TURBINE TIPS
Turbine Tips provided by Pond and Lucier, LLC. ®
634 Plank Road, Suite 103 Clifton Park, NY 12065
Phone: 518.371.1971 Fax: 518.371.1756 E-mail: pal@pondlucier.com

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Subject: Fuel System Calibration
Applies to: All GE Gas Turbines
Example Used Herein: MS5001N or MS7001B, Speedtronic™ Mark I

The proper calibration of the liquid fuel system has many ramifications in the start-up and operation of General Electric gas turbines. White, smoky starts (unburned fuel) and immediate unfired shutdowns (quenching hot gas path parts) can be avoided if the liquid fuel system is properly calibrated. It is vital that the following calibration settings be made using the Control Specifications for the particular turbine.

1. **Zero Effective Stroke** (Less than 4 VCE units)
2. **Maximum Stoke** (Maximum VCE, typically 20 VCE units)
3. **Firing Stoke** (Firing VCE)
4. **Accelerating Stoke** (Accelerate VCE)
5. **Minimum Stroke** (Minimum VCE, typically 1 VCE unit less than the FSNL value)

Regarding a liquid fuel system using a variable-displacement fuel pump, for instance the NY Airbrake pump, fuel flow (gallons per minute, gpm) is proportional to two variables: ***speed*** and ***stroke***. The pump is driven by the gas turbine through the accessory gear, so pump ***speed*** is proportional to turbine speed. Pump ***stroke*** is a function of the variable control voltage (VCE), which is the command signal from the Speedtronic™ Mark I panel. See Fig. 1 for the black Airbrake liquid fuel pump.

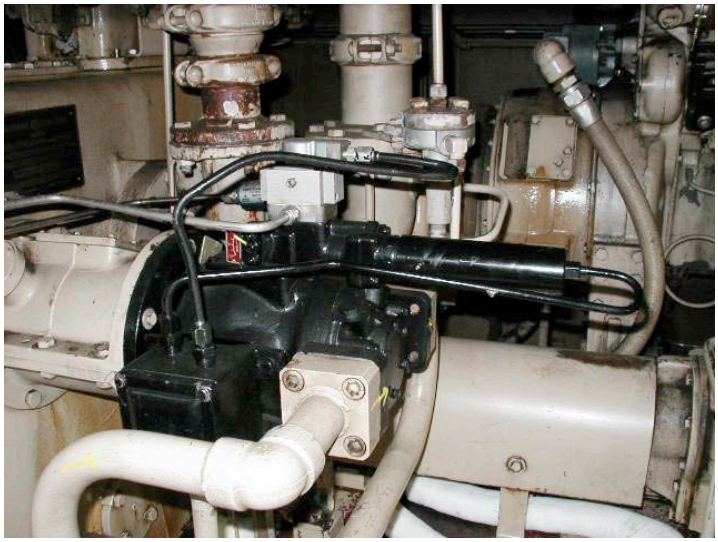

Fig. 1: Typical NY Airbrake Fuel Pump

The NY Airbrake fuel pump in Fig. 1 (above) has a stroke indicator. A close-up of the stroke indicator is shown in Fig. 2 (below), indicating fuel flow from 0 to 10. This actually indicates flow from 0 to 100 percent. The maximum fuel flow will be given on the pump nameplate and in the GE Control Specifications. It is typically 46 gpm for the Airbrake pump. Thus, an indication of 5 on the scale for a turbine running at ***rated speed*** and ***part load***, fuel flow would be approximately .5 x 46 = 23 gpm.

1. *Zero Effective Stroke*

The fuel pump should not begin "stroking" until VCE voltage (units) increases above a minimum value. This is typically 4.0 VCE volts (units) for Mark I control systems. This stroke is referred to as the ***Zero Effective Stroke (ZES)***. When the turbine is at rest, the indicator should read zero.

Note: ***ZES*** is not set at zero VCE volts, because GE does not want the fuel to "dribble" out if the actual VCE signal is slightly greater than zero when fuel is shut off and the turbine is at rest.

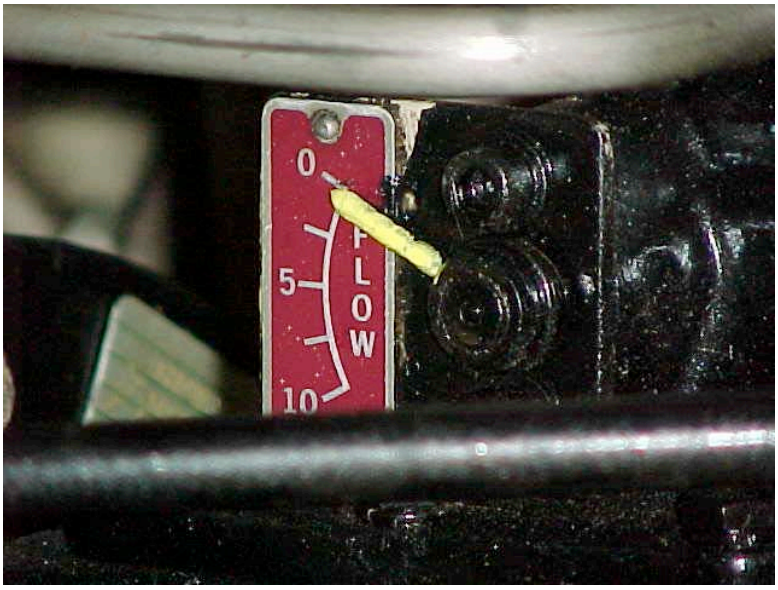

Fig. 1: NY Airbrake Fuel Pump

2. *Maximum Stroke:*

The maximum stroke value is the one expected when VCE is also at maximum. Thus, when VCE is 20.0 DC volts, the LVDT reading would be approximately 2.5 AC volts. It represents the maximum power output of the generator on the coldest day of the year. This value is seldom reached in gas turbine operations.

A more accurate reading of the pump stroke can be accomplished by using a digital voltmeter connected to one of the linear variable differential transformers (LVDT). There are two LVDT on this fuel pump, with a "high select" circuit designed to select the highest of two signals. The LVDT range is as follows:

LVDT Voltage (AC)	*VCE volts (units)*	*Comments*
.70 volts	4.0 volts	Zero Effective Stroke
2.5 volts	20.0 volts	Maximum Pump Stroke

However, the effective pump stroke will be as follows:

Differential Voltage (AC)	*VCE volts (units)*	*Comments*
2.50 - .70 = 1.60 AC volts	20.0 - 4.0 = 16.0 DC volts	Subtract maximum - minimum
1.8 differential AC volts	16.0 differential DC volts	0 to 100 percent stroke

Fig. 3: VCE meter

The VCE meter shown in Fig. 3 reads in absolute volts (units), displaying a range from 0 to 20.0 DC volts. The effective range would be 4.0 to 20.0 volts, or a differential of 16.0 volts. This would represent an LVDT voltage change .7 to 2.5 volts or 0 to 100 percent pump stroke.

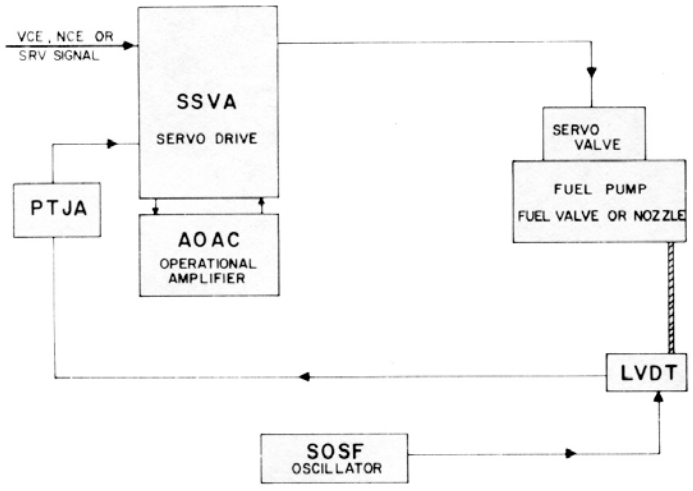

Fig. 4: Simplified schematic of fuel pump control circuit

The liquid fuel system can be calibrated at “cranking speed” using the Manual VCE resistor on the SSZA card. See Fig. 5.

Fig. 5: Manual VCE “Gag” on the SSZA Card at slot location 1L1M.

A jumper must be installed on card SSVA shown in Fig. 6. Jumper TEST to J2. This will allow the MAN VCE adjustment to be used to stroke the fuel pump with selector switch 43 in the CRANK position and the turbine running at 20 percent speed.

Fig. 6: SVSA Card at location 1L3H

Speedtronic™ Mark I Fuel Pump Calibration for MS5001N:

Signal Name	Typical VCE (DC volts)*	Effective VCE	LVDT Feedback (AC volts)	Effective LVDT (AC volts)
Zero Effective Stroke	4.0	**0**	.70	**0**
Minimum	6.5	**2.5**	.98	**.28**
Firing	7.5	**3.5**	1.09	**.39**
Warm-up	7.0	**3.0**	1.04	**.34**
Accelerate	9.5	**5.5**	1.21	**.51**
Maximum	20.0	**16.0**	2.50	**1.80**

**** Note: The fuel system settings from the actual GE Control Specifications must be used.***

3. Firing Stroke:

At approximately 20 percent speed with selector switch 43 in the Fire position (1000 rpm on MS5001N gas turbine), the Firing VCE value is set. The GE control specifications set a value to be adjusted to the SSKA card. See Fig. 5 below for the test pushbutton and adjusting resister adjacent to it. The pump stroke chosen is one that will allow for the fuel/air mixture to ignite and "crossfire" to adjacent chambers. This calibration can be done at "cranking" speed.

4. Warm-up Stroke:

Once flame is sensed in the combustors, VCE is cut back to a value that will sustain flame but allow a warm-up at approximately 550 ºF for a one minute cycle. This is called Warm-up VCE. It is typically about .5 volts less than the Firing VCE value. However, it should be tested and imperially adjusted during actual turbine operation. This calibration can be done at "cranking" speed.

5. Accelerate Limit Stroke:

The Accelerate VCE value is the highest setting that is needed to bring the turbine up to operating speed without exceeding the exhaust temperature limit (typically 950 ºF). It can be reduced if a high temperature is experienced before the temperature "peaks" during acceleration. When the turbine reaches approximately 70 – 75 percent speed (3500 – 3800 rpm), the temperature naturally "peaks" as the airflow through the compressor increases to cool off the turbine exhaust thermocouples. This calibration can be done at "cranking" speed.

6. Minimum Fuel Limit:

The Minimum Fuel Limit is a value set when the generator breaker (52G) opens during shutdown. Minimum VCE is a value that will allow the turbine to "cool down under flame" until a speed of approximately 80 percent (4000 rpm) is reached. It should take approximately 1:30 to 2:00 minutes to slow down from operating speed. Cooling down with flame in the combustors avoids "quenching" the hot gas path parts with cooler combustion gases.

All of the aforementioned settings are very important for the safe and successful operation of the gas turbine. If you are experiencing "white, smoky starts" or unfired shutdowns, it is likely that the fuel system calibration is incorrect.

Note: It is vital that the GE Control Specifications settings be used as the "bible" for all calibrations on your MS5001N gas turbines. This procedure is quite similar for MS7001B gas turbines too. It does not apply to Speedtronic™ Mark II controls for MS5001P and MS7001C gas turbines.

For more information, contact David Lucier of ***PAL Engineering*** on 518-371-1971 if you have any additional questions about fuel pump calibration.