

IE 402 Project Engineering and Management

End Semester Examination (November 2013)

Duration: 8 hours

Marks: 60

Instructions to candidates:

1. All questions are compulsory and carry equal marks
 2. This is open book and comprehensive test based on the thorough understanding of the subject to be eligible to become project Engineer (I & C) in any organization.
 3. The sequence of questions is in chronological order of the project flow hence you are advised to solve them in sequence.
 4. All the questions are based on the process description detailed in the introduction section.
 5. No supplement will be provided.
 6. After 30 minutes from the commencement of the examination student can ask one question each to supervisor and the session will last till all questions are over or the gap between two questions is more than 1 minute. After that no clarification can be sought from the supervisor.
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Introduction:

A plant comprising of five types of vessels viz. raw material storage (5 numbers 7500 liters capacity), pre-processing vessel (2 Numbers 2500 liters capacity), continuous stirred tank reactor (2 Numbers 5000 liters capacity), holding vessel (2 Numbers 3500 liters capacity), and product storage vessel (5 numbers 5000 liters capacity). Besides this the plant has

- a. Tanker loading and unloading facility,
- b. Weigh bridge at entrance and exit,
- c. 11 kV Electrical substation,
- d. Effluent treatment plant, and
- e. Data center for disaster recovery and IT support

Process Description:

The plant is designed for manufacturing a special type of chemical in liquid form. The sequence of operation is as follows with parameter details:

1. In the tanker loading and unloading station the quantity needs to be measured online and the storage (Raw/Product) tank selected through valve sequencing. At a time only one tank can be selected. All

necessary interlocks are to be incorporated. The billing section will receive the accurate supply/delivery quantities and to be billed through corporate network for which server is installed in the corporate office. The temperature, level, and flow conditions are to be maintained so as to reduce waste.

2. The transfer pumps to be selected based on the requirement. The entry and dispatch to be completed in 45 minutes, tanker capacity 5000 liters, hose connection automatic through sequencing, ensure entire liquid transfer, messaging through GPRS to main console and reporting of the completion of transfer through SMS as well.
3. Pre-Processing vessels are required to prepare the raw material for feed. The temperature is to be maintained at 65 °C, with a tolerance band of $\pm 1^\circ\text{C}$. The required steam is available through a boiler, which is in the scope of the utility department. The boiler is controlled through a dedicated control system. Necessary interlocks are to be considered while developing control strategy. Both the vessels can be used simultaneously depending on the process requirement.
4. In the continuous stirred tank reactor the recipe ingredients are added as per the command from process expert through SCADA screen. The temperature profile, stirring cycle, and product ready status is also part of the recipe and availability of all forward vessels prior to start is to be confirmed through control system. The heating and cooling cycle is to be achieved through steam at 150°C and chilled water at 4°C. After removing the product the waste is to be transferred to effluent treatment plant and the readiness of the plant is to be confirmed before start of process. FDA regulations are to be followed in this regard.
5. Once the product is ready it will be sent to holding vessel and to avoid solidification temperature is to be maintained at 40 °C using electrical heat tracing system. The system should have all necessary interlocks in built.
6. In product tank some preservatives are to be added based on nature of the product and capacity of the batch. Process expert through

SACDA will initiate this. The availability of tanker is the pre-condition for dispatch and the transfer will be automatically based on the tanker capacity.

7. For smooth running of the plant an electrical sub-station of 11 KV capacity is erected on the plant premises with all necessary energy measurement and power factor improvement facilities. The DG back up is also provided for critical process components and UPS for all control system components.
8. The data Centre is developed for disaster recovery and smooth running of plant and data security. The IT support services for higher-level communication are to be provided through this center. Besides this the historian data, real time trends and surveillance system is to be managed through this Centre.
9. The management of the plant expects to connect plant data at all levels including ERP seamlessly. Sufficient consoles for activities like testing, development, and control are to be provided. The field operators are to be equipped with live data and acknowledge facility.

Q1. Develop P & I, functional, and data flow based schematic diagram for the above-mentioned plant. The diagram should cover all the details depicting Human Machine interface also. Use of standard ISA symbols is mandatory.

Q2. Design a control strategy for the above-mentioned plant indicating all the details such as interfaces at all levels, control scheme, console details, communication at each level. Draw the flow chart for the logic development and design logic for smooth operation of the plant using FBD.

Q3. Size a control valve used in the temperature control loop for the steam service in the reactor. The process data is

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|--|------------------------|
| a. Line size: | 50 NB sch. 40 |
| b. Flow (Kg/Hr.) Min/Nor/Max | 250/450/500 |
| c. Temperature and pressure from steam table | |
| d. ΔP (Max) | 0.5 Kg/cm ² |

- e. Line Pressure (Kg/cm²) Min/Nor/Max 4.5/5.5/6
- f. Actuator Diaphragm operated Pneumatic
- g. Air Supply pressure 6 Kg/cm²
- h. In case of discrepancy in data assume suitable data

While designing the control valve size the control valve for tight control. Include all the accessories for the smooth operation of control valve. Write detailed specifications of the control valve after obtaining design parameters.

- Q4. Design and develop an Instrument air system for the plant as mentioned above. Based on the standard air consumption pattern of each instrument and plant-operating limit as 85 %, and duty cycle 75%. Draw a schematic of this system indicating all the components required along with bill of material for the same.
- Q5. Design the electric distribution system for the 11 KV sub-station. The system should comprise of HT, LT, MCC, and Instrument panel. Draw the single line diagram for the sample control circuit, control room illumination details, HVAC system details. The energy monitoring system is to be incorporated in this scheme hence include all the details required for energy audit.
- Q6. Prepare the project execution plan comprising of: Activity list, man power requirement and planning, phases of project execution starting with pre-engineering up to hand over of the plant. Prepare list of erection and commissioning activities and BoM, and MBoM for the consumables required for the completion of the project. Prepare cost estimate sheet for this material considering tax structure of the state.