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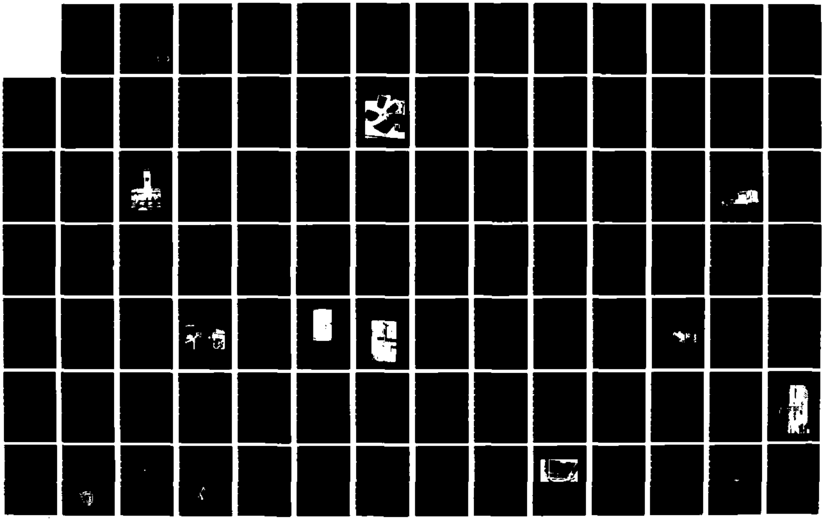

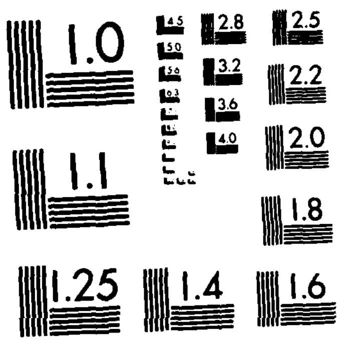

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THERMAL SIMULATION FACILITIES HANDBOOK

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1 February 1983

Technical Report

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Simulation	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this document is to provide persons working in the area of nuclear thermal radiation with a reference document which characterizes thermal simulation facilities having direct or potential application to studies and experiments involving simulated nuclear thermal pulses. The material is arranged to provide the interested experimenter with sufficient facility information to reach a decision in the planning stage for conduct of thermal tests.

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PREFACE

All the contributions are gratefully acknowledged. The efforts of Mr. S.T. Durick and Mr. A.R. Lunde of the Boeing Aerospace Company, Mr. J.T. Holmes of the Sandia Central Receiver Test Facility, Mr. P.H. Adams of Sandia National Laboratories, Division 1531, Mr. Richard A. Hays of the U.S. Army White Sands Missile Range, Dr. C.T. Brown of the Advanced Components Thermal Facility at Georgia Institute of Technology, and W.C. Stevens of New Mexico State University are highly appreciated.

Through the efforts of these personnel, this handbook was made possible in its present form and content.

THERMAL SIMULATION FACILITIES GUIDE

The table that follows attempts to summarize the key data presented in the Thermal Simulation Facilities Handbook (DNA-TR-82-33). The user is reminded that only those facilities having an application potential for studies and experiments involving a simulated nuclear thermal pulse are included in this publication.

All of the data has been furnished by facility personnel or has been extracted from the open literature. The numbers presented in the table are maximum values for the most part. The user is cautioned not to attempt correlation of the data between various facilities because the measurement conditions and operating variables are not identical.

Thermal Simulation Facilities Summary Table

FACILITY	SOURCE TYPE	MAXIMUM FLUX (cal cm^{-2} sec^{-1})	BEAM SIZE	UNIFORMITY OF IRRADIANCE	PULSE SHAPING CAPABILITY	SPECTRAL DATA AVAILABLE	TEST AREA
Boeing Thermal Simulation Facility Kent, WA 98031	Xenon Arc Lamps	1050 (500 cm beam)	5000 cm dia.	15%	yes	yes	3 @ 3.05 cm dia. Appx. 29 cm^2 total
Central Receiver Test Facility Kirtland AFB, NM 87185	Solar	50	n/a	3% over 51 cm dia. beam	no	yes	2.7 m x 2.7 m
Sandia Solar Furnace Kirtland AFB, NM 87185	Solar	100	n/a	n/a	no	yes	1.22 m x 0.61 m
Sandia Radiant Heat Facility Kirtland AFB, NM 87185	Quartz Lamps Graphite Resistors	57 112	n/a n/a	n/a n/a	no yes	no no	n/a n/a
Tri-Service Thermal Flash Test Facility Wright Patterson AFB, OH 45433	Quartz Lamps	55	n/a	n/a	no	no	2.38 cm x 11.43 cm
White Sands Solar Facility White Sands Missile Range White Sands, NM 88002	Solar	100	Variable	5% over 5 cm dia. beam	yes	yes	15 cm dia.
Advanced Component Thermal Facility Atlanta, GA 30332	Solar	55	n/a	n/a	no	n/a	2.44 m x 2.44 m
New Mexico State University Solar Furnace Las Cruces, NM 8803	Solar	16	5 cm dia.	2% over 5 cm dia. beam	no	n/a	.3 m x .3 m

n/a = not available.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION 1

INTRODUCTION

The purpose of this document is to assemble under a single cover quantitative data that characterize simulation facilities suitable for nuclear thermal effects experiments.

Information on possible sources was obtained from a 1970 survey.* This initial list was screened to identify those resources with potential application to studies involving thermal effects from a nuclear detonation. A literature search was also conducted to identify additional facilities with similar potential.

Data for this document were obtained by correspondence with responsible personnel at individual facilities or at firms with multiple facilities. Information was requested that would quantitatively characterize the simulation environment and describe the facility test bed to include instrumentation available onsite. The degree of effort and concern of the personnel at the facilities contacted to generate and document the requested data varied widely. Every effort has been made to objectively and accurately present the characterizing data from the information received. In the acceptance and interpretation of data, it should be kept in mind that uncertainties do exist in measurement techniques; these uncertainties are not identified or explicitly acknowledged in this document.

It is worth mentioning that a significant number of facilities listed in the 1970 survey are no longer in service or have been dismantled. Figure 1-1 is a copy of the outline format for desired information that was sent to individual organizations having facilities applicable to this effort.

Simulation of a nuclear thermal radiation field involves a large amount of energy. Roughly 35 percent of the total energy yield for an airburst nuclear detonation in the lower atmosphere is emitted as thermal radiation. For 1 kiloton of yield (10^{12} calories), thermal radiation accounts for about 3.3×10^{11} calories. This is equivalent to over 380,000 kilowatt hours of energy.

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* Characteristics of High Intensity Facilities for Nuclear Thermal Effects Analysis of Tactical Systems," J.D. Loop, D.L. Nebert, E.L. Quigley, BRL Memorandum Report No. 2083, December 1970.

1. OVERALL DESCRIPTION OF FACILITY

   1.1 Facility Type
   1.2 Sketch of Facility Layout
   1.3 Test Procedure
   1.4 Facility Instrumentation, Available Equipment, Computer Programs and Capabilities
   1.5 Facility Maintenance and Improvements

2. SOURCE CHARACTERISTICS

   2.1 Available Maximum Flux (cal cm^{-2} sec^{-1})
   2.2 Flux Range
   2.3 Pulse Shape
   2.4 Spectral Distribution
   2.5 Uniform Irradiance Area
   2.6 Maximum Operating Times at Highest Flux
   2.7 Pulsing Capabilities (how; repetition rate; etc.)

3. TYPE OF APPLICATION; WORK ACCOMPLISHED, IN-PROGRESS OR PLANNED

   3.1 Materials Tested
   3.2 Experiments Planned
   3.3 References

4. AVAILABILITY OF FACILITY

   4.1 Contact and/or Person in Charge
   4.2 Technical Assistance Available to Experimenter
   4.3 Scheduling
   4.4 Cost

5 REFERENCES

FIGURE 1-1. Outline of desired information requested from thermal simulation facilties

The thermal radiation of a nuclear detonation in the lower atmosphere is emitted in two pulses, the first of which is very short in time and amounts to only about one percent of the total thermal output. The second pulse is the more significant. Not only does the total thermal energy output increase with total yield, but so does the duration of the effective thermal pulse. From a 1-kiloton yield, the effective thermal pulse is about 0.3 second in duration while the pulse from a 1-megaton yield is about 10 seconds in duration.

Some desirable characteristics of a thermal simulation source can be summarized in general, but specific characteristics can depend upon individual experiment or test objectives. The thermal source spectrum should roughly approximate a 6,000K blackbody radiator having wavelengths between 10^3 and 10^5 angstroms; about 4,830 angstroms corresponds to peak radiated power. The flux normal to the test object surface area should be uniform; up to 200 cal cm^{-2} sec^{-1} incident radiation should be provided. A pulse-shaping mechanism is desired to achieve simulation of the nuclear thermal pulse.

Subsequent sections of this document are organized in close parallel to Figure 1-1.

SECTION 2

BOEING THERMAL SIMULATION FACILITY

2.1 FACILITY DESCRIPTION

The Solar/Thermal Radiation Laboratory has been active in developing state-of-the-art technologies for high-flux testing since the 1960s. The high-flux test facility is a versatile, laboratory, radiant-heating system that closely duplicates the spectral content of the sun's rays. The facility is designed for solar power evaluation, thermal nuclear pulse testing, general environmental experiments, and a variety of thermal balance studies.

The high-flux test facility consists of a rotational containment vessel, an A-frame support structure, and a mounting alignment structure for the source modules. The source modules are XM-300 solar simulation instruments consisting of an input-power-adjustable, water-cooled, xenon short-arc lamp capable of delivering from 7 to 35 kilowatts (1,670 to 8,360 cal sec^{-1}) to the test plane. A solid-state dc power supply with suitable controls and monitors, and a collector system to transfer the energy from the source to the target plane are included.

Figure 2-1 is a photograph of a portion of the overall facility showing two XM-300 cylindrical source modules. Figure 2-2 is an overall schematic illustration of the test facility showing the relationship of the test plane to the four XM-300 modules.

2.1.1 Test Procedure

A schematic of the experimental setup for a nuclear thermal pulse test is shown in Figure 2-3. Two XM-300 units are shown. The collectors direct the energy from the source lamps down through a light pipe onto the test specimen. The purpose of the light pipe is to collect the radiant energy and redistribute it uniformly over the target area. A beam douser is mounted above the light pipe. The douser, initially positioned to block the energy beam, is water-cooled and is fitted with a specially shaped aperture that is pneumatically controlled. Passage of the aperture to the beam centerline is accomplished at a controlled rate to simulate desired pulse rise times. Preprogramed control of the power supplies causes appropriate reductions of lamp power at a rate to give the best possible pulse width at half maximum flux and total incident energy. Figure 2-4 is a schematic of the test plane region of the facility showing three test specimen locations.

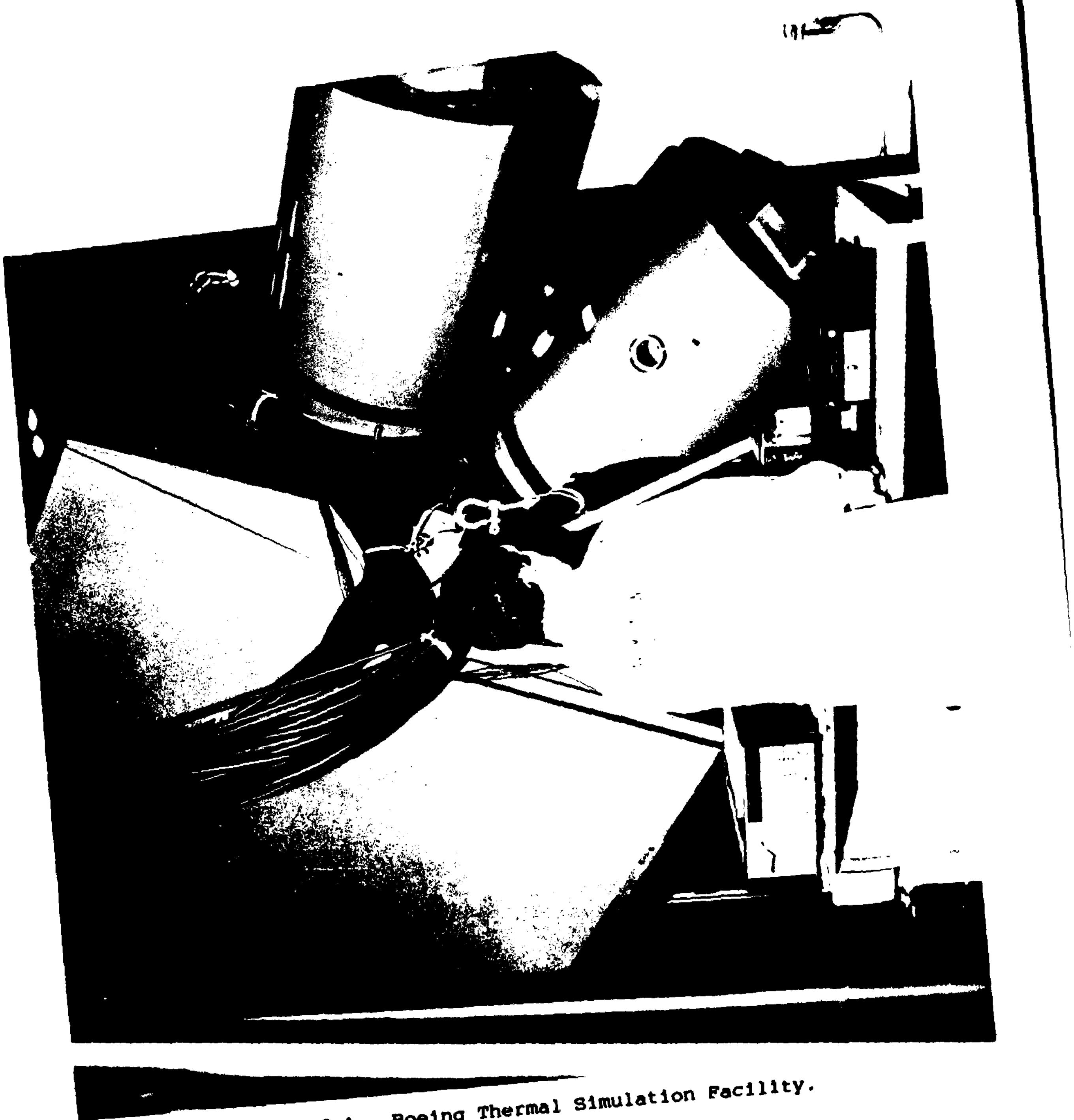


Figure 2-1. Boeing Thermal Simulation Facility.

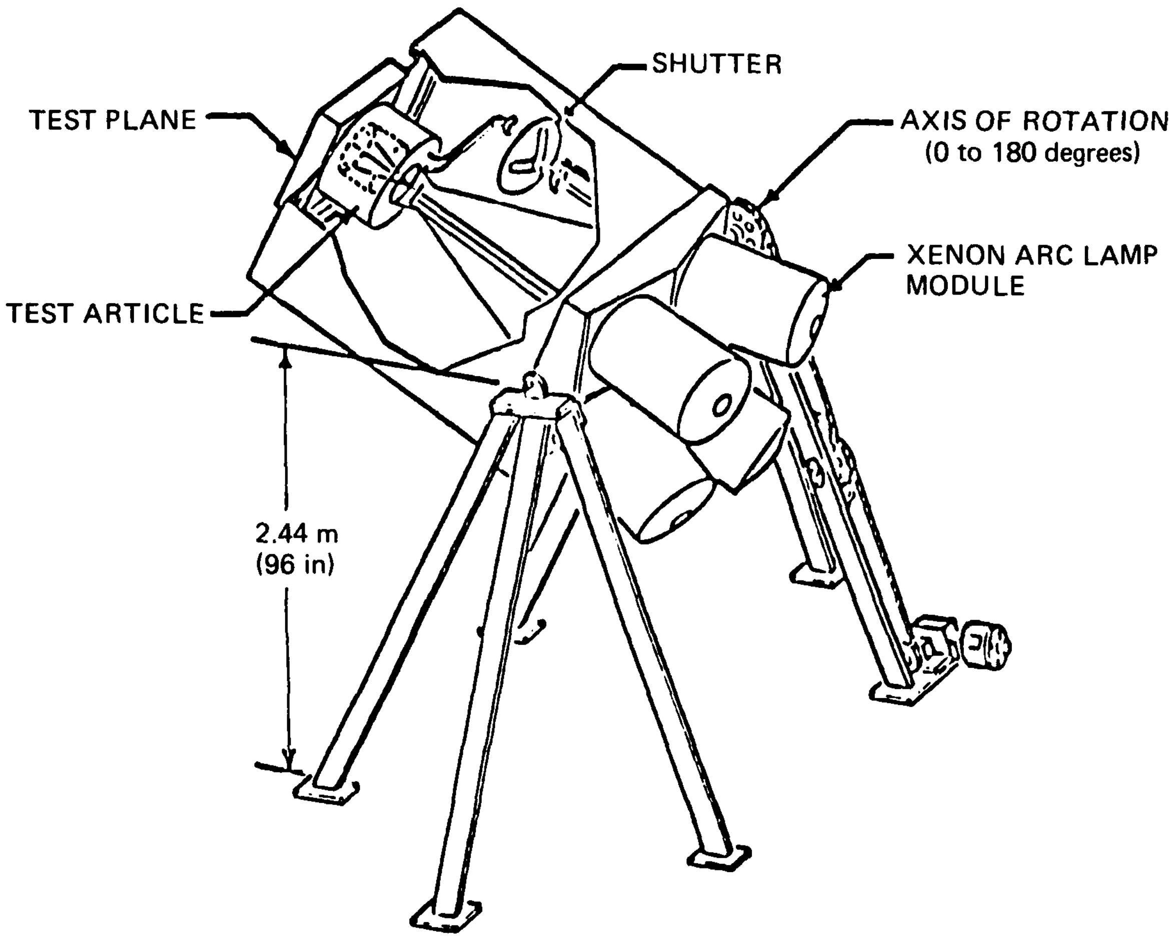


Figure 2-2. Schematic illustration of Boeing Thermal Simulation Facility.

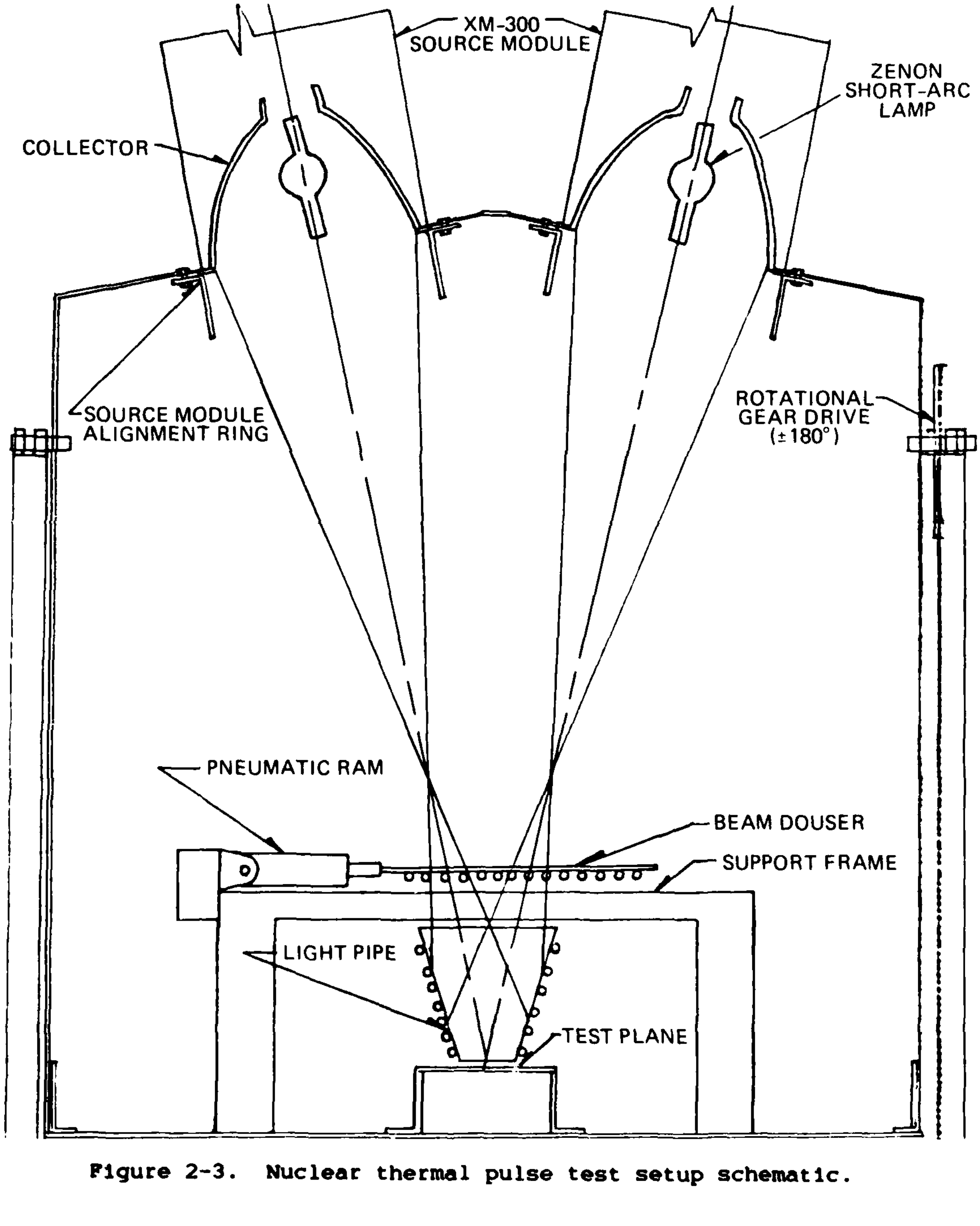


Figure 2-3. Nuclear thermal pulse test setup schematic.

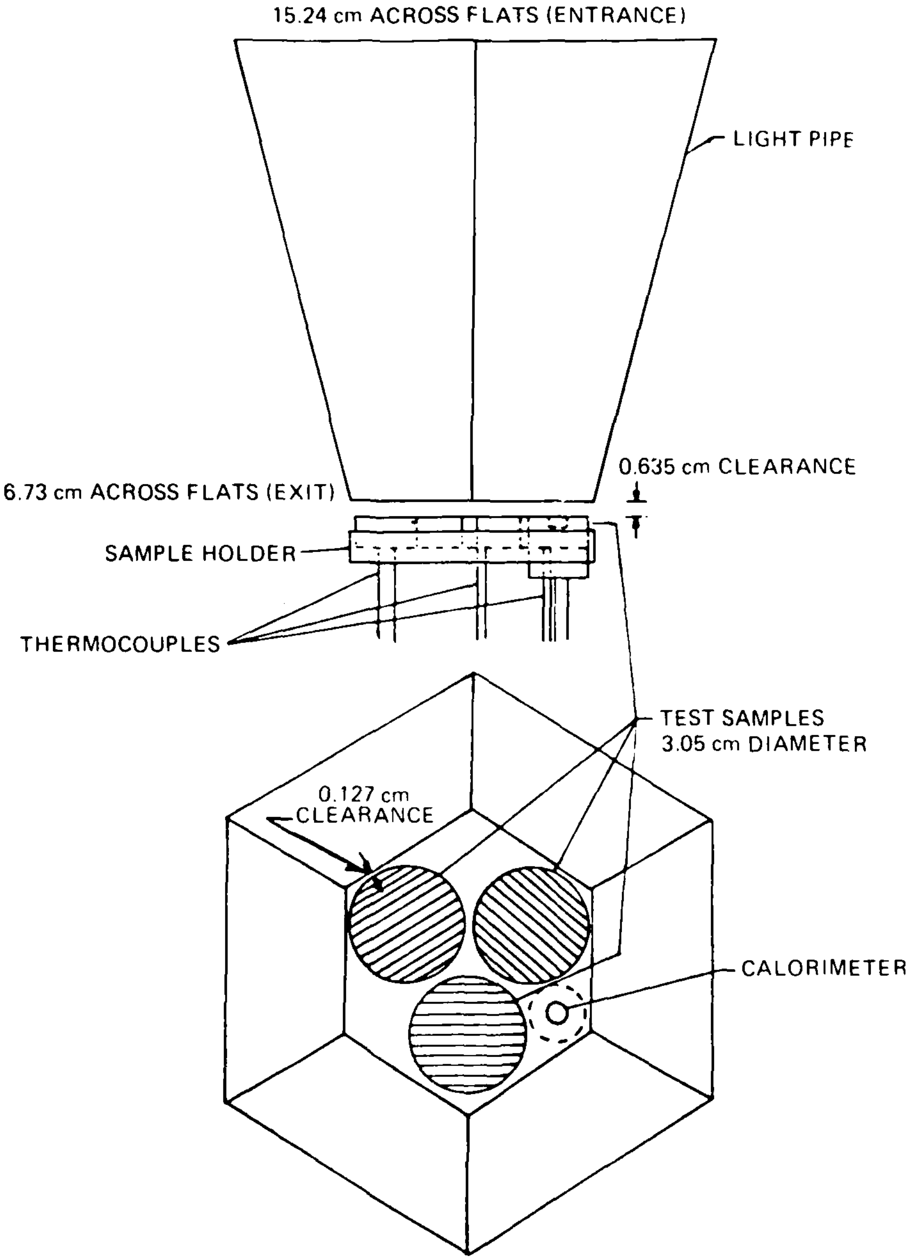


Figure 2-4. Test plane region schematic.

2.1.2 Instrumentation

Listed below are the major test equipment and instrumentation that are routinely used in support of the facility:

- X-Y Plotter, Mosely Model 135
- Visicorder, Minneapolis-Honeywell Model 1508
- Asymptotic Calorimeter, Hy-Cal Engineering Model C-1300
- Data Trak Programmer, Research Inc. Model FGE-5110
- Spectroradiometer, Beckman Model W139323.

2.2 SOURCE CHARACTERISTICS

2.2.1 Flux

The thermal flux levels available at the facility are a function of xenon lamp power and incident beam diameter. Use of the light pipe enhances the flux level by almost a factor of 1.5 for any given lamp power and beam diameter. Table 2-1 summarizes flux capabilities at the facility. The system can operate continuously at maximum flux for about 400 hours.

Table 2-1. Flux capabilities (cal cm^{-2} sec^{-1}).

Lamp Power (kw)	Beam Area (cm^2)			
	5000	3000	1000	500
25	5.3	14.5	124	526
30	6.2	17.4	148	621
35	7.4	20.3	184	717
35[a]	11.0	30.6	241	1050

Note:
[a]With light pipe

2.2.2 Spectral Distribution

The energy distribution of a XM-300 source module is 9 percent for wavelengths of 0.25 to 0.40 microns, 32 percent for 0.40 to 0.70 microns, and 59 percent for over 0.70 microns. Table 2-2 lists more detailed data on the spectrum for a total flux of about 42 cal cm^{-2} sec^{-1}.

2.2.3 Pulse Characteristics

The time pulse width at half maximum irradiance is variable from 0.10 second to continuous open. Pulse shaping can be accomplished through appropriate control of beam douser and lamp power as discussed in Section 2.1.1. Figures 2-5 and 2-6 illustrate some typical pulse shapes of

Table 2-2. Spectral energy distribution.

Wavelengths (microns)	Normalized Energy (cal cm^{-2} sec^{-1})	Wavelengths (microns)	Normalized Energy (cal cm^{-2} sec^{-1})
0.25-0.35	2.24	0.90-1.00	5.01
0.35-0.40	1.51	1.00-1.20	3.80
0.40-0.45	1.95	1.20-1.40	1.88
0.45-0.50	2.43	1.40-1.50	0.94
0.50-0.60	4.63	1.50-1.80	1.59
0.60-0.70	4.52	1.80-2.20	1.14
0.70-0.80	4.16	2.20-2.50	0.73
0.80-0.90	5.51		

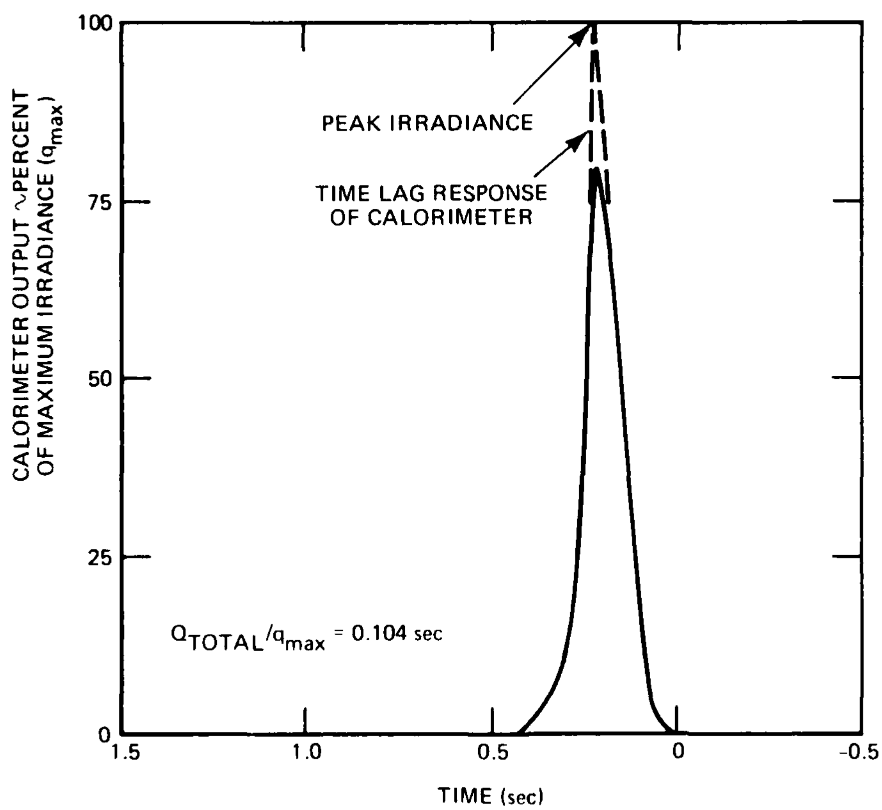


Figure 2-5. Typical pulse shape, set A.

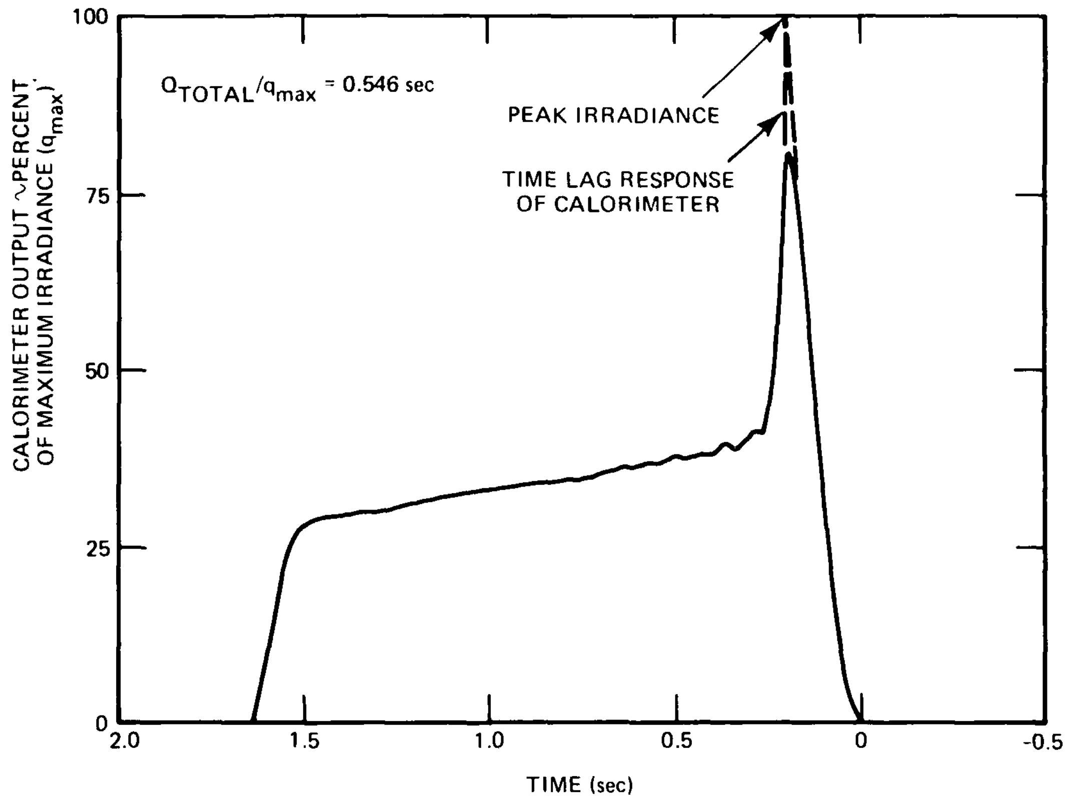


Figure 2-6. Typical pulse shape, set B.

past tests at the facility. Figure 2-5 depicts a short pulse with a symmetrical shape; Figure 2-6 illustrates a pulse shape comparable to that of a nuclear thermal pulse.

The uniformity of irradiance at the test plane is about ±15 percent. Figure 2-7 is a sample curve showing the variance about the centerline on the test plane and at offsets from the centerline along one axis.

2.3 APPLICATIONS SUMMARY

The facility has been used by a variety of defense organizations since 1970. Information and data on specific programs are proprietary to Boeing Company or their customers. The facility is presently being used to evaluate insulation materials for high concentration solar receivers.

2.4 AVAILABILITY

Additional details and specifics regarding test procedures, scheduling, specimen sizes, etc., may be directed to:

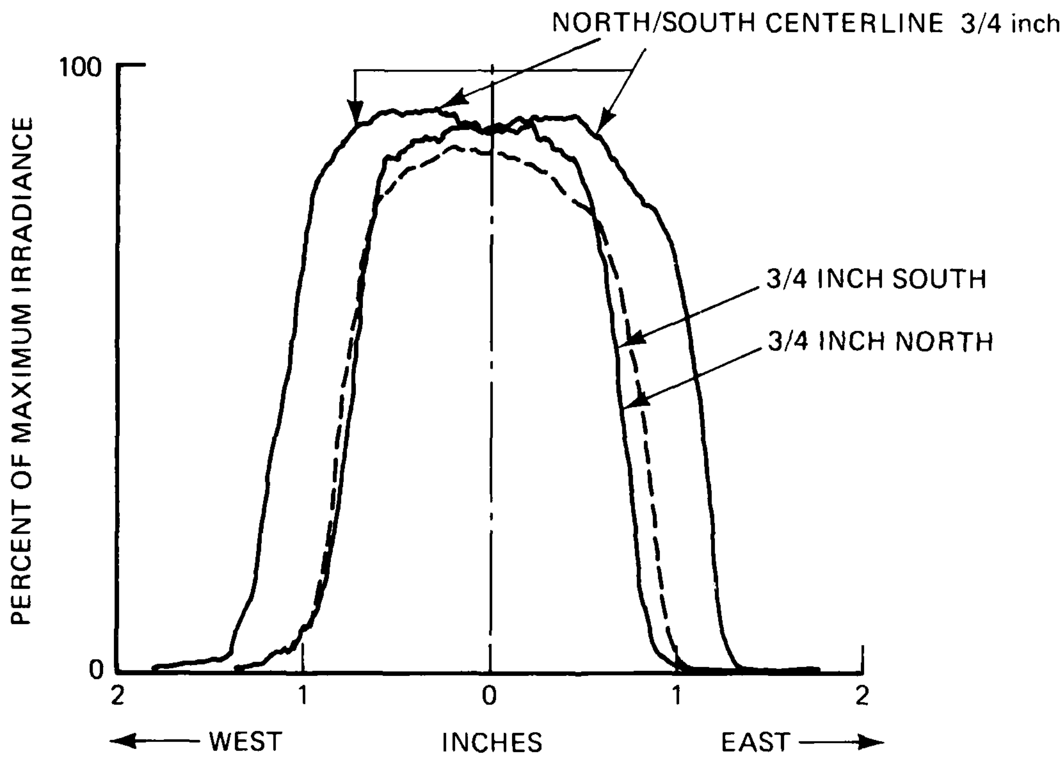


Figure 2-7. Variation in irradiance

A. R. Lunde, Mail Stop 86-01
Test Laboratories Technology
Boeing Aerospace Company
Kent Space Center
Kent, WA 98031
Telephone: (206) 773-8516.

Test requests in the past have been scheduled at the requestor's convenience on a noninterference basis with major Boeing programs.

Technical assistance is available to experimenters. The facility staff has three experienced engineers and two fully qualified technicians.

SECTION 3

CENTRAL RECEIVER TEST FACILITY

3.1 FACILITY DESCRIPTION

The Central Receiver Test Facility (CRTF) is operated by Sandia National Laboratories for the Department of Energy (DOE). The CRTF uses 222 sun tracking mirrors (heliostats) to concentrate 1.3×10^6 cal sec^{-1} of sunlight into a beam that is less than 3 m (10 ft) in diameter. Figure 3-1 is a photograph of the CRTF showing the ground array of heliostats that span the 90° quadrant on the north side of the 61-m (200-ft) tower. Four test locations on the north side of the tower provide incident radiation angles of 90° or less. Since each heliostat is individually controlled, the size of a test item depends on application; target items as large as 2.7 by 2.7 m (9 ft) and 0.9 by 13.7 m (3 by 45 ft) have been used in the past. A fast shutter with a time constant of 0.25 sec is available. The CRTF is located at Kirtland Air Force Base, New Mexico.

3.1.1 Test Procedure

Installation, checkout, operation, and removal of the test item is normally performed by the CRTF staff as directed by the experimenter. Operation of the solar beam is performed by the CRTF staff. Specific procedures depend on the nature of a test and are developed between the experimeter and the CRTF staff working together. Figure 3-2 is a flow chart which depicts typical user and CRTF staff coordination for the design and conduct of a test.

3.1.2 Instrumentation

The CRTF can provide flux density, input power monitoring, optical pyrometry, closed-circuit TV, beam-spillage protection, water or air cooling, electrical power, data recording, and safety equipment to meet the needs of a specific test. Sensors and transducers are normally provided by the experimenter. If the CRTF data systems are used, the data system cables will be provided by the CRTF. The experimenter may provide all or part of his own data acquisition system requirements.

The CRTF data systems provide both digital and analog data processing capability. Table 3-1 summarizes the CRTF data systems availability. Special software for the CRTF data systems will be developed by the CRTF staff for the needs of the experimenter.

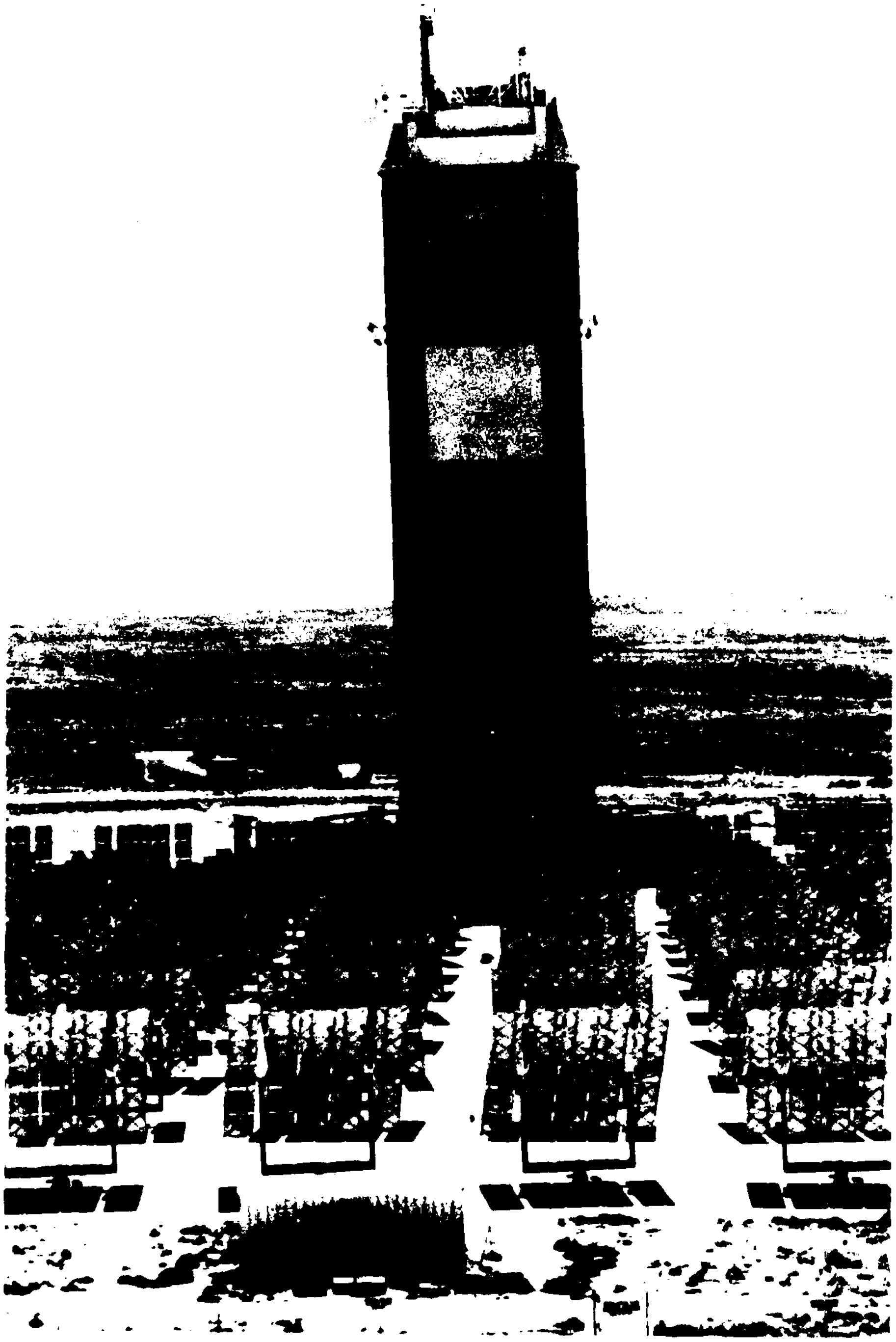


Figure 3-1. Central Receiver Test Facility.

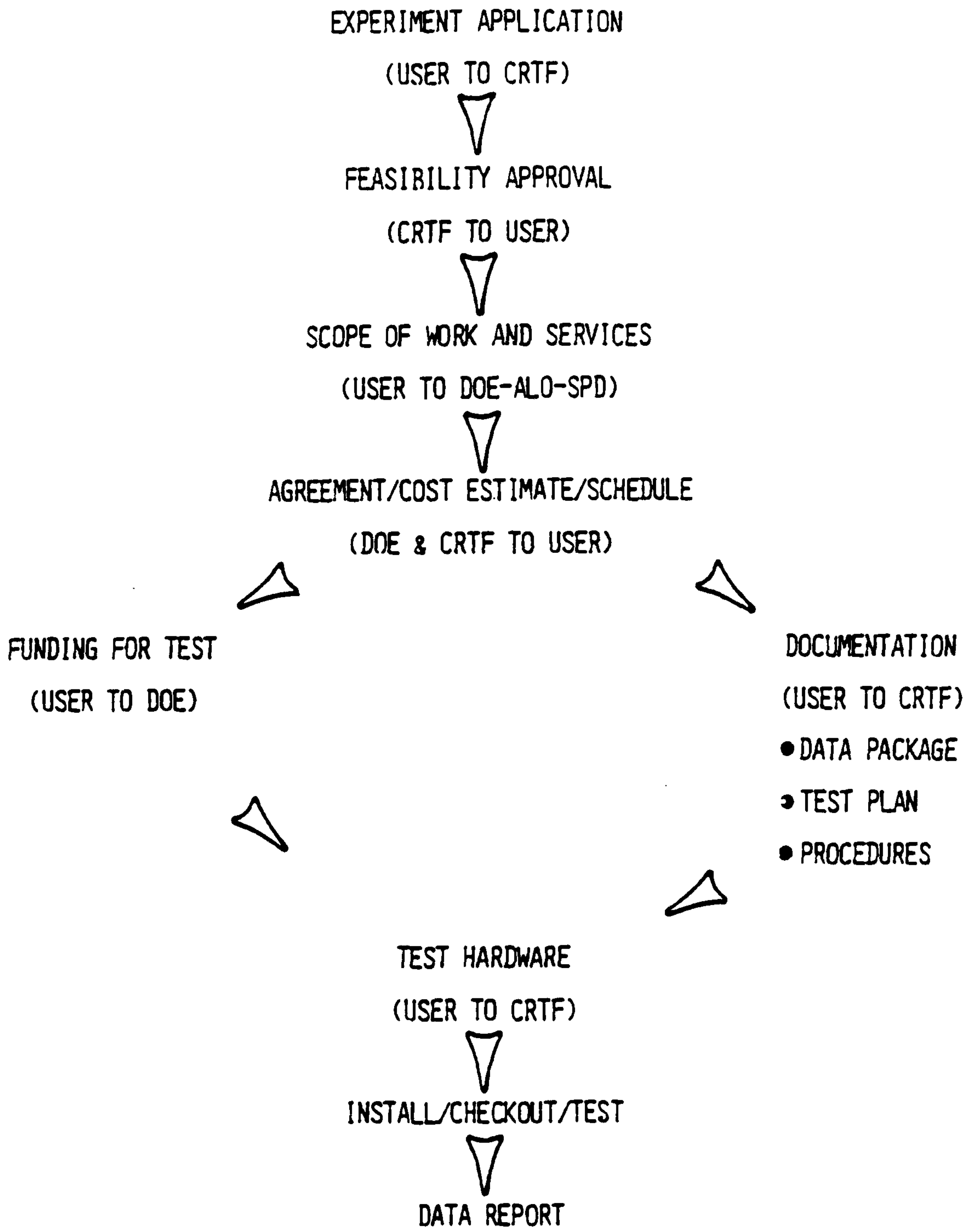


Figure 3-2. CRTF user flow chart.

Table 3-1. CRTF data systems.

DIGITAL, MINI-COMPUTER BASED

500 Channel, 2 sec scan rate (Max Rate)

Real Time -

- CRT Displays (10)
- Hard Copy (tables, histograms)
- Alarm Features
- Process Control
- Disk/Cartridge Storage (8 hr, engineering units)

Archive -

- Pen Plotters
- Line Printers (tables, graphs)
- Magnetic Tape Storage

DIGITAL MICRO-PROCESSOR BASED DATA LOGGERS

3 Mainframes (Acurex and Doric)

700 Channel, Variable Scan Rate

Real Time -

- CRT Displays (3)
- Hard Copy (tables)
- Alarm Features
- Process Control
- Demand Logging

Archive -

- Line Printer
- Floppy Disc Storage
- Magentic Tape Storage - Cassette, Reel to Reel

ANALOG SYSTEMS

Strip Chart Recorders	(5, 2 pen)
Multipoint Recorders	(3, 18 ch)
Oscillograph Recorders	(3, 18 ch)
FM/FM Tape Recorder	(1, 14 ch)
CCTV Beta Tape Recorder	(1, 1 ch)

3.2 SOURCE CHARACTERISTICS

3.2.1 Flux

The maximum flux at the CRTF is 50 cal cm^{-2} sec^{-1} using a single aimpoint strategy. With a multiple aimpoint strategy, the beam profile can be flattened over a larger area, but a lower peak flux is obtained. Figure 3-3 illustrates the CRTF flux contours for one and three aimpoints. Up to 222 aimpoints are possible. Conceptual design for a beam reconcentrator has been completed. When available the beam reconcentrator is expected to provide a flux of about 90 cal cm^{-2} sec^{-1} over a smaller area.

The flux range can be varied in up to 222 incremental steps between 1 and 50 cal cm^{-2} sec^{-1}. Peak flux can be achieved during solar hours.

3.2.2 Spectral Distribution

Figure 3-4 provides spectral data for the beam. A spectral radiometer is available for measurements during a test.

3.2.3 Pulse Characteristics

With the 1-m x 1-m mechanical shutter, pulse rates can be achieved. Figure 3-5 shows the pulse shapes for beam power-on and power-off transients.

Figure 3-3 provided data on irradiance uniformity. With the single aimpoint strategy, the profile is ±3% over a 51-cm (20-inch) diameter. The profile can be tailored using other aim strategies at the expense of lowered peak flux. Figure 3-6 relates the CRTF capabilities to weapon yield and slant range. The limit of the 1-m x 1-m shutter is also shown. The operational regime is above the dashed line for the shutter and to the right of the tower and furnace lines.

3.3 APPLICATIONS SUMMARY

3.3.1 Nuclear Weapons Effects

The CRTF has been used in preliminary studies to characterize the solar beam for use in a study of the soil blowoff phenomena that take place in a nuclear weapons blast. To achieve the close-in effects of a nuclear weapon, a beam reconcentrator and mechanical shutter will be needed. For longer range nuclear effects studies, only the shutter will be required.

3.3.2 Materials Survival

Ceramics and other materials for use as insulation and passive solar beam protection have been tested to failure. These have included high purity aluminas, alumina silicates, zirconia, fused silica, paints, and wood.

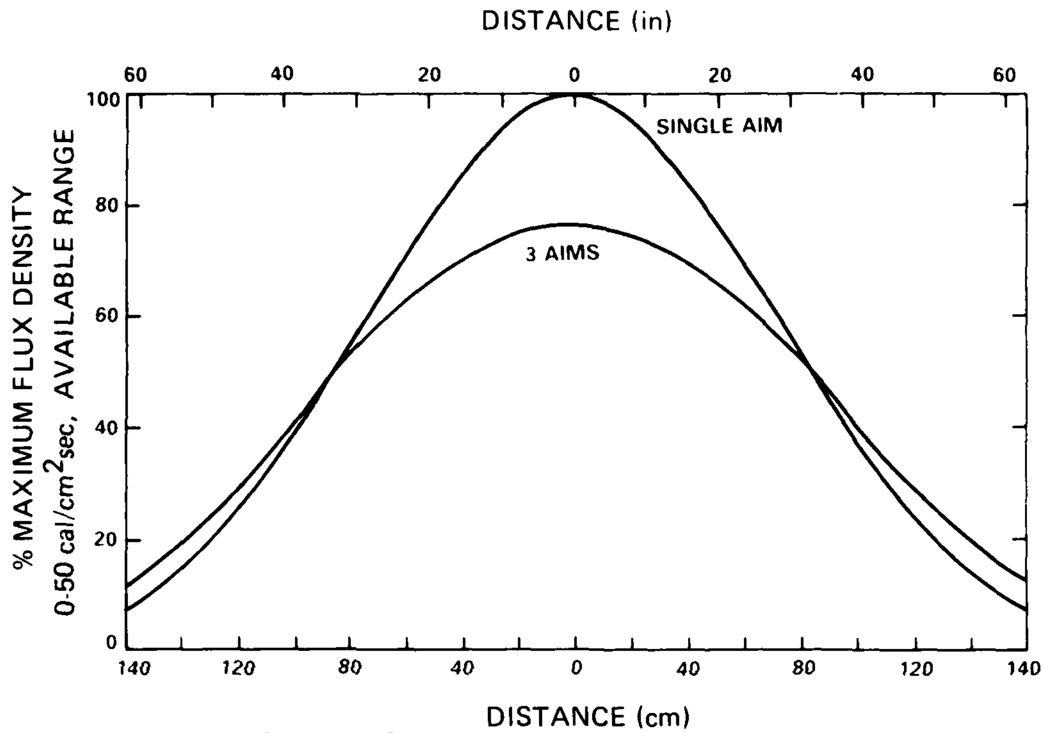


Figure 3-3. CRTF flux contours.

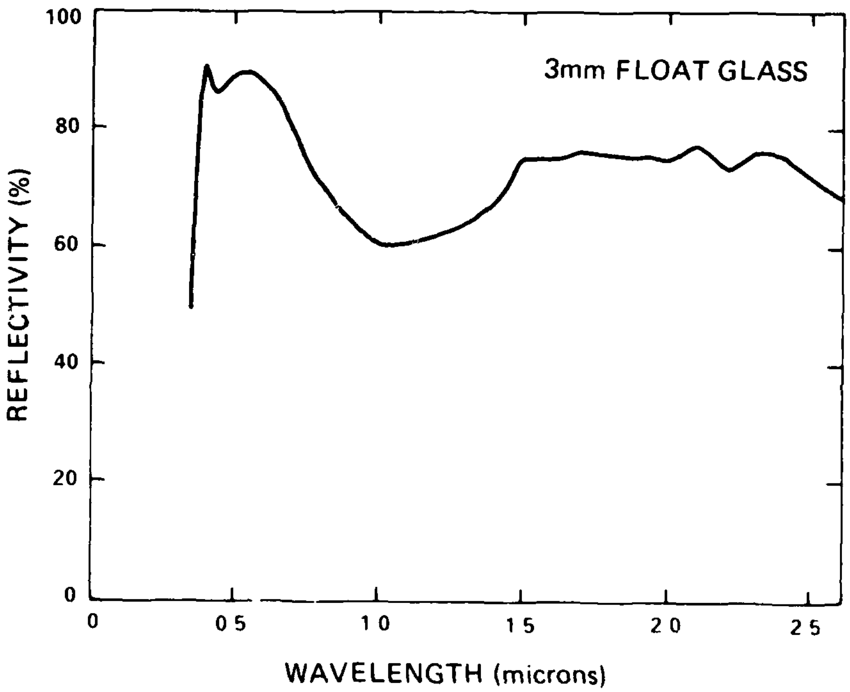


Figure 3-4. CRTF reflectivity.

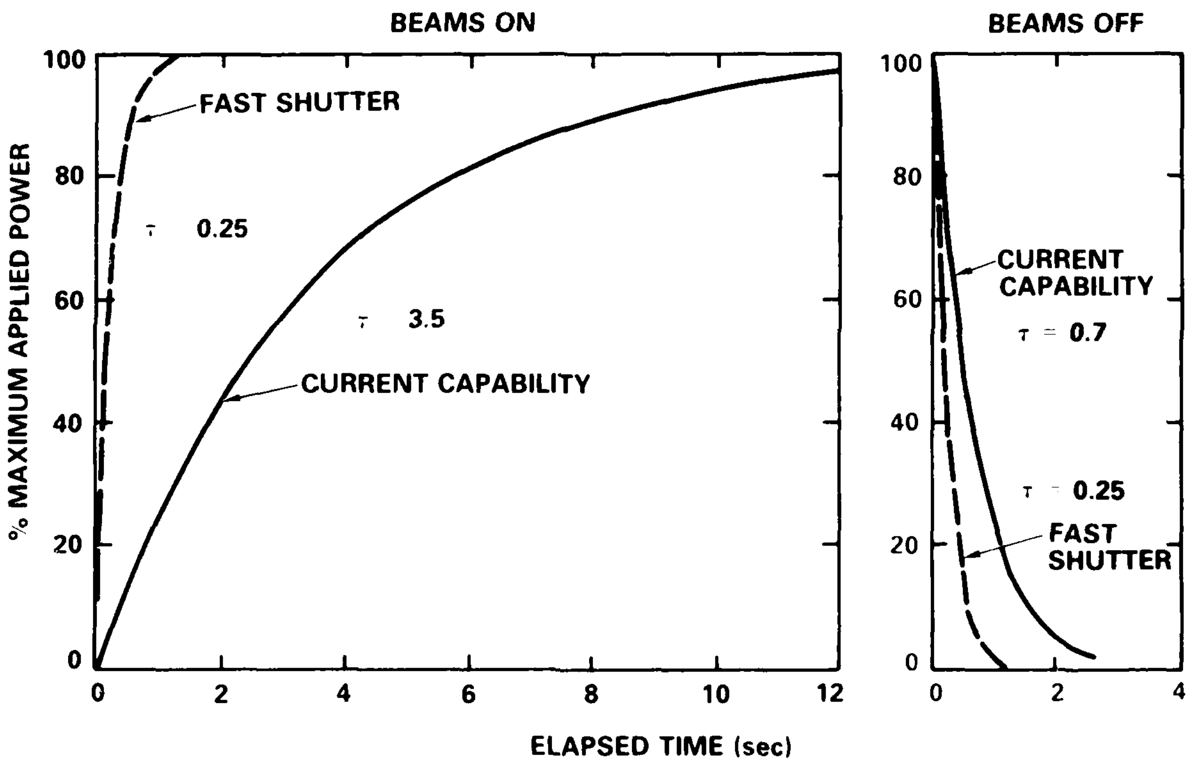


Figure 3-5. CRTF power transients

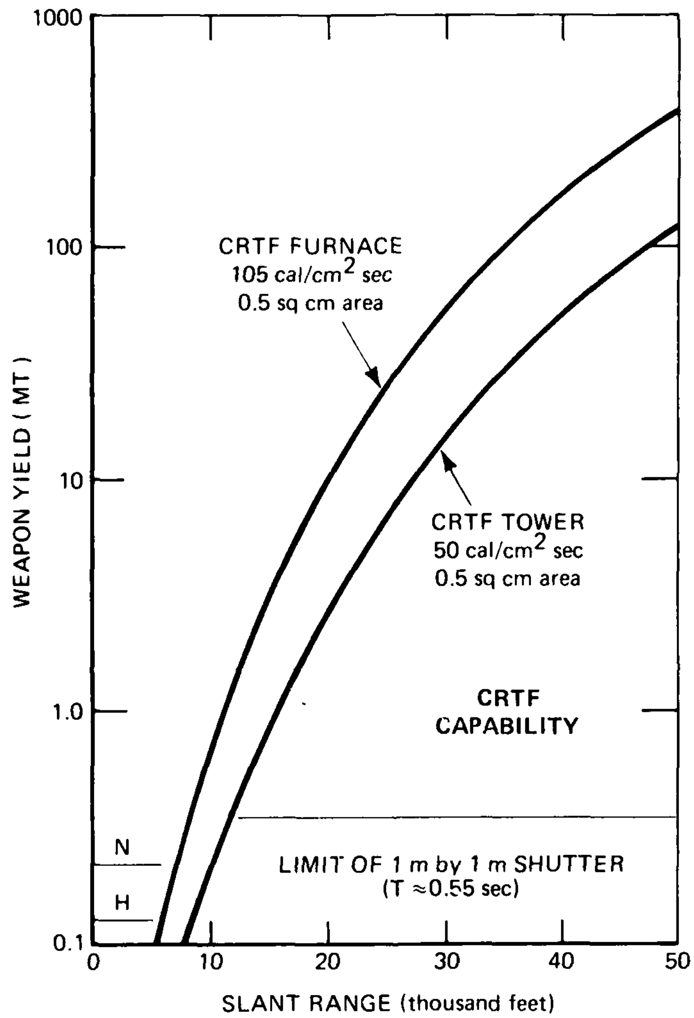


Figure 3-6. Nuclear weapon blast in clear air.

3.3.3 Aerodynamic Heating

A unique experiment was conducted where the CRTF beam was used to simulate the aerodynamic heating profile on a ceramic missile radome. Because the solar beam contains light as its only electromagnetic radiation form and because there are no adjacent structural components, radar tracking accuracy was optimized during the aerodynamic heating excursions. The simultaneous aerodynamic heating and radar measurements are normally not possible in wind tunnels or if electrical radiant heaters are used.

3.3.4 Solar Power Tests

The DOE program to develop the solar central receiver concept has resulted in four major receiver tests since 1978. These include: an air-cooled receiver (1,500F), a water/steam-cooled receiver (960F), a molten nitrate, salt-cooled receiver (1,050F), and a liquid sodium-cooled receiver (1,100F).

3.3.5 Experiments Planned

The CRTF will continue to develop its capability to perform nuclear weapon effects tests. Currently the beam provides a flux density of 1 to 50 cal cm^{-2} sec^{-1}. For close-in nuclear effect simulations a beam reconcentrator may be required. A mechanical shutter will allow simulation of the pulse shape from a weapon.

3.4 AVAILABILITY

3.4.1 Contact

Access to the CRTF is made through:

Supervisor - Division 4722
Sandia National Laboratories
Albuquerque, New Mexico 87185
(505) 844-2280.

3.4.2 Scheduling

The test schedule will be developed when the test agreement and cost estimate are provided to the experimenter. Because the CRTF is a DOE facility, DOE tests will be given priority in scheduling. Non-DOE projects will be accommodated on a time-available basis. To date, non-DOE tests have proceeded with minimum interference from DOE tests due to the multiple test bay arrangement at the CRTF.

3.4.3 Costs

The cost of a test at the CRTF will be based on the time of the manpower, materials, and utilities used for the test and its preparation. There are no "rental charges." Manpower charges will be at Sandia's current loaded rate (~$300/man-day, FY 1982). These charges will include any setup, installation, instrumentation, checkout, maintenance, and teardown assistance requested by the experimenter. Minimum charges for actual solar operation will be at a 2.5 man-day/day rate plus any assistance needed to prepare for the test, operate, or maintain the test hardware.

3.5 REFERENCES

Holmes, J.T.; Matthews, L.K.; Seamons, L.O.; Davis, D.B.; King, D.L., "Central Receiver Test Facility (CRTF) Experiment Manual," SAND 77-1173 (Revised), Albuquerque, Sandia Laboratories, 1979.

SECTION 4

SANDIA SOLAR FURNACE

4.1 FACILITY DESCRIPTION

The Flux Gage Calibration Station, or solar furnace, is part of the Department of Energy's Central Receiver Test Facility. The CRTF is operated for DOE by Sandia National Laboratories. The solar furnace's primary purpose is calibration of flux gages but it is designed such that it can be used for many other applications. (See also Section 3.)

The solar furnace uses both a flat mirror (heliostat) that tracks the sun and a 7-m diameter parabolic dish to concentrate 7,000 cal/sec of sunlight about 4,000 times, giving a spot size approximately 5 inches in diameter and peak flux density of 100 cal cm^{-2} sec^{-1} The concentrated sunlight intercepts the test item from an incident angle of 45°. The light passes through an attenuator, which has 90 repeatable positions of variable flux between full open and full closed.

The solar furnace layout is provided in Figure 4-1. The furnace is composed of a tracking heliostat, an attenuator, a three-axis, test-item-positioning table, a parabolic concentrator, and a data-acquisition system. The heliostat has 54.7 m^2 of reflective surface, and tracks the sun using a closed-loop system. The attenuator is similar to a venetian blind and is used to control the amount of power and flux density at the test plane. It is capable of 90 discrete and repeatable positions between full open and full closed. The test-item table, which has three electronically controlled degrees of freedom, accommodates experiments weighing up to 450 kg. It is 1.22 m by 0.61 m in the horizontal plane and allows for an experiment whose maximum vertical dimension is 1.83 m above the aimpoint. A paraboloidal dish (6.7 m in diameter) is used as the concentrator. It is composed of 228 individually aligned glass mirrors and will give a concentration of about 4,000. The data is acquired through a Hewlett Packard data acquisition system under control of a Hewlett Packard 9845T computer. It provides up to 60 channels of thermocouple input (20 type K, 20 type T, and 20 type S) or up to 80 channels of voltage inputs.

4.1.1 Test Procedure

The exact test procedure depends on the test and is developed by the experimenter working with the solar furnace staff. Installation, checkout, operation, and removal of the test item can be performed exclusively by the experimenter or by the solar furnace CRTF staff as directed by the

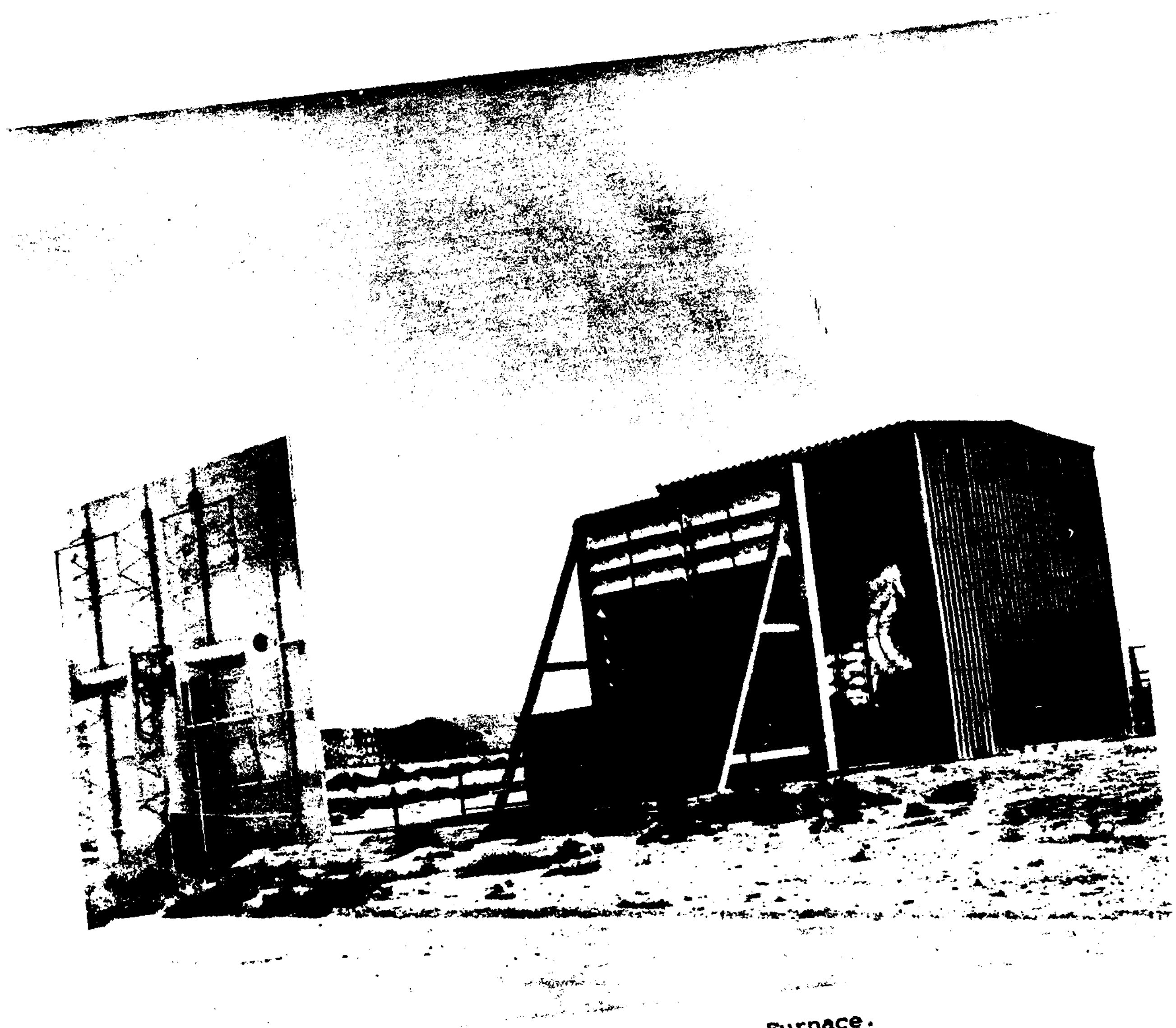


Figure 4-1. Sandia Solar Furnace.

experimeter. Operators of the furnace are provided by the CRTF staff. The test item table is inside the concentrator building so hardware can be set up in advance regardless of weather. Figure 3-2 is applicable to user and solar furnace staff planning procedures.

4.1.2 Instrumentation

Table 4-1 summarizes the main data system for the solar furnace. Special software for these systems will be developed by the CRTF staff to fit the needs of the experimenter. In addition to the equipment in Table 4-1, the digital microprocessor-based data loggers and the analog systems listed in Table 3-2 are also available when CRTF scheduling permits.

Table 4-1. Solar furnace main data system

HP9845B System -
HP9845B Desktop Computer
Disc Drive
Line Printer
Plotter
HP-IB Interface Link to MCS
Data Acquisition System -
HP85F Desktop Computer
HP3054A Data Acquisition System
20 Channel Voltage Input Card (3)
19 Channel Thermocouple Card (2)
16 Channel Digital Input Card
16 Channel Relay Output Card
60 Channel Thermocouple Ref. Junction
System Control -
HP6942A Multiprogrammer
16 Channel D-A Voltage Converter
16 Channel Relay Output (3)
16 Channel A-D Converter
16 Channel Isolated Dig Input (3)
16 Channel Analog Comparator (2)
Channel Interrupt (2)
Alarm Features

The experimenter may provide all or part of his own data acquisition system requirement. Sensors and transducers are normally supplied by the experimenter. When the solar furnace data system is used, data system cables are normally provided by the CRTF staff.

4.2 SOURCE CHARACTERISTICS

4.2.1 Flux

The maximum flux at the solar furnace is 100 cal cm^{-2} sec^{-1} and can be varied in 90 incremental steps betwen 0 and 100 cal cm^{-2} sec^{-1}. Peak flux can be achieved during sunlight hours.

4.2.2 Spectral Distribution

The beam spectrum will be very similar to the spectrum given in Figure 3-4 with some attenuation in the 1-micron range.

4.2.3 Pulse Characteristics

There is no current capability for pulse shaping. One pulse every 20 seconds is available when peak flux is required.

4.3 APPLICATIONS SUMMARY

4.3.1 High Temperature Research

The main purpose of the solar furnace is to calibrate heat flux gages in a solar environment. However, the furnace was designed such that it can be used for many other applications. These include materials evaluation, solar chemistry, selective coating behavior, nuclear weapon effects, and thermal shock studies.

4.3.2 Experiments Planned

The CRTF solar furnace will continue to develop its capabilities to perform nuclear weapon effects tests. Currently the beam can simulate a flux density of 100 cal cm^{-2} sec^{-1}. To simulate the pulse shape from a weapon a mechanical shutter will be required.

4.4 AVAILABILITY

4.4.1 Contact

Access to the CRTF solar furnace is made through:

Supervisor - Division 9722
Sandia National Laboratories
Albuquerque, New Mexico 87185
(505) 844-2280.

Because the solar furnace is a DOE facility operated by Sandia National Laboratories, both DOE and Sandia are involved in the acceptance of work and cost reimbursement.

4.4.2 Scheduling

The test schedule will be developed when the test agreement and cost estimate are provided to the experimenter. Because the solar furnace is a DOE facility, DOE tests will be given priority in scheduling. Non-DOE projects will be accommodated on a time-available basis. Significant interference from DOE tests with regard to non-DOE tests is not expected.

4.4.3 Costs

The cost of a test at the CRTF solar furnace will be based on the time of the manpower, materials, and utilities used for the test and its preparation. There are no "rental charges." Manpower will be Sandia's current loaded rate (~$300/day, FY 1982). Manpower charges will include any set-up, installation, instrumentation, checkout, maintenance, and tear-down assistance requested by the experimenter. Minimum solar operation charges will accumulate at a 2.0 man-day/day rate plus any assistance needed to prepare for the test, operate, or maintain the test hardware.

SECTION 5

SANDIA RADIANT HEAT FACILITY

5.1 FACILITY DESCRIPTION

The Sandia National Laboratories Radiant Heat Facility was built to provide a laboratory simulation capability for studying the effects of high-temperature environments on materials, components, and major assemblies. A wide range of thermal environments has been simulated such as a nuclear thermal pulse, launch pad abort fires, JP-4 fuel fires, and concentrated solar radiation.

The facility has several different types of sources for thermal radiant energy. The two that feature some application to the nuclear thermal pulse area are quartz infrared lamps and graphite resistors. Other sources include a fluidized bed, ceramic fiber heaters, blackbody calibrating furnace, and ovens.

Figure 5-1 shows the layout of the facility which is located in Building 6536 at Sandia National Laboratories, Kirtland AFB, New Mexico. The "Instrument Room" is where most of the delicate instrumentation tasks are performed. The "Computer and D.C. Control Room" contains equipment to control the direct current power supply and houses the computer equipment for data acquisition and storage. The direct current power supply system contains four rectifiers, each capable of 1 MW continuous or 1.25 MW for 30 minutes. The "A.C. Control Room" has the necessary equipment to operate the alternating current power system, which has a total capacity of over 5 MW.

The test bay area comprises the center portion of the building. Manifolds and outlets are available for raw water, deionized water, nitrogen and argon. There is also a 7,000-kg capacity overhead crane.

5.1.1 Test Procedures

Specific procedures will vary widely between specific test projects because of the numerous ways the equipment can be configured to achieve simulation of a given environment. Assistance from the staff of Organization 1535 will closely parallel the flow chart in Figure 3-2. See also Section 5.4 for additional information.

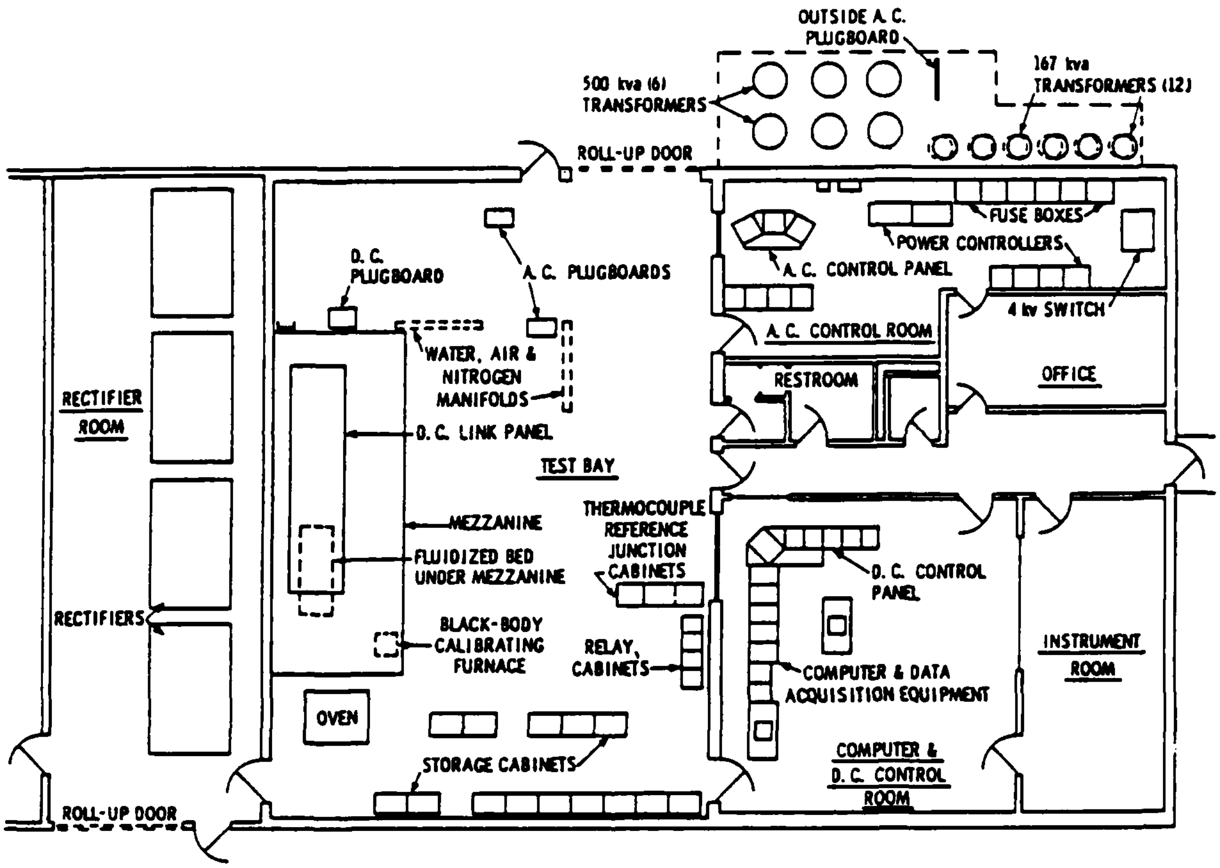


Figure 5-1. Sandia radiant heat facility.

5.1.2 Instrumentation

The facility has a wide variety of gages and sensors for data acquisition. Data acquisition and presentation are controlled by two Hewlett-Packard (HP) general-purpose minicomputers in a central system. Peripherals include the shared HP 7905-A disk and HP 7970-B magnetic tape drives, an external clock, a paper tape photoreader, a high-speed punch, and four 1200-baud modems. Four terminals and a Versatec printer/plotter constitute standalone peripherals.

The acquisition minicomputer system has its own photoreader, punch, and clock. Standalone units for this system consist of the system terminal and two CRT display units. Each CRT can display 48 channels of data in engineering units every 5 seconds. Data presentation other than the 48-channel CRT is handled by the central system.

The complete system can be used as a single entity with a total of 416 multiplexed channels or it can be split up with the data acquisition subsystem handling 112 local channels. The other 304 channels are normally scanned in an autoranging mode, stored in a disc file, and displayed on a CRT by random selection from the disc.

5.2 SOURCE CHARACTERISTICS

5.2.1 Quartz Lamps

A single quartz lamp consists of a tungsten element in an inert, gas-filled quartz tube 9.5 mm in diameter. Some of the lengths available are 127, 254, 406, 635, and 935 mm. The normal heat dissipation of a quartz lamp is 3.93 W per linear millimeter of heated filament. Lamps with heat dissipation values of 7.8, 14.2, and 25.4 W/mm are used here. The operating temperature of the tungsten filament is about 2,500K at rated voltage. Transformation of the input energy into radiant energy is 86 percent efficient. Normal life is 500 hours at rated voltage; operated at 225 percent of rated voltage, lamp life drops dramatically to 350 seconds. The filament color temperature varies with applied voltage. Figure 5-2 gives color temperature and power output data versus percentage of rated voltage.

5.2.1.1 Quartz Lamp Flux. The lamps can be arranged at various angles and distance from test items and in regular--or irregular--shaped arrays to achieve desired heat-flux levels and distribution. Arrays of lamps are designed with water- or air-cooled holders for the lamp ends. Water and air cooling of the reflective surface behind the lamp are sometimes necessary.

Table 5-1 lists some of the various arrays of quartz lamps. Data in the table are for some examples of planar or flat arrays and circular (3-D) arrays. This table is by no means complete in that there are many other forms of arrays available.

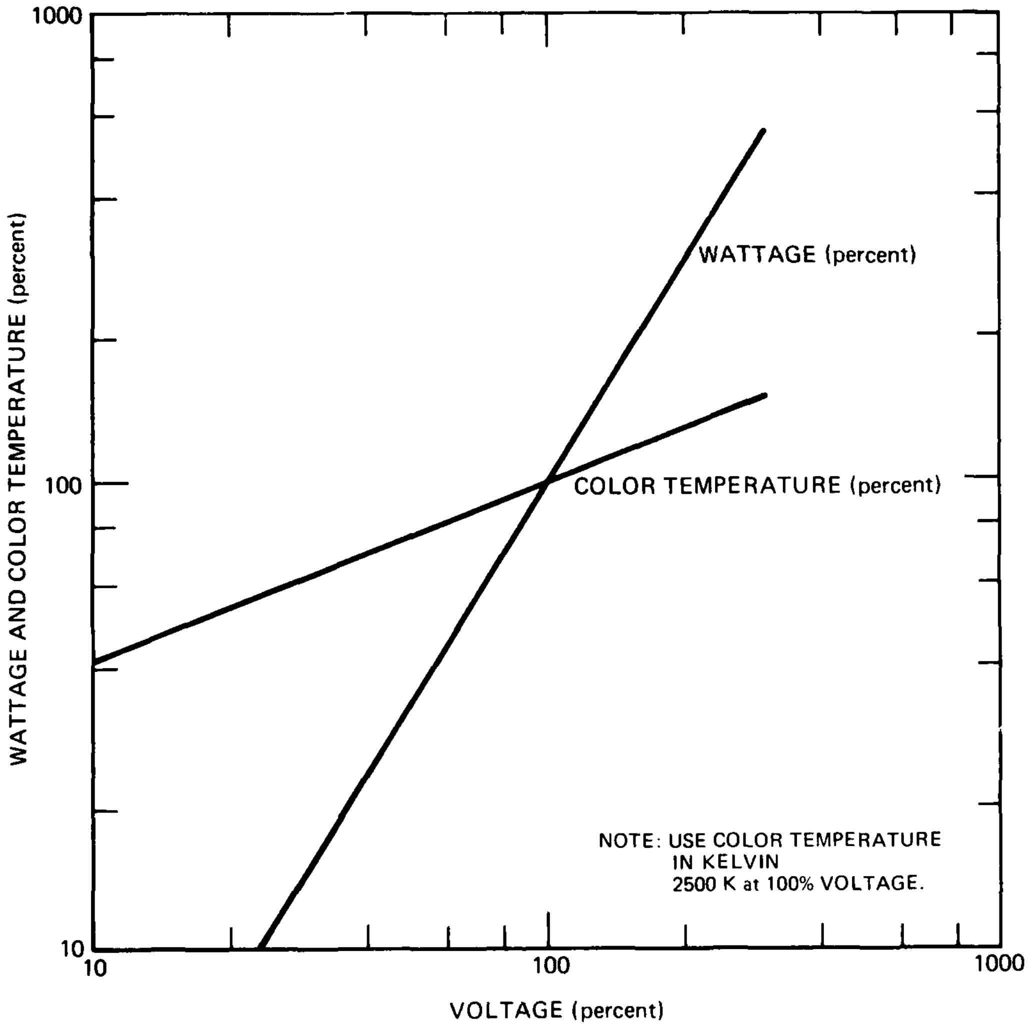


Figure 5-2. Characteristics of quartz lamp.

Table 5-1. Some heater arrays available.

FLAT TYPE						
LENGTH mm	WIDTH mm	LAMP LIGHTED LENGTH mm	NUMBER OF LAMPS	RATING PER LAMP kW	@ volts	FLUX 25 mm FROM LAMPS kW/m^2
520	305	254	41	6.0	480	1850
470	470	406	75	3.2	384	1130
500	780	635	74	5.0	600	940
600	1200	406	56	1.6	240	125
1175	305	254	63	6.0	480	1000
CIRCULAR TYPE						
DIAMETER mm	LENGTH mm					
100	300	254	48	3.2	384	2380
490	330	254	216	2.0	240	1200
550	710	634	174	5.0	600	900
660	350	254	92	2.0	240	250
660	530	406	92	1.6	240	165
690	760	635	96	5.0	600	285
720	1300	254	368	3.2	384	395
860	3000	635	660	5.0	600	400
950	810	635	138	5.0	600	280

5.2.1.2 <u>Quartz Lamp Spectral Distribution</u>. At this writing spectral data are not available.

5.2.1.3 <u>Quartz Lamp Pulse Characteristics</u>. There is no current capability to incorporate an effective shutter or control system for pulse shaping due to the relatively short distance between a test item and the lamp for medium to high flux rates. Figure 5-3 shows the response characteristics of a quartz lamp, which comes close to a square wave in form.

5.2.2 Graphite Resistors

Graphite resistors are a larger thermal mass than quartz lamp filaments. The graphite resistor sources have been used to simulate thermal energy from nuclear bursts, some aspects of reentry vehicle heating, and other studies that require energy levels and time durations unattainable with quartz lamps.

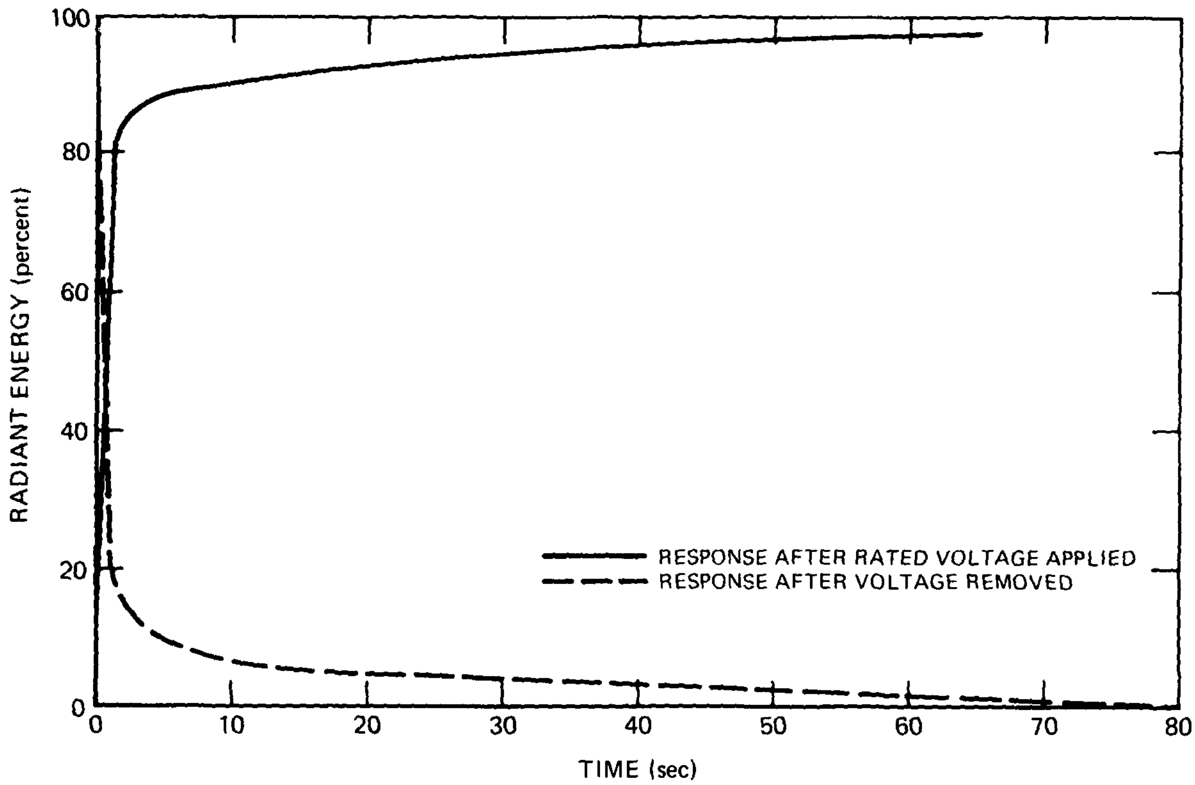


Figure 5-3. Quartz lamp response

The graphite resistors are arrayed with gold-plated copper reflectors and back-face water cooling when maximum levels are desired. An inert gas manifold is used to reduce the resistor oxidation rate. Emittance is considered to be 94 percent of that obtainable from a theoretical blackbody. Sublimation temperatures of the graphite material have been estimated between 3,300K and 3,800K.

5.2.2.1 Graphite Resistor Flux. An array of three graphite resistors arranged in an optimum planar configuration has been repeatedly used to attain incident thermal fluxes of 95 cal cm^{-2} sec^{-1}. On one previous test a maximum flux of 112 cal cm^{-2} sec^{-1} was attained.

5.2.2.2 Graphite Resistor Spectral Distribution. Data on the spectrum for the graphite resistor source is not available.

5.2.2.3 Graphite Resistor Pulse Characteristics. The normal rise and decay times for graphite resistors is about 20 seconds due to the large thermal mass. Pulse shaping is attainable using a shutter or a combination of shutter, moveable table, and heat control. Figure 5-4 shows one pulse shape produced by the shutter and table combination. A number of pulse shapes are theoretically possible using the three variables in combination.

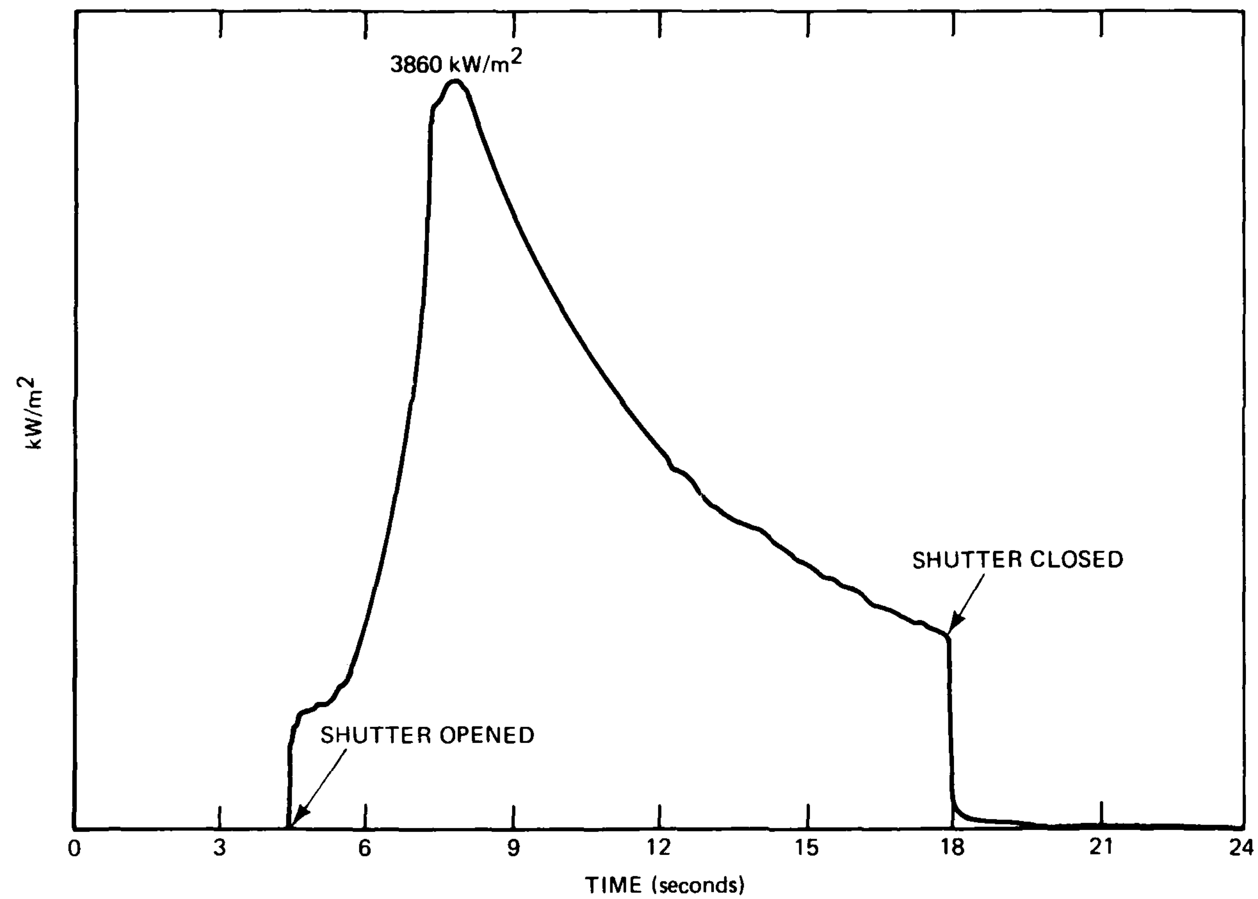


Figure 5-4. Pulse shape using movable table at shutter.

5.3 APPLICATIONS SUMMARY

The capabilities to simulate thermal environments, ranging from high-level/short-duration thermal pulsing to low-level/long-duration exposures, have been applied to thermal effects studies on materials, components, and major assemblies of interest in Sandia programs. Most of the testing has involved nuclear weapon research and is classified.

5.4 AVAILABILITY

Sandia National Laboratories, a prime contractor to DOE is primarily responsible for research and development on nuclear ordnance. Being in no position to compete with commercial testing laboratories, Sandia does support additional DOE, DOD, NASA or other Government agency programs when Sandia has a unique capability. Assistance can be provided on a non interference basis with current DOE programs. Costs in using the Government-furnished facilities is based on labor and material use.

Initial inquiries should be directed to:

J. E. Bear
Sandia National Laboratories
Organization 1535
P.O. Box 5800
Albuquerque, New Mexico 87185
Telephone (505) 844-1632.

Formal requests for quotes should be directed to:
Department of Energy
Albuquerque Operations Office
ATTN: J. L. Bellows
Albuquerque, New Mexico 87115.

5.5 REFERENCES

P.H. Adams, P.L. Class, J.T. Nakos, and B.G. Strait, "Sandia Laboratories Radiant Heat Facility", SAND 79-2182, February 1980.

SECTION 6

TRI-SERVICE THERMAL RADIATION TEST FACILITY

6.1 FACILITY DESCRIPTION

In 1976, the Defense Nuclear Agency contracted the University of Dayton Research Institute to establish and operate a thermal radiation test facility at the AF Wright Aeronautical Laboratories, AFWAL/ML, Wright-Patterson AFB, Ohio. The facility currently has four basic systems for irradiation testing and experiments:

1. Irradiation of test specimens using a Quartz Lamp Bank (QLB)

2. Irradiation of test specimens using a QLB in aerodynamic flow

3. Irradiation of test specimens using a QLB with tension or bending mechanical loads

4. Irradiation of test specimens using a QLB with transient tensile or compressive loads.

Figure 6-1 is a schematic of the Tri-Service Thermal Radiation Test Facility. Two banks of lamps are available; they are designated the Mobile Quartz Lamp Bank (MQLB) and the High Density Lamp Bank (HDLB). The MQLB consists of 24 quartz lamps in an area 22 cm by 25 cm. It is normally mounted on a mobile cart and is used in conjunction with simulated aerodynamic or mechanical loads. The HDLB also consists of 24 quartz lamps contained in a 15-cm by 25-cm area to produce a higher heat-flux capability. The HDLB mounts to the side of the wind tunnel and therefore is used in conjunction with aerodynamic loads. Use of this one-dimensional radiation source is limited to an 11-cm by 22-cm window that forms one wall of the test section.

6.1.1 Test Requests

Material response tests for the Tri-Service community take precedence over all the other activities associated with facility operation. The facility is available to Government users on a no-charge basis. All test projects require the approval of the Defense Nuclear Agency contract monitor. Test requests are scheduled at the test initiator's convenience whenever possible. Since most test programs are from one to five days in length, scheduling conflicts are rare.

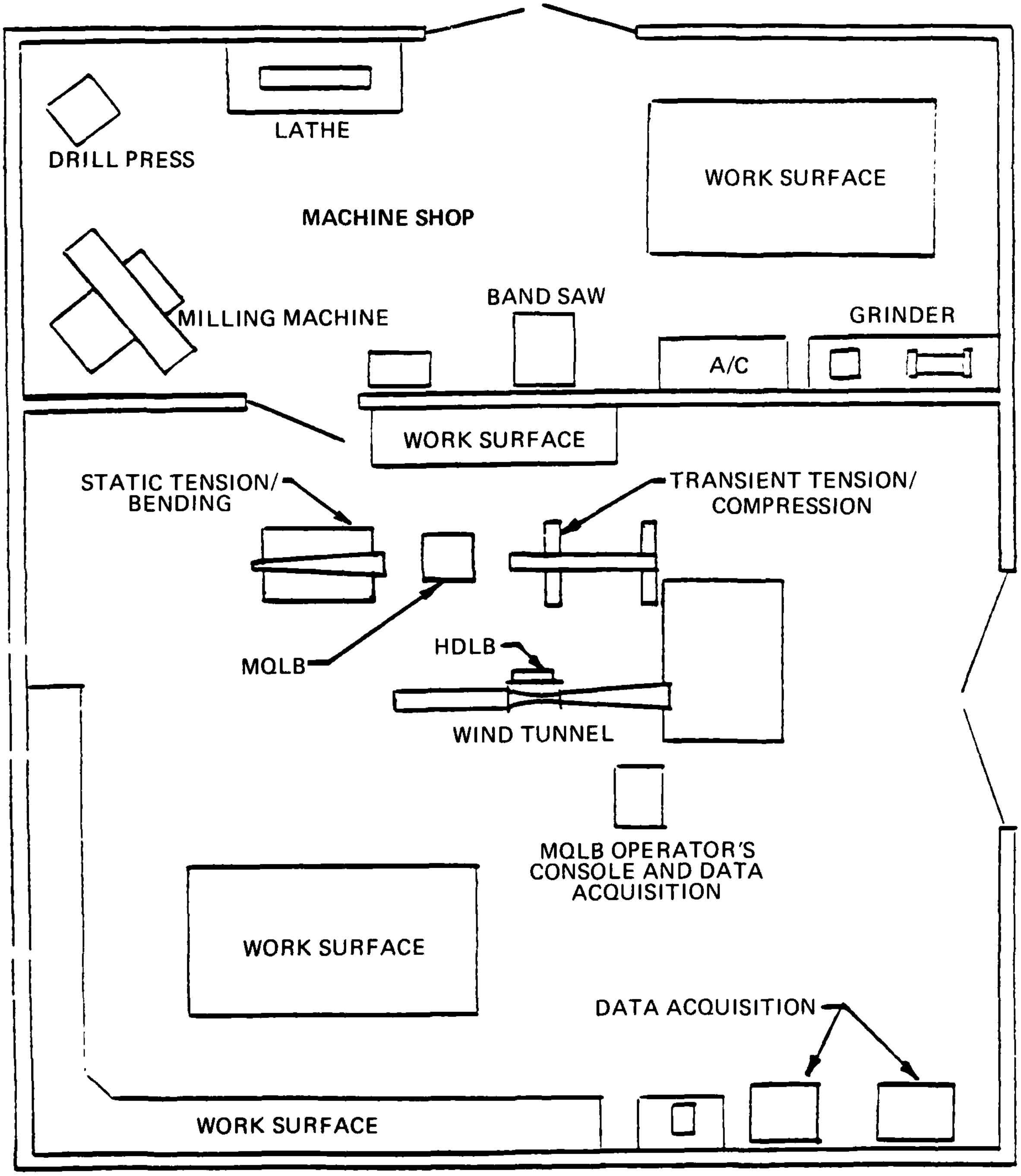


Figure 6-1. Tri-Service Thermal Radiation Test Facility.

Procedures are described in Reference 1 and will vary in accordance with test objectives and facility assets involved. When more advance notice is given to the facility Test Director, the more efficiently the tests can be conducted by appropriately addressing test conditions and variables in the planning stage.

6.1.2 Instrumentation

Available instrumentation includes radiometers, thermocouples, X-Y recorders, cameras, strain gages, pitot tube for flow velocities, and various electronic control devices. Table 6-1 summarizes available instrumentation. Table 6-2 lists specifications on available flux gages, and Table 6-3 provides specifications on recorders.

The data-acquisition system includes an LSI-11 microcomputer which is capable of telecommunications with the AFWAL computer. Figure 6-2 schematically illustrates the system while Table 6-4 lists components available within the facility.

6.1.3 Aerodynamic Load Simulation

An open-circuit, pull-down wind tunnel permits simulation of aerodynamic flow over specimens exposed to thermal radiation. Figure 6-3 is a schematic of the test setup. A photograph of the wind tunnel test section is shown in Figure 6-4. The test section is 70 cm in length and has a 2.38-cm by 11.43-cm cross-sectional area. The constant free-stream velocity for the section is nominally 210 m sec^{-1} with a corresponding Mach number of 0.6. The Reynolds number is 20 x 10^6 based on inlet wall length. Wind tunnel exhaust gases are vented to the atmosphere through the roof of the building.

Either the MQLB or the HDLB can be used in conjunction with the wind tunnel. The beam enters through the quartz window mounted in one wall of the test section. The opposite wall holds the test specimen which is mounted flush with the wind tunnel wall. Specimen sizes up to 10.08 cm by 22.86 cm can be accommodated. Recommended specimen dimensions are illustrated in Figure 6-5.

A shutter is available for the wind tunnel test configuration. The shutter, actuated by an air cylinder, enhances simulation of thermal nuclear heating through a rapid rise time for the pulse and through accurate control.

6.1.4 Mechanical Load Simulation

6.1.4.1 Static Mechanical Loads. A creep frame is available for dead weight simulation of tensile and bending loads. Figure 6-6 illustrates the equipment configured for tensile loading. For the bending mode, a yoke and

Table 6-1. Instrumentation available.

Application	Quantity	Instrumentation	Purpose
Quartz Lamp Banks	10	Radiometers	Heat Flux
	2	Slug Calorimeters	Heat Flux
	2	Hy-Cal Asymptotic Calorimeters	Heat Flux
	1	Photronic Cell	Timing
Aerodynamic Load	1	±10 psi Stathem Pressure Transducer	Flow Calibration
	1	Pitot Probe Assembly	Flow Calibration
	1	Manometer	Flow Calibration
Mechanical Load	1	Wheatstone Bridge[a]	Strain Gage
	1	LVDT[a]	Linear Motion
Timers	1	Closed Loop Power Controller	Heat-Flux Control
	1	Electronic Timer	Shutter and Two Voltage Lamp Controls
	1	Data-Trak Controller	Heat-Flux Control
General	2	X-Y-Y' Recorders	Data Recording
	1	LSI-11 Microprocessor	Data Recording
	1	Dual Trace Storage Oscilloscope	Data Recording
	1	6 Channel Strip Recorder	Data Recording
	1	35mm Nikon Still Camera	Specimen Photographs
	1	MP-4 Polaroid Still Camera	Specimen Photographs
	2	8mm Nizo braun Movie Cameras	Specimen Photographs
	-	Various Thermocouples	Temperature
	1	L&N 8641-S Automatic Recording Pyrometer (760-6,000°C)	Surface Temperature
	-	Barometer, Thermometer, Hygrometer	Ambient Conditions
	1	Keighley Digital Voltmeter	Voltages
	1	L&N K-4 Potentiometer	Calibrations

Note:

[a]Not on site.

Table 6-2. Flux gage specifications.

Mfgr	Type	Model	Range (cal cm^{-2} sec^{-1})	Accuracy (%)
Hy-Cal	Gardon	C1312-A-750-072	0-200	±3
Medtherm	Gardon	64P-20-24	0-5	±3
Medtherm	Gardon	64P-50-24	0-13	±3
Medtherm	Gardon	64P-100-24	0-27	±3
Medtherm	Gardon	64P-100-24	0-27	±3
Medtherm	Gardon	64P-200-24	0-54	±3
Medtherm	Gardon	64P-200-24	0-54	±3
RdF	Gardon	CFR-1A	0-400	±10
RdF	Gardon	CFR-1A	0-400	±10
ADL	Calorimeter	----	50-350	±5

Table 6-3. Recorder specifications.

Mfgr	Model	Channels	Range	Response
Hewlett-Packard	7046A X-Y-Y'	2	0.2mv/cm-4v/cm	0.0-40 sec/cm
Hewlett-Packard	136 X-Y-Y'	2	0.2mv/cm-20v/cm	0.05-5 cm/sec
Soltec	3316	6	0.2mv/cm-20v/cm 50-1,000°C	0.025-1.5 cm/sec

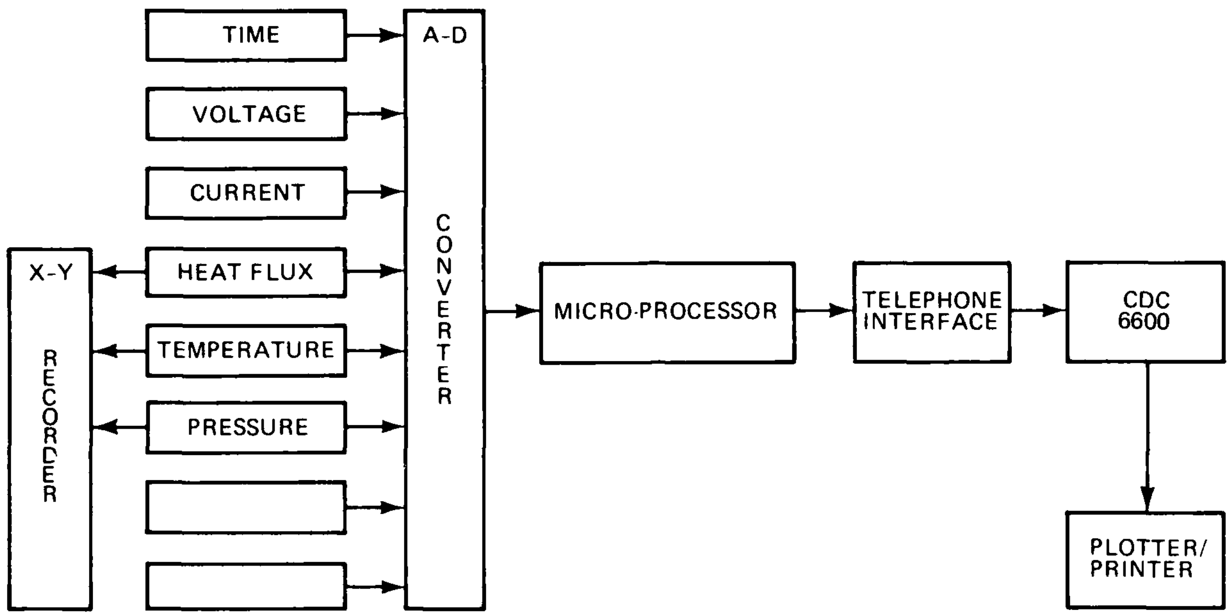


Figure 6-2. Data acquisition system schematics.

Table 6-4. Data acquisition system components.

Operating Controls

- Wind tunnel operation
- Quartz lamp operation
- Quartz lamp cooling operation (blower and air)
- Quartz lamp remote operation jack
- Quartz lamp and shutter exposure time control
- Computer reset, clock and hold operation
- Controller set-point remote operation
- Tri-phaser controller

Monitoring Controls

- Quartz lamp power -- voltage and current indicators
- Wind tunnel pressure indicator
- Peripheral equipment temperature indicator (10 pt.)
- Shutter solenoid overheat indicator
- Quartz lamp cumulative operating time indicator

Data Acquisition

- LSI-11 microprocessor
- Ectron differential dc amplifiers (8)
- Power supply
- Teletype
- Acoustic coupler

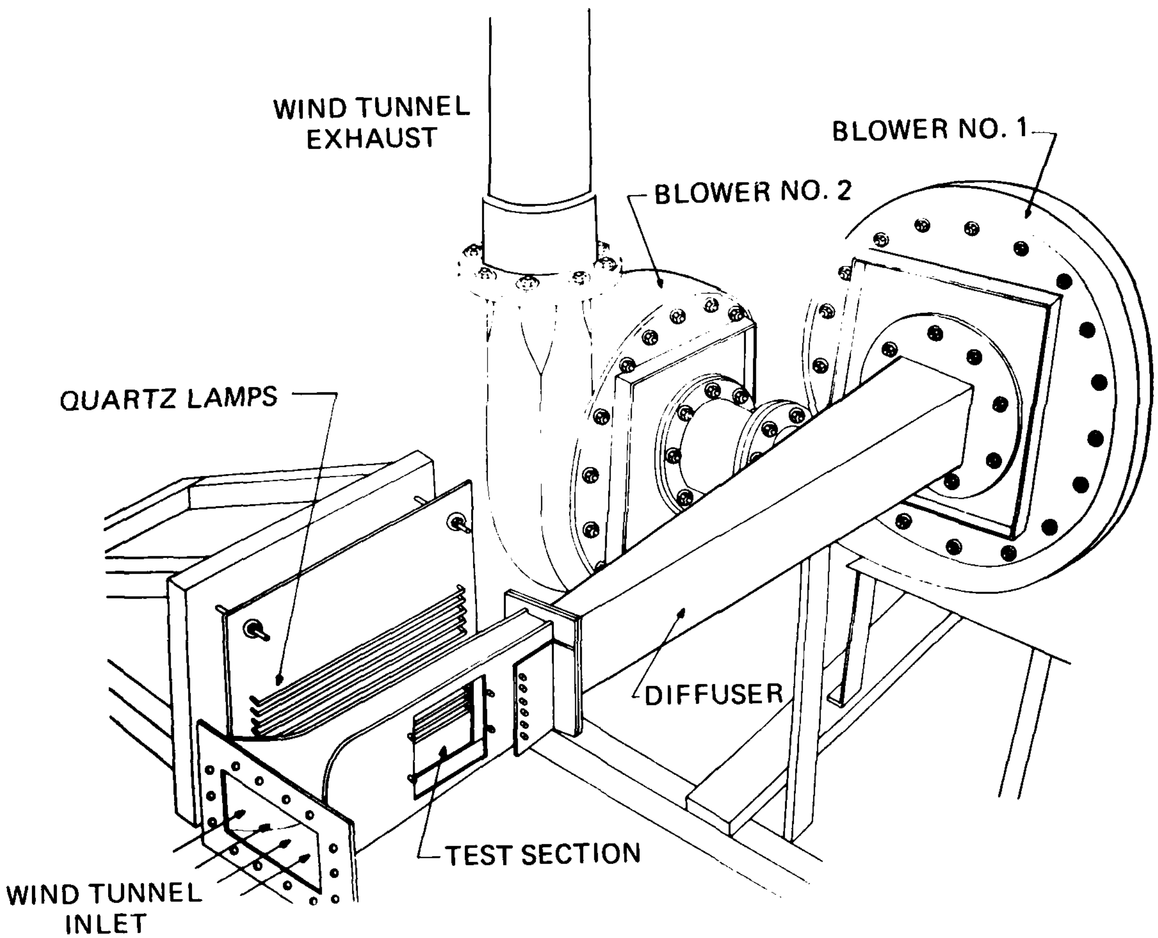


Figure 6-3. Wind tunnel schematic.

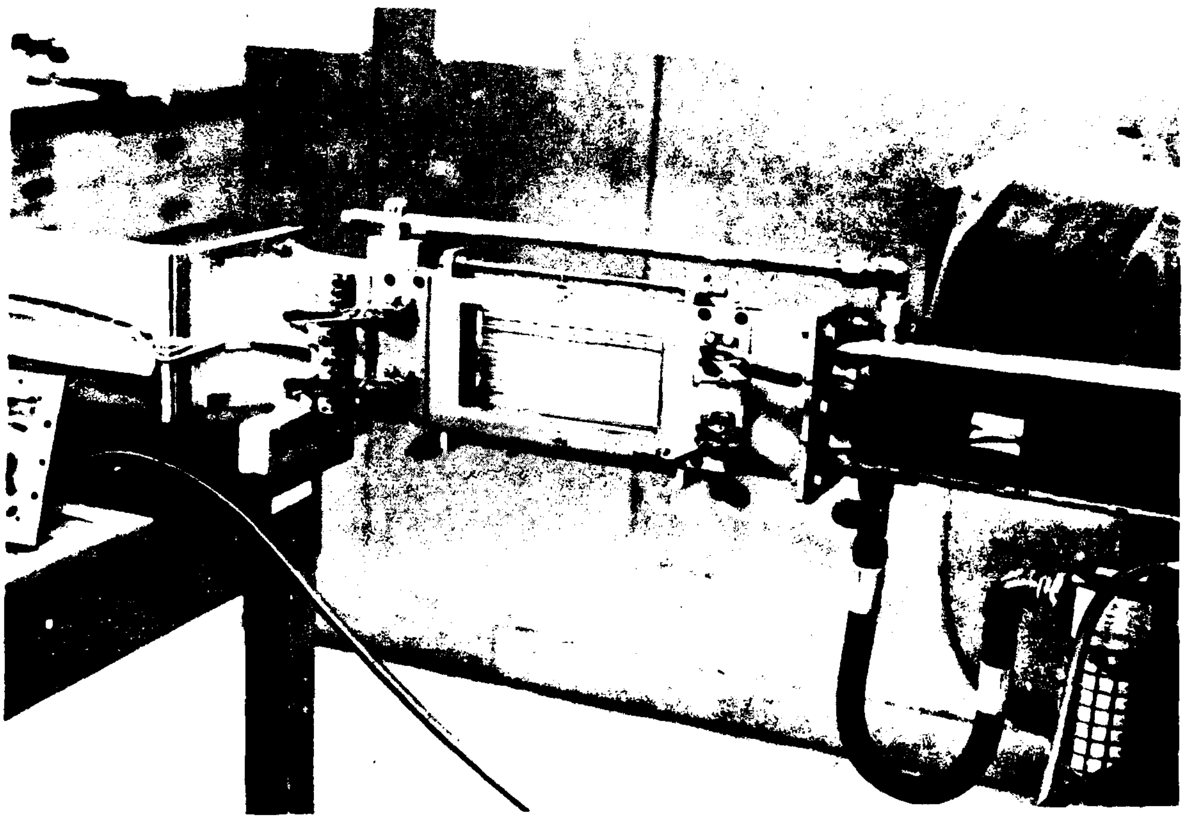


Figure 6-4. Wind tunnel test section.

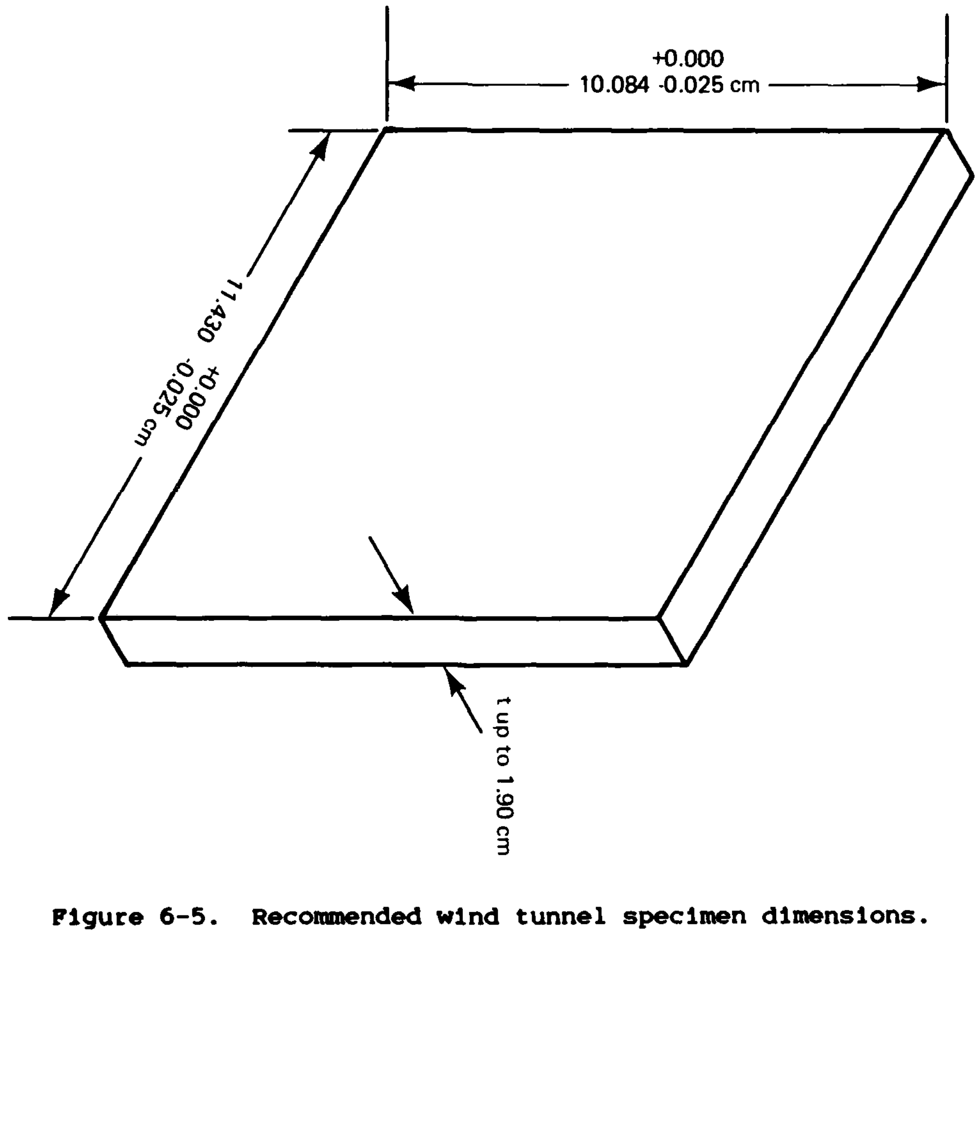


Figure 6-5. Recommended wind tunnel specimen dimensions.

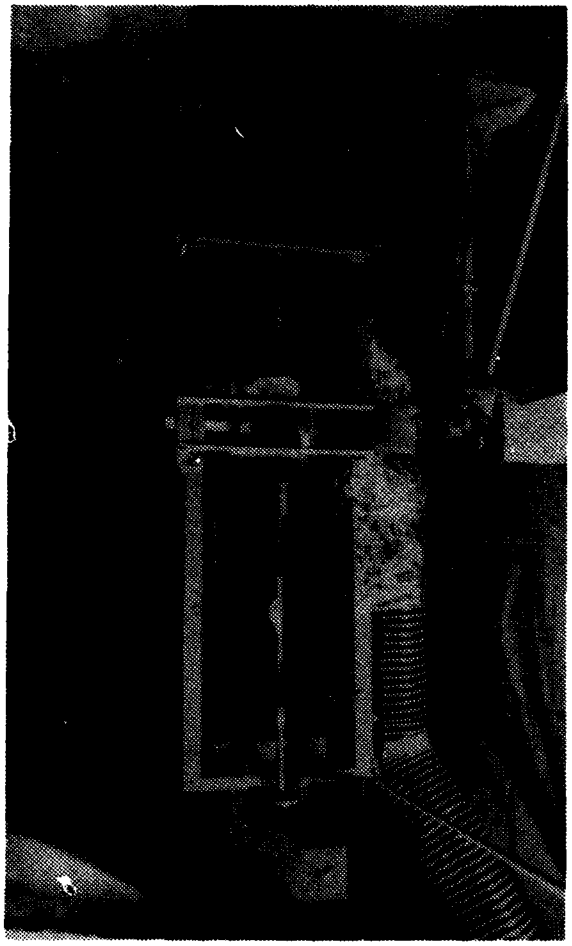


Figure 6-6. Mechanical loading (tensile).

fulcrum are used to achieve three- and four-point bending. Mechanical loading and aerodynamic loading cannot be applied simultaneously. Information on recommended specimen sizes and applied loads is given in Table 6-5.

Table 6-5. Mechanical loading information.

	Uniaxial Tension	Bending Tension or Compression
Specimen Size (cm)		
Width	5-7.5	5-7.5
Thickness	0.02-1.25	0.6-2.5
Length	25-60	50-75
Stress levels (MPa)	3.5-1700	7-1400

6.1.4.2 Dynamic Mechanical Loads. A Materials Test System (MTS) device is available for simulating dynamic loads during exposure to radiant heating. The MTS includes a hydraulically actuated mechanism for applying tensile or compressive loads to a specimen, as pictured in Figure 6-7. The loads are preset and controlled electronically; specific control components that are available are listed in Table 6-6.

At present, simultaneous dynamic loads and radiant heating effects on specimens can be determined. The system is designed for future incorporation with the wind tunnel for simultaneous dynamic and aerodynamic loading while exposing the specimen to radiant heating.

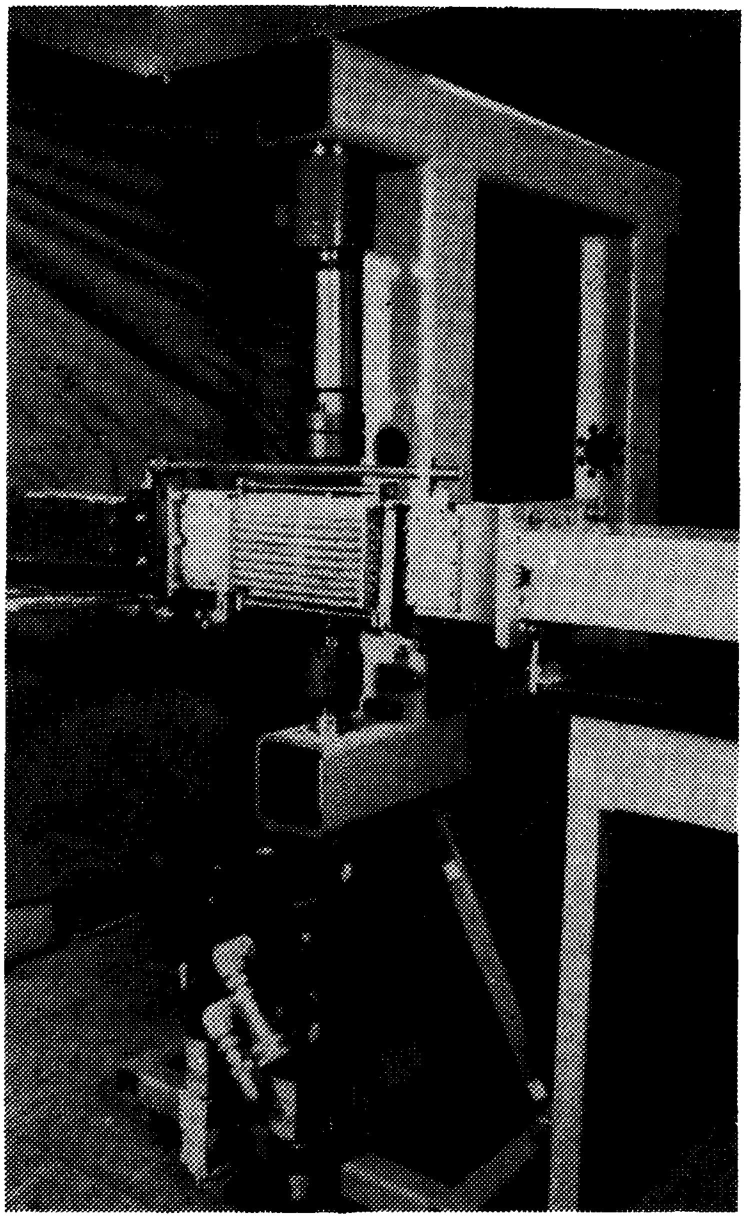


Figure 6-7. MTS tensile loading device.

Table 6-6. MTS Operating System Components

Component	Model
Linear Actuator	204.51
Hydraulic Manifold	294.11
Digital Function Generator	410.31
Electro-Mechanical Counter	417.01
Servo Controller	440.13
dc Transducer Conditioner	440.21
ac Transducer Conditioner	440.22
Servo-Controlled Closed Loop Feedback Selector	440.31
Limit Detector	440.41
Ramp Generator	440.91
Controller	442.11
Hycraulic Power Supply	506.03
Transducer Load Cell	661.21

6.2 SOURCE CHARACTERISTICS

6.2.1 Flux

The MQLB is capable of attaining 40 cal cm^{-2} sec^{-1} at its minimum working distance from the wind tunnel test section. The HDLB is capable of attaining 55 cal cm^{-2} sec^{-1} when mounted on the wind tunnel test section. Irradiance on the test specimen varies with distance between the source and specimen as shown in Figure 6-8.

6.2.2 Spectral Distribution

Specific data on source spectra are not available at this writing.

6.2.3 Pulse Characteristics

At the present time pulse shapes are nearly square wave in profile due to shutter operation.

6.3 APPLICATIONS SUMMARY

The Tri-Service Thermal Radiation Test Facility has conducted over 9,600 experimental tests since March 1977. Testing has primarily involved studies of the effects of thermal radiation on materials using representative specimens. The Appendix to Reference 2 lists numerous varieties of substructure materials and coatings which have been tested at the facility.

6.4 AVAILABILITY

Specific details regarding test program procedures, scheduling, special requirements, etc., should be directed to:

B. H. Wilt
Test Director
Tri-Service Thermal Radiation Test Facility
University of Dayton Research Institute
300 College Park Avenue
Dayton, OH 45469
Telephone: (513) 229-2517.

6.5 REFERENCES

1. B. H. Wilt, R. A. Servais, and N. J. Olson, "Tri-Service Thermal Radiation Test Facility Handbook," University of Dayton, UDR-TR-82-83, July 1982.

2. B. H. Wilt, R. A. Servais, and N. J. Olson, "Materials Evaluation in the Tri-Service Thermal Radiation Test Facility," University of Dayton, DNA 5650F, 28 February 1981.

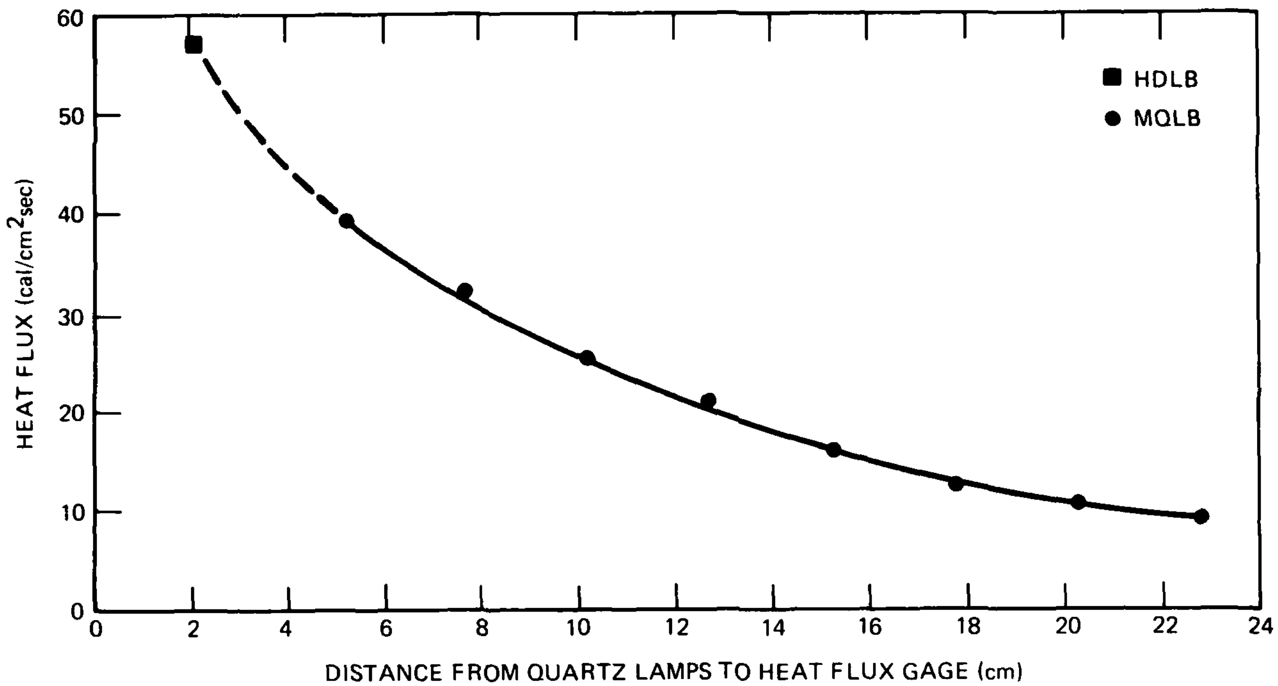


Figure 6-8 Radiation heat flux vs. distance from lamp bank.

SECTION 7

WHITE SANDS SOLAR FACILITY

7.1 FACILITY DESCRIPTION

The White Sands Solar Facility (WSSF) is a focusing-type solar thermal facility. It consists of four main components: (1) heliostat, (2) attenuator, (3) concentrator, and (4) test and control chamber. Figure 7-1 is a photograph of WSSF.

There are 356 flat plate mirrors, each 2 feet by 2 feet (0.6 x 0.6 m), mounted on a stud frame, 40 feet wide and 36 feet high (12.2 x 11.0 m), which comprise the heliostat. The mirrors are front surfaced with an aluminized acrylic material in order to provide as much ultraviolet radiation as possible in the concentrated solar beam. The heliostat automatically tracks the source, the sun or the moon, reflecting the received thermal radiation along the optical axis of the WSSF to the concentrator. In operation, the heliostat thus keeps the concentrated thermal energy in a fixed position at the test object focal plane during the course of an experiment.

The concentrator consists of 180 spherical mirrors, each 2 x 2 feet (0.6 x 0.6 m), mounted on a 30- x 30-foot (9.1- 9.1 m) frame located 96 feet (29.3 m) south of the heliostat. These mirrors are individually positioned to concentrate the thermal energy at the test object focal plane and are front surfaced the same as the heliostat mirrors.

The attenuator is located between the test and control chamber and the concentrator. It consists of a lowered structure whose blades can be variably positioned to regulate the amount of thermal energy reaching the concentrator. The variability of the attenuator is continuous to meet the needs of test requirements.

The test and control chamber measures 8 x 8 feet (2.4 x 2.4 m) in cross section and is 16 feet (4.8 m) long. It contains the experimental test area controls for operation of the facility, and shutter systems for modulating the thermal energy. There is also a subsonic wind tunnel available.

Figure 7-2 is a schematic of the WSSF. Figure 7-3 provides a layout view of the test and control chamber.

7.1.1 Test Procedure

An on-site professional staff is readily available for consultation and assistance to experimenters at the WSSF. The staff currently includes

Figure 7-1. Photograph of White Sands Solar Facility.

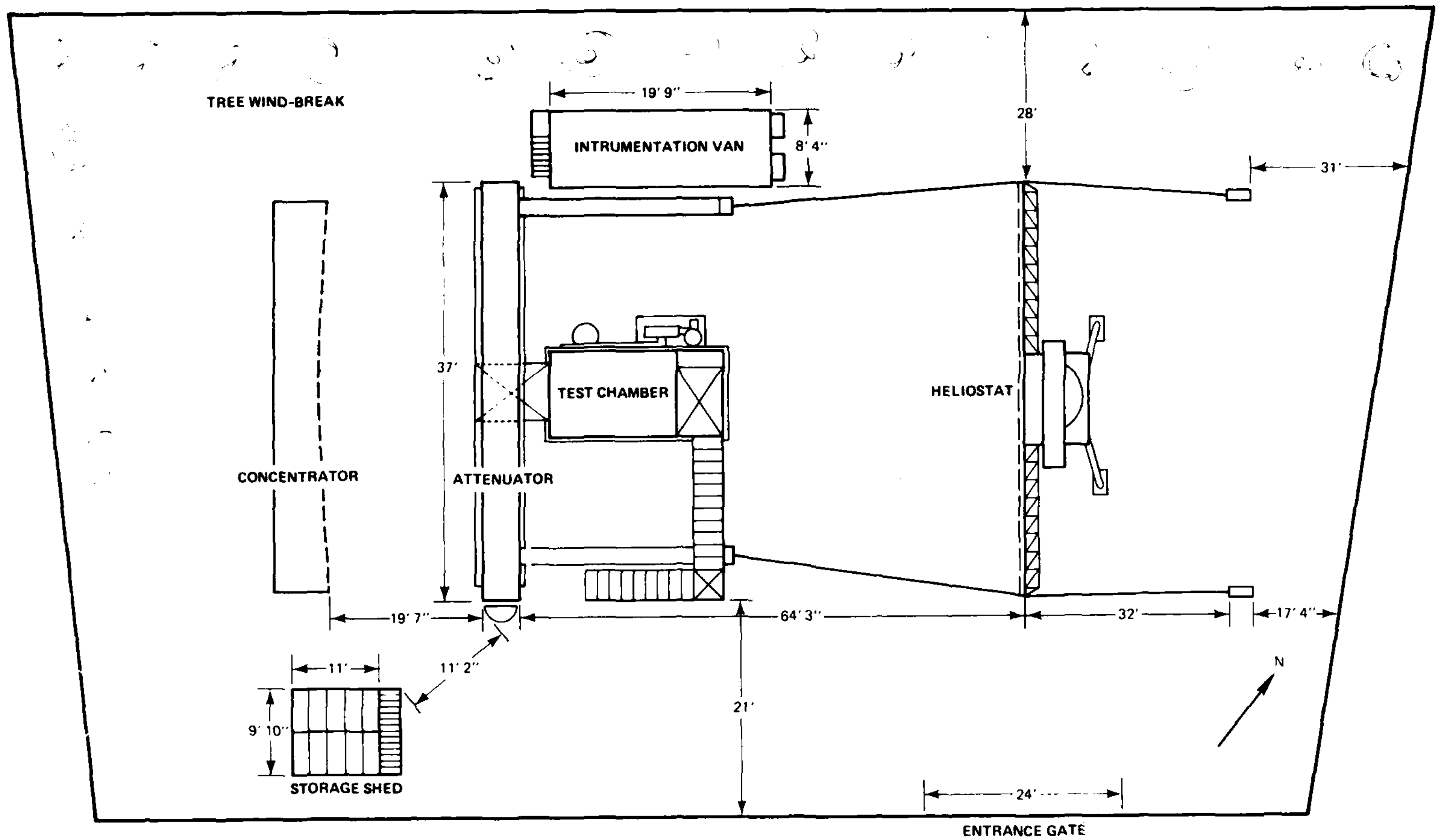


Figure 7-2. Schematic of White Sands Solar Facility.

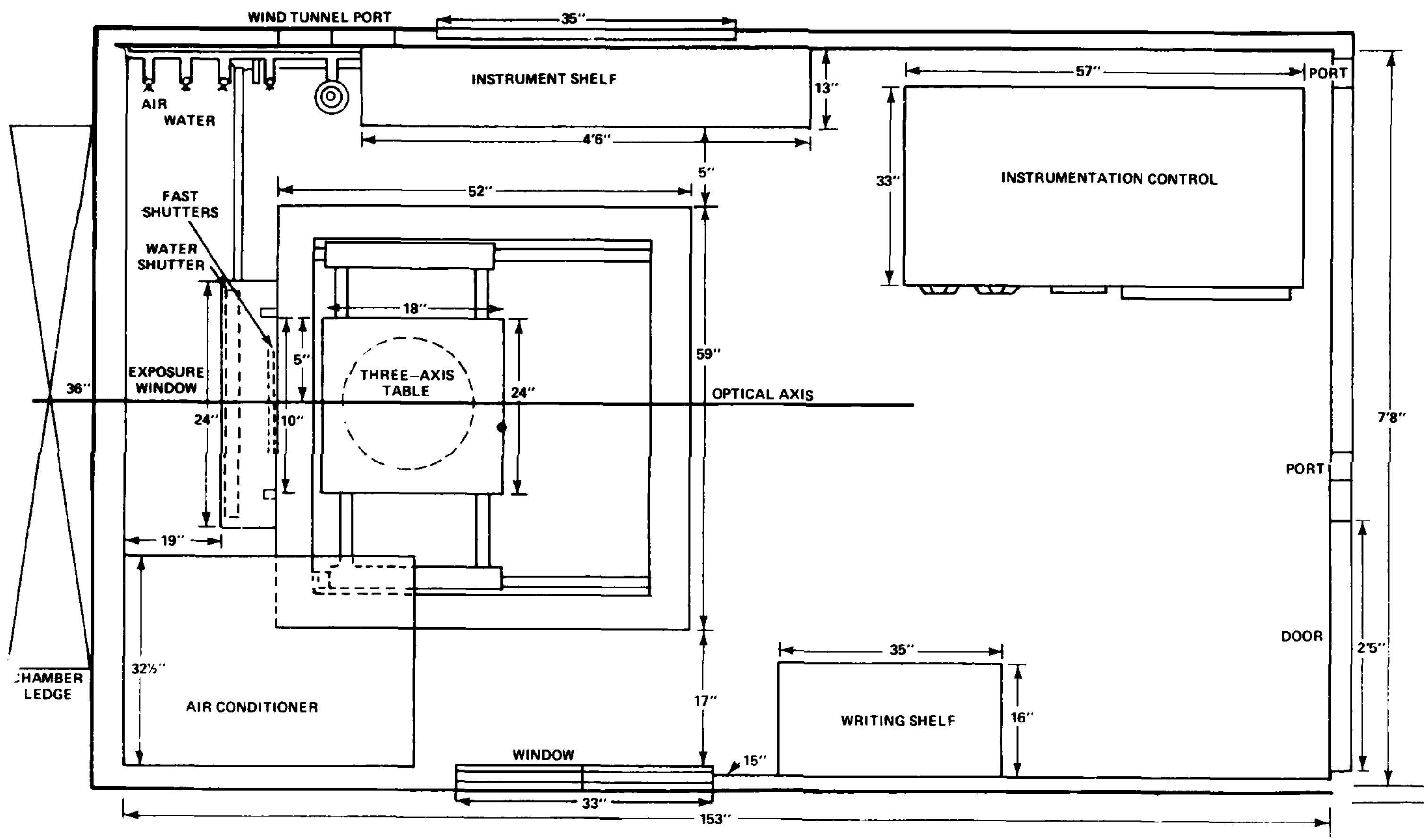


Figure 7-3. Layout view of test and control chamber.

three engineers and four technicians. A test plan (Figure 7-4) must be completed and submitted to WSSF before a test can be conducted. The test plan describes the desired thermal environment, potential hazards associated with the test, test item description, etc. The WSSF assigns a test coordinator to each program in order to assist the experimenter in meeting his requirements as described in the test plan. All tests must be approved by the Army Test and Evaluation Command before execution at the WSSF.

After a complete check of all WSSF safety systems, the heliostat is placed in an autotrack mode. Alignment of the thermal beam with the optical axis is accomplished with the aid of a heat-flux calorimeter. The appropriate pulse shape control system is activated and the exposure time is checked against the criteria designated in the test plan. The WSSF is then calibrated for the specific peak irradiance as well as irradiance as a function of time.

The test item is then positioned with the three-axis table at the focal plane or at the location where calibration was performed. After thermal exposure of the test item and recording of data, a postexposure calibration can be performed for verification.

If there are enough test items of the same type available, the irradiance level can be gradually increased until a damage threshold is determined. Several other items can then be tested at the threshold level to obtain level of confidence data. The threshold level can be established by varying the peak irradiance or the pulse shape or both as required by the test plan.

7.1.2 Instrumentation

Table 7-1 summarizes typical instrumentation used in direct support of the WSSF. In addition to these items there are various power supplies, oscilloscopes, oscillators, oscillographs, pulse generators, counters, and multimeters readily available. Instrumentation from other White Sands Missile Range (WSMR) organizations are also generally available through coordination. Individual experimenters normally provide their own instrumentation unique to the test. Both still and motion picture photography can be provided by the WSMR Pictorial Laboratory.

Electrical power consisting of 440, 208 and 120 VAC is provided. Three phase circuits are rated at 100 amperes per phase. High-pressure air to 150 psi at 50 CFM is available in the test and control chamber as well as in the mechanical equipment soon. Normal domestic water is used for cooling test items.

Services of a machine shop and machinist are available for needs that may arise during the course of the experiment. Laboratory and office space can be made available along with intercom communication services between various components of the WSSF.

PROPOSED PLAN OF EXPERIMENT	NWEB TP NO.	PAGE OF PAGES
SOLAR FURNACE FACILITY	ON-SITE TASK LEADER	
COMPANY/ORGANIZATION:	SECURITY CLASSIFICATION OF EXP:	

TYPE EXPOSURE			
	SHAPED	SQUARE	STEADY-STATE
EXPOSURE LENGTH			
MAX IRRADIANCE			
NUMBER PULSES			
TOTAL Q/PULSE			

Describe items to be exposed; i.e., nomenclature, quantities, dimensions (both overall and area to be irradiated) material; composition, estimated weight.

If "Yes", Describe

NO	YES	
☐	☐	FLAMMABLE
☐	☐	MELTAGE
☐	☐	PYROTECHNIC
☐	☐	TOXIC

Outline test procedures and sequence of test events:

Special requirements; i.e., working hours, instrumentation, experiment documentation, etc.

TEST PLAN APPROVAL COMMITTEE	NWEB TECH COORDINATION
S.F.S H.P. S.F.L. S.F.O.	CHARGE NO. TEST DATE

Figure 7-4. Test plan format.

Table 7-1. White Sands Solar Facility instrumentation.

Item	Manufacture/Model	Quantity	Purpose
TC Recorder	Doric/415	1	Temperature Measurement
Stripchart Recorder	Hewlett-Packard/7402A	2	Signal Recording
XYY Recorder	Esterline Angus/5407	1	Signal Recording
Digital Storage Oscilloscope	Nicolette/206-1	1	Signal Recorder and Digitizer
Spectroradiometer	United Detector/11A	1	Spectrum Measurement
Optical Pyrometer (Solar Blind)	Barnes/128760	1	Surface Temperature Measurement
Optical Pyrometer	Barnes/IT-7	1	Surface Temperature Measurement
Calorimeters	Hycal/1300, 1312	12	Heat flux Measurement
Pyrheliometer	Eppley/NIP	2	Direct Solar Insolation
Pyrheliometer	Hycal/P8405	2	Total Solar Insolation

A subsonic wind tunnel is available with velocities up to 600 ft/sec (18,300 cm/sec). Test samples measuring 4 x 4 inches (10 x 10 cm) with a thickness up to 0.75 inch (1.9 cm) can be accommodated when the wind tunnel is used in conjunction with the WSSF.

7.1.3 Limitations

The WSSF test capabilities are dependent upon prevailing cloud cover and wind velocities. Cirrus-type clouds cause flux level variations at the focal plane while stratus-type clouds can cause erratic solar tracking by the heliostat. Wind gusts can cause a deflection of the solar image at the focal plane of up to 1 inch (2.5 cm) displacement from the optical axis. Normally the solar image can be stabilized to within ±0.1 inch (25 mm) of the optical axis. Winds in excess of 15 miles per hour (7 cm/sec) usually require termination of operations.

Wind and cloud cover data collected over a period of 22 years indicate WSMR is a good location for the WSSF. An average of 1,200 operational hours per year is available based on a 5-day work week and an 8-hour work day over the course of a standard work year.

Relevant weather statistics for WSSF operations are summarized in Table 7-2.

7.2 SOURCE CHARACTERISTICS

7.2.1 Flux

The maximum available flux of the WSSF depends on the solar insolation (cloud cover, atmospheric aerosols, etc.). Flux levels in excess of 100 cal cm^{-2} sec^{-1} have been obtained during good solar days. Flux levels in the average range of 85 to 90 cal cm^{-2} sec^{-1} are readily attainable. A pyrheliometer is used to measure changes in solar insulation. The WSSF can operate continuously at maximum flux.

7.2.2 Spectral Distribution

Efforts are presently underway to measure the spectral distribution of the concentrated solar beam at WSSF. Preliminary data indicate the distribution is a standard terrestial air mass modified by the spectral reflectance of the mirror surfaces. The spectral distribution changes slightly due to seasonal effects and the sun angle. Figure 7-5 is a sample solar distribution measured at the WSSF over the spectral range of 380 to 1,100 manometers. Figure 7-6 shows the spectral reflectance of the aluminized acrylic material used to front surface the heliostat and concentrator mirrors.

Table 7-2. WSSF weather data.

Weather Category	Cloud Cover	Winds (knots)	Operational Availability (hours)
I	Clear	5	395
II	Clear	14	666
III	50%	5	666
IV	50%	14	1200

OPERATIONAL AVAILABILITY SUMMARY

Month	Operational Time (%)	Month	Operational Time (%)
January	50	July	57
February	50	August	59
March	48	September	71
April	51	October	70
May	61	November	60
June	70	December	53

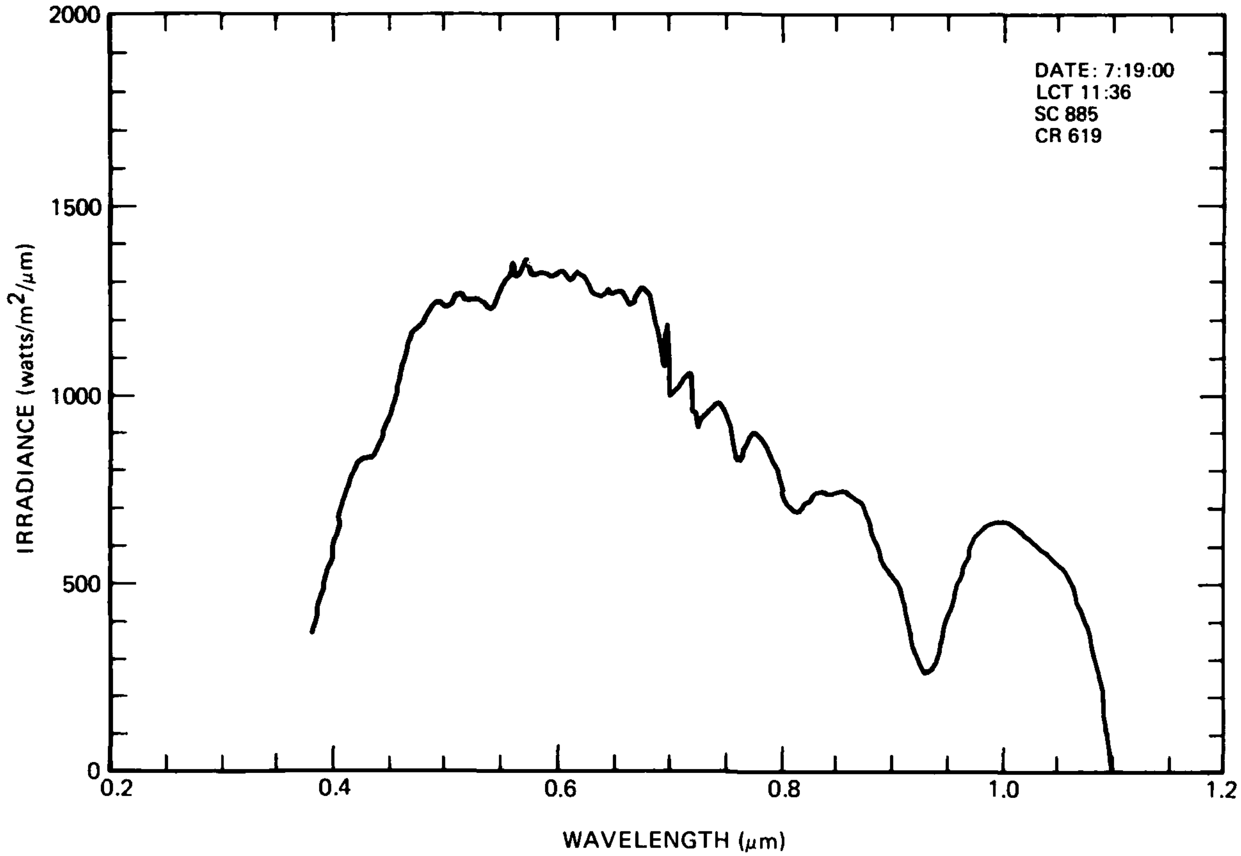


Figure 7-5. WSSF spectral distribution.

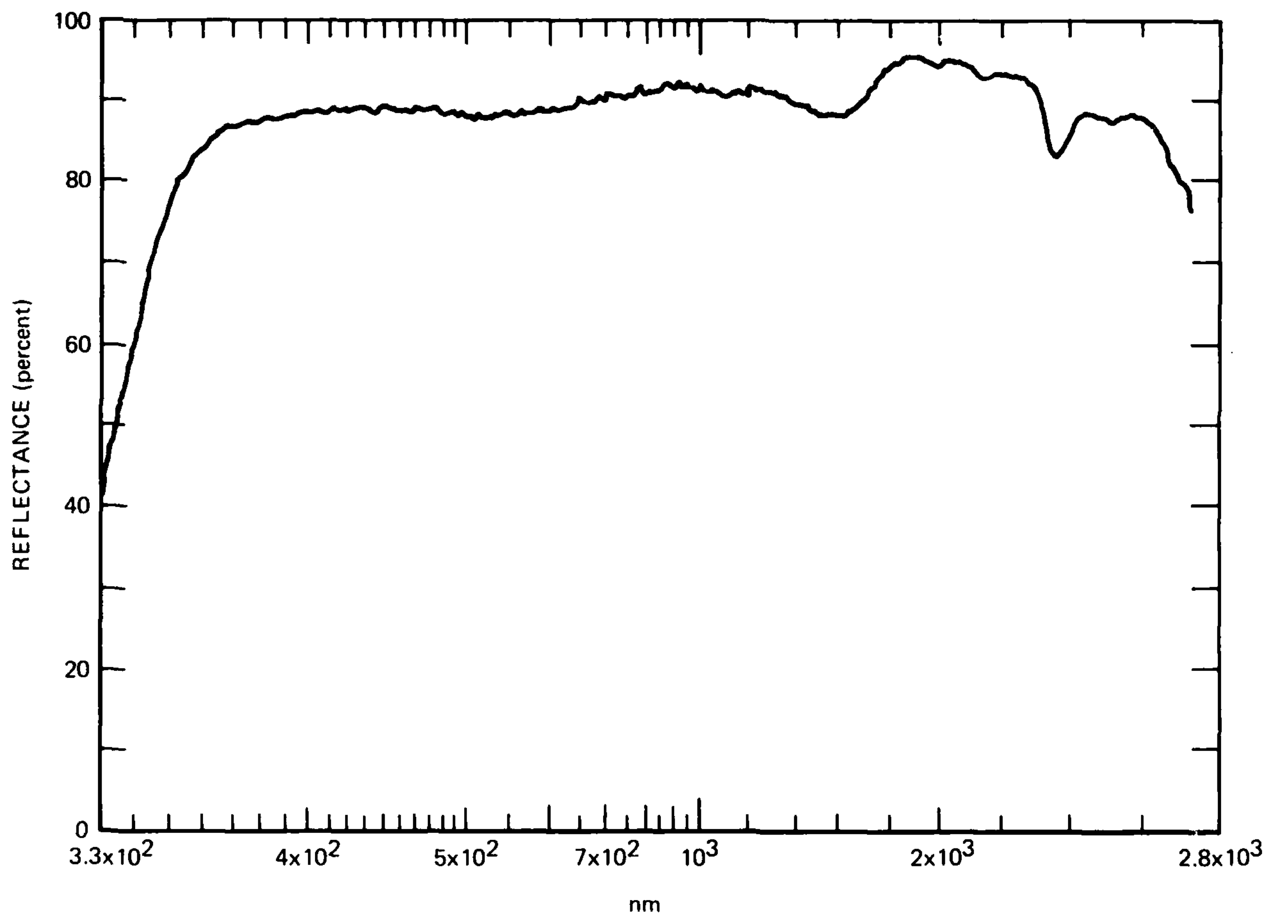


Figure 7-6. Spectral reflectance of WSSF mirrors.

7.2.3 Pulse Characteristics

There are two basic pulse types which can be produced at the WSSF, rectangular and nuclear. The rectangular pulse has a nominal rise and fall time of 25 msec with a minimum exposure time of 100 msec.

The nuclear thermal pulse shapes can be provided to simulate those produced by nuclear weapons with yields in the subkilotron to 50-MT range. Multiple exposures can be produced to simulate a multiburst weapon environment.

Figure 7-7 illustrates a typical pulse shape produced by the pulse-shaping system at WSSF. The curve in Figure 7-6 has been normalized for both irradiance and time.

The rectangular pulse shaping-system is located in the test and control chamber and consists of a water-cooled shutter, an exposure shutter, and a limit shutter. The shutters operate pneumatically and have rise and fall times of approximtely 25 msec with a minimum exposure time of 100 msec. The shutters are mounted 5.1 cm in front of the focal plane.

The pulse shaper produces the simulated nuclear thermal pulse. It consists of a series of 40 trapezoidal modulating segments mounted around the periphery of a circular plate. A magnetic pickup that senses position on the periphery of the pulse shaper is used for timing. In operation, the magnetic pickup sends a signal to the shutter controller that operates the fast shutter. The speed of rotation for the shaper disc is preprogrammed to give the desired pulse characteristics through the use of a variable speed drive motor. One revolution of the disc normally corresponds to one pulse, but mechanical programming to provide other types of pulse shapes is possible. Multiple revolutions are used to simulate the multiple burst environment.

7.2.4 Exposure Characteristics

Table 7-3 summarizes some of the more important typical exposure characteristics of the WSSF. Figure 7-8 illustrates a standard flux profile and Figure 7-9 provides a flux map of isoflux contours at the focal plane normalized to the maximum flux. The highest flux is available between approximately 2 hours before and after noon during the day.

7.3 APPLICATIONS SUMMARY

Since 1973 the WSSF has been used for various thermal effects testing programs and for investigations of nuclear weapon thermal phenomena. Some of the items tested at the WSSF for the Department of Defense fall into the following categories: communications equipment, radomes, IR seekers, aircraft and missile skins, canopies, paints, ammunition, chemical detectors, electrical cables, fiber optics, radar components, thermal curtains, insulation materials, face masks, building materials, fluids, plastics, night vision optics, tracked vehicle components, and windshields.

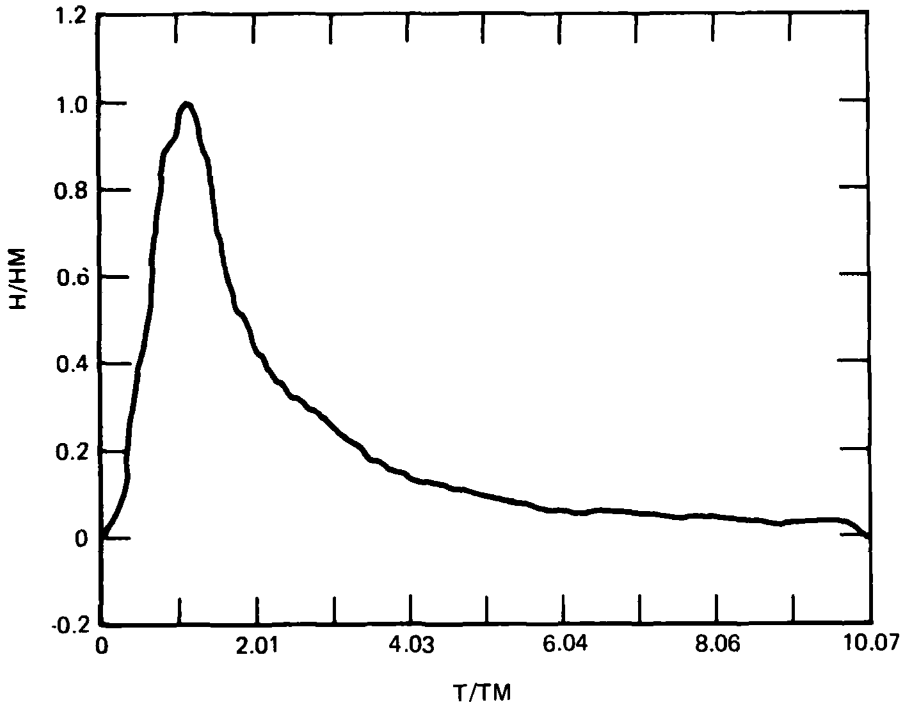


Figure 7-7. WSSF thermal pulse shape (typical).

Table 7-3. WSSF exposure characteristics

Beam Diameter (in.)		Percent Total Power (cm)	Power (kW)	Minimum Flux (cal/cm^{-2}sec^{-1})	Mean Flux (cal/cm^{-2}sec^{-1})
1	2.54	5.0	1.35	78.6	79.3
2	5.08	24.2	6.43	71.4	75.0
3	7.62	48.0	12.75	57.1	60.7
4	10.16	73.7	19.55	35.7	39.3
5	12.70	91.6	24.31	14.3	17.9
6	15.24	100	26.54	0	5.0

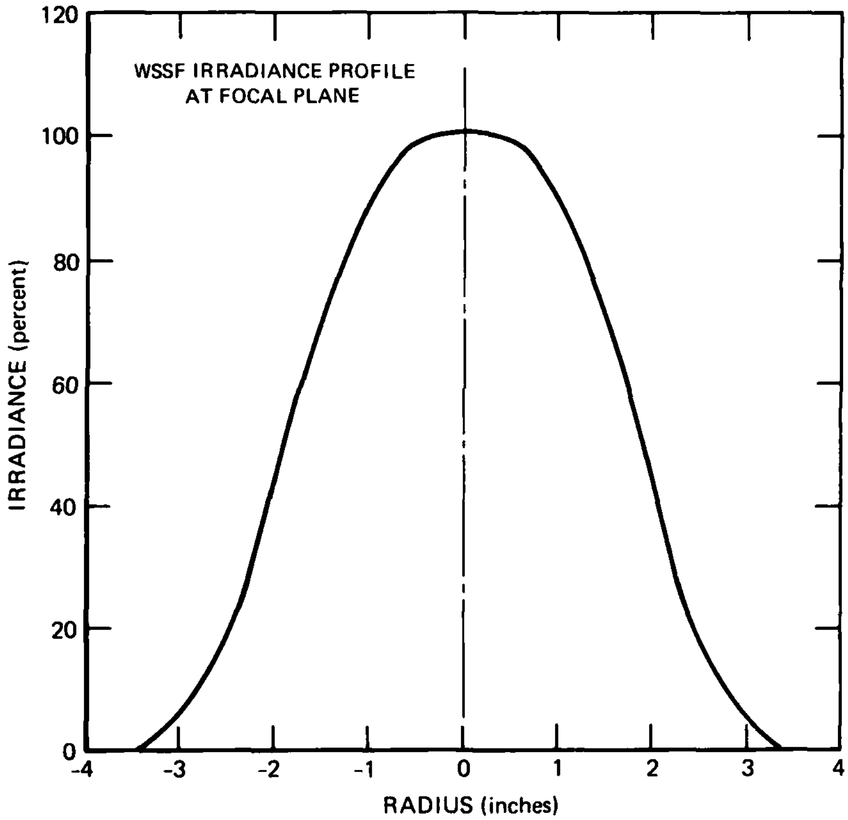


Figure 7-8. Irradiance profile.

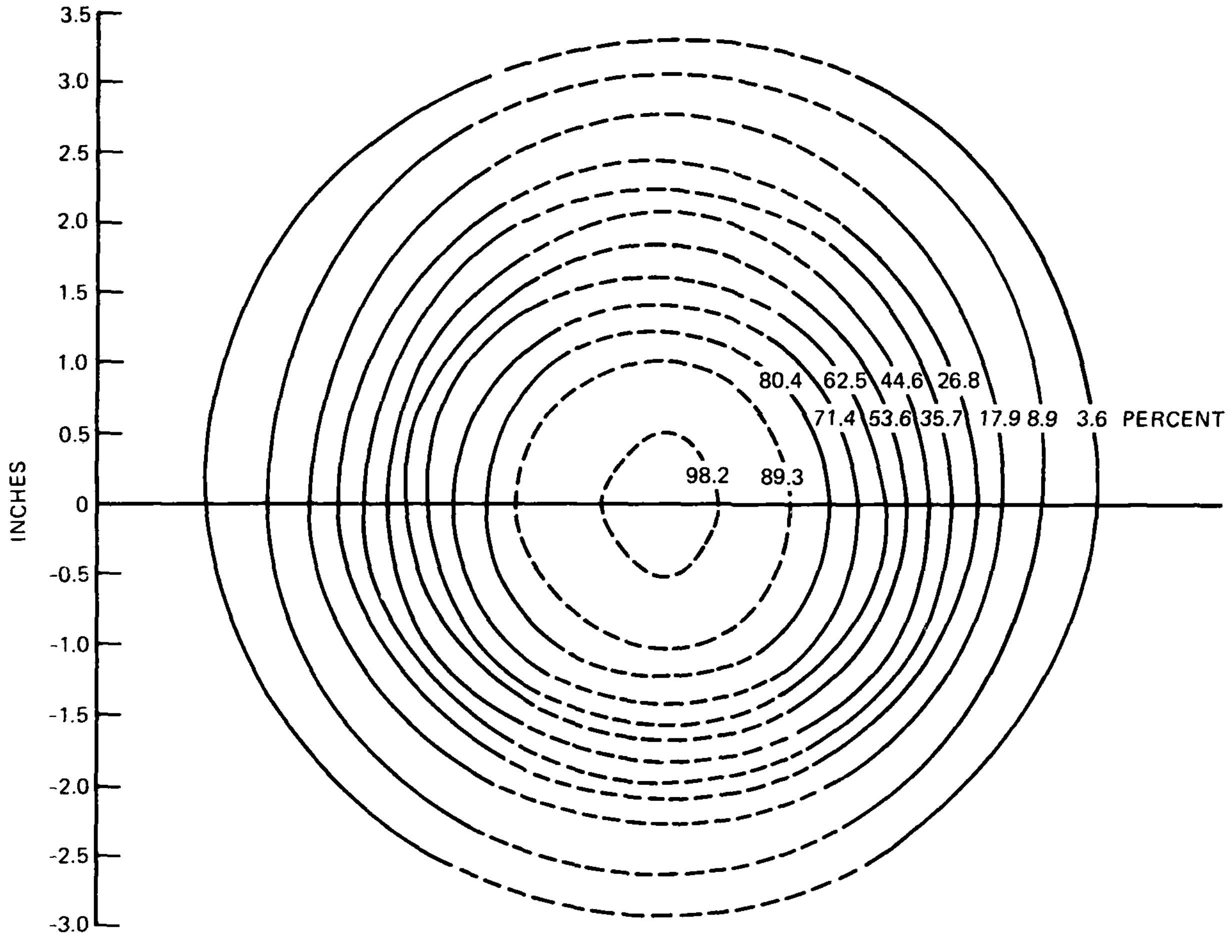


Figure 7-9. Isoflux profile.

High-temperature materials testing has also been conducted for the Department of Energy. Such tests consisted of solar coal gasification, oil shale retort, hot air and liquid receivers, synthetic production of calcium carbide, gas dissociation, insulation materials, reduction of molybdenite ore, cadmium oxide reduction coating tests, decomposition of zinc sulfate, and solar production of elemental phosphorous.

7.4 AVAILABILITY

7.4.1 Contact

The White Sands Solar Facility is operated by the Army Test and Evaluation Command, Army Material Test and Evaluation Directorate, Nuclear Weapon Effects Office located at White Sands Missile Range, NM. The point of contact for the WSSF is:

Commander
U.S. Army White Sands Missile Range
ATTN: Mr. R. A. Hays
(STENS-TE-NO)
White Sands Missile Range, NM 88002.
Telephone: (505) 678-1161 (FTS 898-1161).

7.4.2 Scheduling

The WSSF presently has a heavy test schedule for both DOD and DOE test programs. Scheduling should be initiated as far in advance as possible. Typically four to five weeks are required to administratively coordinate a new test project. Consideration should be given to the weather effects discussed in Section 7.1.3 when planning the actual dates for conduct of tests.

7.4.3 Cost

The direct cost of operation of the WSSF is borne by the experimenter. All funds not actually expended during the test will be refunded. Based upon the contents of the test plan prepared by the experimenter, the WSSF staff will provide a cost estimate. The minimum cost for FY83 will be approximately $900 per day.

SECTION 8

ADVANCED COMPONENTS TEST FACILITY

8.1 FACILITY DESCRIPTION

The Advanced Components Test Facility (ACTF) is a tracking mirror solar concentrator system operated by the Georgia Institute of Technology's Engineering Experiment Station (Georgia Tech EES) for the U.S. Department of Energy (DOE). This facility is illustrated in Figure 8-1 and is located on the Georgia Tech campus in Atlanta, Georgia. The ACTF is a flexible and convenient test facility accessible to all qualified research and development organizations. The primary purpose of the facility is to encourage research and development in high-temperature solar thermal technology.

Major elements of the ACTF include a solar concentrating mirror field, a rigid structural steel test tower on which is mounted the experiment support platform (tower deck), an instrument and a control building, a computerized data collection system, and a heat system. Figure 8-2 depicts the ACTF site plan.

The mirror field consists of 550 heliostats oriented as shown in Figure 8-3, which also shows an east-west section view in the vertical plane. Each mirror is fastened to a polar axis mount that permits both individual manual declination and collective tracking of the sun. This allows individual mirror aiming and focusing at the center of a 2.44-m (8-ft) square aperture in the tower deck. Figure 8-4 illustrates the mirror field drive train. The fast-drive motor is used for coarse translation (slewing) of the mirrors. The tracking motor is controlled with an electronic counter and keeps the solar beam centered. An auxillary compressed-air motor provides for translation of the mirror field in the event of electrical power failure supplying the primary drive motors. The mirrors are circular, second-surface reflectors, 111 cm (43.7 inches) in diameter fabricated from 3-mm- (0.125-inch) thick glass.

The test tower is located in the geometric center of the mirror field. The tower is capable of supporting a 9,100 kg (20,000 lb) experimental package. Figure 8-5 shows plan views of the ACTF test tower. The mirror field aimpoint is centered in the tower deck 2.44 m (8 ft) square aperture 15.2 cm (6 inches) below the deck surface. Pneumatically driven shutters can be used to alternately isolate and expose the test specimen from the concentrated beam. The tower platform is accessed by either an elevator or hydraulic scissors lift; both have a load capacity of 454 kg (1,000 lb). Hardware exceeding weight or size limitations of the lift is elevated to the tower deck with a leased mobile crane.

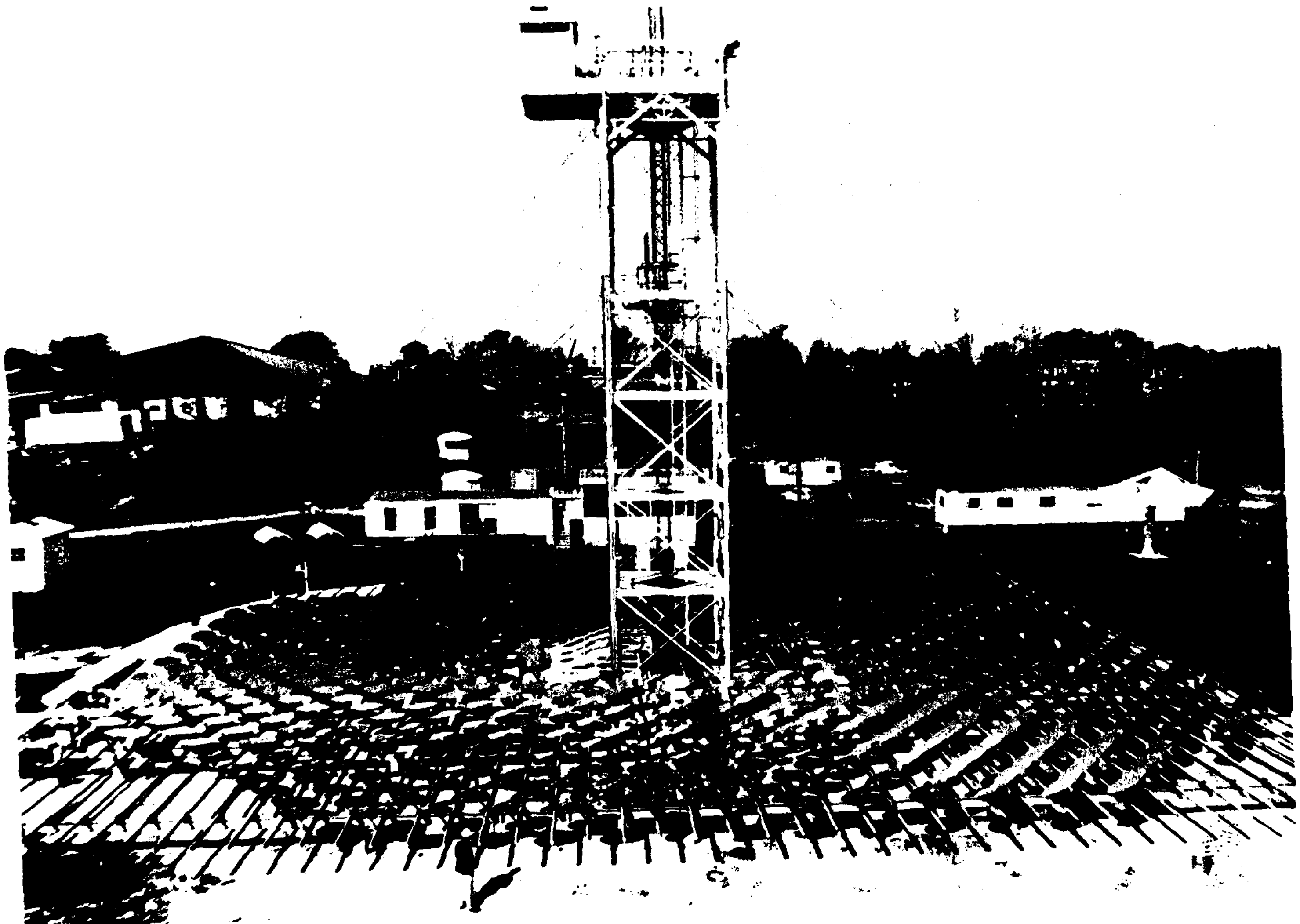
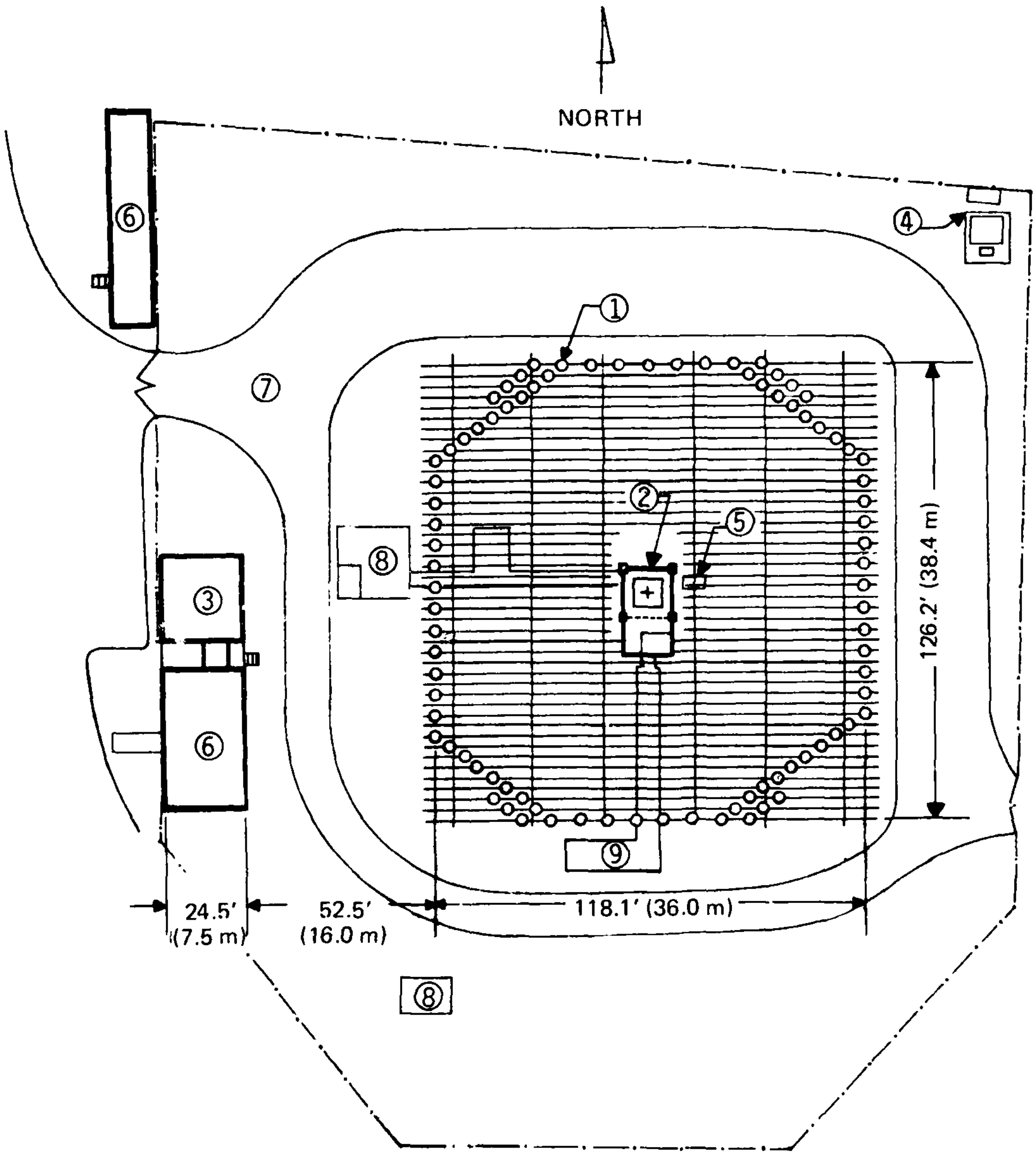


Figure 8-1. Advanced components test facility.



LEGEND:

+ Focus 69.5' (21.2) m) Above Plane of Mirror Field

1-Mirror Field Support Structure & Outermost Mirrors
2-Tower Deck
3-Control Building
4-Heat Rejection System and Tower Water Supply Pump
5-Mirror Drive Motor
6-Offices
7-Asphalt Pavement
8- Concrete Pad
9-Concrete Access Trench

Figure 8-2. ACTF site plan.

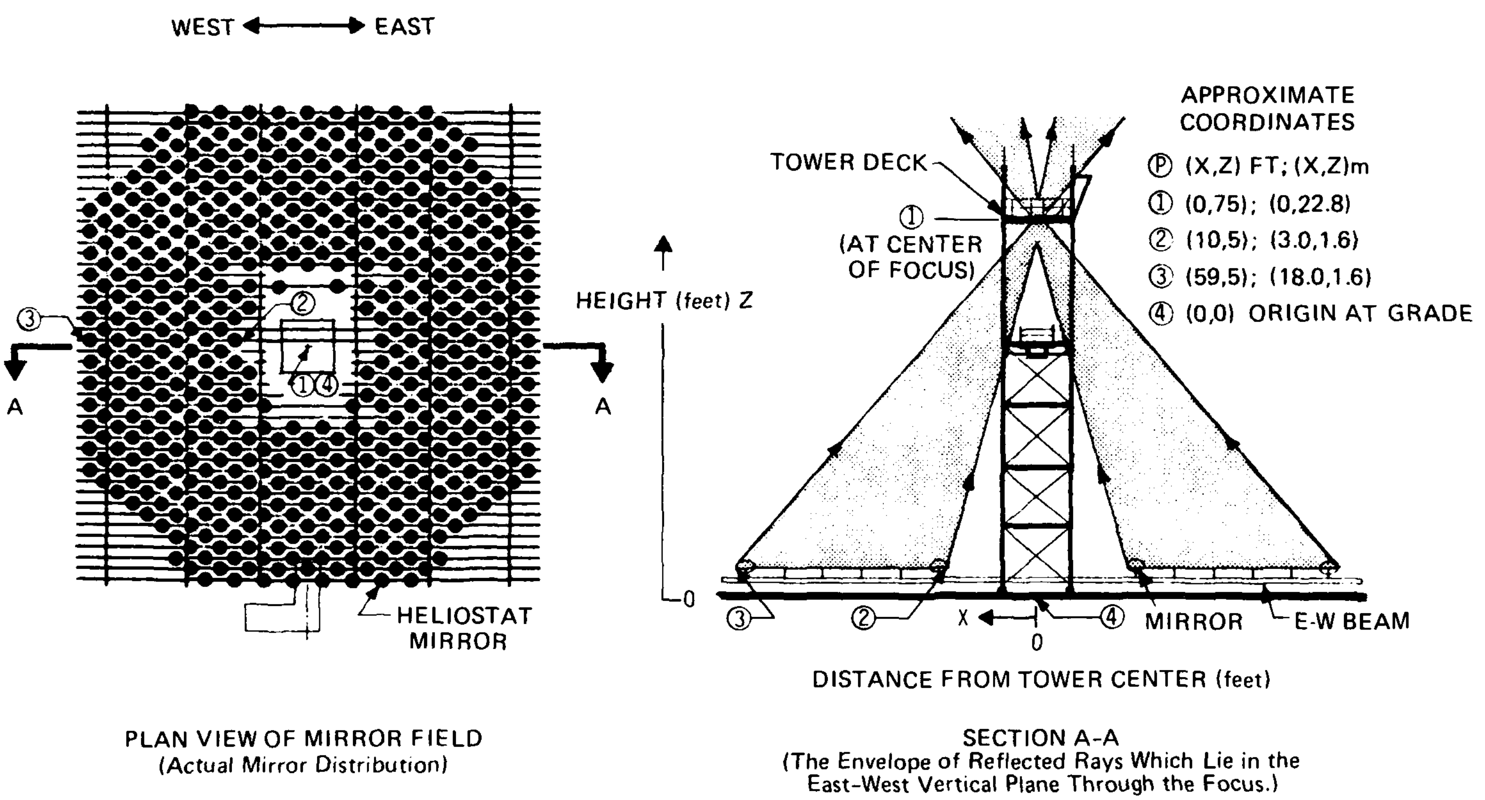


Figure 8-3. ACTF mirror field plan views.

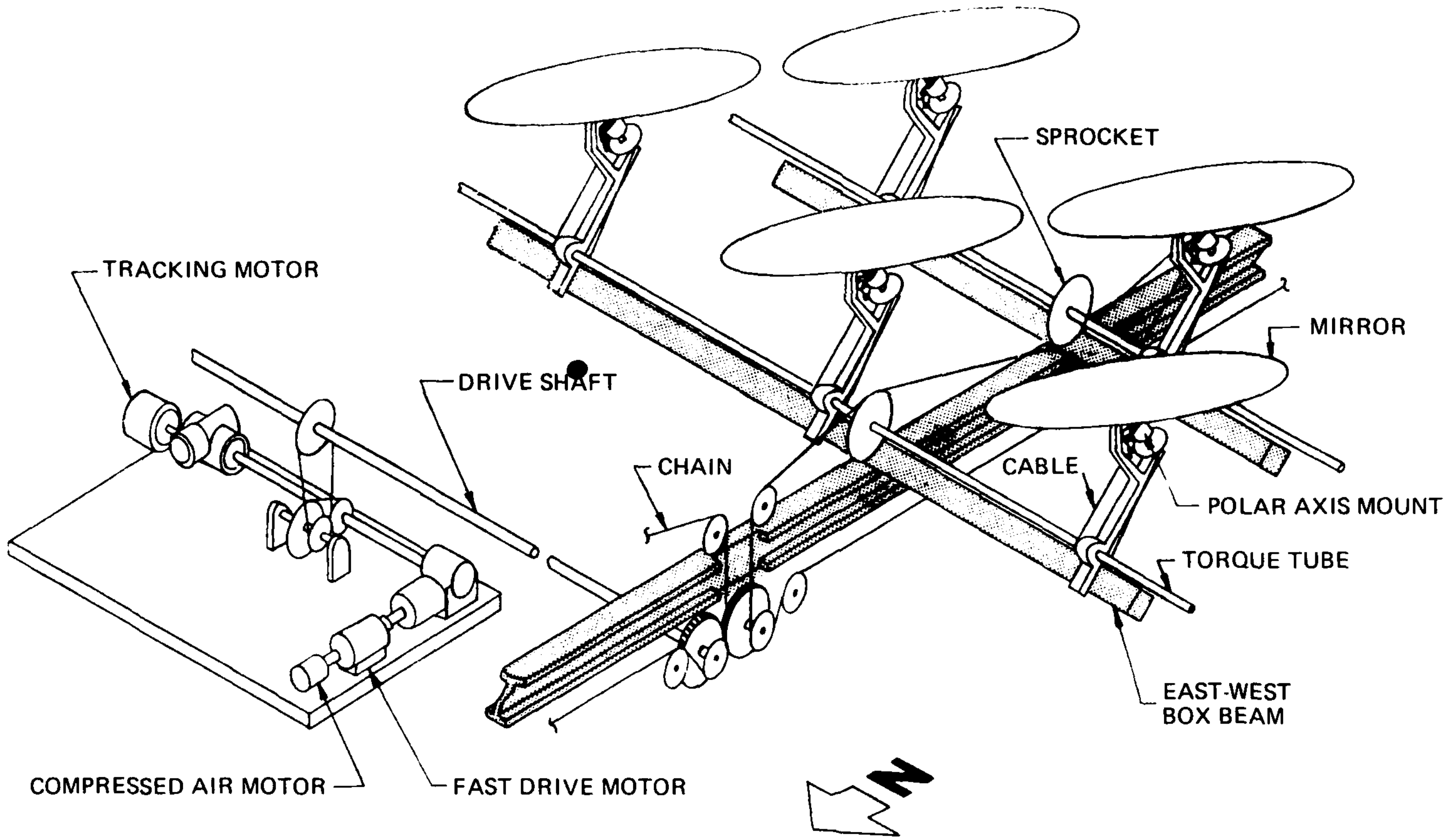
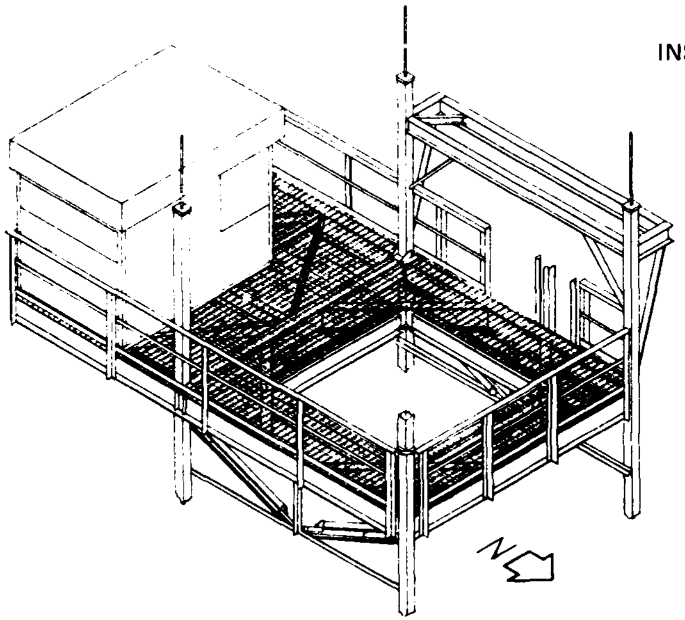


Figure 8-4. ACTF mirror field drive train.



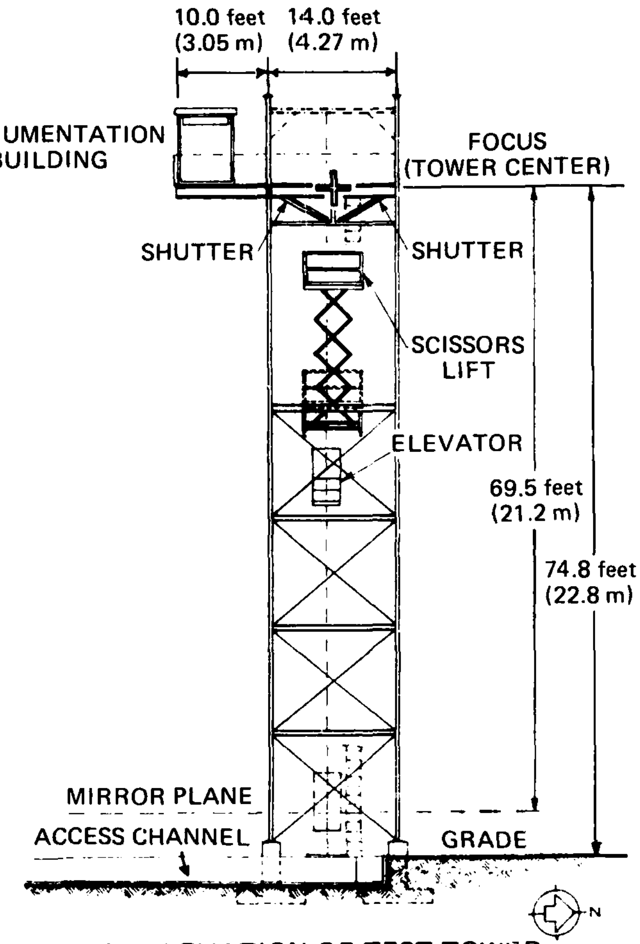


Figure 8-5. ACTF test tower plan views.

The instrument building is a small structure located on the south side of the tower deck (Figure 8-5). This building permanently houses the data-collection system analog interface unit, a thermocouple reference oven, two-way radio and closed-circuit television equipment, weather monitoring hardware, an electrical distribution panel, and a shutter control panel. It is heated and air-conditioned for year round use.

The control building provides a central location for both ACTF staff and user personnel to monitor and control tests (Figure 8-2). A controlled environment (temperature and humidity) is maintained, as this building houses the ACTF computer data system. Local weather and insolation instrument displays are available along with various output devices for real-time inspection of test data and closed circuit television monitors from tower and mirror-field cameras.

8.1.1 Test Procedure

Test programs at the ACTF generally fall into one of three categories:

- DOE-supported-contract between DOE and user.
- Solar Thermal Test Facilities Users Association (STTFUA)-supported contract between STTFUA and user (indirectly from DOE).
- Non-DOE-supported-contract between Georgia Tech Research Institute (GTRI) and user.

Potential users write a detailed program description and submit it to the ACTF Facility Director for appraisal. Regardless of the funding source, the ACTF Facility Director coordinates all potential test programs with STTFUA and DOE. The Facility Director arranges for internal review of the program plan, provides the user with information and guidance on ACTF capabilities, and cost estimates for ACTF participation. The user then prepares a *formal proposal, which must contain a budget that includes funds* for facility use, and submits the proposal to the appropriate funding organization. The key elements required in a user proposal in order to efficiently conduct technical reviews are:

- Description of proposed test(s)
- Estimate of solar flux and distribution needed
- Total input power required
- Size and weight of test apparatus

- Estimate of utility requirements
- Approximate duration of individual tests
- Approximate duration of entire test program
- Safety summary
- List of non-standard needs and services.

Once a program is funded for testing at the facility, an ACTF engineer is assigned to the program. This individual serves in liason capacity between the user and the ACTF before, during and after the tests and is responsible for coordinating user and ACTF facility activities.

Figure 8-6 illustrates in flow chart format the principal activities in establishing a test program at the ACTF. Table 8-1 outlines the documents that must be completed during the pretest phase. The purpose of these documents is to encourage thoughtful test preparation. Procedures, requirements, and goals may change as actual testing progresses, and this natural evolution should be reflected in the documentation. Reference 1 provides detailed guidance on establishing test programs at the ACTF and contains additional information on ACTF policy and procedures.

8.1.2 Instrumentation

The following items are routinely available at the ACTF for test support:

- Closed-circuit, remotely operated, black and white television system
  - -- Two tower-mounted cameras
  - -- One field-mounted camera with zoom lens
- Videotape recording units
- Still 35-mm camera with interchangeable lenses
- Infrared pyrometer (Barnes IT-70)
- Infrared television system (AGA Thermovision).

While the ACTF maintains a small inventory of various flow rate, pressure and temperature-sensing devices, voltmeters, strip chart recorders, and other commonly used instrumentation, users are generally required to arrange for all hardware, instrumentation, transducers, and controls necessary to operate their tests. The Facility Director will assist the user in establishing contacts within the Georgia Tech Engineering Experiment Station for additional resource availability.

8.1.2.1 <u>Scanning Calorimeter</u>. A water-cooled scanning calorimeter is available at the ACTF for measuring solar radiation intensities at or near the mirror field focal plane. This device can be mounted at various levels

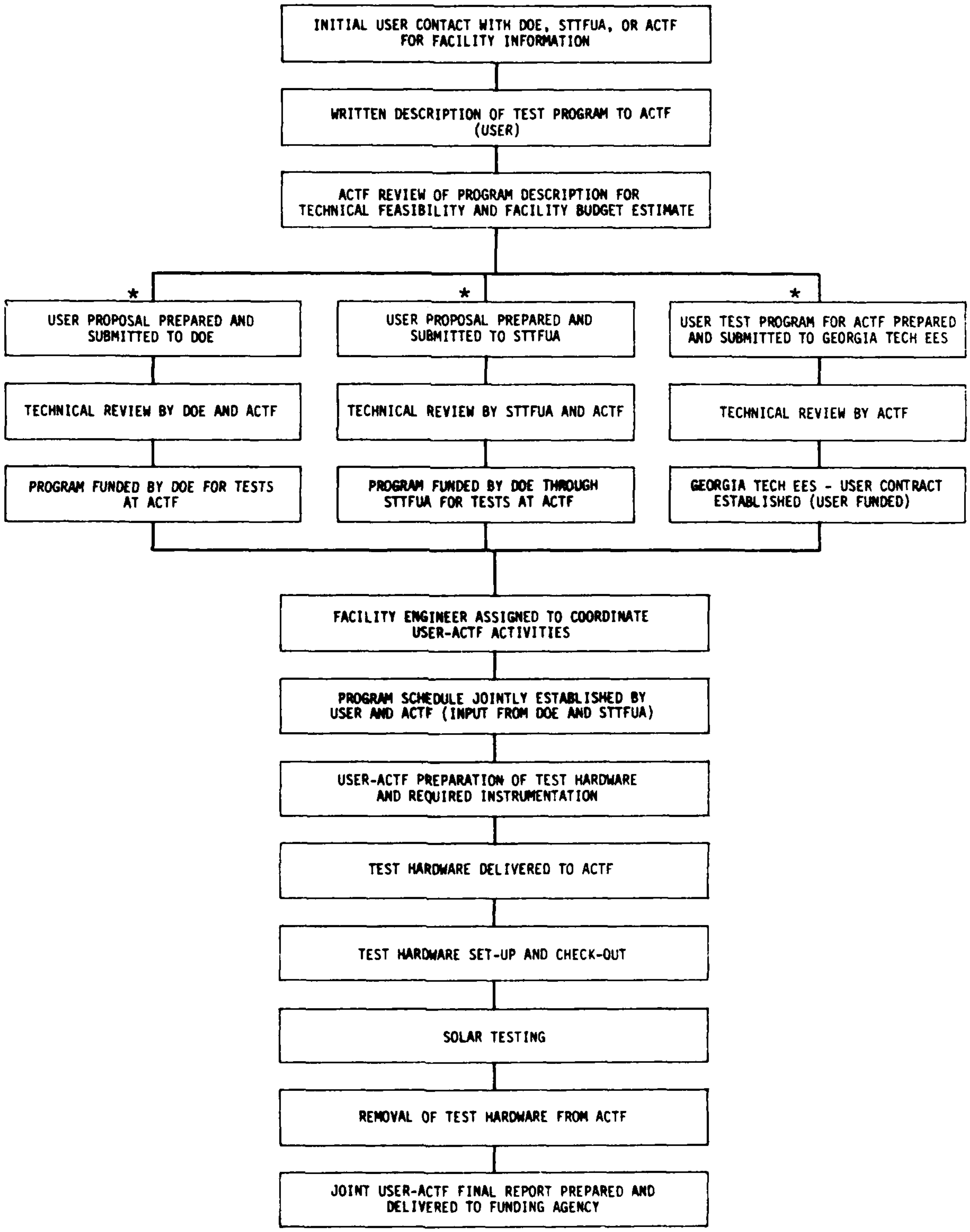


Figure 8-6. ACTF-user test program flow chart.

Table 8-1. Pretest documentation requirements.

Document	Preparation	Review/Approval
Preliminary Test Plan	User	ACTF
Document of Understanding	ACTF	Jointly
Interface Document	ACTF	Jointly
Request for Computer Services	User	ACTF
Safety Document	User	ACTF
Final Test Plan	User	ACTF
Operating Procedures	Jointly	Jointly

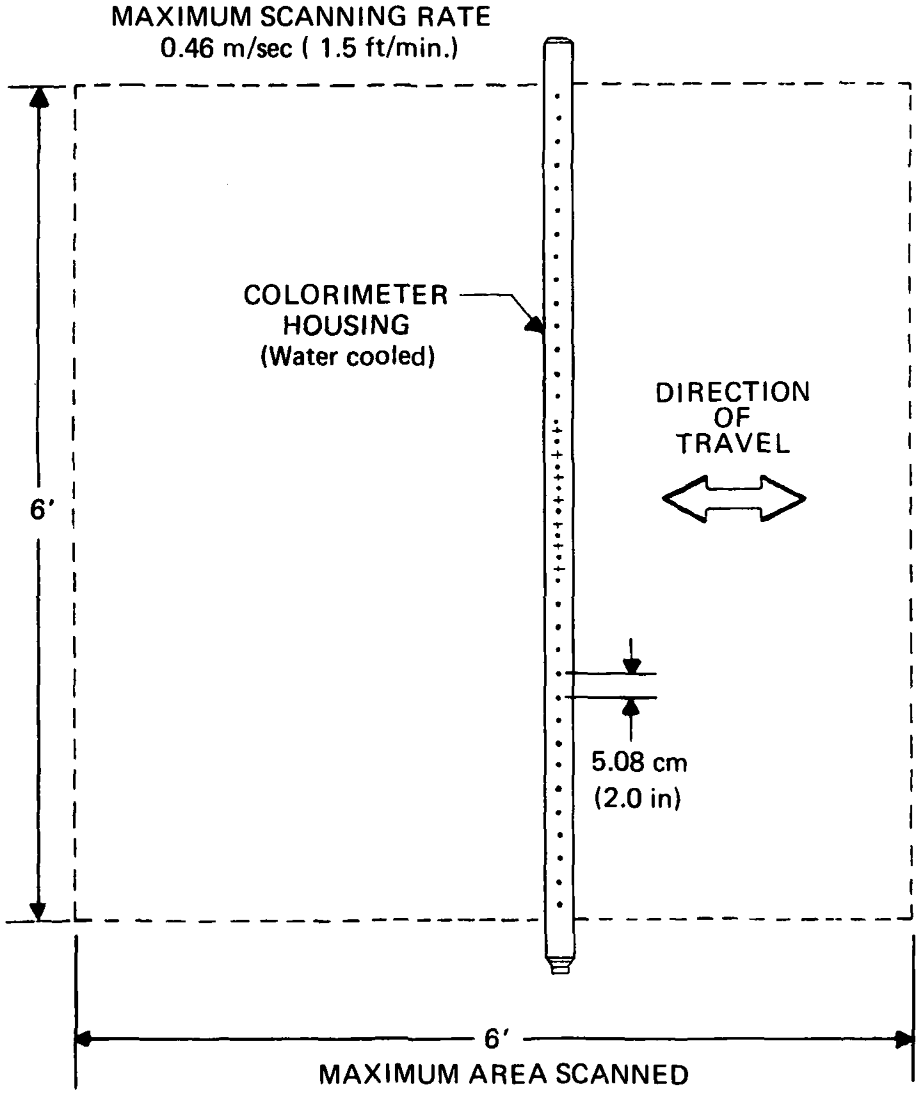
in the tower deck aperture to map the heat-flux distributions on horizontal planes. Figure 8-7 illustrates the scanner detail and Figure 8-8 shows the scanner mounted in the tower deck aperture. The scanning bar houses 45 Gardon gage calorimeter transducers, each of which is individually calibrated. This scanner provides a rectilinear matrix of flux values at a maximum scanning rate of 0.46 m/min (1.5 ft/min) over a 1.83 m (6 ft) square plane.

Analog data from the individual calorimeters are supplied to the data system described in the next section. Scanning speed is limited by the calorimeter response time (50 msec for 63 percent rise) and the data system computational speed and priorities. Although the calorimeter was designed to operate in the horizontal plane, it has been used in a plane tilted 20° from the horizontal. In addition, it has been used in a volume flux-mapping mode. In this mode the scanning covers a series of horizontal planes up to ±2 feet from the system focal point. An ACTF volume flux map usually consists of scans over nine horizontal places separated by 6 inches.

Flux maps are presented in Section 8.2. There are other scanners available at the ACTF that were designed, built, and operated by ACTF personnel for customized application.

8.1.2.2 Data Collection System. A computerized data collection system is available at the facility to record, condition, display, and reduce user data. Figure 8-9 shows the system schematically.

Up to 120 input channels (80 user channels) of analog data are supplied to the converter/multiplexer subsystem and a PDP-8 minicomputer located in the instrument building on the tower deck. These channels can be scanned at rates up to 200 channels/second with a single channel scanning rate of 20 times/second. All scanning routines are under software control.



• LOW RANGE CALORIMETER (~150 watts/cm^2)
+ HIGH RANGE CALORIMETER (~250 watts/cm^2)

NOTE: EACH COLORIMETER IS INDIVIDUALLY CALIBRATED

Figure 8-7. ACTF scanning calorimeter detail.

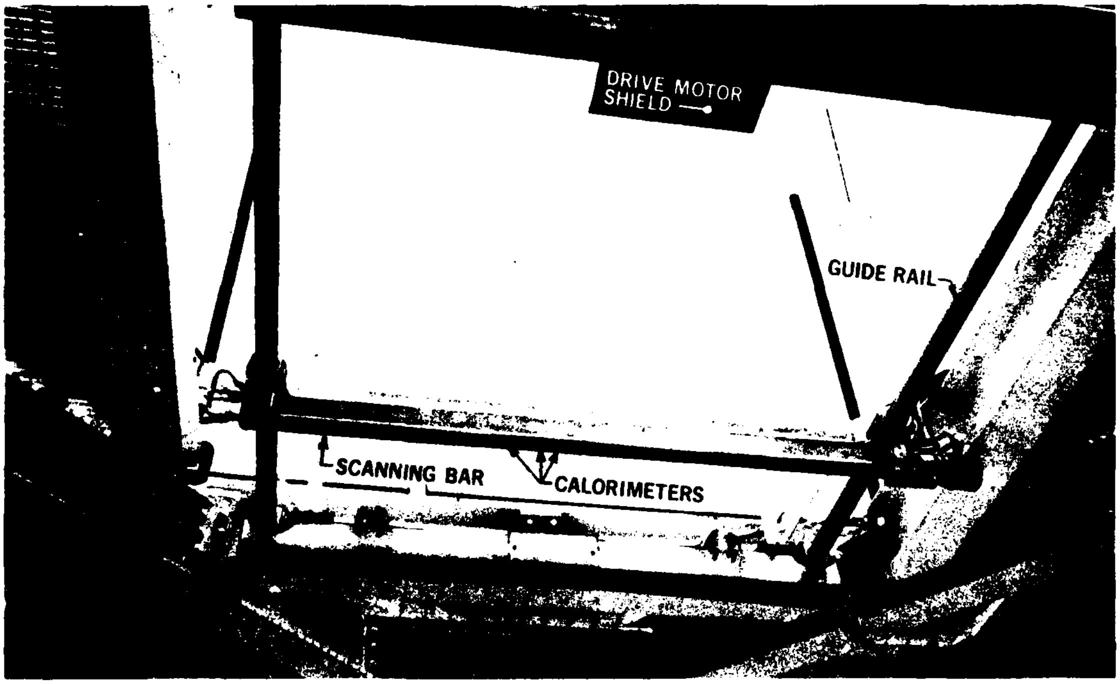


Figure 8-8. ACTF scanning calorimeter mounted in tower deck aperture.

Multiplexed input data is fed to a programmable gain amplifier. The amplifier output is available to the A-to-D converter enabling operation of each data channel over a wide range of sensitivities. A full-scale input range of from ±10 millivolts to ±10 volts in eight overlapping steps is available to each channel. Single bit resolution is approximately 5 millivolts.

A second PDP-8 located in the control room at ground level serves as an interface to the A-to-D converter/multiplexer. This computer is configured to allow unattended operation. Data can be stored on high speed disks and displayed on video terminals. Displayed data is within 10 seconds of real time. Data recording on magnetic tape is accomplished via telephone link to the Georgia Tech CDC CYBER 70/74.

Reference 2 contains more detailed information on input/output data processing and hardware specifications at the ACTF.

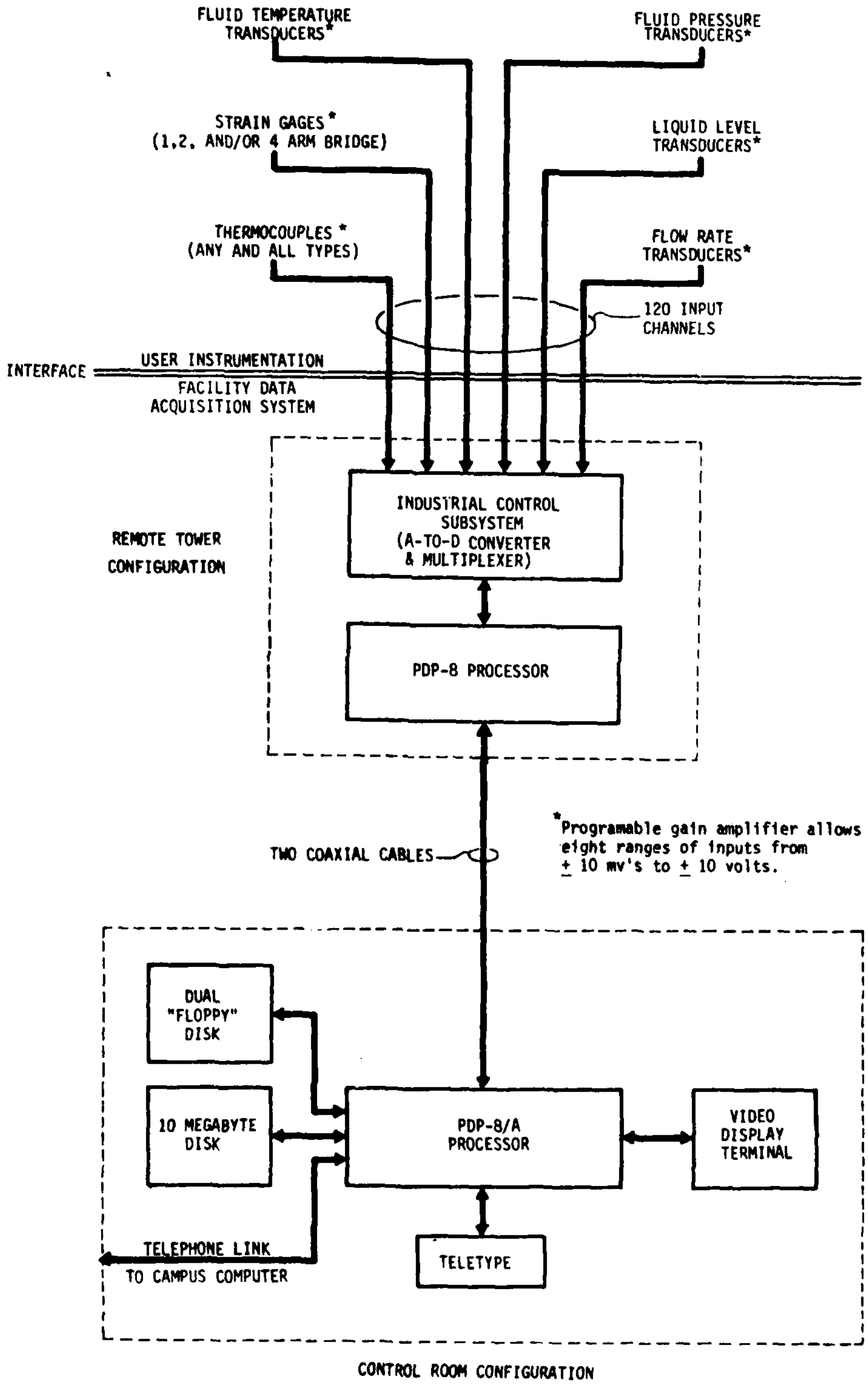


Figure 8-9. ACTF data collection system schematic.

8.2 SOURCE CHARACTERISTICS

8.2.1 Flux

The maximum solar radiative flux at the focus is approximately 55 cal cm^{-2} sec^{-1} (230 W cm^{-2}). Nominal local insolation is 215 cal m^{-2} sec^{-1} (900 W m^{-2}) giving a total power input of 76.7 kcal sec^{-1} (325 kW). These figures are seasonally dependent and records are available at the ACTF on optimum testing windows.

Figures 8-10 and 8-11 depict typical flux maps in a horizontal plane and in a volume mapping mode, respectively.

8.2.2 Spectral Distribution

Information on the spectral distribution was not available at this writing.

8.2.3 Pulse Characteristics

There is no current capability for pulse shaping.

8.3 APPLICATIONS SUMMARY

The Advanced Components Test Facility is well suited for testing:

- Antral receiver components/systems
- High-temperature insulation and structural materials
- High-flux direct energy conversion component/systems
- High-temperature solar chemical reactor components/systems
- Total energy systems using solar energy alone or in combination with fossil-fuel energy (hybrid) systems.

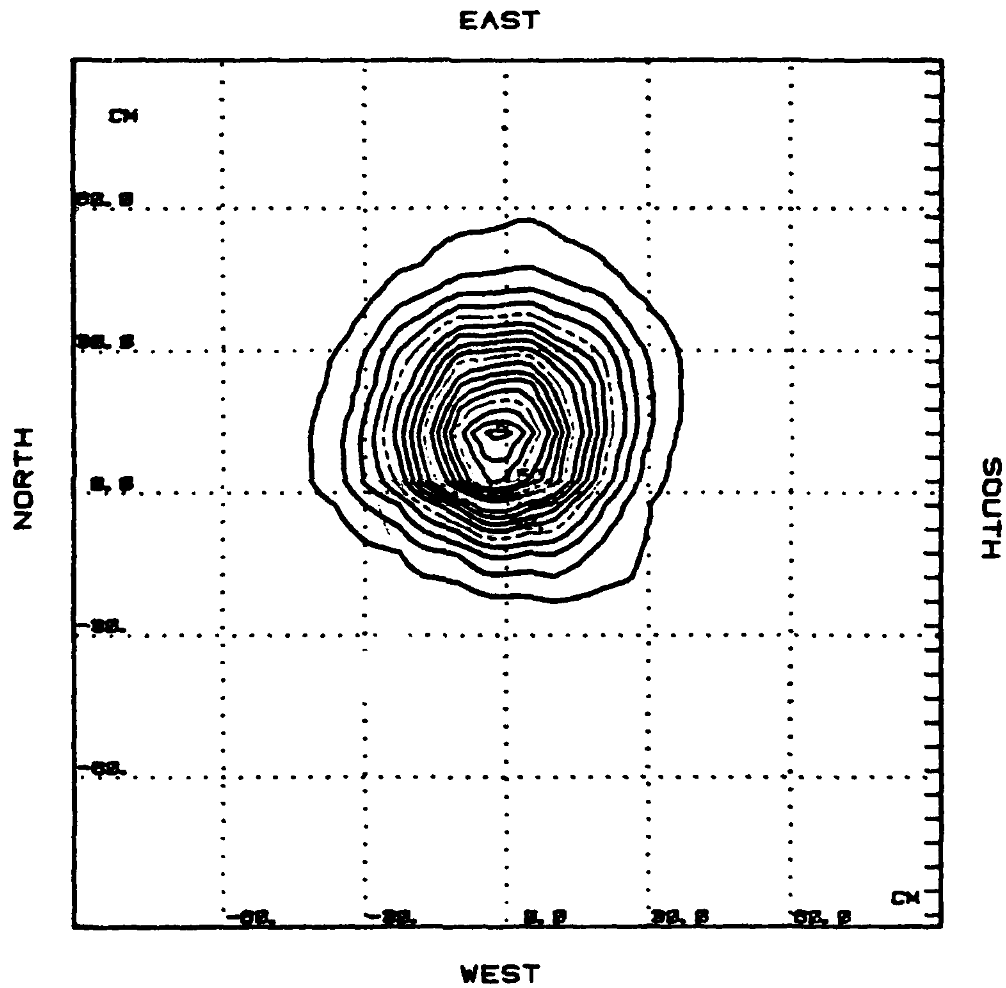
The ACTF maintains an ongoing mirror field improvement program. Modifications are expected to produce a significant increase in peak flux levels and a reduction in image size.

8.4 AVAILABILITY

Prospective experimeters are invited to establish contact with the Facility Director, C. Thomas Brown:

Director, Advanced Components Test Facility
EES/EMSL/Solar Site
Georgia Institute of Technology
Atlanta, GA 30332
Telephone: (404) 894-3329.

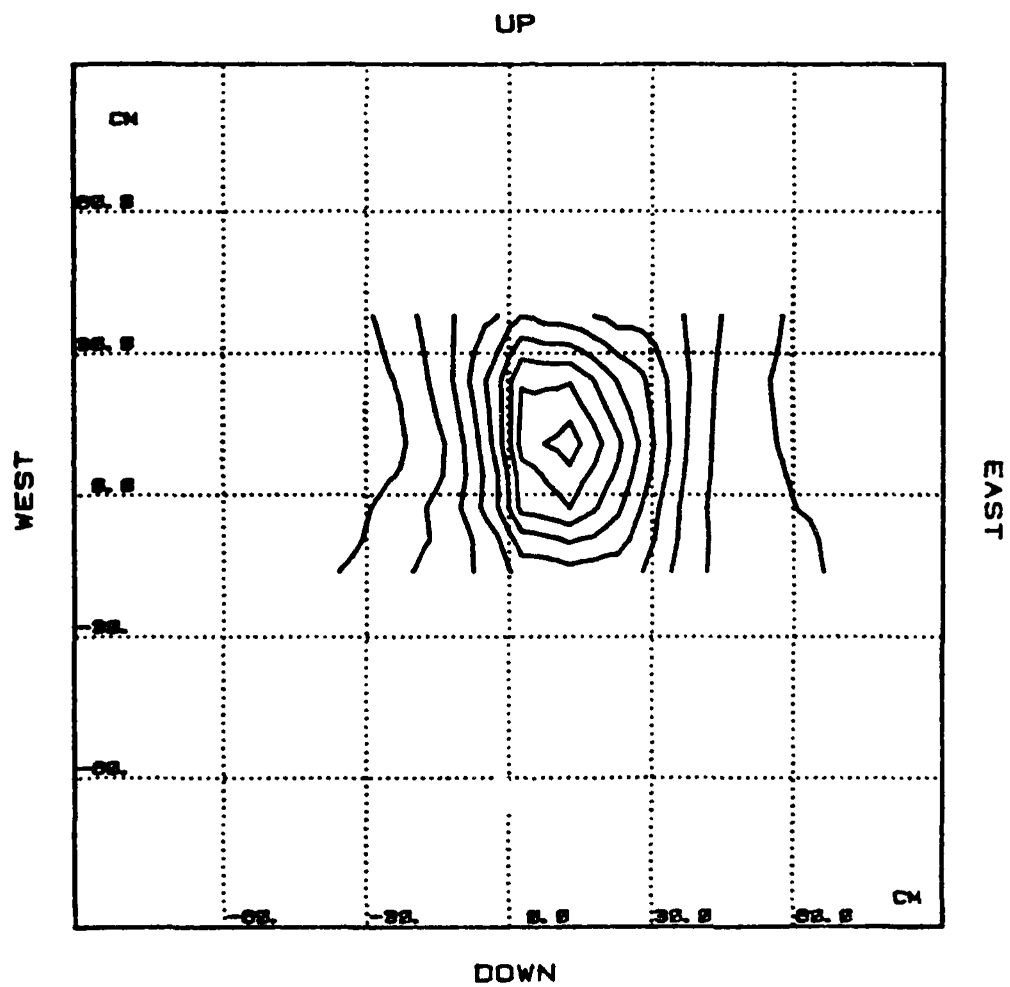
SCAN 3   3" ABOVE
Date 03-23-1982   Run B
11:22: 8 to 11:25:33



THRESHOLD: 10 W/CM^2   CONTOUR INTERVAL: 10 W/CM^2
CENTROID AT 14.6 EAST 1.10 NORTH (CM)
UNNORMALIZED
INSOLATION AVERAGE: 894.7 W/M^2
INTEGRATED POWER: 252.3 kW   RADIUS: 128.0 CM
DOE ACTF
GEORGIA TECH

Figure 8-10. ACTF flux map in horizortal plane.

VOLUME FLUX
Date 03-23-1982 Run B
11: 8:50 to 11:59:41
SLICE TAKEN AT 0.00 CM NORTH , LOOKING NORTH



THRESHOLD: 10 W/CM^2 CONTOUR INTERVAL: 20 W/CM^2
NORMALIZED TO 900. W/M^2

DOE ACTF
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Figure 8-11. ACTF flux map in volume mapping mode.

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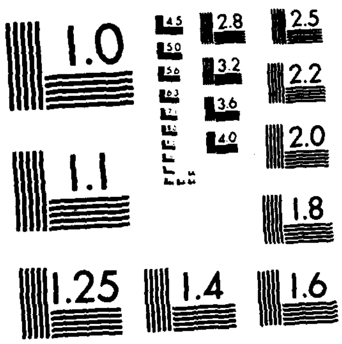

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Information about the Solar Thermal Test Facilities Users Association (STTFUA), including its requirements for proposals, may be obtained by contacting:

Executive Director
STTF Users Association
Suite 1204
First National Bank Building East
Albuquerque, NM 87108
Telephone: (505) 268-3994.

8.5 REFERENCES

1. D.H. Neal, "Advanced Components Test Facility User's Manual," Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Georgia (1971).

2. "Advanced Components Test Facility Real Time Data Collection System, Interface Information," Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Georgia (1979).

3. C.T. Brown, "Concentrated Solar Flux Measurement Experience at the DOE Advanced Components Test Facility," Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Georgia (Undated).

SECTION 9

NEW MEXICO STATE UNIVERSITY SOLAR FURNACE

9.1 FACILITY DESCRIPTION

The New Mexico State University (NMSU) solar furnace is located on the university campus near the junction of Interstate 10 and Interstate 25 at Las Cruces, New Mexico. It is within 35 road miles of the White Sands Solar Facility (Section 7). The facility itself is located within a secure area of the Physical Science Laboratory (PSL) service compound. This secure area has a U.S. Government security classification level of Secret.

Operational since May 1980, the facility was designed for long-duration, high-flux-density material testing and flux-gage calibration and evaluation. It is a horizontal solar furnace as illustrated in Figure 9-1. The basic components are a 3.66 m (12.0 ft) by 4.27 m (14.0 ft) heliostat covered with 0.6-m (24-inch) square mirrors mounted on an Army surplus radar pedestal, a 3.05-m (10.0-ft) square concentrator, an attenuator, and a water-cooled shutter.

The heliostat reflecting surface is an aluminized acrylic (FEK-244) front surfaced on 0.6-cm- (0.25-inch) thick plate glass. Heliostat tracking is accomplished by balancing photoconductive cells that trigger a drive pulse generator to the heliostat motor armatures.

The concentrator is faceted with 2,000 back-surfaced, silvered iron glass. Each facet is 6.3-cm (2.5-inch) square and 0.3-cm (0.1 inch) thick. The facets are geometrically arranged to focus on a test area 2.64 m (8.66 ft) from the center of the concentrator.

The attenuator, located between the concentrator and the test area, is capable of limiting the available flux density at the test area to any level between zero and full power. This attenuator is of venetian-blind design with five rows of blades actuated by an electric motor and clutch. As currently configured, the attenuator requires about 8 seconds to go from full-open to full-closed but in an emergency can close in 0.5 sec.

The test area is located 1.98 m (6.50 ft) above ground on a manually operated three-axis positioning table measuring 0.3 m (1 ft) square.

9.1.1 Test Procedures

The NMSU solar furnace is a relatively small facility but is particularly useful for low-cost evaluation of an experiment or test designed for larger, more expensive facilities. Accordingly, administrative functions

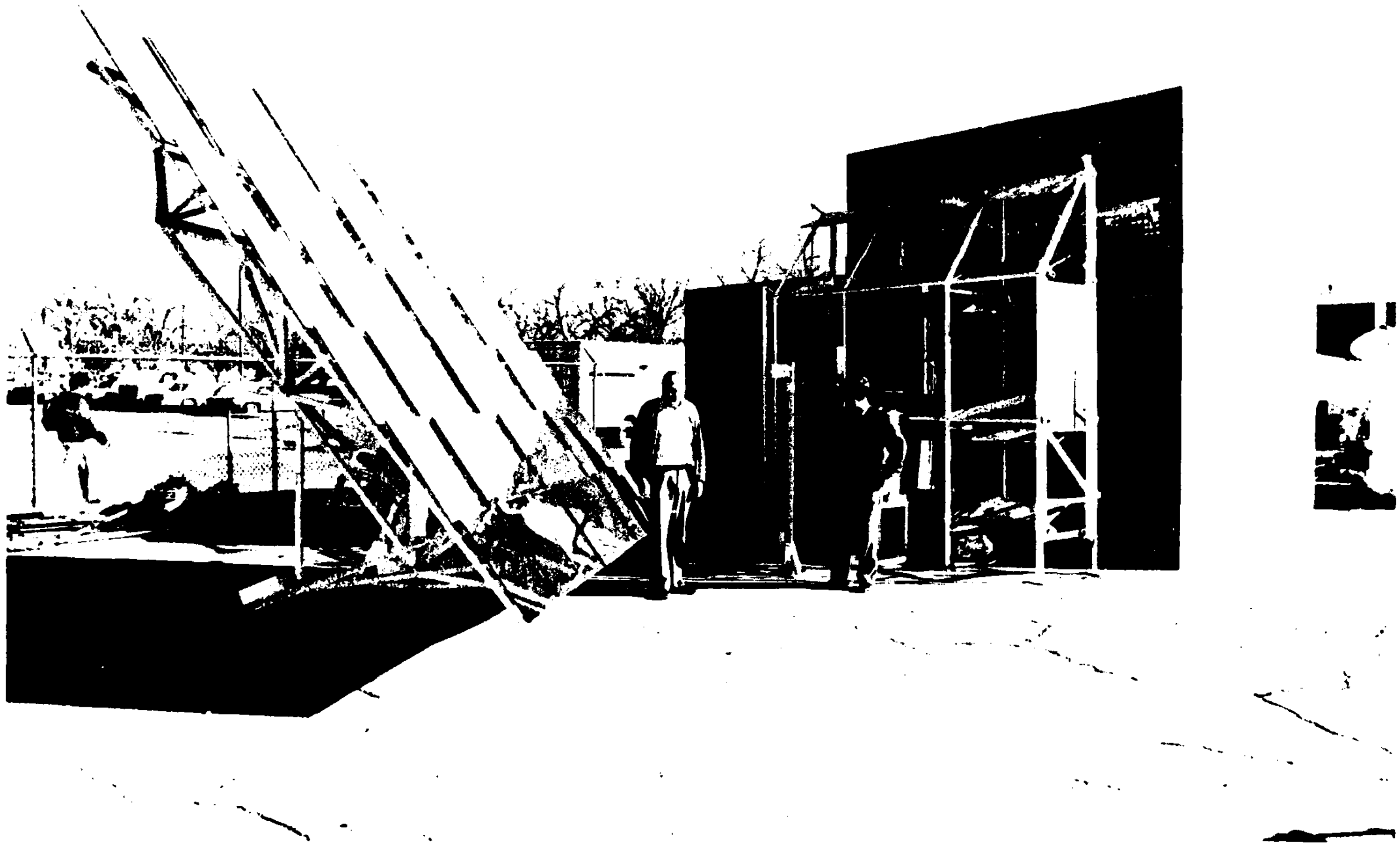

Figure 9-1. New Mexico State University solar furnace

required of potential users during pretest phases are nominal. Staff assistance is furnished to users by the NMSU Physical Science Laboratory.

9.1.2 Instrumentation

Available instrumentation includes infrared thermometers (200° to $2,800^{\circ}C$ range) with remote readout and analog output for recording. A small-diameter, water-cooled flux gage is also available for flux mapping in the focal zone with supporting readout and recording equipment. Digital voltmeters, chart recorders, and service utilities are also available as well as a tracking, normal-incidence pyrheliometer. Data processing support is available by prior arrangement.

9.1.3 Improvement Program

The current facility is normally achieving a flux concentration ratio of 850. Improvements are planned in 1982 to increase this ratio to 1,000. The heliostat will be refitted with back-surfaced, silvered glass mirrors for better reflectivity and concentrator mirror alignment will be fine-tuned.

A second furnace facility is also planned. This facility will consist of two small vertical-beam solar furnaces. Concentrator mirrors for these furnaces will be 1.52- m(5-ft) diameter electroformed copper parabolic mirrors surfaced with rhodium.

9.2 SOURCE CHARACTERISTICS

9.2.1 Flux

Based on a measured solar insolation of 231 cal cm^{-2} sec^{-1} (966 W/m^2), the peak flux at the center of the focal plane was measured at 16 cal cm^{-2} sec^{-1} (69 W/cm^2). Figure 9-2 illustrates flux-density contours, and Figure 9-3 shows a flux-density profile.

9.2.2 Spectral Distribution

Information on the distribution of wavelengths in the concentrated solar beam was not available at this writing.

9.2.3 Pulse Characteristics

There is no current capability for pulse shaping.

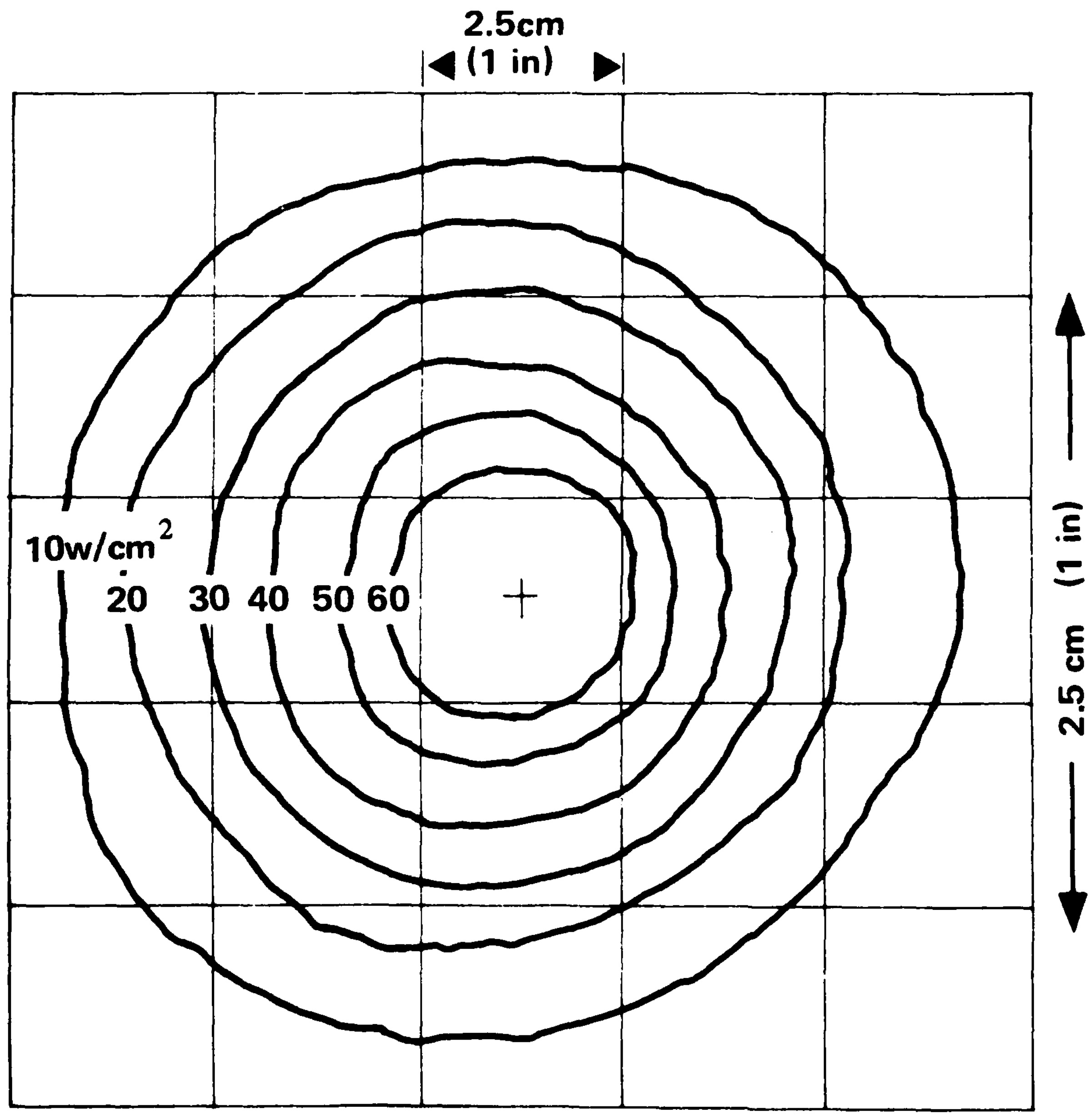

Figure 9-2. Flux-density contours.

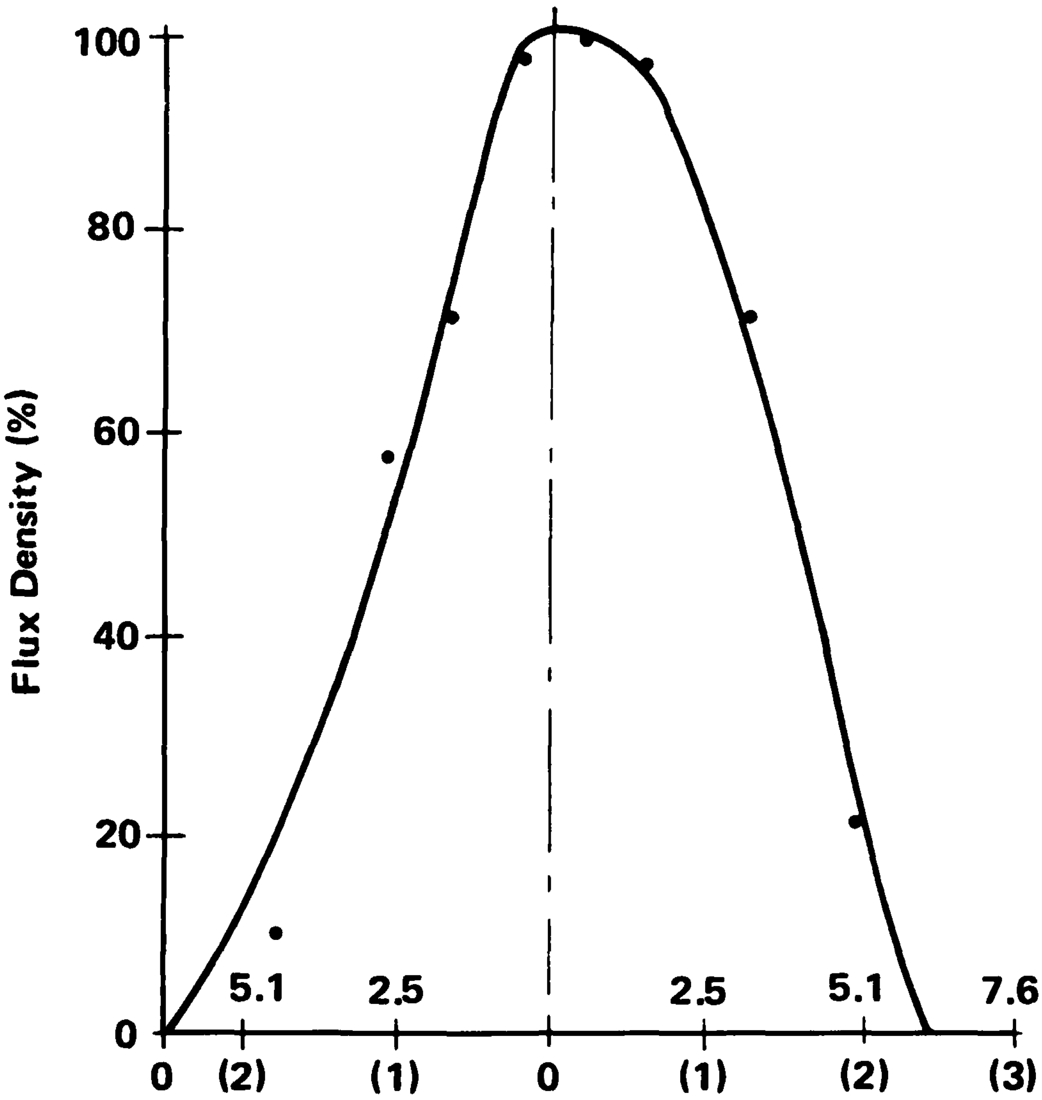

Figure 9-3. Flux-density profile.

9.3 APPLICATIONS SUMMARY

Within the context of this handbook, the NMSU solar facility is well-suited for limited preliminary testing of experiments designed for more costly, larger facilities.

9.4 AVAILABILITY

The standard usage fee for the NMSU Solar Furnace is $350 per scheduled setup/test day. Contacts for scheduling information are:

Mr. Thomas C. McConnell
New Mexico State University
Physical Science Laboratory
Box 3-PSL
Las Cruces, NM 88003
(505) 522-9285

Mr. William C. Stevens
New Mexico State University
Physical Science Laboratory
Box 3-PSL
Las Cruces, NM 88003
(505) 522-9262.

For additional technical information or assistance, contacts are:

Dr. George P. Mullholland
New Mexico State University
Dept. of Mechanical Engineering
Box 3450
Las Cruces, NM 88003
(505) 646-2118

Mr. Robert J. Sabin
New Mexico State University
Physical Science Laboratory
Box 3-PSL
Las Cruces, NM 88003
(505) 522-9209.

9.5 REFERENCES

1. "Central Receiver Test Facility Reflections," Sandia National Laboratories, Albuquerque, New Mexico, Volume IV, Number 3 (undated).

2. G.P. Mulholland and W.C. Stevens, "NMSU/PSL Solar Furnace Facility," New Mexico State University, Las Cruces, New Mexico (undated).

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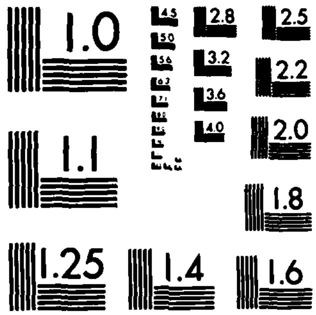

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FOR

DNA-TR-82-33

THERMAL SIMULATION FACILITIES HANDBOOK

1 March 1984

Instructions

Please make the following pen and ink corrections in your copy of DNA-TR-82-33.

Page	Correction
4 (Line 5)	Change "(500 cm beam)" to "(5 cm beam)".
4 (Line 6)	Change "5000 cm dia." to "50 cm dia.".
	Please affix the enclosed adhesive label over Table 2-1 on page 21.

Table 2-1. Flux capabilities (cal cm^{-2} sec^{-1}).

Lamp Power (kw)	Beam Diameter (cm)			
	50	30	10	5
25	5.3	14.5	124	526
30	6.2	17.4	148	621
35	7.4	20.3	184	717
35[a]	11.0	30.6	241	1050

Note:
[a]with light pipe