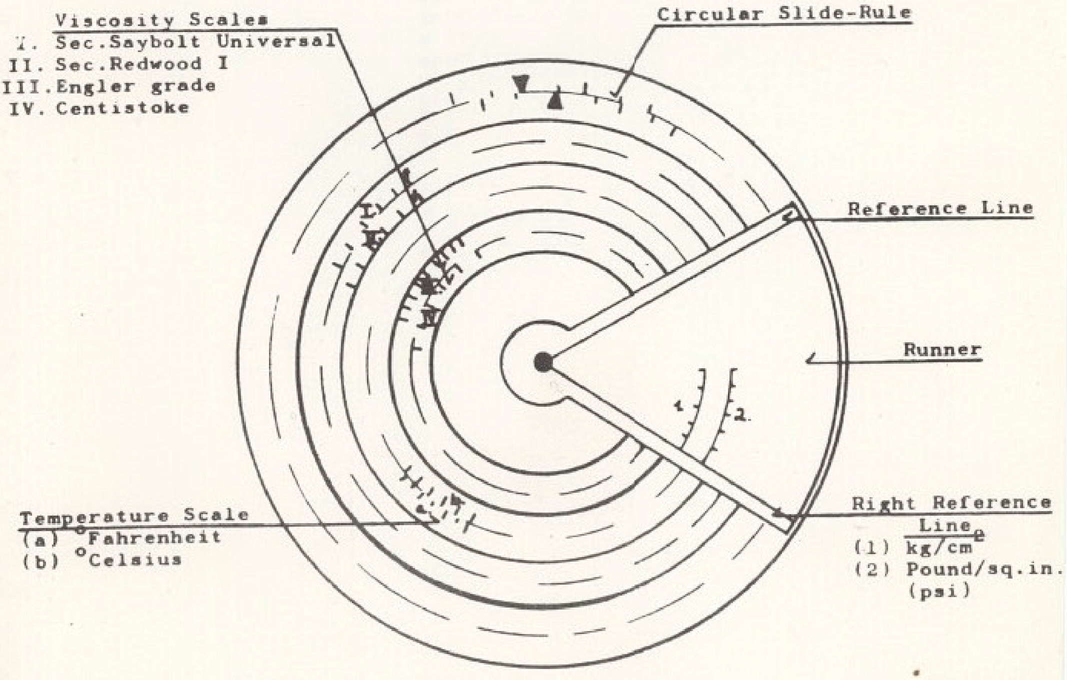
Instructions on the Use of the Viscosity Calculator

This viscosity calculator shows the relationship between different viscosity measuring systems at given temperatures. It has been prepared on the basis of products with a viscosity index of 70 to 80 which have been derived from Middle-East crudes. Moreover, it is especially useful in determining preheating temperatures for oils of any particular viscosity.

On the reverse side of the calculator a table shows the relationship of weights to volumes.

Furthermore, its accuracy is sufficient for the every-day temperature-viscosity calculations that are required when dealing with distillates, residuals, and luboils of different origins and molecular structures.

Description:



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I. Conversion of a given viscosity from any one scale to the other three.

(a) At same temperatures.

Set the left reference line of the runner on the given viscosity.

Read on the other viscosity scales below the left reference line the given viscosity converted into other scales.

Example: Given viscosity:	4000 Sec.Saybolt Univ.	(Scale I)
Read :	3500 Sec.Redwood I	(Scale II)
	113°Engler	(Scale III)
	860 cSt	(Scale IV)

(b) At different temperatures.

Set the left reference line of the runner on the given viscosity and bring the relevant temperature under this line by turning the transparent disc. Without changing this setting,

read under the left reference line of the runner which is moved to the desired temperature reading, the viscosities on the other scales.

Example: Given viscosity:	1500 Sec.Redwood I at 100°F (Set Scale II above Scale A)	
Read :	at 122°F(A)	840 SUS (Scale I)
	at 50°C(B)	24°Engler (III)
	at 20°C(B)	182°Engler (III)
	at 50°C(B)	180 centistokes(IV)
	at 20°C(B)	1400 centistokes(IV)

II. Determination of the temperature to which oils must be heated to achieve desired viscosities.

(a) Burning Fuels.

Set the left reference line of the runner on the viscosity given in the delivery certificate and bring the relevant temperature under this line by turning the transparent disc. Without changing this setting.

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read under the left reference line of the runner which is moved to the desired viscosity reading at the burner, the relevant temperature.

Example:	Viscosity as per delivery certificate 3500 Sec.Redwood I/100°F (Scales II and A)		
	Average viscosity required at the burner	4.00°Engler	(III)
	Required temperature	106°C	(B)

Note: Average viscosity at the burner:
4 to 7°E rotary atomizing burner
2 to 4°E pressure atomizing burner

(b) Combustion Fuels.

Proceed as in II (a) above under set and then

read under the right reference line of the runner which has been moved to the viscosity required at the injector, the relevant temperature at atmospheric pressure. Relevant temperatures at higher pressures can be read directly under the runner without its being moved. Note that since viscosity increases with pressure temperature must also be increased if viscosity is to remain constant.

Example:	Viscosity as per delivery certificate 1500 Sec.Redwood I/100°F (Scales II and A)		
	Required viscosity at injector	2.5°Engler	(III)
	Required temperature without taking into consideration the injection pressure	110.5°C	(B)
	Injection pressure	200 kg/cm²	(1)
	Required temperature under consideration of the injection pressure	118°C	(B)

III. Conversion of temperatures.

The values indicated on the temperature scales (A and B) correspond with each other and consequently conversions from one scale to another can be read directly between -20°C and 200°C.

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Example:			
	$100^{\circ}C$	=	$212^{\circ}F$
	$50^{\circ}C$	=	$122^{\circ}F$
	$0^{\circ}C$	=	$32^{\circ}F$
	$100^{\circ}F$	=	$37.8^{\circ}C$
	$60^{\circ}F$	=	$15.6^{\circ}C$

IV. Conversion of pressures.

The values indicated on the pressure scales (1 and 2) of the runner also correspond with each other and consequently the conversions can be read directly.

Example: 300 kg/cm^2 = 4,270 lb./sq.in. (psi)

V. Determination of the temperature required for pumping.

The average viscosity for pumping should not exceed 4000 Sec.Saybolt Universal (= 3500 Sec. Redwood I = 113°Engler = 860 cSt).

Set the left reference line of the runner on the given viscosity as per delivery certificate and bring the oil's temperature under this line by turning the transparent disc.
Without changing this setting, move the left reference line of the runner to the "Pump Visc." mark at the edge of the Saybolt viscosity scale and

read the relevant temperature. It is the minimum temperature required for pumping.

Example: Viscosity as per delivery certificate 30°Engler at 50°C (Scales III and B)
Minimum required pumping temperature 30°C

VI. If viscosity is given in Saybolt Furol Sec. (SFS), multiply this value by 10 to get the value of Saybolt Universal Sec. to within 1% accuracy. Values in other viscosities might then be determined as in I, II and V above.

Example: 269 SFS = 2,666 SUS

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VII. <u>Viscosities of mixtures.</u>

If a mixture requiring a specific viscosity is to be blended from two oils of different viscosities, we can use this calculator to determine the percentages of each oil to be used. Viscosities must be expressed in the same scale and at the same temperature.

Set	the left reference line of the runner on the viscosity of the heavier oil and bring 0°centigrade under this line by turning the transparent disc. Without changing this setting,
read	under the left reference line of the runner which is moved to the viscosity of the lighter oil the centigrade temperature. This temperature should then be noted. Then
set	the left reference line of the runner on the viscosity of the desired temperature and bring 0 centigrade below this line. Without changing this setting,
read	under the left reference line of the runner which is again moved to the viscosity of the lighter oil, the centigrade temperature.
	The difference between these two temperatures is to the higher temperature as the percentage of the lighter oil is to the total oil mixture.

<u>Example:</u> Oil I : 3500 Sec.Redw.I (at 100°F)
Oil II: 35 Sec.Redw.I (at 100°F)
Desired viscosity of the mixture:1500"Redw.I(at 100°F)

(a) If 0 centigrade is set on 3500 Sec.Redwood I, then <u>144.2°cent</u> appears at 35 Sec.Redw. I.
(b) If 0 centigrade is set on 1500 Sec.Redwood I, then <u>128.4°cent</u> appears at 35 Sec.Redw. I.

From the relationship (144.2 - 128.4) : 144.2 = x : 100 we compute the percentage of the lighter oil as being 11 % and consequently the heavier oil will be 89 %.

If a luboil is contaminated by fuel, the percentage of fuel can be determined as above.

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VIII. <u>Determination of weights and volumes of oils.</u>
(Reverse side of calculator.)

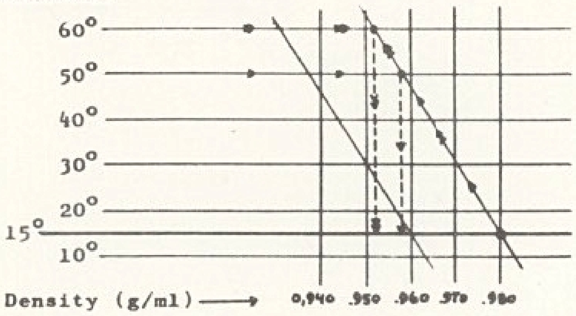
(a) <u>Weight and volume relationship of petroleum products at 60°F.</u>

This table which is self-explanatory is based on the Petroleum Measurement Tables Nos. 3 and 56 of the American Society for Testing Materials (ASTM) and the Institute of Petroleum (IP).

(b) <u>Changes in density and temperature.</u>

With the help of the diagram in the middle of the disc the relationship between density change and temperature can be determined.

<u>Example:</u>



Density (g/ml) 0.980 at 15°C corresponds to: 0.958 at 50°C 0.952 at 60°C

(c) <u>Instructions on the determination of the weight in the air of mineral oils from volume and density for fiscal purposes.</u>

For the determination of the weight in the air for fiscal purposes the volume in litres is multiplied by the weight in the air in kilos per litre (kg/l) at the same temperature. The weight in the air is the weight determined in the atmosphere by means of a scale using weights. The air buoyancy on the weights and the mineral oil is to be considered by means of an average adjustment factor of 0.0011.

Density ./. 0.0011 = weight in the air in kg/l

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*) "Instructions on the determination of the weight in the air of mineral oils from volume and density for fiscal purposes" published by the Federal Minister of Finance, Bonn, 1961.

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For each volume measured in the tank the relevant weight in the air can easily be determined by setting the density, which has been determined at the temperature measured in the tank, less 0.0011 on the outer circular slide-rule (front of calculator).

Example:	Density as per delivery certificate (g/ml) 0.980 at 15°C	
	Volume measured in the tank: 150 m^3 at 50°C	
	Density converted as per diagram at 50°C	0.9580
	less	0.0011
	Weight in the air	0.9569
	150,000 x 0.9569 = 143,500	

(d) Conversion of density.

By means of the factor "kilograms per litre" and the figures on the reverse side of the calculator (outer table) conversions can be done from any density at 15°C to specific gravity at 60/60°F, or API grades.

Example:	Specific Gravity 60/60°F	0.9861
	Kilograms per litre	0.9844
	Density at 15°C=(0.9844+0.0011)	0.9855

All values in between which are not included in this table can be determined by means of interpolation. In the inner circle on the reverse side are given some additional conversion factors.

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