

Fuel

Jump to: navigation, search

In the context of chemical processes, such as chemical rockets, fuel refers to a reducing agent which can be chemically combined with an oxidizer to release energy. In other contexts, such as nuclear energy, it normally refers to the substance which is used as an energy source. In chemical propulsion, Fuel plus the oxidizer are propellants. In electric and most forms of nuclear propulsion, there are only propellants.

On Mars, fuels could be hydrogen, methane, carbon monoxide and solids, such as aluminium or iron. Oxygen is the most likely oxidizer. The abundance of water on Mars favors hydrogen and methane. Methane could be produces using Water electrolysis and the Sabatier process.

Combination	Specific impulse (s)	Exhaust velocity (m/s)	ratio fuel:oxidizer
Hydrogen + oxygen	388 - 454	3816 - 4462	2:1 (stoichiometric)
Methane + oxygen	309 - 368	3034 - 3615	1:2
Carbon monoxide + oxygen	260 - 300	~2770 (est.)	2:1
Aluminium + oxygen			1:1

Actual ISP and exhaust velocities depend on engine design and external pressure. Exhaust velocities are ideal ones for one atmosphere and near vacuum. Table gives stoichiometric fuel ratios, not volumetric or mass based ones.

Note that hydrogen / oxygen gives a high power, but hydrogen is hard to store at Martian conditions. The best engines burn a bit hydrogen rich (to cool the flame & reduce the molecular mass of the exhaust which gives more thrust).

Note that Methane / oxygen can be created from carbon dioxide (CO₂) and water, both from the Martian atmosphere. Also, the two liquids have a similar boiling point which makes storing them inside the rocket's tankage simpler. Methane created on Mars is likely to have a small amount of carbon monoxide mixed in it. This should not materially effect the rocket's performance.

Note that it is fairly hard to ignite carbon monoxide (CO) and oxygen. Such engines have never been flown, and the exhaust velocity above is an estimate.

Note that aluminium + oxygen produces a solid exhaust product which would clog reaction chambers. However, such fuel might be able to be used as part of an expendable solid rocket booster.

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