Interface Control Document NASA 931 KC135A

Aircraft Operations Division

May 2004

National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center
Houston, Texas

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Interface Control Document

NASA 931 KC135A

May 2004

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Approved by

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Change Record

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1 INTRODUCTION

The Reduced Gravity Program, operated by the National Aeronautics and Space Administration (NASA), Lyndon B. Johnson Space Center (JSC) in Houston, Texas, provides a "weightless" environment, similar to the environment of space flight.

1.1 Purpose

The purpose of this guide is to provide a guideline for existing and potential users of the Reduced Gravity Program. This document provides detailed interface definition.

1.2 Scope

This work instruction applies to all users and potential users of the JSC Reduced Gravity Program.

1.3 Reference Documents

AOD 33897, Experiment Design Requirements and Guidelines NASA 931 KC135A

Federal Standard W-C-596/90

Federal Standard W-C-596/91A

National Electrical Manufacturers Association (NEMA) L5-30P

1.4 List of Acronyms

AC	Alternating Current
AOD	Aircraft Operations Division
DC	Direct Current
DIA	Diameter
DOT	Department of Transportation
FAA	Federal Aviation Administration
GFCI	Ground Fault Circuit Interrupter
Hz	Hertz
JSC	Johnson Space Center
MS	Military Specification
MSDS	Material Safety Data Sheet
NASA	National Aeronautics and Space Administration
NEMA	National Electrical Manufactures Association
NPT	National Pipe Thread
PSI	Pounds per Square Inch
RGO	Reduced Gravity Office
SCFM	Specific Cubic Feet per Minute
USAF	United States Air Force
V	Volt
VAC	Volts Alternating Current
VCR	Video Cassette Recorder
VDC	Volts Direct Current

2 FACILITIES PROVIDED

This section describes the NASA facilities available to KC-135 researchers.

The reduced gravity environment is achieved by flying a modified Boeing KC-135 turbo jet through a series of parabolic maneuvers. This results in short periods of less than one "g" acceleration. The lengths of these reduced gravity periods depend on the "g" level required for the specific test. Listed below are typical lengths for various maneuvers:

Negative-g to	1/10 max	15 seconds
Zero-g	0-g	23 seconds
Lunar-g	1/6-g (.16)	30 seconds
Martian-g	1/3 g (.38)	40 seconds

These maneuvers may be flown consecutively, (i.e., roller coaster fashion), or separated by enough time to alter the test setup. Each parabola is initiated with a 1.8-g pull-up and terminated with a 1.8-g pullout. Normal missions, lasting approximately two hours, consist of 40 parabolic maneuvers, and originate and terminate at Ellington Field in Houston, Texas. Changes to the normal mission profile can be made to ensure more efficient test operations. These changes include number of parabolas performed, g level adjustments (i.e., .16, .38, .1, .5), and length of breaks between parabolas or sets of parabolas. Requests for operations away from Ellington Field will be considered on an individual basis addressing the benefit to NASA, fiscal soundness, scientific merit, airspace accessibility, and overall Reduced Gravity Program schedule impact.

The KC-135 aircraft test area is equipped with electrical power, compressed gas, an overboard vent, accelerometer data, and photo lights. NASA JSC can provide photographers for still photography and video coverage. An S-band video downlink with two-way audio capability may also be requested. Workspace is available on the ground for buildup and checkout of test equipment to ensure its operation before installation in the airplane.

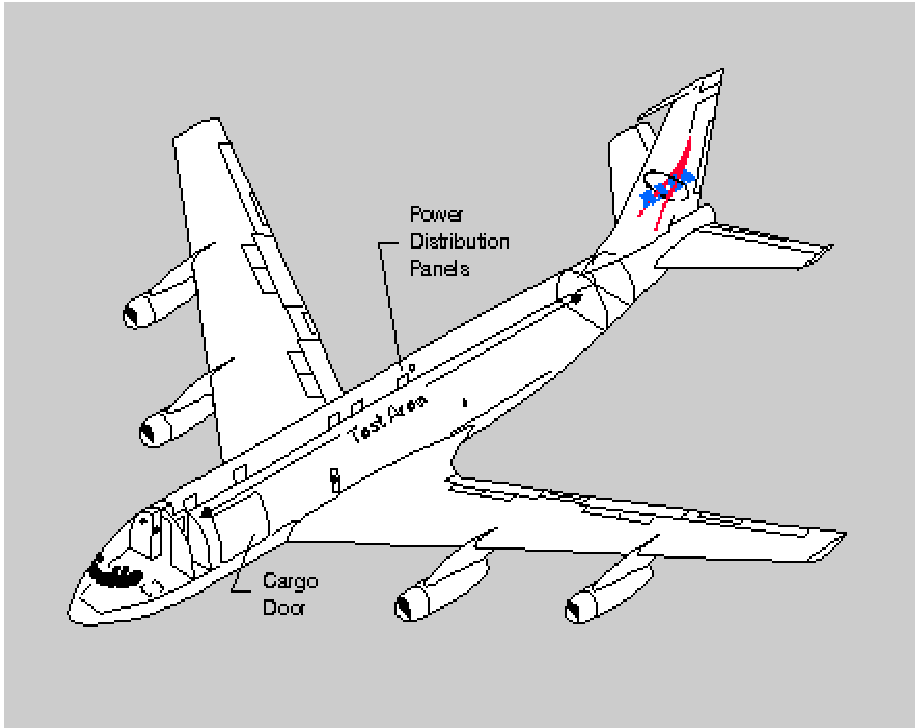


Figure 1. KC-135 Aircraft

2.1 Aircraft

The Boeing KC-135 is a four-engine, swept-wing aircraft similar to the Boeing 707. The United States Air Force (USAF) primarily operates these aircraft as refueling tankers. This particular KC-135, (subsequently named NASA 931), was manufactured and delivered to the USAF in November 1963. NASA obtained the current KC-135 in November 1994 and modified it to support the Reduced Gravity Program. The predecessor to NASA 931, NASA 930, was obtained by NASA in 1973 and flew over 58,000 parabolas before it was retired in 1995. It is now on static display at the entrance to Ellington Field.

The KC-135 is operated as a public aircraft within the meaning of the Federal Aviation Act of 1958, as amended. As such, it does not require or hold a current airworthiness certificate issued by the Federal Aviation Administration (FAA). The KC-135 is not operated as a common carrier or as a military transport. Consequently, any individual manifested to board the KC-135 should determine before boarding whether their personal life or accident insurance provides coverage under such conditions. Also, since the aircraft will be used under test conditions, all researchers and test subjects will be fully informed of the test plans and all risks, hazards, and discomforts inherent to such tests prior to flight.

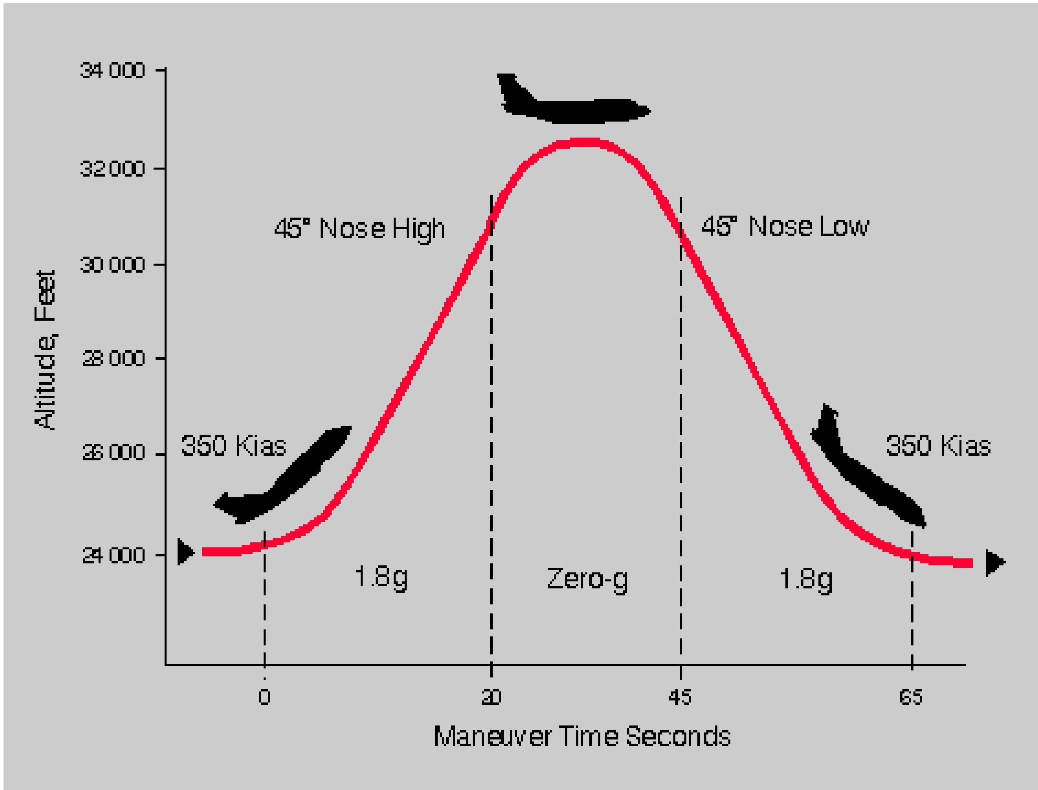


Figure 2. Parabola Diagram for Reference Only

2.1.1 Cabin Environment

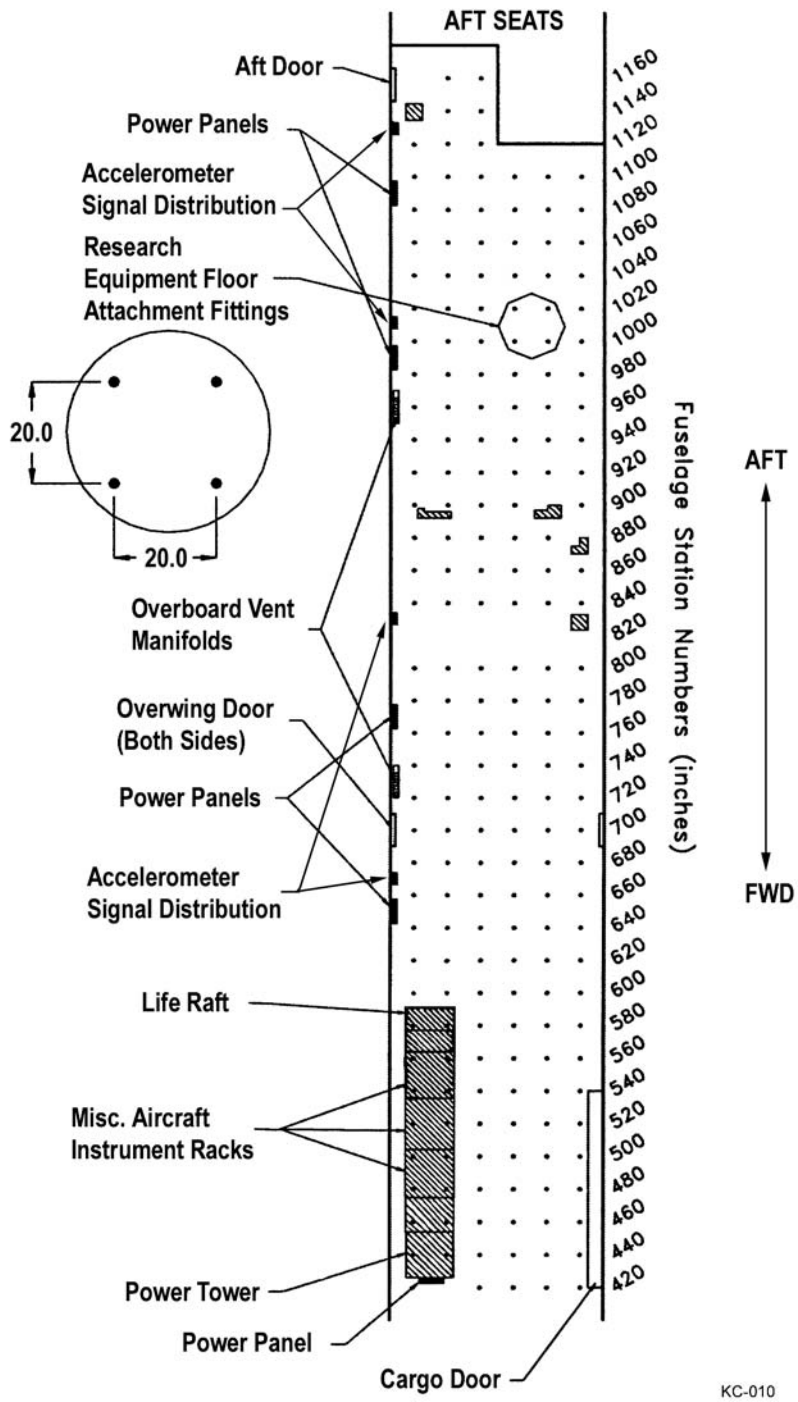
Cabin pressure is maintained at approximately pressure altitude 8,000 feet (10.9 psia) during parabolic maneuvers. Loss of cabin pressurization could result in pressure as low as 3.5 psia; a factor that must be considered in the design of test equipment.

Normally, cabin temperature varies from 50 to 80 degrees Fahrenheit (F) in flight.

The temperature in the cabin is not controlled while the airplane is on the ground; however, a portable ground air conditioner is available during preflight operations. Keep in mind that the aircraft typically sits out on the ramp during the day and overnight during a flight week. Temperature ranges inside the cabin area can be as cold as 30°F during the winter months and as hot as 120°F in the summer. Researchers should make provisions for their experiment hardware to tolerate these conditions.

2.1.2 Cabin Dimensions

Approximately 60 feet of cabin length is available for test purposes. A floor plan schematic is shown in Figure 3. A cross sectional view of the cabin is shown in Figure 4 and Figure 5. Test equipment is usually loaded through the cargo door that is 75 inches high and 118 inches wide. Because of the door actuation mechanism, an area 14 inches tall and 9 inches wide is unusable at each of the top corners of the door. A diagram of the cargo door is shown in Figure 6. A photograph showing the cargo door during loading operations is shown in Figure 7.



Note

Research equipment installation is prohibited on cross-hatched areas.

Figure 3. Aircraft Floor Layout

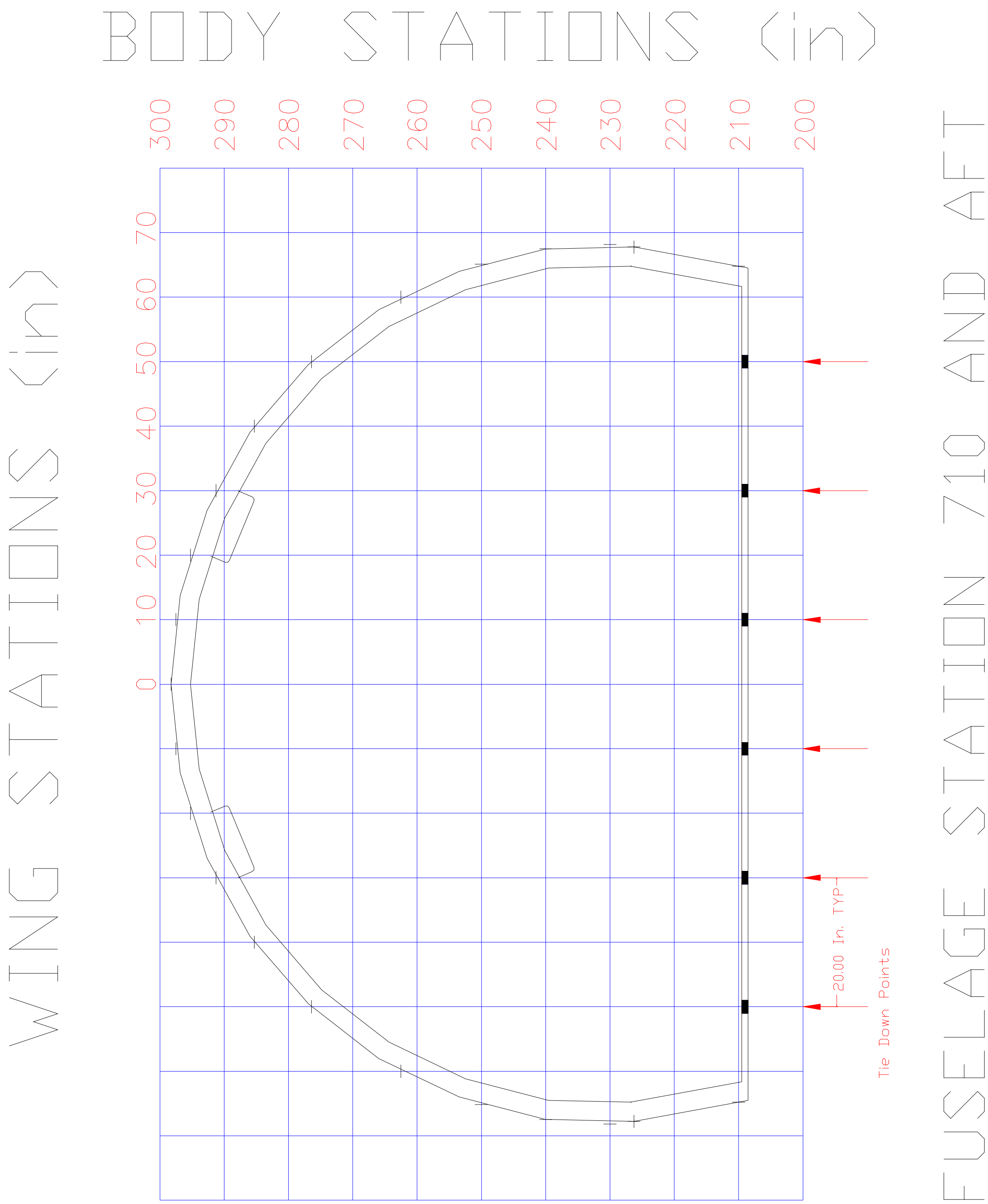


Figure 4. Cross-Section of Fuselage Station 710 and Aft

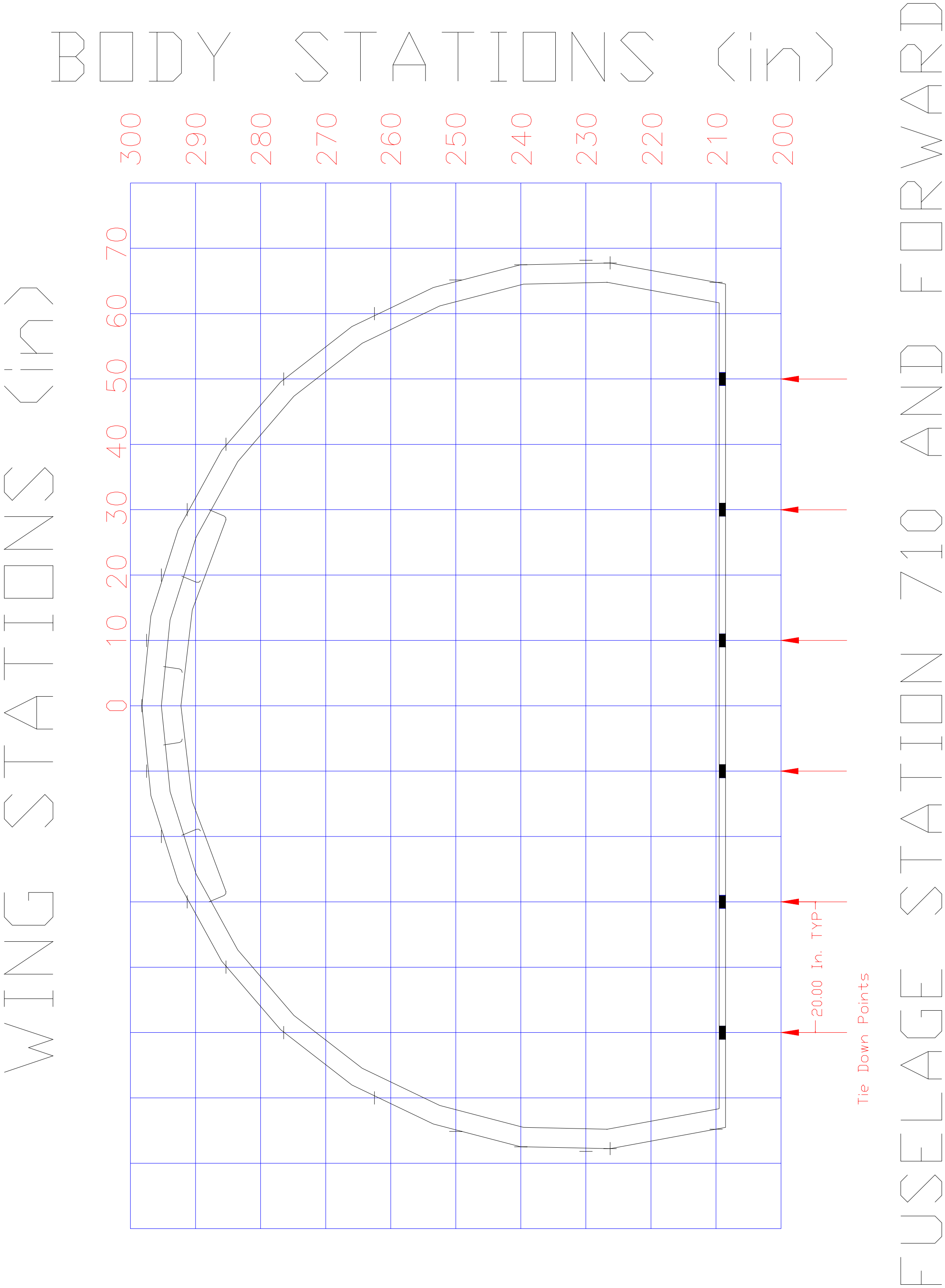


Figure 5. Cross-Section of Fuselage Station 710 and Fwd

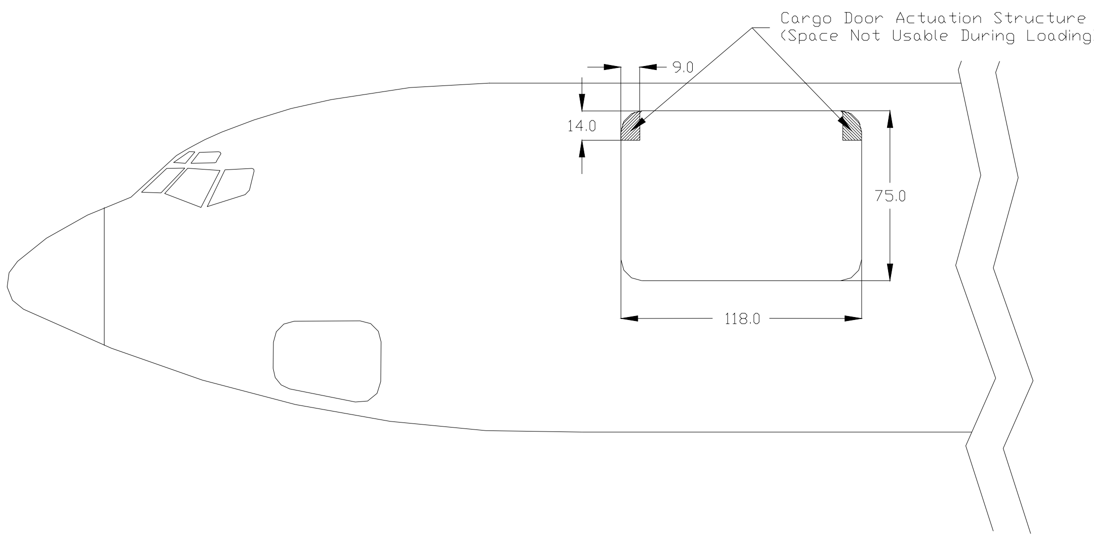


Figure 6. Cargo Door Dimensions in Inches

Figure 7. Cargo Door Operations

2.1.3 Cabin Provisions

The aircraft is equipped with 23 seats aft of the test section. The interior walls of the cabin are covered with foam padding for the protection of personnel and equipment.

2.1.4 Electrical Power and Interface

Four types of electrical power are available, as shown in Table 1. The 115 VAC is distributed into two buses (A and B bus). Each experiment will be allotted a portion of the power budget at the time the aircraft is loaded. Special arrangements can be made for experiments with unusually high power requirements.

Power Type	Total Current Available
28 Volts DC	100 Amps
115 Volt AC, 400 Hz, Three Phase	50 Amps / Phase (from each of two sources)
115 Volt AC, 400 Hz, Single Phase	~ 50 Amps / Phase
115 Volt AC, 60 Hz, Single Phase	110 Amps

Table 1. Total Electrical Test Power

Aircraft electrical power is distributed via five power distribution panels. These panels are located along the lower sidewall of the test cabin at fuselage stations 460, 650, 770, 990, and 1090. A mechanical drawing of a power distribution panel is shown in Figure 8. The following sections will explain the mechanical interface to each type of electrical power.

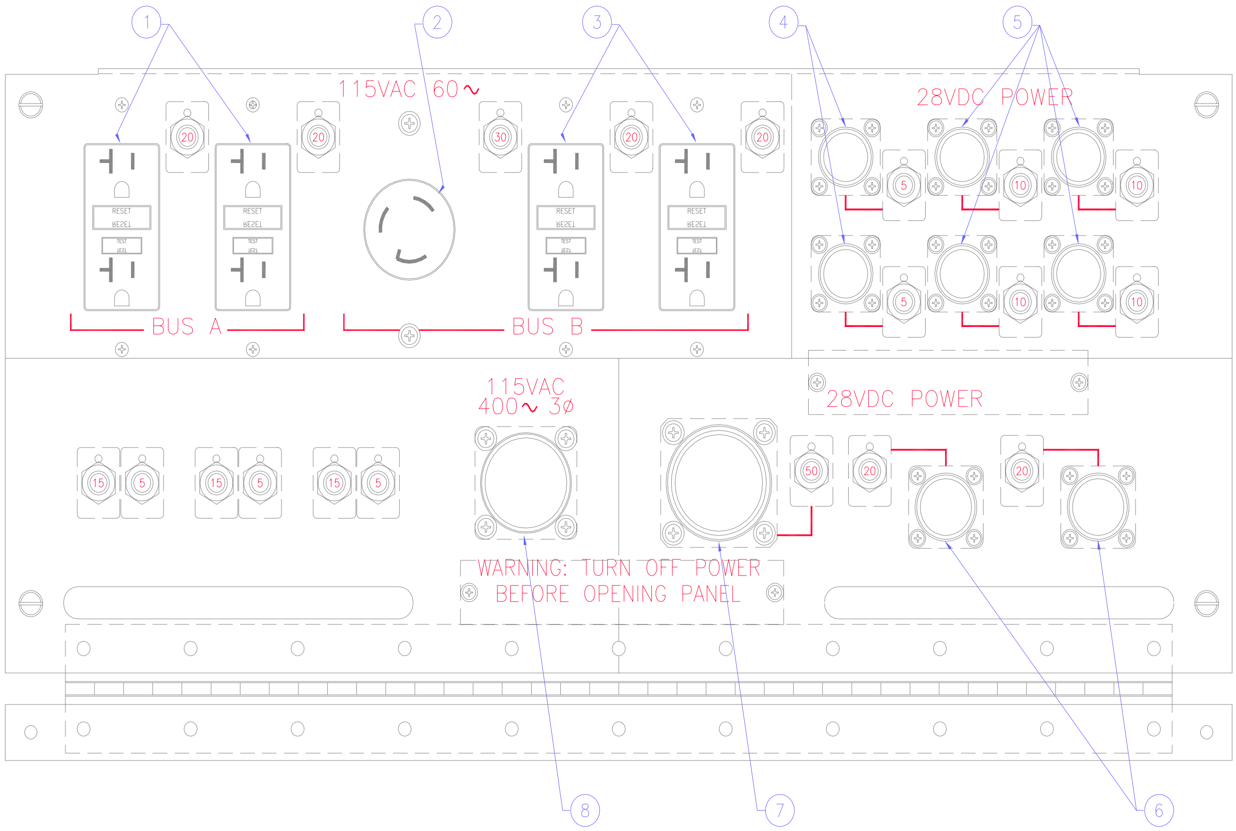


Figure 8. Power Distribution Panel

115 VAC, 60 Hz

115 Volts AC power at 60 Hz is provided by drawing items 1, 2 and 3 in Figure 8. The duplex Ground Fault Circuit Interrupter (GFCI) outlets (drawing items 1 and 3 in Figure 8) are common three-prong receptacles. Each duplex outlet can supply 20 Amps maximum.

The circular outlet (drawing item 2 in Figure 8) is a common industrial 30 Amp receptacle and is compatible with Federal Standard W-C-596/90. Experimenters must provide the mating plug that is compatible with Federal Standard W-C-596/91A and NEMA L5-30P. An example experimenter plug is Hubbell TWIST-LOCK part number HBL2611 rated for 30 Amps at 125 Volts, or equivalent.

28 VDC

Each power distribution panel provides interfaces for 5, 10, 20 and 50 Amp circuits.

All 28 Volt interfaces are standard Military Specification (MS) cannon connectors.

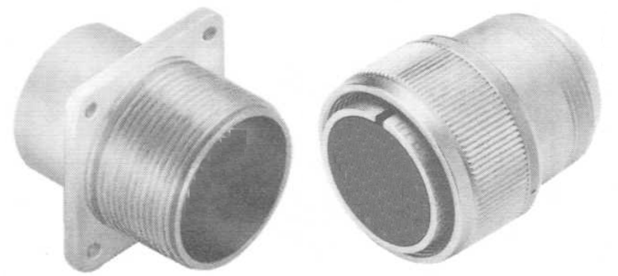


Figure 9. MS Cannon Receptacle (Left) and Plug (Right)

Power Panel 28 VDC Interfaces

Two cannon plugs (drawing item 4 in Figure 8) supply 28 VDC at a maximum 5 Amps.

Four cannon plugs (drawing item 5 in Figure 8) supply 28 VDC at a maximum 10 Amps.

The mechanical connections for drawing items 4 and 5 in Figure 8 are identical. The power distribution panel receptacle is Mil-Spec part number MS3452W14S-9S (female). Experimenters must provide the mating male plug connector, Mil-Spec part number MS3456W14S-9P (or MS3106A14S-9P). Each connector has two pins labeled Pin A (Power) and Pin B (Return). This connector is designed to accommodate 16 or 18 gauge wire. Experimenters must use wire sizes in accordance with "Minimum Wire Gauges" (Table 2 in AOD 33897, Experiment Design Requirements and Guidelines NASA 931 KC135A).

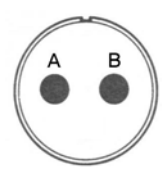


Figure 10. 14S-9 Receptacle Contact Arrangement

Two cannon plugs (drawing item 6 in Figure 8) supply 28 VDC at a maximum 20 Amps.

The mechanical connections for both 20 Amp outlets are Mil-Spec part number MS3452W16-13S (female). Experimenters must provide the mating male plug connector, Mil-Spec part number MS3456W16-13P (or MS3106A16-13P). Each connector has two pins labeled Pin A (Power) and Pin B (Return). This connector is designed to accommodate 12 or 14 gauge wire. Experimenters must use wire sizes in accordance with [missing table "Minimum Wire Gauges" (Table 2 in AOD 33897, Experiment Design Requirements and Guidelines NASA 931 KC135A).

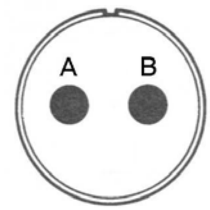


Figure 11. 16-13S Receptacle Contact Arrangement

One cannon plug (drawing item 7 in Figure 8) supplies 28 VDC at a maximum 50 Amps.

The power distribution panel receptacle is Mil-Spec part number MS3452W28-5S (female). Experimenters must provide the mating male plug connector, Mil-Spec part number MS3456W28-5P (or MS3106A28-5P). The connector has five pins labeled Pin A (Unused), Pin B (Power), Pin C (Unused), Pin D (Unused), and Pin E (Return). This connector is designed to accommodate 4 gauge wire on Pins B and E. Experimenters should use wire sizes in accordance with "Minimum Wire Gauges" (Table 2 in AOD 33897, Experiment Design Requirements and Guidelines NASA 931 KC135A).

Note

Power cords used to reach this 50 Amp outlet should be 10 feet in length.

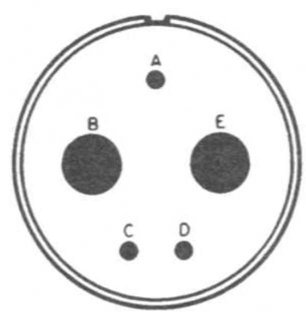


Figure 12. 28-5 Receptacle Contact Arrangement

115 VAC, 400 Hz

One cannon plug (drawing item 8 in Figure 8) supplies raw 115 VAC aircraft power at 400 Hz. This receptacle does not have a dedicated circuit breaker on the local power distribution panel. The 400 Hz bus is breakered at 50 Amps per phase on the main aircraft power panel. The outlet is primarily intended to drive a mobile power-tower, which converts additional 400 Hz power to 60 Hz power. Researchers may use the 400 Hz outlet when it is available; however, it is the responsibility of the researchers to protect their own equipment from electrical faults. Every electrical cable from a power distribution panel should include a current limiting device on the experiment.

The power distribution panel receptacle is Mil-Spec part number MS3452W24-22S (female). Experimenters must provide the mating male plug connector, Mil-Spec part number MS3456W24-22P (or MS3106A24-22P). The connector has four pins labeled Pin A (Phase A Power), Pin B (Phase B Power), Pin C (Phase C Power), and Pin D (Neutral). This connector is designed to accommodate 8 gauge wire. Experimenters must use wire sizes in accordance with "Minimum Wire Gauges" (Table 2 in AOD 33897, Experiment Design Requirements and Guidelines NASA 931 KC135A).

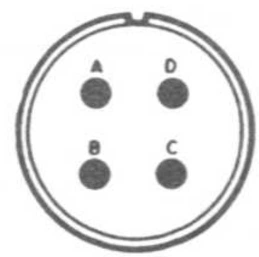


Figure 13. 24-22 Receptacle Contact Arrangement

2.1.5 Aircraft Lighting

The aircraft cabin contains thirty fluorescent photo-lights (approximately fifteen down each side-wall). These lights have been specially designed to provide sunlight-quality illumination. The bulbs are similar to those used in the film industry; they are heavy on the blue end of the color spectrum. Because of the unique design of the bulbs, daylight camera film may be used in the cabin and a flashbulb is typically not required (color temp of xxx).

A switch in the cockpit controls the intensity setting of all cabin photo lights. There are two possible intensity levels: full intensity and half intensity. The lights will be set to full intensity during the reduced gravity portion of the parabolas. During all other phases of flight (including takeoff, landing, parabola pull-up and pull-out) the lights will remain at half-intensity or off.

Each of the lights may be turned off individually. When a given fixture is turned off, it will remain off during all phase of flight regardless of the cockpit switch position.

2.1.6 High Pressure Gas System

High pressure gas systems are allowed for use on the KC-135 through compliance with all safety guidelines. All pressurized gas systems must receive approval through the pressure vessel certification procedure documented in this User's Guide (see AOD 33897, Experiment Design Requirements and Guidelines NASA 931 KC135A section 2.3).

Per customer request, the RGO will provide the following high pressure gas and K-bottle handling equipment:

1. Nitrogen K-bottle (volume 228 ft^3 at 2200 psig)
2. Helium K-bottle (volume 212 ft^3 at 2200 psig)
3. Argon K-bottle (volume 248 ft^3 at 2200 psig)
4. Breathing air K-bottle (volume 233 ft^3 at 2200 psig)
5. K-bottle ground handling carts
6. In-flight, 9g rated, "K-bottle" mounting rack

Researchers should ensure the gas bottles they ship to the RGO are 9 inches in diameter and 55 inches in length if RGO Bottle Racks are used.

All bottles must be DOT certified and current or meet Pressure System requirements for a pressure vessel.

All regulators and gauges must be properly calibrated, and have current certification tags.

All gas systems must have appropriate sized relief valves installed at the regulators to prevent over pressurization of the gas supply line, and current calibration (and tagged).

The RGO does not supply regulators to researchers.

Any high-pressure gas equipment must be approved for use by the RGO prior to its arrival at Ellington Field (see AOD 33897, Experiment Design Requirements and Guidelines NASA 931 KC135A section 2.3).

2.1.7 Overboard Vent System

An overboard vent system is available on the aircraft for the venting of most gases. No liquid can be vented through this system due to freezing which could occur at altitude.

There are two vent lines, one is a multi-user line, the other a dedicated line for use by a single experiment. The multi-use vent line (1 ¼" DIA) has two manifolds (at FS 730 and FS 980), each with five attachment points. For experiments requiring high volumetric flow rates, or to avoid chemical interaction with other experiments, a single dedicated vent line is available at FS 1100. This line (1 ¼" DIA) has no manifolds, which maximizes the suction and flow rates for a single user.

The manifold fittings on the multi-user vent line are female (internally threaded) Army/Navy (AN) 12 fittings (3/4"); researchers must supply a male AN 12 fitting on the research equipment. (Parker Triplelok 37° Flared Tube Fitting)

The dedicated vent line has a male 1¼" National Pipe Thread (NPT) threaded fitting. To attach directly, experimenters should fit their equipment with a 1¼" female NPT thread. The Reduced Gravity Office also has the ability to provide an AN 20 male fitting, an AN 16 male fitting, and a 1" NPT male fitting on this dedicated vent line. The researcher is responsible for providing the matching female fitting on the test equipment.

A simplified table of vent line flow rates is provided below:

Location	**Max Flow (SCFM) 36,000'**	**Min Flow (SCFM) 26,000'**
Fwd Manifold	64 (total*)	61 (total*)
Aft Manifold	72 (total*)	69 (total*)
Dedicated Line	75	72

*total refers to a combination of all experiment flows at that location including all flows introduced upstream at the forward manifold.

Table 2. Flow Rates

Note

These rates apply at the manifold / fitting only. Line losses in researcher equipment must be considered to determine flow rate at researcher's termination point.

A complete study of the volumetric flow rates through the overboard vent system has been performed and a copy is available through the Reduced Gravity Office.

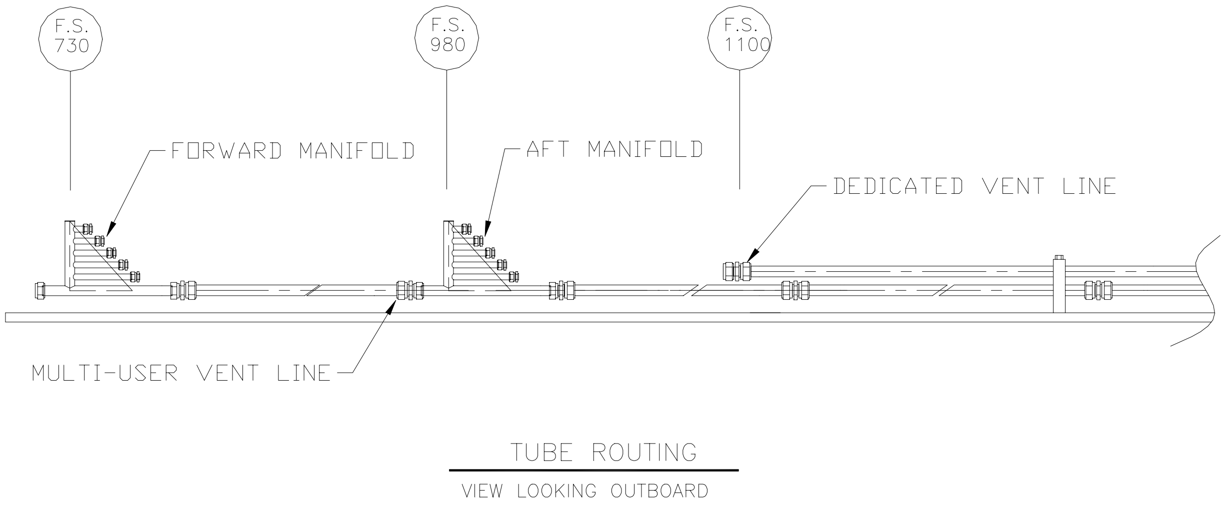


Figure 14. Overboard Vent Line

The cabin volume is = 4346 cubic feet. The cabin air exchange rate is one cabin volume per three minutes.

2.1.8 Aircraft G-Load Display

There are two display panels to show the real-time g-value and the parabola count for reference only. One display is mounted on the forward bulkhead facing aft and the other is mounted on the aft bulkhead facing forward.

2.1.9 Accelerometer Signal

Aircraft accelerometer signals Gx, Gy, and Gz are available for research use. The locations of the signal distribution boxes are shown in Figure 3. Each signal distribution box is buffered to prevent interference with aircraft systems and other researchers.

Each signal is filtered with a normal cutoff frequency of 100 Hz. The RGO staff may independently adjust the cutoff frequency of each channel upon request. Changes to any cutoff frequency will affect the corresponding signal at every signal distribution box in the test cabin.

A male DB-15 connector and 10 to 15 feet of signal cable are required to connect to a signal distribution box. Pin designations are shown in Table 3 and Figure 15.

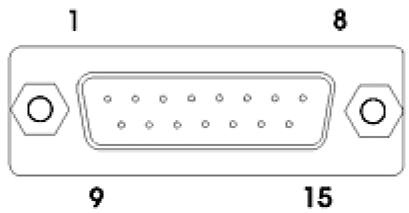


Figure 15. DB-15 Accelerometer Data Connector

Measurement	Pin Number	Signal Value
Gx +	5	9.8 Volts / g
Gx -	9	Signal Ground, 0 Volts
Gy +	6	9.8 Volts / g
Gy -	10	Signal Ground, 0 Volts
Gz +	4	3.6 Volts / g
Gz -	11	Signal Ground, 0 Volts

Table 3. Accelerometer Pin Designations

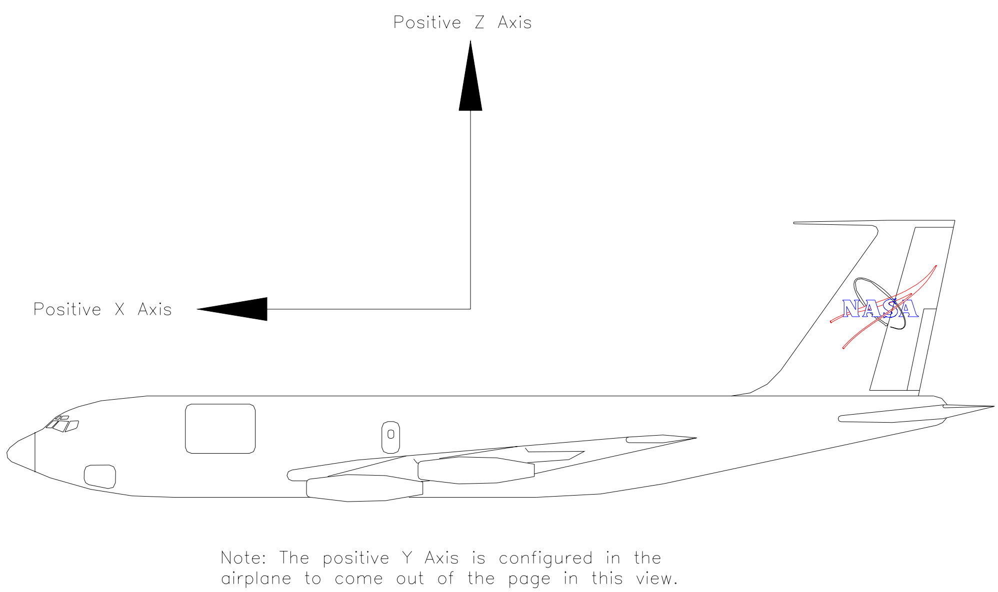


Figure 16. Aircraft Acceleration Vectors

2.1.10 On-Board Tools

The Reduce Gravity Office (RGO) maintains a toolbox with a collection of hand tools sufficient to install most test packages in the aircraft. The toolbox and all tools are removed prior to flight. No tools are provided during flight. See AOD 33897, Experiment Design Requirements and Guidelines NASA 931 KC135A section 2.10 for a description of allowed tools.

2.2 Ground Facilities

This section describes the NASA ground facilities that are provided to KC-135 researchers by the Aircraft Operations Division.

Figure 17. Ground Facilities

2.2.1 Reduced Gravity Office

Building 993 at Ellington Field provides visiting researchers with a 1,760 square foot high bay work area. This air-conditioned workspace is available for test equipment buildup and checkout.

The high bay is equipped with 5-foot, 7-foot, and 10-foot workbenches for researcher use.

Available electrical power includes 115 VAC, 60 Hz, 20 Amp; 115 VAC, 3 phase, 20 Amp, 400 HZ; 28 VDC, 20 Amp. Access to the work area includes two 12' X 12' roll-up doors.

The building also has an adjacent conference room containing computers, telephones, a VCR and 8 mm video equipment, and video monitors.

Note

Building 993 does not have a vent hood for mixing chemicals inside the building.

Figure 18. Building 993 High Bay Work Area

2.2.2 Computers, Network Access, Printers, and Phones

The computers and the network access are provided by the RGO for OFFICIAL business ONLY. Phones are provided in the conference room. All long distance calls must be made collect or third party. Incoming calls or faxes for the researcher should be to the following numbers:

Main Office:	281-244-9874
Conference Room:	281-244-9005
Fax:	281-244-9500

2.2.3 Normal Duty Hours

The Reduced Gravity Office operates Monday through Friday from 7:30 am to 4:00 pm. Researcher access to the High Bay is limited to these hours unless prearranged with the Reduced Gravity Office. Access to the aircraft is from 7:30 am to 4:00 pm during flight days.

2.2.4 Equipment and Material Storage

Very limited storage space is available in Building 993. Requests for space must be prearranged with the Reduced Gravity Office. All chemicals will be stored in the chemical storage locker located in the High Bay of Building 993. Any chemical stored in this locker shall be clearly marked with the name of the researcher, the date it was placed in the locker and the experiment title. Material Safety Data Sheet (MSDS) paperwork should be given to RGO personnel for filing in a 3-ring binder located on top of the chemical storage locker. It is the responsibility of the researcher to notify RGO personnel when a chemical is removed after completion of an experiment.

Note

Building 993 is not equipped with an approved vent hood for chemical mixing.

2.2.5 Cryogenic Storage and Supply System

A cryogenic storage/supply system is available to provide a source of breathing air or nitrogen. The cryogenic system has a 1/2-inch standard AN fitting with a variety of available adapters. Contact the Reduced Gravity Office **six weeks** prior to flight to address any needs in this category.

2.2.6 Crane and Scale

Building 993 is equipped with an overhead crane that spans the distance between the two overhead doors. It has a capacity of 2,000 pounds. The maximum distance from the floor to the crane hook on the crane is 97 inches. Only certified JSC or Ellington Field personnel shall operate the crane.

2.2.7 Forklift

Forklifts are available for the unloading and loading of research equipment, (6SX 30) 4900# capacity at 188" lift.

The forklift is equipped with a loading platform for ease of operation when moving multiple pieces of equipment. This loading platform has a ramp on the front that enables research equipment with wheels to be rolled on and off the platform, capacity of xxx. Only certified JSC or Ellington personnel shall operate the forklift.

2.2.8 Ground Tools

The High Bay of Building 993 provides a complete toolbox for researcher use while at the Reduced Gravity Office. The High Bay facility also includes a 20-gallon air compressor, shop vacuum, bench vice, power available xxx, CFM.

2.2.9 Loading Assistance Tools

Loading assistance tools are available for researcher use, including:

High Lift Truck

Lift Platform (for the forklift)

J-Bars

Roller Pipe (schedule 40 PVC)

Lifting Straps

Lifting Pipe

Furniture Dolly (24" x 44")

It is the researcher's responsibility to ensure that their research hardware has been designed with the proper handholds, lifting bars, and wheels (if required) to allow for safe and easy loading and unloading of the aircraft. (add reference to applicable document)

Figure 19. High Lift Truck

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