WELDED STRUCTURE FROM COMMAND MODULE OF APOLLO 7

Source:	National Museum of Science and Technology, Ottawa, Canada
Program:	Apollo 7 mission - First manned spaceflight test of Apollo moon-flight system launched on October 11, 1968.
Material:	Aluminum alloy 7075-T6
Description:	7075-T6 sheet-aluminum honeycomb bonded as sandwich covered by the heat shield
Attributes:	Providing a housing for the crew, containing the required leak-proof cabin environment and meteoroid protection in the reentry vehicle.

Aluminum alloy 7075-T6 was the material chosen to construct the welded structure(Cabin) in the command module(reentry vehicle). This welded structure was built by the Space Division of North American Rockwell Corporation for the Apollo 7 mission. The major duty of the welded structure was to withstand the external pressures including maximum dynamic pressures and the meteoroid impacts while the covered heat shield provided heat and radiation protection. Therefore, the high stiffness-to-weight, fatigue resistance and high energy impact resistance were the rationales of 7075-T6 in sheet metal form being the material used to construct the welded structure.

The elongated grain structure of 7075-T6 thin sheet-aluminum prevented the development of high stresses along grain boundaries and thus retained the dynamically recovered structure and prevented excessive growth of recrystallized grains by the chromium bearing dispersoids. In addition, the stress corrosion resistance of the sheet-aluminum was improved by retrogression and re-aging. First the alloy was artificially aged at elevated temperatures (24 hours at 120°C). Then heat treated at an intermediate temperature of 200-260°C for a short time (a few seconds to a few minutes) and water quenched. Finally, re-aged for 24 hours at 120°C. After this series of treatment the size and volume fraction of the grain boundary precipitates is increased and the stress corrosion resistance was improved.

After the strengthening, sheet-aluminum was honeycomb bonded sandwich into a double-wall configuration ranging in thickness from 0.25 inches thick at the forward access tunnel to 1.5 inches thick at base. This honeycomb sandwich then results in an increase of at least a factor of 3.8 in the backup thickness required to prevent failure of the welded structure.

[1] H.Buhl, *Advanced Aerospace Materials*. Berlin, Germany: Springer-Verlag Inc., 1992.

[2] P. E. Purser, M. A. Faget, N.F. Smith, *Manned Spacecraft: Engineering Design and Operation*. New York, NY: Fairchild Publications, Inc., 1964.

[3] J. Dumoulin, "NASA Apollo Mission Apollo-7," [Online document], August 2, 2000. Available: http://science.ksc.nasa.gov/history/apollo/apollo-7/apollo-7.html