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DEVELOPMENT OF AUTOMATIC CONTROL SYSTEM AND DATA ACQUISITION SYSTEM FOR AN ENVIRONMENTAL CHAMBER

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The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

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The objectives of this project were to design, fabricate, and install automatic control and data acquisition systems on an environmental chamber. The control system maintains the chamber pressure to within 1 mmHg, temperature to within 1°F, and humidity to within 3% relative humidity, using a modern distributed process control system. The data acquisition system records data, using a minicomputer that is compatible with existing DEC equipment. This report contains information from the final system specification and configuration item development specification for each system.

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DEVELOPMENT OF AUTOMATIC CONTROL SYSTEM AND DATA ACQUISITION SYSTEM FOR AN ENVIRONMENTAL CHAMBER

SECTION 1.0 AUTOMATIC CONTROL SYSTEM

1.1 Scope

1.1.1 Identification

This document establishes the functional, performance, design and development, and interface requirements for the Brooks Air Force Base (AFB) Hypobaric and Thermal Chamber Number 9 Automated Control System (ACS).

1.1.2 Purpose

The Hypobaric and Thermal Research Chamber at Brooks AFB, Texas has been retrofitted with a new ACS composed of a Control Subsystem (CSS) for automatic control and a Data Acquisition Subsystem (DAS) for data acquisition.

a. The CSS portion of the ACS controls the chamber altitude and environmental parameters. In addition to controlling the chamber environment, the CSS also provides:

(1) Direct conversion of raw process variables into engineering units, for display and other uses in the system.

(2) Display of all process variable information on a high resolution color screen either in a bargraph, histogram, or tabular text format.

(3) Continuous scan, log, and alarm monitoring of process variables and key support auxiliaries such as facility electrical power and instrument air.

(4) Preprogrammed altitude ramp profiles.

(5) Historical data storage of operator selected test parameters to be used as a backup or extension for the chamber parameter information collected by the DAS.

(6) Separate stand-alone controllers for dedicated control of chamber altitude and ventilation.

(7) Manual backup stations providing direct control of the process output for all environmental systems.

b. The DAS portion of the ACS captures critical chamber parameters and other associated test data from the numerous experiments performed at this facility. In addition to experiment data collection, the DAS provides:

(1) Direct conversion of raw process variable signals to engineering units.

(2) Convenient means for data channel reassignment to different process variable.

(3) Operator selectable data collection rates.

(4) Data file conversion, reduction, storage, display, manipulation, and output to various hard-copy devices.

(5) Rapid data reduction/manipulation so that raw test data is available for display/plotting in flexible and user selectable formats within minutes after a chamber test sequence.

1.2 Applicable Documents

1.2.1 Government Documents

The following documents of the exact issue shown form a part of this document to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this document, the contents of this document are considered as superseding requirements.

a. Specifications

DOD-D-1000B 28 Oct 1977 with Amendments 1-3, 13 May 1983	Drawings, Engineering and Associated Lists
MIL-I-45208A 16 Dec 1963 with Amendment 1, 24 Jul 1981	Inspection System Requirements

b. STANDARDS

FED-STD-595A Jan 2 1968 with Notices 1-6, 1 Feb 1980	Federal Standard Colors
DOD-STD-100C 22 Dec 1978 with Notices 1-4, 4 May 1983	Engineering Drawing Practice
DOD-STD-480A 12 Apr 1978 with Notice 1, 29 Dec 1978	Configuration Control - Engineering Changes, Deviations, and Waivers
MIL-STD-490A 4 Jun 1985	Specification Practices
MIL-STD-785B 15 Sep 1980	Reliability Program for Systems and Equipment Development and Production

MIL-STD-882B 30 Mar 1984 with Notice 1, 19 Dec 1985	System Safety Program Requirements
MIL-STD-1472C 2 May 1981	Human Engineering Design Criteria for Military systems, Equipment and Facilities.
MIL-STD-1521B 4 Jun 1985 with Notice 1, 19 Dec 1985	Technical Reviews and Audits for Systems, Equipment, and Computer Software

1.2.2 <u>Nongovernment Documents</u>

The following documents of the exact issue shown form a part of this document to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this document, the contents of this document are considered as superseding requirements.

Industry Standards

ANSI/ASME B31.1C-1988 1986 Edition	Power Piping
ANSI/ASME BPV-VIII-1 12-31-88	Rules for Construction of Pressure Vessels
ANSI/ASME BPV-IX 12-31-88	Welding and Brazing Qualifications
IEEE Std 142 (ANSI C114.1) 1973	IEEE Recommended Practice for Grounding of Industrial and Commercial Power System
IEEE Std 488 1981	General Purpose Interface Bus (GPIB)
NEMA Std 250 1985	Standard for Electrical Enclosure Types
IEEE-Std-583 1982	Modular Instrumentation & Digital Interface system (CAMAC)
IEEE-Std-802.3	Broadband Ethernet Communications
IEEE-Std-1003.1 1987	Trial Use Standard for Portable Operating System Interface and Environment Based on UNIX (POSIX)

NFPA 70 1989	National Electric Code
NFPA 99B 1987	Standard for Healthcare Facilities

SECTION 2.0 CONTROL SUBSYSTEM

2.1 System Definition

2.1.1 Mission of System

The CSS portion of the ACS provides safe, smooth, reliable, repeatable, accurate, and convenient control of the hypobaric chambers for all test regimes to the extent that chamber operation does not interfere with the primary mission of collecting and managing experimental test data.

2.1.2 System Modes and States

The CSS has 6 system modes or operating states:

Idle/OFF
Configuration
Local Manual
Local Auto
Remote Automatic
Backup

a. Idle/OFF

The CSS has 2 non-active modes:

(1) Idle - Electronics are powered, auxiliary systems are OFF, and CSS control outputs do not affect final control elements.

(2) OFF - The CSS power distribution main breaker is turned off.

b. System Configuration

The CSS can be configured from the operator console. In configuration mode, scan, log, alarm, and control functions of the CSS is inoperable. In this mode, the system installer can custom tailor the CSS programming to fit individual chamber changes or additions.

c. Local Manual (Hand)

Local Manual disengages the automatic process variable (PV) feedback and Proportional, Integral, and Derivative (PID) algorithm of the selected loop controller. Operator control inputs change the controller outputs and therefore the final control element (valve) directly.

d. Local Automatic

In Local Auto mode, automatic, PID control, of the selected loop with PV feedback is operable. Operator control input is by adjustment of the controller setpoint on the controller faceplate or selection from the operator keyboard.

e. Remote Automatic

In Remote Auto mode, fully automatic, coordinated operation of selected loops is accomplished with designated controllers receiving their control setpoints indirectly from other loops.

f. Backup

Should the CSS or any of its loop controllers fail, a backup means of manually controlling the desired PV is provided either by Hand/Auto stations on the control console or by local hand loaders (control air regulators) selectable by a fail-safe method from the main console.

2.1.3 System Segment Functions

a. The CSS controls the following systems:

(1) Chamber Vacuum Subsystem (CVS) - The primary vacuum source for decompression of the chamber to altitudes.

(2) Chamber Inbleed Air Subsystem (CIA) - Provides ventilation and repressurization air for the chamber.

(3) Cold Media Subsystem (CMS) - Provides chilling of the cold media tank.

(4) Instrument Air Subsystem (IAS) - Provides control air to all final control elements (control valves).

(5) Chamber Coil Defrost Subsystem (CCD) - For warm media to the chamber cooling coils.

(6) Chamber Temperature Control Subsystem (CTC) - Primary temperature control loop for the chamber.

(7) Chamber Air Circulation Subsystem (CAC) - Controls the chamber air circulation fan speed.

(8) Chamber Inbleed Air Cooling Subsystem (IAC) - Controls the inbleed air temperature.

(9) Lock Vacuum Subsystem (LVS) - The primary vacuum source for decompression of the lock to altitudes.

(10) Lock Inbleed Air Subsystem (LIA) - Provides ventilation and repressurization air for the lock.

(11) Data Acquisition Subsystem (DAS) - Primary test data collection/storage.

(12) Chamber Humidity Control Subsystem (CHC) - Controls both the dehumidifying cooling coils and a steam spray.

b. CSS control does not include the starting of the motors and pumps associated with these systems, which is accomplished manually.

2.1.4 System Functional Relations

The control relationships between the systems listed in paragraph 2.1.3 are illustrated in Figure 2-1, the CSS control logic diagram.

2.1.5 Configuration Allocation

The CSS is a functionally integrated process control system. It incorporates 3-mode PID control, discrete logic control, and data manipulation and storage. One operating system must accomplish all requirements listed. It has all the major components as described in the following paragraphs and shown in Figure 2-2.

a. Central Operator Workstation

The chamber operator's primary workstation is the Control Console. From this location a single operator can interface with all the devices necessary to control and monitor the chamber. The Control Console consists of the following:

Sit-down console framework
CRT and keyboard
Single loop controllers as required
Hand/Auto stations as required
Misc switches and indicators
Alarm printer

(1) Console Hardware

The control console is fabricated from industrial grade, sloped front, sit-down console sections. Console sections meet the acceptable standard clearance dimensions of MIL-STD-1472C.

The console has:

(a) 20° sloped face for optimum viewing angle of CRT and panel instrumentation.

(b) Hinged and lockable rear doors and removable front panels.

(c) Laminated plastic, desk height shelf running the length of the Operator Console.

(d) Heavy duty cold-rolled steel construction with minimum 13-gage corner posts, 14-gage top and bottom assemblies, and 18-gage side panels and doors.

(e) Paint finish system of acrylic or water-borne baking enamel in Federal Standard 595A color number 816-T, medium blue, with minimum paint thickness of 1.5 mils.

(f) Typical dimensions as shown in Figure 2.3.

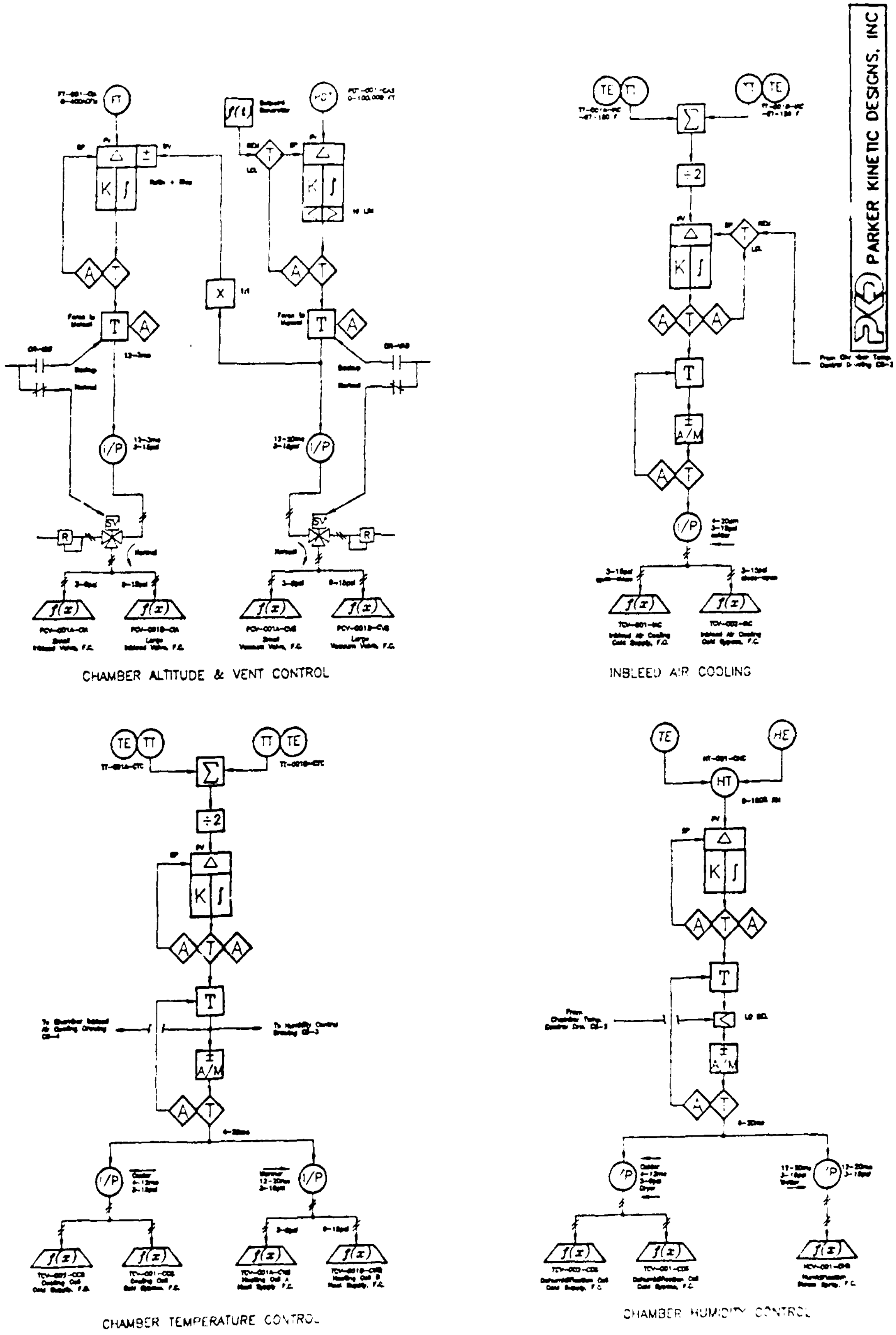

Figure 2-1. Control Subsystem Control Logic.

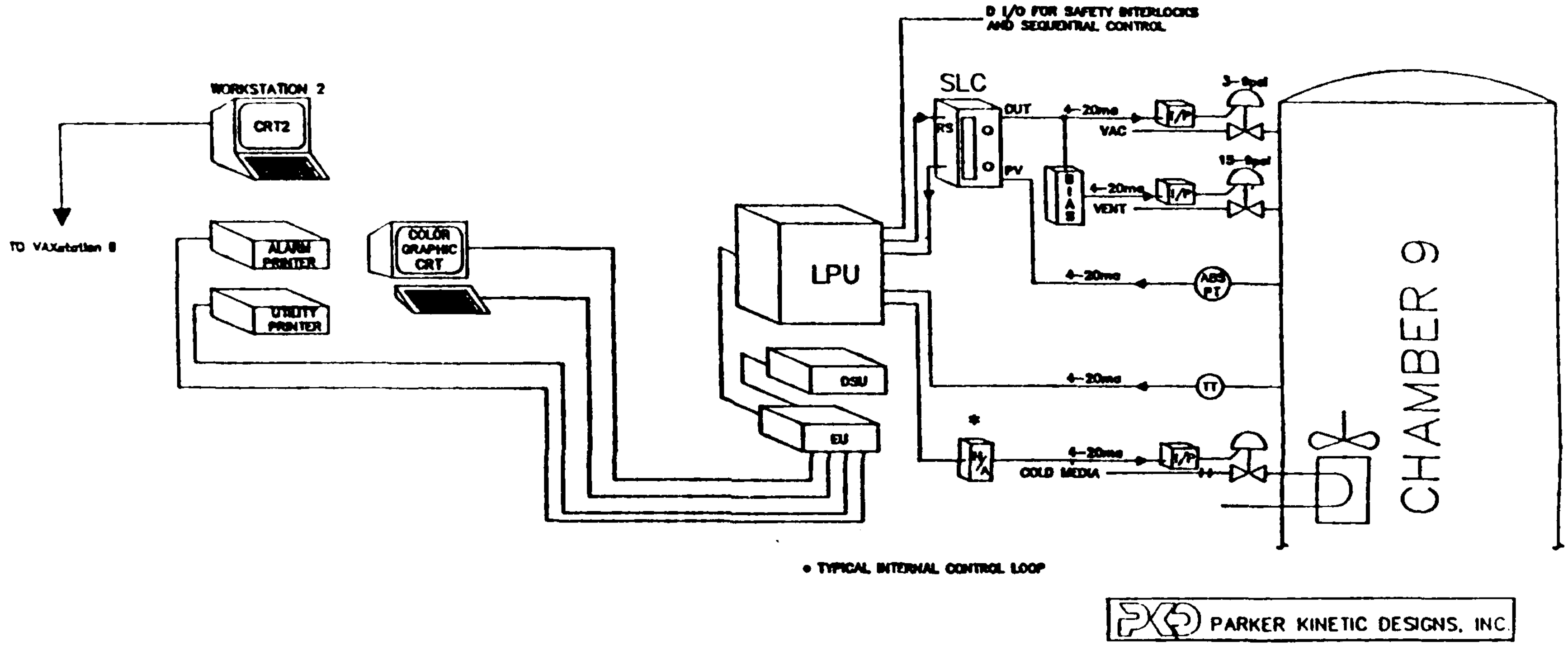

Figure 2-2. Control Subsystem.

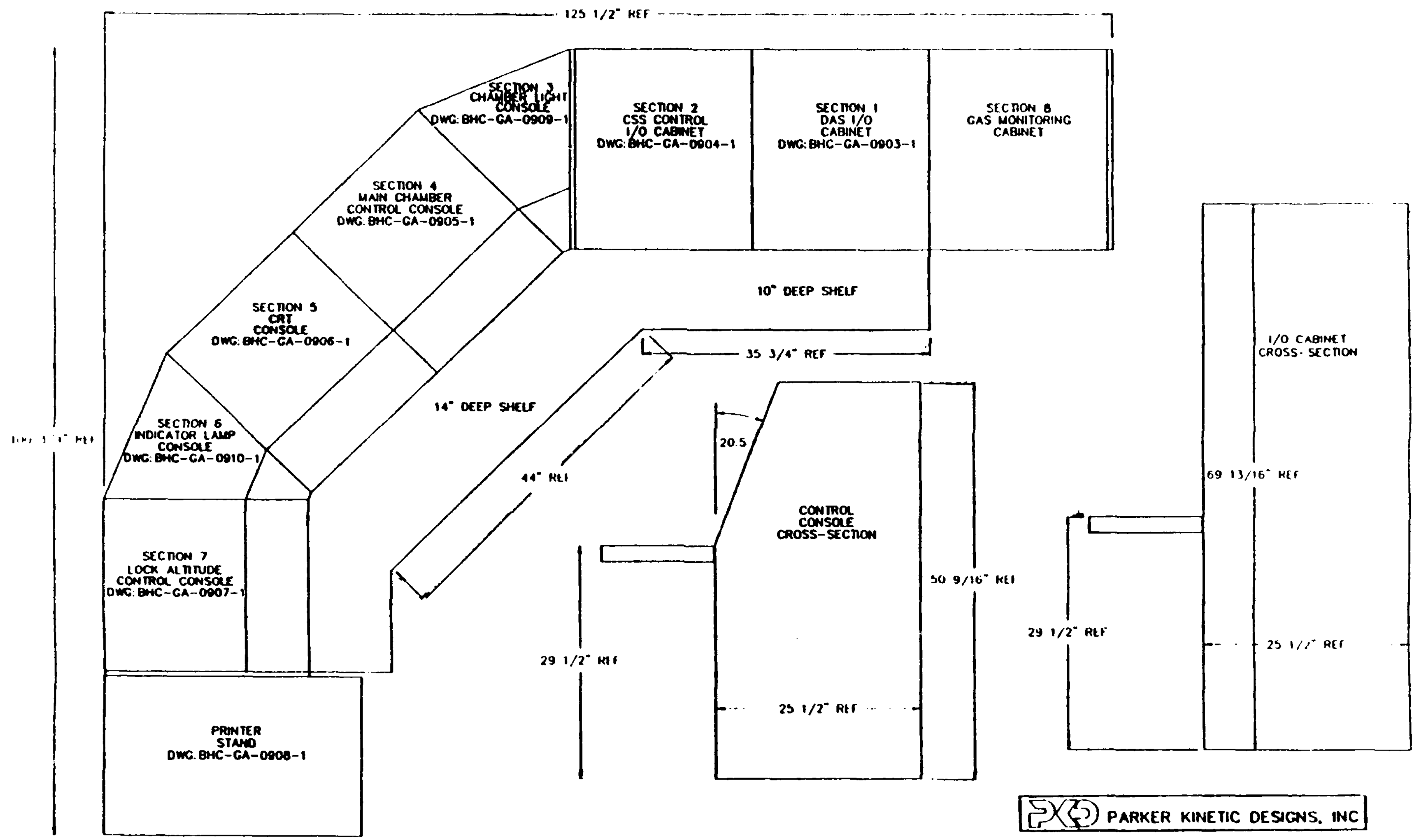

Figure 2-3. Chamber Console Layout.

(2) Operator Information Display

(a) The operator display monitor Cathode Ray Tube (CRT) is the operator's primary visual control interface for the operation of the chamber. It displays all chamber data and control parameters necessary for the operator to properly control the chamber. It also displays information such as historical trends, live data trends, and latest unacknowledged events.

(b) The CRT is 33.02 cm (13 in.) diagonally and uses 16 colors on a high resolution format of 640 x 480 pixels.

(3) Operator Input Device

The keyboard provides operator input of all the necessary command functions for the control and configuration of the CSS computer system. The keyboard is a monoplanar touch panel with tactile feedback keys. The keyboard was designed for process control with dedicated keys labeled for their specific functions; e.g., AUTO/MANUAL, RUN/HOLD, etc. Soft function keys can be used for configuration and CRT screen access. The keyboard resides on a table height shelf in front of the CRT.

(4) Dedicated Controllers

(a) Four stand-alone (dedicated), Single Loop PID Controllers (SLC) are used to individually control chamber and lock altitude and ventilation. They provide the standard operator interfaces including Auto/Manual selection, Remote/Local selection, setpoint adjustment, process variable display, and setpoint display.

(b) The SLC is used to control chamber altitude and ventilation. It is a stand-alone PID controller capable of scanning and updating the process variable and output signal every 0.2 s. The SLC has the following features:

1) Face-mounted mode selector buttons for Auto/Manual and Remote/Local.

2) At least 2 bargraph displays for indicating control parameters (Process Variable, Setpoint, Output, etc.).

3) Programmable digital display for indicating precise control values.

4) Digital outputs indicating mode status

5) Digital inputs for external mode selection

(5) Backup Devices for Control Loops Internal to the LPU.

(a) Six Hand/Auto stations (H/A) are used as primary backup for the LPU's control of the environmental systems of the chamber. The H/A allows the switching from LPU control to backup control of these systems. The H/A provide an output signal to the final control element controlling the system. The H/A contain an output meter that shows demand output on the face of the unit. Hand/Auto selection is from front-mounted pushbuttons. Output adjustment in Hand(manual) is from a front-mounted control knob. H/A have a balance pushbutton for use in manually matching H/A output to the controller output to prevent a large upset in the process.

(b) An H/A is usable in combination with any analog output from the LPU. These outputs include:

Chamber Temperature
Chamber Humidity
Inbleed Air Temperature
Cold Media Temperature
Defrost Media Temperature
Fan Speed

(6) Switches, Pushbuttons, and Indicating Lights

Miscellaneous control switches and pushbuttons are 22.5 mm industrial miniature oil-tight rated. These devices are Underwriters Laboratory(UL)-listed National Electrical Manufacturers Association (NEMA) Type 4-13. Console mounted indicator lights are replaceable Light Emitting Diodes (LED) in military standard T1-3/4 sockets.

(7) Printers

The alarm and utility printers are high speed monochrome dot matrix type, capable of 240 cps. They support IBM/Epson character sets and have both a serial and a Centronics parallel interface. They are interchangeable and have front panel selection capability for print size and type. The ribbon is cartridge type and easily replaceable. They support fan-fold continuous paper with tractor feed.

(8) System Control Programs (software/firmware)

The microprocessor-based CSS is firmware-driven and requires only the completion of downloadable data base tables to configure the system. The firmware contains all the necessary commands to support all scan, log, alarm, display, control, and operator interface requirements. The scan-log-alarm subroutine also evaluates all signals for level and validity with respect to the system configuration tables.

b. System Input/Output Cabinets

The Input/Output (I/O) cabinets house the distributed control hardware portion of the CSS and are the primary termination point for all field wiring. The I/O cabinets interface with all the field devices necessary to control and monitor the chamber. The system I/O Cabinets consist of the following:

I/O cabinet hardware
Field Interface Terminal Blocks
Loop power supplies
Local Processing Unit
Electronics Unit
Data Storage Unit
Oxygen (O_2) Analyzer
Volt-to-Current (V/I) Transducer

(1) I/O Cabinet Hardware

System I/O cabinets are free-standing industrial grade standard 48.46 cm (19 in.) vertical instrument enclosures, 182.9 cm (72 in.) high, and 60.96 cm (24 in.) deep.

Cabinets have:

(a) Hinged and lockable rear doors and removable front cover panels in the unused portions.

(b) Heavy-duty, cold-rolled steel construction with minimum 14-gage frame and internal mounting rails, 14-gage top and bottom assemblies, and 18-gage side panels and doors.

(c) Paint finish system of acrylic or water borne baking enamel in Federal Standard 595A color number 816-T, medium blue, with minimum paint thickness of 1.5 mils.

(2) Field Interface Terminal Blocks

Field Interface Terminal Blocks (FITB) are high density metric class 600 V terminal blocks rated at least 26 amps. Individual fuse terminal blocks are rated at least 10 amps. All FITB accept wire sizes from 22 AWG to 12 AWG. They are DIN rail-mounted, meeting the requirements of international standards (i.e., UL). Wire terminals are recessed for finger protection.

(3) Loop Power Supplies

The CSS has redundant, 100% load capability, power supplies for the analog control loops. These power supplies are diode-auctioneered to the Direct Current (DC) supply bus. Alarm inputs are provided to the CSS for individual supply failure.

The loop power supplies have the following characteristics:

AC Input: 100/120/220/240 VAC +10%, -13%, 47-63 Hz.
DC Output: 24 VDC @ 3.6 A. Adjustment range +/- 5.0% minimum.
Line Regulation: +/- 0.05% for a 10% line change.
Load Regulation: +/- 0.05% for a 50% load change.
Output Ripple: 3.0 mV PK-PK + .02% of output voltage, maximum.
Temperature Coefficient: 0.01%/°C over the operating temperature range of the CSS.
Short Circuit Protection: Crowbar.
Overload Protection: automatic current limiting.
Overvoltage Protection: required.
Electro-Magnetic Interference/Radio Frequency Interference (EMI/RFI) Emissions: Class B equipment limits.

(4) Distributed Controller

The Local Processing Unit (LPU) functions as the heart of the distributed control portion of the CSS. The LPU is the primary focal point for the CSS interface with all field devices. It collects analog and discrete data inputs and output analog and discrete control signals.

The LPU consists of a main processor and I/O card rack assembly housed in a NEMA 4 enclosure which is suitable for 48.26 cm (19 in.) rack mounting.

The system control configuration resides in the LPU. The LPU operates independently of the operator's console.

The main processor card has an independent, battery-backed memory.

The LPU terminal blocks accept input and output wiring up to 14 AWG wire.

Analog inputs are assignable on a point-to-point basis and are 4-20 mA (1-5 V). Input accuracy is +/-0.1% of reading. Analog input resolution is 15 bits or better.

Analog outputs are 4-20 mA into a 600 ohm load. The LPU supports up to 8 analog outputs.

Discrete I/O cards use single solid state modules per point with individual fuses on the outputs. Selection of AC or DC operation is available in groups of 10 or 15 points.

All I/O cards use their own microprocessors to maintain scan times. All discrete values are scanned within 100 ms. All analog values, from input to output, are scanned and updated no slower than 750 ms. These scan times do not degrade as cards are added.

Maintenance of the LPU is by board replacement. All boards are plug-in style with the ability to remove them while power is on.

Field wiring does not interfere with board removal or replacement. Internal diagnostics detect board faults for the maintenance personnel.

(5) Information Management Unit

The Electronics Unit (EU) provides the electronic communication interface from the LPU to the CRT, DSU, Keyboard, and printers. Its function is to allow configuration of the LPU, setup display screens for the CRT, download process data and alarm setpoints to memory, and the printing of real-time alarms, historical data summaries, and reports.

Fill-in-the-blank templates on the CRT are the primary configuration tool using firmware-generated operator prompts.

No higher level computer language is necessary for configuring the system.

Configuration takes place from the operator CRT and keyboard. Once configuration is complete, it remains resident in the LPU. Furthermore, the configuration is downloadable to streaming tape for backup and archival purposes.

Screen configurations and data are stored on battery-backed Random Access Memory (RAM) with up to 1.2 MB of storage capacity. Batteries are lithium with up to 2 years of RAM backup. Batteries are changeable without loss of memory when system is powered down.

The EU communicates with a maximum of 16 LPU. The LPU maintains its own configuration and is able to operate completely independently of the operator console. Communication is via a multidrop RS-422/485 serial link operating at 19.2 kbps. The EU has a parallel (Centronics type) port supporting a parallel printer to a maximum distance of 15.24 m (50 ft).

The EU has optional additional communication port capability for up to 4 additional communications ports. Supported port types include RS-232C port(s), RS-422/485 port(s), and a Small Computer Standard Interface (SCSI) port for long-term data storage.

The EU also coordinates the processing of alarms and system diagnostics to mass data storage, annunciation on the CRT, and/or printers. The EU contains three interface relays for energizing lights or buzzers associated with alarms and/or system diagnostics. Each relay is Single Pole Double Throw (SPDT) with contact ratings of 1 amp @ 120 VAC. The EU supports visual indication of alarms and diagnostics on the CRT.

The EU supports an altitude ramp storage module to provide the means to download altitude ramp profiles to the LPU. The module is accessible from the front of the electronics unit and contains up to 15 nonvolatile altitude ramps. The ramp storage module is able to store altitude ramps up to two years by means of an internal battery-backed memory or other acceptable nonvolatile internal battery-backed memory or other acceptable nonvolatile storage means.

The EU is mounted on drawer slides for convenient maintenance access.

(6) Archival Storage

The Digital Storage Unit (DSU) provides archival storage of any analog input, calculation, discrete value, analog output or internal value available in the CSS by either a 40 MB hard disk (short term) or 60 MB streaming tape (long-term). In addition, the DSU is capable of storing and downloading system configurations from the streaming tape.

Data compression is selectable on a point or group of points. Individual I/O point values can be stored at a maximum rate of 10 s/sample up to 99 min/sample. Averaging, peak picking, high and low can be assigned to points for selectable periods from 5 s to 1 h.

Once data is stored, it is retrievable and displayable on the operator CRT. The historical data is reviewable on both a trend and bargraph displays or printable to a line printer.

Data is also storable in preformatted reports. The DSU supports the ability to recall, view, and print out these reports on demand.

Data retrieval takes place within 10 s for the hard disk and 120 s for the streaming tape.

Historical data files in engineering units, are transferable in Lotus 123 compatible format to an external IBM Personal Computer or compatible through the EU's second serial port.

The Data Storage Unit is mounted on drawer slides for convenient maintenance access.

(7) Oxygen (O_2) Analyzer

The oxygen monitoring system provides accurate percent oxygen indication from ground level to 50,000 ft. The analyzer has range switching capability for monitoring oxygen concentrations of 0-5%, 0-10%, or 0-25%. The analyzer is air calibratable. Chamber atmospheric samples are extracted, compressed, and exposed to the analyzer at a regulated constant pressure, thereby eliminating calibration at altitude. The analyzer provides a 4-20 mA output to the control system for alarming and historical data collection.

It has the following additional characteristics:

Ranges: 0-5%, 0-10%, 0-25% oxygen.
Sensitivity: +/- 0.125% oxygen (0.5% of full-scale).

Accuracy: +/- 0.25% (1% of full-scale).
Response Time: 90% of full-scale in 7 s.
Power Requirements: 115 VAC 50/60 Hz.
Span gas: air.
Operating Temperature Range: 0°C to 50 °C (32°F to 122°F).
Output: 4-20 mA DC isolated.

(8) Voltage-to-Current Transducers

Voltage-to-Current transducers (V/I) are used as required to buffer and split specific medical channels for continuous monitoring by the Control Subsystem. The transducer converts an input signal voltage of 0-1 VDC or 0 10 VDC to proportional 4-20 mA current output. V/Is are industrial grade units sealed for protection against dust, EMI/RFI, moisture, and corrosion. Zero and span are accessible from the top of the unit and screwdriver adjustable.

They have the following additional characteristics:

Accuracy: 0.05% of span (combined effects of linearity, repeatability and hysteresis at constant temp).

Temperature effect: 0.02% of span/°C or $1x10^{-6}$ V/°C, whichever is greater.

Ambient temp range: -40°C to 80°C. (-40°F to 26.67°F)

Maximum loop resistance: 600 ohms.

Supply Voltage Range: 12-90 VDC.

Maximum current range: 3.3-25 mA, typical.

Minimum common mode rejection: 120 dB (DC to 400 Hz).

c. Field Devices

Field Transmitters for this system are industrial-grade standard purchased hardware with published technical specifications for accuracy, repeatability, etc. These devices were carefully chosen to contribute to the overall performance, accuracy, and reliability of the integrated system. Therefore, they are not subject to "or equal" substitution which may significantly degrade the performance of the overall system.

(1) Pressure Transmitters

The chamber altitude Pressure Transmitter (PT) is of the absolute pressure type, employing direct electronic sensing with a sealed capacitance sensing element. It is insensitive to mechanical forces, shock, and vibration. Process pressure is transmitted through an isolation diaphragm and silicon oil fill fluid to a sensing diaphragm. The reference pressure is transmitted to the other side of the sensing diaphragm in a like manner. The transmitter's changing capacitance with process pressure is converted electronically to a 2-wire, 4-20 mA DC signal. It has external span and zero adjustment, explosion-proof construction and separate compartments for electronics and wiring connection. It uses modular construction and printed circuit boards to aid in troubleshooting and in parts stocking. It is mountable in any position and is furnished with a 3-valve manifold for periodic in-place calibration.

It has the following additional characteristics:

Range: 0-150,000 ft (14.6944 psia to 0.0197 psia).
0-100,000 ft (14.6944 psia to 0.1549 psia).
0-45,000 ft (14.6944 psia to 2.145 psia).
Output: 4-20 mA.
Input power supply: 12-45 VDC.
Maximum load impedance: 650 ohms nominal at 24 VDC.
Temperature range: - 28.9°C to 93.3°C
(-20°F to 200°F)
(for specified accuracy).
Humidity: 0 - 100%.
Damping: adjustable from 0.2 s to 1.6 s.
Accuracy: +/- 0.25% of span (including linearity, hysteresis, and repeatability.

(2) Temperature Transmitters

The chamber temperature sensing is accomplished by industrial-grade 100 ohm platinum resistance temperature detectors (RTD) with remote Temperature Transmitters (TT).

The sensing element conforms to international standard IEC-751, Class B, with an alpha coefficient of 0.00385 ohms/ohm/°C. It has an outer sheath of 316 Stainless Steel and Teflon-coated lead wires. It is a single-element, 4-wire device with a basic accuracy of +/- 5/9°C (1°F). The sensor is a general purpose element for direct air immersion with a welded, fixed position 1.27 cm (1/2 in.) NPT process connection. The sensor element is furnished with an explosion-proof connection head of low copper-aluminum alloy with a minimum of 6 terminals on the connector block.

The temperature transmitter accepts the sensing element signal directly and output a 2-wire, 4-20 mA signal. It is in its own explosion-proof housing with 1.27 cm (1/2 in.) NPT threaded connections. Its span and zero are continuously adjustable from the terminal side of the transmitter housing. It employs removable and interchangeable plug-in circuit boards, environmentally isolated from the connections side.

It has the following additional characteristics:

Input range: -100°C to 71°C (-148°F to 160°F).
Output range: 4-20 mA.

Input power supply: 12-45 VDC.
Maximum load impedance: 650 ohms nominal at 24 VDC.
Accuracy: +/- 0.33°C (0.6°F) (0.2% of calibrated span).

(3) Humidity Transmitter

The chamber humidity transmitter (HT) is a Relative Humidity (RH) sensing device. Its operating principle is based on the electrical capacitance change of a thin-film polymer due to water absorption. This capacitance measurement is combined with ambient temperature sensing to provide a relative humidity output signal.

The sensor is of rugged construction with the sensing elements separable from the remote transmitter electronics. The sensing elements are protected from mechanical damage by a suitable shield or guard.

It has the following additional characteristics:

Range: 0-100% RH (over temperature range -40°C to 115°C, -40°F to 239°F).
Output signal: 4-20 mA.
Maximum load impedance: 600 ohm at 24 VDC.
Accuracy: +/- 2.0% for 0-80% RH.
+/- 3.0% for 80-100% RH.
Repeatability: +/- 1.0%.
Response time: 5 s for 90% change.

(4) Ventilation Flow Transmitters

The chamber ventilation Flow Transmitter (FT) is of the vortex shedding type. The meter's operating principle is based on generation of linear flow oscillations from a delta-shaped flow element that are proportional to the volumetric flow rate. It employs direct electronic sensing with a thermal sensing element detecting the velocity oscillations. For Reynolds Numbers 10,000 and above, the meter calibration factor is not affected by changes in temperature, pressure, or density of the flowing air.

The sensing element is removable for servicing in the field without removing the flow meter from the line. The meter is insensitive to mechanical forces, shock, and vibration.

The transmitter's frequency output is converted electronically to a 2-wire, 4-20 mA DC signal. It has external span and zero adjustment, explosion-proof construction, and separate compartments for electronics and wiring connections.

It uses modular construction and printed circuit boards to aid in troubleshooting and in parts stocking. It is mountable in any position and is furnished with a 3-valve manifold for periodic, in-place calibration.

It has the following additional characteristics:

Range: Chamber: 0-1012 ACFM; Lock: 0-120 ACFM.
Output: 4-20 mA.
Input power supply: 12-45 VDC.
Maximum load impedance: 500 ohms nominal at 24 VDC.
Temperature: -40°C to 60°C
(-40°F to 140°F)
(ambient for electronics).
Accuracy: 1.0% of reading.
Repeatability: 0.1% of reading.
Turndown ratio: greater than 20:1.

(5) Current-to-Pneumatic Transducer

The Current-to-Pneumatic transducers (I/P) used to position the CSS final control elements (valves) convert an analog 4-20 mA current signal to a proportional, pneumatic (pressure) output. The output is unaffected by shock, vibration, or mounting position. The I/P employs output correction by internal pressure feedback, and balanced pneumatic supply and exhaust dynamics. Internal jumper selection is provided for full or split range. Direct or reverse output action is jumper-selectable without recalibration. The I/P have the following additional characteristics:

Accuracy: +0.25% of Span including linearity, hysteresis and deadband.
Repeatability: 0.05% of Span.
Deadband: 0.02% of Span.
Frequency Response: -3 db at 5 Hz.
Loop Load: 3.8 VDC + 5 ohms (195 ohms maximum at 20 mA).
Supply Pressure: 3-10 psi above maximum calibrated output.
Output Capacity: 4.5 scfm.
Operating Temp Range: -28.9°C to 65.6°C
(-20°F to 150°F).
Temperature Effect: less than 1% per 55.6°C (100°F).
Failure Mode: for input current < 3.7 ma, output = 1 psi
Enclosure: internally purged NEMA.
Pneumatic Connections: .635 cm (1/4 in.) FNPT.

d. Uninterruptable Power Supply

Power for the CSS and DAS systems is normally provided by a 15 kvA Uninterruptible Power Supply (UPS). The UPS is a continuous duty, on-line system that provides the AC power to all electronic equipment regardless of the condition of the incoming power line.

The UPS consists of a phase-controlled step regulator (PCSR) converting the incoming AC power to DC which feeds an inverter section and keeps the UPS batteries fully charged. The inverter section provides the output AC power. If the incoming AC drops more than 15% below nominal AC line voltage, the inverter will continue to provide output power with the UPS batteries as its primary source. The UPS contains a static transfer switch to immediately switch its output to an alternate source should the inverter section fail. It also has a manual maintenance bypass switch so that work can be performed on the PCSR, inverter, and battery sections.

The battery is sized to carry the normal output load for 20 min. The UPS provides 6,000 V surge suppression and 70 dB of normal mode noise attenuation when not in normal bypass or an alternate source.

2.1.6 Interface Requirements

2.1.6.1 External Interfaces

The CSS interfaces with the following systems external to itself:

Chamber Vacuum Subsystem (CVS)
Chamber Inbleed Air Subsystem (CIA)
Cold Media Subsystem (CMS)
Instrument Air Subsystem (IAS)
Chamber Coil Defrost Subsystem (CCD)
Chamber Temperature Control Subsystem (CTC)
Chamber Air Circulation Subsystem (CAC)
Chamber Inbleed Air Cooling Subsystem (IAC)
Lock Vacuum Subsystem (LVS)
Lock Inbleed Air Subsystem (LIA)
Data Acquisition Subsystem (DAS)
Chamber Humidity Control Subsystem (CHC)

The required interfaces (I/F) are clearly identified on the chamber's Piping and Instrument Diagram (PD) and further detailed in Logic Diagrams (LD), Analog Loop (AL) drawings, Electrical Elementary (EE) drawings, and other detailed system documentation as required.

Each system has a CSS interface for monitoring and, where appropriate, control.

(a) External Interface Identification

The analog control output interface devices from the CSS to the existing final control elements are 4-20 mA current loops. An I/P is used to drive control valves. The pneumatic interface from the I/P device to the valve is typically 3-15 psi. Some split-range control is done with 3-9 and 9-15 psi.

Analog control input interfaces between the CSS and the process are direct process transmitters converting process variables to 4-20 mA current loops. The process transmitter types used in the CSS are as follows:

1) Pressure Transmitters (PT) - capacitive
2) Temperature Transmitters (TT) - RTD
3) Humidity Transmitter (HT) - capacitive
4) Ventilation Flow Transmitters (FT) - vortex shedding
5) Speed Transmitter (ST) - inductive

Discrete control output interfaces from the CSS is either 24 VDC or 115 VAC operating solenoid valves (SV) of like voltage. Discrete control inputs to the CSS are either 24 VDC or 115 VAC. They signal the change in state of a field contact's associated process status. These include pressure switches (PS) and limit switches (ZS)

(b) Hardware-to-Hardware External I/F

The CSS communicates with the facility support systems by using the hardware (HW) interfaces. The following table indicates the device that is used to interface with each of the facility systems.

Existing System	CSS HW Input Interface	CSS HW Output Interface
CVS	PT	I/P
CIA	FT	I/P
CMS	TT	I/P
IAS	PS	---
CCD	TT	I/P
CTC	TT	I/P
CAC	ST	
IAC	TT	I/P
LVS	PT	I/P
LIA	FT	I/P
DAS	---	Digital
CHC	HT	I/P

The details of these interfaces are shown on the AL or EE drawings, as appropriate.

(c) HW-to-Software (SW) External I/F

The CSS provides an RS-232C serial port for utility functions.

(d) SW-to-SW External I/F

The serial port listed supports output of historical data files in Lotus 123 compatible format.

2.1.6.2 Internal Interface Requirements

(a) Internal I/F Identification

The EU provides the electronic communication interface from the LPU to the CRT, DSU, keyboard, and printers. The EU also coordinates the processing of alarms and system diagnostics to mass data storage, annunciation on the CRT, and/or printers.

(b) Hardware Configuration Item (HWCI)-to-HWCI I/F

The CSS has the following physical connections between internal devices:

EU to CRT - Red/Green/Blue + Intensity (RGBI)-Standard 9 or 15 pin, D-connector, 1.83 m (6 ft) cable.
EU to Keyboard - Logic level BCD, shielded, 1.83 m (6 ft) cable w/connector.
EU to DSU - SCSI (small computer system interface), 1.83 m (6 ft) cable w/connector, 5.49 m (18 ft) maximum
EU to Printers - RS-232C/Centronics Parallel, 28 pin, D-connectors, 15.24 m (50 ft) maximum
EU to LPU - RS-485, 4-conductor, shielded, 304.8 m (1,000 ft) maximum

(c) HWCI-to-Computer Software Configuration Item (CSCI) Interfaces

The physical connections use the following protocols:

EU to CRT - RGBI.
EU to Keyboard - ASCII BCD.
EU to DSU - SCSI (Small Computer System Interface).
EU to Alarm Printer - Centronics Parallel.
EU to Utility Printer - RS-232C, 9,600 baud max, 7-bit ASCII, 1 stop bit, even parity, Lotus 123 compatible output from management reports.
EU to LPU - RS-485, 19.2 kB, multidrop.

(d) CSCI-to-CSCI Interfaces

The firmware contains all the necessary commands to support communications between scan, log, alarm, display, control, and operator interface subroutines. This firmware is proprietary, but the system is completely configurable from interactive data tables.

2.1.7 Processing Resources (Computer)

The CSS computer EU uses hardware and firmware to process the input/output (I/O) signals and system configuration.

2.1.7.1 Hardware Characteristics

(a) Memory Size - As required to accomplish all control functions.

(b) Word Size - 16 bit.

(c) Processing Speed - capable of scanning and updating all channels in 0.75 s.

(d) Character Set Standard - ASCII.

(e) Instruction Set Architecture - Proprietary.

(f) Interrupt Capability - Proprietary.

(g) Direct Memory Access (DMA) - YES.

(h) Channel Requirements - 15 Analog inputs
8 Analog outputs
29 Digital inputs
16 Digital outputs

(i) Auxiliary Storage Requirements - Supports DSU with 40 MB hard disk and 60 MB streaming tape.

(j) Growth Capability - See section 2.4.2.b.

(k) Diagnostic Capabilities - Continuous on-line, and batch off-line.

2.1.7.2 Programming Requirements

(a) Programming Language - Firmware

(b) Compiler/Assembler - All system configuration is by interactive, fill-in-the-blank methodology. No specific high level language programming is required.

2.1.7.3 CPU Utilization

The system performance was guaranteed to meet the vendor's published technical performance specifications. This guarantee was accomplished by limiting total I/O count, number of connected peripherals, and number of available CRT and CRT screens to those allowed by the vendor's standard configuration. This methodology of guaranteeing system performance was in lieu of dynamic resource monitoring. As such, variable data recording intervals for dynamic resource monitoring, function under operator control, and data utilization/display reporting methods are not required.

2.1.8 Government Furnished Property List

The only government property for integration into the CSS, was a single, 4-channel intercom station, Model C-824A/AIC-10.

2.2 System Performance Characteristics

2.2.1 Altitude Control

The CSS is capable of controlling the main chamber and its lock to simulate altitude to a 100,000 fmsl and a maximum average climb rate of 8.4 ft/min.

2.2.2 Temperature Control

The CSS can control the main chamber temperature at ground level conditions as defined below:

Temperature (°C) (°F)	Max Avg Temp Rate (°C/h)(°F/h)
Amb to -55 (-67)	6.39 (11.5)
Amb to 65.6 (150)	7.2 (13.0)

2.2.3 Humidity Control

The CSS can control the main chamber humidity at ground level to 1.5% RH at 23.9°C (75°F) through 100% RH at 51.7°C (125°F).

2.2.4 System Life Expectancy

The CSS is capable of the same life expectancy as other industrial grade instrumentation and control systems.

The modular nature of the CSS and the fact that its subcomponents are replaceable and upgradeable as major blocks, make it capable of significantly higher life expectancy than normal. Tnis high system lifetime goal can be accomplished by planning the replacement of obsolete modular (board level) components or peripherals (such as printers), with compatible state-of-the-art components. A non-functional component or peripheral should be considered obsolete when it is no longer repairable or supportable by replacement parts.

See section 2.5 for further discussion of appropriate maintenance and spare parts support.

2.2.5 Mission Duration and Utilization Rates

The CSS supports continuous test durations from fractions of an hour up to 200 h. Smooth and trouble-free automated testing as well as accurate test data are obtainable from the contractor-furnished CSS equipment on a daily basis with nothing more than quarterly system calibration.

2.3 Design and Construction

2.3.1 Material Requirements

The field installation of the CSS meets the minimum design and construction requirement of NFPA 99B, Standard for Health Care Facilities, Section 11 Hypobaric Chambers and applicable portions of NFPA 70, National Electric Code.

All field wiring is in galvanized rigid conduit (GRC) or UL-approved ladder type tray. Field instrument installation is in accordance with the requirements of ISA Standards and Practices for Instrumentation and contractor Field Installation Details.

2.3.2 Physical Requirements

(a) Weight Limits - No subcomponent of the system exceeds the building floor weight limit.

(b) Dimensions - Consoles fit in the available operating area with adequate space for maintenance and operating personnel access.

(c) Transportability - All electronic components of the assembled DAS are capable of being shipped via an air-cushioned van.

(d) Durability Factor - Subsystem components are standard industrial grade equipment meeting the vendor's published technical specification requirement for shock, vibration, and electrical surge withstand capabilities.

'e) Health and Safety Criteria - No system or subsystem component single failure endangers human life.

2.3.3 Environmental Conditions

CSS hardware meets the following minimum environmental conditions:

Temperature Limits:
Operating: 0°C to 40°C (32°F to 104°F)
Storage: -30°C to 60°C (-22°F to 140°F)

Relative Humidity:
Operating: 10 to 90% RH, noncondensing
Storage: 5 to 95% RH, noncondensing

Power Requirements:
120 VAC (108-132), 50/60 Hz, 1-Phase switch selectable to
220 VAC (198-242), 50/60 Hz, 1-Phase

Field transmitters are industrial grade suitable for American National Standards Institute (ANSI) Class I, Division 1 locations unless otherwise noted, with operating and storage environments as specified on the vendor's published data sheets.

2.3.4 Nameplates and Product Markings

Field devices were tagged with a 1.27 x 5.08 cm (0.5 x 2 in.) stainless steel tag engraved with the field device number in 0.635 cm (0.25 in.) letters and attached with stainless steel safety wire.

Tags for penetrator panels, local operator stations, console interior, and console face are laminated plastic, sized and engraved as noted on approved construction drawings. They were attached with double-face tape.

2.3.5 Electromagnetic Radiation

The CSS has been designed to minimize the effects of common-mode noise on the instrumentation and control signals in accordance with the following practices:

a. A quiet, instrument-ground bus is maintained separate from the personnel safety ground bus. The isolated, instrument-ground bus is of the star configuration, carried to earth-ground at a single designated point via an insulated ground conductor. Cable sizing for insulated ground runs was based on a criterion of 5 milliohms in any ground lead.

b. Instrumentation shields are floated at the field device, carried through intermediate terminal blocks, and terminated only at the isolated instrument ground bus in each cabinet.

c. Low level instrumentation and audio wiring are not installed in tray or conduit with any AC power wiring.

d. AC power distribution within the console is kept physically separate from audio and low level analog signals.

e. Analog and digital wiring is not installed in the same conduit, but may be installed in the same tray with an appropriate divider wall.

2.3.6 Workmanship

The CSS is fully integrated from standard industrial grade components into an aesthetically pleasing, neat, and functional control system. It is free of wiring and painting defects, misalignment of tags, sharp edges, and provides adequate maintenance access.

2.3.7 Safety

The design and construction of the CSS considered the safety of personnel when installing, operating, adjusting, and maintaining the CSS. All potentially dangerous items, such as medium voltage wiring, that may lead to injury of personnel, either by manipulation of the system or as a result of component failure, were engineered in accordance with NFPA 99B.

The system safety hazard analysis was factored into the design such that no single failure of a CSS component would endanger the life of the operator or test personnel.

2.3.8 Human Performance/Human Engineering

The CSS conforms to the engineering requirement in MIL-STD-1472C for personnel access clearance dimensions.

2.3.9 Deployment

The CSS installation for Chamber 9 was started January, 1990 and completed September, 1990.

2.4 Quality Factors

2.4.1 Reliability

The CSS was implemented to support an overall ACS Mean Time Between Failures (MTBF) of at least 200 h. The CSS reliability was documented by a parts count prediction in accordance with MIL-STD-785B Task 203 as modified by available vendor documentation of actual component MTBF.

2.4.2 Modifiability

a. Maintainability

Maintainability was a prime consideration of the CSS hardware with consideration given to supporting the ACS reliability constraints defined in 2.4.1. Special attention was given to accessibility of system components and cabling for removable, insertion, and visual inspection. Adequate access was provided for test point usage and insertion/removal of circuit cards in the equipment.

Malfunctions were detected and isolated where possible by internal diagnostics. Failures were identified to the replaceable circuit card or major assembly as applicable. Average Mean Time To Repair (MTTR) is 1 h for the CSS based on having adequate spare parts available on site at the module (board replacement) level. See Logistics (section 2.5) for further comment.

Malfunctions can be detected and isolated to the replaceable circuit card or major assembly as applicable. Vendor supplied diagnostics will be utilized as much as possible to diagnose faults in equipment used within the CSS.

Quarterly calibration requires 2 maintenance man-days. The maintenance man-power requirement for the CSS is to be 1 AF Electronics Technician (ET) on a part-time basis.

(1) System Self Test

The CSS performs an automatic self diagnostic on boot-up to confirm system configuration and system level communications.

(2) On-Line Diagnostics

Diagnostics are performed on a continuous background basis with system level faults alarmed on the operator console. Additional diagnostic detail information is available to the operator via the diagnostics summary screen.

b. Flexibility and Expansion

The CSS computer system supports up to 16 LPU or 2 expansion LPU connected to the base LPU. Each expansion LPU is capable of addressing 5 discrete I/O cards. The EU is capable of addressing the new discrete I/O cards with minor modification of the configuration tables provided by the base firmware.

2.4.3 Availability

Smooth and trouble-free automated testing as well as accurate test data is obtainable from the contractor furnished CSS equipment on a daily basis with nothing more than quarterly calibration.

2.5 Logistics

2.5.1 Support Concept

a. Multipurpose Test Equipment - The CSS requires no more multipurpose test equipment other than a precision digital multimeter (such as a Fluke 8024B) and a portable loop calibrator (such as a Ronan X86).

b. Repair vs. Part Replacement - Maintenance is at the module replacement level. Circuit cards requiring repair are returned to the factory on an exchange basis.

c. Maintenance and Repair Cycle - The CSS was designed to eliminate the use of time phased component parts requiring replacement on a periodic basis.

d. Accessibility - Special attention was given to accessibility of system components and cabling for removal, insertion, and visual inspection of replaceable (board level) components. Adequate access was provided for test point usage and insertion/removal of circuit cards in the equipment.

2.5.2 Support Facilities

The required support facilities are on site, controlled environment, spare parts storage for modules (see 2.5.1b) and UPS power.

2.5.3 Supply

The CSS system is in the class of systems typically supported by a module exchange/repair agreement with the hardware vendor. This type of support agreement typically includes hardware component replacement down to the board level within 24 h. The CSS is capable of resupply through normal commercial channels in this manner.

2.5.4 Personnel

The CSS for each chamber was designed to be operated by a single person. Existing personnel assigned to the facility were trained to operate and maintain the system.

2.5.5 Training

The contractor developed and documented a training plan and conducted in-house training to familiarize the operators with all functional aspects of the CSS. The contractor provided a training manual to each trainee. The training took place at Brooks AFB in a classroom environment using the installed CSS as a training device.

2.6 Order of Precedence

The CSS portion of the ACS functions with the following considered order of precedence: to provide safe, smooth, reliable, repeatable, accurate, and convenient control of the hypobaric chambers for all test regimes to the extent that chamber operation does not interfere with the primary mission of collecting and managing experimental test data.

2.7 Qualification Requirements

2.7.1 General

2.7.1.1 Philosophy of Testing

As near as possible, the Factory Acceptance Test (FAT) simulates the total field environment. The field operational tests then became a repeat of FAT tests.

2.7.1.2 Location of Testing

FAT took place at the contractor's facility. Field operational tests took place at USAF School of Aerospace Medicine, Brooks AFB,TX.

2.7.1.3 Responsibility For Tests

Inspections and analysis were performed and documented by the contractor. Factory as well as field installation, calibration, loop tests, and operational tests were performed by the contractor. Factory acceptance and field operational tests were witnessed by the USAF.

2.7.1.4 Qualification Methods

Verifications of system requirements was accomplished by inspection, analysis, demonstration, and test or a combination thereof. Table 2-1 provides a Verification Cross Reference Index (VCRI) between the Section 2 requirements and the method of verification. The methods of verification are:

a. Inspection - Inspection consisted of physical verification that a specification requirement was met by comparison of that requirement to the documentation.

b. Analysis - Analysis consisted of verification that the specification requirement was met by a technical evaluation of equations, charts, data reduction or representative data.

c. Demonstration - Demonstration consisted of verification of specification requirements by the thorough exercising (conducted using test procedures) of the applicable elements under appropriate conditions that adequately show a qualitative value.

d. Test - Test consisted of the activity of verification of specification requirements by the thorough exercising conducted (using defined procedures) of the applicable elements under appropriate conditions that adequately show a quantitative value.

TABLE 2-1. CSS VERIFICATION CROSS REFERENCE INDEX

N/A - Not Applicable 2 - Analysis 4 - Test
1 - Inspection 3 - Demonstration

Requirement Reference		Verification Method
2.1	System Definition	
2.1.1	Mission of System	4
2.1.2	System Modes and States	N/A
2.1.3	System Segment Functions	N/A
2.1.4	System Functional Relationships	N/A
2.1.5	Configuration Allocation	1, 3
2.1.6	Interface Requirements	N/A
2.1.6.1	External Interfaces	3
2.1.6.2	Internal Interfaces	3
2.1.7	Processing Resources	N/A
2.1.7.1	Hardware Characteristics	1
2.1.7.2	Programming Requirements	N/A
2.1.7.3	CPU Utilization	1
2.1.8	Government Furnished Property	3
2.2	System Performance Characteristics	
2.2.1	Altitude Control	4
2.2.2	Temperature Control	4
2.2.3	Humidity Control	4
2.2.4	System Life Expectancy	2
2.2.5	Mission Duration and Utilization Rates	2
2.3	Design and Construction	
2.3.1	Material Requirements	1
2.3.2	Physical Requirements	1
2.3.3	Environmental Conditions	1
2.3.4	Nameplates and Product Markings	1
2.3.5	Electromagnectic Radiation	1
2.3.6	Workmanship	1
2.3.7	Safety	2
2.3.8	Human Performance/Human Engineering	1
2.3.9	Deployment	1

2.7.1.5 Test Levels - Integration, Startup

FAT was performed at the end of the system integration phase and prior to shipment to Brooks. Installation and startup testing began after system physical installation. See section 2.7.2 for further discussion of test levels.

2.7.2 Formal Tests

Installation tests consisted of loop checks, continuity tests, and verification of the total system installation in accordance with the system documentation. A loop check data sheet provided all this information. Instrument calibration data sheets were also a part of the essential documentation delivered during field testing.

After individual loop checks, overall system startup and control tuning were implemented prior to field acceptance tests. Tuning parameters were recorded on the individual loop sheet.

Field acceptance tests (operational demonstrations) were a repeat of the FAT procedures with the addition of working field devices.

Qualification testing of selected components was not applicable to this contract. All system components are standard purchased hardware which have already been demonstrated by their vendors to meet published technical specifications.

Failure data was taken during field testing in support of the reliability analysis. All failures were recorded to spot future trends.

2.8 Preparation For Delivery - Hardware

The CSS console sections were cardboard protected as appropriate and plastic-wrapped to provide moisture protection for shipment. Inter-console wiring was prefabricated for rapid field termination.

SECTION 3.0 DATA ACQUISITION SUBSYSTEM

This document contains the basic design criteria for the DAS and the requirements for the major DAS components and operator interface.

3.1 System Definition

3.1.1 Mission of System

The primary mission of the DAS portion of the ACS is to facilitate the collection and management of experimental test data.

It provides safe, smooth, reliable, repeatable, accurate, flexible, and convenient data collection/manipulation for all test regimes.

3.1.2 System Functions

The DAS portion of the ACS captures real-time test data from the numerous experiments performed in the Hypobaric and Thermal Research Chambers at Brooks AFB. The DAS also performs convenient and efficient management of all chamber test data files. The primary DAS functions are:

Data Capture (Real-time Data Acquisition)
Data Collection (Storage)
Data Presentation
Data File Management

a. Data Capture

Data Capture is the simultaneous, real-time sampling of up to 16 selected data channels per chamber at a prespecified collection rate until the channel recorder memory is full, or the specified number of channel samples is stored.

b. Data Collection

Data Collect is the automatic block transfer (copy) of raw (unscaled) data from data channel recorder memories to the DAS CPU hard disk. The Collection process also includes the automatic naming of the transferred files, and appending of appropriate data file header information, including the engineering units scale factor.

c. Data Presentation

Data presentation is the Display/Plot of test data in engineering units to the CRT for graphic display, or to an external device for a graphic hard copy.

d. Data File Management

The data file management function of the DAS is the convenient and efficient storage and retrieval of test data files to streaming tape, and/or the host VAX computer.

3.1.3 System Functional Relations

The DAS functions are fully integrated through the application software, which implements a simple, convenient, menu-driven operator interface.

3.1.4 Configuration Allocation

The Hypobaric Chamber (DAS) is a functionally integrated, simultaneous sampling, multichannel, CAMAC (IEEE 583-1982) based, data collection subsystem. It incorporates a DEC-compatible microcomputer for control of the CAMAC data acquisition crates as well as data manipulation and storage. The microcomputer is centrally located within the hypobaric facility and linked to the CAMAC data collection crates by a Fiber Optic (FO) IEEE-488 communications bus as indicated in Figure 3-1. It has the following major components:

DAS I/O Subsystem
DAS Console (4-Plane Color Graphic CRT, and keyboard)
Remote Graphic Workstation (2)
Central Processing Unit (CPU)
Hard Disk (HD)
Streaming Tape Drive
Ethernet Bus Interface
IEEE 488 Bus Interface and FO Bus Extension
Graphics Printer
Multitasking Operating System
Menu Driven, Fortran-Based Operating Software

These components are standard, purchased hardware with published technical performance specifications. These devices were carefully chosen to contribute to the overall performance, accuracy, speed, and reliability of the integrated DAS. Therefore, they are not subject to "or-equal" substitution which may significantly degrade the performance of the overall system.

a. DAS I/O Subsystem

The DAS I/O Subsystem interfaces directly with chamber internal or chamber mounted transducers and transmitters for collection of various analog signals associated with particular experiments in-progress within a given chamber. The DAS I/O Subsystem for each chamber consists of the following components:

Chamber penetrator panel
I/O cabinet hardware
Field Interface Terminal Blocks
CAMAC Crate and Power Supply
Crate Controller
Transient Recorder
Recorder Memory

(1) DAS Chamber Electrical Penetrator Panel

The stainless steel DAS penetrator panel provides air-tight chamber penetrations for the DAS input signals. The primary function of the penetrator panels is to provide convenient, isolated and shielded, BNC electrical connection points at the

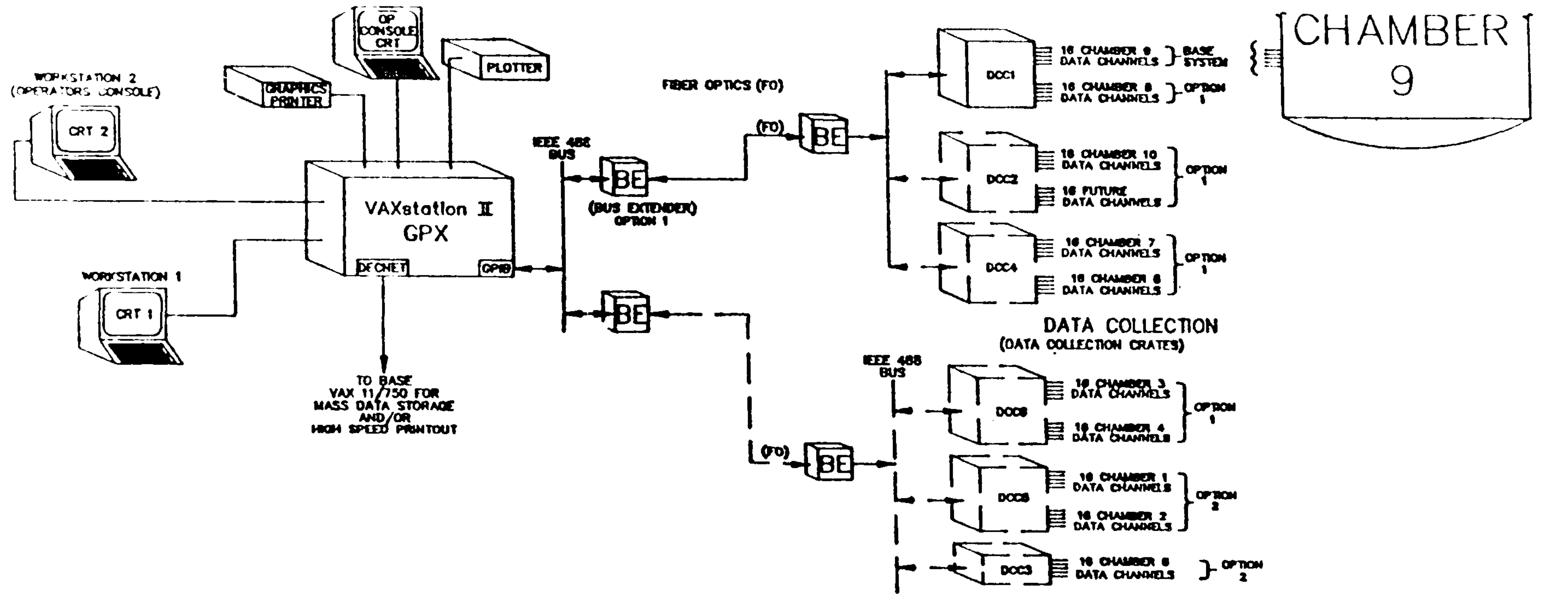

Figure 3-1. Data Acquisition Subsystem.

chamber interior wall for DAS input signals. The DAS BNC connections available at the penetrator panel are:

(a) 4 to CAMAC transient recorder No. 1
(b) 8 to CAMAC transient recorder No. 2
(c) 16 wired to DAS field interface terminal block in the DAS I/O Cabinet for future hardware expansion of DAS I/O channels by the simple addition of more crate cards.

The DAS penetrator panel also provides convenient pass-through electrical connections from the inside panel to the outside panel. These connections are for direct connection of portable instrumentation to a specific experiment. The direct pass-through connections available at the DAS penetrator panels are 8 isolated and shielded BNC pass-throughs and 2 S-Conductor circular MS-type connectors with shells grounded to the chamber wall and overall conductor shield passed through on the 5th pin, (i.e., 4-wire RTD).

(2) DAS I/O Cabinet Hardware

The DAS I/O cabinet houses the CAMAC crate and power supply, and is the primary termination point for all DAS field wiring. The DAS I/O cabinet interfaces with all the chamber instrumentation necessary to capture desired test data and chamber parameters. The DAS I/O Cabinet has the following characteristics:

(a) Free-standing, industrial grade, standard 48.26 cm (19 in.) vertical instrument enclosures, 1.78 m (70 in.) high, and 64.8 cm (25.5 in.) deep.

(b) Hinged and lockable rear doors and removable front cover panels in the unused portions.

(c) Heavy-duty cold-rolled steel construction with minimum 14-gage frame and internal mounting rails, and 18-gage side panels, doors and top.

(d) Paint finish system of acrylic or polyurethane enamel in Federal Standard 595A color number 816-S, medium blue with minimum paint thickness of 3 mils.

(3) Field Interface Terminal Blocks

Field Interface Terminal Blocks (FITB) mounted in the DAS I/O Cabinet are high density metric class, 600 V terminal blocks rated at least 26 amps. All FITB accept wire sizes from 22 AWG to 12 AWG. They are DIN rail-mounted, meeting the requirements of international standards such as UL, VDE, CSA, etc. Wire terminals are recessed for finger protection.

(4) CAMAC Crate and Power Supply

A 25-slot CAMAC crate is mounted in the DAS I/O Cabinet; it contains all the DAS real-time I/O card compliment necessary to perform the real-time data acquisition functions of the DAS. The DAS crate contains the data channel recorders for interface directly with chamber internal or chamber mounted transducers and transmitters. The data channel recorders consist of the I/O card complement necessary to perform the real-time data acquisition functions of the DAS. The crate fully complies with IEEE Std. 583, incorporating the 86-pin CAMAC Dataway card-edge connector at each slot location. The crate includes one or more self-contained blowers for cooling of the cards. The crate is arranged for 48.26 cm (19 in.) relay rack mounting with a separately mounted power supply. The crate power supply is mounted in the DAS I/O Cabinet, and converts the 120 VAC source to the mandatory DC CAMAC Dataway voltages with current capacities as follows:

Volts DC	Amps
+24	6
-24	6
+6	52
-6	52

Power supply voltage and current metering are provided on the face of the rack-mounted crate power supply.

(5) Crate Controller

The CAMAC crate controller resides in the right-most slot of each CAMAC crate and provides the hardware link between the other modules in the crate and the DAS computer's IEEE 488 (GPIB) peripheral bus. The crate controller addresses the modules with appropriate CAMAC commands, transfers data, accepts status information, and monitors the interrupt lines, all via the CAMAC Dataway. In addition, the controller handles the protocol for the GPIB.

The crate controller can operate as a master or auxiliary CAMAC controller. The crate controller is addressable with a unique GPIB address such that multiple crate locations, each with a crate master can be connected to the single DAS.

The crate controller has the following additional features:

(a) Capable of all types of CAMAC transfers, in single or block mode, with 8, 16, or 24 bits per transfer.

(b) Jumper selection of data byte, high or low order byte priority.

(c) Implementation of all GPIB lines including EOI.

(d) Support of CAMAC, UCC, UQC, ACA, and UCS block transfer modes.

(e) Block mode transfer rates to 600 kBps.

(f) Standard GPIB connector on the front panel.

(g) Front panel controls for on-line/off-line selection and initialization of a CAMAC cycle or Clear cycle.

(h) Front Panel LED indication of BUSY, BLOCK, RSV, LSUM, NO X, and NO Q status.

(6) Channel Recorder

The Transient Recorders provide 16 channels of real-time data acquisition for the DAS. This is accomplished with 2 separate, 8-channel, transient recorders which plug into the DAS crate(s).

The first 4 channels of 1 recorder are dedicated to chamber parameters altitude, humidity, and 2 temperatures, making 12 input channels available for other test parameters.

Each transient recorder is a multichannel analog-to-digital converter. Simultaneous sampling of all 8 recorder channels is accomplished by each channel having a track and hold amplifier whose value is stored to memory on command. Each transient recorder has its own internal clocks, with software selectable sampling rates from 1 Hz to 40 kHz.

Each transient recorder incorporates control circuitry necessary to load digitized measurements into external memory modules and to unload the data onto the CAMAC data highway.

When triggered, the transient recorders continue scanning and storing samples until the data memory is filled, or the required number of samples has been collected. The transient recorders are triggered by an external automatic input transmitted by the Control Subsystem (CSS).

All other functions of the transient recorders are controlled by standard CAMAC commands. All dataway and power connections conform to the CAMAC standard, IEEE Std 583-1982.

The front panel of each transient recorder has LED indicators for module status and LEMO connectors for the analog inputs and the external trigger signal.

The transient recorders have the following additional characteristics:

(a) Analog Input full scale ranges, jumper-selectable per module at 0-5.12 V, 0-10.24 V, +5.12 V, +10.24 V.

(b) All inputs are differential and protected for over-voltage to at least 200 V.

(c) Conversion resolution of 12 bits, with conversion accuracy of +0.03% of full-scale.

(d) Internal triangle waveform test signal connected to all channels when module commanded to a do self test.

(7) Channel Recorder (Digitizer) Memory

Each transient recorder has its own static memory module so that each data channel has its own dedicated memory. The transient recorder with 4 dedicated chamber parameters has a 64 k-word memory module, giving 8 k words/channel, or 2.2 h of samples per channel at a 1 Hz sample rate. The other transient recorder has a 256 k-word memory module, giving 32 k words/channel, or 16 s of samples per channel at a 2 kHz sample rate.

The memory modules interconnect to their respective transient recorders via an auxiliary bus ribbon connector. Each memory module has the following additional features:

(a) 12-bit data word size.
(b) 250 ns access time for both read and write cycles.
(c) 20-bit (1 megaword) address decoding capability.
(d) Front panel LED indication of read/write status.
(e) Front panel LED indication of base address switch settings.

b. DAS Console

The DAS Console serves as the DAS System Manager's primary workstation. From this location the designated System Manager interfaces with the DAS Central Processing Unit (CPU) for control of all devices necessary to collect, store, review, and transfer chamber test data. The designated system manager can also perform system backup and archival functions from this location. The DAS Console is a 48.26 cm (19 in.), 4-plane color graphic CRT and keyboard, integrated with the Microcomputer CPU into a desk-type primary workstation as shown in Figure 3-2. The major components of the DAS Console have the following features:

(1) DAS Primary Workstation

The DAS Primary Workstation is a steel, sit-down, table with the microcomputer housed in a benchtop enclosure. The DAS Primary Workstation meets the acceptable standard clearance dimensions of MIL-STD-1472C and has the following additional characteristics:

(a) Laminated plastic, desk height top running the length of the Operator Console.

(b) Heavy-duty, cold-rolled steel construction with minimum 13-gage corner posts, 14-gage side and back assemblies, and 18-gage legs.

(c) Paint finish system of acrylic or water born enamel finished in Federal Standard 595A color number 816-T, medium blue, with leg color 116-T, black. Minimum paint thickness for both colors is 1.5 mils.

(d) Typical dimensions as shown in attached Figure 3-2.

(e) Two matching auxiliary tables of similar size and construction for mounting of the Graphics Printer and Color Graphics CRT.

(2) Operator Display and Interface Keyboard.

The DAS Operators Console Display is a high resolution, 48.26 cm (19-in.) color graphics CRT, furnished with a standard mouse for graphic applications. The mouse resides on the workstation top on either side of the CRT. The separate keyboard is a standard QWERTY key arrangement with tactile feedback keys. The keyboard resides on the wor'station top in front of the CRT.

The DAS Operator's Console CRT and keyboard communicates to the DAS CPU over a dedicated RS-232 serial link. It is compatible with DEC MicroVAX II computers, and support windowing, as well as DEC's ReGIS.

The system meets the following additional performance and functional requirements:

(a) CRT - 4-bit plane, (16 color), 1024 x 2048 resolution.
(b) Character Mode - dot matrix.
(c) Character Set - ASCII with Upper/Lower Case, numeric and punctuation, plus 32 special graphic characters.
(d) Cursor Type - keyboard selectable blinking block, or blinking underline (text mode), flashing crosshair (graphic mode).
(e) Keyboard layout - QWERTY with 18 key auxiliary keypad.
(f) Interface - RS-232C, 25-pin D connector.
(g) Baud Rate - 0 to 19,200 bits/s, keyboard selectable.
(h) Parity - keyboard selectable, even, odd, mark, or none.
(i) Protocol - keyboard selectable, XON/XOFF preferred.
(j) Power - 115 VAC, 60 Hz, 2-wire with ground.

c. Remote Graphic Workstation

The DAS workstation is the experimenter's primary workstation, and located at the control console. From this location an experimenter can interface with the DAS to configure his input channels, transfer captured data to the DAS CPU hard disk, assign unique file names to the raw data set files, and display/plot test data.

The chamber control console has a 16-color graphics CRT and keyboard terminal which communicates to the DAS CPU over an RS-232 serial link. These terminals provide convenient DAS access for the experimenters at the chamber control console for "PREP" and "COLLECT" commands and viewing of graphic and/or tabular test results. This graphics terminal is compatible with DEC MicroVax II computers. An extra workstation terminal is provided at the main DAS Console as shown in Figure 3-2.

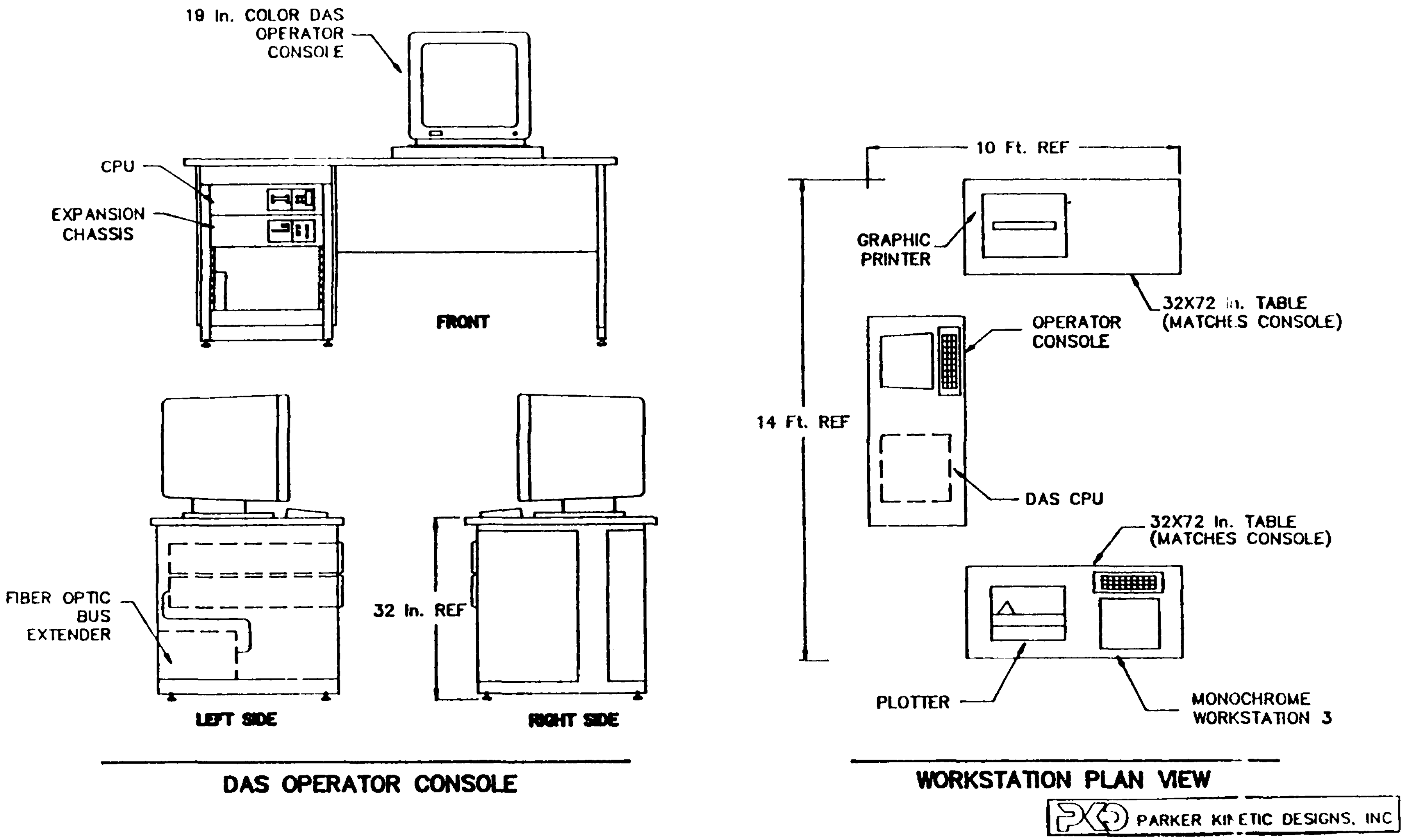

Figure 3-2. Data Acquisition Console and Workstation.

The Graphics terminal has a detached sculptured keyboard. The keyboard resides on the table-height shelf on the front of the chamber operator's console. The CRT is mounted in the vertical rack of the DAS I/O Subsystem, immediately above the keyboard at approximately head height. It supports bit-mapped graphics with a screen resolution of at least 768 x 240 pixels on two graphics planes. It also supports DEC's ReGIS and meets the following additional performance and functional requirements:

(1) CRT - 30.48 cm (12 in.) diagonal, 16 color.
(2) Character Mode - 9 x 7 dot matrix.
(3) Character Set - ASCII with Upper/Lower Case, numeric and punctuation, plus 32 special graphic characters.
(4) Cursor Type - Keyboard selectable blinking block, or blinking underline (text mode), flashing crosshair (graphic mode) .
(5) Keyboard layout - QWERTY with 18-key auxiliary keypad.
(6) Interface - RS-232C, 25-pin D connector.
(7) Baud Rate - 0 to 19,200 bits/s, keyboard selectable.
(8) Parity - keyboard selectable, even, odd, mark, or none.
(9) Protocol - keyboard selectable, XON/XOFF preferred.
(10) Power - 115 VAC, 60 Hz, 2-wire with ground.

d. DAS Central Processing Unit

The DAS CPU functions as the heart of the DAS, coordinating all communications, operator interface, command and data transfers within the DAS. It performs all calculations, conversions to engineering units, data handling, file transfers and initial data file storage. The DAS CPU is a DEC MicroVAX II, a full 32-bit machine with 32-bit data word and 32-bit data registers.

It has a minimum of 16 general purpose registers with 16 hardware interrupt levels and 15 software interrupt levels. It has a Q-22 bus interface with map for DMA transfers, boot and diagnostics features, console serial port and, and interval timers. In addition to the normal interval timers, it has an internal time of year clock with battery backup.

The DAS CPU was furnished with a floating point accelerator, 1 MB of on-board memory and 4 MB of 400 ns local memory, expandable to 16 MB. It was also furnished with hardware/software support for Ethernet (IEEE 802.3). In addition, it has the following key features:

(1) MicroVAX II native mode instruction set.
(2) Single Precision (F), Double Precision (D), and Floating Point (G) data types on the floating point processor.
(3) One or more 8-slot BA-23 rack mount chassis with a 230-W power supply for each.
(4) I/O Distribution Panel with inserts for expansion.
(5) Extended block mode transfer support.
(6) 10 ms interval timer.
(7) 64-kB boot and diagnostic ROM.
(8) Both VAX ASCII console and TTY emulation.

(9) Microverify self-test diagnostics.
(10) Mass storage control protocol.
(11) IEEE 802.3 (Ethernet) to Q-Bus Interface.
(12) 8 asynchronous communications ports.
(13) 159 MB hard disk.
(14) 95 MB streaming tape drive .
(15) Processing Speed - 0.8 million instructions per s (MIPS).
(16) Growth Capability - See section 3.5.2.c.

e. DAS Hard Disk

The DAS CPU's hard disk (HD) provides temporary storage for data files and permanent storage for operating software and application programs. The HD and its controller are state-of-the-art Winchester technology. It has a minimum formatted capacity of 159 MB, using an interleaved storage scheme. It has an average access time no greater than 38.3 ms and an average seek time no greater than 30 ms. The controller and drive have an average transfer rate of 5 MB/s.

f. DAS Streaming Tape Drive Unit

The DAS CPU's streaming tape drive unit (TU) is a backup device for the system operating software on the hard disk.

The TU is also the primary distribution media reader for operating system and application software updates, as well as a means for archiving test data files.

The TU reads and writes a standard CompacTape cartridge and has the following key features:

(1) Read/write speed: 75 ips.
(2) Peak transfer rate: 62.5 kBps.
(3) User data transfer rate: 45 kBps.
(4) Recording Method: Seril Serpentine.
(5) Recording Density: 6667 bpi.
(6) Record size: variable 1 byte to 64 kB.
(7) Maximum Capacity: 95 MB (formatted).
(8) Recording Media: 0.5 in. x 600 ft. magnetic tape.

g. DAS IEEE 802.3 Bus Interface

The DAS CPU was furnished with an IEEE 802.3 (Ethernet) to Q-Bus interface. The interface ties the DAS computer to a larger host VAX computer at BAFB for the transfer of test data files between the host VAX and the DAS. Test data files may be uploaded to/downloaded from permanent long-term storage on removable media at the host VAX. Through Ethernet, large groups of data and test reports executed on the DAS computer may be printed on shared, high-speed line printers at other base locations.

The interface provides physical and data link communications layers at a peak transfer rate of 5 MB/s. It was furnished with an appropriate transceiver and 10 meter transceiver cable for direct connection to the Air Force Ethernet trunk in the Hypobaric Complex.

h. DAS IEEE 488 Bus Interface

(1) GPIB Interface

The DAS CPU communicates with the DAS crates for data collection from the crates over the IEEE 488 (GPIB) bus. It provides all necessary handshake and interface management requirements in accordance with IEEE Std 488-1981 so that the DAS computer may send commands to, and receive data from the DAS crates at each chamber in standard GPIB format. The GPIB bus interface card implements all GPIB transfers as DMA transfers with data rates up to 250 kBps. It was furnished complete with source code and driver routines in Fortran for all interactive control, high level, and primitive GPIB functions implemented.

(2) DAS GPIB FO Bus Extension

An FO IEEE 488 Bus Extender was used in the DAS to achieve high noise immunity and speed for communications between the DAS CPU and CAMAC crates. The GPIB bus extender also removes the restrictions on cable length and device loading imposed by the IEEE 488 standard itself. The GPIB bus extender used for the DAS is capable of extending the bus length to 2 km and the number of devices on a single bus to 28 without compromising the integrity of the GPIB or requiring the user to alter applications programs. Capability to respond to parallel poll commands was retained.

Serial communications over the FO channel use a 4-bit cyclic redundancy check (CRC) code to detect transmission errors. Packets received with an error are discarded and automatically retransmitted. The FO bus interfaces have the following additional features:

(a) Transmission connector: SMA style.
(b) Transfer Rate at 20 m: 144 kBps.
    Transfer Rate at 500 m: 85 kBps.
(c) Power Required: 110/230 V, 47-63 Hz, 26 W maximum

i. DAS Graphics Printer

The DAS graphics printer is used to provide direct hard copy of test data tables and graphs as directed from the DAS Operators Console. The DAS graphics printer is a high-speed monochrome dot matrix type, capable of 240 cps. It supports bit-mapped graphics at resolutions up to 180 x 140 dpi in the Sxel graphics protocol. It has a serial interface and is compatible with DEC MicroVAX II systems. It has front panel selection capability for print size and type. The ribbon is cartridge type and easily replaceable. It supports fan-fold continuous paper with tractor feed. It can intermix text and graphics.

j. DAS Multitasking Operating System

The operating system for the DAS CPU is VMS, a general purpose, multitasking operating system compatible with DEC MicroVAX II computers. It is licensed for the Brooks AFB DAS configuration to support up to 8 simultaneous user sessions. It conforms as near as possible in its current and future development to IEEE Std 1003.1, "Trial Use Standard for Portable Operating System Interface and Environment Based on Unix," (POSIX).

k. DAS Fortran-Based Application Software

The operator interface for the DAS was written in ANSI '77 Fortran, and provides a convenient, menu-driven, self-prompting CRT screen environment for the DAS users. The Fortran compiler is compatible with and operates under the operating system just described. Both source and object code for the operator interface were provided to the Air Force.

The menu hierarchy is as shown in Figure 3-3. Individual selection of menu items is by tabbed movement of a highlighting bar to the desired choice with the up/down, left/right arrow keys and the return key, or appropriate function key.

Fill-in-the-Blank operator input is limited to process variable names, engineering units, and scale ranges for the channel process variable assignments on the DAS setup screens as shown in Figure 3-4. The initial channel setup can be retained in non-volatile memory, and be easily edited by highlighting and overtyping.

The DAS has 8 system modes or operating states:

Idle/OFF
View/Reconfigure Setup
Prep
Capture
Collect
Display/Plot Data
Communications With Host
System Utility Functions

From the Main Menu, the operator selects choices 1-6 as shown on Figure 3.3. The computer will automatically move to the next appropriate menu as shown on Figure 3.3 and briefly described as follows:

(1) Idle/OFF

The DAS has 2 non-active modes:

(a) Idle - DAS and its peripherals are powered but not in use.
(b) OFF - The DAS power distribution main breaker is turned off.

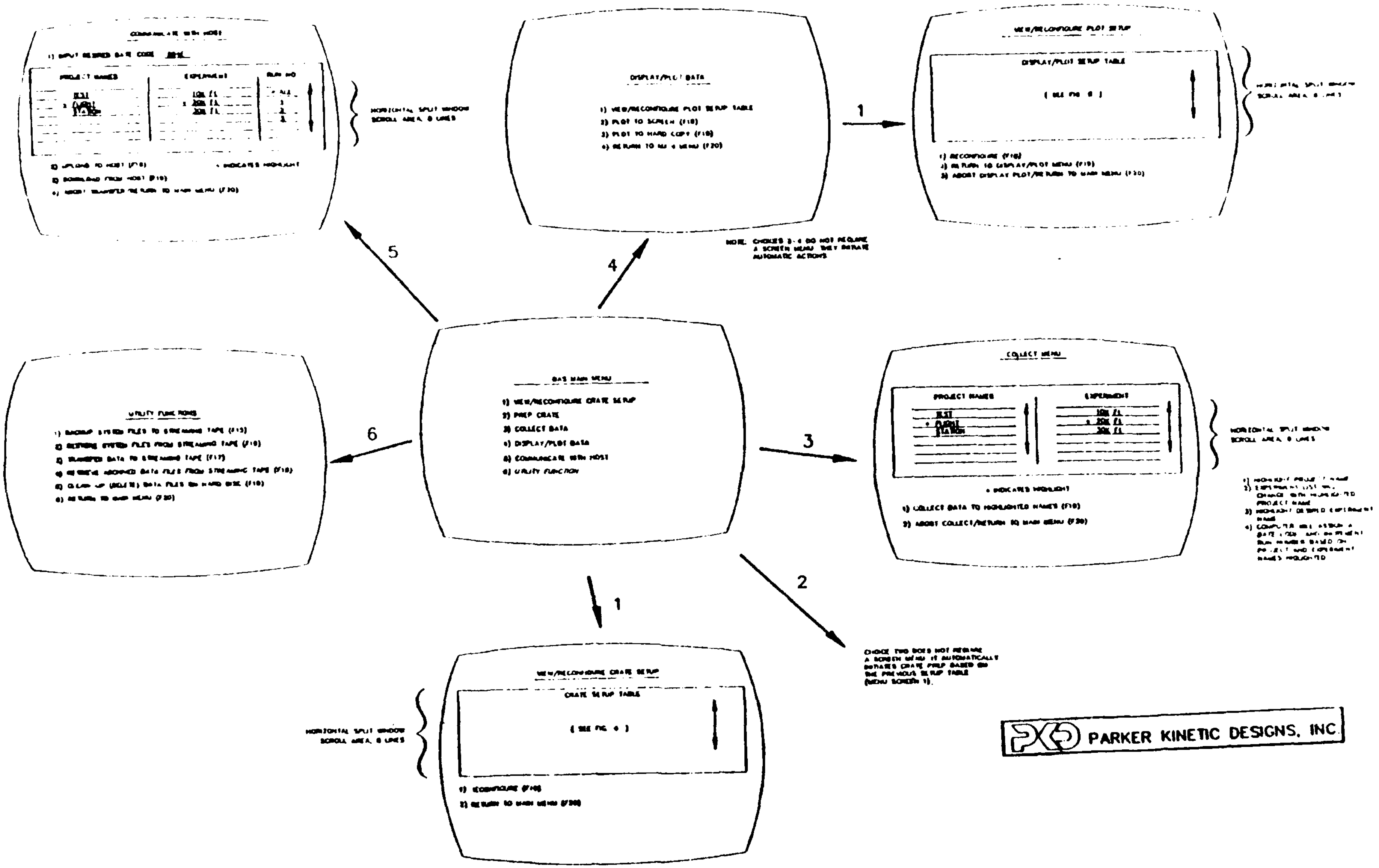

Figure 3-3. Data Acquisition Subsystem Operator Interface Menus.

Mod Type	#CH Use	C I	N	CH #	Sample /CH	Pre Trig	Sample Rate(Hz)	ScF */V	Dataset Name	Engr Units	Digtizer Zero	PV Offset	Comments
3232	8	18	4	1	8192	1024	1	1	CHAMBR_ALTITUDE	FTALT	512		
3232	8	18	4	2	8192	1024	1	1	CHAMBR_FRONT_TEMP	DEG F	512		
3232	8	18	4	3	8192	1024	1	1	CHAMBR_REAR_TEMP	DEF F	512		
3232	8	18	4	4	8192	1024	1	1	CHAMBR_REL_HUMID	% RH	512		
3232	8	18	4	5	8192	1024	1	1	3232 4 TEST1		512		
3232	8	18	4	6	8192	1024	1	1	3232 4 TEST1		512		
3232	8	18	4	7	8192	1024	1	1	3232 4 TEST1		512		
3232	8	18	4	8	8192	1024	1	1	3232 4 TEST1		512		
3232	8	18	16	1	32K	4K	2K	1	EKG_CH1		512		
3232	8	18	16	2	32K	4K	2K	1	EKG_CH2		512		
3232	8	18	16	3	32K	4K	2K	1	EKG_CH3		512		
3232	8	18	16	4	32K	4K	2K	1	EKG_CH4		512		
3232	8	18	16	5	32K	4K	2K	1	3232 16 TEST1		512		
3232	8	18	16	6	32K	4K	2K	1	3232 16 TEST1		512		
3232	8	18	16	7	32K	4K	2K	1	3232 16 TEST1		512		
3232	8	18	16	8	32K	4K	2K	1	3232 16 TEST1		512		

KEY

Mod Type	Module type (model number)
#CH Use	Number of channels used
CI	GPIB address of crate
N	Crate slot number
CH#	Input channel number
Samples/CH	Samples per channel
Pre-Trig	Number of pre-trigger samples
Sample Rate (HZ)	Sample rate frequency in Hertz
Scf */V	Scale factor per volt
Dataset Name	Dataset Name limited to 17 characters
Engr Units	Engineering units
Digitizer Zero	Zero offset in counts
PV Offset	Scaling offset (if required, in counts)

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Figure 3-4. Data Acquisition Subsystem CAMAC Crate Setup.

(2) View/Reconfigure Setup

In this mode the DAS operator may view or change the current setup of a selected chamber's input channels (Crate). This setup of a DAS Crate includes the number of active channels, the process variable name assigned to a given channel, the process variable range in engineering units assigned to a given channel, and the desired data collection rate (sample frequency) for a given set of data channels. (See Appendix B for File Naming Conventions.)

(3) Prep

On initiation of the PREP command, the DAS CPU transmits a command string to the appropriate DAS Crate which clears the crate memory, sets the number of active DAS Channels to 4, 8, 12, or 16, selects the desired collection rate (1-40 kHz) for each channel group, and arms the data channel recorders for receipt of a data capture trigger signal.

(4) Capture

In the data Capture mode, the DAS channel recorders are initiated by an external trigger signal from the Control Subsystem (CSS). Data capture only occurs after a channel recorder module has been armed by the DAS PREP command. Each channel recorder then runs, capturing data samples at the specified rate until the recorder memory is full, or the specified number of channel samples is recorded.

(5) Collect

In the data Collect mode, an operator initiates automatic block transfer (copy) of raw (unscaled) data from transient recorder memories to the DAS CPU hard disk.

During this transfer, each raw data file (block of samples) for an individual data channel is given a unique file name. The unique, raw data set file name is generated by operator selection of the appropriate project name and experiment name. The DAS main application program calls the appropriate subroutine(s) to automatically assign the next available daily run number for that project and experiment. The daily run number is a part of the Date Code format as shown in Figure 3-5.

This process continues until all channel data is transferred.

(6) Display/Plot Data

In the Display/Plot mode, the operator reviews an onscreen setup table which will lead him through the necessary setup for outputting test data in engineering units to the CRT for graphic display, or to a hard copy device for a graphic hard copy.

From the setup table, the operator identifies the file, or files (up to 4 data sets), to be presented on one graphic.

[illegible] PROJECT TASK B [illegible] RUN NUMBER 94E2 DATE 14 APR 89

GRAPH		X-AXIS				Y-AXIS				SIGNAL					
# TYPE	TITLE	TITLE	DATASET NAME	MIN	MAX	#	TITLE	Lower	Upper	TITLE	DATASET NAME	MIN	MAX	SCF	ZERO
[illegible]	B DOT CURVES TASK B (F)			-.001	.007	1	VELOCITY	-800	2500	B DOT VELOCITY	B DOT VELOCITY				
										GUN IDEAL VELOCITY	GUN IDEAL VELOCITY				
										TURR IDEAL VELOCITY	TURR IDEAL VELOCITY				
						2	POSITION	-2	10	B DOT POSITION	B DOT POSITION				
										GUN IDEAL POSITION	GUN IDEAL POSITION				
										TURR IDEAL POSITION	TURR IDEAL POSITION				

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Figure 3-5. Display/Plot Setup Table.

The operator inputs the presentation type: Y-Axis vs Time, or Y-Axis vs X-Axis; the engineering unit scale(s) for the Y-Axis; and/or the scale/time span for the X-Axis. The final operator selection is a choice of display to the CRT, or plot to the hard-copy device. After this selection, the applications program causes the appropriate subroutines and drivers to automatically output the graphic as selected. The setup for a given Display/Plot is retained in the Display/Plot Setup Table for future reference/reuse.

(7) Communicate With Host Computer

Communications with a host computer consists of data file management by upload and download of data files to and from the host VAX computer over Ethernet. Data files are uploadable to the host VAX for permanent storage/archival on removable disk packs or tape. Test data files are also downloadable back to the DAS CPU for review and presentation purposes. The DAS operator can store data files to, and retrieve data files from the Host VAX by specifying the project name, experiment name, and date code as discussed in section 3.1.3.k(2). This mode of operation is supported at the DAS CPU operator interface level with menu-driven selection of upload/download, and data set name.

(8) Utility Mode

The DAS Utility mode allows simple menu-driven selection for backup of the DAS system files to streaming tape, restoration of system files from streaming tape, and archival/retrieval of data files to/from streaming tape. The utility functions menu also supports cleanup (deletion) of test data files by specific file name. Utility functions are restricted to the Main DAS Operator Console and System Manager by password.

3.1.5 Interface Requirements

3.1.5.1 External Interfaces

The DAS interfaces with the CSS, the host VAX computer, and the chamber test data points.

a. External System Description

(1) CSS - The CSS provides automated control of the test chamber environment.

(2) Host VAX - The host VAX computer provides shared printers and long term, removable storage media for DAS test data files.

(3) Chamber Data Points - The chamber test data points are the real-world analog signal interface points where the physical process variables of interest are brought into the DAS for recording.

b. HW-to-HW External I/F

The DAS interfaces with the CSS on a simple digital I/O level. The CSS provides a hardwired TTL level digital signal to the DAS transient recorders to trigger data capture. The DAS transient recorders provide a digital status contact to the CSS indicating whether or not the transient recorders are armed and ready to collect data.

The DAS interfaces with the VAX host computer via an Ethernet (DECNET) trunk coax. It meets all the physical requirements of IEEE 802.3 for broadband communications trunks. It was furnished with an appropriate transceiver and 10 meter transceiver cable for direct connection to the Air Force Ethernet trunk in the Hypobaric Complex.

The DAS transient recorders interface directly with the chamber test data signals at the following levels:

(1) Analog Input full scale ranges, jumper selectable per module at 0-5.12 V, 0-10.24 V, +5.12 V, +10.24 V.
(2) All DAS inputs are differential and protected for over-voltage to at least 200 V.

The details of these interfaces are shown on the Analog Loop (AL) drawings or Electrical Elementary (EE) drawings as appropriate.

c. HW-to-SW External I/F

(1) CSS/DAS - N/A

(2) DAS/Host VAX - The DAS Ethernet interface to the Host Vax computer meets all the communications data-link requirements of IEEE 802.3.

(3) DAS Test Data Inputs - The transient recorders provide analog-to-digital conversion resolution of 12 bits, with conversion accuracy of +0.03% of full-scale.

d. Software-to-Software External I/F

(1) CSS/DAS - N/A

(2) DAS/Host VAX - The DAS Decnet interface to the Host VAX computer meets all the communications protocol layers required by IEEE 802.3 for communications at a peak transfer rate of 5 MB/s.

(3) DAS Test Data Input - N/A

3.1.5.2 Internal Interface Requirements

a. Internal I/F Identification

The internal interfaces for the DAS are the Operator Interfaces through the DAS Console and the Workstations at each chamber, other peripherals supported by the DAS CPU, and the GPIB (IEEE 488) Bus interface to the DAS Crates. These I/F are illustrated in Figure 3-1.

b. HWCI-to-HWCI Interfaces

The physical interface for the DAS Console, workstation, and DAS Printer are RS-232C, 25-pin D-connectors.

The physical interface for the DAS crates is standard GPIB connectors to GPIB FO bus extender, back to GPIB connectors.

c. HWCI-to-CSCI Interfaces

The protocol for the physical RS-232C connections to the DAS Computer is:

CPU to Printer - 9,600 baud max, 7-bit ASCII, 1 stop bit, even parity, XON/XOFF.

CPU to CRT - 19,200 baud max, 7-bit ASCII, 1 stop bit, even parity, XON/XOFF.

The protocol for the physical connection between the DAS CPU and the crates at each chamber provides all the necessary handshake and interface requirements in accordance with GPIB definition in IEEE 488-1981 at transfer rates up to 144 kbps.

d. CSCI-to-CSCI Interfaces

The DAS CPU communications drivers interfacing to the DAS Console and Remote Workstation support windowing as well as DEC ReGIS. The Fortran main menu program calls appropriate subscreen routines, which will in turn call the appropriate subroutines or VMS command files for execution of the CRT screen operator interface.

Subscreen routines involving communications with the DAS Crates call the appropriate Fortran driver routines for GPIB DMA transfers after first building the required command strings from stored look-up tables. These tables have been previously created by the operator's interactions with the Crate Setup, or Display/Plot Setup screens.

The GPIB interface was furnished complete with source code and driver routines in Fortran for all interactive control, high level, and primitive GPIB functions implemented. Graphic display/plotting software uses Precision Visuals DI-3000 Fortran subroutines for building graphs. These subroutines, in turn call DI-3000 drivers for the selected peripherals.

3.1.6 Processing Resources (Computer)

The DAS CPU is the sole processing resource of this subsystem.

3.1.6.1 Programming Requirements

a. Programming Language - ANSI Fortran '77

b. Compiler/Assembler - The Fortran compiler supports a software debugger (ORKIN).

3.1.6.2 Design and Coding Constraints

All application software is in Fortran '77, or VMS command files.

3.1.6.3 CPU Utilization

The system performance was guaranteed to meet the vendor's published technical performance specifications. This was accomplished by limiting the number of connected peripherals, and number of available CRT to those allowed by the vendor's standard configuration. This methodology of guaranteeing system performance was in lieu of dynamic resource monitoring.

Dynamic resource monitoring are, however, available at the DAS Operator's Console. Data available to the operator for continuous monitoring includes free pages of memory, memory page count for number of modified pages, page fault count, memory access (page I/O count), and Disk access (I/O count). These items can be displayed in a window on the operator's CRT.

3.1.7 Government Furnished Property List

The only government property for integration into the DAS was the Ethernet (DECNET) trunk coax, which was tapped with the contractor furnished-transceiver.

3.2 DAS Performance Characteristics

3.2.1 System Through-put

The DAS CPU achieves a 200 ns microcycle and a 400 ns I/O cycle leading to an average execution rate of greater than 0.8 MIPS.

The DAS is capable of supporting up to 4 simultaneous users without significant degradation in system response time. Average screen response time with 8 users is no greater than 2 s.

Data transfer rates are as previously defined in the sections of 3.1.3.

3.2.2 Mission Duration

The DAS supports continuous test durations from a fraction of an hour up to 200 h.

3.2.3 Utilization Rate

Smooth and trouble-free automated testing as well as accurate test data is obtainable on a daily basis.

3.2.4 System Life Expectancy

The DAS computer components are capable of the same life expectancies as commercial grade computer equipment. The DAS instrumentation components are capable of the same life expectancies as industrial grade instrumentation.

The modular nature of the DAS and the fact that its input subcomponents are based on nationally recognized standards make it capable of significantly higher life expectancy than normal. This higher system lifetime goal can be accomplished by planning the replacement of obsolete modular (board level) components or peripherals, (such as printers) with compatible state-of-the-art components. A nonfunctional component or peripheral should be considered obsolete when it is no longer repairable or supportable by replacement parts.

3.3 Design and Construction

3.3.1 Material Requirements

The field installation of the DAS meets the minimum design and construction requirement of NFPA-99B, Standard for Health Care Facilities, Section 11 Hypobaric Chambers and applicable portions of NFPA-70, National Electric Code.

All field wiring, including fiber optic links is in GRC or UL-approved ladder type tray. FO installation is in accordance with the requirements of ISA Standards and Practices for Instrumentation and Contractor Field Installation Details.

3.3.2 Physical Requirements

a. Weight Limits - No subcomponent of the system exceeds the building floor weight limit.

b. Dimensions - Consoles fit in the available operating area with adequate space for maintenance and operating personnel access.

c. Transportability - All electronic components of the assembled DAS can be shipped via an air-cushioned van.

d. Durability Factor - Subsystem components are standard industrial grade or commercial computer grade equipment meeting the vendor's published technical specification requirement for shock, vibration, and electrical surge withstand capabilities.

e. Health and Safety Criteria - No system or subsystem component single failure endangers human life.

3.3.3 Environmental Conditions

DAS hardware meets the following minimum environmental conditions:

Temperature Limits:
Operating: 0°C to 40°C (32°F to 104°F)
Storage: -30°C to 60°C (-22°F to 140°F)

Relative Humidity:
Operating: 10 to 90% RH, noncondensing
Storage: 5 to 95% RH, noncondensing

Power Requirements:
120 VAC (108-132), 50/60 Hz, 1-Phase switch selectable to 220 VAC (198-242), 50/60 Hz, 1-Phase

Storage environments are specified on the vendors' published data sheets.

3.3.4 Nameplates and Product Markings

Tags for penetrator panels, local operator stations, and console interiors are laminated plastic, sized and engraved as noted on approved construction drawings. They were attached with double-face tape.

3.3.5 Electromagnetic Radiation

The DAS was designed to minimize the effects of common-mode noise on the instrumentation and control signals associated with each chamber in accordance with the following practices:

a. A quiet instrument-ground bus was maintained separately from the personnel safety ground bus. The isolated, instrument-ground bus was in a star configuration, carried to earth-ground at a single designated point via an insulated ground conductor. Cable sizing for insulated ground runs was based on a criterion of 5 milliohms in any ground lead.

b. Instrumentation shields were floated at the field device, carried through intermediate terminal blocks, and terminated only at the isolated instrument ground bus in each cabinet.

c. Low level instrumentation and audio wiring was not installed in tray or conduit with any AC power wiring.

d. AC power distribution within the console was kept physically separate from audio and low level analog signals.

e. Analog and digital wiring was not installed in the same conduit, but may be installed in the same tray with an appropriate divider wall.

3.3.6 Workmanship

The DAS was fully integrated from standard industrial grade and commercial grade computer components into an aesthetically pleasing, neat, and functional part of the overall ACS. It is free of wiring and painting defects, misalignment of tags, sharp edges, and provides adequate maintenance access.

3.3.7 Safety

The design and construction of the DAS considered the safety of personnel when installing, operating, adjusting, and maintaining the DAS. All potentially dangerous items such as medium voltage wiring that may lead to injury of personnel, either by manipulation of the system or as a result of component failure, was engineered in accordance with NFPA 99B. The system safety hazard analysis was factored into the design such that no single failure of a DAS component endangers the life of the operator or test personnel.

3.3.8 Human Performance/Human Engineering

The DAS conforms to the engineering requirement in MIL-STD-1472C for personnel access clearance dimensions.

3.3.9 Deployment

The DAS installation for Chamber 9 was started January, 1990 and completed September 1990.

3.4 Other Quality Factors

3.4.1 Reliability

The DAS was implemented to support an overall ACS mean time between failures (MTBF) of at least 200 h. The DAS reliability was documented by a parts count prediction in accordance with MIL-STD-785B Task 203 as modified by available vendor documentation of actual component MTBF.

3.4.2 Maintainability

Maintainability was a prime consideration of the DAS hardware with consideration given to supporting the overall ACS reliability constraints defined in 3.5.1.

Special attention was given to accessibility of system components and cabling for removable, insertion, and visual inspection. Adequate access was provided for test point usage and insertion/removal of circuit cards in the equipment. Malfunctions can be detected and isolated to the replaceable circuit card or major assembly as applicable. Vendor-supplied diagnostics were used as much a possible to diagnose faults in DAS equipment.

a. System Self Test

The DAS performs an automatic self diagnostic on boot-up to confirm system configuration, and system level communications. The crate controller and transient recorders can be placed in self-test mode by command from the DAS CPU.

b. On-Line Diagnostics

Diagnostics are performed on a continuous background basis with system level faults alarmed on the operator console. Additional diagnostic detail information is available to the operator via diagnostics support screens.

c. Flexibility and Expansion

The DAS I/O channel capability is easily doubled from 16 to 32 points by the simple addition of more transient recorder and channel memory cards.

3.5 Logistics

3.5.1 Support Concept

a. Multipurpose Test Equipment - The DAS requires no more multipurpose test equipment other than a precision digital multimeter (such as a Fluke 8024B) and a portable loop calibrator (such as a Ronan X86).

b. Repair vs. Part Replacement - Maintenance is at the module replacement level. Circuit cards requiring repair will be returned to the factory on an exchange basis.

c. Maintenance and Repair Cycle - The DAS was designed to eliminate the use of time phased component parts requiring replacement on a periodic basis.

d. Accessibility - Special attention was given to accessibility of system components and cabling for removal, insertion, and visual inspection of replaceable (board level) components. Adequate access was provided for test point usage and insertion/removal of circuit cards in the equipment.

3.5.2 Support Facilities

The required support facilities are onsite controlled environment spare parts storage for modules (See 3.5.1b) and UPS power.

3.5.3 Supply

The DAS CPU and its peripherals are in the class of computer systems typically supported by a direct maintenance agreement with the hardware vendor. This type of support typically includes hardware component replacement down to the board level on an exchange basis. The DAS is capable of resupply through normal commercial channels in this manner.

3.5.4 Personnel

The DAS is designed for operation of the data capture, collect and display/plot functions by a single user from any workstation location. Existing personnel assigned to the facility are trained to operate and maintain the system.

For the sake of system integrity and data security, only 1 or 2 individuals have been trained as the DAS System Manager, and only these persons were given total password access to all of the file and system manipulation capabilities.

3.5.5 Training

The Contractor developed and documented a training plan and conducted in-house training to familiarize the operators with all functional aspects of the DAS. The contractor provided a training manual to each trainee. The training took place at Brooks AFB in a classroom environment using the installed DAS as a training device.

3.6 Precedence

The primary mission of the DAS portion of the ACS is to facilitate the collection and management of experimental test data. It performs that mission with the following considered order of precedence: to provide safe, smooth, reliable, repeatable, accurate, flexible, and convenient data collection/manipulation for all test regimes.

3.7 Qualification Requirements

3.7.1 General

3.7.1.1 Philosophy of Testing

As near as possible, the Factory Acceptance Tests (FAT) emulate the actual field I/O. The field operational tests then became a repeat of FAT tests.

3.7.1.2 Location of Testing

FAT took place at the contractor's facility. Field operational tests took place at USAF School of Aerospace Medicine.

3.7.1.3 Responsibility For Tests

Inspections and analysis were performed and documented by the contractor.

Factory, as well as field installation, calibration, loop tests, and field operational tests were also performed by the contractor.

Factory acceptance and field operational tests were witnessed by the USAF.

3.7.1.4 Qualification Methods

Verifications of system requirements was accomplished by inspection, analysis, demonstration, and test or a combination thereof. Table 3-1 provides a Verification Cross Reference Index (VCRI) between the section 3 requirements and the method of verification. The methods of verification are defined as:

a. Inspection - Inspection consists of the physical verification that a specification requirements is met by the comparison of that requirement to the documentation.

b. Analysis - Analysis consists of the verification that the specification requirement is met by a technical evaluation of equations, charts, data reduction or representative data.

c. Demonstration - Demonstration consists of the verification of specification requirements by the thorough exercising, conducted in accordance with test procedures, of the applicable elements under appropriate conditions that adequately show a qualitative value.

d. Test - Test consists of the activity of verification of specification requirements by the thorough exercising, conducted in accordance with defined procedures, of the applicable elements under appropriate conditions that adequately show a quantitative value.

TABLE 3-1. DAS VERIFICATION CROSS REFERENCE INDEX

N/A - Not Applicable　　2 - Analysis　　4 - Test
1 - Inspection　　3 - Demonstration

Requirement Reference		Verification Method
3.1	System Definition	
3.1.1	Mission of System	4
3.1.2	System Functions	3
3.1.3	System Functional Relationships	N/A
3.1.4	Configuration Allocation	1, 3
3.1.5	Interface Requirements	N/A
3.1.5.1	External Interfaces	3
3.1.5.2	Internal Interfaces	3
3.1.6	Processing Resources	N/A
3.1.6.1	Programming Requirements	N/A
3.1.6.2	Design and Coding Constraints	
3.1.6.3	CPU Utilization	1
3.1.7	Government Furnished Property	3
3.2	DAS Performance Characteristics	
3.2.1	System Through-put	1, 3
3.2.2	Mission Duration	N/A
3.2.3	Utilization Rate	N/A
3.2.4	System Life Expectancy	N/A
3.3	Design and Construction	
3.3.1	Material Requirements	1
3.3.2	Physical Requirements	1
3.3.3	Environmental Conditions	1
3.3.4	Nameplates and Product Markings	1

3.3.5	Electromagnectic Radiation	1
3.3.6	Workmanship	1
3.3.7	Safety	2
3.3.8	Human Performance/Human Engineering	1
3.3.9	Deployment	1

3.7.1.5 Test Levels During Integration and Startup

FAT was performed at the end of the system integration phase and prior to shipment to Brooks. Installation and startup testing began after system physical installation. See section 3.7.2 for further discussion of test levels.

3.7.2 Formal Tests

The FAT was a demonstration by the contractor in accordance with written test procedures that the DAS meets all the functional requirements of section 3.2. These tests were witnessed by the USAF.

Installation tests consisted of loop checks, continuity tests, and verification of the total system installation in accordance with the system documentation. A loop check data sheet provided all this information.

After individual loop checks, overall ACS startup and control tuning were implemented prior to field acceptance tests. DAS data collection and display/output capabilities were demonstrated as part of the overall ACS system acceptance tests.

Field acceptance tests (operational tests) were a repeat of the factory acceptance test procedures with the addition of working field devices.

Qualification testing of selected components is not applicable to this contract. All system components are standard purchased hardware which have already been demonstrated by their vendors to meet published technical specifications.

Failure data were taken during field testing in support of the reliability analysis. All failures were recorded to spot future trends.

3.8 Preparation For Delivery - Hardware

The DAS console sections were cardboard-protected as appropriate and plastic wrapped to provide moisture protection for shipment. Inter-console wiring was prefabricated for rapid field termination.

All electronic components of the assembled DAS were shipped to the chamber site via an air-cushioned van.

APPENDIX A

ACRONYMS AND ABBREVIATIONS

ACRONYMS AND ABBREVIATIONS

ABBR	DESCRIPTION
AC	Alternating Current
ACS	Automated Control System
AFB	Air Force Base
AL	Analog Loop Drawing
ANSI	American National Standards Intitute
ASCII	American Standard Code for Information Interchange
ASME	American Society of Mechanical Engineers
avg	Average
AWG	American Wire Gage
BCD	Binary Coded Decimal
BNC	Shielded Single-Pin Connection
bpi	bits per inch
CAMAC	Computer Automated Measurement And Control
CAC	Chamber Air Circulation system
CCD	Chamber Coil Defrost subsystem
CHC	Chamber Humidity Control subsystem
CIA	Chamber Inbleed Air subsystem
CMS	Cold Media Subsystem
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
CRT	Cathode Ray Tube
CS	Control Switch
CSCI	Computer Software Configuration Item
CSS	Control Subsystem
CTC	Chamber Temperature Control subsystem
CVS	Chamber Vacuum Subsystem
DAS	Data Acquisistion Subsystem
DC	Direct Current
DEC	Digital Equipment Corporation
DMA	Direct Memory Access
DOD	Department of Defense
dpi	dots per inch
DSU	Data Storage Unit
EE	Electrical Elementary drawing
EMI/RFI	Electro-Magnetic Interference/Radio Frequency Interference
EOI	End Of Input
ET	Electronic Technician
EU	Electronics Unit
FAT	Factory Acceptance Tests
FED	Federal
FITB	Field Interface Terminal Block
FO	Fiber Optic
FT	Flow Transmitter
GPIB	General Purpose Interface Bus
GRC	Galvanized Rigid Conduit
H/A	Hand/Auto station
HD	Hard Disk
HT	Humidity Transmitter
HWCI	Hardware Configuration Item
Hz	Hertz
I/F	Interface

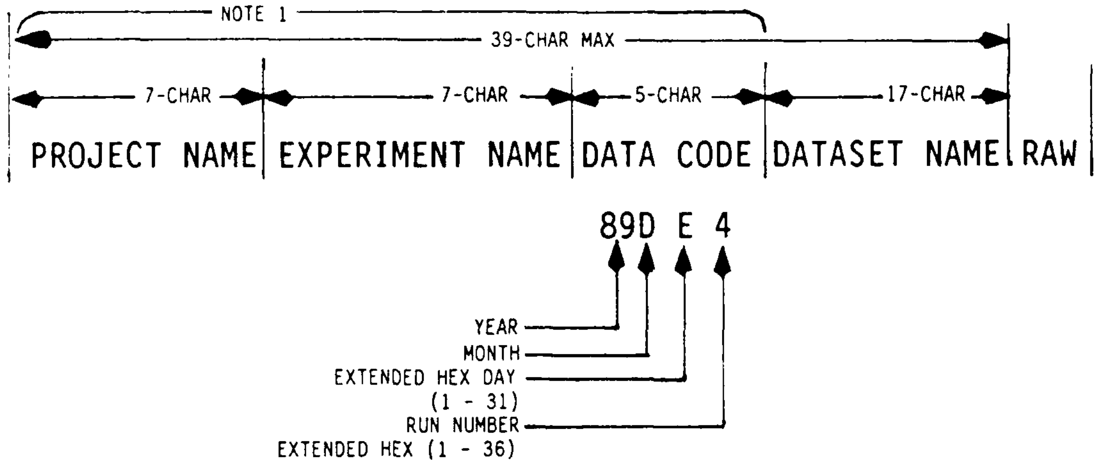
I/O	Input/Output
I/P	Current/Pneumatic transmitter
IAC	Inbleed Air Cooling subsystem
IAS	Instrument Air Subsystem
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ips	inches per second
ISA	Instrument Society of America
kB, kbyte	kilobytes (1,000 bytes)
kBps	kilobytes per second
km	kilometer
kVA	kilovolt-Amperes (1,000 volt-Amperes)
LED	Light-Emitting Diode
LEMO	Trade name for miniature electrical connectors
LIA	Lock Inbleed Air subsystem
LPU	Local Processing Unit
LVS	Lock Vacuum Subsystem
mA	milliAmpere
MIL-STD	Military Standard
MIPS	Million Instructions Per Second
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
MB, Mbyte	Megabyte (1,000,000 bytes)
MBps	Megabyte per second
ms	millisecond
N/A	Not applicable
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
PCSR	Phase-Controlled Step Regulator
PD	Piping and instrument Diagram
PID	Proportional - Integral - Derivative control
POSIX	Portable Operating System Interface/environment based on UNIX
PS	Pressure Switch
PT	Pressure Transmitter
PV	Process Variable
RAM	Random Access Memory
ReGIS	Remote Graphics Instruction Set
RGBI	Red - Green - Blue + Intensity
ROM	Read Only Memory
RTD	Resistance Temperature Detector
SCSI	Small Computer System Interface
SLC	Single Loop Controller
SMA	Fiber Optic Terminator
SPDT	Single Pole Double Throw switch
ST	Speed Transmitter
SV	Solenoid Valve
TT	Temperature Transmitter
TTY	Teletype
TU	Streaming Tape drive Unit
UL	Underwriters Laboratory
UPS	Uninterruptible Power Supply
USAF	United States Air Force
UNIX	AT&T Multitasking Operating System
VAC	Volts Alternating Current
VAX	Digital Equipment Corporation Computer Tradename

VCRI	Verification Cross-Reference Index
VDC	Volts Direct Current
VMS	VAX Multitasking operating System
W	Watts
XOFF-XON	Serial Communication Protocol
ZS	Limit Switch

APPENDIX B

DATA FILE NAMING AND HEADER FORMAT

DATA ACQUISITION SUBSYSTEM
FILE NAMING CONVENTIONS



The entire file name is 43 characters long and is composed of set-length fields.

The first 2 fields describe the project name and the load. They are 7 characters each and are menu selected.

The 3rd field is a 5-character run number which describes the year, month, day, and the run number for that day, using an extended hex format (31 days = Hex 1 through letter V, 12 months - Hex 1 through letter C.

Example: 89CE4 = December 14, 1989, Run number 4.

The 4th field is a 17-character dataset name describing the data channel (process variable).

The file must be appended with the 4 characters ".RAW."

Note 1: Table of contents with *.TOC extension. DIR *.TOC lists all the available experiment files.

DATA ACQUISITION SUB-SYSTEM
RAW DATASET HEADER FORMAT

Each raw dataset begins with a 512 character ASCII header which contains information about the data, such as the number of the data points and the scale factor. The data are stored as an unformatted INTEGER*2 array.

The header is composed of variable length files, which are each surrounded by square brackets. Each field contains a descriptive letter followed by a colon.

Example: [P:3968] means the file contains 3968 data points.

The fields are:

	[E:]	Experiment type and number
	[D:]	Experiment data
	[M:]	Instrument type
*	[P:]	Number of points
*	[PP:]	Number of pre-trigger points
*	[H:]	Collection rate in sample/s (Hz)
*	[R:]	Digitizer resolution in volts/bit
*	[S:]	Scale factor
	[U:]	Units
*	[Z:]	Zero value for digitizer in counts
*	[O:]	Instrumentation offset
	[F:]	Data collection device type
	[I:]	Device identification number
	[C:]	Run time comments

* Indicates a mandatory field.

The data is scaled by the equation:

XARR(I) = {[(IARR(I) - ZERO) * RESOLUTION] - OFFSET} * SCALE FACTOR

A typical block of code used to write to a file, with a unit number of 4, would look like:

```
INTEGER*2               IARR(100000), POINTS
CHARACTER*512           HEADER
     *
     *
     *
OPEN (UNIT=4,NAME='FILENAME',STATUS='NEW',FORM='UNFORMATTED')
WRITE (4)               HEADER
WRITE (4)               IARR(I) = 1, POINTS
CLOSE (4)
```


* U. S. GOVERNMENT PRINTING OFFICE: 1991--561-052/40048