The Philadelphia Experiment With Garbage Cooking

By JOHN A. BAILEY, M.G.A., and ELMER T. WILLIAMSON

PHILADELPHIA became concerned in 1953, as did many other municipalities, with the immediate effect of the 1952 outbreak of vesicular exanthema and the cooking measures recommended for its control (*1–4*) because a substantial portion of the city's raw garbage has long been used for hog feeding.

With the passage of legislation (*5*) which required the cooking of all garbage fed to hogs in Pennsylvania after July 1, 1953, the Philadelphia Department of Streets-Sanitation became active in the control program. When too little information could be found in the literature on the effects, methods, and standards for the pressure cooking of garbage, the department decided to gather its own information so that it could intelligently advise local garbage feeders. After an evaluation of the city's two garbage reduction facilities, experiments in cooking garbage by steam pressure and open truck methods and in feeding the cooked products to hogs were started in the fall of 1953.

Facilities at Harrowgate

Philadelphia owns two garbage reduction plants, the Harrowgate incinerator and the city reduction plant. Both plants have processed garbage over the years for its grease content, although the processing was profitable only when greases were in short supply during World War II. The two plants have a combined capacity of approximately 400 tons a day; it is not used to its fullest extent because garbage cannot be delivered on a 24-hour basis.

Rubbish is incinerated in the Harrowgate, Bartram, and Southeast incinerators, but even when these plants are operating at full capacity, they cannot handle all the rubbish in the city, much less the garbage being processed at the two reduction plants. This situation will be remedied somewhat, however, upon the completion in 1955 of a major incinerator modernization and construction program which will add 2,000 tons of daily capacity to the existing capacity of 570 tons.

It was decided to conduct the garbage cooking tests at the Harrowgate incinerator since its buildings and digester tanks were more readily adaptable to pressure cooking experiments than the facilities at the city reduction plant and since the trucks delivering the cooked garbage from the reduction unit to the cooperating farmers would interfere less with the daily operation of the plant. The Harrowgate plant could handle the additional trucks necessary and, with only slight modifications to its conveyor system, could deliver cooked garbage to the farmers' trucks by conveyor and gravity.

The Harrowgate incinerator, erected in 1923, is now being rebuilt as part of the city's incinerator expansion program. It has a reduction unit of 8 steel digester tanks and 2 hydraulic presses. This unit was added to the inciner-

Mr. Bailey is the deputy commissioner of the City of Philadelphia Department of Streets and has line direction of the sanitation division (all sanitation operations). Mr. Williamson is superintendent of the city's Harrowgate incinerator, where the experiments discussed in their report were conducted.

Table 1. Philadelphia experiment with garbage cooking under steam pressure at Harrowgate incinerator—3 to 5 tons of garbage cooked in each of 25 tests [1]

Test No.	Steam pressure (p.s.i.g.)[2]	Time cooked (minutes)	Amount of water added (gallons)	Observations
1	50	8	100	Overcooked and unpalatable.
2	70	10	50	Do.
3	35	10	100	Partly cooked; 25 percent in solid state; too fluid.
4	50	10	None	80 percent cooked; insides of potatoes uncooked.
5	70	13	None	Well-cooked; 80 percent solids; palatable.
6	70	15	None	Do.
7	70	10, then 10 [3]	None	Well-cooked; 100 percent solids; palatable.
8	70	15	None	80 percent cooked.
9	70	15, then 5 [3]	5	Well-cooked; palatable but too fluid.
10	15	30	None	Well-cooked; palatable.
11	55	20	5	Do.
12	50, then 15 [4]	5, then 25	5	Do.
13	35	25	5	Do.
14	50, then 15 [4]	10, then 10	5	Do.
15	40	20	5	Do.
16	55, then 15 [4]	8, then 15	5	Well-cooked; 100 percent solids; palatable.
17	20	12	5	80 percent cooked.
18	50	7, then 25 [3]	None	Difficult to dump, but well-cooked; palatable.
19	35	25	5	Well-cooked; palatable.
20	50, then 15 [4]	10, then 21	None	Do.
21	30	30	None	Do.
22	35	15 [5]	None	Well-cooked; palatable; to facilitate dumping, 10 gal. of water added after cooking.
23	25	20, then 17 [3]	5	Well-cooked; palatable.
24	40	25	5	Do.
25	35	30	5	Do.

[1] Tests were run prior to obtaining instrument (equipment reference A) for measurement of temperature; however, a few temperatures were measured with a portable galvanometer.

[2] Pounds per square inch, gauge.

[3] Cooked for additional time without added steam but under pressure.

[4] In test 12, steam was maintained at 50 p.s.i.g. for 5 minutes, then reduced to 15 p.s.i.g. and held for 25 minutes. In the other tests noted, the pressure was reduced and maintained for the time and at the pressures indicated.

[5] Held until pressure went to zero.

ator in an expansion program in 1935. The tanks are lined with 2 inches of cement concrete, which has adequately withstood the corrosive effects of garbage. Only 2 tanks have had this lining patched in 18 years of service, although the hard burned brick lining in the bottom neck has permitted deterioration of the steel necks, and 7 of the 8 necks have been replaced during this period. In addition to increasing incinerator capacity, 4 additional steel digester tanks and 1 hydraulic press are being added to the reduction unit, increasing its capacity by 50 percent.

Garbage at the Harrowgate incinerator is normally processed by waste heat from the furnaces, the steam being produced by a 215-horsepower horizontal water tube boiler operating at 125 p.s.i.g. (pounds per square inch, gauge). The garbage is dumped from the collection truck into a pit and delivered to the digester tank by means of conveyors.

The capacity of each digester tank is from 6 to 10 tons, depending on the density of the garbage. A filled tank is cooked under a steam pressure of 70 p.s.i.g. for 2 to 4 hours to cause a breakdown of the solids. Each 4 tanks feed to a single press through a receiving box. After pressing, the juices flow from the press by gravity to a sump pump and are then pumped under pressure to storage tanks. The tankage (cake)

Table 2. Philadelphia experiment with garbage cooking under steam pressure at Harrowgate incinerator—2 to 2½ tons of garbage cooked in each of 10 tests [1]

Test No.	Steam pressure (p.s.i.g.) [2]	Time cooked (minutes)	Amount of water added (gallons)	Observations
26	15	65	None	Well-cooked; difficult to dump.
27	50	5, then 48 [3]	None	Inadequately cooked; potato green on inside.
28	20	60	None	Well-cooked.
29	35	41	None	Well-cooked; difficult to dump.
30	5	90	None	Well-cooked.
31	10	60	None	Do.
32 [4]	30, then 10	7, then 53	None	Do.
33	0	25 [5]	110	Adequately cooked, but too fluid.
34	10	20, then 40 [3]	None	Well-cooked.
35	15	45	None	Do.

[1] Tests run after obtaining instrument (equipment reference A) for measurement of temperature.
[2] Pounds per square inch, gauge.
[3] Cooked for additional time without added steam but under pressure.
[4] Tank preheated. After 7 minutes at 30 p.s.i.g., pressure reduced to 10 p.s.i.g. for 53 minutes.
[5] Open tank used for this test. After steam was cut off, material cooked in tank for an additional 35 minutes without steam.

is delivered to an incinerator furnace by means of a conveyor system. Grease in the storage tank is separated from the water by means of gravity.

A farmer living near Bristol, Pa., actively cooperated in all the pressure cooking tests by accepting the cooked garbage and feeding it to some of his hogs. The first tests at the incinerator were made with the assistance of a representative of the United States Department of Agriculture. A representative of the Pennsylvania Department of Agriculture, bureau of animal industry, was present at one of these tests and later visited the farm to observe the feeding of the cooked garbage. All tests were supervised by one of the authors.

The length of time, the amount of steam pressure, and the quantity of water added to the garbage were varied from test to test in attempting to determine the most economical and suitable method for processing garbage for feeding to hogs.

Pressure Cooking Method

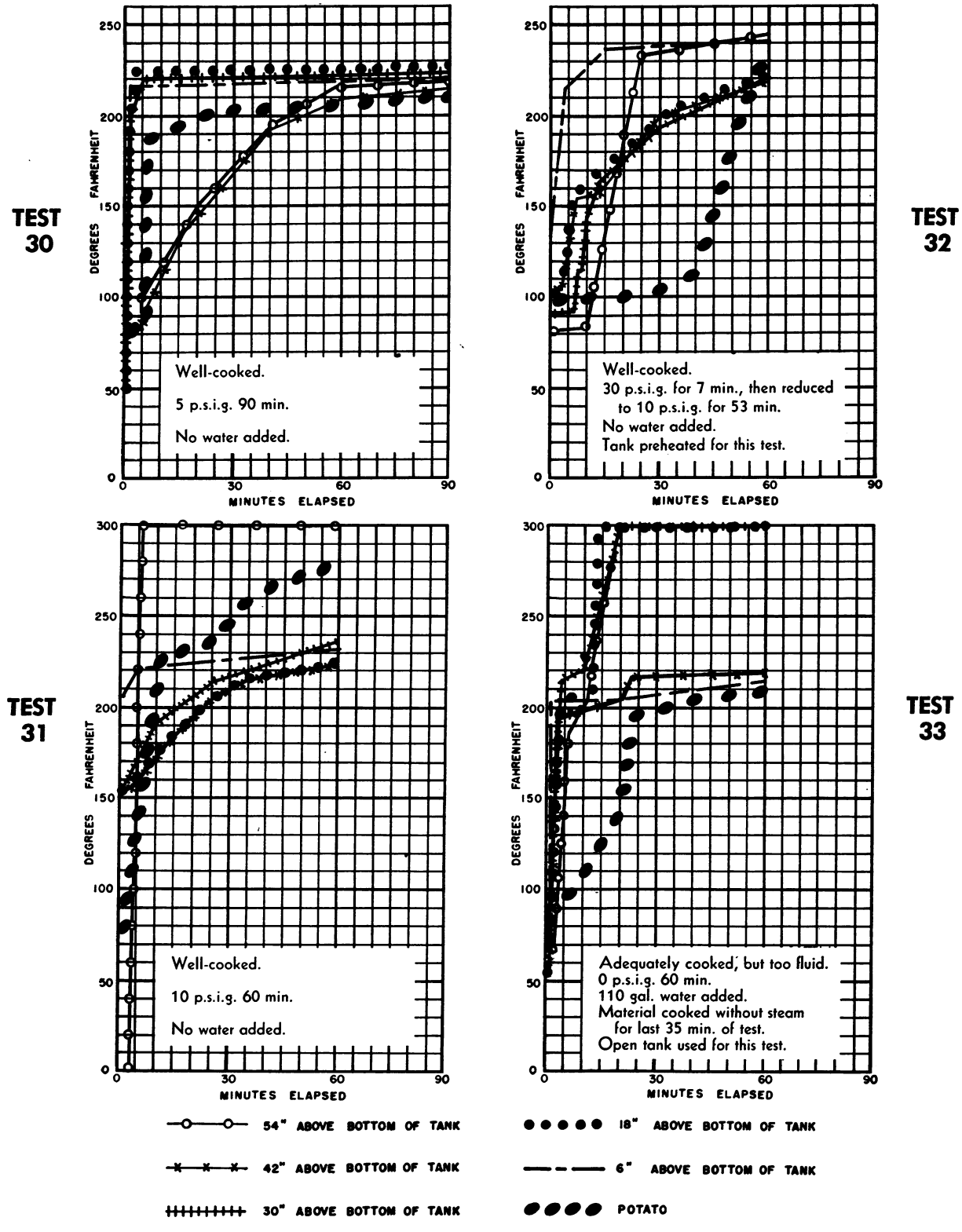
The pressure cooking tests were conducted at the incinerator site. The superintendent of the incinerator made the necessary piping and conveyor modifications and installed a pressure reducing valve and gauges on 1 of the 8 digester tanks at the incinerator. Cooked garbage was discharged from the bottom of this tank through a 12-inch gate valve. The other dimensions of this tank are as follows:

Height	18 ft., 11⅜ inches.
Inside diameter	6 ft.
Cement concrete lining	2 inches.
Steel casing	⅝ inch.
Charging port diameter	18 inches.
Discharge port diameter	12 inches.
Diameter-height ratio	1:3.

The first series of tests (25) was run without a complete record of temperature. However, a portable galvanometer was used for measuring temperature on some of the earlier tests. In the second series of tests (10), the temperature was measured by a temperature-recording instrument (A) with 6 recording stations at which the temperature was measured in rotation every 15 seconds. Thermocouples were spaced at 6 points throughout the digester tank. At the sixth point, the thermocouple was placed in the center of a raw potato, approximately 3 inches in diameter, to measure accurately the temperature throughout the cooking process.

Observations made on these two series are shown in tables 1 and 2. In the first 25 tests (table 1), 3 to 5 tons of garbage were cooked in each test. In the 10 additional tests (table 2), 2 to 2½ tons of garbage were cooked in each

Figure 1. Garbage cooking tests—pressure-cooking method.



experiment, and the thermocouples recorded the temperature at points which were 6 inches, 18 inches, 30 inches, 42 inches, and 54 inches from the bottom of the tank. All of these recording stations were located on the vertical axis of the tank. The sixth thermocouple, inside a raw potato, was located approximately in the center of the tank.

In the cooking process, we were attempting to produce a garbage which would be palatable and still not caramelized, which would require a temperature preferably below 275° F., yet one which could be maintained above 212° F. for 30 minutes to meet the specific requirements spelled out in the Pennsylvania legislation (*5*). Tests 30, 31, 32, and 33 produced a desirable quality in the shortest period of time. The time-temperature graphs for these tests are shown in figure 1.

The first 6 tests were run at high pressures for short periods of time. The garbage in tests 7, 9, 18, and 23 was also cooked at relatively high pressures for short periods of time. Then the steam was cut off, and the material was held under pressure but without additional steam as shown in table 1.

In tests 12, 14, 16, and 20, the loads were cooked at relatively high pressures for short periods of time. The pressure was then reduced, and the cooking was continued for an additional time.

The technique of cooking under pressure, cutting off the steam, and holding the material in the tank under a gradually reducing pressure was also used in tests 27 and 34, while that of cooking for a short period at high pressure and then reducing the pressure and continuing the cooking with steam for an additional period was used on test 32.

Generally, we found that it was not desirable to try to shorten the cooking period by the use of high pressures. However, using relatively low pressures (5–15 p.s.i.g.) for a slightly longer period of time produced considerable savings in time and steam over open truck cooking. Figures 1–6 illustrate the savings in time. At high pressures, the length of time is critical: Overcooking caramelizes garbage, and undercooking gives inadequate temperatures.

Open Truck Cooking Method

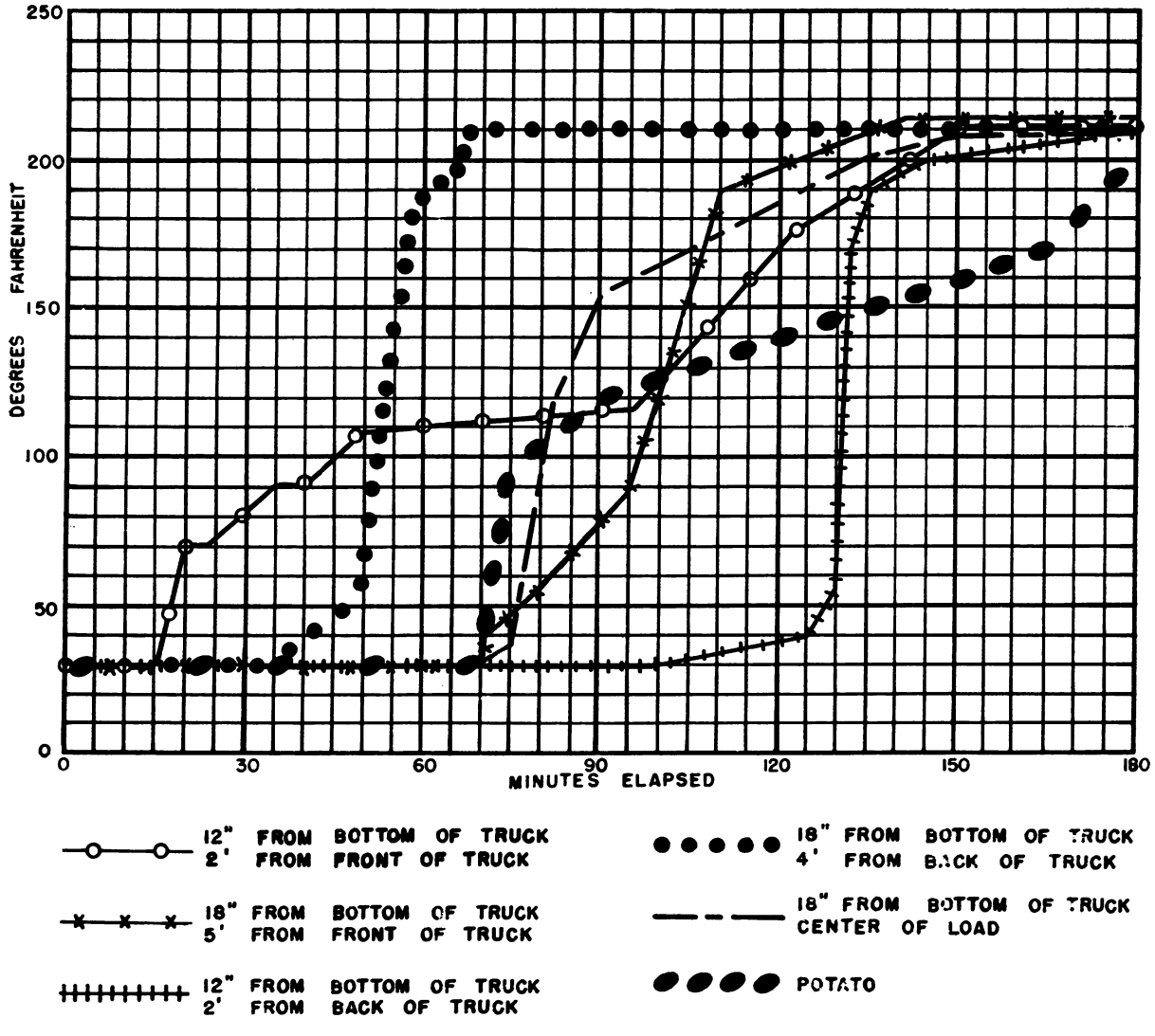
When the Harrowgate incinerator was closed for rebuilding on January 7, 1954, the garbage cooking tests were continued by experimenting with open truck cooking. All of these tests were carried on outdoors. They were run at the city

Table 3. Philadelphia experiment with garbage cooked in open truck fitted with steam pipes in truck floor—5 to 8½ tons of garbage cooked in each of 9 tests [1] [2]

Test No.	Line pressure (p.s.i.g.)[3]	Time cooked (minutes)	Amount of boiling water added (gallons)	Observations
36	[4] 50	120	None	Load not cooked; inadequate steam.
37	70	150	None	Load not cooked in center.
38	[5] 70	165	None	Not adequately cooked, yet caramelized on top.
39	75	180	None	Load not cooked in center.
40	[6] 75	180	None	Adequately cooked.
41	[7] 75	180	35	Center of load well-cooked.
42	[8] 80	160	25	Well-cooked.
43	80	120	30	Do.
44	[5] [9] 80	180	25	Overcooked.

[1] Equipment reference A used to record temperatures.
[2] Truck piped for tests 36–39 in accordance with reference 6.
[3] Pounds per square inch, gauge.
[4] Steam line partly clogged.
[5] Load frozen solid.
[6] New pipe installed above center of load with 18-inch nipples pointing down and drilled with 4 holes every 6 inches.
[7] Size of steam line increased from 1 inch to 1½ inches for this test and subsequent tests in this series.
[8] Header in truck increased from 1 inch to 1½ inches and nipples in center increased from 18 inches to 24 inches in length for this test and subsequent tests in this series.
[9] Each thermocouple placed in center of potato, 3 inches in diameter, most severe test of all. Additional injector nipple added in front of truck.

Figure 2. Garbage cooking test 40—open truck method. Adequately cooked. 75 p.s.i.g. 180 min. No water added. Installed new pipe in center of load with 18" nipples pointing down and drilled with 4 holes every 6".

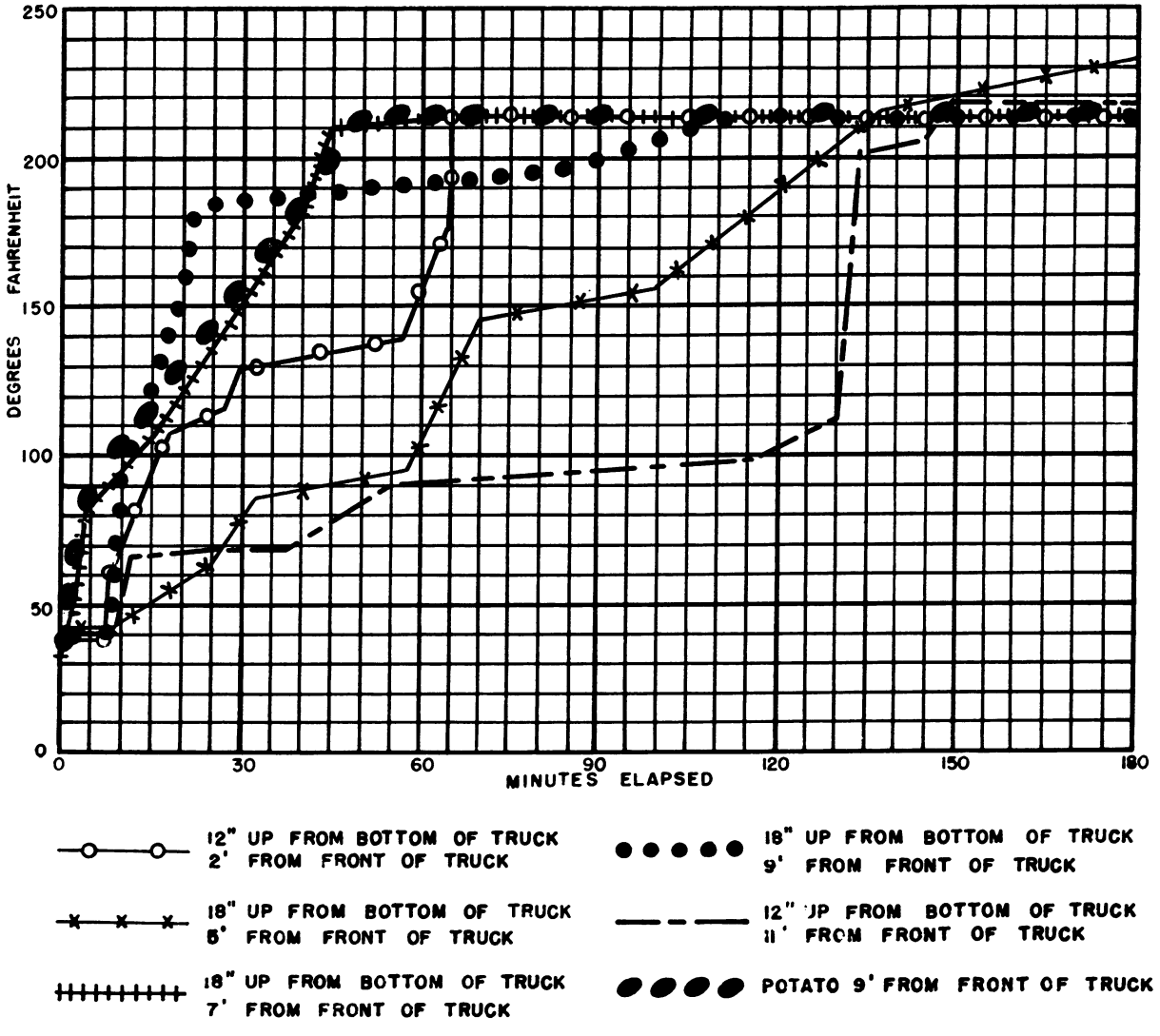


reduction plant using steam produced in 16 250-horsepower horizontal fire tube boilers, fired with fuel oil.

One of the farmer's trucks was piped for steam, and 9 tests (tests 36–44) were run (see table 3 and figs. 2–6), using steam produced by the power plant of the city reduction plant. Temperatures were measured by the same recording instrument (A) used for the second series of tests at the incinerator. The locations of the temperature-recording stations varied from test to test, and the weight of the loads varied from 5 to 8½ tons. The line pressure was about 70 p.s.i.g. A canvas cover was tied over each load of garbage. Recommendations of the United States Department of Agriculture were followed in fitting the floor of the truck with steam pipes (*6*).

After running 4 tests which indicated that inadequate heat was reaching the center of the load, a 1-inch header with 5 vertical pipes, each 18 inches long and one-half inch in diameter, was installed for test 40. This header was placed on top of the load, and the 18-inch pipes were pointed down into the center of the truck. These pipes had holes drilled every 6 inches.

Figure 3. Garbage cooking test 41—open truck method. Center of load well-cooked. 75 p.s.i.g. 180 min. 35 gal. boiling water added. New pipe in center of load as in test 40. Size of steam line increased from 1" to 1½".

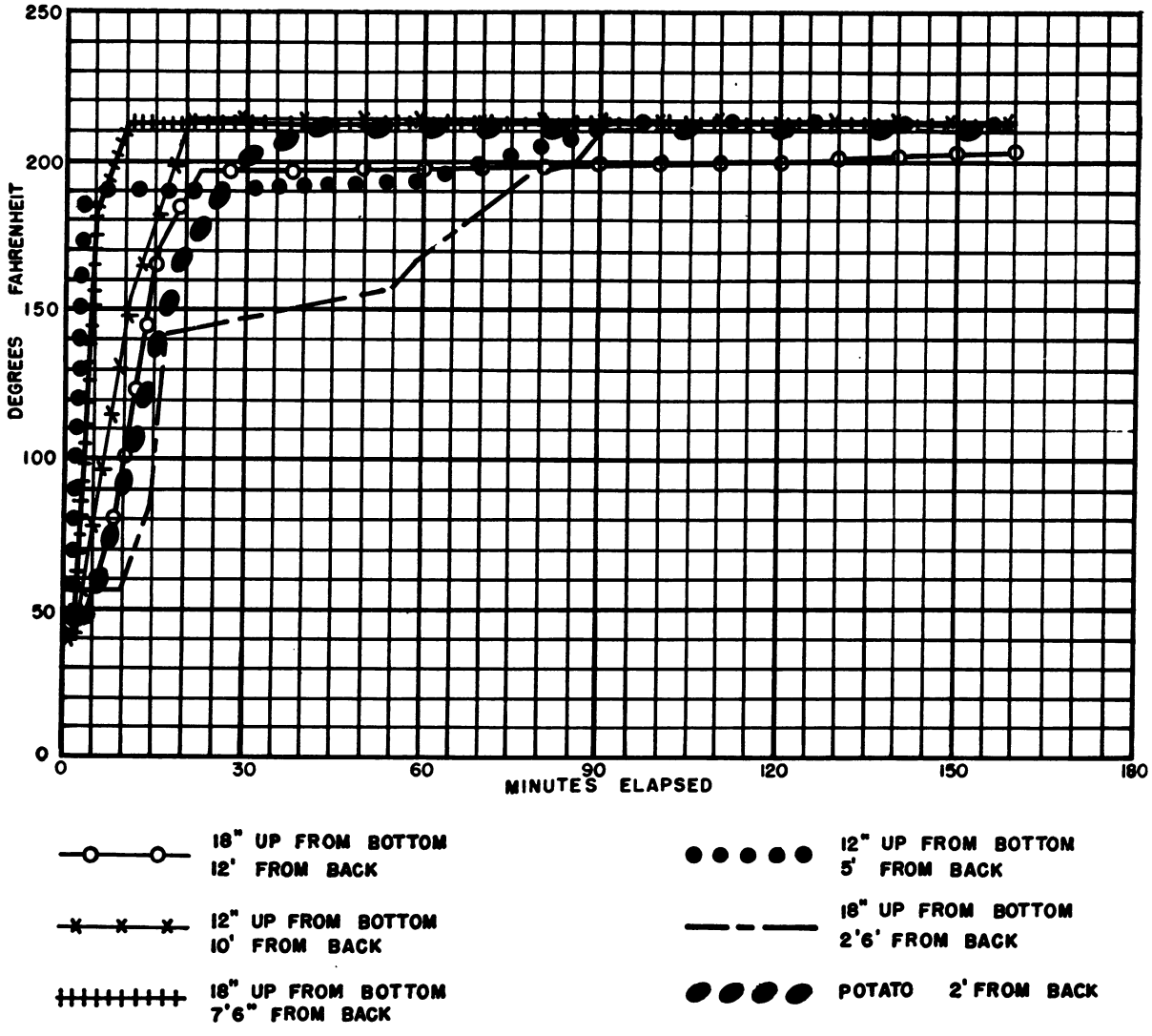


The lowest holes were 18 inches from the floor of the truck.

When we found that it was still taking too long to cook the garbage, the size of the steam line to the truck was increased from 1 inch to 1½ inches from the main steam header in the plant. This was done beginning with test 41. Beginning with test 42, the diameter of the header in the truck was increased from 1 inch to 1½ inches, and the length of the one-half-inch vertical pipes was increased from 18 to 24 inches. The lowest holes for the emission of steam into the center of the load were then 12 inches above the truck floor; and there were 4 holes one-sixteenth inch in diameter at points along every 6 inches of the vertical pipes.

All 9 tests were made at freezing and below freezing garbage temperatures—the most difficult conditions to be met in the Philadelphia area. In tests 38 and 44, the garbage was frozen solid. Hot water at 190° F., which was available at a flow of 5 gallons a minute, was sprayed on top of the loads in tests 41–44. The last test (44) was the most severe of all tests because all 6 thermocouples were placed in the centers of raw potatoes approximately 3 inches in diameter, and the potatoes were distributed throughout the load.

Figure 4. Garbage cooking test 42—open truck method. Well-cooked. Material sufficiently cooked at 120 min. 80 p.s.i.g. 160 min. 25 gal. boiling water added. Same conditions as in test 41. In addition, header in truck increased from 1" to 1½". Nipples in center increased from 18" to 24" in length.



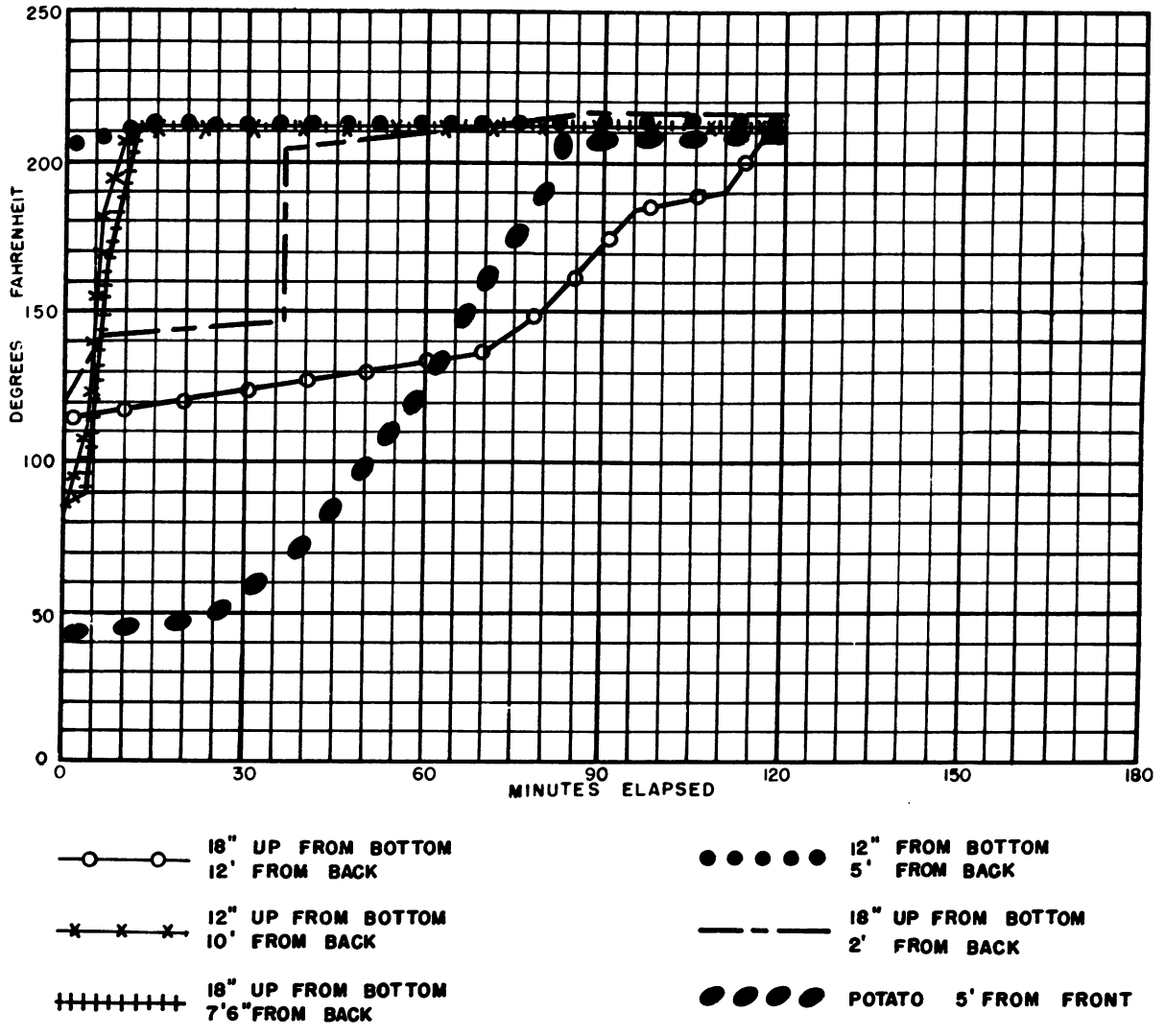
Observations and Conclusions

It would have been desirable to have run additional tests, but this was not possible because the farmer who was cooperating in the tests by feeding the garbage to his pigs withdrew from the experiments. He has since purchased his own boiler, however, and is prepared to cook by steam in an open truck. Also, we lacked measuring equipment to determine the amount of steam used in the different types of tests. Some of our observations are not substantiated by data because of the lack of equipment and the shortened test program.

Experience since 1935 at the Harrowgate incinerator with the use of waste heat for garbage processing has convinced us that at a very reasonable cost the city can provide high pressure steam from the heat which would normally be wasted at an incinerator. Consequently, we have made provisions at the new Northeast incinerator, construction of which is expected to begin by November 1954, for the future installation of waste heat boilers with a capacity of 90,000 pounds an hour.

One possible use of this steam in Philadelphia would be for truck cooking of garbage for

Figure 5. Garbage cooking test 43—open truck method. Well-cooked. 80 p.s.i.g. 120 min. 30 gal. boiling water added. Same conditions as in test 42.



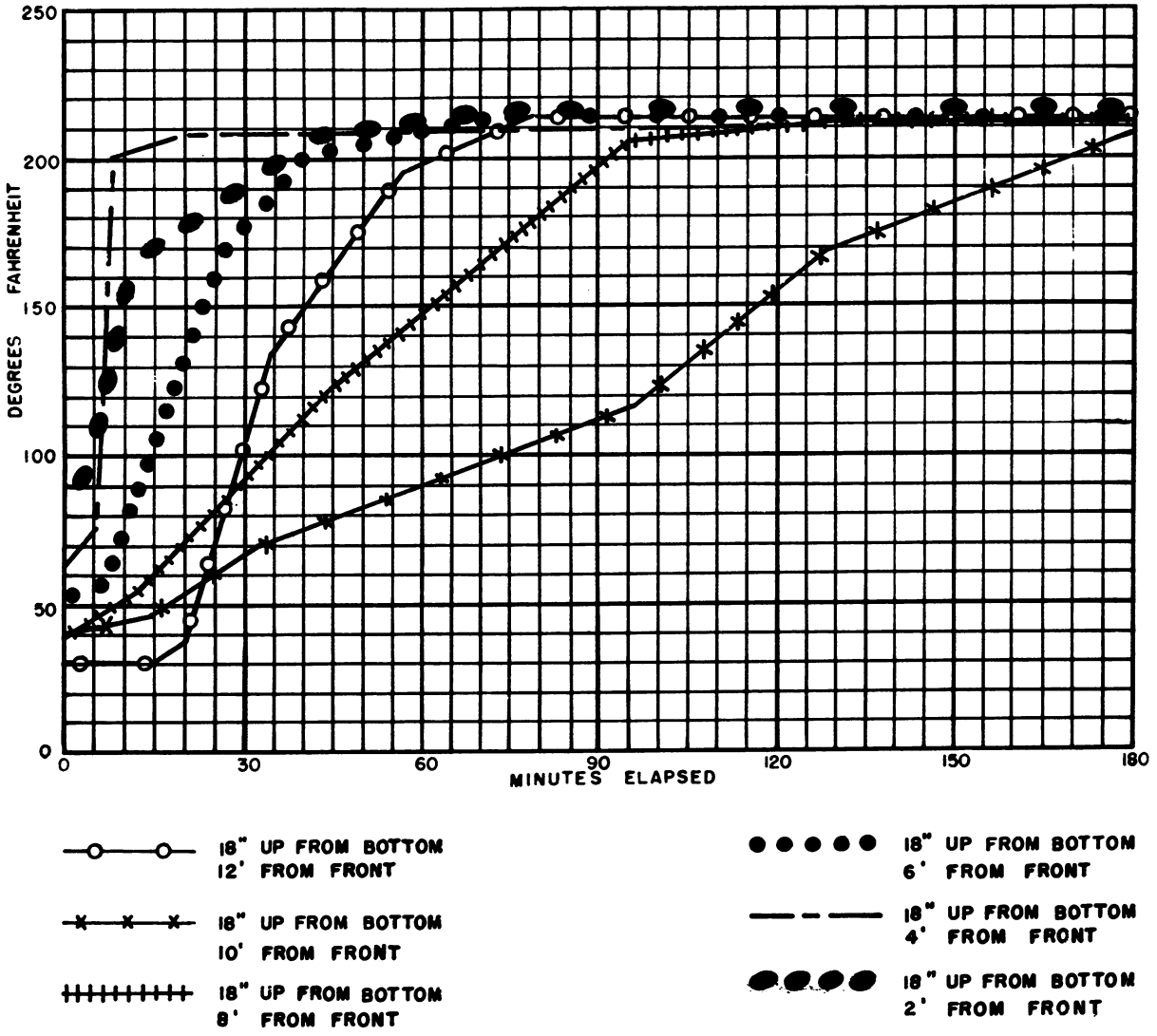
the farmer-collector. However, to obtain the savings from the use of waste heat steam, the farmer would either have to require his laborers to stand by idle for 1½ hours, or he would need twice as many trucks for collection, so that he could leave one truck overnight at the incinerator for cooking at the same time he picks up the truckload cooked the day before.

We believe that the collector would prefer to have his own steam at his own farm rather than to use the method described. According to our experience, he also would prefer the garbage he collects to that collected by others. This would eliminate cooking all garbage at the plant, then exchanging cooled cooked garbage for the raw garbage the collector brings to the plant.

Although cooking garbage is certainly not an insuperable problem for the small farmer-collector, we believe that his reluctance to assume the added capital investment for purchasing equipment can best be overcome through the use of competently supervised feeding tests in which he is demonstrated the practical benefits to be derived from cooking garbage. Others have reported benefits in written reports, but the small feeder is wary of written reports (*7*, *8*).

As a result of these experiments in Philadelphia with pressure and open truck cooking,

Figure 6. Garbage cooking test 44—open truck method. Most severe test of all. Load frozen solid. Overcooked. Material sufficiently cooked at 130 min. 80 p.s.i.g. 180 min. 25 gal. boiling water added. Conditions same as in preceding tests 42, 43. In addition, another injector nipple placed in front of truck. Each thermocouple placed in center of a raw potato 3 inches in diameter.



some observations and conclusions about their value may be helpful to health department officials and others interested in pressure cooking or in making similar tests.

Pressure Cooking

At high pressure, from 50 to 70 p.s.i.g., much of the garbage material is caramelized on the outside before it is thoroughly cooked on the inside. In the first 25 loads tested, a large amount of garbage was obviously unpalatable since the pigs left the burned matter on the feeding floor.

If the digester tank is brought quickly to a predetermined pressure by use of high steam pressure and the garbage is then cooked at the predetermined pressure (usually relatively low, from 5 to 15 p.s.i.g.), the product is palatable. By the time the load is dumped, the temperature approximates the recommended 30 minutes at 212° F. (*5*), or above, without having reached a point high enough to caramelize the garbage. Undoubtedly, all material has reached the critical point (*1, 9*) of 145° F. (fig. 1).

The overall time required for pressure cooking in a tank is considerably less than the time

required for cooking in an open truck. The savings in fuel, and possibly in manpower, may offset the higher cost of equipment and should be studied further by anyone interested in cooking garbage.

Agitation of the garbage being cooked plus cooking under pressure would undoubtedly reduce the time required. Also, in our opinion, all health authorities should give proper consideration to operating pressure cookers in a fixed plant having adequate instrumentation to permit a combination of time and temperature where the critical temperature of 145° F. is exceeded rather than to require a temperature of 212° F. for 30 minutes.

The pressure tanks used at the Harrowgate incinerator were not the most suitable for pressure cooking. A diameter-height ratio more nearly approximating 1:1 would have been preferable for continued operations and for ease of cleaning.

Addition of small quantities of water to the load facilitates the dumping of cooked garbage, but in processing garbage it is not necessary to add water provided the pressures are low and saturated steam is used.

Cement concrete lining such as that in the digester tanks at the Harrowgate incinerator increases the life of steel tanks substantially.

Open Truck Cooking

Although each load was covered with a tight tarpaulin, considerable steam was wasted to the atmosphere. According to our estimates, 4 to 8 times more steam is required to cook a ton of garbage in an open truck than to pressure-cook the same amount in a closed tank. The severe weather conditions outdoors at the time of the tests also affected the amount of steam required for these tests, it should be pointed out.

If the steam flow had been measured accurately, accurate costs would have been available, but the cost of cooking in open trucks seems excessive. It is estimated that garbage cooking in a large plant would cost approximately $0.60 a ton, including depreciation, labor, and supplies, as compared with $0.95 a ton in open trucks, exclusive of labor.

The use of closed trucks would undoubtedly save steam and reduce odor emission to the atmosphere, an important consideration for an urban community.

The use of the header in the center of the garbage speeds the cooking time and assures temperatures of desired levels throughout the load.

Adding hot water to the garbage load reduces the time required to reach the boiling point, 212° F., by about one-half hour.

EQUIPMENT REFERENCE

(A) Brown electronik multipoint recorder model 153x64p6–x4IN6. Brown Instrument Division, Minneapolis-Honeywell Company, Minneapolis, Minn.

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