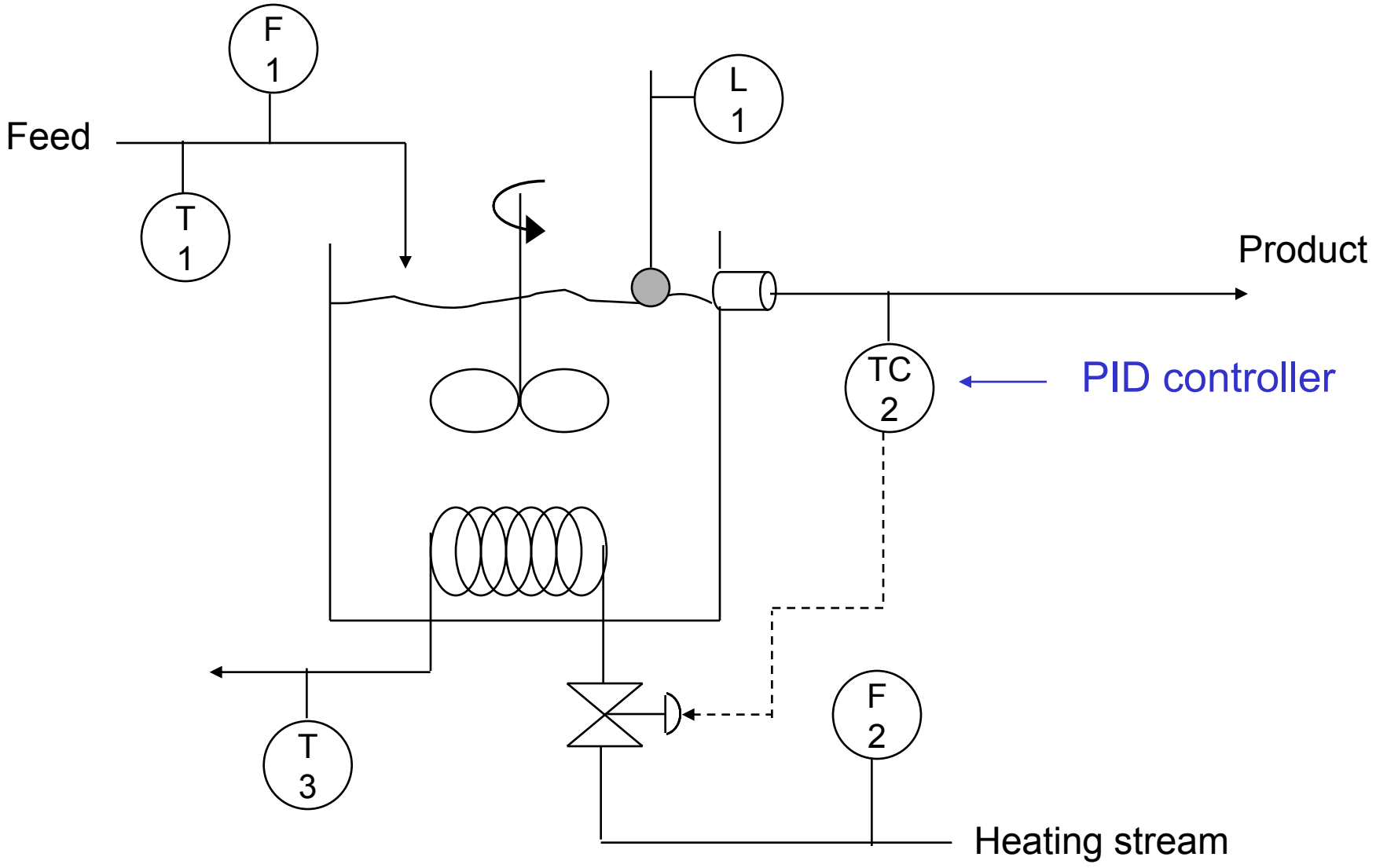
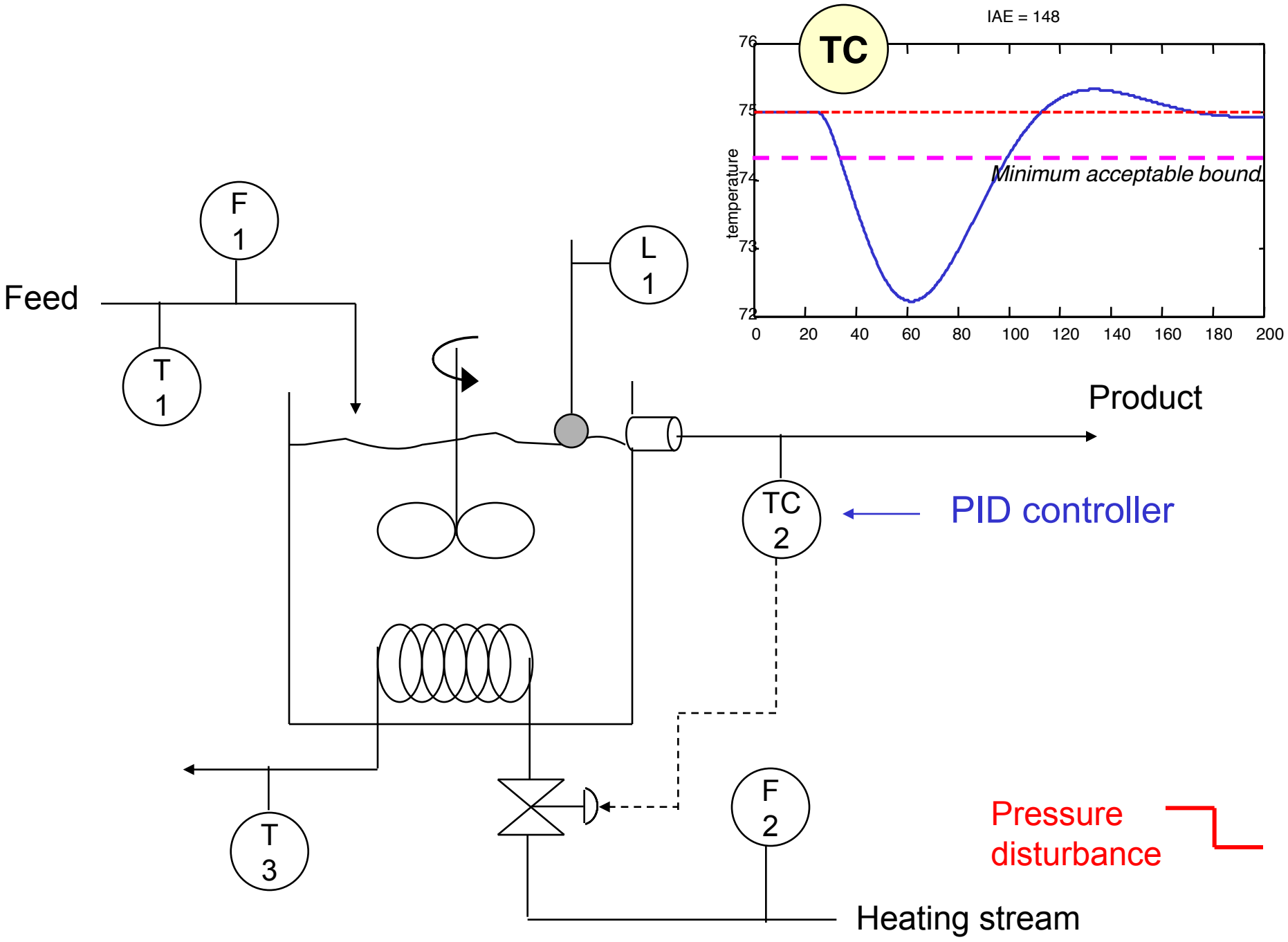
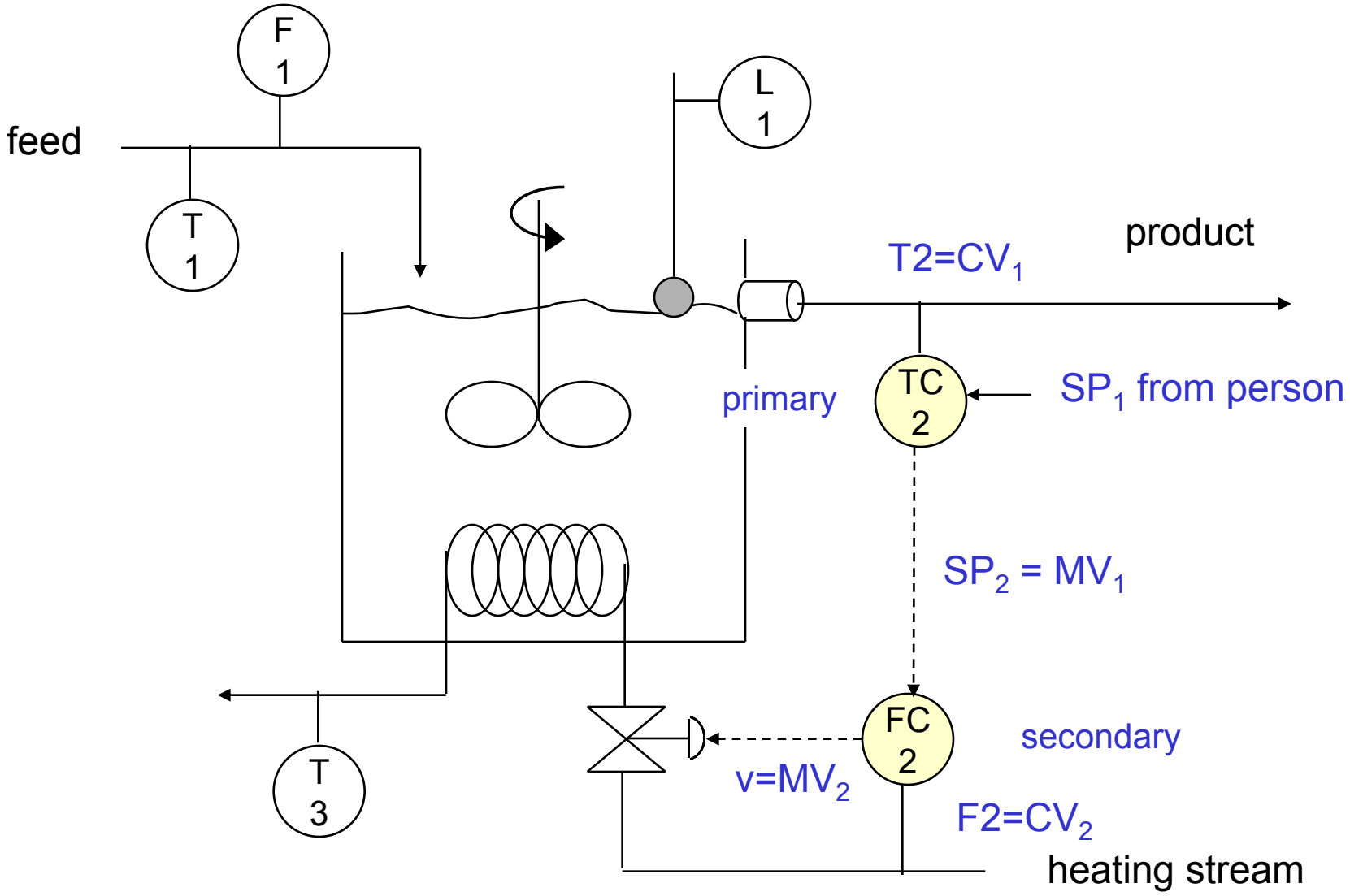
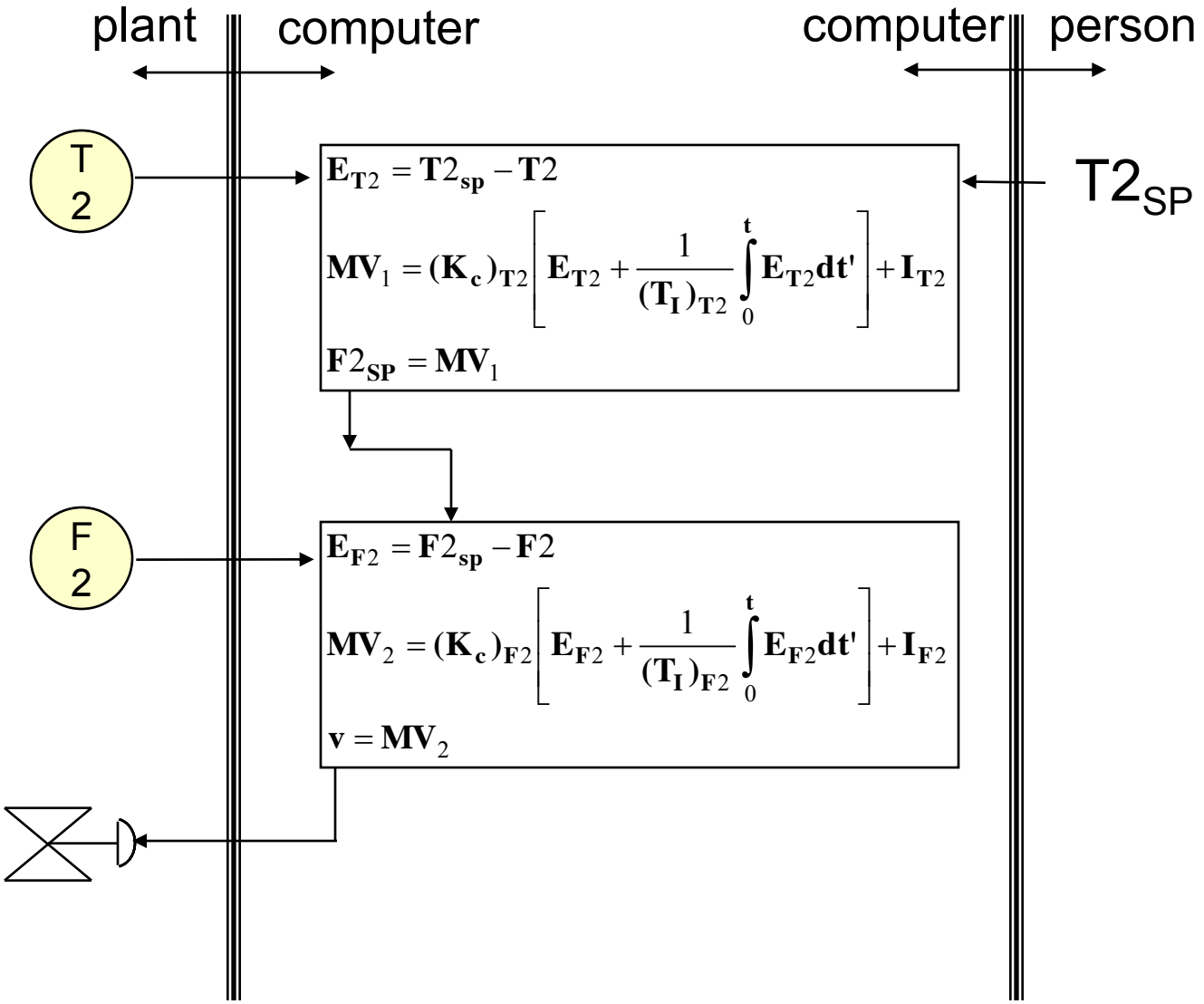
These slides are from Dr. Thomas Marlin


F
1
Feed
T
1
L
1
Product
TC
2
PID controller
T
3
F
2
Heating stream

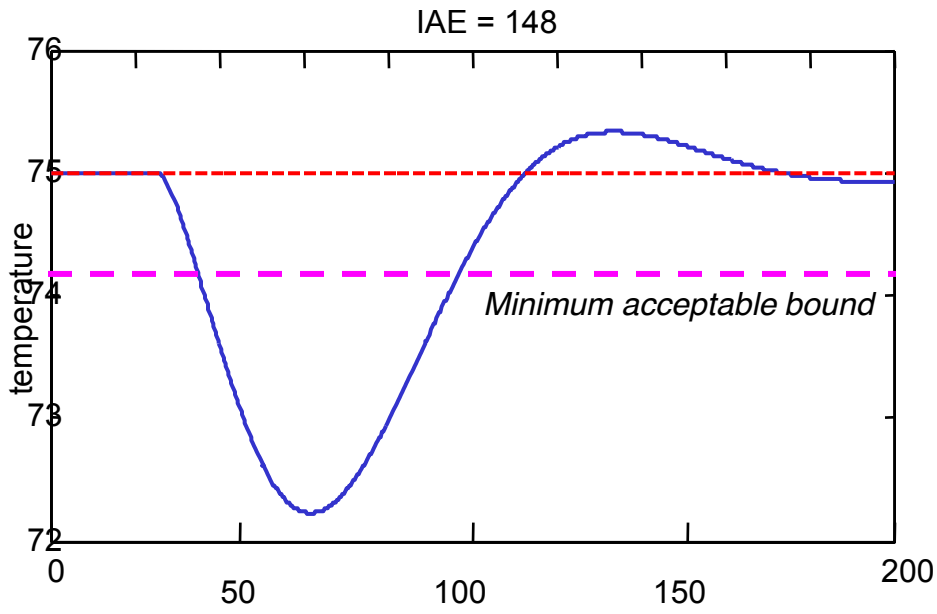

IAE = 148
TC
temperature
Minimum acceptable bound
76
75
74
73
72
0
20
40
60
80
100
120
140
160
180
200
F
1
Feed
T
1
L
1
Product
TC
2
PID controller
T
3
F
2
Pressure
disturbance
Heating stream


F
1
feed
T
1
L
1
product
T2=CV1
primary
TC
2
SP1 from person
SP2 = MV1
T
3
FC
2
secondary
v=MV2
F2=CV2
heating stream

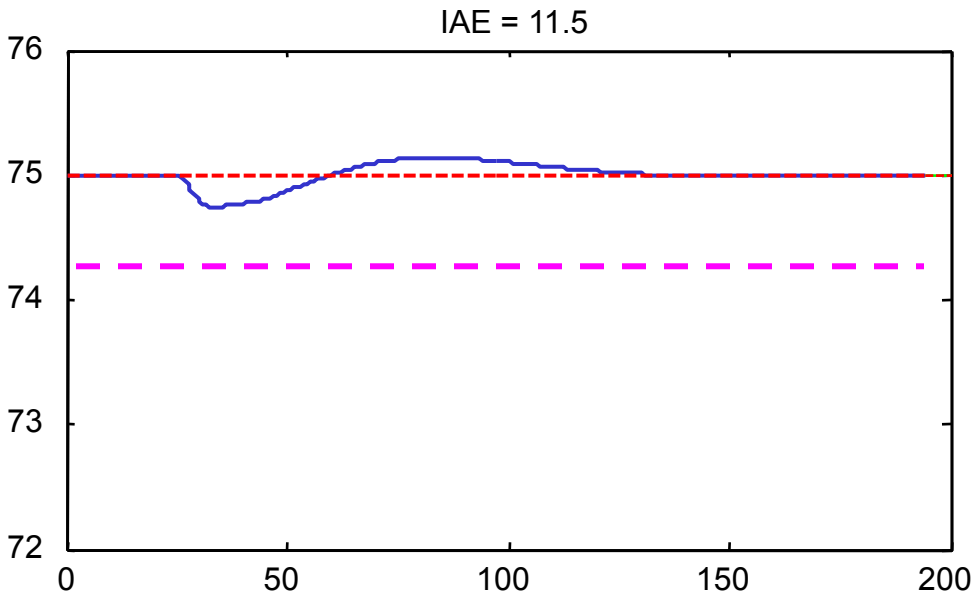
Each controller
is a PID!



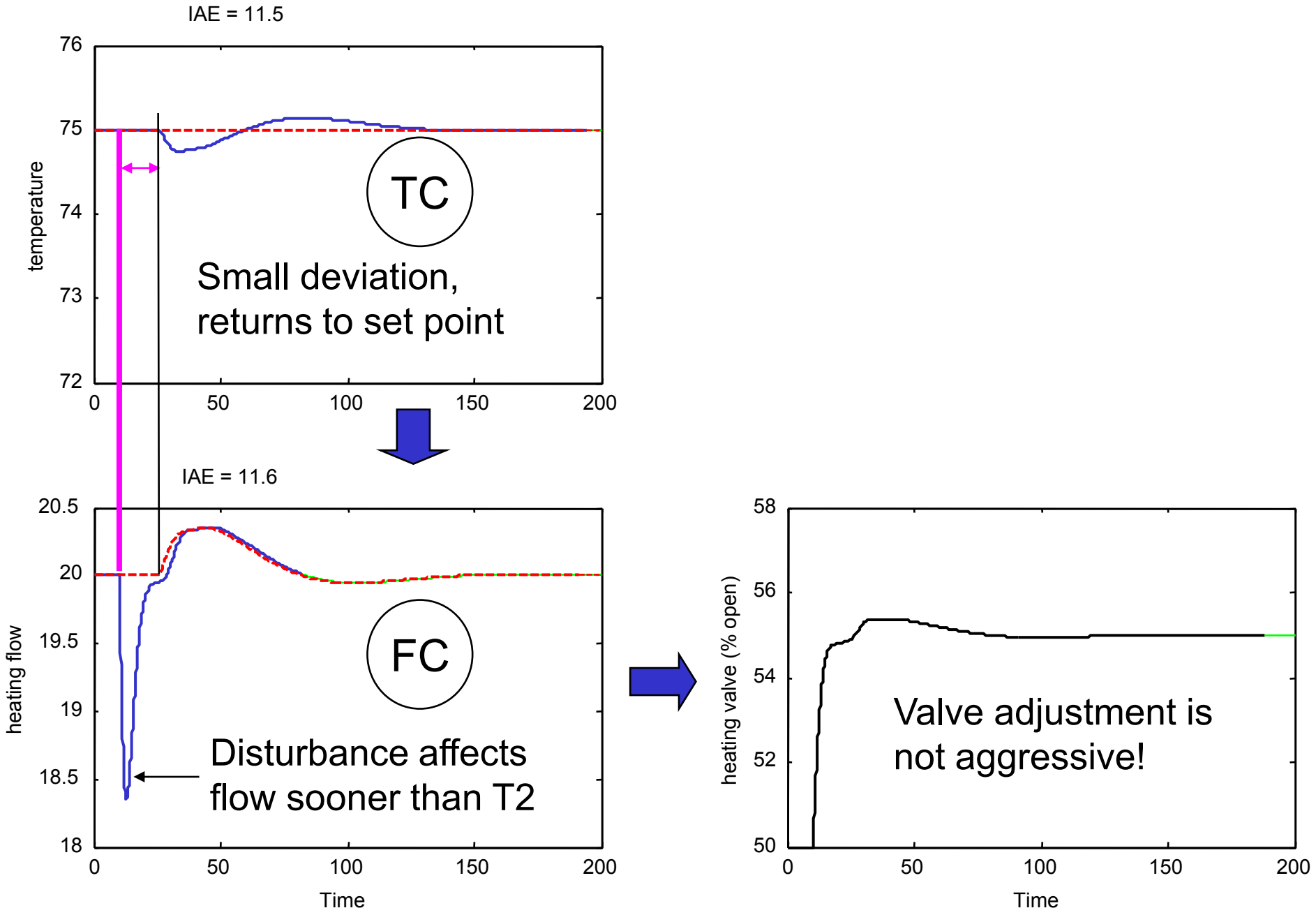
Single-Loop



Cascade



Why is the performance so much better?



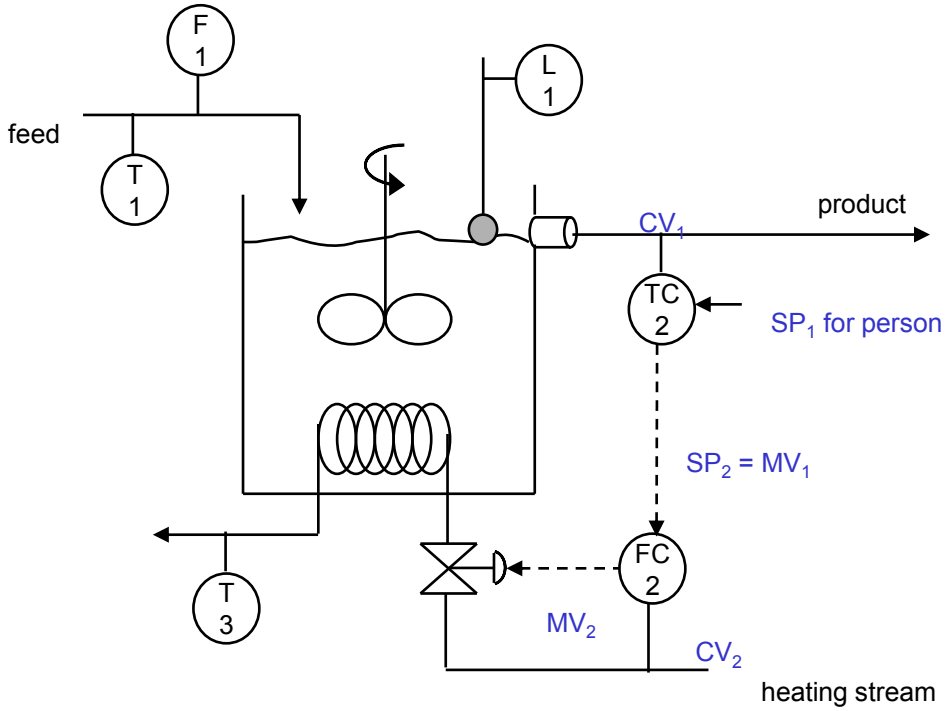
Dashed lines are set points; in the case of F, the set point is a "trajectory", coming from outer loop.

What have we gained and lost using cascade control?

For each case, is cascade

better, same, worse

than single-loop feedback (TC2 → v)?



- A disturbance in heating medium inlet pressure
- A disturbance in heating medium inlet temperature
- A disturbance in feed flow rate
- A change to the TC set point

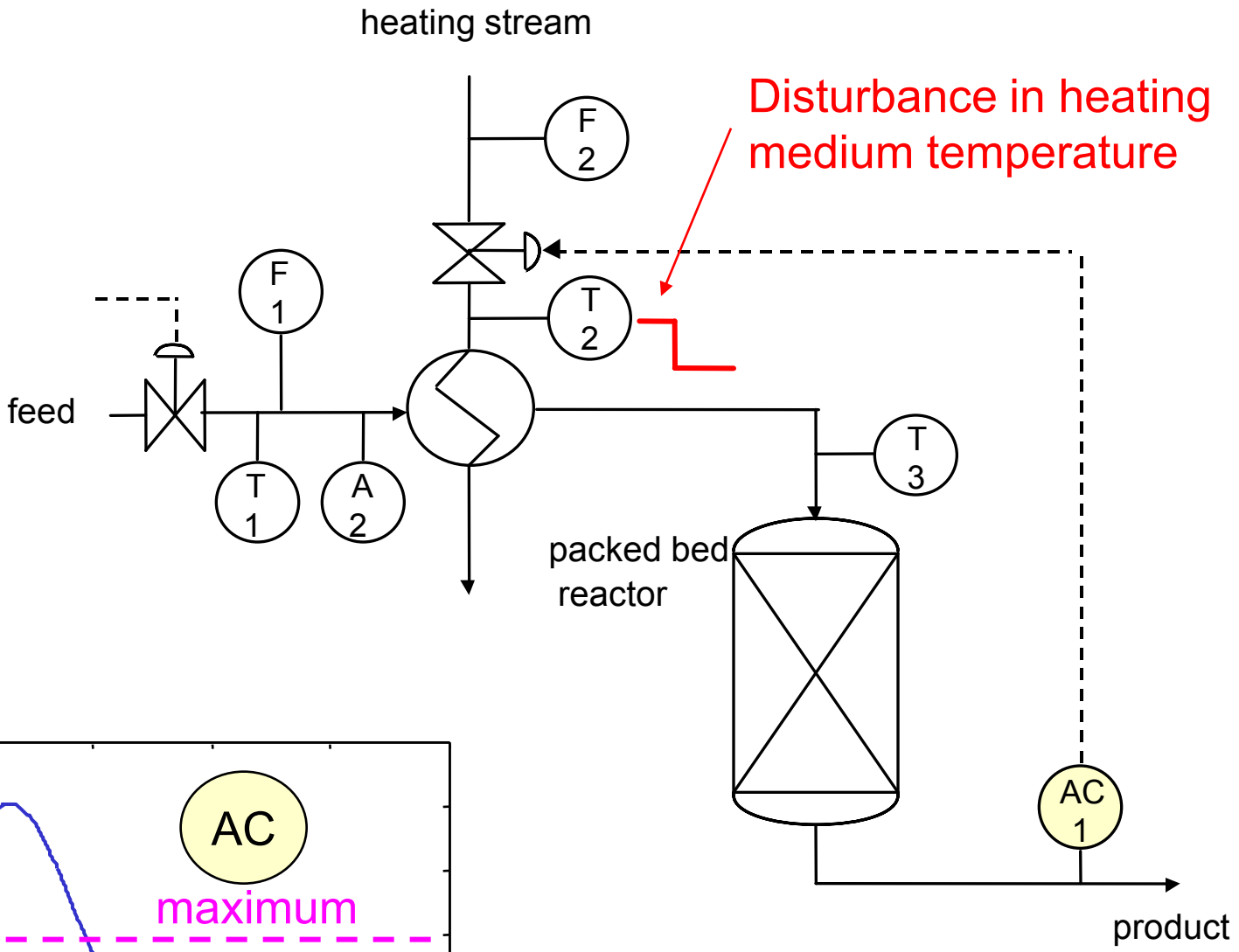
Cascade control summary

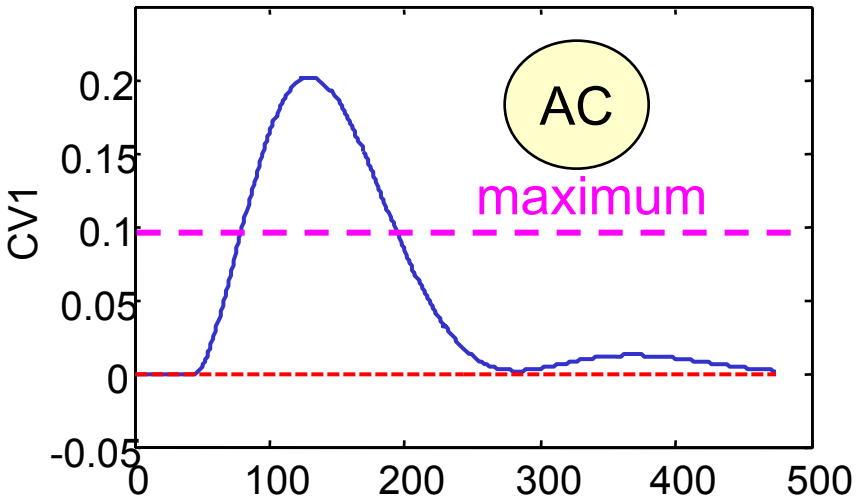
Cascade is desired when

1. Single-loop performance unacceptable
2. A measured variable is available

A secondary variable must

3. Indicate the occurrence of an important disturbance
4. Have a causal relationship from valve to secondary (cause $\rightarrow$ effect)
5. Have a faster response than the primarys

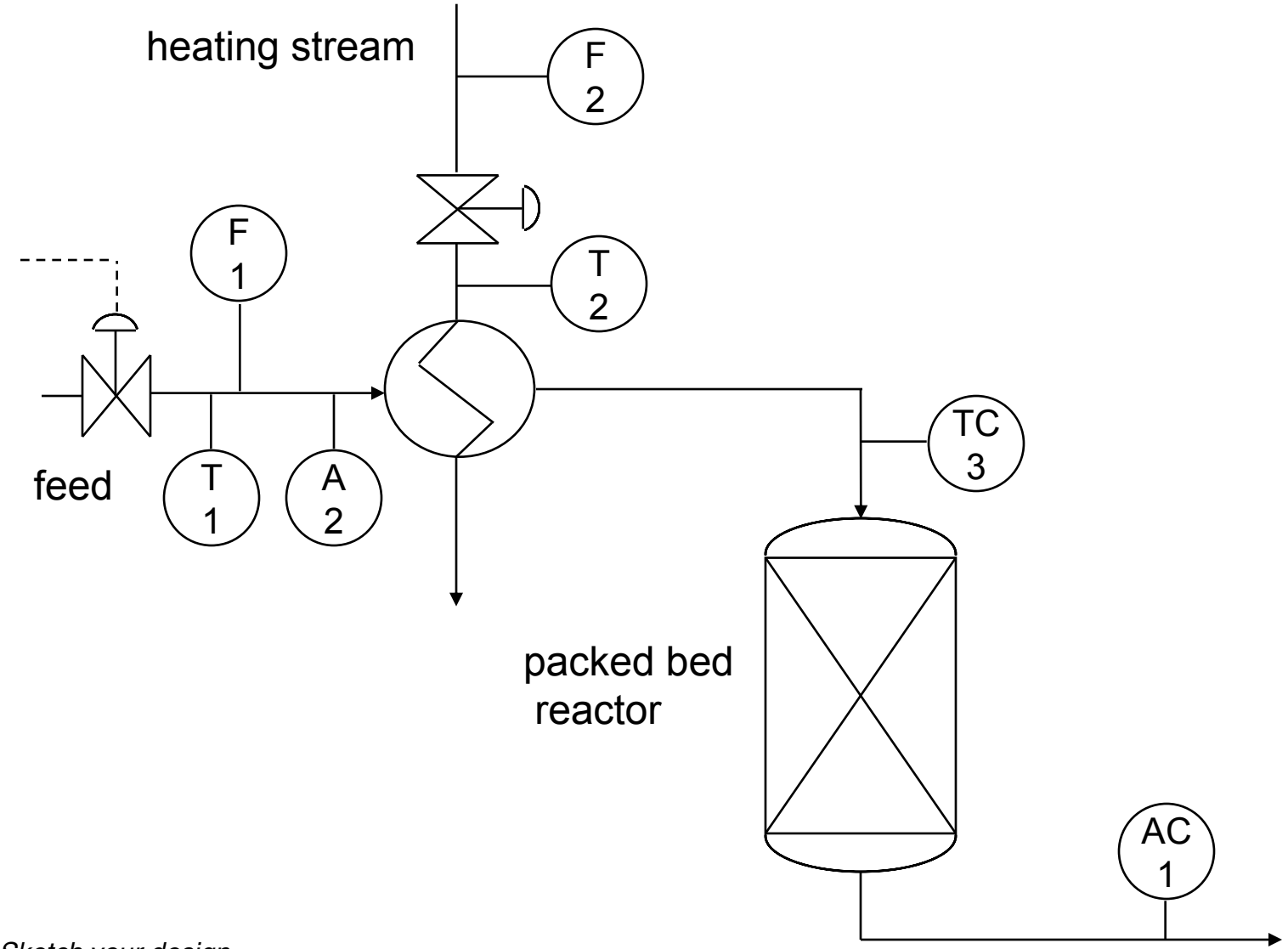




1. A1 measures reactant concentration
2. “Circle” is a shell and tube heat exchanger
3. Feed valve is adjusted by upstream process
4. Increasing temperature increases reaction rate

Class exercise: Design a cascade control structure to improve performance, **due to fluctuations in heating medium temperature**, using the cascade design rules.

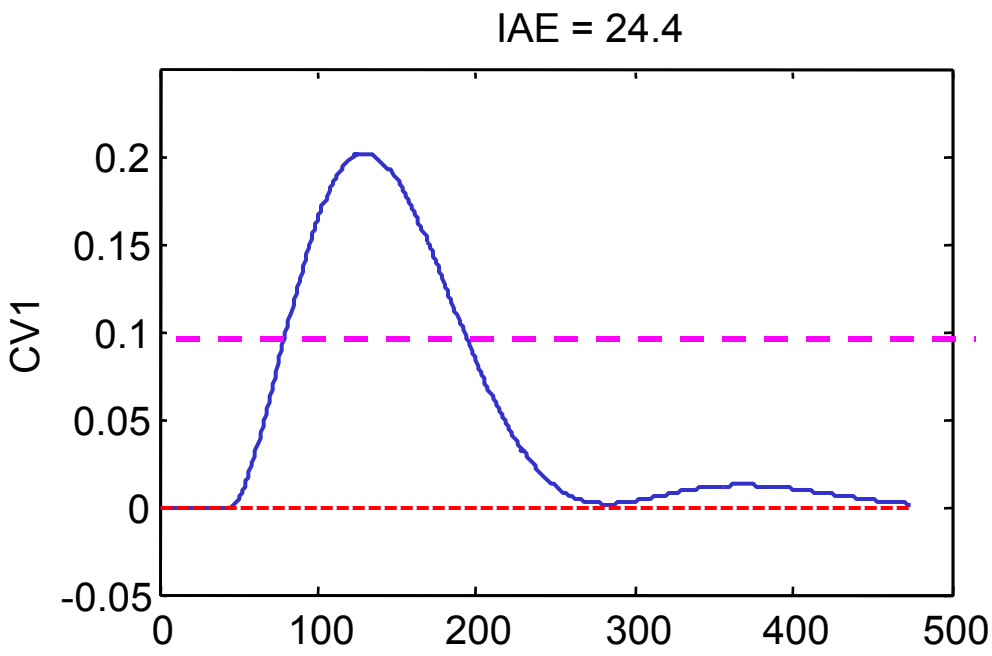
Cascade design criteria	A2	F1	F2	T1	T2	T3
1. Single-loop not acceptable	Y					
2. Secondary variable is measured	Y					
3. Indicates presence of key disturbance	N					
4. Causal relationship, valve $\rightarrow$ secondary	N					
5. Secondary dynamics faster than primary	N/A					



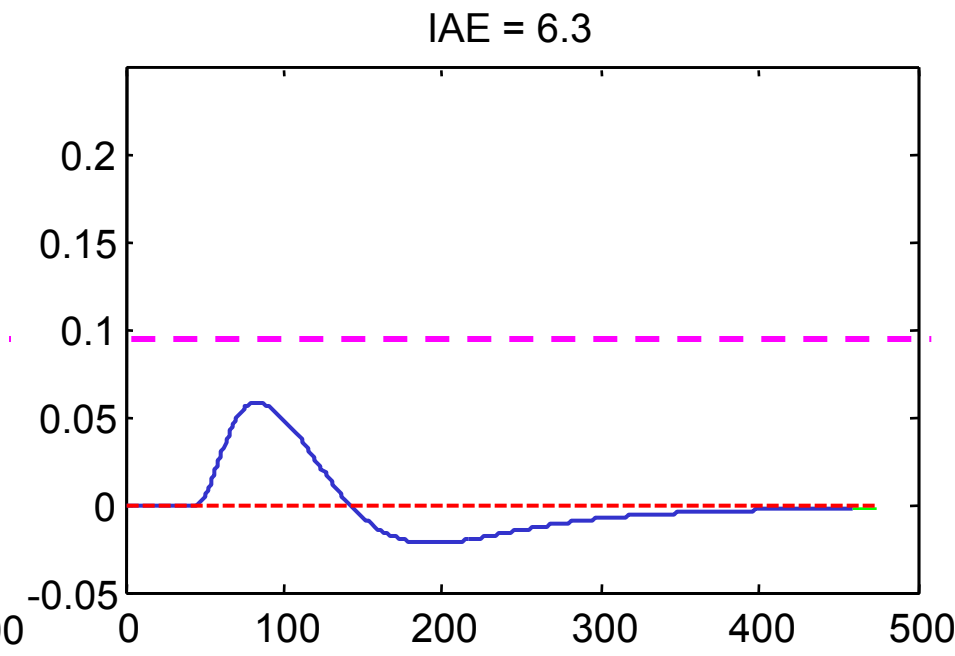
Sketch your design on this drawing

Control Performance Comparison for Packed Bed Reactor

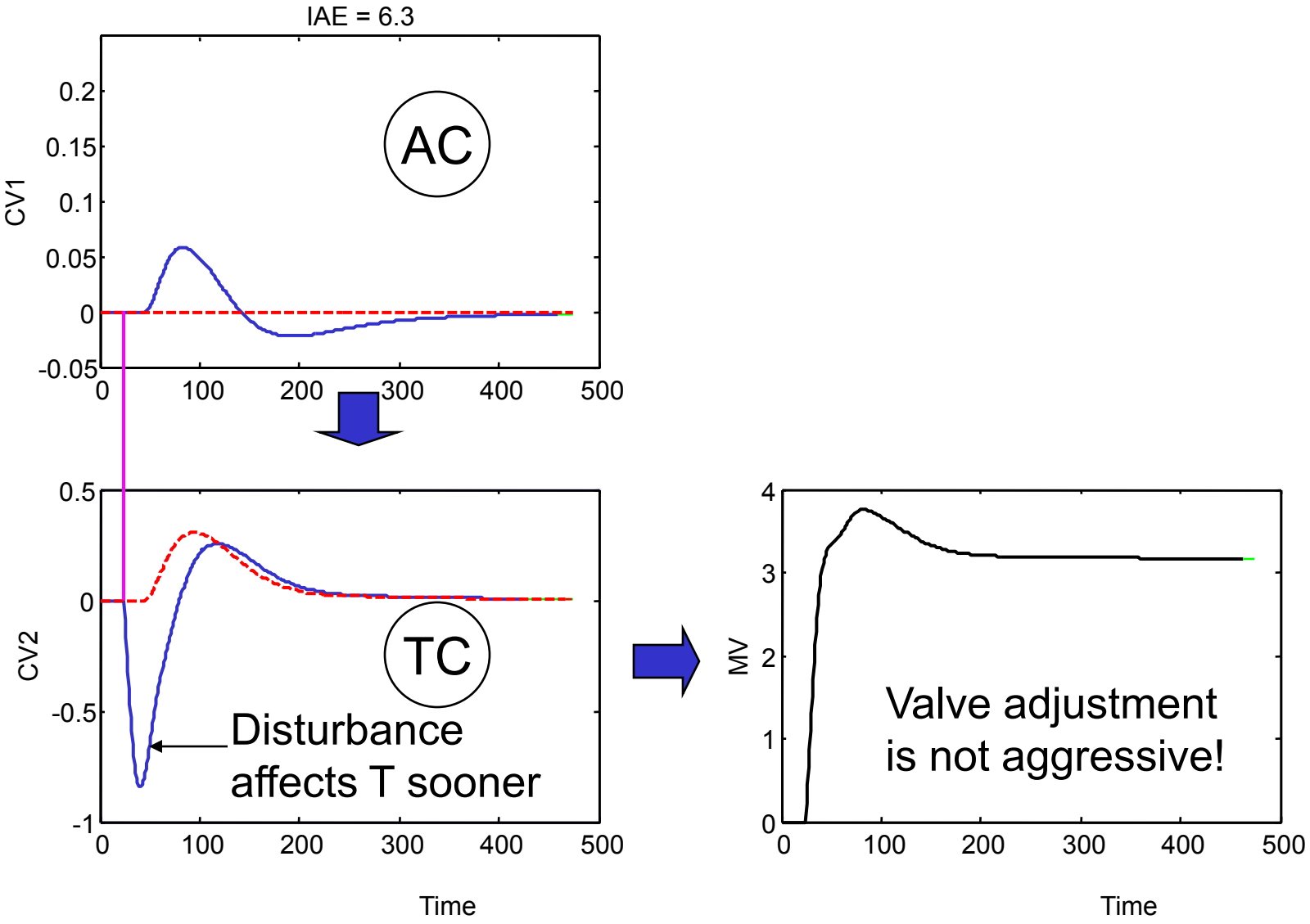
Single-Loop



Cascade

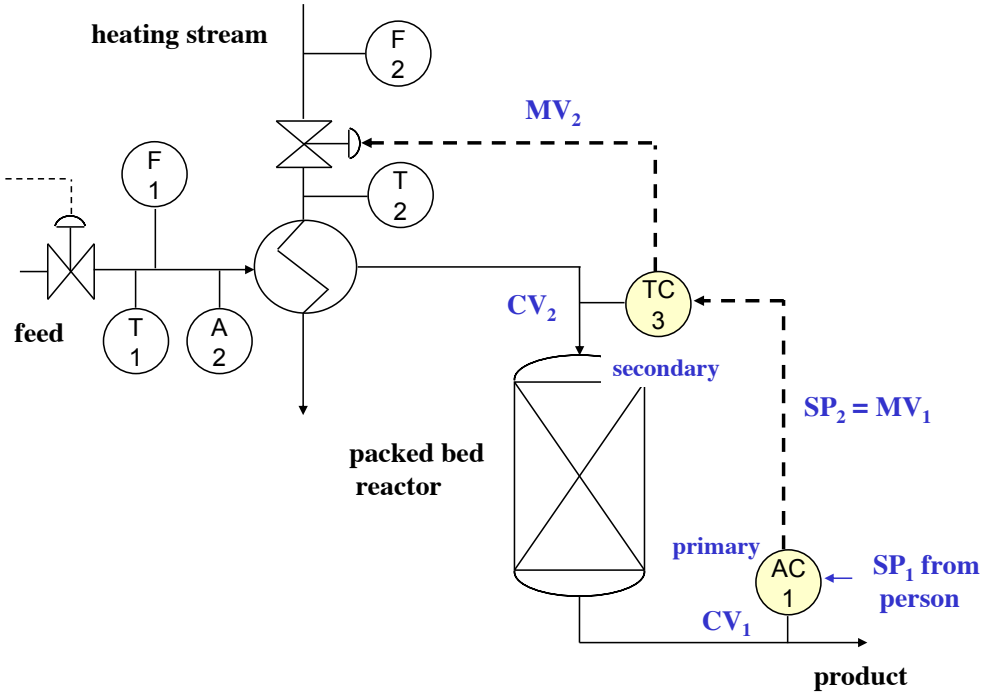


Control Performance Comparison for Packed Bed Reactor



What have we gained and lost using cascade control?

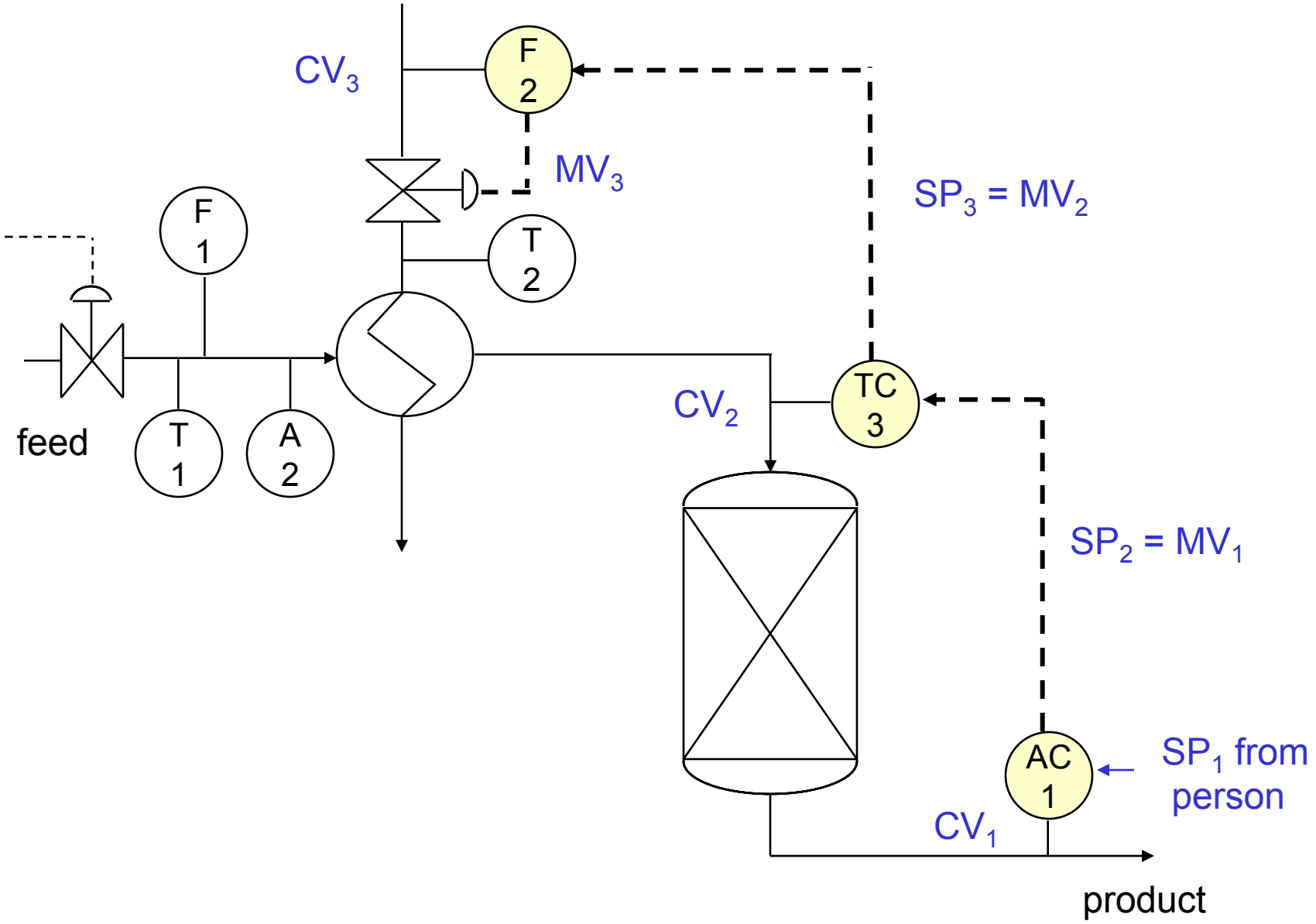
How does the system respond to the following?



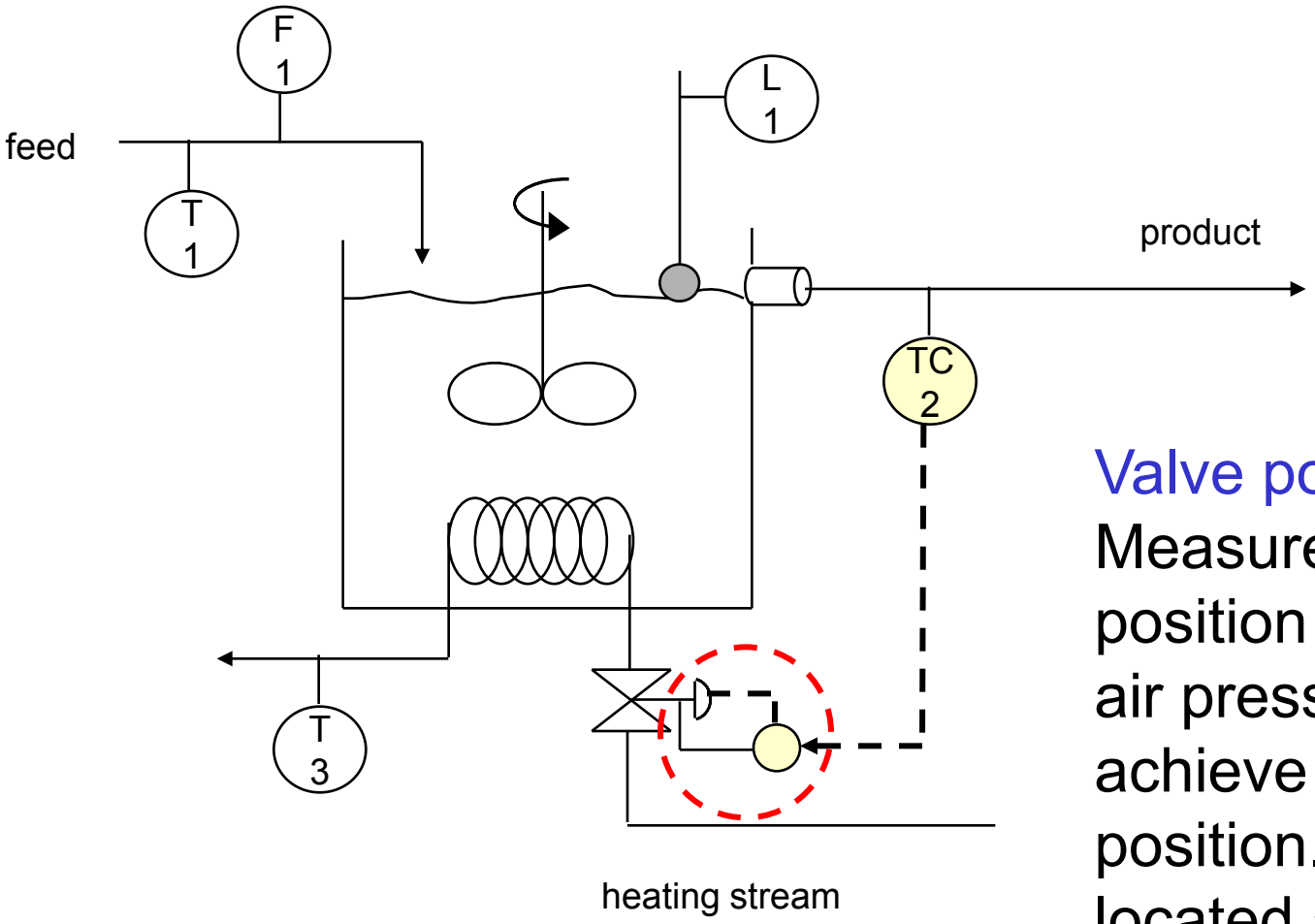
- A disturbance in T1
- A disturbance in heating medium inlet pressure
- A disturbance in feed pressure
- A disturbance to feed composition, A2
- A change to the AC-1 set point

Three-level cascade!

No limit to number of levels of cascade! But, each must meet the criteria.

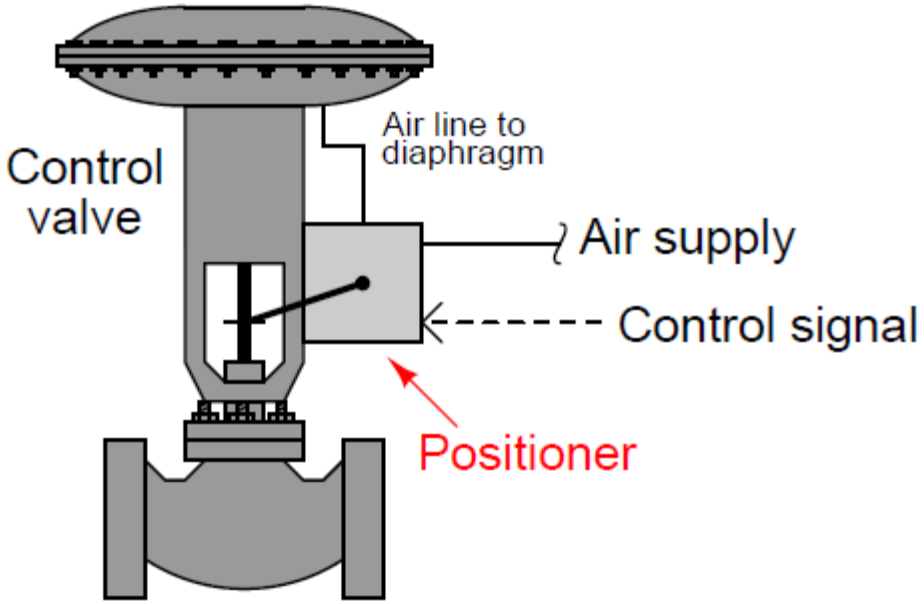


Does cascade apply to instrumentation? Yes, a valve positioner is a ***secondary*** that reduces effects of friction!



Valve positioner:
Measures the stem position and adjusts the air pressure to (closely) achieve the desired position. This is located at the valve.

Does cascade apply to instrumentation? Yes, a valve positioner is a ***secondary*** that reduces effects of friction!



Kuphalt, T. (2012) Lessons in Industrial Instrumentation, http://www.openbookproject.net/books/socratic/sinst/