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Revision Memo

12/01 Minor editorial changes only.

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SCOPE

This section presents thermal and physical properties of fuels and flue gas for use in heat transfer and pressure drop calculations. Some of these charts have been reprinted from the Esso Blue Book.

REFERENCES

Exxon Blue Book, EMRE Manual Nos. 012 and 011

API Research Project Number 44

DISCUSSION OF COMBUSTION DESIGN FIGURES

LIQUID FUELS

Figures 1A and **1B** give the heat of combustion of fuel oils and petroleum fractions as a function of API gravity or density. Both the higher (HHV) and lower (LHV) heating values are shown. These values have been corrected for the effect of the average impurities (other than water) which are usually found in liquid fuels. These average impurities are fairly representative, although there may be appreciable deviations for any given fuel. In general, the heating values of average fuel oils are within 1% of the values obtained from the curves.

Figures 4A, 4B, 5A, 5B, 6A and **6B** give the heat available from combustion at 60°F (15°C) of fuel oils of 5° API (1050 kg/m³), 10° API (1000 kg/m³) and 15° API (950 kg/m³), respectively. Since these charts differ very slightly from one another, interpolation is unnecessary. The available heat at any given temperature and given percent excess air may be read from the figure for the fuel oil whose gravity most nearly corresponds to that of the fuel oil in question. If the impurities are known to be appreciably different from those of the average fuels in **Figures 1A** or **1B**, the available heat may be corrected in direct proportion to the hydrocarbon portion of the fuel, with sulfur considered as inert material.

GASEOUS FUELS

Figures 2A and **2B** give the heat of combustion of paraffinic and olefinic gases as a function of molecular weight. Heat of combustion of the pure components usually found in fuel gases are shown in the table below.

HEAT OF COMBUSTION AT 77°F, Btu/lb (25°C, MJ/kg) *		
COMPONENT	HHV	LHV
Hydrogen	61,000 (142.0)	51,600 (120.0)
Carbon Monoxide	4,300 (10.0)	4,300 (10.0)
Hydrogen Sulfide	7,500 (17.4)	6,900 (16.0)
Methane	23,900 (55.6)	21,500 (50.0)
Ethane	22,300 (51.9)	20,400 (47.4)
Ethylene	21,600 (50.2)	20,300 (47.2)
Propane	21,600 (50.2)	19,900 (46.3)
Propylene	21,000 (48.8)	19,700 (45.8)
Butane	21,300 (49.5)	19,700 (45.8)
Butylene	20,800 (48.4)	19,500 (45.4)

Note:

* From API Research Project 44.

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DISCUSSION OF FIGURES (Cont)

Figures 7A through **10B** show the heat available from combustion at 60°F (15°C) of gaseous fuels of various heat values. These curves represent typical refinery fuels which are mixtures of H₂, hydrocarbons and inerts. They do not represent mixtures that are essentially pure hydrocarbons (i.e., natural gas). For other fuels, heat available curves can be calculated by use of Computer Program 3558.

PROPERTIES OF FLUE GAS

Figures 3A and **3B** give the enthalpies of flue gas components. **Figures 11A** and **11B** give the weight of flue gas per weight of fuel as a function of percent excess air. **Figure 12** gives the flue gas oxygen percentage on a wet basis as a function of percent excess air. **Figure 13** provides for conversion from percent oxygen on a wet basis to a dry basis for fuel oil and gaseous fuels.

The effect of percent excess air on the physical properties of flue gas is understandably very slight. Therefore, it has been neglected in **Figures 14A** and **14B**, which give viscosities and thermal conductivities of flue gas as a function of temperature alone.

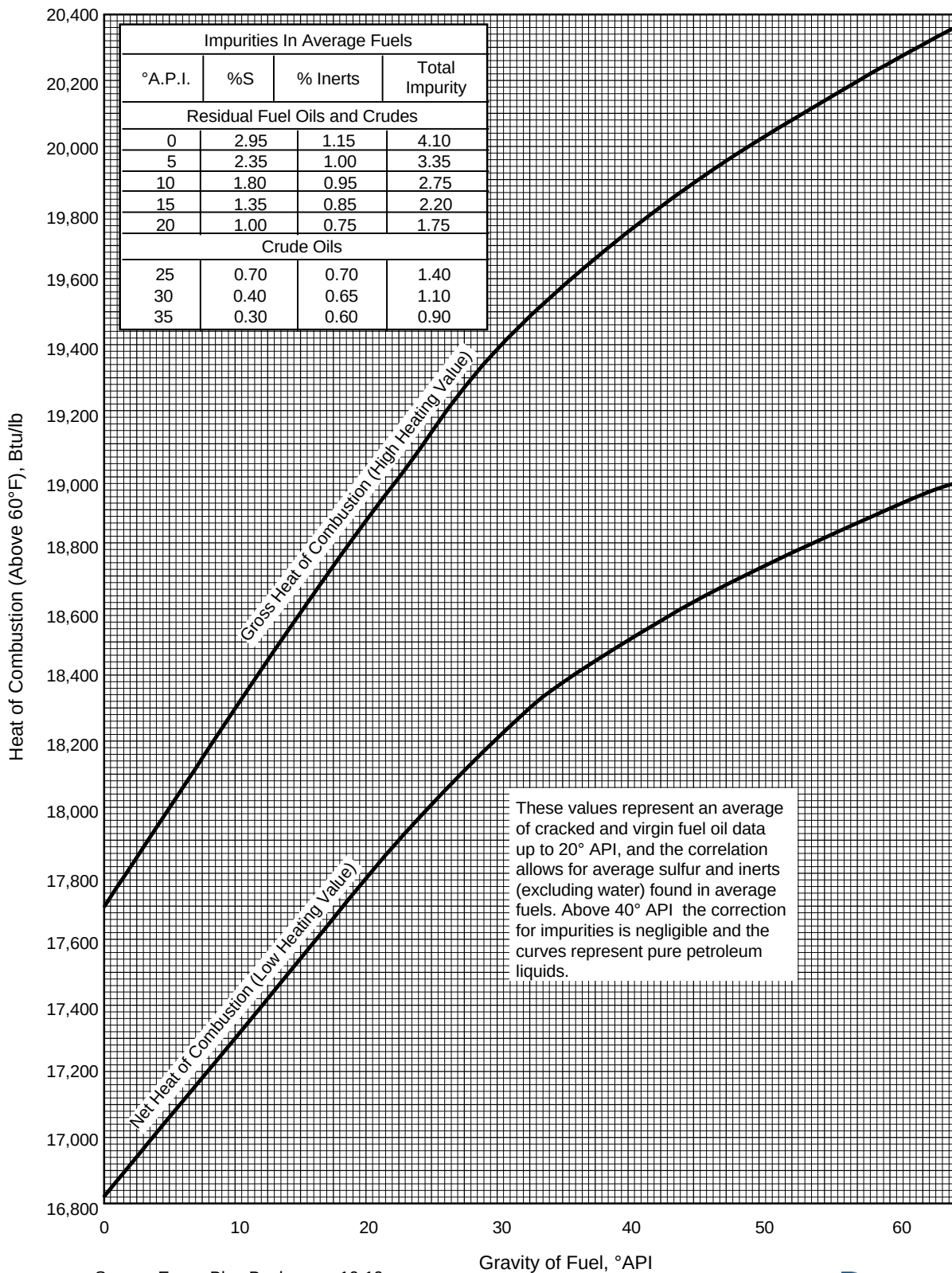


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FIGURE 1A
HEAT OF COMBUSTION OF FUEL OILS AND PETROLEUM FRACTIONS (CUSTOMARY UNITS)



Source: Exxon Blue Book, page 10-10

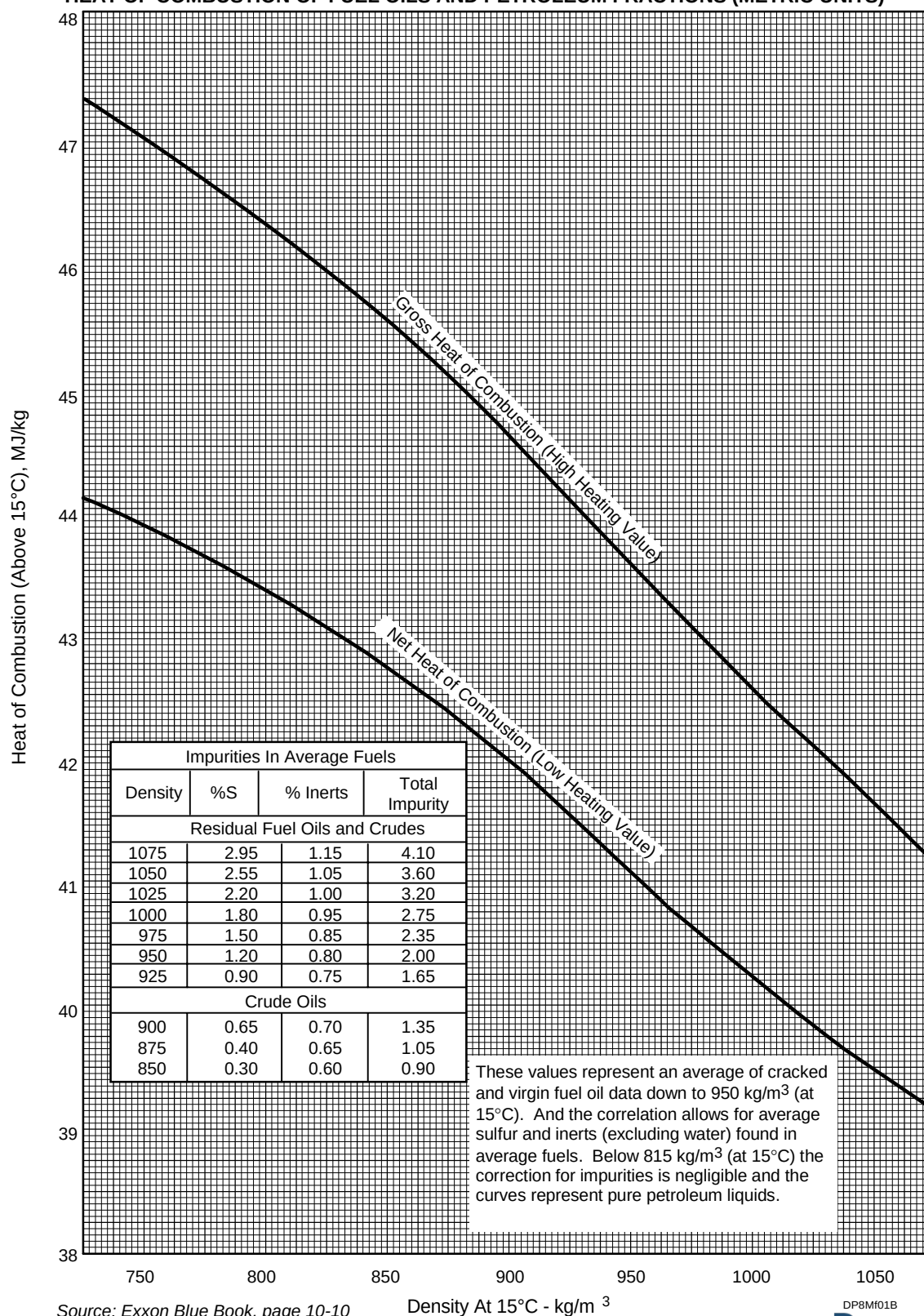
Gravity of Fuel, °API


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FIGURE 1B
HEAT OF COMBUSTION OF FUEL OILS AND PETROLEUM FRACTIONS (METRIC UNITS)



Source: Exxon Blue Book, page 10-10

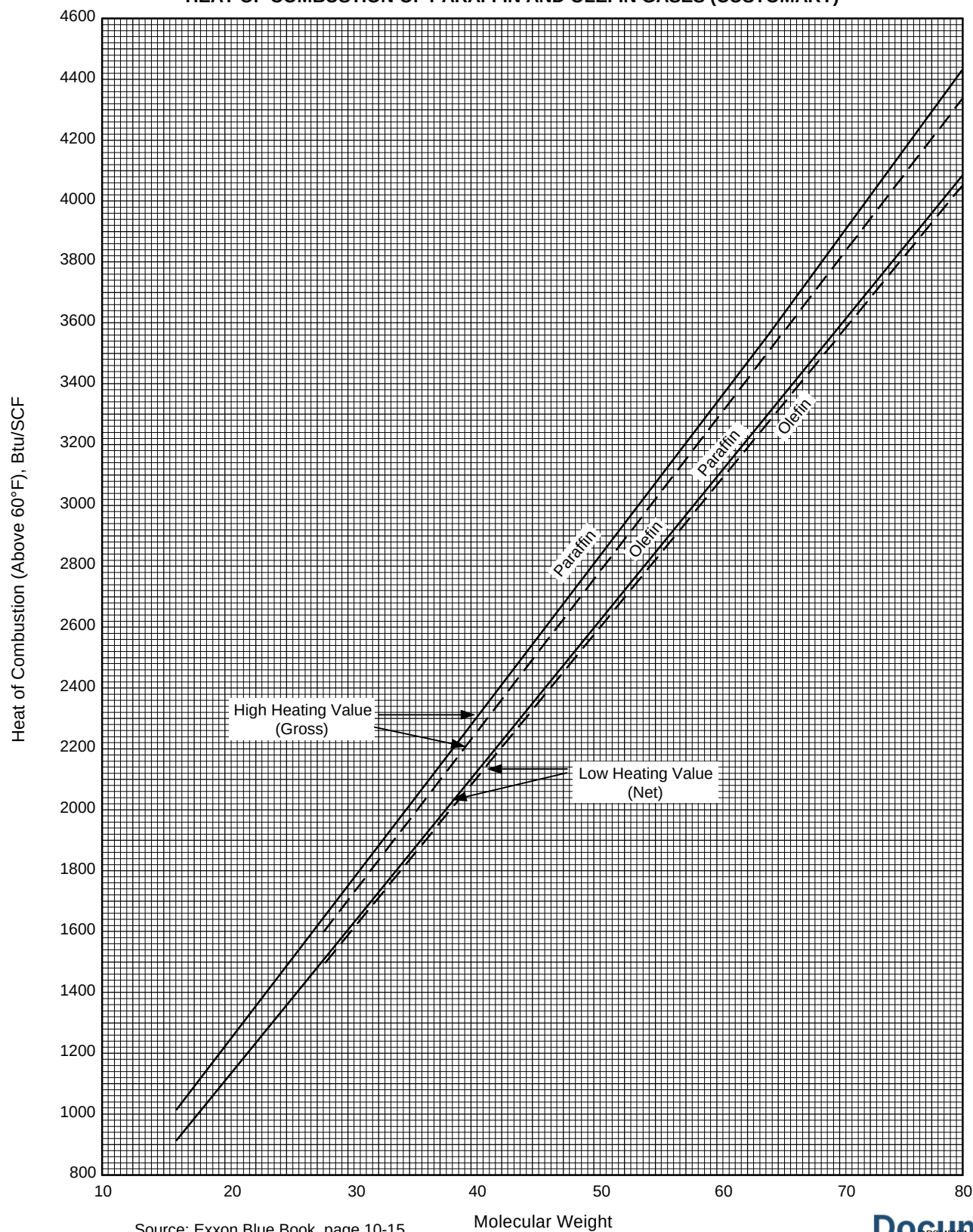
Density At 15°C - kg/m³

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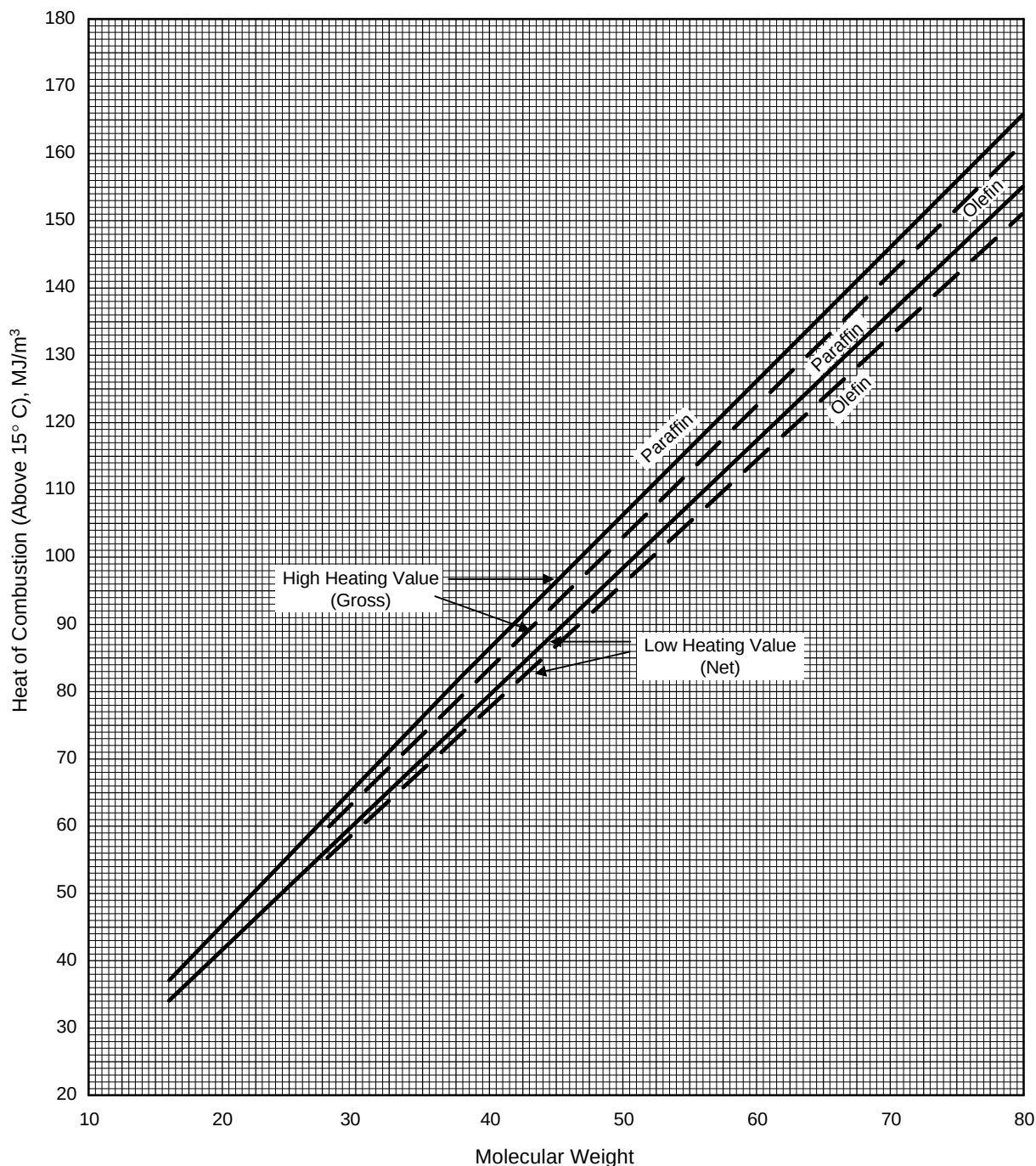
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FIGURE 2A
HEAT OF COMBUSTION OF PARAFFIN AND OLEFIN GASES (CUSTOMARY)

Source: Exxon Blue Book, page 10-15

Molecular Weight

FIGURE 2B
HEAT OF COMBUSTION OF PARAFFIN AND OLEFIN GASES (METRIC)



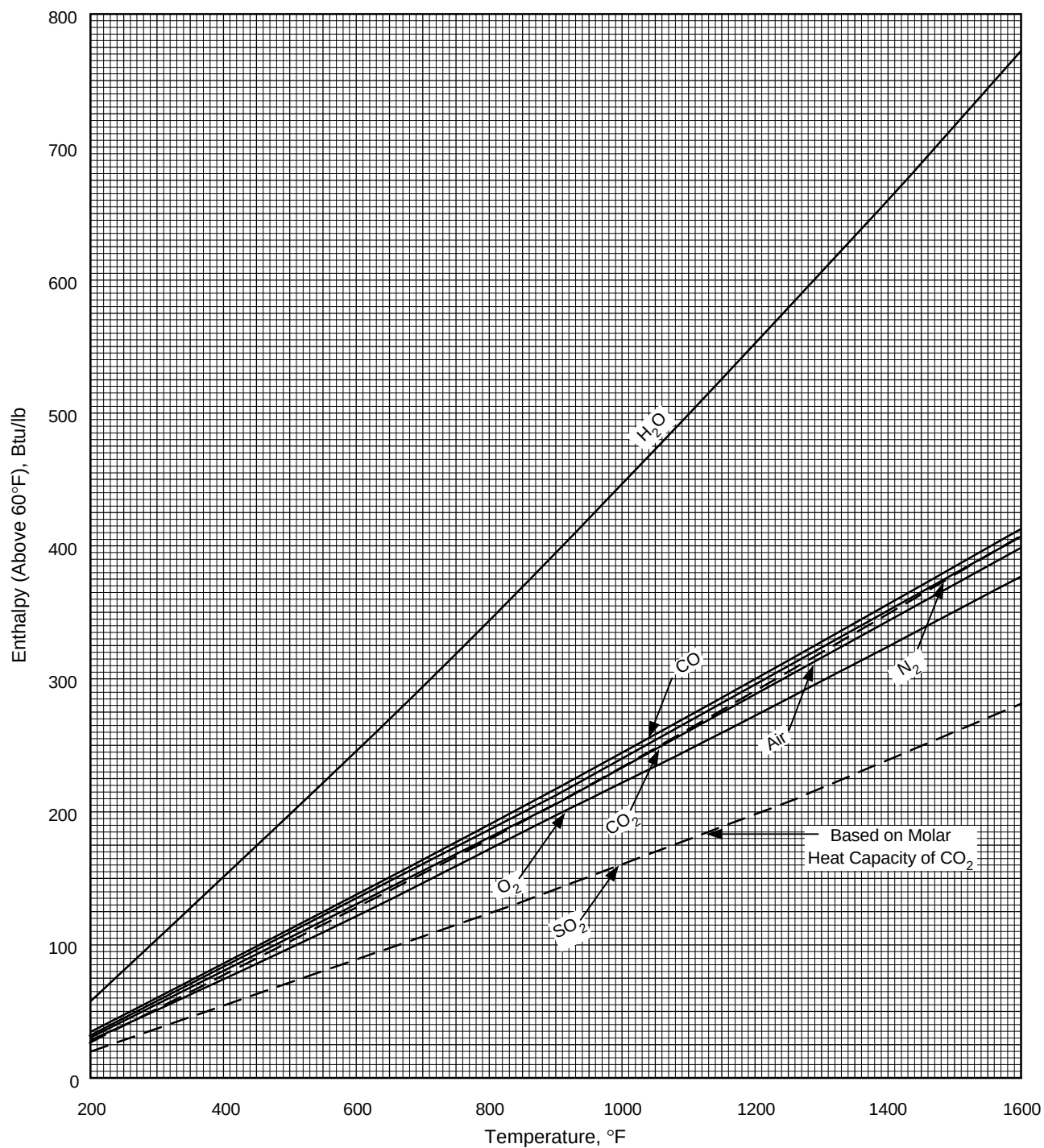
Source: Exxon Blue Book, page 10-15

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FIGURE 3A
ENTHALPY OF FLUE GAS CONSTITUENTS (0 TO 1 ATM) (CUSTOMARY)

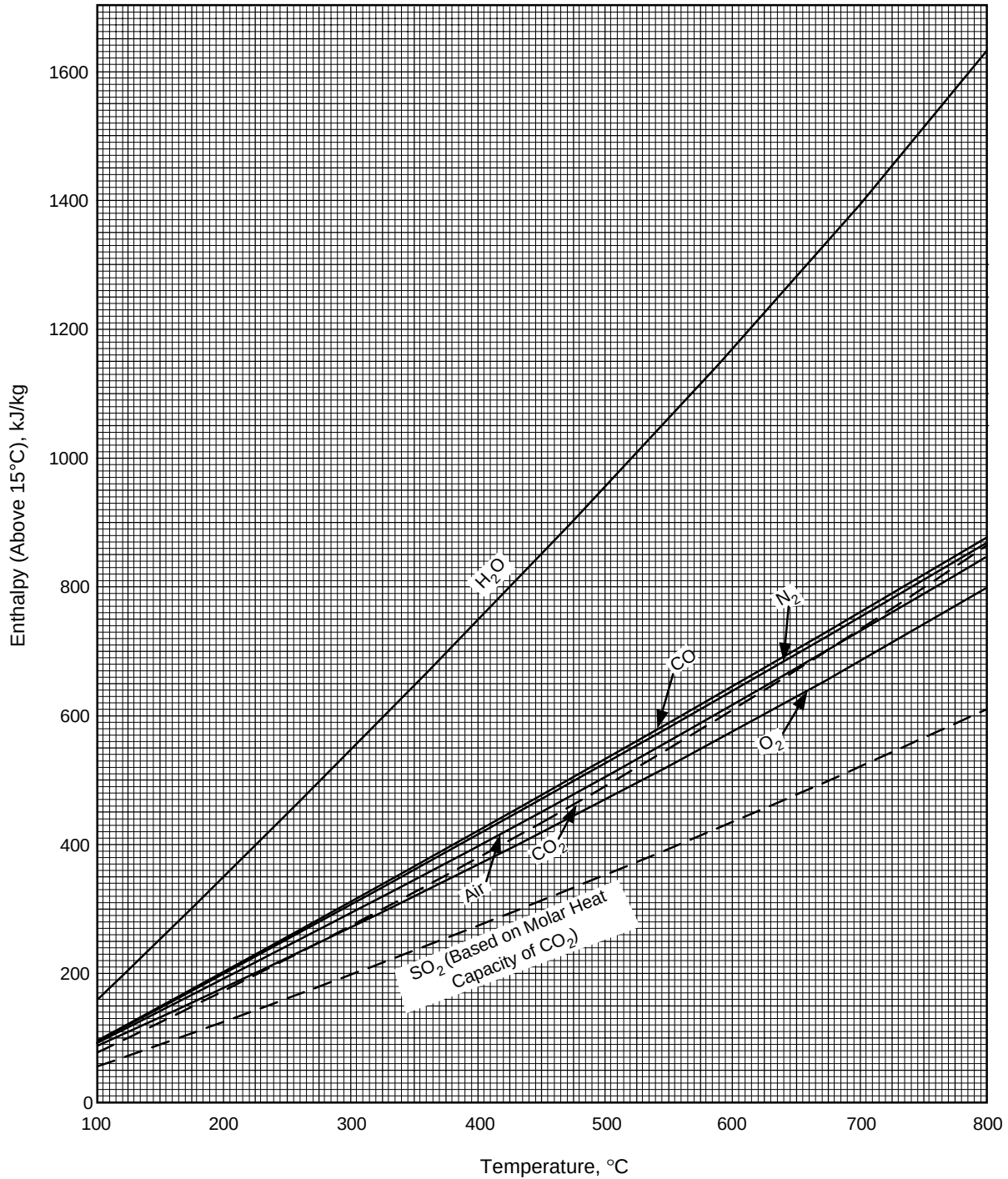


Source: Exxon Blue Book, page 10-20 and 10-21 (for higher temperature range).

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FIGURE 3B
ENTHALPY OF FLUE GAS CONSTITUENTS (0 - 100 kPa) (METRIC)



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Source: Exxon Blue Book, page 10-20 and 10-21 (for higher temperature range).