

DYNAMIC PRESSURES ACTING ON THE INNER BULKHEAD OF THE ESC-LH₂-TANK

Stefan Dieker *

Reimerdes + Dieker Ingenieure GbR

Robert Beck †

MAN Technologie AG

Robert Gajdacz ‡

DaimlerChrysler Aerospace AG

Abstract

The inner bulkhead of the LH₂-tank of the A5-ESC-stage must be designed against buckling. The design of the bulkhead (wafflegrid) depends on the total pressure acting on it (internal pressure, hydrostatic pressure due to the static acceleration, dynamic pressure).

The amount and influence of the dynamic part of the pressure is evaluated. The simplified approach takes into account an equivalent hydrostatic pressure given by ρgh where ρ denotes the density of the fluid, g the amplitude of the dynamic acceleration and h the height of the fluid. On the other hand, the correct amount of the dynamic loads depends on the mode shape, the mass inertia of the structure and the fluid/structure interaction including the pressure acting on the wafflegrid.

Results are presented that demonstrate the deviation between the equivalent quasistatic loading and the dynamic pressure. The dynamic analysis – including the prestresses of the shell due to the static pressure – will give information concerning the buckling under inertia loads. Taking into account both the static and dynamic pressure acting together, an allowable critical pole acceleration of the inner dome is estimated. Due to the low density of LH₂, the allowable critical pole acceleration is about one order of magnitude higher than the expected flight accelerations.

Nevertheless, the investigated effects will have considerable influence for similar tanks filled with fluids with a higher density than LH₂.

1 Introduction

The LH₂-tank is a tank of the cryogenic stage ESC of the launcher Ariane 5 (see figure 1). The stage has two propellant tanks; the LOX-tank is smaller and positioned below the LH₂-tank. In order to limit the height of the stage, the LH₂-tank has an inner spherical bulkhead. A part of the LOX-tank is placed within the region of this half-sphere.

The inner bulkhead is a buckling sensitive item and designed as waffle grid structure. The pressure acting on the shell is the internal pressure, the hydrostatic pressure due to a constant static acceleration of the launcher and a dynamic pressure as a result of a modal response of the stage.

MAN Technologie AG is responsible for the design of the inner bulkhead, while DaimlerChrysler Aerospace AG is responsible for structure dynamic aspects, including the fluid-structure-interaction.

*D-28203 Bremen, Prangenstr. 8, Tel: (+49) 421 701590, Fax: (+49) 421 701585
E-mail dieker@t-online.de

†D-85751 Karlsfeld, P.O.Box 1347, Tel: (+49) 8131 891766, Fax: (+49) 8131 891939
E-mail robert.beck@mt.man.de

‡D-28361 Bremen, P.O.Box 286156, Tel: (+49) 421 5395148, Fax: (+49) 421 5394164
E-mail robert.gajdacz@ri.dasa.de