TURBINE TIPS
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**Subject: Troubleshooting a Malfunction of the Motor-Operated Atomizing Air Bypass Valve**

**Disclaimer:** This document outlines the procedures followed when troubleshooting an atomizing air system on an F-class gas turbine, which is equipped with the compressor-less system. Some F-class gas turbines use a separate Atomizing Air compressor, the old boosted purge system, and the troubleshooting procedures for the old system are not included in this document. This document does not supersede any factory instructions.

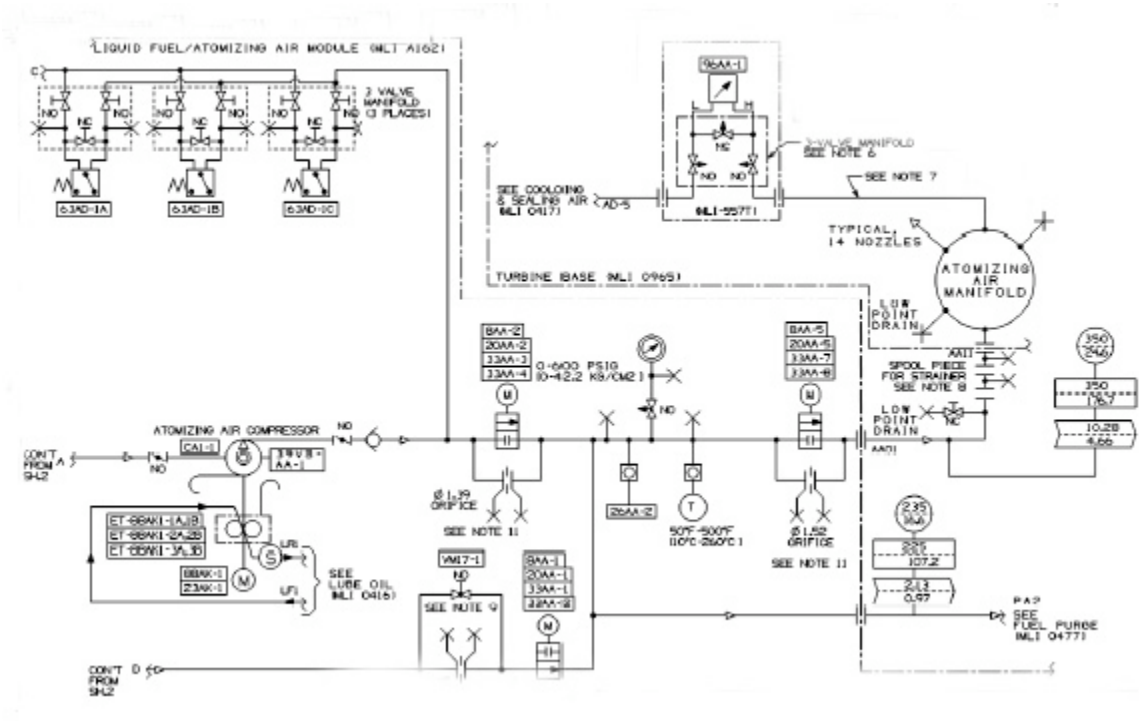


**Fig. 1: Atomizing Air Schematic (simplified from GE drawing)**

**Problem:** The customer could not start the gas turbine due to an incorrect "Ready-To-Start" status on their Mark 5 panel operator display or "<I>". It was determined by the customer that the motor operator on the 20AA-1 valve had failed. The valve was not in the correct position to permit startup. Once the actuator had been replaced with a new one from stock, it needed to be tested prior to startup.

**Discussion:** It is best to start with a description of the operation of the atomizing air (AA) system. Please refer to the above schematic for the details of the system as described below.

When liquid fuel oil is sprayed into the turbine combustion chambers, it forms large droplets as it leaves the fuel nozzles. The droplets will not burn completely in the chambers and may go out the exhaust stack in a state of unburned hydrocarbons. A low-pressure atomizing air system is used to provide air through supplementary orifices in the fuel nozzle, which directs the air to impinge upon the fuel jet discharging from each nozzle. This stream of atomizing air breaks the fuel jet up into a fine mist, permitting ignition and combustion with significantly increased efficiency and a decrease of combustion particles discharging through the exhaust into the atmosphere. It is necessary, therefore, that the atomizing air system be operative from the time of ignition firing, through acceleration, and during normal operation of the turbine.

In addition to supplying air for atomization of liquid fuel, the atomizing air system also supplies purge air to the atomizing air, liquid fuel and water injection passages when the gas turbine is operating on gas fuel (refer to Fuel Purge system description supplied in the GE instruction books for the applicable unit)

Air taken from the atomizing air extraction manifold of the compressor discharge casing passes through the air-to-water heat exchanger to reduce the temperature of the air sufficiently to maintain a uniform air inlet temperature of 225°F to the atomizing air compressor. This atomizing air pre-cooler (HX1-1) uses water from the turbine cooling water system as the cooling medium to dissipate the heat.

Temperature switches (26AA-1A and 26AA-1B) are provided to send an alarm to the control panel when the temperature of the air from the atomizing air pre-cooler entering the main atomizing air compressor becomes too high (set point 275°F). These two temperature switches work in conjunction with 26AA-2 (described later) and participate in a 2 out of 3 voting process. A high temperature alarm is annunciated and a fast-fired shutdown is issued in order to protect the fuel nozzles, liquid fuel distributor valves, and the atomizing air compressor. Downstream of the pre-cooler, the air passes through a moisture separator (PDS1-1) with a continuous blowdown drain, and then through the main atomizing air filter (FA5-1). Differential pressure switch 63AF-1 monitors pressure drop across the filter and signals an alarm if the DP exceeds a preset level.

During liquid fuel operation, air flows to the compressor (CA1-1). Triple redundant differential pressure switches 63AD-1A, 1B, and 1C monitor the differential pressure across the compressor and signal an alarm and transfer to CA1-2, if so equipped, in the event of low pressure. If pressure is not regained after 30 seconds, the turbine is tripped.

Downstream of the compressor, the airflow passes through the discharge throttle valve 20AA-2 equipped with limit switches 33AA-3 and 33AA-4. Downstream of this motor operated butterfly valve, temperature switch 26AA-2 (set point 375°F) monitors the atomizing air compressor discharge temperature. Next the air passes through the scavenge valve 20AA-5 equipped with limit switches 33AA-7 and 33AA-8. The air then exits the Liquid Fuel/Atomizing Air module

through interconnecting piping to the manifold and then, via flexible metal piping pigtails, to the nozzles. Boosted air is also supplied for water injection purge when operating at low loads with liquid fuel.

When operating on gas fuel, un-boosted purge air is supplied from a full diameter tee located between the moisture separator PDS1-1 and filter FA5-1, while the compressor(s) are shutdown. The purge air passes through a manual purge tuning valve VM17-1/orifice combination and then through the bypass throttle valve 20AA-1. The flow then splits and supplies un-boosted purge air to the atomizing air passages and to the liquid fuel/water injection passages. Atomizing air purge differential pressure transducers 96AA-1A, 1B and 1C monitor the atomizing air purge pressure ratio and also detects if the last chance strainer is plugged. Similarly, liquid fuel purge differential pressure transducers 96PL-1A, 1B, and 1C monitor the liquid fuel purge pressure ratios and the water injection purge differential pressure transducers 96WP-2A, 2B, and 2C monitor the water injection purge pressure ratios and also detect if this circuit's "last chance" strainer is plugged.

**Solution:** ***PAL Engineering*** was consulted to develop a procedure to test the valve. The consequences of miss-operation of the 20AA-1 valve could be catastrophic. The customer correctly diagnosed the failed valve, repaired and tested it before attempting to re-start the unit. Based on the CSP (Control Sequence Program) file rung SEQ_TRB1 -149, to get a "Ready-to-Start" indication, below are the required positions of the three AA valves.

To test them, apply 110 VAC power to the valve actuator and force the logic as directed below:

**GAS Startup:**

20AA-1 closed (to test, force L83AA1HI_PR to a "1")

20AA-2 closed (to test, force L83AA2HI_PR to a "1")

20AA-3 not closed (to test force L20AA5O to a "1" after assuring that L20AA5C is forced to a zero)

**LIQUID Startup:**

20AA-1 closed (to test, force L83AA1HI_PR to a "1")

20AA-2 not closed (to test, force L83AA2HI_PR to a "0"))

20AA-3 not closed (to test force L20AA5O to a "1" after assuring that L20AA5C is forced to a zero)

**Recommendations:** There are 3 Motor-Actuated Butterfly Valves in the Atomizing Air System: AA Bypass Valve (20AA-1), AA Discharge Throttling Valve (20AA-2) and AA Scavenging Valve (20AA-5). They should be checked annually as follows:

The three valves are all operated by similar 120VAC, single-phase motors so the checkout procedure will be the same for all 3 valves. Each valve should be completely removed from the pipeline and checked that the shaft cannot slip inside the center of the butterfly valve body. If the shaft is found to be in a loose condition, it is a good idea to apply loctite to the screws that grip the shaft to the valve body before tightening them. Force the appropriate logic in the Mark

5 contact output to a “1” and the valve should open fully. Each valve will have 4 limit switches, each one riding on an adjustable cam. If the valve is not stopping in the correct full open and fully-closed position, the 2 motor control limit switch cams will have to be adjusted. The other two open and close limit switches are wired back to the Mark 5 as a contact input, and should show a logic “1” on the <I> when they pick up. These are 33AA-1, 3, & 7 should be closed when the valve is open and 33AA-2,4, & 8 should be closed when the valve is closed. Each valve has a local disconnect switch, 8AA-1, 2, & 5. These switches electrically isolate the valves for maintenance purposes, and should be checked that they do exactly that. Both 20AA-2 and 20AA-5 have a bypass orifice that is important for the different modes of steady state and transient operation. These orifice sizes should be verified.

> **Note:** These valves are extremely important devices, used in the successful operation of the AA system. Great care should be taken when servicing and inspecting them. Any combination of the above valves operating incorrectly could cause compressor damage, lack of AA pressure, lack of or incorrect purge air pressure, failure to complete fuel transfer and possible nozzle damage.

**Never** “force” logic or bypass critical safety systems to start a unit. Always refer to the unit documentation and established commissioning or troubleshooting procedures to diagnose the root cause of the problem and to implement corrective action.

**For more information or for assistance in troubleshooting controls problems, please contact Pond And Lucier, LLC.**