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MDC G7895

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10 MWe Solar Thermal
Central Receiver Pilot Plant

SOLAR FACILITIES DESIGN INTEGRATION

TECHNICAL OBJECTIVES REPORT – MCS (RADL ITEM 2-26)

Revised December 1979

WORK PERFORMED UNDER CONTRACT
DE-AC03-79SF10499

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
5301 BOLSA AVENUE
HUNTINGTON BEACH, CA 92647

U.S. Department of Energy

MCDONNELL DOUGLAS CORPORATION

Solar Energy

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U.S. DEPARTMENT OF ENERGY
SOLAR ENERGY
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PREFACE

This document is provided by the McDonnell Douglas Astronautics Company (MDAC) in accordance with Department of Energy Contract No. DE-AC03-79 SF 10499, Reports and Deliverables List, Item 2-26. The material contained in this document describes the master control subsystem (MCS) technical objectives and the MCS capability required to meet these objectives. Additional details on the MCS technical objectives and requirements will be included in any updates to this document and in subsequent MCS requirements documentation.

Questions concerning this document should be directed to R. G. Riedesel at (714) 896-3357.

CONTENTS

Section 1
INTRODUCTION

This document establishes the technical objectives and general requirements for the Master Control Subsystem (MCS) of the Solar 10 MWe Pilot Plant, which will hereafter be referred to as the plant. The technical objectives define the operating capabilities of the plant which concern the MCS. The general requirements are high-level requirements which must be observed in the design and procurement of the MCS.

1.1 SUMMARY

The MCS is a set of hardware and software to be used to monitor and control the plant operations from a central control room. The operations described here include plant control in various power-generating and/or energy-storing modes (operating modes), and normal and emergency mode transitions. The MCS shall interface with the collector subsystem (CS) and the subsystem distributed process control (SDPC). The MCS and SPDC provide the automatic and manual control of the solar power plant.

1.1.1 MCS Objectives

The primary objectives for MCS are as follows:

A. The MCS shall contain sufficient flexibility in control and display to allow for testing of a sufficient number of plant control configurations to determine the most feasible and productive method of operating the plant.

B. The MCS shall be capable of demonstrating that an automated plant under computer control and a minimum number of plant operators can utilize available insolation for a given scenario in an efficient manner.

C. The MCS shall be capable of gathering, displaying, and logging sufficient data for the purpose of evaluating pilot plant design and performance along with its application to a commercial plant.

D. The MCS control and display system shall have a low risk of losing plant control or display capability.

1.1.2 MCS Components

The MCS consists of the following:

A. The operational control system (OCS) - computer and console required for automatic plant control.

B. The peripheral control system (PCS) - computer and console required for data reduction, software development, OCS backup, and beam characterization subsystem (BCS) computing.

C. The data acquisition system (DAS) - computer and console required for gathering and displaying plant evaluation data.

1.1.2.1 OCS

The OCS computer system is the primary means of automatically controlling the plant. Its function is to monitor and supervise the plant during various operating modes, to transition the plant between modes, and to assist the operator in other operations such as plant startups, shutdowns, and conditioning.

The OCS communicates with most of the plant equipment through the SDPC data highway and distributed controllers. Communication with the CS, PCS, and DAS is via a MODCOMP MAXNET operating system.

1.1.2.2 PCS

The PCS computer system provides the general-purpose computing function and the capability to generate in real time OCS displays on the PCS CRT. It is used to reduce and display data obtained during power generation, experiments, etc., and is used during on- and off-line software development. It is also used to back up the OCS computer in case it fails. In this document, any reference to the OCS function also applies to the PCS when it is functioning as the OCS.

1.1.2.3 DAS

The DAS computer system is used as an instrument to monitor the plant equipment and collector subsystem during the various plant operations. Data gathered with the DAS will be used to evaluate the plant performance and is not required to run the plant. Neither SDPC nor OCS depends upon the DAS for control or monitor information.

1.1.3 SDPC Description

The SPDC plays a major part in the control of the plant equipment. This description is included to complete the description of the control equipment.

The SDPC consists of consoles located in a control room and distributed controllers located at monitor (transducers) and control (valves, pumps, etc.) elements throughout the plant. These controllers contain the control strategy (control algorithms, logic, etc.) required to control via these elements the various components in the receiver, thermal storage, turbine/generator and balance of plant. The consoles are used to load and/or modify the control strategies and to monitor the resultant operations. Communication between the consoles and distributed controllers is through a digital data highway. The SPDC is sufficiently complete to allow the operator(s) to control the plant without the MCS in all but the most complicated operations.

1.2 GROUND RULES

The following ground rules shall apply to the MCS design:

A. Startup and shutdown of the turbine and receiver will be accomplished through the SDPC and the local (non-MCS) hardware. Some OCS assistance may be provided.

B. All plant conditioning including conditioning to hot standby shall be accomplished through the SDPC and local hardware. Some OCS assistance may be provided.

C. The equipment required for TSS charge and discharge loops including the turbine can be kept in hot standby.

D. The length of downcomer between TSS charge and turbine inlet port can be kept in hot standby.

E. The TSS charge and discharge loop time constants are assumed to be sufficiently fast to handle the defined cloud disturbance.

F. No manual operation is required to start steam into the turbine inlet port or admission port if the turbine is already operating through the other port.

G. The interface to the electrical grid demand shall be simulated.

1.3 ACRONYMS

The following acronyms are used in this document:

BCS	Beam characterization subsystem
BOP	Balance of plant
CA	Cascade control
CC	Control configuration
CO	Coordinated control
CS	Collector subsystem
DAS	Data acquisition subsystem
DDC	Direct digital control
EPGS	Electrical power generator subsystem
HAC	Heliostat array controller
ICC	Integrated control console
ILS	Interface logic system
LF	Load following
MCS	Master control subsystem
MWe	Megawatt-electric
OCS	Operational control system
OL	Open loop
OPDD	Overall plant design description
PCS	Peripheral control system
PID	Proportional, integral, derivative (controller)
PIU	Process interface unit
PLC	Programmable logic controller
PSS	Plant support subsystem
RS	Receiver subsystem
SDPC	Subsystem distributed process control

SF	Sun following
SFDI	Solar facilities design integration
TBD	To be determined
TOD	Time of day
TSS	Thermal storage subsystem

Section 2
OPERATIONAL OBJECTIVES

The operational objectives define the operating capabilities to be built into the plant. These capabilities shall be provided by the combination of the SDPC and the MCS. The MCS shall be capable of the following during plant operation:

A. Assist as required in plant startup, conditioning, hot standby, and shutdown.

B. Control the plant in the 8 steady state operating modes shown in Figure 2.2-1.

C. Provide sun following, open loop, cascade control, and coordinated control strategies in conjunction with the 7 active modes.

D. Transition the plant from one control configuration to another.

E. Perform a predefined clear day scenario.

2.1 STARTUP, CONDITIONING, AND SHUTDOWN

Startup, conditioning, and shutdown of the plant shall generally be through the use of SDPC and local hardware (control panels, manual valves, CS console, etc., provided by the subsystem supplier). OCS assistance shall be provided where the task is very complex or where time constraints make it too difficult for the operator to handle and there is sufficient information and control capability available. The following definitions shall apply:

A. Startup - the collection of non-maintenance operations required to bring the plant equipment from any normal inactive state to a desired active operating mode.

B. Conditioning - the collection of non-maintenance operations required to bring the plant equipment up to the desired operating condition or state (temperature, pressure, etc.) so that this equipment is ready to use upon demand. After conditioning operations, the affected equipment is said to be conditioned.

C. Hot standby - a standby state in which the required equipment is kept conditioned so that its function is available upon demand.

D. Shutdown - the collection of non-maintenance operations required to bring the plant equipment from any active or inactive state to a desired inactive state.

The following example explains the relationships between A, B, and C above. Assume that the plant is currently shut down. It is to be started in operating mode 1 and transitioned to operating mode 2 when sufficient insolation becomes available. Startup procedures must be performed on the collector, receiver, turbine/generator, and balance of plant until the plant is in mode 1. These startup procedures must have included conditioning procedures where required. In addition, conditioning of the thermal storage charging equipment to hot standby is required so that the transition to mode 2 can be made as soon as the insolation becomes sufficient.

2.2 OPERATING MODES AND CONTROL CONFIGURATIONS

The power plant shall be controlled in the eight steady-state operating modes shown in Figure 2.2-1. The seven active modes shall be controlled under the following strategies:

A. Sun following - the load (electrical power generated or thermal energy stored) is a function of the available insolation.

B. Open loop - the load is determined by a steam flow setting that is not a function of the load.

C. Cascade control - a load following control method where one component reacts to a load error and all other affected components react in turn.

D. Coordinated control - a load following control method where two or more components are made to respond simultaneously to a load error.

The current plans are to operate the turbine throttles under pressure control. The seven active operating modes with the above control strategies for a pressure controlled turbine are depicted by the control configurations shown in Figure 2.2-2. In this figure, the pressure (P), flow (F), and load (L) represent the dominant control parameters for the represented element (valve, pump, etc.).

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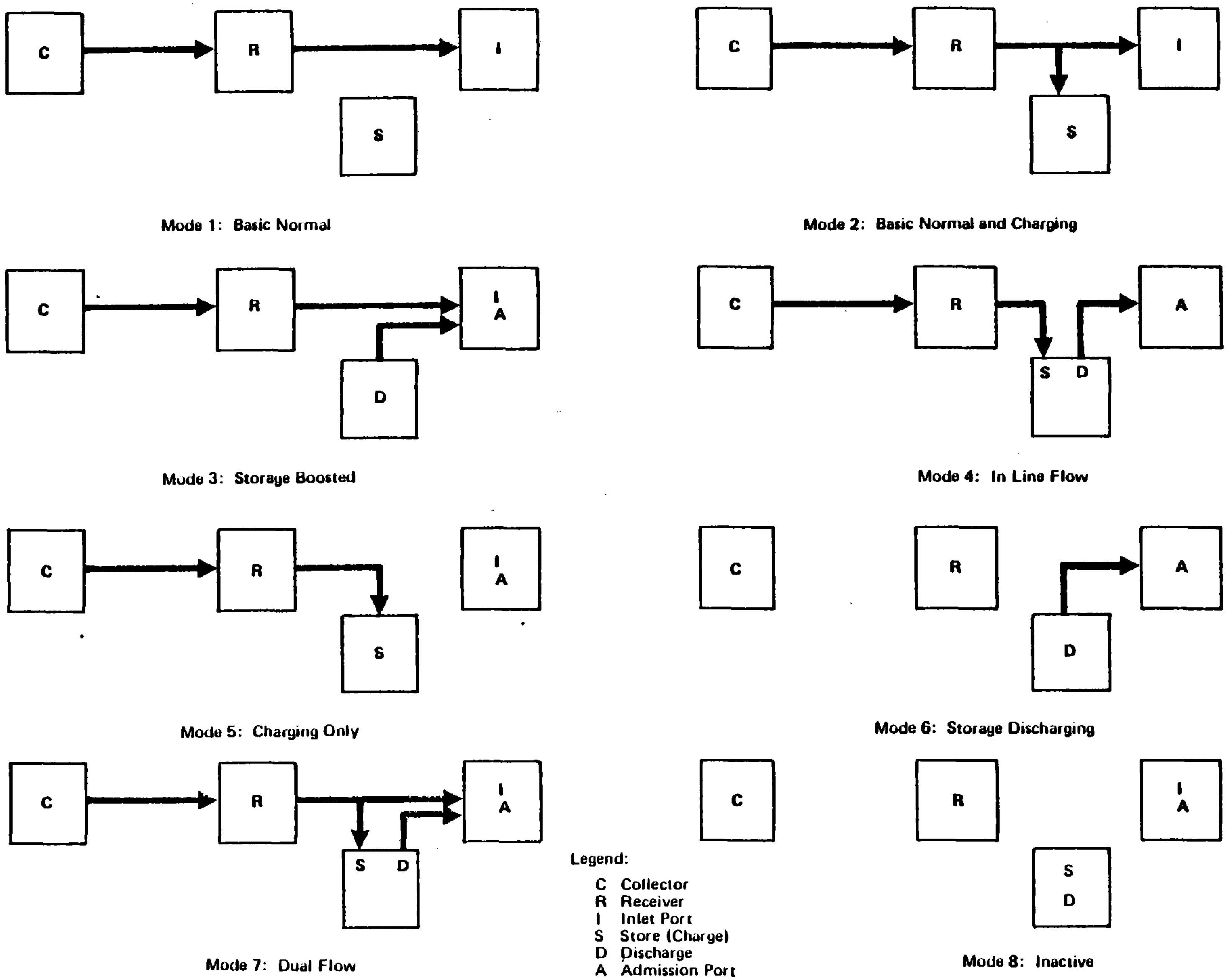
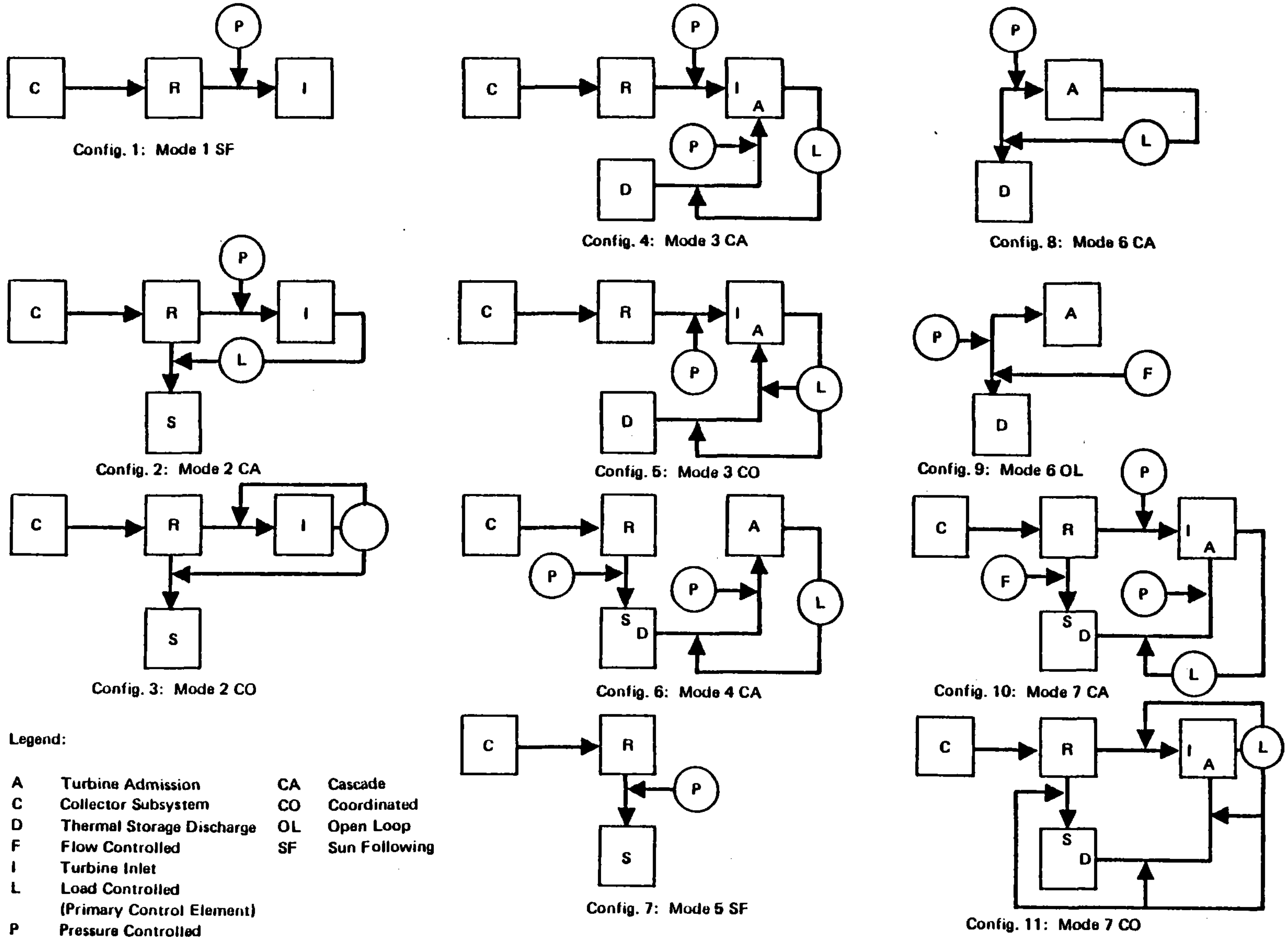


Figure 2.2-1. Operating Modes



Legend:

A	Turbine Admission	CA	Cascade
C	Collector Subsystem	CO	Coordinated
D	Thermal Storage Discharge	OL	Open Loop
F	Flow Controlled	SF	Sun Following
I	Turbine Inlet		
L	Load Controlled (Primary Control Element)		
P	Pressure Controlled		
R	Receiver Subsystem		
S	Thermal Storage Charge		

Figure 2.2-2. Control Configurations

Any load controlled element is a primary control element which the remainder of the plant follows. If the control configuration (CC) has no primary control element, its operation is either sun following or open loop. If the CC contains one primary control element, it is cascade controlled. If the CC has more than one primary control element, it is coordinated controlled. Some of the operating modes shall be represented by several control configurations.

2.3 TRANSITIONS

The MCS shall provide for transitions from one control configuration to another as defined by Figure 2.3-1. In the transition matrix the left column shows the "from" configurations and the top row shows the "to" configurations. For the purpose of the software logic, the "from" configuration shall remain in effect until the transition to the "to" configuration is initiated even if the energy flow configuration has already changed.

An "A" at any intersection in the matrix denotes that the MCS shall automatically detect transition points while in the "from" configuration and shall be capable of automatic transitions to the "to" configuration. An "A" or "M" denotes that the MCS shall be capable of automated transitions between the indicated configurations at the command of the operator whether or not an automatic transition point has been reached. The transitions shall be made if the load point and energy levels are compatible with the new configuration and no anomalies exist which would prevent the transition.

An "I" denotes that the indicated automated transition shall be possible but need not be direct. This indirect transition may be accomplished through two or more intermediate configurations (some manually initiated) and may require manipulation of the load control point and/or energy level (modulation of the collector field) by the operator.

To

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From

Control Configuration	Mode Strategy	Control Configuration 1	2	3	4	5	6	7	8	9	10	11	Mode 8
1	1 SF	–	A	I	A	A	M	•	I	I	I	I	R T H
2	2 CA	A S	–	M	I	I	I	T	I	I	M	I	R H
3	2 CO	I S	M	–	I	I	I	T	I	I	I	I	R H
4	3 CA	A D	I	I	–	M	I	•	R A	I	A	I	T H
5	3 CO	A D	I	I	M	–	I	•	I	R A	I	A	T H
6	4 CA	I	I	I	I	I	–	D T	R AS	I	M	I	H
7	5 SF	•	•	•	•	•	•	–	•	•	•	•	R S H
8	6 CA	X	X	X	X	X	X	X	–	M	X	X	D T H
9	6 OL	X	X	X	X	X	X	X	M	–	X	X	D T H
10	7 CA	I	M	I	A S	I	M	T	R A	I	–	M	H
11	7 CO	I	I	I	I	A S	I	T	I	R A	M	–	H

- • Requires Turbine Start or Shutdown
- A Automatic transition (Some of the automatic transitions shown above are for the cloudy day scenario)
- D TS Discharge Trip
- I Indirect Transition
- H Hotwell/Condensor Failure
- M Manually Initiated Transition
- R Receiver or CS Trip
- S TS Store Trip
- T Turbine Trip
- X Requires Receiver Start

- CA Cascade Control
- CO Coordinated Control
- OL Open Loop
- SF Sun Following

Figure 2.3-1. Transition Matrix

The "T", "R", "H", "S", and "D" denotes that an automatic transition shall be provided when the turbine, receiver or collector subsystem, hotwell/condenser, thermal storage charge, or thermal storage discharge subsystem, respectively, trips or otherwise fails to perform its function.

Automated transitions that require receiver startup, or turbine startup/shutdown, denoted by "X" and "*" respectively in the table, will not be provided at this time. The thermal storage charge and/or discharge equipment and the length of downcomer between the thermal storage charge and turbine inlet port must be in hot standby before transitions which invoke their use can be made.

The automatic transitions referred to above do not preclude operator action. The transition may leave the thermal storage system in hot standby, receiver steam flowing through the condenser dump, etc. These must be shut down by the operator through the SDPC and local hardware.

2.4 CLEAR-DAY SCENARIO

The MCS will perform the clear-day scenario shown on Figure 2.4-1. The scenario will start in mode 1 after receiver start and turbine roll at minimum load and will proceed from mode 1 sun following, through mode 2 cascade control (CA), back to mode 1 sun following, mode 3 CA, and finally to mode 6 CA. Operator action will be required for the plant startup, receiver shutdown, and plant shutdown.

2.5 POWER-GENERATION OPERATION CONTROL

The power-generation operations are defined as the active operations between startup and shutdown of the plant. During these power generation operations the following control options shall be available: automatic, OCS manual, and subsystem manual.

2.5.1 Automatic

Under automatic control, OCS shall supervise the power-generation operations through the clear-day scenario described in Section 2.4 or any part of it. During these operations, OCS shall automatically detect mode transition points and automatically perform the required mode transitions.

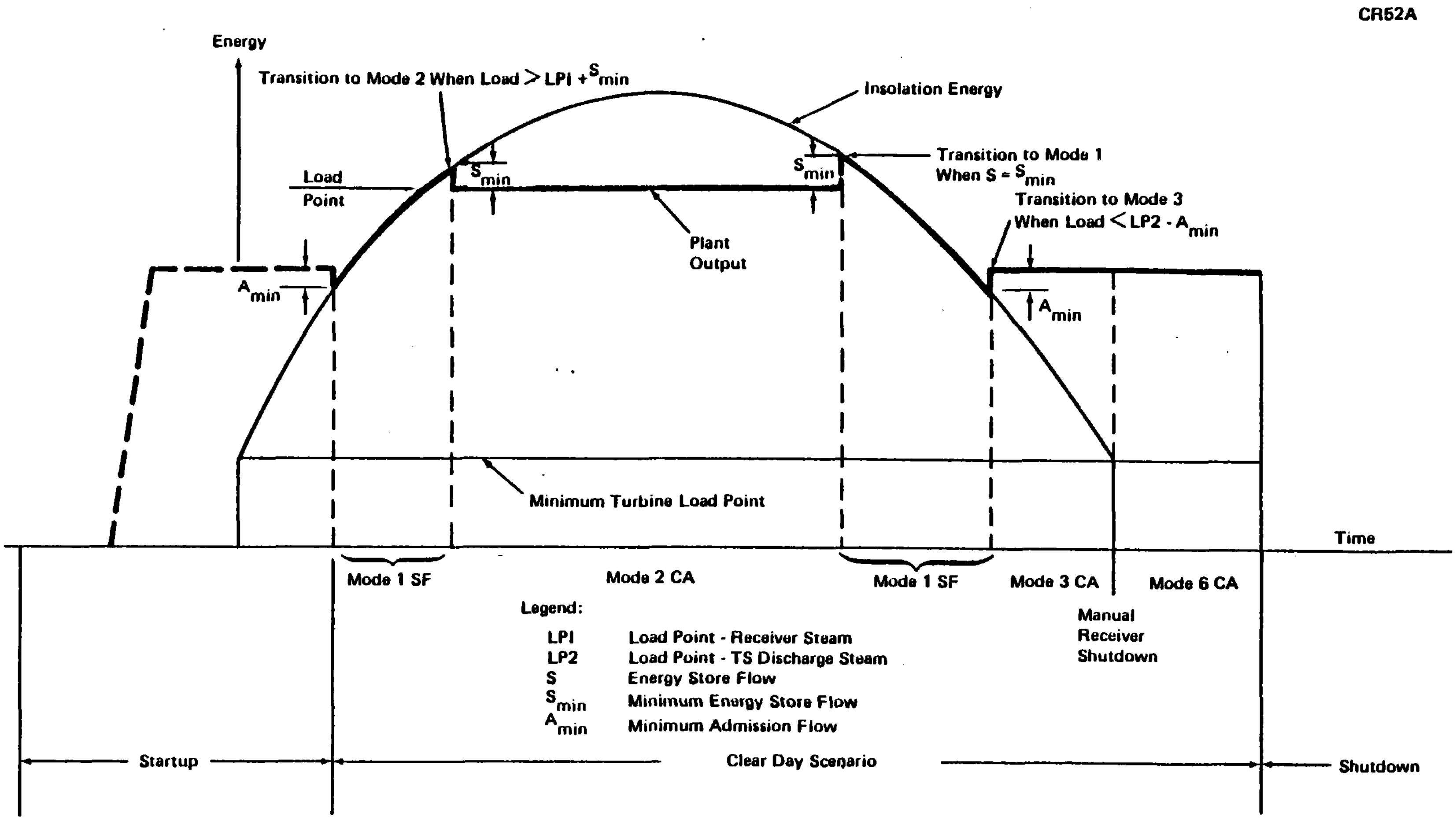

Figure 2.4-1. Clear-Day Scenario

2.5.2 OCS Manual

Under OCS manual control, OCS shall supervise the power-generation operations as under automatic control except that all operating modes are selected by the operator and all transitions are initiated by the operator. The OCS shall perform the transitions initiated by the operator as long as (1) the transition is allowed by the transition matrix, (2) the energy level, load point setting, and plant status are satisfied, and (3) the plant is not performing a transition.

2.5.3 Subsystem Manual

Under subsystem manual, the operator shall supervise the power generation operations through the SDPC consoles. The OCS status monitor capabilities can be invoked to assist the operator.

Section 3
MCS REQUIREMENTS

In order to meet the master control subsystem technical objectives, the MCS shall be required to have the control, display, and recording capability and consist of the equipment described in this section.

3.1 MCS GENERAL REQUIREMENTS

The general requirements for the MCS are:

A. All computers in the MCS shall be MODCOMP classics.

B. The OCS, PCS, DAS, and the two Heliostat Array Controller (HAC) computers shall be connected in a network (MAXNET operating system) in order to provide CPU-CPU communications.

C. The control and display consoles shall be located close together to facilitate observation and control.

D. A separate room (the Engineering Evaluation or DAS room) will be provided for data display in support of testing and engineering evaluation. This room shall contain consoles for the PCS, DAS, and SDPC.

E. The PCS shall backup the OCS in the event of an OCS failure. The OCS shall record sufficient data so that the PCS can assume control of the plant. Failover can be initiated automatically from the PCS or manually by the operator and control can be restored to the OCS by operator command.

F. Redundancy will be provided when practical to prevent a single point failure from disabling both the OCS and the PCS.

G. Application programs which provide the complete control and display functions for steady state operations and transitions shall be resident in the OCS and PCS computers and peripherals without interchanging disk packs, tapes, etc.

H. The MCS shall determine and report the state of the communications links with interfacing subsystems and devices. The MCS shall provide sufficient error/failure detection and reporting capability to determine the health of the MCS.

Besides the requirements given above, the MCS shall have as design goals: standardized interfaces, standard control practices, easily read human engineered displays, off-the-shelf equipment, and the same generic hardware between systems.

3.1.1 Control Capability

The MCS control system shall:

A. Control the plant in the 8 steady-state operating modes.

B. Transition between operating modes either by operator control or software control.

C. Control the power plant in a TBD cloud disturbance.

D. Permit the automatic operation of the plant by a single operator during normal power producing operation (excluding maintenance).

E. Provide the operator with a means of taking over control of any or all remotely controlled elements while operating under OCS control.

F. Be able to change the set point values or reconfigure the control algorithms in the SDPC.

G. Mechanize controls through the use of function keys and alphanumeric keyboards.

H. Have the capability to detect, generate an audible alarm, acknowledge, and log events/parameters that cross predefined alarm limits.

3.1.2 Display

The MCS display system shall:

A. Provide monitoring and alarm capability through color CRT displays and on-line printers.

B. Provide graphic and tabulated trending data.

C. Display or print all parameters and data in units understood by the operator and participating engineering personnel.

D. Provide the capability to build and change displays on-line.

E. Provide access in the DAS room to all displays available in the control room.

3.1.3 Recording

The MCS recording system shall:

A. Provide recording capability within computer core, on disks and tapes, and by printers.

B. Time tag data according to their time of receipt. Time tags shall be correlatable between computers within 50 msecs.

C. Log data during plant operation in support of MCS software and hardware integration testing.

D. Collect data regardless of the type of control being exercised.

E. Allow data from each computer to be recorded on the line printer or the hardcopy unit.

3.1.4 Equipment

Figure 3.1-1 shows a diagram of the MCS and its functional relationship within the MCS and its interface with other subsystems. The peripheral equipment identified in the figure are quantified in Table 3.1-1. Figure 3.1-2 shows the MCS equipment in the floor plan for the Daggett Site.

3.2 OPERATIONAL CONTROL SYSTEM

The manual plant control equipment of the SDPC is, in general, complete within itself. Once configured, its distributed processors keep the individual and interfacing hardware operating stably throughout the plant until a system limit is reached or until the operator intervenes.

The OCS is a host computer system overlaid upon this manual system. OCS will interface with the PCS, DAS, CS, SDPC, and operator. It shall perform two basic functions: 1) supervise the plant control operation, and 2) transition the plant to other modes when limits are reached or at the command of the operator.

3.2.1 Control

The OCS shall consist of one MODCOMP computer (with associated peripherals) and two color CRT/keyboard/function key combinations. These CRT's with controls shall be contiguous in the control room and shall be simultaneously available for control and display selection. The operator shall be prompted for each required command or command option by an appropriate message on the CRT. The command shall be entered into the keyboard and/or one of the function keys. The command shall be verified and 1) if incorrect, an appropriate message shall be displayed or 2) a message describing the result of the command shall be displayed. The number of keyboard entries and/or function key selections required by the operator for each command shall be minimized. Function keys shall be provided for commands which are issued frequently.

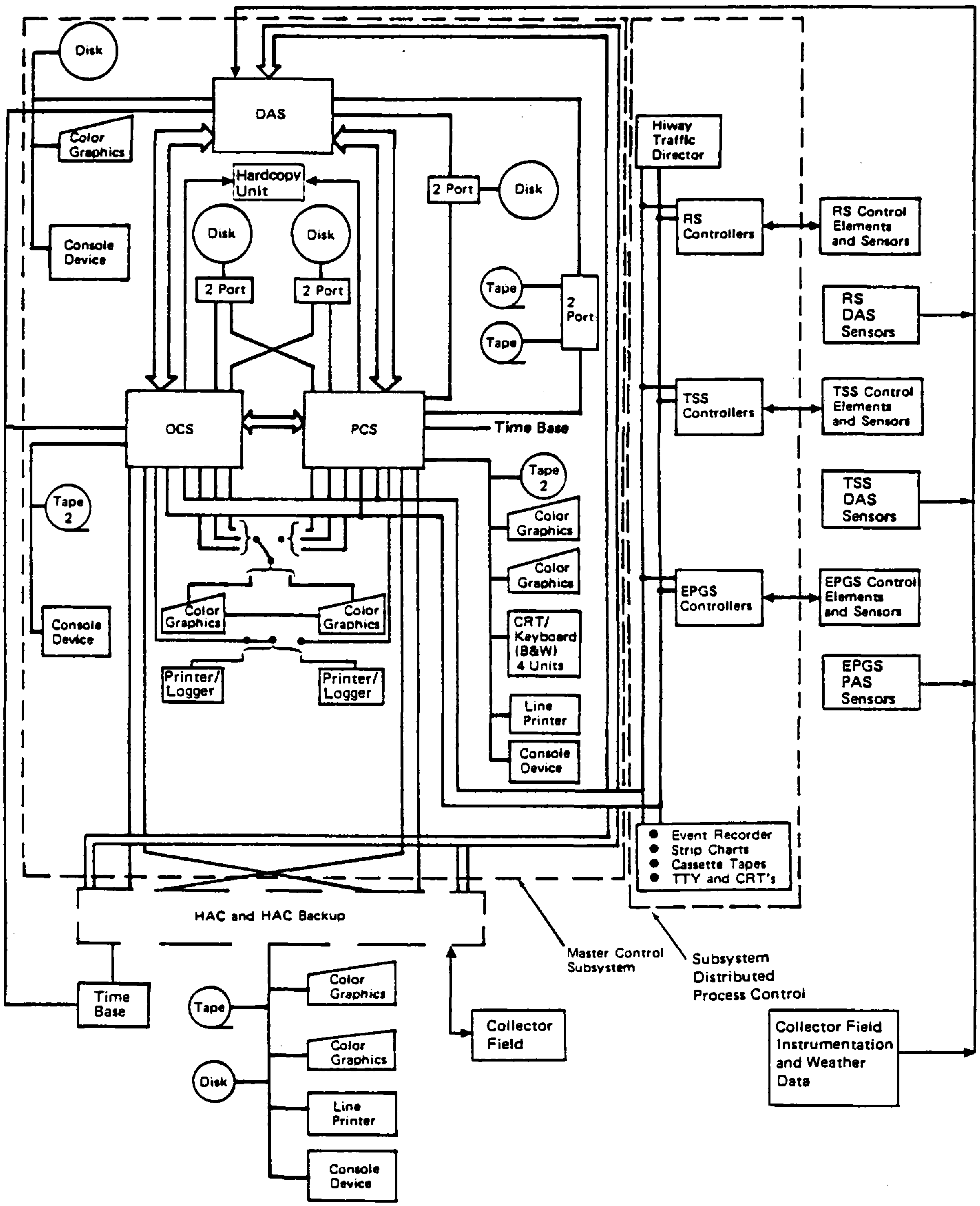

Figure 3.1-1. The Master Control Subsystem and Interfaces

Table 3.1-1. MCS Peripheral List

Peripheral Equipment	System: OCS	System: PCS	System: DAS	SDPC*	Collector Subsystem*
Color Graphics/Keyboard	2	2	1	4	2
Line Printer	0	1	0	1	1
Tape Unit	2	2	2	1	1
Disk	1	1	2	0	1
Console Device	1	1	1	0	1
CRT/Keyboard (B&W)	0	4	0	0	0
Printer/Logger	2	0	0	0	0
Strip Chart Recorder	0	0	0	3	0

Note:* Peripherals for the SDPC and CS are shown here to provide an overview of the complete equipment available for control and display.

The control options defined in Section 2.5 will be implemented in OCS as discussed below. In this discussion, the term "function" does not imply "software module."

3.2.1.1 Automatic Operation

Automatic operation of the plant will allow the operator a total "hands off" operation where all control functions are handled by the OCS. The OCS shall provide for steady-state control in all the control configurations, detection of a need to transition to another control configuration, automatic transition to a new control configuration, and monitoring of all plant parameters for out-of-tolerance conditions, alarms, etc. These functions shall consist of the following:

A. The plant may be operated automatically by the OCS control function in any of the eleven steady state control configurations shown in Figure 2.2-2. This control function is initiated after the operator has selected the control configuration to be used and the plant has been manually conditioned or previously set up to be in that control configuration. Where required, the receiver must have been started and/or the turbine must be at least at minimum load. The control function is stopped only upon manual or anomalous termination. The OCS shall use a combination of setpoint commands and SDPC remote controller configurations to maintain the plant in the required steady state control configuration.

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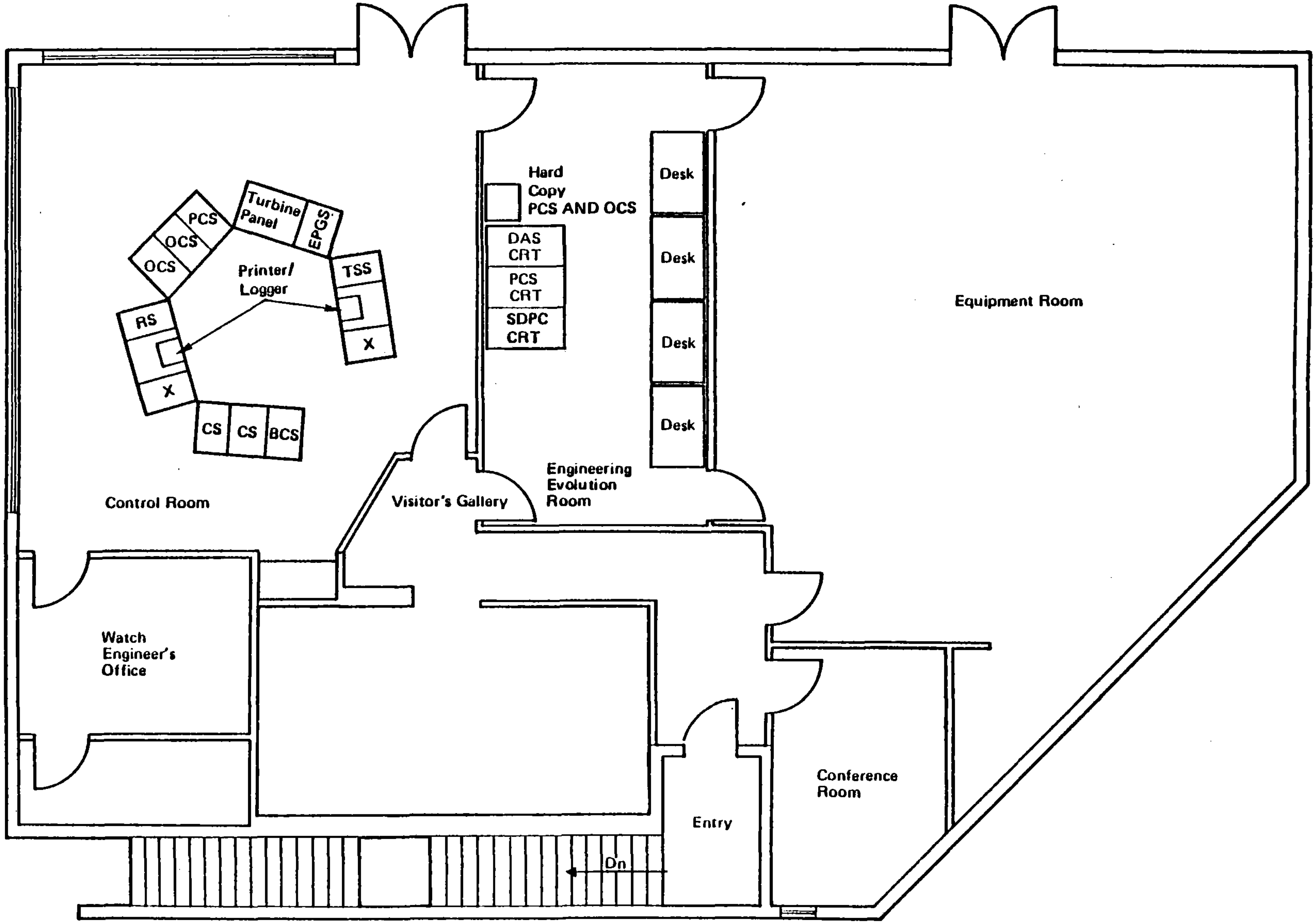

Figure 3.1-2. MCS Equipment Floor Layout

B. The OCS shall provide a capability of detecting a required transition to another control configuration based on parameters such as insolation level, time of day, and equipment status. The transitions to be detected shall be those as defined for the clear day scenario in Figure 2.4-1. Indication of the transition point shall be given to the operator at the console and the automatic transition function notified.

C. The OCS shall provide the capability to automatically transition the plant from one control configuration to another. The automatic transition to be provided are as defined in the transition matrix of Figure 2.3-1. Normal transitions are those as requested by the detection function in paragraph B above while emergency transitions are provided based on plant trips.

D. The OCS shall provide a monitor function of plant parameters to determine if the steady state control and transition functions can operate properly. This monitoring shall be for such conditions as subsystems not properly conditioned for use, thermal storage thermocline approaching the top or bottom of the tank and turbine flow overload. Monitoring may be used for alarming only but shall also provide the function of initiating transitions or preventing them based on the circumstances.

3.2.1.2 OCS Manual

A semi-automatic plant operation shall be provided where the OCS shall control the plant in any of the control configurations and will transition the plant to other control configurations based on operator request. Of the four functions described above for the automatic operation, only the control, transition, and monitor shall be active. All decisions of which control configuration to be in and which one to transition to will be made by the operator (with the possible exception of emergency transitions). This option will be used for most plant testing and prior to the integration of the full automatic software for clear and cloudy days.

3.2.1.3 Subsystem Manual

The subsystem manual option shall be provided for the OCS to monitor plant operations while all control is exercised via the control consoles of the SDPC by the operator. This monitoring shall consist only of functions such as alarming, trending, data display and piping diagrams. These capabilities are provided merely to augment the SDPC displays. The subsystem manual option will be used for plant startup and shutdown and in those testing modes where total operator manual control of the plant is required.

3.2.1.4 Manual Overrides

An override capability shall be provided for the automatic and OCS manual options where the operator may place one subsystem (or a portion of a subsystem) in subsystem manual while the rest of the plant is controlled by OCS in the selected mode. This option shall result in a lockout of control commands from the OCS to the specific controlled element(s). This would allow the operator to control that portion of the plant from an SDPC console without interference from the OCS.

3.2.2 Man/Machine Interface

The man/machine interface provides the means for the operator/engineer to (1) request information in the form of displays and/or hardcopy reports, (2) to manipulate the displays (e.g., paging, cancelling, etc.)., and (3) enter new data and/or change data.

A. Printers, recorders, and CRT's shall be combined to form a system for presentation of plant operating information. Specifically these devices are:

1. CRT Displays (color, alphanumeric, graphic)
2. Entry keys (alphanumeric, numeric, and function keys)
3. Printers (printer/logger, hardcopy unit, line printer)

B. The basic considerations for the design of operator communications which involve the man/machine interface devices are:

1. Accessibility of all process data on a normal, abnormal, or request basis.
2. Alarm and operator guidance information.
3. Rapid machine responses requiring minimum entries.
4. Reliable, pertinent information.
5. Flexibility in changing and upgrading operation techniques.
6. Interactive communications to guide the operator and minimize errors.

All operator commands and requests entered at the functional and alphanumeric keyboards shall be echoed back on the CRT monitor. Error and prompting messages are provided on the CRT to advise the operator when an erroneous entry has been made and to assist the operator in making entries necessary to obtain the desired display.

3.2.3 Display Function

The display function of the OCS provides the operator via CRT's and printer/loggers with readily understandable alarm information, operating status, and performance data for control of the power plant from the OCS or to monitor the system during automatic or subsystem control of the power plant. Display update rate shall be compatible with the dynamic response times of the plant variables and the ability of the operator to read the display. The number of keyboard entries and/or function key selections required by the operator for a display shall be minimized. Function keys shall be provided for frequently requested displays. Displays shall be selectable for either CRT from either keyboard. DAS data shall be available for display by the OCS.

Each OCS CRT shall have the time of day (TOD), date, and times of sunrise and sunset on a dedicated portion of the screen. Except for this information, each CRT display shall be independent of the other.

3.2.3.1 Status Data

The option of displaying status data shall be selectable by the operator. Status information shall be provided in terms of on/off data and measured and set point values. Alarm limits retrieved from the data base may be displayed with its measured value. An OCS computer file shall be maintained which contains the current reading of every control parameter.

Status displays shall consist of the following:

A. Preselected system effectiveness parameters.

B. Flow diagrams of each subsystem annotated with key measurements and setpoints. Exterior elements shall be included in each diagram if appropriate to the subsystem operation. Equipment and elements shall be represented by standard symbols. Color and blinking schemes shall be used to indicate the operational status.

C. A tabulation of all control parameters. The following rules apply:

1. The operator shall request a list of parameters by a subsystem

or control path function key and page number entry or shall be able to generate using special function keys a user-requested list of parameters.

2. The information in each list consists of:

a. Page number and total number of pages.

b. Subsystem or control path name.

c. Parameter name, identification number, measured and setpoint values, allowable variation, and units.

D. Bar charts of measured and setpoint values shall be selectable by function keys for a subsystem or control path group, a module within the group, or a component within a module. The module and component displays shall be selectable by function keys in conjunction with the group and module display data respectively.

E. An index display that lists the graphic and summary displays available for the plant or specific process areas, the data logs available, etc.

F. a real time program activity display which includes the identity of programs which are running and waiting to run.

3.2.3.2 Alarm Data

The OCS shall provide alarming capability for system level alarms and shall augment the SDPC alarm capability. Items from the data base to be alarmed shall be dependent on the SDPC system selected. Alarms shall be triggered in the event that prespecified thresholds are exceeded.

3.2.3.3 Trending Data

Tabular or plotted performance data such as water temperature and pressure, pump speed, and power output history, shall be selectable by the operator by specifying the parameter name and format. The tabulated and plotted data shall have the following features:

A. The operator shall select the historical duration and sample rate from one of the three specified at process construction.

B. One, two, three, or four plot parameters per CRT can be selected.

C. Up to ten parameters and time of day (TOD) shall be displayable in a table.

D. The setpoint value or values and allowable variation shall accompany the measured values.

E. All parameters shall be annotated with the following information:

1. Parameter name, identification, and subsystem name.
2. Units.

3.2.4 Data Collection

The OCS shall:

A. Log and maintain hardcopy of commands and responses and alarm and status data (changes in status only) given or received by the OCS. All data shall be time tagged. Whether a parameter or group of parameters is logged and/or copied shall be specified at process construction or defaulted to a prespecfiied condition.

B. Log significant parameters. These parameters shall be logged when prespecified by the user for each software task processed.

C. Record task statistics such as task dispatching sequence and time and execution duration.

D. Log sufficient current data so that the PCS can assume control of the plant in the event of an OCS failure.

E. Log plant trips.

F. Log all data obtained from the DAS and PCS.

G. Provide color hardcopy of a CRT display upon request.

H. Have the capability of recording data on the PCS line printer in the event of a PCS failure.

3.2.5 Data Base Generation and Management

The OCS shall have access to all field data points via the SDPC. The data that is received shall be stored in the data base. Data base values shall be available for graphic displays, calculations, reports, and historical analysis.

Sufficient data shall be stored in the data base to facilitate detection and isolation of alarm conditions. Control data (i.e., data representing the type of control algorithm, constants and gains for the algorithms, setpoint values, logical device on/off status) shall be contained in a computer data base. The inputs to the control data base shall be generated by software programs which are controlling the plant in a supervisory control configuration or come from operator entries via a keyboard.

Control command shall be transmitted from the OCS to the applicable field devices via the digital communication link to the SDPC.

3.3 PERIPHERAL CONTROL SYSTEM

3.3.1 Control, Display, and Recording

The PCS shall provide the following:

A. The same control and display functions as the OCS. The display function shall be available when requested without the PCS having control of the plant.

B. Two types of backup to the OCS:

1. An inactive one requiring the PCS during activation to obtain the plant information recorded by the OCS before the PCS can assume control of the plant.

2. An active backup where the PCS has been monitoring the plant operation and has the same control information as the OCS.

C. Computer communications with the DAS disk and magnetic tape storage devices. The PCS shall present the DAS data in displays such as tables, bar charts and diagrams and print the data in tabular form as requested by the operator.

D. Automatic off-line data processing.

E. Display on a CRT of prespecified data pertaining to its off-line computation.

F. The same recording capability as the OCS with the option of being selectively turned-off at process construction or in realtime.

G. Collector subsystem (CS) information in an identical format required for the CS CRT display.

H. The computer function of the beam characterization subsystem.

3.3.2 Data Reduction

The PCS shall be capable of processing data recorded by the OCS, DAS, and PCS.

A. The programs on the PCS shall provide the following types of information:

1. Listings or plots of time histories of selected parameters

recorded by the OCS, PCS, or DAS.

2. Listing or plots of selected parameters and edited parameters merged from standard data and/or data recorded on:

   a. Different days.

   b. Disks or tapes by the OCS, DAS, and PCS.

3. Listings and histograms of plant statistics as a function of time, sample rate, etc.

4. List internal process data and task statistics acquired during the execution of the OCS.

B. In addition to programs required for the above, programs shall be provided which:

1. Purge data from disks.
2. Dump data from disk to tape or tape to disk.
3. Provide diagnostic testing of the computer and peripherals.

3.4 DATA ACQUISITION SYSTEM

The primary function of the DAS computer is to independently collect and store data which can be used for off-line plant performance evaluation. The secondary function is to process real time data and display to the operator via the PCS displays.

3.4.1 Data Collection and Storage

The DAS is designed to sample and input up to TBD and TBD parameters per second into the DAS tape and disk files, respectively. Each parameter shall be selectable from a selection menu which will determine the frequency at which a particular parameter will be sampled.

Each parameter shall be formatted into logical records and stored on the storage device. The DAS shall record all data outputs from the sensors distributed throughout the power plant. The DAS shall time-tag each measurement.

The operator shall be able to select parameters for realtime storage in computer core.

3.4.2 Data Reduction

The DAS shall be capable of realtime and off-line data reduction.

3.4.2.1 Realtime Processing

Realtime processing of the data recorded in computer memory shall be performed by manual manipulation by the operator or by application programs or special reduction programs.

3.4.2.2 Off-Line Processing

The DAS shall be capable of processing data recorded by the DAS, OCS, and PCS. Programs developed for the PCS shall also execute on the DAS. In addition, the following shall be provided by the DAS:

A. Plotted or tabulated raw data displays on a CRT.

B. A listing of the data transferred between the DAS, OCS, and PCS.

Section 4
EVALUATION REQUIREMENTS

Evaluation requirements are as follows:

A. The MCS shall collect and reduce selected RS, TSS, CS, instrumented EPGS data received by the DAS and internal MCS data. Water analysis and weather data shall be evaluated by the MCS regardless of whether the data was collected in realtime.

B. Realtime data evaluation shall be performed on data collected in OCS, PCS, and DAS memory and/or disk.

C. Post test evaluation shall utilize data collected on tape and disk and/or input by keyboard.

D. Data reduction shall be limited to the utilization of the post processor designed for the solar power plant program and the PCS and DAS computers.

E. Non-MCS evaluation efforts shall be supported by supplying data collected on MCS disks and tapes.

4.1 ROLES AND RESPONSIBILITIES

The Solar Facilities Design Integration (SFDI) contractor shall be responsible for all evaluations data processing, reductions, and display. Subsystem personnel shall provide the analysis of their equipment with the SFDI contractor integrating the evaluations and publishing a comprehensive report. Performance and statistical data shall be determined and published by the SFDI contractor.

4.2 OPERATION EVALUATION

The power plant and subsystems including the MCS shall be evaluated to determine their performance and provide data to support the evaluation of the plant in meeting the objectives defined in the Overall Plant Design Requirements document.

Section 5
OPERATIONAL PERFORMANCE REQUIREMENTS

Operational performance requirements shall be imposed on the MCS for events which must be accomplished within specified times and/or accuracy in order to ensure plant safety and reliability, demonstrate MCS flexibility in plant control, and provide sufficient data gathering ability for plant evaluation.

5.1 SYSTEM

The MCS shall provide control of the plant in a manner such that the MCS attributed errors due to the data update rate or accuracy or the algorithms are not major contributors to overall system accuracy and do not significantly limit transient performance. In addition, the MCS shall control the plant during insolation disturbances (cloudy day scenario) down to the minimum acceptable energy flow conditions of the subsystems. MCS control strategies shall provide, when required, smooth transitions between operating modes during these disturbances.

5.2 SUBSYSTEM

The MCS shall have the capability to remotely reconfigure subsystem controllers and change gains and set points at a rate which allows full utilization of the subsystem controller performance.

Section 6
TEST REQUIREMENTS

Test support by the MCS from the control room will be required during integrated subsystem testing in Phase II. The PCS and DAS shall be available to the test personnel during the conduct of the plant integrated acceptance tests.

During the initial portion of the test activities, the DAS shall record the instrumented control and DAS parameters related to the test hardware and display and/or print at least status and alarm data. The majority of the off-line DAS programs shall be available for post test evaluation support.

During checkout of the control capability of the OCS and/or PCS, the majority of the display functions and data reduction programs shall be available.