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Final Report

LOW DENSITY ALUMINUM ALLOY DEVELOPMENT PROGRAM

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To

Boeing Commercial Airplane Company
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From

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ABSTRACT

Study of the RS alloys comprised of inert gas atomized powder from Pratt & Whitney Aircraft has been centered on Alloys No. 1 and 2. Samples of extruded bars were examined in the as-received and SHT conditions. Microstructural features were revealed by electropolish and bromine etching techniques. A relatively large volume fraction of precipitate phase intermetallic particles was evident in the as-received condition. Solution heat treatment at 811K for 0.5 hr. provided the best results; however, a significant amount of precipitate phase particles remained in the microstructures. Based on morphology and x-ray diffraction data, the precipitate phase particle distribution is at least trimodal.

Tensile tests performed on all seven RS alloys in the SHT condition demonstrated relatively low ductility. Examination of tensile fracture surfaces revealed a large number of precipitate phase particles on the surfaces, apparently intact. The precipitate phase-aluminum matrix interface seems to be involved in the crack initiation and propagation processes.

Microstructural features and x-ray data indicate that the precipitate phases are present in the RS powder prior to extrusion. A fine dendritic microstructure exists in the unprocessed RS powder, with no precipitate phase particles apparent at magnifications up to 6000 diameters after a sodium hydroxide etch. Diffraction lines resulting from precipitate phases do appear in DeBye-Scherrer measurements on the unconsolidated RS powder. Heat treatment of unconsolidated powder results in a breakdown of the fine dendritic structures and apparent coarsening of precipitate phase particles. In the extruded material, fragmented precipitate phase particles are evident indicating

their formation prior to extrusion. Based on the information developed at this time, the formation of precipitate phase particles as they appear in the extruded samples is occurring during the extrusion preheat treatment. Optimization of this preheat treatment may significantly improve the mechanical properties of these alloys by changing the precipitate phase particle type, size and distribution.

The alloy with nominal composition Al-2.5Li-1.5Cu-1.0Mg, produced by INCO's mechanical alloying process, has been studied. A fine grained microstructure with finely distributed, equiaxed particles is apparent in this alloy. The monotonic and cyclic mechanical properties were investigated in an appropriate SHT and aged condition. This treatment involved SHT at 811K for 0.5 hr, stretching to 2% total strain, followed by natural aging for 48 hrs and artificial aging at 463K. High strength and low ductility are demonstrated by this alloy. The high strength and low ductility is associated with a high volume fraction of particles and dense substructure. Low cycle fatigue properties of this alloy in the naturally aged condition show initial softening at the first cycle, followed by cyclic hardening. The initial softening is due to residual stress relief. Cyclic hardening is associated with dislocation-particle interaction.