DESIGN OF POWER PLANT AND HEATING SYSTEM FOR CAMP FUNSTON

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Design and installation of power plant and heating
DESIGN AND INSTALLATION OF
POWER PLANT AND HEATING SYSTEM
FOR THE ZONE OF CAMP ACTIVITIES AND
AMUSEMENTS, CAMP FUNSTON, KANSAS

A THESIS

PRESENTED BY

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The object of this thesis is to give the reader an insight into the problems which confront the engineer who is designing a central heating plant for a group of buildings, the character of which is not definitely known at the outset; and to show how those problems were handled in the design of a central heating plant for the Zone of Camp Activities and Amusements at Camp Funston, Kansas.
CHAPTER 1.

INTRODUCTION.

SYNOPSIS: A brief history of the project and a discussion of the problems to be solved.

HISTORY OF THE PROJECT:

In October 1917, the War Department authorized the construction of an amusement zone at Camp Funston, Kansas. A new department, called the Department of Camp Activities and Amusements, was organized for the purpose of preparing plans for the proposed zone and superintending its construction.

A plot of ground, 1092 feet long and 150 feet wide, near the center of the camp, was allotted for the Zone by the Camp Commander. This ground was divided up into four blocks, each 243 feet by 150 feet, separated by three forty foot streets.
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EXPLAIN
According to the War Department provisions, the Zone had to be built by civilian capital; so it was necessary to run it on the concession plan and to design the various buildings according to the needs of the concessionaires. The principal concessions contemplated by the Department of Camp Activities and Amusements were three theatres, each to have a capacity of 2,000 people, a large pool hall, barber shop, several restaurants, clothing stores and an arcade to contain about fifty small booths.

THE HEATING PROBLEM.

As winter was almost at hand, and as some of the concessionaires started work on their buildings long before all the space had been allotted for the different concessions, it was imperative that heat, light, water and sewers be provided for them as soon as possible. It was decided that a central heating plant and a vacuum system of heating would be the most economical to install, the cost to be paid by the different concessionaires in proportion to the service they would receive from it. The
number and character of the buildings which the plant would have to serve was largely a matter of conjecture, so the design had to be made with enough elasticity to provide for any future demands that might be made upon the plant.

**THE ELECTRICAL PROBLEM.**

The provisions to be made for electric current supply was one of the problems to be solved. The camp was supplied with current from three sources, Abilene, Junction City, and Manhattan, Kansas; but the combined capacity of these plants could hardly carry the load then being placed upon them. The architect's plans for the Zone buildings provided that the fronts be liberally sprinkled with lights, and the power requirements for motion picture machines, fans, etc. would be considerable.

The main question to be considered was whether it would be more economical to install generators and use the exhaust steam from the engines for heating, or to purchase the current from outside sources. As the maximum length of
time during which the Zone could be considered a paying proposition was five years, the first cost of installing generators proved prohibitive. Therefore, an agreement was reached with the various electric companies supplying the camp whereby they promised to enlarge their equipment to handle the Zone, and to run lighting and power lines to it at their expense. Provisions had to be made in the design of the plant, however, for the installation of generators in the future, in case it would become necessary.

THE WATER PROBLEM.

The question of water supply became quite a serious one. The camp derived its water supply from seven wells sunk near the Kansas River banks. The supply from these wells proved inadequate for the camp, so the authorities objected to the Zone drawing on it. It therefore became necessary to drill a well to supply the Zone, and as the surface water was used for the camp supply, a deep well through the bed rock was the only solution. This was drilled on the
power plant site, and provisions for the deep well pump and the pressure tank had to be made in the power plant building.

THE SEWER PROBLEM.

The main cantonment sewer line ran under the third block of the Zone (see sheet #6) at such a level that a good fall could be obtained by draining both ends of the Zone toward it. This made the sewage disposal problem a comparatively easy one to solve.
SYNOPSIS: An outline of the calculations necessary to determine the size of the boilers and auxiliaries of the power plant.

BOILERS.

The first thing to be decided upon in designing the plant was the boiler capacity necessary. To get an idea as to the capacity that would be required for the heating system, it was necessary to resort to a rule of thumb; i.e. for a temperature difference of ninety degrees between the inside and outside, fifty cubic feet of contents require about one square foot of radiation to heat them. Assuming that the average story height over the entire four blocks would be fifteen feet, the cubic contents of the buildings would be

\[ 4 \times 243 \times 150 \times 15 = 2,187,000 \text{ cu.ft.} \]

\[ 2,187,000 + 50 = 43,740 \text{ sq.ft. of radiation and mains required for heating.} \]
One square foot of radiation condenses on an average of .28 pound of steam per hour.

\[ .28 \times 43,740 = 12,247 \] pounds of steam to be evaporated per hour to supply the heating system.

A hot water heater capable of heating 3,000 gallons of water per hour (the estimated amount required) from fifty degrees F. to one hundred eighty degrees F. requires 525 pounds of steam per hour.

The demands for live steam for coffee urns, sterilizers, steam tables, etc. were estimated at about 300 pounds of steam per hour.

Therefore the total pounds of steam required for the above mentioned items would be

\[ 12,247 + 525 + 300 = 13,072 \] pounds.

The boiler feed and vacuum pumps were considered as requiring about 4% of the steam generated for other purposes, that is 4% of 13,072 pounds or 523 pounds of steam.

This made the total steam to be generated by the boilers 13,072 + 523 or 13,595 pounds.
Under ordinary conditions, a return tubular boiler evaporates approximately 30 pounds of steam per rated horsepower. Therefore the rated horsepower required for this plant would be \(13,595 + 30 = 453\) or about 450 H.P.

In choosing the units to be installed, provisions had to be made to handle the hot water and live steam demands efficiently during the summer, when steam was not required for heating. Therefore it was decided that four 150 horsepower return tubular boilers be installed. This would give a capacity of 450 horsepower in three boilers, which could be run continuously in the coldest weather, and would still leave one boiler for emergency and cleaning purposes. During the summer months, one boiler would be sufficient to handle all the demands for hot water and live steam. In the design of the plant every provision was made for the addition of another 150 H.P. boiler in case it would become necessary to supply more steam than was originally calculated.
AUXILIARIES.

The sizes of all the power plant auxiliaries were determined with a view of handling a load of 750 H.P., so they would be large enough to handle the load in case another boiler were added in the future. The boiler feed and vacuum pumps were made large enough so one boiler feed and one vacuum pump could handle the entire load.

RADIATION.

The radiation necessary for the various buildings was calculated by the B.T.U. loss method to keep the temperature in the buildings at 70 degrees F. when the outside temperature was 20 degrees below zero F.

EQUIPMENT.

The following is a list of the principal equipment of the plant, as installed:

4 - 72"x 18'-0" Murray Horizontal Return Tubular Boilers

4 - #8 Gauge smoke stacks, diameter 34"; height above stack plate 60'-0".
2 - 10"x 14"x 12" Worthington Vacuum Pumps

2 - 10"x 6"x 10" Worthington Duplex Boiler Feed Pumps.

1 - 750 H.P. Webster Standard Feed Water Heater.

1 - Alberger Hot Water Heater having a capacity of raising 3000 gallons of water per hour from 50 degrees F. to 180 degrees F.

1 - Economy centrifugal Circulation pump direct connected to 2 H.P., 3 phase, 60 cycle, 220 volt motor.

2 - 5" Webster Suction Strainers.

2 - 1 1/2" Webster Vacuum Governors.

1 - 1 1/4" Low Pressure Steam Trap

1 - 1" High Pressure Steam Trap

1 - 1" Low Pressure Steam Trap.

1 - 24"x 72" Water Controlled Webster Air Separating Tank.

2 - 5"x 10" Pressure Reducing Valves

1 - 4" Pressure Reducing Valve

1 - 2" Pressure Reducing Valve

1 - 3" Powers Water Temperature Regulator

1 - 3" Back Pressure Valve

1 - 3" Exhaust Head

4 - 4" Crosby Pop Safety Valves

4 - One Quart Detroit Sight Feed Lubricators with double connection.
SYNOPSIS: A description of the design of the power plant with reference to the blue prints in the pocket on the back cover of this book.

DESIGN OF THE POWER PLANT.

Blue print number one is a plan of the power plant showing the arrangement of the various units. A forty foot incline leads up to a platform from which the coal trucks dump the coal directly into the bins, which are in front of the boilers. No provisions were necessary for ash storage, as the ashes could be wheeled outside and utilized in road building.

A 6" lead from each boiler connects into a 12" drop header. From this header, two 10" leads are taken off for the heating system, a 3" line to the pumps, a 4" line to the hot water heater and an 1 1/2" high pressure steam supply line. An 8" plugged tee was left in the header for a possible future steam engine connection. The header is drained by a 1" high pressure steam trap, which discharges into a
line leading to the Feed water heater.

The boilers are fed through the blowoff connection, a detail of which appears on blue-print number three. There is also an emergency 1" cold water connection to the front of each boiler and a 2" line from the pressure tank to the rear of the boilers.

The 4" pop safety valves on the boilers discharge through the roof, and the discharge pipes are drained to the blow off tank.

The 2 1/2" blow off from each boiler is valved with two blow off valves and connects into a 3" blow off line, which empties into a 36" x 48" cast iron blow off tank placed under the floor (see detail on XX blue print #3). A 3" vent was run from the blow off tank through the roof and a 4" connection was made to the sewer.

Blue print number two shows a section through the power plant looking toward the side of the boilers, and also the boiler setting details.

Individual stacks were used for each
boiler. These stacks were 34" in diameter and 60'-0" high above the stack plates on the boilers. They were guyed at two points approximately 10'-0" and 30'-0" respectively from the tops. One half and three eights inch cable were used for guying the stacks and the cable was anchored to special supports placed in surrounding buildings and to posts, which in turn were guyed to dead men buried in the ground. Eight guy wires were used for each stack, and the stacks were fastened together by stays made of 3" pipe with the ends flattened and bolted to the bands around the stacks where the guy wires were fastened. The detail on blue print number two shows the type of hood used on each stack and the section (AA) shows the position of this hood.

Blue print number three shows several details of the connections to the pumps and hot water heater. The discharge from the circulating pump is by-passed to the air separating tank, so that in case the cantonment water supply were used, and the pressure were not enough to lift the water to the air separating tank, the
hot water circulating pump could act as a booster pump taking the water direct from the cold water line or from the hot water return and discharging it into the air separating tank.

The vacuum pumps were placed in a pit so the lift on the suction side would be reduced to a minimum. A by-pass which would allow the returns from the heating system to run directly to the sewer by gravity was installed at a manhole just outside the power plant (see blue print number six).

The exhaust from the boiler feed and vacuum pumps is piped to the open type feed water heated, where it is used to raise the temperature of the boiler feed water. The discharge from the traps bleeding the header, main steam mains and the hot water heater is also turned into the feed water heater through a special inlet for high pressure drips. There is also a 2" emergency live steam connection through a 2" pressure reducing valve from the pump steam supply line to the feed
the procedure for analyzing the data collected in the experiment. The data was analyzed using statistical software, and the results were presented in a clear and concise manner. The conclusions drawn from the analysis were well-supported by the data and provided valuable insights into the research question.

In addition to the statistical analysis, the results were also validated through peer review and expert consultation. The findings were disseminated through a variety of channels, including academic journals, conferences, and public presentations. The research had a significant impact on the field, leading to further studies and applications in related areas.

Overall, the research project was a success, and it demonstrated the importance of rigorous methodology and thorough analysis in scientific research.
water heater to heat the feed water in case there is not sufficient exhaust steam.

The feed water heater has a 3" connection passing through a spring type back pressure valve to the roof, where it is capped by an exhaust head which is drained to the air separating tank.

The various lines are so valved and bypassed that one half of the header can be shut down for repairs and steam can still be supplied to the mains and auxiliaries through the other half.

The pressure tank for the water supply was installed where the future generators, if put in later, would be placed. Arrangements were made, however, to bury the tank in the alley surrounding the power plant, in case the generators were installed.
CHAPTER 4.

INSTALLATION.

SYNOPSIS: A description of the method of installing the boilers and mains throughout the Zone. Blue prints referred to are in the pocket attached to the rear cover of this book.

BOILERS.

The first step in the installation of the power plant equipment was to put in the boiler foundations. It was found that the main cantonment sewer line ran directly under the spot selected for the boilers, but the foundations of the boilers were bridged in such a way that their weight was not supported by the sewer line. The boilers were placed on roller trucks and hauled from the railroad siding by a steam roller. They were blocked up on the foundations and the brickwork was started before the power plant building was built around them. The power plant equipment was installed as shown on blue prints nos. 1, 2, and 3.

17.
MAINS.

Blue prints numbers 4, 5, 6 and 7 are plot plans of the four Zone blocks served by the central heating plant. On these plans are indicated the various steam, return and water lines and their approximate location. The main steam mains and hot water supply lines were run as much as possible overhead through the buildings and dropped into wood conduit only under the streets. The hot water and heating return lines were run in wood conduit in a trench about five feet in the rear of the Zone buildings. The cold water supply lines and local sewer mains were also run in the same trench. Whenever steam or hot water mains were exposed in the open, they were covered with 1" asbestos air cell pipe covering, 1 1/4" hair felt and tar paper.

In the various buildings the supply ends of the radiators, which were of the steam type, were equipped with Packless radiator valves, and the return ends with Webster Sylphon radiator valves traps. In most cases
the supply mains were run in the attic space over the buildings or near the first floor ceiling, and the return mains were covered and run underground in tile until they connected into the main return lines in the trench at the rear of the Zone. The steam mains were pitched about 1" in 20'-0" in the direction of the flow of steam, and wherever it was necessary to raise them they were dripped through Webster drip traps into the vacuum returns.

Expansion Joints and manholes were placed at various points. In most cases the steam mains were anchored at the ends of the blocks and the expansion joints were placed near the middle of the blocks.

As steam had to be supplied to some buildings remote from the power plant before other nearer buildings had even been started, it was necessary to leave plugged tees in all the service lines to take care of the additions and the pipe sizes had to be figured large enough to handle any load that might be placed upon the mains.
SYNOPSIS: A resume of the final result and the operation of the plant.

FINAL RESULTS.

When the Zone was finally completed, all the space allotted to it, with the exception of a space 50' x 72' in one corner of Block #4, was covered by buildings, (see accompanying photographs.)

The load on the power plant is as follows:

Direct radiation installed— 29,375 sq.ft.

Equivalent in direct radiation of mains,,........ 6,445 "

Equivalent in direct radiation of hot water heater.... 1,870 "

Equivalent in direct radiation of high pressure steam. 1,100 "

Equivalent in direct radiation of pumps................ 1,550 "

Total load in equivalent direct radiation.............. 40,339 sq.ft.

It can be seen from the above table that
the final load on the plant was not as great as the maximum provided for. It was found that two boilers were sufficient to handle the load for the larger portion of the winter, and three were required for only about two months of the coldest weather. A good steam circulation was kept up with less than one pound of steam pressure on the low pressure side of the pressure reducing valves and 5" vacuum on the vacuum returns. Fifty pounds gage pressure was kept on the boilers to run the pumps.

The occupants of the Zone seemed to be perfectly satisfied with the service they received, and the plant had ample capacity to meet the demands of the coldest weather.