TURBINE TIPS
Turbine Tips provided by Pond and Lucier, LLC. ®
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Subject: Liquid Fuel flow measurements for gas turbines with Roper flow dividers
Applies to: General Electric MS5001P & MS7001C-E with ***Speedtronic™ Mark II***

GE gas turbines that burn liquid fuel utilize Roper flow dividers. See Fig. 1 below. On frame 5 turbines there were ten flow elements, one supplying each turbine fuel nozzle and combustor. During the ***Speedtronic™ Mark II*** era (circa 1973 to 1983), these tandem-flow dividers came with 60-tooth wheels and magnetic speed pickups installed on each end.

Note: MS7001C-E gas turbines utilize a circular flow divider with speed pickups, but the principles herein also apply.

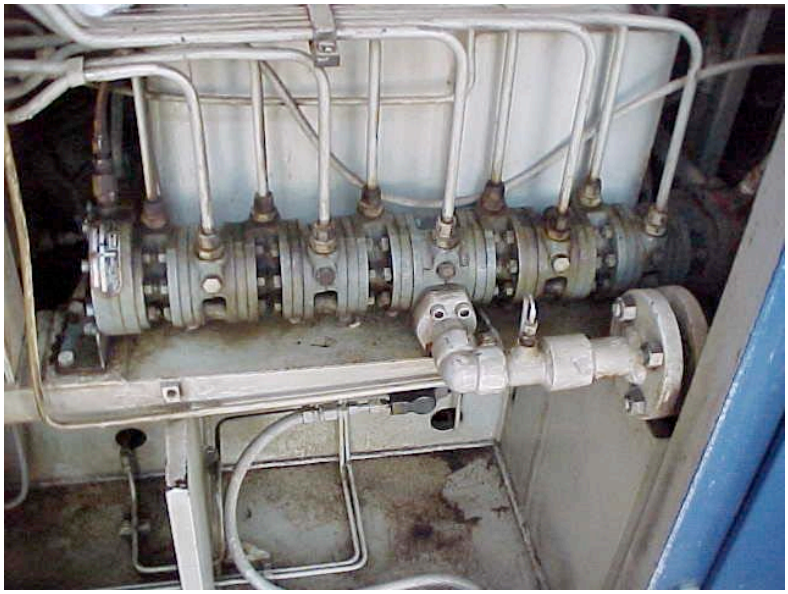

Fig. 1: Roper tandem flow divider (10-elements) with magnetic speed pickup on left end

The purpose of the speed pickups is to send digital pulses proportional to fuel flow to the control system. In this era, there are two (redundant) pickups. There is a "high select" feature should one pickup fail. The rating of a typical frame 5 flow divider was 3704 cycles per second (cps) for a maximum total flow of 52.5 gallons per minute (gpm). Calculating the relationship, you divide 3704 by 52.5. The result is **70.7 cps per gpm**. This is an important constant to remember.

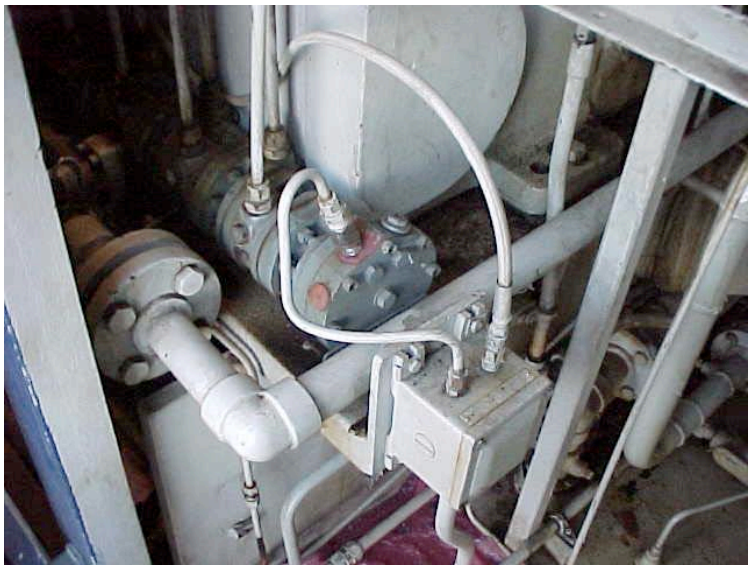

Fig. 2: Roper flow divider with one speed pickup on right end

This count value (measured in cps or Hertz) is converted to an analog signal in the ***Speedtronic™*** on the SFKC card, which is used to set the "called for" fuel flow. However, GE decided **not** to use this same digital or (analog signal out of SFKC) for a flow meter on the control panel as a visual display for plant operators.

Note: The signals did, however, go to the connector location where the ***Speedtronic™ Calibrator*** can be connected. This allowed for testing and calibration of the circuit boards.

Pond and Lucier, LLC suggests that an "after-market" flow meter be installed on the turbine control panel to read flow divider speed or fuel flow. This will give the control room operator very valuable information (See Fig. 3 below):

- If the flow divider is turning during the ***firing*** sequence, it means that fuel must be flowing to the combustors. It is valuable to know this should a "failure-to-fire" alarm occur during start-up. This is a free-wheeling flow divider. Any rotation of the flow divider generally means that the control system is functioning properly. Actual fuel flow might be too high (rich) or too low (lean), but at least the operator knows that the system is working.

- As stated, the speed of the flow divider is "proportional" to fuel flow. The flow divider delivers one gallon of fuel for every 70.7 cycles per second. This is slightly more than one revolution of the flow divider for a 60-tooth wheel. Thus, if the frequency is measured, the fuel flow in gallons per minute (gpm) can be displayed. Fig. 3 below shows a digital flow meter (currently displaying **00** gpm since the turbine is stopped).

- A totalizer flow meter can be installed to record the total fuel consumed during a turbine run.

Fig. 3: After-market flow meter shown in upper left hand corner of the photo above

The operator can measure fuel flow at critical times during turbine start-up and operation.

1. Fuel flow can be measured at ***firing*** speed. The firing cycle is typically one minute. From the GE Control Specifications for a MS5001P, the expected fuel consumption in one minute of ***firing*** is expected to be 2.6 gallons. That's .26 gallons per combustor or about 1 quart of fuel each. The expected frequency of the flow divider is 185 cps. The operator can determine if the fuel flow is sufficient to initiate and sustain combustion.

2. Fuel flow measurement at full speed/no load (FSNL) can also be useful. If the axial-flow compressor is dirty, excessive fuel consumption is likely to be experienced. This observation, along with a diminished compressor discharge pressure (PCD), would give the operator a clue as to this deterioration of the compressor. The expected fuel flow for a MS5001P at FSNL is 7.4 gpm. The expected frequency of the flow divider is 787 cps.

3. At Base or Peak load, the operator can record the fuel consumption for the calculation of Heat Rate (in BTU/KW-hr). Knowing the heat content of the fuel (BTU per gallon) and measuring the power output (KW) will allow the heat rate calculation. Typical fuel heating value is 18,800 BTU/LB. The specific gravity is typically .83. Knowing the fuel consumption in gpm and the power output, the Heat Rate can be calculated.

For further information about the installation of a flow meter for fuel measurement and troubleshooting, contact Dave Lucier of ***Pond and Lucier, LLC*** by calling: 518-330-4801.