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Featured Projects

New Coatings Provide Protection of Cold War-Era Aircraft into Mid-21st Century

By Brett Ingold

The B-52 Stratofortress was originally designed to fight the cold war. Though the war has long since ended, the four-engine aircraft continues to serve its mission as a heavy bomber. Since being deployed in 1955, the B-52 has been in operation for more than 50 years, and the Air Force intends to keep the aircraft flying through the year 2040. If this life span is achieved, the high-altitude, subsonic bomber will have been in service for 85 years by the time it is retired.

Over the past six decades, the B-52 platform has witnessed a variety of changes and technological advancements. (See "*Upgraded B-52 is Still on the Cutting Edge*.") One such change was the transition from the use of JP-4 jet fuel to the JP-8 formulation, which is less flammable and improves the B-52's safety and survivability. The transition to the improved formulation, however, led to unanticipated consequences inside its fuel tanks.

Fuel Additive Causes Coating Failure

The B-52 is designed to fly at high altitudes where the air has a very low pressure and temperature. In these conditions, the moisture in the jet fuel is susceptible to freezing. Thus, a fuel system ice inhibitor (FSII, pronounced fizz-ee) is used to prevent this from happening.

In recent years, the FSII additive has been found to cause a phenomenon known as fuel tank topcoat peeling (FTTP), in which the interior surface coating of the integral fuel tanks becomes delaminated. Michael Spicer, Chief of the Air Force Research Laboratoryís (AFRL) Coating Technology Integration Office, explained that temperature cycles experienced by the aircraft throughout a 24-hour period aided this phenomenon. "The FSII would separate from the fuel and exist as a vapor in the headspace of the fuel tank," said Spicer. "This would happen during the day as the tarmac and the aircraft would heat up with the sun. As night would fall, the FSII would condense and form as droplets on the side of the fuel tank." The high concentration of the additive, as it vaporized and condensed, caused the fuel tank coatings to fail.

The FSII compound that is currently added to JP-8 jet fuel is diethylene glycol mono-methyl ether (DIEGME). "DIEGME is a very good paint stripper at high concentrations," said Spicer, who serves as project manager of AFRLís effort to develop a DIEGME-resistant fuel tank coating.

The B-52H is expected to remain in service until 2040. Photo courtesy of the U.S. Air Force.

Most of the FTTP has been observed in the headspace of the fuel tanks, above the fuel line. However, some FTTP has occurred in other locations, such as the fuel tank's sump areas where water separates from the fuel and collects. The extent of these problems prompted the need for a DIEGME-resistant fuel tank coating that could be applied across several platforms, including the B-52, KC-135, C-17, and P-3 aircraft.

Why Didn't This Happen with JP-4 Jet Fuel?

According to the B-52 System Group, the origin of this problem can be traced back to one specific event in 1994—the switch from JP-4 to JP-8 as the primary jet fuel. The JP-4 blend was more volatile than the fuel used today. It would vaporize more readily than the DIEGME additive in JP-4. The excess JP-4 vapor in the headspace of the tank would keep the DIEGME vapor concentration at a minimum. The introduction of the JP-8 blend resulted in the opposite relationship between the volatilities of the vapors because DIEGME is more volatile than JP-8.

Development of a DIEGME-Resistant Coating

"The FTTP damage caused by DIEGME has led to additional costs, unscheduled maintenance, decreased safety, and decreased mission readiness and overall capability," said Spicer. There is currently no DIEGME-resistant paint available, which is why the development of a DIEGME-resistant coating is essential to sustaining the B-52 and other aircraft throughout their service lives.

In March 2006, with funding from the DoD's Corrosion Policy and Oversight Office, AFRL's Coatings Technology Integration Office embarked on an effort to develop a DIEGME-resistant coating to prevent the FTTP on several aircraft platforms. Other organizations including AFRL's former coatings research group, the Air Force Materiel Command's B-52 System Group at Tinker Air Force Base, Boeing Wichita, and NAVAIR participated in the process to identify and test a new coating.

A typical lower-skin, fuel tank topcoat shows peeling and water staining. Photo by Michael Spicer, Air Force Research Laboratory (AFRL).

"The effort had two objectives," Spicer said. "The first objective was to work with two coating manufacturers to develop a DIEGME-resistant fuel tank coating. The second objective was to develop an accelerated test method that could be incorporated in the military standard AMS-C-27725, currently used for evaluating the resistance that a fuel tank coating has to DIEGME. The resistance of the newly developed coatings and the accelerated test will be validated by a field test in the fuel tanks of a B-52," said Spicer. This second objective allows for the modification of an existing material specification to account for DIEGME resistance.

The project to develop and implement a DIEGME-resistant coating on the B-52 fuel tank is ongoing, but AFRL has already made significant progress toward achieving the objectives of the project. AFRL identified two manufacturers that could develop DIEGME-resistant coatings. In laboratory tests, AFRL determined that both coatings provide better DIEGME resistance than the current fuel tank coating on the B-52.

Here, the topcoat peeling has occurred above the nominal fuel level. Photo by Michael Spicer, AFRL.

If the new coatings are successful, the Air Force is expected to avoid significant maintenance costs. The new fuel tank coating can be applied during a single repair cycle. By contrast, if the current coating system is used, fuel tank repair is required every four years on each B-52 in operation.

"The estimated cost right now is $120,000 per aircraft, $11.3 million every four years for the B-52 fleet, or $90 million for the remaining service-life of the entire fleet," said Rex Cash from the B-52 Systems Group at Tinker Air Force Base, Oklahoma. "This expense can be avoided with a DIEGME-resistant coating, which would require only a single repair cycle."

"The DIEGME-resistant coating should last for the rest of the aircraftís life and prevent corrosion from occurring inside the fuel tanks," said Spicer. According to the B-52 System Group, the new coating will also meet the requirement for all new aircraft. The coatings, moreover, could have a tremendous impact on the B-52 and other aircraft well into the mid-twenty-first century.