**Step 1: Mathematical Identification of Fuel Quality (°API)**

In power plant engineering, the heating value of petroleum products is intrinsically tied to its specific gravity and chemical composition. The ASME/Bureau of Standards provides empirical relations to map the Higher Heating Value (HHV) to the American Petroleum Institute (°API) gravity scale. When evaluating fuel properties, the standard relation widely adopted in mechanical engineering board exams is given by the formula:

HHV = 41130 + (139.6)(°API) ;

Where HHV is expressed in kJ/kg. Substituting the given heating value of 45,068.32 kJ/kg into the linear equation allows us to isolate and solve for the API gravity of the fuel:

45,068.32 kJ/kg = 41130 + (139.6)(°API)

°API = 28.2215

**Step 2: Derivation of Specific Gravity at Standard Temperature (15.6°C)**

By international standard definition, °API gravity is measured at a baseline reference temperature of 60°F (which precisely converts to 15.6°C). To link this arbitrary scale back to standard physical metrics, we utilize the classical hydrometer scale conversion equation:

$$SG_{f(@60^\circ F)} = \frac{141.5}{^\circ API + 131.5} = \frac{141.5}{28.2215 + 131.5} = 0.88597$$

This reveals that at the reference temperature, the petroleum fuel is roughly 88.6% as dense as pure liquid water.

**Step 3: Thermal Expansion and Temperature Correction Factor**

Fluids expand when heated, meaning their density decreases as temperature rises. To determine the specific gravity at the actual operating temperature of 32°C, a thermal correction coefficient for petroleum oil must be introduced. The standard empirical correction factor for this class of petroleum products is 0.0007 per degree Celsius change from the reference line:

$$SG_{corrected} = SG_{f(@15.6^\circ C)}\left[1 - 0.0007(t_o - 15.6^oC)\right]$$

Substituting our operating temperature (t = 32°C) and our baseline specific gravity into the equation:

$$SG_{32^\circ C} = SG_{f(@15.6^\circ C)}\left[1 - 0.0007(32 - 15.6^oC)\right] = 0.8758$$

**<u>Step 4:</u> Final Density Calculation**

Specific gravity is a dimensionless ratio defined as the density of the fluid divided by the reference density of water ($\rho_w$). At standard conditions, the density of water is functionally taken as 1 kg/L (or 1000 kg.m$^3$).

$$SG_f = \frac{\rho_f}{\rho_w}$$

$$0.8758 = \frac{\rho_{f@32\circ C}}{1\ kg/L}$$

$$\rho_{f@32\circ C} = 0.8758\ \frac{kg}{L}$$

Because this fuel exhibits a distinct drop in density (expansion) at32ºC relative to standard conditions, fuel storage tanks must feature adequate expansion allowances. Furthermore, understanding the precise density variation helps in configuring fuel injection pumps and centrifuges, which rely heavily on fluid density and viscosity to ensure clean atomization and complete combustion inside the diesel engine cylinders.