Bulletin No. 13

DESIGN, FABRICATION, AND APPROVAL OF USER-SUPPLIED EQUIPMENT FOR NSF/NCAR AIRCRAFT

This Bulletin sets forth the procedures to be followed for the design, fabrication, and approval of user-supplied research equipment to be flown on board NSF/NCAR aircraft. Failure to adhere to the procedures set forth herein may result in **delay** or **cancellation** of your project.

The installation of user-supplied research equipment is one of the more demanding and time consuming aspects of airborne research. Proper design and fabrication of equipment before the installation period are most important, as design or fabrication defects usually cannot be corrected during the installation period. This is particularly important, in that design deficiencies must be corrected prior to equipment installation on board the aircraft.

All newly-designed, commercially-purchased, and other equipment not designed for aircraft use must be evaluated for structural integrity and, if necessary, be modified or strengthened to conform to the criteria outlined in this Bulletin. Also, all equipment designed for aircraft use will be reviewed for conformity. In addition to structural considerations, any wiring in user-supplied equipment must adhere to guidelines established and outlined herein.

All equipment must be designed or modified to attach to the various instrument racks and attaching points on the specific aircraft to be used. Information on these mounting points is contained in the RAF Bulletins for each aircraft. The load-carrying capability of these racks and attaching mounts must not be exceeded.

The criteria of this Bulletin are strictly enforced, and it is the responsibility of the user to comply. Noncompliance will cause the user's equipment to not be flown or the program to be delayed. RAF will assist the user in meeting the standards set forth in this Bulletin.

Design Load Criteria

All equipment that attaches to or is used on the NSF/NCAR aircraft must conform to the following basic design load criteria: emergency landing conditions, in-flight lift and drag forces and gust loads--all acting

independently. Emergency landing loads are defined as loading that occurs during other than a normal landing, such as a wheels-up landing or veering off the runway. Lift and drag forces are defined as those loads encountered during flight at maximum design airspeed and sea level conditions due to the shape and size of externally-mounted equipment. In-flight gust loads are defined as the loads resulting from turbulence. The following design load criteria are from Federal Aviation Administration or aircraft manufacturer-approved data and include appropriate safety factors.

All equipment, including racks, instruments, pallets, tie-downs, etc., and supporting structure that attaches to hardpoints inside the aircraft cabin (the cabin being defined as that space occupied by personnel) must be designed for the emergency landing conditions listed in Table 1. The emergency landing condition loads are independent of the in-flight loads and must be calculated separately.

Table 1. Emergency Landing Criteria

Load Direction	Load Factor (Ultimate) Occupied Areas	Load Factor (Ultimate) Unoccupied Areas
Forward	9.0 g (9.0 x wt. of equip.)	3.0 g
Up	3.0 g (3.0 x wt. of equip.)	2.0 g
Down	6.0 g (6.0 x wt. of equip.)	4.5 g
Side	3.0 g (3.0 x wt. of equip.)	1.5 g
Aft	1.5 g (1.5 x wt. of equip.)	1.5 g

All externally-mounted equipment and supporting structure that attaches to external hardpoints on the aircraft must be designed for the airspeed (lift and drag) loads and the in-flight gust loads listed in Table 2, whichever are greater.

Table 2. In-flight Load Criteria

Aircraft	Airspeed	In-flight Gust Load
Electra	328 KIAS & sea level cond.	8.25 g down, 5.25 g up
C-130Q	250 KIAS & sea level cond.	8.25 g down, 5.25 g up

All equipment and its supporting structure that attaches inside the aircraft must also conform to the in-flight gust load criteria listed in Table 2.

The Aeronautical Engineering Department of the RAF will assist in the interpretation of these criteria as well as provide guidance in the design or attachment of user-supplied equipment on the NSF/NCAR aircraft.

All equipment for pressurized aircraft (e.g., optical view ports, air sampling chambers, valves or lines) must maintain the pressure differential between cabin pressure on one side and outside ambient pressure on the other. It must be designed to a collapse or burst pressure of at least 1.41 kg/cm2 (20 psi) for the Electra and C-130Q.

The loads calculated for the above design criteria, for both internal and external equipment, will result in internal stresses for the structural components. These calculated stresses must not exceed the accepted yield stress values for the material used. Refer to MIL-HDBK-5B, *Metallic Materials and Elements for Aerospace Vehicle Structures*, for the accepted values.

The user should design equipment to be as light as possible, since weight is an important consideration for airborne equipment. If the analysis for structural components shows large margins of safety for the design loads, the design should be refined to reduce weight.

Materials and Fasteners

The commonly-accepted metallic materialss for airborne structural components are aluminum and steel, with aluminum being the most widely used. The 2024, 6061, and 7075 series of tempered-aluminum alloys are the most popular. The 6061 series aluminum is the most readily available; it is also readily weldable, while the others are not. The most widely-used steel alloy is 4130, but 301 and 302 stainless steel alloys are acceptable, as well. Other materials such as copper, brass, plastics, wrought iron, non-tempered aluminum, etc., must not be used for structural members.

The use of non-metallic materials is acceptable for some applications, such as sensor design. The materials should be non-flammable and not support combustion. The user is required to supply certification for the non-flammability of all the non-metallic materials used. The RAF Design Guide RAF-DG-00-001 has additional, important information on the use of non-metallic materials.

Aircraft structural fasteners (MS, AN, or NAS standards) such as screws, bolts, nuts, and rivets must be used for all structural members. All threaded fasteners must be secured by self-locking nuts, self-locking inserts, or safety wire. Wherever possible, these fasteners also should be used for other elements of the equipment. The holes for the fasteners should be sized for the specific fasteners and must not be oversized or elongated. When flat-head, countersunk fasteners are used, the 100-degree countersink is preferred over the 82-degree countersink. RAF can supply specifications for these fasteners.

Any threaded holes drilled and tapped in aluminum members should use inserts, such as Heli-Coil or Keen Serts, to eliminate thread galling and to improve strength.

Bolted and riveted construction is recommended for structural members. Welding is permitted, but it must be of high quality and performed according to the MIL-T-5D21C specification or equivalent. The load-carrying strength of welded aluminum joints must be reduced by 50%, since the welding process reduces the strength of the parent metal next to the weld. Heat-treating welded structures to regain or increase strength is acceptable, but the process must be done according to certain specifications which the RAF can provide.

Hazardous Materials and Equipment

Any hazardous materials (pyrotechnics; flammables, toxic gases or liquids; lasers; etc.) and associated containers and handling apparatus required for user-supplied equipment must be noted by the user. These materials will be reviewed by the NCAR Safety Officer and cognizant NCAR and RAF staff. As part of the review process, the user will be required to complete a form declaring the type of material, quantities, concentrations, containers, plumbing, hazards to personnel, etc. This form can be obtained from the RAF and, once filled out, should be returned to the NCAR Safety Officer.

Any pressurized containers, valves and plumbing must be capable of sustaining at least twice the operating pressure needed for use. Any gas cylinders to be used must have a current hydrostatic testing date (as per Department of Transportation regulations pertaining to gas cylinders).

Any cylinders containing toxic or flammable gases will require an enclosure over the cylinder top and a regulator such that, in the event of a leak, the gases will be vented outside the aircraft.

The decision to permit hazardous materials and/or instruments to be used on board NSF/NCAR aircraft will be made by the RAF Safety Committee after a complete review of the materials and equipment involved. The committee will ensure that the aircraft and the personnel on board are not subject to unreasonable hazards under conditions which can be expected during the conduct of the operation. The committee will specify safeguards, when appropriate.

Certain types of wire, such as solid wire and rubber covered wire, are **not** acceptable for use in equipment mounted on board the aircraft. Acceptable types of wire include, in order of preference: stranded copper wire with woven fiberglass and teflon covering, stranded copper wire with teflon and nylon covering, and stranded copper wire with teflon covering. Wire size relative to current-carrying capacity also is a safety concern. Table 3 gives guidelines for this.

Table 3.

Wire Size (gauge)	Current Capacity (amps)
14	20
16	15
18	12
20	9

In general, workmanship in the wiring of user-supplied equipment shall be of the highest quality possible. Some examples of unacceptable workmanship include: insufficiently-soldered joints, cold solder joints, poor or inadequate insulation, and improper crimping. User-supplied equipment with substandard wiring will be repaired by the user and reinspected by the RAF prior to installation on the aircraft.

Design Review and Changes

It is the user's responsibility to design, fabricate, or modify equipment in accordance with the criteria of this Bulletin. The user is required to submit detailed drawings of the equipment (including commercial or existing equipment) which show dimensions, fasteners and fastener pattern, materials, and estimated

weights. A description of power requirements is required. Photographs of the equipment should be furnished, if they are available. Load and stress analyses must accompany the drawings and must include at least an analysis of the basic structure and the support and tie-downs to the aircraft mounting points.

Actual load testing of the equipment to simulate in-flight conditions for verification of the design criteria is not recommended, as equipment easily can be destroyed or damaged by the test. Any test plans must be approved by RAF if actual load testing is to be done.

All design data must be submitted **at least three months in advance** of the **installation** of the equipment on board the aircraft. Longer lead times may be required for complex equipment installations. RAF will review and approve or suggest changes to the design, as needed. RAF approval must be obtained before the equipment is constructed or shipped. Delays in meeting this schedule can result in project **delay** or **cancellation**. In addition, RAF requires that equipment be made available for installation on the aircraft **at least 30 days in advance** of the project start date.

The RAF Safety Committee reviews all safety aspects of a program, including instrumentation and equipment, and must approve each project for safety prior to its execution. The user should be aware that, once a program has been reviewed by the RAF Safety Committee, any user-initiated changes involving instrumentation or equipment will require another complete review. These changes could delay the program or cause late equipment additions to be unacceptable.

Aircraft Modifications

The user is strongly urged to design equipment to use the existing capabilities of the RAF aircraft. (Refer to the specific RAF Bulletins for the aircraft of interest.) Any modification of existing capabilities or new modification to the aircraft is, in most cases, extremely expensive and time consuming. The user is cautioned that s/he may be required either to share the cost, or to assume the total cost of any requested aircraft modifications.

Since the aircraft could be removed from service to other users for extended periods of time, any required modifications will be handled by RAF.

Equipment Inspection and Acceptance

User-supplied equipment will be inspected under the RAF inspection program when it arrives at the Facility and before it is installed on the aircraft. This inspection will verify the design, construction, weight, and general condition of the equipment to determine its conformance to the previously-approved design data. Minor discrepancies can be corrected at this time. As pointed out earlier, major discrepancies probably cannot be corrected at this time, and such discrepancies could cause the equipment not to be flown or the program to be delayed or cancelled.

Weight Control on RAF Aircraft

An accurate estimate of the weight and size of user equipment to be installed on the aircraft is a critically-important requirement in the initial request for aviation support. Estimated weights and sizes also must include any support equipment (e.g., gas cylinders, spares, tools, supplies) which are to be carried on the aircraft during ferry or research flights. RAF's feasibility evaluation of a program is based on this information. Any changes to the original proposal will require a reevaluation of the proposed flight profiles, and possibly require changes in the cabin layout, to comply with aircraft balance requirements.

Prior to installation on the aircraft, all user equipment will be weighed and identified by an appropriate tag and entered in the instrumentation log book. Prior to departure, all spares, supplies and associated

gear, including personal baggage, also will be weighed and properly marked. These actual weights will be used in the weight-and-balance calculations required for the safe operation of the aircraft. Strict compliance is mandatory. Any unweighed and unmarked items will be removed from the aircraft.

Equipment Installation

At least four weeks should be allowed for installation of approved equipment on board the RAF/NSF aircraft, and the installation will be supervised by cognizant RAF personnel. More time may be required for installation of complex equipment. Some of the necessary incidental hardware can be supplied by RAF. FAA approval of the installation will be obtained at this time and will be handled by RAF.

During flight, any removal or disassembly of equipment from its approved installation is prohibited, since such alteration can create potentially hazardous conditions.

Flight Tests

Flight tests sometimes are required, especially in the case of externally-mounted equipment, to evaluate flutter or vibration characteristics and effects on aircraft performance and handling. This requirement usually can be assessed early in the program at the time the user's proposal is reviewed by RAF. RAF will lay out the flight test program, if required, in conjunction with the user, and will conduct the test.

Further Information

Investigators interested in discussing the procedures and standards covered in this Bulletin may contact RAF's Aeronautical Engineer, Mark Lord by email or by phone: (303) 497-1046.

RAF Technical Bulletins* / *RAF Home Page* / *EOL Home Page* / *NCAR Home Page

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Last update: Tue Aug 6 16:02:06 MDT 2002

RAF Design Guide: RAF-DG-00-001

Revision/Date: Rev.0/October 20, 2000

Subject: Non-metallic materials usage aboard NSF/NCAR aircraft

This memo is intended to give guidance and direction to experimenters designing research systems for flight aboard NSF/NCAR aircraft. Commercial electronic components need not comply with this memo. Additionally, small parts (such as knobs, handles, rollers, fasteners, clips, grommets, rub strips, pulleys, and small electrical parts) that would not contribute significantly to the propagation of a fire are exempted per Title 14, Code of Federal Regulations, Part 25, Appendix F, Part 1(a)(1)(v). Unique electronic components, wiring and cabling external to individual electronic boxes, and plumbing between different pieces of research equipment are expected to comply with this memo.

Materials that are flammable, produce smoke, or emit toxic fumes when exposed to a combustible or high-temperature environment should not be used in research equipment assemblies. The following non-metallic materials are acceptable for cable and wiring insulation and for supply and exhaust line plumbing:

- Teflon TFE (tetraflourethylene)
- Teflon PFA (perflouroalkoxy)
- Teflon FEP (flourinated ethylene propylene)
- Teflon PTFE (polytetraflouroethylene)
- Tefzel ETFE (ethylene & tetraflouroethylene)
- Halar ECTFE (ethylene & monochlorotriflouroethylene)
- Kynar PVDF (homopolymer of vinylidene flouride)
- Silicone Rubber
- Polysulfone
- Hypalon CSPE (chlorosulfonated polyethylene)
- Neoprene (polychloroprene)
- Natural Rubber (NR isoprene)

The following materials are not acceptable for use in research systems to be carried aboard NSF/NCAR aircraft:

- Polyester
- Nylon
- Polyvinyl Chloride (PVC)
- Polyethylene (PE)
- Polypropylene
- Polyurethane
- Kapton (polymide resin)

Experimenters are responsible for reviewing their drawings and parts lists to ensure non-acceptable materials are not specified for use in their system design. Non-metallic materials not listed in this memo must have data substantiating the acceptable use of the material aboard aircraft. If no such data exist, the experimenter will be required to demonstrate compliance with Title 14, Code of Federal Regulations, Part 25.853(a). One method of showing compliance for materials in compartments occupied by crew and for electrical system components is detailed in Title 14, Code of Federal Regulations, Part 25, Appendix F, Part 1(a)(1)(v) and Title 14, Code of Federal Regulations, Part 25, Appendix F, Part 1(a)(3) respectively. NCAR RAF will supply copies of these applicable sections upon request. Alternate methods of showing

compliance must be negotiated with NCAR RAF Engineering, Operations, and Safety. The experimenter should allow ample time for this process prior to anticipated participation in research programs.

NCAR RAF personnel will inspect experimenter packages prior to installation on the aircraft. Experimenters should be able to provide certification for materials used in their equipment assembly. Material certifications should be requested from the supplier when material is ordered. Failure to provide acceptable information or data could result in equipment rework prior to obtaining approval for installation aboard the aircraft.

Experimenters are also encouraged to familiarize themselves wit RAF Bulletin No. 13: Design, Fabrication, and Approval of User-Supplied Equipment for NSF/NCAR Aircraft.

Further questions or clarifications regarding this memo can be addressed to the NCAR RAF Aviation Safety Officer.

Last update: Fri Nov 10 11:40:07 MST 2000