

AmSafe Observations to WPR18LA174

11 July 2018

Recovered from first 'Debris Tote' dumped for analysis at Air Transport:

- Restraint Buckle/Connectors recovered:
'Front Side' view



'Back Side' view



No detectable indications of malfunction.

- Inflator "1"



Figure 1 Inflator "1" Overview



Figure 2 Inflator "1" Output End view (threaded diffuser, interface to Inflatable Restraint)



Figure 3 Inflator "1" Igniter-end view (reference-compare to Fig 8)

Recovered from larger 'Debris Pallet' at Air Transport:

- Inflator "2":



Figure 4 Inflator "2" Overview



Figure 5 Inflator "2" Output End view (threaded diffuser, interface to Inflatable Restraint)



Figure 6 Inflator "2" Igniter-end view (reference-compare to Fig 8)

For information only/clarification of elements being addressed:



Figure 7 -For Reference- "As Delivered" Inflator Overview



Figure 8-For Reference- "As Delivered" Inflator Igniter-End



Figure 9-For Reference- Inflator interfaced and assembled to inflatable restraint

Technical Discussions

For Reference - Nominal Inflator/inflatable Restraint Function overview:

During a crash environmental stimulus (vectored-threshold G's) the AmSafe EMA (Electronics Module Assembly) delivers an electrical firing pulse to the igniter of the Inflator, (ref Fig 8) igniting the integral pyrotechnic charge within the inflator. As the pyrotechnic propellant charge rapidly burns it produces (designed) heat (and gas) which increases the internal inflator gas pressure to a designed level sufficient to rupture an internal burst membrane and release the inflator gas into the Inflatable Restraint's fabric gas hose,(ref Fig 9) inflating and deploying the airbag of the restraint to produce a 'barrier' between the seat occupant and downstream obstacle(s).

For Reference - Alternate Scenario Inflator Deployment – fire overview:

Inflators are also designed to function safely (structurally) in a fire. In the event that the inflator has not been deployed and remains fully loaded it will deploy/discharge safely its pressurized contents at a predetermined unit temperature in order to preclude developing thermally-degraded material properties which could permit the inflator body to catastrophically overpressurize before or during subsequent venting. These designed temperature levels will safely vent the pressurized gases above 130°C, and consume any propellant above 250°C.

The two inflators in this event exhibit characteristics of live inflators exposed to, and deployed in, a fire. Residual event debris confirms the presence of intense heat close to, on, and/or around the inflators and restraint systems, (melted Aluminum puddles, $\geq 593^{\circ}\text{C}$); no inflatable restraint residue remains due to being consumed by the fire (typical restraint webbing ignites above 450 -550°C).

1. Inflator "1"

- The Aluminum hose fitting (ref Fig 9) was completely absent from the threaded diffuser of the inflator, (ref Figs 1&2), completely melted off. No evidence of consumable restraint components surviving in the recovered debris.
- The igniter end exhibited consumption and/or expulsion of the several igniter components (Fig 3 compared to Fig 8).
 - The igniter carrier housing (concentric feature in Figure 8 outboard of the igniter pins/plastic shorting insert) has been expelled from the inflator (Fig 3) – possibly weakened weld degraded by the fire, then overcome by internal back pressure of the ignited/overheated internal gas pressure venting thru the region.
 - The pins of the igniter remain engaged in the residue of the electrical connector and residue of the plastic header of the igniter which has been burned/extruded from the inflator.
- The internal burst membrane exhibits petaling outward (toward downstream diffuser cavity) (Fig 10) – This characteristic is a typical functional response to rapid pressurized/rupture/blowdown, regardless of normal deployment or deployment due to heating. (If the Fig 10 petaling would have been inward, (pointing back inside the body) then the venting from the igniter end would have been the primary exhaust path instead of this apparent simultaneous venting.)



Figure 10 Inside inflator “1” body, looking at Burst Membrane exiting into Diffuser

These characteristics collectively suggest that Inflator “1” had not deployed prior to the fire because of the expelled igniter housing (Figure 3). If the igniter housing element had remained on the unit (ref Fig 8) then the disposition would have been –inconclusive–.

2. Inflator “2”

- Residual, melted, Aluminum puddle attached to the inflator threaded diffuser (Figs 4 & 5) is likely the hose fitting (ref Fig 7 & 9). This melt likely occurred after discharge and was in a ‘cooler heat’ environment than Inflator “1” otherwise the residual debris around the diffuser (Figs 4 & 5) would have distinct jetting holes blasting thru the softened/molten Aluminum Fitting, or more material being absent. Also there is no evidence of consumable restraint components surviving.
- The igniter end (Fig 6) exhibited complete expulsion of the igniter and its housing.
 - Again, likely weakened weld degraded by the fire on this end of the inflator, then being overcome by internal back pressure of the ignited/overheated internal gas pressure venting thru the region
- The internal burst membrane also exhibits outward petaling (Fig 11) (toward downstream diffuser cavity), same as Inflator “1”. Again, this characteristic is a typical functional response to rapid pressurized/rupture/blowdown. (If the petaling would have been inward, (pointing back inside the body) then the venting from the igniter end would have been the primary exhaust path instead of this apparent simultaneous venting.)



Figure 11 Inside inflator “2” body, looking at Burst Disk exit into Diffuser

These characteristics collectively suggest that Inflator “2” had not deployed prior to the fire because of the expelled igniter housing (Figure 6). If the igniter housing element had remained on the unit (ref Fig 8) then the disposition would have been –inconclusive–.

Conclusion

From the preceding evidence it appears unlikely that the Inflatable Restraint System deployed prior to the subsequent fire, but did perform safely in the post-crash fire.