

## CHAPTER 5

### START-UP SEQUENCE

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**1 GENERAL**

The setting of the MODE SELECTOR Switch on the Turbine Control Panel, in the Local Control Room, will determine the origin of the Start Command. By selecting the START command at either the local Turbine Control Panel or at the Remote Terminal, the Start Sequence will proceed.

Irrespective of the Operator Interface at which the Start Command was given the Start Sequence will commence in an similar manner.

The Gas Turbine Generator Unit may be restarted after 10 minutes have elapsed since shut-down and during the remaining cool-down period. Under these conditions the Gas Turbine and Generator Enclosure Blowers; Generator Lubricating Oil and Hydraulic Oil Pumps may already be in operation.

**WARNING:** Due to the high pressures and temperatures within operating systems, as a precautionary measure, personnel should not be within the Turbine/Generator Enclosures when operating the Gas Turbines.

Also personnel should not be in the vicinity of the Hydraulic Start Console and flexible pipelines at the time of starting a Gas Turbine.

**NOTE:** The references to Timer intervals and Parameter values in the following descriptions refer to the designed settings. Circumstances at the time of installation, or subsequently, may require the resetting of some values.

Therefore, should values appear to deviate from the descriptions, the current values for Timer settings and other Parameters should be confirmed. The current values for these settings can be confirmed by observation of the respective Video Display Unit Screens.

Keying in the appropriate number and depressing the RETURN key Turbine Control Panel keyboard will call the selected 'Timers page' to the display. Those Timers that are active will show the timer value count up to the preset value.

**2 STARTING SEQUENCE AND OBSERVATIONS**

The following descriptions relate to the observations made at the Turbine Control Cabinet in the Local Control Room or at the Remote Control Console.

**Note:** There are two different start crank cycles provided. If the unit was shut-down by an emergency stop or safety shut-down (a non-cool-down cycle shut-down) when operating at an exhaust temperature above 621°C, the unit will undergo a hot restart cycle if two hours have not passed since shut-down. A hot start cranks the unit at 2050 rpm for three minutes providing a high speed cool-down purge. Upon completion of the hot start crank, the unit will coast to a stop (zero rpm) after which the normal starting sequence cranks the unit at 1200 rpm for two minutes. When the two minute purge timer has timed out the ignition is energized and the normal operating sequence follows.

If the unit was shut-down by a normal shut-down sequence during which a cool-down run period is utilized, the following starting sequence is followed.

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With all permissives cleared, a permissive to start indication will be displayed on the Terminal Screen. Using the operator interface screen scroll down to start, press enter. The start display will change from white to yellow indicating that a start is in progress. The start sequence continues as per the following steps:

1. The turbine enclosure vent fan will begin to run. If the vent fan does not begin to run within 5 seconds of initiating a start, the unit will shut-down on a turbine enclosure vent fan not running shut-down. The turbine enclosure & atmospheric pressure differential pressure low alarm are also activated at this time. The turbine enclosure heater, where active, will also be disabled at this time.
2. The hydraulic oil pump will begin to run six seconds after a start has been initiated. Either Pump 'A' or Pump 'B' will come on depending on which one is selected as MAIN on the operator interface. If the main pump does not start within 10 seconds the control logic will transfer operation to the stand-by pump. An alarm will be indicated. The hydraulic oil pressure alarm shut-down are activated at this time.
3. The generator lubrication oil pump will begin to run within 10 seconds after a start has been initiated. Either Pump 'A' or Pump 'B' will come on depending on which one is selected as main on the operator interface. If the main pump does not start within 10 seconds the control logic will transfer to the standby pump. An alarm will be indicated. The generator lubrication oil pressure alarms and shut-down are activated at this time. Once lubrication oil pressure is sensed a 15 minute lubrication oil level delay timer is started. The generator drive end and non-drive end run down tanks are charged with oil and must be filled by the time this timer times-out or the unit will be shut-down. The lubrication oil reservoir eductor fan will also be started at this time. If the eductor fan does not start within 3 seconds after initiation an alarm will be indicated.
4. The gas fuel purge sequence will begin after verification that the turbine enclosure vent fan is in operation. The gas fuel valve is verified to be in the minimum position. If it is not the unit will be shut-down. The external gas fuel shut-off valve and the gas fuel valve No.1 are energized open. Gas fuel is vented through the system and out of the gas fuel vent valve. If after 30 seconds the gas fuel temperature is greater than 5°C the gas fuel sequence is complete. If the gas fuel temperature is less than 5°C, the gas fuel will continue to purge for a total of 180 seconds. If after the 180 seconds the gas fuel temperature is below 5°C, the unit will be shut-down on low gas fuel supply temperature.

During the gas fuel purge test, the gas fuel supply pressure is verified. An alarm will be activated if the gas supply pressure is not within its proper limits.

5. At the completion of the purge test, the gas fuel leak test is enabled. The gas fuel leak test begins by closing the gas fuel shut-off valve No.1, the vent valve remains open. After a 10 second time delay, the gas fuel vent valves are closed. The first leak test verifies that the gas fuel shut-off valve No.1 does not leak. With the gas fuel shut-off valve No.1 closed, the gas fuel vent valve closed and the gas fuel shut-off valve No.2 closed, the pressure is checked between these valves for 10 seconds. If this pressure exceeds 0.5 bar the unit will be shut-down on gas fuel shut-off valve No.1 leakage. At the completion of this first leak test, the sequence proceeds to the second leak test. With the gas fuel vent valve and the gas fuel shut-off valve No.2 remaining closed, the gas fuel shut-off valve No.1 is opened for 3 seconds. This pressurizes the gas fuel piping between the three valves. The gas fuel shut-off valve now recloses. The pressure is trapped between the 3 gas shut-off valves. If this pressure decreases below 28 bar the unit will be shut-down on gas fuel valves XV 4112 and XV 4118 leakage shut-down. At the completion of this test, the gas fuel vent valves are reopened.

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6. At this point, the following conditions must be met to proceed with the sequence:
- a) A normal stop has not been activated.
  - b) The Turbine Enclosure Fan is running.
  - c) A Hydraulic Pump is running.
  - d) A Generator Lubrication Oil Pump is running.
  - e) The gas fuel purge sequence is complete.
  - f) The gas fuel leak test is complete.
  - g) The Fuel Nozzle Manifold Drain Valve FSV 4568 is closed.
  - h) The Compressor Discharge Pressure Manifold Drain Valve FSV 4569 is closed.
  - i) The Generator Drive End and Non-drive End Run-down Tanks are full.

With all these conditions satisfied, a Gas Generator sequence permissive will be indicated on the Terminal Screen. The Hydraulic Starter Motor will be energized at this time. If the Hydraulic Starter Motor does not start in 10 seconds, the unit will be shut-down on a Hydraulic Starter Motor failure to start.

7. As the Start Sequence progresses observe the START SEQUENCE Screen on the Terminal. As each 'milestone' in the Start Sequence is reached those items will achieve a positive status. As many of the various stages in the start sequence happen so rapidly the Operator may prefer to observe the various operational stages by accessing either the Pressures or Timers Screen on the Display.
8. The starter comes on and cranks the unit at 1200 rpm for 2 minutes of purge before ignition.

**Note:** At this time, if the unit requires a hot start, the Starter cranks the Gas Generator at 2050 rpm for a high speed purge for three minutes. Then the unit is ramped down to 0 rpm and cranked at 1200 rpm for a two minute purge. The auxiliaries remain running during this process.

9. When the purge sequence is complete, the Starter speed increases to drive the Gas Generator Rotor (N1) to 1700 rpm.
10. When the 1700 rpm Gas Generator Rotor (NI) speed is attained, the ignitors are energized.

**Note:** The two ignitors alternate in firing the engine each time the start sequence is initiated. This provides for equal duty on each ignitor.

11. The fuel is turned on to the combustor. The unit lights off, with resultant increases in Power Turbine Inlet Temperature (T5.4), and accelerates to warm-up speed.
12. The unit warms-up at Gas Generator Speed (NI) of 5000 rpm for a period of three minutes.

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13. After a warm-up time is complete, the unit ramps up to synchronous speed. The Generator Control Panel then synchronizes the electric generator. This will be done either manually or automatically depending on the generator synchronous control system.

Refer to Chapter 6 - Synchronization for details of the automatic and manual synchronization processes.

### 3 ALARMS DURING THE START SEQUENCE

If a parameter is not attained within the preset time interval then the start sequence will be aborted.

Any Alarm or Shut-down generated during the Start Sequence will be automatically displayed on the respective Terminal Screen in the bottom window of the screen.

The alarm status for active and/or alarms may be viewed by depressing the Escape Key (Esc) to return to the MAIN MENU Screen and depressing the 'T' Key to obtain the TIMERS and ALARMS Sub-menu Screen. Depress the '2' Key to access the CURRENT ALARM 'Pages'.

The last 75 Events are retained by the local Control System and can be viewed on the Terminal Screen. To view events prior to the last items displayed on the screen the 'Down Arrow' on the Keyboard allows for scrolling down the events.

**NOTE:** The print function for the Data Logger is not available at the Local Control Room. Where a print-out is desired it can be obtained from the Remote Terminal facilities.