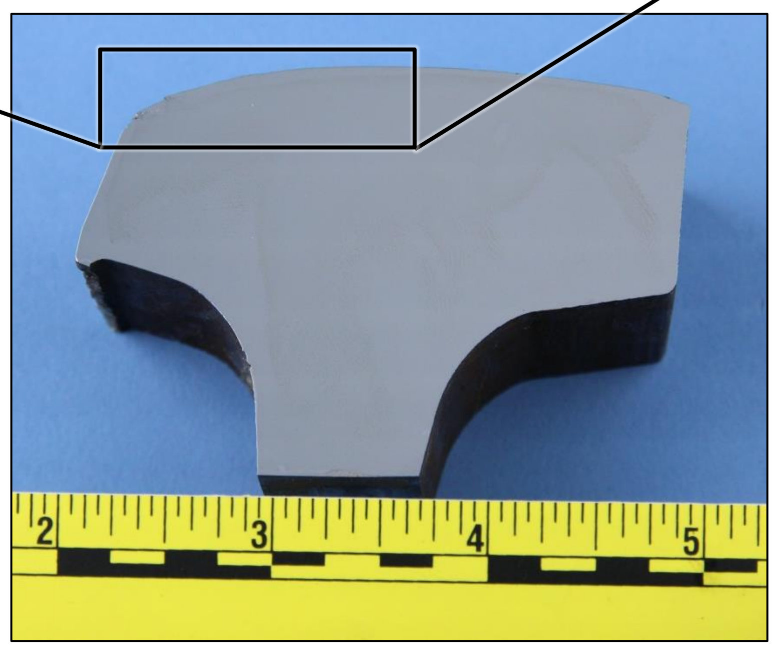


Figure 11. Overall view of as-polished cross-section of the rail head from piece 14N (image to the right) with a closer view of the gage corner after etching with nital (upper image). Head checks (cracks) at the gage corner are indicated with arrows.

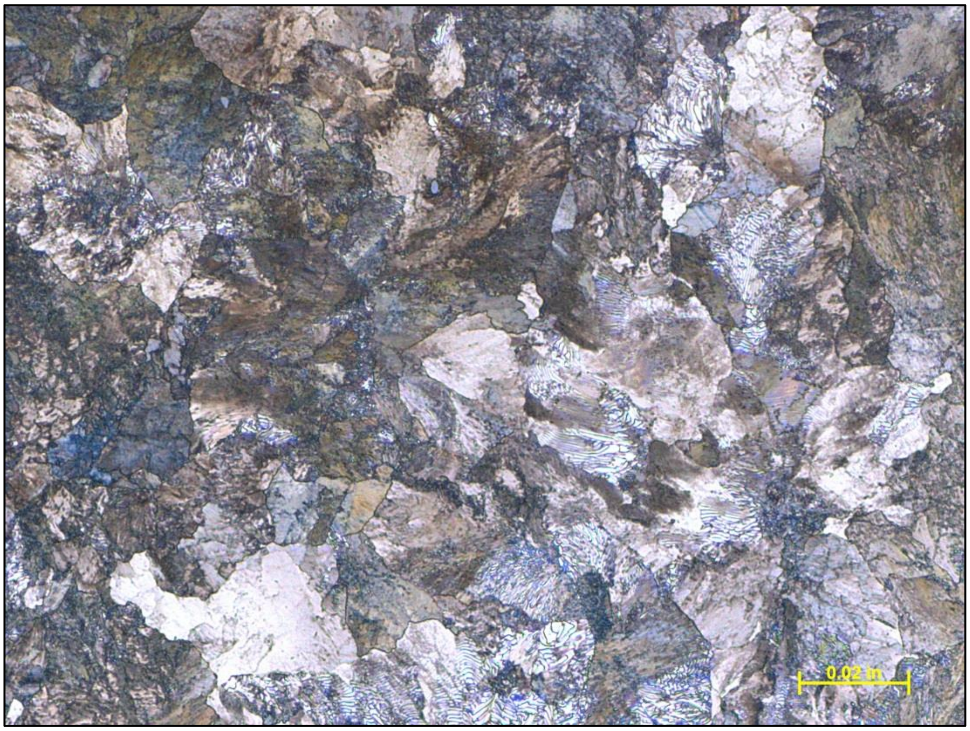


Figure 12. Micrograph from the polished and etched cross-section through the head of piece 12N showing a pearlite microstructure (nital etchant).