INTERSTATE COMMERCE COMMISSION

REPORT NO. 3353

IN THE MATTER OF MAKING ACCIDENT INVESTIGATION
REPORTS UNDER THE LOCOMOTIVE INSPECTION ACT
OF FEBRUARY 17, 1911, AS AMENDED

NORFOLK AND WESTERN RAILWAY

October 11, 1950

Accident (boiler explosion) near Eastwood, Ohio, on August 23, 1950, caused by overheating of the crown sheet due to low water.

REPORT OF THE COMMISSION[1]

PATTERSON, Commissioner:

On August 23, 1950, about 7:30 p.m., near Eastwood, Ohio, the boiler of Norfolk and Western Railway locomotive 2114 exploded while the locomotive was hauling a freight train at an estimated speed of 20 miles per hour. The engineer and fireman were killed.

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[1]Under authority of section 17 (2) of the Interstate Commerce Act the above-entitled proceeding was referred by the Commission to Commissioner Patterson for consideration and disposition.

DESCRIPTION OF ACCIDENT

Norfolk and Western Railway locomotive 2114, hauling eastbound freight train Third No. 84, departed from Clare, Ohio, yards at 6:45 p.m., August 23, 1950, enroute to Portsmouth, Ohio, a distance of 99.35 miles, and proceeded without any known unusual incident to a point 680 feet east of mile post 35, which is 26.84 miles from Clare, Ohio, yards and near Eastwood, Ohio, where at about 7:30 p.m., while the train was moving at an estimated speed of 20 miles per hour, the boiler exploded. The engineer and fireman were killed.

The train consisted of thirty-nine loaded and seven empty cars and a caboose, 1964 tons. The tonnage rating for this locomotive eastbound between these points is 2900 tons. The engineer and fireman, as far as is known, were at their proper positions in the cab and the head brakeman was seated in the brakeman's cupola. The track eastbound from Clare, Ohio, to the point of accident is generally ascending with a maximum grade of 1.52 percent and was 1.10 percent at point of accident.

The force of the explosion tore the boiler from the chassis; tore the interior and exterior firebox sheets away from the shell section of boiler. The boiler shell was blown upward and descended 130 feet forward and 6 feet south of the track with the combustion chamber end down, depressing a hole 6 feet deep in the embankment; the boiler bounded forward, striking the smokebox section on the rails, then rebounded, coming to rest headed east at an angle approximately 45 degrees to the track with the smokebox end 275 feet forward from point of accident and 16 feet north of center line of track. The roof sheet with left side wrapper sheet and upper section of boiler back head attached was blown forward 475 feet and 46 feet north of center line of track; the rear section of crown sheet with a section of the door sheet and major portions of the side sheets attached was blown 62 feet rearward and 30 feet north of the center line of track; part of right side wrapper sheet was blown 675 feet forward and 234 feet north of center line of track; the lower section of the boiler back head extending below the arch tube plugs was blown 130 feet forward and 212 feet north of center line of track; the lower section of the smokebox was badly distorted and torn approximately 40 percent through its lower rear circumference; the smokebox front was blown 573 feet forward and 37 feet north of center line of track. The cab was blown rearward 557 feet and 72 feet north of center line of track. Various other parts were found

within a radius of 600 feet from the point of explosion. The chassis of the locomotive with tender attached moved forward about 385 feet and came to a stop with all of the wheels of locomotive and tender derailed. The first three stock cars of the train, loaded with hogs, were derailed; one of these was turned over and the other two were slewed on their trucks.

The engineer's body was found in a field 530 feet west and 127 feet south of the point of explosion. The fireman's body was found in a field 112 feet west and 200 feet north of the point of accident.

DESCRIPTION OF LOCOMOTIVE

Locomotive 2114 was of the 2-8-8-2 (Mallet) type; built by the Norfolk and Western Railway Company at their Roanoke, Virginia shops in August 1930; carrier's classification Y-5; cylinders 25 inches by 32 inches and 39 inches by 32 inches; driving wheels 58 inches in diameter over new tires; total weight of engine, 582,900 pounds, in working order; weight on driving wheels, 522,850 pounds; total tractive effort: compound, 126,838 pounds, simple, 152,206 pounds; was equipped with Baker valve gear; precision reverse gear and a front end throttle and the driving, engine truck and trailing truck wheels were equipped with roller bearings. The locomotive had made 4,514 miles since last classified repairs. The tender was a rectangular cast steel water bottom type with a capacity of 22,000 gallons of water and 30 tons of coal, weight in working order 378,600 pounds. A brakeman's cupola was located on top of the water tank at the rear of the coal space.

The boiler, builder's number 250, was a four-course straight top radial stayed type with a sloping back boiler head; inside diameter of first course was 95-9/16 inches; second course, 97-7/8 inches; the third course originally was nickel steel, 1 inch in thickness and 100¼ inches inside diameter; and the fourth course was nickel steel, 1 inch in thickness and 102¼ inches inside diameter. The thickness of the first course sheet was 1-5/32 inches and of the second course sheet 1-3/16 inches. The carrier's record shows that the third course was renewed in November 1939 with a carbon steel sheet, 1-7/32 inches in thickness. The front tube sheet was 3/4 inch in thickness. The boiler was equipped with 252, 2¼ inch and 53, 5½ inch tubes, 23 feet 11-7/8 inches in length;

5 arch tubes, 3½ inches in diameter; a Nathan special type horizontal injector; a type BL 4½ Worthington feedwater pump; a type A superheater; a Standard type HT stoker; a Nathan low water alarm; a Franklin #8 butterfly firedoor; two 2 inch Okadee manually operated blow-off cocks; an automatically operated blow down valve and four 5½ inch muffled Ashton safety valves. The working steam pressure was 300 pounds per square inch.

The firebox was 8 feet 10¾ inches wide, 14 feet 2-1/8 inches long, and had a combustion chamber 24-1/8 inches long, 88 inches wide and 62-9/16 inches high. A new firebox was applied at Roanoke, Virginia, July 17, 1946. The external firebox sheet thicknesses were: throat sheet 7/8 inch; roof 3/4 inch; back head and side wrapper sheets ½ inch. The back flue sheet and inside throat sheet were ½ inch thick and the crown, side, door and combustion chamber sheets were 3/8 inch thick. All seams in the firebox were fusion butt welded. The carrier's print showed the crown sheet to have been 8 inches higher at the front end than at the back end. The crown sheet was supported by 18 longitudinal and 49 transverse rows of stays spaced 3.875 by 3.875 inches. The first three longitudinal rows on each side of center line were rigid taper hammer-headed stays 1¼ inches in diameter in crown sheet and 1 inch in diameter in roof sheet. The 4th to 9th, inclusive, longitudinal rows on each side of center were straight radial stays 1 inch diameter in crown sheet and 1-1/8 inches diameter in roof sheet; the 10th to 14th, inclusive, longitudinal rows on each side of center were 1 inch flexible stays. All other stays in the firebox were 1 inch rigid stays with the exception of some flexible staybolts in the breaking zones. A number of patches had been applied to inside and outside firebox sheets and were apparently in good condition prior to the accident.

EXAMINATION OF BOILER AND APPURTENANCES

BOILER

An area of approximately 53 square feet of the crown sheet had been overheated and was discolored to a deep blue and the ends of the stays were a distinct blue. The overheated area extended to the 9th longitudinal row of stays on each side of center at the back flue sheet and extended rearward tapering to the 33rd transverse row of crown stays. A number of stay

ends were cupped with a maximum cupping of 3/8 inch. The crown stay holes were elongated, varying from ¼ to 1 inch with the maximum elongation from 1¼ inch original diameter to 2¼ inches found in the 19th transverse row of stays in the 2nd longitudinal row left of the center line. The line of demarcation was clear and distinct and measurements indicated that the water level had been 4 inches below the highest point of the crown sheet.

The initial tear extended through the 18th transverse row of crown stays vertically downward to the mud ring on each side. The edge of this tear in the overheated area was thinned from 3/8 inch in thickness to a dull knife edge. A diagonal tear extended from this initial tear starting at the 12th longitudinal row of stays right of center line and extended to the mud ring at the 34th transverse row of stays from the throat sheet; a tear extended from the rear edge of crown sheet to the stay in the 48th transverse and 2nd longitudinal rows right of center and then extended through the 48th transverse row of stays to the 13th longitudinal row left of the center line. On the left side sheet a tear extended from the 10th longitudinal row in the 48th transverse row to the 15th longitudinal row in the 29th transverse row. Tears through the right and left side sheets extended through the mud ring rivet holes, the side sheets and the 1st, 2nd, 3rd and 4th lower longitudinal rows of stays, from the throat sheet to the door sheet.

To the right of the center, the door sheet tore diagonally through the upper flange to the 4th stay in the upper row, extended to the 7th stay in the 6th transverse row from the upper flange and then vertically downward through the 7th row to the mud ring; the tear then extended through the riveted mud ring seam to the right side sheet. A door sheet tear from the 7th vertical row right of center and the 12th row from upper flange extended upward and adjacent to the right firedoor flange welded seam, then followed the seam upward and across the upper firedoor horizontal seam for a distance of 12 inches then extended downward adjacent to the left side of firedoor seam and through the plate to the mud ring at a point near the 2nd stay left of center line and tore through the plate at mud ring rivets to the left back corner.

The front section of the crown sheet extending over the combustion chamber and ahead of the 18th transverse row of crown stays, was pulled from the stays and torn from the upper

section of the back flue sheet through the upper row of superheater flues and was blown downward into the lower section of the combustion chamber. The section of the crown sheet rearward from the 18th transverse row of stays with the major portions of side sheets and door sheet attached was blown out of the firebox.

The external firebox sheets were blown completely away from the barrel section. The entire double riveted circumferential seam of the roof and side wrapper sheets connecting the barrel course and outside throat sheets failed from the right to the left sides of mud ring. The riveted longitudinal seam between the roof and right side wrapper sheet failed for a distance of nine feet six inches rearward from the circumferential barrel sheet seam then tore through the plate rearward for a distance of four feet one inch to the back boiler head, and from this point the back boiler head seam rivets sheared downward for 28 inches. The left side of wrapper sheet remained attached to the roof sheet. A tear through the riveted seam of the back boiler head and left side wrapper sheet extended from the 1st rivet above the left back mud ring washout plug hole upward to the 1st rivet below the wrapper and roof sheet longitudinal seam, then extended forward a distance of 21 inches. A tear extended across the back boiler head from the outer flange on right side and through the arch tube washout holes to outer flange on left side. The upper section of this sheet remained attached to the roof sheet.

The upper section of the back flue sheet was folded downward, torn and pulled from twelve 5½ and thirteen 2¼ inch flues.

The mud ring, 4-3/8 inches by 7 inches in cross section, was broken at the four corners and the several pieces remained attached to the front inside and outside throat sheets, to the two outside wrapper sheets and to the back boiler head.

There was a total of 3,263 stays in the boiler. Stays that remained intact after the explosion were located as follows: firedoor and back boiler head sheets 42; throat sheets 41; combustion chamber 202; left side sheet 18; total stays intact 303; total stays pulled from sheet 2,960. No stays were found with indications of being broken prior to the accident. The threads on sheets and stays were apparently in good condition prior to the explosion. The interior of the boiler was practically without scale formation.

APPURTENANCES AS FOUND

Safety valves: The boiler was equipped with four 3½ inch muffled Ashton safety valves. These were tested with air pressure. The left outside safety valve lifted at 310 pounds per square inch. The left inside safety valve lifted at 307 pounds per square inch. The right inside safety valve lifted at 310 pounds per square inch. The right outside safety valve lifted at 305 pounds per square inch.

Steam gages: The two steam gages from the boiler were not found. The brackets to which the gages were attached were found near the lower section of the back boiler head. One steam gage syphon valve was found with the distorted steam pipe attached. The valve was found in open position and the syphon pipe apparently had been in good condition prior to the accident.

Water level indicating devices: The boiler was equipped with a Nathan WOA type water column with three gage cocks and top and bottom water glass fittings mounted thereon, and was located 27 inches to the right of the vertical center line of the boiler back head, and a water glass located 18-1/8 inches to the left of the vertical center line of the boiler head. The water column steam pipe connection spud entered the roof sheet 8-3/4 inches ahead of the boiler back head and 5½ inches to the right of boiler center line, and had an opening 13/16 inch in diameter which was found clean and unobstructed.

The 1½ inch outside diameter water column steam pipe was found attached to the water column with upper end broken off and badly bent, it was otherwise in good condition with openings unobstructed. The water column was found attached to the upper section of the back boiler head with all fittings broken off with the exception of the steam pipe. The water column bottom spud extended into the water space 1½ inches and had an opening 3/4 inch in diameter which was found clean and unobstructed.

The boiler was equipped with two Nathan reflex type water glasses with clear readings of 6 inches. One of these was mounted on the water column and one on the left side of the boiler, prior to the explosion. One water glass with its upper and lower fittings broken off at the cage body was found. Examination disclosed that it was in good condition with upper and lower fittings having openings 3/8 inch in diameter and unobstructed. The other water glass was not found. The boiler was equipped with 4 Nathan type water glass fittings, two of which were threaded into the water column, one into the left lower water glass boiler spud, and one was threaded into the left water glass roof sheet connection spud. Two of the fittings were found, one of which had the shut-off valve bonnet

section broken with bonnet and valve missing and the other with the valve stem broken off even with the packing nut, and the valve in open position. The fittings were otherwise in good condition with horizontal and vertical openings 3/8 inches in diameter clean and unobstructed. The drain valves and pipes to water glasses were not found. The left water glass lower boiler spud fitting had an opening 13/16 inch in diameter and extended into the water space 3 inches. The upper water glass spud was located 5½ inches to the left of the vertical center line and 8-3/4 inches ahead of the boiler back head, the 13/16 inch opening was found clean and unobstructed. The steam connection between the top of the water glasses and water glass fittings was 5/8 inch outside diameter copper pipe. These pipes were not found.

The carrier's print showed and an examination of a similar locomotive indicated that locomotive 2114 was equipped with 3 Nathan double seated gage cocks spaced 3-3/32 inches vertically. Only one gage cock was found, it had been broken off at the water column threads and examination disclosed that it was in good condition with the valve in closed position. The gage cock dripper was found attached to the water column, badly crushed. The dripper drain pipe was not found. The carrier's print showed the lowest reading of the water glasses and the bottom gage cock to have been 5 inches above the highest point of the crown sheet.

Injector and fittings: The boiler was equipped with a Nathan Norfolk and Western special type horizontal injector with a rated capacity of 10,000 gallons per hour. It was mounted on a bracket secured to the rear section of main frame below the right side of the cab. The injector was so badly damaged that a test was not possible. The starting or operating steam valve had been attached to the upper section of the injector; extension rods and handles had been located within the cab for the operation of injector. The delivery, steam and overflow sections of the injector were found torn and distorted. The water regulating valve was found in full closed position. The extension rods were not found. The injector steam, suction, and delivery pipes, with the exception of a section of delivery pipe attached to the boiler check, were not found. The opening in this section of delivery pipe was found clean. The injector tubes were removed and found to be in good condition. The main steam supply valve at the turret was not found.

Feedwater pump: The Worthington type BL 4½ feedwater pump was mounted on the left side of boiler; rated capacity was 10,000 gallons per hour. When tested on Norfolk and Western locomotive 2117 at 275 pounds steam pressure, with the steam valve full open, the water in the glass was raised 3¼ inches and when tested at 290 pounds pressure, with the steam valve 3 turns open, the water in the glass was raised 3-7/16 inches. Each test was 2 minutes in duration with 5/8 inch water in the glass at start. The test at 290 pounds pressure was made with main turret valve open 2½ turns and air compressors working at approximately full capacity. A slip test made with the pump disclosed that it made 3½ single strokes per minute with a steam pressure of 290 pounds per square inch.

The feedwater pump steam, delivery, and suction pipes, with the exception of a section of steam pipe between the main turret and operating valve and a section of the delivery pipe attached to boiler check, were not found; the openings in the sections of steam and delivery pipes were found clean. The operating valve was a 1½ inch Lunkenheimer, located near the main turret, and was operated by a rod and handle which extended into the cab. The extension rod and handle were not found. The valve was found with its stem bent, which was straightened in order to ascertain the valve position; it was found to be open 3 turns or ⅜ inch measured on the stem. It required 4½ turns to fully open the valve from fully closed position. The carrier does not use a control valve between the operating steam valve and feedwater pump. The feedwater pump gage located in the cab was not found.

Main turret: The main steam turret was located on top center line of the boiler directly ahead of the cab and was found with openings clean and unobstructed.

All of the fittings were broken off and missing except the feedwater pump operating valve and the main turret valve. The main turret valve stem was found bent, and was straightened in order to ascertain the valve position. The valve, 4½ inches in diameter, was open 3 turns and required 4½ turns or 1-1/16 inches measured on the valve stem to full open from closed position.

Boiler checks: A Nathan 3-inch twin boiler check and stop valve was mounted on top of the first boiler shell course. The two boiler checks were examined and found in good condition, check body passages unobstructed and openings clean. Both stop valves were found in full open position. The lift of the right boiler check was ⅜ inch, and the lift of the spring loaded left boiler check was 3/16 inch.

Blow-off Cocks: The boiler was equipped with two 2-inch Okadee blow-off cocks; one was located near the right front mud ring corner and was not operative from cab, the other located at the left back mud ring corner was operative from cab by means of an extension rod and handle. These were not found after the explosion.

Low Water Alarm: The boiler was equipped with a Nathan low water alarm, the operating mechanism of which was located near the vertical center line of the boiler approximately 24 inches rearward from the back flue sheet. The drop pipe was found bent upward, apparently caused by the force of the explosion. The company blue print showed the drop pipe to extend to 3½ inches above the highest point of crown sheet. On locomotive 2117 the drop pipe measured 3½ inches above the highest point of crown sheet. The operating mechanism was torn from the boiler and damaged to the extent that no test could be made. The low water alarm whistle was not found. The low water alarm trip valve, which when operated by-passes the steam that sounds the whistle and permits the steam to be discharged into the cab, was found attached to the upper section of the boiler back head. When tested this trip valve functioned satisfactorily.

Firedoor: The Franklin #8 butterfly type firedoor was demolished. The only parts found were two broken sections of the door ring attached to the boiler back head.

Feedwater Tank: The tender was a rectangular cast steel water bottom type. This was inspected and found in good condition with a slight amount of scale in bottom. The tank well screens were in proper position, clean and in good condition. The right tank valve was fully open, and the left tank valve was 3/4 open. The right and left tank hose were found in good condition. The left tank hose was found pulled loose from the feedwater strainer end. The right tank hose remained in position. The right and left tank hose strainer boxes were found in good condition with openings and screen unobstructed.

Boiler Water: A record of the concentration at Clare, Ohio, enginehouse on August 23, 1950, showed that the water in this boiler tested 190 grains total dissolved solids inbound. Company officials stated that their permissible total dissolved solids is 500 grains, and that ½ of a glass of water was blown out of the boiler when an employee tested the feedwater pump.

INSPECTION AND REPAIR REPORTS

Locomotive 2114 had its last annual inspection and class 3 repairs at Portsmouth, Ohio, on July 28, 1950, at which time the boiler was washed.

Daily inspection and repair reports from Clare, Columbus and Portsmouth, Ohio, covering the period from July 28, 1950 to the time of the accident were examined. The following items which might have a bearing on this accident were found reported and signed off as repaired except as noted otherwise:

August 1, at Clare, Ohio, reported by engineer:
"Renew left water glass. Water raising badly. Repair leaks to water pump. Check leak to injector."
Notation: "Portsmouth enginehouse notified."
Report approved by foreman.

August 3, at Clare, Ohio, reported by engineer:
"Tighten steam valve to water pump."
Report approved by foreman.

August 9, at Clare, Ohio, reported by engineer:
"Check water pump. This works OK at times and at times it will not work. Please check very carefully to find trouble."
Report approved by foreman.

August 10, at Portsmouth, Ohio, reported by engineer:
"Check water pump. This pump stops many times and it looks like it does not get proper lubrication."
Repairs signed for by machinist with notation:
"Tested out - checked and found pump getting sufficient oil - runs good. No repairs made."
Report approved by foreman.

August 10, at Clare, Ohio, reported by engineer:
"Injector will not take up water."
Report approved by foreman.

August 12, at Clare, Ohio, reported by engineer:
"Examine injector does not supply boiler. Feedwater pump does not supply boiler."
Report approved by foreman.

August 20, at Clare, Ohio, reported by engineer:
"Oil water pump - very dry."
Report approved by foreman.

August 23, at Clare, Ohio, reported by engineer:
"Examine water pump, will not supply boiler. Blow boiler good."
Report approved by foreman.

SUMMARY OF EVIDENCE

Two spectators stated orally that they were eye witnesses of the explosion from a near-by farm house. One stated that the front of the boiler ascended above the tree tops and steam was discharging from the front of the boiler; that flying parts were visible moving toward him. The other stated that he noticed the roof sheet and wrapper sheets descending.

Another spectator stated orally that he witnessed the explosion; that the boiler was visible above the tree tops; that the back end of the boiler descended and made a hole about 6 feet in diameter and then jumped; and that after the accident water ran out of the tank hose for about one-half hour.

Shop employees at Clare, Ohio enginehouse stated that prior to departure of locomotive 2114 on August 23, 1950, they had tested the injector and found that it operated satisfactorily and that the water tank was filled with water at about 6:15 p.m. A machinist stated that he tested the low water alarm and feedwater pump and operated the injector and that these operated properly.

The head brakeman stated that he was riding in the cupola with its windows open enroute from Clare, Ohio to the point of accident; that the operation was normal, and that he did not hear the low water alarm whistle.

A fisherman stated that he was fishing under a trestle which was about 40 feet in height and about 1 mile west of the point of explosion; that he was directly under the ties on the right side of the track eastbound; that when the locomotive passed over him clear cool water came on him like someone using a sprinkling hose; that his son-in-law who was fishing about 12 feet from him did not feel any of this water.

The road foreman of engines stated that he arrived at the scene of the accident at about 9:50 p.m. on August 23, 1950; that the engine and tender were coupled; that the tank hose on the injector side of engine was intact; that the tank hose on the feedwater pump side of the engine was down on the branch pipe end; that there was no evidence of this hose dragging or leaking; that there was indication that water had run out of the tank westward toward the scene of explosion after the explosion and tank hose was blown down; that the starting valve of injector was found a distance of 50 feet southwest of the point of explosion and that he was unable to ascertain the operation due to its condition.

CAUSE OF ACCIDENT

It is found that this accident was caused by overheating of the crown sheet due to low water.

Dated at Washington, D. C., this 11th day of October, 1950.

By the Commission, Commissioner Patterson.

SEAL

W. P. BARTEL,

Secretary.