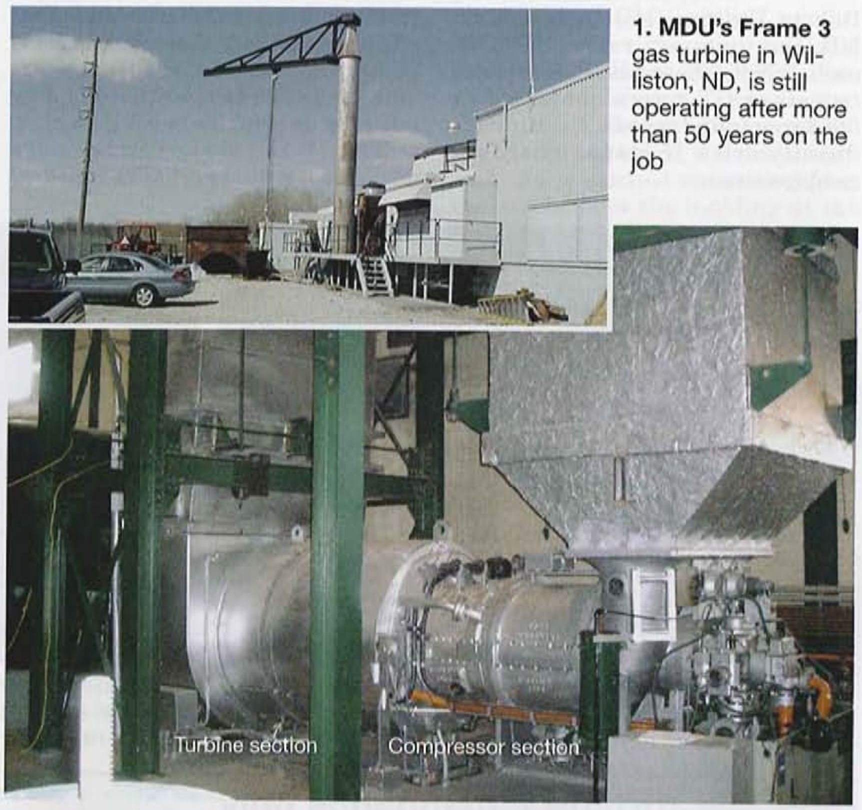
These baby boomers also deferring retirement

By **David Lucier,** partner, Pond and Lucier LLC

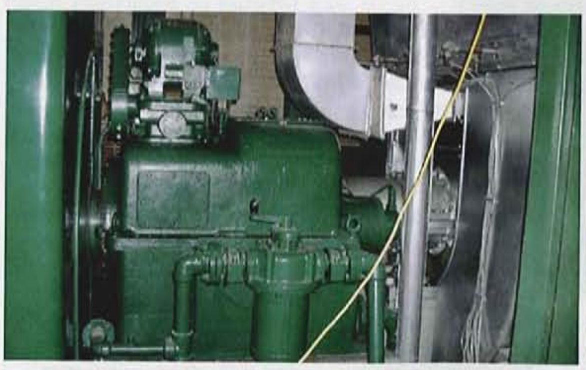
What is the lifetime of a land-based gas turbine? Is it 10, 20, 30, or possibly even 40 years? The answer, of course, depends on how well the GT is operated and maintained. Cumulative fired operating hours and fired starts, and maintenance practices, certainly will impact turbine condition and longevity. In today's throwaway society, however, you still find gas-turbine-based powerplants in operation that were installed in the 1960s, or even earlier.

Would you believe that two General Electric Frame 3 turbines in the remote town of Williston, ND, have been operating for nearly 55 years? Sure, this pair typically is used only to meet winter-peak power demands or emergency situations. Nevertheless, these turbines, with auxiliary systems and controls from 1953, are still viable contributors to the power pool. And it is undeniable that electricity coming from the generator terminals of these "old boys" is indistinguishable from that flowing from modern power contributors.

Owned and operated by Montana-

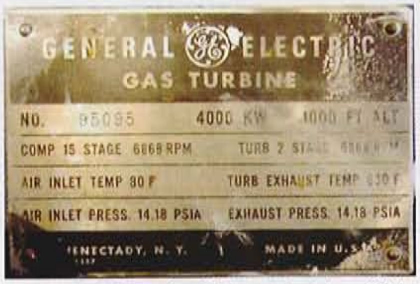


1. MDU's Frame 3 gas turbine in Williston, ND, is still operating after more than 50 years on the job



2. Turning-gear mechanism is mounted on top of the speed reduction gear (above)

3. Motor-driven auxiliary pumps, filters, valves, etc, are located on the accessory base. Liquid fuel system is in the center with all the hoses (right)



4. Nameplate for GE gas turbine S/N 95095 provides design data. Additional information of interest: Air flow to the compressor at rated conditions is 98 lb/sec, temperature of compressed air flowing to the combustors is 500F, combustion gas enters the turbine at 81.7 psia/1400F

Dakota Utilities (MDU), Bismarck, ND, the units are rated 4000 kW each. S/N 95095 and S/N 95096 have two-stage GT rotors operating at 6868 rpm (rated speed). The turbines directly drive 15-stage, axial-flow compressors.

Reduction gears on the turbine end reduce the speed to 3600 rpm to drive 2-pole generators. The units are single-shaft in a unique four-bearing design with the turbine and compressor rotors internally coupled by a spline drive. The turbine/generators are located inside a building, so no compartment lagging is used or required (Fig 1).

The speed-reduction gearbox is connected to the generator (Fig 2). Atop the gearbox is a motor-driven turning-gear mechanism. Cooling air for the No. 4 turbine bearing passes through the exhaust plenum from a ducting elbow (at the right in the photo). The generator, painted green, barely can be seen on the left side.

As is the case with most GE gas turbines, many auxiliaries are located on the accessory base (Fig 3). This allowed for testing of the gas turbine in the Schenectady (NY) factory using its own auxiliary equipment.

The Williston units were designed as dual-fuel GTs (natural gas and No. 2 distillate fuel oil). They could only run on liquid fuel at the GE manufacturing facility back in the 1950s (natural gas was unavailable), so all units were started and tested at rated speed on oil. The reduction gears and generators were built in Lynn, Mass, so they first "greeted" the turbines in Williston.

The turbine nameplate (Fig 4) states the expected power output (4000 kW) if operating at 1000 ft altitude, at an 80F compressor inlet temperature, and 14.18 psia ambient pressure (rated at NEMA conditions). Actual performance rating would need to be adjusted for the site location and typical operating temperatures. It is often much colder in North Dakota, so a winter rating is likely above 5000 kW.

As installed, both MDU gas turbines could start and operate on liquid fuel or natural gas. They also could transfer fuel during fired operation, although this was not often

5. Gas-only machine. Fuel gas controls (orange piping) are at the front of the axial compressor. Note the stop valve hanging off the gearbox. Accessory base for a gas-only unit certainly is less complicated than that for the dual-fuel machine in Fig 3

6. Fuel regulator is driven off the accessory gearbox

For gas-turbine afficionados only

John Lovelace, who recently retired from Arizona Public Service Co and started his own turbine consulting practice, is participating in the launch of the Gas Turbine Historical Society (GTHS) as curator. Goal of the organization is to gather information both on significant technology developments related to industrial gas turbines and on landmark installations before it fades from memory.

Recall that the world's first industrial gas turbine began operating in Neuchatel, Switzerland, in 1938. Time is of the essence. Retirements of both people and plants make the new organization's goal more challenging with each passing day.

The first order of business is to identify developments and facilities that should be recognized. They would be placed "on display" in the virtual museum being planned in association with the CTOTF. The Combustion Turbine Operations Task Force is the world's oldest gas-turbine user organization in continuous service. Lovelace had been the chairman of that group for nearly two decades until announcing his retirement last spring.

Lovelace

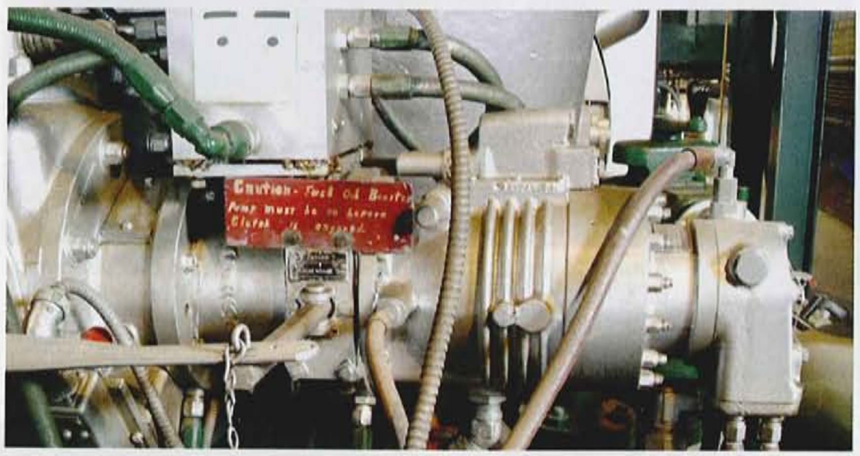
Dave Lucier (Pond and Lucier LLC, Clifton Park, NY), who has devoted much of his professional career to problem-solving and rehabilitation of legacy engines and their auxiliaries (in particular, fuel and control systems) also is helping to move the GTHS forward. He contributed the Williston profile and has provided a list of other noteworthy projects—some still in service, others dismantled.

The ad hoc committee directing this effort welcomes your thoughts, ideas, suggestions. Please send these to the organization's acting secretary, Bob Schwieger, editor, COMBINED CYCLE Journal, at bob@psimedia.info.

Progress reports will be included in each issue.

7. Instructions remind operators how to transfer from gas to oil during operation

8. Transferring from oil to gas is only a seven-step process



9. Original fuel pump has an engaging clutch mechanism at left and flow divider at right. Notice the flex hosing that goes to the fuel nozzles of each of the six combustors.

done. In recent years, operation has been restricted to natural gas, so on one of the turbines the liquid fuel controls were removed (Fig 5).

Fuel flow control is accomplished by a device called the fuel regulator. However, fuel does not actually flow through the device. Designed in the late 1940s by Young & Franklin, Liverpool, NY, for General Electric, the fuel regulator is an electrohydraulic governor with a pneumatic exhaust temperature control system. It was GE's control system of choice for gas turbines until 1969.

GE shipped nearly 1000 turbines (principally Frame 3 and 5) with this type of system. Most of these engines still are operating today with the same controls. However, only a handful of single-shaft, generator-drive Frame 3s were ever built. Interestingly, Pond and Lucier recently reconditioned one of MDU's fuel regulators, which, by appearances and lead tag seals, had never been disassembled in more than 50 years of service.

The fuel regulator (Fig 6) is mounted on the accessory gear. The circular case on the front encloses the stabilizing rheostat—part of the electric governor circuit. Inside the regulator is a series of pilot valves and pistons that establish the following settings for the command signal called variable control oil (VCO) pressure that sets the fuel flow demand:

- Fuel limits: Firing, accelerate, and maximum.
- Minimum fuel (for fired shutdown).
- Speed governor and load control.
- Exhaust temperature limit (startup, base, and peak loads).
- Rate of rise of turbine exhaust temperature.

The fuel regulator operates by using a series of internal links and levers to establish a minimum value gate (MVG) which determines the *lowest* called-for fuel flow. Thus, fuel flow always can be reduced to limit power output and control the gas turbine's exhaust temperature at all times during fired operation. The controls are backed up by protective devices as well, to guard against such adverse conditions as over-firing, over-speed, vibration, and loss of flame.

Instructions for switching fuels during operation were hand-painted on placards (Figs 7, 8). No fancy human/machine interface (HMI) here. This was the 1950s, when the procedure was posted on the wall for operators to follow.

The GT could transfer fuels during online fired operation by use of a VCO divider. It splits the output signal from the fuel regulator between the fuel pump and the gas flow control valve. The theory of operation is to maintain the total flow of energy to the combustors during the transfer, to hold the generator power output constant. However, most operators likely chose to make fuel transfers when operating at full speed/no load (FSNL) to avoid power swings or inadvertent trips.

The fuel pump (Fig 9) is still in place on one of the MDU turbines. An engaging clutch is on the left and a flow divider for six combustors is at the far right. Dual fuel systems were very unusual and particularly complicated back in the 1950s.

The MDU gas turbines in Williston remain viable and available for operation even after more than five decades since commissioning. When local ambient temperatures dip to zero and below, it is not uncommon to see exhaust emanating from the stacks over the building at the Williston powerplant. This longevity is testimony to the OEM's design and manufacturing capabilities and MDU's sound O&M practices. CCJ