FORCE LIMITED VIBRATION TESTING OF CASSINI SPACECRAFT COSMIC DUST ANALYZER

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The German Aerospace Research Establishment in Berlin (GR conducted the vibration qualification tests of the Cosmic Dust Analyzer (CDA) instrument being developed jointly with the Max Planck Institute in Heidelberg GR for the CASSINI spacecraft being integrated by the Jet Propulsion Laboratory for NASA. The shaker force limiting technique, described the 1994 Conference 011 Spacecraft Structures Materials and Mechanical Testing held in Paris, was used in the vibration tests of the prototype CDA and most 01 the other instruments on the CASSINI spacecraft.

In force limited vibration tests, the acceleration input to the instrument under test is automatically notched at the equipment resonances by limiting the shaker forces to values predicted for flight. Ideally, the acceleration and force specifications used in the tests would envelope the peaks in the spacecraft/instrument interface environment during the launch with a desired test margin. However, since interface acceleration data are not often available at the time of the instrument vibration tests, the acceleration specification is usually scaled from previously obtained flight or system test data. Since no flight data and little system test data on the interface forces are available, force limits are usually derived from measurements of the mounting structure mechanical impedance (apparent weight) and two-degree-of-freedom models as previously described in the aforementioned 1994 conference. Interface force data were measured during acoustic tests of the CASSINI spacecraft Development Test Model (DTM), and that data provided verification of the force limit prediction methods used for the CDA.

In the CDA tests, which were conducted in three perpendicular axes, force limiting was used in both the sine and the random vibration tests. The 16 Kg CDA prototype instrument, which is also the flight spare, was mounted on four medium sized triaxial force gages using an aluminum adapter ring which weighed 0.6 Kg. In every **Case** the total force, the sum from the four gages, in the direction of shake was limited to the predicted flight values. Fixture and procedure checkout was accomplished with a mass simulator of the CDA. In the random vibration tests,

force limiting was used to notch the acceleration in real-time using the extremal (peak) control mode. Since the controller used did not support independent reference specifications for limit channels, a flat force limit was used, and scaled into a pseudo-acceleration which the controller compared with the acceleration referencespectrum. This technique has been used in many force limited random vibration tests and worked well in the CDA tests. In the sine vibration tests of the CDA, the measured force was compared off-line to the calculated force limits and to the equivalent rigid body acceleration design limits, and manual notching was utilized. Manual notching was used because of the absence of the automatic notching feature in the controller and the insufficient experience with the scaled pseudo-acceleration control in conjunction with the fast, six octave per minute, Sweep rate.

Both the sine and random vibration tests of the CDA prototype instrument in three axes were successfully completed in three working days. Notches between six and twelve dB resulted at the CDA resonance frequencies on the shaker. There was a general consensus among those present at the test that these notches, necessary to avoid overtesting, were essential to the successful completion of the test without damage to the CDA unit.