National Aeronautics and Space Administration

NASA Facts

Space Shuttle Use of Propellants and Fluids

At liftoff, an orbiter and external tank carry 835,958 gallons of the principal liquid propellants – hydrogen, oxygen, hydrazine, monomethylhydrazine and nitrogen tetroxide – currently costing approximately $1,380,000. Their total weight is 1,607,185 pounds.

Hydrogen

The external tank of the shuttle carries about 384,071 gallons (227,800 pounds) of liquid hydrogen, but about 628,540 gallons (372,800 pounds) are used in all during shuttle vehicle loading. Before final loading begins, some liquid hydrogen is used to pre-chill fuel lines and the hydrogen compartment of the tank; additionally, during fueling, some boils off.

The Power Reactant Storage and Distribution System (PRSDS) also uses liquid hydrogen. About 2,000 gallons are used in all for PRSDS loading because of pre-chill operations, boil-off and ground storage tank dumping.

Gaseous hydrogen is used for fuel cell purging during operations in the Orbiter Processing Facility and while the orbiter is on the launch pad.

The hydrogen used at KSC is produced from natural gas by a steam-reforming process in New Orleans, La. It is shipped in 13,000-gallon mobile tankers.

Oxygen

The shuttle uses two types of liquid oxygen.

1. The oxygen loaded into the external tank, 141,750 gallons (1,350,000 pounds), is produced at Mims, Fla., by liquefying and separating air. The oxygen is trucked to KSC in 6,000-gallon tankers. As in the case of hydrogen, shuttle servicing requires more oxygen than the actual capacity of the oxygen compartment. About 250,000 gallons (2,580,000 pounds) are used in all.

Small quantities are also used aboard the orbiter to provide its breathable atmosphere.

2. The purer type of oxygen used in the Shuttle PRSDS requires 327 gallons (2,340 pounds) per mission for a four-tank set and is more expensive. About 800 gallons are used in all for PRSDS loading due to pre-chill, boil-off and ground storage tank dumping. Fuel cell oxygen is produced in Orlando, Fla., by the same process as the propellant oxygen. Because it must be of higher purity, however, a more modern plant in a locale with low atmospheric contamination is required. The plant is used solely for this purpose during a production run, and the curtailment of other operations is among the reasons for the higher cost. Fuel cell oxygen is shipped in 4,000-gallon tankers.

Hydrazine

Hydrazine is produced by the chemical reaction of chlorine, caustic soda and ammonia. This produces a hydrate version (containing water) used extensively in the chemical industry. The shuttle uses an anhydrous (waterless) version produced by additional reaction of the hydrate with aniline and heptane.

Both the auxiliary power units on the shuttle and the hydraulic power units of the solid rocket boosters use hydrazine as fuel. The total on board at liftoff is 129.2 gallons (1,085 pounds). The fuel

is shipped to KSC in specially designed 500-gallon safety containers from Lake Charles, La.

Monomethylhydrazine (MMH)

The orbiter carries 1,480 gallons (10,800 pounds) of MMH. This fuel is also produced at Lake Charles, La. It is the result of a reaction of monomethylamine with ammonia in a process similar to that for hydrazine production. With nitrogen tetroxide, it is used in the orbiter's reaction control system (RCS) and orbital maneuvering system (OMS). The former provides the thrust for rotational maneuvers (pitch, yaw and roll) and for small velocity changes along the orbiter axis. The latter provides the thrust for orbit insertion, circularization, transfer, rendezvous and deorbit.

The two tanks of the OMS each hold 640.7 gallons (4,690 pounds) of MMH. The two aft RCS tanks each require 134.8 gallons (987 pounds), and the single tank of the forward reaction control system takes 126.8 gallons (928) pounds. Depending on mission requirements, the OMS tanks may not be filled to capacity.

MMH is shipped in specially designed 2,500-gallon safety mobile tankers to a bulk storage area controlled by NASA on Cape Canaveral Air Force Station (CCAFS). It is transported to the pad as needed.

MMH, and its oxidizer, nitrogen tetroxide, are hypergolic fuels. They ignite on contact with each other, and for that reason are stored on opposite sides of the launch pad and loaded separately with extreme safety precautions over a five-day period.

Nitrogen Tetroxide (N_2O_4)

The oxidizer for the OMS and RCS is an intermediate product of the production of chlorine and fertilizer from nitric acid and potassium chloride. It is produced at Vicksburg, Miss., and shipped to KSC in specially designed safety 2,500-gallon mobile tankers. Like MMH, it is stored in bulk at CCAFS and transported to the pad as needed. The orbiter carries 1,378 gallons (17,500 pounds).

The two tanks of the OMS each hold 647.250 gallons (7,767 pounds) of N_2O_4. The two aft RCS tanks each hold 235,600 gallons (1,627 pounds) and the single N_2O_4 tank of the forward RCS takes 123,100 gallons (1,477 pounds). Each tank manifold holds 17 gallons (204 pounds).

Other Fluids and Gases

Helium

The helium used by the space shuttle for purging (rinsing) and pressurization is extracted from helium-rich natural gas in Kansas, Oklahoma, Texas and Wyoming. The principal consumption, 1 million cubic feet (10,340 pounds), is during launch countdown, but a small amount, 30,000 standard cubic feet (310 pounds), is carried on board for pressurization.

Liquid helium is shipped in specially designed cryogenic tankers holding 11,000 gallons. The liquid is converted to gas on-site, which saves in transportation costs. One tanker of liquid helium is equivalent to six trailers of gaseous helium.

Nitrogen

Like oxygen, nitrogen is produced by air separation. Liquid nitrogen is provided from Orlando, Fla., in 6,000-gallon mobile tankers. Liquid nitrogen is not used on board the shuttle.

Most of the nitrogen used at KSC is in gas form, produced in a Merritt Island, Fla., facility and piped through 34 miles of 6000 psi pipeline to various locations on KSC and CCAFS. The shuttle carries only 3,500 cubic feet (253.6 pounds), but large amounts are used during ground processing. About 30 million cubic feet (2,173,500 pounds) will be used for a typical launch countdown. KSC uses more than 1-billion cubic feet of nitrogen a year.

Refrigerant 21

Fifty-two gallons (59.7 pounds) are used as a closed-loop heat transport liquid on the orbiter. Previously, the product was provided from Bremen, West Germany, and was shipped in one-ton containers (about 175 gallons) at $25 per gallon. R21 is no longer produced, and ongoing support is provided by a stockpile and recycling programs.

Ammonia

The orbiter uses 19.2 gallons (110 pounds) of liquid ammonia as a coolant in the active thermal control subsystem, which removes waste heat from various parts of the spacecraft and releases it into space. It is shipped in 150-pound cylinders to KSC from Morrow, Ga.

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