Advanced Control

Simple Level Control Loops

Example 1:

In most petrochemicals when a mixture of gaseous components passes over catalyst particles in a reactor, as we know from what we learned in university, a part of this mixture is converted and in outlet stream we would have product and some unreacted gaseous components. First thing to know is that the product should be separated from those unreacted gaseous components so we need a separator. The liquid is separated from the gaseous components but it is unpurified; for instance, it is a mixture of A+B. It means that we need to send the mixture to distillation column for further purification. Yes, we have separated the gas from the liquid but it is normal if we think that there is some amount of gas which is trapped or dissolved in the liquid. Isn't it better if we separate the dissolved gas before sending the gas to distillation unit?

Rule of separators:

1. If the gas flowrate to liquid flowrate is very high, then select vertical separator.
2. If the liquid flowrate to gas flowrate is very high, then select horizontal separator.

Now let's decide for the example with one assumption that the conversion is 25%, which means the flowrate of gaseous mixture is noticeably more than the flowrate of liquid mixture. Se we select a vertical separator. Since most of the gas is separated by means of first separator, then the amount of dissolved gas would be very low, which means that the second separator should be horizontal. By the way, horizontal is the best configuration for this one since it gives the dissolved gas enough space to escape.

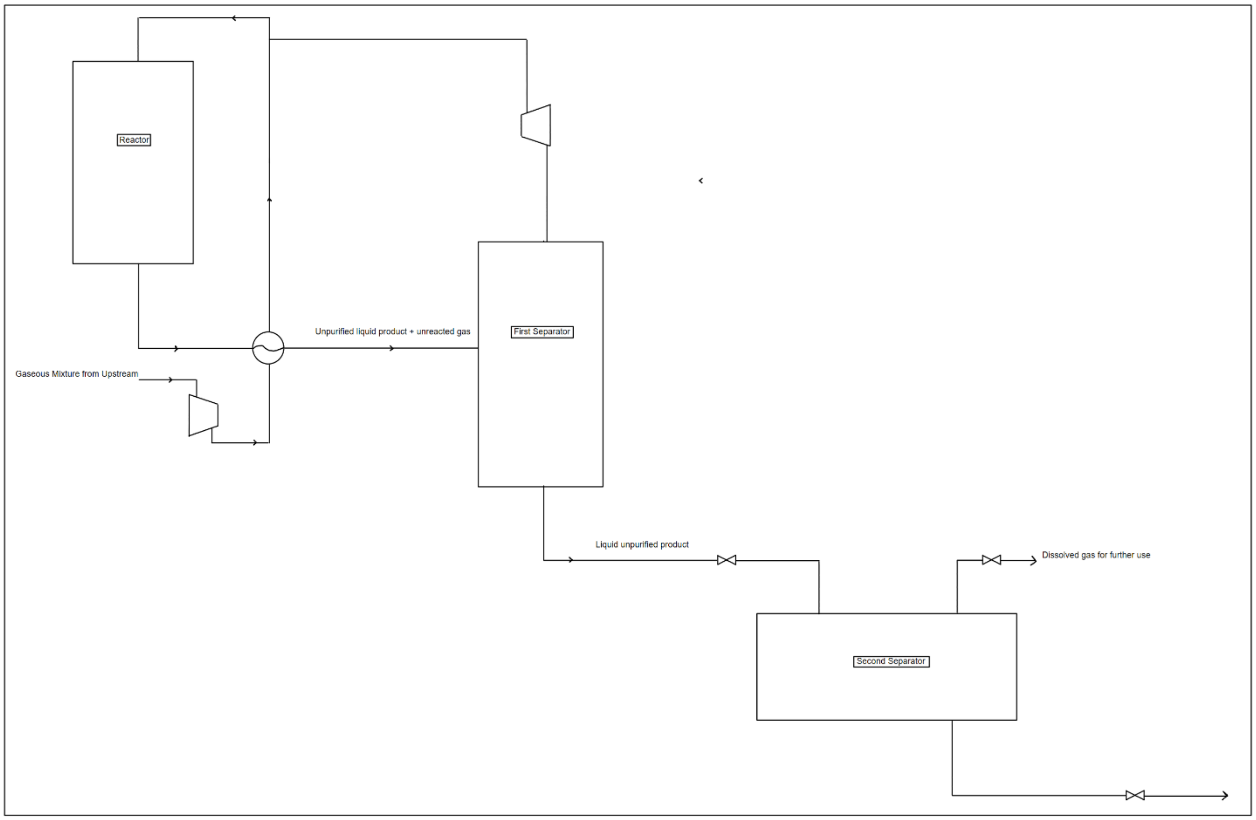
So far, the developed PFD-like sketch would be like what is shown in next page:

Now we know the process and we should specify:

1. The type of control system (simple, cascade, split-range, override and complex)
2. The parameter which should be controlled
3. The configuration

To answer the second question, it is clear that the level should be controlled. So, we need a LIC.

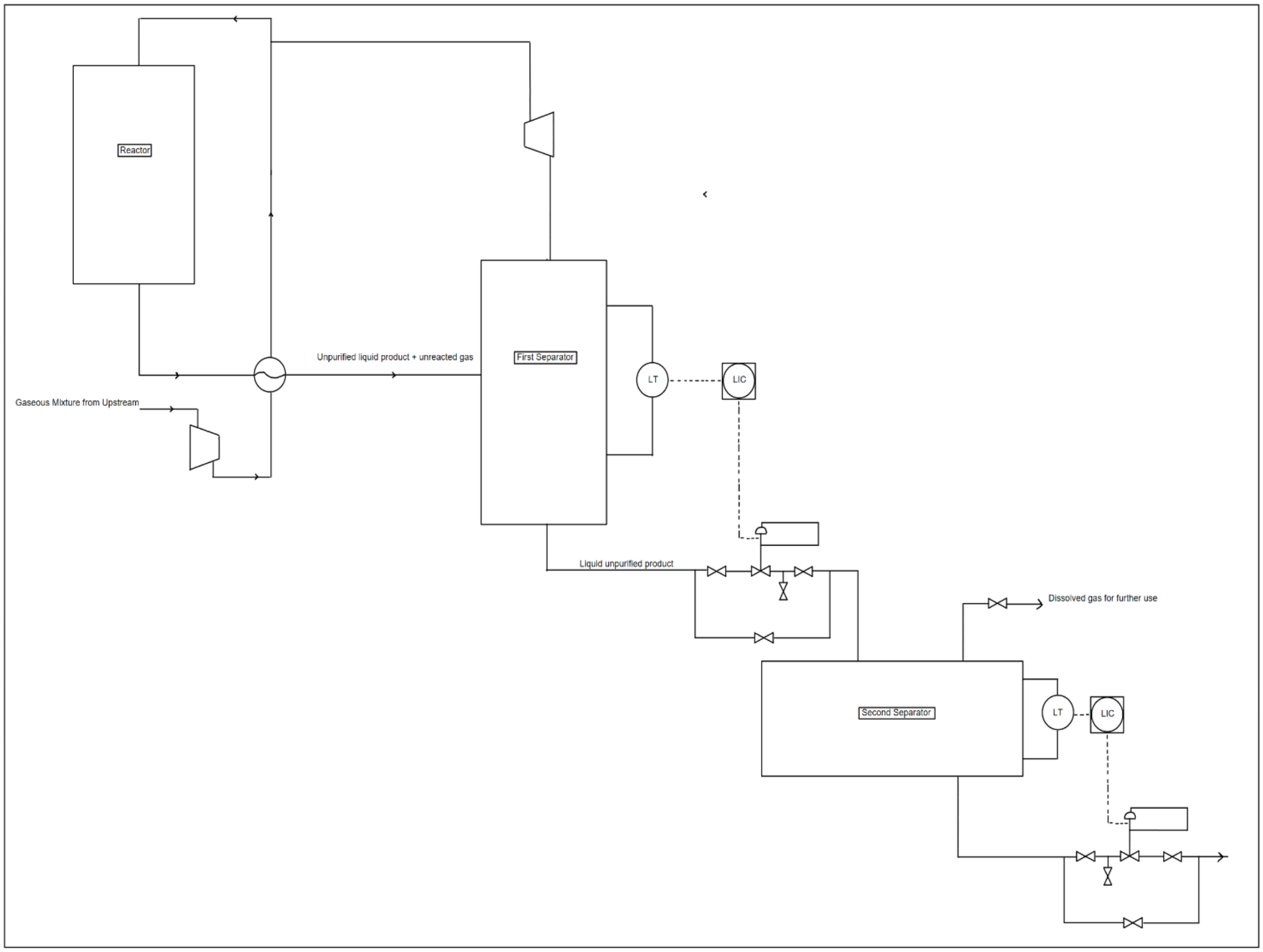
To answer the first question it is simple that we need a simple control loop.



So finally, we select simple control loop.

Lastly, we need to determine the configuration. To complete the configuration, we need to:

1. Show LIC on the P&ID
2. Show LT on the P&ID
3. Show the control valve and its assembly
4. Connect them together like below

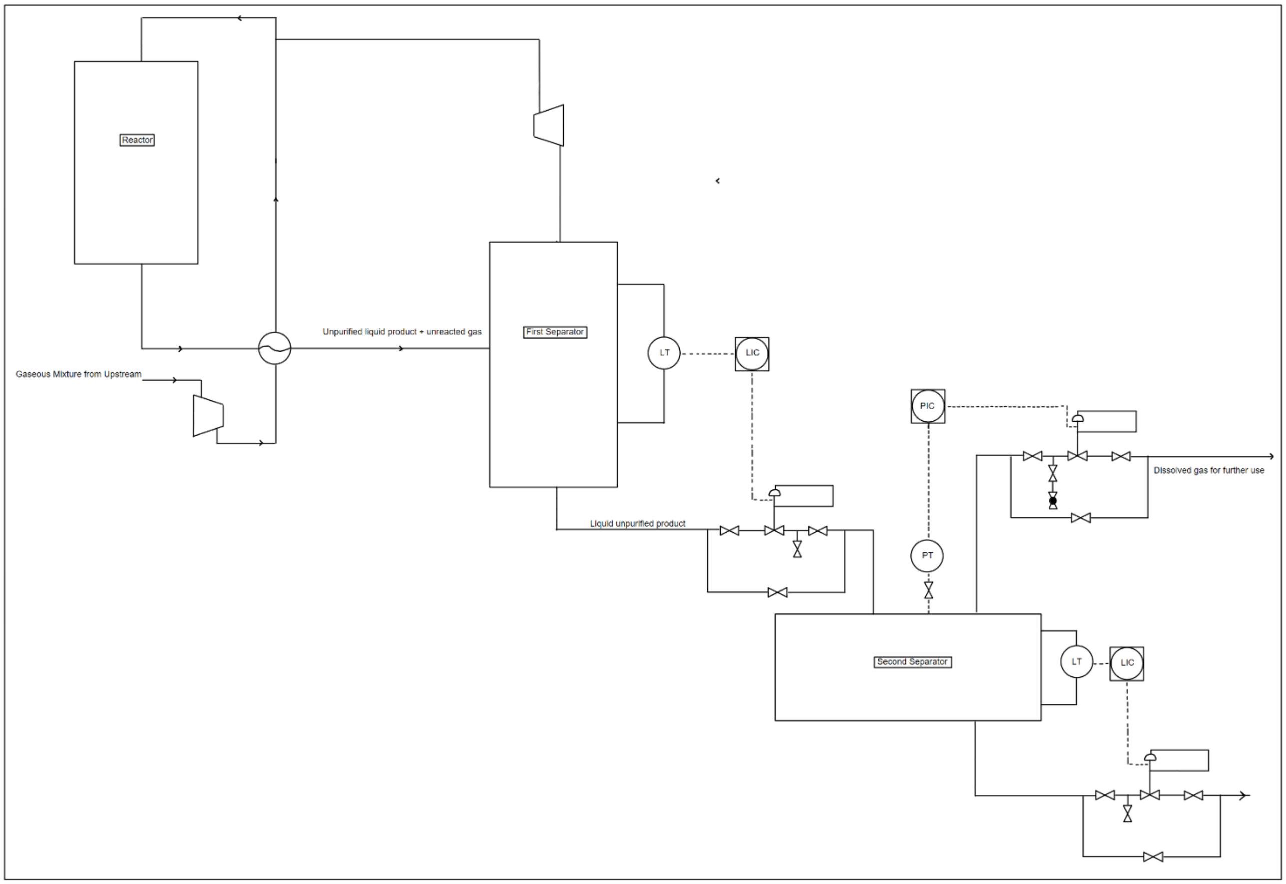


Do you remember the practice of last session?

Next page sketch is the answer.

If the objective of the course was to just familiarize learners with control system, we would stop here. But we want you to become professional so that you can use such knowledge in the project you are involved in.

Here we are not dealing with two simple drums. Nope! One of the drum is located at the suction of a compressor and from another one, the dissolved gas is sent to fueling system of a fired heater. So, the levels should be measured, transmitted, checked meticulously. It means we need it to be more reliable. As a result, we have to use three transmitters with the configuration of 2 out 3 voting and as a result it should be implemented in ESD.



Two-out-of-Three Voting(2oo3)

According to IEC-61511 safety and availability can be achieved if three transmitters are combined as signals to IS-groups in what is known as a two-out-of-three voting configuration. The three input signals are compared and any unacceptable division is alarmed. When all three signals are healthy, a suitable algorithm such as “middle of three” shall produce the resulting signal from the three transmitters. If one fails, the resulting signal is the average of the two healthy signals. A second detected failure before the repair of the first will initiate a trip.

In order to achieve maximum safety of the plant, 2oo3 voting philosophy shall be applied to a number of the measurements connected to the ESD system.

In order to achieve maximum availability of the plant, all three signals from transmitters already connected to the ESD system shall be repeated to the DCS system as Process Values for controllers. In the DCS a “middle-of-three” algorithm produces the process value. The same strategy used for the ESD system can also be adopted in the case of transmitter failure.

In addition, according to IEC 61511-2, the signals from the three transmitters connected to the ESD system can be used for control purposes in the DCS, providing the signals are repeated from the ESD to the DCS by suitable repeater isolators.

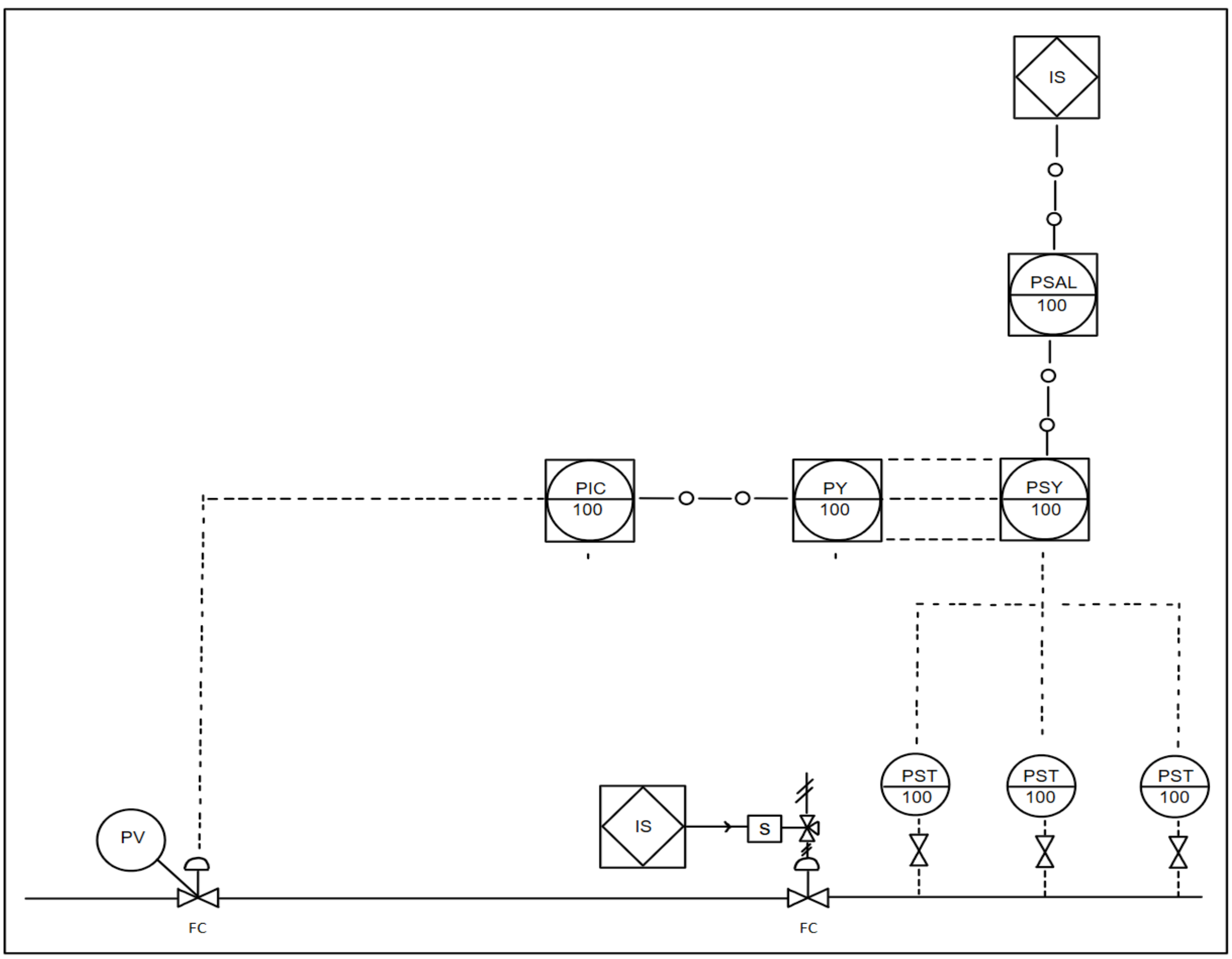
According to IEC 61511-2 this combination will lead to higher safety, as the increased availability will lead to less demand on the ESD system, and consequently reduce the risk of failure on demand in the ESD system.

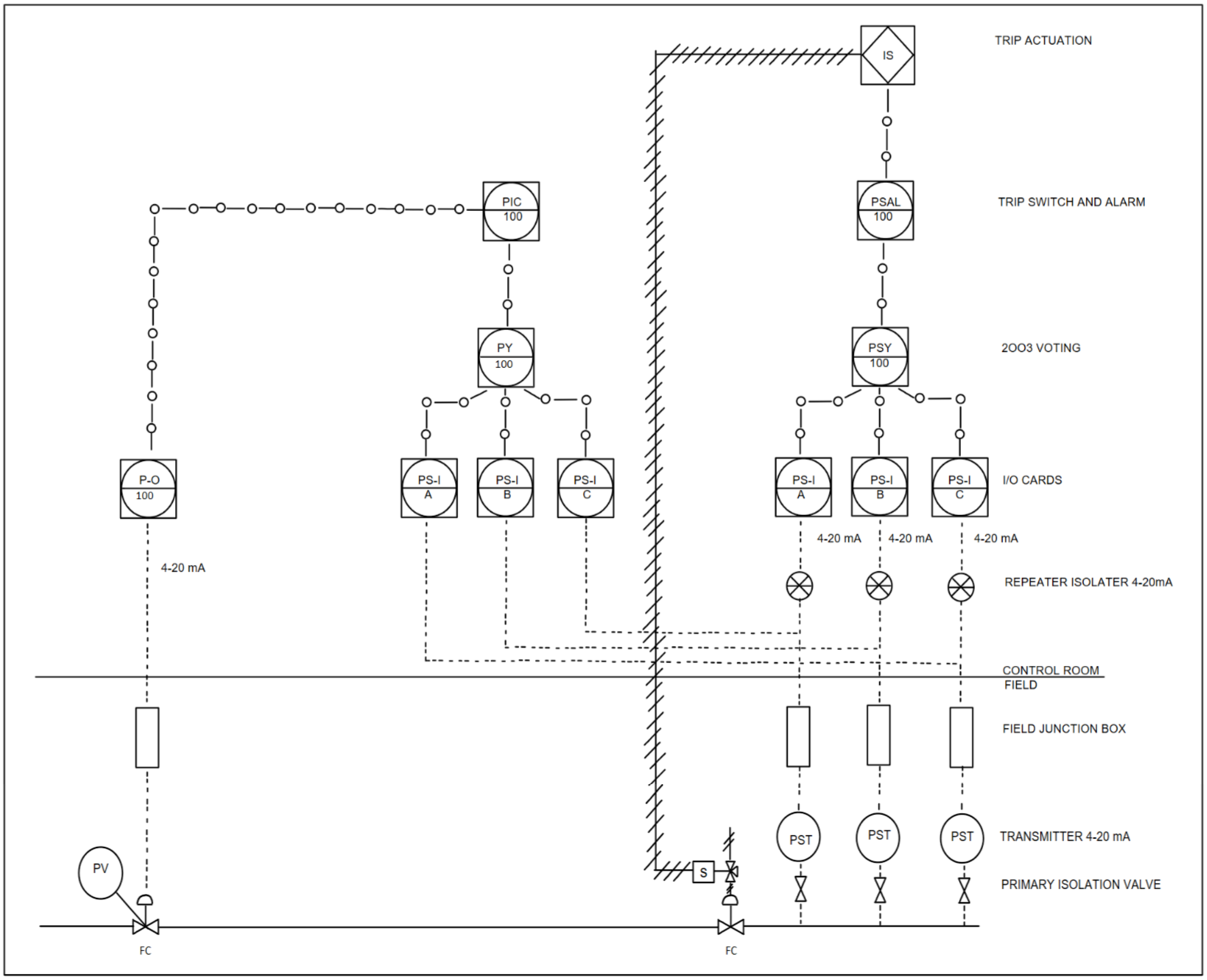
In order to avoid common mode failures, each of the three transmitters shall have individual process tapping, and the three transmitters shall be connected in multi-core cables through different junction boxes and on different I/O cards in the DCS.

The transmitter must be analogue technology with 4-20 mA signals. Transmitter with HART protocol are permitted, providing the option of writing parameters to the transmitter is disabled when the transmitter is in normal operation.

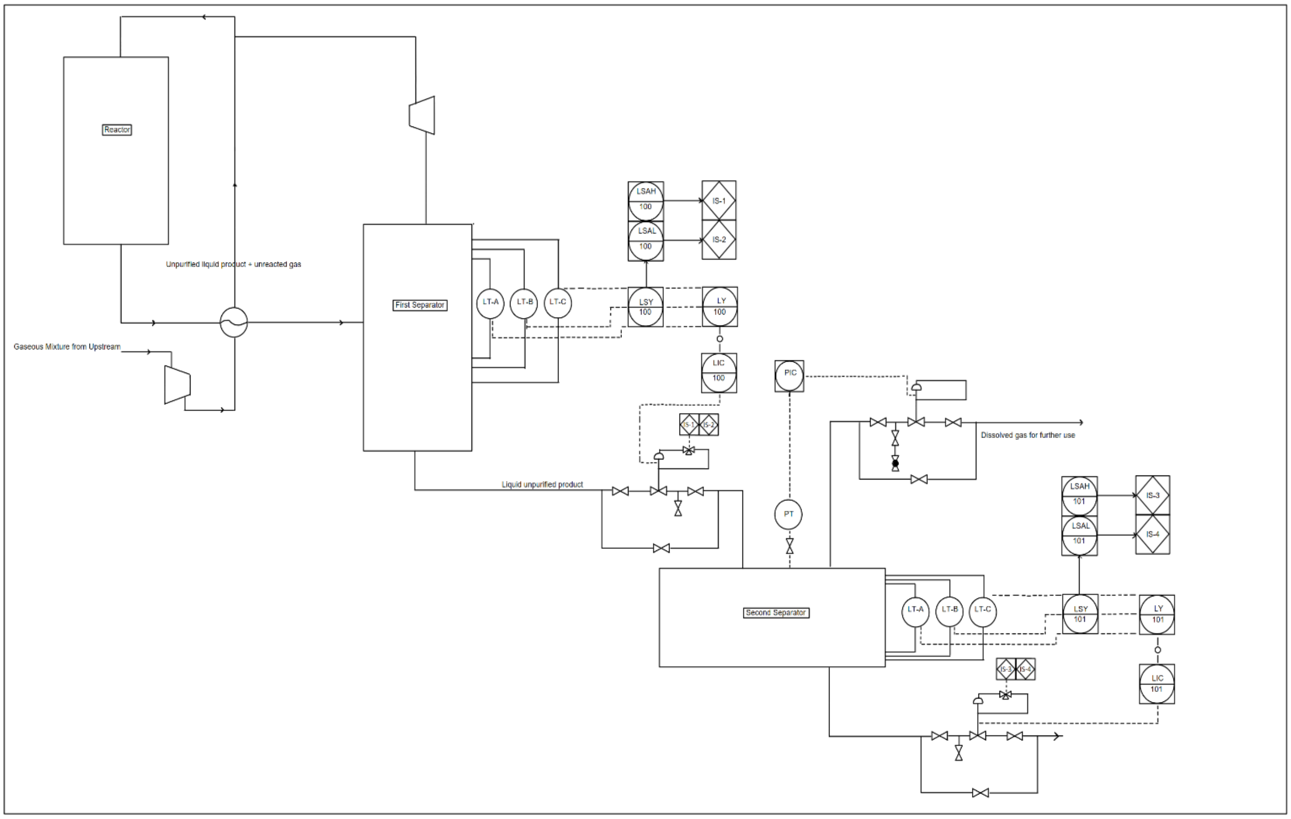
Instead of using repeaters, three galvanic isolated analog outputs suitably configured repeating the signals from the ESD to the DCS may be considered.

The way the configuration is shown on the P&ID and FCS is shown below:




TRIP ACTUATION
IS
TRIP SWITCH AND ALARM
PSAL 100
PIC 100
2OO3 VOTING
PSY 100
PY 100
I/O CARDS
P-O 100
PS-I A
PS-I B
PS-I C
4-20 mA
REPEATER ISOLATER 4-20mA
CONTROL ROOM
FIELD
FIELD JUNCTION BOX
TRANSMITTER 4-20 mA
PST
PRIMARY ISOLATION VALVE
PV
S
FC

Now that we fully know the concept, let’s apply it for our example:



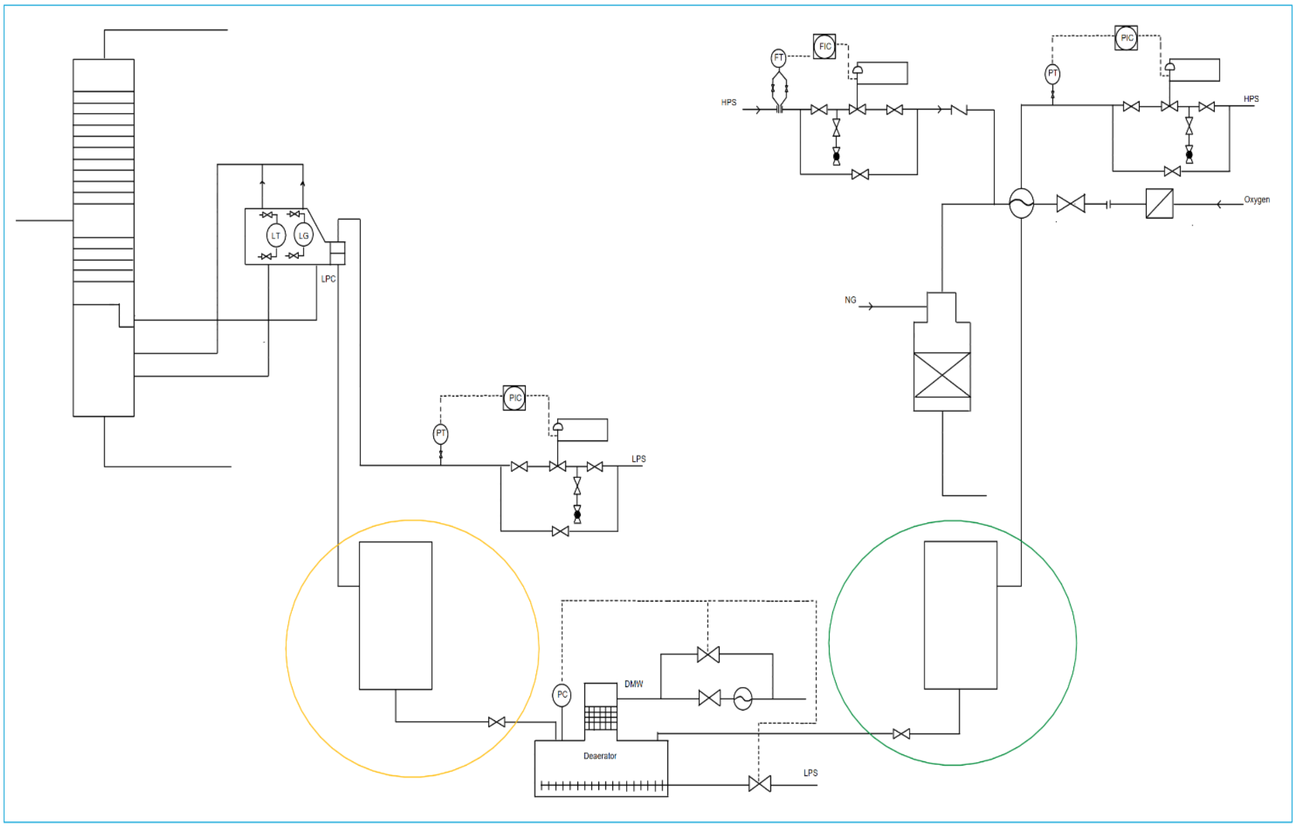
Example 2:

In order to produce steam inside a process plant, simply we need to have a boiler and boiler feed water (BFW). The BFW is created in deaerators where DMW comes in as inlet and by means of LPS, the trapped oxygen gets removed. The DMW without oxygen is called BFW in all petrochemicals.

In order to do some optimization, we can use low pressure condensate (LPC) as the feed to the deaerator since the water quality is good and more importantly, it brings heat to the deaerator.

Do you remember examples 2 and 3 from simple pressure control loops where we talked about reboilers and oxygen preheater for which we used LPS and HPS as hot medium? Theses LPS and HPS, after heat exchange, become LPC and HPC respectively.

Here is the PFD-like sketch:



Now let's review the algorithm we developed for previous example:

we should specify:

1. The type of control system (simple, cascade, split-range, override and complex)
2. The parameter which should be controlled

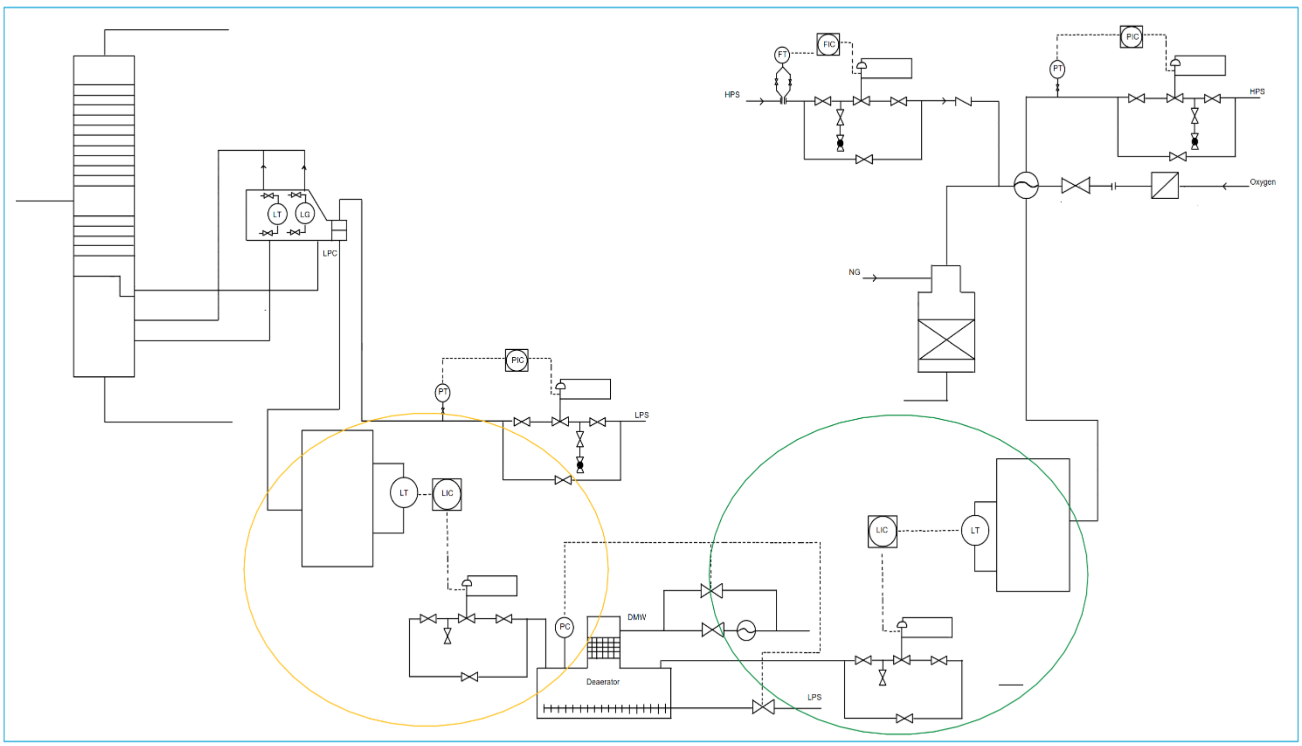
3. The configuration

To answer the second question, it is clear that the level should be controlled. So, we need a LIC.

To answer the first question, a simple loop is enough. You don't need to overthink it.

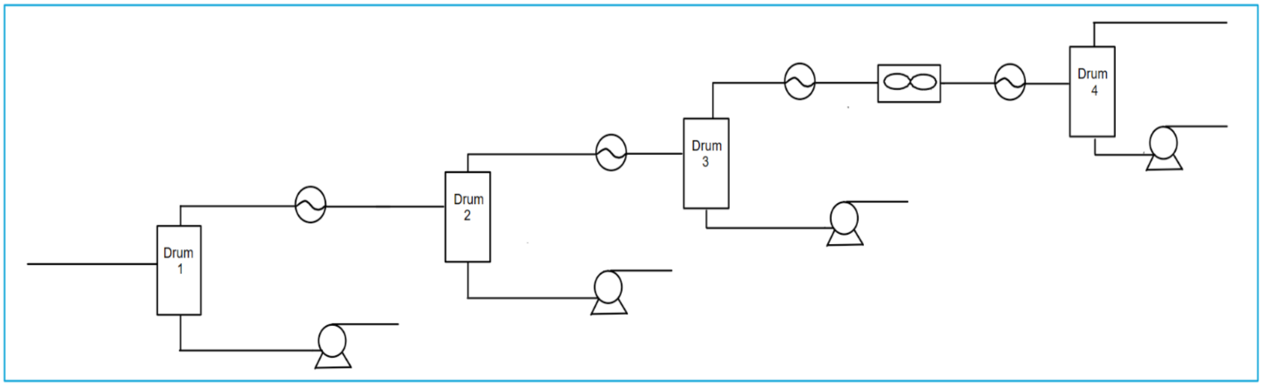
Lastly, we need to determine the configuration. To complete the configuration, we need to:

1. Show LIC on the P&ID
2. Show LT on the P&ID
3. Show the control valve and its assembly
4. Connect them together like below



Homework/Practice:

In some process plants when in reactors the conversion happens and an intermediate mixture is produced, the intermediate mixture has a great deal of energy. So, to optimize the process, we process engineers route the intermediate mixture through some heat exchangers to heat-up the cold side. Alongside passing through heat exchanger, the intermediate mixture gets cooled. In this regard, we use separator to separate the condensed water from the gaseous mixture. Here is the PFD-like sketch.



Develop the level control system for drum 1.