

**INTRODUCTION TO PRACTICAL
INDUSTRIAL
FEEDBACK PROCESS CONTROL**

**PART 1: BASICS AND PROCESS
TYPES**

Presented by Michael Brown

How well are control loops operating in the real world?

Our experience in hundreds of plants has shown:

- ▣ Approximately 85% of loops are ineffective in automatic.
- ▣ 50 to 60% of loops have equipment and/or design problems.
- ▣ Less than 5% of loops really work well in automatic.

Why Controls Are Operating So Badly

- ▣ Up to recently, virtually all control training courses have been entirely theoretical, or specifically product based
- ▣ There have been no courses to educate people on practical aspects of control

Optimisation as Opposed to Tuning

- ▣ In many plants it is common to try and fix a badly performing loop by tuning the controller
- ▣ Many people coming on my courses say they are coming on a loop tuning course
- ▣ In reality if you try and solve loop problems just by tuning, you will probably be really successful in less than 30% of the time
- ▣ Getting a loop to operate optimally requires a series of actions, the final one being the actual tuning
- ▣ It is vital for the people doing the optimisation to fully understand what they are doing

Basic Steps in Performing Optimisation

- ▣ Talk with process experts about the control requirements and problems
- ▣ Study the actual control loop and its elements
- ▣ Study and understand the control strategy
- ▣ Perform tests in automatic and manual to determine the dynamics of the process and uncover any loop problems
- ▣ Finally perform the tuning and test it

These Talks Will Introduce A Very Practical Approach To Loop Optimisation

Subjects to be covered:

1. Basics of the control loop and definitions
2. The two “classes” of processes
3. Dynamics of simpler processes
4. Final control elements, with detailed discussions on valve problems.
5. Understanding the PID controller, and ensuring it is operating correctly
6. Noise and filtering
7. Tuning of processes with simple dynamics

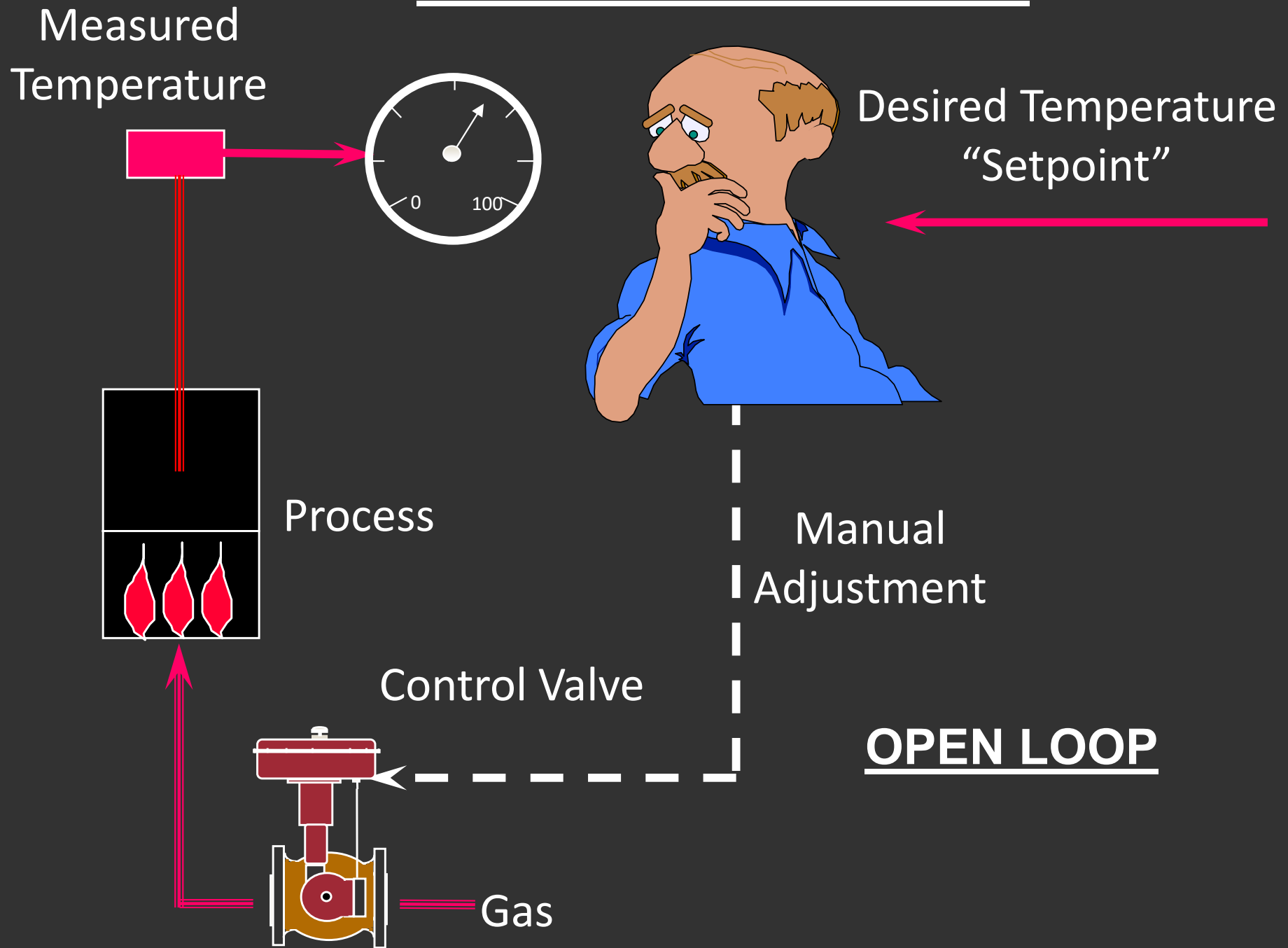
Note: A huge amount of information will be covered, and at this stage it is hard for me to judge how many sessions this will take, so we are just going to carry on and see how it goes.

Importance of Measurement

- ▣ Measurement will not be covered further in these talks
- ▣ However remember that you can't control optimally with poor or incorrect measurement
- ▣ The measuring transmitter is one of the components in the loop, and is of equal importance to the other elements
- ▣ I have found too often that practitioners ignore the measurement. Even though we use computerised "smart" transmitters, you need to understand their capabilities
- ▣ I have encountered many loop problems caused by poor measurement
- ▣ Not only accuracy, but factors like suitability, rangeability, measurement drift over time and temperature, and repeatability should be considered

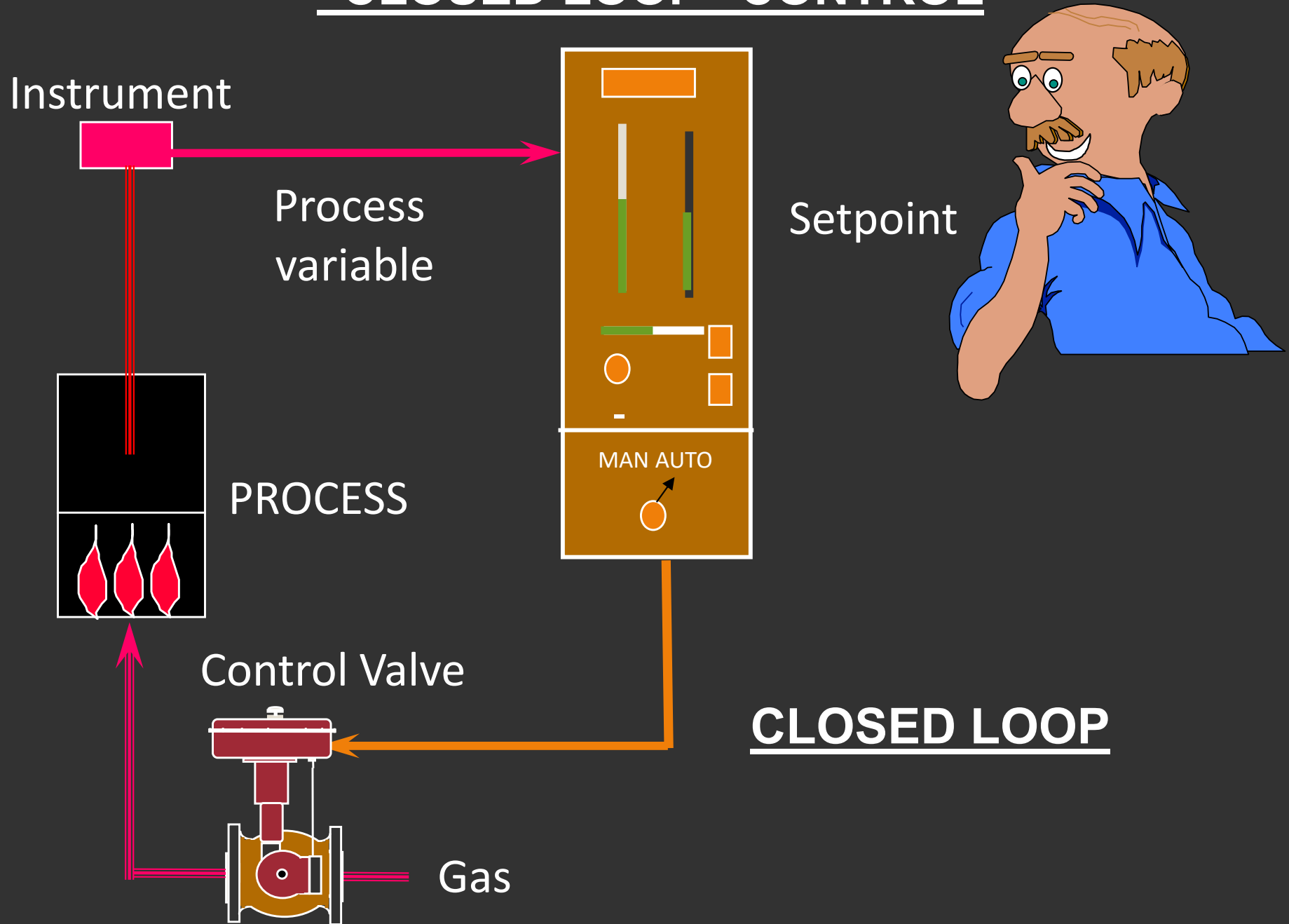
MANUAL FEEDBACK CONTROL

"OPEN LOOP" CONTROL



AUTOMATIC FEEDBACK CONTROL

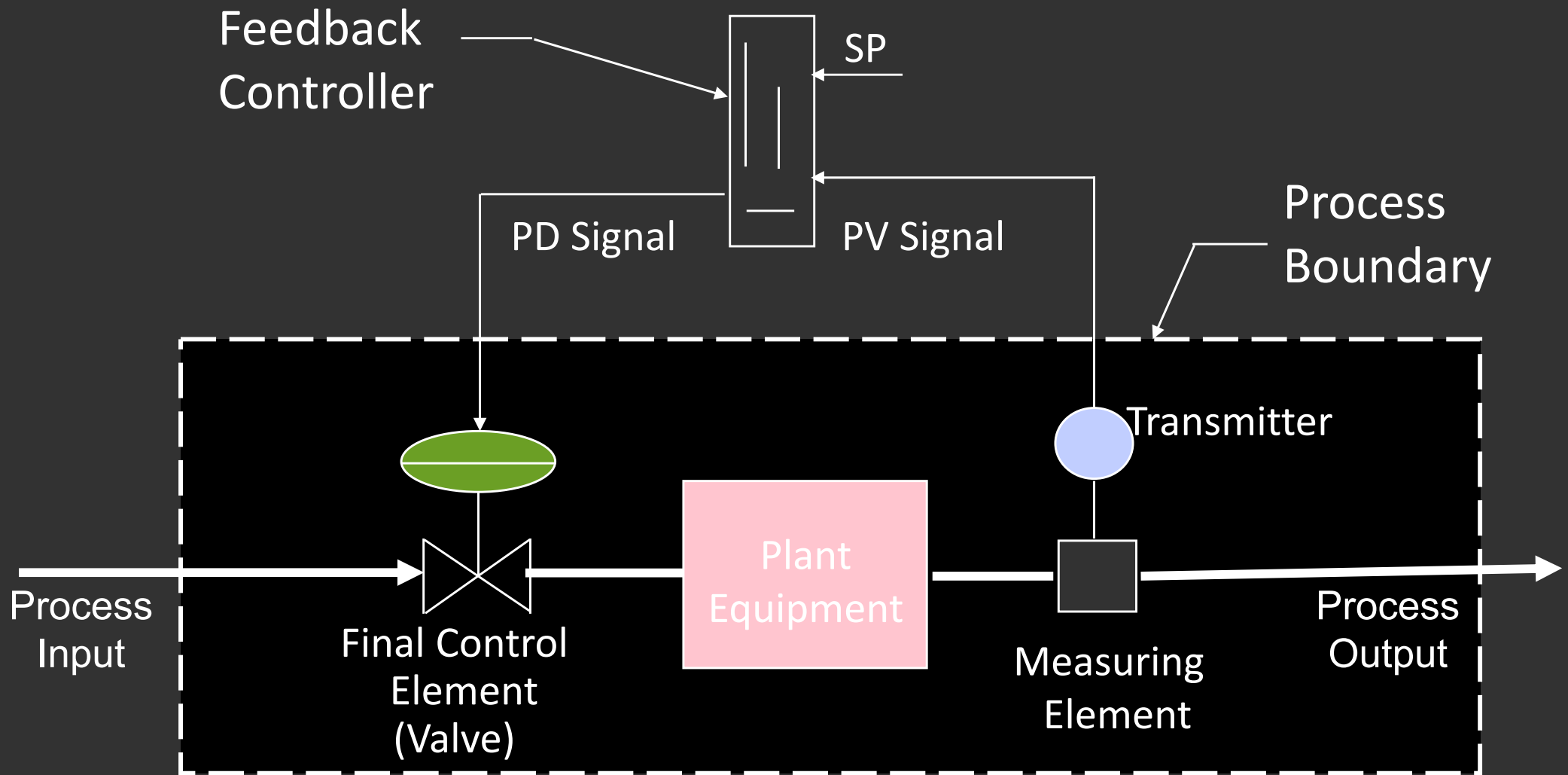
“CLOSED LOOP” CONTROL



Understanding Feedback Control

- ▣ Feedback control is an integral part of nature. For example most living creatures use “inbuilt” feedback control. For example see how a human baby learns to use its hands to feed.
- ▣ Primitive, mostly mechanical feedback systems have been used in controlling machines for centuries, but modern feedback control was only developed in the early 20th century, by world leading mathematicians, so that we ordinary mortals could properly apply the science to be able to control virtually any process
- ▣ Many people question why it is still being used with the advent of sophisticated modern advanced control systems. The answer is that it is still the best and probably only system that can deal very simply with unknown, and possibly immeasurable factors, and will keep on trying to get the process variable to setpoint

The Feedback Control Loop



Error is the difference between SP and PV

Control variance is essentially the total error over a period of time, but other measures like statistic calculations can also be used.

Why PD? Why not MV?

- ▣ There are very few standards in control systems. Manufacturers generally use their own names and specifications which can be confusing
- ▣ The controller output is often called MV, which stands for “Manipulated Variable”, but some manufacturers refer to the MV as : “Measured Variable”, which is the Process Variable (PV)
- ▣ We call it PD which stands for “Process Demand” as the controller is actually demanding that a certain amount of product be fed into, or out of, the process
- ▣ The PD is normally a signal from the controller in units of percentage, and this is fed to the final control element, most commonly a valve.
- ▣ The final control element then has to “translate” the signal into an actual physical happening. We will come back to this later

Limitations of Feedback Control

- ▣ Feedback control cannot be perfect as it cannot have zero variance. This is because the control can only react after an error arises.
- ▣ Feedback control can only react as fast as the process dynamics allow. This means that fast processes can be controlled relatively quickly, and slow processes can only be controlled slowly.
- ▣ This means that the loop components in very slow processes should operate well, as the feedback control will take much longer to compensate for problems in them. This makes it much more critical to ensure that everything works properly and tuning is good for such slow processes.

Tools Are Essential To Perform Optimisation

- ▣ At the minimum one needs a relatively high speed, high resolution recorder to record the tests that are performed during the optimisation procedure
- ▣ The recorder must have inbuilt accurate measuring tools
- ▣ The recorder is connected to measure the signals coming into and out of the controller, viz. SP (setpoint), PV (process variable), and PD (controller output).
- ▣ A good tuning packet will also be invaluable

THE PROCESS

The most important item
in the control loop

The Two “Classes” of Processes

- ▣ There are two, (what I call) classes of processes
- ▣ Many people are not aware of this
- ▣ Each one behaves completely differently from the other, and has very different characteristics
- ▣ They are tuned completely differently
- ▣ It is vital when optimising a loop that you identify the class to which the process belongs

The Two Types of Responses to a Step Change in the Controller Output

Self - Regulating Class of Process



Step Change in PD



PV Response

Integrating Class of Process

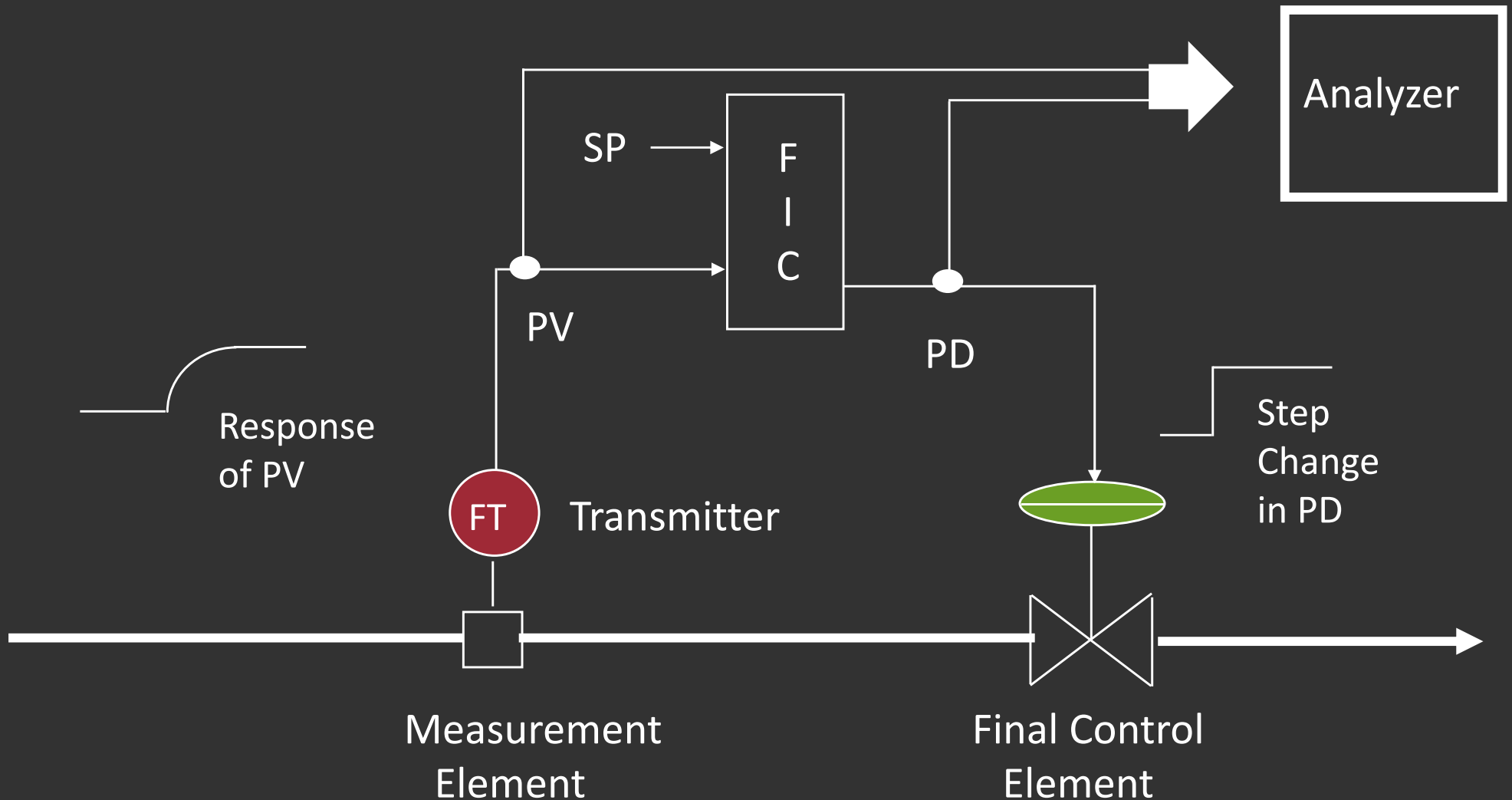


Step Change in PD

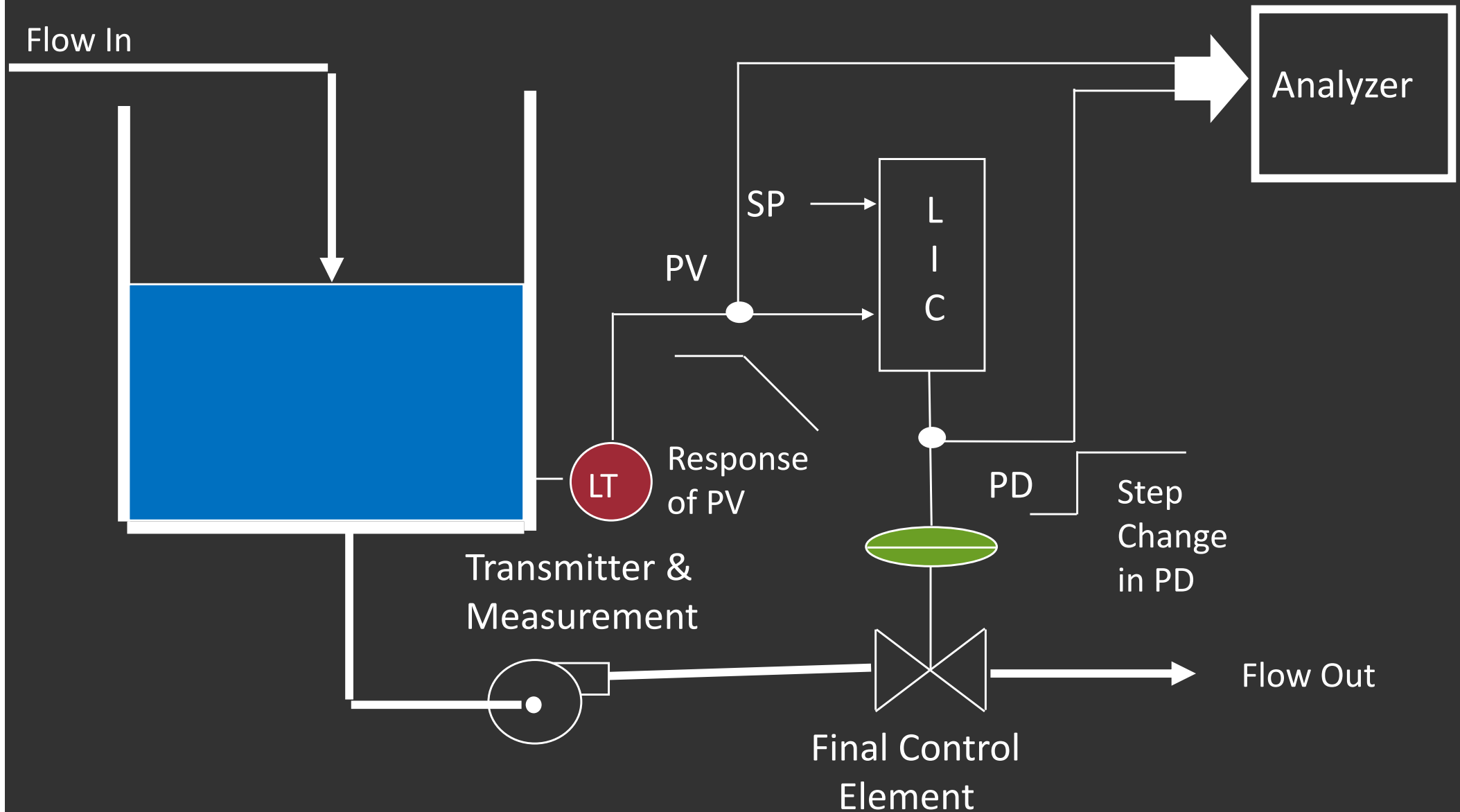


PV Response

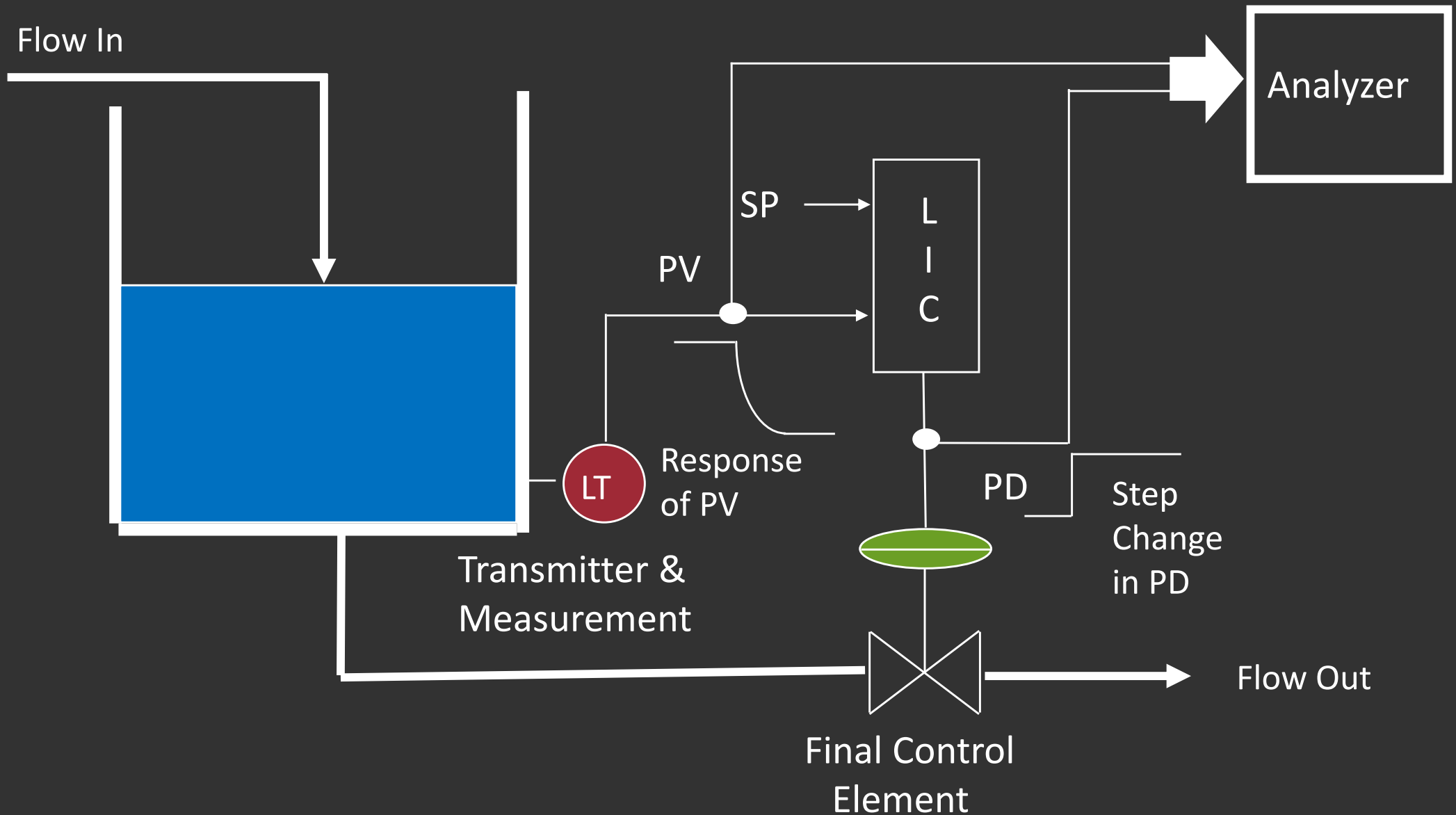
Self-Regulating Flow Control Loop



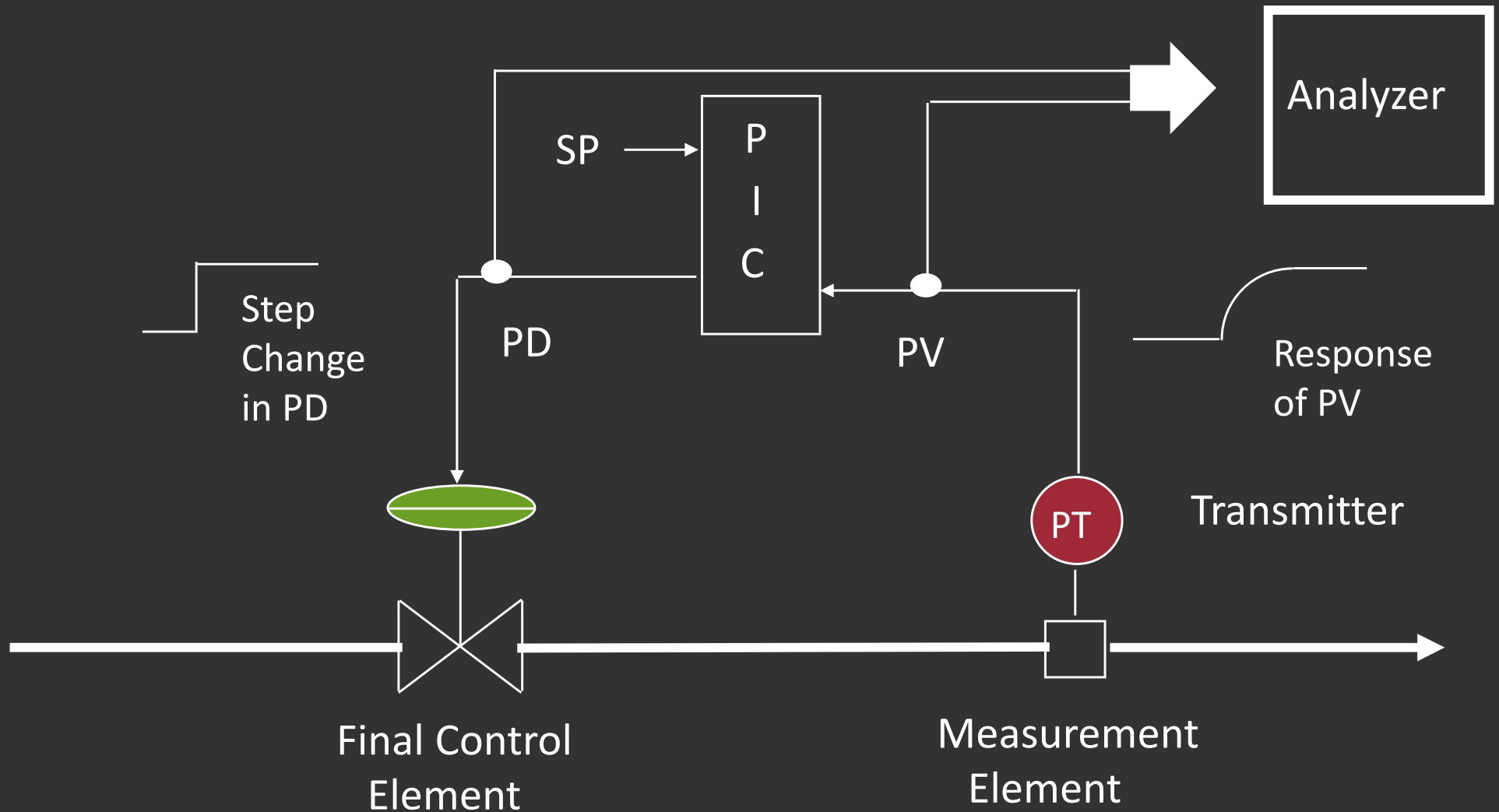
Linear Integrating Level Control Loop



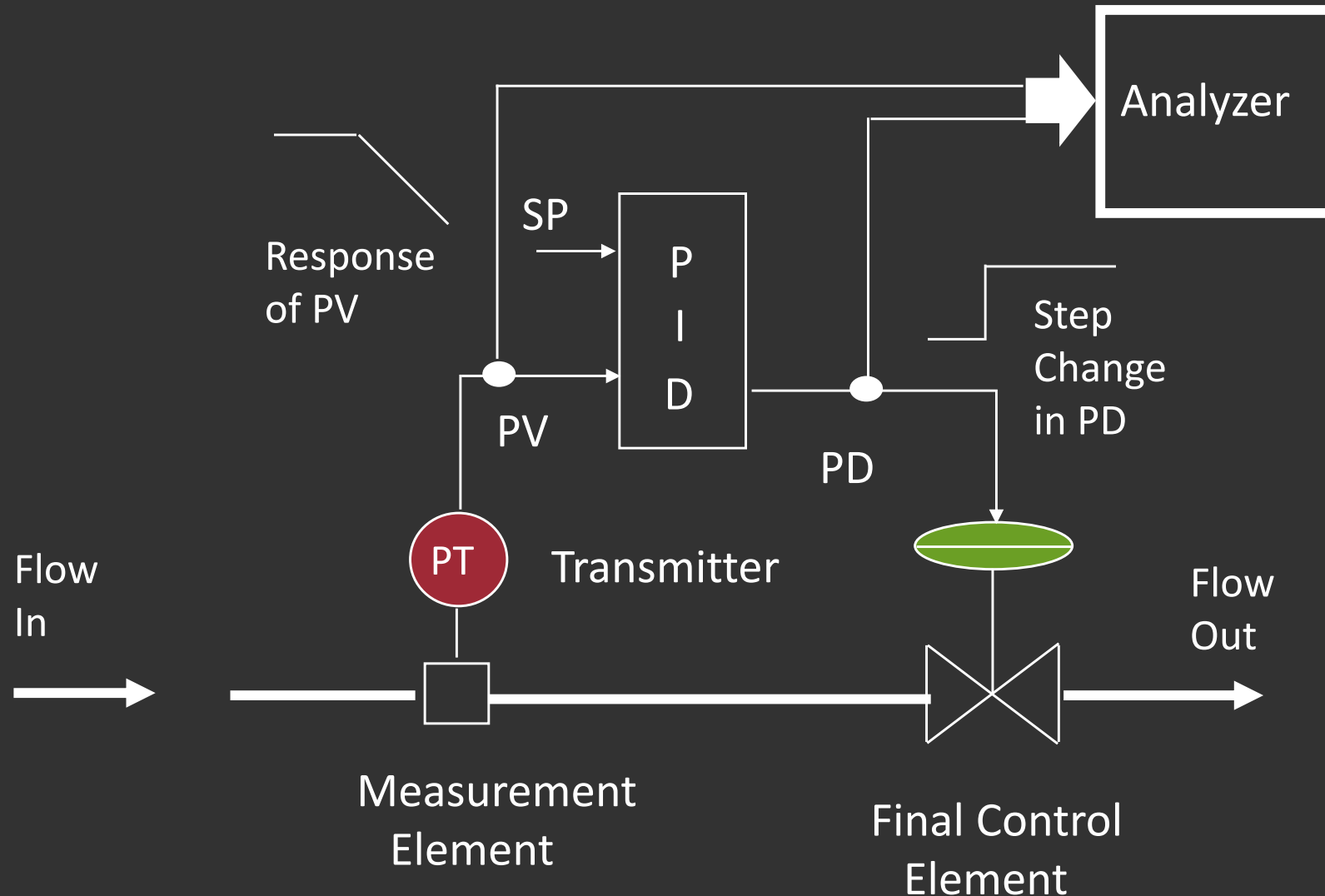
Non-Linear Integrating Level Control Loop



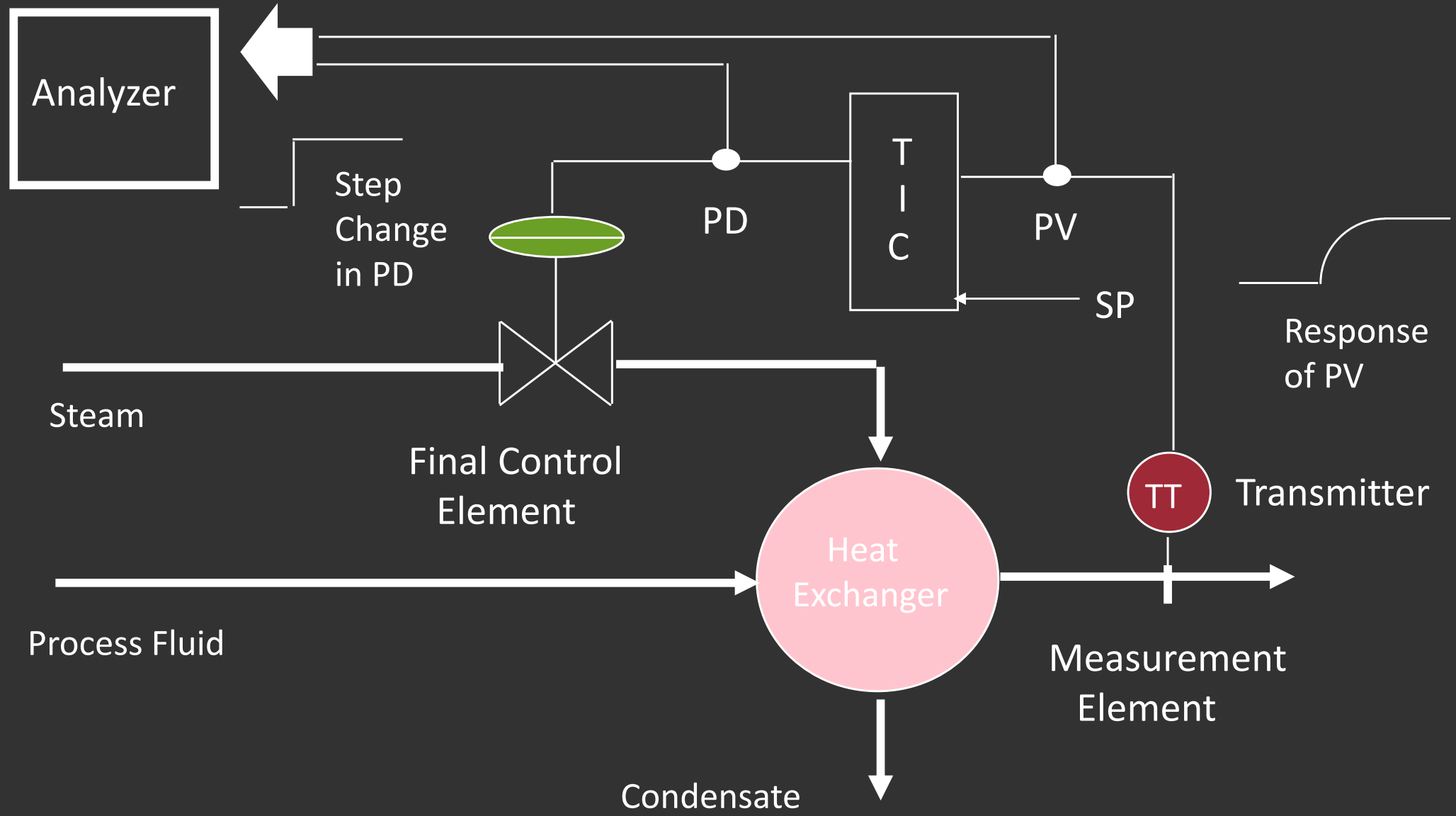
Self-Regulating Small Volume Pressure Control Loop



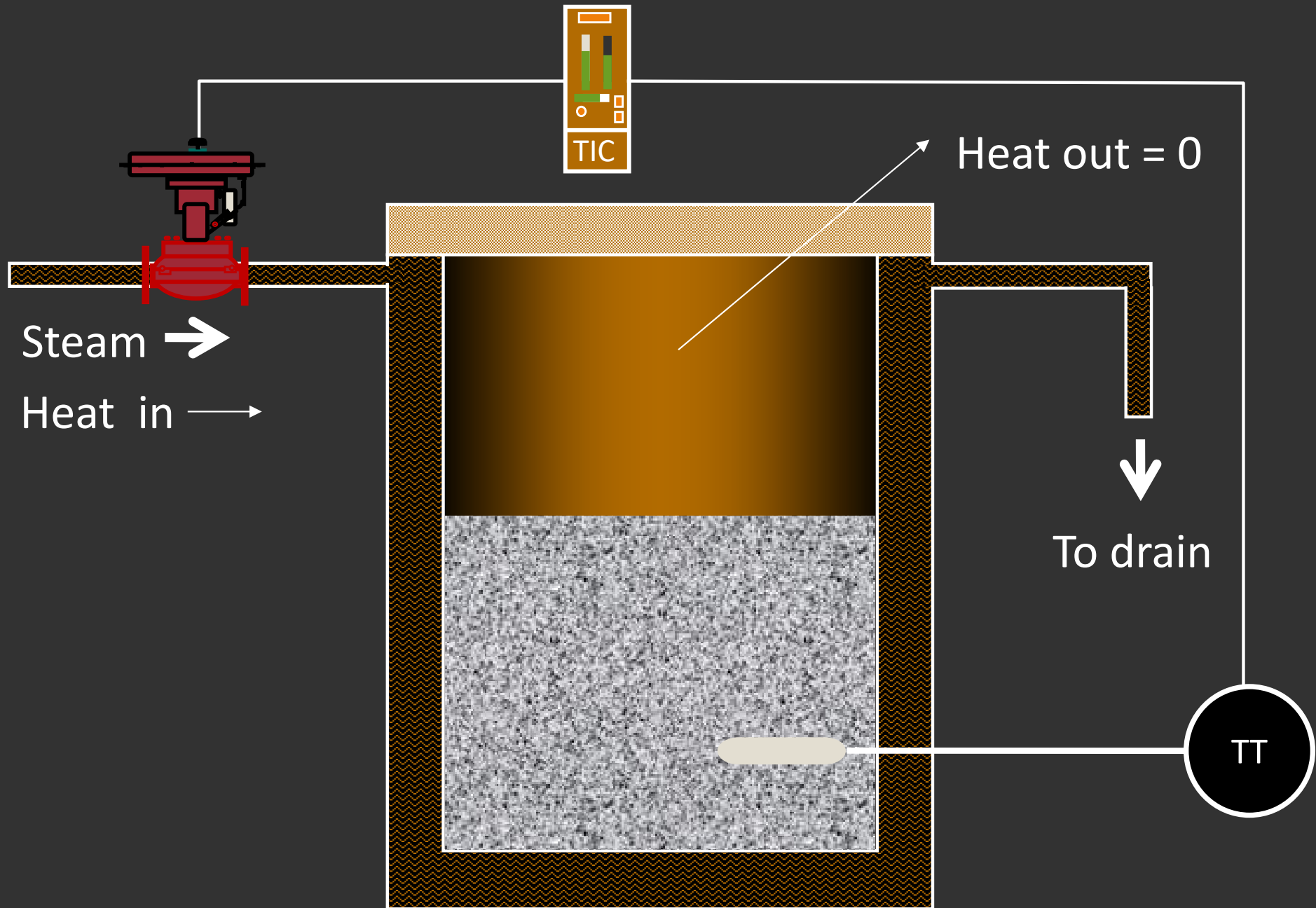
Integrating Pneumatic Large Volume Back Pressure Loop



Self-Regulating Temperature Control Loop



End Point Control (Batch Reactor)



Tests to Determine if Self Regulating or Integrating

SELF REGULATING

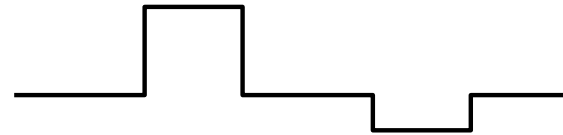
INTEGRATING

Open Loop Tests

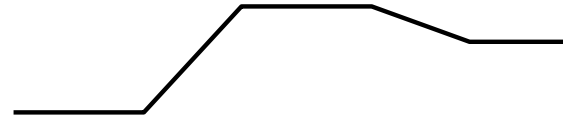
PD



Balance point →



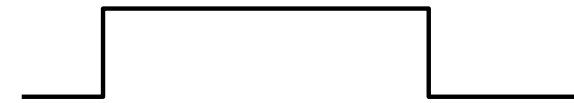
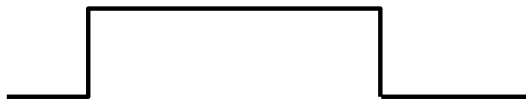
PV



Closed Loop Tests

(Assume reasonably tuned)

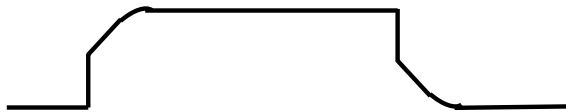
Setpoint



PV



PD



Balance point →

