flue gas analysis. The test showed the following relative conditions:—

Sample of gas taken.	5:00 P.M.	5:30 P.M.
Carbon dioxide, CO_2, per cent...	11.3	14.3
Oxygen, O_2, per cent.	6.5	5.5
Carbon monoxide, CO, per cent...	2.4	0.0
Nitrogen, N_2, per cent.	79.8	80.2
Air excess, per cent.............	45	36
Temperature flue gas, of.	545	700
Heat lost due to CO, per cent....	9.7	
Heat lost due to increased temperature of flue gas, per cent.		4.3

The first analysis shows a considerable amount of CO to be present. Before taking the next sample the CO started to burn through the passes of a 600 horse-power Aultman & Taylor boiler, and the CO was being entirely consumed. The flue temperature rose 155 degrees on account of the burning of the CO through the passes of the boiler instead of in the furnace. There was no combustion chamber and the fire was so thick that it came close to the bottom row of tubes.

A number of points can be drawn from this instance. (1) Had the boiler been set with an ample combustion chamber all gases would have been burned before coming in contact with the heating surface, resulting in a gas analysis like No. 2, but with a temperature corresponding to No. 1.

(2) The fire should not be carried so thick that CO will be formed, as it is very difficult to burn it all in a boiler furnace when once formed and the loss due to small percentages of CO is very great.

. . .

(3) The determination of CO_2 alone is not sufficient to determine whether the boiler is being properly fired. In the case of No. 1 sample a CO_2 indicator should have shown 11.3 per cent. CO_2, which would ordinarily have been considered very good, but there would have been no indication that CO was present, while the loss due to it was as great as if the CO_2 had been only 7.5 per cent. with no CO

TIGHT JOINTS IN PIPE SEWERS.*

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The importance of tight joints in pipe sewers was impressed upon my mind early in life in a small western town for which I prepared plans and specifications for a sewer. It was my first experience in this sort of work and I prided myself that I had fixed the joints so that none of the sewage would get away, by providing that the pipe layer should use his hands in applying the cement mortar until the joints were evenly filled on the bottom, sides and top of the pipe, and that the joints be swabbed from the inside to remove any mortar that might have passed through between the ends of the pipe. The town council decided to import from a neighboring city an experienced sewer man. He proved to be a big husky son of Erin, who, after looking over my specifications proposed to tell me "more in a minute about sewers than the person who wrote those specifications would ever know." He said, "the joints should be open on the bottom so that a portion and sometimes all the water would seep out, thereby causing less odor at the outlet," and added, "whoever heard of a man using his hands to place mortar when trowels were made for that purpose," together with many caustic remarks which caused my ears to burn for days.

Some 2,000 feet of sewers were laid under those specifications by the experienced sewer man from the city, but not under my supervision. So well did the contractor carry out his idea of open joints that when, several months later, I examined the work, I found, to my great mortification, a small creek of spring-like water flowing from the outlet, the sewers having drained a number of wells and cisterns along their course.

The ordinary contractor is averse to making tight joints, arguing that they are an unnecessary expense. I have found it exceedingly difficult, and in many cases impossible, to satisfactorily impress on the average person that has to do with the laying of sewers, the importance of making the joints tight, and I have personal knowledge of cases where due consideration was not given this important feature in sewer work by those who prepare plans and specifications for sewer systems. I recently examined a few sewers with a view of determining as near as possible the exact amount of infiltration. To my surprise I found that in one extreme case fifty-two gallons per minute was flowing from four hundred and twenty feet of nine inch sewer laid in 1896 for a real estate company. There is but one small residence connected with that sewer.

Sewer contractors have frequently assured me that it is not at all difficult to make tight joints in a dry trench, meaning probably that the joint they make, though imperfect according to my standard, would answer the purpose under such conditions. I have found, however, that when they were permitted to use water to settle the earth in the trench, a method which I avoid if possible, there was considerable leakage into the sewer whether the trench was dry or wet.

The Department of Engineering of the city of Erie, which I represent, has expended during the past fifteen years a great deal of money repairing breaks in sewers and streets, caused by defective joints. In an effort to stop that financial leak on future improvements, I procured copies of sewer specifications from neighboring cities and personally experimented with every scheme suggested for making tight joints. All kinds of trouble was experienced in trying to persuade or compell the pipe layer to follow instructions and give the various methods a fair trial. The main fault seemed to lie in his failure to properly place the gasket in the socket under the pipe. For after a pipe was finally set, it was often found that the gasket, on the under side, was either out of the socket or had been caught by the pipe which was being laid and jammed between the ends of the two pipes. From the point of view of the inspection, at the top of the trench, the joint would appear to have been perfectly made. It soon became evident to me that success depended as much upon the man in the trench as upon the method. The man had to be taught and this I did by giving demonstrations.

I decided to use a fairly large oakum gasket, prepared in advance in lengths sufficient to pass around the pipe and with the ends lapped over enough to equal the diameter of the pipe. The gasket should be immersed for several minutes before using in a bucket of Portland cement and water mixed in the proportions of about one to one. It should be so placed in the bucket that it can be readily removed and speedily placed in position by the pipe layer's assistant by taking one end in each hand, in which position, he draws it around the end of the pipe as it is being laid, or he drops the centre of it in the lower part of the socket of the pipe previously laid and the next pipe is laid on it. Then the ends of the gasket are drawn across the top of the pipe and it is driven into the annular space, working from the sides to the top, after which the joint is neatly trimmed with stiff mortar. Either manner of placing the gasket, as mentioned above, is satisfactory in a dry trench, but in a wet trench the best results are obtained by placing it around the end of the pipe as it is laid.

The greatest difficulty encountered was to procure a desirable oakum and in such form as to insure economy and dispatch in preparing the gaskets. The common practice of using plain or tarred baled oakum, from which the contractor twisted his gaskets, proved unsatisfactory because the gaskets were of uneven thickness and could not be forced into the joint, and the tarred spun oakum was discarded because it would not absorb the cement. An investigation among the dealers in hemp, from which oakum is produced, revealed a product spun into strands, of which two or more were twisted into a loose rope called "hemp packing." It can be cut into the desired lengths with a very small per cent. of waste and it absorbs a large quantity of the thin cement mortar. One strand is about the proper thickness for an eight-inch pipe, and two strands for a

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