2. Soviet Propellants for Ballistic Missiles:

[redacted] Since the end of World War II, when the Soviets initiated a large-scale program to exploit German missile developments, the native Soviet research and development program has closely followed the precepts laid down by the Germans. In fact, all of the currently operational Soviet surface-to-surface ballistic missiles, with a range capability of 150 nautical miles or more, use liquid propellants, as had all those either built or designed by the Germans.

To date, there has been only tenuous evidence that the Soviets are interested in the use of solid propellants, and there is no firm intelligence indicating an intent on their part to use solids in long-range ballistic missiles. However, in some latter Soviet missiles, the propellant mixtures have been made storable through the use of storable oxidizers. These oxidizers have an advantage over the previously used liquid oxygen (LOX) that must be maintained at temperatures of about minus 300°F to prevent excessive boil-off losses. Most of the fuels used in missile propellant combinations, are storable at ambient temperatures; therefore, the use of an oxidizer with similar storable characteristics makes a combination usually referred to as "storable propellants." Such propellants can be "stored" in the missile itself, thereby greatly improving reaction* times.

The Soviet SS-1 (150-n.m.), the SS-5 (2,200-n.m.) IRBM, and the SS-7 ICBM probably use storable propellants, while the SS-2 (350-n.m.), the SS-3 (700-n.m.), and the SS-6 and SS-8 ICBM's probably use the nonstorable oxidizer, LOX, as one of the propellants. The propellants used in the SS-4 (1,100-n.m.) missile cannot be determined at the present time.

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*Time between decision to fire and missile launching.

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[redacted]

The estimated propellants used in Soviet ballistic missiles of 150 n.m. to ICBM range are given below with the derived characteristics used for their selection as the specific propellants.

SS-1 150-n.m. Missile

Propellants: Storable
Oxidizer: RFNA (Red Fuming Nitric Acid)
Fuel: T-1*
Characteristics:
Volumetric ratio: 1.8:1

SS-2 350-n.m. Missile

Propellants: Nonstorable
Oxidizer: LOX
Fuel: 92% ethyl alcohol
Characteristics:
This missile is believed to be based on a further development and improvement of the original German V-2 design and therefore is estimated to use the same propellants as the V-2.

*T-1 is the Soviet designation for a specific grade of kerosene.

TABLE

PERFORMANCE CHARACTERISTICS OF PROPELLANTS POSSIBLY USED IN SOVIET BALLISTIC MISSILES

Propellant	Volumetric Mixture Ratio	Vacuum Specific Impulse
LOX-92% ethyl alcohol	1.05	301
LOX-hydrazine	0.66	331
LOX-hydyne (60% UDMH/40% diethylene-triamine)	1.13	320
LOX-hydrazine/UDMH	0.85	328
LOX-T-1	1.59	315
LOX-UDMH	0.96	325
RFNA-UDMH/hydrazine	0.99	299
RFNA-hydyne	1.44	290
RFNA-UDMH	1.24	294
RFNA-T-1	2.12	284
Nitrogen tetroxide-T-1	1.93	289
Nitrogen tetroxide-hydrazine/UDMH	1.01	307
Nitrogen tetroxide-hydyne	1.31	298
Nitrogen tetroxide-UDMH	1.16	301
Hydrogen peroxide-UDMH/hydrazine	1.81	301

The table assumes the following performance conditions:

1. Combustion chamber pressure = 1000 pounds per square inch.
2. Nozzle exit pressure = 14.7 pounds per square inch absolute.
3. Optimum nozzle expansion ratio $= \frac{\text{(exit area)}}{\text{(throat area)}}$
4. Contraction ratio $= \frac{\text{(chamber area)}}{\text{(throat area)}}$ (assumed to be infinite)
5. Adiabatic combustion
6. Isentropic expansion of ideal gas
7. Shifting equilibrium

Mathematical corrections to this table must be made for each engine.

SS-3 700-n.m. Missile

Propellants: Nonstorable
Oxidizer: LOX
Fuel: 92% ethyl alcohol, or an amine mixture such as methyl alcohol/hydrazine hydrate mixture
Characteristics:
Volumetric ratio: 1.1:1
Specific Impulse: 265 ± 15 seconds (vacuum)

SS-4 1100-n.m. Missile

Propellants: Undetermined because of conflict in data which has not yet been resolved.
Characteristics:
Volumetric ratio: 1.84:1
Specific Impulse: 261 ± 4 seconds (vacuum)

SS-5 2,200-n.m. IRBM

Propellants: Probably storable
Oxidizer: RFNA or Nitrogen Tetroxide
Fuel: UDMH (Unsymmetrical dimethyl hydrazine) or 50% UDMH/50% hydrazine
Characteristics:
Volumetric ratio: 1.1 to 1.36:1
Specific Impulse: 286 seconds (vacuum)

SS-6 6,000-n.m. ICBM

Propellants: Nonstorable
Oxidizer: LOX
Fuel: Kerosene or an amine mixture

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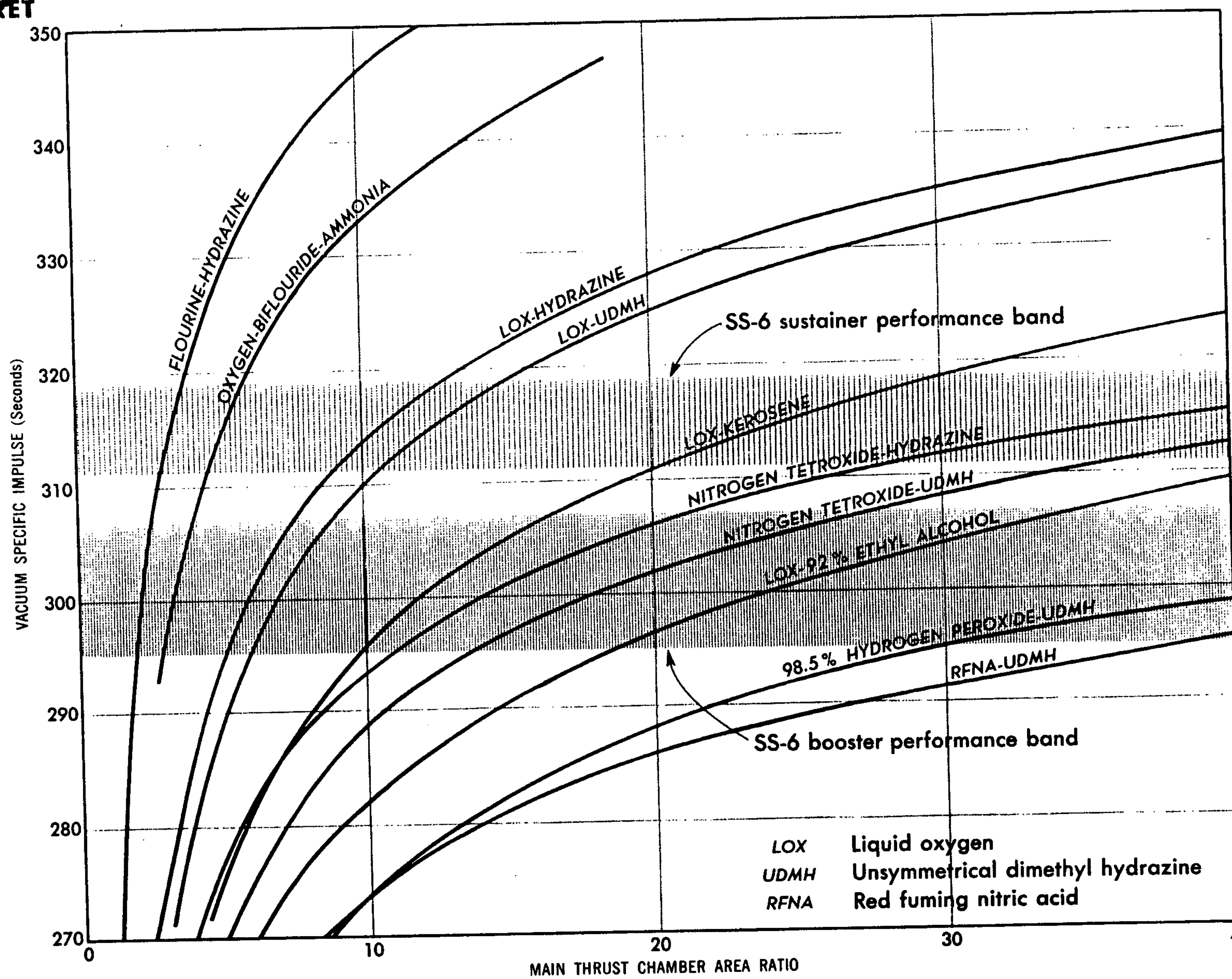

EXPECTED OVERALL ENGINE VACUUM SPECIFIC IMPULSE

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GROUP 1
EXCLUDED FROM AUTOMATIC DOWNGRADING AND DECLASSIFICATION

Characteristics:

Volumetric ratio: Unknown, but from the specific impulse and other data, the above propellant selection provides the best fit for the demonstrated performance capabilities (See chart)

Specific Impulse: Booster, 302 ± 7 seconds (vacuum)
Sustainer, 315 seconds (vacuum)

SS-7 6,000-n.m. ICBM

Propellants: Probably storable

Oxidizer: RFNA or Nitrogen Tetroxide

Fuel: UDMH or 50% UDMH/50% hydrazine

Characteristics:

Volumetric ratio: 1.14 to 1.21:1

Specific Impulse: First stage, 285 seconds (vacuum)
Second stage, 296 ± 2 seconds (vacuum)

SS-8 6,000-n.m. ICBM

Propellants: Nonstorable

Oxidizer: LOX

Fuel: Hydrazine

Characteristics:

Volumetric ratio: 0.8

Specific Impulse: First stage, 310 ± 4 seconds (vacuum)
Second stage, 330 ± 9 seconds (vacuum)

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