













# ENGINEER'S REFERENCE FOLDER

- PETROLEUM
- REFINING
- PETROCHEMICAL
- CHEMICAL ENGINEERING





# **PREFACE**

This folder is prepared mainly for two groups of readers:

- 1. Petroleum and Chemical Engineering students
- 2. Chemical engineers whose major interest is gas and petroleum production, refining and processing operations

The folder provides well-organized technical data in form of tables, charts and diagrams, indispensible for a chemical engineer.

The preparation of the folder was a joint effort of WR Training engineers who compiled data, charts and diagrams for which they were especially qualified and possess valuable experience.

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**WR Training** 



- A PHYSICAL CHARACTERISTICS OF PURE SUBSTANCES
- VAPOR PRESSURE
- PHYSICAL PROPERTIES OF WATER AND STEAM
- SPECIFIC HEAT
- ENTHALPY
- VISCOSITY
- THERMAL CONDUCTIVITY
- DENSITY OF LIQUIDS
- BEHAVIOUR OF GASES AND COMPRESSION
- LIQUID / VAPOR EQUILIBRIUM
- **COMBUSTION**
- FLUID DYNAMICS
- **W** CENTRIFUGAL PUMPS
- MEAT TRANSFER AND HEAT EXCHANGERS
- COMPRESSORS
- PROPERTIES RELATIVE TO THE PETROLEUM CUTS
- O DISTILLATION, ABSORPTION AND STRIPPING
- SAFETY
- **CONVERSION TABLES**



- A PHYSICAL CHARACTERISTICS OF PURE SUBSTANCES
  - Periodic table of elements
  - Physical characteristics of hydrocarbons, sulfur, nitrogen, and oxygen compounds
  - Physical characteristics of pure substances
- WAPOR PRESSURE
  - Vapor pressure of some hydrocarbons, ethanol and water
  - Vapor pressure using Antoine's equation
  - Hydrocarbon vapor pressure curves
  - Correlation between Reid Vapor Pressure (RVP) and True Vapor Pressure
  - Vapor pressure curves of some solvents
  - Vapor pressure curves of some chemical compounds
  - Vapor pressure curves of some sulfur compounds
  - Vapor pressure Harlacher coefficients
  - Vapor pressure curves for aromatic hydrocarbons
  - Vapor pressure curves for acrylic and methacrylic acids and derivated esters
  - Vapor pressure curve of ammonia
  - Vapor pressure curves of methanol and ethanol



- PHYSICAL PROPERTIES OF WATER AND STEAM
  - Vapor pressure and enthalpy for saturated water and steam
  - Vapor pressure of water
  - Water latent heat of vaporization variation with temperature
  - Enthalpy of pressurized liquid water
  - Density of saturated liquid water and steam
  - O Density of steam
  - Mollier chart for steam
- SPECIFIC HEAT
  - Molar specific heat of ideal gases
  - Specific heat of liquid hydrocarbons
  - Specific heat of gaseous hydrocarbons and some gases at atmospheric pressure
  - Mass specific of gaseous petroleum cuts at atmospheric and vacuum conditions
  - Molar specific heat correction as a function of reduced pressure and temperature
  - **6** Average molar heat for some gases
  - Determining molar heat for liquids at 20°C using the contribution group method



# ENTHALPY

- Introduction to the Maxwell enthalpy diagram
- Enthalpy diagram of methane, ethane and propane
- Enthalpy diagram of iso-butane, n-butane and iso-pentane
- Enthalpy diagram of pentane, hexane and heptane
- Mollier diagram for propane
- Propane enthalpy diagram
- Enthalpy diagram of petroleum cuts
- Enthalpy of O<sub>2</sub> and N<sub>2</sub>
- Enthalpy of H<sub>2</sub>O, CO<sub>2</sub> and SO<sub>2</sub>
- Enthalpy diagram of ethylene
- Enthalpy diagram of propylene
- Enthalpy diagram of iso-butene and 1-butene
- Enthalpy diagram of 2-butene cis and trans
- **1** Enthalpy diagram of benzene
- Enthalpy diagram of toluene
- Enthalpy pressure diagram of R12, CCl<sub>2</sub>F<sub>2</sub>
- Enthalpy pressure diagram of R22, CHCIF<sub>2</sub>
- Standard enthalpy of formation



VISCOSITY
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- Viscosity : Definition and units
- Viscosity of some gases at atmospheric pressure
- Oynamic viscosity of liquid hydrocarbons
- Graphic determination of viscosity of mixture of 2 liquid petroleum products
- Standard viscosity-temperature chart for liquid petroleum products
- Viscosity of mixtures
- Viscosity diagram of heavy fuels n°2
- Calculation of viscosity index
- Viscosity grades for motor lubes
- **Conversion into centistokes**
- Viscosity of some liquids
- Viscosity of liquid chemical products
- Viscosity-temperature chart

G	THERMAL	CONDUCT	<b>CIVITY</b>

- Thermal conductivity of metals
- Thermal conductivity of liquids
- Thermal conductivity of liquid petroleum cuts
- Thermal conductivity liquid pressure correction
- Thermal conductivity in gaseous phase at atmospheric pressure
- Thermal conductivity of gases
- Thermal conductivity gases pressure correction
- Average thermal conductivity of a material under temperature gradient
- Thermal conductivity
- Conduction resistance

# DENSITY OF LIQUIDS

- Specific gravity of liquid organic compounds
- Specific gravity of miscellaneous liquid
- Variation of liquid hydrocarbon specific gravity with temperature
- Expansion coefficient of liquids versus reduced coordinates
- ASTM table extractions
- Concentration and specific gravity of sodium hydroxide solutions



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8	Correction of entropy of ideal gases using Edmister method	
LIQU	ID / VAPOR EQUILIBRIUM	
	Equilibrium coefficients of hydrocarbons – Scheibel and Jenny chart	

Transformation of TBP to ASTM distillation curve – Edmister correlation

Calculation of the atmospheric flash curve starting from the TBP curve

Flash curve under vacuum – TBP correlation using Van Winkle method

Specific gravity of equilibrium liquid and vapor phases

Calculation of the atmospheric flash curve starting from the TBP or ASTM curve

BEHAVIOR OF GASES AND COMPRESSION

Fugacity of methane and ethane

Choice of thermodynamic model

Shift of flash curve – Edmister method



	COMPLICATION
N	COMBUSTION

- Reaction heat and calorific value of pure hydrocarbons
- Fuel oil LHV determination
- Fuel gas LHV determination
- Excess air versus CO<sub>2</sub> content in dry flue gas
- Excess air versus O<sub>2</sub> content in dry flue gas
- Furnace efficiency estimate Case of a fuel gas fired furnace
- Heat transmission in a furnace Black body properties
- Heat transmission in a furnace Emissivity coefficients for material and gases

### FLUID DYNAMICS

- Main characteristics of seamless and welded pipes
- Head losses in straight tubes Friction factors for steel pipes
- Resistance of valves and fittings to fluid flow K values (1/2)
- Resistance of valves and fittings to fluid flow K values (2/2)
- Resistance of valves and fittings to fluid flow Equivalent straight pipe length
- Resistance of valves and fittings to fluid flow Equivalent straight pipe length
- Friction losses in flowmeters
- Correction of flowmeter indications Mass flowrate indication
- Surface tension of some chemical compounds





Baker flow pattern for horizontal pipes

2 phase flow pattern – Upflow in vertical pipes

Orrection of pressure drop with diameter

Gas flow in horizontal pipes based on Lockhart and Martinelli correlation

Liquid and vapor hold-up in horizontal pipe – Lockhart and Martinelli correlation

Friction losses for liquids in 2", 4" and 6" pipes

Control valves : full open Cv

#### CENTRIFUGAL PUMPS

Measurement of head

Typical impeller selection according to K number

Performance correction chart

- M HEAT TRANSFER AND HEAT EXCHANGERS
  - Convection heat transfer coefficients
  - Film coefficient
  - Correction of the heat transfer coefficient with the allowed pressure drop
  - Losses due to convection
  - Heat losses for an insulated pipe
  - Heat insulator : External surface temperature estimate
  - Estimation of the overall heat transfer coefficient
  - Estimation of the overall heat transfer coefficient for water and hydrocarbons
  - Fouling resistance
  - Heat exchanger efficiency : cocurrent and countercurrent
  - Heat exchanger efficiency: countercurrent and 1-n exchangers
  - Heat exchanger nomenclature : TEMA standards
  - Different heat exchangers (from TEMA tables)
  - Exchanger tube standards
  - Surface efficiency
  - Convection coefficient
  - Simultaneous conduction and convection
  - LMTD correction factor (1shell pass, 2 or 2n tube passes)
  - Chart for solving LMTD



COMPDESSORS
COMPRESSORS

- Dynamic and positive displacement compressors : Areas of application
- Centrifugal compressor polytropic efficiency estimation
- Oetermination of isentropic efficiency
- Polytropic coefficient chart
- Reciprocating compressor isentropic and overall efficiency estimation

#### PROPERTIES RELATIVE TO THE PETROLEUM CUTS

- Mean boiling point temperature for petroleum cuts
- Characterization factor (K<sub>IIOP</sub>) for hydrocarbons and petroleum cuts
- Pseudo-critical temperature and pressure for petroleum cuts
- Automotive fuel susceptibility to tetra-ethyl lead
- **5** K<sub>HOP</sub> determination for heavy feeds
- Water solubility in some liquid petroleum cuts
- Air solubility in liquid petroleum products

- **Q** DISTILLATION, ABSOPRTION AND STRIPPING
  - Gilliland's correlation
  - Tray efficiency for distillation and absorption columns
  - Absorption (or stripping) ratio vs Absorption (or stripping) factor
- SAFETY
  - Flammability
- CONVERSION TABLES
  - Temperature
  - Relation between specific gravity and API degrees
  - Length
  - Area
  - Mass
  - **Volume**
  - Pressure
  - Opensity
  - Force
  - Energy
  - Power