AETRON-BLUME-ATKINSON

INTER-OFFICE MEMORANDUM

4 February 1964

To: E. Leys and W. Harris

From: L. W. Swanson

Subject: END STATIONS A and B, HEATING, ABA-89

Attached are 12 copies of the subject report. Please give us SLAC's comments or approval for inclusion in the Title I Reports for End Stations A & B.

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DRAFT
ABA-89

HEATING

END STATIONS A AND B

REPORT TO STANFORD LINEAR ACCELERATOR CENTER - ABA No. 89

STANFORD UNIVERSITY SUBCONTRACT S-136

UNDER AEC CONTRACT AT(04-3)-400

Submitted by W. R. Niedhamer

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AETRON-BLUME-ATKINSON
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February 3, 1964

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Introduction

This report presents the results of a study on heating systems for the End Stations A and B Buildings. Included are costs of heating End Station A by an electric radiant heating method and by a conventional electric air-heating method.

Conclusions and Recommendations

Heating at End Stations A and B should be by means of conventional electric heating units of the blower-heater type. Ventilation air should be heated before, or as, it enters the building. This can be done by propeller-fan type electric unit heaters mounted in the utility tunnels. Conduction heat losses can be most economically offset by blower type unit heaters mounted on the end walls at say 15 feet above the floor and arranged to draw air from near the roof and discharge it so as to blanket the building wall openings. These wall-mounted heaters would be the low temperature element type for hydrogen safety. The attached sketches SK-M-106, 107, and 108 show the recommended method.

Radiant heat lamps are not recommended because (1) a suitable low surface temperature unit has not as yet been developed; (2) manufacturers' printed literature does not recommend them for use at the heights which they would have to be mounted to adequately cover the floor area; (3) they will not satisfactorily heat the ventilation air (auxiliary heaters are required); and (4) cost for the radiant heating system is several times the cost for the blower heater system, and considerably above the budgeted amount.

Costs

The estimated costs of providing (1) radiant heating system, with pressurized quartz shields, auxiliary ventilation air heaters, and interior surface treatment of the building, and (2) a system of heating and ventilating units with auxiliary ventilation air heaters, are compared below. Costs include thermostatic controls for the ventilation air heaters, manual controls for other units, electrical work, air ducts, and normal overhead and profit. Sound attenuators and replaceable media filters are included for the heating and ventilating units. The load for the conventional heating and ventilating unit system was calculated using 65°F temperature at the occupied zone and 77°F at the roof. This should provide comfort comparable to the 60°F temperature requested for radiant heating. Additional local heating, desirable for sedentary workers, is not covered in this report.

RADIANT HEATING, END STATION A

Lamps, installed, with pressure duct	$ 44,400
Insulation, reflective and absorbent paint	24,000
Ventilation air heaters	5,000
TOTAL	$ 73,400

HEATING AND VENTILATING UNIT SYSTEM, END STATION A

Units, installed, with duct	$ 15,500
Ventilation air heaters	5,000
TOTAL	$ 20,500

Note: Costs for End Station B are approximately proportional to the building areas.

Building Characteristics

Aside from the requirements for radiation shielding, the buildings present problems not normally considered in other structures. The two-foot-thick concrete walls and roof have a high heat storage capacity. It will take a lot of heat, gain or loss, to change the temperature appreciably. Concrete is a poor insulator but, because of its mass, twelve hours or more are required for a change in temperature on one side to be felt appreciably on the other side. The building transmission heat gains and losses and the ventilation gains and losses will be completely out of phase. They will tend to neutralize each other and stabilize the inside temperature. The high roof permits the heat to rise and stratify, or be discharged by the exhaust system. It also provides a high column of heated air which by chimney effect will promote infiltration of cold air.

Cranes cover the entire floor area and to blow heated air down to the floor level from above the cranes is not the best practice, particularly with electric heating units which are not manufactured in standard units suitable for this service. There are no interior columns on which to mount equipment. Huge stacks of shielding blocks will cover large areas of the floor, and machine foundations may be installed at any location, so a radiant floor system is not practical. Openings in roof or walls should be kept to a minimum since they must be shielded with two feet of concrete. Because of this, it is not desirable to locate the equipment outside the building and penetrate the building shell with supply and return ducts.

Heating is required only when the structure is occupied. The building is not occupied while an experiment is in progress; that is, while the beam is directed into the structure. During an experiment it is assumed that a considerable amount of heat will be given off to the air and the building will require ventilation for cooling, even in winter. Personnel will enter only after the exhaust fans have changed the air in the building. At this time the structure will still be warm. But during occupancy in cold weather, heat will be required to maintain the building at a temperature in keeping with the nature of the work being performed. The heat supplied must be sufficient to offset the heat transmission losses from the structure and warm the ventilation air. The winter time infiltration rate, even without fans running, should be ample for the ventilation requirements of the occupants, but it is expected that welding fumes and other contaminants will make it desirable to keep one exhaust fan running at half speed at all times. The entering ventilation air, unless it is warmed, could be at freezing temperature, and will flow from the air inlets, staying close to the floor until warmed by contact with warm surfaces or by mixing with warm room air.

Free Hydrogen

Free hydrogen may be released within the building, rise rapidly and concentrate under the roof. Hydrogen ignites at about 1050^{o}F so high temperature elements or sparking devices at the roof level would be hazardous.

Ventilation Air Heating

Most of the ventilation air will normally enter by way of the utility tunnels. It is proposed to temper this air by means of fan-type electric unit heaters mounted in the tunnels near the first access opening, as shown on the attached sketches. In that location they need not be the explosion-proof type and may be thermostatically controlled with two stages, to turn on only during beam-off times, whenever the entering air temperature drops below 60^{o}F. Even with only one exhaust fan operating at half speed, the ventilation air heating requirement is 150 kw, nearly one-half of the 330 kw total heat required, based on an inside temperature of 65^{o}F, and an outside temperature of 35^{o}F. It has been assumed that temperatures lower than 35^{o}F will be of short duration, normally at night.

Radiant Heating

Pacific Gas and Electric Company has referred to us several representatives of heat lamp manufacturers with whom they have had satisfactory dealings, and we have contacted others. In talking to these people the following pertinent points were made:

a. Quartz lamps provide the most economical radiant heating because they are a high intensity, high temperature source, But these are the problems:

(1) They operate at temperatures of 1800° to 4000°F.

(2) A large percentage of the radiation is in the visible spectrum. The building lighting level would fluctuate as heat lamps go on and off.

(3) They cannot be made explosion proof.

(4) The highest recommended mounting height varied from 50 feet for one manufacturer to 18 feet for another. Ours must be at 65 feet to clear the crane.

(5) Wall mounted units could not satisfactorily cover the area.

b. Free hydrogen in the space would concentrate at the high point of the building, or right at the lamps. Several minutes are required for the lamps to cool below 1000°F, so it would not be a satisfactory solution to turn off the lamps when hydrogen is detected. It is not feasible to enclose the lamps with a glass shield since glass is nearly opaque to low frequency heat radiation and would quickly overheat. A pressurized quartz shield is a possibility which is being promoted by Fannon Division of Hupp Corporation, a lamp manufacturer. They propose to use a filament temperature of about 1800°F. They claim the quartz tube would be at a temperature less than 1000°F and the shield less than 400°F. The shields would be pressurized and cooled with outside air at about 2 psig. To do this, an air duct must parallel the lights.

c. The Fannon representative, Mr. Hottenroth, said that a pressurized quartz shield, to his knowledge, has never been built, but that the company is confident it is feasible. Upon receipt of an order, they will build, test, and guarantee performance of the fixture. There is a question whether such an arrangement could be approved for this project. It appears that with proper reflectors and sufficient lamps to give a watt density at floor level of about 8 watts per square foot, the heating would be satisfactory to offset the transmission heat losses for the building. However, because there are two unproved factors in the design (1) mounting height, and (2) hydrogen proofing, any recommendation of this method must be contingent on certified tests of an actual fixture under the conditions we expect. We are taking considerable precautions in other areas with regard to hydrogen. It is our opinion that the use of devices having surface temperatures over 500^{o}F where hydrogen contact is possible should be seriously questioned.

Another method of radiant heating briefly considered is the use of ceiling-mounted low temperature radiant panels. But these would be very inefficient because a high proportion of the heat would be given off by convection, which would not benefit the occupants at floor level. The cost would be high also because of the large amount of heated surface required.

The cost of any radiant heating installation is not simply the price of the fixtures and their installation. The building interior surfaces must be of a type to supplement the radiant heat. Reflective building surfaces are required in the upper portions of the building, and absorbent surfaces, backed by insulation, are required in the lower portions of the building. If these measures are not taken, the watt density must be greatly increased.

High watt densities are undesirable, not only because of the increased cost, but because portions of the body directly exposed for long periods become overheated and dry. It is preferable for the occupant to be heated by low temperature secondary radiation from building surfaces. Radiant heating is said to provide a more uniform floor to ceiling temperature distribution than other heating methods. It is understood that this is not as pronounced at higher mounting heights, and the mounting heights we contemplate are higher than the available test data covers, so this factor cannot be evaluated. It is important to minimize stratification, however, since high temperatures at the ceiling result in high heat loss both by transmission through the roof and by the fact that with stratification the hottest air in the building is exhausted.

Radiant heating will not correct the cold draft problem outlined above, but must be supplemented with an air heating system as described under Ventilation Air Heating.

Conventional Air Heating

Heating by electric unit heaters as described under Ventilation Air Heating plus the use of conventional heating and ventilating units mounted on the end walls of the buildings offers the most economical solution. The latter units would be mounted on the end wall to avoid interference with the cranes as shown on the attached sketches. The units would be the inverted type, drawing warm air from near the roof, through ducts, and discharging into the occupied zone so as to blanket the wall openings as much as possible. The surface temperature of the heat elements can be kept below 500°F. Spark proof fans and belts, and explosion proof motors can be supplied. The units should be provided with filters and with sound attenuator sections. Ducting the air from the roof zone to the intake of the units will provide a vertical recirculation pattern and minimize stratification. Discharging the air horizontally will set up horizontal circulation patterns to minimize dead-air spots.

A less satisfactory plan would be to mount the heaters above the crane, between beams, and discharge vertically. The discharge velocity pressure, a constant, must buck the variable chimney effect as the temperatures change in the vertical zones. The colder the building, the harder it is to throw the heat to the floor.

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