UNITED STATES AIR FORCE MATERIALS TECHNOLOGY HIGHLIGHTS

Air Force Research Laboratory

Materials & Manufacturing Directorate

Wright-Patterson Air Force Base • Dayton, Ohio Winter 2004

Engineers Develop First Response Expeditionary (FRE) Fire Vehicle

Engineers at the Air Force Research Laboratory (AFRL) have developed a deployable, lightweight vehicle that provides crash and rescue firefighting capability in a variety of mission profiles. The First Response Expeditionary (FRE) Fire Vehicle, developed to meet Air Combat Command and Civil Engineering requirements, has already established its value during Operation Iraqi Freedom, when several of the units were deployed to protect helicopters, aircraft, tent cities, and other bare base operations.

The standard fire truck usually deployed to remote locations for firefighting purposes is the P-19 firefighting vehicle, which uses Aqueous Film Fighting Foam (AFFF). However, the P-19 is most effective in extinguishing 2-D (pool) fires. Many times, pool fires become 3-D when they are fed by fuel or another flammable liquid that comes from an aircraft's damaged fuel or hydraulic lines. This phenomenon makes the fire extremely difficult to extinguish.

In response to an urgent need for an easily operable, lightweight air transportable, highly-effective firefighting system, engineers at AFRL's Materials and Manufacturing Directorate (ML) Airbase Technologies Division developed a system capable of effectively and successfully fighting both 2-D and 3-D (running fuel fires) hydrocarbon fuel fires.

The First Response Expeditionary Fire Vehicle, developed to bridge the gap between flightline fire extinguishers and full-sized crash and rescue fire trucks, is ideal for small aircraft and helicopter crashes, for hot pit refueling, and for tent city or deployed base fire protection. It is designed to provide firefighters with the quick-reaction capability to extinguish small aircraft or structural fires before they become uncontrollable. The vehicle can be operated with minimal training or experience, is virtually maintenance free, and is adaptable to a wide variety of mission profiles and vehicle platforms. In addition, the FRE vehicle is sized to occupy minimal pallet space on a cargo aircraft, and offers reduced water requirements and equipment weight.

The FRE vehicle consists of a Rosenbauer Ultra High Pressure Water System with a six-cylinder, 22 horsepower Briggs and Stratton engine, and a 1500 psi (pounds per square inch of pressure) pump. The 60-gallon system is capable of providing 14 gpm (gallons per minute) of foam/water to the aspirated/non-
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The First Response Expeditionary (FRE) Fire Vehicle sits in front of a much larger P-19 firetruck at a small U.S. seized Iraqi airbase.

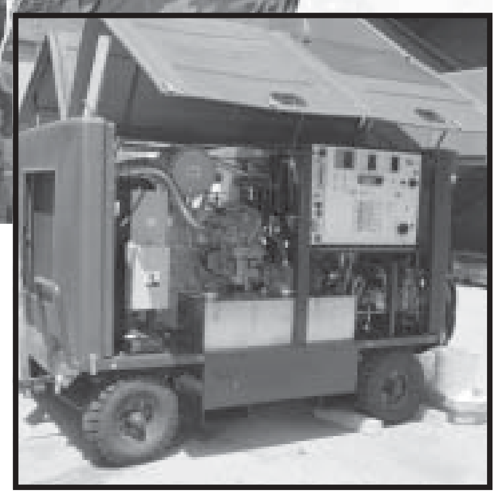
Directorate Researchers Validate Capabilities of Hydraulic Fluid Purifier

A team of experts from Air Force Research Laboratory's Materials and Manufacturing Directorate (ML) recently conducted specialized testing on purified hydraulic fluids to validate a new piece of hydraulic ground test and support equipment, which is in the process of procurement by the Support Equipment Program Management Division at Robins AFB, Ga. Researchers verified that the system, a combination hydraulic ground test stand with a built-in hydraulic fluid purification system, is capable of reducing air, moisture, dirt and solvent contaminants in used hydraulic fluid to acceptable levels, and that used fluid can be reused rather than replaced.

By verifying the effectiveness of hydraulic fluid purification processes, ML experts have pushed the technology one step further towards application in the field. Purification processes are expected to be a viable method for reducing the source of the Air Force's second largest waste stream by 75 to 90 percent without negatively affecting the maintainability of aircraft hydraulic systems. Implementation of purification processes are expected to provide the Air Force with millions a year in savings by eliminating procurement and hazardous waste disposal costs. Additional savings are expected due to the simplification of the life cycle of the fluid and a reduction in quality-assurance testing. Improved reliability and life extension of hydraulic system components in the aircraft will be achieved through the use of cleaner purified hydraulic fluid in aircraft hydraulic systems. In addition, the new equipment will be the first computer controlled test stand and has been long awaited by aircraft maintainers in the field.

Hydraulic fluids are a critical, safety of flight material for all Air Force aircraft. Hydraulically actuated mechanisms are responsible for a large number of aircraft functions ranging from highly sophisticated flight controls to applications such as accessory door actuation. The Air Force alone uses approximately 1,500,000 gallons of hydraulic fluid per year, costing over $15 million in procurement and disposal costs.

Currently, during routine aircraft maintenance, the used fluid from aircraft and components is drained and disposed of as hazardous waste. But, the Air Force technical order covering hydraulic fluids was recently changed to allow reintroduction of purified fluid, which would be purified with an Air Force approved purifier, into the aircraft.



Top: Hydraulic system maintainers inspect the Air Force's next generation hydraulic test stand. Right: A combination hydraulic ground test stand with a built-in hydraulic fluid purification system.

Malabar International, a company based in Simi Valley, Calif., developed four similar hydraulic ground test and support, purifier combination systems to meet varying Air Force requirements. Because every aircraft has redundant hydraulic systems, Malabar developed both two- and three-system test stands. In aircraft with four hydraulic systems, as is found in the B-2, two two-system test stands can be used simultaneously to accomplish maintenance. To meet varying deployment requirements, they developed separate test stands that run on either diesel or electricity.

Scientists and engineers from ML's Nonstructural Materials Branch participated in a collaborative program with program managers at Robins AFB, the Aeronautical Systems Center's Aging Aircraft and Pollution Prevention offices, and Malabar International to verify whether the system could achieve the desired degree of cleanliness and value in the fluid in the required amount of time. Directorate experts added water, chlorine, particles, and air to 40 gallons of hydraulic fluid in order to recreate the contaminants a fluid would acquire during its use in an aircraft. Then they ran the test stand/purifier for several hours, taking samples every hour, and bringing them to their laboratories for specialized water, solvent and particle determination, and air content testing. Their testing results demonstrated that the purifier would be successful in cleaning the fluid, and that purified fluid was acceptable for reintroduction to aircraft hydraulic systems.

Field trials of the test stand are the next and final validation requirement for the system. If the tests are successful, Malabar will build and deliver 600 separate systems for the Air Force.

For more information, contact the Materials and Manufacturing Directorate's Technology Information Center at techinfo@afrl.af.mil or (937) 255-6469. Refer to item 03-301 .

Beryllium-Aluminum Alloys Reduce Weight Of Spacecraft Components And Provide Greater Stiffness Than Conventional Materials

Scientists and engineers at the Air Force Research Laboratory's Materials and Manufacturing Directorate (ML), working with industry, demonstrated the feasibility of using beryllium-aluminum alloys to fabricate components for spacecraft. The project team succeeded in producing multiples of near net shape and net shape parts and in joining subassemblies to make complex structures like those used on spacecraft.

Beryllium-aluminum alloys could help reduce the weight of vital spacecraft components, while increasing payload and/or performance. Continued research in this promising area could lead to expanded applications and streamlined manufacturing processes, as well as significant cost reductions for the Air Force and the Department of Defense.

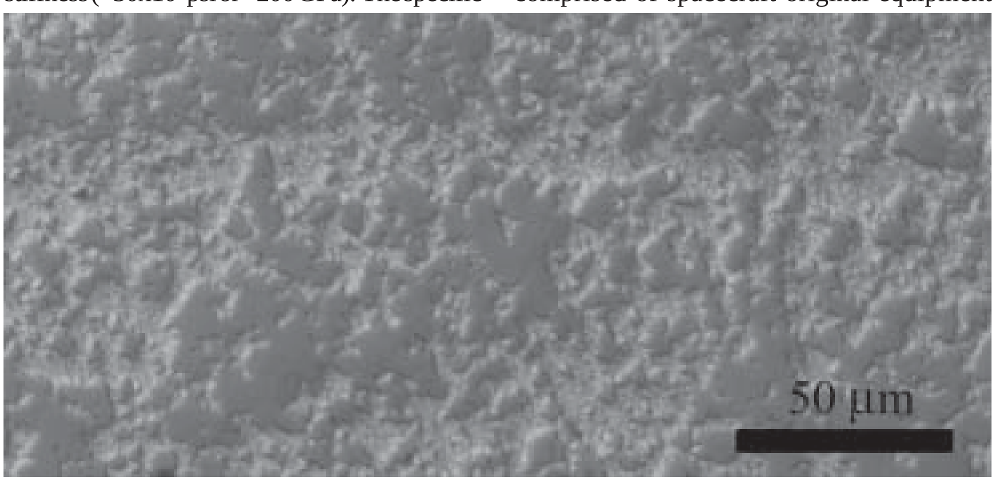
Beryllium-aluminum (Be-Al) alloys have been used in a number of high performance applications such as gas turbine engines, racing cars, space launch vehicles and satellite structures, due to a unique combination of low density (~0.08 lbs/in^3 or ~2.2 g/cc) and high stiffness (~30x10^6 psi or ~200 GPa). The specific strength and stiffness characteristics of Be-Al exceed those of traditional titanium alloys. These properties enable reduced structural weight and increased payload and/or performance. Be-Al is also of interest as a replacement for pure beryllium (Be), because it offers much greater stiffness than Al alloys at lower material cost than pure Be and improved formability, enabling fabrication into near-net shapes and further cost reductions.

To date, Be-Al has been used in only a few spacecraft component parts. That could change, however. Researchers at ML are engaged in a dynamic research and development effort as part of the *Metals Affordability Initiative* (MAI), designed to extend the use of Be-Al to both primary and secondary structural space applications. Be-Al alloys being investigated under this program cover a Be content range of 35-65 percent by weight, with a focus on materials with lower Be contents, to better manage costs.

The project team, overseen by researchers in the directorate's Metals, Ceramics and Nondestructive Evaluation (NDE) Division, is comprised of spacecraft original equipment manufacturers (OEMs) and material suppliers. OEMs have design and component validation responsibility for the collaboration and the material suppliers have the lead role in developing cost effective manufacturing technologies.

So far, the Be-Al MAI program has succeeded in increasing the technology base and has demonstrated cost effective manufacturing capabilities for fabricating prototype components. The project team has successfully formulated and demonstrated the worthiness of a detailed collaborative design process and the feasibility of producing near net shape and net shape parts. They have joined subassemblies to make complex structures and made significant progress in materials development, component selection and design, and component fabrication and testing.

A major accomplishment of this research and development effort has been the successful production of multiples of two important structural components. Validation testing is underway and both Be-Al components are expected to fly on spacecraft during the 2004-2005 time frame. This research program has increased the technology base and demonstrated cost effective manufacturing capabilities in prototype components derived from a detailed collaborative design process. These advancements will benefit the space program and national security, and could lead to important applications in the commercial sector.



Beryllium-Aluminum Micrograph

For more information, contact the Materials and Manufacturing Directorate's Technology Information Center at techinfo@afrl.af.mil or (937) 255-6469. Refer to item 03-337 .

Fire Vehicle

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aspirated nozzle, which delivers the firefighting agents in either a mist, stream, or aspirated foam. The unit, fabricated by ML engineers, uses a John Deere military gator as its vehicle platform.

Engineers from ML made several modifications to the FRE system to increase its effectiveness including: changing the original nozzle design to combine aspirated and non-aspirated foam functions; increasing the engine size to accommodate a higher flow rate; exchanging the foam tank for a standard five gallon foam can; adding a sump pump to draft water from alternative sources; and adding a 1kW generator to operate additional tools.

Research efforts also included working with the System Program Office at Eglin AFB, Fla., to obtain air drop/air lift certification of the system. This took place in April 2003 at Pope AFB, N.C., when an FRE was successfully dropped three times from a C-130 at an altitude of 15,000 feet.

ML delivered six prototype units to the Air Combat Command and to the U.S. Central Command Air Forces. Two more units are scheduled to be provided to the Air Force Special Operations Command. Through on-going AFRL efforts, this technology is being transitioned to Rosenbauer America, who will make the system available for additional fire protection and crash and rescue efforts via the General Services Administration.

For more information, contact the Materials and Manufacturing Directorate's Technology Information Center at techinfo@afrl.af.mil or (937) 255-6469. Refer to item 03-201.

NEW sTART Contracts

- High Temperature Polymer Composites For Propulsion - FA8650-04-C-5001
- Durable High-Temperature Superalloy Disks - F33615-03-C-5229
- Durable High-Temperature Superalloy Disks - F33615-03-C-5230
- Fourth Generation Superalloy Compatible Thermal Barrier Coatings - F33615-03-C-5231
- Advanced Lightweight Hybrid Mirror For Space Based Applications - F33615-03-C-5211
- Research On Advanced Nondestructive Evaluation Methods For Aerospace Materials - F33615-03-C-5219
- Research On Advanced Nondestructive Evaluation Methods For Aerospace Materials and Processes - F33615-03-C-5220
- Strategy And Software Environment For Virtual Design - F33615-03-C-5226
- Production Technology For Replica Seeker Mirrors - F33615-03-M-5725
- Universal Building Blocks For Modular Photonics - F33615-03-C-5444
- Laser Materials Technology For Countering Optical Guided Missiles - F33615-03-C-5403
- Fabrication Of Polycrystalline Infrared-Transparent Ceramics - F33615-03-C-5414
- Gallium Nitride Wafer Preparation For Epitaxial Growth - F33615-03-C-5419
- Development Of A Resonant Microwave Technology - F33615-03-M-5429
- Manufacturing Process For Production Of Doped Gallium Nitride Crystals - F33615-03-M-5434
- Superlattice Materials For Very-Long Wavelength Infrared Detection - FA8650-04-C-5423
- Logistics Fuel Organic Sulfur Trap For Fuel Cell Used By Air Expeditionary Forces - F08630-03-C-0206
- Closed Cell Foam Material Technology - F08637-03-C-4009
- Firefighter Effectiveness Research - F08637-03-C-6016
- Decontamination Of Aerosols And Airborne Particles - F08637-03-C-6021
- Filter For Airborne Pathogens And Toxic Liquids - F08637-03-C-6022
- Air-Transportable, Gaustic Production System - F08630-03-C-0208

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2977 HOBSON WAY, ROOM 406
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