TURBINE TIPS
Turbine Tips provided by Pond and Lucier, LLC. ®
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Subject: Minimum Value Gate (MVG) for Gas Turbine Control
Applies to: Speedtronic™ Control Systems

GE gas turbines control fuel flow to the combustors using a ***Minimum Value Gate (abbreviated MVG).*** By definition, it means that the control sub-system that "calls for" the **least** amount of fuel flow will be selected. Whenever fuel is flowing, the operating parameter that wants to maintain or reduce fuel flow will be "in charge." On most GE turbines, there are the following sub-system controls:

- Fuel Limits (Fire, Accelerate, Maximum)
- Speed Control (Full Speed, No-Load and Minimum "blow-out" speed)
- Speed Exponential (Rate of Change of Speed, sometimes called ***Acceleration***)
- Temperature Exponential (Rate of change of exhaust temperature)
- Temperature Control (Warm-up, Base or Peak curves)

Thus, during start-up, firing, acceleration, operation at FSNL, loading, unloading and shutdown sequencing, the sub-system that "demands" the lowest fuel flow will be in control.

Below is a hydraulic analogy of the ***MVG***. A supply tank sends oil to a manifold. The pressure in the manifold can be maintained or reduced by the ***check valves*** shown to the left called A or B or C. For this analogy, let the following be true:

- A = Start-up Control
- B = Speed Control
- C = Temperature Control

The pressure in the manifold wants to be controlled by one of the ***check valves***. Assume at the moment we have the following pressures on the **left side** of the three check valves:

- A = 2 psig
- B = 3 psig
- C = 4 psig

The pressure in the manifold (point 1) will decrease until it is equal to which pressure? If you said A = 2 psig, you'd be correct. The pressure decreases until it is equivalent to the lowest "called for" pressure.

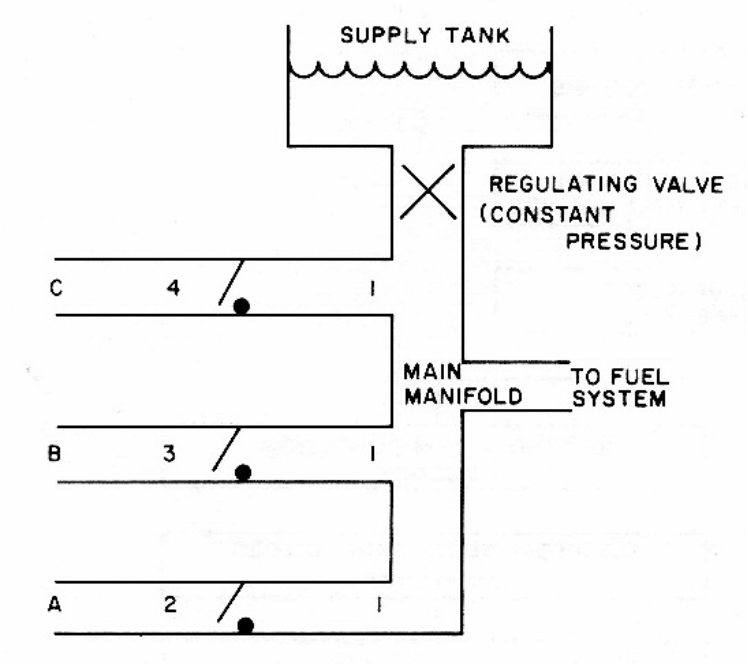

Fig. 1: Hydraulic Equivalent of a Minimum Value Gate

GE gas turbines use the **Fuel Limits** to restrict flow during all phases of fired operation to allow only the amount that might be needed for that particular operating condition. For instance, during firing, the maximum fuel flow would be limited to a value that would allow for proper ignition and cross-firing to all chambers, the **Firing Limit**. Once flame is sensed, the fuel flow is reduced to a lower level, the **Warm-up Limit,** which allows for a sustainable and controlled flame in all combustors. The warm-up period is typically one minute. In the graph in Figure 2 below, the acceleration period follows warm-up, as **TIME** is shown to progress toward the right. Assuming liquid fuel operation for this example, the turbine accelerates, driving the gear-driven fuel pump faster. The fuel bypass valve is slowly closed (increasing fuel, VCE signal) to cause more acceleration. During this starting period (typically 3-4 minutes in duration), any one of the following sub-systems can control fuel flow:

- Fuel Limit Exponential (fixed voltage rate that increases to a voltage limit)
- Speed Exponential (typically 1.0 percent speed change per second)
- Temperature Exponential (typically 5 ºF temperature change per second)

If the turbine rotor speed is sensed to be increasing **TOO** quickly, the Speed Exponential (or Acceleration) will control or reduce fuel flow. If the turbine exhaust temperature is sensed to be increasing **TOO** quickly, the Temperature Exponential will take control to maintain or reduce fuel flow, as required. Thus, the ***Minimum Value Gate (MVG)*** is always monitoring the conditions so as to safely and effectively bring the gas turbine up to operating speed without exceeding acceptable limits.

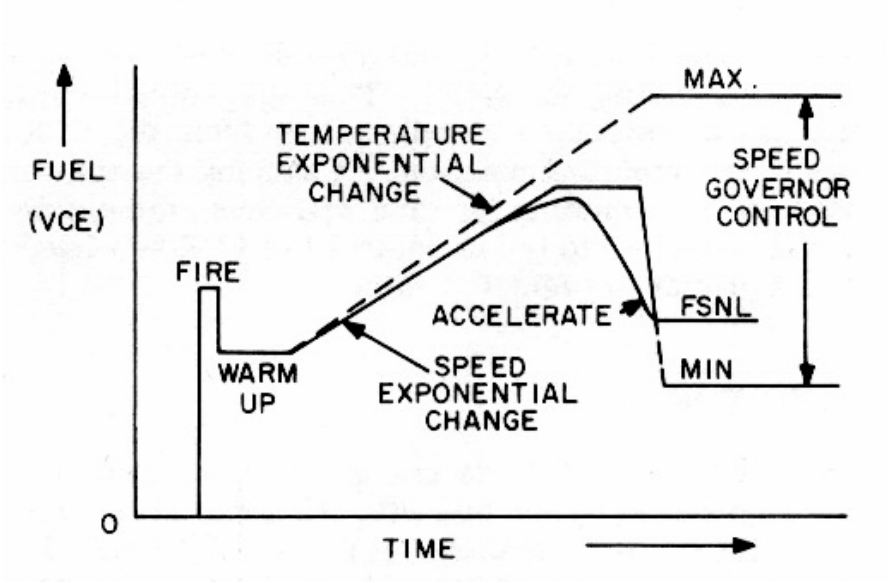

Fig. 2: Typical Start-up Curves

The ***MVG*** shown in Figure 3 below represents the basic configuration for a Speedtronic™ control system. Notice the three ***diodes*** in the dotted area. All three are connected to the **VCE Bus,** which in turn is connected to a 12-volt power source. ***Diodes*** are electronic elements that are analogous to the ***check valves*** shown in Figure 1 above. They allow current to flow in the direction of the arrow when the voltage to the left is less than that on the **VCE Bus**.

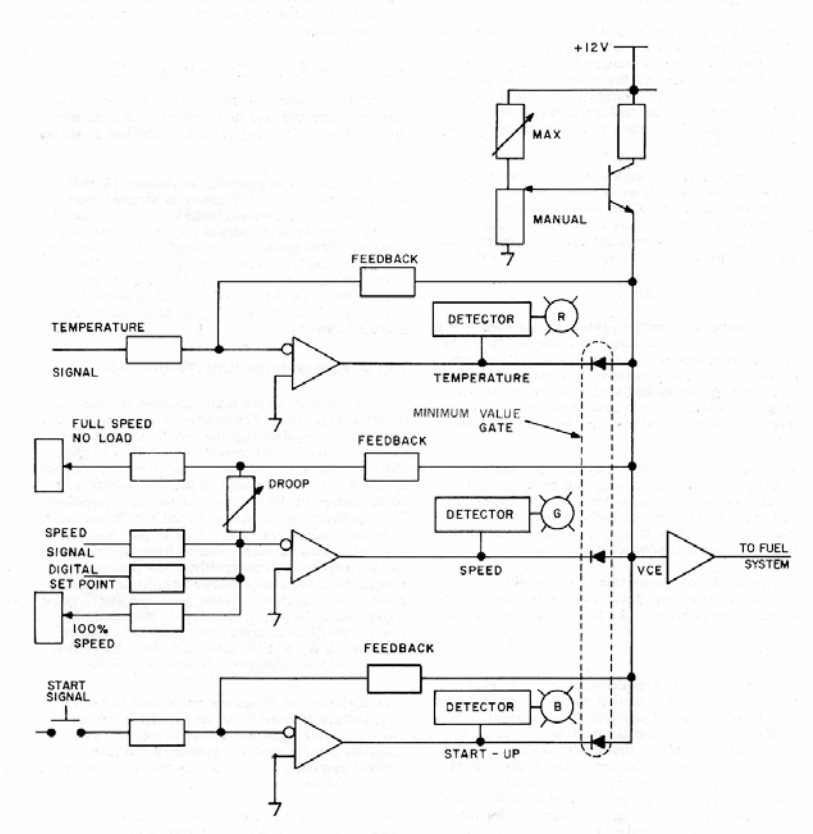

Fig. 3: Minimum Value Gate for Speedtronic™ Mark I

There are three subsystems in the diagram of Figure 1: Start-up, Speed and Temperature. One of the three will always be in control, specifically the one that "calls for" the lowest VCE voltage (lowest fuel flow).

Contact Dave Lucier or Charlie Pond of ***Pond And Lucier, LLC*** if you have any questions regarding problems associated to your liquid fuel system of if you need technical services on your GE gas turbines. Engineers can be dispatched to your site on short notice.