

**Tikrit University**

**The College of Petroleum Processes Engineering**

**Petroleum Systems Control Engineering**

**Department**

**Properties of Petroleum & Natural Gas**

**Third Class**

**Lecture 16**

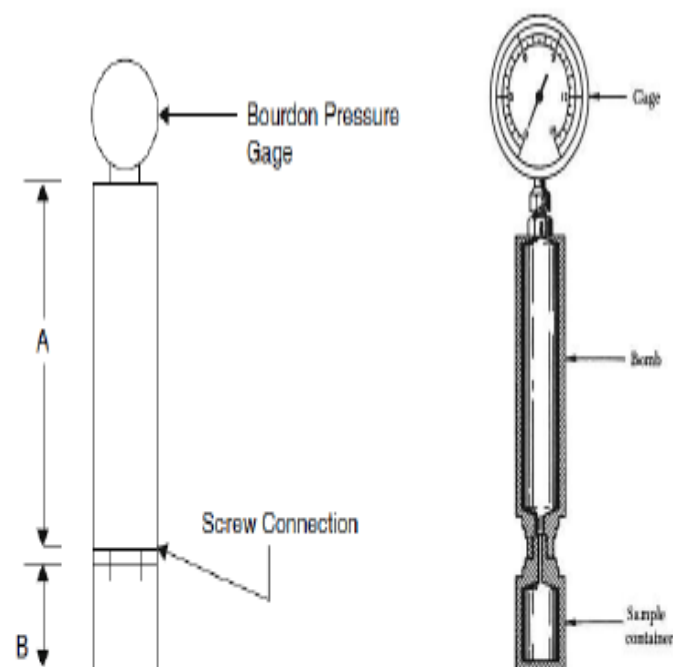
**By**

**Jasim I. Humadi**

## Reid vapor pressure (ASTM D323)

- RVP is the standard test for **low boiling point distillates**: naphtha, gasoline, light cracked distillates and aviation gasoline with vapor pressures above 26 psig at 37.8°C (100°F).
- RVP test measure the potential impact of gasoline on engine performance and help benchmark fuels for various emission.
- RVP testing for crude oils helps refiners understand the nature of feedstocks coming into the refinery, helping the refiner make optimal processing decisions.
- RVP test measures **evaporation rates**.

The apparatus used for RVP test is described below

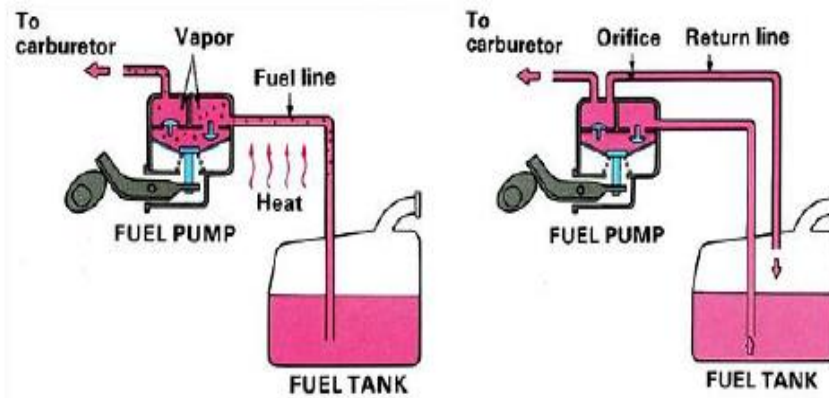


- The diameters of both the vapor chamber and the liquid chamber should be the same.
- The ratio of the volume of the vapor chamber to liquid chamber shall be between 3.8-4.2.
- The liquid chamber is connected to the vapor chamber (L:254 mm & d:51 mm) and the pressure gage inserted vertically in a water bath up to a level of 190 mm of the vapor chamber.
- The water bath is kept at a temperature of 100°F for 30 min and then removed tilted once or twice and replaced for a further 15 min.
- At the end of this time the vapor pressure of the test sample is read from the pressure gage to the nearest 0.2 psi

### Reid Vapour Pressure

- RVP is also a useful parameter for estimation of losses from storage tanks during filling or draining.
- For example, according to Nelson method losses can be approximately calculated as follows: **Losses in Vol % = (14.5 RVP – 1)/6** where RVP is in bar
- In general, true vapor pressure is higher than RVP because of light gases dissolved in liquid fuel.

- RVP measures the **vapour-lock tendency of a motor gasoline** in which excessive vapours are produced in the **fuel line causing interruption of the supply of liquid fuel** to the engine.
- The **fuel** can vaporize due to being heated by the engine, by the local climate or due to a lower boiling point at high altitude.
- RVP indicates the explosion and evaporation hazards of the fuel.



**RVP of several pure hydrocarbons are given as follows:**

i-C<sub>4</sub>: 4.896 bar (71 psia);

n-C<sub>4</sub>: 3.585 bar (52 psia);

i-C<sub>5</sub>: 1.338 bar (19.4 psia);

n-C<sub>5</sub>: 1.0135 bar (14.7 psia);

i-C<sub>6</sub>: 0.441 bar (6.4 psia);

n-C<sub>6</sub>: 0.34 bar (5.0 psia);

benzene: 0.207 bar (3.0 psia);

toluene: 0.03 bar (0.5 psia),

**RVP directly proportional to Volatility** (the tendency of a substance to vaporize). At a given temperature, a substance with higher vapour pressure vaporizes more readily than a substance with a lower vapour pressure.

### **Prediction of the Reid Vapour Pressure**

- High levels of vaporization are desirable for winter starting and operation
- lower levels are desirable in avoiding vapour lock during summer heat.
- Fuel cannot be pumped when there is vapour in the fuel line (summer)
- winter starting will be more difficult when liquid gasoline in the combustion chambers has not vaporized.

Thus, oil refineries manipulate the Reid Vapour Pressure seasonally to maintain gasoline engine operation reliable.

- Vapour lock tendency is directly related to RVP and at ambient temperature of 21°C (70°F) the maximum allowable RVP is **75.8 kPa** (11 psia), while this limit at 32°C (90°F) reduces to 55.2 kPa (8 psia).

**TVP at 100°F (311 K) can be estimated from equation below:**

$$\log_{10} TVP_{100} = 3.204 \times \left( 1 - 4 \times \frac{T_b - 41}{1393 - T_b} \right)$$

Where  $T_b$  is the normal boiling point in K and  $TVP_{100}$  is the true vapour pressure at 100°F (311 K).

Once TVP is calculated it may be used instead of RVP in the case of lack of sufficient data.

RVP data on 52 different petroleum products (light and heavy naphtha, gasoline, and kerosene) have been used to develop a simple relation for prediction of RVP in terms of boiling point and specific gravity in the following form:

$$RVP = P_c \exp(Y)$$

$$Y = -X \left( \frac{T_b SG}{T_r} \right) (1 - T_r)^5$$

$$X =$$

$$-276.7445 + 0.06444 T_b + 10.0245 SG - 0.129 T_b SG + \frac{9968.8675}{T_b SG} + 44.6778 \ln T_b +$$

$$63.6683 \ln SG$$

$$T_r = \frac{311}{T_c}$$

$$T_c = 19.06232 T_b^{0.58848} SG^{0.3596}$$

$$P_c = 5.53027 \times 10^7 T_b^{-2.3125} SG^{2.3201}$$

- $T_c$  is the pseudocritical temperature (maximum temperature at which compression can cause liquefaction of liquid) in kelvin.
- $P_c$  is the pseudocritical pressure (defined as the pressure above which liquid and gas cannot coexist at any temperature).
- RVP is the Reid vapour pressure in bars.
- For conditions where RVP should be lowered (hot weather), heavier hydrocarbons with lower RVP are used for blending purposes.

**Q: An finished** fuel (Sp.G: 0.744) has ASTM D86 distillation data as given in the table below. What is **this fuel**?. Does the fuel have a vapour lock tendency?. Does the vapour lock tendency will change if the fuel blended with i-C<sub>6</sub> (RVP: 0.441 bar)?.

V% distilled	IBP	5	10	30	50	70	90	95	EP
ASTM°C	48	67	76	110	141	163	184	190	201

**Solution:**

To determine whether the fuel have a VLT or not, we must find RVP for the fuel.

$$RVP = P_c \exp(Y)$$

$$T_b = \frac{IBP+FBP}{2} = 124.5$$

$$P_c = 5.53027 \times 10^7 T_b^{-2.3125} SG^{2.3201}$$

SG	Tb	X	Tr	Y	Tc	Pc	RVP
0.744	397.5	0.464102	0.528	-6.08975	580.2983	27.15286	0.061528

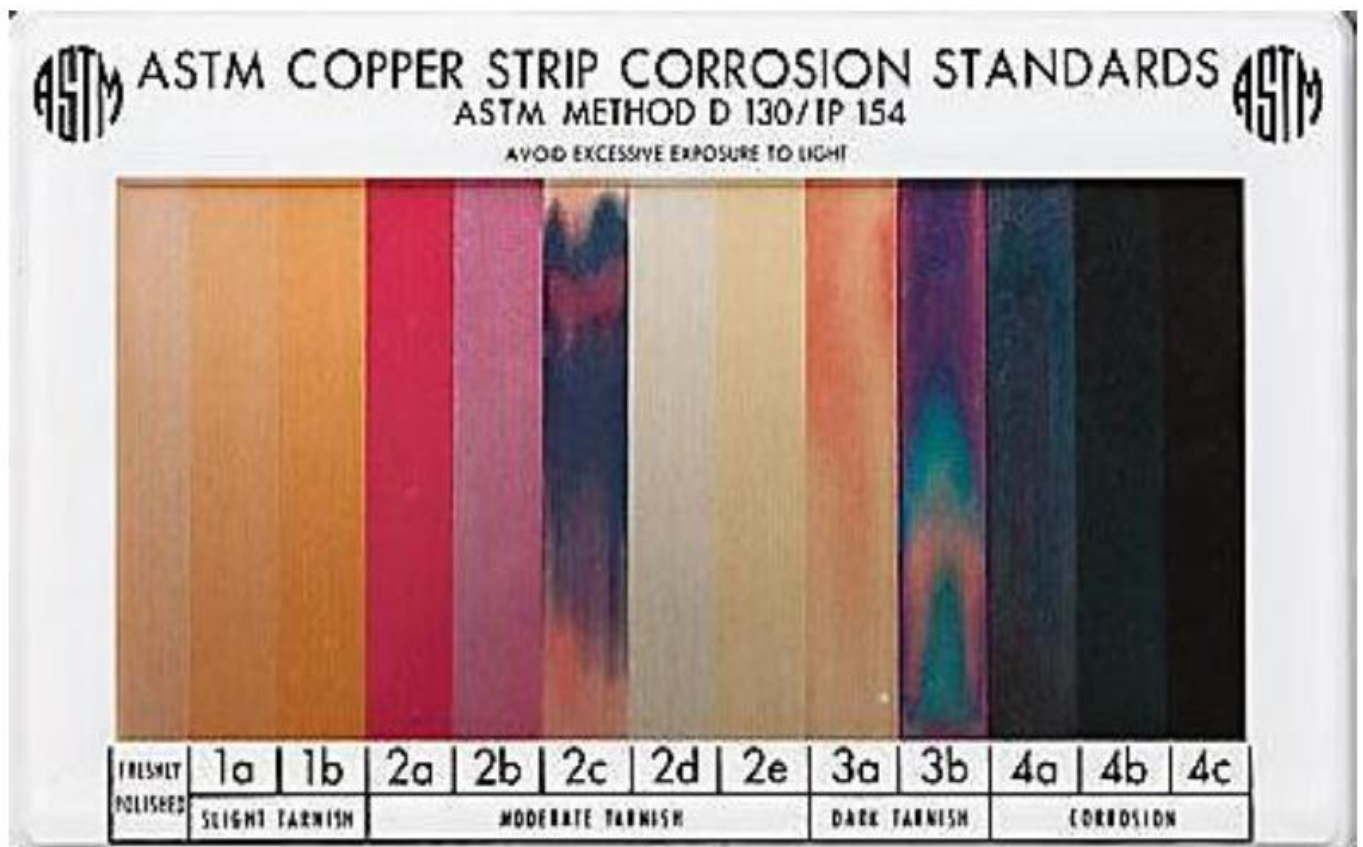
**The fuel is summer gasoline**

Now if we blended iC<sub>6</sub> (RVP 0.441 bigger than 0.0765 bar) will definitely increases the vapour lock tendency of the final blend.



## Copper strip corrosion test

- Measures the corrosivity of light and mid distillates due to presence of sulphur compounds.
- **ASTM D130** for Petroleum products (gasoline, aviation fuel, kerosene, diesel, fuel oil, natural gasoline).
- A **polished copper strip** is immersed in the sample for **three hours at 50°C (122°F)**. The strip is then removed and tested for discoloration and corrosion of a copper strip under standard test conditions.
- Classification number ranges from 1 to 4 after a comparison with the **ASTM D130 copper strip corrosion standard** is given as below.





class	Designation	Description
1	Slight Tarnish	<ul style="list-style-type: none"> <li>a) Light orange, almost same as the finely polished strip</li> <li>b) Dark orange</li> </ul>
2	Moderate Tarnish	<ul style="list-style-type: none"> <li>a) Claret red</li> <li>b) Lavender</li> <li>c) Multi colored</li> <li>d) Silvery</li> <li>e) Brassy or gold</li> </ul>
3	Dark Tarnish	<ul style="list-style-type: none"> <li>a) Magenta overcast on brassy strip</li> <li>b) Multi colored with red and green showing no gray</li> </ul>
4	Corrosion	<ul style="list-style-type: none"> <li>a) Transparent black, dark gray, or brown</li> <li>b) Graphite or lusterless black</li> <li>c) Glassy or black</li> </ul>