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# GEORGIA INSTITUTE OF TECHNOLOGY
## ENGINEERING EXPERIMENT STATION

## PROJECT INITIATION

Date: 25 August 1975

Project Title: Conceptual Design Activities for the 5MW Solar Thermal Test Facility

Project No.: A-1762

Project Director: S. H. Bomar, Jr.

Sponsor: Black & Veatch

Agreement Period: From 1 July 1975 Until 27 September 1975*

Type Agreement: Letter contract dated 14 July 1975 (Subcontract under ERDA Prime Contract E(04-1)-1078)

Amount: $22,602 (Total anticipated funding - $32,043)

Reports Required: Interim

Sponsor Contact Person: H. W. Strobm, Project Administrator
Black & Veatch, Consulting Engineers
P. O. Box 8405
Kansas City, Missouri 64114

Telephone: 316/361-7000

*Execution of Definitive Contract anticipated by 27 September 1975.
Total contract period anticipated - 6 months.

Assigned to: EES - EMTD

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| | Other Sue Corbin; Bonnie Mettlaufer |

RA-3 (8-75)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

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# SPONSORED PROJECT TERMINATION

B270 32

Date: May 18, 1976

Project Title: Conceptual Design Activities for the 5MW Solar Thermal Test Facility

Project No: A-1762

Project Director: S. H. Bomar, Jr.

Sponsor: Black & Veatch

Effective Termination Date: January 31, 1976

Clearance of Accounting Charges: N/A - all have cleared

Grant/Contract Closeout Actions Remaining:

NONE

- _ Final Invoice and Closing Documents
- _ Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
- _ Classified Material Certificate
- _ Other ____________________

Assigned to: Applied Sciences (School/Laboratory)

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CA-4 (3/76)

1-4

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

August 29, 1975

Black and Veatch
P.O. Box 8405
Kansas City, MO 64114

Attention: Dr. J. C. Grosskreutz
Project Coordinator

Subject: Interim Progress Report on ERDA Solar Test Facility
(Black and Veatch Project No. 6987.007)

Dear Charlie:

Task 1 Data Collection

Subtask 1.2

Data on existing and planned test facilities for the testing of solar thermal energy systems, subsystems and components are being continually updated as additional information becomes available. Tables I and II give the latest information available on such facilities. Personnel and support data are being collected, but most of these facilities are just part of larger facilities with shared personnel and support operations, making it difficult to determine solar facility requirements only.

Subtask 1.3

Data on existing and planned receiver design concepts for solar thermal energy power plants of the central receiver type are being compiled. Existing facilities are no problem and are covered in Table III. Planned facility concepts change so fast, information becomes obsolete before it is published. These data are being revised and will be available soon.

Subtask 1.4

EES personnel are continuing to provide consultation services to Black and Veatch related to existing facility equipment. The attached description of our experience with the CNRS 1 MW facility and the White Sands 35 MW facility covers the only two facilities which are readily available for contract testing.

Task 2 Facility Capabilities Definition

Subtask 2.1.1

EES personnel have worked directly with Black and Veatch personnel in the preparation of two drafts of the Facilities Capabilities Definition and are working with Black and Veatch to obtain the latest POCE Contractors input necessary to prepare a third Capabilities Definition.

Task 3 Site and Facility Requirements Definition

Subtask 3.2

The attached letter report to Dr. J. C. Grosskreutz provides Georgia Tech's initial input toward identification of the facility requirements. Based on our experience with the Capabilities Definition, these initial facility requirements will be modified considerably to incorporate the viewpoint of personnel from various ERDA laboratories.

Task 4 Conceptual Design

Subtask 4.3

Georgia Tech personnel have worked with Black and Veatch personnel on the initial input necessary for the conceptual design. Work will continue and effort expanded from this point on.

Yours very truly,

James M. Akridge

COST REPORT NO 1

Georgia Tech Effort Under
Black And Veatch Project No. 6987.007

July 1 - August 31, 1975

Prepared by

The Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

| Task | Man-Hours | Dollars |
|---|---|---|
| 1.2 | 75.80 | 875.36 |
| 1.3 | 37.90 | 437.68 |
| 1.4 | 75.80 | 875.36 |
| 2.1.1 | 113.70 | 1313.04 |
| 3.2 | 56.85 | 656.52 |
| 4.3 | 18.95 | 218.84 |
| Totals | 379 | 4376.81 |
| * Materials and Supplies | | 62.00 |
| * Travel | | 0.00 |
| Overhead and Retirement | | 3370.14 |
| | | $7808.94 |

*These charges are not up to date due to accounting procedures.

A-1762

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

August 29, 1975

Black and Veatch
Consulting Engineers
P. O. Box 8405
Kansas City, Missouri 64114

Attention: Dr. J. C. Grosskreutz

Subject: Preliminary ERDA 5 MW Solar Test Facility Requirements Definition

Dear Charlie:

I am attaching a copy of our input to the ERDA Solar Test Facility Requirements Definition. I initially tried to follow the methodology example Black and Veatch calls attachment A. I soon found that I was going to have volumes and might still be writing at Christmas.

After determining that the material was desired in the format given in your attachment B, I decided to work directly in that format rather than go through the intermediate step. While the intermediate step was not written it was necessarily a part of the mental approach to the requirements definition.

Although much of the material seems extraneous and repetitive, I feel that it is probably necessary information for the facility designers. Several areas, such as the structure section, are obviously highly dependent upon the design approach selected and were not considered in as much detail. I did try to be much more specific in those areas where we have the most experience and expertise, such as the optical pyrometry and thermal instrumentation areas.

Some of the equipment may not be necessary to the facility although it might be desirable. The thermal imaging system, for instance, may be unnecessary although it should prove beneficial in identifying energy loss patterns and hot spots on receivers. I feel it was better to suggest too much than too little.

Because of my decision to go directly to the requirements guideline format rather than go through the lengthy process of filling out the individual sheets necessary to follow the methodology outlining, I do not have written support for why each component or system is desirable. I believe that in most cases the reason is evident. If you needed additional written support or explanation, please let me know. This report in late as it is, assisted in my decision to use the most expeditious approach.

Steve Bomar has written a section covering our experience at CNRS and White Sands which I am attaching. I have not been involved with either of these facilities yet and thus do not have the specific knowledge of the facilities that Steve has. Since the CNRS facility is used as a research facility with programs involving equipment not a part of the 1 MW furnace, it probably is not representative of what one might desired at the ERDA solar facility.

I would like to emphasize, again, that you should let me know when you need additional material or backup. The material I am sending is highly condensed, thus containing a lot of information and little discussion, so I will not be surprised to hear that you need more explanation.

Yours very truly,

James M. Akridge

FACILITY REQUIREMENTS DEFINITION
BASED ON CNRS AND WHITE SANDS EXPERIENCE

Over the past four years, Georgia Tech has developed experience in the operation of large solar test facilities through the performance of research at the CNRS Solar Furnace in southern France and at the U. S. Army Solar Furnace at White Sands Missile Range, New Mexico. It is pertinent to consider this experience in defining requirements for the proposed 5 MW United States Solar Test Facility in order to provide a working envrionment which is conductive efficient operations.

Subtask 1.4

In both the existing facilities listed above, test operations are somewhat hampered by insufficient space in the focal area and by this area's remoteness from shop and laboratory rooms. These characteristics are inherent in the design of solar furnaces using fixed concentrators because the focal building must be positioned so that it intercepts the redirected beam of radiant energy from the heliostats; the facility design must arrive at a comprimise between the size of the focal building and the area of the redirected beam which is intercepted. Similarly, the focal zone must be located at a position in front of the concentrator and therefore cannot be adjacent to large shop and laboratory spaces.

The use of a fixed concentrator in the CNRS and U. S. Army Solar Furnaces does, however, permit a vantage point to be provided for observation of experiments by photographic and other optical techniques. The portion of the concentrator which lies within the shadow of the focal abuilding is directly in front of the focal zone, and the structure supporting the concentrator is an excellent position from which to view experiments. This feature is definitely desirable in the United States Solar Test Facility but may not be practical in the geometric configuration which is expected to be adopted.

Neither the CNRS nor U. S. Army Solar Furnaces are extensively equipped with data recording and instrumentation apparatus. The normal practice is for each experimenter to provide his own instrumentation, depending on his individual needs. All participants in the conceptual design of the United States Solar Test Facility seem to agree that the common equipment used by all investigators should be owned by the facility; this policy does not exist at the two older facilities, probably because funds have not been made available for purchase of such equipment.

Subtask 3.2

The following specific requirements for the United States Solar Test Facility are identifiable based on Georgia Tech's previous experience and should be provided if technically and economically feasible:

A. Central Control

a. Control of all heliostats from one control room
b. Line of sight viewing of all heliostats from the control room
c. Scram switch or other device for interrupting radiant flux to the focal zone by defocussing heliostats or closing doors; the shutdown time should not exceed 15 seconds
d. Provision for measuring and adjusting the pointing accuracy of individual heliostats
e. Emergency cooling water supply and heliostat control in the event of electrical power interruption
f. Protection of personnel working in the focal zone and control room from accidental exposure to concentrated radiation

B. Central Data Recording

a. 100 channels of recording capacity for documentation and future access to recorded data
b. 25 channels of real time data display including paper recordings for observation of trends in control parameters
c. Closed-circuit television with video recording
d. Black and white photographic services with on-site developing and printing
e. Meteorological data recording including direct solar insolation, total solar insolation on a horizontal surface, air temperature, wind speed and direction, temperature of cooling water supplied to focal zone

C. Ancillary Buildings and Facilities

a. High-speed personnel elevator to control room and focal level
b. Freight elevator to focal level
c. Small machine and electrical shop near focal level, 150-250 $ft^2$
d. Final assembly area near tower base, 2500 $ft^2$, 75 ft overhead clearance, with access to main tower crane, welding equipment, drill press, grinders, band saw, cut-off saw, hand tools
e. Main assembly and set-up area, remote from tower base, 10,000 $ft^2$, with major machine shop, sheet metal, rough woodworking, instrument and electrical capability
f. Lockable laboratory space for each contractor to be working at one time, 500 $ft^2$, 15 ft overhead clearance, hot and cold water, instrument service bench, drawing board, telephone
g. Platform or tower for television and photographic observation of test equipment while operating
h. Pneumatic conveyor system from assembly area to focal area

D. Facility Personnel (not including contractor personnel)

a. Facility operators (technician 3, engineer 1) - 4
b. Instrument and control maintenance (technician 2, engineer 1) - 3
c. Machine shop and set-up (technician 5) - 5
d. Receptionist, secretary, telephone operator - 3
e. Administrative and public relations (engineer 1) - 1
f. Heliostat maintenance, cleaning, repair (technician 3) - 3
g. Janitorial - 2
h. Draftsman, photographer - 1
i. Security guard - 4

# PRELIMINARY ERDA 5MW SOLAR TEST FACILITY REQUIREMENTS

## 1.0 GENERAL

### 1.1 INSTALLATION AND MOVEMENT OF RECEIVERS

1.1.1 50 ton crane

1.1.2 Welders

- 1.1.2.1 Gas welder
- 1.2.2.2 Heli-arc welder

1.1.3 10 ton bridge crane

1.1.4 One three-axis assembly lift

1.1.5 Hand tools

1.1.6 Helium leak detector

### 1.2 ASSEMBLY AND MAINTENANCE

1.2.1 20 ton bridge crane

1.2.2 Welders

- 1.2.2.1 Gas welders
- 1.2.2.2 Arc welders
- 1.2.2.3 Heli-arc welders

1.2.3 Two three-axis hydraulic assembly lifts

1.2.4 Water pressure test rig

1.2.5 Control test panel

- 1.2.5.1 Receiver controls test panel
- 1.2.5.2 Auxiliary equipment controls test panel
- 1.2.5.3 Heliostat controls test panel

1.2.6 Machine shop

1.2.7 Hand tools

1.2.8 Helium leak detector

### 1.3 PERSONNEL

| | E. | T. | M. | Op. | P. |
|---|---|---|---|---|---|
| 1.3.1 Receiver installation | .5 | 1 | | | |
| 1.3.2 Assembly and maintenance | .5 | 1 | 2 | | |
| 1.3.3 Heliostat maintenance | .2 | 2 | | | |
| 1.3.4 Heliostat movement | | 1 | | | |

| | | E. | T. | M. | Op. | P. |
|---|---|---|---|---|---|---|
| 1.3.5 | Tower shop | .3 | | 1 | | |
| 1.3.6 | Control center | 1 | 2 | | 1 | 1 |
| 1.3.7 | Safety | .5 | 1 | | | |
| 1.3.8 | System checkout and pretest | .5 | 2 | | | |
| | TOTAL | 3.5 | 10 | 3 | 1 | 1 |

1.4 SAFETY

1.4.1 Elevator interlocks

1.4.2 Personnel interlocks (to insure everyone is out of test area)

1.4.3 Scanning T.V. of receiver test area

1.4.4 Safety team

1.4.4.1 Available and approval for all receiver movement

1.4.4.2 Available and approval for all receiver tests - pressure and thermal

1.4.4.3 Available and approval for control tower control of one or more heliostats

1.4.4.4 Available and approval for thermal storage tests and movement

1.4.4.5 Available and approval for auxiliary power plant operation and interconnect

1.4.5 Interlocks on all valves and fittings

1.4.5.1 Valve sequence must be correct before valve will operate

1.4.5.2 Valve cannot be manually overridden without safety team approval

1.4.5.3 Interconnects cannot be made or opened with pressure on fitting

1.4.6 Safety test procedures for all tests

1.4.6.1 Receiver tests

1.4.6.2 Heliostat tests

1.4.6.3 Heliostat stow

1.4.6.4 Heliostat movement and interconnect

1.4.6.5 Receiver movement and interconnect

1.4.6.6 Thermal storage movement and interconnect

1.4.6.7 Thermal storage test

1.4.6.8 Auxiliary power plant operation and interconnect

1.4.7 Electrical interlocks

1.4.7.1 Short-proof interconnection

1.4.7.2 Interconnection interlock to prevent connection if connection contains control signal

1.4.7.3 All connections have visual power light both at connection and control room

1.4.7.4 Failsafe power lights

1.4.8 Safety rails and nets

1.4.8.1 Safety rails and nets automatically deploy when personnel on elevated test areas

1.4.8.2 Safety shield for liquids, gases, and solids between test areas and occupied areas

1.4.9 Optical shields

1.4.9.1 Optical shields for control room

1.4.9.2 Optical shields for assembly and checkout areas

1.4.9.3 Optical shield for office area

1.4.9.4 Optical shield for other occupied areas

1.4.9.5 Optical glasses worn by all personnel when in facility boundry if test underway

1.4.9.6 Computer control to prevent slewing solar image across occupied areas

1.4.10 Test warnings

1.4.10.1 Audible warning signal when tests underway

1.4.10.2 Visual (flashing lights) signal when tests underway

1.5 INSTALLATION AND MOVEMENT OF HELIOSTATS

1.5.1 5 ton special design heliostat mover (Note! This should require facility heliostats to have special holding attachments)

1.5.2 Heliostat control test set

1.5.3 Heliostat alignment reference test apparatus

1.5.4 Special heliostat van

1.5.4.1 Air supply to drive pneumatic tools

1.5.4.2 Water supply to clean heliostats after movement

1.5.4.3 Power tools - electric, pneumatic

1.5.4.4 Hand tools

1.5.4.5 Hydraulic power

1.6 MOBILE OR SEMI-MOBILE TEST EQUIPMENT

1.6.1 Nondestructive test apparatus

1.6.1.1 X-ray metal inspection

1.6.1.2 Ultrasonic flaw detector

1.6.1.3 Magnetic flaw detector

1.6.1.4 U.V. flaw detector

1.6.2 Universal electrical signal test equipment

1.6.2.1 Voltage and continuity tester

1.6.2.2 Heliostat simulator (portable mini computer)

1.6.2.3 Remote instrumentation calibration test console

1.6.3 Optical

1.6.3.1 Laser heliostat alignment instrument

1.6.3.2 Laser theodolite

1.6.3.3 Laser source for night heliostat alignment

1.6.3.4 Reference heliostat target on tower

1.7 HELIOSTAT CLEANING

1.7.1 Water distillation plant

1.7.2 Heliostat cleaning vehicle

1.7.2.1 High pressure (variable) water

1.7.2.2 Dry air

2.0 RECEIVER TEST AREA

2.1 OPERATION

2.1.1 Operating modes

2.1.1.1 Preliminary heliostat checkout with calorimeter

2.1.1.2 Instrumentation checkout

2.1.1.3 Controls checkout

2.1.1.4 Safety system checkout

2.1.1.5 Receiver checkout under partial power, increasing in subsequent test to 100% rated power

2.1.1.6 Receiver startup and shutdown

2.1.1.7 Cloud simulation

2.1.1.8 Emergency shutdown

2.1.1.9 Exploratory research modes

2.1.2 Times of test/operations

2.1.2.1 Scheduling committee

2.1.2.1.1 Receiver priority

2.1.2.1.2 Receiver test availability

2.1.2.2 Contractor test schedule

2.1.2.3 Facility research tests

2.1.3 Control philosophy/parameters

2.1.3.1 Safety engineering

2.1.3.2 Scheduling committee

2.1.3.3 Contractor program personnel

2.1.3.4 Research advisory committee

2.1.4 Emergency

2.1.4.1 Safety procedures

2.1.4.2 Safety committee

2.1.4.3 Emergency procedures

2.1.4.3.1 Personnel safety

2.1.4.3.2 Facility safety

2.1.4.3.3 Receiver safety

2.1.4.3.4 Miscellaneous safety

## 2.2 STRUCTURAL

2.2.1 Receiver support and handling (upper test area)

2.2.1.1 Lift test receivers into position

2.2.1.2 Move test receivers into hook-up position

2.2.1.3 Receiver support during tests

2.2.1.4 Test area enclosed when not testing

2.2.2 Receiver support and handling (lower test area)

2.2.2.1 Lift test receiver into position

2.2.2.2 Move test receivers into hook-up position

2.2.2.3 Receiver support during tests

2.2.2.4 Test area enclosed when not testing

2.2.3 Receiver support and handling (1 MW receiver)

2.2.3.1 Lift test receiver into position

2.2.3.2 Move test receiver into hook-up position

2.2.3.3 Receiver support during tests

2.2.3.4 Test area enclosed when not testing

2.3 MECHANICAL/FLUID TRANSFER/COOLING

2.3.1 Water

2.3.1.1 Receiver feedwater - 3 levels

2.3.1.2 Calorimeter water feed - 3 levels

2.3.1.3 Calorimeter condenser water - 3 levels

2.3.1.4 Instrumentation cooling water - 3 levels

2.3.1.5 Instrumentation condenser water - 3 levels

2.3.1.6 Condenser feedwater to 1 MW level

2.3.1.7 Condenser discharge from 1 MW level

2.3.1.8 Water to shop level

2.3.1.9 Drinking water to all levels

2.3.2 Steam

2.3.2.1 Receiver discharge-upper test area

2.3.2.2 Receiver discharge-lower test area

2.3.3 Air

2.3.3.1 To upper test area

2.3.3.2 To lower test area

2.3.3.3 To 1 MW test area

2.3.3.4 To shop

2.3.4 Heating/cooling

2.3.4.1 To upper test area

2.3.4.2 To lower test area

2.3.4.3 To shop

2.3.4.4 To 1 MW test area

2.3.5 Fire control

2.3.5.1 Fire control water to all levels

2.3.5.2 $CO_2$ to all levels

2.3.6 Helium/oxygen/acetylene (to all test areas and shop)

2.3.7 Elevator (equipment and personnel)

2.3.7.1 Lower test area

2.3.7.2 Shop level

2.3.7.3 1 MW test level

2.3.8 Sidewalk lift (from lower test area to upper test area)

2.3.9 Stairs (to all levels)

2.3.9.1 Internal

2.3.9.2 External

2.4 ELECTRICAL

2.4.1 277/480V

2.4.1.1 To upper test area

2.4.1.2 To lower test area

2.4.1.3 To 1 MW test area

2.4.1.4 To shop

2.4.2 208 V

2.4.2.1 To upper test area

2.4.2.2 To lower test area

2.4.2.3 To 1 MW test area

2.4.2.4 To shop

2.4.3 120 V

2.4.3.1 To upper test area

2.4.3.2 To lower test area

2.4.3.3 To 1 MW test area

2.4.3.4 To shop

2.4.4 Motors

2.4.5 Cabling and connection

2.4.6 Shielding

2.4.7 Grounding

2.4.8 Auxiliary power to serve

2.4.8.1 Control room

2.4.8.2 Heliostats

2.4.8.3 Receiver feedwater pumps

2.4.8.4 Fire protection equipment

2.5 SOLAR

2.5.1 Calorimeter

2.5.1.1 Flux distribution at aperture

2.5.1.2 Total flux at aperture

2.5.2 Heliostat aim accuracy

2.5.2.1 Heliostat tracking accuracy

2.5.2.2 Heliostat position or reference accuracy

2.5.3 Continuous flux density

2.6 OPTICAL

2.6.1 Closed circuit T.V.

2.6.1.1 Scanning camera for all test areas

2.6.1.2 Camera fixed on specific test receiver

2.6.2 Optical pyrometry

2.6.2.1 Automatic recording at long wavelength

2.6.3 Photography

2.6.3.1 Sequential color-still

2.6.3.2 Color motion-real time

2.6.3.3 Color motion-high speed

2.6.3.4 Infrared motion-real time

2.6.4 Thermal imaging

2.6.4.1 Thermal imaging at long wavelength

2.7 CONTROL AND INSTRUMENTATION

2.7.1 Controls and instruments checkout console

2.7.2 Controls and sensor safety signal

2.7.3 Interlock to prevent heliostat focus on receiver test areas while occupied

2.7.4 Strain measurement

2.7.5 Flow measurement

2.7.5.1 Steam flow rate

2.7.5.2 Feedwater flow rate

2.7.5.3 Recirculation water flow rate

2.7.5.4 Air flow rate

2.7.5.5 Condenser water flow rate

2.7.6 Pressure Measurement

2.7.6.1 Feedwater pressure

2.7.6.2 Receiver inlet

2.7.6.3 Boiler inlet

2.7.6.4 Boiler outlet

2.7.6.5 Superheater inlet

2.7.6.6 Superheater outlet

2.7.6.7 Condenser inlet

2.7.6.8 Condenser outlet

2.7.6.9 Calorimeter inlet

2.7.6.10 Calorimeter outlet

2.7.7 Temperature measurement - Pt RTD's

2.7.7.1 Feedwater

2.7.7.2 Preheater inlet

2.7.7.3 Preheater outlet

2.7.7.4 Boiler inlet

2.7.7.5 Boiler outlet

2.7.7.6 Superheater inlet

2.7.7.7 Superheater outlet

2.7.7.8 Condenser inlet

2.7.7.9 Condenser outlet

2.7.7.10 Calorimeter inlet

2.7.7.11 Calorimeter outlet

2.7.8 Calorimeter

2.7.8.1 Flux distribution

2.7.8.2 Flux summation

2.7.9 Heliostat accuracy test panel

2.7.9.1 Tracking accuracy

2.7.9.2 Position accuracy

2.7.9.3 Flux distribution

2.7.9.4 Concentration ratio

2.7.10 Test area environmental doors

2.8 ENVIRONMENTAL

2.8.1 Display of facility flux capability

2.8.2 Ambient temperature

2.8.3 Test area temperature

2.8.4 Test area hazardous condition detectors

2.8.4.1 Toxic gas

2.8.4.2 High pressure gas or water

2.9 INTERFACES

2.9.1 Control and instrumentation interfaces

2.9.1.1 Control signal interface console

2.9.1.2 Pressure interface console

2.9.1.3 Temperature interface console

2.9.1.4 Strain interface console

2.9.1.5 Flow signal interface console

2.9.1.6 Calorimeter interface console

2.9.1.7 Heliostat test panel interface

2.9.2 Operational interfaces

2.9.2.1 Feedwater

2.9.2.2 Steam

2.9.2.3 Condenser water

2.9.2.4 Air

2.9.3 Auxiliary interfaces

2.9.3.1 Electric power

2.9.3.2 Cooling and instrumentation water

2.9.3.3 Drinking water

3.0 CONTROL CENTER FOR RECEIVER TEST

3.1 OPERATION

3.1.1 Operational modes

3.1.1.1 Preliminary checkout with calorimeter

3.1.1.2 Instrumentation checkout

3.1.1.3 Controls checkout

3.1.1.4 Safety system checkout

3.1.1.5 Receiver checkout under partial power, increasing gradually to rated power

3.1.1.6 Receiver startup and shutdown

3.1.1.7 Cloud simulation

3.1.1.8 Emergency shutdown

3.1.1.9 Exploratory research modes

3.1.2 Times of test/operation

3.1.2.1 Scheduling committee

3.1.2.1.1 Receiver priority

3.1.2.1.2 Receiver test availability

3.1.2.2 Contractor test schedule

3.1.2.3 Facility research tests

3.1.3 Control philosophy/parameters

3.1.3.1 Safety engineering

3.1.3.2 Scheduling committee

3.1.3.3 Contractor program personnel

3.1.3.4 Research advisory committee

3.1.4 Safety

3.1.4.1 Safety procedures

3.1.4.2 Safety committee

3.1.4.3 Emergency procedures

3.1.4.3.1 Personnel safety

3.1.4.3.2 Facility safety

3.1.4.3.3 Receiver safety

3.1.4.3.4 Miscellaneous safety

3.2 STRUCTURAL

3.2.1 Personnel and instrumentation support

3.2.2 Vibration isolation for control room

3.3 MECHANICAL/FLUID TRANSFER/COOLING

3.3.1 Water to control room

3.3.2 Air to control room

3.3.3 Heating/cooling to control room

3.3.4 Fire control

3.3.4.1 Fire control water to control room

3.3.4.2 $CO_2$ to control room

3.3.5 Elevator to control room

3.3.6 Stairs to control room

3.3.6.1 Internal

3.3.6.2 External

3.4 ELECTRICAL

3.4.1 Power

3.4.1.1 277/480V to control room

3.4.1.2 208 V to control room

3.4.1.3 120 V to control room

3.4.2 Motors (possibly)

3.4.3 Cabling and connection

3.4.3.1 To heliostat control centers

3.4.3.2 To receiver area

3.4.3.3 To thermal storage area

3.4.3.4 To auxiliary power plant

3.4.3.5 To other

3.4.4 Shielding

3.4.5 Grounding

3.4.6 Auxiliary power to control room

3.5 SOLAR

3.5.1 Control

3.5.2 Measurement

3.5.3 Display

3.5.4 Recording

3.6 OPTICAL

- 3.6.1 Closed circuit T.V.
  - 3.6.1.1 Color television
  - 3.6.1.2 Black and white T.V.
- 3.6.2 Optical pyrometry
  - 3.6..2.1 Automatic recording at long wavelength
- 3.6.3 Photography
  - 3.6.3.1 Sequential color-still
  - 3.6.3.2 Color motion - real time
  - 3.6.3.3 Color motion - high speed
  - 3.6.3.4 Infrared motion - real time
- 3.6.4 Thermal imaging
  - 3.6.4.1 Thermal imaging at $SiO_2$ absorption band

3.7 CONTROL AND INSTRUMENTATION

- 3.7.1 Heliostat control computer
  - 3.7.1.1 Simulated startup and shutdown
  - 3.7.1.2 Simulated cloud movement
  - 3.7.1.3 Emergency shutdown
- 3.7.2 Television displays
- 3.7.3 Video tape recording
- 3.7.4 Pyrometer displays
- 3.7.5 Pyrometer output recording
- 3.7.6 Thermal imaging displays - heliostat shutdown
- 3.7.7 Thermal imaging recording
- 3.7.8 Temperature displays - over temperature shutdown
- 3.7.9 Temperature recording
- 3.7.10 Pressure displays - overpressure shutdown
- 3.7.11 Pressure recording
- 3.7.12 Strain displays - overstrain shutdown
- 3.7.13 Flow displays
  - 3.7.13.1 Steam flow display
  - 3.7.13.2 Feedwater flow display - underflow shutdown
  - 3.7.13.3 Recirculation water flow display

3.7.13.4 Air flow rate display (Brayton cycle)

3.7.13.5 Condenser water flow rate

3.7.14 Flow recording

3.7.14.1 Steam flow

3.7.14.2 Feedwater

3.7.14.3 Recirculation

3.7.14.4 Air flow rate

3.7.14.5 Condenser water flow rate

3.7.15 Calorimeter

3.7.15.1 Energy distribution display and recording

3.7.15.2 Total energy display and recording

3.7.16 Computer

3.7.16.1 On-line

3.7.16.1.1 Facility control

3.7.16.1.2 Facility performance

3.7.16.1.3 Data accumulation

3.7.16.2 Processing

3.7.16.2.1 Conversion and reduction

3.7.16.2.2 Analysis

3.7.16.2.3 Prediction

3.8 ENVIRONMENTAL - FACILITY

3.8.1 Insolation - working - receiver and 4 field locations

3.8.1.1 Total - pyranometers - multiple orientations

3.8.1.2 Direct - pyrheliometers

3.8.1.3 All-sky camera

3.8.1.4 Nephelometer

3.8.1.5 Rawinsonde

3.8.2 Insolation - reference - calibration

3.8.2.1 Total - pyranometer standard

3.8.2.2 Direct - pyrheliometer standard

3.8.3 Wind - receiver and 4 field locations

3.8.3.1 Direction

3.8.3.2 Velocity

3.8.4 Humidity - receiver and 4 field locations

3.8.4.1 Relative

3.8.4.2 Absolute

3.8.5 Prediction of above

3.8.6 Storage of above

3.8.7 Analysis of above

3.9 INTERFACES

3.9.1 Analog to digital converters

3.9.2 Digital to analog converters

3.9.3 Signal conditioning

3.9.3.1 Control computer to heliostat control

3.9.3.2 Steam conditions to flow controls

3.9.3.3 Facility control to contractor control

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NOTE:

E = Engineer

T = Technician

M = Machinist

Op = Operator

P = Programer.

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ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

September 2, 1975

Dr. J. C. Grosskreutz
Black and Veatch, Consulting Engineers
Post Office Box 8405
Kansas City, Missouri 64114

Subject: Tests of 1 MW Bench Model Receiver at United States Solar Thermal Test Facility, B&V Project 6987, Georgia Tech Project A-1762

Dear Charlie:

After our program review meeting with the ERDA team, Black and Veatch, Honeywell and Georgia Tech in Albuquerque on August 18-19, I went to Martin Marietta in Denver on August 20. One of the chief purposes of this side trip was to discuss testing of the 1 MW Martin Marietta-Georgia Tech Bench Model Cavity Receiver at the proposed 5 MW United States Solar Thermal Test Facility in 1977. Floyd Blake and I spent about two hours talking over this subject and related matters such as the probable characteristics and configuration of the 5 MW facility.

We reached the following conclusions:

1. Useful tests can be accomplished at the 5 MW test facility after the tests at CNRS are completed. In particular, we can expect many more hours of good sun each month at Albuquerque than at Odeillo, so that it should be possible to log a significant number of operating hours and cycles at Albuquerque in a shorter time than would be possible at Odeillo. Furthermore, operation of the Bench Model receiver any place in the United States would permit Pilot Plant investigators to observe and begin to get real experience, and would give United States operators a head start in learning to run a large number of heliostats.

2. The problem of achieving the desired flux distribution on the receiver walls can probably be handled by locating groups of heliostats in various areas of the field north of the tower and by tilting the receiver slightly forward. The flux distribution on the cavity walls achieved at the United States Solar Thermal Test Facility of course cannot exactly match that obtained at the CNRS Solar Furnace, but if we have the freedom to position heliostats at selected locations within the north field rather than in one large group, it should be possible to get a flux

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distribution which permits operation. This requirement has an impact on the facility planning and construction because it will not be feasible to develop the center one-fifth of the north field early and complete the remainder later.

3. Fairly extensive modification of the Bench Model plumbing may be required if we have to tilt the receiver for tests. The steam drum is sensitive to orientation and any significant tilt would require that it be removed and remounted. We expect that the boiling circuits would operate satisfactorily with a moderate amount of tilt.

4. The most significant problem associated with conducting Bench Model tests at the United States Solar Thermal Test Facility is getting enough radiant energy through the small aperture. If we assume that the same heliostats will be used for the one-megawatt and five-megawatt tests, they will be larger than desired for the Bench Model aperture. Even when the heliostats are capable of focussing, aberrations at the beginning and end of the day will cause a large fraction of the energy to be deposited around the aperture. The structure can be protected with water-cooled shields, but the lost power must be made up by increasing the number of heliostats, shortening the operating day, or both. Another alternative is to make the heliostats smaller for the Bench Model tests than for the Research Experiment receiver tests; this also requires that an increased number of heliostats be procured.

I notified Floyd of Black and Veatch's plans to ask for updated Research Experiment data about the middle of September and to include a questionnaire on the Bench Model at that time.

Very truly yours,

Steve H. Bomar, Jr.
Energy & Materials Technology Division

jw

cc: Mr. Akridge, GIT
Mr. Blake, MMC
Mr. Lippert, B&V