§213.113 Defective rails

(a) When an owner of track to which this part applies learns, through inspection or otherwise, that a rail in that track contains any of the defects listed in the following table, a person designated under §213.7 shall determine whether or not the track may continue in use. If he determines that the track may continue in use, operation over the defective rail is not permitted until --

(1) The rail is replaced; or
(2) The remedial action prescribed in the table is initiated.

REMEDIAL ACTION					
Defect	Length of defect (inch)		Percent of rail head cross-sectional area weakened by defect		If defective rail is not replaced, take the remedial action prescribed in note
	More than	But not more than	Less than	But not less than	
Transverse fissure Compound fissure			70	5	B
			100	70	A2
				100	A
Detail fracture Engine burn fracture Defective weld			25	5	C
			80	25	D
			100	80	[A2] or [E and H]
				100	[A] or [E and H]
Horizontal split head Vertical split head Split web Piped rail Head web separation	1	2			H and F
	2	4			I and G
	4				B
	(1)	(1)	(1)		A
Bolt hole crack	1/2	1			H and F
	1	1-1/2			H and G
	1-1/2				B
	(1)	(1)	(1)		A
Broken Base	1	6			D
	6				[A] or [E and I]
Ordinary break					A or E
Damaged rail					D
Flattened rail	Depth ≥ 3/8 and Length ≥ 8				H

([1]) Break out in rail head.

Notes:

A. Assign person designated under §213.7 to visually supervise each operation over defective rail.

A2. Assign person designated under §213.7 to make visual inspection. After a visual inspection, that person may authorize operation to continue without continuous visual supervision at a maximum of 10 m.p.h. for up to 24 hours prior to another such visual inspection or replacement or repair of the rail.

B. Limit operating speed over defective rail to that as authorized by a person designated under §213.7(a), who has at least one year of supervisory experience in railroad track maintenance. The operating speed cannot be over 30 m.p.h. or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower.

C. Apply joint bars bolted only through the outermost holes to defect within 20 days after it is determined to continue the track in use. In the case of Classes 3 through 5 track, limit operating speed over defective rail to 30 m.p.h. until joint bars are applied; thereafter, limit speed to 50 m.p.h. or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower. When a search for internal rail defects is conducted under §213.237, and defects are discovered in Classes 3 through 5 which require remedial action C, the operating speed shall be limited to 50 m.p.h., or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower, for a period not to exceed 4 days. If the defective rail has not been removed from the track or a permanent repair made within 4 days of the discovery, limit operating speed over the defective rail to 30 m.p.h. until joint bars are applied; thereafter, limit speed to 50 m.p.h. or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower.

D. Apply joint bars bolted only through the outermost holes to defect within 10 days after it is determined to continue the track in use. In the case of Classes 3 through 5 track, limit operating speed over the defective rail to 30 m.p.h. or less as authorized by a person designated under §213.7(a), who has at least one year of supervisory experience in railroad track maintenance, until joint bars are applied; thereafter, limit speed to 50 m.p.h. or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower.

E. Apply joint bars to defect and bolt in accordance with §213.121(d) and (e).

F. Inspect rail 90 days after it is determined to continue the track in use.

G. Inspect rail 30 days after it is determined to continue the track in use.

H. Limit operating speed over defective rail to 50 m.p.h. or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower.

I. Limit operating speed over defective rail to 30 m.p.h. or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower.

(b) As used in this section --

(1) *Transverse Fissure* means a progressive crosswise fracture starting from a crystalline center or nucleus inside the head from which it spreads outward as a smooth, bright, or dark, round or oval surface substantially at a right angle to the length of the rail. The distinguishing features of a transverse fissure from other types of fractures or defects are the crystalline center or nucleus and the nearly smooth surface of the development which surrounds it.

(2) *Compound Fissure* means a progressive fracture originating in a horizontal split head which turns up or down in the head of the rail as a smooth, bright, or dark surface progressing until substantially at a right angle to the length of the rail. Compound fissures require examination of both faces of the fracture to locate the horizontal split head from which they originate.

(3) *Horizontal Split Head* means a horizontal progressive defect originating inside of the rail head, usually one-quarter inch or more below the running surface and progressing horizontally in all directions, and generally accompanied by a flat spot on the running surface. The defect appears as a crack lengthwise of the rail when it reaches the side of the rail head.

(4) *Vertical Split Head* means a vertical split through or near the middle of the head, and extending into or through it. A crack or rust streak may show under the head close to the web or pieces may be split off the side of the head.

(5) *Split Web* means a lengthwise crack along the side of the web and extending into or through it.

(6) *Piped Rail* means a vertical split in a rail, usually in the web, due to failure of the shrinkage cavity in the ingot to unite in rolling.

(7) *Broken Base* means any break in the base of the rail.

(8) *Detail Fracture* means a progressive fracture originating at or near the surface of the rail head. These fractures should not be confused with transverse fissures, compound fissures, or other defects which have internal origins. Detail fractures may arise from shelly spots, head checks, or flaking.

(9) *Engine Burn Fracture* means a progressive fracture originating in spots where driving wheels have slipped on top of the rail head. In developing downward they frequently resemble the compound or even transverse fissures with which they should not be confused or classified.

(10) *Ordinary Break* means a partial or complete break in which there is no sign of a fissure, and in which none of the other defects described in this paragraph (b) are found.

(11) *Damaged Rail* means any rail broken or injured by wrecks, broken, flat, or unbalanced wheels, slipping, or similar causes.

(12) *Flattened Rail* means a short length of rail, not at a joint, which has flattened out across the width of the rail head to a depth of 3/8 inch or more below the rest of the rail. Flattened rail occurrences have no repetitive regularity and thus do not include corrugations, and have no apparent localized cause such as a weld or engine burn. Their individual length is relatively short, as compared to a condition such as head flow on the low rail of curves.

(13) *Bolt Hole Crack* means a crack across the web, originating from a bolt hole, and progressing on a path either inclined upward toward the rail head or inclined downward toward the base. Fully developed bolt hole cracks may continue horizontally along the head/web or base/web fillet, or they may progress into and through the head or base to separate a piece of the rail end from the rail. Multiple cracks occurring in one rail end are considered to be a single defect. However, bolt hole cracks occurring in adjacent rail ends within the same joint must be reported as separate defects.

(14) *Defective Weld* means a field or plant weld containing any discontinuities or pockets, exceeding 5 percent of the rail head area individually or 10 percent in the aggregate, oriented in or near the transverse plane, due to incomplete penetration of the weld metal between the rail ends, lack of fusion between weld and rail end metal,

entrainment of slag or sand, under-bead or other shrinkage cracking, or fatigue cracking. Weld defects may originate in the rail head, web, or base, and in some cases, cracks may progress from the defect into either or both adjoining rail ends.

(15) *Head and Web Separation* means a progressive fracture, longitudinally separating the head from the web of the rail at the head fillet area.

Application

The remedial actions required for defective rails specify definite time limits and speeds, and allow certain discretion to the track owner for the continued operation over a defect. All rail defects should be considered dangerous by the Inspector and care should be taken to determine that proper remedial action has been undertaken by the railroad. When more than one defect is present in a rail, the defect requiring the most restrictive remedial action shall govern.

The remedial action table and specifications in the rule address the risks associated with rail failure. These risks are primarily dependent upon defect type and size and should not be dependent upon the manner or mechanism that reveals the existence of the defect. Failure of the track owner to comply with the operational (speed) restrictions, maintenance procedures and the prescribed inspection intervals specified in §213.113 and §213.237 (defective rails and inspection of rail, respectively), may constitute a violation of the TSS.

Note “A2” addresses mid-range transverse defect sizes. This remedial action allows for train operations to continue at a maximum of 10-m.p.h. up to 24 hours, following a visual inspection by a person designated under §213.7. If the rail is not replaced, another 24-hour cycle begins.

Note "B" limits speed to that as authorized by a person designated under §213.7(a) who has at least one year of supervisory experience in track maintenance. The qualified person has the responsibility to evaluate the rail defect and authorize the maximum operating speed over the defective rail based on the size of the defect and the operating conditions; however, the maximum speed over the rail may not exceed 30 m.p.h or the maximum speed under §213.9. for the class of track concerned, whichever is lower. Notes "C," "D," and "H" limit the operating speed, following the application of joint bars, to 50 m.p.h. or the maximum allowable speed, under §213.9 for the class of track concerned, whichever is lower. When the maximum speed specified in notes "B", "C", "D", and "H" exceeds the current track speed, the railroad is required to record the defect. For example, when a railroad determines that remedial action "B" is required and the track speed already is 30 m.p.h. or less, the railroad must record the defect. This indicates that the railroad is aware of the

characteristics of the defective rail and has authorized a maximum speed over the rail.

When an FRA inspector discovers a defective rail that requires the railroad representative to determine whether to continue the track in use and to authorize the maximum speed over the rail, the inspector should inquire as to the representative's knowledge of the defect and remedial action. If the railroad was not aware of the defect prior to the FRA inspection, the FRA Inspector should observe the actions taken by the railroad representative to determine compliance. If the railroad had previously found the defective rail, the FRA inspector should confirm that the proper remedial action. During records inspections, the FRA inspector should confirm that the defects were recorded and proper remedial action taken.

The remedial action table for defects failing in the transverse plane (transverse and compound fissures, detail and engine burn fractures, and defective welds) specifies a lower limit range base of five percent of the railhead cross sectional area. If a transverse defect is reported to be less than five percent, the track owner is not legally bound to correct and no remedial action would be required under the TSS. Defects reported less than five percent are not consistently found during rail breaking routines and therefore, defect determination within this range is not always reliable.

Transverse and compound fissure defects, weakened between five and 70 percent of cross-sectional head area, require remedial action (note B), as indicated by the prescribed notes. Defects in the range between 70 and less than 100 percent of cross-sectional head area, require remedial action (note A2), as prescribed. Defects that affect 100 percent of the cross-sectional head area, require remedial action (note A) as prescribed, the most restrictive. Inspectors should be aware that transverse and compound fissures are defects that fail in the transverse plane and are characteristic of rail that has not been control-cooled (normally rolled prior to 1936).

Defects identified and grouped as detail fracture, engine burn fracture, and defective welds, will weaken and also fail in the transverse plane. Detail fractures also fail in the transverse plane and are characteristic of control-cooled rail [usually indicated by the letters CC or CH on the rail brand (i.e., 1360 RE CC CF&I 1982 1111)]. Their prescribed remedial action relates to a low range between 5 and 25 percent and a mid-range between 25 and 80 percent, for note (C) and note (D), respectively. Those defects require joint bar applications and operational speed restrictions within certain time frames. Defects extending less than 100 and between 80 percent require a visual inspection, an elective to restrict operation to a maximum of 10 m.p.h. for up to

24 hours, then another visual inspection, if the rail is not replaced, effectively repaired or the track removed from service.

The second paragraph in remedial action note (C) addresses defects which are discovered in Classes 3 through 5 track during an internal rail inspection required under §213.237, and which are determined not to be in excess of 25 percent of the rail head cross-sectional area. For these specific defects, a track owner may operate for a period not to exceed four days, at a speed limited to 50 m.p.h. or the maximum allowable speed under §213.9 for the class of track concerned, whichever is lower. If the defective rail is not removed or a permanent repair made within four days of discovery, the speed is limited to 30 m.p.h., until joint bars are applied or the rail is replaced.

The requirements specified in this second paragraph are intended to promote better utilization of rail inspection equipment and therefore maximize the opportunity to discover rail defects which are approaching service failure size. The results of the FRA's research indicates that defects of this type and size range have a predictable slow growth life. Research further indicates that even on the most heavily utilized trackage in use today, defects of this type and size are unlikely to grow to service failure size in four days.

In the remedial action table, all longitudinal defects are combined within one group subject to identical remedial actions based on their reported size. These types of longitudinal defects all share similar growth rates and the same remedial actions are appropriate to each type.

Defective rails categorized as Horizontal split head, Vertical split head, Split web, Piped rail, and Head-web separation, are longitudinal in nature. When any of this group of defects is more than 1 inch, but not more than 2 inches, the remedial action initiated, under note (H), is to limit train speed to 50 m.p.h., and note (F) require reinspecting the rail in 90 days, if deciding operations will continue. Defects in the range of more than two inches, but not more than four inches, require complying with notes (I) and (G), speed is limited to 30 m.p.h. and the rail reinspected in 30 days, if they decide operations will continue in service. When any of the five defects exceed a length of four inches, a person designated under §213.7(a) must limit the operating speed to 30 m.p.h., under note (B).

Another form of head-web separation, often referred to as a "fillet cracked rail," is the longitudinal growth of a crack in the fillet area, usually on the gage side of the outer rail of a curve. The crack may not extend the full width between the head and the web, but it is potentially dangerous. Evidence of fillet cracking is a hairline crack running beneath the head of rail with "bleeding" or rust discoloration. Fillet cracks often result from improper superelevation or from

stress reversal as a result of transposing rail. The use of a mirror is an effective aid in examining rail and the determination of head-web cracks or separation in the body of the rail, extending beyond the joint bar.

A "bolt-hole crack" is a progressive fracture originating at a bolt-hole and extending away from the hole, usually at an angle. They develop from high-stress risers, usually initiating as a result of both dynamic and thermal responses of the joint bolt and points along the edge of the hole, under load. A major cause of this high stress is improper field drilling of the hole. Excessive longitudinal rail movement can also cause high stress along the edge of the hole. When evaluating a rail end which has multiple bolt hole cracks, Inspectors will determine the required remedial action based on the length of the longest individual bolt-hole crack.

Under note (H), the remedial action for a bolt-hole crack, more than 1/2-inch but not more than 1-inch, if the rail is not replaced, is to limit speed to 50 m.p.h., or the maximum allowable under §213.9 for the class of track concerned, whichever is lower, then reinspect the rail in 90-days, if operations will continue in service. Cracks discovered greater than 1 inch, but not exceeding 1-1/2 inches, should be reinspected within 30 days and the speed limited to 50 m.p.h. For a bolt-hole crack exceeding 1-1/2 inches, a person qualified under §213.7(a) may elect to designate a speed restriction, but cannot exceed 30 m.p.h., or the maximum allowable under §213.9 for the class of track concerned, whichever is lower.

Under notes (F) and (G), where corrective action requires rail to be reinspected within a specific number of days after discovery, several options for compliance may be exercised depending on the nature of the defect. For those defects which are strictly internal and are not yet visible to the naked eye, the only option would be to perform another inspection with rail flaw detection equipment, either rail-mounted or hand-held. For defects that are visible to the naked eye and therefore measurable, a visual inspection or an inspection with rail flaw detection equipment are acceptable options. For certain defects enclosed within the joint bar area, such as bolt hole cracks and head-web separations, the joint bars must be removed if a visual reinspection is to be made.

The reinspection prescribed in notes (F) and (G) must be performed prior to the expiration of the 30 or 90-day interval. If the rail remains in track and is not replaced, the reinspection cycle starts over with each successive reinspection unless the reinspection reveals the rail defect to have increased in size and has therefore become subject to a more restrictive remedial action. This process continues indefinitely until the rail is removed from track.

- # Where corrective action requires rail to be reinspected within a specific number of days after discovery, the track owner may exercise several options for compliance. One option would be to perform another inspection with rail flaw detection equipment, either rail-mounted or hand-held. Another option would be to perform a visual inspection where the defect is visible and measurable. In the latter case, for certain defects enclosed within the joint bar area such as bolt-hole breaks, removal of the joint bars will be necessary to comply with the reinspection requirement. If defects remain in track beyond the reinspection interval, the railroad must continue to monitor the defect and take the appropriate action as required in the remedial action table.

- # A broken base can result from improper bearing of the base on a track spike or tie plate shoulder, from over-crimped anchors, or it may originate in a manufactured seam. With today's higher axle loads, Inspectors can anticipate broken base defects in 75-pound and smaller rail sections with an irregular track surface, especially on the field side. For any broken base discovered that is more than one inch but less than six inches in length, the remedial action (note D) is to apply joint bars bolted through the outermost holes to defect within 10 days, if operations will continue. In Class 3-5 track, the operating speed must be reduced to 30 m.p.h. or less, as authorized by a person under §213.7(a), until joint bars are applied. After that, operating speed is limited to 50 m.p.h. or the maximum allowable under §213.9 for the class of track concerned, whichever is lower.

  A broken base in excess of six inches requires the assignment of a person designated under §213.7 to visually supervise each train operation over the defective rail. The railroad may apply joint bars to the defect and bolt them in accordance with §213.121(d) and (e) and thereafter must limit train operations to 30 m.p.h. or the maximum allowable under §213.9 for the class of track concerned, whichever is lower. As reference, the dimensions between the outermost holes of a 24-inch joint bar vary between approximately 15 and 18 inches and a 36-inch joint bar approaches 30-inches.

  Inspectors should point out to the track owner that broken bases nearing these dimensions and originating in track, may negate the purpose for which the joint bars are applied. A broken base rail may be caused by damage from external sources, such as rail anchors being driven through the base by a derailed wheel. It is improper to consider them "damaged rail," as this defect is addressed by more stringent provisions applicable to broken base rail, under note (A) or (E) and (I).

- # Damaged rail can result from flat or broken wheels, incidental hammer blows, or derailed or dragging equipment. Reducing the operational speed in Classes 3 through 5 track to 30 m.p.h. until joint bars are applied, lessens the impact force imparted to the weaken area. Applying joint bars under note (D) insures a proper horizontal and vertical rail-end alinement in the event the rail fails.

Flattened rails (localized collapsed head rail) are also caused by mechanical interaction from repetitive wheel loadings. FRA and industry research indicate that these occurrences are more accurately categorized as rail surface conditions, not rail defects, as they do not, in themselves, cause service failure of the rail. Although it is not a condition shown to affect the structural integrity of the rail section, it can result in less-than-desirable dynamic vehicle responses in the higher speed ranges. The flattened rail condition is identified in the table, as well as in the definition portion of §213.113(b), as being 3/8-inch or more in depth below the rest of the railhead and eight inches or more in length. As the defect becomes more severe by reducing rail-head depth and width size, wheel forces increase. If located either on the outside or inside rail, the limited cross-sectional area of the rail may increase the lateral-to-vertical ratio and cause a wheel-lift condition.

The rule addresses the issue of "flattened rail" in terms of a specified remedial action for those of a certain depth and length. Those locations meeting the depth and length criteria shall be limited to an operating speed of 50 m.p.h. or the maximum allowable under §213.9 for the class of track concerned, whichever is lower.

"Break out in rail head" is defined as a piece that has <u>physically</u> separated from the parent rail. Rail defects meeting this definition are required to have each operation over that rail visually supervised by a person designated under §213.7. Inspectors need to be aware that this definition has applicability across a wide range of rail defects, as indicated in the remedial action table. Where rail defects which have not progressed to the point where they meet this strict definition, but due to the type, length and location of the defect present a hazard to continued train operation, Inspectors should determine what remedial actions, if any, are to be instituted by the track owner.

The issue of "excessive rail wear" continues to be evaluated by the FRA's rail integrity research program. The FRA believes that insufficient data exists at this time to indicate that parameters for this condition should be proposed as a minimum standard.

The Sperry Rail Service prints an excellent reference manual on rail defects. Inspectors are expected to be conversant with rail defect types, appearance, growth, hazards, and methods of detection.

Defect Codes	
113.01	Transverse Fissure
113.02	Compound Fissure
113.03	Horizontal Split Head
113.04	Vertical Split Head
113.05	Split Web
113.06	Piped Rail
113.07	Bolt-Hole Crack
113.08	Head Web Separation
113.09	Broken Base
113.10	Detail Fracture
113.11	Engine Burn Fracture
113.12	Ordinary Break
113.13	Broken or Defective Weld
113.14	Damaged Rail
113.15	Flattened Rail

§213.115 Rail end mismatch

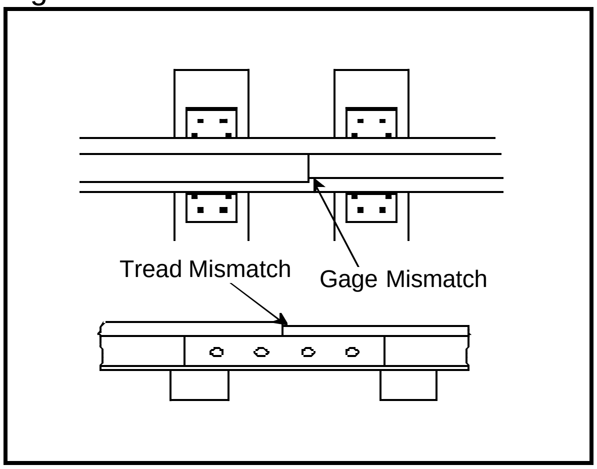
Any mismatch of rails at joints may not be more than that prescribed by the following table --

Class of track	Any mismatch of rails at joints may not be more than the following	
	On the tread of the rail ends (inch)	On the gage side of the rail ends (inch)
1	1/4	1/4
2	1/4	3/16
3	3/16	3/16
4 and 5	1/8	1/8

Application

Measure when track bolts are tight. If bolts are not tight, report the condition as loose joint bars, under §213.121.08. Use a straight-edge to measure the distance between each rail ends. Do not bridge the two rail-ends, but hold the straight-edge longitudinally along the higher rail (tread) or along the gage-side (5/8-inch down from the running surface) of the rail. Measure the distance directly between the two rails. Disregard plastic overflow (gage-side rail edge lipping), if any.

Figure 5-21



A mismatch may result in high impact forces especially at higher speeds. If a mismatch in excess of the allowable results in significant rail end damage, a violation should be considered.

Particular attention should be given to the mismatch on the gage-side of a rail. A thin flange, skewed truck, or combination of both may cause a wheel to climb, particularly on the outer rail of a curve.

Defect Codes	
115.01	Rail-end mismatch on tread of rail exceeds allowable.
115.02	Rail-end mismatch on gage side of rail exceeds allowable.

§213.119 Continuous welded rail (CWR); general

Each track owner with track constructed of CWR shall have in effect and comply with written procedures which address the installation, adjustment, maintenance and inspection of CWR, and a training program for the application of those procedures, which shall be submitted to the Federal Railroad Administration by March 22, 1999. FRA reviews each plan for compliance with the following:

(a) Procedures for the installation and adjustment of CWR which include

(1) Designation of a desired rail installation temperature range for the geographic area in which the CWR is located; and

(2) De-stressing procedures/methods which address proper attainment of the desired rail installation temperature range when adjusting CWR.

(b) Rail anchoring or fastening requirements that will provide sufficient restraint to limit longitudinal rail and crosstie movement to the extent practical, and specifically addressing CWR rail anchoring or fastening patterns on bridges, bridge approaches, and at other locations where possible longitudinal rail and crosstie movement associated with normally expected train-induced forces, is restricted.

(c) Procedures which specifically address maintaining a desired rail installation temperature range when cutting CWR including rail repairs, in-track welding, and in conjunction with adjustments made in the area of tight track, a track buckle, or a pull-apart. Rail repair practices shall take into consideration existing rail temperature so that;

(1) When rail is removed, the length installed shall be determined by taking into consideration the existing rail temperature and the desired rail installation temperature range; and

(2) Under no circumstances should rail be added when the rail temperature is below that designated by paragraph (a)(1) of this section, without provisions for later adjustment.

(d) Procedures which address the monitoring of CWR in curved track for inward shifts of alinement toward the center of the curve as a result of disturbed track.

(e) Procedures which control train speed on CWR track when –

(1) Maintenance work, track rehabilitation, track construction, or any other event occurs which disturbs the roadbed or ballast section and reduces the lateral or longitudinal resistance of the track; and

(2) In formulating the procedures under this paragraph (e), the track owner shall–

(i) Determine the speed required, and the duration and subsequent removal of any speed restriction based on the restoration of the ballast, along with sufficient ballast re-consolidation to stabilize the track to a level that can accommodate expected train-induced forces. Ballast re-consolidation can be achieved through either the passage of train tonnage or mechanical stabilization procedures, or both; and

(ii) Take into consideration the type of crossties used.

(f) Procedures which prescribe when physical track inspections are to be performed to detect buckling prone conditions in CWR track. At a minimum, these procedures shall address inspecting track to identify –

(1) Locations where tight or kinky rail conditions are likely to occur;

(2) Locations where track work of the nature described in paragraph (e)(1) of this section have recently been performed; and

(3) In formulating the procedures under this paragraph (f), the track owner shall –

(i) Specify the timing of the inspection; and

(ii) Specify the appropriate remedial actions to be taken when buckling prone conditions are found.

(g) The track owner shall have in effect a comprehensive training program for the application of these written CWR procedures, with provisions for periodic re-training, for those individuals designated under §213.7 of this part as qualified to supervise the installation, adjustment, and maintenance of CWR track and to perform inspections of CWR track.

(h) The track owner shall prescribe recordkeeping requirements necessary to provide an adequate history of track constructed with CWR. At a minimum, these records must include:

(1) Rail temperature, location and date of CWR installations. This record shall be retained for at least one year; and

(2) A record of any CWR installation or maintenance work that does not conform with the written procedures. Such record shall include the location of the rail and be maintained until the CWR is brought into conformance with such procedures.

(i) As used in this section –

(1) *Adjusting/De-stressing* means the procedure by which a rail's temperature is re-adjusted to the desired value. It typically consists of cutting the rail and removing rail anchoring devices, which provides for the necessary expansion and contraction, and then re-assembling the track.

(2) *Buckling Incident* means the formation of a lateral mis-alinement sufficient in magnitude to constitute a deviation from the Class 1 requirements specified in §213.55 of this part. These normally occur when rail temperatures are relatively high and are caused by high longitudinal compressive forces.

(3) *Continuous Welded Rail (CWR)* means rail that has been welded together into lengths exceeding 400 feet.

(4) *Desired Rail Installation Temperature Range* means the rail temperature range, within a specific geographical area, at which forces in CWR should not cause a buckling incident in extreme heat, or a pull-apart during extreme cold weather.

(5) *Disturbed Track* means the disturbance of the roadbed or ballast section, as a result of track maintenance or any other event, which reduces the lateral or longitudinal resistance of the track, or both.

(6) *Mechanical Stabilization* means a type of procedure used to restore track resistance to disturbed track following certain maintenance operations. This procedure may incorporate dynamic track stabilizers or ballast consolidators, which are units of work equipment that are used as a substitute for the stabilization action provided by the passage of tonnage trains.

(7) *Rail Anchors* means those devices which are attached to the rail and bear against the side of the crosstie to control longitudinal rail movement. Certain types of rail fasteners also act as rail anchors and control longitudinal rail movement by exerting a downward clamping force on the upper surface of the rail base.

(8) *Rail Temperature* means the temperature of the rail, measured with a rail thermometer.

(9) *Tight/Kinky Rail* means CWR which exhibits minute alinement irregularities which indicate that the rail is in a considerable amount of compression.

(10) *Train-induced Forces* means the vertical, longitudinal, and lateral dynamic forces which are generated during train movement and which can contribute to the buckling potential.

(11) *Track Lateral Resistance* means the resistance provided to the rail/crosstie structure against lateral displacement.

(12) *Track Longitudinal Resistance* means the resistance provided by the rail anchors/rail fasteners and the ballast section to the rail/crosstie structure against longitudinal displacement.

Application

The definition "buckling incident" is provided to explain the industry-accepted threshold for such an event. However, the rule recognizes the importance of conditions that are precursors to buckles.

Paragraph (a) requires the railroad to have in effect and comply with their own written procedures that address the installation, adjustment, maintenance and inspection of CWR.

The written procedures should be reasonable and consistent with current research results. The FRA will review each plan for compliance with paragraphs (a) through (f). The FRA Headquarters track specialists and Regional track specialists shall have primary responsibility for reviewing each set of railroad CWR procedures. Inspectors may be requested to provide recommendations concerning the comprehensiveness of those procedures.

In addition to safety critical procedures listed in this section, the railroad may decide to include procedures based on administrative or economic considerations. For example, a railroad may choose to include instructions that limit the use of worn secondhand replacement rail because of an economic concern about the length of time that it might take to perform a satisfactory weld. The railroad may also include specific actions in their procedures that are to be taken when installation or maintenance work does not comply with its overall procedures.

The railroad must record the location of any installation or maintenance work in CWR that does not conform to its procedures in accordance with Section 213.119(h)(2). The record shall be maintained until the CWR is brought into conformance with the railroad's written procedures. The railroad may also wish to include a narrative explanation of the special circumstances involved. Inspectors should periodically review the information recorded in accordance

with §213.119(h)(2) to determine if any work performed on CWR, that does not comply with the railroad procedures, is being properly recorded.

Inspectors must be aware of the procedures in effect before inspecting each railroad. When conducting inspections, the Inspector must make observations to determine if the railroad is following its basic safety procedures. If the railroad fails to follow its procedures and the failure may lead to a serious safety problem, the Inspector should consider citing the railroad for failure to comply with their CWR procedures. A violation memorandum must document the circumstances involved, including whether or not the railroad recorded the conditions as required under §213.119(h)(2). However, the Inspector should exercise judgment in the reporting of circumstances that do not fully comply with the written procedures. Minor deviations from written CWR procedures should not be considered for enforcement action unless, together with other violations, they are part of a larger safety problem.

Merely recording an activity that does not conform to the railroad's CWR procedures does not provide the railroad with indefinite relief from responsibility for compliance when its procedures are not followed and continued noncompliance may lead to an unsafe condition. The recordkeeping procedure is intended to provide a safety net by flagging those activities of noncompliance which, if not brought into compliance in a timely manner, could lead to an unsafe condition. For example, CWR track installed in the winter months without adequate rail anchors as prescribed by the written procedures and discovered in late summer would clearly be a deficient condition, whether it was recorded or not. When in doubt as to what activities are considered safety-related, the Inspector should consult with the Regional Track Specialist.

Under guidance from the Regional Track Specialist, Inspectors must determine the adequacy of the railroad's formal training program under §213.119(g) and (h). Those training procedures are required to be consistent and current with research results, clear, concise, and easy to understand by maintenance-of-way employees.

Railroads typically establish a desired rail installation temperature range for the geographical area that is higher than the annual mean temperature. This higher installation temperature will account for the expected reduction of the force-free temperature caused by track maintenance, train traffic and other factors. A railroad's failure to establish a designated installation temperature range for a specific territory is addressed under §213.119(a).

The two failure modes associated with track constructed with CWR are track buckles and a pull-aparts. A track buckle is considered the more serious of the

two and is characterized by the formation of a large lateral mis-alinement caused by:

- high compressive forces in the rail (thermal and mechanical loads);
- weakened track conditions (weak track resistance, alinement deviations); and
- vehicle loads (a dynamic "wave" uplift and lateral vs. vertical ratios).

Thermal and mechanical loads are opposed by three parameters: lateral, longitudinal, and torsional resistance of the track. Track buckles almost always occur in the lateral direction. Lateral resistance is the most important and is dependent upon weight and size of crosstie material, ballast material type, shoulder width, crib content and the level of consolidation, and vertical loads.

A crosstie's base, side (crib) friction and ballast shoulder resistance contribute to the overall lateral resistance sustained. In general, each contributes (base 50%, side 20-30%, and shoulder 20-30%) to this resistance but the ratios can vary dependent upon ballast condition. Lateral resistance varies in location depending on the ballast shoulder geometry, crosstie size and type, and state of ballast consolidation.

Thermal loads by themselves can cause a buckle and are often called "static buckling." Most buckling however, occurs under a combination of thermal and vehicle loads, termed "dynamic buckling." Inspectors should place emphasis on vehicle (dynamic) effects on track lateral stability, where high rail temperatures and vehicle loading could progressively weaken the track due to dynamic uplift (flexural waves) and a buckle mechanism response induced by misalignment "growth."

Because the majority of buckles occur under dynamic train movements, loading is an important element in the buckling mechanism. Elements of track lateral instability include:

- formation of <u>initial track misalinements</u> caused by reduced local resistance;
- high impact loads, initial rail surface (weld) imperfections and 'soft' spots in ballast, and curve (radial breathing) shifting; and
- <u>misalinement growth</u> caused by high lateral loads, increased longitudinal forces, track uplifts due to vertical loads, and train- induced vibration.

Inspectors may consider the above elements combined with related evidence of actual or incipient geometry defects or other defective structural conditions when evaluating the adequacy of a railroad's CWR stability procedures (or lack thereof) under §213.119(b), (c), and (d). Locations where imminent track buckling is more likely to occur include: horizontal and vertical curves, bottom of grades, bridge approaches, highway-rail grade crossings, recently disturbed track, and areas of heavy train starting or braking.

The signs or precursors of buckles include:

- newly formed alinement deviations; wavy, kinky, snaky, etc.,
- minute rail alinement;
- rails rotating or lifting out of the tie plates and intermittent loose tie plates;
- excessive "running" rail causing ties to plow or churn the ballast;
- insufficient and moving anchors;
- insufficient ballast section in the crib and shoulder areas;
- gaps at crosstie ends, especially on the low (inner) rail; and
- previous buckles improperly repaired.

Curves are more prone to buckling because of the curvature effect, alinement imperfection sensitivity, and train loads. It is important for Inspectors to consider when and where a buckle may occur (e.g., on track segments where the CWR was laid "cold" below the desired rail installation temperature range and there was inadequate control of the laying temperature or inadequate adjustment of the rail afterwards). Also, Inspectors should observe areas of recent maintenance involving either ballast or rail, where there was inadequate reconsolidating time for disturbed ballast or inadequate temperature adjustment when replacing a defective rail. As curvature increases, the buckling resistance decreases. Under some conditions, high degree curvature can undergo gradual lateral shift (progressive buckling). Lateral alinement deviations reduce the track buckling strength and can initiate growth to critical levels. Vertical alinement deviations can also influence buckling.

Lateral mis-alinement is an important consideration and it influences buckling strength significantly. An alinement offset or mid-ordinate within allowable limits may "grow" under the imposed loads, the ballast, subgrade movement and settlement. This is called "track shift." A longitudinal force in curved track will cause CWR rail to move radially. Compressive loads in the rail during the summer tend to move the track outwards and tensile loads in the winter will pull the track inward, a term known as "radial breathing." Inspectors should review the allowable limits, under §213.55, and evaluate the relevant alinement and track strength (§213.13, movement under load) due to repeated thermal and vehicle loadings.

Generally speaking, a decrease in the force-free temperature of 30 to 40 degrees from the installation temperature can be critical and lead directly to buckling. Inspectors should monitor the following factors that may influence shifts in the force-free temperature: improper rail installation, inadequate rail anchors or fastenings, lateral movements in curves through lining operations, "skeletonized" track segments, and inadequate ballast section. Lateral and longitudinal restraint is influenced by the factors mentioned above and, if improperly executed or allowed to exist in a defective state, may produce a potential track buckle.

Tangent track buckling incidents are less frequent than in curves. However, buckling in tangent track will generally occur suddenly and with more severe consequences.

The second of the two failure modes can be associated with track constructed with CWR is a pull-apart. A rail's decrease in temperature in the winter will create tensile forces. The maximum tensile load in the rail is determined by the difference in the installation or force-free temperature and the lowest rail temperatures. Enough tensile force can cause direct fracture at rail cross-sections with prior cracks, weak welds or shear joint bolts at CWR string end locations.

A track owner may update or modify CWR procedures as necessary, upon notification to the FRA of those changes.

Defect Codes	
119.01	Failure of track owner to develop and implement written CWR procedures.
119.02	Failure to comply with written CWR procedures.
119.03	Failure of track owner to develop a training program for the implementation of their written CWR procedures.
119.04	Failure to keep CWR records as required.