Evaluation of Boiling Point Ranges for Petroleum Products Using an Innovative Vacuum Distillation System as per ASTM D1160

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Background

In the refining industry, heavier materials distill at high temperatures, which can lead to thermal cracking. The solution to this issue is reducing the boiling points of the lighter materials. The method for dropping the boiling point is reducing the pressure with a vacuum system. The temperature needed for vaporization is lowered, reducing the risk of ignition or thermal breakdown. The introduction of the Koehler VDS5000 Manual Vacuum Distillation System allows the user to evaluate boiling point ranges for petroleum products. The instrument can reduce the pressure of the system using a vacuum pump. The materials are vaporized earlier than they would be at atmospheric pressure. The reduced boiling points creates a lower temperature environment, which prevents potential thermal damage done to the oil or unit. The VDS5000 is beneficial in determining boiling point ranges of oils at reduced pressures.

Figure 1 (above)
VDS5000 Manual Vacuum Distillation System

Instrument

The Koehler VDS5000 Manual Vacuum Distillation System performs ASTM D1160, an established technique for distillation at reduced pressures. This allows the range of boiling points for a petroleum product to be determined. The unit can reach a maximum temperature of 400 °C. The vacuum system needed for reduced pressures requires the K80320 VDS Vacuum Pump. The pump is joined with a 5-liter stainless steel surge tank, which minimizes pressure fluctuations. The K33062 Constant Temperature Circulation Bath is also needed to supply water to the receiver and condenser. The control box is displayed in figure 2 and is responsible for powering on the unit. It is equipped with a dual temperature display for the vapor and flask. Dials are present to control the temperature of the mantle as well as the pressure of the system. The cooling fans allow the glassware to be handled safely in between tests. Leaks are prevented thanks to the shut off and vent valves equipped. The standard glassware set, and accessory kit require assembly instructed in the manual.

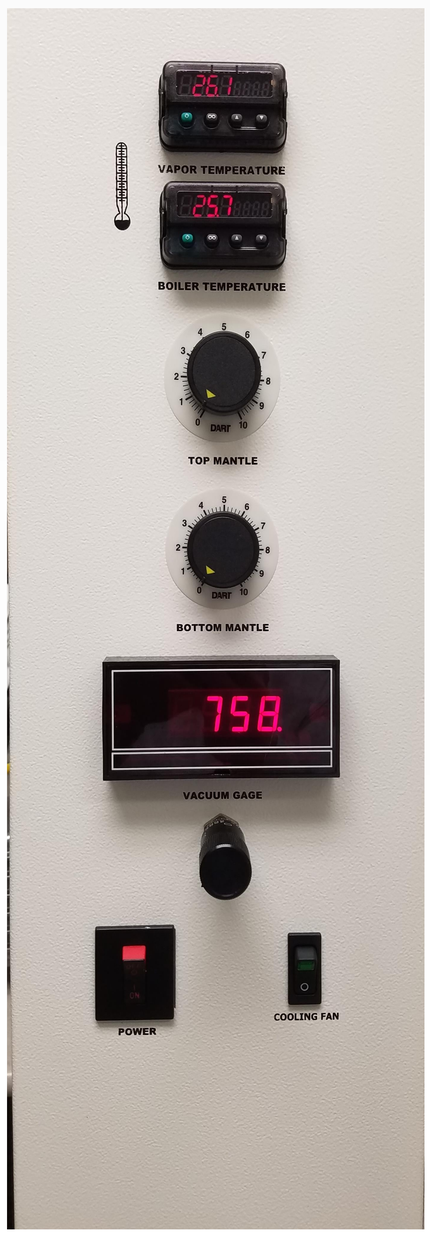

Figure 2 (left)
The front control panel equipped with temperature and vacuum displays.

ASTM D1160

ASTM D1160 is the standard test method for distillation properties of materials at reduced pressures. The VDS5000 accomplishes the tasks outlined in the guidelines because of the reduced pressure created by the vacuum. The test method is significant for determining the boiling point ranges of products at lower temperatures than normal. This is helpful for analyzing petroleum products that decompose or dissipate at high temperatures. The boiling point ranges obtained are used for engineering calculations, design specifications, regulations, and more. The data retrieved provides the suitability of the petroleum product, biodiesel, or fraction in its intended application. The distillation limits for the product of interest can also be identified. ASTM D1160 is beneficial to the petroleum industry due to many applications.

Pressure		Range of Temperatures,° C	
kPa	mm Hg	*n*-tetradecane	*n*-hexadecane
0.13	1.0	78.9 to 81.9	104.3 to 107.6
0.67	5.0	106.4 to 109.4	133.1 to 136.4
1.34	10.0	120.2 to 123.2	147.5 to 150.8
2.7	20.0	135.5 to 138.5	163.3 to 166.7
5.3	40.0	152.5 to 155.5	181.1 to 184.4
6.7	50.0	158.3 to 161.3	187.2 to 190.6

Table 1 (above) Distillation temperatures for *n*-tetradecane and *n*-hexadecane [1]

The boiling point ranges for two products are displayed in Table 1. The pressure of the system is shown in both kilopascals and millimeters of mercury. The boiling point of both *n*-tetradecane and *n*-hexadecane increase with the increasing pressure. The table validates the benefits of vacuum distillation.

Atmospheric Equivalent Temperature

Vacuum distillations evaluates the boiling point ranges for chemicals at lower than atmospheric pressure. The boiling point ranges determined can find the atmospheric equivalent temperature (AET). AET is the expected distillate temperature if distillation occurred at atmospheric pressure. Figure 3 showcases the equations used to calculate the AET. The value depends on the observed temperature and operating pressure of the system under vacuum conditions. The boiling point ranges for petroleum products that surpass the instrument's temperature limits can still be determined. Additionally, the AET of materials that undergo thermal decomposition at high temperatures can be calculated. The equations as per ASTM D1160 improve the versatility of the VDS5000 and display the advantages of vacuum distillation.

Figure 3 (below) The equations used to calculate atmospheric equivalent temperature (AET).

$$AET = \frac{748.1A}{[1/(T+273.1)]+0.3861A-0.00051606} - 273.1 \quad \text{(A7.1)}$$

where:

AET = atmospheric equivalent temperature, °C, and
T = observed vapor temperature, °C.

$$A = \frac{5.143222 - 0.972546 \log_{10} P}{2579.329 - 95.76 \log_{10} P} \quad \text{(A7.2)}$$

where:

P = operating pressure, kPa, (operating pressure ≥0.266 kPa), or

$$A = \frac{5.994295 - 0.972546 \log_{10} P}{2663.129 - 95.76 \log_{10} P} \quad \text{(A7.3)}$$

where:

P = operating pressure, mm Hg (operating pressure ≥2 mm Hg).

References

ASTM D1160-18, Standard Test Method for Distillation of Petroleum Products at Reduced Pressure, ASTM International, West Conshohocken, PA, 2018

News, Petro Industry. "Cutting Edge Petroleum Distillation System Ensures Simple, Safe and Reliable Compliance with ASTM D1160." *Petro Online*, 2 June 2021.