MASS ACCELERATION CURVES Revision A

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STS/IUS/Galileo Mass Acceleration Curves, NASA-HDBK-7005

Figure 1.

Introduction

The mass acceleration curve (MAC) method was developed by JPL to perform preliminary structural sizing.

It is a semi-empirical method to determine the upper bound for the low-frequency dynamic loads at the payload and for its subsystems and components. But it is not a simulation of the actual response.

The MAC curves may be given as function of either physical mass or modal mass, per Reference 3.

Modal Mass Case

The MAC method is inexpensive to apply. It requires only payload modes. It can be verified or refined by coupled-loads analysis (CLA). Individual acceleration values are calculated for each mode, per the effective modal mass. The resulting load is then taken as the square-root-of-the-squares.

The rigid-body acceleration load from the launch vehicle thrust should be added for the analysis in the vehicle's longitudinal axis. Other relevant loads should also be included, such as pressure, thermal, misalignment, etc.

Internal loads and stresses can then be calculated.

Historical Derivation

The first MAC curves were derived assuming

acceleration
$$\propto \frac{1}{\sqrt{\text{mass}}}$$
 (1)

MAC curves were modified thereafter to including damping effects. The derivation of any MAC curve ultimately depends on engineering judgment.

Further background is given in Reference 4.

References

- 1. NASA-HDBK-7005 Dynamic Environmental Criteria, 2001.
- 2. NASA PD-ED-1211, Combination Methods for Deriving Structural Design Loads Considering Vibroacoustic, etc, Responses.
- 3. T. Irvine, Effective Modal Mass & Modal Participation Factors, Rev H, Vibrationdata, 2013.
- 4. M. Trubert, Mass Acceleration Curve for Spacecraft Structural Design, JPL D-5882, NASA Jet Propulsion Laboratory, 1989.

APPENDIX A

NASA PD-ED-1211, Excerpt



Figure A-1.

Mass Acceleration Curve

A typical mass acceleration curve (MAC) is shown in Figure A-1. The MAC is an upper bound acceleration level for all components of a given mass, regardless of location, orientation, or frequency. Applicability is limited to appendage masses up to 500 kg, with frequencies up to approximately 100 Hz. Such a curve can be derived based on analytical and flight data, and includes the effects of both transient and mechanically transmitted random vibration. That is, the load predicted by the curve is already a combination of transient and random vibration.