BOSTON SOUTH BAY INCINERATOR — DESIGN AND CONSTRUCTION

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(Presented at a meeting of the Sanitary Section, B.S.C.E., held on December 3, 1958.)

Mr. Flaherty has described the difficulties of obtaining any site upon which this plant could be constructed. The one finally secured is about as tight a site as could possibly be used. Examination of old maps indicated that this was at one time water front property, in fact it may have been completely under water before the construction of the docks at the south end of South Bay.

In addition to having limited space around the plant, the site required expensive foundations.

GENERAL DESCRIPTION OF PLANT

The purpose of the plant is to burn mixed municipal refuse, consisting of garbage and rubbish. There are six furnaces, each of a rated capacity of 150 tons per day and three waste heat boilers, each of a capacity of 75,000 lbs. of steam per hour. Each waste heat boiler is served by two furnaces.

The building is approximately 241 feet long by 200 feet wide and there are three large chimneys.

The collection vehicles enter the building at the east end passing over truck scales at the entrance. They back against the curb and discharge their contents into the receiving bin. From the bin, refuse is hoisted by grab bucket cranes to the charging hoppers on the top floor, then falls by gravity onto the grates in the furnaces on the stoking floor. After combustion the ashes are dropped into ash pits below the furnaces whence, after quenching, they are discharged by gravity into trucks and hauled away from the plant and dumped.

The flow of gases from the furnaces and combustion chambers normally passes through waste heat boilers, fly ash arrestors, and induced draft fans into the chimneys. Bypass flues are provided from each furnace to bypass the boilers when they require cleaning or are not required for steam production. When the bypass flues are in use

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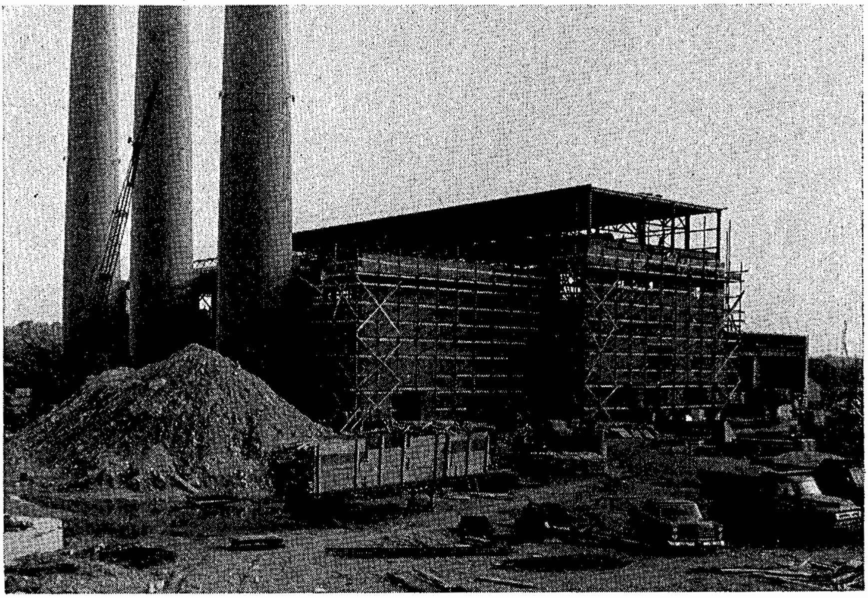
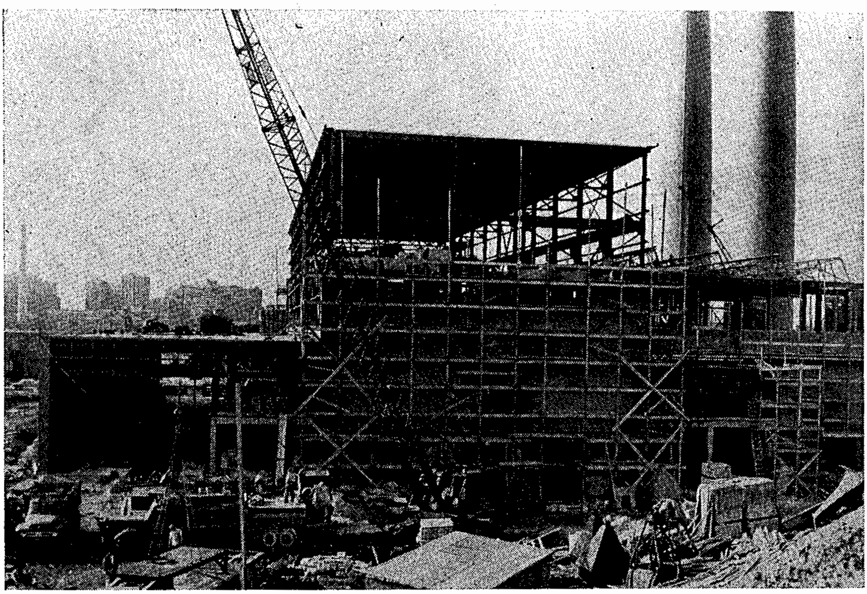


South Bay Incinerator Looking Southeasterly.

the gases may be cooled in a spray chamber before entering the fly ash arrestors and the induced draft fans, or may flow directly to the chimneys, bypassing boilers, fly ash arrestors and I.D. fans. The fly ash arrestors and I.D. fans were manufactured by the Fly Ash Arrestor Corp. and are the dry multiclone type. From the induced draft fans the gases go directly to the chimneys, one chimney being provided for each pair of furnaces. The chimneys are 22 feet in outside diameter at the base and have complete self-supported refractory linings to the top.

The boilers were manufactured by Babcock & Wilcox. They are three-drum, single pass, water tube, waste heat boilers and are equipped with the usual superheaters, soot blowers, and other auxiliaries. In addition, each boiler has auxiliary oil burners to permit steam generation at periods when the refuse furnaces are not in operation. These boilers will generate steam at 250 lbs. per square inch gage.

The steam will be used primarily at the large City Hospital nearby. As Mr. Flaherty has pointed out, a connection will probably be made with the Boston Edison steam system. If this is done, sur-



SOUTH BAY INCINERATOR—BOSTON CITY HOSPITAL IN LEFT CENTER BACKGROUND.

plus steam from the incinerator would become available for use in the Edison system. A small amount of steam will be used for certain auxiliaries in the incinerator building.

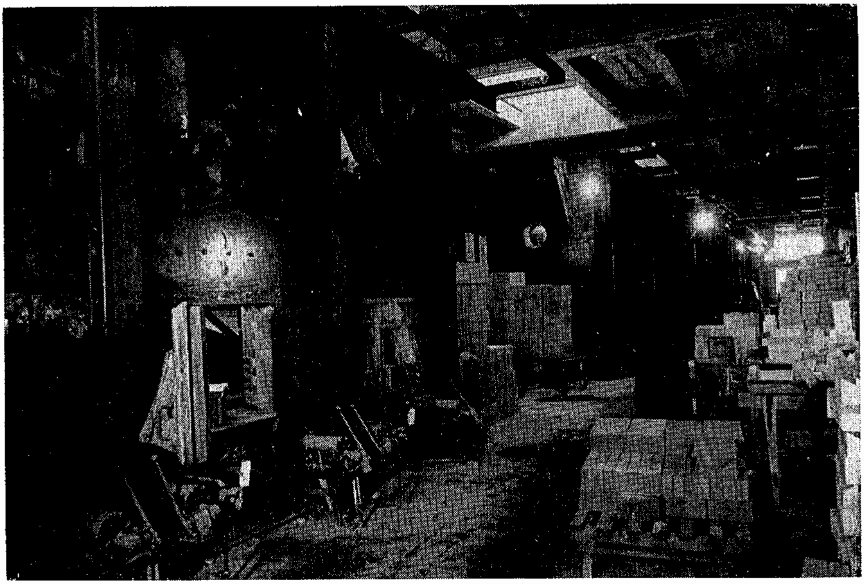
The cranes, of which there are three in number, span the entire width of the bin and charging floor, a total of 67 feet. An end crane can be parked at either end of the room if out of order, at which time the other two cranes can serve all the furnaces.

Charging of the furnaces is controlled by means of hydraulically operated charging gates with water cooled throats located at the bottom of the charging hoppers. The grates are operated hydraulically and are inclined at an angle of approximately 15 degrees from the horizontal. As burning proceeds, the fuel bed is moved forward to the front of the furnace by the upward tilting of alternate sections of the grate. This grate action is controlled by the fireman as the condition of the fire warrants. After the refuse has been thoroughly burned and reaches the front of the furnace, the ash remaining is dropped through a hinged section of the grate into the ash pit below. The refuse for each furnace enters through three charging gates, one for each cell, and falls onto the high end of the stoker grates at the back of the furnace.

There are three ash pits, one for each cell of the furnace. They are closed on the bottom by water-sealed horizontal sliding gates. The ashes are quenched in the ash pits and then dropped through the gates into a dump truck on the floor below.

The furnace and boiler contract was awarded to George Allen & Son Inc. and subsequently was assigned to the Tynan Incinerator Co. Although at the time the contract was signed by the City, sufficient funds were available for only four furnaces and two boilers, subsequent allocations made it possible to extend this contract to include all six furnaces and three boilers, thus providing for the complete plant a furnace capacity of 900 tons of refuse per 24 hour day, with steam generating capacity of 225,000 pounds per hour. The furnaces are designed around the Flynn & Emrich Co. inclined rocker grate stokers. Furnace walls are of the gravity type consisting of first quality refractories with a carborundum brick facing extending 4 ft. above the grate to withstand abrasion and spalling of the furnace walls. Nosings around the charging opening are also of carborundum brick shapes. Arches over the furnaces, combustion chambers and

South Bay Incinerator Boiler Room—Showing Erection of 3 Drum Tubular Waste Heat Boilers—Capacity 75,000 lb. per hr. Each.



SOUTH BAY INCINERATOR, STOKING FLOOR, INSTALLING REFRACTORIES IN RECTANGULAR FURNACES WITH FLYNN & EMRICH STOKERS.

flues are of the Detrick Co.'s American Design flat suspended arches. All walls outside of the furnace chamber are of the insulated unit or sectionally supported walls. Floors which are in contact with hot gases are insulated and air cooled.

For use during periods when refuse may be received with considerable moisture content or a relative high volume of noncombustible material, oil burners have been installed in the furnace chambers to aid in burning the refuse or to maintain proper temperatures for deodorizing the gases. Forced draft fans, one for each furnace, are also provided to aid combustion or to increase steam production when their use may be required. Air for the forced draft fans is drawn from outside the building and blown directly into the furnaces without preheating.

A complete system of controls is provided to record temperatures, drafts and other pertinent information which will be recorded on instrument panels on the operating floor. Part of the control system is the provision for automatically controlled water sprays in the bypass flues to reduce the gas temperature to a degree to permit the gases to enter safely the fly ash collectors and I. D. fans when they are not being chilled by the boilers. In the boiler room sufficient steam driven auxiliary equipment has been provided so that steam generation can be accomplished in case of power failure.

FOUNDATIONS

Borings indicated a deep layer of soft blue clay underlying several layers of fill, silt, peat, fine sand and clay, with compact material and hardpan beginning approximately 113 to 150 feet below the surface. Rock was encountered at a depth of 243 feet at one point. After thorough consideration of various types of construction, it was decided that end bearing pile foundations should be used to support the heavy loads of this building, the chimneys and other equipment.

Because of the steel shortage which was prevalent at that time, contractors were using great ingenuity in the use of used material. Accordingly, bids were invited for driving piles of various types and the bidders were given the option to bid on any number of types which they chose as well as on new and used material. Bids were received in October 1956. The lowest was for driving H piles but the delivery of the steel would have resulted in a delay of seven to eight months before starting driving. Therefore, the next higher bid, for driving second-hand concrete-filled steel pipe piles, was accepted. The pipe used was 12¾ in. o.d. oil country line pipe weighing approximately 50 pounds per lineal foot. This pipe looked as if it had been used in acid Louisiana marshes because one side of it, perhaps the invert, apparently had been almost continuously riddled with corrosion but when delivered to the site it had been so thoroughly patched by welding that it was considered acceptable for use. In accordance with the Engineering News Record formula, these piles driven to a resistance of 22 blows per inch with a Vulcan No. 1 hammer will carry a safe working load of 70 tons. A pile carrying 70 tons and filled with 4,000 pound concrete will have stresses in the steel of 6,700 psi. and in the concrete 670 psi. which are above the Boston Building Code limits of 6,000 psi. and 400 psi., respectively. Also, the borings indicated that the required resistance would not be met until a depth of between 150 and 180 ft. had been reached. This violates the slenderness provision of the Boston Building Code which requires that the load be reduced when the depth to diameter ratio exceeds 40. An appeal was made, however, on the grounds that there had been in the past, no known failure of such a pile due to buckling, and the stresses were within reason and permitted by other codes. This appeal was granted.

A pile loading test was made in November 1956, with two adjacent piles for use as tension or anchor piles. The first section of the test pile was 98 feet in length and no driving was necessary for the first 18 feet as the weight of the pipe and hammer caused the pile to penetrate to that depth. Moderate resistance was encountered for the next 10 to 14 ft. and then little resistance as it entered the deep layer of soft blue clay until the 96 ft. depth was reached where driving was stopped to permit splicing of the upper section. When driving was resumed, little resistance was encountered to the 160 ft. depth where the resistance increased rapidly until 26 blows were recorded for the last inch of penetration at a final depth of 163.4 ft. below cut-off elevation. The loading test was conducted in accordance with the building code, applying the load in five ton increments every four hours, the final load of 140 tons remaining on the pile for a 48-hour period. The maximum settlement recorded was 0.372 inches which was well within the limit of .500 inches allowable. With successful conclusion of tests the pile driving was commenced immediately.

During the driving, careful observations were made in each pile as to its deflection from the vertical by means of dropping a light down the pipe. In granting the appeal the Boston Building Department had stipulated that after driving, the pile should not be out of plumb more than 2 ft. for the upper 100 ft. and the remainder of the pile should not be out of plumb more than 2 percent of the remainder of its length. It was soon obvious that with piles of the length that were being driven, this specification was not being met in a number of cases. We were fortunate at this time that Dr. Bjerrum, the head of the Norwegian Geotechnical Institute, was serving as a visiting professor at M.I.T. Dr. Bjerrum had made extensive studies concerning the driving of piles in soft material and the lateral support that could be expected from such soil. Dr. Bjerrum recommended and the Building Dept. agreed that piles be acceptable if the radius of curvature for the upper 75 ft. were not less than 1,400 ft. and for the lower portion not less than 1,000 ft. This criterion is based on a maximum allowable stress in the pile of 15,000 psi. resulting from the initial curvature and the load imposed by the superstructure. The use of this criterion has to be tempered to some extent by the nature of the loads which are carried and the consideration of the number of piles which share the load.

In order to determine the curvature of the piles, an inclinometer was devised. This instrument consisted of a frame with wheels that fit snugly inside the pile. Within the frame there was inserted a three-tube manometer connected to a common stop cock which was located at the lower end of the instrument. A nylon fish line was attached to the handle of the stop cock, so that it could be closed by a jerk at the surface of the ground. The inclinometer was lowered into the pile with the stop cock open. At a predetermined depth, the stop cock was closed and the instrument raised. By reading the difference in the level of liquid in the manometer tubes, the slope and direction of slope at the desired level was obtained. Of the 566 piles driven, it was found necessary to use this instrument on approximately 140. Of this number, 30 piles were rejected as unsatisfactory. Seven additional piles were rejected for various other reasons, including indications that the pile had cracked during driving. The worst deviation noticed was approximately 25 ft. from the top of the pile to the horizontal projection of the estimated location of the tip. In another instance, a deviation of 33 degrees was observed within a vertical distance of 10 ft.

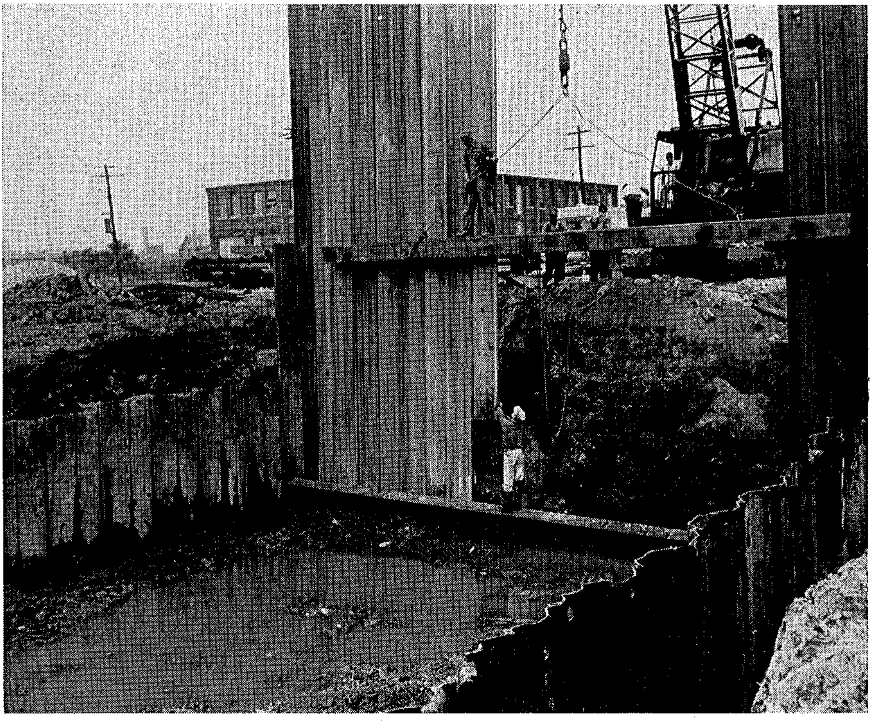
CORROSION SURVEY

A study was carried out to determine the amount of corrosion of the steel pipe that could be expected. This study was made by the Electro Rustproofing Corporation of New Jersey and included an analysis of the galvanic action due to the differences in the various layers of soil and a survey of stray currents in the area due to the proximity of the New Haven Railroad yards. The results of their investigations indicated that the pipe piles would suffer minor galvanic attack in the blue clay area adjacent to the sand and gravel. In addition, minor corrosion would also take place in the fill due to the presence of cinders and other deleterious materials. It was estimated that based on surface potential gradients, a single pile would lose approximately 540 pounds of steel over a 50-year period due to stray currents. Considering all factors involved, it is estimated that without protection the steel pipe piles will have a useful life well in excess of 50 years. In order to minimize the effects of the small amount of corrosion expected, design provided for keeping the piles insulated from one another and to ensure that they would not be used for grounding purposes or come in direct contact with any electrical current.

RECEIVING BIN

In order to provide storage for the refuse which will be collected during a day shift and burned throughout the 24 hours, a large storage bin was provided. It is 200 ft. long by 24 ft. wide and the length of the row of six furnaces. The bin had to be below ground because the site was so small that ramps could not be provided for an above-ground bin and dumping floor.

The excavation for the bin was approximately 210 ft. long by 35 ft. wide and 30 ft. deep below the ground surface. Observations made during pile driving indicated that the water table remained fairly constant at 6 ft. below the ground surface which meant a depth of excavation of approximately 24 ft. below the ground water level.



SOUTH BAY INCINERATOR REFUSE BIN COFFER DAM.

Consideration was given to two methods of construction of the bin without using piles. One of these involved building it as an open tank or barge and launching it into a dredged channel and then sinking it into position, with the weight of the building helping to overcome flotation. Another method was to build the bin in place within close sheeting, placing a heavy floor of tremie concrete sufficiently thick to overcome buoyancy. In either of these two methods the rest of the building would have been carried on pile foundations and there would have been hinged joints to permit differential movement of the bin due to loading and unloading. It was finally decided to use pile foundations like those of the building with the bin tied into the piles to overcome flotation. As added protection, the bin was filled with water after its completion and prior to construction of the building to help resist buoyancy. The walls were designed to resist hydrostatic lateral pressure by cantilevering from the bottom slab. The base slab was waterproofed by means of brick in mastic plus a 2-ply membrane. The sidewalls were waterproofed by means of a 5-ply membrane seal covered by a poured concrete protecting cover.

The 66-ft. high bin wall in the direction of travel of the loaded bucket is completely armored with steel plate welded to I beams placed in the concrete wall, because with high speed crane operation the crane will bump into it and slide up the face of the wall so much of the time that otherwise disintegration of the concrete would probably be rapid.

A contract for construction of the bin was awarded to Coleman Bros. in May 1957. Steel sheeting for the cofferdam was driven approximately 3 ft. outside the line of the bin walls to about 35 ft. below the ground surface. Excavation inside the cofferdam was then carried on by clam shell bucket. At first water was pumped from inside the cofferdam at sumps at either end of the excavation. As excavation proceeded, however, the steel sheeting tended to move in and a system of well points was installed. The well points were pumped from July until the project was completed the following January.