General Store. — Office. —

Arthur E Mo

The MODERN BOILER TUBE

TNC

The MODERN BOILER TUBE

A STORY OF ITS EVOLUTION AND DEVELOPMENT △ SOME EXPERT OPINIONS ON ITS EFFICIENCY △ ILLUSTRATED BY STANDARD MILL TESTS

NATIONAL TUBE COMPANY
GENERAL OFFICES: PITTSBURGH, PENN.

DISTRICT SALES OFFICES

ATLANTA
CHICAGO
DENVER
NEW ORLEANS
NEW YORK
PHILADELPHIA
PITTSBURGH
ST. LOUIS
SALT LAKE CITY

PACIFIC COAST REPRESENTATIVES
U. S. STEEL PRODUCTS COMPANY: SAN FRANCISCO SEATTLE PORTLAND LOS ANGELES

EXPORT REPRESENTATIVES
U. S. STEEL PRODUCTS COMPANY, NEW YORK CITY

A chain is no stronger than its weakest link — a boiler no stronger than its flues

Table of Contents

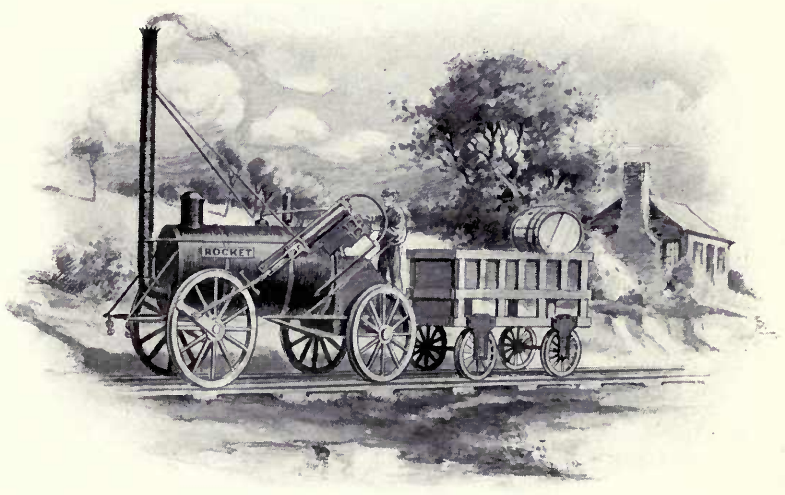
INTRODUCTORY

WE feel that it is unnecessary to offer any detailed explanation or description of the processes employed in the manufacture of steel boiler tubes, these having been fully covered in other publications issued by this Company ("Modern Welded Pipe" and "Shelby Steel Tubes and Their Making"). This book was primarily designed to discuss the development and characteristics of modern boiler tubes, rather than as a treatise on their manufacture.

The earliest records we have of the manufacture of wrought iron tubes dates back to the patent of Henry Osborn, of Birmingham, 1812, and refers to the manufacture of gun barrels by bending wrought iron plates over a circular and tapered mandrel and welding the heated metal thereon under a tilt hammer. The cessation of the European wars left a large amount of this material on the market which was used as gas pipe in 1815 during the early days of gas lighting.

The extension of gas lighting called for cheaper pipe in longer lengths, resulting in the first approach to modern butt welding, using a tilt hammer with semi-circular grooves in the die, welding the heated and bent plate without a mandrel. (James Russell patent, 1824.) In the following year the hammer was dispensed with by Cornelius Whitehouse, who welded wrought iron strips by pressing the edges of the skelp together by drawing through dies—the basis of the butt-weld process as we have it to-day.

The success of Geo. Stephenson's first locomotive in 1829 pointed out the necessity for a stronger tube and the problem of increasing the strength of tubes by lap welding received the attention of inventors, but it was not until about 1845 that the process of lap welding came into successful operation; since then it has been vastly improved in detail.



Seamless steel boiler tubes were first made in 1885 by piercing solid round billets, opening a new and wider field for tubular goods. A few years later soft steel was successfully substituted for charcoal iron in lap-weld tubes.

Since Stephenson's time the locomotive tube has been developed step by step with the demands of locomotive service (the most severe which the tube-maker has to meet); indirectly the manufacture of tubes for merchant and marine service has reaped the benefit of the extensive experiments made to meet the exacting conditions imposed by modern locomotive practice.

The evolution of the boiler tube is comparable with the developments of other branches of the iron and steel industry, where the use of steel has gradually superseded the use of iron, for the reason that it has proved better fitted to meet the demands of modern conditions.

The boiler tube of to-day, as manufactured by this Company, is the result of forty years of constant experiment and experience, various methods and materials having been adopted and discarded in turn as soon as their limitations were found. For many years we made all boiler tubes of charcoal iron. As the use of soft steel became a success in the manufacture of welded pipe it was tried in lap-welded boiler tubes and gave satisfactory results. In the meantime seamless steel tubes began to find their place in the market and charcoal iron tubes became almost entirely displaced by steel in the merchant tube business. In view of this experience and the opinion of practical boiler men of the trade, it was decided to devote our entire attention in the boiler-tube line to the manufacture of steel tubes, both lap-welded and seamless.

No product of our mills must stand such demands in service as the locomotive boiler tube of to-day. It is the weak member of the boiler, on the stability of which the record of the locomotive depends. Recognizing the increasing demand on modern railroad locomotives, we have endeavored by careful experimenting, assisted to a large extent by the liberal policy of the railroads themselves, to better adapt the tube to this service. Tubes failed mainly through (1) corrosion, (2) wearing out of the ends or breaking off the bead in the flue-sheet, due to repeated working of the tube ends in the effort to keep them tight in the flue-sheet.

During the past decade the manufacture of boiler tubes has undergone great improvement so that to-day, with modern blast furnaces, steel works, rolling-mills and manufacturing plants especially designed for this industry, the steel boiler tube is now much better than that made ten years ago. We find it expedient to use the same grade of steel for both lap-welded and seamless locomotive tubes, namely, the steel which has proved by experience to be best adapted to severe conditions of service in the flue-sheet.

The first mentioned cause of failure, corrosion (usually due to bad water conditions), was met by giving special attention to the uniformity in the manufacture of the steel and to the working of the metal while hot. A new process of working the hot bloom was devised which gave the surface portion of the metal a continuous, uniform, dense surface, and this has been found to benefit the tube by making it less liable to local corrosion, or pitting. Soft steel so treated was found to corrode more uniformly and to a lesser degree under natural conditions* than charcoal iron. This fact has been abundantly demonstrated by tests made at our own mills, and by leading railroads in all parts of the country during the last four years, wherever these tubes have been put into service side by side with standard charcoal iron. Material so treated has become known as "Spellerized steel." At the present time we are treating all lap-welded boiler tubes by this process.

The question of corrosion having been practically disposed of by actual experience investigation was continued into the wider field of flue-sheet troubles. Here also it was found by laborious comparisons of engines operating with steel and those operating with charcoal iron under the same conditions, that a decidedly better mileage was obtained with the stronger metal. It was found, however, that steel for tubes must be carefully made for this purpose of a special grade of open hearth quality, moderately low in phosphorus and sulphur, and easily weldable, yet not so soft as to give way too easily under the roller or prosser. Failures were naturally experienced at first, and doubtless more improvements will follow, but one of the leading railroad lines shows by actual record of more than a hundred locomotives that the durability of tubes in the flue-sheet has been increased at least 50 per cent, on the average, by the use of steel.

The following extracts from reports of the Special Committee on Steel versus Iron Tubes submitted to the Convention of the International Master Boiler Makers' Association, 1909-10-11, may be of interest here as indicating the scope and results of some of these locomotive boiler tube tests. By way of making clear what the system of inspection and testing amounts to in the manufacture of steel boiler tubes, illustrations are shown of mill tests to which these tubes are now regularly subjected.

---

* The practice, advocated by some, of testing different grades of iron and steel, by placing samples for an hour in strong acid, has not been found to afford results comparable with natural corrosion, and it has been pointed out by the Committee on Corrosion of the American Society for Testing Materials (see following extract) in their report for 1909, that when so used the acid test is misapplied and may be very misleading.

ABSTRACT FROM REPORT OF COMMITTEE ON THE CORROSION OF IRON AND STEEL, PROCEEDINGS OF THE SOCIETY FOR TESTING MATERIALS, 1910.

It has come to the attention of the Committee that the conditions for uniformity in carrying out an accelerated acid test to determine the rate of solution as a possible measure of tendency to corrosion, which was contained in this Committee's report of 1907, has been misinterpreted by some as a standard method proposed by the Committee. This is not the case. It was merely the intention of the Committee, that those who cared to make such an acid test should use certain uniform conditions as to concentration of acid, size of specimen, time of immersion, etc., in order that the results thus obtained should be comparable, with a view of determining whether the results of such a test bore any relation whatever to corrosion as observed in service. The results so far obtained show that the test is not generally applicable, and in some cases may be very misleading.

Respectfully submitted on behalf of the Committee,

W. H. Walker,
Secretary

Allerton S. Cushman,
Chairman

Concerning Spellerized Steel Boiler Tubes

From time to time we have been asked various questions about the Spellerized Steel Boiler Tube, and for the benefit of those desiring information, we answer below three of the most common queries.

No. 1. What are the specific advantages of Spellerized Steel Boiler Tubes?

No. 2. How does this steel tube compare with the charcoal-iron tube in point of workability?

No. 3. In actual practice is it more difficult, as a matter of manufacture, to get uniform material in iron or in steel, speaking now with reference to boiler tubes?

1 Spellerizing is a process of roll-knobbling steel, while hot. This method of working the metal has the effect of making the surface more uniformly dense, hence it is better adapted to resist corrosion, especially in the form of pitting. Experiment and practice have demonstrated that Spellerized Steel Boiler Tubes will, in actual service, resist corrosion at least as well as, and under many conditions better than, charcoal-iron tubes.

2 The Spellerized Steel Boiler Tube is more ductile than the charcoal-iron tube, and lends itself to manipulation, distortion and "punishment" to a much greater extent, and at the same time has greater toughness and strength. For instance, in experiments to determine the durability of the Spellerized Steel Boiler Tube, in the flue-sheet it was found that the Spellerized Steel Boiler Tube, when set in the flue-sheet in the ordinary way, would withstand at least fifty per cent reduction in gauge under the roller without cracking. Charcoal iron will rarely withstand twenty-five per cent reduction without failure.

3 Methods of steel making are now so improved that it is possible to get a more uniform product in steel than in iron, and the tendency year by year is towards further improvement. The steel tube of to-day is far better than the steel tube of ten years ago, and is better than any iron tube we have ever made. Most metallurgical advances in the last ten years have been along the line of improvements in steel, whereas comparatively few, if any, have been made in the line of iron improvement.

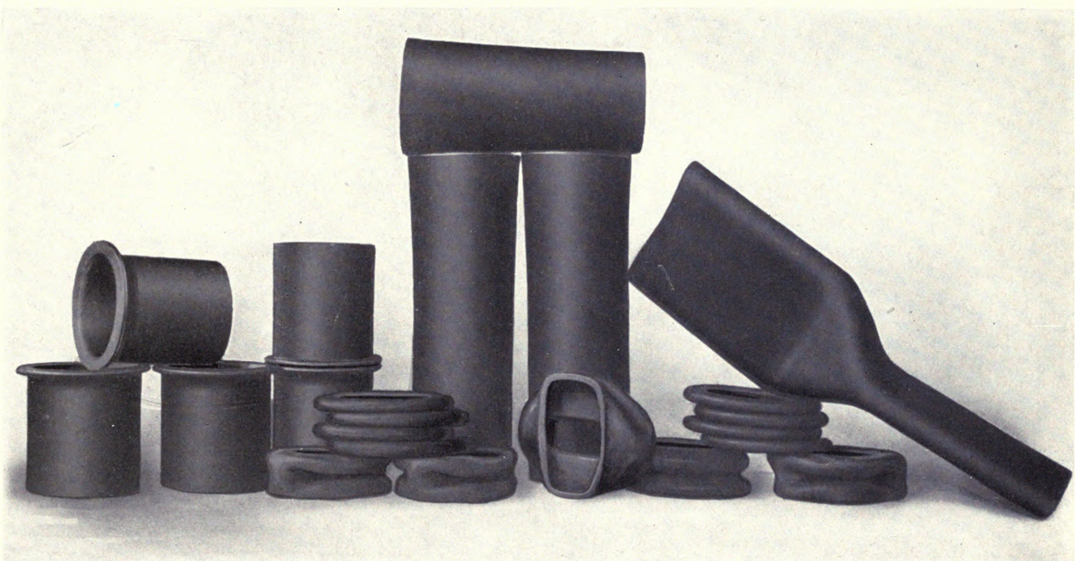
Tests Applied to Boiler Tubes

In order to ascertain that the quality of material and manufacture are satisfactory, all boiler tubes are subjected to severe tests. These tests, assisted by rigid inspection, insure that steel boiler tubes as manufactured by this company, whether intended for locomotive, stationary or marine boilers, will give satisfactory service.

A flattening test is made on both crop ends of each lap-welded tube. This test is used to indicate the strength of weld and ductility of the metal and a guaranty of the uniformity of the product.

Every boiler tube is subjected to an internal hydrostatic test pressure of 500 or 1,000 pounds pressure, according to the size and kind (all seamless boiler tubes are tested to 1,000 pounds pressure).

Details of tests which may be applied to boiler tubes are given in the specifications pages 9 and 11.

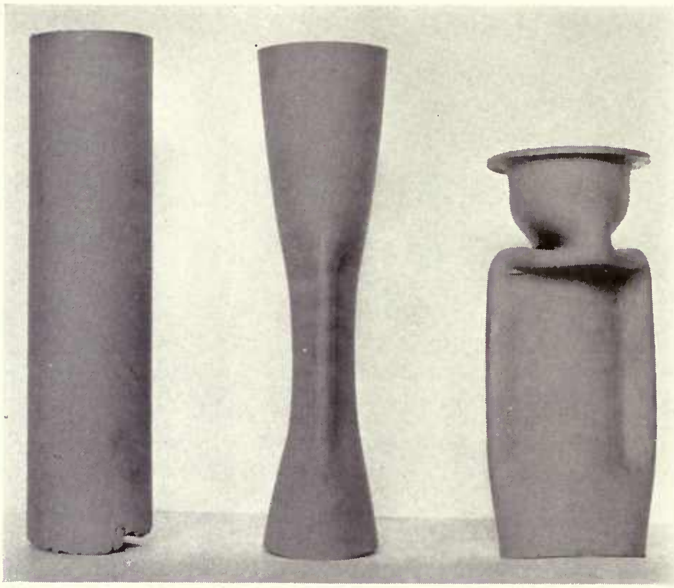


Standard Tests on Steel Boiler Tubes

Test of Lap-Welded Locomotive Flues

Every SPELLERIZED LAP-WELDED LOCOMOTIVE TUBE is given a special test, applied to both crop ends.

This test, illustrated on this page, combines the vertical crushing, horizontal flattening and flange tests on one piece. A special machine has been designed, which enables the test to be made very quickly, and as crop ends are used the cost is reduced to a minimum. If the test piece opens at the weld or elsewhere the tube from which it was cropped is rejected. If the tube stands the above test on the ends the regular internal pressure test is then applied.



Special Test on Spellerized Lap-Welded Locomotive Tubes

First piece to the left shows a crop end of a Boiler tube (two crop ends are cut from every SPELLERIZED STEEL LOCOMOTIVE BOILER TUBE). The second piece shows the crop end laterally crushed; and the third piece shows the crop end crushed vertically with a flange turned on the top. It should be borne in mind that every single SPELLERIZED BOILER TUBE for locomotive service receives this test twice—once on each crop end—the combined test being made in one operation while the piece is held in the testing machine.

National Tube Company

Specifications for Lap-Welded and Seamless Steel Boiler Tubes for Merchant and Marine Service

Material

Material must be good quality soft steel rolled from solid ingots. Sufficient crop shall be cut from the ends to insure sound material.

Dimensions, Weights and Test Pressures

March 15, 1912 — Merchant and Marine Boiler Tube Specification No. 1

Outside Diameter, Inches			Thickness, Inches	Thickness, Birmingham Wire Gage	Weight Per Foot, Pounds	Test Pressure, Pounds	
Seamless		Lap Welded				Seamless	Lap-Welded
Hot Finish	Cold Finish						
...	1	....	.095	13	.918	1,000	...
...	1¼	....	.095	13	1.171	1,000	...
...	1½	....	.095	13	1.425	1,000	...
...	1¾	1¾	.095	13	1.679	1,000	750
2	2	2	.095	13	1.932	1,000	750
2¼	2¼	2¼	.095	13	2.186	1,000	750
2½	2½	2½	.109	12	2.783	1,000	750
2¾	2¾	2¾	.109	12	3.074	1,000	750
3	3	3	.109	12	3.365	1,000	750
3¼	3¼	3¼	.120	11	4.011	1,000	750
3½	3½	3½	.120	11	4.331	1,000	750
3¾	3¾	3¾	.120	11	4.652	1,000	750
4	4	4	.134	10	5.532	1,000	750
4½	4½	4½	.134	10	6.248	1,000	500
5	5	5	.148	9	7.669	1,000	500
...	...	6	.165	8	10.282	....	500
...	...	7	.165	8	12.044	....	500
...	...	8	.165	8	13.807	....	500
...	...	9	.180	7	16.955	....	500
...	...	10	.203	6	21.240	....	500
...	...	11	.220	5	25.329	....	500
...	...	12	.229	4½	28.788	....	500
...	...	13	.238	4	32.439	....	500

The permissible variation in weight is 5 per cent. above or 5 per cent. below that given in table.

Inspection

(*a*) Tubes shall have a reasonably smooth surface, free from injurious pits, laminations, cracks, blisters or imperfect welds; they shall also be free from kinks, bends and buckles, signs of unequal contraction in cooling or injury during manufacture.

(*b*) The thickness of the wall shall not vary more than 10 per cent above or below the gauge specified, except at the weld, where .015 inch extra thickness will be allowed.

(*c*) Tubes shall not vary more than one-half (½) of one per cent either way from being round or true to the mean outside diameter, except in the smaller sizes, where a variation of .015 of an inch will be accepted.

(*d*) Tubes shall not be shorter than the length ordered, nor more than .125 inch longer.

Physical Tests

Flattening Test: A section three (3) inches long shall stand hammering flat, cold, until the inside walls are within three times the thickness of the material without cracking at the bend or elsewhere. In case of Lap-Welded tubes for Marine work, the bend at one side shall be made in the weld.

Flanging Test: For Marine purposes on Lap-Welded tubes four (4) inches and smaller, and on all sizes of seamless tubes, a flange three-eighths (⅜) of an inch wide shall be turned over at right angles to the body of the tube without showing crack or opening at the weld.

Internal Pressure Test: Each tube shall be subjected by the manufacturer to an internal hydrostatic pressure for the respective size and gauge, as given in table of Dimensions, Weights and Test Pressures.

General Requirements

In addition to the above tests, each tube when inserted in the boiler must stand expanding and flanging where required without cracking or opening at the weld. Tubes which fail in this way may be returned to the manufacturer.

A certificate of test shall be furnished the purchaser of each lot of tubes for Marine service, describing the kind of material from which the tubes were made, and that the tubes have been tested and have met all the requirements prescribed by the Board of Supervising Inspectors, Department of Commerce and Labor, Steamboat Inspection Service.

All tests to be made at place of manufacture.

American Society for Testing Materials

Locomotive Materials

Specifications for Lap-Welded and Seamless Steel Boiler Tubes and Safe Ends, 2½ Inches Diameter and Under

Manufacture

1. The steel shall be made by the open-hearth process.

Chemical Properties and Tests

2. The steel shall conform to the following requirements as to chemical composition:

Carbon	not over 0.15 per cent
Manganese	0.30 — 0.50 per cent
Phosphorus	not over 0.04 per cent
Sulphur	not over 0.045 per cent

3. (*a*) Analyses of two tubes in each lot of 250 or less shall be made, and these analyses shall conform to the requirements specified in Section 2. Drillings for analyses shall be taken from several points around each tube.

(*b*) If the analysis of only one tube does not conform to the requirements specified, analyses of two additional tubes from the same lot shall be made and each of these shall conform to the requirements specified.

Physical Properties and Tests

4. A test specimen not less than 4 inches in length shall have a flange ⅜ inch wide turned over at right angles to the body of the tube without showing cracks or flaws.

5. A test specimen 4 inches in length shall stand hammering flat until the inside walls are in contact, without cracking at the edges or elsewhere. For lap-welded tubes, care shall be taken that the weld is not located at the point of maximum bending.

6. A test specimen 2½ inches in length shall stand crushing flat longitudinally without showing cracks or flaws.

7. Tubes of Nos. 9, 10 and 11 B.w.g. shall stand an internal hydraulic pressure of 1,000 pounds per square inch, and tubes of Nos. 12 and 13 B.w.g. an internal hydraulic pressure of 900 pounds per square inch.

8. (*a*) Test specimens shall consist of sections cut from a tube. They shall be smooth on the ends and free from burrs.

(*b*) All specimens shall be tested cold.

9. One flange, one flattening, and one crush test shall be made from each of two tubes in each lot of 250 or less. Each tube shall be subjected to the hydraulic test.

10. If the results of the physical tests of only one tube do not conform to the requirements specified in Sections 4, 5 or 6, retests of two additional tubes from the same lot shall be made and each of these shall conform to the requirements specified.

Standard Weights

11. The standard weights for tubes of various outside diameters and thicknesses are as follows:

Table of Standard Weights

Thickness		Weights, Lbs. per Ft. of Length — Outside Diam., In.			
Nearest B. w. g.	Inches	1¾	2	2¼	2½
13	0.095	1.68	1.93	2.19	2.44
12	0.110	1.93	2.22	2.51	2.81
11	0.125	2.17	2.50	2.84	3.17
10	0.135	2.33	2.69	3.05	3.41
9	0.150	2.56	2.96	3.36	3.77

12. The weight of the tubes shall not vary more than 5 per cent from that specified in Section 11.

Workmanship and Finish

13. (*a*) The finished tubes shall be circular within 0.02 inch and the mean outside diameter shall not vary more than 0.015 inch from the size ordered. They shall not be shorter than the length ordered, but may exceed it by 0.125 inch.

(*b*) For lap-welded tubes, the thickness at any point shall not vary more than 0.01 inch from that specified, except at the weld, where an additional thickness of 0.015 inch shall be allowed.

For seamless tubes, the thickness at any point shall not vary more than 10 per cent from that specified.

14. The finished tubes shall be free from injurious seams, flaws, or cracks, and shall have a workmanlike finish. They shall be free from kinks, bends and buckles.

Marking

15. The name or brand of the manufacturer, and "Tested at 1,000 pounds" for Nos. 9, 10 and 11 B.w.g., or "Tested at 900 pounds" for Nos. 12 and 13 B.w.g., shall be legibly stenciled in white on each tube.

Inspection and Rejection

16. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspections shall be made at the place of manufacture prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

17. Tubes when inserted in the boiler shall stand expanding and beading without showing cracks or flaws, or opening at the weld. Tubes which fail in this manner shall be rejected, and the manufacturer shall be notified.

"Steel *vs.* Iron Flues"

Summary of Data Presented at International Master Boiler Makers' Association Conventions, 1909, 1910 and 1911

The proceedings of these three Conventions on the subject of boiler tubes are reproduced in the following pages. For the convenience of those interested in the subject and too busy to read all the details, the main conclusions have been condensed into a few paragraphs under the following topics:

Corrosion and Pitting: Twenty opinions on this subject are nearly equally divided, the experience of six members indicating that the steel pits less than the iron, while as many went on record with just the opposite opinion, and the remaining eight considered the two materials to be equally affected. Several men of wide experience prefer iron for body tubes, because of supposed superiority in resisting corrosion, yet recommend steel for safe ending where the material is really subject to more severe conditions of service.

The view of eight of the members that iron and steel are about equally resistant to corrosion, under the usual conditions of service, would appear to be a reasonable conclusion. In 1901-2 the United States Navy Steam Engineering Department conducted extensive tests which indicate that there is relatively little difference in the corrosion loss of tube materials:

		Loss grams per Sq. In. in aerated distilled water, comparing with iron as 100 per cent.
1.	Hot drawn seamless open-hearth steel	93.7 per cent
2.	Lap-weld Bessemer steel	94.5 per cent
3.	Cold drawn seamless open-hearth steel	101.3 per cent
4.	Charcoal iron	100.0 per cent

Mileage and Efficiency: The greater part of the evidence presented refers to this subject rather than to corrosion. The experience of one of the largest railway systems is typical: a test including ten locomotives, five passenger and five freight, each equipped with iron and steel tubes, shows the steel to have given an average additional mileage over the charcoal iron of 40,400 in case of passenger engines and of 23,700 for freight engines (page 16); while in another case it was found that twenty-eight freight locomotives averaged 25,000 miles more with steel tubes than had been attained previously with iron tubes under the same conditions (page 28). On another system iron flues in the passenger service afforded 55,000 to 65,000 miles between "shoppings," while steel gave 110,000 to 148,000 miles. Seventeen members favor the modern steel tube for efficiency, five are opposed to this and ten report equally good results with the two materials, so that most of the evidence favors steel tubes.

Conclusion: The idea has been advanced that the pitting of iron and steel is preventable to a great extent (page 26); and it is generally accepted, according to this discussion, that steel tubes expand and bead into the flue sheet better and hold their position more permanently than iron, are stronger, of smoother finish and truer to size and gauge than the older material; also with ordinary care they are welded with as good results as iron; and finally, that their service efficiency is higher, so that the statement of one of the members that "steel flues are the coming thing" (page 32), seems to aptly express the trend of opinion at these meetings.

Official Report

and Discussion of Report of the Special Committee on

Steel *vs.* Iron Flues

before the International Master Boiler Makers' Association in Convention at Louisville, April 27-30, 1909

(See pages 150 to 166 of Official Proceedings)

Fourth Day's Session

The Convention met pursuant to adjournment at 9:30 A. M. and was called to order by the President.

The President: The first order of business this morning is the report from the Committee on Steel versus Iron Flues.

Report of Committee on Steel *vs.* Iron Flues

Mr. O'Connor: I wish to make a few explanations before this report is read. You will note in the body of the report when read that my experience has been very limited with the steel flues, consequently I can say at this time but little concerning these two metals. On the Chicago & Northwestern lines west of the Missouri River we have had since May, 1909, several locomotives equipped with the steel and iron flues, half and half in each locomotive. Up to date we have not had occasion to remove any of them, either the iron or the steel, from our boilers. From reports received from time to time we cannot complain of the service given from either the iron or the steel flues, both giving, so far, good satisfaction. I have, however, made personal inspection of the flues in the fire-box of a few of the engines, and by close observation relative to the flue bead at fire-box end I found the steel-flue bead to have a little advantage over the iron bead, as the steel bead remains closer and firmer to the flue-sheet surface than the iron bead. That is all the material difference I could note between the two metals.

By the time of our next Convention in 1910, I will, in all probability, have removed some of these experimental flues from the engines so equipped, and then I can make a more complete report, giving the accurate service and general condition of the two metals as found in our section of the western country. We must not forget that water conditions are not the same in all parts of the country, and in that respect we must depend on what will be brought forth from a thorough test of actual service.

Therefore, I will say that in my short experience with these two metals I would consider this report that will be read before you incomplete, and would suggest that this Association continue this Committee over another year. I would also suggest that the incoming president appoint two more members on this Committee, making the number five instead of three, and that the two additional committeemen be among those that have had good experience with both the steel and iron flues.

The President: Mr. Sarver was on that Committee, too.

Mr. Sarver: Let the Secretary read the report, please.

In submitting to you our report the undersigned Committee on the above subject would respectfully present the following:

Our personal experience and our investigations have furnished us such a wide difference of opinion, relative to the two metals mentioned in this subject, that it proved quite interesting as well as a hard problem for the Committee to determine anything like a satisfactory report; hence, it was decided so to present this paper to the Convention, giving our personal experiences as well as those of other members, thereby affording an opportunity for general discussion among all the members of the Convention with the object in view that by general discussion we, the Committee, would profit by the information obtained as well as other members.

We are also of the opinion that the introduction of the steel flue is not as widely known as the iron flue, consequently the ultimate possibilities are yet to reach a good many of us who, as yet, have not had sufficient experience to determine which of the two metals has proven the most successful in a general way, in economy, as well as securing the best service.

The following report from Mr. B. F. Sarver of the Pennsylvania Lines, Fort Wayne, Ind., will be of interest to the members relative to steel flues. Mr. Sarver has this to say:

Mr. Chairman: The locomotive at the present time is required to carry almost double the steam that it was a few years ago, and as a matter of safety, those in charge of the motive power department should advocate the use of the highest class of material obtainable, having in view, at all times, economy and safety.

In regard to seamless cold-drawn flue tubes, I might say that the steel is made by the open hearth process and must be of the finest quality that can be purchased, otherwise it cannot be pierced. It is always uniform in quality, and as you do away with the welding of the flues it makes a stronger tube than the ordinary iron tube. It expands and beads perfectly, and in service the tubes hold their position in the flue-sheet much better than the softer product. The steel tubes are truer in size and gauge than the welded ones, and are free from the objectionable scale caused by welding, and the surface defects can more readily be found.

The surfaces of the steel flues are so densified that they are not so liable to be affected by pitting and corrosion, caused by the foreign substances in the water. They are very readily welded and can be installed in a boiler at a less expense than the iron tubes.

Although the steel makers do not guarantee their steel to run below .04 per cent in sulphur and .03 per cent in phosphorus, I give you below the maximum and minimum carbons taken from sixteen heats, made by steel makers for steel tubing:

Carbon	.10%	Carbon	.16%
Phosphorus	.008%	Phosphorus	.01%
Manganese	.39%	Manganese	.49%
Sulphur	.03%	Sulphur	.025%

And in neither test the sulphur showed above .03 per cent and the phosphorus above .017 per cent.

I might state that a great many of the large railroad systems of this country are using almost exclusively the seamless cold-drawn tubes for safe ends. And as a great many of the roads have large quantities of charcoal iron tubes in service, in looking this matter up I find they weld very readily into steel.

It is generally understood that the end of the tube, especially the fire-box end, has to stand the most severe punishment, and if the railroads, generally speaking, have selected the seamless tube for the purpose of safe ends, they must recognize in it a quality superior to iron. I cannot see why, at a less expense than iron, it would not be the most economical body tube for locomotives.

The physical quality of seamless cold-drawn steel tubes is as follows:

Tensile strength, pounds per square inch.......................50,000 to 60,000
Elastic limit, pounds per square inch........................30,000 to 35,000
Elongation in eight inches....................................20% to 25%

I might further say that after extensive tests made by the Steam Engineering Department of the United States Navy, they recommended some years ago seamless cold-drawn steel tubing for the boilers of their battleships. This is also a fact with all the great navies of the world; their steam boilers are all fitted with seamless cold-drawn steel tubing.

I believe the time is not far distant when the superintendent of motive power as well as the boiler-maker foreman will all specify seamless cold-drawn steel tubing for all purposes.

One of the lines with which I am connected used steel tubing for safe ends exclusively. Since the adoption of steel at this particular place they have increased their flue mileage at least 25 per cent. The maintaining and calking of flues in engine house has also been reduced the same proportion, 25 per cent. I have experienced no difficulty whatever in welding the steel safe ends to iron flues.

Below you will find a chart showing five passenger as well as five freight engines with the mileage made with iron flues, as well as steel safe ends, we applied.

	Mileage made, Iron Flues	Mileage made, Steel Flues	Steel over Iron
1 Passenger	60,299	108,478	48,179
1 "	96,273	103,330	7,059
1 "	41,684	115,723	74,039
1 "	50,128	87,524	37,396
1 "	84,561	120,088	35,527
1 Freight	33,260	55,063	21,803
1 "	39,390	76,788	37,398
1 "	46,371	54,639	8,268
1 "	30,614	59,967	29,353
1 "	28,130	50,014	21,884

I will conclude by saying that my experience in this particular line, with what I have been able to find in looking this matter up, and also with the increased flue mileage shown in the above chart, I cannot help but say that we are coming to the use of steel flues very rapidly.

Mr. Clement Ryan, of the Union Pacific Railway, Omaha, Neb., also presents the following report:

Mr. Chairman: I hereby beg to submit the following on the above subject, and hope that it will at least open up a line of discussion that will be of benefit to all concerned.

Regarding the use and value of steel in comparison with iron flues, beg to say that in my opinion iron is the best for all purposes, especially as regards pitting. We have had a great deal of experience on the Union Pacific with both iron and steel tubes, and find the steel so badly pitted after a service of from eight to twelve months as to necessitate 75 per cent of the flues to be scrapped, while iron flues running over the same district and under same water conditions last for years. I would, therefore, respectfully recommend the use of iron flues with steel safe ends, as the steel safe ends in fire-boxes stand the heat better than iron. It is standard on the Union Pacific to use iron flues with steel safe ends for fire-box, and the results have been good.

The welding of steel and iron flues requires a good deal of attention, as the heating of these two metals is not the same, and we have had a good deal of trouble in the past welding steel safe ends to iron flues. We would find after the weld was made that at a point about one-half inch from the weld the steel would be cracked sometimes half way around the flue. To overcome this difficulty will say, that after the steel piece has been fitted to the flue and put in the fire, it should never be removed until it is ready to weld, because immediately it comes in contact with the air and is then replaced in the fire, a certain per cent of the welding power is destroyed.

Respectfully submitted,

M. O'Connor, Chairman,
B. F. Sarver,
Clement Ryan.

The President: You have heard the report of the Committee and also the recommendation of the Chairman. What do you wish to do with the report?

Mr. Lucas: I move that the subject of this report be continued for another year. The proposition is a new one, and a good one, and one we will always have before us. I believe we ought to go into it thoroughly, and I suggest that the Committee be increased by the addition of two members.

The motion was seconded.

The President: The motion before the house is that the report from the Committee on Steel versus Iron Flues be accepted, with thanks to the Committee, and the Committee be continued one year with the addition of two members, making it five. Do the members wish me to appoint the other two?

Mr. Smythe: Two of the members of this Committee expressed themselves in the report and they disagreed. Do I understand that we accept the report and agree that they are both right?

The President: No, we cannot do that. We are accepting their report as presented. They have given us the best information and conclusion they could. If the Committee is continued they will still be gathering information. We are not satisfied with what we have so far, but it is the best they could furnish us for the time and experience they have had. So we continue the Committee with the addition of two more members to make still deeper investigation and report at the next Convention.

Mr. Smythe: No doubt the charcoal-iron tube people are perfectly satisfied to give the steel flue another year's trial and let it speak for itself; but I, for one, would dislike to take any part in deciding which one is the best. I think we came here for other purposes than to advertise any one make of an article or material; so I don't think that the charcoal-iron people are a bit worried about being given another year's trial.

Mr. Goodwin: I would think that the motion should read "received" instead of "accepted," and that would clear it up. There is no final report, and the Committee is to be continued so that the subject is still open. In reference to the appointment of the Committee, it would be well enough for the new President to appoint the two new members. I believe our Chairman would be glad to have the new President receive all the honors that belong to his office.

Mr. Sarver: I do not think it is the duty of any committee to recommend whether steel or iron should be used. It is not the sense of my report at all. When you appoint a committee on a subject and ask that committee whether steel or iron is best, they must certainly say one thing or the other. What is left for a committee to do if they do not do that? It is nothing to me who furnishes the steel, whether it be Mr. Smythe or Mr. Goodwin. My report does not specify that we shall use the steel those men make, or any other makes of steel. The topic to my mind was this: Whether this Committee thought steel or iron flues were best, and I gave you just exactly what my experience has been. From my experience, from the figures, and from the mileage and the service that we have obtained from steel safe ends, it would be impossible for me to come here and advocate iron; and if I am not allowed to give in my report the conditions that exist, you might as well not have a committee. I cannot come here and say iron flues are what I want when those of steel have run from 25 to 35 per cent more than iron in actual service. I only put in the paper what I know to be actual facts. Another thing has come up since I wrote that report. We had an engine that ran 40,000 miles with iron flues. We took it into the shop and applied steel safe ends. It has run 72,000 miles and is running yet. So you see that I cannot come here and say that iron flues are as good as steel. (Applause.)

Mr. Lucas: I believe what the gentleman has just said is just exactly what we want to know. The Committee has certainly made a good report. They have given us all the information they can. They have not specified anybody's make, but they should specify whether it was steel or iron. I don't think the Committee has anything to feel sorry about in this respect, at all.

Mr. Brown: It is my opinion that when these questions arise before the body for recommendation, we ought not to lose sight of conservatism. In my yard conditions are not the same as in your yard. There are members who can take either kind of flues and give good reports as to their use in their jurisdiction. I don't see how this assembly can adopt or recommend what material we shall use. The railroad company which I represent covers a vast area of country. We have good water and bad water districts. You have heard the good results reported by Mr. Sarver of the service steel flues have rendered his company. I presume we have members here who could give us a report of the good service iron flues have given.

Mr. Hemphill: I rise to a point of order. Is there a motion before the house?

The Chairman: I believe there is. I put the motion and then asked whether the Convention was ready for the question. We are open for discussion as long as anybody wants to talk. Mr. Brown, continue.

Mr. Brown: I don't believe that I am out of order. All questions are debatable before being put to a vote. That is parliamentary rule. I want to cite you conditions on the Louisville & Nashville Railroad. I don't see how we could conscientiously recommend the adoption of any material. It is only recently that I had to throw out flues weighing 22 pounds to the foot—that were practically new. There ought to be a long life in store for those flues, but the defect was on account of the action of the water upon them. It caused pitting. We have iron tubes in those same districts and you would not know there was any trouble with them. You can cite me as using both iron and steel. We are building twelve high-pressure boilers and a test is being made with steel versus iron. A year from now I will have information as to the results. I want to remind you that it would be impertinent for this Convention to recommend any material that would not be good in certain localities.

The President: I believe there might, perhaps, be a tendency, and some members be somewhat inclined to believe that your Chairman has been influenced in this matter. I am not of that sort of makeup. I am, perhaps, rather sensitive. When I appointed this Committee, I did so fully and solely for the interest of this organization. When elected President of this organization no subjects were put before me. I selected them. The members of this Committee made just as able a report as they could. What are these meetings for if not for information? I have spent hours and hours in the evening, after my work, and out on the road, to select these committees. I have been turned down, time and time again, by members who were asked to serve on committees, and had to take others. I was not connected with the concern that I now represent when I appointed this Committee, and had no thought of going with any company of its kind. Some of our members talk as if I appointed this Committee just to bring out this subject, in order to make recommendations for the adoption of certain material. That is not the principle of this Association. We have no line of material to recommend. We are here to discuss whether the material has given satisfaction or not, and if there is anything in the line of an evil, to eliminate it and determine the remedy to be applied. It is our duty to look into it. When this Committee was appointed I was general foreman boiler maker of the Missouri Pacific Railway. I found in certain places in the country that steel would not give the same satisfaction as iron; and that steel would give satisfaction in certain parts of the country where iron would not. What I wanted to do was to bring out before this Association what steel and iron had been doing. (Applause.)

Mr. Goodwin: I can fully realize the embarrassing position of our President, and I want the floor just long enough to express my opinion about these facts. I don't believe we have in this Association a more conscientious, or a man more devoted to the interests of this Association than our President, Mr. Conrath. (Applause.) I have known him for years and years, and always found him to be straightforward. I know that Mr. Conrath had no idea or intention of appointing any one on this Committee to give his opinion in reference to one side of the question. I don't believe that the members of this Association think Mr. Conrath would do such a thing. He is naturally a little sensitive, because to-day he is associated with the National Tube people. I do hope and trust that Mr. Conrath will not think that there is a member of this Convention who would consider for a moment that he had any selfish personal interest to serve in making these appointments, or that he sought to give advantage to one or the other side. His only object was to bring out the true facts and the true conditions, and the honest opinions of the members of this Committee. I spoke a moment ago of the appointment of the other Committee. I did that simply because I was fully aware of the fact that, possibly, it might be embarrassing on the part of the President to appoint the other two committeemen, as he might think there would be some criticism or reflection with reference to it. I believe it would be more appropriate for the incoming President to fill this Committee. I hope Mr. Conrath will not assume that there is a member in this hall who feels that he would do anything wrong whatever in making appointments. (Applause.)

The President: That is just why I asked the question from the member who made the motion, because it was putting me in an embarrassing position. I asked him whether he wished me to appoint the Committee. I thank you. That is all right.

Mr. Troy: I believe we ought to have all the information we can get on this subject. Many members have not said anything at all, and I am sure many are using both steel and iron tubes. Is the subject open for debate now?

The President: The subject is still open for debate.

Mr. Troy: I have had a little experience with steel tubes, and I presume that in some places they will run, but not in my district. I have not a written report, but I can give you a verbal statement. I applied a set of steel tubes in an Atlantic engine carrying 200 pounds steam pressure. After it had run 30,000 miles I removed the tubes, and I had to throw fifty of the bottom tubes into the scrap, they were so badly pitted.

Mr. Gray: I do not know of a more live subject at the present time among railroad men than steel versus iron tubes. It is a pretty serious proposition for a man to change from one kind of tubes to the other, especially if he changes the body flues, because, if he gets started on one kind of flues and finds they are not suitable for his district, he has to throw away several thousand dollars' worth. I would like to hear from members in different water districts as to what their experience has been. We have a number of steel body tubes and a great many safe ends, and as far as the leaking and the life of the tube in the fire-box are concerned, I have not been able to find practically any difference in my district.

Mr. Walker: Was it not the motion that the report of the Committee be accepted and the Committee be extended for one year, with two members added to it?

The President: That is right.

Mr. Walker: That motion ought to be put before the house and carried, and then a motion that the subject be open for discussion would be in order.

The President: The motion before the house is that the report be received and the subject be open for discussion. The rest of the motion was explained before—that the Committee be extended for one year with two additional members.

The question was put and the motion carried unanimously.

Mr. Lucas: Seamless steel tubes are rather new to us all. I presume there are few members who have not a set of steel flues in service undergoing test. Some are getting first-class results where others are having trouble. We put in our first set of seamless tubes in January, 1905. We removed them after forty-five months' service, 168,000 miles. There was no pitting. Every tube went back into the boiler. We have about eight or ten sets in service still doing business, and have not found any of them pitted. We have iron tubes that are pitted badly on one of our divisions, scrapping 2,400 in six months, where we only scrapped 542 during the same period, on account of light weight.

Mr. Reddy: Is there anybody in the Convention who has had any experience with steel tubes in connection with treated water? We have no steel tubes on our road, but have contemplated putting in two sets for test purposes. We have treated water on our system.

Mr. Brown: I believe I am the member's honeysuckle. (Laughter.) We weld iron ends on steel tubes and steel tubes on iron ends, and we have trouble in making these welds. But going back to the water conditions on the Louisville & Nashville. It is, as Mr. Lucas states. We all have a story to tell. I still say we ought to be conservative. Speaking of mileage, I have iron tubes that have made 130,000 miles between changes of tubes.

Mr. Filcer: We find pitting on the tubes on several divisions of the C., C., C. & St. L., both in steel and iron tubes. This is owing to the condition of the water. We have not discovered any pitting on divisions where we have water-treating plants. We are getting better results from steel tubes than we did from the iron tubes.

Mr. Sarver: Mr. President, in making up my part of this report, I never took into consideration who was going to furnish these tubes. Nobody asked me that. I wrote my report simply on the conditions that exist. I would like to hear from Mr. Letteri, who has had more experience with steel safe ends on the Pennsylvania than anybody I know of.

The President: Mr. Sarver, we believe your report is very conscientious. It is a poor man who would not express his opinion and his experience.

Mr. Letteri: I started in on the steel tubes, I think, in 1896. We made a three-year test of them. Regarding pitting, my experience does not go so very far. We have very hard lime water, and we all know that no pitting takes place in lime water. It only occurs in places where they have real pure water. As far as service is concerned, just as Mr. Sarver stated in his report, the end of the flue that is in the back sheet, when the flues are removed, is heavier at the time of removal than the iron flue would be in three months' service, and the flues at the present time are not removed on account of being worn out, but simply to get the mud and scale out of the boiler.

Mr. Wanberg: I have had some experience in the last twenty or more years, and I find that an engine in constant service is not as apt to pit the flues as one that is taken out of service and left out from time to time. As between iron and steel, I could not say which would pit the quicker. My attention was called to a condenser less than two years ago, which I applied to a set of flues. We took out the flues and found that an iron flue put in less than nine months before was badly pitted, and was scrapped. I knew the trouble was not in the water altogether, because we had flues that had given us better service. I found the dynamo set so close to this condenser that it made electrical connection between the two, and that was the cause of the trouble. That was two years ago. I put in a set of the same tubes made by the National Tube Company, and we have had no further trouble from them. The previous trouble was due to the electric current, and not to the material of the tube. My attention was also called to the west end of the H. & E., where we put in one set of flues. In eight months' service the entire set was scrapped on account of pitting. We knew it was not the water, because we had iron flues that ran longer on that same division. They had run for years and not caused us any trouble from pitting. We investigated, and found that a man was using blue vitriol in the water. It was not the flue, but the vitriol this man used. The same thing may exist on your road. I do believe, however, that the pitting of flues is due a great deal to taking an engine out of service and leaving it out from time to time. More damage is done in one week out of service than a month in service.

Mr. McKeown: I would like to ask Mr. Sarver or Mr. Letteri whether they find any difference with scaling in iron flues or steel flues—do they find any difference in cleaning with a flue cleaner?

Mr. Sarver: No, sir.

Mr. McKeown: Mr. Letteri, how about it; do you find any difference?

Mr. Letteri: Practically the same; I could not tell any difference in the cleaning.

Mr. Cushing: I have been handling steel flues since about 1900, and I have also had iron flues mixed in with them. When I started on this subject of steel flues we were getting 22,000 and 23,000 miles out of a set of flues. We put a test set in and got 69,000 miles. I removed the tubes, had them cleaned and examined, and found no signs of pitting. I also had some iron flues, and found no signs of pitting in them. But in the last two years, flues in service four or five or six years, show pitting on both the iron and steel. I don't attribute it to the material, but to laying the engine up for a month or six weeks at a time, also to the flues being taken out of the boiler and put outside and left in the weather. They rust, and that starts the pitting. I don't think it is the fault of the steel or iron, but of the handling.

Mr. Linderman: I have been handling steel flues about six years. On our passenger power with the iron flues, the best we could do was 55,000 to 65,000 miles. With steel we raised our mileage from 110,000 to 148,000 miles. We have no pitting. With regard to Mr. McKeown's question relative to the cleaning of tubes, we found that steel tubes cleaned a little easier than the iron.

Mr. Johnston: Some time ago I was connected with a small road in the northwest, now a part of the Northern Pacific, where the blacksmith foreman and boiler foreman were requested to order or specify the material desired in their line; as boiler foreman, I tried steel and iron flues; also welded steel safe ends on iron flues, and vice versa. We had no trouble either on account of welding or the service received, the steel and iron flues giving practically the same mileage—from 40,000 to 50,000 miles; that is, from shopping to shopping. We gave the purchasing department to understand, that whatever tubes they could buy to the best advantage to the company we would use. I am now connected with the Santa Fe, and in the past two years we have had considerable trouble from flues pitting, in several instances getting only eight months' service, when it was found necessary to scrap them.

Mr. President: Was that with iron or steel?

Mr. Johnston: Iron tubes; and I believe as Mr. Cushing does, that considerable of this pitting is caused by having them out in the weather, causing them to rust considerably, to which, in my opinion, the pitting, after setting, can be traced.

Mr. Smythe: I believe an explanation is due Mr. Sarver of my remarks about the Committee. I would suggest to the Chairman that he write to the members that are using iron flues, and in his report also embody a report from the iron flues. I know there are large roads that are taking out steel flues and adopting iron, for what purpose I do not know. I have not the experience of you gentlemen, but I think that next year the Committee should have a report from both sides. The two gentlemen who were on the Committee had experience with steel flues, and there was nobody who knew anything about iron flues at all. Surely it ought to be possible to say something good about iron flues, and we ought to hear from the gentlemen who have the information.

The President: Excuse me, but iron tubes are mentioned.

Mr. Andrew Green: I think everybody in the hall has had experience with iron tubes, and I think those who have not had any experience with steel tubes will get good results if they try them.

Mr. James E. Cooke: The Bessemer Railroad, which I represent, is a comparatively small road, yet we haul the largest tonnage of any road in the United States. We have engines carrying 225 pounds, and during the past eight or ten years have used nothing but steel tubes. We weld No. 10 steel ends onto iron and steel tubes, using oil or coke for fuel. We have little trouble with the flues breaking after they are put into the boiler, but we do experience some trouble with flues pitting. We find that iron tubes pit as readily as steel in bad water districts, therefore, cold-drawn steel tubes are the best in the market for our service.

Mr. Kelly: We have men here that use both kinds. I suggest that each one act as a committee of one, so we will know what we are talking about next year, and be able to recommend something to our officials. I suggest that we each make a test. I would also suggest that the Chairman of the Committee write to the manufacturers. I believe next year, or two years from now, we will know just exactly what we are talking about, and I recommend we ascertain just where these pitted flues come from, and report the outcome of the test.

The President: It was my idea that we would discuss the matter here, the members to then go home and go into the matter deeper and find out where they are.

Mr. Kelly: I would like to have them put in half and half in the same engine, the right side iron and the left side steel.

Mr. Lowe: As a representative of the Canadian Pacific Railroad I will state that we are operating in the neighborhood of 1,500 locomotives. The western lines, which I represent, have about 740. I believe I should have something to say in connection with our tubes and the material used. We are using steel tubes except in those cases where we are having experiments with other brands. In the good water district, as regards renewal, we are governed by the time adopted for internal inspection of the boiler. In the same districts with the iron ends, we find no gain or loss in connection with either material. But when we come into bad water districts, it is not a question of the vitality of the bead or security to the tube-sheet, but of having to remove them for scale. We had been using the steel tube for many years before I came to your Convention. I am not interested in one particular brand of tubes over another. Every brand that is supplied us for experiment will get a fair trial. We have practically found no gain or loss in bad water districts, and in good water territory any flue stays in long enough to come within the time limit of internal inspection of the boiler.

Mr. Lucas: In making this test, when you get your people to buy a set of iron tubes, I would like the members to keep a record of the work done on each set, and the number of flues plugged when in the shop, and give us complete data of what has been done. It will be well to state whether it was a good grade of iron tube against the steel tube, or a common body grade of iron against the steel tube. Let us show up everything.

Mr. O'Neill: I have had a great deal of experience with steel tubes, and I find after making several tests, that by putting in a half set of iron flues and a half set of steel, in certain districts where we applied these flues and the condition of the water was very bad, we took flues out in about fourteen months. The steel flues were pitted so badly we could not put them back; the iron flues were not pitted at all that we could notice. Before this I had been ordering all steel flues. I am still ordering some for safety ends, and I find I get better service from the steel ends than I do from the iron ends, but the steel seems to pit. It doesn't seem to have any particular place, either at the bottom or top of the flue. After noticing it very closely, and studying these little pits, I think there is some kind of sediment or sulphur, making a soft place in the flue, that causes it; the action of our water has a tendency to cut through. There will be a small pit, and the flue will be all right all around for twelve or fourteen inches, and still this little pit eats right through it. In the iron flue we don't notice that at all. However, I find that the steel end does better in the sheet than the iron end, and for that reason we have adopted the iron body, welding the steel end on, and we get very good results.

Mr. Rapp: In regard to this proposed test, to be absolutely fair with both materials, I believe it would be better, instead of putting in one material on one side and the other material on the other side, to put in alternate rows. I conducted a test several years ago with Swedish iron and steel on two engines. One engine had both injectors on the right side and the other engine had one injector on the left side and one on the right. I found in the engine that had both injectors on the right side, the left side flues played out first; and on the engine that had the injectors on each side, the injector on the fireman's side was evidently used most, and the right side played out soonest. I would recommend in this test to make alternate rows of iron and steel.

The President: They might get mixed up and not be able to find out which was which.

Mr. Rapp: The only way would be to make a chart of the sheet, and represent one material by an x.

Mr. Elkins: I tried that scheme a few years ago. I put in a set of flues, using iron and steel in alternate rows, but did not get any satisfaction from the experiment, for when they leaked we could not tell which had started the trouble, as all of the bottom ones would be leaking; when we removed the flues after eleven months, the steel flues seemed to be pitted a little more than the iron ones. However, we safe-ended the entire set.

Mr. Brown: The flues that we applied were never touched by the weather. Our flues are kept under cover. In our mineral districts, where steel will not live and iron will, the twelve boilers we are making I think will afford a fine test. There will be six Pacific types and six heavy freight engines, both high pressure. The flues on one side will be iron and on the other steel. For the benefit of this Committee I promise that I will give this my undivided attention for the next twelve months. If a report from me on this subject will be acceptable I will be only too pleased to give it to them, at whatever time they wish.

Mr. Lucas: There is one point I want to bring before the Convention relative to welding steel safe ends onto iron tubes. I want to know what they are going to put them up against. If you use a good iron tube against a steel tube it will be a more fair test than if you use common ordinary body grade iron against the steel tube.

Mr. J. B. Smith: We have been using steel tubes for the last eight years. Previously we had been using charcoal iron. We started in to buy safe ends the same as tubing and we got two or three more months' service out of the iron. Last fall we had a great deal of trouble in our vicinity with bad water and the tubes pitting, and our mechanical department investigated to see what was the matter. I thought the steel flues were giving us the trouble, but we made a chemical analysis and it turned out to be the iron. We are now making several tests with Swedish iron flues versus steel, also sterilized iron flues and sterilized cold-drawn seamless tubes. So I don't know what the result will be. I suppose by the time of the next Convention I can make a report. We are making a test now, putting one-half iron on one side and steel on the other, but every other flue is steel and iron, steel and iron, and so on.

Mr. Brown: The Master Mechanics' Convention some years ago adopted specifications as to the best method, in their judgment, of making a test. This test we have accepted and it has been our guide. The end we put on a flue has to pass the specification, whether it be steel or iron; if it is a safe end it passes the specification and if it is a body flue likewise. This also specifies the gauge for the different parts, that is, the body and the safe end, and I think it is a complete test.

Mr. Linderman: I have been handling steel flues for nearly six years. On our passenger power, with iron flues, the best we could do was 55,000 to 65,000 miles from a set of flues. After adopting a cold-drawn steel flue, we raised our mileage on the same class engines to 100,000, with some engines running as high as 148,000 miles on one set of flues. We have no pitting. Referring to Mr. McKeown's question regarding the cleaning of tubes, we found that steel tubes cleaned easier than the iron.

Mr. McCarrahan: East of Pittsburgh and Erie we have about 3,200 engines. Up to the present time we have been using the best grade of charcoal iron. We have under construction at the present time in the Juniata shops thirty-three consolidation engines, having 465 two-inch tubes, 15 feet by 2½ inches. One-half of these engines are to be equipped with steel tubes and the other half with iron. One year from now I may be able to give you some data as to how they compare.

Mr. Elkins: I move that the discussion be closed.

Mr. Brown: I second the motion.

The President: It has been moved and seconded that the discussion be closed.

Mr. German: I have listened to the discussion on the pitting of flues. I have not heard any remedy advanced for the prevention of pitting. We use both steel and iron flues on the Lake Shore system. We have points on our system where the flues pitted very badly, but we have overcome that difficulty by the use of soda ash and the frequent washing out of boilers.

The President: I want each and every one to take an interest in this matter during the year, and write to the Committee on this subject so as to give them a chance to make a good report at our next annual Convention.

The question was put and the motion carried unanimously.

Official Report

and Discussion of Report of the Special Committee on

Steel *vs.* Iron Tubes

before the International Master Boiler Makers' Association in Convention at Niagara Falls, Ontario, May 24-27, 1910

(See pages 128 to 133 of Official Proceedings)

Report of Committee on Steel *versus* Iron Tubes

The President: The next topic for discussion will be the report of the Committee on "Steel versus Iron Tubes."

M. O'Connor, chairman, read the report of the Committee.

Your Committee on above subject beg leave to report as follows:

During the past year since our last Convention at Louisville, Ky., your Committee made every effort to ascertain the very best information from a great many localities using both steel and iron, relative to obtaining the most accurate knowledge of this subject.

We are pleased to report that the returns came in very satisfactorily as far as promptness is concerned, but materially different in opinion; however, the greatest number reported that as far as actual service is concerned, steel tubes give just as good service as iron tubes, and vice versa.

Relative to welding, we have found to our satisfaction that where an oil furnace is used there is no difficulty or secret in welding steel tubes. In an open coke or coal fire, some opposition is met, due to the impurities in the fuel.

Respectfully submitted,

M. O'Connor, Chairman.
D. G. Foley,
M. M. McAllister,
C. L. Hempel,
B. F. Sarver,
Committee.

Mr. O'Connor: On this subject, "Steel versus Iron Tubes," I would respectfully report that the paper I have on this particular subject is not a long one by any means, but simply a short paragraph, just enough to bring the subject before the Convention in a general way. My excuse for this short paper is that I was unable to get the reports from the other members of the Committee within the time specified by our Secretary: to have them sent in ninety days before opening of the Convention, therefore I deemed it advisable to say just enough to introduce the subject for general discussion; however, Mr. President, I have some data on this subject, and after I hear from other members on this important subject, I will be pleased to give it, and my personal experience with the two metals.

Mr. B. F. Sarver: I have a little report which I would like to read. I made quite an extensive report last year in favor of steel flues; I have a few figures here to verify my assertions made at that time. I will read this report to the Convention.

I have not a great deal to say on this subject at this time. You will remember that I submitted quite a lengthy report on this subject last year, and I am pretty well exhausted with the exception of a few figures, which I would like to submit to substantiate the argument I made last year in my report in favor of steel flues and safe ends.

Since I made my last report to you before the Master Boiler Makers' Association I have gathered some data. I have one engine that has 2¼-inch by 21-foot tubes to submit to you as evidence at this time. This engine when first turned out of shop was equipped with iron tubes and safe ends, making a flue mileage of 47,230 miles. These flues were then removed and the same flues were safe ended with steel safe-end material. After these flues had been applied this engine made a flue mileage of 68,361 miles, thus making a gain of 21,131 miles in favor of the steel safe ending.

We have experienced no trouble to speak of on account of flues leaking since this engine was equipped with steel safe ends. We have also had a test made of twenty-eight freight locomotives which were equipped with steel tubing, and these engines made an average of 75,000 miles per engine.

Our previous flue mileage in this particular location, equipped with iron flues, would not average over 50,000 miles per engine; this would make a gain of 25,000 miles in favor of the steel flues. We do not experience any trouble in welding the steel safe ending in the iron flue. We have also had a great deal less of flue leakage with steel than we do with iron. I do not know that I have anything more to say at this time.

President Brown: What do you propose doing with the subject?

Mr. Laughridge: I move it be received and discussed. Carried.

The President: We will take twenty-five minutes on this subject, if it is the pleasure of the Convention.

Mr. Green: We use iron flues and steel safe ends mostly.

Mr. Bennett: That is our practice on the New York Central, and we get good results

Mr. O'Connor: Acting as your Committee Chairman during the year just passed on the subject matter of "Steel versus Iron Tubes," I am now pleased to give some data, also personal experience with these two metals. On our lines west of the Missouri River where we have some bad water conditions, we have had equipped during the past two years for experimental purposes several engines with steel and iron flues, half and half in each engine, or, if you please, steel on one side of flue-sheet and iron on the other. Five of these engines mentioned have, since May, 1908, passed through the shop, receiving light, heavy, or general repairs, the first engine taken in shops, July, 1909, having following record: Equipped with steel and iron tubes, half and half, May, 1908; removed July, 1909; total number of tubes in engine, 245; condition of tubes when taken from boiler and carefully inspected: 20 steel tubes badly pitted and scrapped, 6 iron tubes slightly pitted but not scrapped; all iron tubes repierced and replaced in boiler; all steel tubes except the 20 scrapped, repierced and replaced at same location in boiler. Iron tubes, while engine was in severe service during ninety days previous to shopping, leaked quite frequently; steel tubes leaked occasionally; efficiency of beads in fire-box in favor of steel.

Second engine equipped May, 1908, with both steel and iron tubes, located in boiler same as first engine, removed from boiler October, 1909; total number of tubes in boiler 245; condition of iron and steel tubes when inspected: 8 steel tubes badly pitted and scrapped, no iron tubes found pitted, and all tubes, both iron and steel except the 8, were repierced and replaced in same boiler, same location as removed from.

Third engine equipped May, 1908, steel and iron tubes; removed 49 tubes from bottom of shell (24 steel and 25 iron tubes) while engine was in shop for light repairs. All tubes were repierced and replaced in boiler; none scrapped. Engine still in service, giving good satisfaction with her tubes.

Fourth engine, steel and iron tubes applied April, 1908; all removed December, 1909; condition of tubes after inspection: 26 steel tubes slightly pitted, 20 iron slightly pitted; neither steel or iron tubes in condition to be scrapped, and all were repaired with safe ends and put in same location in boiler as when removed. Condition of tube beads in fire-box end: material strength of steel good, material strength of iron soft and spongy.

Fifth engine, total number of tubes 289; steel and iron tubes applied May, 1908, and all removed from boiler January, 1910. Engine in passenger service, and total mileage made with these tubes without any renewals between May, 1908, and January, 1910, 103,663 miles. Condition of tubes when removed from engine boiler and closely inspected: 14 steel tubes badly pitted and scrapped, 49 iron tubes, badly pitted and scrapped; all other tubes taken from this engine were repaired with safe ends and replaced in same location in boiler. While engine was in service from May, 1908 to January, 1910, the tubes, both iron and steel, gave us very little trouble on account of leaking.

Mr. Lucas: Were the iron tubes safe-ended?

Mr. O'Connor: No, sir, they were new flues; they had no safe ends on the flues.

Mr. Linderman: Did you follow up your engine-house work with the roller?

Mr. O'Connor: We use the roller but very little. We use the sectional expander entirely. There is hardly a roller applied in the shop unless it is a loose flue or the first resetting of flues.

Mr. Lucas: We are using both steel and iron tubes, mostly iron, due to the fact that the steel tubes have been recently put on the market, and we are getting fairly good results with all classes; we have had iron tubes pit and steel tubes pit. We are using mostly charcoal iron tubes. We weld on a special charcoal tube for safe ending. We have a number of engines running with steel safe ends, which give us good results. We made a report showing 517 engines, all running with flues twenty-five months and over. Our mileage has gone up to 280,000 in our big passenger engines. We average pretty close to 100,000 miles; and in our good water we could do better. We have a number of sets of steel tubes that have not been in long enough to report on them. On our own district we have 117 engines running with flues twenty-five months and over.

Mr. Linderman: The New York Central is using charcoal iron tubes on which we weld steel safe ends. We do not experience any trouble in welding the steel to the iron, and are getting the best of results. For some time we kept a very close record of the number of defective welds, and found that they averaged five per 1,000.

Mr. McKeown: I think I have probably the report of one engine that has been running, giving the mileage of the steel and iron flues. This was gotten out since I forwarded the report to Mr. O'Connor. One engine has run 49,000 miles, and the other four have been running ten to eleven months. The first one has been running sixteen months, and we have removed two iron flues on account of beads being partly broken off and worn out. According to the report the steel flue has a little the best of the iron flue so far. In the meantime we have removed five flues on account of being split inside of the sheet. In two of them we found a couple of little pieces broken out, indicating that they were probably crystallized a little. That engine is still running to-day, and will probably run two months longer. The iron flues are apparently in very good shape. The report shows a little more work of the iron flue than of the steel flue. If the subject is carried over to our next meeting, I will be able to tell you more about it. I am sorry Mr. O'Connor has not our report in.

The secretary read Mr. McKeown's statement as follows:

Statement showing the number of Steel Tubes worked and the cost thereof as compared with the Iron Tubes which were applied to several engines for test purposes:

Engine 1698

No. Flues Worked	Cost
4913 Steel	$13.55
5919 Iron	15.65

Engine has made 34,480 miles from July, 1909, to May 1, 1910.

Engine 1704

No. Flues Worked	Cost
4770 Steel	$13.39
5712 Iron	15.31

Engine has made 29,294 miles from September, 1909, to May 1, 1910.

Engine 1702 — Detroit

No. Flues Worked	Cost
6112 Steel	$17.87
7520 Iron	21.28

Engine has made 31,629 miles from August, 1909, to May 1, 1910.

Engine 1751

No. Flues Worked	Cost
5618 Steel	$15.94
6773 Iron	19.89

Engine has made 33,478 miles from August, 1909, to May 1, 1910.

Engine 2008

No. Flues Worked	Cost
5734 Steel	$22.89
8547 Iron	29.91

Engine has made 49,451 miles from March, 1909, to May 1, 1910.

Mr. L. M. Stewart: On the Atlantic Coast Line at the Waycross new shops, where I am located, until six months ago we welded steel ends on charcoal iron bodies. In other words, it made no difference what material the safe ends or flue bodies were made of, we welded together and had good results. In the past six months we have adopted a standard No. 10 gauge charcoal iron safe end and No. 11 gauge Spellerized flue bodies. We weld about 4,000 per month with Furgerson oil furnaces, and get good results.

On motion the discussion was closed.

Official Report

and Discussion of Report of the Special Committee on

Steel *vs.* Iron Flues

before the International Master Boiler Makers' Association in Convention at Omaha, Nebraska, May 23 to 26, 1911

(*See pages 193 to 204 of Official Proceedings*)

Steel *versus* Iron Flues

The President: We now come to the topic, "Steel versus Iron Flues. What Advantages and What Success in Welding Them, and the Effect of Length of Tubes and Maintenance."

The President: Mr. Raps, have you the report of the Committee?

Mr. Raps: Mr. Linderman is chairman of this Committee but he is unable to be present. I wrote a short report myself and sent it to Mr. Linderman, but I have no copy. I was unable to prepare the report that I would like to have made, and I would suggest that the Committee be given another year's time, as I know that Mr. Linderman is making some very interesting experiments. I think the Committee can promise you a good report if you so order.

Mr. President: I will ask Mr. Kelly to read the report of the Committee.

Albany, N. Y., May 20, 1911.

Dear Mr. Lucas: It will be impossible for me to meet with you at Omaha. Owing to labor troubles we are having it has been impossible for me to get out the report of the Committee of which I am Chairman. I have been working night and day for the last three months and have not been to the office in ten weeks.

I am sorry to disappoint you in this matter and I assure you that my intentions were of the best, but I have been going the limit since the trouble started.

I am enclosing what information I was able to get from the other members of the Committee, which may be of some use to the Convention.

Hoping you will have a pleasant and profitable Convention, I remain,

Yours truly,

F. A. LINDERMAN.

Mr. F. A. Linderman, Chairman, West Albany, N. Y.

Dear Sir: This subject is of vast importance. My first experience with steel flues was in 1900. We received a set from the Shelby Steel Tube Company. We applied them to one of our engines; they worked fine and gave good results. We also welded a set of safe ends to iron flues without any trouble whatever. We have handled the Detroit steel flues, also with good results. We have five engines running on test with one-half set of Spellerized flues and one-half set of iron flues, which are giving good results. We have no trouble in welding safe ends to flues, nor in welding steel safe ends to iron flues.

In regard to pitting, we haven't noticed any so far. I am of the opinion that steel flues are the coming thing. I have a preliminary report of 171 Spellerized steel and 171 charcoal iron flues as applied to this engine, No. 2008. Summarized the test from time flues were first applied to this engine, 2-12-09, until the engine was again shopped and flues removed, 10-1-10.

Yours truly,

JOHN McKEOWN.

Preliminary report of 171 Spellerized steel and 171 charcoal iron flues, as applied to engine No. 2008, summarizing the result of test from time flues were first applied to this engine, 2-12-09, until the engine was again shopped and flues removed, 10-1-10

Requirements

Flues for use in locomotive boilers should be of such a character that safe ends can be easily welded onto the body of the flue, without danger of injuring the material so as to make it brittle. The material in flues should be of such a composition that they can be rolled or prossered without danger of breaking the flue inside the flue-sheet, or without having the beads break off. The flues should be of such material as to resist the pitting action of water, and should also resist the formation of scale as much as possible.

Conclusions

The test as made shows the first cost of steel flues per foot is 28 per cent cheaper than iron flues, that the cost of maintenance of the steel flues is 38 per cent cheaper than the iron flues.

From the results it is noted that seven iron flues were removed, due to worn beads, as compared with one steel flue removed for the same cause. It has been the impression that the beads of the steel flues were not as serviceable as the beads on the iron flues on account of the nature of the material. Previous tests have been made in which it is shown that beads on the iron flues would last longer. Other tests of Spellerized steel and charcoal iron flues are in progress, which will determine this point decisively.

Seven steel flues were removed due to bursting inside of flue-sheet when being worked. This may be explained by the fact that considerably more care must be exercised in welding the steel flues onto the safe ends to be sure that the metal in the steel flues is not burned, making it brittle. They can be welded satisfactorily, but greater care must be exercised in welding them at the proper heat.

The results of the present test show that the steel flues accumulated or held two times as much scale as the iron flues. This accumulation of scale would make the steel flues less efficient regarding the transmission of heat, and if this condition prevails in the case of other steel flues on test it will be a heavy argument against their usage.

By referring to the attached table of results it is noted that the loss of weight due to corrosion and cutting off the beads, when removing the flues, is 1.22 pounds per flue for the iron flues and 1.79 per flue for the steel flues. The steel flues were somewhat heavier when first applied, but from the test made it could not be ascertained just why the loss in weight on the steel flues should be greater.

Tests

Engine 2008, which left Galion shop February 12, 1909, was equipped on the right side with 171 Spellerized steel flues, on the left side with 171 charcoal iron flues, for comparison. These flues were removed about October 1, 1910, when engine was again shopped for T. B M. F. repairs. The length of service was approximately nineteen and one-half months, with a mileage of 64,460 miles.

Preliminary reports have been furnished each month showing the number of flues worked and cost of working. The complete figures have been tabulated and are attached, and show the number of flues worked and the cost per month since the flues were applied.

A blue-print is attached showing the flue arrangement, also showing location of certain flues which failed in service.

A tabulated statement is attached which shows the results of the steel and iron flues. This sheet shows figures obtained in regard to weights of flues when applied and weights of flues after removal, before and after cleaning.

Sheet showing work necessary to keep flues in engine 2008 in repair; 171 Spellerized and 171 iron flues were applied to this engine, 2-12-09.

Month	IRON FLUES				STEEL FLUES			
	No. Worked	Time Required	Cost Total	Cost Per 100	No. Worked	Time Required	Cost Total	Cost Per 100
March	319	2-55	.85	.497	310	2-59	.83	.484
April	556	8-05	2.39	1.40	357	3-40	1.09	.638
May	390	5-52	1.76	1.03	263	4-43	1.45	.850
June	658	8-35	2.54	1.51	556	6-53	2.11	1.24
July	643	9-31	2.13	1.85	557	9-11	2.80	1.64
Aug.	655	6-07	2.01	1.18	339	5-41	1.87	1.09
Sept.	523	5-21	1.64	.96	372	4-44	1.41	.825
Oct.	704	7-42	2.31	1.35	564	6-15	1.90	1.11
Nov.	983	12-09	3.66	2.14	458	4-33	1.39	1.813
Dec.	988	9-38	2.89	1.69	1,061	9-46	2.97	1.74
Jan.	528	6-15	1.93	1.13	509	6-20	1.52	.89
Feb.	390	3-10	.93	.543	425	3-50	1.15	.67
March	1,112	9-30	2.89	1.69	1,043	10-17	3.12	1.82
April	1,086	12-52	3.87	2.26	781	7-08	2.15	1.23
May	1,290	12-20	3.73	2.18	760	5-30	1.67	.975
June	1,383	14-46	4.48	2.62	766	6-18	1.93	1.12
July	1,297	18-54	5.97	3.48	544	5-15	1.58	.925
Aug.	1,090	14-	4.36	2.55	550	5-35	1.76	1.03
Sept.	982	11-55	3.62	2.12	271	2-20	.70	.41
Total	15,472	179-35	53.96	32.18	10,486	111-58	33.40	19.80

Result of Test

	Steel Flues	Iron Flues
Number applied	171	171
Average weight per flue when applied, pounds	41.1	37.12
Average weight when removed, with scale, pounds	43.28	37.86
Average weight when removed, clean, pounds	39.31	35.9
Weight of scale held by each flue, pounds	3.97	1.96
Weight lost due to corrosion and cutting beads off when removing, per flue, pounds	1.79	1.22
First cost of Flues per foot	$ .09	$ .125
Total first cost	243.00	342.00
Total cost of maintenance	33.40	53.96
Cost per engine (with all flues iron or steel)	552.50	791.92
Flues removed, due to bursting inside of flue-sheet while working	7	0
Flues removed, due to worn beads	1	7
Total mileage made by engine	64,460	64,460

Remarks: Engine failure, one, 7-29-10, due to flues leaking, causing one and one-half hours' delay to west bound freight train.

Mr. Goodwin: I move that the report be received and opened for discussion. Carried.

Mr. Goodwin: I see here is a report which claims that on one side the accumulation of scale was greater on the steel than on the iron tubes. I wish to ask which side the injector is on that particular engine.

Mr. McKeown: On the left side.

Mr. Goodwin: And all the water that was applied to the boiler went in on the steel side, then?

Mr. McKeown: Our engineers are responsible for the water going into the boiler; therefore it is natural for them to use the right hand injector most, and that is why I think, probably, there is a little more scale on the steel flues.

Mr. Goodwin: Do I understand that it is usual for the engineer to work the injector?

Mr. McKeown: Both work. I think they use a little of both. They work the injector on the engineer's side the most.

Mr. Hodges: And invariably when it is possible the engineer wishes to have the fireman work the water, and Mr. McKeown says that the injector on the right side was used the most. From experience I have had and conversation with engineers, as a rule the fireman works the water and the engineer keeps the injector open in case the left side fails.

Mr. McKeown: As a general thing the engineer is responsible and works the right hand injector the most. If anything goes wrong with the right hand injector he has the other one to fall back on. That is why I think probably there is a little more scale on the steel flues.

Mr. Goodwin: In applying those tubes, were they first weighed? Did you weigh the new steel tubes and the new iron tubes when you took them out? How did you find out that there was more scale on the steel than on the iron?

Mr. McKeown: According to the weight, that is the way it averages up. You could not notice very much difference by looking at them with the naked eye.

Mr. Goodwin: When you applied them the second time do you remember whether the steel weighed more than the iron?

Mr. McKeown: I believe the report shows that the steel tubes are heavier.

Mr. Raps: I think I owe the gentlemen of the Convention an explanation. I asked a gentleman, whom I supposed knew, whether the Chairman on this subject had made a report, and he said he had not. I naturally supposed there was nothing before the Convention until it was brought out here this morning. That is how I came to make the remarks I did.

Mr. Kelly: Some three years ago we started dealing with iron and steel flues, and our experience with iron flues is that we cannot get an iron flue that will stand expanding without splitting. The material in the iron flue seems to be all right, but it is simply impossible to maintain engines in service without splitting the flues in the prossering. Take, for instance, engines coming right from the locomotive works, and the first time we expand them they split in the lap weld. The steel flue, the seamless steel flue I prefer, will not do that, and in our experience as to beads with all kinds of steel flues, the iron had a shade the best of it, but I believe that in a steel flue without a seam they will work up easily without working the sheet too much. I don't believe in getting in there with a big sledge hammer. From my experience I think that an iron flue with a steel safe end is the proper thing in bad water.

Mr. McKeown: I have heard of different men having trouble welding steel flues; that they would split at the weld and fall off, would not weld, and all sorts of trouble. We have handled quite a number of different makes of steel flues and have had no trouble whatever.

Mr. Lucas: We have made several tests of iron and steel tubes and have several tests under way now. We find very little difference, and we have no trouble in welding either way. We are getting good results out of both.

Mr. McKeown: We have an engine now running with one side steel lined and the other side copper lined. It has been in service, I think, about three months and is doing pretty well so far.

Mr. Kelly: Mr. McKeown, are those tubes seamless steel?

Mr. McKeown: Yes.

Mr. Kelly: What gauge?

Mr. McKeown: 125 Master Mechanics' gauge.

Mr. Kelly: You have no trouble with them at all?

Mr. McKeown: None.

Mr. J. H. Smythe: I did not intend to take part in the discussion, as the speaker thinks that any one interested in the sale of an article should not be allowed the privilege of the floor while you are talking about his article. In fact, I think your Constitution and By-Laws state that very clearly, but my competitors, Mr. Goodwin and Mr. Conrath, seem to have things cut and dried, and a great deal to say—showing the advantage of their production, but failing to show the disadvantages.

The speaker does not see how Mr. McKeown could make such a showing in favor of any one kind of tubes, when applied as Mr. McKeown has in his engine, as you all know that a round house boiler maker will do his work as quickly as he can in a hot locomotive, and make out his report to suit himself.

I wish to offer an apology to this Association for violating your Constitution and By-Laws by taking part in this discussion, as I believe the Parkesburg Iron Company's charcoal iron boiler tube is able to stand on its own merits. I thank you.

Mr. McKeown: Now, then, Mr. Smythe, we have a blue-print of the shape of the flue-sheet, and those flues are numbered one, two, three, etc., from the center line. The steel flues are on the right side, and the iron flues are on the left side and they are all numbered on the blue-print. Our boiler makers are thoroughly instructed when they go in to note what flues they report, and note the time they do it and the hour. We watch them pretty closely. We also have them note the time they work the left or the right side, and we have the blue-print marked for that purpose.

Mr. A. Green: We have been using steel safe end flues for the last five years. Previously we used iron flues. I find that steel gives the best service on our lines. I believe that every foreman with the same experience with both steel and iron will say that steel gives the best service where they use the expander to make repairs to flues in round house. The iron will not stand it. I think the steel flue is here to stay, as it gives better service than the iron flue especially in bad water districts.

Mr. Wandberg: I consider that I handle and work about as many flues as any one man present, and I have as much bad water, and therefore as many bad flues to work on as any one. I don't agree with some of the remarks made, especially by Mr. Kelly, when he claimed an iron flue wouldn't stand without splitting. I am under the impression that the flue Mr. Kelly refers to is simply an iron body flue. We have steel safe ends on our flues with a space deep enough, and we have no trouble with our flues splitting on either end; but I find, with the present coal that we are using—the Iowa coal—that it has a large percentage of iron, and unless we clean out the flues before the expander is put in we experience trouble inside of the flue-sheet. We have had a number of flues burst in that way, but that is the only trouble we have had. As far as the iron flue standing up and working, with the steel safe ends, I tell you there is no difference; but the iron flue has a little the best of the steel when it comes to pitting.

Mr. Conrath: Mr. Kelly, what has been your experience with Spellerized versus iron tubes in comparative tests?

Mr. Kelly: The test was in favor of the iron, but it was so little you could hardly notice it. I didn't inspect those flues alone. I had the superintendent of shops with me and we both made our report. And we didn't look at one flue. We looked at each flue and every part of it all the way through.

Mr. Conrath: How did the tubes test out in the bad water territory between Missouri Valley and Sioux City? This was a comparative test with iron, to ascertain which would resist corrosion to the greatest extent. I have a record which is taken from Mr. O'Connor's report at the Niagara Falls Convention, and the numbers of these engines were 202, 1209, and Wyoming No. 3.

Mr. Kelly: I can't recall the case you speak of.

Mr. Conrath: One was engine No. 202, the other No. 109, I believe—on the Wyoming-Northwestern.

The President: Ordinarily I am on the floor, and always wanting to say something, too; but you have put me up here and don't give me a chance to say a word, and I am getting all out of practice. You know the claims made for the Jacobs-Shupert Fire-box—something new—and it sounded good. A few years ago we started out with the steel tube. It has been developing and we have been getting results. We started experimenting with steel flues a little over six years ago, and the first flues we put in at that time are still in service. So far none are pitted. We have iron flues furnished us twelve or thirteen years ago, and a great many of them are still in the service—a great many of them have been scrapped and some are pitted. During that time we have had steel tubes of all makes in the service, and we have some in service twenty-nine months—still in service and still doing business. The same is true of iron flues. We have steel tubes in service forty-five months and still doing service; we have iron tubes in service that length of time and still doing service; so I say there is good in both. It will take years to show what the actual life of a steel tube is over and above and against an iron flue. I claimed a few years ago that the life of an iron tube was about twelve years. Under certain conditions we have iron tubes alongside of them and they pitted through in about the same time; so again I say, we can get good results from both.

Mr. Laughridge: I have not been taking much part in these discussions, but I don't want to get tongue-tied. I don't want to say too much on the flue business. We have been using steel flues for seventeen years, and I think we are pioneers in the business. About six years ago our superintendent of motive power thought we would try a couple of sets of iron tubes, to see if we could keep the flues tight. At that time we were having trouble on account of the dry season in keeping our flues tight. We applied those sets of iron tubes and they lasted ninety days, where we were getting about eight months out of the others. The Pennsylvania Railway is in the same locality—I think their record shows about the same percentage as ours, but the days and the service are in favor of the steel tube. As far as pitting is concerned, I believe that is entirely a local condition. *We* don't have any pitting either on iron or steel. We have such a heavy encrustation of lime that after one trip the tube is covered like a coat of whitewash; so I think the question of pitting is entirely local. It may be that some localities can use the steel and cannot use the iron, and vice versa. As I have said, we are pioneers in the steel business and we are in it to stay. We have had seventeen years' experience with it, and we are not going to change to the iron tube unless local conditions change.

Mr. McKeown: I wish to ask all the gentlemen who spoke of the flues pitting, where they split—in the boiler, or on top or bottom or at the front flue-sheet?

Mr. Wandberg: We find that the bad flue is invariably where there is the heaviest pitting, and at the bottom side of the flue also. Mr. Laughridge remarked that the pitting is local; but he also stated, practically, that a scale was formed on the flue and that it gave the flue no chance to pit. I don't agree with that. I find, while we may have a coat or two of scale throughout the flues, before doing anything with that, if the scale is knocked off, pitting is found under the scale and in the body of the material.

Mr. McKeown: I find in our divisions there is very little pitting. We have some, but find it on the bottom side of the flues toward the front flue-sheet, but we do not find any on top. In certain localities it occurs, but we find it on the bottom part of the flues at the front end; we do not find it at the back end, nor on top.

Mr. Conrath: The pitting of tubes is not altogether due to impurities in the water, but sometimes to poor circulation and low temperature. Where the degree of heat is below 160 degrees F., the gases that enter into the boiler with the feed water will attack the material, as along about that temperature the gases are at their most destructive power, and I find that in our modern long locomotive, the tubes pit to a greater extent in the front end. This I believe to be due to the low temperature and poor circulation.

Mr. Chapman: I disagree with Mr. Conrath that it is in the circulation. The circulation ought to certainly work on all boilers on railroads alike, when you are working your engines and flues under similar conditions. On that part of the Union Pacific where I am, the pitting does not occur in the front end at all. I can show you flues that pit only in the first eighteen inches of the fire-box. I don't believe it is in the circulation at all. I believe in water circulation, and I know that the circulation ought to be alike, and I believe you will agree it is alike when the districts are the same.

The President: Most of this is due to local conditions and electrolysis. I think we will have to close this subject, as the time allotted has long been exceeded.

Mr. Gray: On the Chicago & Alton we have used about all the different makes of iron and steel. As far as mileage is concerned and the amount of care we have to give the flues while in service, I have been unable to discover any difference between the iron and the steel flue; but when it comes to welding there is a great deal of difference. We have had considerable trouble with steel flues breaking off at the weld. This does not always occur in the new weld, but frequently at the second. After this weld has been in the boiler for the second time and made considerable mileage, it will suddenly break off and cause an engine failure, which goes to prove that you are never sure of what kind of weld you have on a steel flue. We have had many engine failures owing to the breakage I have mentioned.

Mr. Laughridge: I move that the subject be closed.

Mr. Kelly: I would like to have Mr. O'Connor answer that question about the test on the lines west of here that I couldn't answer, with reference to pitting, in connection with engine No. 202, as I did not see the flues when removed.

Mr. O'Connor: In reference to Mr. Kelly's suggestion requesting me to state to the members my experience with steel and iron tubes and what success we have obtained:

I assure you, gentlemen, that I am only too glad to report to the body just what the test of steel and iron tubes gave us on the C. & N. W. lines west of the Missouri River.

The manner of making the tests was carried out accurately, and the results reported to my superior officers, according to their instructions to carefully inspect and report all defects in either steel or iron tubes when they were removed from the locomotives having test tubes applied. These locomotives under test were not all assigned to any one district of our division, but to several districts along the division. The lines west of the Missouri River, comprising the Nebraska and Wyoming Divisions of the C. & N. W. Ry., cover a large territory and consist of about 1,700 miles of railway. So you can readily see that in such a large territory it is possible to expect different water conditions, which naturally bring about the defects, pitting, etc., in our boiler tubes.

Engine No. 202, referred to in this subject, in passenger service, running between Omaha and Norfolk, Nebraska, eastern district, was equipped with the test tubes, half and half, steel tubes right side, iron tubes left side. The mileage made from the time the engine was equipped with these tubes until taken into the shops for general repairs to machinery and resetting of all tubes, was 103,000 miles. In removing these tubes from the boiler care was taken to keep them separate, and also when placing them in flue rattler to clean them.

After removing them from the cleaning rattler they were thoroughly inspected, with the following results: 49 iron tubes badly pitted and scrapped; 14 steel tubes badly pitted and scrapped.

All of the tubes mentioned in these tests were new tubes. No welded tubes were applied. At the same time a similar test of steel and iron tubes was made on one of our locomotives on the western district, in Wyoming, with results just the reverse—more steel tubes pitted than iron tubes. I could not say just at this time the number of defective tubes involved in this test, but the total number of scrapped tubes was not as great as in the test made on the eastern district with engine 202.

Attention was also given those engines having steel and iron tubes applied, relative to service obtained at fire-box end, and after making personal inspection I found that the material strength of the steel tube bead was better than the iron, the latter material being of a more soft and spongy nature, while the steel bead remained almost in its natural condition; hence the results were that we had fewer leaky tubes from the steel than from the iron tubes.

A Member: Do you use steel safe ends or iron ends?

Mr. O'Connor: We use both. On our heavy power we use steel safe ends; on our small power we use iron ends.

Mr. Conrath: There were 14 steel against 46 iron. I think I have the record—only nine were thrown away.

A Member: Why do you use steel safe ends on your heavy power?

Mr. O'Connor: We get better service in the fire-box end.

The motion to close the discussion was put and carried.

It is generally understood that much depends on the boiler tube, especially in locomotive service, this being relatively the weaker member, so that the usefulness of the engine is frequently determined by the strength of the weakest tube.

Rogers & Company
Chicago – New York