

GV/G500/G550 (ATA 28): Fuel Density Variations

A GV flight crew reported experiencing the inability to fully fuel their aircraft during a fueling stop. During fueling, the Fuel Quantity Monitoring System (FQMS) indicated a maximum fuel load of 39,900 lb. The flight crew also indicated that the ambient and wing fuel tank temperatures were low.

The crew further attempted to fill the wing by pulling the left- and right-fueling shutoff circuit breakers, parking the aircraft nose down, shaking the wing, and eventually over wing fueling. The over wing fueling resulted in only an additional 15 gallons of fuel.

The maximum volumetric fuel capacity of the GV aircraft is nominally 6,100 U.S. gallons (USG). Based on a fuel temperature of 60°F and a typical fuel density of 6.767 lb./USG, the maximum fuel weight is 41,300 lb. (Note: The aircraft range is determined by fuel weight, not volume.)

Variations in fuel density and expansion at elevated temperatures, especially when fuel is stored above ground in hot climates, will result in an inability to obtain the nominal maximum fuel weight of 41,300 lb. at 6,100 USG.

Per specifications as listed in the AFM, Section 1, “Engine Fuel Grades,” manufactured fuel density at a constant temperature can vary to the acceptable lower limits of 6.47 lb./USG at 60°F. The GV FQMS includes a densitometer and will automatically compensate for density effects and correctly display the actual fuel weight. At the lower limit of 6.47 lb./USG at 60°F, the FQMS would indicate a full fuel reading of approximately 39,400 lb. at 6,100 USG.

Fuel temperatures greater than 60°F also limit the nominal maximum fuel weight due to thermal expansion of the fuel. For each additional 10 degrees in fuel temperature, the maximum fuel weight is reduced by approximately 200 lb. at 6,100 USG.

The following table, generated by the Gulfstream ECS Power Plant group, illustrates fuel density variations as affected by temperature and the acceptable upper and lower limits at constant temperature. The source data used in the table is compiled from the Coordinated Research Counsel (CRC) Report 530 – Aviation Fuel Properties, and the American Society for Testing & Materials ASTM D1655 – Standard Specification for Aviation Turbine Fuels. CRC Report 530 contributors include participation from the major petroleum companies, and sustaining members include the American Petroleum Institute (API) and the Society of Automotive Engineers (SAE).

Table on following page:

Jet-A Fuel Density Variation with Temperature

Temperature °F (°C)	Min and Max Density lb./USG based on rel density to water @ 15.5C X 8.336		Typical Density lb./USG Typical	lb Jet-A Fuel @ 6100 USG	$\Delta \gamma$ Max - Min	Δ Wt./Max Fuel $\Delta \gamma \times (6100)$
	Min	Max				
-4°F (-20°C)	6.68	7.19	6.985	43,859@Max γ	.51 lb./USG	3,111 lb.
				42,609@Typ γ		
				40,748@Min γ		
14°F (-10°C)	6.62	7.13	6.927	43,493@Max γ	.51 lb./USG	3,111 lb.
				42,255@Typ γ		
				40,382@Min γ		
32°F (0.0°C)	6.55	7.07	6.860	43,127@Max γ	.52 lb./USG	3,172 lb.
				41,846@Typ γ		
				39,955@Min γ		
50°F (10°C)	6.49	7.02	6.802	42,822@Max γ	.53 lb./USG	3,233 lb.
				41,492@Typ γ		
				39,589@Min γ		
54°F (12°C)	6.47	7.00	6.793	42,700@Max γ	.53 lb./USG	3,233 lb.
				41,473@Typ γ		
				39,467@Min γ		
59°F (15°C)	6.46	6.99	6.777	42,639@Max γ	.53 lb./USG	3,233 lb.
				41,340@Typ γ		
				39,406@Min γ		
63°F (17°C)	6.44	6.98	6.760	42,578@Max γ	.53 lb./USG	3,233 lb.
				41,236@Typ γ		
				39,284@Min γ		
68°F (20°C)	6.43	6.96	6.743	42,456@Max γ	.53 lb./USG	3,233 lb.
				41,132@Typ γ		
				39,223@Min γ		
77°F (25°C)	6.39	6.93	6.710	42,273@Max γ	.54 lb./USG	3,294 lb.
				40,931@Typ γ		
				38,979@Min γ		
86°F (30°C)	6.36	6.90	6.685	42,090@Max γ	.54 lb./USG	3,294 lb.
				40,779@Typ γ		
				38,796@Min γ		
104°F (40°C)	6.30	6.85	6.626	41,785@Max γ	.55 lb./USG	3,355 lb.
				40,419@Typ γ		
				38,430@Min γ		
122°F (50°C)	6.24	6.79	6.560	41,419@Max γ	.55 lb./USG	3,355 lb.
				40,016@Typ γ		
				38,064@Min γ		