DC-8 AIRBORNE LABORATORY EXPERIMENTER HANDBOOK

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Edwards, CA 93523-0273

NASA
DC-8, AIRBORNE LABORATORY
EXPERIMENTER HANDBOOK

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INTRODUCTION

Since August 1987, NASA has been operating A Douglas DC-8-72 Aircraft (NASA 817) for research activities in earth, atmospheric, and space sciences. This aircraft, extensively modified as a flying laboratory, is based at Dryden Flight Research Center (DFRC), Edwards, California. It is operated for the benefit of researchers whose proposals have been previously approved by NASA Headquarters. Airborne laboratory flights may be operated out of DFRC or from deployment sites worldwide, according to the research requirements.

The DC-8 is a four-engine jet aircraft with a range in excess of 5,000 nmi (9,200 km), a ceiling of 41,000 ft (12,500 m), and an experiment payload of 30,000 lb (13,600 kg). Utilization is planned to be 350 to 500 flight hours per year. Special viewports, power systems, and instruments have been installed in the aircraft to support a wide range of research programs.

Airborne research missions for the DC-8 are planned, implemented, and managed by the Airborne Science Directorate at DFRC. A designated mission manager is responsible for all phases of an assigned mission and is the official point of contact for experimenters as well as for ground support and flight operations groups. The mission manager leads a core team, specific to each mission, consisting of him/herself, an operations engineer, a project pilot, and the contract maintenance lead. This team makes all significant decisions regarding mission aircraft operations. The mission manager also functions as the onboard mission director during flight phases of the mission. The mission director coordinates and monitors science and operations activities on the aircraft during flights.

The purpose of this handbook is to acquaint prospective DC-8 researchers with the aircraft and its capabilities. The handbook also contains procedures for obtaining approval to fly experiments, outlines requirements for equipment design and installation, and identifies the personnel and facilities that are available at DFRC for supporting research activities in the DC-8 airborne laboratory. This handbook is managed and revised from time to time by the DFRC Airborne Science Directorate. Therefore, before arranging for experiments it is advisable to review the web site listed below, then contact the DFRC Airborne Science Directorate or your assigned mission manager for a current issue.

For information about the overall DFRC Airborne Science Program, including aircraft schedules and Airborne Science flight request procedures, and for an electronic version of this and other experimenter handbooks, look on the World Wide Web at:

http://www.dfrc.nasa.gov/airsci/.

NOMENCLATURE

AC	alternating current
ADC	air data computer
ADF	automatic direction finder
AED	automated external defibrilator
APT	automatic picture transmission system
ASCII	text format
ATC	Air Traffic Control
BCP	best computed position
CCTV	closed circuit television
CDU	control display units
CONUS	contiguous United States
CPU	central processing unit
DC	direct current
DCE	data communications equipment
DCP	Dryden Centerwide Procedure
DFRC	Dryden Flight Research Center
DME	distance measuring equipment
DTE	data terminal equipment
EIF	Experiment Integration Facility
EMI	electromagnetic interference
EPOS	emergency passenger oxygen system (or smoke hood)
FAA	Federal Aviation Administration
FMS	flight management system
GFI	ground fault interrupter
GMT	Greenwich Mean Time
GPS	Global Positioning System
GS	glideslope receiver
HF	high frequency
HP	horsepower
ICATS	information collection and transmission system
IDLH	immediately dangereous to life or health
ILS	instrument landing system
INS	inertial navigation system
IR	infrared
IRIG	Inter-Range Instrument Group
KTAS	knot, true airspeed
LOC	localizer receiver
MFD	multi-function display
MIL-STD	military standard
MS	military specifications

MSDS	Material Safety Data Sheet
NAS	National Aerospace Standard
NASA	National Aeronautics and Space Administration
NEMA	National Electrical Manufacturers Association
NM	nautical mile
NMS	navigational management system
NOAA	National Oceanic and Atmospheric Administration
NTSC	National Television Standards Committee
PARM ID	parameter identification code
PMS	Particle Measuring Systems
PVC	polyvinyl chloride
RF	radio frequency
RIB	Research Instrumentation Branch
SAT	static air temperature
SATCOM	satellite communications system
SLA	sealed lead acid
SVHS	super video home system
TACAN	tactical air navigation transmitter/receiver
TAS	true air speed
TAT	total air temperature
TCAS	traffic alert and collision avoidance system
TCG	time code generator
TLV	threshold limit value
UHF	ultra high frequency
UPS	uninterruptible power systems
UTC	Coordinated Universal Time
VDC	volts of direct current
VHF	very high frequency
VOR	VHF omnidirectional ranger
W	watts
WGS	World Geodetic System

CHAPTER 1

AIRCRAFT PERFORMANCE

1. Basic Aircraft Performance

The NASA DC-8-72, serial no. 46082 (NASA 817), is similar in appearance and performance to other four-engine, standard-body jet transports, as shown in figure 1-1(a) and 1-1(b). The aircraft is powered by four CFM International, CFM56-2-C1, high bypass ratio turbofan engines developing a maximum thrust of 22,000 lb each.

Basic aircraft performance in standard atmospheric conditions is summarized in the following subsections. Adding external instrument pods or pylons that increase drag will reduce performance parameters correspondingly.

A. Range

Maximum aircraft range with normal fuel reserves, for several payload weights, is as follows:

Table 1-1. Maximum aircraft range with normal fuel reserves.

Payload[1], lb	Fuel wt, lb	Gross wt[2], lb	Range, nmi
20,000	160,000	334,000	5,700
30,000	150,000	334,000	5,400
40,000	140,000	334,000	5,000

[1] Payload = experimenters, crew, equipment, seats, and baggage.
[2]Assumed empty weight = 154,000 lb

Payload weights seldom exceed 30,000 lb (13,608 kg), so that a 5,400 nmi (10,000 km) range is usually available except as reduced by special requirements for altitude profiles, flight patterns over ground test sites, external experiments, or headwinds.

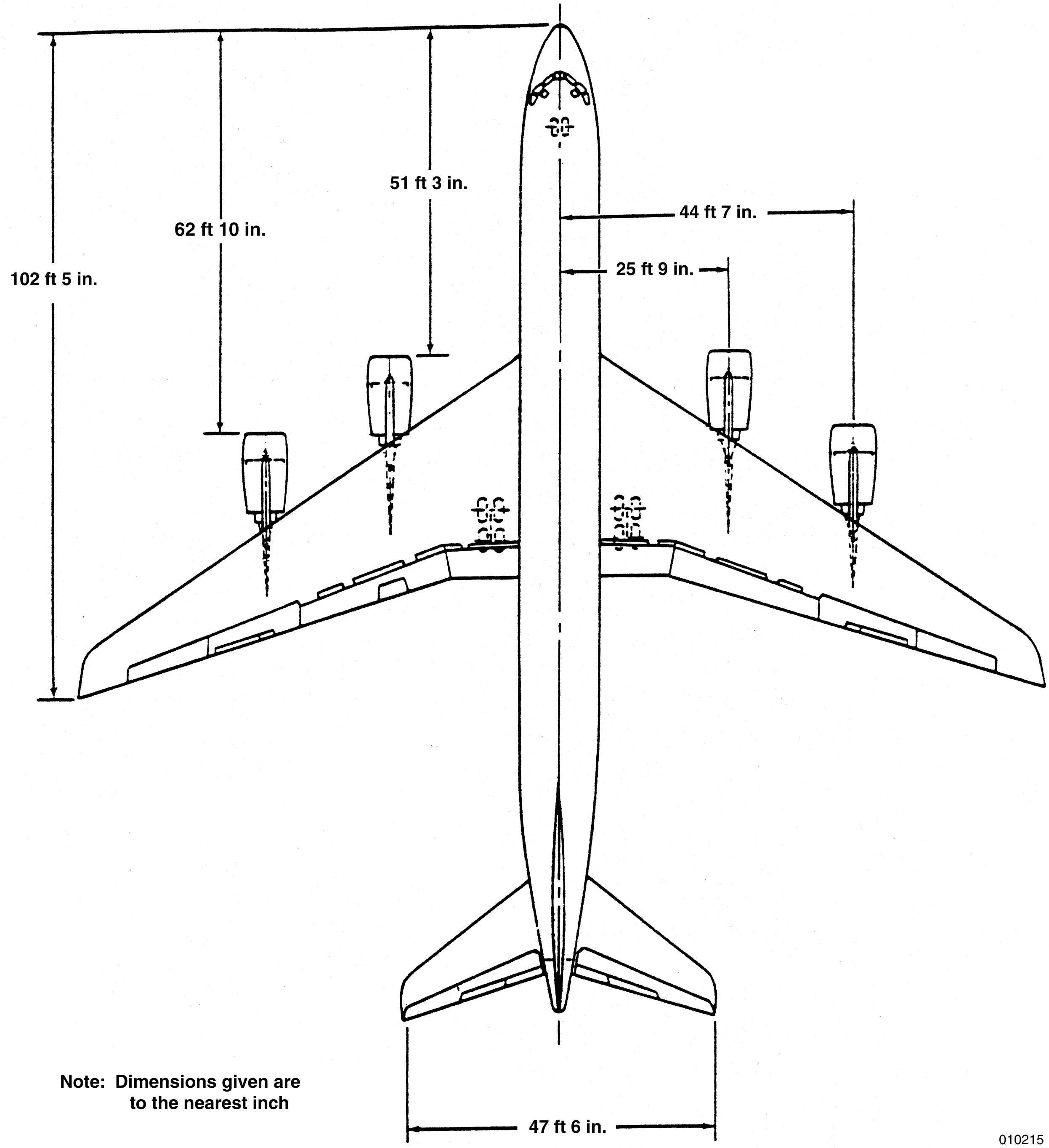
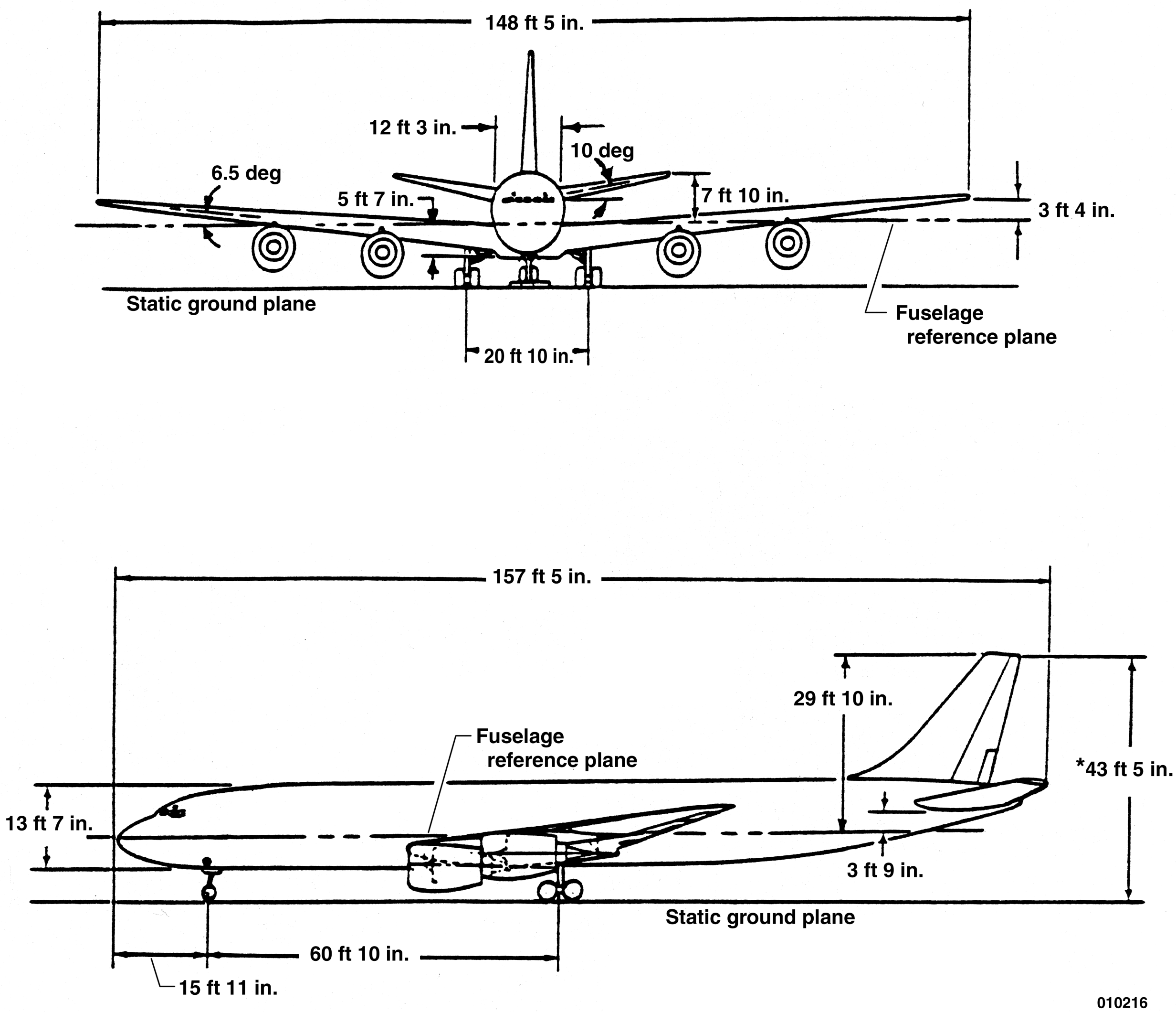


Figure 1-1(a). General view and over-all dimensions of the DC-8.



Note: Dimensions given are to the nearest inch

* **Based on: 13.9 in. rolling radius for the nose gear and 17.9 in. rolling radius for the main gear with the airplane at operator's weight empty**

Figure 1-1(b). General View and over-all dimensions of the DC-8.

B. Runway Length

At standard sea level conditions, the DC-8-72 typically requires a jet transport-rated runway of 7,500 ft (2,286 m), when take off weight is 300,000 lb (136,079 kg). For a take-off weight of 325,000 lb (147,419 kg), the runway length must be at least 8,500 ft (2,591 m). With a maximum take-off weight of 350,000 lb (158,759 kg), the runway length must be 9,800 ft (2,987 m), minimum. The allowable aircraft take-off gross weight will be reduced by such limiting factors as runway length, weight-bearing capability, slope, height above sea level, as well as by air temperature, wind, and obstacles.

C. Time at Altitude

The time at a desired research altitude is dependent upon numerous factors. The table below gives times for various take-off weights and two sample payloads, as representative of aircraft performance. The one-hour allowance for time to climb and descend is an average, allowing variations in local air traffic control. The initial flight altitude will be reached in about 30 min. If a higher altitude is desired, a step-climb can be achieved after aircraft weight has been reduced by fuel burn-off. Factors such as air temperature, aircraft configuration (probes, pylons, antennas etc.), and air traffic control will determine when the aircraft can climb to a higher altitude. Traditionally, an individual flight plan is developed for each case, to optimize total research requirements.

1) 20,000 lb (44,092 kg) Payload

Table 1-2(a). Mission duration and initial altitude for 20,000 lb payload.

Take-off Gross wt, lb	Fuel wt, kg	Initial Flight Altitude, ft	Climb & Descent	Time at Altitude
230,000	60	41,000	1 hr	3 hr 15 min
270,000	100	37,000	1 hr	7 hr 15 min
300,000	130	35,000	1 hr	9 hr 45 min
330,000	160*	35,000	1 hr	12 hr 0 min

* Maximum fuel

2) 30,000 lb (66,138 kg) Payload.

Table 1-2(b). Mission duration and initial altitude for 30,000 lb payload.

Take-off Gross wt, lb	Fuel wt, kg	Initial Flight Altitude, ft	Climb & Descent	Time at Altitude
230,000	50	41,000	1 hr	2 hr 15 min
270,000	90	37,000	1 hr	6 hr 15 min
300,000	120	35,000	1 hr	8 hr 45 min
340,000	160*	33,000	1 hr	11 hr 30 min

*Maximum fuel

The maximum allowable flight duration is dependent on crew rest and aircraft weight limitations. Also, regulations require that sufficient fuel reserves be maintained at all times to assure adequate fuel for airport and air traffic delays plus reaching an alternate landing field. Fuel loads are subject to the discretion of the air commander. The need for this reserve and the distance between possible alternates in remote areas may combine to shorten the listed flight times. Exceptions to this reserve fuel requirement, in order to prolong experiment time, are not permitted.

D. Speed Envelope

At standard atmospheric temperature conditions, the true airspeed (KTAS) envelope for this aircraft is shown in table 1-3.

For preliminary planning, normal cruise speed at altitudes above 30,000 ft can be estimated at 450 KTAS.

E. Turn Radius

For certain types of experiments, it may be desirable to fly over several closely spaced checkpoints. However, the DC-8-72 is a relatively high-speed aircraft and its turning radius is quite large. Experimenters planning closely spaced checkpoints should consult with their mission manager regarding flight planning. The following table indicates radius of turn, with no wind, in nautical miles as a function of speed and bank angle. See table 1-4.

Table 1-3. True airspeed envelope.

Altitude, ft	--- min	Knot, True Airspeed KTAS[1], Long Range Cruise	--- max	Mach no. max
5,000	220	275 to 355	370	0.57
10,000	235	315 to 395	410	0.63
15,000	260	325 to 415	440	0.70
20,000	275	350 to 450	470	0.77
25,000	300	380 to 465	485	0.86
30,000	320	400 to 470	490	0.88
35,000	350	425 to 465	495	0.88
40,000	390	430 to 460	500	0.88

Dynamic pressure (Qmax) = 572 lb/ft^2

[1]KTAS = (knots nautical miles per hour), true airspeed. One nautical mile = one arc-minute of latitude at the equator, or 6,076.12 ft (1,852 m).

Table 1-4. DC-8 turn radius in NM, as a function of airspeed and bank angle.

Bank Angle, deg	Airspeed, KTAS						
	300	325	350	375	400	425	450
5	15.0	17.6	20.5	23.5	26.7	30.2	33.8
10	7.5	8.8	10.2	11.7	13.3	15.0	16.8
15	4.9	5.8	6.7	7.7	8.7	9.9	11.0
20	3.6	4.2	4.9	5.6	6.4	7.3	8.1
25	2.8	3.3	3.8	4.4	5.0	5.7	6.3
30	2.3	2.7	3.1	3.6	4.1	4.6	5.1

2. Frequency and Duration of Flights

During the early stages of each mission, the mission manager develops mission specific operational guidelines affecting flight frequency and duration. These guidelines take into account the type of flights being proposed by the scientists, the proposed flight duration, the location, take-off times, and other mission specific conditions, and reflect the overall agreement of the aircraft flight crew, operations engineer, safety, mission management, and maintenance crew. The following general guidelines can be used for initial planning.

The duty day for DFRC personnel, including contractors, is limited to 14 hours maximum. The rest period between duty days must be a minimum of 12 hours. Given requirements for pre-flight and post-flight aircraft access, maximum flight duration is nominally 10 hours. Longer flights can be made but flight planning will be restricted and crew augmentation may be necessary.

A limit of 30-flight hours in a seven-day period and 100 hours per month is used for planning purposes. This has proven to be a practical limit for aircraft maintenance crews and, as experience has shown, for experimenters participating in the flights. However, given adequate crew rest and reasonable flight pacing, an absolute maximum of 40-flight hours in seven days can be allowed. Requests to exceed the 30-in-7 guideline will be evaluated on a case-by-case basis.

A typical operational schedule will consist of "fly days," "no-fly days," and "down days." Any day the aircraft flies, or the flight and maintenance crews arrive and complete preflight preparations and then the flight is cancelled, is considered a fly day. Generally, the number of consecutive fly days is limited to a maximum of six, to be followed by a no-fly day or a down day. Any day the aircraft is accessible to experimenters but does not fly is considered a no-fly day. Members of the DC-8 crew will be at the aircraft on these days. Fly days and no-fly days are duty days and subject to the limitations outlined above. A down day is a day off. The aircraft is not accessible to experimenters and aircraft crews will perform no mission duties. A down day must be planned at no greater than ten-day intervals. Scheduling will be flexible to accommodate real time conditions; however, down day planning must be done from the outset within the overall scheduling of the campaign.

3. Cabin Environment

The cabin, cargo areas, and electronics compartment are pressurized to an equivalent altitude of approximately 7,500 ft (2,286 m) when the airplane is at its 40,000 ft (12.2 km) cruise level. Humidity during flight nominally averages about ten percent; the temperature is held between 65 and 74 °F (18 and 24°C). Different sections of the interior can vary considerably in temperature, however, depending on the airflow patterns and the location of heat-producing equipment. Also depending on operating location, low altitude operator may significantly increase cabin temperature and humidity.

4. Aircraft Stability

An SP-30AL analog autopilot system controls the heading and attitude of the aircraft. In smooth air, the autopilot limits deviations of pitch, yaw, and roll to within ±1 deg.

Records of aircraft stability from the inertial navigation system (INS) can be made available to experimenters. In flight, the information collection and transmission system (ICATS) acquires the aircraft attitude and altitude, and then distributes this information to experimenters (see chapter 7).

5. Aircraft Attitude

A. In-flight

When cruising at a constant speed and altitude, the aircraft flies at a one to three deg nose-up attitude. A nominal value is 1.5 deg; however, the actual angle depends on a combination of gross weight (decreases as fuel is consumed), altitude, and true airspeed. A gross weight increase, altitude increase and an airspeed decrease results in an increased nose-up altitude.

B. Parked

When parked, the aircraft is at a 1.5 deg nose-down attitude. If necessary, during the installation and/or calibration of equipment, the aircraft can be leveled to zero deg by elevating the nose.

6. Worldwide Capability

NASA 817 is equipped and certified to meet airspace, communication, altimetry, and navigation performance specifications worldwide. All experiment payloads and aircraft configuration changes are reviewed to ensure that worldwide capability is not degraded.

A flight test to verify and re-certify aircraft performance will be accomplished when appropriate. If flight test determines the aircraft does not meet requirements throughout its normal operating envelope and the deficiencies cannot be corrected, limitations may be imposed. Such limitations may restrict the altitude, airspeed, or geographic regions within which the aircraft may operate.

CHAPTER 2

COMMUNICATION AND NAVIGATION

1. Basic Equipment And Operation

The NASA DC-8 is equipped with color weather radar and multiple communication and navigation systems. Communication equipment consists of: two high frequency (HF), very high frequency (VHF), and ultra high frequency (UHF) radios, one VHF-FM transceiver, and an ATT AirOne and Inmarsat Aero-H SATCOM telephone. Navigation aids include dual flight management systems (FMS), which include two 12-channel GPS receivers, two inertial navigation systems (INS), two VHF omnidirectional range (VOR) systems, two distance measuring equipment (DME) systems, a traffic alert and collision avoidance system (TCAS), 2 glideslope receivers, a tactical air navigation (TACAN) transmitter/receiver, and two automatic direction finders (ADF). Additional equipment, such as radar tracking beacons and GPS receivers, can be installed for experimenter support (see section 4).

A. Frequency and Interference

Frequency ranges of the navigation, radio, and radar units are listed below. Experimenters are cautioned to engineer their equipment to prevent spurious response at these frequencies, and to limit any output from their systems to 100 milliwatts (as in telemetry).

Table 2-1. Frequencies and interferences.

Equipment	Frequency	Receive	Transmit
Low Frequency ADF	190 to 1750 kHz	1	
HF Radio	2.0 to 30.0 MHz	1	1
Marker Beacon	75 MHz	1	
Localizer Receiver (LOC)	108 to 112 MHz	1	
VHF Omnirange (VOR)	108 to 118 MHz	1	
FM Radio	30 to 87.975 MHz	1	1
VHF Radio	108 to 173.975 MHz	1	1
Glideslope Receiver (GS)	329.3 to 335.0 MHz	1	
UHF Radio	225 to 400 MHz	1	1
DME & Tactical Air Nav (TACAN)	1025 to 1150 MHz	1	1
Air Traffic Control, transponder	1030 MHz	1	
	1090 MHz		1
Global Positioning System (GPS)	1575.42 (±2.0) MHz	1	
DC-8 Radar Altimeter	4.2 to 4.37 GHz	1	1
Experimenter Radar Altimeter	4.25 to 4.35 GHz	1	1
Weather Radar (C-Band)	5400 (±40) MHz	1	1
Traffic Alert and Collision Avoidance System (TCAS)	1030 MHz	1	
	1090 MHz		1
AirOne Telephone	850 MHz	1	
	895 MHz		1
SATCOM Telephone	1530 to 1559 MHz	1	
	1626.5 to 1660.5 MHz		1
Stormscope		1	

B. Radio System Specifications

Detailed specifications, for the radio equipment installed in the DC-8, are listed in the table below.

Table 2-2. Radio systems specifications.

Characteristic	HF Radio	VHF Radio	FM Radio	UHF Radio
Frequency Range	2.000 to 29.999 MHz	108.0 to 173.975 MHz	30.00 to 87.975 MHz	225.00 to 399.95 MHz
Number of Channels	28,000	2,160	2,320	7,000
Channel Spacing (Increments)	1.0 kHz	8.33 kHz	25 kHz	25 kHz
Power Output	AM: 125W* SSB: 400W PEP CW: 125W	AM: 25W*	AM: 25W*	AM: 30W*
Type of Emmission	USB: Compatible AM, (USB with carrier inserted)	Amperage and frequency modulated; double sideband, full carrier		
	SSB: (with carrier suppressed, USB or LSB)			

* Carrier power

C. Location and Operation

The communications systems, both flight management systems, and the weather radar are set and controlled from the cockpit. The flight management system can be controlled from the navigator's console. The control display units (CDU) for the inertial navigation systems are also located at the navigator's console.

2. Navigation Accuracy

The following are general guidelines of the accuracy attainable with selected systems under average flight and weather conditions.

A. Global Positioning System (GPS)

The global positioning system provides the most accurate location and motion coordinates for the aircraft. Accuracy is as follows:

Horizontal Position	49 ft
Altitude	49 ft
Ground Speed	1.0 kn
Track Angle	0.5 deg
Vertical Velocity	0.1 kn
Horizontal Velocity	1.0 kn

B. Distance Measuring Equipment (DME)

Distance measuring equipment permits locating the aircraft within a two-nmi radius. DME measures slant range and is not accurate directly over the station.

C. Inertial Navigation System (INS)

The inertial navigation system permits locating the aircraft with an average position error of less than two nautical miles (3.7 km) per flight hour. The INS also provides displays of present position (latitude and longitude), wind speed and direction, ground speed and track, and time and distance to next waypoint. These displays are updated every 0.6 seconds.

D. Flight Management System (FMS)

The flight management system accepts primary position information from short and long-range navigation sensors. Inputs from the DME, VOR, TACAN, and GPS are utilized to determine the aircraft's position. In addition to the navigation inputs, the system also receives true airspeed and altitude information from the air data computer (ADC) and heading reference from the INS. The primary position data received from the sensor is filtered within the FMS to derive a "best computed position" (BCP). Using the BCP, the FMS navigates the aircraft along the programmed flight path.

3. Navigation Planning

DFRC Flight Crew Branch navigators provide navigation planning and support to accommodate experimenters' requirements. A flight plan including positions, headings, airspeed, and altitude is developed for each segment of the flight. Additionally, a vector map of the route of flight, and when required, an altitude-profile, are provided.

4. Radar Tracking Beacons

Radar tracking of the aircraft by a ground station is sometimes needed for certain missions (such as operation near a sounding rocket range, or oceanographic measurements coordinated with a surface ship). Radar beacons to be placed on the aircraft must be supplied by the experimenter. Power supplies and controls for the transponder may be mounted on a standard equipment rack in the main cabin.

NOTE: Information and specifications defining radar beacons must be supplied in advance, to insure correct interface with aircraft power and fixtures.

CHAPTER 3

INTERIOR DIMENSIONS AND SUPPORT FACILITIES

1. General Information

The DC-8-72 is similar in size and basic furnishings to other four-engine, standard-body jet transport aircraft. Passenger seating, windows, lavatories, emergency oxygen supplies, and the general cabin environment conform to current commercial standards. Extensive modifications have been made to accommodate a wide variety of experiments; these will be described in this and subsequent chapters.

2. Cabin and Cargo Areas

Figures 3-1, 3-2, 3-3, and 3-4 give the general layout of the cabin, aircraft, and the cargo areas.

A. Figure 3-1

This figure illustrates a top and side view of the fuselage, and a plan view of the main cabin and cargo areas that identifies entrances, exits, housekeeping systems, the data system, and stations for the navigator and mission director. Optical viewports and electrical power outlets, for experimenters' use, are also identified at their approximate locations.

Positions within the aircraft are identified by station numbers (in inches) beginning with 0 at the nose and increasing to 1620 at the rear of the fuselage. The basic structural locators are the belt frames, 20 in. apart longitudinally, and running throughout the aircraft.

B. Figure 3-2

This figure identifies the antennas and their location. It also gives the frequency of each antenna.

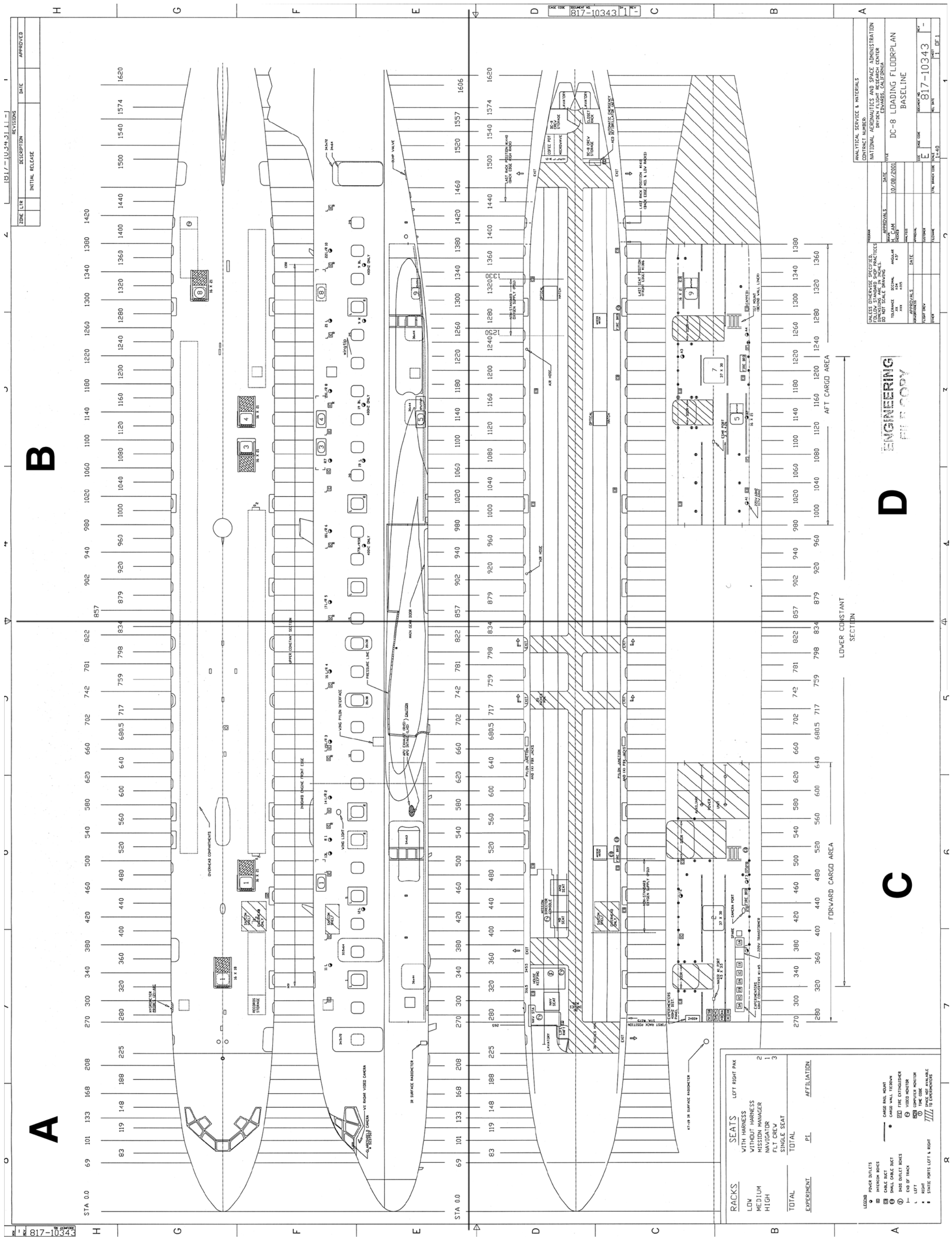


Figure 3-1. Plan and side views of the aircraft, overview.

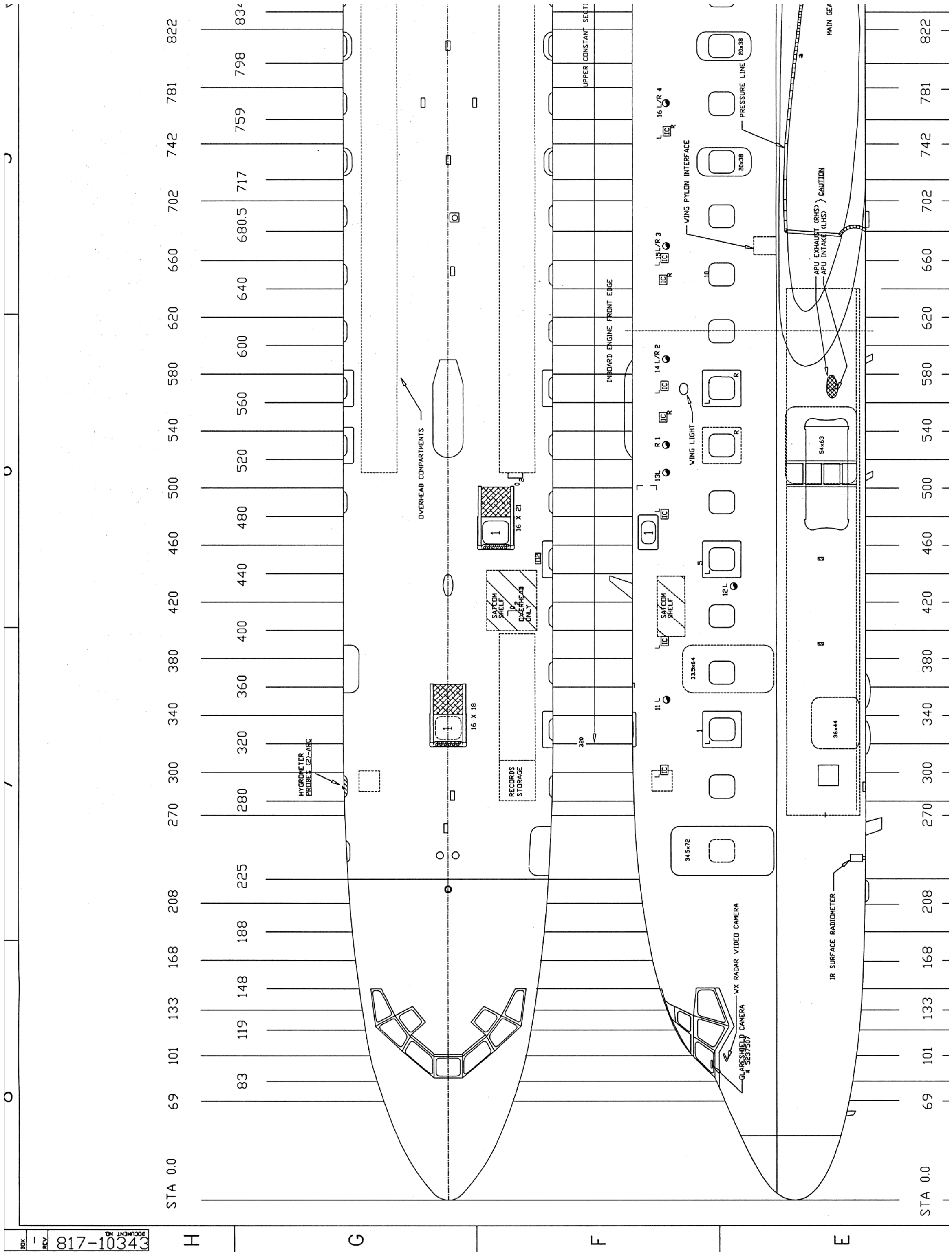


Figure 3-1(a). Section A.

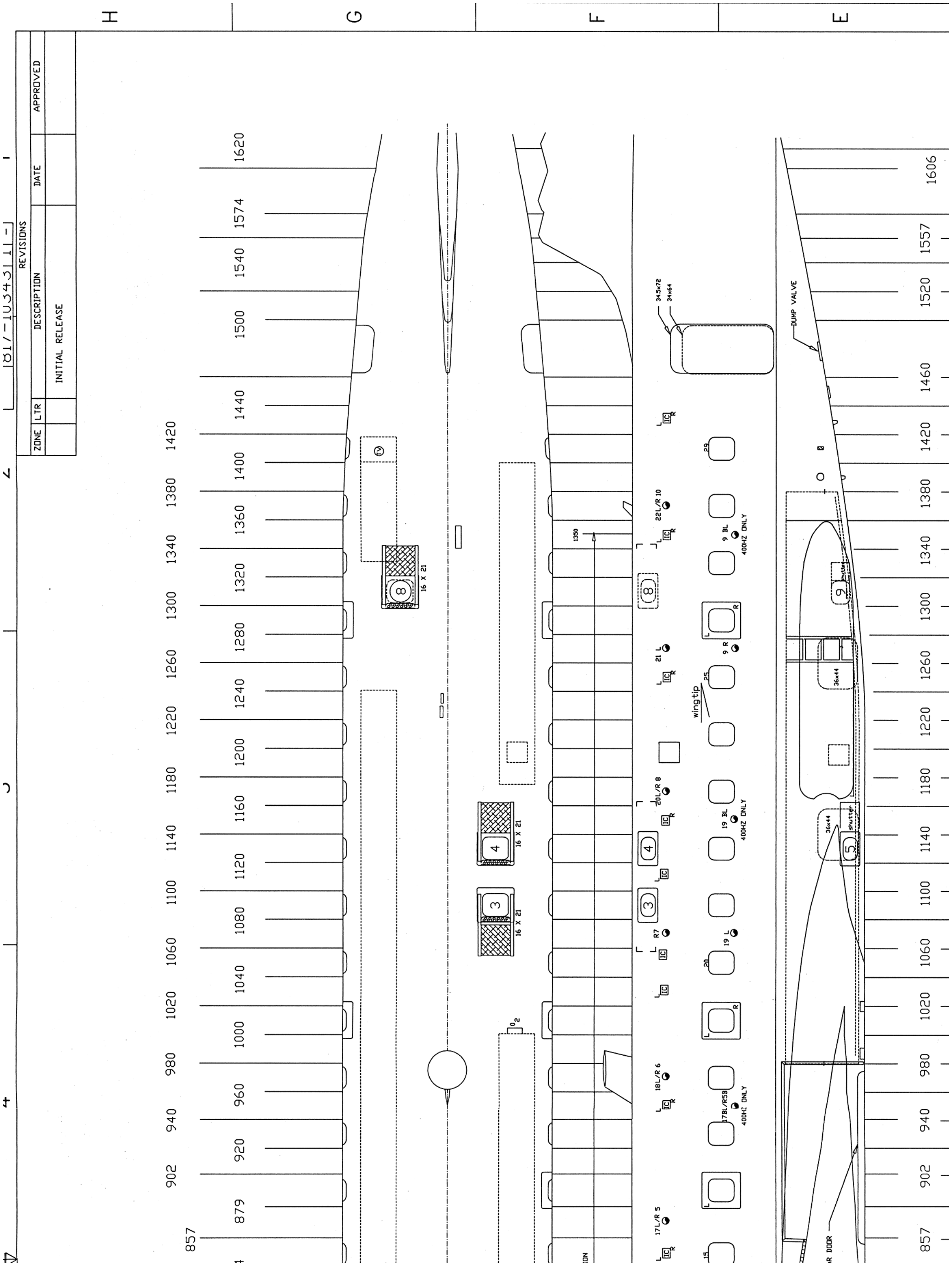


Figure 3-1(b). Section B.

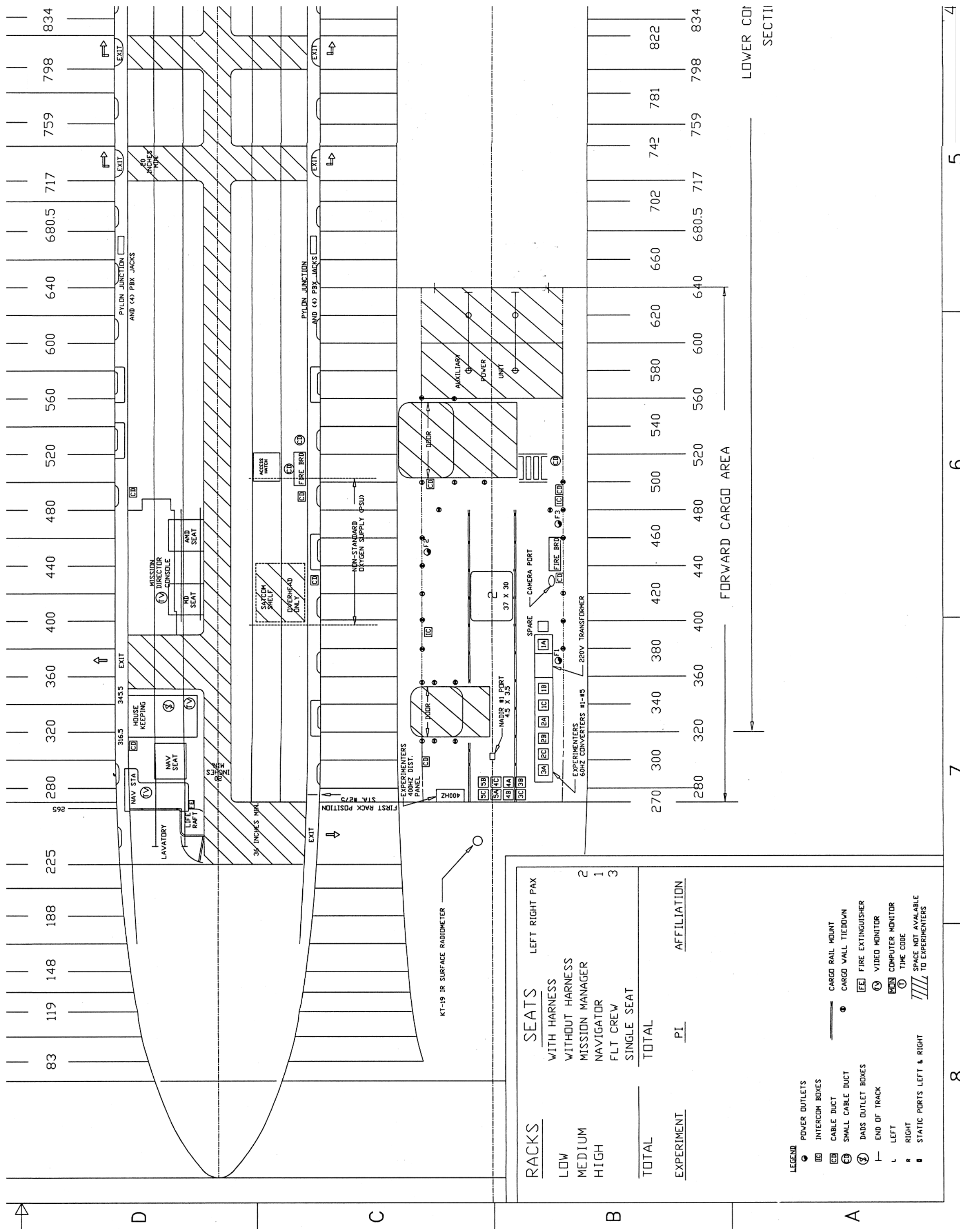


Figure 3-1(c). Section C.

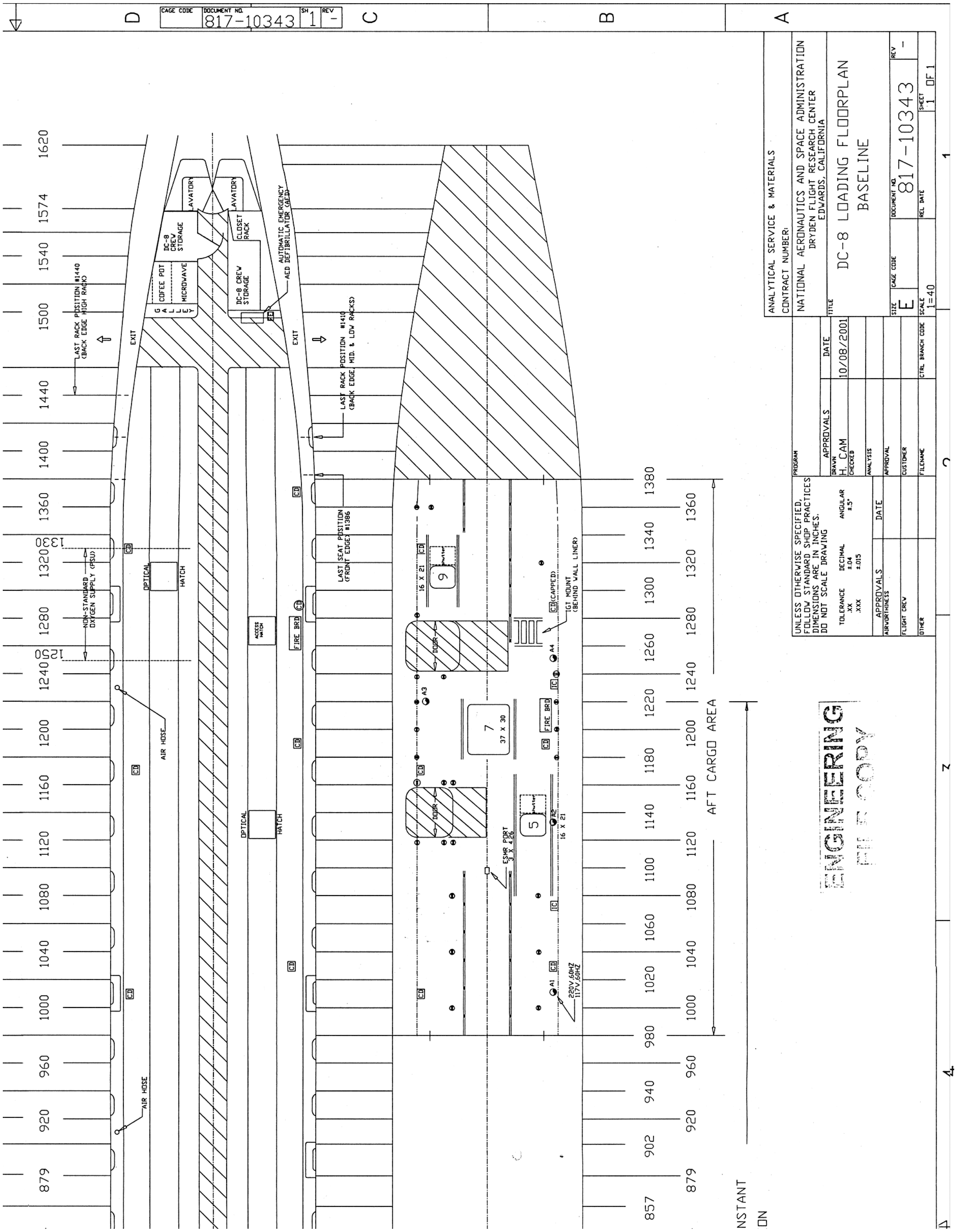


Figure 3-1(d). Section D.

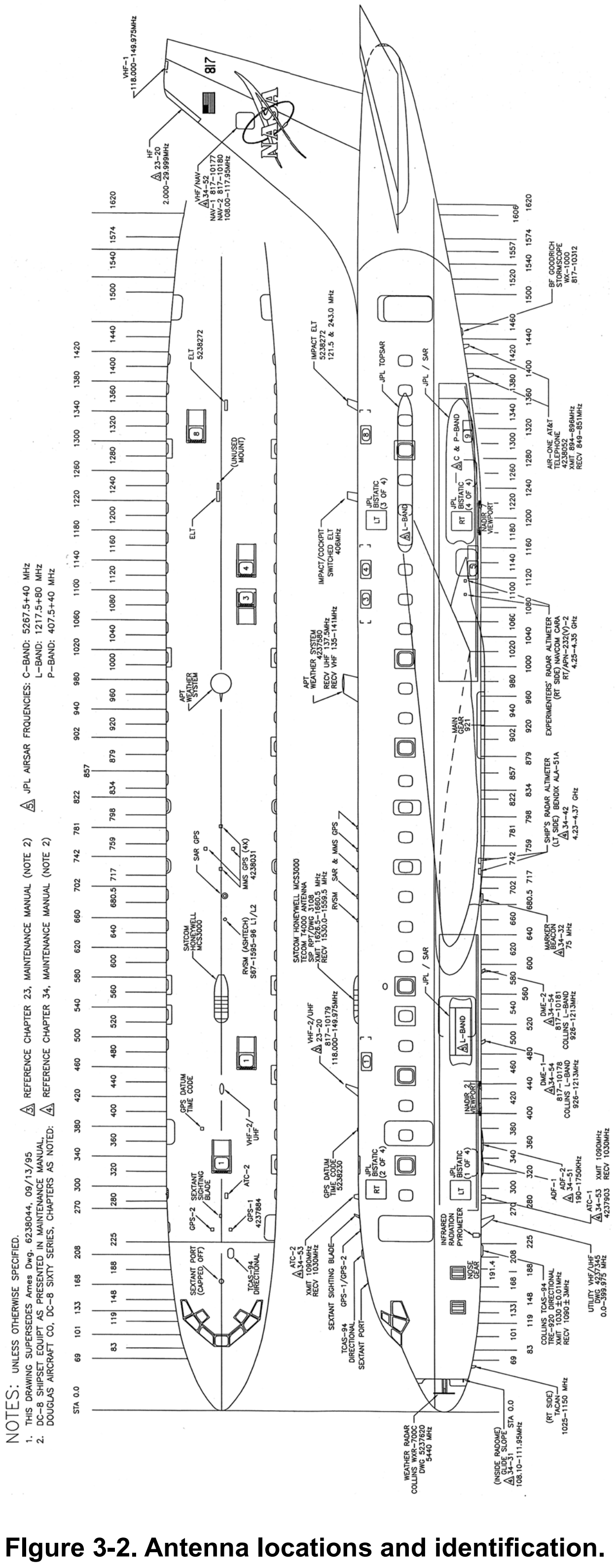


FIgure 3-2. Antenna locations and identification.

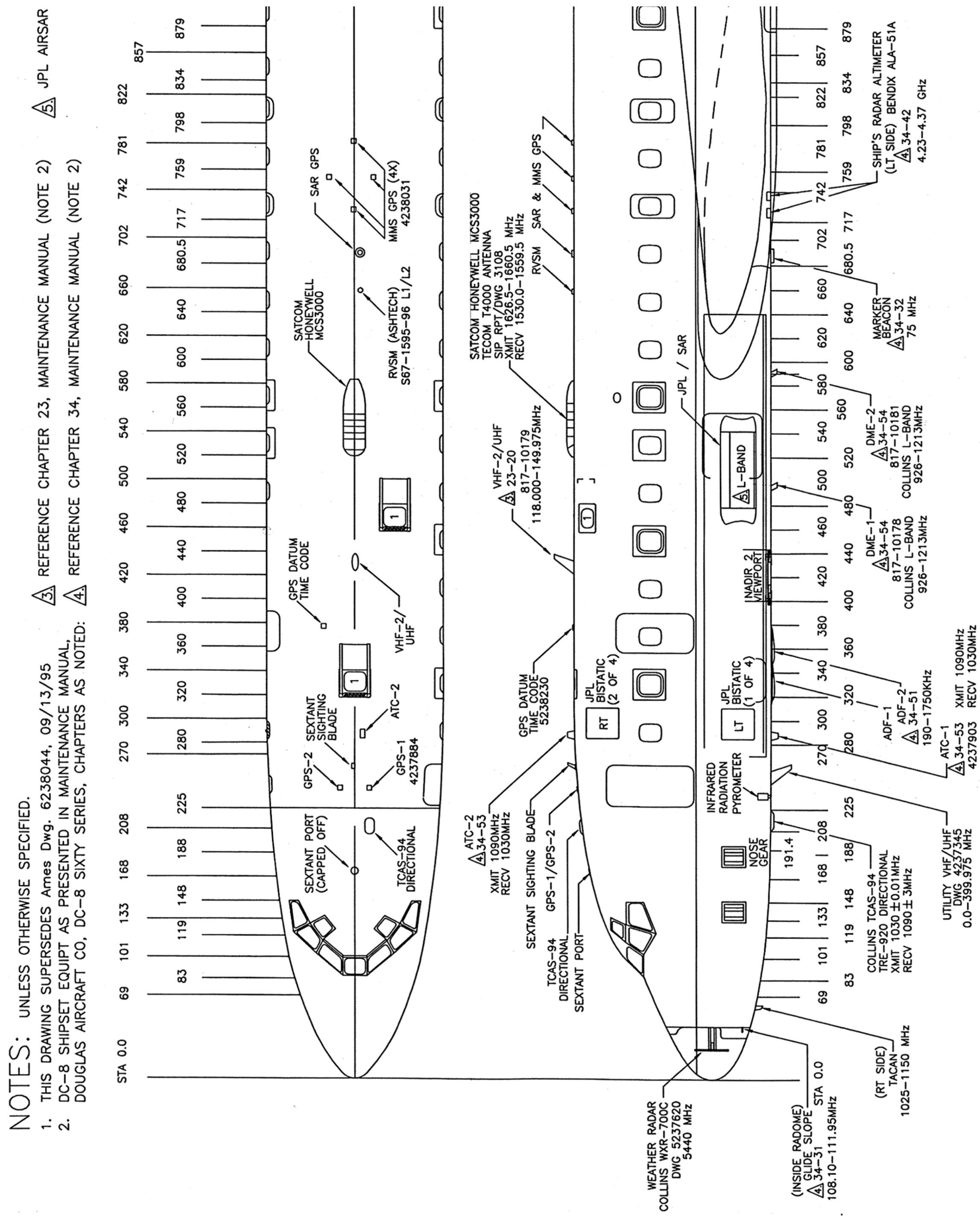


Figure 3-2(a). Section A.

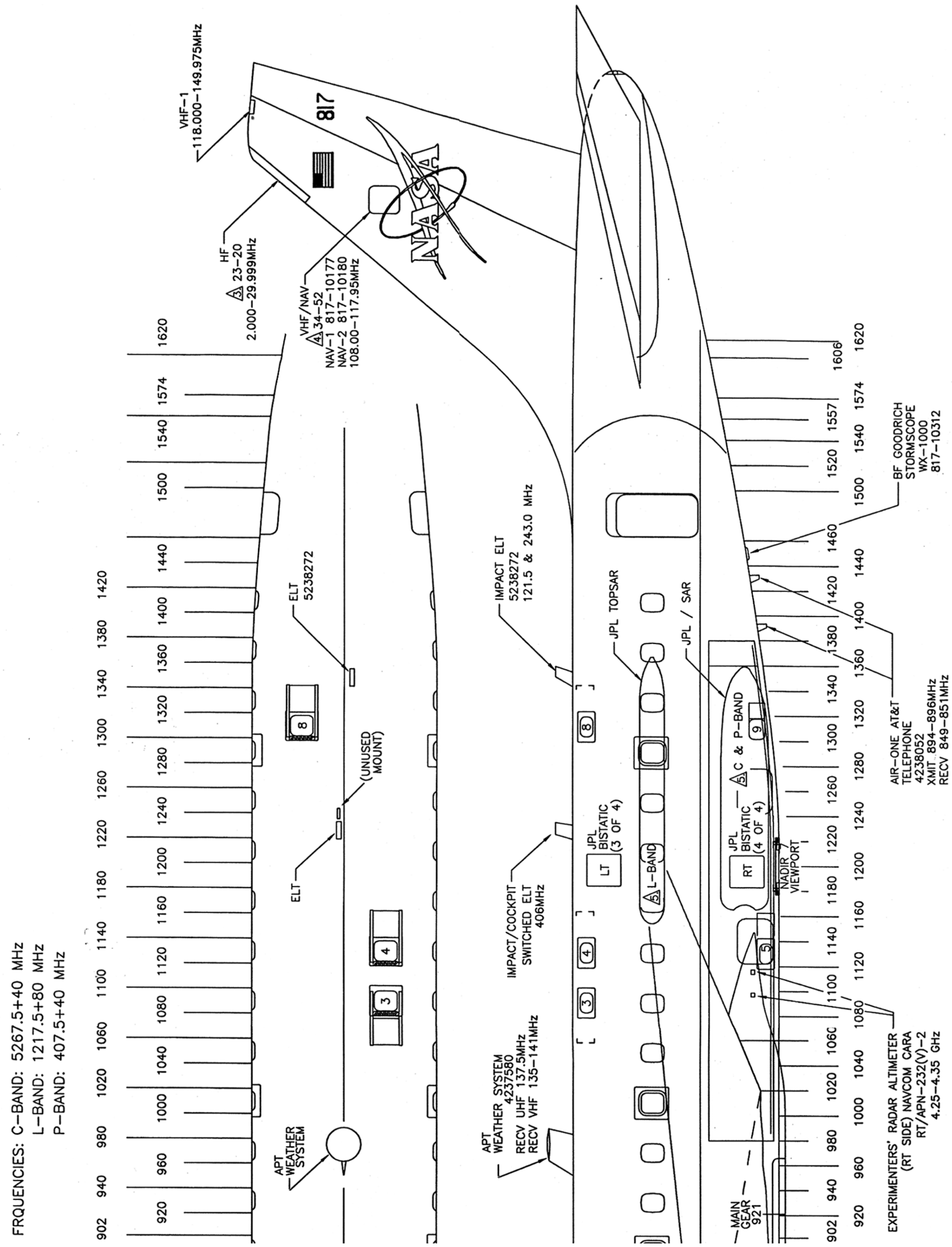


Figure 3-2(b). Section B.

C. Figure 3-3

This figure illustrates a cross section of the fuselage, which is approximately symmetrical about the vertical centerline. The illustration summarizes the space available in the cabin and cargo areas. The main cabin is 127.5 in. wide at floor level, with approximately 82 in. of headroom. The cargo area has Brownline rails centered 33.6 in. apart at floor level, with approximately 52 in. of headroom.

Four Brownline seat-support tracks extending the length of the cabin provide the primary attachment points for equipment racks.

The floor, made of aluminum panels, can withstand a distributed download; however, fore, aft, and lateral forces must be sustained by the seat-support tracks.

D. Figure 3-4

This figure illustrates the external access doors in the main cabin and two cargo areas.

3. Fuselage Access

The main cabin has two passenger access doors, approximately 34 in. by 72 in., on the left hand side of the aircraft. There are two similar service doors, approximately 33 in. by 64 in., on the right hand side. Only the aircraft crew may operate these doors.

CAUTION: When any of these four doors are in the open position, a stairway or a safety net must be in place.

There are two cargo areas and each has two exterior access doors, three approximately 36 in. by 44 in. and one 54 in. by 63 in., on the right hand side of the aircraft (figure 3-4). In addition, there are two interior floor hatches that are approximately 18 in. by 20 in., granting in-flight access to both of the cargo areas (figure 3-1).

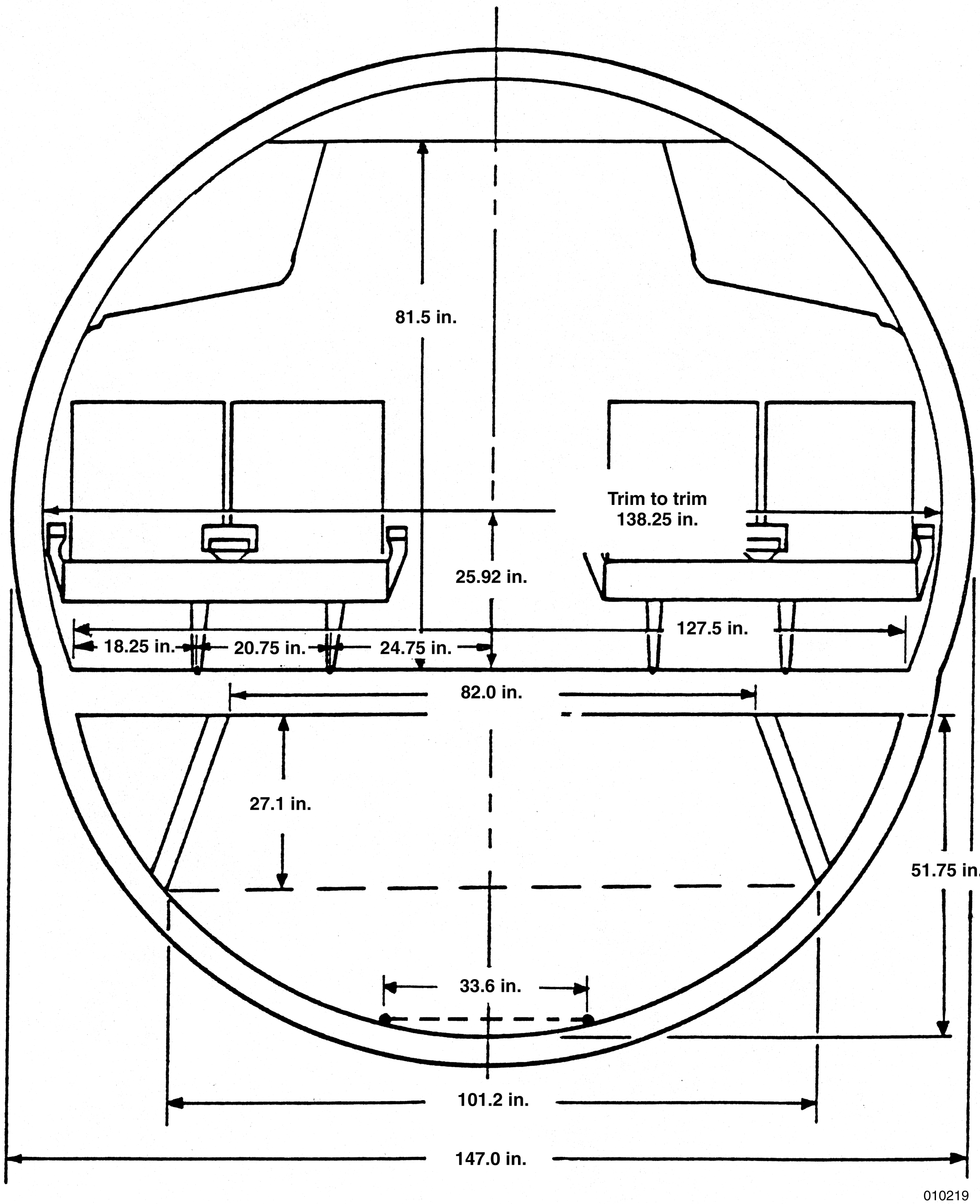
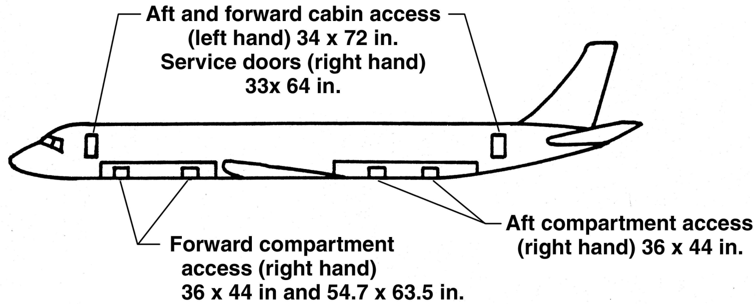


Figure 3-3. Cross section of the fuselage.



		A	B
Compartment	Door	Inches	Inches
Forward	Fwd	20.0	24.7
	Aft	8.0	28.0
Aft	Fwd	20.0	24.7
	Aft	13.0	20.0

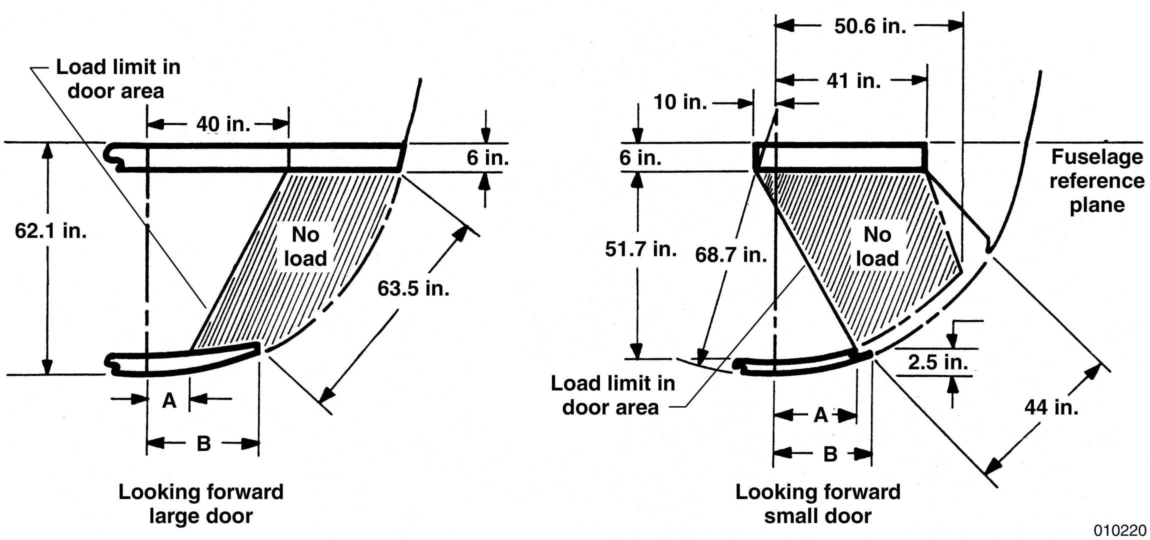


Figure 3-4. Cabin and cargo area acess doors.

4. Support Facilities

Facilities lending support to the experimenters' operations are listed briefly below.

A. Mission Director Console

The mission director and his/her assistant are stationed at a command console in the forward part of the main cabin (figure 3-5). This console is the central control point for mission operations. From here the mission director can control the power to the experiments, nadir viewport shutters, and the cabin communications systems including the intercom system.

The console also has controls for several research support instruments, specifically, hygrometers that measure atmospheric dew point or frost point, and an IR surface temperature radiometer. Radio/telephone communication with the ground, ships, or with other aircraft can be conducted from this location. An eight-channel closed circuit PBX system switchboard with an interface to an Inmarsat Satellite Communication (SATCOM) telephone is also located at the console.

Remote display units at the mission director console include closed circuit television from the data system (ICATS), video cameras, time code, NMS, radar and pressure altimeters, and cargo area temperatures.

B. Intercom System

The aircraft intercom system extends throughout the cabin and cargo areas, with outlets adjacent to wall power stations. The system has two channels of communication between the mission director and the experimenters. There are discrete channels to the cockpit and the navigator available to the mission director.

One of the channels is normally selected for general communication between the mission director and the experimenters. Upon request, experimenters needing a separate communications channel may use the second channel. Either or both channels will be recorded for an audio log using the aircraft's video recorders.

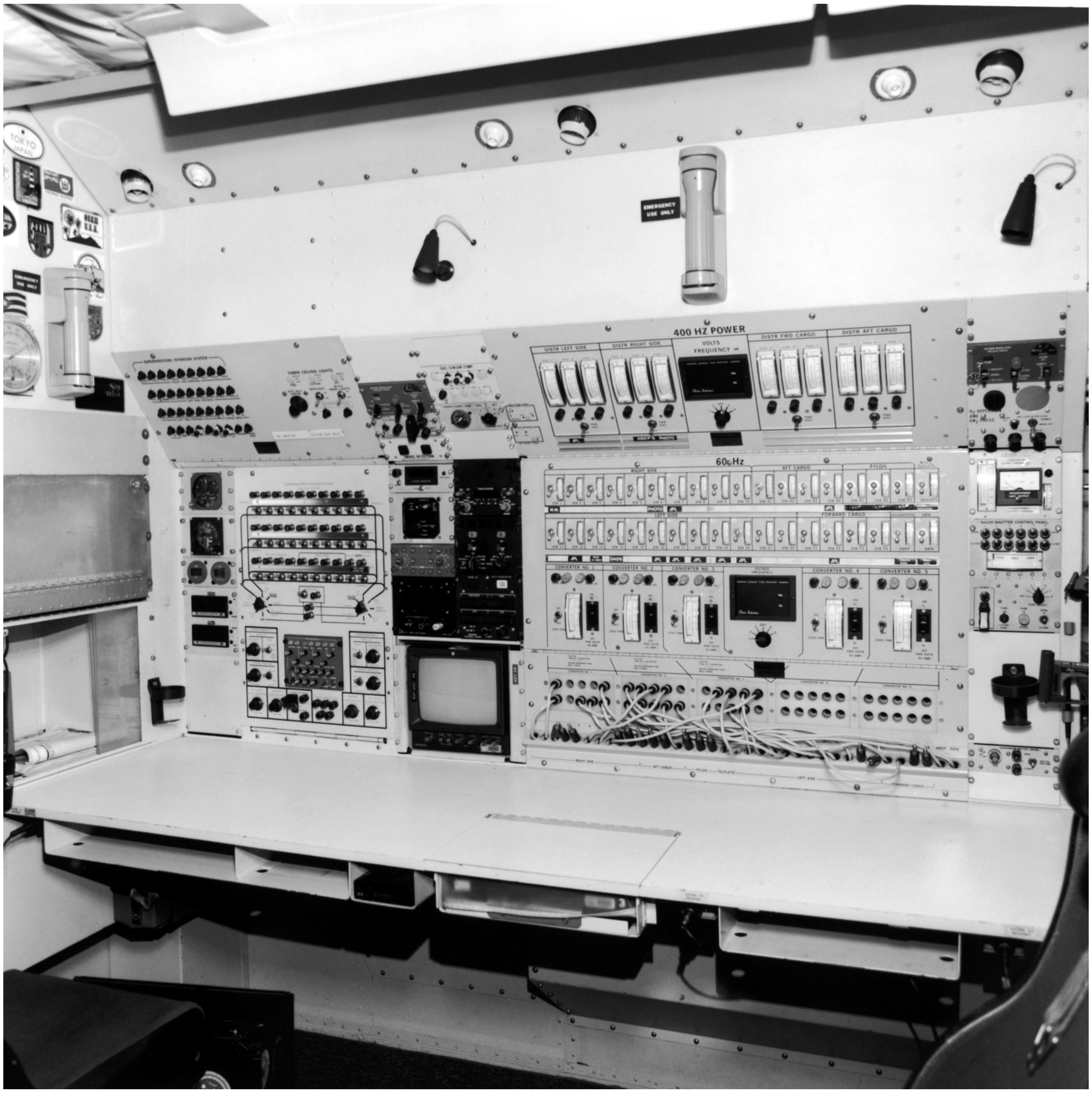


Figure 3-5. Mission director's console.

C. Liquid Nitrogen

Three 35-liter dewars can be located in the main cabin, and arrangements can be made for local storage of smaller amounts of liquid nitrogen at the experimenter's station.

CAUTION: Personnel must wear personal protective gear during in-flight and ground handling of liquid nitrogen.

D. Dry Nitrogen Supply

Cylinders of dry nitrogen can be placed adjacent to the experiment or in the cargo areas. Advance notice to the mission manager is required for these types of facilities.

NOTE: Aluminum cylinders are preferred for all types of gases.

E. Liquid Helium

A container system is available to transport liquid helium to field bases for experimenter use. One 60-liter or two 30-liter dewars can be accommodated. Advance notice to the mission manager is required for use of this facility. Shipment of liquid helium to a remote site by commercial or military aircraft is very difficult, and requires special arrangements. Most commercial cargo flights will not carry liquid helium. The most careful consideration should be given to consumption rates, and arrangements made well in advance to ensure adequate re-supply deliveries to remote sites.

NOTE: In-flight handling of liquid helium is not permitted aboard the DC-8.

F. Passenger Seats

Conventional airline type seats are installed aboard the aircraft, each accommodating two people and equipped with safety belts and shoulder harnesses. These seats are placed facing forward at intervals between equipment racks throughout the cabin. The location of the seats is fully adjustable, in one-inch increments, throughout the length of the aircraft. The seats feature a non-removable center console/arm rest extending three inches forward of the edge of the seat cushion. The console has compartments containing life preservers and emergency passenger oxygen systems (EPOS), also known as smoke hoods. The console is 26 in. high. Keyboard drawers installed in experiment rack should be 27 in. above the floor to avoid obstruction. Experimenters may indicate their seating preference, coordinating their seating with their equipment location. A limited number of individual swivel seats are also available for experimenters who require access to equipment from the side or aft of their seat while seated. All seats must face forward for take-offs and landings.

G. Wing Pylon Installation

A wing pylon can be installed near each wing tip to accommodate 100 lb (45 kg) of experimenter equipment. While each pylon is designed to hold two laser aerosol probes (such as PMS), other instruments of comparable size and weight could be used. Power, signal cables, and a dry nitrogen purge line are available at each pylon. Since pylon installations may require extensive structural and aerodynamic analysis to assure flight safety, it is mandatory that the mission manager be notified at least nine months prior to a proposed application.

H. SATCOM and AirOne Telephones

An Inmarsat Aero H Satellite Communications System (SATCOM) provides global in-flight voice and modem communications (excluding the arctic regions). Calls are placed or received by the mission director at the mission director console and then routed to one of eight handsets that can be located at experimenter stations in the cabin. Two SATCOM calls can be accommodated simultaneously. Data can be transmitted with prior arrangements.

The two-channel ATT AirOne telephone of the DC-8, provides air-to-ground communications within the forty-eight contiguous United States region only. This is a less expensive but more limited alternative to SATCOM. Experimenters must use a handset located at the mission director console to place calls using this telephone.

The cost of calls on both SATCOM and AirOne systems are charged to the appropriate mission sponsor as a mission peculiar cost.

A VHF radio for mission scientist communications is available with prior arrangements. VHF radio transceivers operate only in line of sight and are unsuitable for over-the-horizon communication.

CHAPTER 4

FUSELAGE VIEWPORTS AND WINDOWS

1. General Information

An assortment of special viewports, accommodating up to 16 in. (0.41 m) diameter clear aperture windows, have been installed in the fuselage at various elevations and longitudinal locations. In addition, several of the standard passenger windows have been modified for special viewport uses (see chapter 3, figure 3-1). These special viewports and windows can be used for optical viewing; therefore, they have been equipped with defogging systems and appropriate safety features that permit the use of various transparent materials. The ports will also accommodate aluminum plates that can be used to support external gas sample probes, small antennas, radiometers, and other lightweight units that require fuselage penetration.

Unmodified passenger windows are on occasion used for optical viewing when surface and transmission quality are acceptable. For example, film and video cameras can document surface or cloud information to support other instruments.

2. General Description

Viewports and windows in the cabin area are identified by their angle of elevation within the fuselage. There is one zenith (90°) viewport on the aircraft centerline, four 62° upward-looking viewports (three left and one right hand side), and ten passenger windows modified to be 8° viewports (six left and four right hand side). In addition, there are four nadir ports (downward looking). They are located in the fore and aft cargo compartments with one port in each cargo compartment on the aircraft centerline, and two smaller ports (both left and right hand side) in the aft cargo compartment positioned directly beneath 62° overhead viewports. There are hatches in the cabin floor aligned with these upper and lower ports so that an instrument may view up and down the vertical axis simultaneously. The zenith, 62°, and nadir viewports are equipped with external sliding shutters that can be opened and closed in flight. These shutters are to protect the external surfaces of the optical windows on the ground, and during takeoff and landing.

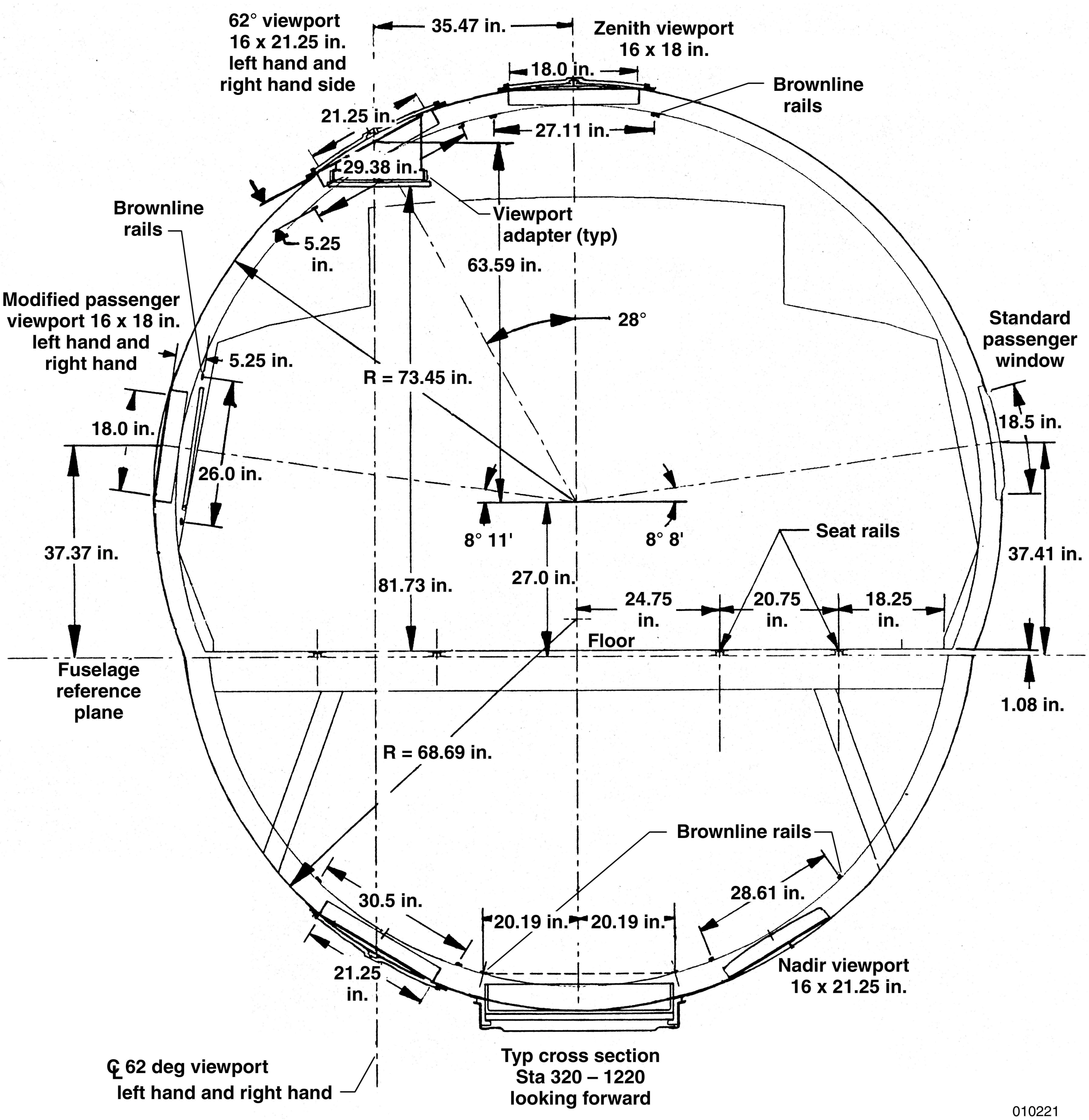


Figure 4-1(a). Viewport information.

Table 4-1. Location, aperture size, and load capacity of viewports.

Viewport	Approximate Location on Centerline	Size[1], in.	Number of Hardpoints[2]	See Figure:	Capacity[3] lb @ in.
Zenith, Nadir, and 62 ° Ports:					
Zenith no. 1	Sta. 330 C/L	16 x 18.0	4	4-4	100 @ 10
Nadir no. 2	Sta. 420 C/L	37.25 x 30.0	6	4-5	250 @ 24
Nadir no. 7	Sta. 1200 C/L	37.25 x 30.0	6	4-5	250 @ 24
62 ° no. 1	Sta. 470 LH	16 x 21.25	4	4-2	100 @ 10
62 ° no. 3	Sta. 1090 LH	16 x 21.25	4	4-2	100 @ 10
62 ° no. 4	Sta. 1130 LH	16 x 21.25	4	4-2	100 @ 10
Nadir no. 5	Sta. 1130 LH	16 x 21.25	4	4-2	150 @ 15
62 ° no. 8	Sta. 1310 RH	16 x 21.25	4	4-2	100 @ 10
Nadir no. 9	Sta. 1310 RH	16 x 21.25	4	4-2	150 @ 15
Camera Ports:					
Nadir no. 1	Sta. 300	5 x 3	0	-	-
45 °	Sta. 330 LH	3 dia.	0	-	-
Modified 8 deg Passenger Window Ports:					
8 °	Sta. 330 LH	16 x 18	4	4-3	100 @ 10
8 °	Sta. 450 LH	16 x 18	4	4-3	100 @ 10
8 °	Sta. 530 RH	16 x 18	4	4-3	100 @ 10
8 °	Sta. 570 L&R	16 x 18	4	4-3	100 @ 10
8 °	Sta. 890 LH	16 x 18	4	4-3	100 @ 10
8 °	Sta. 1010 L&R	16 x 18	4	4-3	100 @ 10
8 °	Sta. 1290 L&R	16 x 18	4	4-3	100 @ 10

1. Longitudinal (fore/aft) dimension appears first.
2. Minimum number required for experiment.
3. Total, perpendicular to the plane of the hardpoints.

3. Configuration Details

The location, aperture size, and load capacity of the viewports are given in figure 4-1 and table 4-1, while the detailed dimensions of frames and the immediate surroundings are given in figures 4-2, 4-3, 4-4, 4-5,and 4-6.

Figure 4-6(a) and (b) give the specifications of the viewports, size of the glass (and other selected materials), and the corresponding inner frame and the seal arrangements. Figure 4-7 gives the size and panel thickness of the standard passenger windows.

A variety of techniques are available for mounting optical windows in the fuselage viewports. Two representative samples are shown in figure 4-6(a) and 4-6(b). Figure 4-6(a) illustrates a 7.0-in. (17.8 cm) diameter window installed in an 8-deg (modified passenger) viewport, while figure 4-6(b) illustrates a 16-in. (40.6 cm) diameter window installed in a 62° viewport. In each example, the bare glass (or optical material) is surrounded by a cushion of silicon rubber gaskets, and then by a metal casing ring or plate, which protects the window during handling. This casing also allows the window to be mounted to an appropriate adapter, which in turn fits the viewport of the aircraft.

All optical viewports have internal sliding safety shields, to provide pressure safety and to protect the inner surfaces of the optical windows. Normally, the shields are closed when the viewport is not being used and during takeoffs and landings. Experiment installations should be designed to clear the safety shields. The shields may be refitted to accommodate an experiment, if justified by special requirements. Advance request of at least three months is required, to allow for approval, design, and fabrication.

4. Special Inserts

A special adapter is provided for 62° and nadir viewports, to position the optical window parallel to the cabin floor and permit viewing normal to the window surface (see figure 4-2). At any viewport, an approved metal plate sized to frame dimensions, may be used to mount an instrument or antenna (see figure 4-8). The load that these inserts can support without attachment to window hardpoints is limited. Each installation is considered individually and must be discussed with the DC-8 mission manager during the preliminary planning. Correspondingly, when hardpoints are used to support equipment that extends through the metal viewport insert (such as a blade antenna), the unique loading and sealing requirements must be treated as a special case.

5. Optical Windows

Numerous experimenters on the DC-8 have utilized optical (quality) windows. There is a limited stock of these windows, in various materials, held in secured storage. DFRC maintains a program of pressure/thermal testing and refurbishment, to meet aircraft safety requirements. Each optical window (or spare), from whatever source that will fly on the DC-8, must be inspected, tested, and approved as airworthy at DFRC test facilities prior to installation. Optical data files are maintained for these windows; the data includes transmittance, reflectance, flatness, and condition of surface or coating.

If an appropriate window is not available from stock, the experimenter must provide one. Either DFRC or the experimenter may supply the frames and the port inserts to accommodate the window materials.

Adapter plates must be used for all circular optical materials in order to adapt them to the standard rectangular shape of the aircraft window.

Special window requirements should be requested as early as possible, to allow for design, fabrication, and testing. Lead time to acquire finished optical materials can be six months or more, depending on composition and size.

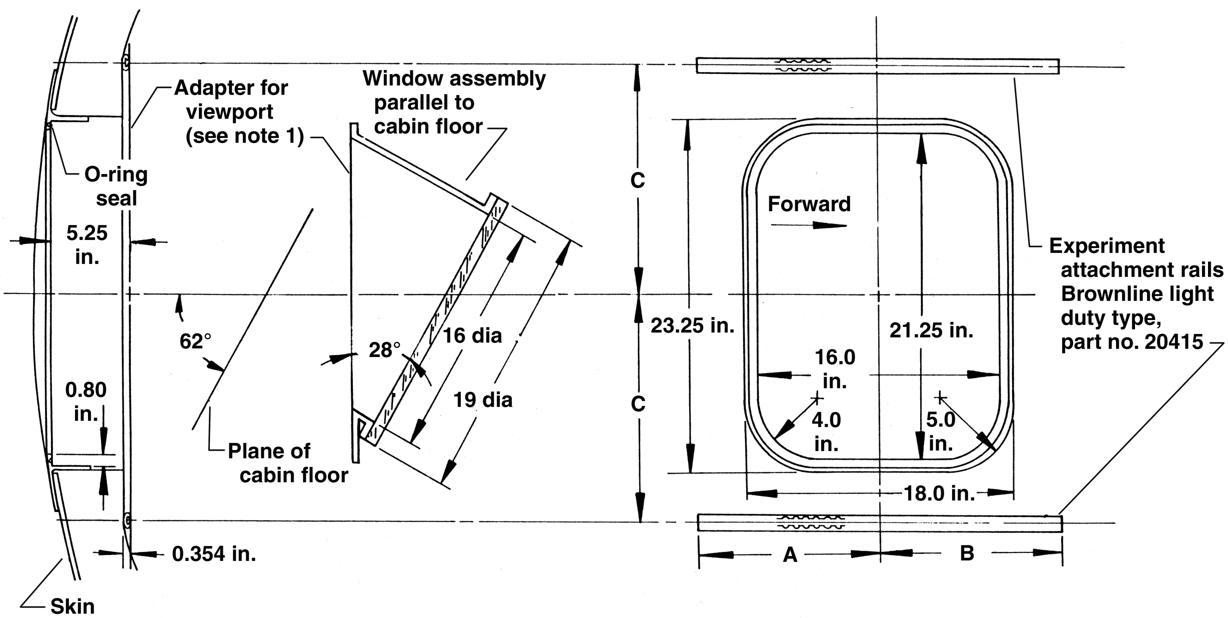
A. Window Materials

Stock full-aperture, 16 in. (40.6 cm) diameter, window materials include borosilicate crown glass (BK-7), and UV grade fused silica. There are also a variety of other optical materials, all less than full aperture in size, such as high-density polyethylene, IrTran, germanium, and Pyrex.

As a guide to the design of special-purpose windows, table 4-2 lists representative materials, sizes, and minimum allowable thickness. Note that circular shapes are strongly preferred due to lower stress levels. All edges of glass-type materials must be chamfered (figure 4-6) and scratches, digs, or un-smoothed edge chips may disqualify a window for use. It is mandatory that any window material be isolated from metal inserts or frames by silicone rubber gaskets (grade 40), with sufficient tolerance to prevent strain from thermal and mechanical effects. The optical characteristics of the standard unmodified passenger windows (figure 4-7) are given in figure 4-9.

B. Environmental Testing Of Optical Windows

Each window assembly, complete with frame and gaskets, is tested at DFRC prior to installation aboard the aircraft. To allow adequate time for testing, window parts must be at DFRC a minimum of four weeks prior to the scheduled installation. Each window must be marked to identify the cabin side before tests begin.



Notes:

1. Cylindrical adapter inserted into the viewport to install a 16-inch window parallel to the cabin floor.
2. Nadir number 9 is located in the conical tail section. Therefore, the window surface is inclined 5-degrees relative to the floor plane.

Viewport	A	B	C
62°, no. 1, 8	24	24	14 11/16
62°, no. 3,4	12	12	14 11/16
Nadir no. 5	37	51	15 1/4
Nadir no. 9	28	24	14 5/16

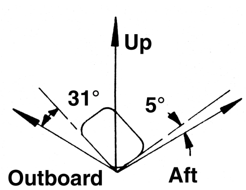


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Figure 4-2. Typical 62 ° viewports and nadir 5 and 9.

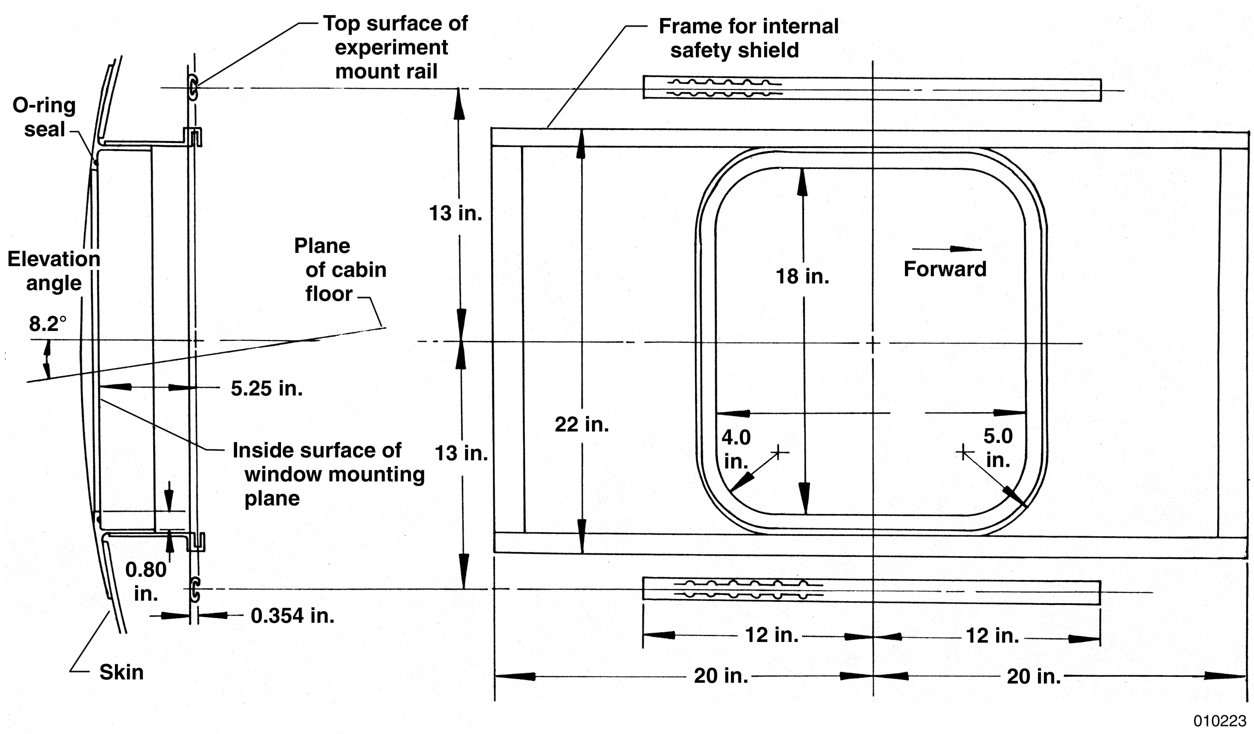


Figure 4-3. Typical 8° viewport.

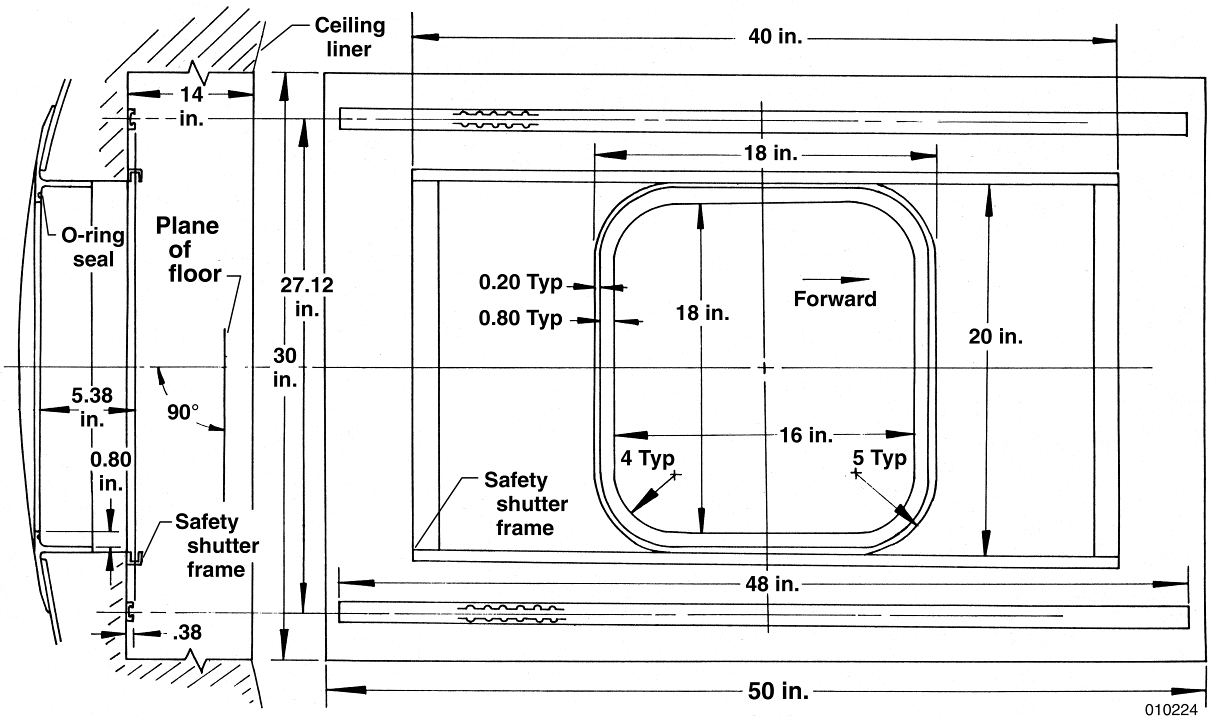


Figure 4-4. Typical zenith viewport.

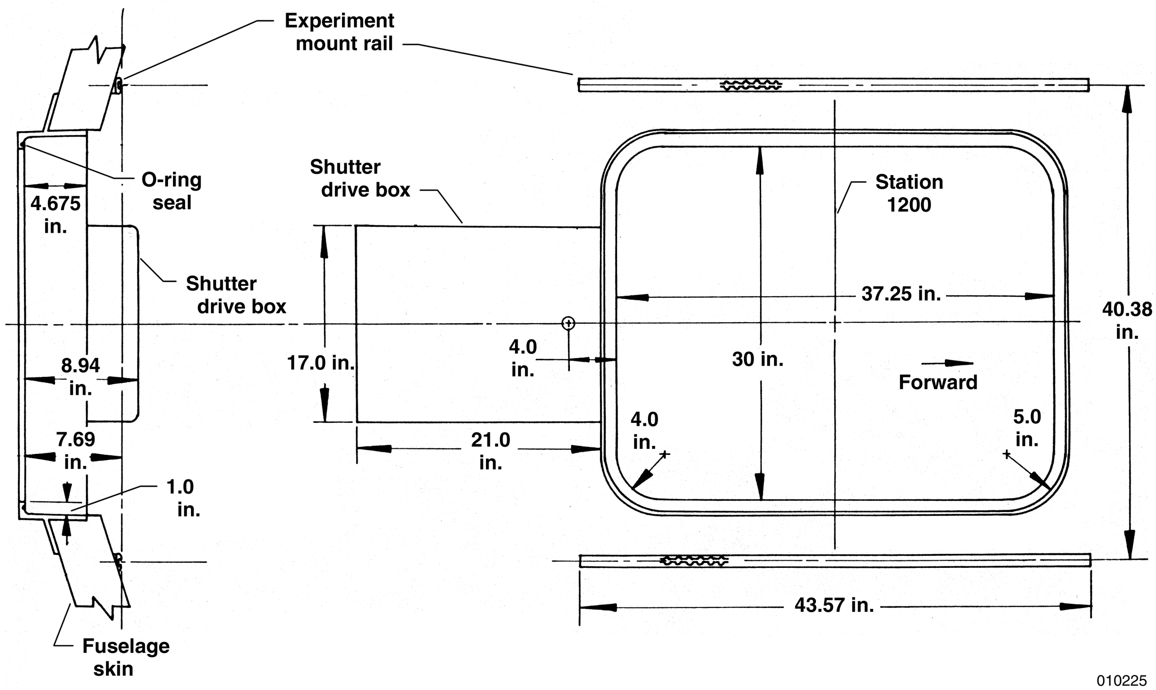


Figure 4-5. Nadir no. 7 viewport (nadir no. 2 similar).

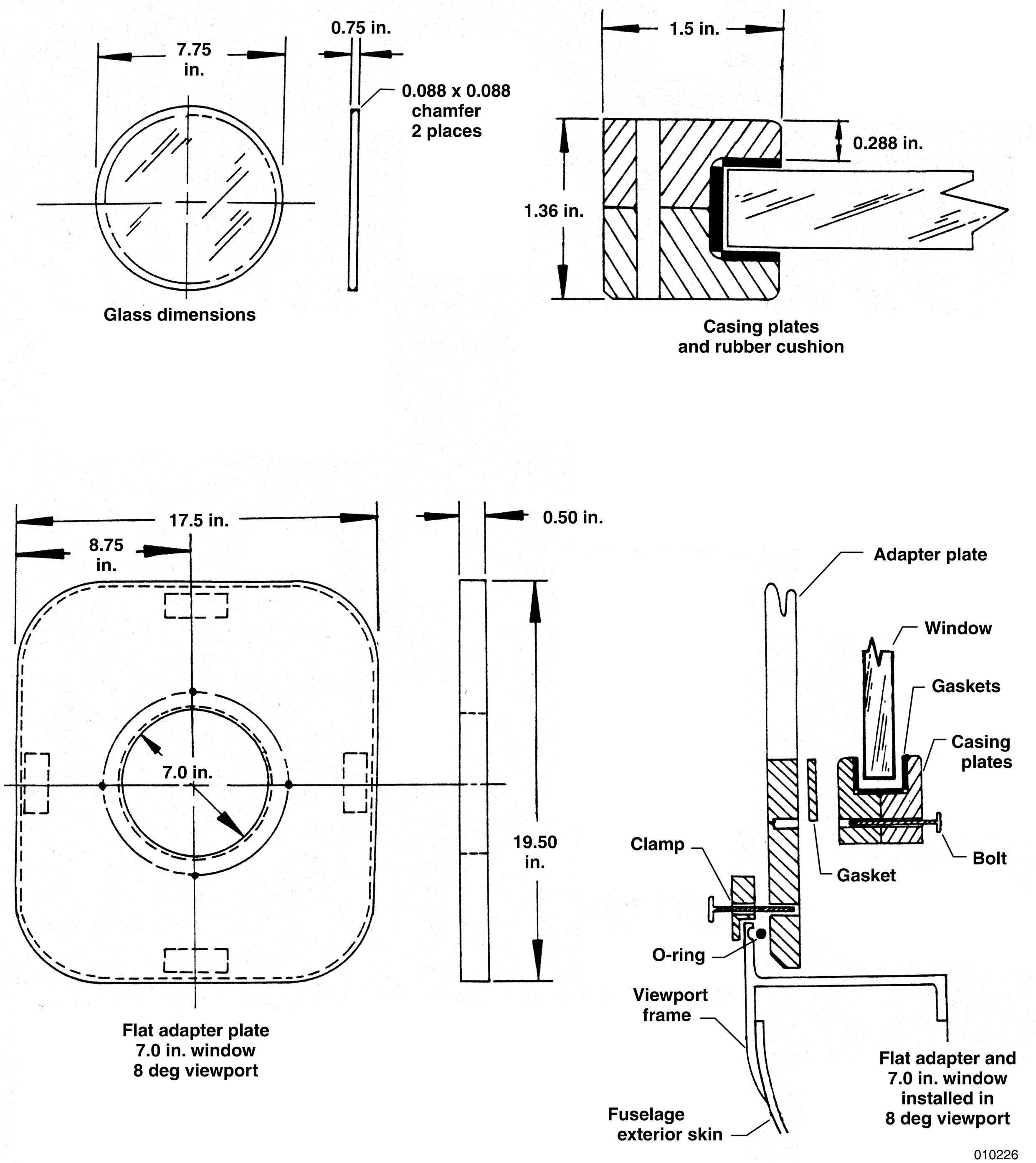


Figure 4-6(a). Optical viewport, frame and glass dimensions.

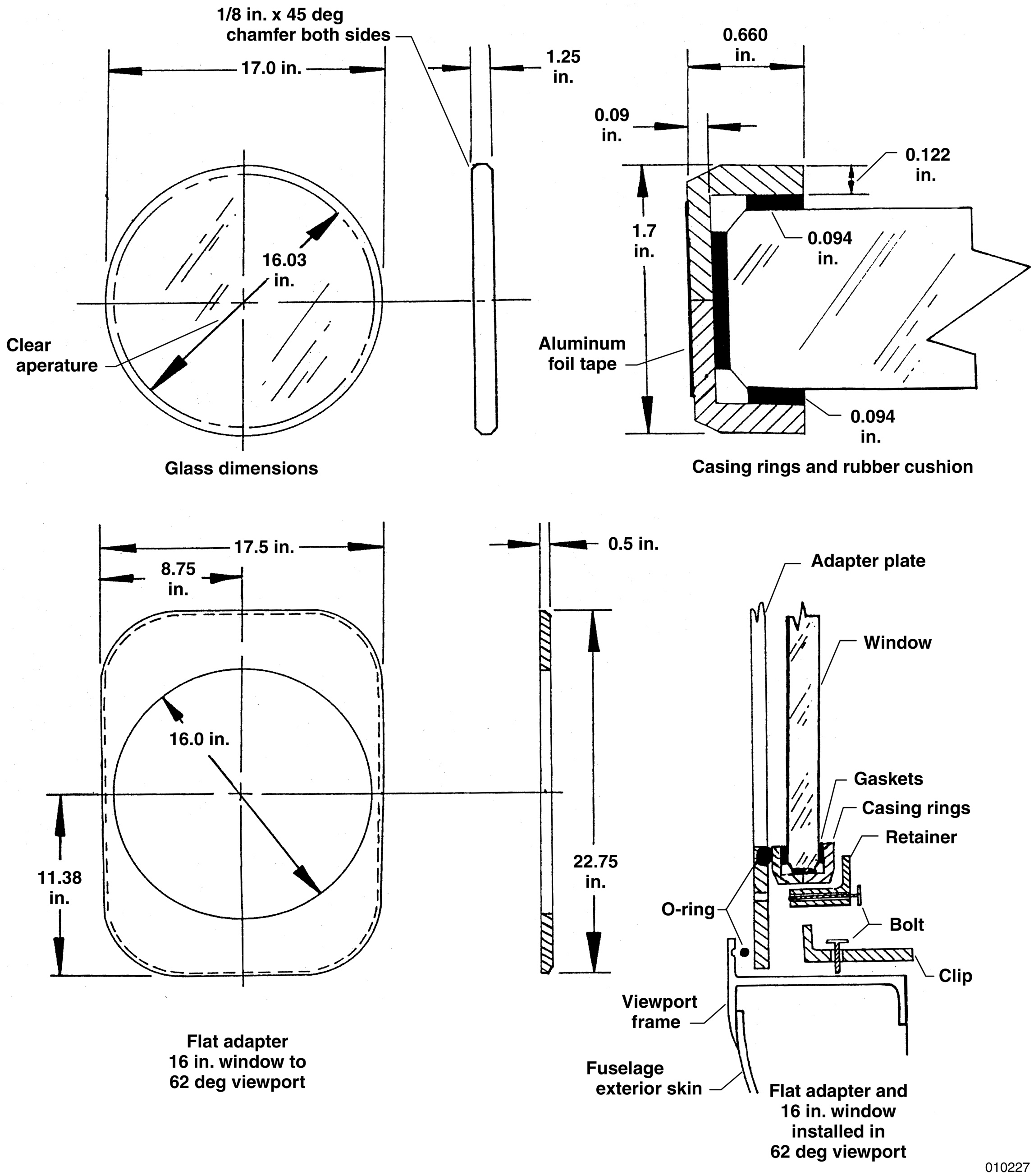


Figure 4-6(b). Optical viewport, frame and glass dimensions.

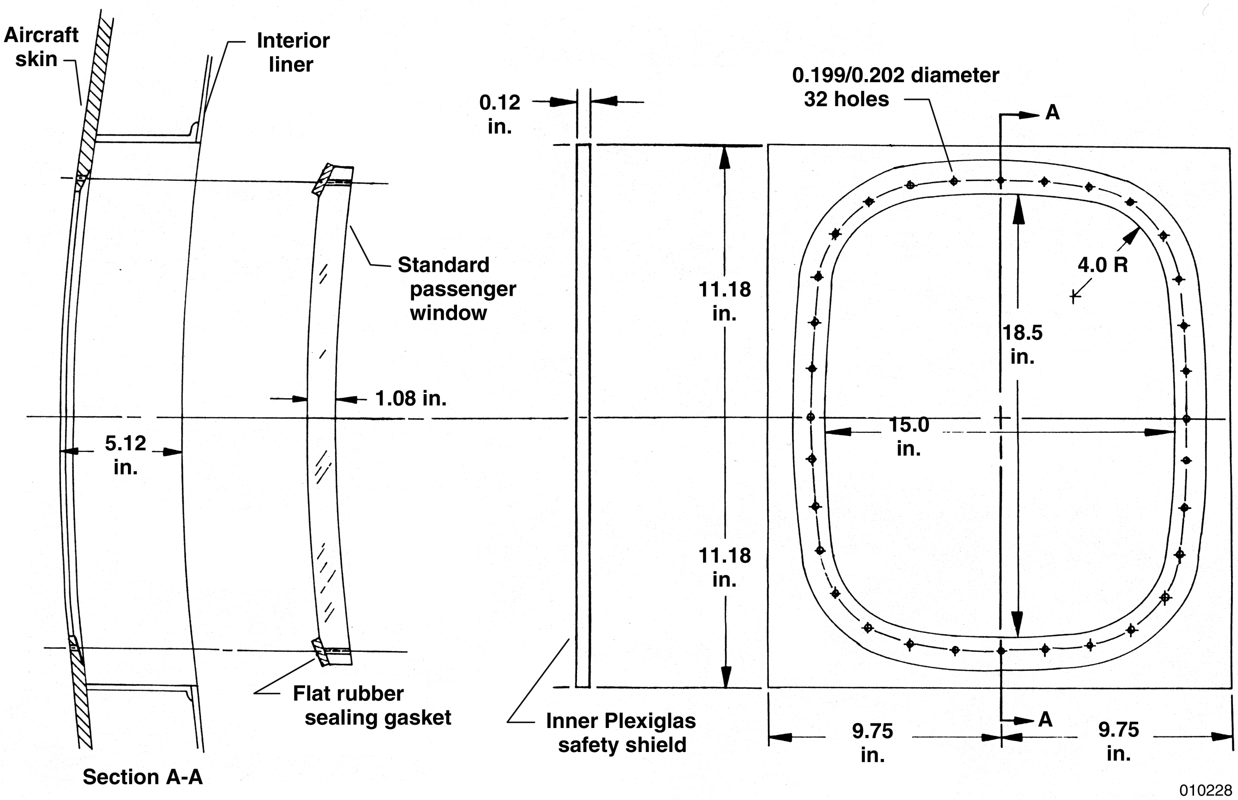


Figure 4-7. Standard unmodified passenger window.

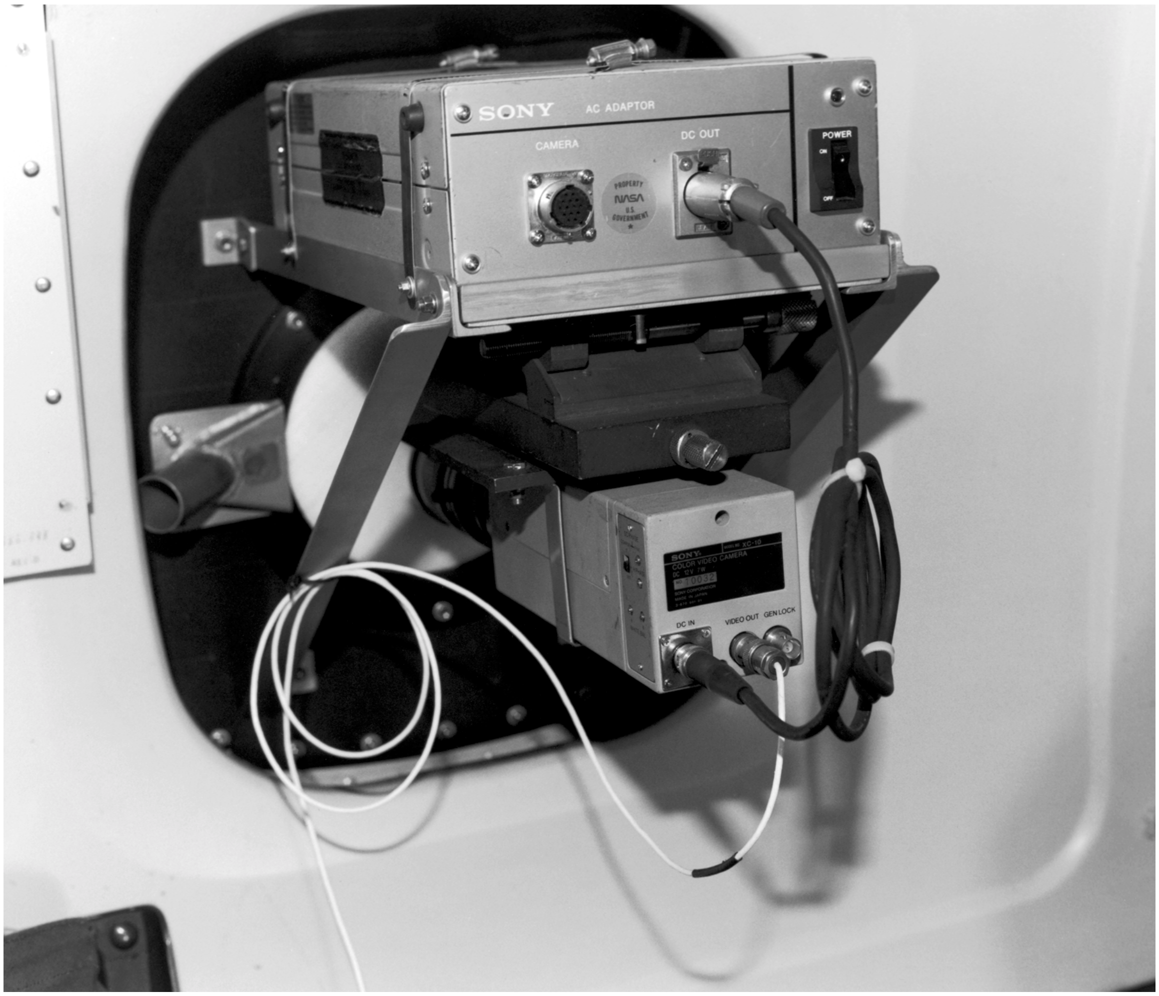


Figure 4-8. Radiometer on 8 ° insert panel.

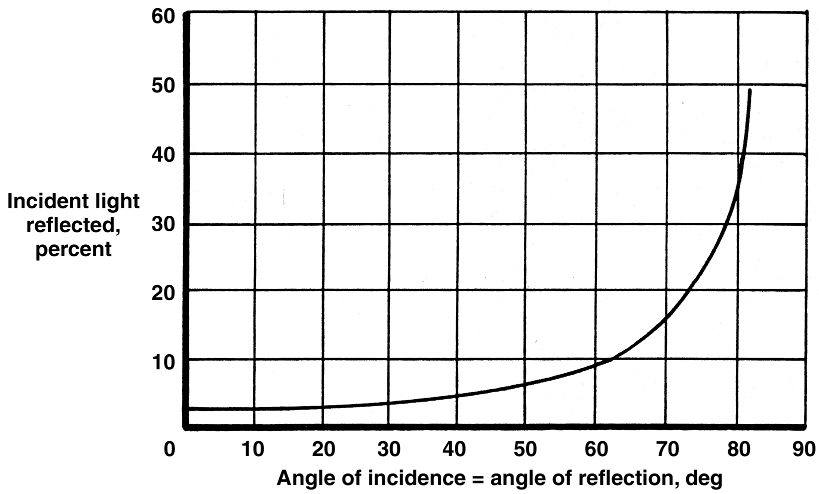
Table 4-2. Minimum thickness of window materials.

Material	Dimensions, in.		
	Outside Diameter	Clear Aperture Diameter	Minimum Thickness[1]
Soda Lime, Borosilicate Crown, Quartz, Fused Silica, Pyrex or Germanium	1.50	1.00	0.10
	2.50	2.00	0.20
	4.75	4.00	0.35
	6.75	6.00	0.50
	9.00	8.00	0.65
	11.00	10.00	0.80
	13.00	12.00	0.95
	15.00	14.00	1.10
	17.00	16.00	1.25
Zinc Selenide[2], Arsenic Trisulfide Glass, Calcium Fluoride, Polyethylene, Polypropolene, etc.	1.75	1.00	0.15
	2.75	2.00	0.25
	5.00	4.00	0.45
	7.00	6.00	0.65
	9.50	8.00	0.85
	11.50	10.00	1.05
	13.50	12.00	1.25
UHMW Polyethylene[3]	15.50 (diagonal)	14.5 (diagonal)	1.60

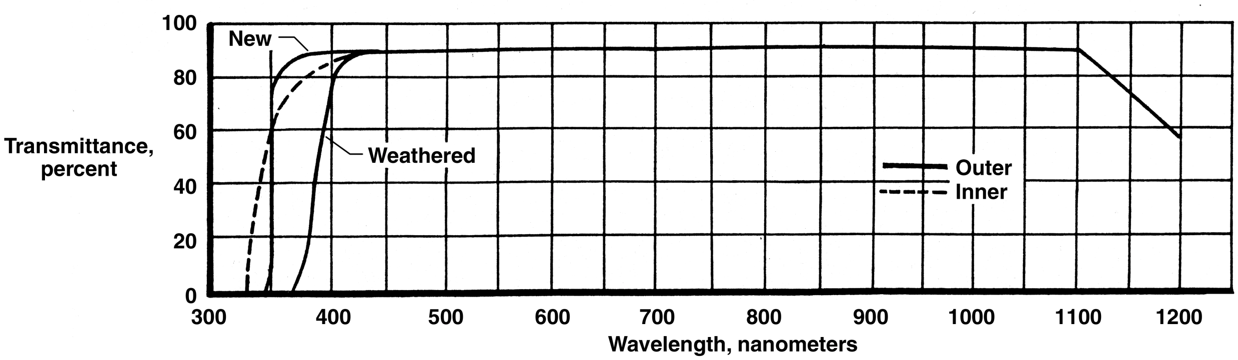
[1] Minimum thickness allowed. Greater thickness is allowable up to the space available in the port system. Generally, the maximum thickness that can be accommodated is 1.25 in.

[2] Window thickness for materials in this group will be individually determined, based upon physical properties.

[3] For non-circular windows, the minimum thickness is determined by the largest diagonal measurement.



Reflection from Plexiglas for unpolarized light



Transmittance of outer (double) pane and inner safety cover

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Figure 4-9. Optical characteristics of standard unmodified passenger windows.

The assembly is first subjected to a leak test by applying a pressure differential to the window and its mounting frame. This assembly is then subjected to a greater pressure differential at room temperature to proof test the glass. Then it is subjected simultaneously to a pressure and temperature differential to environmentally test the entire assembly. Obtain a copy of the "Airborne Science Optical Window Program Plan" from your mission manager, for window testing details.

After testing, the window assembly is held in secured storage until installation. If any disassembly or alteration is required, this test must be repeated. The nominal test procedure may be tailored to a specific window material when an appropriate fracture analysis is available.

C. Precautions After Installation

Assembly, adjustment, or repair operations to an experiment near a window must be performed with a window safety shield in place. Equipment should be designed so operations of this type take place with the shield closed. A scratch, gouge or chip in the window is likely to immediately disqualify it from further use. Therefore, the space between the optical window and safety shield should never be used for storage of loose items.

A defogging system is available for each modified viewport. Air supplied by the cabin gasper air system is directed across a designated window with a manually operated valve controlling the flow. The defogging system is normally adequate to prevent frosting or fogging at high altitudes. However, in regions of high humidity, if the aircraft has been cooled at a high altitude and descends quickly to an altitude where the optical surfaces have temperatures below the cabin dew point, condensation can occur on the window. If observations are then to be made, the window must be manually cleaned with an appropriate solution by an aircraft crewmember. If windows need cleaning, special arrangements for engineering assistance should be requested throught he mission manager.

6. External Airflow Parameters

A. Angle of Airflow Over Viewports

For experiments that have elements mounted external to the fuselage, it is important to know the angle of the local airflow over a viewport. Air sampling probes attached to window blanks are generally aligned with this angle to ensure proper operation. Table 4-3 shows the approximate airflow angle relative to the fuselage floor plane for the passenger windows. Tables 4-4 and 4-5 show the same information for 62° and nadir viewports. Note that these angles are for Mach no. 0.8, which represents cruise conditions. The angle varies slightly with speed and aircraft trim, therefore if designing for other specific conditions, you should request engineering assistance through the mission manager.

Table 4-3. Inviscid flow over passenger ports, relative to fuselage floor plan.

Window Number *	Fuselage Station	Flow Angle, deg	Window Number *	Fuselage Station	Flow Angle, deg
1	290	1.7	16	891	-7.8
2	330	2.1	17	930	-8.7
3	370	2.4	18	970	-9.2
4	410	2.7	19	1010	-8.7
5	450	3.0	20	1050	-6.9
6	490	3.5	21	1090	-5.4
7	530	4.3	22	1130	-4.2
8	570	6.4	23	1170	-3.4
9	610	10.6	24	1210	-3.1
10	650	9.3	25	1250	-3.1
11	691	4.5	26	1290	-3.3
12	729	1.0	27	1330	-3.4
13	770	-2.0	28	1370	-4.3
14	810	-4.2	29	1410	-5.3
15	846	-5.8			

Fuselage angle of attack: 1 deg (cruise conditions), Mach no. 0. 8
* See Figure 3-1

B. Boundary Layer Thickness

A thin, variable thickness layer of air, known as the boundary layer, exists at the skin of the aircraft. The properties of this air do not represent free stream, undisturbed conditions; therefore, experimenters should place their devices far enough away from the fuselage to be in free stream air. Free stream conditions can be obtained by placing the sampling device at a spacing defined as approximately 1.2 in. per 100 in. of distance measured from the aircraft nose. Station numbers represent the distance, in inches, from the nose of the aircraft. For example, a probe placed in the first passenger window at station no. 290 must be spaced away from the fuselage by: 290 x 1.2 divided by 100 = 3.48 in. (8.84 cm).

Table 4-4: Inviscid flow over 62° ports, relative to vertical centerline and fuselage floor planes.

62° Viewport Number	Fuselage Station	Flow Angle Y-Direction, deg	Mach = 0.8 Z-Direction, deg
1	470	–1.4	0.8
3	1090	2.2	–1.2
4	1130	1.8	–1.0
8	1310	1.2	– 0.7

+Y = Outboard
+Z = Up
Mach = 0.8

Table 4-5: Inviscid flow over nadir ports, relative to vertical centerline and fuselage floor planes.

Nadir Viewport Number	Fuselage Station	Flow Angle Y-Direction, deg	Mach=0.8 Z-Direction, deg
2	420	0.0	0.0
5	1130	–0.8	–0.1
7	1200	0.0	–0.1
9	1310	–5.5	2.6

+Y = Outboard
+Z = Up
Mach = 0.8

C. Fuselage Angle of Attack

At a Mach no. 0.8 and cruise altitude, the fuselage will have approximately a 1° angle of attack relative to the horizontal plane of the earth. Instruments that require an absolute line-of-sight should account for this angle in their design. Scanners and cameras are examples of instruments that often require an accurate nadir view.

7. Optical Windows

Numerous experimenters on the DC-8 have utilized optical (quality) windows. There is a limited stock of these windows, in various materials, held in secured storage. DFRC maintains a program of mechanical/thermal testing and refurbishment, to meet aircraft safety requirements. Each optical window (or spare), from whatever source that will fly on the DC-8, must be inspected, tested, and approved as airworthy at DFRC test facilities prior to installation. Optical data files are maintained for these windows; the data includes transmittance, reflectance, flatness, and condition of surface or coating.

CHAPTER 5

EXPERIMENT CONSTRUCTION AND INSTALLATION

1. General Information

The installation of experimenters' equipment onto the aircraft is one of the most difficult and time-consuming aspects of airborne research. Accustomed to the relative ease of commercial airline travel, experimenters may not fully comprehend the problems encountered in the secure mounting of airborne test equipment to comply with the mandated safety requirements.

For this reason, adherence to the specifications, deadlines, and technical requirements listed in chapters 4, 5 and 6 is expected.

NOTE: Due to manpower limitations, major engineering and/or construction defects cannot, ordinarily, be corrected during equipment installation. Therefore, in the past, some experimenters with unacceptable equipment have been required to withdraw at the last moment. Careful adherence to the standards described in this chapter, and the procedures and timing for equipment certification (see Equipment Certification and Hazardous Equipment and Materials Certification, sections 8 and 9 of this chapter), will ensure a relatively trouble free installation. These standards fully meet or exceed all FAA mandated safety requirements for DC-8 type aircraft.

2. General Arrangement

The mission manager customarily prepares the aircraft floor plan. The plan is based on experimenters' requirements, equipment, auxiliary systems and seating. In certain cases, however, a partial floor plan may be proposed by another organization, coordinating the efforts of several different experimenters. Individual requests for specific locations, as well as proposals with partial floor plans, will observe the following restrictions.

A. Exit Areas

Cabin exit areas and the forward and rear interior cargo access hatches will be kept clear at all times. A single overwing exit may be blocked, depending on cabin configuration.

B. Aisles

An aisle at least 20 in. wide, along the entire length of the main cabin, will be maintained.

C. Seat Spacing

The nominal passenger seat spacing is 38 in. (96.5 cm). Between the forward edge of any passenger seat and the aft edge of an instrument rack, 15 in. (38.1 cm) nominal is allowed. There is a center-located armrest which extends 3 in. (8 cm) forward of the seat cushion and is 26 in. (66 cm) high. Drawers mounted in outboard bays of standard instrument racks should be installed 27 in. (69 cm) above the floor to avoid obstruction.

D. Unavailable Areas

The housekeeping rack, the navigator console, and the mission director console are positioned between station 265 and station 480 on the right side of the cabin. This area is not available for experimenter equipment.

E. Cargo Areas

Limited cargo compartment floor areas are available to experimenters. On flights based away from DFRC, cargo space must be reserved for aircraft spare parts, aircraft support equipment, and baggage. This may require shipping experimenter support equipment to forward locations well in advance of actual DC-8 deployment.

3. Construction Guidelines

The design of aircraft systems and equipment installations for use on the DC-8 shall follow standard aircraft industry design practice and Douglas Aircraft design criteria. In addition, current FAA certification standards are to be met to the maximum extent practical, consistent with the intended mission of the payload. For more complete coverage of the design requirements, contact DFRC for a current copy of "DC-8/N817 Design Requirements." Brief guidelines for the construction of experimenter equipment follow.

A. Load Factors

1) Passenger Cabin and Cargo Areas

All structures, attachments and fasteners for racks, instruments, pallets, tie-down retainers, carry on items, etc. must be designed to withstand the load conditions listed below. These load factors, when applied one at a time, must not produce a stress in any structural element of the equipment beyond the accepted ultimate strength of that construction material.

Table 5-1. Minimum crash load design criteria.

Load Direction	**Ultimate Load Factor, g**	
	Passenger Cabin	Cargo Compartments
Forward	9.0	3.0
Down	4.5	4.5
Up	2.0	2.0
Lateral	3.0	1.5
Aft	1.5	1.5

The load factors listed are for the structural design of the equipment only. It is not required that alignment, calibration, or other instrument functions be maintained under these load conditions.

2) External Attachments

All external structures must be designed to withstand the maximum aerodynamic and gust loads encountered. A safety factor of 2.25 is applied to each of the maximum loads (except gust loads). Then the appropriate sums are compared with the accepted limits of the fabrication materials and surrounding structure. Close coordination with DFRC is advised.

B. Design Pressures - Cabin Environment

In general, experiment structures (other than optical windows) designed to act as a critical component of the aircraft's pressure vessel shall be designed to ultimate pressure, 2P (see table 5-2) plus flight loads and aerodynamic pressure or suction effects.

It is the policy of DFRC Airborne Science Directorate to design such structures at DFRC to experimenter requirements. Exceptions to this procedure require consultation, review, and approval of the mission manager and operations engineer prior to fabrication.

Table 5-2. Minimum pressure vessel design criteria.

Design Parameter	Pressure Limit, psi
Maximum Cabin Differential Pressure	8.77
Maximum Emergency Relief Pressure (P)	9.27
Design Limit Pressure	9.27 x 1.33 = 12.33
Design Ultimate Pressure (2P)	9.27 x 2 = 18.54
External Fuselage Pressure (Ditching)	Variable, depending on station number. Up to 15 psi on initial impact in the tail section and 12 psi in the nose due to pitch-over.

C. Materials

Aircraft structural material should be used on the design of special load-carrying supports. Aluminum such as 2024, 6061, and 7075 is readily available for this purpose.

Experimenters designing their experimental equipment should avoid using flammable materials or materials that emit toxic fumes. For example, the external cabling of commercial electronic components must have self-extinguishing insulation, such as Teflon or Tefzel. Accessories such as cable ties, clamps, or identification sleeves must be of a similar material (see chapter 6).

Polyvinyl Chloride (PVC) is not approved for use in airborne applications. Experimenters should carefully review their drawings and parts lists to insure that PVC insulated external wire or cable, or PVC hose is not specified. Internal wiring of commercial off-the-shelf products, such as computers, is excepted. PVC products cannot be used on the aircraft due to the highly toxic fumes and dense black smoke emitted upon exposure to high temperature (see chapter 6).

The use of toxins, flammable gases, or corrosive liquids must be approved by the mission manager prior to planning for an experiment. See section 9 of this chapter for additional information about certification of hazardous materials.

D. Welding

Welding structural members of experimental equipment may be acceptable; however, bolting and/or riveting are preferred. Welded structures should be avoided for significant load bearing and/or externally mounted structure. Where necessary, use stainless steel or steel. When welding is required, a welder who is currently certified to AMS-STD-1595 specifications must perform it. The assembly should then be heat-treated, if full joint strength is required. The welds must be performed in accordance with the “Fusion Welding for Aerospace Appliations” SAE-AMS-STD-2219 specification. Proof of conformance to both specifications must be submitted with the welded assembly. If this is not done, the assembly will be subjected to rigid NASA DFRC inspections and, if not passed, may not be permited on the aircraft. Care must be taken to use only materials suitable for welding. Welding is not permitted on the aircraft.

E. Fasteners

Standard aircraft structural fasteners (MS, NAS, or the equivalent) must be used for all structural members and must be secured by some locking method (such as self-locking nuts, lock washers, cotter pins, or safety wire.) This requirement includes the installation of components into standard DC-8 equipment racks, and mounting on other support frames or aircraft hard points. These types of fasteners should also be used for other elements of the equipment whenever possible.

Data sheets, giving detailed nomenclature and the engineering specifications for this type of hardware and a list of suppliers is available on request.

F. Hydraulic or Pneumatic Systems

Hydraulic and pneumatic lines and fittings should be aircraft quality, or equivalent, and should operate at the lowest pressure possible. Fluids should be non-flammable, non-corrosive, and non-toxic.

G. Alignment with Existing Hardpoints

Experimenters' equipment to be attached to aircraft hardpoints, existing shelves, viewport Brownline rails, or to the top of DC-8 standard racks, should be match-drilled at assembly. Local fitting dimensions may vary slightly from nominal values, and safety requirements may preclude the use of slotted or enlarged holes to obtain a fit.

H. Aircraft Fuselage Penetrations

Fuselage penetrations larger than one-half in. diameter from the pressurized areas of the aircraft to the aircraft exterior for probe inlet or exhaust tubes require shutoff valves. The valve should be located in the proximity of the bulkhead penetration.

4. Aircraft Vibration

In-flight vibrations are generally not a problem for experimenters as the DC-8 exhibits a low level of vibration characteristic of large jet aircraft. Figure 5-1(a), 5-1(b), and 5-1(c) show the in-flight vibration spectra in five areas of the aircraft.

Vibration frequencies and amplitudes imparted to experimental equipment are subject to the widely varying contribution of different mounting structures. If instrument components are sensitive to any of the frequencies at the power densities shown, then it is recommended that isolation mounts for these components be considered in the over-all design of equipment. Captive-type isolators should be used.

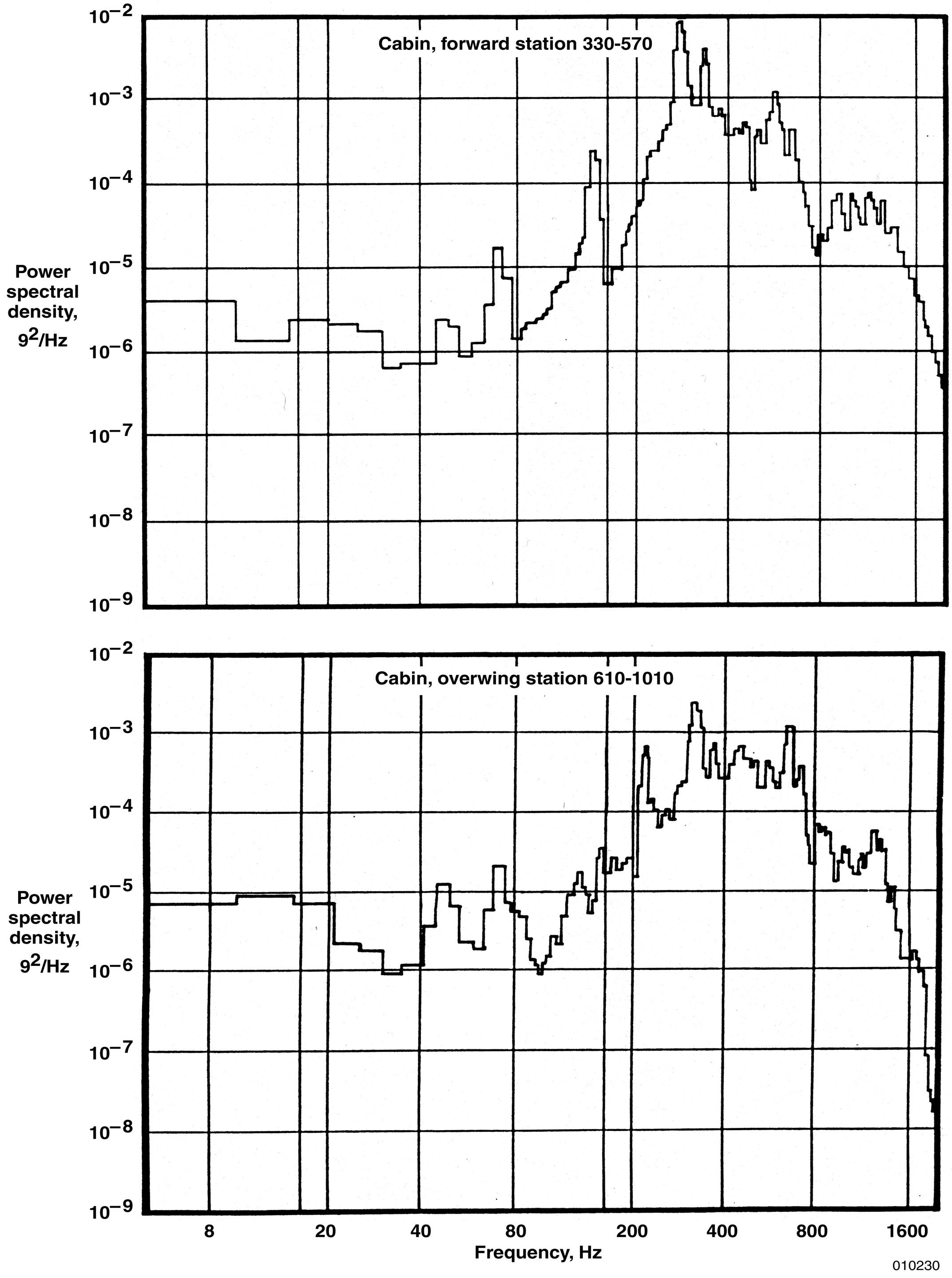


Figure 5-1(a). In-flight vibration spectra.

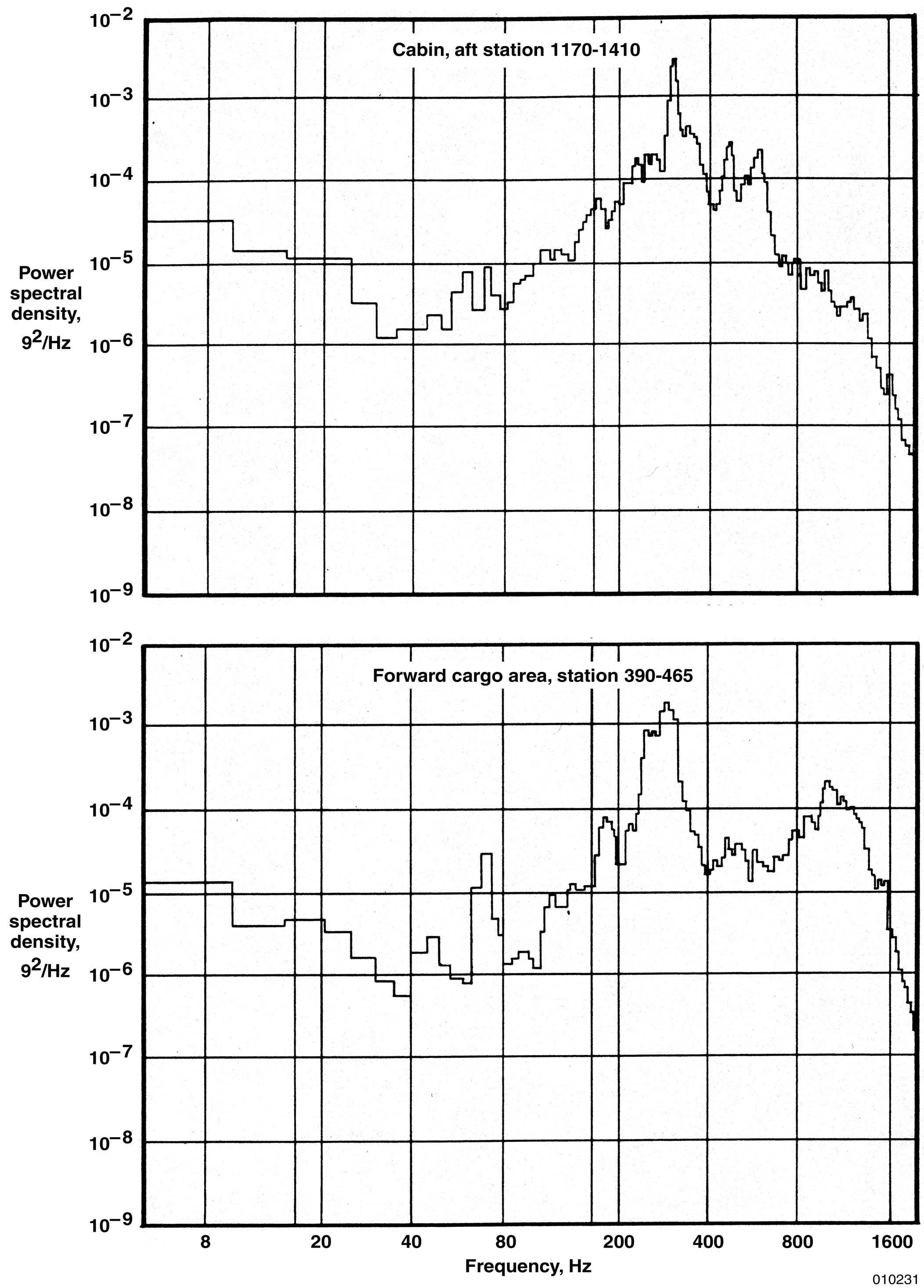


Figure 5-1(b). In-flight vibration spectra.

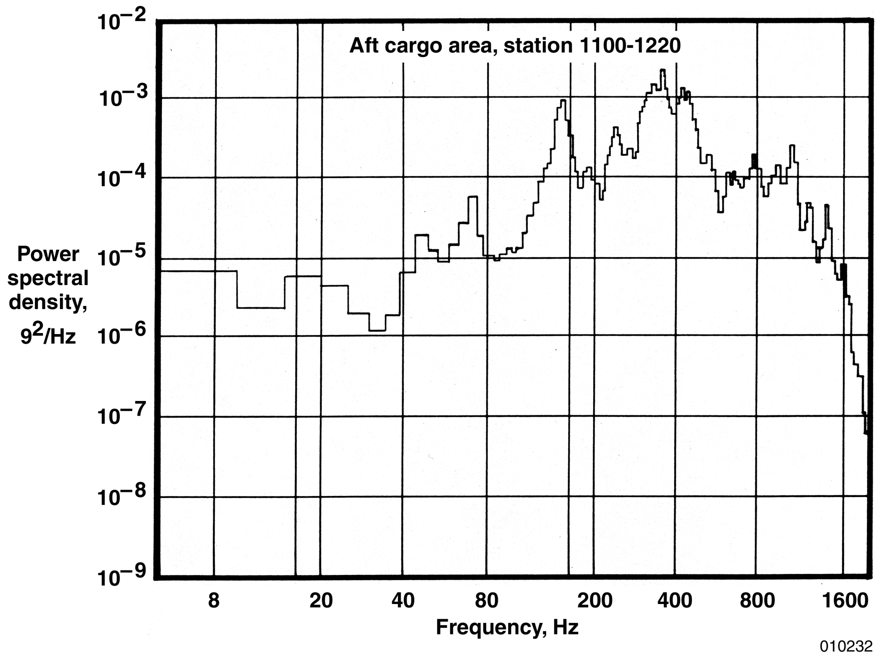


Figure 5-1(c). In-flight vibration spectra.

Experimenters should remember that, except for air turbulence, the most severe vibration usually occurs during taxi, take-off and landing. For example, on rough runways, printed circuit cards and connectors have become dislodged, and optical components have been jolted out of alignment. Mechanical support, by clamps, brackets or dampener should be provided as a precaution, for such problems may prove difficult to correct in flight. Representative values for these conditions are one-quarter to one-half at 10 Hz and below.

The DC-8 mission manager should be consulted for specific guidance on vibration-related concerns. Arrangements can be made for component tests at DFRC, if required. The test facility generates sinusoidal forces up to 8,000 lb, at frequencies from 5 to 2,000 Hz, and random forces up to 5,000 lb. Components up to 24 in. in size can be tested, one axis at a time, at accelerations up to 100 g.

5. Structural Attachments

Guidelines follow for the attachment of experimenters' equipment to the aircraft.

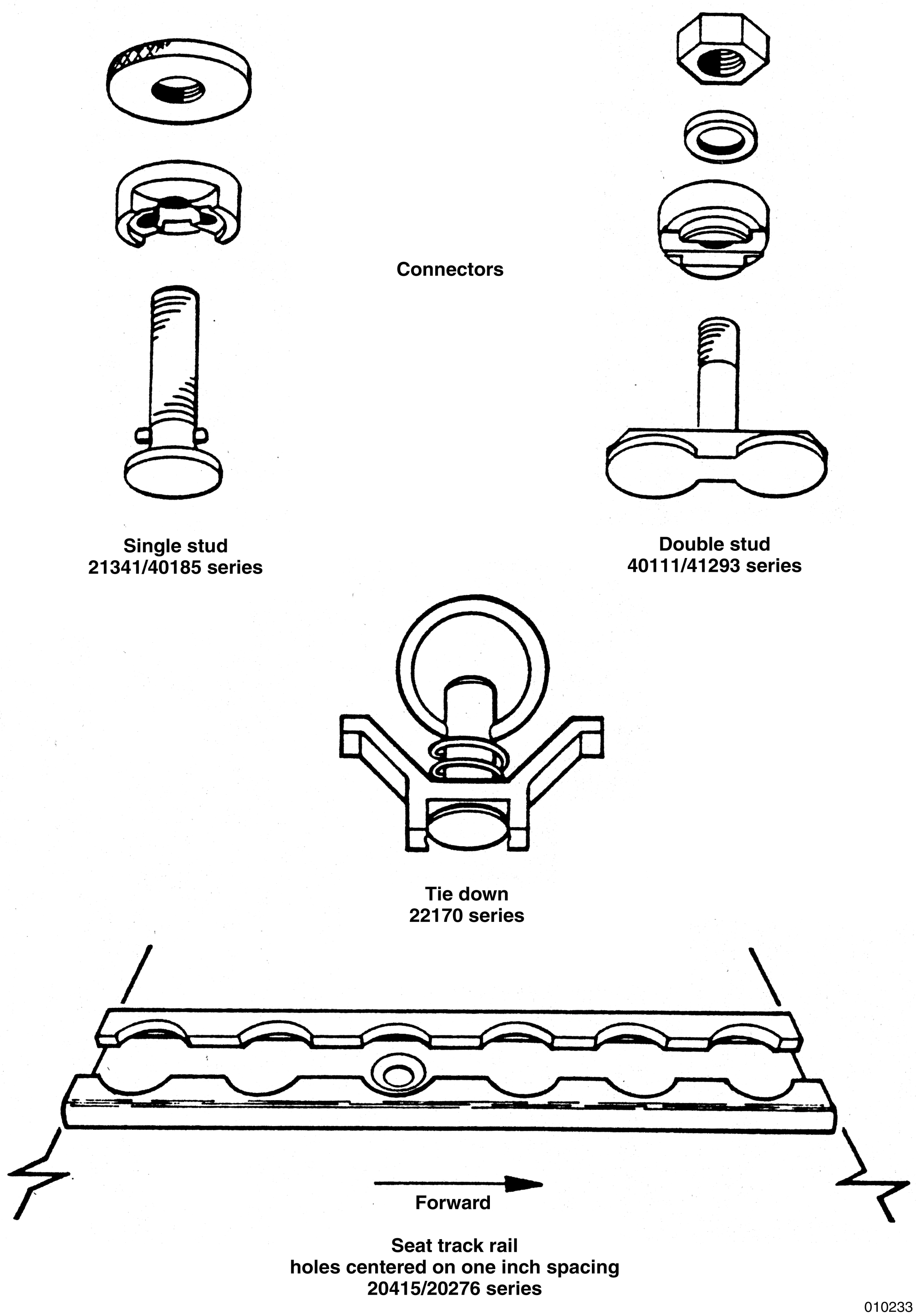


Figure 5-2. Seat rails and clamps.

A. Aircraft Cabin

Structural attachment in the cabin area will be primarily accomplished by connection to seat and viewport rails.

1) Seat Rails

A pair of rails on each side of the main cabin floor is used to attach the passenger seats, using special fittings (figure 5-2). These same fittings are also used to attach experiments to the seat rails and to the viewport Brownline rails. The maximum allowable loads that can be applied to each of the floor rail fittings are given in figure 5-3.

2) Viewport Rails

Brownline rails in fore-aft orientation at the top and bottom of each viewport can be used for experiment attachment. Only shear and/or tension loads are permitted at these rails. Therefore, single stud attachment of hardware to the rails, that will cause a moment reaction to the rail, will not be permitted.

B. Cargo Compartments

Experimenter equipment can be mounted (to the Brownline rails) in both the forward and aft cargo compartments. Due to the limited floor space available on flights based away from DFRC, cargo compartment installations should be discussed beforehand with the DC-8 mission manager.

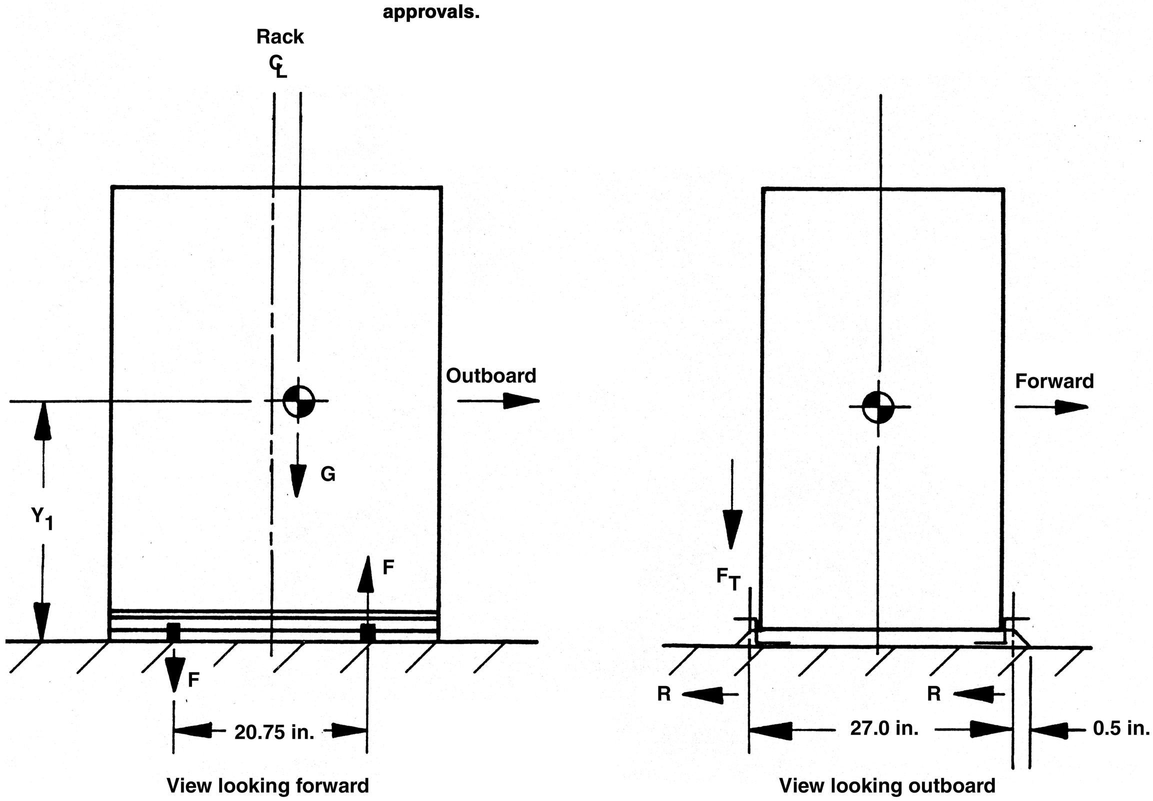
The cargo loading doors open inward, sliding along the curved hull of the aircraft. Equipment installations must not interfere with the movement of these doors (figure 3-4).

C. Other Equipment Mounting Locations

It is possible to mount experimenters' equipment on the exterior of the aircraft at certain specified locations. All such requests must be considered individually. Experimenters who consider installations of this type should visit DFRC at least twelve months in advance, to examine the aircraft and discuss plans in detail with personnel.

Maximum applied load per connector (Including load factors)	
Tension	5,000 lb
Shear	5,000 lb
Bending	2,300 in. lb

Note: When connectors are subjected to combined loads. The above limits may be reduced. Contact DFRC for specific requirements and approvals.



Forward overturn moment = force x 27 = weight x 9 x Y_1

$$F_T = \frac{\text{Weight} \times 9 \times Y_1}{27}$$

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Figure 5-3. Loads for a standard rack and connectors.

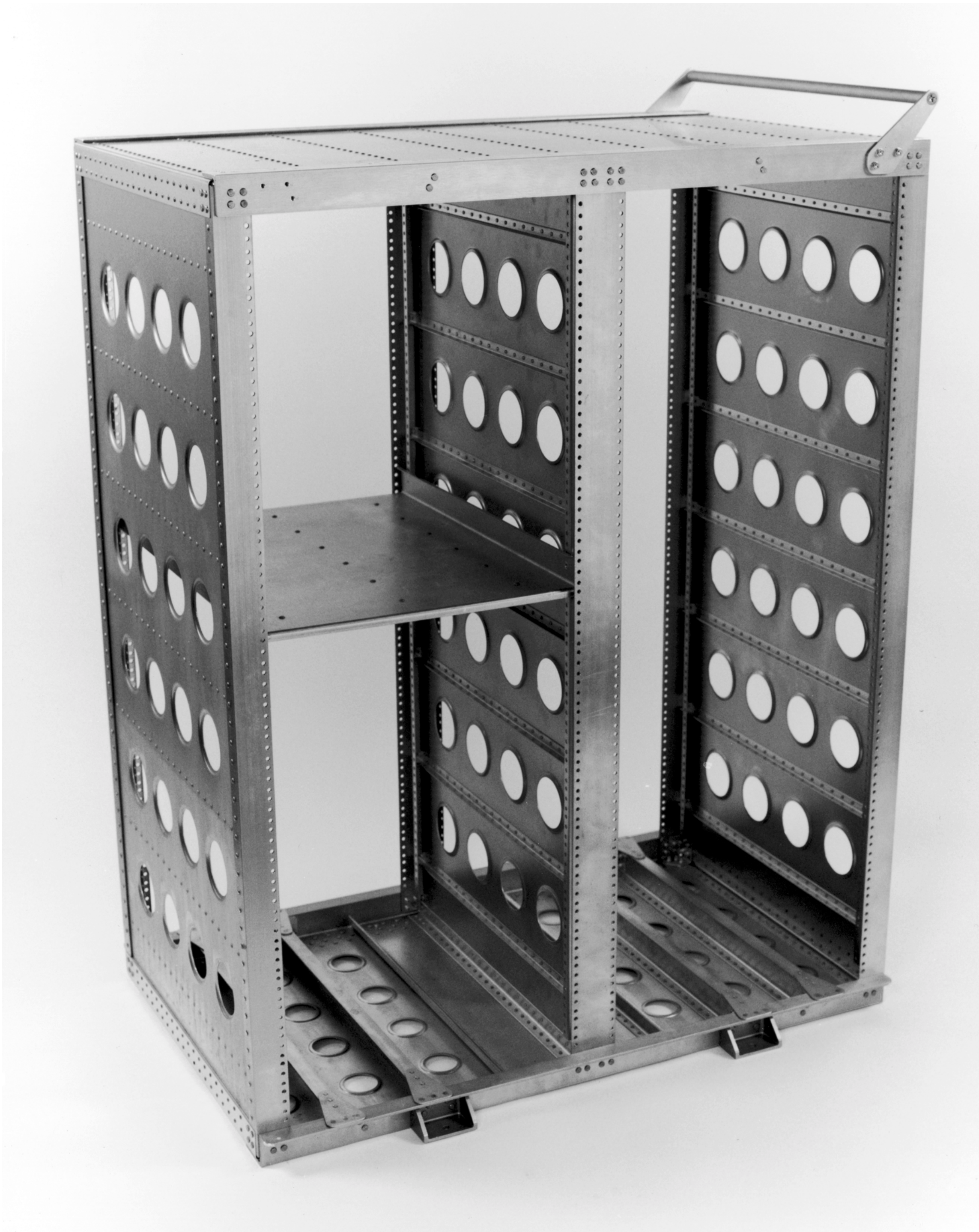

Figure 5-4(a). Standard equipment racks – high rack.

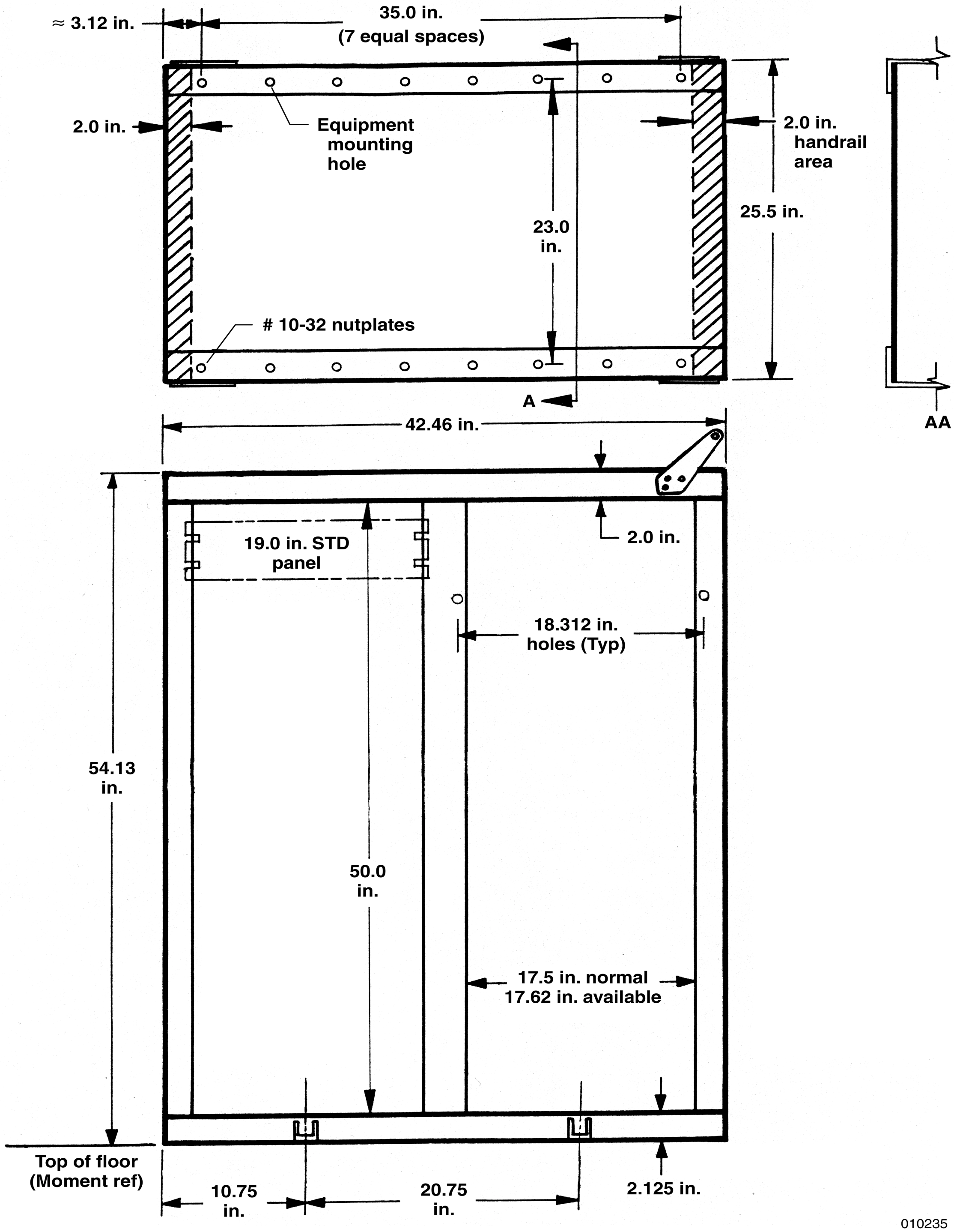

Figure 5-4(b). Standard equipment racks – high rack – dimensions.

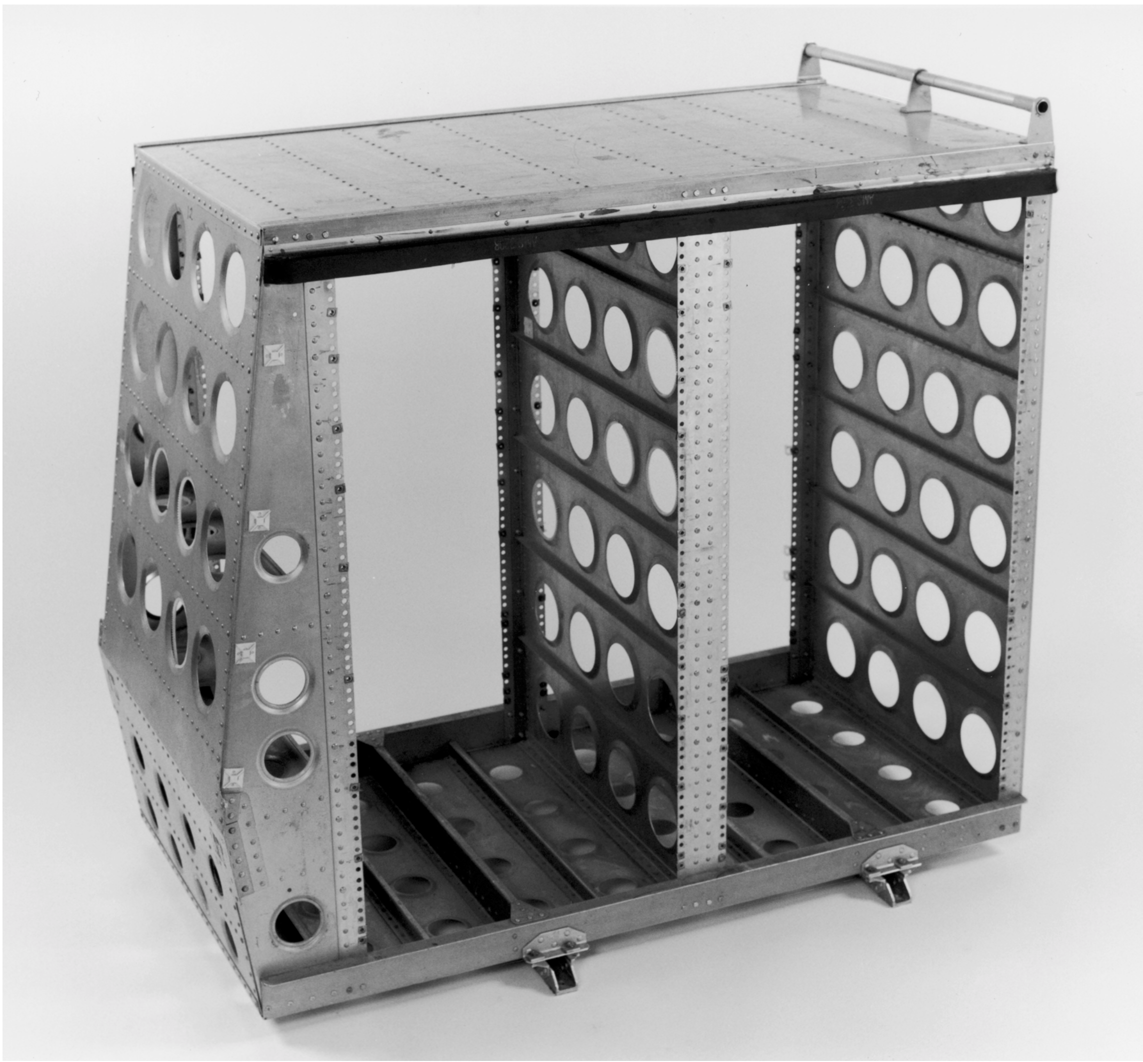

Figure 5-5(a). Standard equipment racks – medium rack.

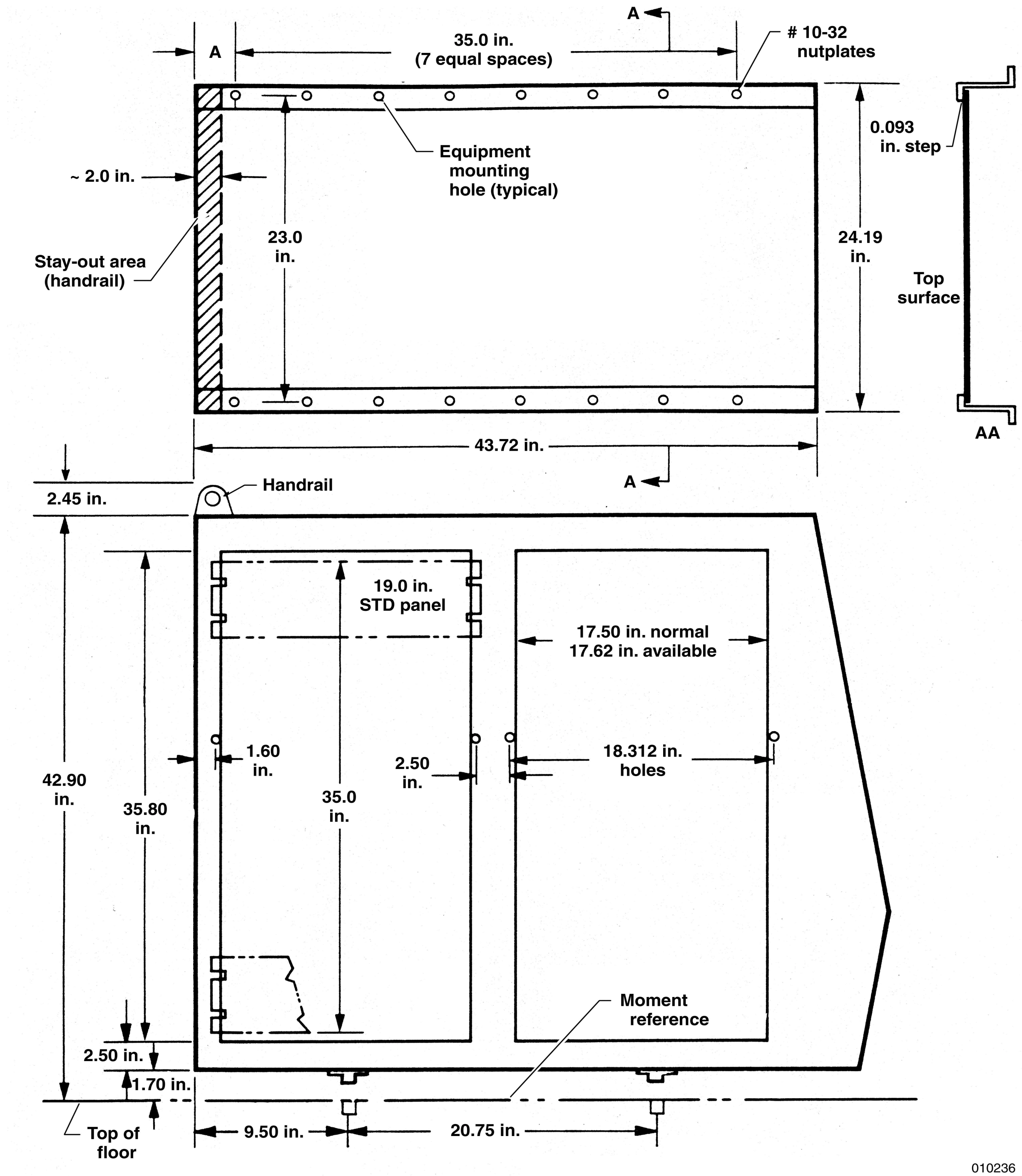

Figure 5-5(b). Standard equipment racks – medium rack – dimensions.

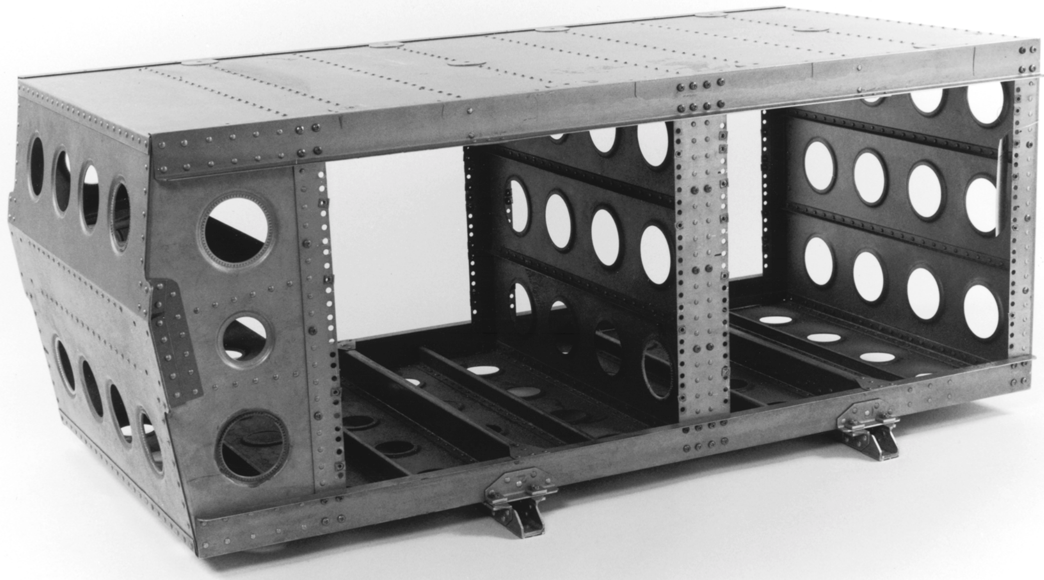

Figure 5-6(a). Standard equipment racks – low rack.

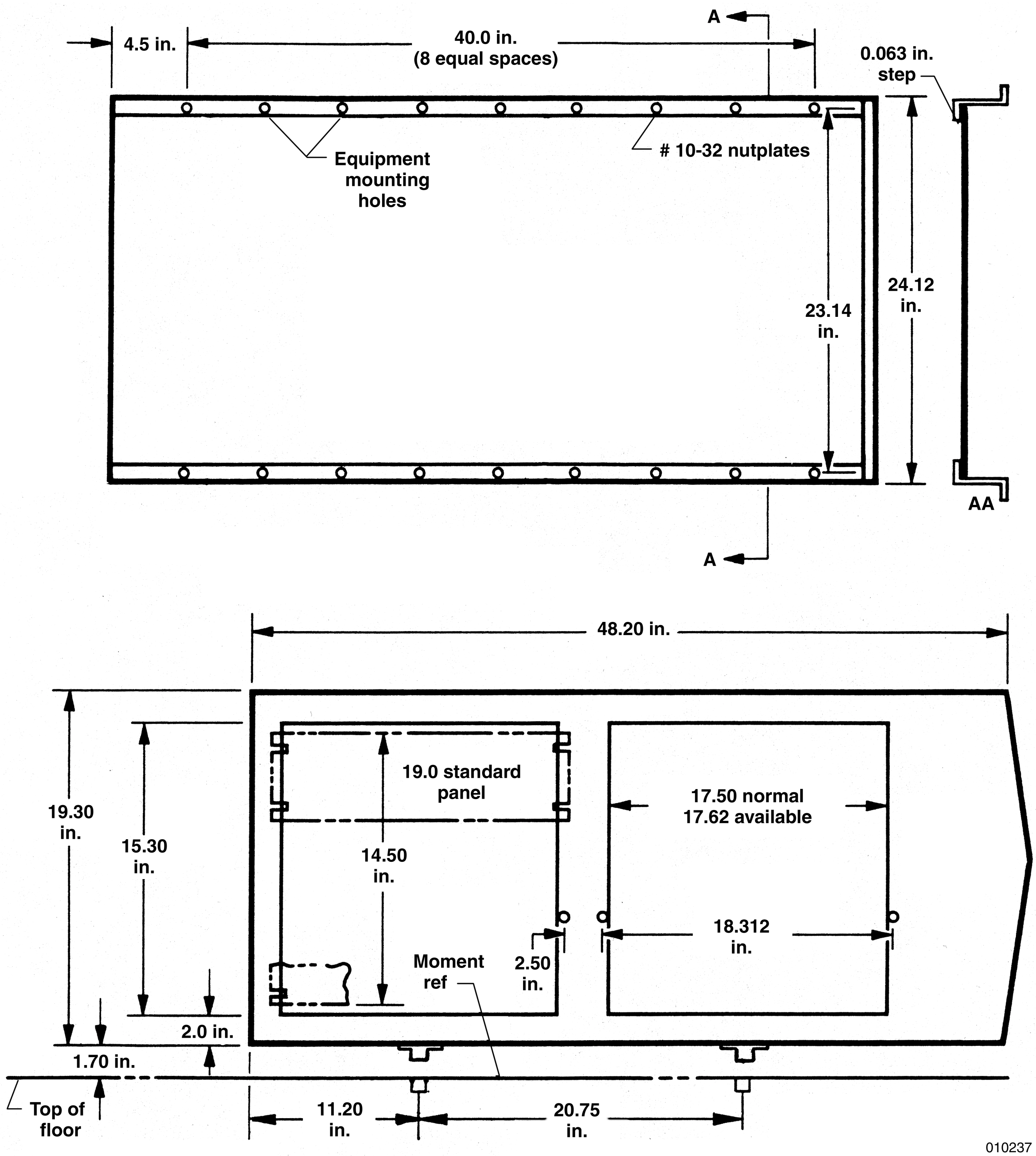

Figure 5-6(b). Standard equipment racks – low rack – dimensions.

6. Standard Equipment Racks

Equipment racks that fasten directly to the seat rails have been designed for use in the aircraft main cabin. The racks are designed to accept standard rack-mounted test equipment, 19 in. (48.3 cm) wide, and are available to all experimenters. The racks are available in three sizes: a high rack with two bays, each 50 in. (127 cm) high by 25 in. (63.5cm) deep, as shown in figure 5-4(a) and 5-4(b); a medium rack with two bays, each 35 in. (88.9 cm) high by 24 in. (61.0 cm) deep, as shown in figure 5-5(a) and 5-5(b); and a low rack with two bays, each 14 1/2 in. (36.8 cm) high by 24 in. (61.0 cm) deep, as shown in figure 5-6(a) and 5-6(b). Equipment can be mounted on either side of the racks facing both forward or aft.

The maximum allowable equipment (or tare) weight for low and medium racks is 300 lb (136 kg) per rack bay; for high racks, it is 450 lb (204 kg) per rack bay[1]. These weights include any equipment mounted on top of the racks. The total allowable overturning moment for all equipment, in or on low and medium racks is 6,000 in.-lb per rack bay; for high racks, it is 9,000 in.-lb per rack bay. Moment arms are measured vertically from the floor level to the center-of-mass of each component. These weight and moment values take into account the load factors and allowable loads and do not include the weight of the rack itself. Stress analysis of rack structure or rail attachments is not required, except for nonstandard installations.

The equipment racks are often used as support platforms for mounting equipment. The high and medium racks are used for experiments utilizing overhead view ports, and the low rack for those utilizing the passenger viewports or windows, as well as for other heavy equipment. Experimenters should consult with the mission manager when planning to use the top of any rack to mount equipment. These types of installation requests are considered individually and may, in certain cases, require stress analysis even though the weights and moments do not exceed the values listed. The positions of the high, medium, and low racks relative to the viewports are shown in figure 5-7 to assist the design of rack-top mounts.

NOTE: Modifications to the standard equipment racks, however minor, are not permitted under any circumstances.

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[1]. For rack loads approaching limiting values, the lateral center of gravity should be located at the vertical center post. Deviations from this requirement may reduce the allowable weight for all racks.

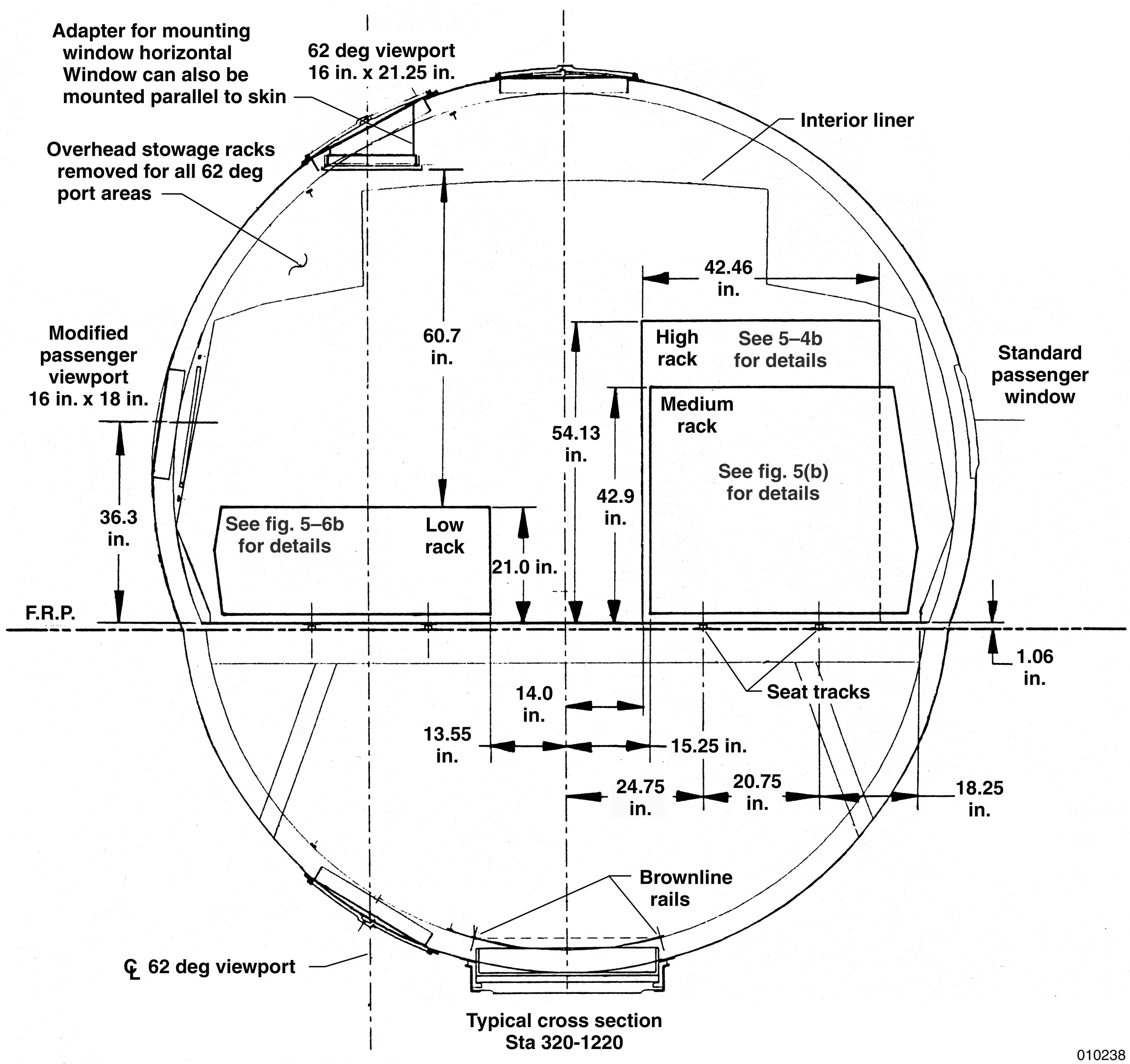


Figure 5-7. Installed equipment racks and viewports, cross section.

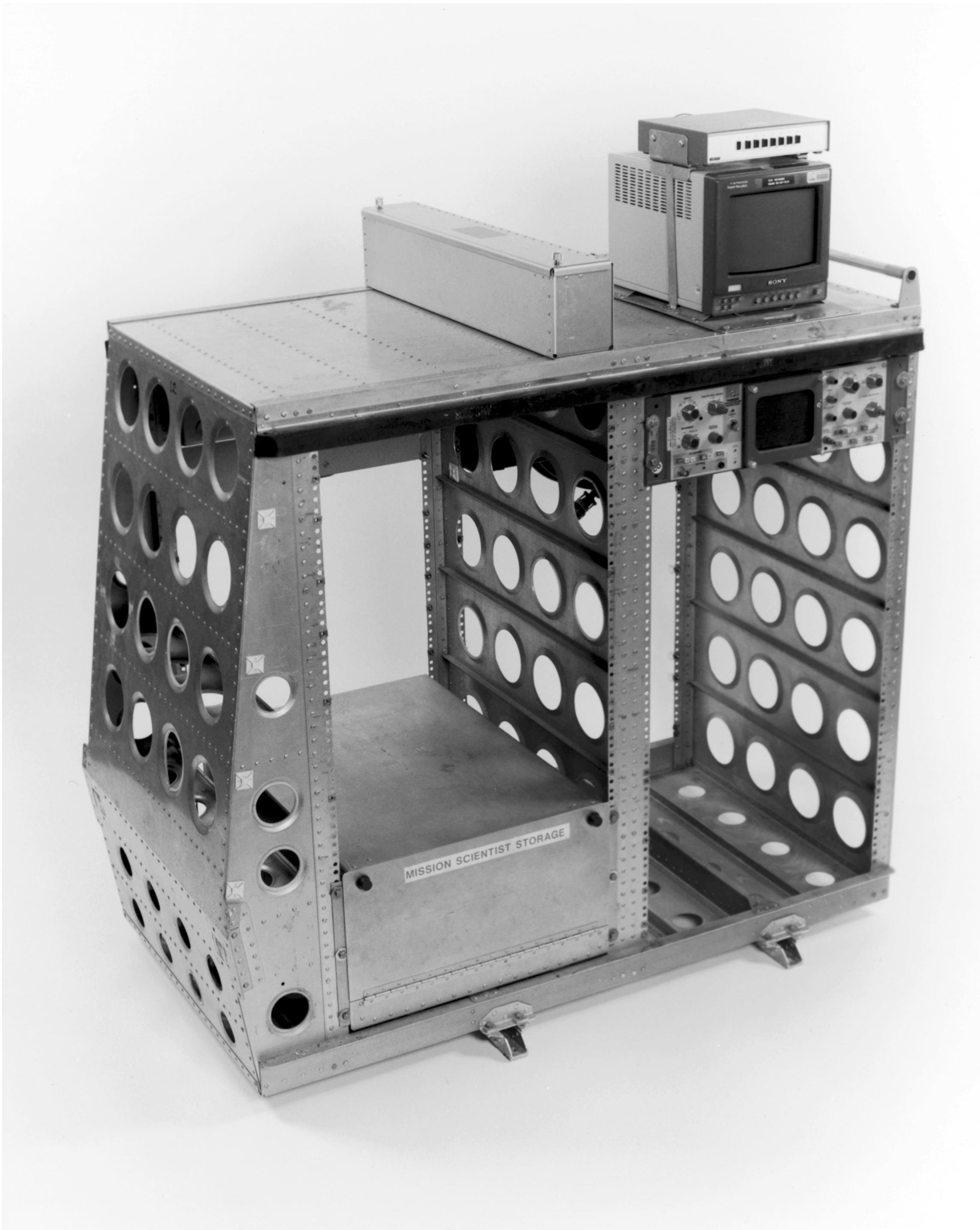


Figure 5-8. Typical installation in equipment rack.

Experimenters are requested to make preliminary scale layouts of their equipment in the racks (calculating allowable loads and moments given earlier), and to prepare a list of sizes and weights (panel height, depth, and individual weight). Further, it is advisable to place the heavier items near the bottom whenever possible, to reduce the overturning moment. DFRC will use this information to check loading and moments, and to determine the internal support and bracing required to distribute the loads to the rack structure. For help performing these calculations, contact the mission manager to request engineering assistance.

7. Mounting Techniques

All articles, regardless of size, must be secured during takeoff and landing. When airborne, it is permissible to relocate items that are necessary for experiment operation or maintenance and that weigh less than ten lb (4.5 kg). Because of the potential for air turbulence, however, those items should be secured again after relocation. Personal possessions such as bags, briefcases, cameras, laptops, and binoculars are included in this requirement.

A. Cabin Area

The preferred method of mounting equipment is to use the standard racks. Equipment with standard 19 in. (48.3 cm) panels can often be mounted directly into the vertical support rails.

Refer to appendix A for guidelines to the mounting of individual items of equipment in the experimenter racks. A supply of rack-mounted support trays is in stock at DFRC. Typical examples of their use are shown in figure 5-9.

When a rack is shipped to an experimenter for equipment installation, a supply of clip nuts, NAS fasteners, and trays can be included if arranged in advance. Since unique support requirements cannot be anticipated, experimenters are encouraged manager for engineering assistance.

Smaller components and components without mounting panels can be supported on solid trays of structural-grade aluminum (figure 5-9 and appendix A). These trays span the full depth of the rack and have flanged edges for stiffness and to expedite attachment to the vertical rails.

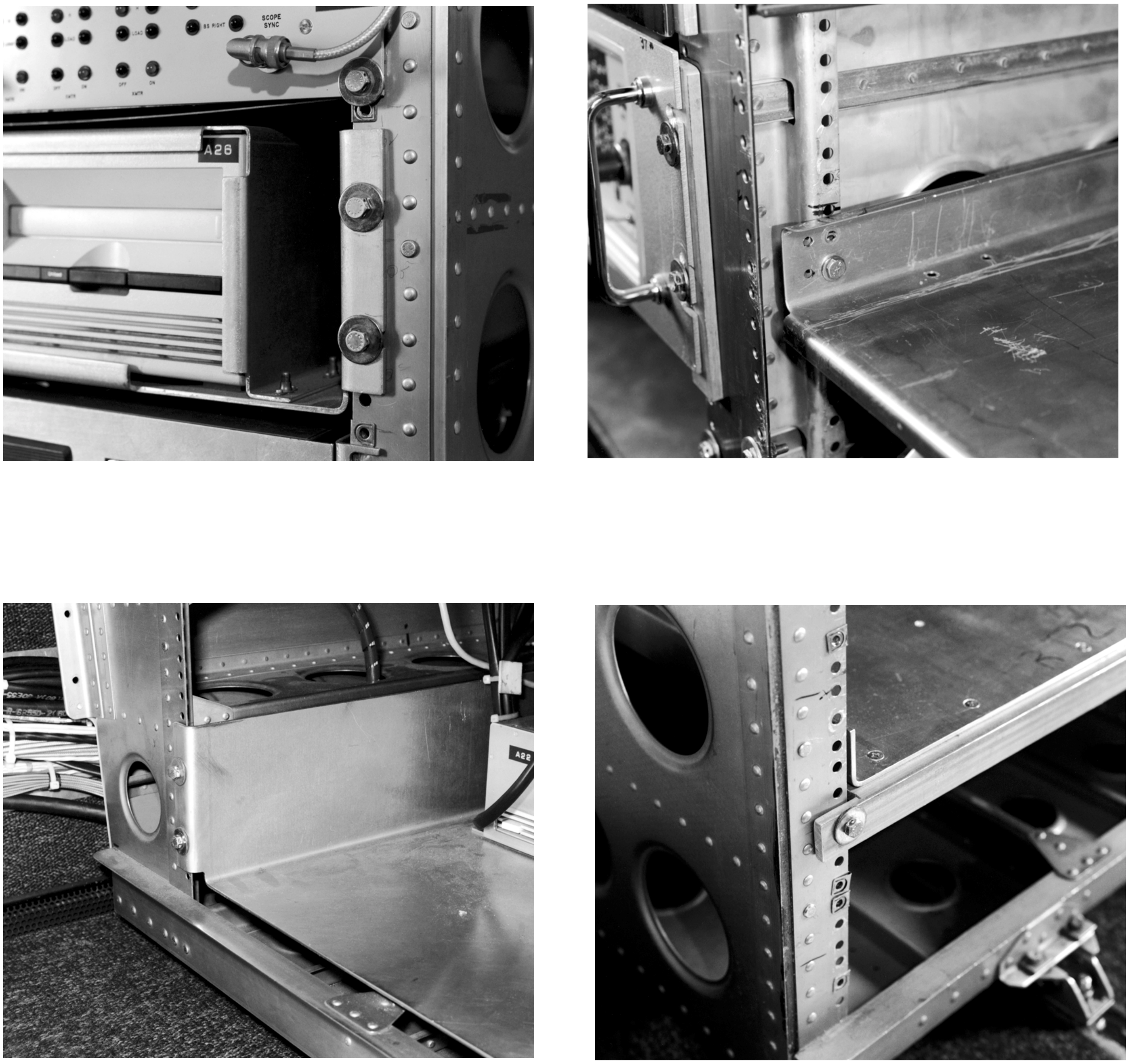


Figure 5-9. Typical tray mounting configurations.

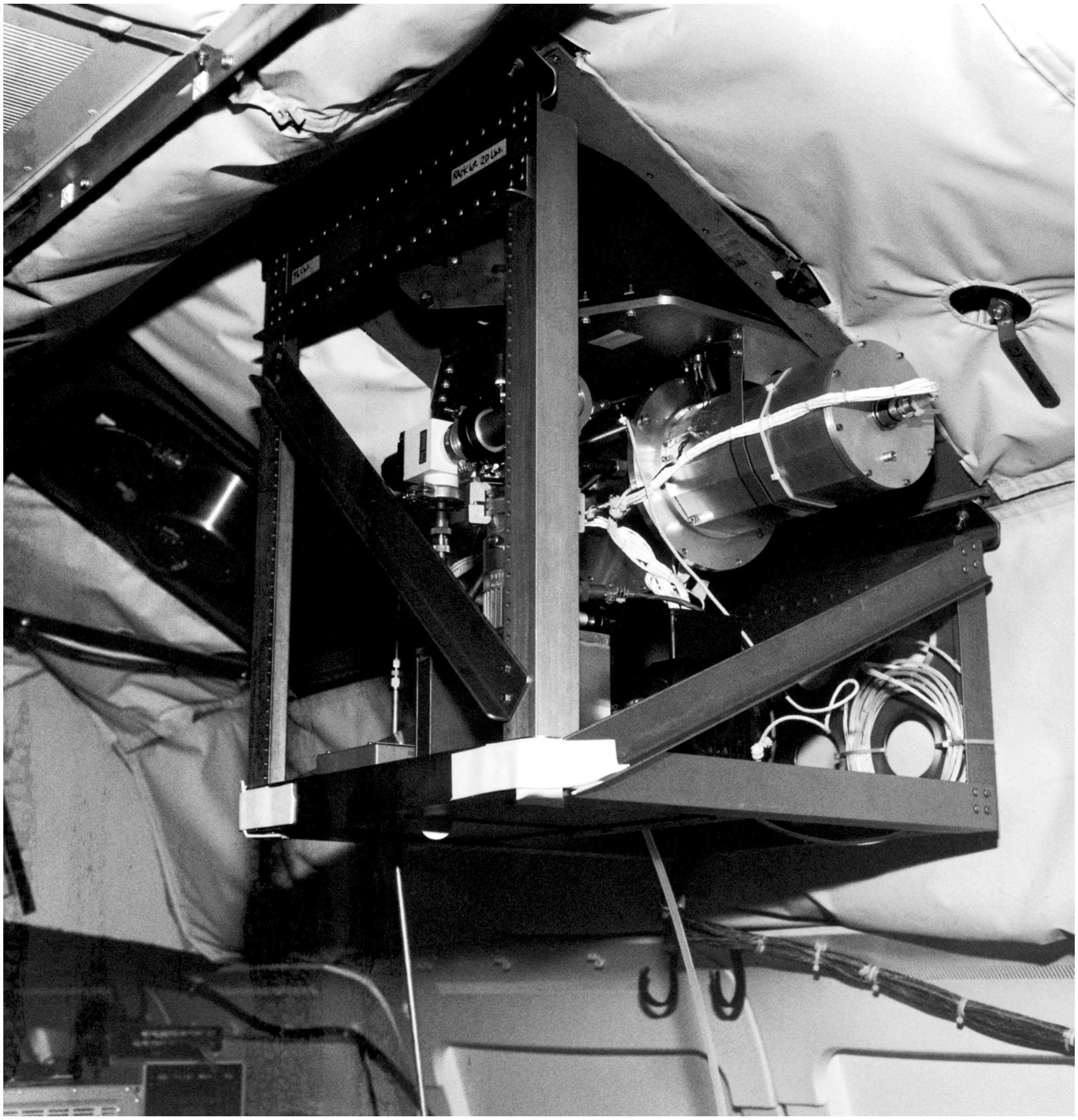


Figure 5-10. Typical equipment mounting techniques – 62° Viewport.

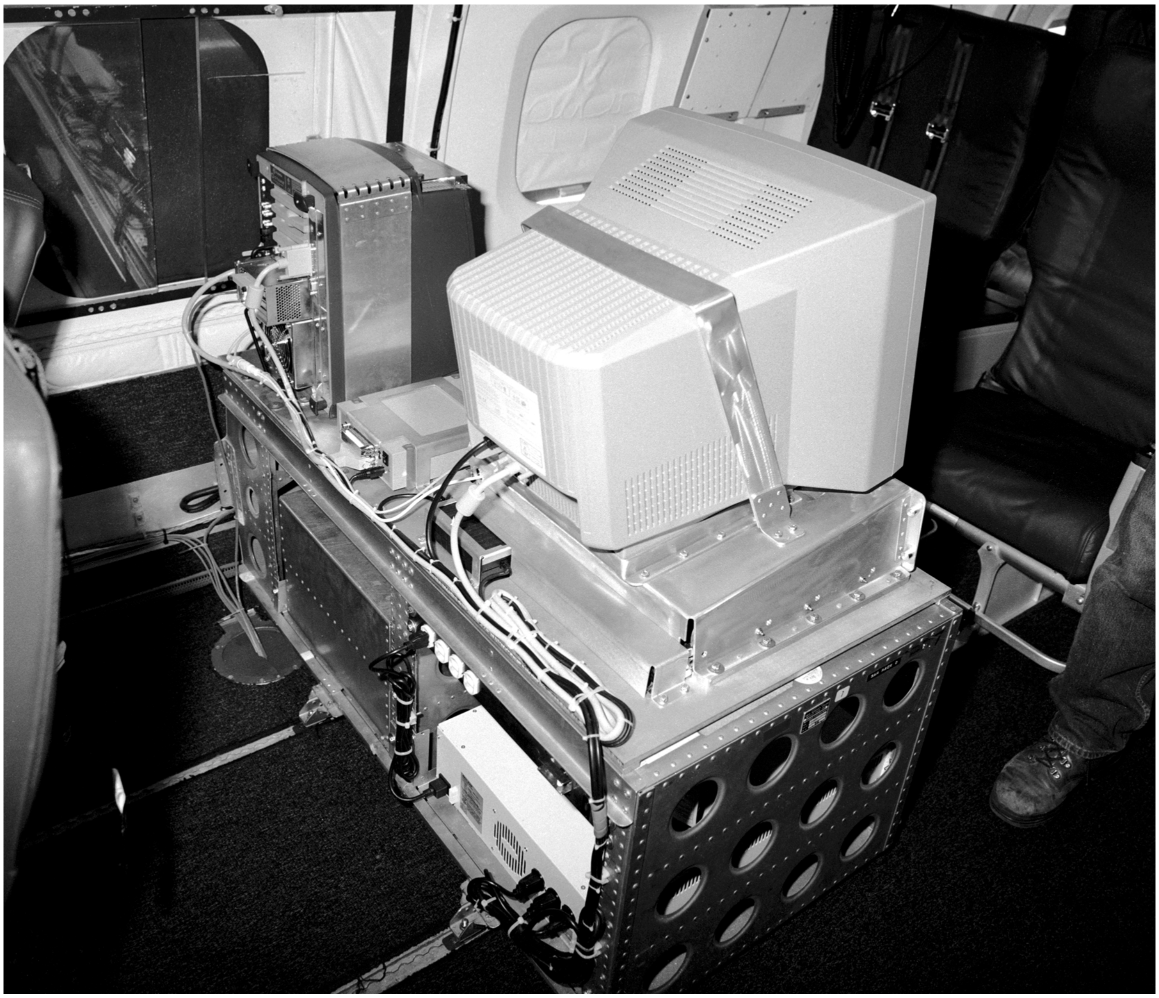


Figure 5-11. Typical equipment mounting techniques – low rack.

NAS-type fasteners must be used throughout the rack assembly. Contact DFRC for suggestions on mounting such equipment.

Certain types of equipment, due to size, shape, or orientation, cannot be mounted in the standard racks, and require special mounting arrangements. In all cases, including use of a standard equipment rack for supporting equipment, the experimenter should design, stress-analyze, and fabricate the entire structure. Where circumstances warrant, and within the limits of the available manpower, the mission manager can make arrangements for design and fabrication support, with the cost charged to the experimenter.

Generally, rack-top mounts use intermediate support plates, which attach to the equipment and span the top surface. These supports are then match-drilled to the existing fittings at the rack edges (figures 5-4 through 5-6).

All experimenters' equipment in the main cabin, except for small and light components attached to the viewport rails, must be supported by the seat tracks. Some examples of equipment mounting techniques are shown in figures 5-10 and 5-11.

For equipment that cannot be adapted to the standard rack support structure, two techniques are recommended:

- Equipment can be mounted on a framework that attaches directly to the seat rails. This method is especially applicable for equipment positioned for viewing or sampling through viewports (figure 5-12).

- An aluminum pallet can be attached to the seat rails and the equipment then mounted to the pallet. Equipment can also be bolted to the brackets restraining the pallet or attached to it by means of base-plates (figure 5-13).

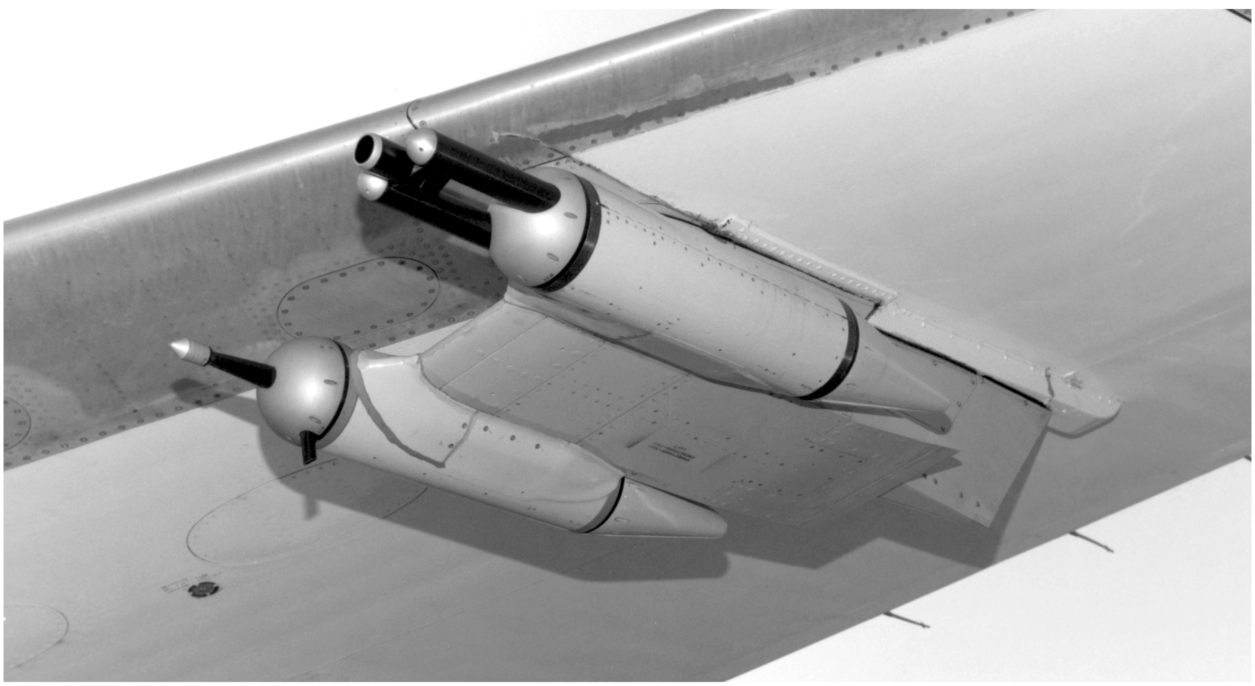
NOTE: All non-standard mounting designs must be approved by NASA-DFRC engineering. Structural certifications and receiving inspections are required prior to installation and flight.

NOTE: Do not pre-drill equipment mounting holes prior to installation at DFRC. Nonstandard equipment will be match-drilled at installation to fit the seat rails.

Figure 5-12. Large experimenter equipment mounted on special framework.

Figure 5-13. Large experimenter equipment mounted on special framework.

(1 of 2)



(2 of 2)

Figure 5-14(a). Typical wing tip pylon.

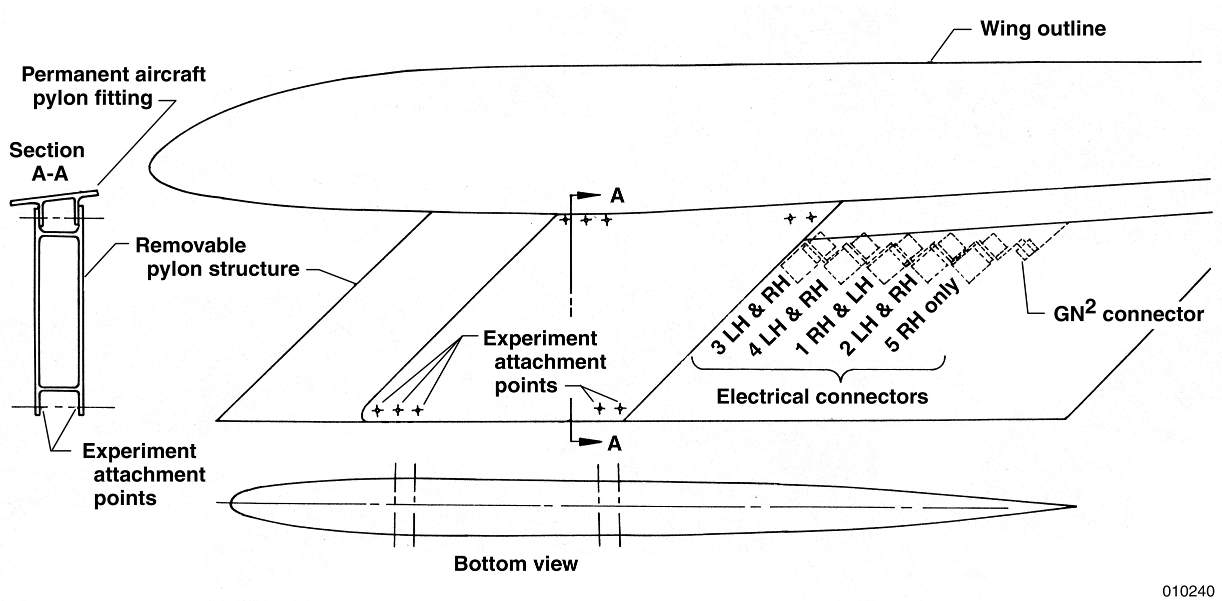
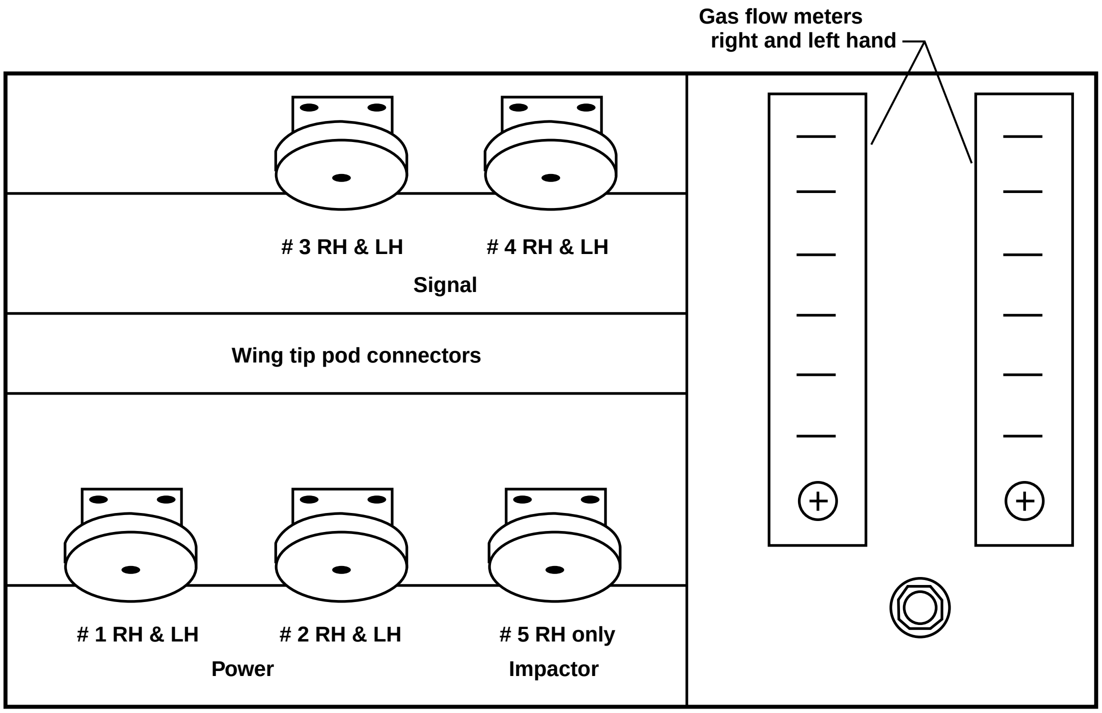


Figure 5-14(b). Typical wing tip pylon.



Wing tip pylon connector panel
in main cabin – station 670

Cable function	Number of cables		Conductors each cable	Wire size	Max current amp	Resistance ohm	Mating connectors	
	Left hand	Right hand					Pylon end part no.	Cabin end part no.
Power	2	2	1 each twisted pair, shielded 1 each twisted quad, shielded 1 each single, unshielded	12 14 14	20 15 15	0.19 0.30 0.30	MS24266R18-B8P or M83723/75R18-8PN	MS24266R18-B8S or M83723/75R18-8SN
Signal	2	2	13 each twisted pair, shielded	22	5	1.60	MS3126F20-41P	MS3126F20-41S
Signal	0	1	10 each twisted triplet, shielded	22	5	1.60	MS3126F18-32P	MS3126F18-32S
Resistance is approximate for one-way. Voltage at sensor will be voltage at cabin panel. Minus the two times one-way drop.								

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Figure 5-15. Wing tip connector panel in main cabin – station 670.

The DFRC Airborne Science Directorate has some special pallets and other supporting structures that were used in the past. These are available to experimenters who can adapt them to their use.

B. Cargo Compartments

Equipment mounted in the cargo compartments must be secured to the Brownline rails, cargo wall tie-downs, or available shelves.

C. Underwing Pylons

Certain types of equipment can be mounted under both left and right wingtips. Located there, are pylons designed for small sensors that must be far removed from fuselage air turbulence. The pylon's longitudinal centerline is parallel to the aircraft centerline and is set at zero angle-of-attack during normal flight.

Each pylon is designed to accommodate an equipment package with a maximum weight of 100 lb. See figure 5-14(a) and 5-14(b) for attachment details. Electrical power, signal, and nitrogen gas connections exist at each pylon and extend to a connector panel at station 670 on both left hand and right hand sides of the aircraft (see figure 5-15).

Experimenters desiring to utilize the wing-tip pylons should obtain approval from the DFRC Airborne Science Directorate well in advance to allow time for equipment mountings to be designed and fabricated. Flight tests may be required depending on actual equipment size, shape and weight.

All wing-mounted/pylon experimenter equipment must be grounded to the airframe. Resistance to ground checks will be performed. Equipment with greater than 1 Ohm resistance to ground will required additional grounding.

D. Exterior Locations

Equipment can be mounted on the exterior of the fuselage; however each request is considered individually. A long lead time must be allowed for the design of attachments and aerodynamic fairings that will support the gust loads and air loads encountered over the entire operating range of the aircraft.

The design and fabrication of all external fairings is closely controlled by DFRC and, in most instances, that work is performed at DFRC. In-flight tests will be required to evaluate aircraft performance and the response of fairings to imposed air loads before the actual research flight series can begin. A safety factor of 2.25 must be used for exterior location designs, unless structural ultimate load testing has been accomplished.

8. Equipment Certification

It is the experimenters' responsibility to design and construct their research equipment in accordance with the general specifications herein. Problems should, of course, be discussed with DFRC personnel. Field measurements of the DC-8 by the experimenters are strongly recommended when new or modified installations involve tight tolerances to existing aircraft structure. If special requirements do arise, the mission manager can arrange for limited engineering design support at DFRC, provided he/she is notified well in advance.

Experimenters are required to submit detailed shop drawings of all equipment to be modified or fabricated, showing dimensions, materials, fastener types and patterns, and component weights, before initial approval for aircraft integration can be made. Stress calculations must accompany the drawings and include an analysis of the support and tie-down structure and fasteners. If the experimenter chooses not to use a standard DC-8 rack for equipment mounting, that structure must also be detailed in drawings and substantiated by analysis. The experimenter should also submit a functional block diagram of the experiment, and scaled and dimensioned layouts of equipment mounted in standard or experimenter supplied racks, with summaries of weights and moments (see sections 6 and 7). Photographs of existing equipment are very desirable.

All such data should be submitted prior to fabrication, and at least eight weeks prior to the scheduled installation of the equipment aboard the aircraft. The mission manager may specify a longer lead time in cases of complex installations.

This material will be evaluated at DFRC, and changes will be requested as necessary. Final approval should be obtained from DFRC, prior to shipping the equipment. The actual equipment construction, weight, center-of-mass, and resultant loading, are all verified at DFRC before final approval for installation is given. Experimenters should allow time for this verification when planning installation schedules.

9. Hazardous Equipment And Materials Certification

WARNING: listed below are equipment and processes potentially hazardous to either personnel and/or equipment. Please read the following carefully.

The operation of any potentially hazardous equipment, or use of hazardous materials at DFRC, must be reviewed and approved by the appropriate DFRC safety personnel. This applies to the shipping, operational use, and disposal of all hazardous materials, including the operation of hazardous equipment in the Experiment Integration Facility, or on the aircraft, either in flight or on the ground. Sufficient lead-time must be allowed for the necessary reviews and obtaining the proper authorization. Depending upon the specifics of the experiment, this process can take as long as several months. To help identify potential hazards, which may require DFRC approval, the following equipment categorization is used.

A. Lasers

The use of lasers at DFRC and at DFRC controlled off-site operations is governed by Dryden Centerwide Procedure DCP-S-024, "Non-Ionizing Radiation Safety." This document must be reviewed and understood by those contemplating the installation of laser systems or the use of instruments containing lasers. Contact the mission manager for a current copy.

B. Radio Frequency and Microwave Emitters

The use of radio frequency (RF) and microwave emitters at DFRC and at DFRC controlled off-site operations is governed by Dryden Centerwide Procedure DCP-S-024, "Non-Ionizing Radiation Safety" and by Dryden Policy Directive DPD-2570.1, "Radio Frequency (RF) Spectrum Management." These documents must be reviewed and understood by those contemplating the installation of radio frequency or microwave emitters. Contact the mission manager for current copies.

Experimenters should engineer their equipment to prevent direct and spurious radiation from interfering with the aircraft avionics equipment, which may cover the frequency range of 10 kHz - 10 GHz or more (see chapter 2).

C. Cryogens

Use of cryogenic liquids at DFRC is controlled by Dryden Center-wide Procedure DCP-S-039, "Cryogen Safety". Contact the mission manager for a current copy. Additional guidelines are contained in appendix B of this handbook. Cryogen usage is reviewed with respect to physiological, fire, explosion or other possible hazards associated with the use and/or transport aboard the aircraft. Type, volume, storage, and usage data is required by DFRC for all cryogens. Some cryogens are prohibited from use and/or transport due to exceptional hazards. These cryogenic liquids include:

- Oxygen
- Methane
- Ethylene
- Ethane
- Hydrogen

D. Compressed Gases

Use of compressed gases at DFRC is controlled by Dryden Center-wide Procedure DCP-S-030, "Pressure Vessels and Pressurized Systems". Contact the mission manager for a current copy. All compressed gases are reviewed, like cryogens, with respect to physiological, fire, explosion or other possible hazards associated with their use and/or transport aboard the aircraft. If the particular gas is in the extremely hazardous category, or is used in sufficient quantity to be otherwise considered a high-risk item, special design and risk mitigation practices will be required.

E. Hazardous Materials

Hazardous material is defined as anything with a flashpoint below 140 °F or with a threshold limit value (TLV) below 500 ppm, below 500 mg/m^3 for fumes, below 10 mg/m^3 for dust, or with a single oral dose (if liquid) at 50 percent lethality below 500 mg/kg. Each installation is reviewed for potentially hazardous materials. A complete account must be made of all gases, and dry or liquid chemicals, toxic or otherwise. This includes all cleaning solvents, refrigerants and coolants, and instrument additives, such as butanol and laser dye.

The use of toxic gases in the aircraft, during flight or ground operations, is of particular concern. Data on the instrument design, installation, and proposed use of the gases will be evaluated to determine the hazard level. Where it is determined that the use and/or transport of a gas presents an unacceptable risk, containment of that gas in a secondary containment vessel may be required.

Generally, secondary containment is required when full release and mixture of the gas into a 4 ft bubble (33.5 ft^3) results in a concentration exceeding 50 percent of the amount known to be immediately dangerous to life and health (IDLH). Handling of hazardous materials at DFRC and at DFRC controlled off-site operations is governed by Dryden Centerwide Procedure DCP-S-038, "Hazard Communication and Material Safety Data Sheet (MSDS) Instruction Guide and Dictionary." Also see DCP-S-029, "Laboratory Safety." Contact the mission manager for current copies of both documents.

F. Batteries

While the proper use of small commercial grade batteries (such as AA, AAA, C, and D size Alkaline or Ni-Cd units) is normally acceptable for use on the DC-8, the use of large numbers of batteries or large capacity batteries, particularity lithium based, may present a significant hazard and therefore require DFRC review and approval. Special approval and operating procedures are required to allow unattended operation of any battery-powered equipment aboard the aircraft. See chapter 6 for additional detail and requirements regarding batteries and uninterruptible power systems (UPS).

G. Pressure Vessels/Systems

High pressure and vacuum systems (including research dewars) are reviewed to assess the hazards associated with failures. Use of these systems at DFRC is controlled by Dryden Centerwide Procedure DCP-S-030, "Pressure Vessels and Pressurized Systems." Contact the mission manager for a current copy.

H. Motors/Pumps

All electrical motors (except the very small fan units found in most commercial electronic equipment) and motor assemblies are reviewed for electrical safety and sparking potential (see chapter 6, section 8, for motor specifications).

I. Heaters

All heater assemblies are reviewed for electrical safety, proper circuit protection devices and the presence of high temperature exposed surfaces that might serve as ignition points for flammable gases, or hot surfaces that may cause burns to personnel. Exposed surfaces, which are above 130 °F, are generally considered safety problems and must have adequate shielding and caution signs (see chapter 6, section 9, for additional heater requirements).

J. Power Distribution Equipment

Power distribution equipment and large power conversion equipment require special DFRC approval. All non-DFRC ac power distribution boxes require inspection and approval for electrical safety. They should have hospital grade duplex outlets and an approved three-wire (grounded) power cord.

K. Radioactive Materials

The use and/or transport of radioisotopes and/or radiation generating equipment involving the NASA DC-8 is controlled by Dryden Centerwide Procedure DCP-S-023, "Ionizing Radiation Safety." This document must be reviewed and understood by those contemplating the installation or transport of such systems containing radioactive materials. Contact the mission manager for a current copy.

L. Other Hazards

Each installation is reviewed for potentially hazardous ground or airborne operations. Use of PVC jacketed wire (except within commercial units) and cable or plumbing is not acceptable. Teflon based insulating materials should be used. The use of high power equipment, moving equipment, and/or optical windows will be reviewed. Also, the requirement to change gas cylinders in flight, purging and filling of highly flammable and/or toxic substances in an instrument, or other such items may be evaluated as high risk and require some level of risk mitigation.

For potential hazards external to the aircraft (such as laser beam, radio frequency, and microwave emissions), special approval may also be required from outside agencies, such as the military, FAA, state and local government agencies, and/or agencies in foreign countries. This approval sequence can take several months and should begin well in advance of the proposed equipment installation date (a minimum four months lead-time is recommended).

CHAPTER 6

ELECTRICAL POWER

1. General Information

Aircraft electrical power is controlled and supplied to the experimenters by the mission director at his/her station (see figure 3-5). Outlet stations are spaced along both walls of the main cabin and in the cargo areas (see figure 3-1). The following two types of power are available:

- The 400 Hz (±1%), 115 volt (±1%), single-phase AC power, of which a nominal 40 kVA total is available.
- The 60 Hz (±0.1%), 115 volt (±1%), single-phase AC power, of which a nominal 40 kVA total is available.
- Limited 220 volt capability.

For 28 volt DC, power supplies operating from 400 Hz power are available on request. The regulation of these power supplies varies according to the type supplied. For safety considerations, acid type batteries with liquid electrolyte are not permitted on board. Other types of batteries can be used; however, they must be approved in advance by DFRC (see section 4). Recharging in flight is not permitted.

2. Power Sources and Frequency Converters

The basic power source within the aircraft, from the engine-powered generators, is 115/200 volt, three-phase, 400 Hz AC. The four engine generators are normally paralleled by a synchronizing bus, but in special cases they can be switched to operate independently. Both 115 volt, single-phase and 115/200 volt, three-phase 400 Hz power are available to experimenters. The ground return wire of the five-wire circuitry is tied to the aircraft structure (see section 6). It is recommended that 400 Hz be used to power experiments wherever equipment permits. Good regulation, excellent waveform, and low ripple are characteristic of this system.

Fifteen 3.5 kVA solid-state converters in the forward cargo area, in five bundles of 3 converters each, provide 115 volt, 60 Hz power for experiments. The normal configuration limits the current from each bundle to a maximum of 60 A, or 6.90 kVA per each bundle. The ground return wire of three-wire circuitry is also tied to the aircraft structure. The system has good voltage regulation, excellent frequency stability, excellent transient regulation, and good waveform relative to commercial standards.

These solid-state converters have transient overload capacity up to 175 percent (10 sec) rated load for starting motors. This accommodates the use of devices with large inrush currents. However, vacuum pump motors, for example, should be limited to 1/2 hp (375 W) when possible.

Larger size motors require advance notice and special handling to avoid power outages. Experimenters must consult with the mission manager when motor loads are planned for 60 Hz power.

Normally, the central data system (ICATS) has priority power from one of the converter bundles; so less than full power is available to the experimenters.

NOTE: The 60 Hz system is not stable enough for precise timing requirements. Accurate time signals are available from the onboard timing system.

Equipment is not available to supply 50 Hz power on the aircraft. The experimenter needing this frequency in a critical application must provide the capacity. DFRC can provide a limited amount of 28-VDC power to drive a 50 Hz converter, if arrangements are made in advance.

3. Experimenters' Power Stations

Power outlet boxes (stations) are located along both walls of the main cabin (approximately 5 ft above the floor) and in both of the cargo areas (see figure 3-1). Each station is controlled locally by switch/circuit breakers (figure 6-1), with primary control from the mission director's distribution panels. A maximum of 20 amps of 60 Hz power and 20 amps per phase of 400 Hz power is available at any one station.

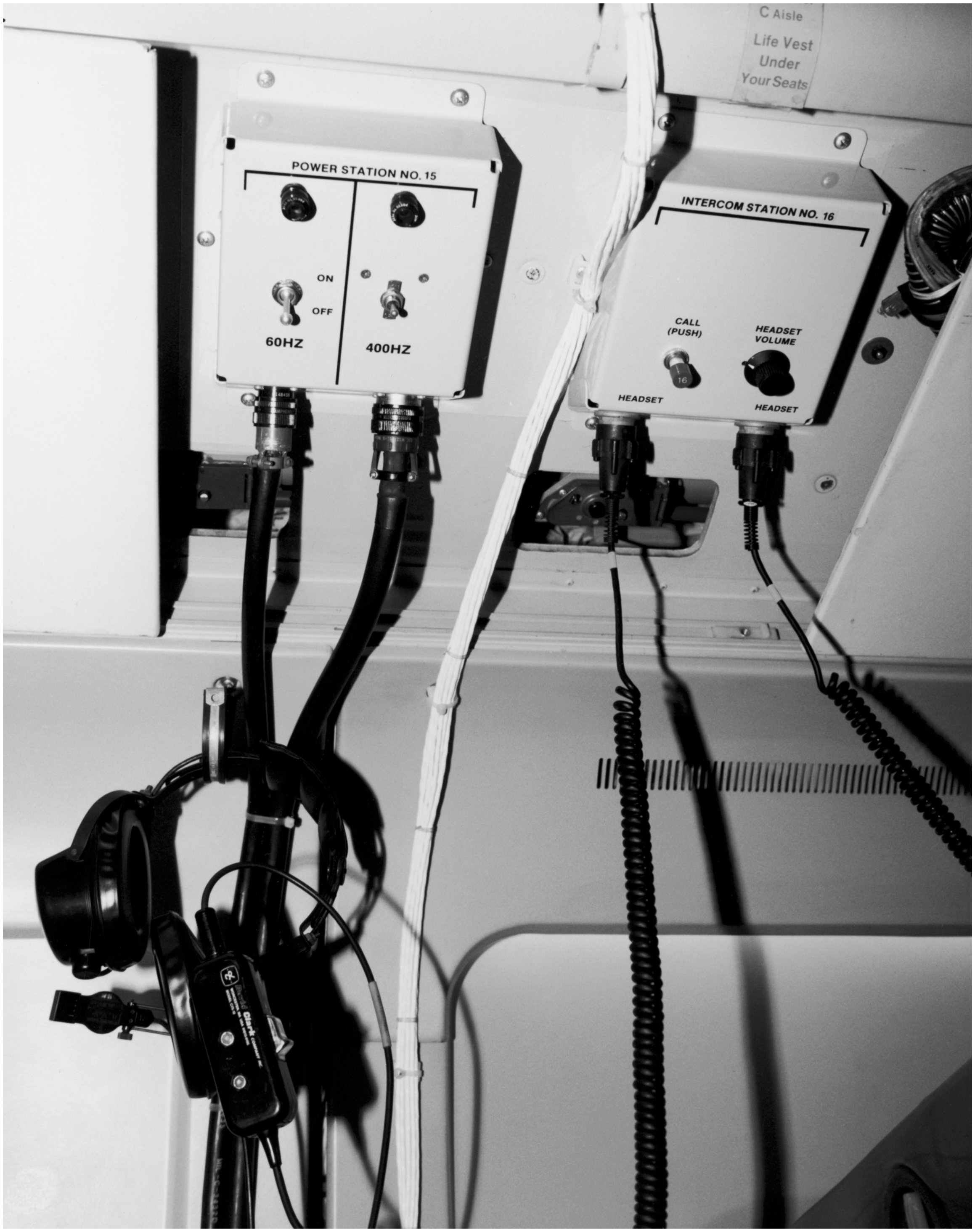


Figure 6-1. Typical power and intercom station in cabin.

Power is connected from cabin wall stations to the experiment by DFRC-supplied cables that terminate in standard rack-mounted panels, 5 1/4 in. high, containing hospital-grade grounded receptacles. On the 60 Hz panels the receptacles are color-coded white and will accept a standard three-prong grounded plug (NEMA 5-15P or 5-20P). On the 400 Hz panels the receptacles are color coded brown and will accept a three prong grounded plug (NEMA 6-20P). Standard plugs for 60 and 400 Hz are not interchangeable, as shown in figure 6-2(a) and (b). Two-wire power leads and/or plugs are not allowed; adapters (from U.S. to European plugs) also cannot be used.

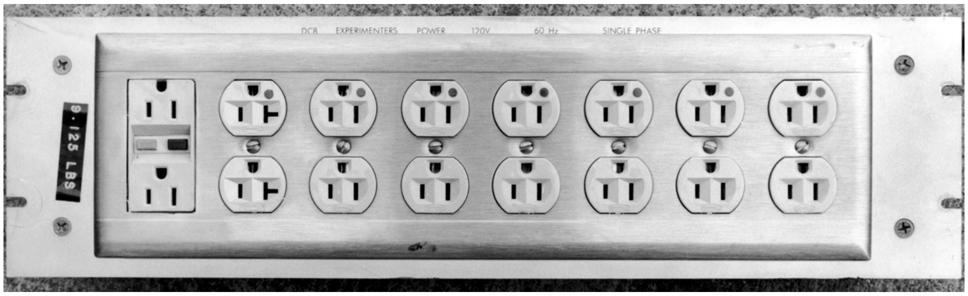
Rack panels are mounted with grounding prongs at the top. Additionally, there are special rack panels for 400 Hz, 200 volt, three-phase loads that require an eight-pin plug (MS24266R18B-8PN); DFRC can supply these on request. Rack panels are arranged as follows (see figure 6-2):

A. For 60 Hz power, the white-colored receptacles can accommodate sixteen plugs, with a total load of 20 amps. The panel is provided with a single ground fault interrupter (GFI), which will trip off the entire panel for a ground leakage current of 5 mA.

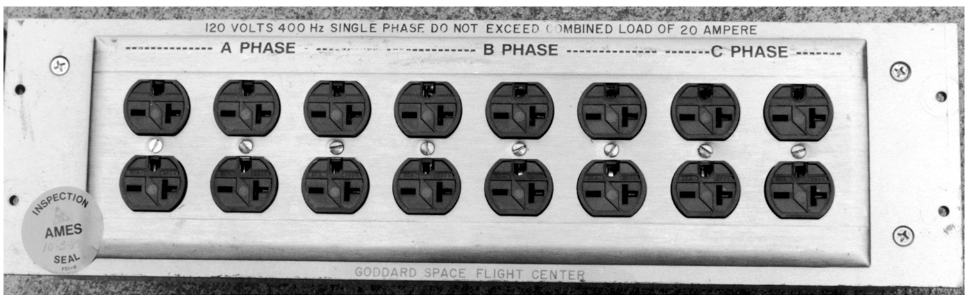
B. For 60 Hz power, a Pulizzi Engineering Inc. model TPC 12F-A2 power distribution panel is available as a supplement to the standard 60 Hz power panel or can be used standing alone. It can accommodate twelve plugs, with a total load of 20 amps and has EMI/RFI filtering and multi-stage spike and surge suppression.

C. For 400 Hz power, the brown-colored, single-phase, 115 volt receptacles can accommodate sixteen plugs, with a total load of 20 amps per phase. All three phases are brought out to this panel with either four or six receptacles per phase. The mission director will control the phase use to keep the overall load as well balanced as possible.

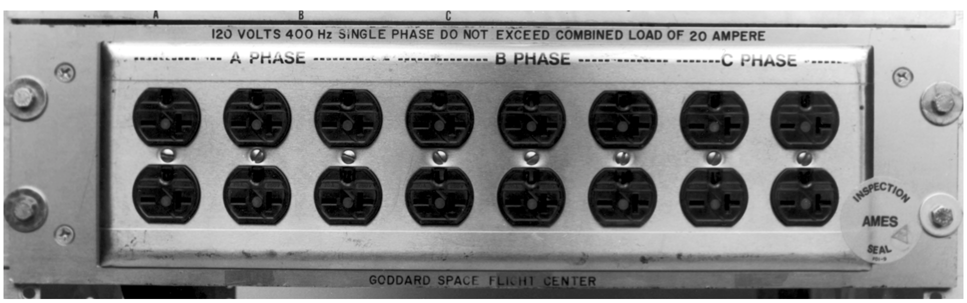
D. A special 400 Hz panel, also with brown colored receptacles, can accommodate two plugs for each of the three phases, and four MS plugs for 200 volt, three-phase loads. The total panel load is 20 amps per phase. A composite power panel is used in the cargo areas. Six 60 Hz plugs can handle a total load of 20 amps; two have GFI protection. Four 400 Hz 115 volt plugs (all on one phase) are limited to a total of 20 amps. One 200 volt, three-phase MS plug can provide a maximum of 20 amps per phase, provided that the 115 volt single-phase receptacles are not in use. Experimenter supplied



1 of 3. 60 Hz.



2 of 3. 400 Hz, single-phase.



3 of 3. 400 Hz, three-phase.

Figure 6-2(a). Typical rack power panel.

power distribution equipment, such as outlet strips, which incorporate transient surge and noise suppressors, require special DFRC approval. Their use is limited to applications where they are plugged into the normal rack mounted DFRC power distribution boxes, or other approved aircraft duplex power outlets. Modifying or bypassing the grounding pin is not permitted.

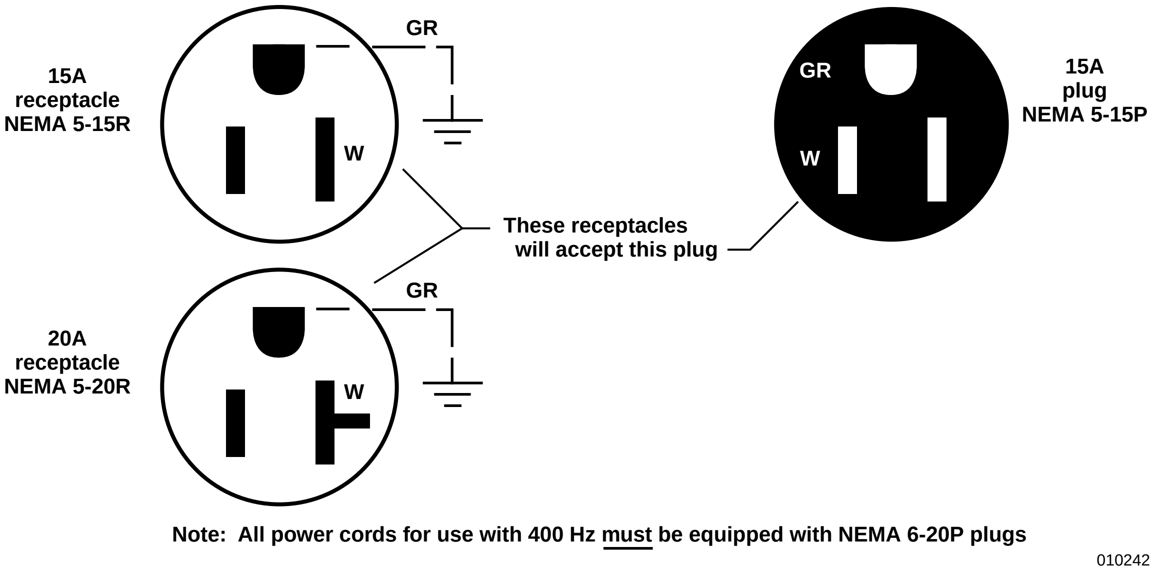


Figure 6-2(b). Rack power panel receptacles.

4. Batteries

Small numbers of AA or D type alkaline or "button" Ni-Cd batteries can be used without special approval. All other battery usage on the aircraft requires approval of DFRC. Unless application absolutely requires otherwise, select benign battery chemistries with hermetically sealed cell designs from the following:

- Alkaline (Zn/MnO_2)
- Silver-Zinc
- Nickel Cadmium
- Sealed Lead Acid ("starved electrolyte" or "immobilized electrolyte" type)

The overall experiment design must consider battery assembly, shipment to the field, storage, packaging safety, shipping restrictions, shelf life limitations, and final disposal (some types require treatment as hazardous waste). Specific design guidelines are as follows:

A. Use smallest size (minimum capacity) battery suitable for intended application, thus minimizing stored energy and electrolyte quantity.

B. Battery installations must withstand normal aircraft structural loads, and safely contain battery failure modes. Typical failure modes include cell rupture or explosion and cell overheating.

C. All batteries must be in secondary containment to prevent leakage of electrolyte onto the aircraft interior. Additionally, all liquid electrolyte batteries must be within sealed secondary containment and vented to the exterior of the aircraft to prevent toxic, corrosive, or oxidizing gases or fumes from entering the cabin. Sealed lead acid (SLA) batteries, for example, are exempt from sealed containment and venting; however, they must be mounted on a drip tray or in a housing sufficiently constructed to prevent leakage from escaping.

D. Use a fuse or circuit breaker as close to the battery pack as possible.

E. Minimize hazards due to cell failure through use of isolation and/or bypass diodes, thermal cutout switches, electrolyte resistant wire insulation, etc.

F. Label battery housings with applicable safety warnings (such as corrosive/caustic liquid, flammable gas, high voltage or current capability).

G. Unattended battery charging on the aircraft is not allowed. Battery must be isolated when not in use.

Battery approval is dependent upon the total aircraft mission configuration and assessed risk level for all potentially hazardous items on board. Approval will be for a particular mission series. Complete vendor battery specification and material safety data sheets must be submitted along with application information for DFRC review and approval action. Special approval will be required to allow unattended or overnight operation of battery-powered equipment in the aircraft.

5. Uninterruptible Power Systems (UPS)

The structural integrity and circuitry guidelines in chapter 4 apply to UPS batteries. All units will be subjected to safety inspection and battery assembly procedures. The following specific requirements will be inspected:

A. A front panel mounted switch or circuit breaker must provide complete battery isolation from UPS circuitry. It must be easily accessible and clearly marked "Battery Isolation."

B. A Material Safety Data Sheet (MSDS) must be supplied for the battery.

C. The battery must be a sealed lead acid (SLA) type, or other DFRC approved type, with immobilized electrolyte.

D. All batteries must be in secondary containment to prevent leakage of electrolyte onto the aircraft interior. This is accomplished by mounting the battery or UPS on a drip tray or insuring that the battery housing, or UPS, is sufficiently constructed to prevent leakage from escaping.

E. The battery assembly must be as supplied by the vendor and must have been installed by the vendor, or other qualified personnel. If the experimenter designs the battery assembly, it must be new (within 90 days) and installed at DFRC with an aircraft inspector witness. If the battery is of the type that requires periodic maintenance, adequate documentation must be presented that traces the last battery installation date and subsequent UPS use and maintenance history.

F. If the battery was installed before arrival at DFRC, the unit will be subject to a "covers removed" inspection for general workmanship and compliance with wiring requirements, containment, and isolation systems.

G. Along with an MSDS for the battery, a copy of the owner's manual for the UPS must be provided. Provide circuit schematics, if available.

6. Aircraft Ground System (AGS)

The 400 Hz bus (in the forward cargo bay), and the 60 Hz bus (behind the mission director console), are grounded by being electrically strapped to the aircraft structure. All ground connections in experiment equipment must be made to the third wire of a 115-volt plug, or the fifth wire of a 400 Hz three-phase plug. These ground conductors then return to their own bus. All power neutral leads from 400-Hz or 60-Hz loads must be returned to the power system; they cannot be grounded.

Receptacle panels are also grounded at the receptacle and serve in turn to ground the individual racks. To assure good electrical contact between panel and racks, the contacting surfaces should be cleaned with a bond brush.

As previously stated, "...the GFI units are provided on both power systems". The 60-Hz power panels have a GFI unit incorporated into each panel. A ground current in excess of 5 mA will trip the panel's GFI, causing power disconnect from all receptacles on that panel. Experiment equipment with internal power grounds, resulting in ground currents exceeding the above, will activate the GFI to disconnect power. Should it be impractical to eliminate such internal power grounds, it may be necessary to supply an isolation transformer between the equipment and aircraft power.

7. Electromagnetic Interference (EMI)

The power grounding system described above minimizes the possibility of generating ground loops within the aircraft structure. Also, every effort is made, in ground testing before flights, to assure that there is no interference between experiments because of their electrical power characteristics. However, occasionally such interference may show up in flight. In such circumstances it may become necessary to rearrange power distribution to eliminate mutual interference. It is incumbent upon the experimenters to assure that their experiment equipment is not adversely affected by any minor voltage transients, and also to assure that operation of their equipment does not adversely affect the other experiments.

Experimenters are cautioned that transmitters on the aircraft may cause interference with their equipment. Refer to table 2-1 for a list of frequencies to be considered in experiment design. Conversely, experiment equipment must not interfere with aircraft receivers; outputs should be limited to 100 mW. Other factors relative to EMI and/or experiments follow:

A. Power leads along both sides of the cabin are in close proximity to signal leads. Some physical separation can be arranged at installation, but shielding should be considered for critical cases.

B. EMI measurements have shown that aircraft power is contaminated with broadband RF.

C. High-impedance detector circuits are often subject to EMI, (unshielded detector leads may pick up noise from radio frequency fields within the aircraft).

8. Electrical Safety

Electrical safety procedures are governed by Dryden Centerwide Procedure DCP-S-025, “Lockout/Tagout”; and DCP-S-026, “Electrical Safety.” These documents must be reviewed and understood by experimenters who bring their equipment to DFRC. Contact the mission manager for a current copy. Safe installation and operation of electrical equipment depends on observance of the following design considerations.

A. High Voltage Protection

Reduced atmospheric pressure increases the possibility of corona discharge and arcing between high voltage components and ground. High voltage leads should be sufficiently insulated to prevent flashover. Normal cabin pressure is equal to 7,500 ft (2.29 km), and break down distance, for a given voltage, is one-third greater than at sea level pressure. For equipment in pressure canisters that are open to the outside at 40,000 ft (12.2 km) altitude, the equivalent distance is greater by a factor of 3.5.

These conditions should guide equipment design with respect to lead separation, insulating high voltage components, avoiding sharp bends, solder peaks, and other rational practices. High voltage components and cables must be clearly marked and, where practical, electrical and mechanical interlocks should also be used. Contacts on terminals carrying fifty volts or more to the ground must have guards to prevent accidental contact by personnel.

B. Wire and Cable Insulating Materials

Polyvinyl Chloride (PVC) is a thermoplastic material composed of polymers of vinyl chloride. It is widely used for primary insulation or jacketing on a variety of wire and cable types. However, as attractive as it is as an insulating medium, it does possess properties that make it hazardous for use in an airborne environment. When exposed to high temperatures, it has the unfortunate property of outgassing noxious/toxic products as well as heavy black smoke. For these reasons, wire and/or cable using PVC as the primary insulating material or jacket is not considered airworthy.

Electrical wire and cable used by experimenters, external to commercial manufactured components, should be clad with non-flammable or self-extinguishing insulation, with at least 150 °C rated outer insulation material. Some commonly encountered materials and their usability are listed in table 6-1.

NOTE: MIL-W-22759/11 or /16 wire is always acceptable.

Questions about material usage and acceptability should be directed to DFRC. Large volume and extended use of non-self-extinguishing insulation, in experiments to be flown on DFRC research aircraft will not be approved by the aircraft inspectors at time of installation.

Accessories such as identification sleeves, cable ties, chafe guards (spiral wrap), and cable clamps, should be of similar material. To avoid the time and cost of on-site cable replacement, suitable materials should be utilized to the fullest extent possible when assembling new components and their interconnecting cable assemblies. For those portions of experiments that have flown before, with cable assemblies that fail the above criteria, it is often acceptable to use a flame resistant outer sleeve.

Power cords that are attached to commercially procured equipment should also have other than PVC jackets. UL Type SO (neoprene jacketed, 600 volt / 90 °C) is recommended, is readily available, and is usually accepted for this application despite a lower temperature rating. Exceptions to this guideline may require special treatment.

C. Electric Motors

The use of electric motors aboard the aircraft requires individual approval by DFRC. Preferred are 400 Hz motors, to avoid starting transients on 60 Hz converters. Larger motors (such as those used in vacuum pumps) must be protected by thermal overload devices. In addition, single-phase motors must be equipped with solid-state switches to inhibit arcing at the contacts during start-up. In the absence of arc-suppressors, motors must be spark free during operation. Motors rated explosion-proof or totally enclosed non-ventilated

Table 6-1. Commonly encountered wire/cable insulation materials.

Fluorocarbons	Max. Operating Temp °C (nominal)
❑ Teflon TFE (tetrafluorethylene)	+260
❍ Teflon PFA (perfluoroalkoxy)	+250
❍ Teflon FEP (fluorinated ethylene propylene)	+200
❍ Teflon PTFE (polytetrafluorethylene)	+150
❍ Tefzel EFTE (ethelene & tetrafluorethylene)	+150
❍ Halar ECTFE (ethylene & monochlorotrifluorethylene)	+150
❍ Kynar PVDF (homopolymer of vinylidene fluoride)	+135
❍ Silicon, Rubber (Good low-temperature flexibility at -90 °C)	+200
❍ Polysulfone	+130
❍ Hypalon CSPE (chlorosulfonated polyethylene)	+90
❍ Neoprene (polychloroprene)	+90
❍ Natural Rubber (NR isoprene)	+70
■ Kapton (polymide resin)	+200
● Polyester	+150
● Nylon (polymide polymer)	+105
● Polyvinyl Chloride (PVC)	+80 to +105
● Polyethylene (PE)	+80 to +105
● Polypropylene	+90
● Polyurethane	+80

❑ = TFE is recommended as the preferred wire insulation for general use in DFRC aircraft. Proper installation procedures are credited with avoidance of problems, related to cut-through resistance and cold-flow properties. Some MIL-W-81044, MIL-W-81381, and MIL-W-16878 wire is acceptable in certain applications, but DFRC approval should be obtained prior to final product specification to ensure proper airworthiness standards are met.

❍ = Acceptable Materials.

■ = Kapton insulated wire (MIL-W-81381 or equivilant) has had a number of reported incidents of short circuit arc tracking (flashover) which resulted in severe propagating destruction of wire bundles in military and aerospace hardware. The use of Kapton insulated wire should be avoided. Contact DFRC for additional guidelines and usage criteria.

● = These materials are not normally acceptable due to flammability and/or toxic pyrolysis products. Contact DFRC for additional guidelines and usage criteria.

motors are recommended. However, many fractional horsepower AC permanent split-capacitor motors are acceptable depending upon application and location. Large DC brush type motors are generally not acceptable due to the electrical arcing at the brushes. Early consultations with DFRC will help avoid problems at installation.

9. Heaters

All heater assemblies are reviewed for electrical safety, proper circuit protection devices, and the presence of high temperature exposed surfaces that might serve as ignition points for flammable gases, or cause injury to personnel. The following must be supplied to DFRC for review:

A. A simple electrical schematic must be provided for each heater. The schematic must show the heater, the temperature controller, any fuses or circuit breakers, the power supply, and the wire size between these components. A thermal fuse is recommended between the controller and the heater for added protection.

B. Provide product literature for the components of the assembly (heater, controller, temperature sensor, etc.).

C. Provide a description of the location and function of the heaters. A sketch showing the location of the heaters in relation to instruments and/or probes is most helpful.

CAUTION: Exposed surfaces above 130 °F (54 °C) are generally considered safety problems, and must have adequate shielding and caution signs.

10. Experiment Cabling

Generally, DFRC provides all cabling to the experiment from the power outlet boxes and the central computer (ICATS); the experimenter provides matching connectors. The experimenters are responsible for the cabling between two or more racks of their own equipment. These cables must be routed off the floor to permit free access between racks. Cables that connect racks on opposite sides of the aisle, are routed overhead in metal trays; 22 ft should be allowed for the overhead run.

All cabling inside of the racks must be clamped to inhibit movement, utilizing existing holes and/or openings.

11. Equipment Certification

Experimenters are responsible for the design and assembly of electrical systems in accordance with these specifications. They are requested to submit to DFRC a power break down (such as 60 Hz, 400 Hz, single-phase, three-phase) by component, for each standard rack, and any other installations elsewhere in the cabin or cargo areas.

Additionally, information should be provided about all electric motors in the experiment, to include type, starting (inrush) current magnitude/time scale, and thermal overload protection. This information should be submitted along with all the mechanical design specifications at least eight weeks prior to installation.

DFRC will review the material, request changes as needed, and prepare a power distribution plan for all the experiments in the payload. Final verification of electrical systems will be made at DFRC, prior to approval for installation on the aircraft.

CHAPTER 7

INFORMATION COLLECTION AND TRANSMISSION SYSTEM (ICATS)

1. General Information

The on-board Airborne Science DC-8 Information Collection and Transmission System (ICATS) was designed, assembled, and programmed by the DFRC Research Instrumentation (RI) Branch. The ICATS post-flight data processing archive and data access system was developed by the DFRC Research Facilities Directorate.

Functions of the on-board ICATS include:

A. Interfacing to and processing avionics and environmental parameters derived from the navigational management system, the global positioning system, the central air data computer, the embedded GPS/INS, and analog voltage sources from the aircraft and experimenters.

B. Furnishing engineering unit values of selected parameters and computed functions for real-time video display and archiving ASCII data at experimenter stations.

C. Archiving the engineering unit values of all ICATS parameters on data storage for post flight retrieval.

The resulting post-flight archiving system provides World Wide Web-(WWW) based access with secure permission-based remote login. The data will be available anytime 24 hours/day, 7 days/week. In addition to the World Wide Web, an ftp server is also available.

2. Overview of ICATS

A. Hardware Configuration

Hardware components for ICATS consist of a prime and spare VME chassis and associated hardware. These are located in the house-keeping rack between the mission director console and the navigator station. Prime and spare Sun Ultra 80 workstations and associated hardware are located at the operator station in the DC-8.

1) VME chassis

All computations and data interfaces for the ICATS system are implemented in a 20 slot VME chassis, which presently contains a CPU controller card, MIL-STD-1553 and ARINC-429 interface cards, analog/digital converter card, and a broadcast memory card. The broadcast memory card is used to interface with the Sun Ultra 80 installed in the operator station. The Numeric Parameter Display Page routine is run in this chassis.

2) ICATS Operator Station

The ICATS operator station contains two Sun Ultra 80 workstations. The Ultra 80 will serve as a control point for all ICATS functions. Boot-up and all archiving functions are implemented in the Ultra 80. Track plot and parameter plot routines are run in this computer. The mission manager's PC, used for keyboard entry commentary, is connected to the Ultra 80. Ultra 80 hard drives will be used for archiving mission binary data at one and ten samples/second and ASCII data at one sample/second.

B. Other ICATS Hardware.

1) Rack-mounted PC

The ICATS operator station contains a rack-mounted PC. This computer will serve as a back up for logging the ASCII data generated during the flight. The computer can also be used to boot-up the VME chassis.

2) Broadcast Memory Hub

The broadcast memory hub has been established. The Ultra 80 workstation communicates with the broadcast memory card in the VME chassis via a fiber optic line.

3) Ethernet Hub

The Ethernet hub connects the VME Chassis, Sun Ultra 80, printer, mission director's X term, and experimenter stations.

4) RS-232 lines

The RS-232 routes data to each experimenter station.

5) CD read/write hardware

The CD read/write hardware will burn either ASCII and/or binary files up to 700 Mb for on-mission archiving.

6) RS-232 line

The RS-232 line connects the mission manager's PC to Ultra 80.

7) DC-8 network printer

The DC-8 network printer is available for use by all DC-8 mounted experiments.

8) NOAA Satellite Weather Pictures

This automatic picture transmission (APT) system is located at the ICATS operator station. When on a remote deployment or during a flight, the onboard APT system can be used to obtain near real time observation of weather.

9) Software Configuration

The VME chassis utilizes the VxWorks operating system. Output of this software is described in this handbook.

3. Data Sources for the ICATS System

ICATS receives digital and analog input signals from a number of sources. All data is acquired by ICATS at 30 samples/second. This data is converted to engineering units and recorded in binary format at one and ten samples/second. The ASCII files of selected data is distributed and stored at one sample/second.

A. Digital Input Signals

- MIL-STD-1553 bus data

  Honeywell Embedded GPS/INS

  Radar altimeter (RA)

- ARINC-429 bus data

  Navigational management system (NMS)

  Air data computer (ADC)

  Global positioning system (GPS)

B. GPS Updated Time Code Receiver

Aircraft time code generator (TCG) furnishes time to all requirements on aircraft. The TCG receives updates from a GPS receiver. ICATS has a timecard reader, which continuously synchronizes the IRIG-B from TCG and inputs data to memory at 30 samples/second. Time code values are combined in ICATS and are available to users in real time and post flight as parameter "Time". Time is available in ASCII format with a range of 00:00:00.000 to 23:59:59.999 and also is contained in the post-flight binary files. The TCG also provides time to the video distribution system, providing a time tag for all video displays and recorded video.

C. Mission Manager's Log

The mission manager's log file enables the mission manager to provide time-stamped keyboard entry commentary of his/her observations or those from other sources. The logging subsystem automatically records the start and end of data runs, annotating them with present time, position, altitude and other information. ICATS provides the capability for future upgrades to the existing log file system.

D. Analog Sources

A 64-channel high-speed analog to digital converter card resides in the ICATS VME chassis for analog signals from aircraft and environmental sensors. This card will also be used for analog signals routed to the VME from the experimenters' hardware. These analog inputs are converted to engineering units and become part of the parameter database as listed in appendix C. These analog sources include the following:

- Rosemount model 1241 A6CD for cabin altitude.
- General Eastern model 1011C thermoelectric hygrometer.
- EG&G model 300 cooled mirror hygrometer system.
- Heitronic Model KT-19 infrared radiometer.
- Honeywell APN-232 electronic radar altimeter system.
- Analog signals routed to ICATS from experimenters.

4. Output Parameters from ICATS

Appendix C lists output parameters from ICATS, which are available in the data base for use in display, computations, and archiving. This appendix identifies the (1) source for each parameter, (2) the ICATS parameter identification code (PARM ID), (3) units for the parameter (deg, ft/sec, kn, °C, etc), (4) sign convention definition if appropriate (for example for vertical speed + for ascending, – for descending) (5) parameter range (for example, GPS alt range —1000 to 131,072 ft) (6) other comments.

Appendix C shows the ASCII parameter set and format for the ICATS parameters distributed on the 1200, 9600 and 19.2k baud rates from the RS-232 distribution systems. This set of ASCII parameters (9600/19.2k) is what will be archived at one sample/second. For each mission, additional parameters from the ICATS output parameter list may be added or substituted within the limitations of the RS-232 system.

5. Video Distribution in ICATS

A. Parameter alphanumeric displays

The DC-8 closed circuit television system displays to the on-board experimenters' choices from a number of video sources including a data page of parameters, which is generated in the ICATS system and sent out in NTSC format to the video switching system. The present format consists of two columns of seventeen parameters each. Parameter name, engineering unit's value, and units are displayed in each column.

B. Track Plot on TV monitor

The ICATS system generates a track plot of the DC-8 flight.

C. Parameter Plot on TV monitor

The ICATS system generates a parameter plot consisting up to 6 parameters on the y-axis.

D. Video recorders

Includes three VHS format time-lapse, which can provide two to six hours of continuous recording. A quad video splitter is available to consolidate four video NTSC views onto one NTSC distribution cable. This feature can be used for comparison of related video images.

6. RS-232 Data Line To Experimenter-operator Computers

The ICATS provides the ASCII formatted engineering unit data to experimenter-operated computers via RS-232 line at a rate of one sample/second. Transmission rates of 1200, 9600 and 19.2 baud are available. Formats are shown in appendix C.

A data distribution subsystem accepts the standard RS-232-C signal outputs from the ICATS serial output interface, converts the signal to RS-422 (for noise immunity and improved signal-to-noise) and distributes the data along both sides of the aircraft. The signals are tapped at intervals and regenerated as RS-232-C at each experiment station. Each station has three DB-25 connectors, each dedicated to one of the three baud rates (1200,9600, and 19.2K) for use by the experimenters. Connectors may be used simultaneously, in any combination. The signals are opto-isolated from the main data path and the RS-232-C drivers are current-limited in order to protect the system from defective experimenter equipment or accidental shorting of output lines. The experiment station box may be configured as a modem (DCE) or as a computer (DTE). The configuration is defined by a switch setting at each experiment station box. This switch functionally exchanges pins two and three of the DB-25 connector.

7. On-deployment Data Delivery Available After Flight

During the flight mission, data output parameters discussed in section 4, are archived in both binary (one and ten samples/second) and ASCII format (one sample/second) to hard disc on ICATS Sun Ultra 80, located in the ICATS operator station.

A. Experimenter retrieval of data on aircraft on deployment:

- ICATS creates a hard copy of track plot or parameter plot if required.
- ICATS accesses the data through an ethernet connection to an ftp or http browser.
- ICATS produces a SCSI 8 mm tape and/or CD if required.
- ICATS makes a SCSI 8 mm tape for use with portable UNIX workstation (laptop) which runs ORACLE software.

B. Experimenter retrieval of data off aircraft on deployment:

- Data will be made available on the World Wide Web and ftp server.
- CD, disc or 8 mm tape.

8. Dryden-Based ICATS Post Flight Data Delivery and Archiving

A. ICATS Data Archive

- NASA will utilize a Sun Ultra 80 and associated storage capacity as host for the data archive of all data referenced in section 4 of this chapter. This parameter set may change as DC-8 missions continue.

- The NASA archive will contain the ICATS DC-8 Binary files at one and ten samples/second.
- The NASA archive will contain the ICATS ASCII files at one sample/second with parameters on the 9600/19.2k baud.

B. ICATS Data Retrieval Methods

- Access to the Sun Ultra 80 ftp server.
- In addition, the Sun Ultra 80 will be configured as a web server. Data requests may be made with a web browser. Data downloads may be made with a web browser. Data parameter ID codes identifying parameters, parameter ranges and sign conventions will be the same as those referenced in section 4.

CHAPTER 8

FACILITY INSTRUMENTATION

1. General Information

A variety of systems are available to acquire aircraft flight parameters and related environmental data in support of the research activities. Many of these systems are standard on-board facilities; others can be provided on request. Outputs vary from real-time electrical signals distributed to experiments to post mission copies of film or magnetic tape, as outlined in the following section.

2. Standard Aircraft Systems

Data acquisition systems listed in table 8-1 are standard to the aircraft. Output signals and the formats available to experimenters are listed below.

A. Inertial Navigation System (INS)

The Delco Carousel IVA-3 Inertial Navigation System operates by sensing aircraft accelerations from a gyro-stabilized, four-gimbal, all-attitude platform. Dual two-degree-of-freedom gyros, that feature self-generating gas bearings, have very low drift characteristics and excellent turn-on repeatability. A general purpose, microelectronic digital computer is part of the system. Output functions include position information, course-line computation, steering commands, and angular pitch/roll/heading information. The system also accepts a true airspeed signal that is used to compute wind speed and direction.

The full data stream, in binary coded decimal (BCD) format, is output to a remote display unit at the mission director's console and to the ICATS. In turn, ICATS converts the data stream into separate parameters for output to experiments. Selected INS analog outputs also go to the housekeeping rack.

Table 8-1. Standard aircraft data systems available on CCTV and ICATS data stream.

System	Output Data
Intertial Navigation Systems (2)	Pitch and Roll Drift Angle Latitude and Longitude [1] Ground Speed [2] True Heading [3] Wind Vector [4] Distance to Go [5] Time to Go [6] Cross Track Distance [7] Course (desired track) [8] Track (Angle) [9] Track Error [10] Align Status [11]
GPS System	Also produces items 1-11 above
Total Air Temperature Probe	Total Air Temperature
Dew/Frost Point Hygrometers	Prevailing Ambient Dew Point/Frost Point
Surface Temperature Radiometer	Surface and Cloud Top Temperature
Radar Altimeter	Absolute Altitude above Land or Water
Central Air Data Computer (Flight Instruments)	Pressure Altitude & True Airspeed Mach no. & Static Air Temperature Vertical Velocity
Cabin Altimeter	Equivalent Pressure Altitude
Time Code	IRIG-B

B. Flight Management System (FMS)

The flight management system is a fully integrated navigation management system designed to provide the pilot with centralized control of the aircraft's navigation sensors and computer based flight planning. The FMS accepts primary position information from short and long-range navigation sensors. Inputs from DME, VOR, TACAN, and GPS can be utilized to determine the aircraft's position. In addition to the navigational inputs, the system also receives true airspeed and altitude information from the air data computer and heading reference from the INS. The primary position data received from the sensor is filtered within the FMS to derive a "best computed position" (BCP). Using the BCP, the FMS navigates the aircraft along the programmed flight path.

C. Global Positioning System (GPS)

The global positioning system is a system whereby GPS satellites transmit highly monitored position and timing data allowing a receiver to precisely determine its range to the transmitting satellite. By observing multiple satellites, the receiver can accurately determine and track its position in longitude, latitude, and altitude allowing precision point-to-point navigation to be performed. The DoD World Geodetic System of 1984 (WGS-84) is the convention used for all positioning and navigation purposes.

D. Weather Radar System

A Collins WXR-700C horizontal scanning, two-axis, gyro-stabilized C-band radar antenna is located in the nose of the aircraft. Color images are displayed on a multi-function display (MFD) that is also used to display the aircraft's flight instrument system. The mission director can also observe and record on videotape the same weather display the flight crew is observing.

E. Total Air Temperature System (TAT)

The Rosemount 102 AH2AG Total Air Temperature system features an accurate, quick response probe that measures the total temperature of air outside the aircraft, using a platinum-resistance sensing element. This value is warmer than static air temperature (SAT) by reason of aircraft speed. The TAT is used by the central air data computer (CADC) to compute the true airspeed. Signals from the probe electronics package are sent to the housekeeping rack, and from there they are available to both ICATS and the experimenters. The TAT sensing range is from –65 to +35 °C with an accuracy of ±1.0 °C.

F. Dew/Frost Point Hygrometers

The General Eastern 1011C is a two-stage, thermoelectric hygrometer system designed to obtain in-flight measurements of the prevailing ambient dew point or frost point temperature. It does this over a range of –75 to +50 °C by stabilizing the temperature of a mirror at the point where moisture starts to condense on its surface. Accuracy is ± 0.1 °C over entire range.

Signal outputs from this instrument is routed to indicator units in the mission director's console and to the ICATS for presentation on the CCTV and recording. Hygrometer system status is signaled to the ICATS and is coded in the data. Response time of the hygrometer systems is about 1 °C per second; and has decreasing response and depression capabilities as temperatures drop below –60 °C.

G. Surface Temperature Radiometer

A Heitronics model KT19.85 nadir-viewing infrared radiation pyrometer measures earth's surface (land or water) or cloud top temperature in the spectral band of 9.6 to 11.5 microns. The radiometer has a 2-deg field of view, and covers the range –80 to +200 °C. A signal is sent from the system electronics in the housekeeping rack to ICATS for recording and display on CCTV.

H. Radar Altimeter

A NavCom Defense Electronics, Inc., APN-232 combined altitude radar altimeter determines the aircraft's altitude above land or water (0 to 65,000 ft) by means of reflected, sub-microsecond rf pulses between 4.2 to 4.4 GHz. The specified accuracy ranges between ±1.0 to 2.0 percent, depending on altitude and whether the digital or analog output is being used. Visual readout units are located in the mission director's console, and signals are sent to ICATS for CCTV display and recording.

I. Aircraft Flight Instruments

The outputs from various flight instruments can be made available to experiments. Ordinarily, the instrument signals are processed by the CADC, sent to the housekeeping rack for conditioning, and provided to ICATS. The available parameters from the CADC are listed in appendix C.

J. Cabin Altimeter

The equivalent altitude pressure in the cabin (–1000 ft to 20,000 ft) is detected by a Rosemount Mod 1241 A5CD cabin altimeter. The signal output is sent to ICATS for recording and display on the CCTV.

K. Time Code

IRIG-B time code, in serial format, is available on video and camera displays. It is sent to ICATS for recording on experimenters' data.

3. Camera Systems

For missions requiring photographic coverage, the mission manager can arrange for various camera systems. These camera systems are frequently used to obtain photographic records of the area surrounding the aircraft's flight path. Experimenters should make their camera requirements known as far in advance as possible of the planned mission.

The camera systems can be controlled manually or automatically at frame rates to accommodate most aircraft speeds and altitudes. The automatic frame rates can be controlled by either time or percentage overlap. Film is marked with universal time (UT) code. Specific information is given below and in table 8-2.

A. Flight Research, Inc. Model 4E (Giannini Camera)

This is a 35mm camera taking 14 pictures per foot of film; capacity is 100-ft or 400-ft film magazines.

B. W. Vinton, Ltd. Reconnaissance Camera

This is a 70mm camera taking 4.8 pictures per foot of film; capacity is 100-ft or 200-ft film magazines. The camera has automatic exposure control.

Table 8-2. Supplemental data systems.

FILM CAMERAS			
Cameras	**Film Size**	**Frame Size (in.)**	**Range of Operation**
FRI-4E	35 mm	3/4 x 3/4	Frame rates variable to 20 per sec; wide selection of lenses.
Vinton	70 mm	2 1/4 x 2 1/4	Frame rates variable to 8 sec; 11/2-in. lens, 73 deg m FOV
CAI-KS87B	5 in.	4 1/4 x 4 1/4	Frame rates variable to 6 per sec.; 14 deg, 21 deg, 42 deg, 73 deg FOV; 18-in., 12-in., 6-in., 3-in., focal length.
WHRC-10	9 1/2 in.	9 x 9	Frame rates variable to 1 per 7 sec; 6-in. lens, 73 deg FOV or 12-in. lens, 41 deg FOV

VIDEO SYSTEM			
Cameras	**Lens**	**Sensor**	**Recorder**
SSC-DC50	8-48 mm zoom CS - mount type f1.4 Auto Iris	CCD color; 768(H) x 494(V) Pixels 470 TVL Composite Output	Panasonic AG 6740 VHS/SVHS; 2, 6 Hour or Time Lapse 1 to 5/16 ips (2H mode)
EM 102 II	Non-Auto-Iris 4-24 mm	CCD Color 574(H) x 489(V) Pixels 350 TVL	WJ-450 Panasonic Video Splitter
EM 202 II	Auto-Iris 6-12 mm zoom f1.0 to 1.4		
EM 202 II	Auto-Iris C-Mounted 8-48 mm zoom f1.2		
SSC-DC50	35 mm fixed C-mount type f1.8 Auto Iris	CCD Color; 768(H) x 494(V) Pixels 470 TVL Composite Output	Panasonic AG 6740 VHS/SVHS; 2, 6 Hour or Time Lapse 1 - 5/16 ips (2H mode)

C. Chicago Aerial Industries Model KS87B

The CAI KS87B uses 5 in. film taking 2.4 pictures per foot of film; capacity is 600-ft film magazines. The camera has automatic exposure control and forward motion compensation.

D. Wild Heerbrugge Model RC-10

The WH RC-10 camera uses 9 1/2-in. film, taking 1.25 pictures per foot of film; capacity is 400 ft film magazines. The camera has a variable shutter and f-stop exposure. It can be equipped with either a 6- or 12-in. focal length lens as required.

E. Sony Video Camera Model SSC-DC50

Three small video cameras (2 5/8-in. wide, by 2 1/4-in. high, by 5 1/2 -in. deep) are available for mounting at various positions within the aircraft, or at an exterior window, to record events significant to the experimenters. The cameras have color capability and use solid-state CCD imaging devices. The camera body has a "C/CS" mounting, permitting experimenters to utilize their own non-zoom lenses if necessary. Special camera mounts must be custom fabricated for each application; therefore, experimenters must make these types of requirements known early in the design phase. The three available camera assemblies have a common control panel at the housekeeping rack for remote focus and zoom. SVHS and NTSC outputs from each assembly are available.

F. Elmo mini-Video Camera Model EC 202 II

This camera is mounted on the glare shield in the cockpit, providing a view ahead of the aircraft. It is equipped with an auto-iris f 1 to f 1.4, manual 6 to 12-mm zoom lens. The output signal is available for NTSC distribution.

G. Elmo mini-Video Camera Model EC 202 II

This camera can be placed in many locations throughout the aircraft. Nadir, side, or zenith views can be obtained from various viewports. The lens is "C" mounted, auto-iris f 1.2-, 8-48-mm. The output signal is available for NTSC distribution.

H. Two Elmo Video Cameras, Model EM 102 II

These cameras can be used in very small places due to the miniature CCD lens assemblies, approximately 2.75-in. long with a 0.7-in. diameter. They are non-auto-iris with 4-, 7.5-, 15-, and 24-mm lenses available.

I. Duncan CIR Camera

The Duncan CIR (Color Infrared) camera is a 3-CCD false-color Near Infrared digital camera. It images 3 spectral bands from 400-1100 nm, producing high resolution images similar to false-color photographic film. It also provides an analog real-time NTSC video output.

J. Panasonic Video Recorder Model AG-6740

Three S-VHS/VHS format time-lapse recorders are available, which can provide 2 to 6 hours of continuous recording. Time-lapse recording is also available at a selection of interval rates. With the S-VHS/VHS format, 400 lines of horizontal resolution are available. Internal, operator-set clock time or date can be inserted on the tape record in either continuous or time-lapse mode. Audio recording is only available when operating in the continuous mode.

K. Panasonic Video Splitter, Model WJ-450

A quad video splitter is used to consolidate four video NTSC views onto one NTSC distribution cable. This can be used for comparison of related video images.

4. Dropsonde System

A launch tube for the release of standard and Vaisala radiosondes can be located in the aft portion of the cabin, at station 1390. These sondes parachute to the surface while relaying information on atmospheric conditions back to the aircraft. Experimenters must supply their own sondes, receiving, and recording instrumentation.

5. Satellite Weather Pictures

Visible and infrared channel weather images from orbiting satellites can be obtained on the aircraft in flight. An automatic picture transmission (APT) system uses the polar-orbiting NOAA satellites to obtain near real time observation of weather systems. Image availability is subject to satellite ephemeral.

6. Time Information

A. Time Code System

A Datum model 9390-6000 ExacTime GPS Time Code and Frequency Generator (TCG) has been installed in the DC-8 housekeeping rack to provide a standardized time base for the data acquisition system. Time information is available at each experimenter's station, from ICATS via the RS-232 data bus. If required, date and time information can be supplied directly from the GPS timing unit to the experimenter's instrument in IRIG B serial time code.

Prior to a data flight the TCG will be powered up. The unit automatically acquires and tracks satellites based on health status and elevation angle. Time and frequency is determined from satellite transmissions and calculations referenced to UTC through the GPS master clock system.

B. Time Displays

Small display units for universal time can be provided for experimenter's use when a visual clock would assist experiment operation.

CHAPTER 9

FLIGHT OPERATIONS

1. Flight Safety

Aircraft flights in general are governed by specific safety rules. Flight conditions in the DC-8 airborne laboratory are different from conditions in commercial passenger airplanes; a major difference is the presence of experimental equipment. This apparatus can pose potential hazards in the aircraft just as it does in conventional laboratories. For this reason, certain safety regulations are implemented for all flights in the DC-8, and specialized safety equipment is carried. All participants in DC-8 flights are required to abide by these regulations, which will be enforced by the command pilot and the mission director. Before flight, an inspection of equipment items in the aircraft will be conducted to assure that they conform to those regulations.

A. Safety Briefings

Safety training sessions are held at the start of each mission. Attendance by all participants is mandatory. These briefings cover the use of emergency exits, life rafts, life vests, fire extinguishers, emergency oxygen (in the event of sudden cabin depressurization), and survival methods following a ditching or Arctic surface landing.

B. Specialized Safety Equipment

The DC-8 carries safety equipment equal to, and often exceeding that carried by comparable passenger aircraft.

1) Seat Belts

All passenger seats are equipped with a combination seat belt/shoulder harness. This must be used during take-off and landing, and whenever the seat belt sign is illuminated. The pilot will indicate when its use is required. The mission director will ensure that all passengers comply.

2) Fire Protection Equipment

A wide variety of fire protection devices are located throughout the aircraft. Two fireboards with fire fighting equipment are located in the main cabin, and one fireboard is located in each cargo hold adjacent to access hatches. Each of these fire boards includes a fire extinguisher (Halon), fireproof gloves, a fire axe, a smoke mask, a seatbelt cutter, and an emergency oxygen bottle.

In addition, individual emergency passenger oxygen system (EPOS) smoke hoods, are provided for both experimenters and the flight crew. These fire hoods provide a 30-minute oxygen supply and are located in the center armrest of each seat pair.

3) Water Survival Equipment

There are four life rafts carried on all flights over water. They are located in the main cabin - two in the ceiling adjacent to the overwing emergency exits, one forward and one aft near the cabin doors. The rafts contain enough rations and gear to sustain each person for one week.

Individual life vests are stowed in the center armrest of each seat pair. The bottom cushion of each seat can be easily removed and used as a flotation aid.

4) Arctic Survival Equipment

Arctic survival kits are carried on all flights over Arctic regions. These kits will sustain each person for one week. They are contained in duffels adjacent to the overwing emergency exits or the aft cabin doors. In addition, virtually all the contents of the life rafts can be used in Arctic conditions. Emergency protective clothing (outer garments) is also provided for each flight participant. These are vacuum packed in duffels stored in the cabin and cargo compartments and are for emergency use only. Arctic clothing for non-emergency ground use, and all inner clothes layering, are the responsibility of the individual.

5) Emergency Exit Lighting

In case of an emergency, a lighting system will automatically illuminate exit signs at each door. Lights located on the seats or experimenter racks will also illuminate the aisles to facilitate egress from the aircraft.

6) Automated External Defibrillator

An automated external defibrillator (AED) is mounted at the rear of the DC-8 cabin for the delivery of early defibrillation to victims of sudden cardiac arrest. Designated aircraft crewmembers are trained in the maintenance and use of this equipment.

In addition, several dedicated medical breathing oxygen bottles are available. These bottles are equipped with cup masks for comfortable use.

C. In-flight Safety

NOTE: Significant information for in-flight safety is outlined below.

1) Emergency Oxygen Equipment

Oxygen masks are located throughout the cabin in the overhead compartments or designated surface mounted boxes. They are within convenient reach of all participants when seated. Should the need arise, the bottom of the compartment or box will automatically open, and the oxygen masks will drop down. The crewmembers and the mission director have portable emergency oxygen bottles, and can assist anyone on the aircraft.

2) Intercom Regulation

The aircraft intercom system enables the mission director to monitor experimenter operations and become aware of any safety-related problem immediately. At least one member of each research group is required to be on the intercom at all times. Extra-length cables can be provided if necessary to aid experiment operations.

3) Cargo Areas

Access to cargo areas is permitted in flight, but not during take-off and landing. Also, at aircraft altitudes above 25,000 ft, the experimenter must be accompanied by an aircraft crewmember while in the cargo area. Experimenters must inform the mission director before moving into the cargo areas. They must remain on the intercom while in the cargo area, and must confirm their return to the main cabin with him/her.

4) Proper Attire

Sandals and open-toed or high heel shoes are not allowed in the Experiment Integration Facility, the hangar, or the DC-8. Also, skirts and shorts are not appropriate flight attire for the DC-8. Flight participants wearing these will be asked to change into long pants or a flight suit before being allowed to fly.

5) Airport Security

DC-8 flight participants are warned not to carry items on the DC-8 that are restricted within airport security areas (illegal substances, weapons, etc.) Keep tools aboard the DC-8. Prior to transit flights, the mission manager will check for visa, passport, and other required identification.

6) Optical Windows

An aircraft crewmember will inspect optical windows after take-off and report their status to the mission director. The mission director will then clear the windows for use (rules governing the use of safety slides are covered in chapter 4).

7) Repair Equipment

Electric motor-driven hand tools, heat guns, pencil-type soldering irons, and soldering guns cannot be used in flight. Use of volatile solvents on the DC-8 is not permitted in flight, and must be cleared for use on the ground.

8) Smoking

Smoking is not permitted at any time on the DC-8 or in any DFRC building.

D. Additional Safety Considerations

NOTE: Additional safety considerations are outlined below.

1) Engineering Check Flights

When all the experimental equipment for a mission has been installed, but prior to the scientific data flights, one or more check ("shake-down") flights are made. Experimenters may not participate in these flights.

2) Liquid Disposal

Beverage cups and open containers should not be left unattended, particularly around experimental equipment where accidental spillage could damage electronic components. Glass beverage containers are not allowed on the aircraft, and no liquids are allowed in the overhead compartments.

3) Flight Insurance

Participants must arrange for their own insurance. Please be advised that the DC-8 is operated as a public law aircraft, and as such does not have, or require, a certificate of airworthiness issued by the Federal Aviation Administration. As a consequence, many commercial riders to insurance policies may not provide insurance protection. Insurance can be purchased from commercial sources, on a yearly basis, covering flights on the DC-8 within the U.S. and overseas. Consult with your insurance agent about the coverage of policies you hold.

4) Medical Clearance

DC-8 flight participants must be free from significant medical conditions, which would put the individual at risk from flight or travel to another country. Contact the mission manager for specific requirements.

2. Flight Management

Various aspects of the DC-8 flight management regimen follow.

A. Aircraft Crew

The aircraft crew consists of the flight crew (pilot, copilot, flight engineer, and navigator), the mission director and assistant mission director, and two technicians. The mission director provides the direct link between experimenters and the flight crew. Stationed at the main control console, he/she arranges for power, gives pertinent instructions over the intercom, and provides general assistance to the experimenters.

Two technicians accompany each flight to operate the housekeeping equipment (time code generator, TV system, and recorders), to operate the ICATS, and to service the intercom and power systems, if necessary. They may be available to assist experimenters with limited in-flight repairs if the mission director permits. A photo technician is available to operate DFRC camera equipment, when necessary.

B. Flight Planning

General flight plans are developed before the start of the flight period. Experimenters should develop desired plans and acceptable alternates in consultation with the mission manager and navigator. Flight planning can be a lengthy process, and may require several iterations to develop a plan satisfactory to all personnel concerned. In addition, flight over foreign countries requires approval of specific flight plans by the host country well in advance (at least two months) of the actual flight period.

Selection of a specific flight plan should be made at least a day in advance, or in accordance with guidelines developed for each specific mission. This will allow the Airborne Science flight planners time to incorporate minor changes, update weather information, and obtain clearance, prior to pilot review and approval. Copies of the flight plans are available from the mission director.

C. Logistics

Logistical considerations (notice of flight times, flight meals, and off-base operations) are briefly outlined in the following text.

1) Flight Times

A notice will be posted in the Experiment Integration Facility, at the Airborne Science Directorate office, and on the aircraft, giving the time and date of each flight. It will also state the time for power-up and door closing. The aircraft door is closed well in advance of the take-off to permit necessary checks to be made. Any experimenter not on board by that time will miss the flight.

2) Flight Lunches

Experimenters are generally responsible for their own lunches. However, the aircraft galley may be provisioned for flights originating from locations where the purchase of a bag lunch by an individual is inconvenient. This will be announced prior to the flight. Bottled water, coffee, tea, packages of instant soup, and a microwave oven are available in the galley area at the rear of the main cabin.

3) Deployed Operations

Experiment installation and checkout are completed at DFRC before transit to a deployment site. Whenever possible, experimenters and their support team members will be accommodated on this transit flight. However, as the ground crew may also be on the transit flight, it may be necessary to limit team size. Some participants may be required to fly commercially to the deployment site. The mission manager will assign available space for experimenter teams on the DC-8. Experimenters' baggage is hand carried aboard the aircraft. Each piece should be identified with the owner's name.

Within size and weight limits, which vary for each mission, experimenters may carry spare parts for their experiments on the aircraft. Special arrangements can be made for shipping larger amounts of spare equipment and supplies.

DFRC Airborne Science Directorate Office or the designated science-project office normally make arrangements for housing, group transportation at deployment sites, and for customs inspections in foreign countries. The mission manager will publish details of these arrangements including visa and passport requirements in an experimenters' bulletin.

4) Housekeeping Considerations

Experimenters are responsible to pick up and clean up after themselves. Tools, while not in use, must be properly stowed away and trash or debris must be disposed of in an appropriate manner.

D. Experiment Operational Considerations

NOTE: Operational matters of concern to experimenters are included below.

1) Electrical Power Blackouts

A power interruption of a few minutes occurs when the engines are started, during the change over from ground power to aircraft power. The mission director informs all experimenters, and requires shutdown of all experiments for this period. A similar delay occurs at the end of a flight, when the engines are shut down. Prior arrangements should be made if electrical power is needed for post-flight calibration or other purposes.

2) Cabin Environment

For high altitude cruise conditions, the cabin is pressurized to an equivalent of 7,500 ft (2.286m) altitude, and temperature is maintained at 65 to 75 °F (18 to 24 °C). Relative humidity normally decreases with time in flight, from the local airfield value at takeoff to a relatively stable 10 to 15 percent within an hour or two (cargo areas are pressurized the same as the cabin, but some areas remain at a lower temperature). Cabin lighting can be controlled as required by experiments.

Special provisions should be made for the local control of temperature-sensitive and/or light-sensitive equipment. The mission manager can advise on these matters.

3) In-Flight Repairs

Experimenters may work on their equipment in flight if it is necessary and can be done without affecting other experiments or creating an unsafe condition. However, the mission director's approval must be obtained before any repair work may begin. Equipment removed from its usual position must be replaced securely before landing. The use of aisle space for repairs is not permitted.

CHAPTER 10

GROUND OPERATIONS

1. General Definition

The full and continuous involvement of the experimenters and their teams is required during the mission integration and operation periods at DFRC. Experimenters are responsible for the timely completion and submittal of the "Dryden Airborne Science Investigator Questionnaire", available at http://www.dfrc.nasa.gov/airsci/question.html. Once at DFRC, the experimenter is responsible for the assembly, installation, checkout, and operation of their equipment, to specified aircraft standards. The mission manager is responsible for all the mission functions, facilities, schedules, reviews, and support resources. The mission manager and the Airborne Science staff are always prepared to assist in the solution of problems that may arise.

2. Experiment Assembly and Checkout

Assembly and checkout of all the experiments involve the following elements:

A. The Experiment Integration Facility

The Experiment Integration Facility (EIF) is located on the ground floor of Building 1623. The EIF provides an area for assembly and checkout of experiments before their installation on the aircraft. Incoming equipment is delivered to this point. The EIF manager will provide supplies and other routine services on request.

EIF facilities include: 60-Hz, 400-Hz, and 28 VDC power, compressed air, a freezer for photographic film storage, and oscilloscopes. Gaseous and liquid nitrogen and helium are available for cryogenic or other use by advance request to the mission manager. The mission manager will assure a continuing supply; however, he/she should be advised well in advance of requirements for additional amounts of liquid helium. Approved fasteners and other equipment mounting hardware are also available.

Tools belonging to NASA DFRC and Airborne Science contractor personnel are not for loan. Experimenters are encouraged to bring a complete set of needed tools with them.

All tools belonging to the experimenters are to have identification markings on them. It is expected that the tools will be inventoried and a system of control over the tools will be used during equipment installation and while on deployment.

The EIF is open in the morning at 7:30 a.m. and can be made available for evening work. For safety reasons, two or more people must be present in the EIF at all times. Requests for evening use must be coordinated with the mission manager.

B. Support Services

The mission manager will arrange engineering, fabrication, and safety resources, as needed, to support mission activities. The staff includes a DC-8 operations engineer who can assist the experimenter with the interface of equipment to the aircraft. The operations engineer is responsible for the airworthiness of the aircraft, the proper integration of the payload, and the safe disposition of aircraft maintenance and inspection issues. He/she is available for questions regarding aircraft ground operations, airworthiness approvals of experimenter equipment, and integration issues.

Technicians are located near the EIF and can assist in the interfaces between the experiments and aircraft systems such as aircraft power, ICATS, and the timing system. The technicians are assigned to the aircraft, and are not available to support work on experimental equipment. Experimenters should include an electronics technician on their team, if the need for such assistance is anticipated during experiment assembly and checkout. For special needs, it is not unusual for experimenters to arrange for electronics support from local suppliers of specific equipment.

The metal fabrication shops at DFRC are equipped to make special mounting hardware. However, unless requirements are discussed, and agreement reached during the early planning phase with the mission manager, it is assumed that the experimenter will provide such items. Requests for minor adjustments or small brackets can be handled on short notice during assembly.

NOTE: Shop facility's ability to support short notice requests or requirements may be limited by other priorities.

C. Inspection

Before any equipment may leave the EIF for installation in the aircraft, an inspection is required for its compliance with all safety requirements. The aircraft inspectors will explain any irregularities and suggest ways of handling them. A clipboard with a discrepancy sheet will be attached to each rack to indicate any problem and proper corrective actions.

The inspectors and operations engineer are generally available throughout the checkout period, and they should be asked for advice and assistance regarding the need for straps, trays, or other special restraints during the process of assembly. The inspectors also look for other safety hazards, such as equipment with sharp or projecting edges, and they will request that such hazards be corrected (such as padding with a suitable material). The inspection will also cover conformity to electrical safety requirements. The inspector will check to see that all the cabling is properly secured and protected against abrasion. A check will be made to ensure proper equipment operation without tripping the ground fault interrupter (GFI) devices.

D. General Procedures

The assembly and checkout period should be used to full advantage since problems delayed until installation can impact the scheduled sequence of operations for all the experimenters. It is customary to hold daily formal group meetings, at which the experimenters discuss their progress and problems with the mission manager and operations engineer. Timely action will be initiated to resolve problems that may delay the installation schedule.

To assure a successful final inspection and corresponding safety approval, the experimenter should consult frequently with the mission manager and the operations engineer during assembly concerning the use of support hardware, fasteners, and cable ties. The operations engineer will be available to sketch small brackets for fabrication, to recommend structural changes to existing hardware, and to arrange for items to be mounted on top of racks.

Each item of equipment must be weighed and its weight marked on it (removable tape may be used). An inspector can then readily check the total calculated weight and the overturning moment of each rack. Scales are available adjacent to the EIF.

Storage bins in which small test equipment, tools, notes, tapes, etc. may be stored, are available for panel mounting on the racks. The mission manager will arrange for these bins on request.

Operation of all equipment should be checked out in the EIF. Power connectors for both 60 and 400-Hz, identical to those used in the aircraft, are available. These connectors should be used to ensure that assembled equipment, in each rack, will not trip the GFI devices in the aircraft.

E. Safety and Emergency - Hangar

CAUTION: Significant instructions for hangar safety are listed below.

At DFRC, experimenters work in an environment generally unavailable to the public. The EIF is housed in a large hangar containing a number of aircraft, and it is sometimes necessary to walk through the hangar and on to the ramp area. Therefore, a certain number of safety precautions must be observed:

1) Smoking in the hangar, on the ramp, or in any DFRC building is prohibited.

2) Look out for cables, hoses, boxes, tow bars, moving vehicles, and movement of the hangar doors when crossing the hangar floor.

3) Do not walk directly across the ramp. Travel along the edges of the ramp when entering or exiting the DC-8 outside.

4) Do not approach aircraft with engines running. Jet exhaust or prop wash is dangerous for a considerable distance behind the aircraft.

5) Wear adequate clothing and shoes that totally enclose the foot.

6) Ear protection is required while outside the aircraft when engines are running.

IN AN EMERGENCY

If a DFRC employee is not available for immediate assistance, dial this number from any phone:

911
For Emergency Aid
Fire, Accident, Etc.

This emergency number is available at any hour. Callers should also be able to describe their location, so that emergency help can respond promptly.

3. Installation of Experiments

Following inspection and approval of equipment for aircraft installation, DC-8 technicians will transport and install it in the aircraft. They will be working to the cabin layout drawings and time schedule provided by the mission manager. The experimenters or their representative must be present during installation to advise and assist as necessary. Following the mechanical installation, the engineering technicians will work with the experimenter. They will complete the cabling installation from the aircraft systems to the experiment, and they will advise as requested on cabling between racks and other experiment equipment.

No work may be done in the aircraft unless a crewman or other designated Airborne Science representative is present (aircraft doors may not be opened or closed by any experiment personnel). The aircraft is usually available on a split-shift basis, from 7 a.m. to 7 p.m., or a two-shift basis, from 7 a.m. to 11 p.m. Additional time, including weekends, requires over-time for the ground crew and must be arranged for in advance. Budgetary limitations may preclude time in excess of two shifts on a five-day-week basis.

If special positioning of the aircraft is required for experiment alignment or checkout, the mission manager or operations engineer should be notified a week or more in advance. This will allow time for obtaining the proper approval, and scheduling of ramp activities. Laser tests require NASA and FAA approval, which often require several weeks' time.

A. Electrical Power

Power is normally available on the aircraft for checkout when the aircraft is in the hangar or parked on the ramp. At these times, power comes from the ground generators producing 400-Hz ac. The stability of these sources is not necessarily as well controlled as the aircraft engine generators used in flight. Power in 60-Hz form is obtained from the electronic converters in the aircraft, or from an external source of ground power.

CAUTION: Power distribution in the aircraft is controlled from the mission director's station. Experimenters are not authorized to switch power at this location. Upon request, only the aircraft technicians, the mission manager, his/her assistant, the operations engineer, or a member of the ground crew will switch power to the appropriate station.

Due to periodic maintenance and/or installation procedures, the ground crew may need to shut down electrical power for short periods of time. If power is needed for an uninterrupted period of time for checkout of experimenter equipment within the aircraft, the mission manager or operations engineer must be advised well in advance. This will allow the work of the ground crew on the aircraft to be coordinated with experimenter's needs.

The mission manager will designate a time for a power check of all experiments. Each experiment’s power station will be turned on sequentially to make current measurements at the mission director’s console. This procedure is necessary to balance loads among the five 60-Hz converters, and to minimize interference among experiments from power transients. This also provides an opportunity for experimenters to check for interference from other experiments.

B. Weight and Balance

Following equipment installation, before any mission flights, the aircraft will be weighed and the balance calculated to determine the center of gravity. Thereafter, weight and location of any equipment that is added or removed must be noted on the record sheet for that purpose, posted near the front door of the aircraft. No removals or add-ons will be permitted less than two hours before door-close on fly-days. This procedure is necessary to maintain the current weight and balance record. Each experimenter is responsible for his own equipment (tool boxes, boxes of manuals, etc.), and must post entries when items are removed (even for short periods of time) or returned.

C. Safety and Inspection - Aircraft

CAUTION: Significant instructions for aircraft safety are listed below.

While working in the aircraft on the ground, all participants must observe the following safety rules.

1) No Smoking in the hangar, on the ramp, aboard the aircraft, or in any DFRC buildings.

2) No electric drills or other tools with universal electric motors may be used in the aircraft.

3) Only small, pencil-type soldering irons and electronic-grade rosin-core solder may be used on the aircraft.

4) No high wattage heat guns are permitted on the aircraft. If it becomes necessary to heat shrink insulation, the material must be taken into the EIF, where such treatment can be performed safely.

5) No volatile solvents of any kind are permitted without prior approval of the mission manager.

The inspectors will recheck each experiment installation on the aircraft for full conformity with all safety regulations. Any deficiencies will be noted on an inspection sheet and attached to each rack. These must be signed-off before flight.

4. The Flight Period

Prior to the scheduled mission flights, a series of check flights will be accomplished. The operations engineer will plan and conduct an engineering "shakedown" flight, which verifies the structural integrity and loading of the newly configured aircraft. No experiments will be powered on and no experimenters will on board for this flight. The mission manager will conduct one or more experiment check flights at simulated mission conditions. The purpose of these check flights is to allow experimenters to verify the correct operation of all their equipment, and to become familiar with the flight environment and procedures. These and the subsequent mission flights are scheduled to allow the necessary ground time for aircraft and instrument maintenance procedures.

Generally, the aircraft will be open to experimenters only at stated times, to allow for both research requirements and aircraft maintenance activities.

The experimenters and their teams are expected to observe the procedures and constraints stated in this and the preceding chapters, as well as other limits that may need to be set by the mission manager.

Data processing between flights that requires DFRC support should be arranged in advance through the mission manager.

5. Post-Flight Activities

When the flight period is completed, one or two days are scheduled for removal of experiments under the supervision of the operations engineer.

Equipment can be removed rack by rack, or by hand-carrying the various components, at the experimenter’s discretion. Equipment is then returned to the Experiment Integration Facility where research teams pack it for return shipment. Once the experiment team completes the packing, DC-8 shipping and receiving personnel will arrange for transport.

The mission manager will hold a mission debriefing to review results, complete requests for aircraft systems data, and to arrange for post-mission science reviews, if required. The mission manager will also provide any mission related data held in the DFRC Airborne Science Directorate files, upon request. Conversely, the Airborne Science Directorate requests that a copy of any published research results be sent to the Airborne Science Directorate office, in order that science accomplishments may be documented.

APPENDIX A

GUIDELINES FOR EXPERIMENTER RACK LOADING

1. Guidelines

Standard DC-8 experimenter racks for mounting test equipment are available in three sizes (low, medium, and high), which are illustrated in figures 5-4 thru 5-6 of this handbook. This appendix presents the allowable loading limits for these racks, and the calculations for determining suitability of a proposed equipment-loading configuration.

Applicable design criteria that establish the loading limits include a 9g forward "crash" load and a 7g downward "gust" load. Overall rack limits encompass the total rack assembly and its attachment to the aircraft, and face-mounted equipment limits consider installation of individual units into the rack. The rack-loading configuration must satisfy both limits.

Table A-1 addresses the overall effects between rack and aircraft. Total allowable loading values are tabulated for each type of rack, both in terms of total weight and overturning moment (total torque). Values for vertical center-of-gravity of installed equipment must be known. Figure A-1 illustrates the rack geometry used to calculate the overturning moment. Note that maximum allowable load is reduced if unequal weight distribution between bays (left and right) offsets the lateral center-of-gravity (L) away from the center post.

Face-mounted equipment is attached to panels of standard 19 in. width and optional height. The panels bolt onto the edge flanges of either bay on each rack, and can be installed either forward- or aft-mounted (distance between forward and aft faces is 24 in.). Figure A-2 illustrates the geometric convention for panel height (H) and center-of-gravity location (L) of face-mounted equipment.

Table A-2 lists the loading limits for face-mounted equipment, as determined by panel height (H), equipment weight (W), moment (M = W x L), and direction of mounting (forward or aft). These limits affect choice of configuration required to install specific equipment. Figure A-3 presents a logic diagram to select type of mounting, whether or not a tray is required, and illustrates four resulting configurations (cases A thru D).

Table A-1: Basic loading allowables for low, medium, and high racks.

	Maximum Loads	
	Low/Medium Racks (lb)	High Racks* (lb)
Total Equipment Weight per Rack Mounting Face	300	450
Total Equipment Weight per Rack Bay	300	450
Rack Total Equipment Weight	600	900
Total Moment Produced by Equipment per Rack Bay $\Sigma M = hw + h_1 w_1 + h_2 w_2 + \ldots$	6,000 in.-lb	9,000 in.-lb

*. For rack load on high racks near limiting value, the lateral center-of-gravity (C.G.) should be located at the vertical center post. C.G. offset may reduce allowable weight:

C.G. Offset, in.	Allowable Weight, lb
3.0	780
6.0	700

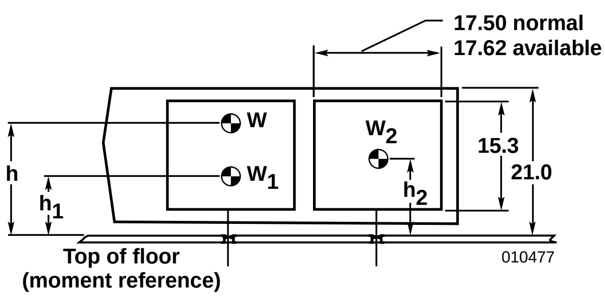


Figure A-1(a). Low rack.

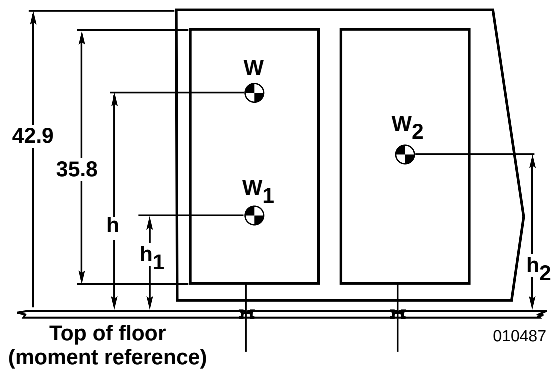


Figure A-1(b). Medium rack.

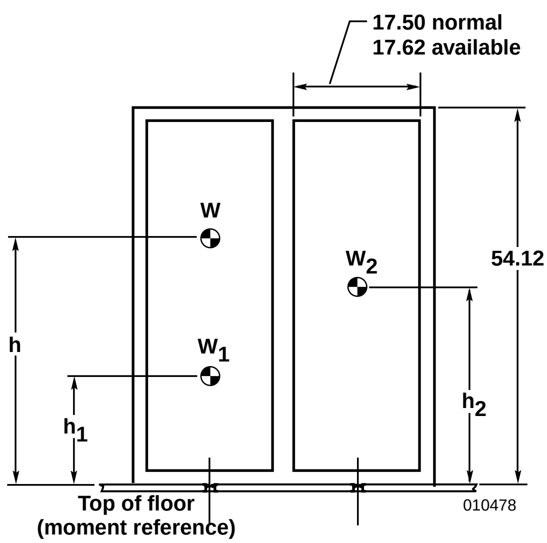


FIgure A-1(c). High rack.

Examples to illustrate usage of table A-2 and figure A-3 to determine suitability and selection of loading configurations are also presented. If questions arise concerning a particular loading configuration or applicable limits, contact the mission manager to request engineering assistance.

2. Examples

Some loading examples with calculations are presented here to illustrate the use of figure A-3 and table A-2. Figure A-3 shows rack-loading options using four types of support (cases A through D). As equipment weight increases, so does the corresponding support and restraint requirements.

The accompanying logic diagram in figure A-3 traces a decision tree to compare actual values against the limits tabulated in table A-2, and thereby determine which loading option is appropriate for each instance and within allowable limits.

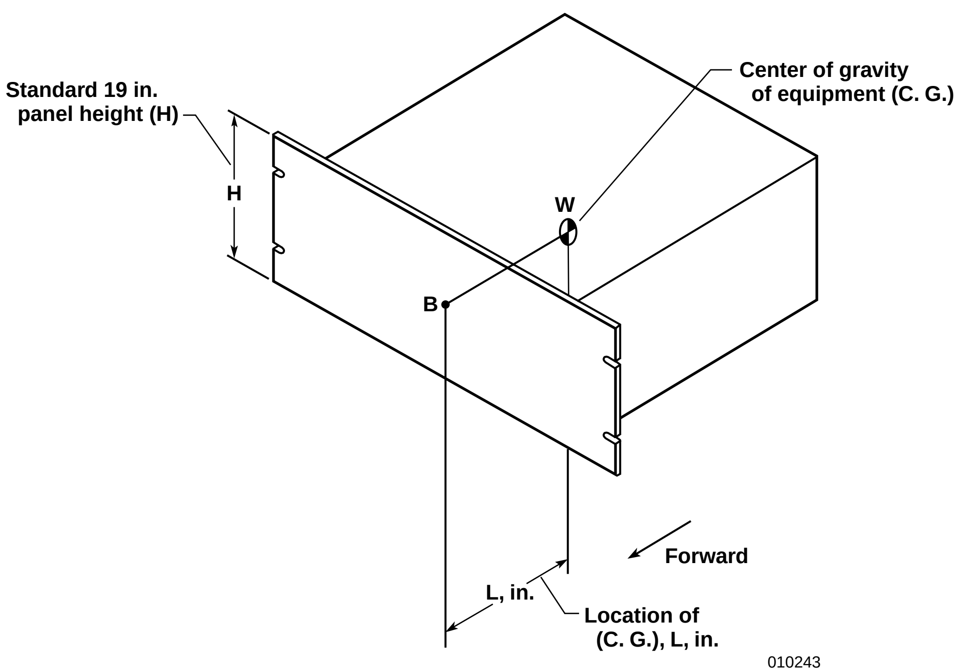


Figure A-2. Standard face mounted equipment.

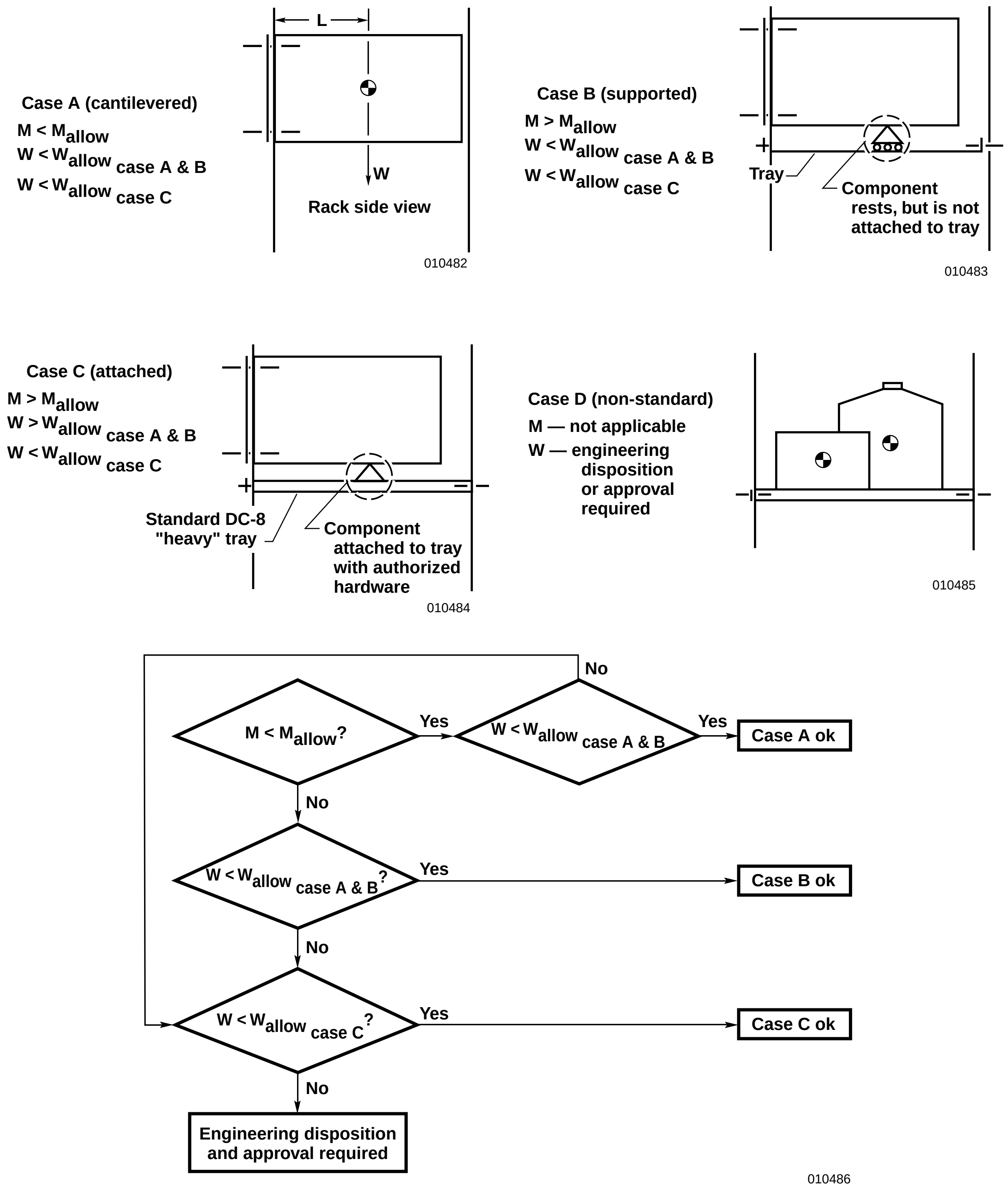


Figure A-3 . Configuration examples and flow chart.

Table A-2. Allowable loading for face-mounted equipment.

	Low and Medium Rack			High Rack		
Standard panel height (in.)	M_{allow} (in.-lb)	W_{allow} Fwd/aft-mount (lb)		M_{allow} (in.-lb)	W_{allow} Fwd/aft-mount (lb)	
	case A	cases A and B	case C	case A	cases A and B	case C
3.5	73	23/35	38/63	123	53/53	92/129
5.25	84	35/52	50/80	185	79/79	118/155
7	124	46/70	61/98	245	105/105	144/181
8.75	163	58/87	73/115	305	132/132	171/208
10.5	244	70/105	85/133	365	158/158	197/234
12.25	2912	81/122	96/150	430	184/184	223/260
14	338	93/140	108/168	490	211/211	250/287
15.75				550	237/237	276/313
17.5				615	263/263	302/339
19.25				675	290/290	329/366
21				735	316/316	355/392
	△1	△1 △2 △4	△3 △4	△1	△1 △2 △5 △6	△3 △5 △6

Case D (figure A-3) requires engineering disposition/approval when equipment weight on tray exceeds 28 lb (Low/Medium Rack, aft-mounted) or 76 lbs (high rack, aft-mounted). Reduce these allowables by 1/2 if tray is fwd-mounted.

△1 Case A (cantilevered)

△2 Case B (cantilevered, supported on standard DC-8 light or heavy tray)

△3 Case C (attached and constrained by standard DC-8 heavy tray)

△4 Values based on 30 lb/in. flange allowable (fwd-mount) and 45 lb/in. flange allowable (aft-mount) in a 9-G forward loading condition

△5 Values based on 101 lb/in. flange allowable (fwd- and aft-mount) in a 9-G forward loading condition

△6 Component lateral CG displaced 25 percent left or right of equipment bay centerline

A. Example 1 Rack type medium

Panel height H = 5.25 in.

Equipment weight W= 12 lb

Center of gravity L = 6.0 in

Calculate moment = W x L = 12 x 6 = 72 in.-lb

M_{allow} from column (1) of table A-2 shows an 84 in.-lb limit. W at 12 lb is less than either weight in column (2), so case A applies. The equipment can be simply face-mounted (cantilevered) in a low or medium rack, either forward- or aft-mounted.

B. Example 2 Rack type unspecified

Panel height H = 5.25 in.

Equipment weight W = 15 lb

Center of gravity L = 6.0 in.

Calculate moment = W x L = 15 x 6 = 90 in.-lb

This equipment is only 3 lb heavier than example 1, but the 90 in.-lb moment now exceeds the M_{allow} of 84 in.-lb for case

A. It is still below the weight limits of column (2), so case B applies. The equipment can be face-mounted in a low or medium rack, either forward- or aft-mounted, but a tray is needed to help support the equipment. Note that this equipment may be safely mounted in a high rack without a tray.

C. Example 3 Rack type unspecified

Panel height H = 5.25 in.

Equipment weight W = 50 lb

Center of gravity L = 3.5 in.

Calculate moment = W x L = 50 x 3.5 = 175 in.-lb

This equipment represents a heavier load, with the center of gravity (L) closer to the face. The moment exceeds low and medium rack allowables (case A), and the weight exceeds the tray-supported limit of case B. However, it is within the aft-mounted limit (52 lb) for case B. Note that it could still be forward-mounted in a low or medium rack if it were configured as case C (attached) where 50 lb is just at the limit for forward face-mounted hardware attached to a tray. Note also that it could be cantilevered on a high rack as in case A, where the moment limit is 185 in.-lb.

D. Example 4 — Rack type unspecified

Panel height	H = N/A
Equipment weight	W = 120 lb
Center of gravity	L = 12 in.

This case represents non-standard equipment attached directly to a tray, without any rack facing, as shown in case D. Contact the mission manager to request engineering assistance, as this type of case requires individual consideration. The method of tray installation requires adequate attachment of the tray to the flanges of the rack to properly distribute a 9-g forward load, and is dependent on the equipment configuration being installed.

APPENDIX B

DFRC AIRBORNE SCIENCE CRYOGENIC HANDLING PROCEDURES

1. Scope

Use of cryogenic liquids at DFRC is controlled by Dryden Centerwide Procedure DCP-S-039, "Cryogen Safety". This document contains supplemental information for the use of all personnel that have a need to plan requirements, service, or handle cryogen relative to Airborne Science Directorate operations. Areas of operations are defined as any Airborne Science Directorate facility at DFRC or on any deployment, and the DC-8 aircraft and payloads.

2. Purpose

The purpose of this document is to describe the principal hazards and appropriate safety procedures associated with cryogens that are commonly used such as liquid oxygen, hydrogen (not allowed on NASA DC-8), amonia, nitrogen, helium, argon, fluorine, and carbon dioxide.

3. Equipment Requirements

- Gastech GX-82 three-way gas alarm or equivalent
- Gastech OX-82 oxygen indicator or equivalent
- Gloves, cryogenic
- Apron, Neoprene or heavyweight rubber coated
- Safety glasses
- Goggles
- Full face shield

4. General Properties

Because all cryogenic fluids exist as liquids only at temperatures considerably below ambient (temperatures in the range of –324 °F), normal storage facilities and fluid containment in process systems must allow for the unavoidable heat input from the environment. For ordinary operations this means good insulation, adequate pressure-relief devices, and proper disposal or recycling of the gases that are continually produced. Full containment of the fluid as a liquid at room temperature is usually not feasible: the pressure required to maintain helium at liquid density at room temperature is 18,000 psi; for nitrogen it is 43,000 psi.

The chemical properties and reaction rates of substances are changed under cryogenic conditions. Liquid oxygen, for example, will react explosively with materials usually considered to be noncombustible. Remember that condensing a cryogen from a pure gas at room temperature will concentrate the material typically 700-800 times.

Cryogenic temperatures drastically affect material properties: ductile materials become brittle, material shrinkage exceeds anticipated values, leaks can develop that are not detectable at room temperature even under considerable pressure, etc. Hence, the suitability of materials must be carefully investigated before they are employed in cryogenic service.

5. Labeling

Storage dewars, process vessels, piping, etc., shall be labeled with the common name of the contents. In many cases, it is also desirable to post emergency instructions, emergency call numbers, etc. adjacent to the equipment.

6. Pressure Relief

Heat flux into the cryogen is unavoidable, regardless of the quality of the insulation provided. Pressure relief must be provided to permit routine off gassing of the vapors generated by this heat input. Typically spring-loaded relief devices or an open passage to the atmosphere best provides such relief.

Additional relief devices should be provided as backup to the operational relief, especially when the capacity of the operational relief device is not adequate to take care of unusual or accident conditions. This may be the case if the insulation is dependent on the maintenance of a vacuum in any part of the system (this includes permanently sealed dewars), if the system may be subject to an external fire, or if rapid exothermic reactions are possible in the cryogen or a container cooled by the cryogen. In each case, relief devices capable of handling the maximum volume of gas that could be produced under the most adverse conditions must be provided. Frangible disks are recommended for this service.

Each and every portion of the cryogenic system must have uninterruptible pressure relief. Any part of the system that can be valved off from the remainder must have separate and adequate provisions for pressure relief.

All parts in contact with the fluid shall be rated for cryogenic service. Careful consideration must be given to material compatibility with respect to prevention of embrittlement at cryogenic temperatures.

7. Hazards of Oxygen Deficiency

Liquefied gases frequently have a significant potential for creating an oxygen deficiency. When expelled to the atmosphere at room temperature, they evaporate and expand on the order of 700-800 times their liquid volume. Consequently, leaks of even small quantities of liquefied gas can expand to displace large amounts of oxygen, thereby rendering an atmosphere lethal. Without adequate oxygen, one can lose consciousness in a few seconds and die of asphyxiation in a few minutes.

Calculations shall be made to determine whether a given situation of cryogen storage or use will pose an oxygen-deficiency hazard in the event of the worst possible accident. When the level of hazard potential has been ascertained, appropriate safety procedures must be taken. Where the danger is sufficient to warrant it, this may entail the use of an oxygen monitor such as an OX-82 or GX-82. Positions for oxygen monitors should include the lowest point in the area because the cold, dense, escaping gases will be heavier than the warmer ambient air, at least initially.

All employees working in the vicinity of an area where an oxygen deficiency could develop shall be trained as to the nature of the hazard and the appropriate response they should make in the event of cryogen release. Along with training, these areas shall be posted to remind the workers and alert visitors in the area to the hazard.

CAUTION: Any rescue work conducted in an oxygen-deficient atmosphere must be done in a self-contained breathing apparatus or airline equipment.

8. Hazards of Air-Freezing Cryogens

Certain cryogens, such as helium and hydrogen, are cold enough to solidify atmospheric air. The system must be pressurized in order to prevent the entry of air into such cryostats. If openings to the atmosphere exist, they are likely to become plugged by solidified air, leading to overpressure and vessel failure if they are relied on for pressure relief. Such conditions will also result in hazardous contamination of the fluid. Again, adequate pressure-relief devices must be provided to vent all gas produced in case of maximum possible heat flux into the system. Unless these fluids are handled in vacuum-jacketed vessels and piping, air will also condense on the exterior of the system. This condensate will be rich in oxygen content. The hazards created by this include frostbite from touching the cold surfaces, dripping liquid air (because it is oxygen-enriched), and exploding insulation. The latter can happen when air condenses between the metal surface and the insulating layer. On warming, the air vaporizes and can rip off the insulation with explosive force. Such insulation systems must be specially engineered to prevent air penetration.

9. Hazards of Carbon Dioxide Toxicity

In addition to producing an oxygen deficiency, carbon dioxide also affects the breathing rate because of its role in the respiratory process. A concentration of 0.5% carbon dioxide in the air will begin to stimulate a more rapid breathing rate; when 3% carbon dioxide is present in the air, lung ventilation will double; 10% carbon dioxide can be tolerated for only a few minutes. A condition of 10% carbon dioxide and 90% normal air actually has an oxygen concentration of 20.9%. This degree of oxygen deficiency would not be considered immediately dangerous to life or health if the contaminant gas were nitrogen, helium, or argon instead of carbon dioxide. Obviously it is important to measure the carbon dioxide/nitrogen concentration, especially if it is suspected that this gas may be present at levels greater than 0.5%.

CAUTION: Any rescue work conducted in an oxygen-deficient atmosphere must be done in self-contained breathing apparatus or airline equipment.

10. Hazards of Oxygen Enrichment

Cryogenic fluids with a boiling point below that of liquid oxygen have the ability to condense oxygen out of the air if exposed to the atmosphere. This is particularly troublesome if a stable system is replenished repeatedly to make up for evaporation losses; oxygen will accumulate as an unwanted contaminant. Violent reactions (such as rapid combustion or explosions) may occur if the system or process is not compatible with liquid oxygen.

Oxygen enrichment will also occur if liquid air is permitted to evaporate (oxygen evaporates less rapidly than nitrogen). Oxygen concentrations of 50 percent may be reached. Also remember that condensed air dripping from the exterior of cryogenic piping will be rich in oxygen.

11. Personal Protective Equipment

The potential for freezing by contact with the extreme cold of cryogens necessitates varying degrees of eye, hand, and body protection. When cryogens are spilled, a thin gaseous layer apparently forms next to the skin. This layer protects one from freezing, provided the contact with the cryogens involves small quantities of liquid and brief exposures to dry skin. However, having wet skin or exposure to larger quantities of cryogens for extended periods of time can produce freezing of the tissue.

The most likely cause of frostbite to the hands and body is contact with cold metal surfaces. Because there is no protective layer of gas formed, frostbite will occur almost instantaneously, especially when the skin is moist.

The damage from this freezing (frostbite) occurs as the tissue thaws. Intense hyperemia (abnormal accumulation of blood) usually takes place. In addition, a blood clot may form along with an accumulation of body fluids, which decreases the local circulation of blood. Gangrene may result if the consequent deficiency of blood supply to the affected cells is extreme.

Cooling of the internal organs of the body can also disturb normal functioning, producing a condition known as hypothermia. It is very dangerous to cool the brain or heart to any great extent.

Using safety glasses with side shields is required at all times when cryogenic fluids are present. Goggles provide the best protection for the eyes. If a cryogen is poured or if the fluid in an open container may bubble, a full-face shield is required. This additional protection is also recommended when valves are actuated on piping systems, etc., unless the operator is shielded from leaks at potential failure points.

Hand protection is primarily required to guard against the hazard of touching cold surfaces. Loose, non-asbestos insulating gloves, that can be tossed off readily in case they become soaked with cryogen, may be worn. Special gloves made for cryogenic work are required.

Cryogenic handlers should wear boots and cuff-less trousers extending over the boot. All persons handling cryogens shall wear closed-toe shoes that cover the top of the foot. Industrial clothing made of nonabsorbent material is usually satisfactory. Long-sleeved clothing is recommended for arm protection. An apron made of Neoprene or heavyweight rubber coated material is required for use with cryogens. Where exposure to drenching is possible, a full protective suit with supplied air should be considered; however, the system should be engineered to prevent the possibility of such an exposure.

Tongs or other tools should be used to lift objects out of the liquid or liquid baths.

12. Immediate Treatment for Frostbite

- Warm the affected area rapidly by immersion in water not to exceed 105 °F, with body heat, or by exposure to warm air. Safety showers with warm water should be provided where there is a sufficient probability of the occurrence of such an accident. In the event of massive exposure, remove clothing while showering. Do not expose the body to open flame. Maintain the affected area of the victim at normal body warmth until professional help arrives.

- Calm the victim and avoid aggravating the injury. People with frostbitten feet should not walk on them. Do not rub or massage the affected parts of the body.

- Prevent infection—use a mild soap to clean the affected area. Dressings need not be applied if the skin is intact.

- If affected, flush eyes with warm water for at least 15 minutes.

- Report to NASA DFRC Health Unit for medical attention promptly.

13. Training Procedures and Safety Notes

Only personnel fully aware of the properties of cryogenic fluids should handle cryogenic materials and equipment. They should be mindful of the consequences of misadventure. Operators should be selected on the basis of capability to understand the hazards and the equipment, mature judgment, and the ability to follow established procedures. Copies of the appropriate MSDS shall be posted in the vicinity of the cryogen being used, handled, or stored.

APPENDIX C

OUTPUT PARAMETERS FROM ICATS

1. Introduction

This appendix to ICATS description document lists all parameters presently available for selection from the ICATS data output file. From this output file, parameters are selected to be distributed on the RS-232 data lines to experimenters, on video displays at each experimenter rack, for post-flight data retrieval and for future data delivery functions. Each data source is identified, and the output data parameters from that source are described. Column 1 lists the parameter identification code (Parameter ID) to be used when retrieving that parameter. Column 2 lists the engineering units for that parameter. Column 3 contains general information on the parameter, which includes parameter name, parameter engineering unit range, sign convention, and other comments regarding the measurement, when applicable.

2. Data From Time Code Generator (TCG)

Note: All parameters from TCG shown below are available in ICATS database for use in display, computation and archiving.

Parameter ID	Units	Comments
year	year	Year as measured from GMT Source: IRIG-B May be input manually if IRIG-B invalid.
month day of month day of year	month day days	The day number of the present date according to GMT. Source: Datum Model 9110-663 TCG Range: 1 to 366
time in hr time in sec time in msec	hr sec msec	Time: time code values combined in ICATS available to user in real time and post-flight. ASCII format. Range: 00:00:00.000 to 23:59:59:999

3. Data From Honeywell Embedded GPS/INS MIL-STD-1553

Note: All parameters from GPS/INS shown below are available in ICATS database for use in display, computation and archiving.

Parameter ID	Units	Comments
eo06_egr_lat	deg	e egr-lat
eo06_egr_lon	deg	e egr lon
eo06_egr_alt	ft	e egr alt
eo06_egr_vel_east	ft/sec	e vel east
eo06_egr_vel_north	ft/sec	e vel north
eo06_egr_vel_up	ft/sec	e vel up
eo17_mode_word1	n/a	e mode w/1
eo17_velocity_x	ft/sec	e vel x
eo17_velocity_y	ft/sec	e vel y
eo17_velocity_z	ft/sec	e vel z
eo17_platform_az	deg	e plat az
eo17_roll_angle	deg	e roll
eo17_pitch_angle	deg	e pitch
eo17_pres_true_hdg	deg	e hdg true
eo17_pres_mag_hdg	deg	e hdg mag
eo17_accel_x	ft/sec^2	e acc x
eo17_accel_y	ft/sec^2	e acc y
eo17_accel_z	ft/sec^2	e acc z
eo17_msl_alt	ft	e alt msl
eo17_mode_word2	n/a	
eo17_roll_rate	deg/sec	e roll rate
eo17_pitch_rate	deg/sec	e pitch rate
eo17_yaw_rate	deg/sec	e yaw rate
eo19_lon_accel	ft/sec^2	e acc long
eo19_lat_accel	ft/sec^2	e acc lat

Parameter ID	Units	Comments
eo19_normal_accel	ft/sec^2	e acc nor
eo19_roll_ang_accel	deg/sec^2	e acc r ang
eo19_pitch_ang_accel	deg/sec^2	e acc pang
eo19_yaw_ang_accel	deg/sec^2	e acc y ang
eo19_blended_lat	deg	e blend lat
eo19_blended_lon	deg	e blend long
eo25_true_air_spd	kn	e true a/s
eo25_pres_mag_gnd_trk	deg	e mag gnd trk
eo25_pres_drft_ang	deg	e drift ang
eo27_pres_pos_lat	deg	e pres lat
eo27_pres_pos_lon	deg	e pres long
eo27_wind_direction	deg	e wind dir
eo27_wind_velocity	kn	e wind vel
eo27_pres_gnd_spd	kn	e gnd spd
eo27_pres_true_gnd_trk	deg	e tru gnd trk
eo27_predicted_gnd_spd	kn	e pred g/s
eo27_position_err_north	nmi	e pos-err n
eo27_posi_error_east	nmi	e pos-err e

4. Data From Radar Altimeter MIL-STD-1553 Data

Parameter ID	Units	Comments
ra_01_mode_word	n/a	
radar alt	ft	Radar Altitude - aircraft altitude in feet above land or water as measured by radar. Source: NavCom Defense Electronic, Inc. APN-232 altimeter system. Range: 0 to 70,000 ft
ra_01_rada_alt_rate	ft/sec	Radar altitude rate

5. Data From Navigational Management System ARNIC-429

Note 1: Primary source for display and other output uses of nms data will be from nms1. nms2 could be selected during flight should one fail. Also mission manager can request ICATS operator to select nms1 or nms2 for data source if required.

Note 2: All parameters shown below are available in ICATS database for use in display, computation, and archiving.

Parameter ID	Units	Comments
dist to go	nmi	Distance to go- the distance measured along a great circle path with respect to the aircraft's present position and the next selected waypoint. Range: ± 4,096 nmi Orientation: + to selected waypoint – from selected waypoint
nms time go	min	nms time to go - time to arrive at the next waypoint.
x track dist	nmi	Cross track distance - the distance left or right from the desired track to the aircraft's present position measured perpendicular to the desired track. Range: ± 128 nmi Orientation: + right of desired track – left of desired track
des track	deg	Destination track - the great circle on the earth's surface connecting the departure and destination positions or two waypoints measured with respect to true north. Range: O to 360 deg
drift angle	deg	Drift angle: the angle between the desired track and the aircraft's heading. Range: ± 39.9 deg Orientation: + desired track right of aircraft heading – desired track left of aircraft heading

Parameter ID	Units	Comments
nms latitude	deg	Latitude - the aircraft's present latitudinal position over the surface of the earth relative to the equator. Range: ± 90 deg Orientation: + north of the equator – south of the equator
nms longitude	deg	Longitude - the aircraft's present longitudinal position over the surface of the earth relative to the prime meridian. Range: ± 180 deg Orientation: + east of the prime meridian – west of the prime meridian
ground speed	kn	Ground speed - the aircraft's speed over the ground in kn. Range: 0 to 2,000 kn.
track angle	deg	Track angle - the actual path of the aircraft over the surface of the earth measured with respect to true north through 360 deg. Range: 0 deg to 360 deg
true heading	deg	True heading - the angle between true north and the longitudinal axis of the aircraft. Range: 0 to 360 deg
wind speed	kn	Wind speed - the horizontal velocity of the air mass at aircraft's present position. Range: 0 to 256 kn
wind dir	deg	Wind direction - the direction the wind is coming from as measured from the north. Range: 0 to 360 deg
pitch	deg	Pitch angle - the angle between the longitudinal reference axis of the aircraft and the horizontal plane of the earth. Source: nms Range: ± 90 deg Orientation: + up – down

Parameter ID	Units	Comments
roll	deg	Roll angle - the angle between the aircraft's lateral axis and a horizontal plane measured about the aircraft's longitudinal axis. Source: NMS Range: ± 180 deg Orientation: + right – left
NS velocity	kn	North-South vector velocity - the north-south vector velocity component of the aircraft's ground speed. Range: ± 2000 kn Orientation: + north – south
EW velocity	kn	East-West vector velocity - the east-west vector component of the aircraft's ground speed. Range: ± 2000 kn Orientation: + east – west
wind nose	kn	
pres alt	ft	
nms status	n/a	
nms fromto	n/a	
fp hdr	n/a	
msg type	n/a	
dist dest	nmi	
time dest	min	
waypt lat	deg	Waypoint latitude - the latitude of waypoint 'waypt num' Range ± 180 deg Orientation: + north of the equator – south of the equator
waypt lon	deg	Waypoint longitude - the longitude of the waypoint 'waypt num' Range ± 180 deg Orientation: + east of prime meridian – west of prime meridian

Parameter ID	Units	Comments
nms_msg1	n/a	
nms_msg2	n/a	
nms_msg3	n/a	
nms_msg4	n/a	
nms_stn_type	n/a	
nms_msg_csum	counts	
nms_tac_freq	MHz	
nms_vor_freq	MHz	
nms_dme_freq	MHz	
nms_hoz_cmd	deg	
nms_plocal_dev	DDM	
nms_glide_dev	DDM	
nms_nav_status	n/a	
nms_frto_ms_to_wpt	n/a	
nms_frto_ms_fr_wpt	n/a	
nms_frto_ls_to_wpt	n/a	
nms_frto_ls_fr_wpt	n/a	
nms_fp_hdr_tot_recd	records	
nms_msgt_wrd_in_msg	n/a	
nms_msgt_wpt_type	n/a	
nms_msgt_wpt_num	n/a	
nms_cal_timetogo	min	
nms_trk_ang_err	deg	
to wynptnum	n/a	
fr wyptnum	n/a	
towypt lat	deg	
towypt lon	deg	
frwypt lat	deg	
frwypt lon	deg	

6. Data From Air Data Computer ARINC-429

Note 1: Primary source for display and other output uses of ADC data will be from ADC1. ADC2 could be selected during flight should one fail. Also mission manager can request ICATS operator to select ADC1 or ADC2 for data source if required.

Note 2: All parameters shown below are available in ICATS database for use in display, computation, and archiving.

Parameter ID	Units	Comments
pressure alt	ft	Pressure altitude - aircraft pressure in ft corresponding to U.S. Standard Atmosphere. Range: –1,871 to 57,343 ft
baro alt	ft	Barometric altitude Range: –1 ,871 to 57,373 ft
stat air tmp	°C	Static air temperature - ambient air temperature at aircraft's present position. Range: –99 to 60 deg C
Mach no.	no.	Mach no. - the aircraft's speed as a ratio to the speed of sound. Range: 0.1 to 0.99
vertical spd	ft/min	Vertical speed - vertical climb rate of the aircraft, measured in ft/min. Range: ±20,480 ft/min. Orientation: + ascending – descending
adc tat	°C	ADC total air temperature
ind air spd	kn	Indicated airspeed - indicated airspeed corrected for airspeed indicator instrument error and static pressure source. Range: 30 to 510 kn
true air spd	kn	True airspeed - the actual speed of the aircraft through the air. Computed airspeed corrected for density altitude.
adc_dis_270	n/a	Message word 270 - message when converted to binary contains status of ADC.
adc_dis_350	n/a	Message word 350 - message when converted to binary contains status of ADC.
adc_dis_351	n/a	Message word 351 - message when converted to binary contains status of ADC.

7. Data From Global Positioning System (GPS) ARINC-429

Note 1: Primary source for display and other output uses of GPS data will be from GPS1. GPS2 could be selected during flight should one fail. Also mission manager can request ICATS operator to select GPS1 or GPS2 for data source if required.

Note 2: All parameters shown below are available in ICATS database for use in display, computation, and archiving.

Parameter ID	Units	Comments
gps utc time	n/a	GPS time relative to GMT Source: GPS Range: 00:00:00:000 to 23:59:999
gps utc fine	sec	
gps latitude	deg	GPS latitude - the aircraft's present latitudinal position over the surface of the earth relative to the equator.
gps long	deg	GPS longitude - the aircraft's longitudinal position over the surface of the earth relative to the prime meridian. Range: ±180 deg Orientation: + east of prime meridian – west of prime meridian
gps alt	ft	GPS altitude - the aircraft's present altitude. Range: –1000 to 131,072 ft.
gps lat fine	deg	
gps lon fine	deg	
gps vert spd	ft/min	
gps ns vel	kn	
gps ew vel	kn	
gps trk ang	deg	
gps_hfom	nmi	
gps_vfom	ft	
gps_status	n/a	
gps time hr	hr	

8. Data From Analog Sources and Computed Functions

Parameter ID	Units	Comments
d/f point 2	°C	Dew frost point - 2 stage ambient dew or frost point in degrees Centigrade. Source: General Eastern 1011 C two-stage thermoelectric hygrometer system Range: –75 to 50 deg C Source: computed utilizing dfp 2 analog signal, heat/cool 2 analog signal, and max cool 2 analog signal Note: The following state flags appear in thousands digit of the data field: 1 max cooling (internal) 2 max heating (internal) 4 max cooling commanded by operator 5 max cooling (commanded and internal) 6 max cooling (commanded) and max heating internal
ir surf temp	°C	IR surface temperature - the infrared temperature of the surface of the earth or cloud top beneath the aircraft. Source: Heitronics, KT 19.85 nadir viewing, infrared radiometer Range: –65 to 55 degC Note: analog parameter
sat computed	°C	Static air temperature - ambient air temperature at aircraft's present position as calculated from total air temperature corrected for aircraft speed. Range: –99 to 33 degC Source: calculated from total air temperature and Mach no.
pressure (atm)	mb	Ambient atmospheric pressue at aircraft's present position as calculated from pressure altitude. Source: calculated from pressure altitude Range: 114 to 1,050 mb
partpres H_2O	mb	Partial pressure of water vapor - the pressure of water vapor as a component of the total atmospheric pressure. Source: calculated parameter from: selectable (d/f point 3 is default) Range: 0.0012 to 388 mb

Parameter ID	Units	Comments
specific hum	g/kg	Specific humidity - ambient specific humidity at aircraft's present position as calculated from partial pressure of water vapor and atmospheric pressure. Source: calculated from partpres H_2O pressure Range: 0 to 20g water/kg air
H_2O sat vp - wtr	mb	Saturated vapor pressure with respect to water - the pressure exerted by water vapor in equilibrium with water when the air mass is over a plane surface of water at the same temperature and pressure. Source: calculated from static air temperature Range: 0.00004 to 125 mb
H_2O sat vp–ice	mb	Saturated vapor pressure with respect to ice - the pressure exerted by water vapor in equilibrium with ice when the air mass is over a plane surface of ice at the same temperature and pressure. Source: calculated from static air temperature Range: 0.00002 to 200 mb
rel hum-watr	percent	Relative humidity with respect to water - ambient relative humidity with respect to water - at aircraft's present position. Source: calculated from partpres water and water sat vp Range: 0 to 100%
rel hum-ice	percent	Relative humidity with respect to ice - ambient relative humidity with respect to ice. Source: calculated from partpres water and water sat vp-ice Range: 0 to 100%
local sidereal time	rad	Local sidereal time - the time defined by the daily rotation of the earth with respect to equinox. Uses the local meridian as the terrestrial reference. Source: calculated from year, day, time, longitude Range: 0 to 2 pi radians

Parameter ID	Units	Comments
ra sun	rad	Sun right ascension - the arc of the celestial equator measured eastward from the vernal equinox to the foot of the great circle passing through the celestial poles and the sun. Source: calculated from year, day, time Range: 0 to 2 pi radians
dec sun	rad	Sun declination - the angular distance of the sun from the celestial equator. Source: calculated from year, day, time Range: ± pi/2rad Orientation: + north of the celestial equator – south of the celestial equator
sun el-earth	deg	Sun elevation relative to earth; Sun elevation relative to the horizontal plane of the earth. Source: calculated from 1st, ra sun, dec sun, latitude. Range: ± 90 deg Orientation: + above the horizontal plane of the earth – below the horizontal plane of the earth
sun az-earth	deg	Sun azimuth relative to earth - the azimuth relative to true north. Source: calculated from 1st, ra, sun, dec, sun, latitude. Range: 0 to 360 deg
sun el-ac	deg	Sun elevation relative to aircraft - the sun elevation relative to the horizontal plane of the aircraft. Source: calculated from 1st, ra sun, dec sun, latitude, pitch, roll, true heading Range: ± 90 deg Orientation: + above the horizontal plane of the aircraft – below the horizontal plane of the aircraft

Parameter ID	Units	Comments
sun az-ac	deg	Sun azimuth relative to aircraft - the sun azimuth relative to the nose of the aircraft. Source: calculated from 1st, ra sun, dec sun, latitude, pitch, roll, true heading Range: ± 180 deg Orientation: + right from nose of aircraft – left from nose of aircraft
sun el rf/ac	deg	Sun elevation - corrected for refraction relative to aircraft. The sun elevation corrected for refraction - relative to the horizontal plane of the aircraft. Source: calculated from sun el-ac, pressure, static air temperature Range: ± 90 deg Orientation: + above the horizontal plane of the aircraft – below the horizontal plane of the aircraft
sun el rf/ea	deg	Sun elevation - corrected for refraction - relative to earth. The sun elevation - corrected for refraction - relative to the horizontal plane of the earth. Source: calculated from sun el-ea, pressure, static air temperature Range: ± 90 deg Orientation: + above the horizontal plane of earth – below the horizontal plane of earth
sun az-left	deg	Sun azimuth - relative to left side of the aircraft. Source: calculated from sun az-ac Range: ± 180 deg Orientation: + right from left of aircraft – left from left of aircraft
sun az-right	deg	Sun azimuth - relative to right side of the aircraft. Source: calculated from sun az–ac Range: ± 180 deg Orientation: + right from right of aircraft – left from right of aircraft

Parameter ID	Units	Comments
solar zenith	deg	Solar zenith - the angular distance of the sun from zenith. Source: calculated from sun el-ea Range: 0 deg to 180 deg
ra moon	rad	Moon right ascension - the arc of the celestial equator measured eastward from the vernal equinox to the foot of the great circle passing through the celestial poles and the moon. Source: calculated from year, day, time Range: 0 to 2 pi radians
dec moon	rad	Moon declination - the angular distance of the moon from the celestial equator. Source: calculated from year, day, time Range: ± pi/2rad Orientation: + north of the celestial equator – south of the celestial equator
moon el-ea	deg	Moon elevation relative to earth - the moon elevation relative to the horizontal plane of the earth. Source: calculated from 1st, ra moon, dec moon latitude Range: ± 90 deg Orientation: + above the horizontal plane of earth – below the horizontal plane of earth
moon az-ea	deg	Moon azimuth relative to earth - the moon azimuth relative to true north. Source: calculated from 1st, ra moon, dec moon, latitude Range: 0 to 360 deg
moon el-ac	deg	Moon elevation relative to aircraft - the moon elevation relative to the horizontal plane of the aircraft. Source: calculated from 1st, ra moon, dec moon, latitude, pitch, roll, true heading Range: ± 90 deg

Parameter ID	Units	Comments
moon az-ac	deg	Moon azimuth relative to aircraft - the moon azimuth relative to the nose of the aircraft. Source: calculated from 1st, ra moon, dec moon, latitude, pitch, roll, true heading
moon el-rf_ea	deg	Moon elevation-corrected for refraction - relative to earth; the moon elevation - corrected for refraction relative to the horizontal plane of the earth. Source: calculated from moon el-ea, pressure, static air temperature Range: $\pm$90 deg Orientation: + above the horizontal plane of earth – below the horizontal plane of earth
moon_el-rf/ac	deg	Moon elevation - corrected for refraction - relative to aircraft - the moon elevation - corrected for refraction - relative to the horizontal plane of the aircraft. Source: calculated from moon el-ac, pressure, static air temperature Range: $\pm$90 deg Orientation: + above the horizontal plane of the aircraft – below the horizontal plane of the aircraft
moon az-left	deg	Moon azimuth relative to left of aircraft - the moon azimuth relative to the left side of the aircraft. Source: calculated from moon az-ac Range: $\pm$ 180 deg Orientation: + right of the left side of aircraft – left of the left side of aircraft
moon az-rt	deg	Moon azimuth - relative to the right side of the aircraft. Source: calculated from moon az-ac Range: $\pm$ 180 deg Orientation: + right of the right side of aircraft – left of the right side of aircraft

Parameter ID	Units	Comments
lunar zenith	deg	Lunar zenith - the angular distance of the moon from zenith. Source: calculated from moon el-ea Range: 0 to 180 deg
poten temp	kelvin	Potential temperature - the temperature that a dry air parcel would have if lowered adiabatically to a level of 1,000 mb pressure Source: calculated from static air temperature computed pressure Range: 171.7 K to 601 K
pres alt metric	meter	Pressure altitude in meters - aircraft pressure altitude in meters corresponding to U.S. Standard Atmosphere, 1962. Source: calculated from pressure alt Range: -570 to 17,480 m
cabin alt	ft	Cabin altitude - effective altitude of the aircraft cabin as a function of cabin pressure-as it relates to sea-level. Source: Rosemount Mod 1241 A6CD Range: –1000 to 20,000 ft
nms a/p cmd	n/a	Auto-pilot command status - computed function returns a flag value which tells which nms (if either) is currently in command of the autopilot Output message: If Output = 1 then NMS1 is in command of autopilot Output = 2 then NMS2 is in command of autopilot Output = 3 then autopilot is OFF Output = 4 then an error was detected
total air temp	° C	Total air temperature