CHEMISTRY

Solid Fuels for Missiles

Guided missiles are being made more dependable. Taxpayers will save money and the armed services will save lives through the switch to solid propellants.

By DAVID PURSGLOVE

➤ THE FUELS being used to propel America's ever-increasing number of guided missiles are not now reliable enough. They are too dangerous for handling by the soldier, sailor or airman with average military training. And they make the entire missile effort cost more than is necessary.

The Defense Department knows this and is doing something about it.

Nearly all present thinking and some current practice by missilemen is being directed, by order, toward making the rocket and missile program a more reliable defense effort and one that is safer for the men of the armed services as well as for civilians living near missile centers. A by-product will be tremendous money savings for the American taxpayer.

The missile experts are starting by substituting solid propellants for liquid fuels in the biggest part of their program, thus leading to less and less use of liquid oxygen, fuming nitric acid and unpredictable hydrogen peroxide in the future.

Rockets and guided missiles will be powered by such strange fuels as plastics, rubber, nitroglycerine, compounds resembling guncotton and the "exotic" boron compounds.

None of these fuels are entirely new to rocketry. In fact, nobody was surprised when the Defense Department announced in April, 1957, that a study was being made on solid fuels in the light of future fuel requirements of the entire guided missile program. A Defense Department guided missiles official has told SCIENCE SERVICE: "Most of the new smaller rocket missiles now being planned or developed are of the solid fuel type."

Most of these fuels were already being used to some extent in both operational and developmental rockets. They had proved themselves, in general, to be safer, more reliable and less costly to use than the liquids that were then powering most of our missiles.

Advantages of Solid Fuels

These are some of the reasons why solid fuels are slated for an increasingly bigger role in powering rockets and missiles:

1. They are more reliable than liquid fuels. Bringing together just the right amounts of liquid propellant and liquid oxygen, nitric acid or hydrogen peroxide, at just the right time, and igniting them is a tricky business that often fails to result in the successful launching of the rocket. In a solid rocket engine the fuel components are blended at the factory and cast together in the steel or glass fiber shell of the missile. There is no mixing and adjusting required in the field.

2. The greatest problem facing missilemen—storage of rockets and fuels—is minimized by use of the safe, compact solid engines. Present launching sites of liquid propelled missiles require widely dispersed, heavily shielded bunkers or caves, containing corrosion-resistant pressure tanks for the dangerous liquids, special handling apparatus for fueling prior to launching and more firefighting and rescue equipment on hand. Temperature and humidity must be carefully controlled. After certain periods of time unused fuel of some types must be discarded. Solid fuels, already cast into engine shape, can be handled like ordinary artillery shells. They generally are not subject to temperature and humidity extremes and, if accidentally ignited, merely burn rapidly rather than explode violently. A bullet can be fired through a casing of most solid fuels and the result is most often a ruined casing.

3. Personnel with only average military training can handle solid fuels, while ground crews now handling liquid-fueled missiles must undergo expensive specialized training.

4. In addition to the money saved on misfires, storage and special training, the Defense Department anticipates saving money on the actual costs of the fuels themselves. Although some solids cost more than some liquids, most liquid fuels require more money to move a given rocket a specified distance at a desired velocity because of the higher engine and auxiliary equipment costs.

These four reasons would be just a good start on a full list of reasons for the big switch in our rocket and guided missile program. A missileman, especially an engineer, would be quick to point out that solid propellant missiles are not nearly as complicated as their liquid-fueled brothers. In a solid rocket, the fuel tank and combustion chamber are the same. The fuel ingredients are mixed together at the factory and poured into the casing where they solidify, or are molded and machined to shape. This forms the basic rocket to which are added fins, a warhead and, in some cases, a guidance system.

Liquid-fueled missiles require separate storage tanks for each fuel component and pipes or hoses to carry the fuel to the combustion chamber. Accurate valves are also needed for regulating the flow and mixture of the fuel.

Advantages of Liquids

Solid fuels, however, do not have all the advantages.

In liquid propellant rockets the fuel tanks can be very light—just strong enough to support the weight of the fuel. There is no explosion taking place in the storage tanks.

LAUNCH SOLID PROPELLANT ROCKET—An Honest John free-flight artillery rocket is fired at a U. S. Army training area in southern Germany. A solid fuel provides all the energy needed to send this 27-foot-long, 6,000-pound rocket to a target up to 15 miles away. The solid fuel is safer and more dependable than the liquid fuels formerly used in similar weapons.

In the solid rocket, the entire casing must be strong enough and heavy enough to support the propelling explosion reaction. That is one reason the Defense Department believes liquids will continue to propel the long-range missiles.

An enormous quantity of fuel goes into even a 1,500-mile intermediate range missile. A solid steel casing to carry all this fuel and still act as the combustion chamber would be too heavy for use. Casings of glass fiber, however, are somewhat lighter and already have proved themselves stronger than the steel shells.

The flow of liquids can be controlled for slow or fast flight, cut off completely for coasting and then resumed for direction changes. Once a solid is ignited its burning rate cannot be changed.

Liquids generally have a higher impulse ratio. This means that liquids do more work per pound of fuel than do solids. This advantage of the liquids is now being overcome by solid fuel researchers who are rapidly closing the gap between the efficiencies of the two propellants.

Specialized Needs in Fuels

Each of the armed services has its own particular needs in a missile fuel. The Air Force, which will operate large, long-distance missiles from permanent fixed bases, with fuel lines laid and storage bunkers built, is expected to continue using many liquid fuels.

The Army, on the other hand, is becoming increasingly mobile and wants missiles that can be transported easily, with no problems of storage and handling. The Army is expected to power almost all its rockets and missiles by solid fuels. One exception might be the big, long-range Jupiter. It probably will be propelled by a liquid fuel until a more efficient solid is available.

The Navy wants its rockets as small, compact and as easy to handle as possible. Storage space is at a premium on board a ship. A liquid fuel explosion and fire in cramped quarters would be disastrous. The Navy's joint project with the Army on development of the Jupiter was abandoned because of difficulty in using a large liquid missile on board ship. The Navy is proceeding with a new solid propellant missile, called Polaris, to be used instead of the Jupiter.

In addition to calling for solid propellant engines in most new missiles, the armed services are replacing engines on many existing systems. The Nike missiles, already familiar sights around America's major cities, are being modified to be propelled entirely by solid fuels. They had been boosted off the ground by solid fuels and sustained in flight by liquids. The Army liquid-fueled Corporal system is being replaced by the solid propellant Sergeant system.

Over a dozen rockets and missiles in production and being used by tactical forces are powered by solid fuels.

And a solid-fueled rocket will carry the forthcoming earth satellite on the final stage of its powered journey. Stages one and two of the Project Vanguard vehicle will be liquid powered. A solid fuel will power the third stage to the fringe of the earth's gravitational pull and eject the satellite into its orbit.

High Energy Fuels for the Future

A new prize to be sought by backers of both solid and liquid fuels has entered the scene to influence the battle between these two propellants—high energy fuels. A call has been sounded for fuels capable of releasing far more energy than is possessed by any existing fuel. High energy fuels are going to be needed to propel not only long-range, ultra-fast guided missiles, but also to power globe-circling supersonic bombers already being designed. The Defense Department wants fuels that are as safe as present solid rocket propellants and have greater "oomph" than even the best of our present liquid propellants.

They could be solids, they could be liquids. Current thinking is that the super fuels will be a mixture of both.

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WILDLIFE CONSERVATION

States Cooperate In Deer Mortality Study

➤ THE SERIOUS increase during recent years in the mortality rate of white-tailed deer has brought about what the U. S. Department of the Interior calls "a new type of interstate cooperation on wildlife problems."

Alone or in small groups, the ten southeastern states cooperating could not afford the necessary men or dollars for a study of the causes for such increase. Together, however, the ten states will spend $20,000 on the project. The University of Georgia will provide the necessary scientific and laboratory services.

The research program will include field work at the scene of outbreaks as they occur, laboratory work and studies with test deer herds. The study will cover deer diseases and nutrition problems, with attention also to toxicity in plants as a possible cause of heavy deer mortality.

Shaler E. Aldous of the Fish and Wildlife Service, Washington, told SCIENCE SERVICE that the problem of high deer mortality in certain areas has existed since the 1800's, but that only recently have efforts been made to study the possible causes. In some countries, Mr. Aldous reports, hunters have found as many as 50 or 100 deer dead as a result of natural causes.

Actually, hunters will indirectly be paying for the research project. The 11% tax on sporting arms and ammunition provided for by the Pittman-Robertson Act for the "restoration of wildlife" goes to state fish and game departments. This money will provide part of the $2,000 each state is contributing to the deer study. Federal Government matching funds amounting to $1,500 will be paid to each state so its expenditure is really only $500.

The ten states participating in the study are Florida, Georgia, Alabama, Mississippi, Louisiana, Arkansas, Tennessee, South Carolina, Virginia and Maryland.

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TECHNOLOGY

X-17 Rocket Tests Nose Cones for Missiles

➤ THE FIRST official announcement that nose cones can return from hundreds of miles above the earth's surface without burning up from intense air friction and resultant heating came simultaneously with the first public showing of the huge Lockheed X-17 at the Air Force Association's convention in Washington, held in connection with the Air Force's 50th anniversary.

The Air Force said that the X-17 research rocket has successfully been used to test nose cones for intercontinental ballistic missiles re-entering the earth's atmosphere from the ionosphere.

Techniques and materials used in the nose cone design and construction are secret. However, details of how the X-17 blasts the various nose cone shapes into space and then brings them smashing down through the earth's heavy layer of air in a severe test of survival were reported.

The X-17 is a three-stage rocket, using only solid propellants. The 40-foot-tall projectile weighs six tons.

After blast-off, it coasts upward to the ionosphere, then drops earthward tail first. As it reaches heavier air, the rocket's nose turns downward. At this point the first stage is ejected and the second fired. A few seconds later, that is ejected and the third stage fired.

During the X-17's flight, which takes little more than six minutes, information on velocity, acceleration, heat and other performance details are continually broadcast to ground stations.

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ASTROPHYSICS

"Magic Carpet" Foreseen as True

➤ THE "MAGIC CARPET" of childhood dreams may actually be a reality some day, Dr. Fritz Zwicky, California Institute of Technology astrophysics professor, predicts.

He foresees the carpets as made of tiny closed cells filled with hydrogen or helium, the cell walls being so strong and light that the whole carpet would be lighter than air. Dr. Zwicky reports that the successful production of strong, thin, single crystals suggested the idea of a "magic carpet."

The lifting power, he suggests, could be managed by different degrees of elastic compression of its spongy metallic substance. Dr. Zwicky's ideas are outlined in the first issue of *Astronautics,* a new monthly publication of the American Rocket Society.

In the same issue, Dr. Simon Ramo, executive vice-president of Ramo-Wooldridge Corp., Los Angeles, predicts space conquest may soon become a reality. Unmanned space flight, he reports, appears feasible by reducing the payload of the intercontinental ballistic missile.

"It is easier to hit the moon than to hit a militarily useful target several thousand yards from the launch point," Dr. Ramo says.

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