KLM Technology Group

TRAINING MANUAL

Process Engineering

Introduction

This KLM Technology Group training manual is designed to introduce new and experienced engineers in the field of process / chemical engineering to their engineering responsibilities and their interactions with other areas of engineering. It also outlines the tasks they will undertake while working for an engineering contracting company or operating company.

Additionally, the manual serves as a reference and quick look-up for a range of standards applicable to their everyday process engineering tasks, such as the Kolmetz Handbook of Process Equipment Design, and KLM Technology Group Project Standards. It also aims to provide an understanding of process engineering tasks for engineers from other disciplines.

This manual aims at providing professional industrial training & exposure to various Process Engineering design principles for Process / Chemical Engineers. The training program provides knowledge to candidates starting from explaining the roles & responsibilities of Process Design Engineer to development of final process design engineering document i.e., Piping & Instrumentation Diagrams (P&IDs). This program is designed to cater to the needs of fresh graduates as well as experienced professionals. Process Engineering involves developing new processes, project engineering and troubleshooting.

This Manual will assist Chemical Engineers to enter industry as Process Design Engineer and Operations Engineer. Chemical / Process engineers are found in vast range of industries, such as;

Oil & Gas,
Upstream Processing / Offshore,
Natural Gas Processing – Midstream,
Ammonia,
Refining,
Ethylene,
EB / Styrene,
Polymers,
Petrochemical,
Chemical Plants,
Mineral Processing,
Food,
Palm Oil,
Pharmaceutical,
Biotechnological industries.

The goal of this Manual is to introduce the basic concepts of the process Design Engineering. The Style and approach of the training manual is to provide insight view of the Process techniques to Chemical Engineers.

"Kolmetz Universal Law of Project Stupidity".

Kolmetz Universal Law of Project Stupidity: a law strictly followed by most engineering projects.

"Save money and poorly design the process equipment by awarding it to the low- cost bidder. Loose money for the next twenty years on plant capacity, maintenance reliability, and excess energy."

According to this law, awarding a process equipment contract to the lowest bidder may save you money in the short term, but it can cost you heavily in the long run. You may end up losing money for the next twenty years on plant capacity, maintenance reliability, and excess energy. So, next time you are tempted to cut corners, remember the Kolmetz Law of Project Stupidity.

Typically, process equipment is awarded to the lowest bidder with very low standards of guarantees. Typical guarantees by the manufacturers are hydraulic capacity only, and this test must be carried out within three to six months, while the process equipment is still clean and new. Typical process guarantees are by the process engineering company which includes capacity and energy, again the performance test must be carried out within three to six months.

Imagine buying a car and receiving a three-to-six-month warranty and only good gas milage for the first six months. You would think the car manufacturer was taking advantage of you, yet this is what we do for process equipment, and cars are much more complex than heat exchangers.

What are things that should be included in process equipment design that are not being utilized because of the sweetheart guarantees and low-cost bidders.

1. KLM is a recognized expert in Process Equipment Design, only utilize groups with technical expertise.
2. KLM only partners with high quality suppliers, often from the same factories as the Original Equipment Manufacturers (OEM) and has senior inspectors to ensure your equipment is installed correctly
3. Anti Fouling Designs to improve the process equipment over the life of the run length
4. Ensure correct metallurgy.
5. Review Galvanic Corrosion Potential for extended life. If you have polar liquids (water, acids, caustics) and a carbon steel vessel, stainless steel demister pads will experience bi-metallic corrosion with reduced life.
6. Review the failures of the non-technical suppliers.

KLM can assist your team in providing Senior Engineering and Operations Staff to provide support for your local team in many areas including demister pads, distillation towers, heat exchanger and pump design.

Contents

1. Process / Chemical Engineering

Chemical engineering is a branch of science that applies physical sciences (physics and chemistry) and life sciences (microbiology and biochemistry) together with applied mathematics and economics to produce, transform, transport, and properly use chemicals, materials and energy. Essentially, chemical engineers design large-scale processes that convert chemicals, raw materials, living cells, microorganisms and energy into useful forms and products.

Process engineering design involves the use of chemical, petroleum, and gas technologies, along with mechanical, instrumentation, and other engineering skills, in the development, planning, design, and decision-making processes necessary for the economical and efficient execution of a process project.

The process design engineer actually engineers the process chemistry into appropriate hardware (equipment) to accomplish the process requirements. His task is to find the best way to produce a given quality product, safely and economically.

Process engineer has the following responsibilities:

1. Studies process systems for manufacture of a product or to implement improvements / changes in existing production units.
2. Prepares economic studies associated with process performance.
3. Evaluates operating data of existing or new equipment.
4. Designs and/or specifies items of equipment required to define the process flowsheet or flow system.
5. Evaluates competitive bids for equipment.

The process engineer must understand the interrelationship between the various research, standards, engineering, purchasing, expediting, construction and operational functions of a project. He must appreciate that each function may and often does affect or influence the process design decisions.

In a consulting or engineering contractor organization, process design and/or process engineering is usually a separate group responsible for developing the process with the customer or presenting the customer with a turnkey proposed process.

Process Engineering is the application of Chemical, Mechanical, Petroleum, Gas and other engineering disciplines in the Development, Design, Construction, Efficient, Safe and economic operation of a plant / processing facility meeting customer's Specifications

- In a Consulting or Engineering contractor Organization, Process Design and / or Process Engineering is usually a Separate Group Responsible for Proposing / Developing / Designing a Process plant / facility for the customer.
- In an Operating or Production Company, Process Design and / or Process Engineering is involved in Research and Development, Technical Services or Engineering Department for developing new projects and processes.

Introduction to Chemical Engineering Guideline

https://www.klmtechgroup.com/PDF/EDG-KNO/ENGINEERING-DESIGN-GUIDELINES-introduction-to-chemical-engineering-Rev1.2web.pdf

2. One, Three and Five Year Engineering Goals

A fresh graduate engineer is typically taught the fundamental principles necessary to solve complex engineering problems but may not receive guidance on applying these concepts in the field. It is essential for them to be trained in using these fundamental concepts to evaluate and size process equipment.

The Kolmetz Handbook of Process Equipment Design was developed for this purpose and includes chapters on various types of process equipment. The International Association of Certified Practicing Engineers offers certification to teach the content of the Kolmetz Handbook. What competencies (abilities to solve assigned tasks) should engineers with one, three, or five years of experience possess?

Process Engineer - One Year Competency

A. Have the ability to size and rate equipment for potential use in the process unit (KLM Process Equipment Design Course).
   - Piping
   - Control Valves
   - Flow Orifices
   - Pumps
   - Compressors
   - Relief Valves
   - Flares
   - Drums
   - Heat Exchangers
   - Distillation Towers
   - Tanks
   - Cooling Towers

B. Understand Piping Codes, Specifications and Temperature Limits.

C. Understand Pressure Relieving and Flaring Systems (KLM Advanced Pressure Relieving and Flaring Systems Training Course)

D. Understand Distillation Operation Fundamentals (KLM Introduction to Distillation Course)

E. Have the ability to Simulation Simple Distillation Columns

F. Have the ability to participate as a HAZOP Team Member. (KLM Hazard Analysis Course)

G. Understand furnace and boiler oxygen requirements, efficiencies, and utility cost. (KLM Furnace and Boiler Overview Course)

H. Understand Cooling Tower Water Treatment Operations

I. Understand Boiler Water Treatment Operations.

J. Understand Wastewater Treatment Operations.

K. Understand Basic Process Control (KLM Introduction to Process Control)

L. Understand the plant steam systems; build a detailed model of the system for process monitoring and improvements. (KLM Intro to Energy Optimization Course).

Third Year Competency

A third-year engineer should have mastered all of the one year competency requirements along with the additional items.

A. Have the ability to calculate a rigorous heater efficiency for process monitoring and improvements (KLM Advanced Energy Optimization Course)

B. Have the ability to calculate a rigorous compressor efficiency for process monitoring and improvements (KLM Advanced Energy Optimization Course)

C. Understand the plant steam systems and steam turbine efficiency relationships. (KLM Advanced Energy Optimization Course)

D. Have the ability to simulate complex distillation systems. (KLM Process Simulation Course)

E. Understand Distillation Column Tray and Packing Design Parameters. Have a working knowledge of vendor hydraulics programs. (KLM Advanced Distillation Course)

F. Have knowledge of unit economics. Understand Return on Investment and Net Present Value (KLM Finance for Non Financial Professionals Course).

G. Have the ability to review commissioning and start up procedures. (KLM Safe Commissioning of Process Units Course)

H. Begin to understand the relationship between people, equipment, process and safety. (KLM Building Operational Excellence Course)

I. Have knowledge of reactor design and catalyst functions. (KLM Catalytic Processes Course)

J. Obtain general costing of heat exchangers, pump, compressor, and distillation equipment.

K. Obtain general maintenance cost of cleaning and repairing heat exchangers, compressors and distillation equipment.

L. Be a team member in a project. (KLM Project Management Course or IACPE Project Management Certification)

M. Have knowledge of Advanced Process Control (KLM Advanced Process Control)

N. Begin to be at least 20% self directed.

Five Year Competency

A five year engineer should have mastered all of the one and three year competency requirements along with the additional items.

A. Have the ability to write commissioning and start up procedures. (KLM Safe Commissioning of Process Units or IACPE Commissioning Certification)
B. Have the ability to lead a HAZOP Team. (KLM HAZOP Team Leader Course of IACPE Safety Certification)
C. Be able to lead a project from conception through construction, commissioning to startup. (KLM Projection Management Course or IACPE Project Management Certification)
D. Develop project lists and prioritize projects for optimum project execution.
E. Understand critical safety design guidelines by reviewing past safety incidents. (KLM Achieving Zero Accidents Course)
F. Be at least 30% self directed.

3. Process Engineering Projects

Project management is the application of knowledge, skills, tools, and techniques for project activities in order to meet or exceed stakeholder needs and expectations in a project. A project is a temporary endeavor undertaken to create a unique product or service that is different in some distinguishing way from all similar products or services.

A project management certification like Certified Practicing Project Management (CPPM) will assist in gaining the knowledge needed to manage projects. Knowledge will assist your carrier by increasing you ability to interview and speak in meetings.

https://www.iacpe.com/cppm-program.html

For any typical process related project, the process engineer begins by gathering all the data / information he can about the process and the physical & chemical information of the substances involved in the process.

The initial goal of the preliminary process study is to obtain an economic evaluation of the process, with the minimum expenditure of time and money. During this stage, all information necessary to obtain a reasonably accurate cost estimate for building and operating the plant is determined.

In the design and evaluation of a process, the process engineer takes the following activities. These are the selection of a site, the writing of the scope (definition of project), the choosing of the process steps, the calculation of material and energy balances, the listing of all major equipment with its specifications, the development of the physical layout of the plant, the instrumentation of the plant, the development of a cost estimate, and finally the economic evaluation of the process.

If the techno-economic evaluation appears promising, then this process must be compared with all other alternatives to determine whether taking the proposed action is really the best course to follow. All these feasibilities must be economically evaluated to determine the best course of action to take.

If, after comparing alternatives, a project is approved by the management, the project is returned to process engineering for the detailed process design. Now the process engineer must provide all the information necessary to the project engineering specialists, so that equipment can be designed and specified.

Project Management Guideline

https://www.klmtechgroup.com/PDF/EDG-PRO/ENGINEERING-DESIGN-GUIDELINES-project-management-Rev1.2web.pdf

4. Role of Process Engineer

In an engineering consultancy or owner's representative, process engineers are usually involved to varying degrees in different phases of a project. Process engineers should try to adapt to the phase of the project, while doing their work.

- Study (Concept and Feasibility) – Generates Design Data / Information
- Engineering (Basic/FEED and Detail) – Validates and Disseminates the Design data / Information
- Procurement – Evaluation of Technical Bids / Discussion with vendors
- Construction – Response to Site Queries
- Commissioning / Start-up – Prepare procedures and assist in smooth / trouble –free commissioning

In a nut shell, the role of a process engineer is to provide services from concept to commissioning.

Additional Responsibilities of a Chemical / Process Engineer

- Business Development
- Gathering knowledge on technologies (from Principals, Licensors, Vendors)
- Developing design capabilities in new areas
- Development of design tools, calculation procedures, technical database
- Training other engineering disciplines on general / specific process design aspects
- Site services - Data collection for revamping (brown field engineering), commissioning assistance
- Maintaining good customer relations and providing opportunities for repeat orders

Capabilities of a Chemical / Process Engineer

- Carrying out Simulation Study to develop Mass & Heat Balance and to establish fluid property databank.
- Performing Equipment (Vessels, Pumps, etc.) Sizing calculations
- Performing Line sizing and Hydraulic calculations
- Developing and updating Process Engineering deliverables
- Carrying out Effluent study to develop suitable Flare, Vent and Drain Systems for the facility
- Carrying out Utility System Design
- Participating in HSE (Health, Safety and Environment) studies like HAZOP (Hazard v/s Operability), SIL (Safety Integrity Levels) to record the design changes and to implement in Engineering
- Technical Assistance for Procurement
- Vendor offer review & clarifications
- Assistance in Technical Bid Evaluation
- Final Vendor data incorporation

Process Design Engineering Deliverables

Some of the major process design engineering deliverables are:

- Process Design Basis
- Process Simulation Study
- Process Flow Diagrams (PFDs)
- Equipment Design and specifications
- Line sizing and hydraulics
- Instrument sizing and specifications
- Piping and Instrumentation Diagrams (P&IDs)
- Utility consumption summary
- Cause and Effect Diagrams

The process engineer must be able to perform the following activities to build a basic design package.

a. Prepare heat and material balance studies for a proposed process, with and without use of software applications.
b. Prepare rough cost economics, including preliminary sizing and important details of equipment, factor to an order of magnitude capital cost estimate, prepare a production cost estimate, and work with economic evaluation representatives to establish a payout and the financial economics of the proposed process.
c. Participate in layout planning for the proposed plant.
d. Prepare operating, control and safeguarding philosophies of the plant.
e. Prepare and supervise drafting of process flow diagrams (PFD).
f. Prepare and supervise drafting of piping and instrumentation diagram (P&ID), with necessary preliminary sizing of all piping, equipment and representation of all instrumentation for plant monitoring, automation and protection.
g. Prepare detailed sizing of all process equipment and utility systems, with and without use of software applications.
h. Prepare process datasheet for all equipment and package systems. This is used by mechanical engineers to prepare a detailed equipment specification.
i. Determine size and specifications for all safety relief valves.
j. Select piping specifications from existing company standards for the fluids and their operating conditions for incorporation in P&ID.
k. Select from company insulation standards the insulation codes to be applied to each hot or cold pipe or equipment as applicable.
l. Prepare line schedule, equipment summary schedules, summary schedules for safety relief valves and rupture disks.
m. Perform technical evaluation of bids and recommendation of qualified vendors.

Basic Design Package Standard

https://www.klmtechgroup.com/PDF/ess/PROJECT_STANDARDS_AND_SPECIFICATIONS_basic_design_package_Rev01.1.pdf