Approved by: Hugo Franco Date: October 14, 2004

NOTICE: Document follows.

STRUCTURAL REQUIREMENTS FOR BALLOON GONDOLAS

The gondola certification program helps to ensure that containment frames and suspension systems supplied by scientists are mechanically capable of withstanding the stresses placed on them by launch, flight, termination, and impact.

The NSBF Engineering Department uses the scientist's design information and stress analysis to assess a gondola's suitability and to certify the structure. The scientist is responsible for the design and analysis of the gondola. The gondola stress analysis must be performed by an engineer whose qualifications must be provided to the NSBF in the form of a brief resume. Primary point of contact is the Manager of NSBF Engineering contacted through Amy Rainoshek at 903-731-8541 or amy.rainoshek@nsbf.nasa.gov.

Although NSBF engineers are available to answer questions on design problems or unusual projects, the NSBF certifying engineer's primary role is to identify critical structures, determine whether the analysis has examined these structures and spot-check pertinent calculations. Based on the stress analysis provided, the engineer gives the gondola an overall rating and determines how much weight the entire structure can handle. The scientist is then notified of the certification based on his design and stress analysis.

Using the following guidelines, the scientist must provide design specifications and a stress analysis of the gondola to the NSBF at least 60 days prior to the anticipated flight date.

1. Drawings showing the relative locations and dimensions of all structural and load-bearing gondola members. Materials identification shall be included in all drawings.
2. At least one complete assembly drawing.
3. Working drawings and specifications for all purchased and fabricated mechanical components and assemblies that are part of the flight train (e.g., rotators, swivels, turnbuckles, clevises, rings, and universal joints).
4. A stress analysis of all major structural members, including decks and ballast attachment points. Identify the components, equipment, and weights comprising the loads.

   *Manager of Engineering will assign a staff engineer to interface with each payload group.
5. A statement certifying that the aforementioned requirements have been met. This statement must be signed by the principal investigator and the engineer responsible for the gondola structure.

The documentation for a certified gondola design is filed by the NSBF Engineering Department, and gondolas need not be re-analyzed for subsequent flights unless design changes are made. However, NSBF engineers visually re-inspect the assembled gondola before each flight, and the principal investigator is required to sign a Science Gondola

Modification Certification Form verifying that the previously certified design was not changed.

The following design criteria should be used in planning gondola structures and suspension. Gondolas must be designed so that all load-carrying structural members, joints, connectors, decks, and suspension systems are capable of withstanding the conditions listed below without ultimate structural failure.

1. A load 10 times the weight of the payload applied vertically at the suspension point.
2. For multiple-cable suspension systems, each cable must have an ultimate strength greater than five times the weight of the payload divided by the sine of the angle that the cable makes with horizontal (should be >30 degrees) in a normal flight configuration. Cable terminations, cable attachments, and gondola structural members must be capable of withstanding the load described above. Some exceptions to this criterion may be allowed for gondolas with more than four suspension points at the discretion of the NSBF certifying engineer.
3. A load five times the weight of the payload applied at the suspension point and 45 degrees to the vertical. This load factor must be accounted for in the direction perpendicular to the gondola's short side, perpendicular to the gondola's long side, and in the direction of the major rigid support members at the top of the gondola structure. If flexible cable suspension systems are used, they must be able to withstand uneven loading caused by cable buckling.
4. A side acceleration of 5 g applied to all components and equipment attached to and/or onboard the gondola structure or any portion of the flight system below the balloon.
5. The effects of stress concentration factors must be considered in the analyses of all critical mechanical structures and assemblies. The ultimate strength of the element should be de-rated proportionately to the applicable stress concentration factor. The stress concentration factors shall be based upon the specific load case and standard mechanical engineering design practices. A specific example of a structural element in which stress concentrations are to be considered is the shaft and housing of a swivel or rotator assembly.

   If a particular element does not pass when derated by the full effects of the stress concentration factor, the stress analyst must demonstrate that other factors such as material ductility offset the effects of stress concentrations. For instance, a tensile/pull test of an assembly can be used to demonstrate that it has an ultimate strength greater that the above criteria will allow. The NSBF recommends that proof tests be conducted by the science group as a standard practice to ensure that their hardware has adequate strength.
6. The ductility of all materials used for critical mechanical elements shall be considered in the analysis of the gondola structure. Specifically, the NSBF does not encourage the use of materials that are determined to be brittle or that are not recommended for use in shock loading applications. Close examination of all materials that have a percent elongation less than or equal to 10% at an ambient temperature of -60 degrees Celsius shall be made to determine if the material is to be considered brittle.

   If a material is determined to be brittle, the certification criteria listed in paragraphs 1, 3, and 4 must be multiplied by a factor of 1.5. That is, the particular element that is fabricated using a brittle material must be able to

sustain a 15 g vertical load, a 7.5 g load at 45 degrees, and a 7.5 g horizontal load without failure.

The gondola design also must ensure that all scientific equipment, NSBF equipment, and ballast remain contained when subjected to the loads described above and that the gondola is capable of supporting the weight of NSBF equipment. The NSBF Engineering Department should be contacted during the design stage for information on equipment and ballast weight for the flight.

The following assumptions are made by the NSBF certifying engineer in reviewing gondola design analyses:

1. The suspension point is defined as the point where the scientist-furnished gondola suspension equipment interfaces with the NSBF-furnished flight system hardware.
2. The payload weight includes the gondola structure, all scientific equipment and components, and all NSBF equipment (including ballast) affixed to the structure below the gondola suspension point.
3. For analysis purposes, the base of the gondola may be assumed to be rigidly fixed (i.e., in a static condition). Other boundary conditions may be used upon prior approval of the NSBF.

The final stage of gondola certification is a visual inspection by an NSBF engineer. The gondola is checked for adequate suspension and crush pad cushioning. In addition, the certifying engineer checks welds and verifies that the construction matches the description submitted by the user.