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Reply to Attn of: ES2-06-003

TO: MO2/Engineering Integration Office
Attn: Mr. J. W. Sills

FROM: ES2/Structures and Dynamics Branch
Space Shuttle Program Cargo Integration Structures Working Group
(SSP-CI SWG)

SUBJECT: Alpha Magnetic Spectrometer-02 Structural Verification Plan, JSC-28792 Rev. D

The SSP-CI SWG reviewed revision D of the structural verification plan (SVP) of the alpha magnetic spectrometer (AMS)-02 cargo element for compliance with NSTS-14046 Rev. E. The AMS-02 cargo element is a complex, non-linear structure which includes a superconducting magnet that is cooled by super-fluid helium and supported by 16 pre-tensioned non-linear support straps designed to minimize thermal conduction. The magnet is contained within the vacuum case (VC), which is supported by the unique support structure (USS)-02 that interfaces with the Orbiter using four longeron trunnions and a single keel trunnion. Various secondary components are mounted to the VC and USS-02 to support the operation of the system or for various scientific experiments, some of which are similar or identical to those flown on the original AMS mission. The AMS-02 payload will be attached to the ISS on-orbit using the payload attach system and is designed for a five year operational life.

The SWG previously accepted revision A of the plan in letter ES2-01-040, but the current version has incorporated significant changes to previous releases, including the refinement of design loads, updates to the factors-of-safety and additional rationale on component testing. Based on review of the current SVP release as well as extensive discussions with the payload developer, the SWG has found that the current plans meet the verification requirements. The verification philosophy and approach include a significant amount of testing to characterize the dynamic response and strength capability of the cargo element. However, the AMS-02 is a complicated non-linear payload and will require close scrutiny for the acceptability of the proposed approach. The significant areas of concern and items that include unique agreement are noted in the paragraphs below:

a) The AMS project assumes that a standard linear analysis approach will be utilized in the verification loads analysis (VLA). The current plan is to develop a conservative linearized representation of the support straps in the dynamic math model for the VLA, the results from which will be supplemented by project performed non-linear coupled transient analysis. The details of the linearization and non-linear analysis have not been defined but will be coordinated with the SWG as part of the test and model correlation process.

b) The overall cargo element will be tested and correlated to a level of 1.1 times design limit load (DLL) with select components tested to 1.4 times DLL per paragraph 5.1.1.3.1.c of NSTS 14046E. The current plans include component testing the static test article of the VC. However, this test will be performed as part of the integrated assembly; therefore, system loads must remain at or below 1.1 times DLL for this case. Detailed analysis has not been performed to confirm the load levels and, as a result, the feasibility of this approach has not been confirmed. The SWG will review all analysis results supporting this test case and coordinate any changes to the verification approach with the project, including possible alternatives, as the data becomes available.

c) The strength verification of the electromagnetic calorimeter (ECAL) is currently defined as a sine burst test to 1.4 times DLL, which is intended to justify the use of tested factors-of-safety. The ECAL is a significant subcomponent, with a total weight of approximately 1400 lb. However, the sine burst testing has already been completed and the project was only able to obtain levels up to1.2 times DLL. In subsequent discussions, the project proposed an alternative correlation plan that relies on the sine burst test and verification of the fundamental modes of the system to correlate the stiffness of the primary attachment brackets. The project has also agreed that the bracket could be statically tested, either alone or as part of the USS-02 system level test. The SWG recommends this additional static testing and associated model correlation since the sine testing did not induce flight-level loads in the bracket. Successful correlation of the model will allow tested factors-of-safety at the ECAL interface, associated fasteners and brackets. All remaining internal structure should be assessed with untested factors-of-safety as defined in section 6.1 of the SVP.

d) The AMS-02 contains a large amount of super-fluid helium in the helium tank, which may result in slosh. If present, the resulting sloshing effects could induce significant loads in the tank as well as change the dynamics of the overall structure such that predicted loads are invalid. The nominal configuration for the tanks will be full on launch and empty on return; however, in a contingency return the tanks may contain some intermediate amount of fluid. The project has performed analyses of this condition and calculated loads that have been combined with the previous values of the tank and support structure. However, rationale must also be provided to determine the appropriate representation for use in the VLA. Since current plans specify a high level sine-sweep test of the tank system, the project has suggested the possibility of performing slosh characterization at that time. The need for this

additional testing and resolution to the remaining issues will be coordinated with the SWG.

e) A temperature of -60° Fahrenheit is being assumed on landing to calculate the trunnion coefficient of friction. This assumption must be verified by appropriate thermal analysis as the mission matures.

f) The acoustic loads on the time of flight panels and the ring imaging Cherenkov counter have not been defined. These components have large surface areas; therefore, the acoustic loads may be significant. The project has agreed to perform appropriate assessments of the hardware in coordination with the SWG.

g) The AMS-02 project is using the guidelines defined in JSC-25863A, Fracture Control Plan for JSC Flight Hardware, to satisfy the requirements of NASA-STD-5003 and SSP 30558C. The fatigue spectra to be used in these assessments are currently under review and updates will be defined in LMSEAT 33818, as required. In addition, the baseline approach for the composite strap fatigue verification is a proof test to 1.2 times DLL. This approach has been coordinated with the JSC fracture control experts; however, the project also plans to perform a dedicated fatigue test of a strap using a simplified spectrum with a scatter factor of one. This test is being performed to provide added confidence in the design and is highly recommended by the SWG, but is assumed to exceed JSC fracture control requirements.

h) All fasteners will include some type of back-out prevention and the use of the various locking features has been coordinated with JSC Materials. Approved prevailing torque features or lockwires will be used for critical fasteners; however, Vibratite will be used for small non-structural fasteners that are not in a component load path.

i) The project is following the requirements of NSTS 08307A for preloaded bolts; however, several of the interfaces will require detailed coordination with the SWG to ensure compliance due to design and margin issues.

j) The project may elect to use S-basis material properties if A-basis values are not available. The use of these properties will be coordinated with the SWG and JSC Materials.

k) The SVP includes a significant amount of detail related to ISS on-orbit verification as well as on the pressure and vacuum systems. These items are beyond typical SWG oversight and should be reviewed and concurred with by the appropriate ISS, materials, pressure systems and safety organizations.

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