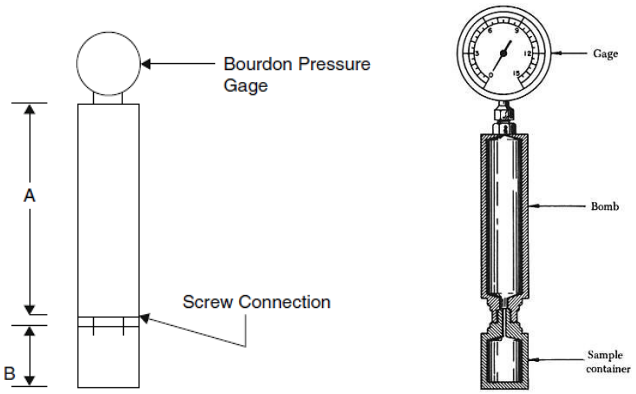
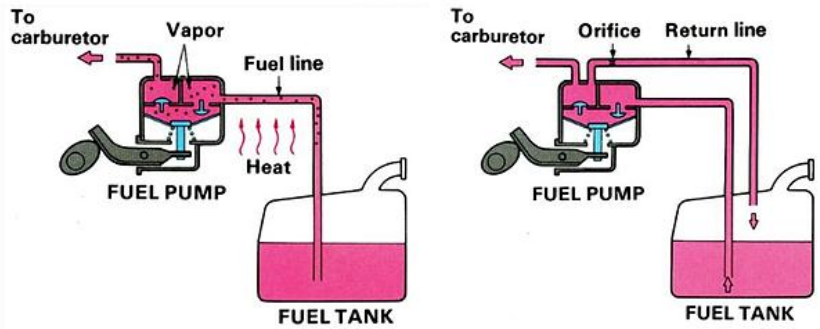
Reid vapor pressure (ASTM D323)

- RVP is a 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 for crude oil **helps refiners understand the nature of feedstocks** to make the optimal processing decisions.
- RVP test measures **evaporation rates**.
- RVP is the **absolute vapor pressure exerted by the vapor of the liquid** and any dissolved gases at 37.8 °C (100 °F)

The apparatus used for RVP test is described below



- The vapor chamber and the sample container have the **same diameter**.
- The volume of the vapor chamber is **4 times** bigger than the volume of sample container.
- The RVP tester inserted vertically in a water bath up to a level of **190 mm** of the vapor chamber at 100°F (37.8 °C) 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.
- RVP measures the **vapour-lock tendency of a motor gasoline** in which excessive vapours are produced in the **fuel line causing interruption of the liquid fuel supply** to the engine.
- The **fuel** can vaporize due to being **heated** the **local climate** or due to a lower boiling point at **high altitude**.



RVP of several pure hydrocarbons are given as follows:

i-C_4: 4.896 bar (71 psia);

n-C_4: 3.585 bar (52 psia);

i-C_5: 1.338 bar (19.4 psia);

n-C_5: 1.0135 bar (14.7 psia);

i-C_6: 0.441 bar (6.4 psia);

n-C_6:0.34 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.

- RVP is used for estimation of **losses from storage tanks** during filling or draining.

$$\textbf{Losses in } Vol\,\% = (14.5\,RVP - 1)/6 \textbf{ where RVP is in bar}$$

- In general, true vapor pressure TVP is **higher than RVP** because of light gases dissolved in liquid fuel. (1bar =14.5psig) (1psig 0.068 bar).

Prediction of the Reid Vapour Pressure

- High levels of vaporization are desirable for winter starting and operation (**High RVP Gasoline)**
- lower levels of vaporization are desirable for hot summer to avoid vapour lock (**Low RVP Gasoline)**
- 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.
- 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:

$$\log_{10} TVP_{100} = 3.204\,x\,(1 - 4\,x\,\frac{T_b - 41}{1393 - T_b}) \ldots . 25$$

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

$$RVP = P_c\,exp(Y) \ldots . 26$$

$$Y = -X\left(\frac{T_b\,SG}{T_r}\right)(1 - T_r)^5 \ldots . 27$$

$$X = -276.7445 + 0.06444\,(T_b) + 10.0245\,(SG) - 0.129\,T_bSG + \frac{9968.8675}{T_bSG} + 44.6778\,\text{In}\,T_b + 63.6683\,\text{In}\,SG \ldots\ldots 28$$

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

$$T_c = 19.06232 T_b^{0.58848}\, SG^{0.3596} \ldots 29$$

$$P_c = 5.53027x10^7\, T_b^{-2.3125}\, SG^{2.3201} \ldots\ldots 30$$

- 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**).
- For conditions where RVP should be lowered (hot weather), **heavier hydrocarbons with lower RVP are used for blending purposes**.

Exercise: 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_6 (**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.

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

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

$$P_c = 5.53027x10^7\, T_b^{-2.3125}\, SG^{2.3201}$$

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_6 (RVP 0.441bar bigger than 0.061528 bar) will definitely increases the vapour lock tendency of the final blend.

Problem 1: A TBP data for crude oil is given in the table below. Find the following:

a)EFV curve $T_{0\%}$,$T_{10\%}$, $T_{30\%}$, $T_{50\%}$, $T_{70\%}$, $T_{90\%}$, $T_{100\%}$

b)ASTM D86 curve if ASTM $T_{50\%}$ is equals to 534°F

c)The base of the crude sample by Kw if API is 37

d)If the wt% of the SR gasoline cut is equals to 20, what would be the RON

Vol % distilled	T0	T10	T20	T30	T40	T50	T60	T70	T90	T100
TBP °F	**62**	**150**	**255**	**344**	**437**	**531**	**623**	**717**	**800**	**897**

Problem 2: ASTM D86 distillation data for the straight run gasoline (Sp.G: 0.720 at 60/60 °F) are given in the table below. Calculate the following:

a)RVP

b)RON

c)RON & MON + 33.3% MTBE/US gallon (RON for MTBE:113-117, MON for MTBE:95-101)

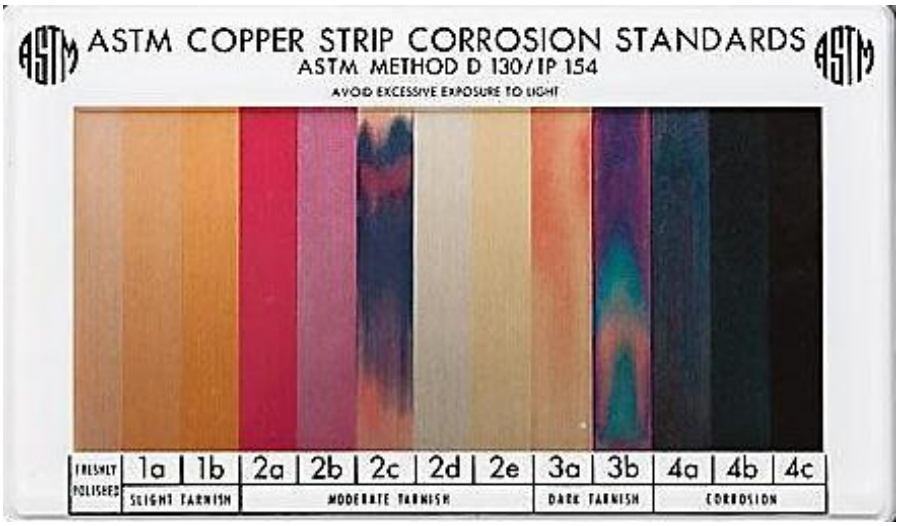
d)If the gasoline from point c is blended with a mixture consist of 33.3% alkylate/US gallon (RON 96) and 27.27% Coker gasoline/US gallon (RON 92), what would be the RON for the final blend.

Vol % distilled	IBP	5	10	30	50	70	90	95	EP
ASTM D86 °C	**37**	**42**	**49**	**66**	**93**	**133**	**203**	**211**	**217**

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	a) Light orange, almost same as the finely polished strip b) Dark orange
2	Moderate Tarnish	a) Claret red b) Lavender c) Multi colored d) Silvery e) Brassy or gold
3	Dark Tarnish	a) Magenta overcast on brassy strip b) Multi colored with red and green showing no gray
4	Corrosion	a) Transparent black, dark gray, or brown b) Graphite or lusterless black c) Glassy or black