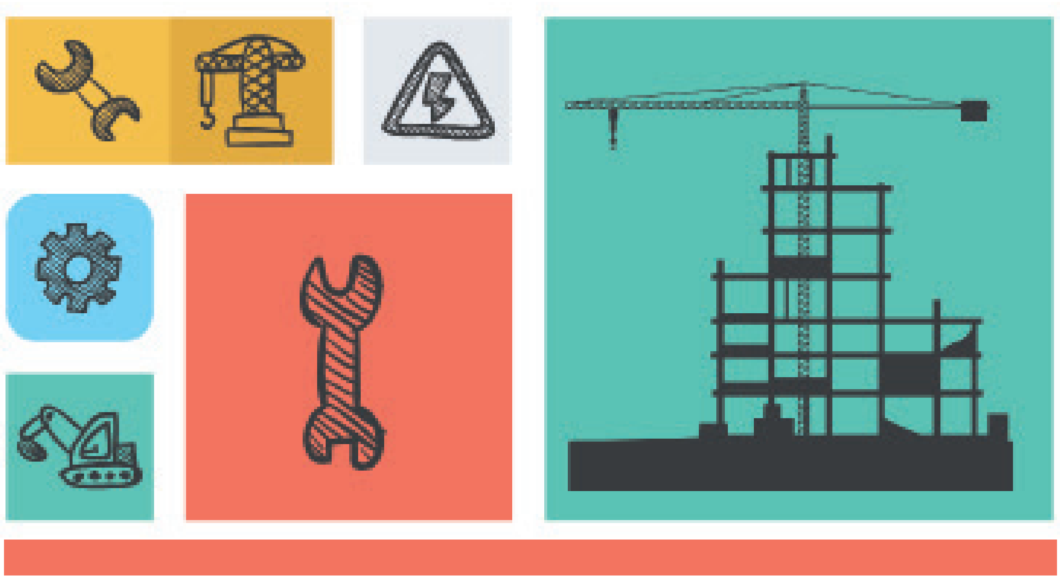
الهيئة السعودية للمهندسين
SAUDI COUNCIL OF ENGINEERS

المركز الوطني للقياس
National Center for Assessment

Engineering Fundamentals Exam

Chemical Engineering Standards



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Introduction

Engineering standards are the set of knowledge, abilities, and professional attributes necessary to practice the engineering profession [3-5]. Every Engineering Standard is linked to a number of indicators. These indicators can be viewed as instruments that measure the examinee fulfillment of the corresponding standard. In other words, a Standard is a broad statement about a specific topic, whereas, the Indicators are specific requirements extracted from the Standard and directly linked to the exam question.

Some of these first level standards are drawn from the completion of a Bachelor of Engineering degree from an accredited engineering college. An accredited engineering degree program usually has the breadth of understanding of a wide range of technologies and applications. It also usually has sufficient depth in at least one specific area of practice to develop competence in handling technically complex problems [6].

The knowledge part of the first level standards include, generally, knowledge of science and engineering fundamentals, in-depth technical competence in an engineering discipline, knowledge of theoretical and experimental techniques, knowledge of basic business and project management practices, and broad general knowledge.

The ability part of the first level standards include, generally, the ability to identify, formulate, and solve problems, ability to understand environmental and social issues, ability to deal with ambiguity and complex problems, ability to perform engineering design, and an ability to interpret and visualize data [3-5].

The professional Attributes part of the first level standards are the sets of skills often sought by employers for hiring engineers either fresh graduates or experienced. They are sometimes called “soft” or “general” skills. They include capacity for effective communication [7] with the engineering team and costumers, capacity for effective work within multidisciplinary and multicultural teams, capacity for lifelong learning and professional development, self-drive and motivation, creativity and innovation, leadership, and capacity to maintain a professional image in all circumstances [3-5].

Chemical Engineering Standards

The Engineering Standards for the Chemical Engineering Discipline are structured around ten core Topics:

1. Chemistry
2. Chemical Engineering Principles
3. Thermodynamics
4. Fluid Mechanics
5. Heat Transfer
6. Mass Transfer
7. Reaction Engineering
8. Process Control
9. Process Economics
10. Safety, Health, and Environment

Each Indicator is projected onto three Learning Levels (obtained by combining every two consecutive levels in the revised Bloom's taxonomy into one level)

1. Remembering and Understanding
2. Applying and Analyzing
3. Evaluating and Creating

Standards are coded CHE-TJ where:

- CHE denotes Chemical Engineering
- TJ denotes Topic Number J

Indicators are coded CHE-TJ-K (where K denotes the Indicator number).

Example

Topic Area: **T2:** Chemical Engineering Principles

Standard: **CHE-T2:** Chemical Engineers are expected to perform material and energy inventory on units, processes, and whole plants. The balances should be performed on nonreactive and reactive systems including recycling, bypassing, and purging streams.

Indicator: **CHE-T2-04**: Perform material balances on nonreactive systems

Learning Level: Applying and Analyzing (AA)

Topic T1: Chemistry Foundation (10%)

CHE-T1 Chemical Engineers are expected to demonstrate knowledge in inorganic, organic and physical chemistry including: identification of compounds; utilization of chemical properties of materials in separation processes and reactive systems; performing concentration-related calculations, etc. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T1-Indicators

CHE-T1-01 Recognize, differentiate and identify acids and bases

CHE-T1-02 Define the various concentration terms such as: normality, molarity and molality

CHE-T1-03 Relate and calculate various concentration terms (e.g., ppm, normality, molarity and molality)

CHE-T1-04 Perform titration calculations

CHE-T1-05 Complete and balance chemical reaction equations

CHE-T1-06 Calculate and use equilibrium constants

CHE-T1-07 Calculate reactant conversion and equilibrium conversion

CHE-T1-08 Apply gas laws (ideal and real)

CHE-T1-09 Recognize and describe paraffins

CHE-T1-10 Recognize and describe olefins

CHE-T1-11 Recognize and describe aromatic compounds

CHE-T1-12 Recognize major chemical reactions

T2: Chemical Engineering Principles (14%)

CHE-T2 Chemical Engineers are expected to perform material and energy inventory on units, processes, and whole plants. The balances should be performed on nonreactive and reactive systems including recycling, bypassing, and purging streams. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T2-Indicators

CHE-T2-01 Convert units between and within Engineering Systems of Units

CHE-T2-02 Identify and use the major process variables

CHE-T2-03 Convert mole fractions into mass fractions and vice versa

CHE-T2-04 Perform material balances on nonreactive systems

CHE-T2-05 Perform material balances on reactive systems (single and multiple reactions)

CHE-T2-06 Apply the concepts of conversion, selectivity, and yield in performing material balances on reactive systems

CHE-T2-07 Perform energy balances on nonreactive systems

CHE-T2-08 Calculate heat of reaction using heat of formation and heat of combustion

CHE-T2-09 Perform energy balances on reactive systems

CHE-T2-10 Perform simultaneous material and energy balances on systems with recycling

CHE-T2-11 Perform simultaneous material and energy balances on systems with purging

CHE-T2-12 Perform degree of freedom analysis (units, overall, and process)

CHE-T2-13 Use and interpret psychrometric charts

T3: Chemical Engineering Thermodynamics (10%)

CHE-T3 Chemical Engineering Thermodynamics involve the knowledge and applications of the first law and second law of thermodynamics, utilization of properties of materials and application of the equations of state. Chemical Engineers must also be well versed in performing phase and chemical equilibria; and should be able to analyze power cycles, refrigeration and liquefaction, in addition to observing the limitations and constraints imposed by thermodynamics on systems and units. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T3-Indicators

CHE-T3-01 State and apply the first law of thermodynamics

CHE-T3-02 State and apply the second law of thermodynamics

CHE-T3-03 Apply the equations of state (for real and ideal gases)

CHE-T3-04 Calculate entropy changes

CHE-T3-05 Determine ideal work and lost work for various processes (isothermal, isobaric, adiabatic, etc.)

CHE-T3-06 Use the first and second law of thermodynamics

CHE-T3-07 Apply phase and chemical equilibria

CHE-T3-08 Analyze the processes of refrigeration, liquefaction, heat pumps, and steam power cycles

CHE-T3-09 Determine cycle efficiency

CHE-T3-10 Observe and estimate the limitations imposed by thermodynamics on units and their designs

T4: Fluid Mechanics (10%)

CHE-T4 Fluid Mechanics involve a thorough knowledge of fluid statics and dynamics; flow measurement devices; flow around submerged bodies and through porous media and in fluidized beds. It also involves the knowledge of the effects of flow regimes, properties of flowing fluids and pipe materials on the design of pumps and piping system. It involves quantification of friction losses, fittings and elbows and their effects on the overall performance, power requirements, and design. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T4-Indicators

CHE-T4-01 Describe and explain fluid statics and dynamics

CHE-T4-02 Calculate the hydrostatic pressure drops

CHE-T4-03 Apply the mechanical energy balance equation

CHE-T4-04 Recognize the differences between flow through annulus, submerged bodies, and porous media

CHE-T4-05 Quantify the implications and the differences in flow regimes

CHE-T4-06 Calculate the friction factor for laminar and turbulent flow for different types of materials

CHE-T4-07 Quantify the effects of elbows, constrictions, and pipe size on power requirements of pumps

CHE-T4-08 Use the properties of materials to select a suitable material for constructing pipes based on flowing fluid properties

CHE-T4-09 Design pumps, pipes, and turbines

CHE-T4-10 Choose and apply codes and standards in the design

T5: Heat Transfer (10%)

CHE-T5 Chemical Engineers are expected to know, differentiate, and use the different modes of heat transfer (conduction, convection and radiation). They must be able to calculate heat transfer coefficients and heat transfer areas giving due consideration to phase changes and flow configuration. They must be able to design heat transfer/exchange units (e.g., heat exchangers and evaporators) considering the various design constraints and using codes and standards. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T5-Indicators

CHE-T5-01	Define the main modes of heat transfer and their media requirements
CHE-T5-02	Calculate heat transfer coefficient considering the factors that affect them
CHE-T5-03	Calculate heat transfer coefficient using correlations
CHE-T5-04	Calculate the overall heat transfer coefficient
CHE-T5-05	Perform steady state analysis related to different modes of heat transfer
CHE-T5-06	Determine the heat transfer area considering flow configuration
CHE-T5-07	Select the proper flow pattern and tube arrangement in heat exchangers
CHE-T5-08	Design heat exchangers
CHE-T5-09	Design evaporators and observe the effects of phase variation on the design
CHE-T5-10	Apply codes and standards when selecting and configuring heat transfer equipments

T6: Mass Transfer (12%)

CHE-T6 Mass transfer involves the knowledge of the basic principles of diffusion and calculation of mass transfer coefficients. It also involves analyzing and designing stage-wise and continuous separation units or processes (e.g., absorption, distillation, extraction, humidification units) using equilibrium, graphical, and differential methods as well as applying rules of thumbs. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T6-Indicators

CHE-T6-01 State the principles of diffusion and mass transfer

CHE-T6-02 Estimate diffusivity

CHE-T6-03 Quantify the main factors that affect distillation, absorption, liquid-liquid extraction, and leaching

CHE-T6-04 Determine mass transfer coefficients and analyze stage-wise and continuous gas-liquid separation processes

CHE-T6-05 Determine various efficiencies (local, Murphree, etc.)

CHE-T6-06 Apply the fundamentals of stage operations and use phase diagrams and phase equilibrium

CHE-T6-07 Analyze stage-wise and continuous gas-liquid separation processes by applying graphical and analytical methods for stages determination for absorbers and distillation columns

CHE-T6-08 Distinguish and use the different types of distillation columns

CHE-T6-09 Design distillation columns using graphical and differential methods

CHE-T6-10 Design absorption units

CHE-T6-11 Design humidification and liquid-liquid extraction units

CHE-T6-12 Design mass transfer units using codes and rules of thumbs

T7: Reaction Engineering (12%)

CHE-T7 Reaction Engineering involves knowledge of reactions (completion and balancing) and determination of reaction rates for irreversible, reversible, single and multiple reactions. It also involves calculations of conversion, selectivity, and yields as well the quantification and observation of the effects of changes in temperature, pressure, and volume on the design of reactors (batch, CSTR and PFR). The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T7-Indicators

CHE-T7-01 Use reaction stoichiometry and rate equations for irreversible and reversible reactions

CHE-T7-02 Determine reaction kinetics from experimental data

CHE-T7-03 Perform material and energy balances around the reactor using rate expressions

CHE-T7-04 Calculate conversion for single reactions

CHE-T7-05 Calculate equilibrium conversion for reversible reactions

CHE-T7-06 Observe the implications of changes in temperature and pressure on ideal reactors

CHE-T7-07 Observe the implications of changes in volume on ideal reactors

CHE-T7-08 Determine and apply the concepts of conversion, selectivity, and yield for multiple reactions

CHE-T7-09 Design a batch reactor

CHE-T7-10 Design a Continuous Stirred Tank Reactor (CSTR)

CHE-T7-11 Design a Plug Flow Reactor (PFR)

CHE-T7-12 Define catalysts and determine their role in reaction

T8: Process Control (6%)

CHE-T8 Process control involves the knowledge of the various terms used in control (e.g., set point, manipulated variable, controlled variable, disturbances, transfer functions, etc.) and the different controllers (e.g., P, PI, PID). It also involves determination of transfer functions for open and closed loops and devising a proper control strategy for SISO and MIMO systems. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T8-Indicators

CHE-T8-01 Recognize the concepts of set points, disturbances, controlled variables, manipulated variables, controller gain, time constant, etc.

CHE-T8-02 Recognize the process control structure

CHE-T8-03 Obtain transfer functions for open loops

CHE-T8-04 Obtain transfer functions for closed loops

CHE-T8-05 Design a proper control structure for SISO and MIMO systems

CHE-T8-06 Apply various controllers (e.g., P, PI, PID)

CHE-T8-07 Analyze the performance and stability of systems.

T9: Process Economics (10%)

CHE-T9 Chemical Engineers must be able to develop, draw, interpret and discuss process flow diagrams including piping and instrumentation. They should also be familiar with the terms (profit, cash flow, depreciation, rate of return, present value, etc.) used in engineering economy and be able to apply them to perform economic analysis and cost estimation. Process economics also involves discrimination between investment alternatives. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T9-Indicators

CHE-T9-01 Draw and discuss process flow diagrams

CHE-T9-02 Define terms used in engineering economy, e.g., profit, depreciation, profitability, cash flow, present value, alternative investment, break-even point, payback period, grass roots, battery limit, off-site facilities, etc.

CHE-T9-03 Apply the basics of economic analysis in plant design

CHE-T9-04 Perform cost estimation

CHE-T9-05 Compare alternative investments including discounted cash flow, net present value, and rate of return

CHE-T9-06 Optimize design based on economic analysis results

CHE-T9-07 Apply linear programming in economic analysis

T10: Safety, Health, and Environment (6%)

CHE-T10 Safety, Health, and environmental issues are of vital importance to chemical engineers and for the operation of safe plants. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T10-Indicators

CHE-T10-01 Demonstrate knowledge regarding classification of hazardous materials

CHE-T10-02 Identify and analyze hazards using hazard identification methods and techniques in the workplace

CHE-T10-03 Predict the flammability characteristics of liquid, vapor, and gasses and the nature of fire

CHE-T10-04 Calculate the lower flammability limit (LFL) and upper flammability limit (UFL)

CHE-T10-05 Calculate the permissible exposure limit (PEL)

CHE-T10-06 Assess means to preserve clean environment on issues related to waste treatment and disposal

CHE-T10-07 Perform calculations related to fire, explosion, and toxic release hazards

CHE-T10-08 Relate safety issues regarding the design and operation of equipment to their discipline

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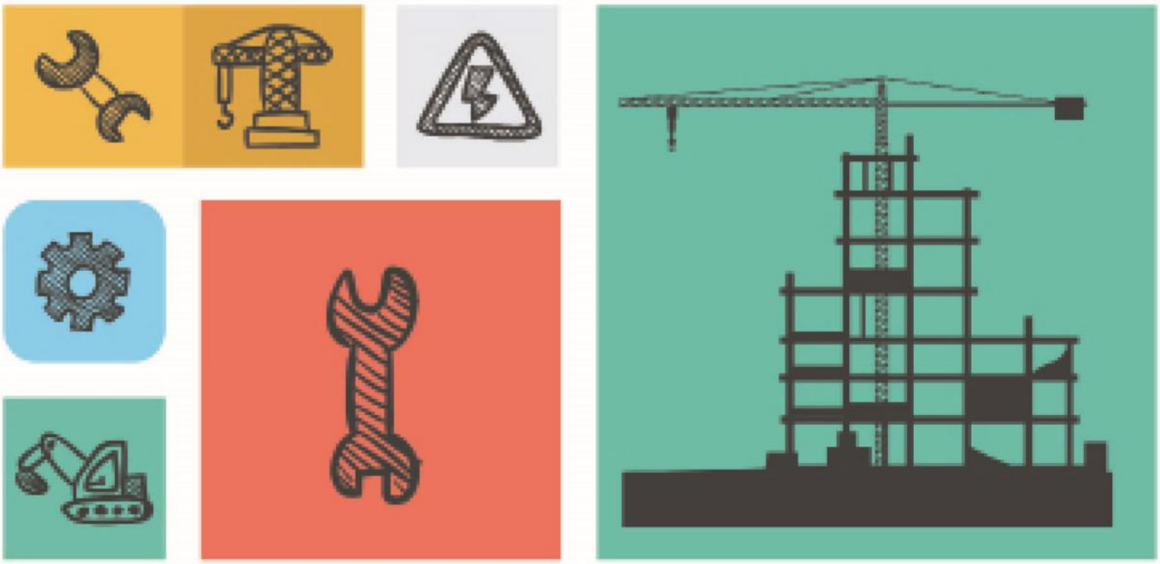

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