Pyro-Technique Shocks in Launch Vehicles

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Pyro-technique separation events in launch vehicles induce severe dynamic loads. These loads are extremely high in acceleration and in frequency. Generally, the dynamic responses of the launcher structures are derived from pyro-separation testing during the qualification campaign of the launcher. In special cases, when a launcher primary structure is being modified a repetition of a separation test is not necessary. The dynamic responses of the modified structure can be derived from a comparative transient response analysis. However, the analysis tool shall be able to predict the dynamic responses up to 20kHz.

In order to express the severity of the induced loading, the transient dynamic responses of the launcher structures are transformed into the frequency domain and plotted as shock response spectra.

Failure of the primary structure due to pyro-separation induced shock loads are very seldom and could be directly observed by inspection of the test specimen after separation testing. The situation is different for equipment accommodated on the launcher primary structures. Here, not only stress failures might occur, but also mal-function during or after the separation event. The equipment generally has to be shock qualified on equipment or subassemly level. Sometimes equipment is very sensitive to shock induced loads, and therefore has to be accommodated on shock attenuating devices.

In this paper different shock sources will be introduced and the qualification of the launcher towards the shock environment is described. In this context, the numerical simulation of separation events is explained and the quality of the numerical results is shown by comparison with separation test measurements and flight measurements.

The paper ends with an overview of isolation principles in order to protect sensitive equipment against pyro-technique shocks, and, with some design examples of shock attenuation devices and the verification of their performance on basis of tests.