

DESIGN MANUAL

SPD0016ERN-USA
PROCESS DESIGN MANUAL

PROCESS CONTROL

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**SAMSUNG
ENGINEERING**

SAMSUNG ENGINEERING AMERICA INC

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1. SCOPE

This manual describes the basic concepts and procedures for planning the control schemes of process plants on the piping and instrumentation diagrams. Computers have wide applications in the field of process control systems including various complex control schemes. However, computer controls will not be part of this document. Computer controls have numerous features, and it is difficult to standardize them. Therefore, in the case of computer controls, consultations with the specialists will be required.

2. BASIC THOUGHTS ON CONTROL SCHEME DESIGN

2.1. General precautions to be taken

To design a well-suited control scheme, it is very important to select correct control objects, measuring points, and controlling points with the full understanding of the following:

- Characteristics of the processes concerned
- Control techniques and their principles
- Function(s) of equipment to be controlled

Control schemes cannot be planned or designed separately from the process design. The process flows and objectives, equipment types and sizes, and allowances along with the planning of the control schemes must be studied together.

The streams should be classified as shown below (as an approach to the design of the control scheme):

(1) Main streams:

Examples of the main streams in the process plant are the feed, tower overheads, and tower bottoms. These are the dominant streams in the process plant and would cause a wide range of serious plant operating problems due to fluctuations of main stream conditions.

(2) Auxiliary streams:

Refluxes, Reboiler circuits, lean oil streams are auxiliary because their flows are limited to within the process unit. The process performance can be affected by their conditions.

(3) Miscellaneous streams:

Cooling water, make-up and purge streams can be included in this classification. In usual cases, these streams do not require any strict control.

Further, the following must be considered in the planning of the control systems and the execution of the engineering.

- Owner's philosophy of process control
- Grade, economics, operability and safety of control systems

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- Utilization of computer systems (CRT-display) as a man-machine interface
- Utilization of direct digital control (DDC) with micro-processors

2.2. Selection of Controlled Variables and Manipulated Variables

The selection of controlled and manipulated variables is very important in the planning of the control schemes.

2.2.1. Selection of Controlled Variables

Select process variables representative of the process objectives. Select other process variables which can affect the above variables largely. However, in many actual cases, measurement may be difficult and/or time lags may be too large for direct control. Therefore, review the fluctuation ranges and the degree of importance on the product quality, yield, and cost, then decide on the controlled variables. Consideration must be given to their ease of measurement, their dynamic characteristics, the effects of external disturbances, and other relevant matters.

2.2.2. Selection of Manipulated Variables

Select process variables which have a primary variance on the controlled variable; namely variables which can widely change the intended variable without affecting other conditions (variables). The time lag must be small in comparison with the control amount. The controllable ranges of the variables must be sufficiently large for correction control (i.e. their allowances must be sufficient for changes in the set point and external disturbances).

2.3. Product Quality Control

Normally product quality control is not provided by so-called "direct control" in which the composition is directly measured and controlled. So-called "inferential control" in which the product quality is evaluated and controlled indirectly by measuring process variables such as temperatures, pressures, flow rates, and liquid levels is used. For example, the quality of overhead products from distillation towers can be substantially regulated by temperature control with the pressure fixed at a certain level.

The major reasons why direct control is usually not used are as follows:

- Time lag of analyzer is long (including sampling time).
- Reliability of analyzer is low.
- Direct control itself is difficult.

Also, there are limitations on inferential control. When the operating conditions vary, variations will occur in the relationships between the product quality and the control amount. However, as analyzers have improved, direct controls have started to be used in some plants.

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3. BASIC CONTROL LOOPS

3.1. Single Feed Back Control

Single feedback controls are used, in most cases, where the effects of external disturbances on the process operation are sufficiently small, compared with the required control range, and the cycles of the external disturbances are long, compared with the response in the process operation.

3.2. Multi-variable Control

Depending on the conditions of process disturbances, single feedback controls cannot or may not serve the required purpose. In such cases, the following measures are used:

- (1) Remove disturbances by using minor loops before they affect the controlled variables (i.e., cascade control).
- (2) Measure (predict) external disturbances and adjust the manipulated variables to offset the disturbances before their effects appear (i.e., feed forward control).
- (3) Switch the control loop to another one which is suitable for the type and/or size of the disturbance (i.e., selective control and split range control).

3.2.1. Cascade Control

In cascade control, the set point of the secondary controller is adjusted by the output of the primary controller. Cascade control is intended to improve the response by reducing the effects of time lag and/or several other disturbances. If the response of the secondary controller is not sufficiently prompt, compared with that of the primary controller, interference may occur between the two controllers.

For this reason, the secondary controller must be a quick response type, such as flow control. Refer to Fig. 3-1, which is an example of cascade control used for liquid draw-off from a vessel.

3.2.2. Selective Control (Override Control)

In cases where two or more variables are to be controlled by the same manipulated variable, the most important variable must be selected for control in accordance with a certain rule. When the controlled variable has reached the limit, there may be a case where better results can be obtained if the control method is changed, by switching the control signal to another one or to the one specifically provided. The control scheme, in which a process variable is selected from among two or more variables, is "Selective Control". Selective controls can be classified largely into two types. The selection of measurement signals and the selection of manipulation signals. In either case, high or low signal selectors are used to select the highest or lowest signal from among a multiple number of input signals. The selection of signals is as follows:

- (1) Selection of measurement signals:

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Temperature distributions in reactors may vary, therefore, maximum temperature shifts occur as a result of a decrease in the catalyst activity in the case of fixed bed reactors. In such a case, the temperatures at the various points in the reactor are measured and compared. The highest temperature is selected and controlled (Refer to Fig. 3-2).

(2) Selection of manipulation signals:

Fig. 3-3 shows an example of selective control, pressure control in a depropanizer reflux drum and level control in a condenser.

3.2.3. Averaging Level Control

In cases where the level control is desired and the draw-off rate is to be kept at a fixed value, averaging level control is available for such applications. Various methods are conceivable for this purpose. One of them is when the liquid level has exceeded the set range, the output gain is increased to prompt the level control function, otherwise the liquid level remains in the set range and the output gain is held in the dead band so that the flow control setting will not change (Refer to Fig. 3-4).

3.2.4. Split Range Control

Split range control is similar to selective control except it uses different manipulated variables for the same controlled variable, depending on the control range. This control is effective in controlling a variable in a broad range. Fig. 3-5 shows an example of split range control used for a drum pressure. In this case three control valves are used since both total condensation and partial condensation are expected to occur in the air fin cooler outlet line.

3.2.5. Ratio Control

Ratio control is intended to keep the ratio of a process variable (A) to another process variable (B) set ($K = A/B$). In ratio control, two variables are measured and the secondary variable is regulated to maintain a predetermined ratio to the primary variable. Ratio control is widely used in cases where the direct measurement of final controlled variables is difficult or the response is very slow. It improves the controllability against quick disturbances, such as flow rate fluctuations.

Typical applications are follows:

- Calorie control for gas blending
- Fuel-air ratio control for boilers and heaters
- Feed ratio control for reactors

Fig. 3-6 shows an instance in which the ratio of hydrocarbon and steam is maintained.

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3.3. Feed Forward Control

A feed forward control measures the disturbances and offsets them by regulating the manipulated variables in proportion to the effects of the disturbances, before the controlled variables are affected. Hence, the controlled variables can possibly be maintained at the set point without conducting unnecessary overshooting. Also, the process dynamic characteristics will not worsen. However, the process control model, namely, the correlations of the load change effects between the controlled variables and the manipulated variables must be clear to use this control. In most cases, this control is used together with feedback control. Fig. 3-7 shows an instance of feed-forward control used on a drum boiler in which the water feed is controlled in proportion to the steam consumption and the material balance is maintained by level control.

3.4. Computer Control

Since various functions can be performed by computer control in process plants, applications of computer control are increasing with improvement on the reliability of the hardware. However, as many studies are required for actual applications and as the purposes and methods of applications cannot be generally explained, computer control will not be taken up for discussion herein.

4. TYPICAL PATTERNS OF CONTROL SCHEMES

4.1. Control Schemes for Distillation Towers

The product composition must be controlled, but it is not general practice to analyze and control the composition of products directly. Normally, the product composition can be maintained by temperature control with the pressure kept at the set point.

4.1.1. Pressure Control

- (1) In cases where the pressure is atmospheric or slightly positive and non-condensable gas does not exist:

Pressure control can be carried out by introducing inert gas (in the case of general distillation towers, as shown in Fig. 4-1 (a)) or fuel gas (in the case of petroleum distillation towers) into the receiver and by releasing gas from the receiver through a vent or to flare. In this case, as pressure hunting will occur if the size of the piping from the receiver nozzle to the flare header is excessively small, the piping must have a size sufficient for the purpose. The possibility of hunting can be reduced by using the control shown in Fig. 4-1 (b). This control is used in topping main towers and almost all other atmospheric distillation towers. In this control, the gas to be introduced must be insoluble.

- (2) In cases where the pressure is positive and non-condensable gas existing:

In this case, the gas introduction is not controlled, the gas released from the receiver must be controlled. This control (as shown in Fig. 4-2) is used in

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deethanizers, hydrodesulfurization strippers, and catalytic reforming stabilizers and so on in which non-condensable gas is existing.

(3) In cases where the pressure is positive and all gas is condensable:

Various controls are available for this service as shown in Fig. 4-3. The control shown in Fig. 4-3 (a)¹ is most usually used in petroleum refineries and petrochemical plants. It is adopted for use in depropanizers and other towers. When the receiver is elevated above the condenser, the tower pressure increases accordingly, but this is not a problem in pressurized distillation towers. Adequate hot bypass flow calculation and condenser design are required in cases where this control scheme is used. In the condenser, subcooling is conducted. The hot bypass flow must meet condensation by heat release through the receiver wall and condensation in the receiver. The maximum hot bypass flow rate is calculated on the basis that the condensate should be mixed and turned into liquid at the equilibrium temperature and pressure in the receiver. Even in the case of distillation towers of the same conditions as these, if the condensers are air fin coolers, the receiver cannot be elevated above them; the control shown in Fig. 4-3 (b) must be used. In this case, a bypass is provided to control the differential pressure to keep the receiver pressure at a certain level.

In the control scheme shown in Fig. 4-3 (c), a valve is provided on the condensate line and the pressure is controlled by adjusting the heat transfer area for condensation (excepting the subcooling zone, that is condensate retention zone). Meanwhile, in the control scheme shown in Fig. 4-3 (d), pressure is controlled by adjusting the condensation rate, and the condensation rate is controlled by the flow rate of the cooling water. This control has a disadvantage in that subcooling is difficult and the cooling water outlet temperature may rise excessively. In cases where these disadvantages are intolerable, this control cannot be used.

Besides the above, though not illustrated, the pressure control can be done by regulating the reboiler heating rate. It is said that the pressure controllability of the method is good, but judging from the relationships with other controls, this control is not generally used, though it can be applied, depending on the conditions in individual cases.

(4) Vacuum distillation towers:

Pressure control in vacuum towers, if required, is conducted by regulating the load of the vacuum producing equipment and the load regulation is carried out by circulating a part of the exhaust gas from the ejector or vacuum pump or by introducing some air (Refer to Fig. 4-4).

(5) Towers without pressure control:

No pressure control is conducted in towers which are open to the atmosphere at any point or connected with headers maintained substantially at a fixed

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pressure. Pressure control is not used in distillation towers which are operated at relatively high vacuum (for instance, vacuum produced by using three stages of ejectors) and are highly self-equilibrating.

4.1.2. Temperature Control

Usually, temperature control is conducted in distillation towers for the purpose of controlling the composition. In this case, the pressure must be maintained at the set point. Either the overhead or bottom is controlled, but both cannot be controlled simultaneously. The point which should be controlled shall be decided based on the following criteria:

- The temperature of the intended product shall be controlled as a rule.
- In cases where it is expected that the purity of the intended product will not fluctuate significantly, temperature control shall be conducted for the purpose of maintaining the yield. In this case, temperature control will have to be carried out on the components other than the intended product.

Normally control valves are provided in the reflux line in the case of overhead control, and on the reboiler heating medium line in the case of bottoms control. As shown in Fig. 4-5 (a) and Fig. 4-5 (b), temperature sensors placed in the overhead line or in the bottoms line are typical, but in cases where temperature variations related with compositional fluctuations are too small at those locations, temperature measurement is taken at an intermediate tray where it can be done with high accuracy, as shown in Fig. 4-5 (c) and 4-5 (d). A plot of trays verses temperature can be made for the tower and a point selected where there is a large change in temperature per tray is general selected for a good temperature control point.

In the case of super-fractionation (where a large number of trays are used and the temperature difference between the top section and bottom section is small) the temperature difference between two points, several trays apart, is measured to control the product purity, as shown in Fig. 4-6. Benzene towers are an example of this. In such a case, as temperature variations are caused by pressure fluctuations, rather than by composition fluctuations, mere temperature control cannot serve for the quality control of the intended product. For this reason, the effects of pressure fluctuations (which will be possible) can be offset by control based on the temperature difference (in which case pressure control is required).

In the case of so-called "condition control" which is not directly related with the quality of the product, the temperature control point is located at intermediate trays, and temperature difference of these trays is used as the controlled variable. In these cases where the number of trays between the two temperature measurement points for obtaining high accuracy may be excessively large or the number of trays between the top or bottom and the intermediate tray are excessive, the "condition control" scheme is undesirable from the standpoint of the dynamics. Hence, it is important that suitable locations should be selected.

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Further, in special cases, no temperature control is provided at any point of the tower. In such cases, other control schemes (for instance flow control in each section) must be considered to maintain stable operating conditions and the operating conditions must be provided with some allowances for instance, slightly excessive reflux should be provided. In these cases, the related equipment items (reflux pumps, etc) must be designed with the same allowances on the operating capacities.

4.1.3. Flow Control

All process lines must generally be operated by flow control, as a rule, except for the lines on which the above mentioned pressure or temperature control valve is provided. In the case of a single distillation tower, flow controls shall be provided for the feed, reflux and reboiler heating medium; if neither pressure control nor temperature control is provided. Overhead and bottoms are withdrawn generally under level control, but in cases where they are directly fed to other equipment, flow control may be required. In such cases, studies must be conducted from overall standpoints.

4.1.4. Level Control

In the case of distillation towers, level control is required in the bottom and overhead receiver. Since the flow stability of liquids from them is not so important in cases where the liquids are run down as products, level control is used, with control valves provided on the lines as shown in Fig. 4-7. The holding capacity of the liquid retention sections must be decided together with the level control method. Especially in the case of the bottoms in high temperature fractionators where liquid deterioration is probable, the liquid level must be held as low as possible to minimize the holding time, even if the flow stability is sacrificed. If these liquids are utilized for heat recovery in the reboilers and/or feed preheaters, their controls must be considered separately. In cases where flow stability is required to feed the following section, the outlet stream should be flow controlled and the liquid level should be controlled by regulating the inlet rate as shown in Fig. 4-8 (a). The level control and flow control might be cascaded, as shown in Fig. 4-8 (b); however, cascade control is not always effective. In many cases, it can be used effectively in processes where large disturbances may occur or the product properties are affected by flow rate variations and in single loops where response cycles are long.

4.1.5. Control of Reboiler

(1) Reboilers in which steam is used as heating medium:

Reboiler controls can be classified into flow controls and temperature controls as shown in Fig. 4-9 (a) and Fig. 4-9 (b). Which should be used depends on the purpose and conditions of the tower. The problem here is the flow measuring point and the location of the control valve. If flow measurement is conducted downstream of the reboiler, a small size orifice can be used. However the measurement difficulties will rule out this flow orifice location.

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Meanwhile, if the control valve is located downstream on the condensate side, the following merits can be obtained:

- (a) If the control valve is located downstream of the reboiler (on the condensate side), the required valve size will be smaller than the case where the control valve is located upstream of the reboiler (on the steam side).
 - (b) Since the reboiler steam pressure can be kept at the same pressure as the steam supply pressure (the pressure before pressure reduction in the valve), the higher temperature difference can be effectively utilized.
 - (c) The pressure on the return side can be maintained at a fixed level. If the control valve is located before the reboiler, probably the reboiler pressure or the condensate pressure will become lower excessively due to the control valve pressure drop. This lower pressure reduces the associated condensing temperature which affects the required reboiler heat transfer area. Fig. 4-10 shows an instance of flow control used for the outlet stream from a kettle type reboiler.
- (2) Reboilers in which the main fractionator side stream or effluent is utilized as the heating medium:

Figs. 4-11 (a)ⁱⁱ and 4-11 (b) show cases where an FCC main fractionator side stream is utilized as the heating medium. Reboiler controls in topping units are almost the same as those shown in Figs. 4-11 (a) and 4-11(b), but in the case of FCC units, after use in the reboilers, the side stream is passed to a steam generator for further heat recover. In Fig. 4-11 (a), flow control is provided for the main stream after the junction, to turn the effects of disturbances to the steam generator, and hence the steam generation in the steam generator is not stable. In Fig. 4-11 (b), flow control is located on the stream (before the junction) to the steam generator. Hence, the steam generation in the steam generator is more stable than in Fig. 4-11 (a), but some fluctuations in the flow rate and temperature of the process fluid are unavoidable after the junction.

These applications are decided based on the conditions of the main fractionator. For instance, the control shown in Fig. 4-11 (a) is used in the case of a side stream and that shown in Fig. 4-11 (b) is used in the case of bottoms. Meanwhile, it may be required to supply a fixed amount of heat to the reboiler by using steam together with the process fluid as the heating medium. In this application, controlling the flow rate and the temperature of the process fluid stream can be considered as discussed in (4).

- (3) Hot oil system:

Fig. 4-12 shows an instance of control in a hot oil system covering several reboilers. Flow control or temperature control is provided for each individual reboiler and their applications are decided from the fractionator side.

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Differential pressure control (PdC) is provided to stabilize the header pressure to prevent interference between the individual reboilers.

(4) Heat input controller:

There are cases where heat input control is required, other than flow, level, pressure, and temperature. The principle of heat input control is shown in Fig. 4-13 (a) & (b). Fig. 4-13 (a) shows that the amount of the heat input is calculated from the flow rate and inlet and outlet temperatures and is controlled to keep the required value of heat input to the reboiler. Fig. 4-13 (b) shows the heat input control as an instance of application. The conditions of the fluid to the following section is stabilized by controlling the flow rate and outlet temperature of the high temperature process fluid in the No. 1 reboiler (right in the figure), and at the same time, the heat input to the reboiler is calculated for steam control in the No. 2 reboiler (left in the figure) so that the sum of heat inputs to the two reboilers can be maintained constant at the required level.

4.1.6. Internal Reflux Control

In cases where the reflux rates are controlled in fractionation, the external reflux rates are controlled without regulating their temperatures. The rates of the internal refluxes, which are the substantial refluxes, will vary with temperature or the temperature variations will become disturbances. Such disturbances must be precluded in the case of towers designed to produce high purity products. Hence, controllers must be provided for the purpose of controlling the internal reflux rates as shown in Fig. 4-14. In the figure, the FRC internal reflux controller is cascaded with the overhead receiver level controller. In short, the difference between the overhead temperature and reflux temperature is measured to correct the external reflux rates.

4.1.7. Quality Control and Distillation Tower Control

Distillation tower controls generally used are based on Fig. 4-15, which can be selected depending on the purpose and conditions in each individual case after review and discussion. Since pressure controls can be used in combination with any of the above mentioned controls, the most suitable combinations can be selected for the conditions involved in each individual case. Fig. 4-15 (a) shows a general case of product quality control in which the heat input to the bottom section is kept at a fixed level and the overhead is regulated by temperature control. Inversely, in Fig. 4-15 (b), the reflux rate is fixed and temperature control is provided in the bottom section to control the bottoms quality.

Distillation towers designed for separation of small boiling-point-difference components require a large number of trays (over 100 trays) and a reflux ratio of over 10. In such high reflux ratio towers, the product composition and flow rates are largely affected by variations in the reflux ratio. For instance, in cases where the reflux ratio is 10, one percent increase in the distillate rate will result in a ten percent increase in the reflux rate. Hence, to maintain an appropriate material balance, the

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distillate rate must be regulated by flow control and the product composition must be monitored by analyzers (as shown in Fig. 4-16). Meanwhile, in Fig. 4-17, bottom product is withdrawn under flow control. This is used in cases where the bottom product rate is smaller than the distillate rate. The controls shown in Figs. 4-16 and 4-17 are called "material balance control system". Fig. 4-18 shows an instance of instrumentation for a topping main tower which is a typical complex fractionator.

4.2. Control Schemes for Absorber

Usually the absorber is designed together with the regenerator (or stripper). Herein, the absorber and regenerator control system is shown in Fig. 4-19. The diagram is the basic flow of an acid gas removal unit in which amine solution is used as an absorbent. In such a case as this where the process form a loop, an inadequately planned control loop may result in a so-called "closed loop" in which case external disturbances will be amplified and the operating conditions of the system may be left unstable.

In the case of Fig. 4-19, if level control is added to the bottom of the regenerator and the outlet streams of the two towers are regulated by the respective control valves and level controllers, a "closed loop" will form. Since closed loops will form, even if the system is carefully planned, in such cases and more complicated cases, scrupulous care must be taken.

4.3. Control Schemes for Extractor

Fig. 4-20 is a control system for the extractor of a sulfolane unit. The extractor is of a rain deck type, but if it is of a RDC type, there will be no intrinsic difference. In the figure, level indicating control (liquid-liquid interface controller) is provided in the bottom. The reason for this is that the tower is designed to hold the light liquid (hydrocarbon) in the continuous phase and the heavy liquid (solvent) in the disperse phase. Operating temperature of this extractor is governed by the temperature of the lean oil charged to the tower. The controls used around the heat exchanger on which the lean oil temperature depends, are as shown in Fig. 4-20.

4.4. Control Schemes for Reactor

There are numerous hydrodesulfurization processes for petroleum distillates such as naphtha and kerosene. Since the flow schemes of these processes are mostly similar, their controls must be mostly similar. An example is given in Fig. 4-21. Catalytic reforming (such as Platforming) is an endothermic reaction while hydrodesulfurization is an exothermic reaction, in most cases, but the exothermic rate is sufficiently low that it can be offset by heat loss. In some processes, the rate of reaction heat is less than the heat loss. In most cases, the reaction heat raises the process temperature no more than several degrees C. Hence, the reaction temperature can be maintained in the required range only by the temperature control of the reactor influent. On the other hand, in cases where a large quantity of reaction heat is released or absorbed, the reaction temperature will go outside the required range. Fig. 4-22 shows an instance of styrene formation which is conducted by the dehydrogenation of ethyl-benzene, in which case the reaction temperature is maintained

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by heat supply since the reaction is endothermic. As seen from the figure, superheated steam is charged to the reactor at the two intermediate trays.

4.5. Control Schemes for Pump

In many applications, pumps are provided with flow controls on the discharge side, but basically pump control systems can be classified into the following two:

- (1) Flow control with control valve on discharge:

Refer to Fig. 4-23 (a).

- (2) Flow control with control valve on spill back line:

Refer to Fig. 4-23 (b)

The control (2) is not so economical, but in the case of large capacity pumps which are expected to conduct shut-off operation, potential damages from excessively low or no flow situation can be prevented. In cases where turbines are used as drivers, the turbine speeds (rpm) may be controlled by regulating the governor. In the case of such large capacity pumps as those used in offsite facilities, override control is often used for the purpose of pump protection (Refer to Fig. 4-24).

4.6. Control schemes for Compressor

Compressor controls are primarily intended for the prevention of surging. Anti-surge control of a centrifugal compressor is generally carried out by controlling the suction flow rate by means of the kickback valve. At some centrifugal compressors, anti-surge control is carried out by controlling the ratio of the suction flow rate and compressor differential pressure (Refer to Fig. 4-25).

Multi-stage compressors are provided with bypasses as shown in Fig. 4-26: all-stage bypass (called N-1 bypass in the case of N-stage) and one-stage bypass (called 1-1 bypass). The former is advantageous, in that the pressure balance between the individual stages can be well maintained, but is disadvantageous in that the power loss is large. The merit and demerit of the latter are reverse to those of the former. Selection of the bypass system for surge protection should be best made by after reviewing the recommendations from the vendor and considering additional control schemes to improve the surge protection system.

The flow rate or discharge pressure of a reciprocal compressor are usually controlled by manipulation the spill back flow rate and/or the unloader. Fig. 4-27 shows an example of the control scheme for a two stage reciprocal compressor. The special feature in this case is that the differential pressure in each stage is controlled within such a range that no excessive force is exerted on the compressor shafts.

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5. TABLES AND FIGURES

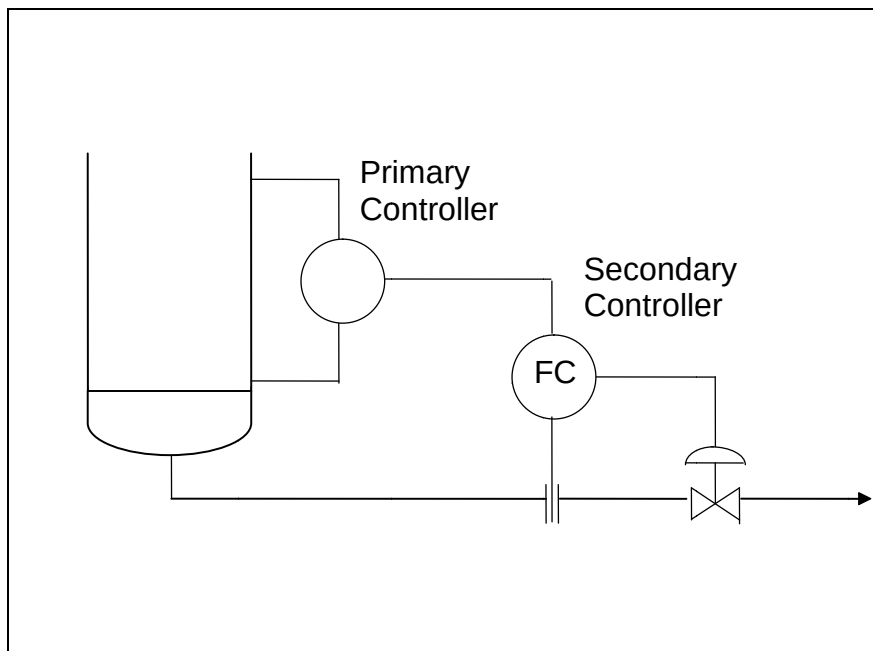


Figure 3-1. Cascade Control

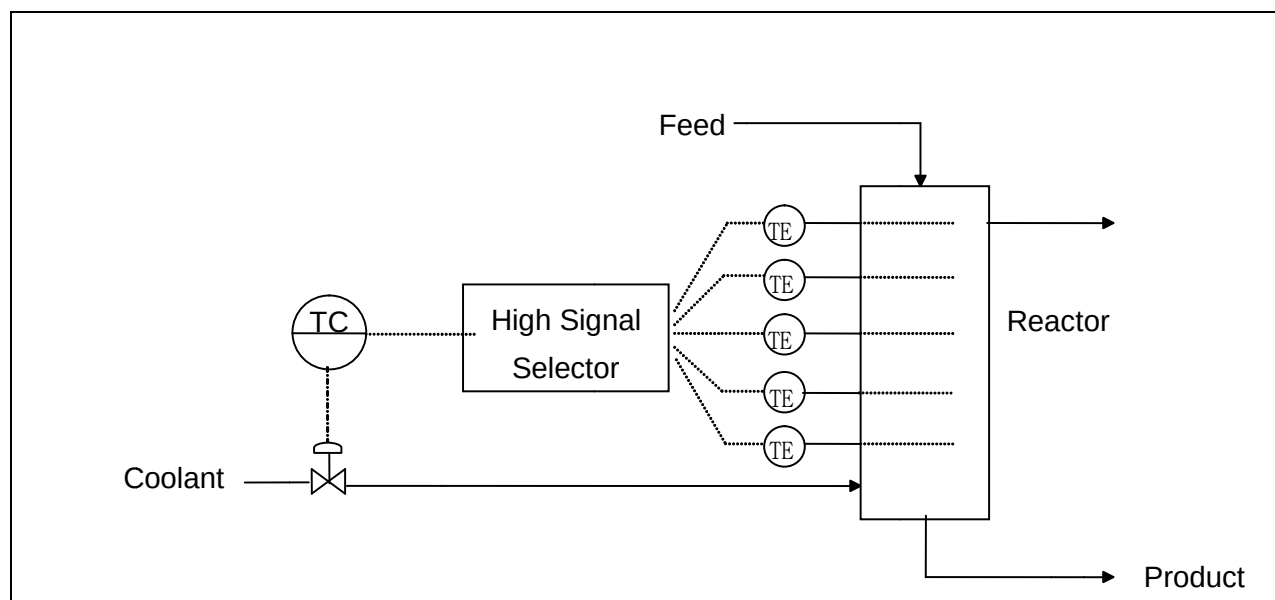
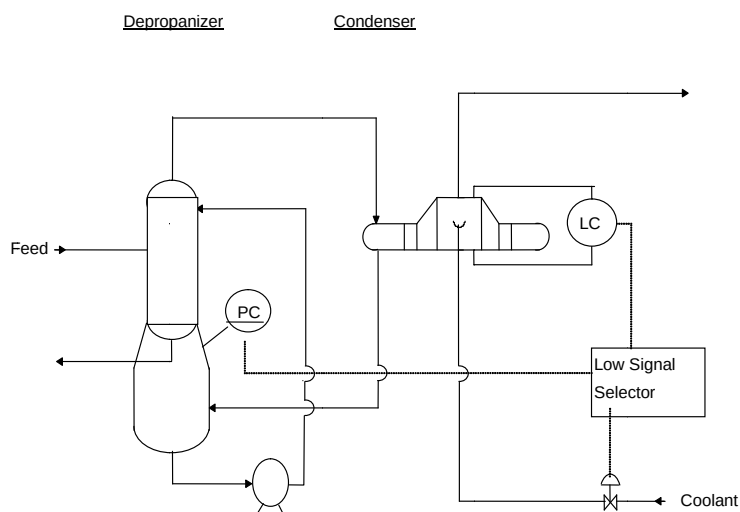
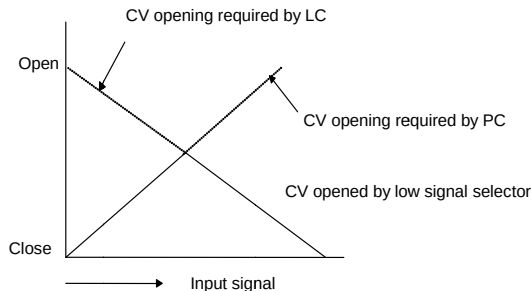
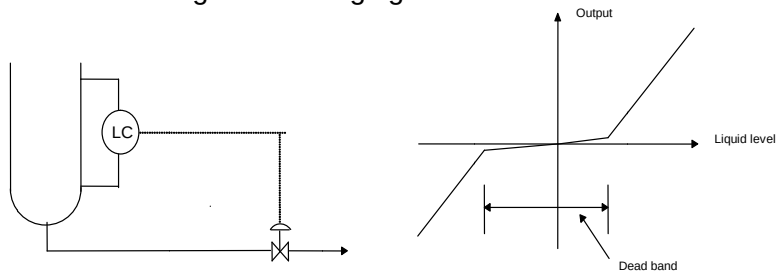


Figure 3-2. Selection of Measurement Signals

Fig. 3-3 Selection of Manipulation Signals


Operations of the control valve in response to pressure control and level control signals are conceptually as shown below.


Fig. 3-4 Averaging Level Control

Figures 3-3 and 3-4. Selection of Manipulation Signals and Averaging Level Control

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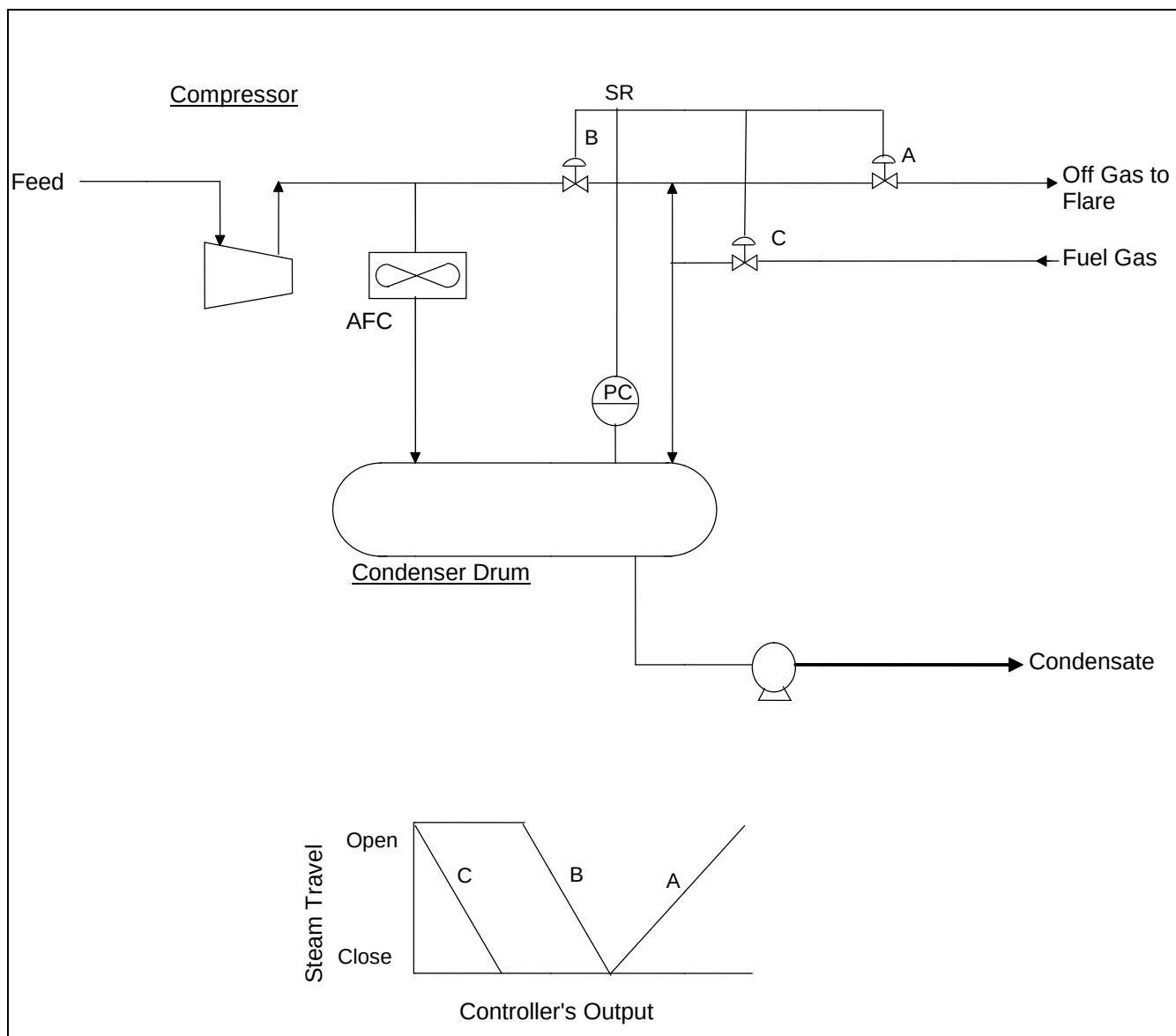


Figure 3-5. Split Range Control

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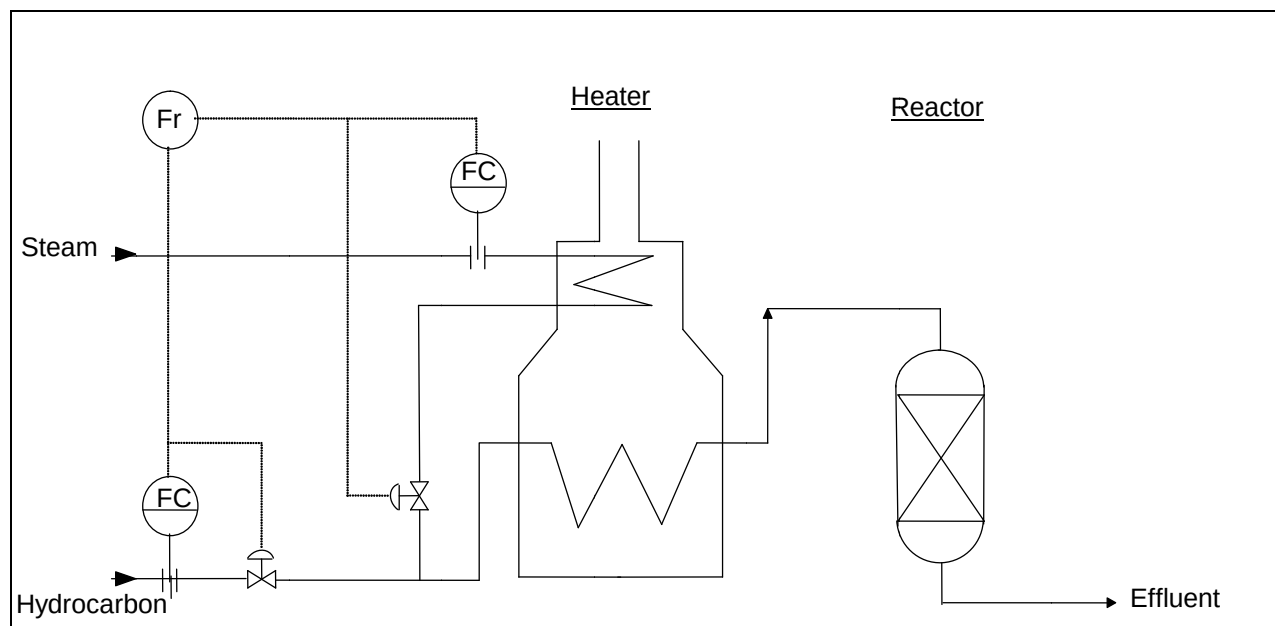


Figure 3-6. Ratio Control

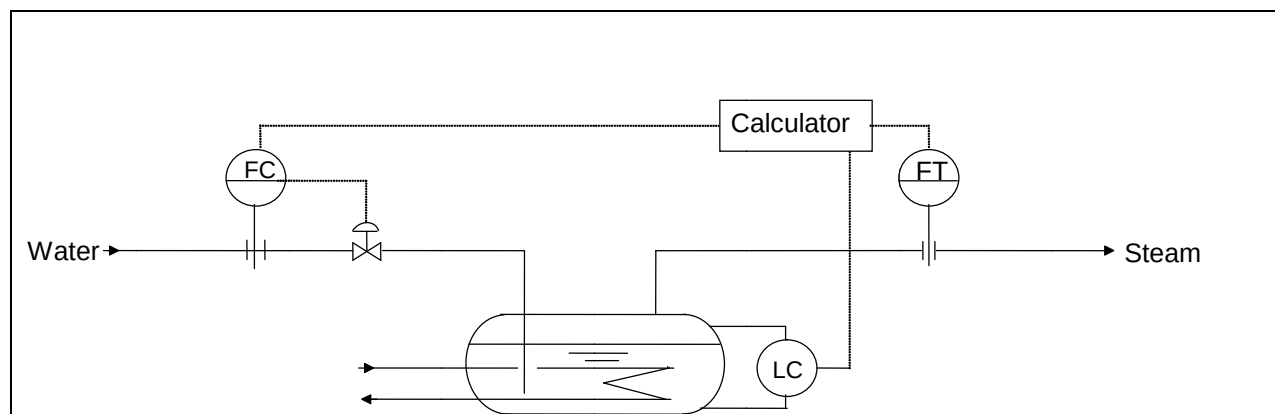


Figure 3-7. Feed Forward Control

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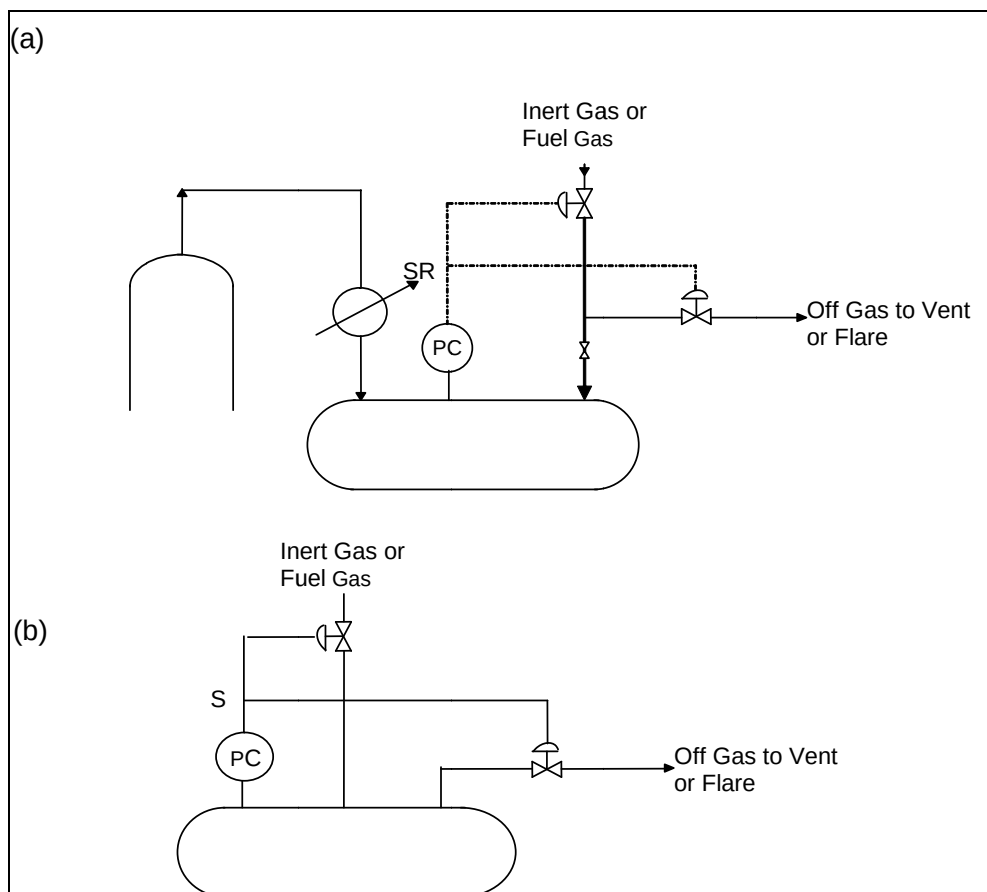


Figure 4-1. Pressure Control of Distillation Tower 1

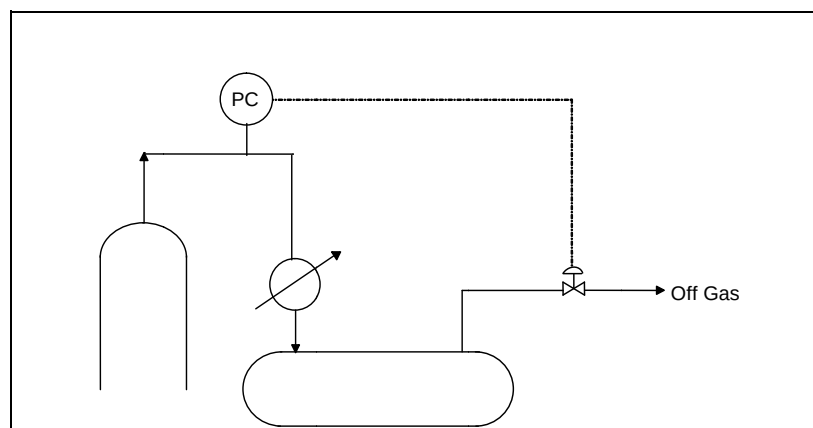


Figure 4-2. Pressure Control of Distillation Tower 2

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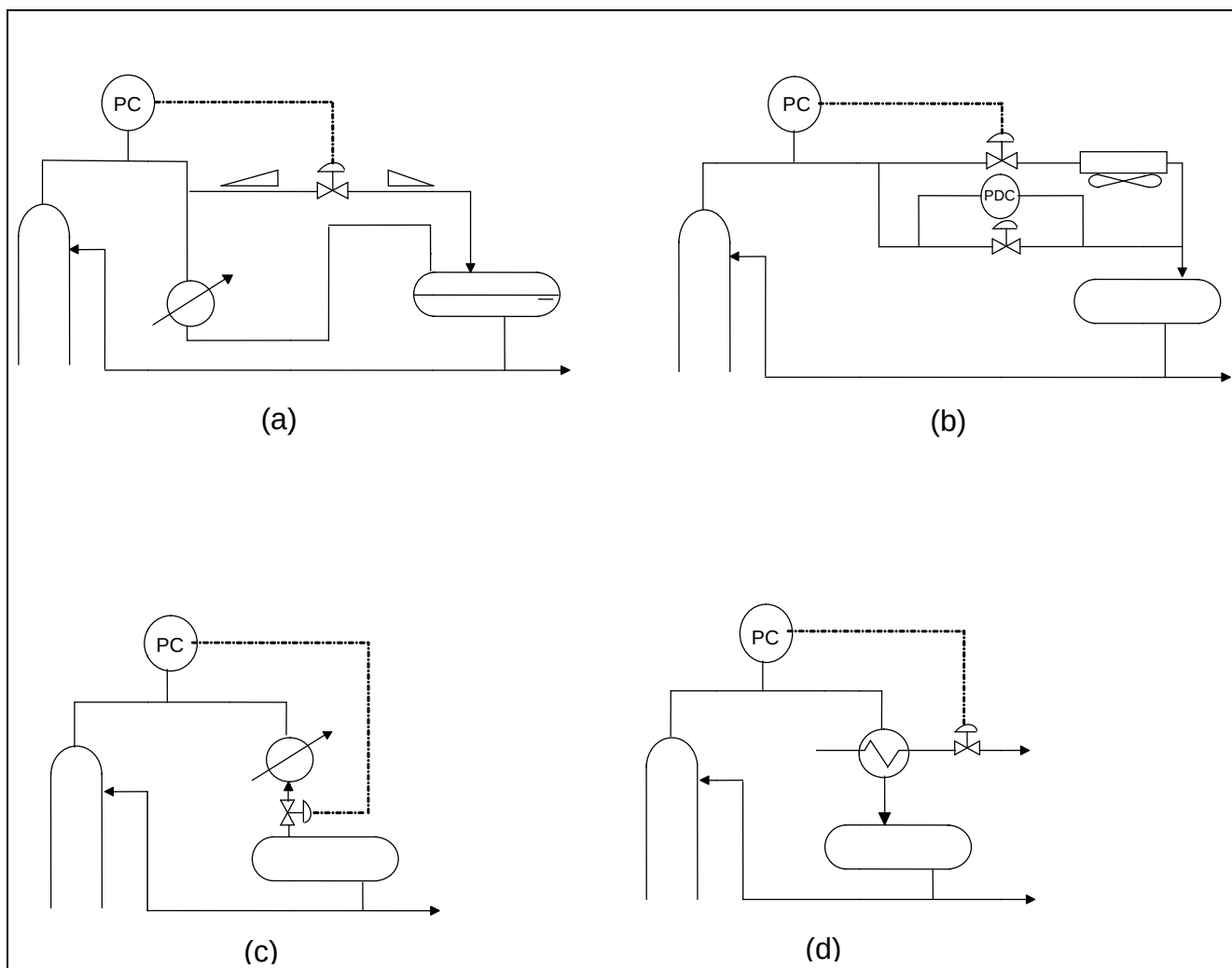


Figure 4-3. Pressure Control of Distillation Tower 3

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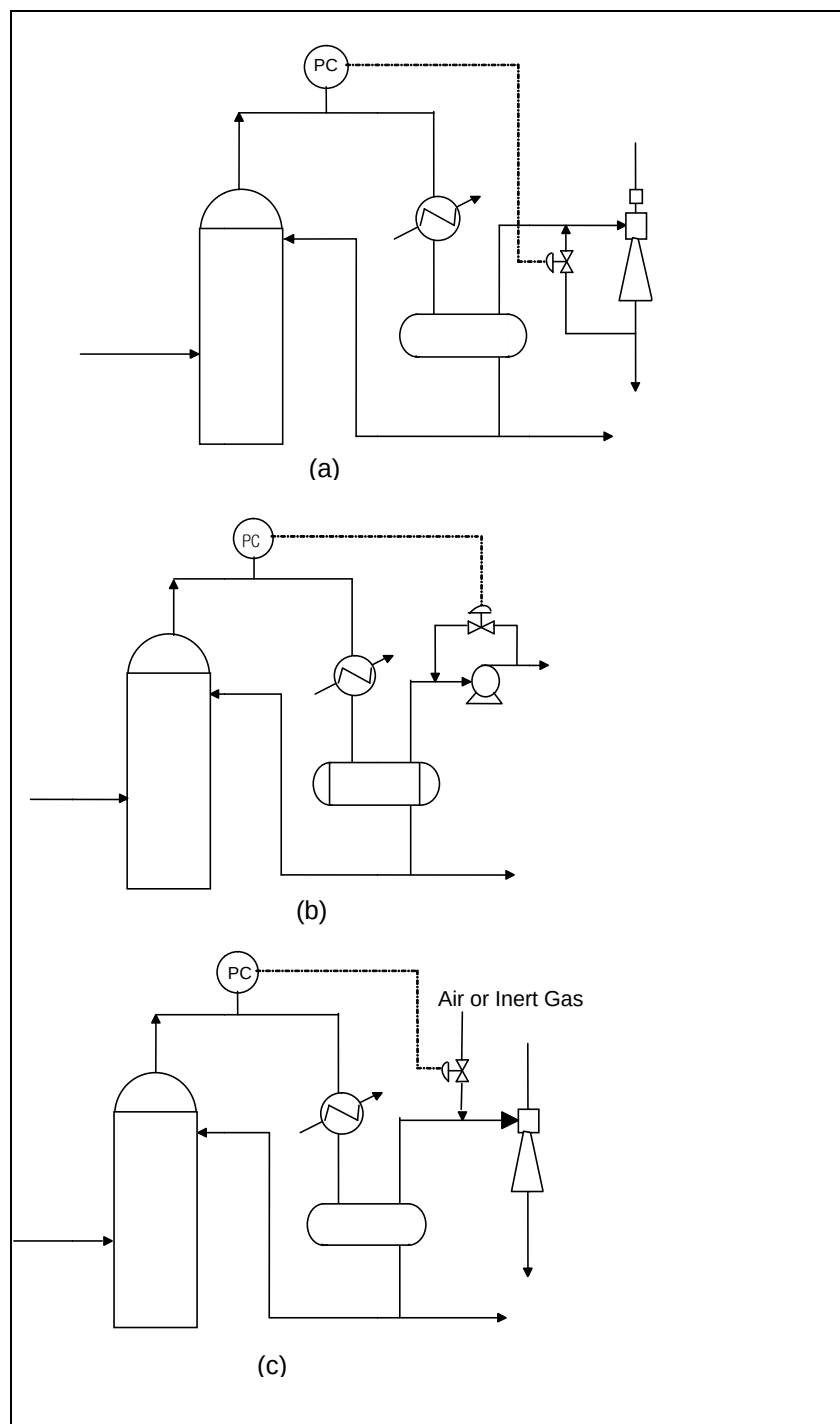


Figure 4-4. Pressure Control of Distillation Tower 4

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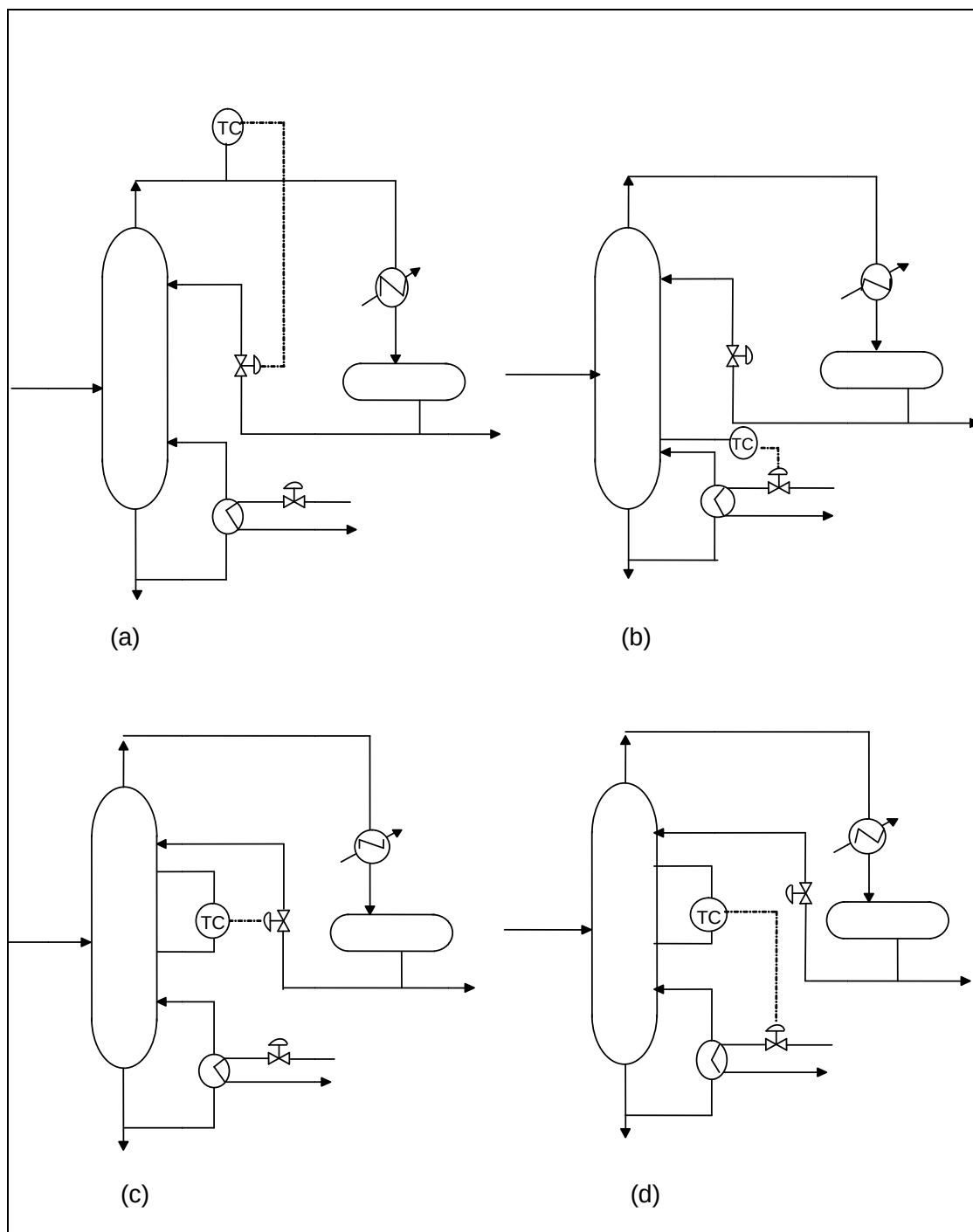


Figure 4-5. Temperature Control of Distillation Tower

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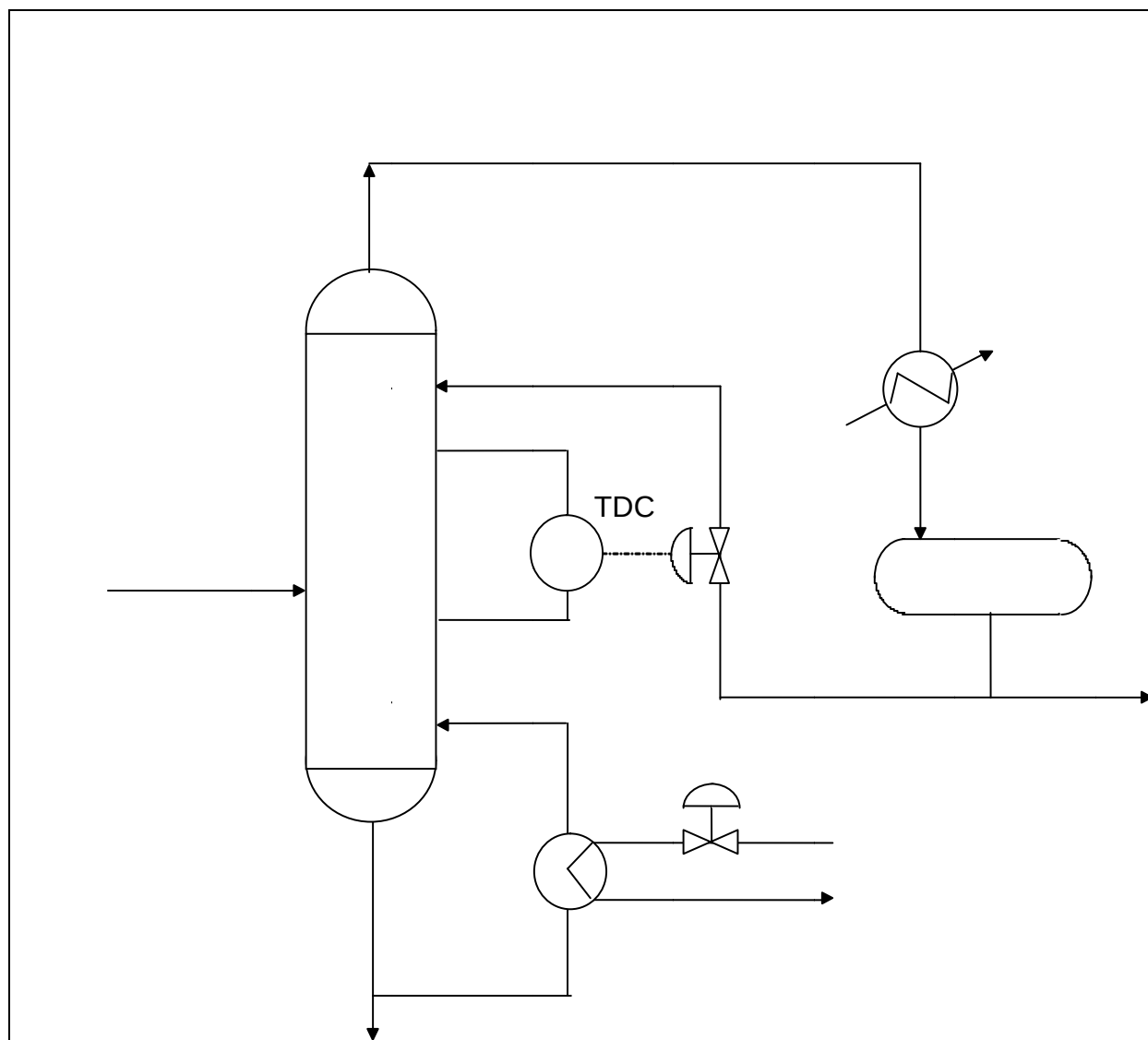


Figure 4-6. Temperature Difference Control of Distillation Tower

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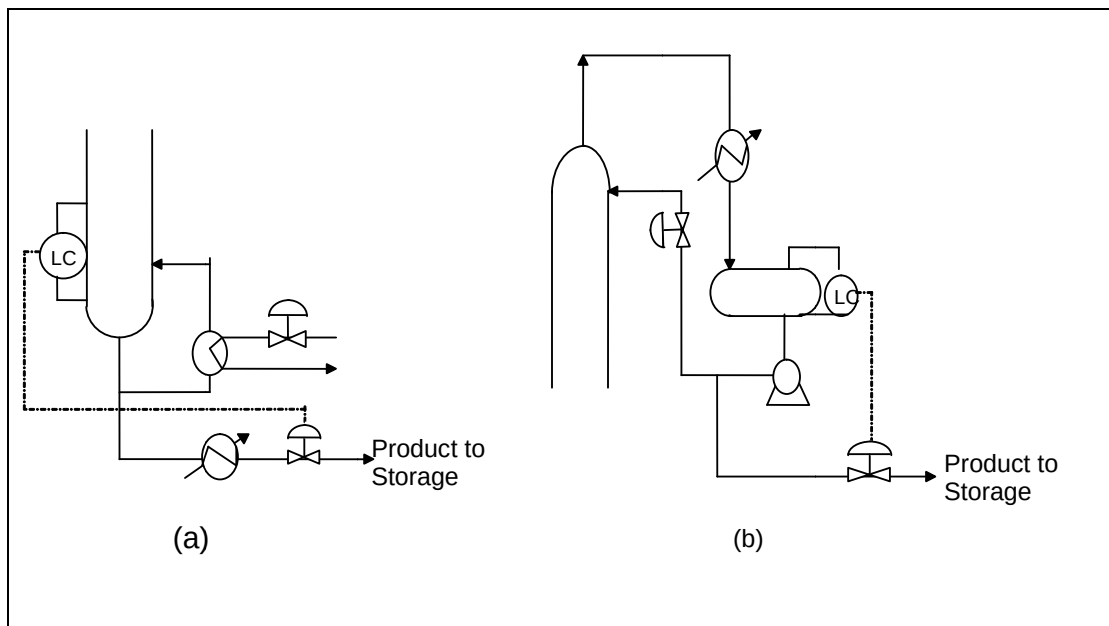


Figure 4-7. Level Control of Distillation Tower 1

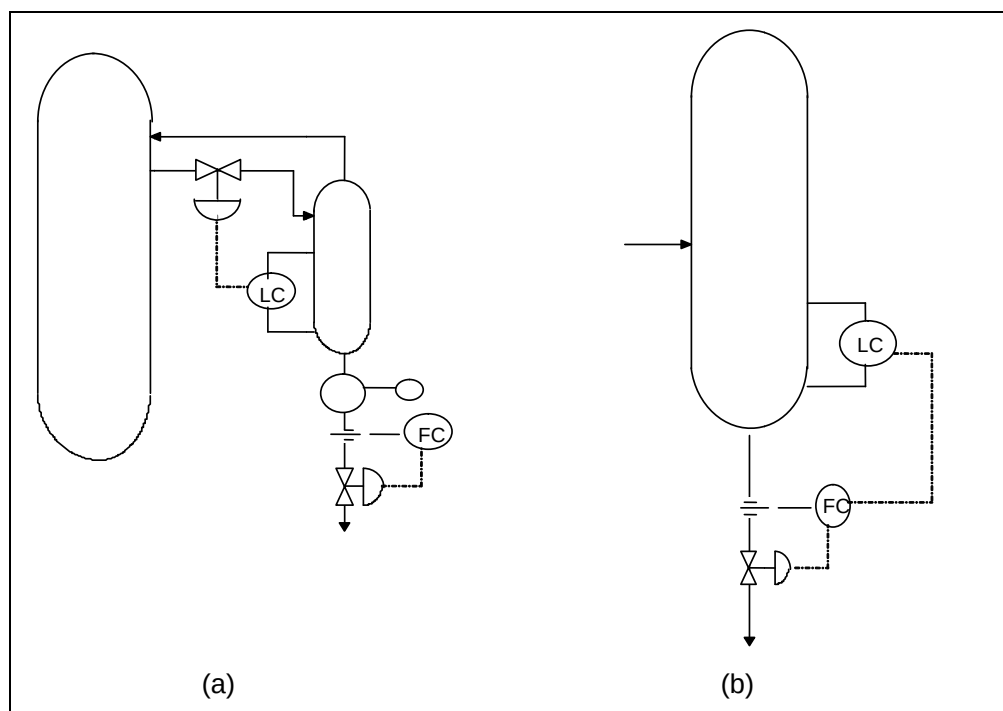


Figure 4-8. Level Control of Distillation Tower 2

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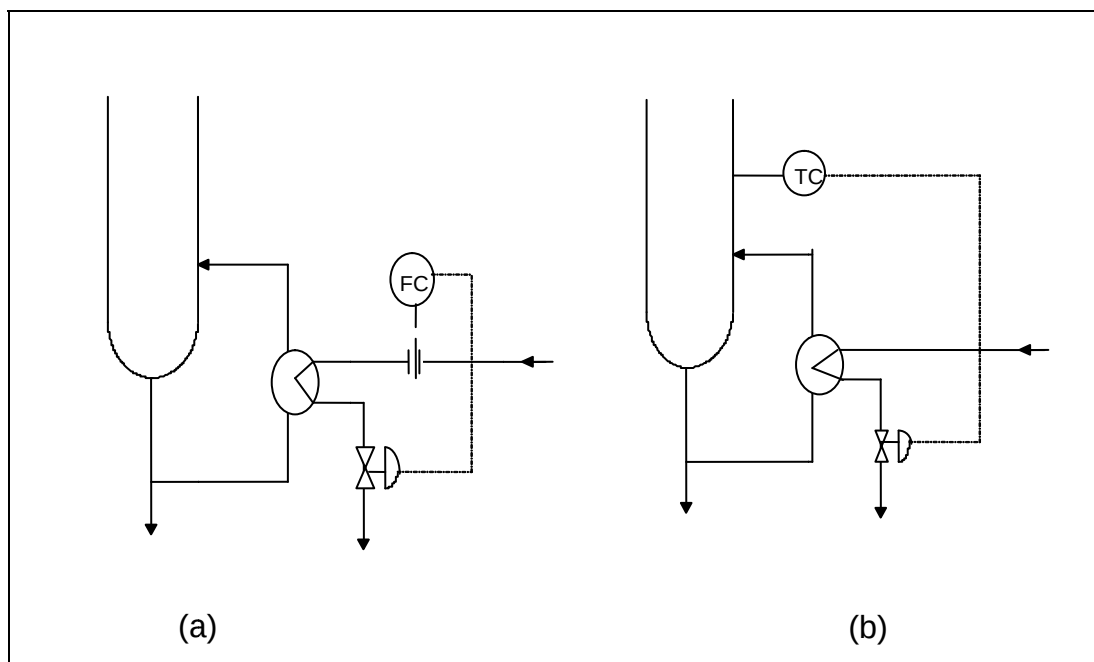


Figure 4-9. Control of Reboiler 1

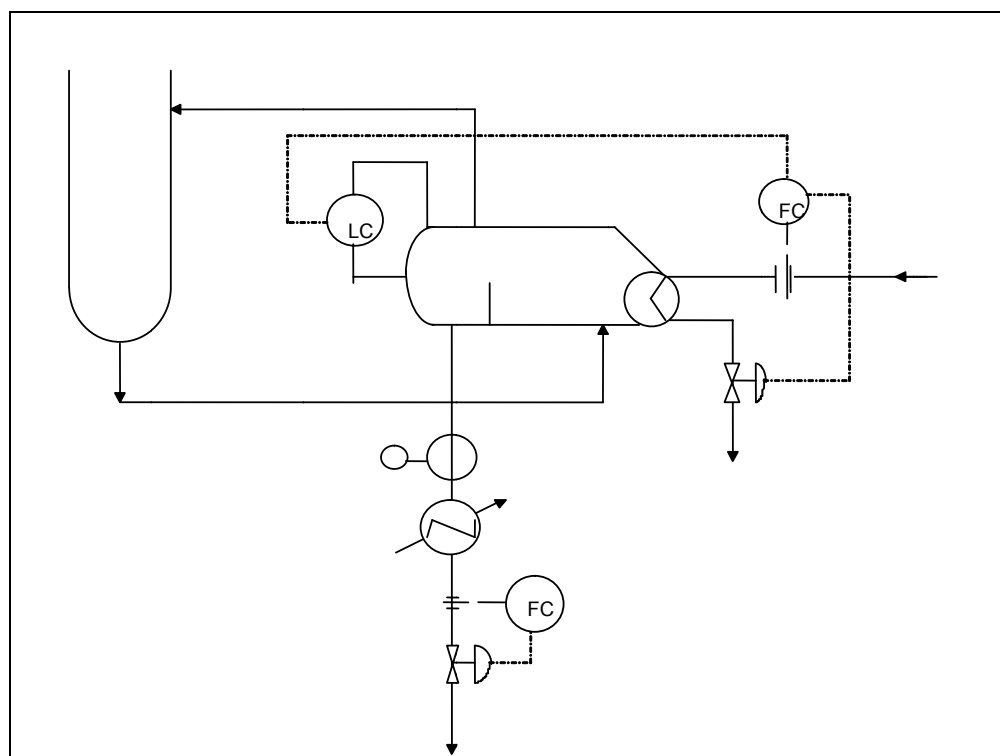


Figure 4-10. Control of Reboiler 2

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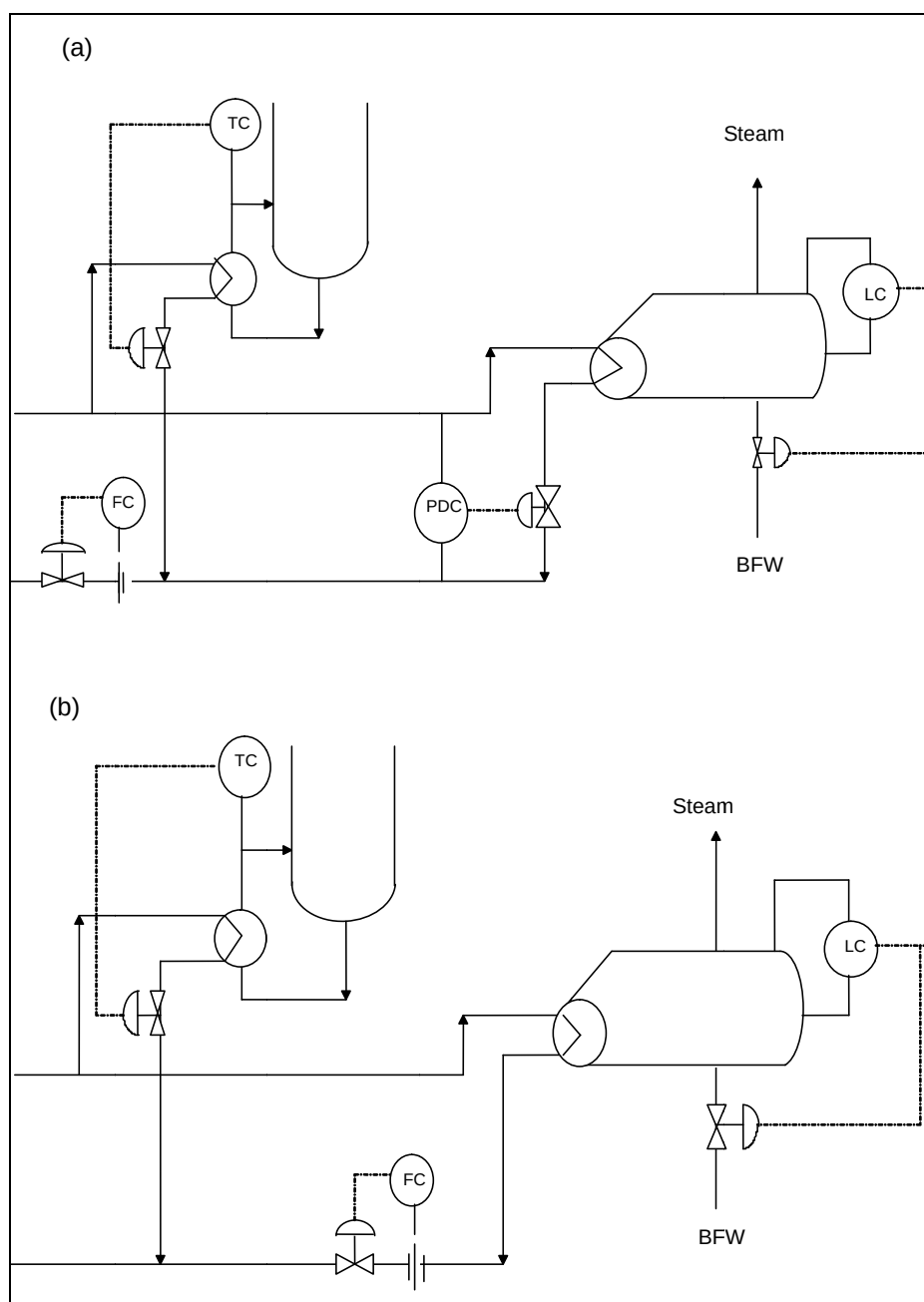


Figure 4-11. Control of Reboiler 3

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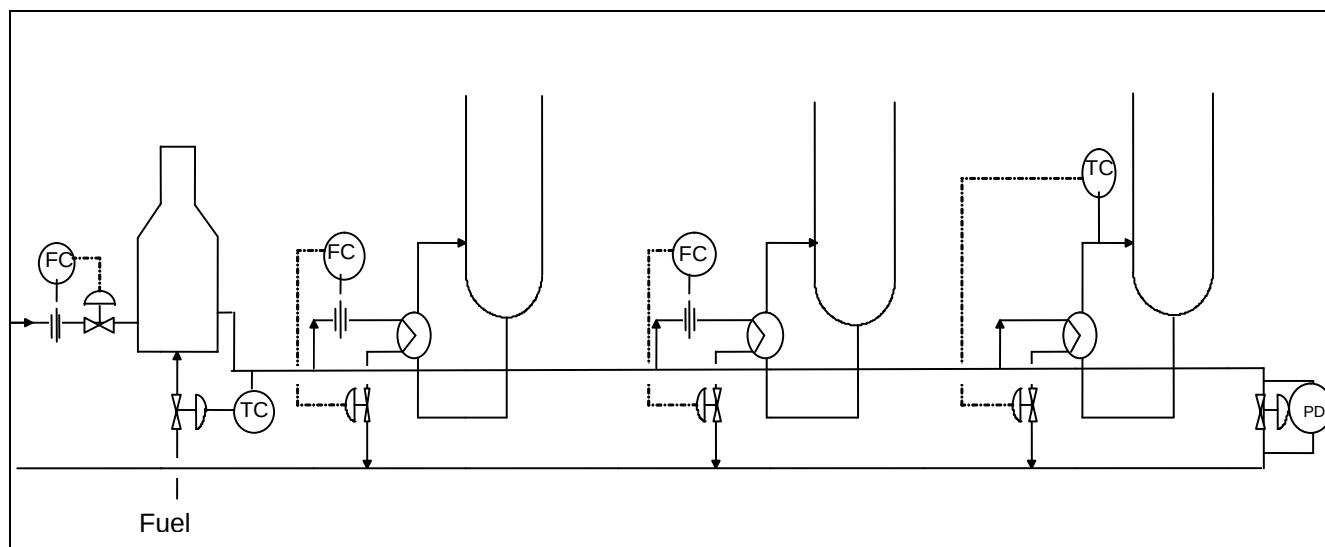
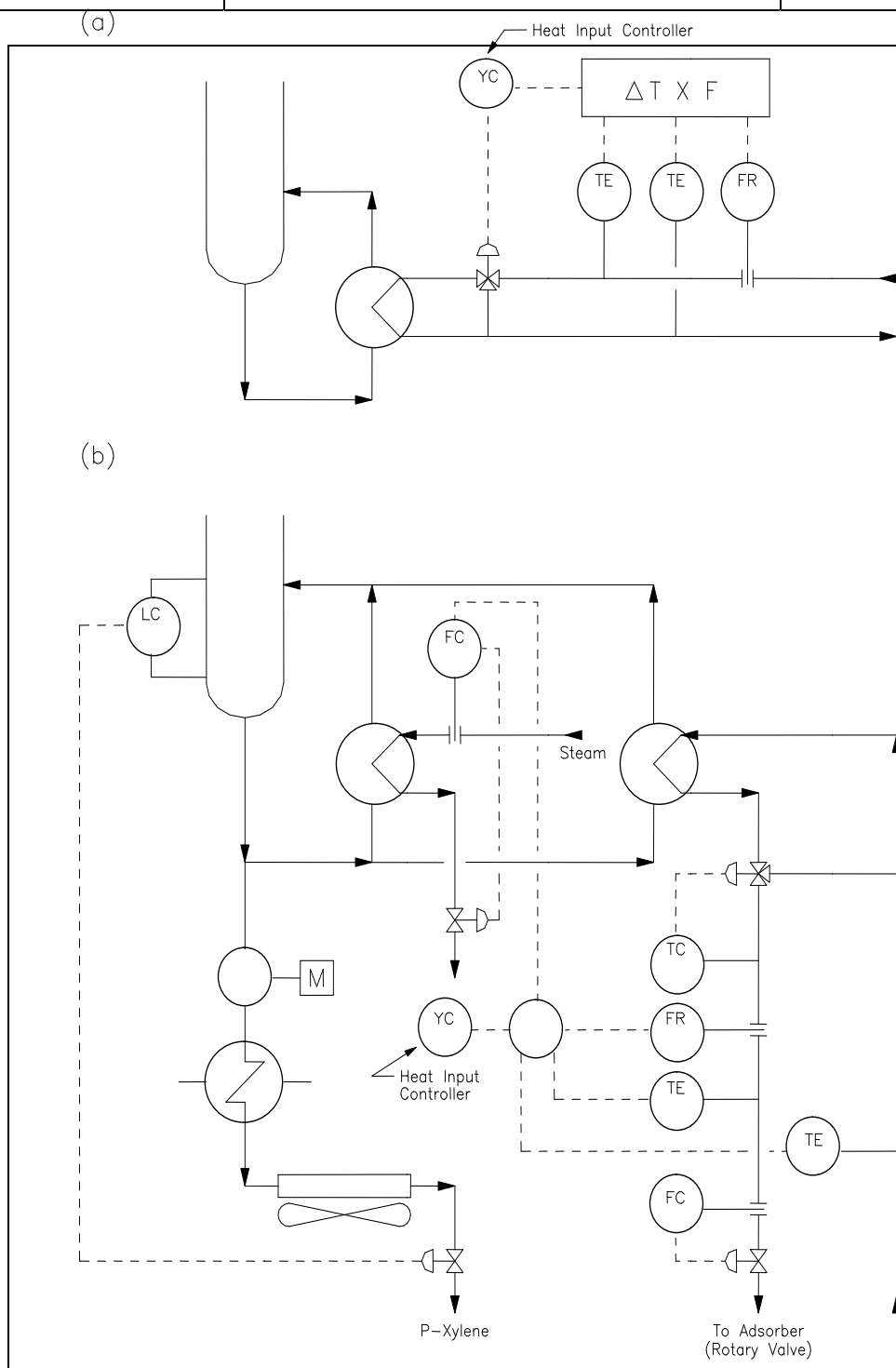


Fig. 4-12. Control Reboiler for Hot Oil System



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Fig. 4-14. Internal Reflux Control

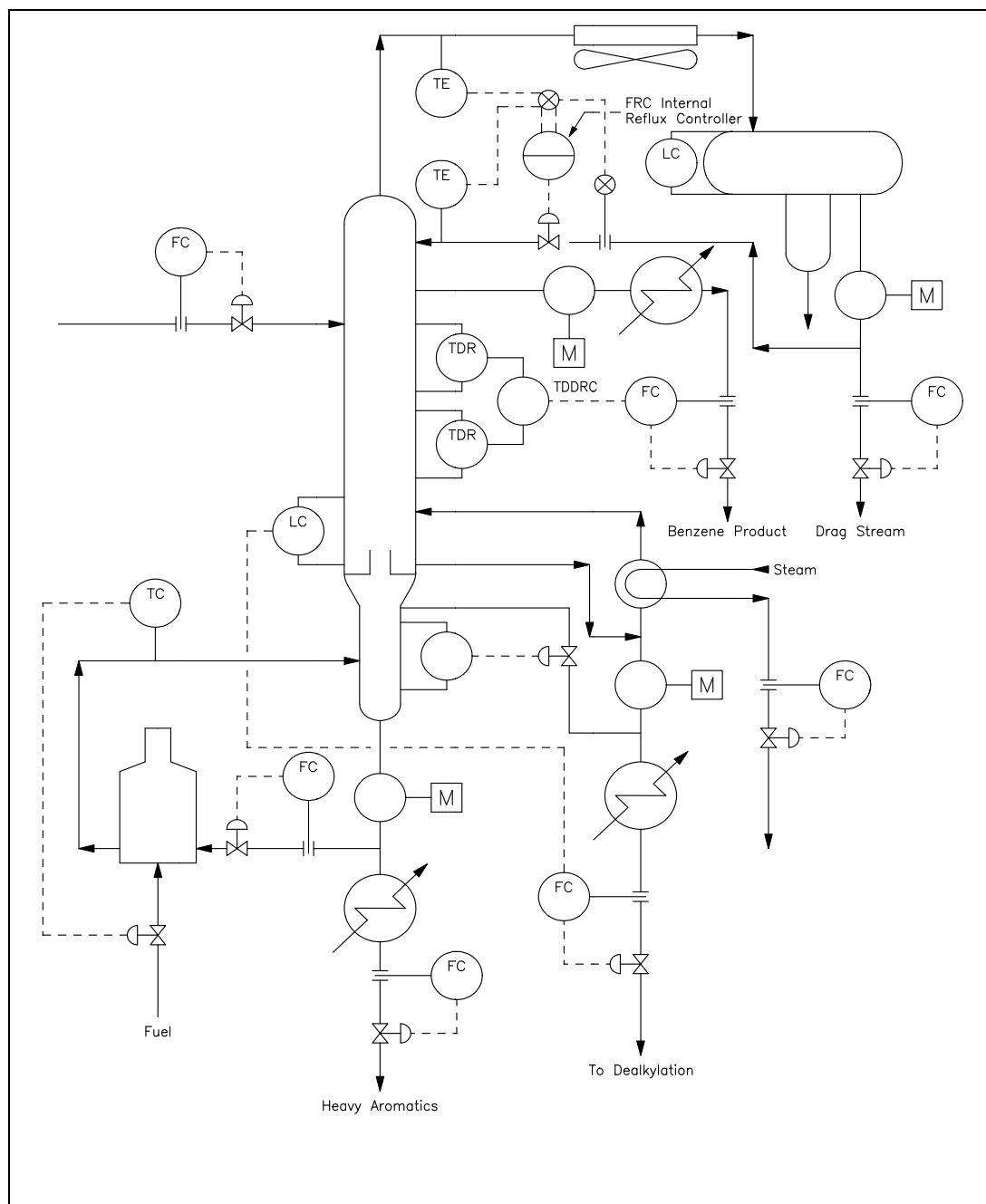


Figure 4-14. Internal Reflux Control

Fig. 4-15. Product Quality Control

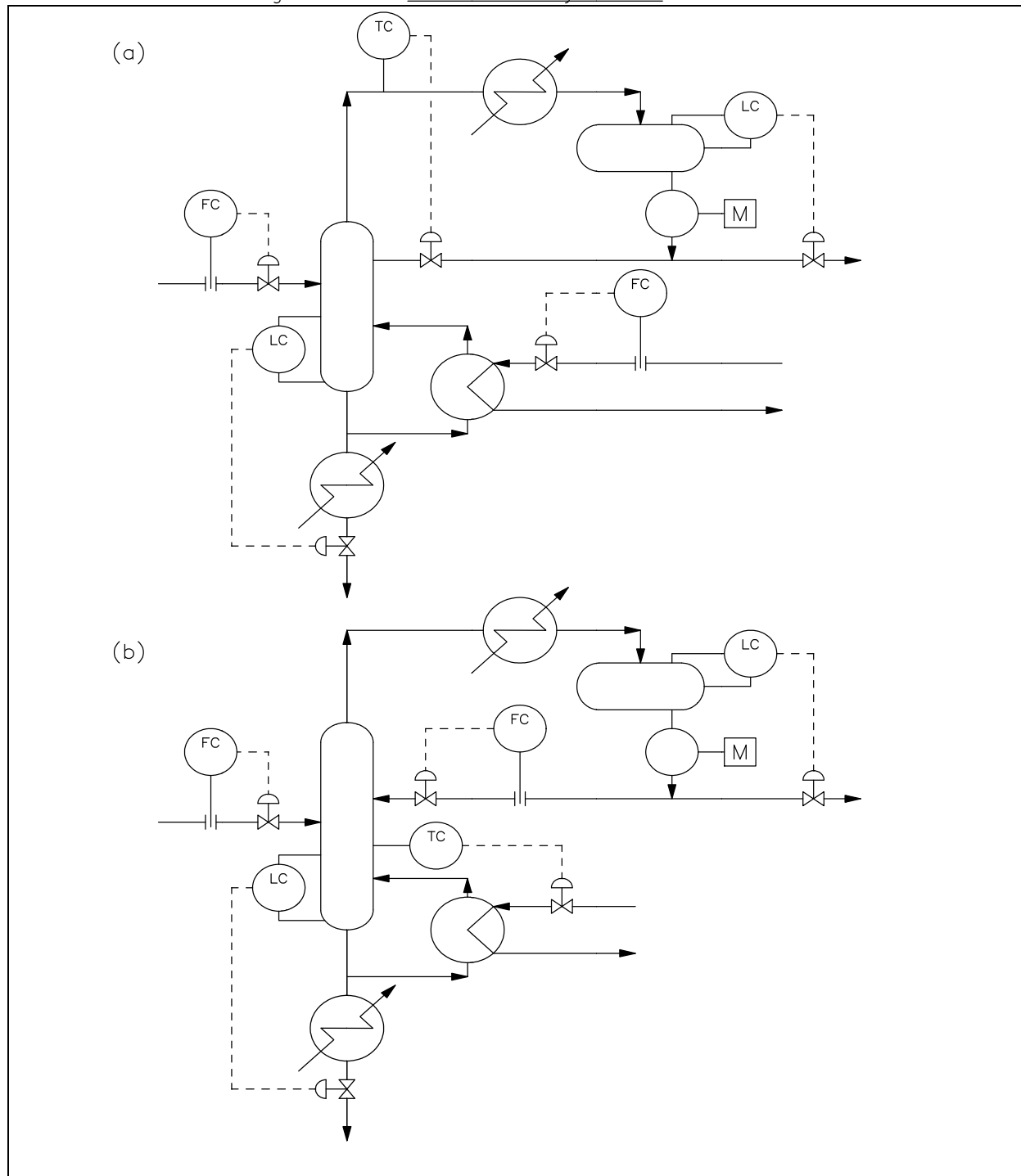


Figure 4-15. Product Quality Control

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Fig. 4-16. Material Balance Control System 1

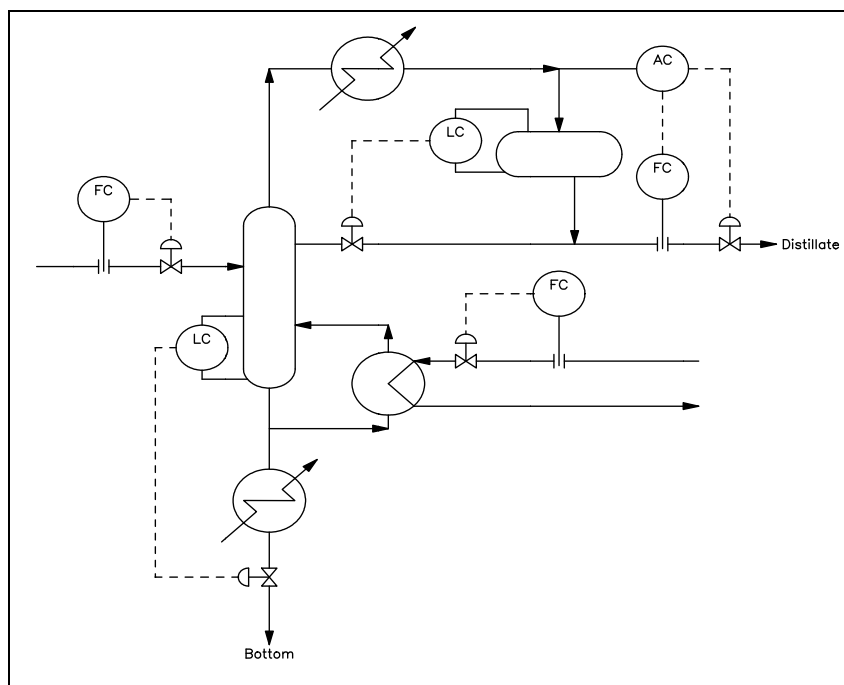


Figure 4-16. Material Balance Control System 1

Fig. 4-17. Material Balance Control System 2

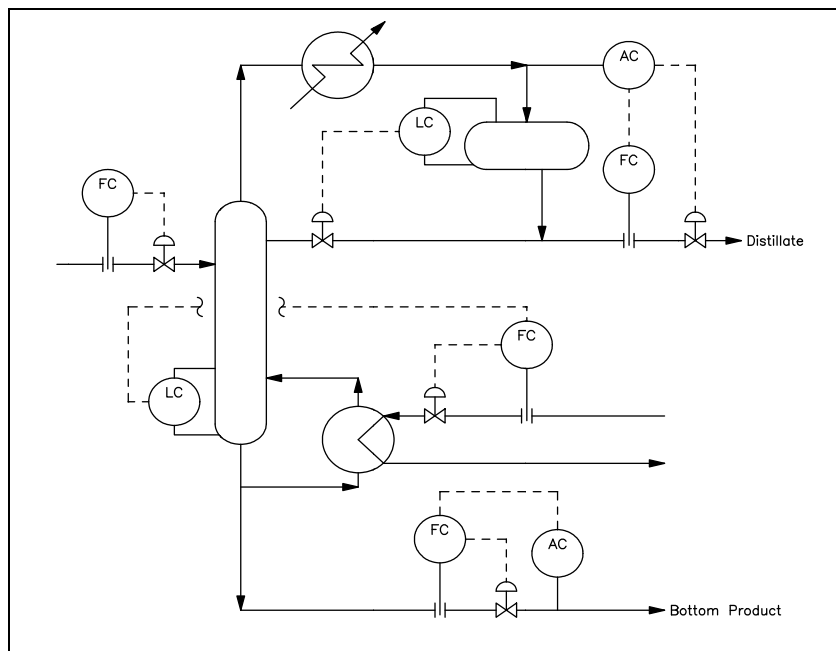


Figure 4-17. Material Balance Control System 2

Fig. 4-18. Control of Topping Main Tower

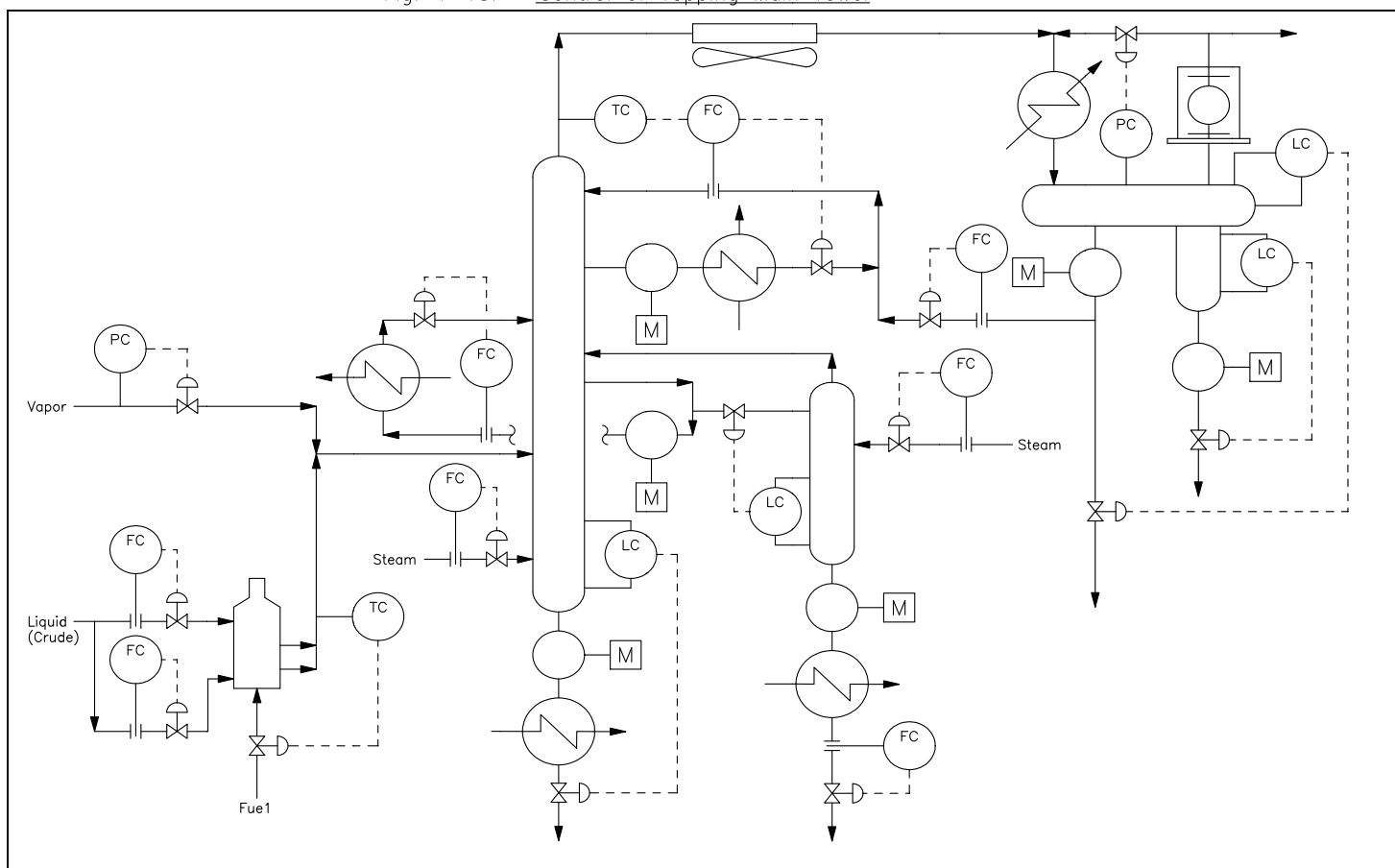


Figure 4-18. Control of Topping Main Tower

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Fig. 4-19. Control of Acid Gas Removal process

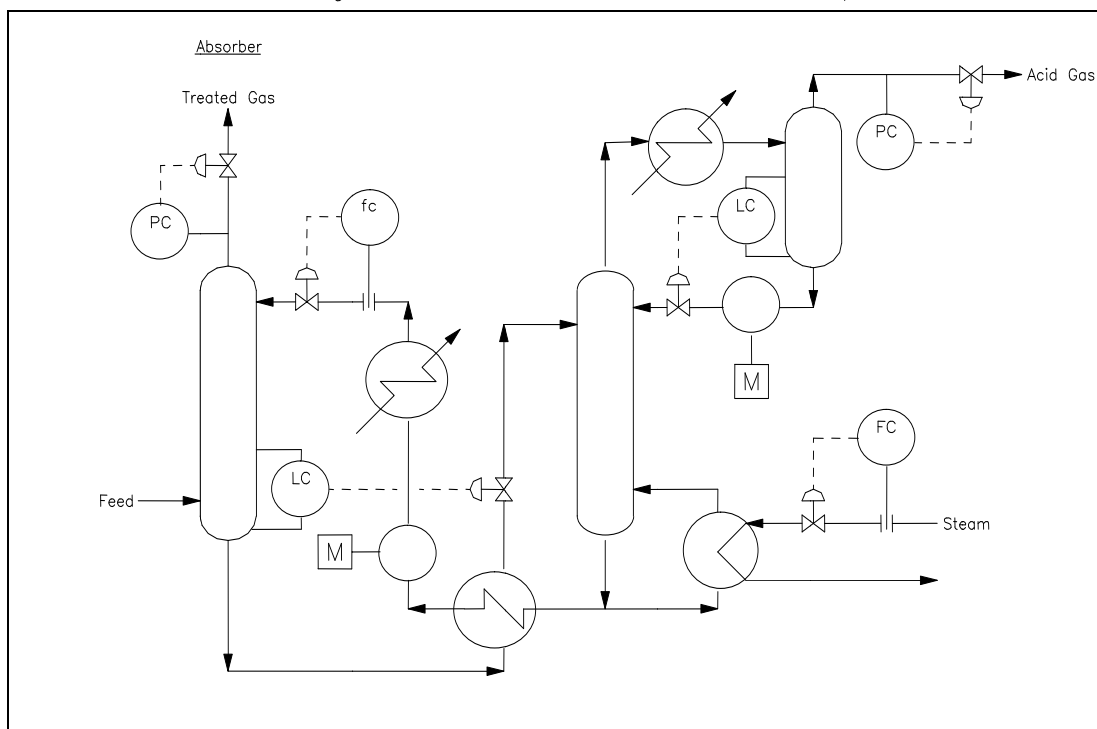


Figure 4-19. Control of Acid Gas Removal Process

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Fig. 4-20. Control of Extractor

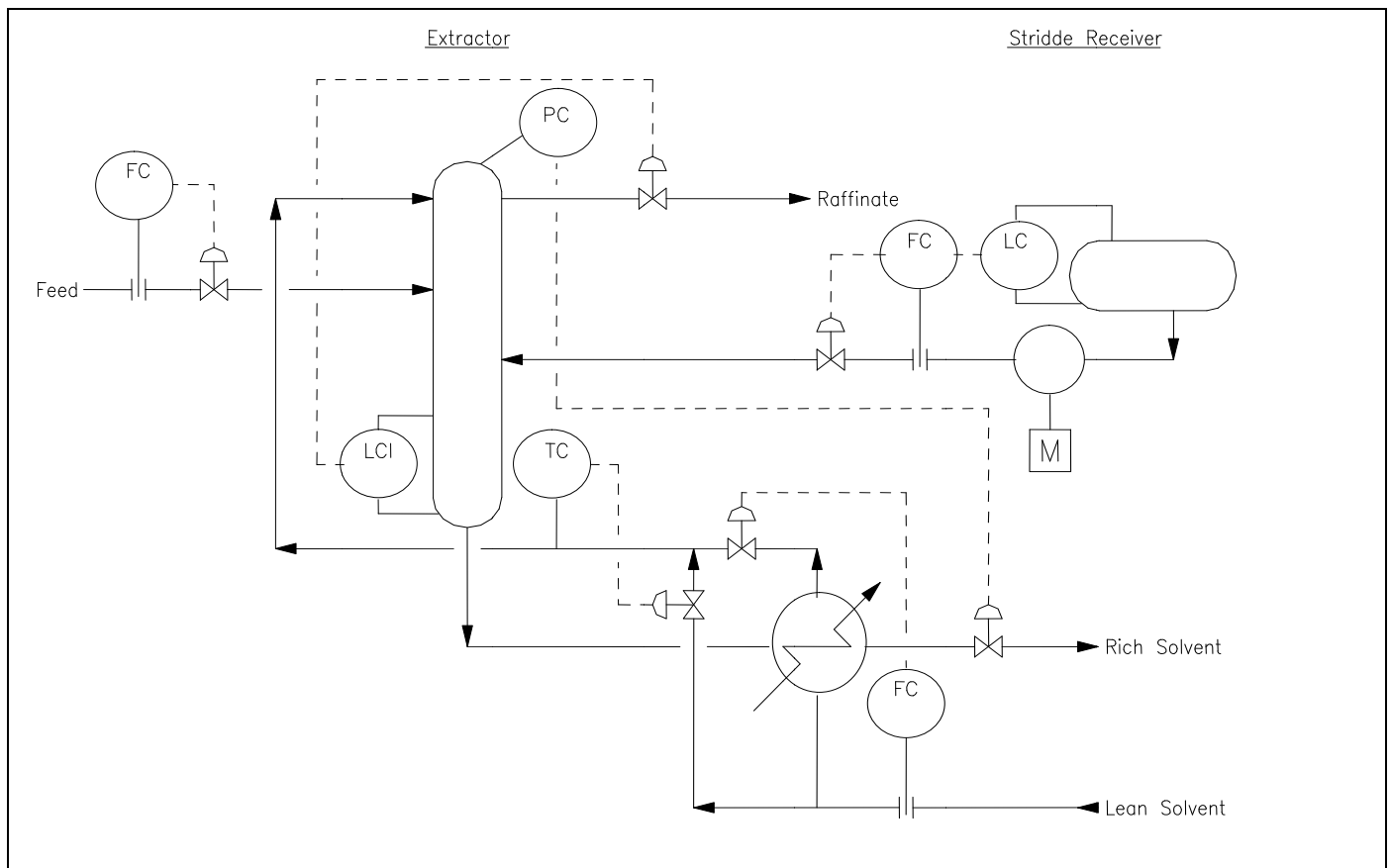


Figure 4-20. Control of Extractor

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Fig. 4-21. Control of Reactor 1

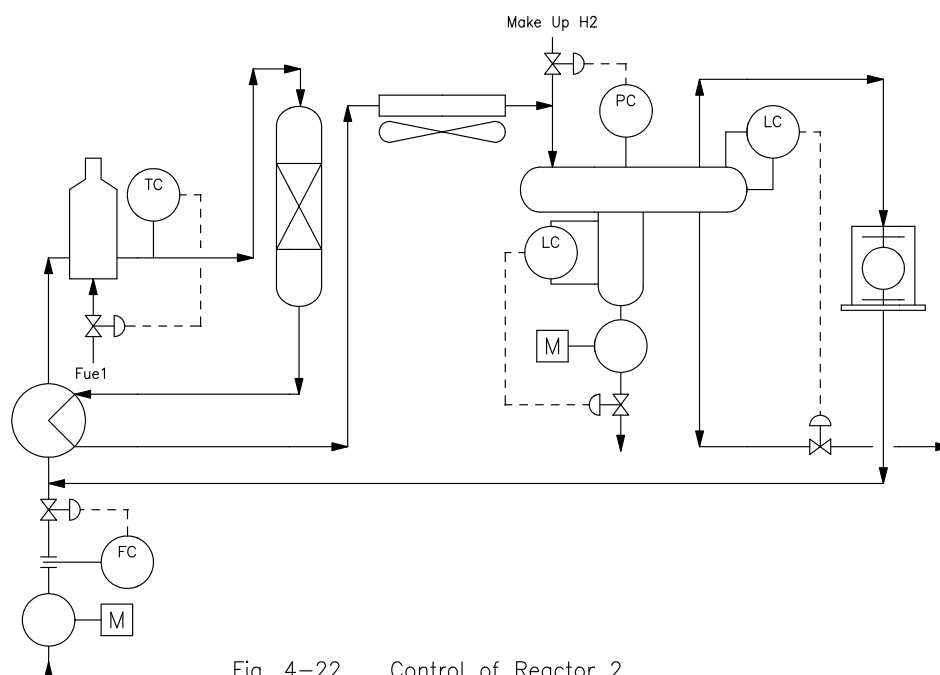
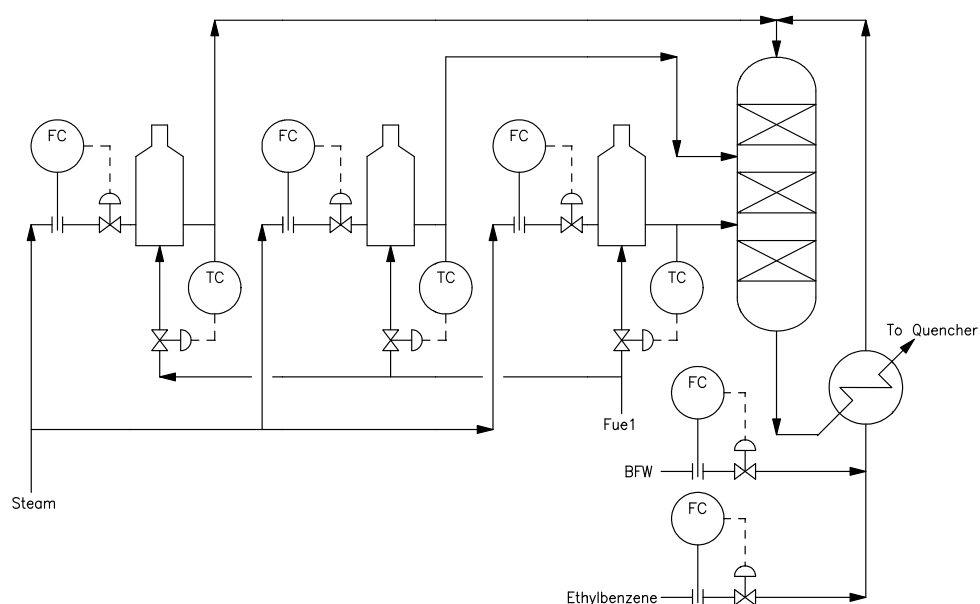


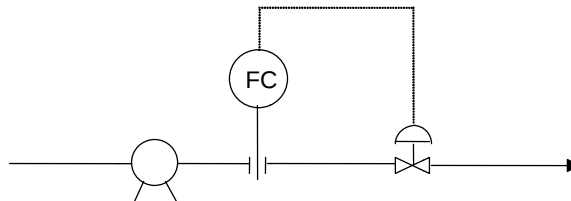
Fig. 4-22. Control of Reactor 2



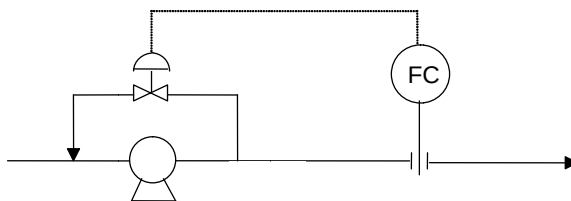
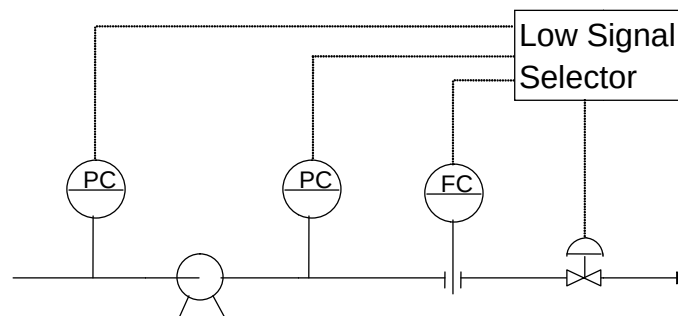
Figures 4-21 and 4-22. Control of Reactor 1 and Control of Reactor 2

Fig. 4-23 Pump Control System 1

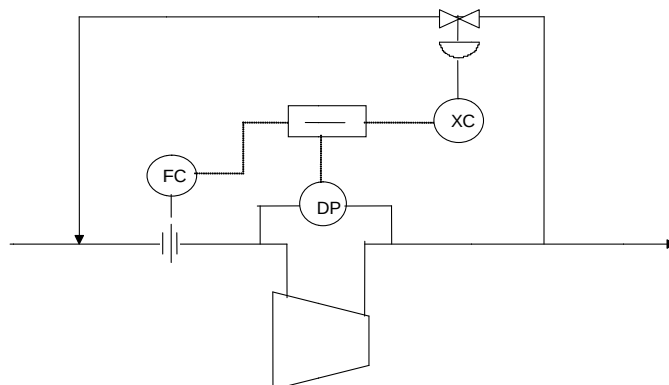
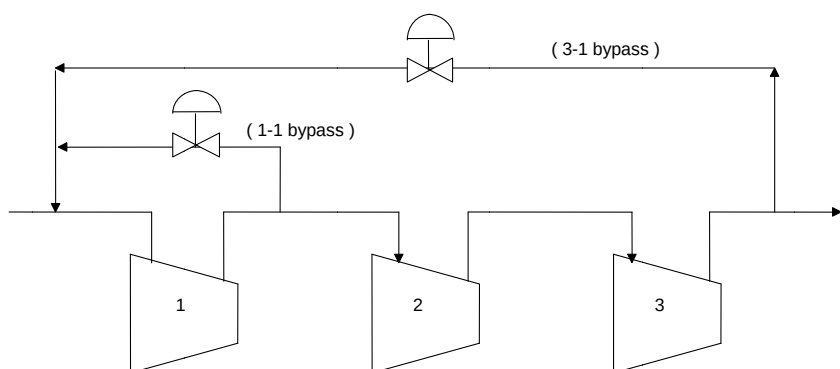
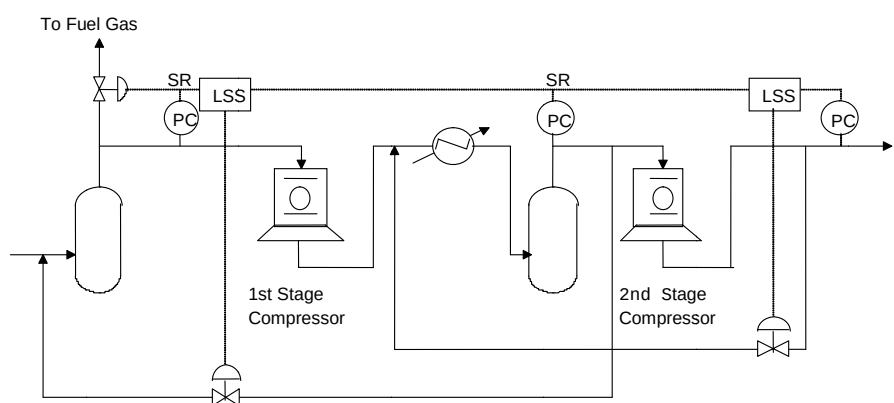
a)



b)


Fig. 4-24. Pump Control System 2


Figures 4-23 and 4-24. Pump Control System 1 and Pump Control System 2

Fig. 4-25. Compressor Control System 1

Fig. 4-26. Compressor Control System 2

Fig. 4-27. Compressor Control System 3


Figures 4-25, 4-26 and 4-27. Compressor Control System 1,2 and 3

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6. REVISION HISTORY

SEA issue of SPD0016ERN-USA

REV NO.	DATE	SCOPE	DESCRIPTION
2	09 Jun 2011	Revised for new Doc. Numbering System	-Team: Process Engineering -Prepared by: K. Elliott -Checked by: S. Wenger -Approved by: M. Czaikowski

Previously issued as SEM-9412E-USA

Rev. No.	Date	Scope	Description
1	29 Nov 2010	All Pages	First Edition – SEA -Team: Process Engineering -Prepared by: A. Coulam -Checked by: M. Czaikowski -Approved by: J. Tait

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7. FOOTNOTES

- ⁱ Condensate inlet location on the drum seems questionable.
- ⁱⁱ The need for the FCV seems questionable.