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Fuels for Calibration of Fuel Flowmeters

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Approximately two years ago, a contract was signed between Bendix Aviation Corporation and St. Ambrose College of Davenport, Iowa, initiating the Student Industrial Research Program.

For the past nine months, in conjunction with this program, work has been done on the project entitled "Fuels for Calibration of Fuel Flowmeters."

It is a known fact that in calibrating any measuring device, it is necessary to use a standard reflecting the properties of the material to be measured in service. Specifically, we are concerned with aviation fuel flowmeters. It has recently become apparent that some jet fuels in current production depart from the calibrating standards now in force at Pioneer-Central Division of Bendix. An awareness of this fact led to the initiation of this project.

In calibrating a fuel flowmeter, the physical properties of the fuel, namely, specific gravity and viscosity, must be accurately controlled. Temperature variation does not affect the calibration due to temperature compensators within the sealed system.

In order to determine the most advantageous values of specific gravity and viscosity, it was necessary to obtain samples of these fuels from oil companies all over the world. In view of this, the investigation was divided into two phases; the first concerning domestic fuels, and the second concerning foreign fuels.

DOMESTIC FUELS

It was believed that the type of fuels most abundantly produced would yield the best results. For this reason, JP-4 and Aviation Kerosene were chosen, and, as an afterthought, JP-5 was also included due to its increasing popularity.

Upon studying report listings of properties of crude oils pumped from different wells, it became evident that they were not all the same. In fact, they formed a pattern according to location. Therefore, in requesting samples——data as to company specifications and geographic location of refinery were also requested. (fig. 1)

Each sample that was received was tested according to A.S.T.M. standard procedures for determination of specific gravity and viscosity.

In determining the specific gravity of a fuel sample, a specific gravity balance similar to the Becker Westphal type was used. (fig. 2) It is accurate to $\pm .01°$ API within the temperature range

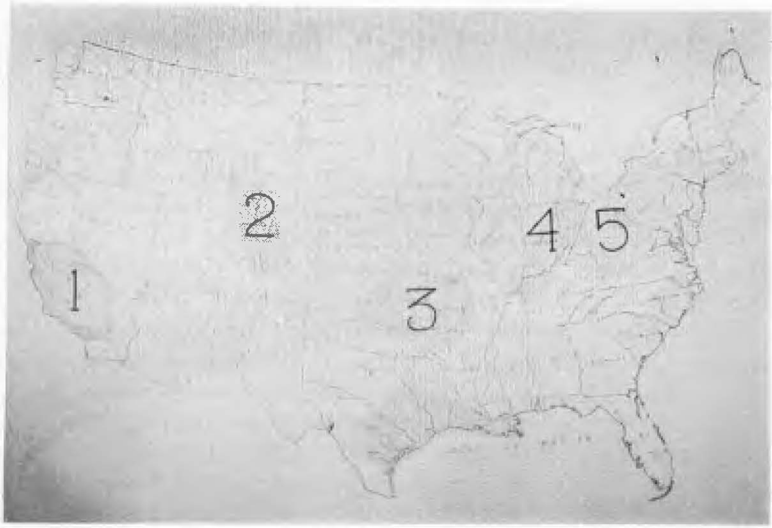

Figure 1.

of 15° to 30° C. Using an oil gravity computor, the specific gravity values at temperature (T) were adjusted to values at 60° F. and measured in units of ° API.

In determining the viscosity of various samples, a Cannon Fenske Viscometer of the type prescribed for transparent liquids was used. (fig. 3) These viscometers are accurate to the ±.001 centistokes within the range defined in A.S.T.M. standards according to the

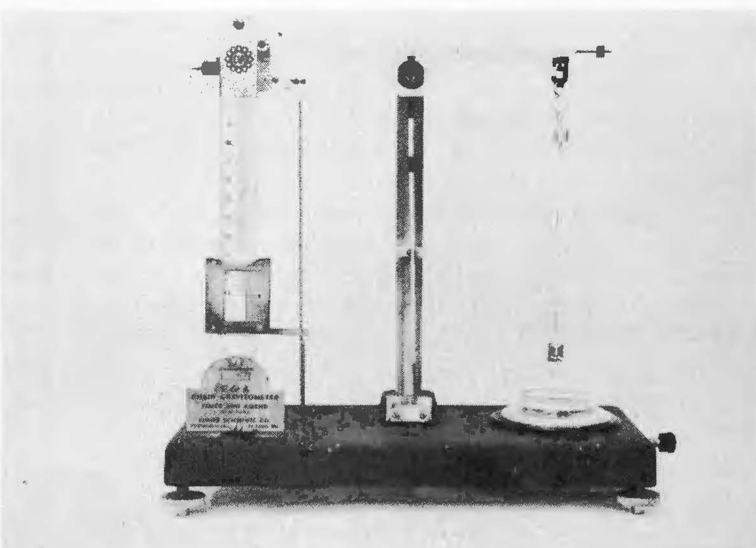

Figure 2.

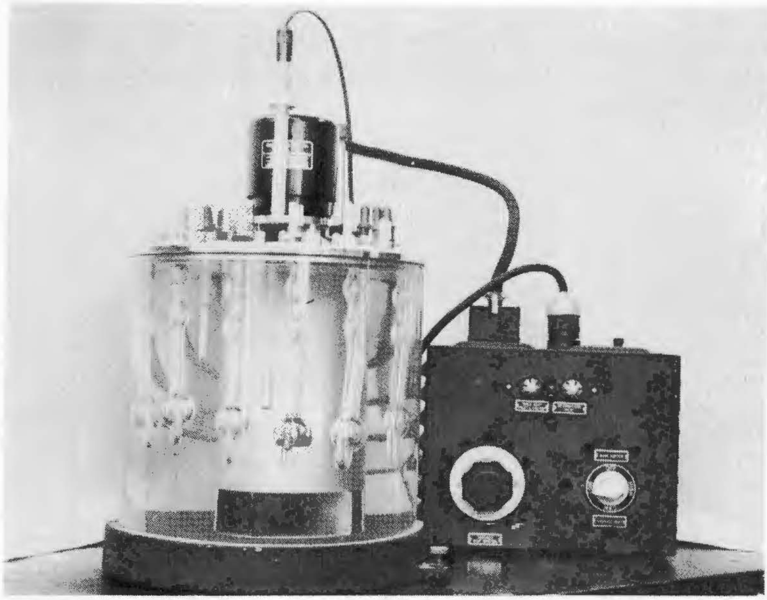

Figure 3.

inner diameter of the capillary tube. Determinations of the kinematic viscosity were made at 100° F., 70° F., and, when possible, at −65° F. as a check. These values were plotted on A.S.T.M. standard kinematic viscosity charts.

The data compiled through testing of samples was then correlated according to the oil producing areas from which they originated. There are five of these general areas; each having a definite variation in physical properties of their product.

Let us first consider the specific gravity of the samples. Each sample was tested in the prescribed manner and data was recorded. At the completition of the first phase, data was correlated and formulated as shown on the chart. The minimum and maximum are shown for each section along with the average value for each section. From this data, the average of the overall values was determined.

This procedure was carried out for all three types of fuels; Kerosene, JP-4, and JP-5. (fig. 4) The values for the maximum, minimum, and average of these are indicated in the following tables.

At the present time, there are company specifications on JP-4 and JP-3 Jet Fuels. There are approximately 52° API and 50° API respectively.

Next let us consider the kinematic viscosity of the fuels. The Military specification for JP-5 is 16.5 C_s at —30° F. as a maximum.

There are no specifications for JP-4 or Kerosene. Pioneer-Central Division carries specifications on JP-4 and JP-3 of .964 at 100° F. The values for the various areas indicated on the map are shown in the following tables:

Table 1
Aviation Kerosene

Sect.	Max.	Min.	Average	
1.	43.8	43.2	43.5	
2.	45.15	44.00	44.00	
3.	43.59	40.05	42.90	
4.	45.98	43.25	44.88	
5.	46.1	41.42	43.60	
Total	46.1	40.05	43.80	31 Fuels

Table 2
JP-4 Jet Fuel

Sect.	Max.	Min.	Average	
1.	49.11	49.00	49.05	
3.	54.59	50.73	52.6	
4.	55.99	50.88	54.2	
5.	56.11	46.70	53.60	
Total	56.10	46.75	52.80	30 Fuels

Table 3
JP-5 Jet Fuel

Sect.	Max.	Min.	Average	
5 + 3	43.59	41.01	42.20	
Total	43.59	41.01	42.20	12 Fuels

Table 4
Kinematic Viscosity, Western Section

Sect. 1	Kerosene	JP-4	JP-5
Maximum	1.76 at 100° F.	.908 at 100° F.	——
Maximum	.828 at 100° F.	.828 at 100° F.	——
Average	1.70 at 100° F.	.895 at 100° F.	
			14 Fuels

Table 5
Kinematic Viscosity, Rocky Mountain Area

Sect. 2	Kerosene	
Maximum	1.46	
Minimum	1.40	
Average	1.43	8 Fuels

Table 6
Kinematic Viscosity, South, Central, & Gulf Area

Sect. 3 & 3b	Kerosene	JP-4	JP-4 Ref.	JP-5
Maximum	2.01	.880	1.19 at 100° F.	1.78
Minimum	1.54	.816		1.62
Average	1.60	.850		1.69
				23 Fuels

Table 7
Kinematic Viscosity, Middle Eastern Area

Sect. 4	Kerosene	JP-4	
Maximum	2.131	.966	
Minimum	1.441	.764	
Average	1.56	.801	16 Fuels

Table 8
Kinematic Viscosity, Eastern Area

Sect. 5	Kerosene	JP-4	JP-5	
Maximum	1.688	1.01	1.55	
Minimum	1.509	.72		
Average	1.55	.88		12 Fuels

Table 9
Overall Values in Viscosity

Sect.	Kerosene	JP-4	JP-5
Maximum	2.831—Texas	.960	Tex. 1.768
Minimum	1.441—Ill., Penn.	.735	Penn. 1.55
Average	1.59	.850	1.59

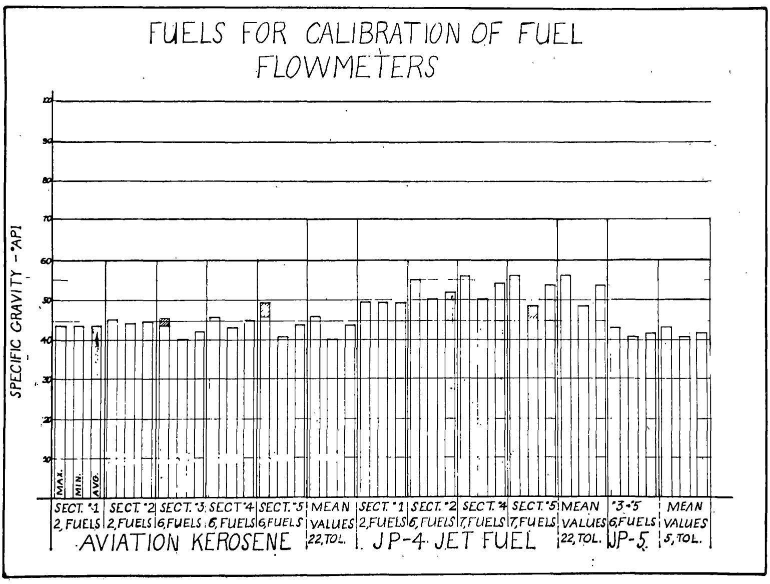

Figure 4.

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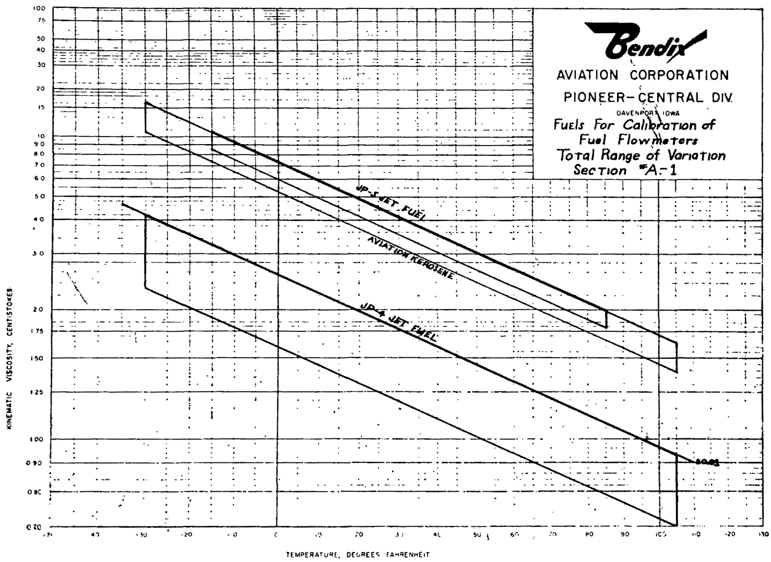

Figure 5.

These results, in addition to producing valuable data, show that the properties of the crudes carry over into their distillates.

For example, Texas has a high viscosity and specific gravity crude. The data collected shows that this property carries over into its distillates.

In view of the fact that the Texas area is the largest oil producing area in the United States, it may be expected that the mean average of the values of these properties would be correspondingly high.

At this point, it is possible to make only a tentative proposal as to the values that should be adopted as company specifications. (fig. 5) These values are shown in Table X.

Table 10
Proposed Specifications

Fuel	Viscosity	Specific Gravity
Kerosene	1.59 at 100° F.	43.80° API
JP-4	.850 C_s at 100° F.	52.80° API
JP-5	1.50 C_s at 100° F.	42.2° API

Foreign Fuels

The second phase of this investigation is now in progress. However, at the present time, there are no conclusive results that can be presented.

At some later date, perhaps, the final results of this investigation may be made available.

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