Sales Training Series

Gas Turbines

How Gas Turbines Work

- Gas Turbines are air engines that produce work through the continuous burning of fuel.
- A Gas Turbine consists of 3 basic sections; an axial compressor, combustor and expansion turbine.

The Compressor Section

- Ambient air is drawn into the compressor section where multiple axial flow stages compress the air to about 40 atmospheres.
- The compressor consists of rotating and stationary blades.
- Air passes through a row of stationary blades that turn the air stream into a row of rotating blades where it is accelerated into the next compressor stage.
- Each succeeding stage converts the air velocity into pressure.
- Each row of blades is shorter than the preceeding stage as the air volume is reduced while the pressure increases.

The Combustion Section

- Compressed air flows from the compressor discharge into the combustion section where the temperature is raised by the combustion of fuel in the air stream.
- Combustion occurs at very high temperatures, +2000K, higher than any metals are capable of withstanding.
- Thus the combustor liner must be cooled by a portion of the compressed air flowing through cooling holes in the liner body.
- Hot gases flow out of the combustors through a transition tube into the first stage of the expansion turbine

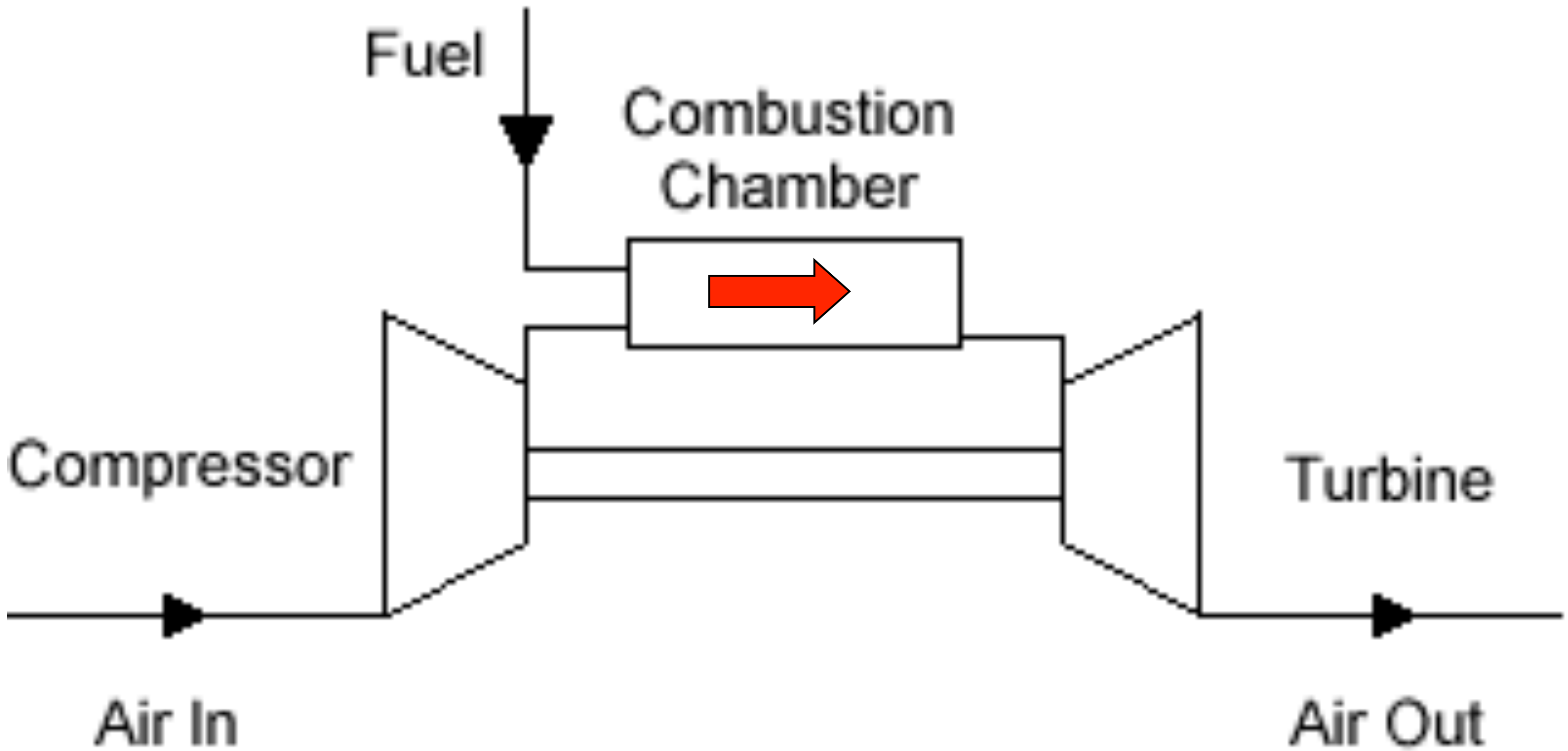
The Turbine Section

- The heated "gas", is constrained by the fixed volume of the turbine as it seeks to expand through the turbine section.
- The gas thus flows at high velocity into multiple turbine stages where it is converted to pressure energy.
- Hot gas passes through a row of stationary blades that turn the gas into a row of rotating blades where the velocity energy is converted to pressure energy to rotate the turbine.
- Work is developed during the expansion process through the turbine section, Enough work to drive the compressor and have enough left for shaft work.

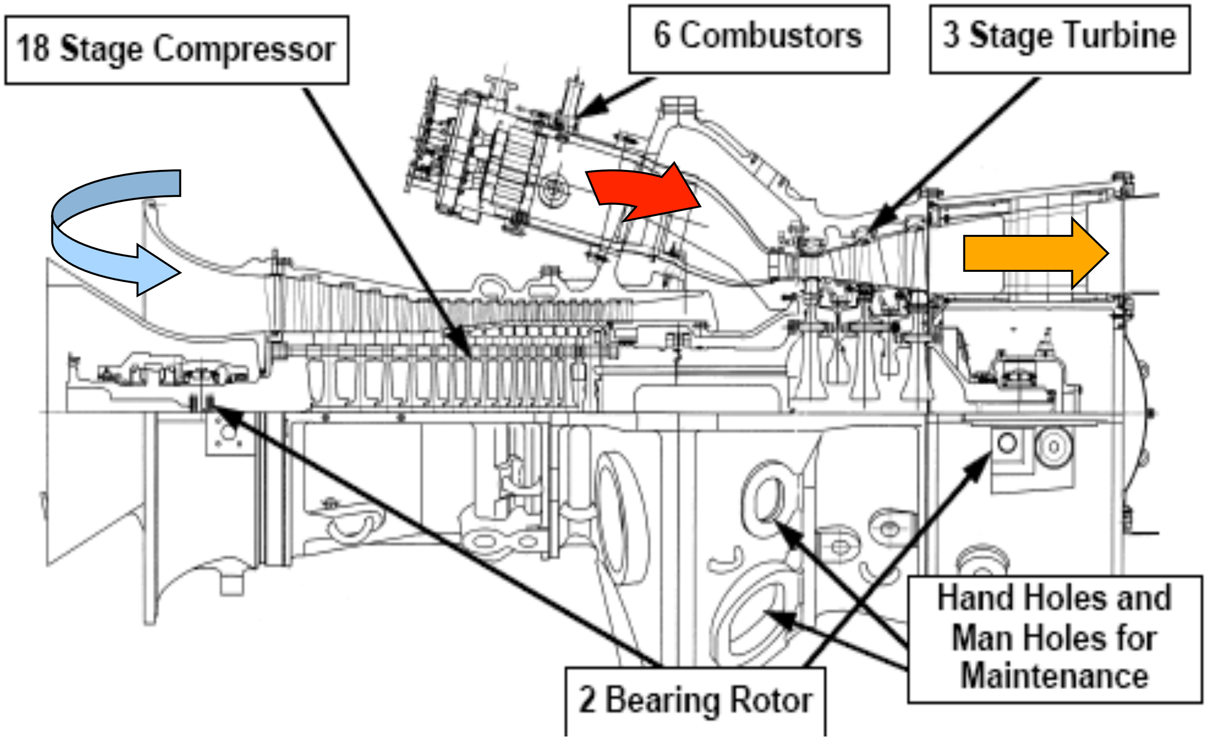
Turbine Operating Requirements

- While a gas turbine is comprised of 3 basic sections it requires a few auxiliary systems to function.
- Ambient air contains airborne contaminants, small particles of dust, dirt and aerosols, that if not removed would deposit on the compressor blades causing degradation in performance.
- Compressor noise requires an inlet silencer be provided for acceptable noise levels in and around the plant.
- The turbine shaft requires bearings and therefore a lubricating oil supply and cooling system.
- Fuel must be supplied under controlled conditions requiring fuel conditioning and regulation system.
- The exhaust gases must be ducted high enough into the atmosphere to avoid local environmental issues. An exhaust silence is also required.
- An electronic control system (PLC) provides logic for starting/ stopping and changing the load on the machine.

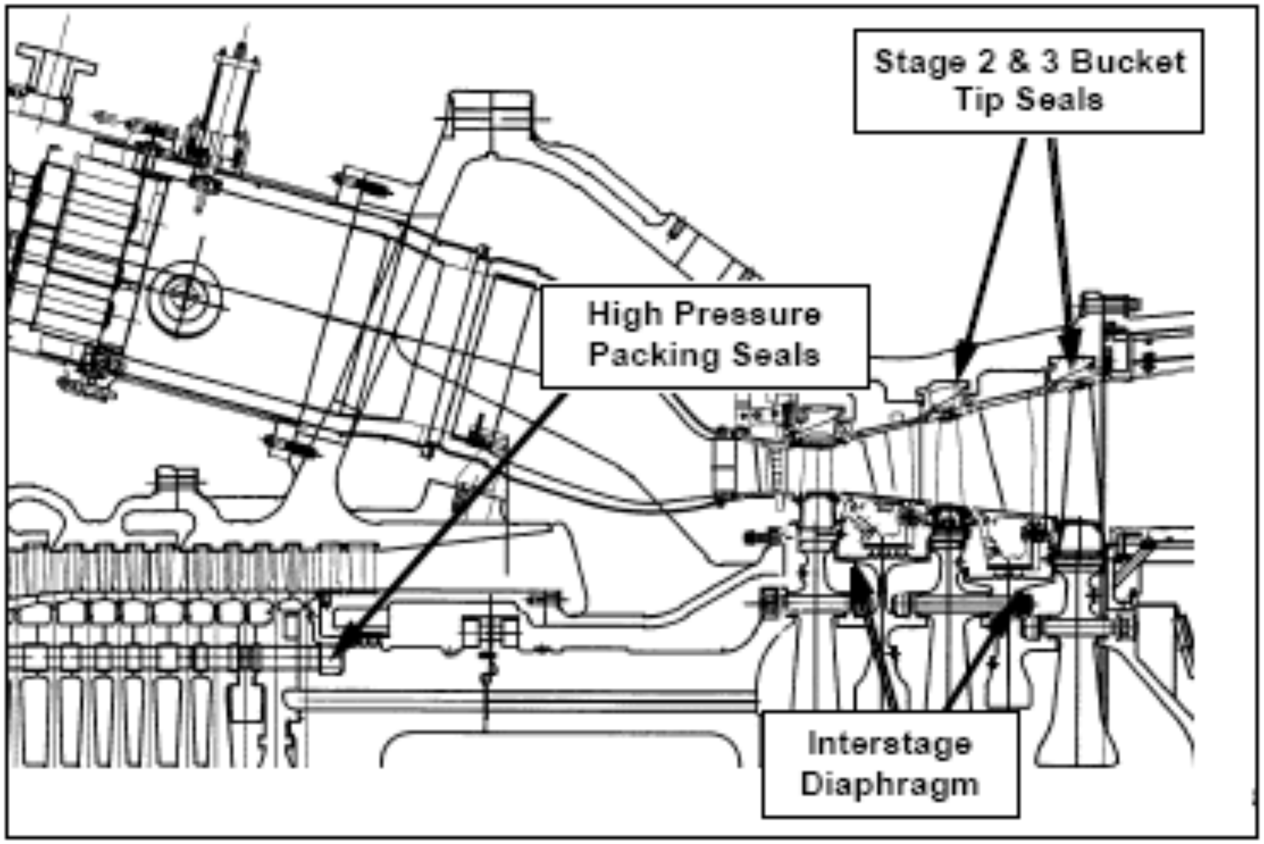
Basic Gas Turbine Diagram



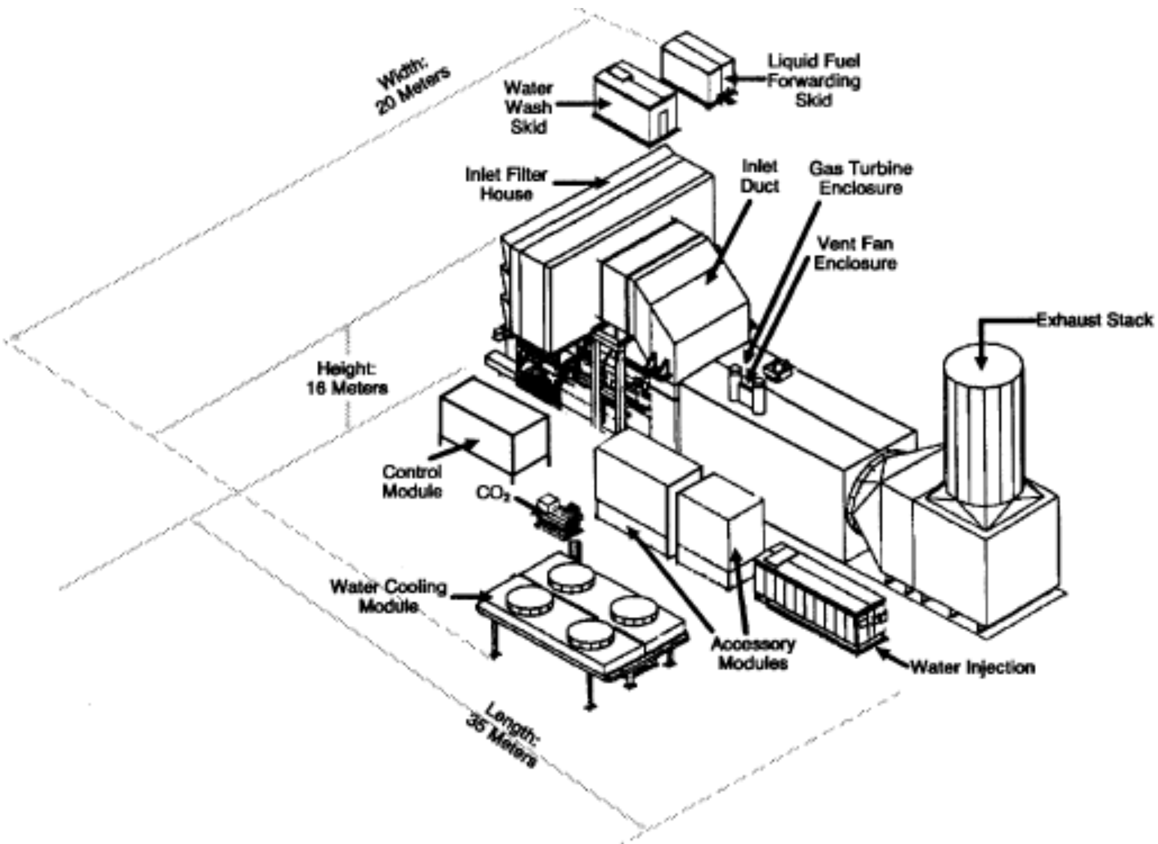
Cutaway of GT



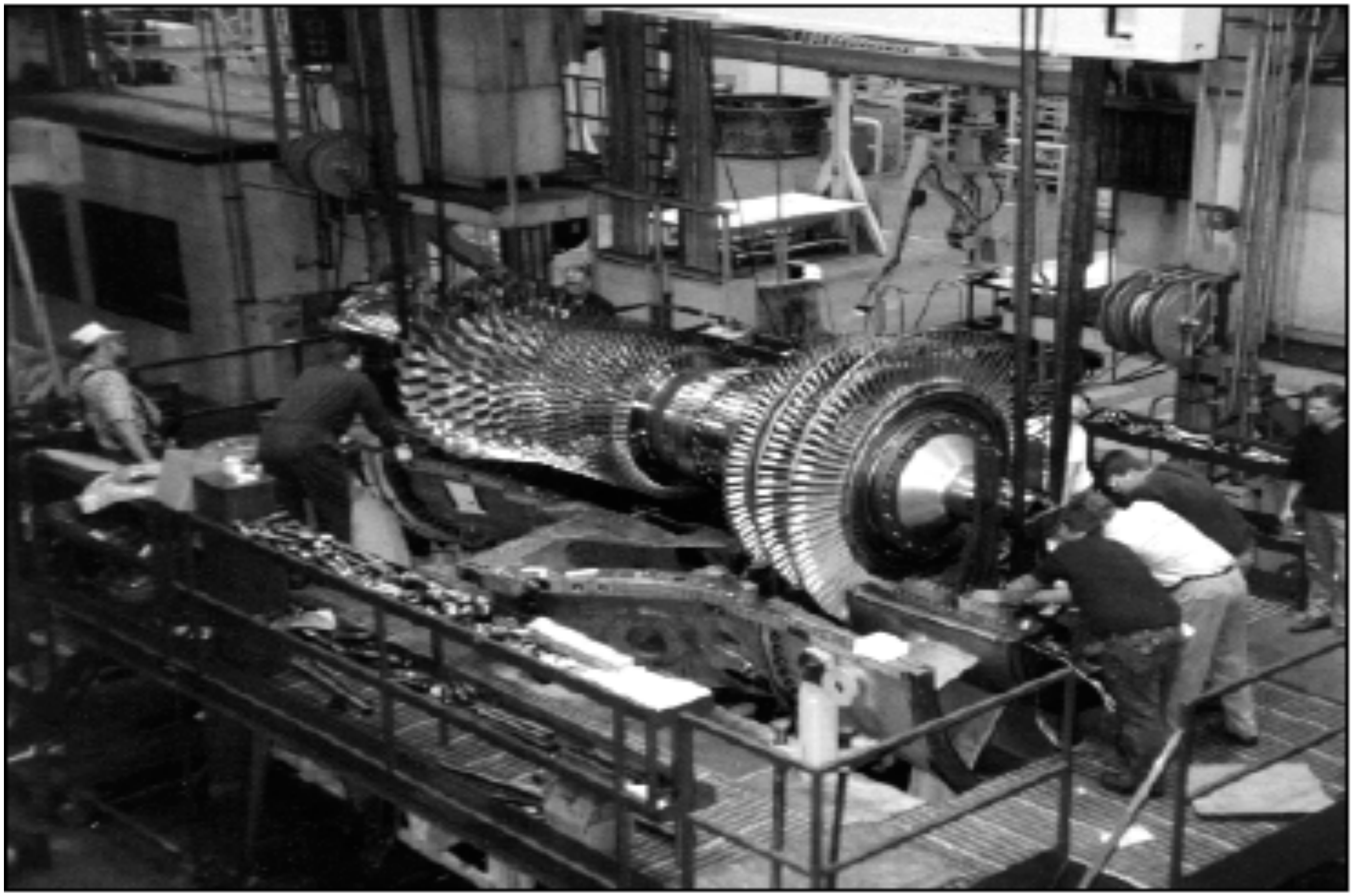
Details of GT Internals



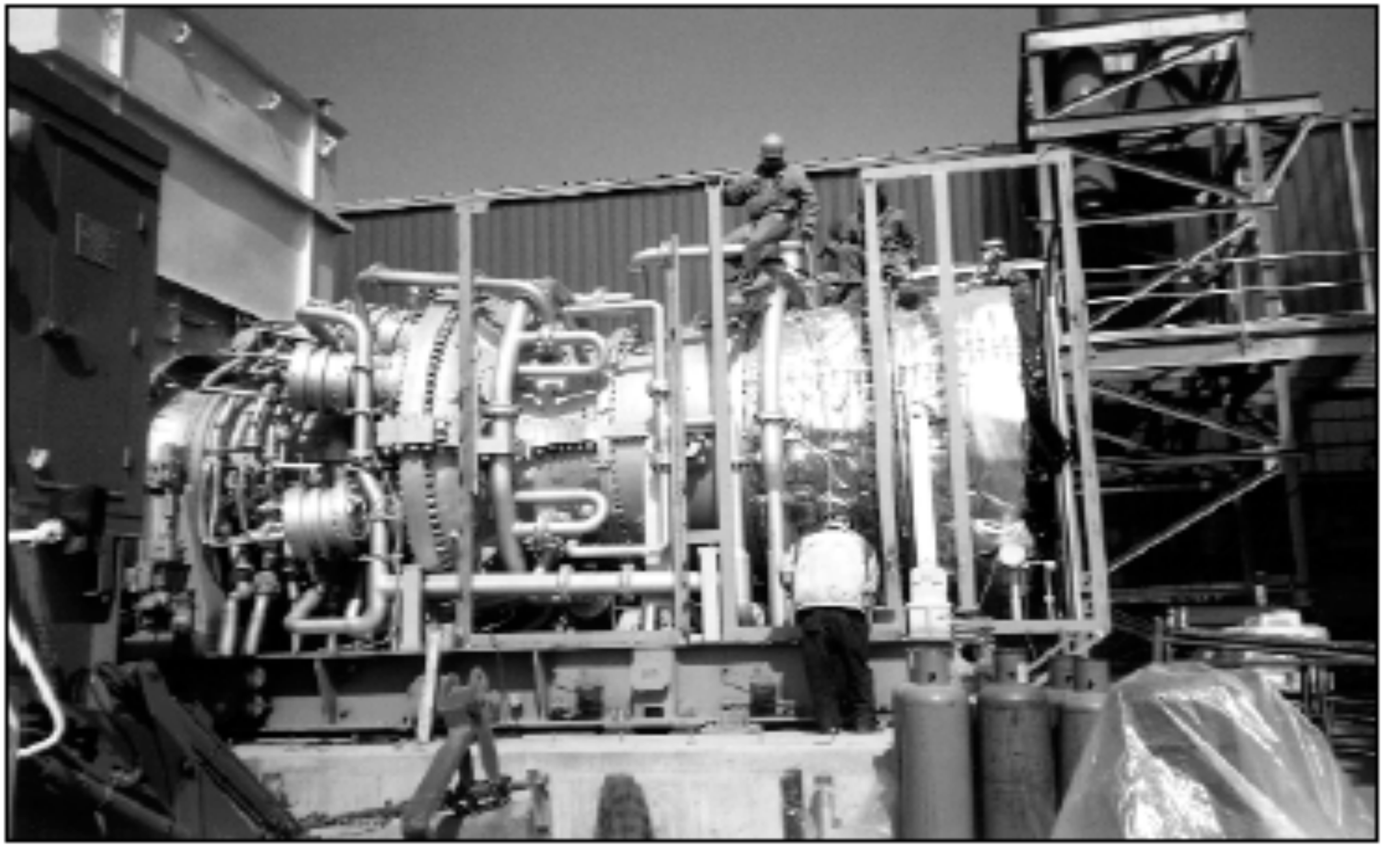
Typical Plant Arrangement



Gas Turbine Rotor Assy

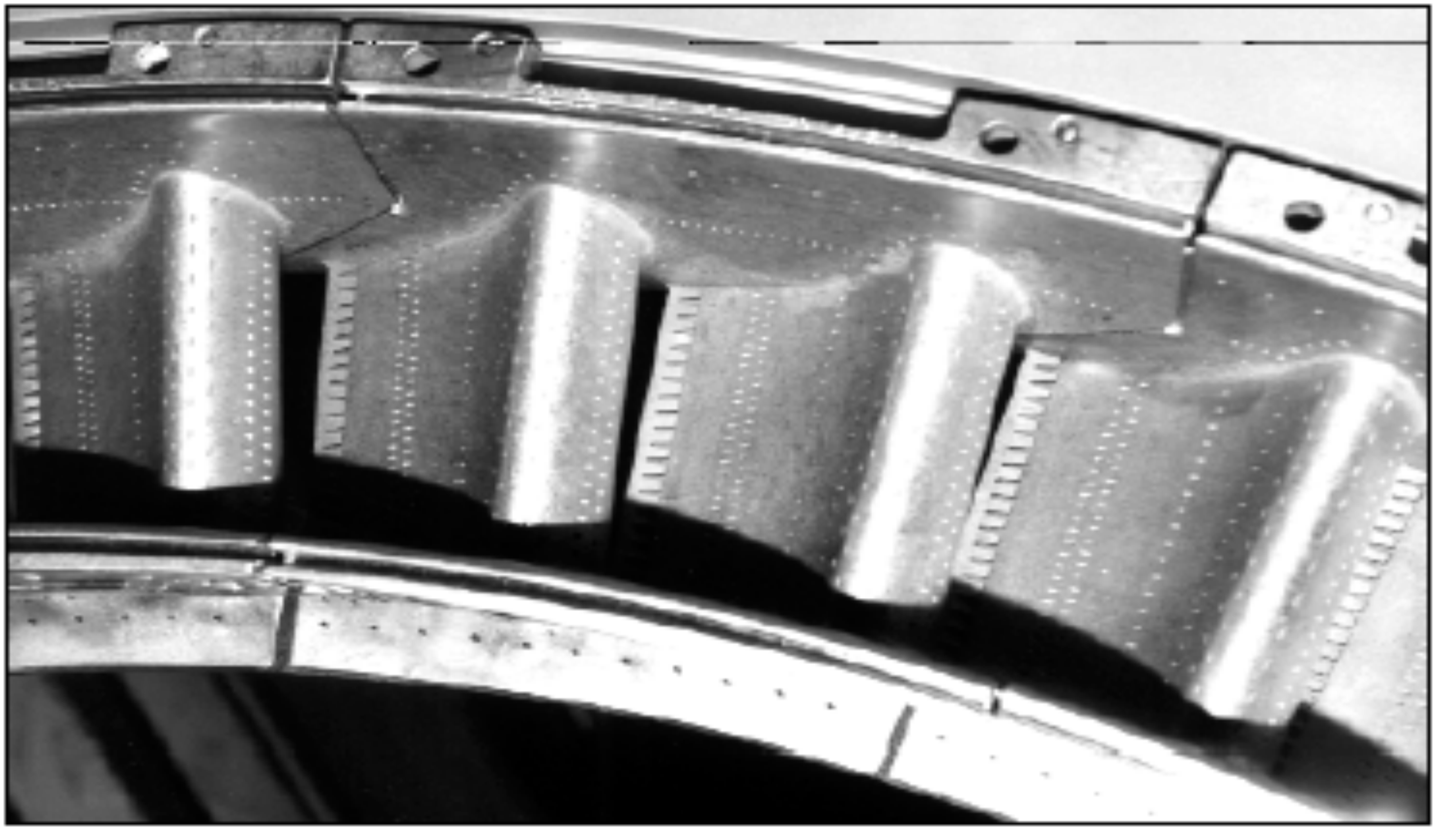


Unit Nearly Assembled



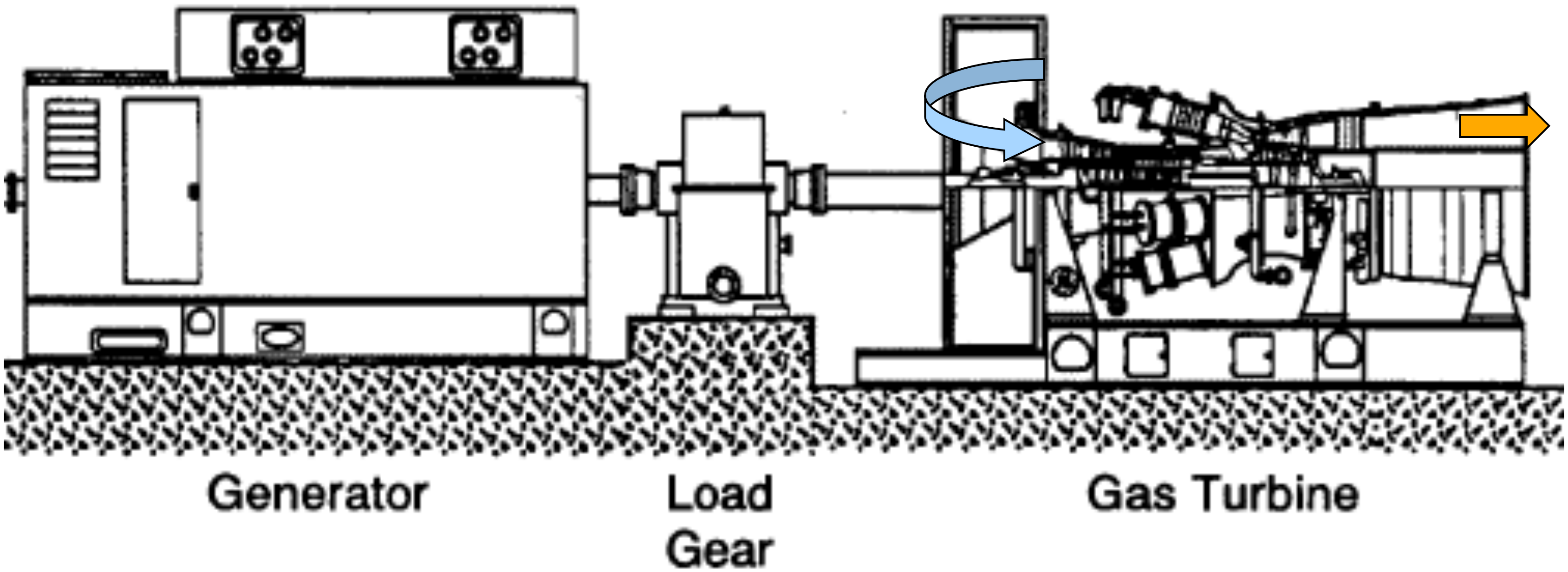
Unit shown without enclosure

First Stage Turbine Nozzle



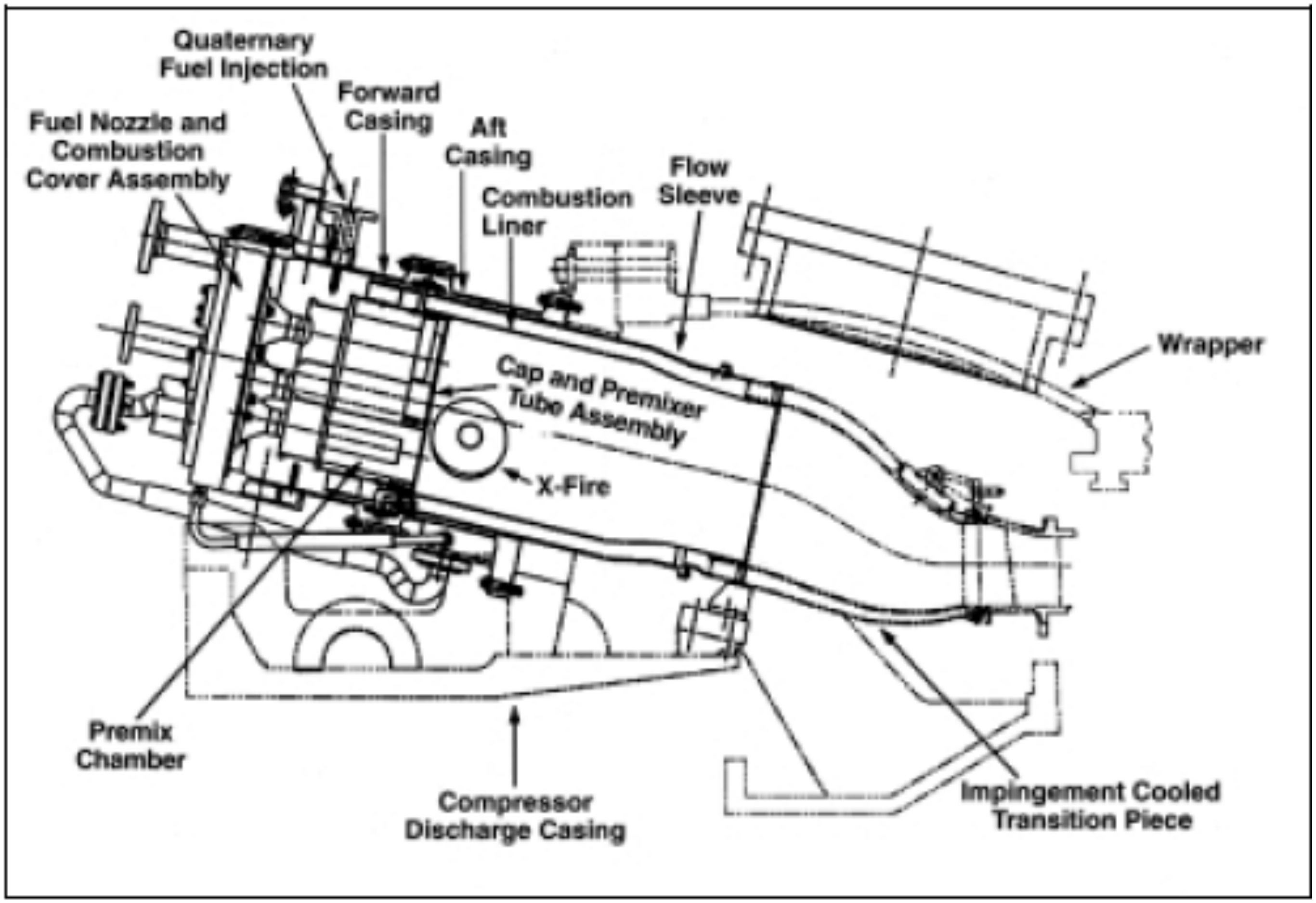
Showing cooling air holes

Typical GT Profile



Simple cycle GT gen set, cold end drive

Cross section of Combustor



Gas Turbine Emissions

The significant products of combustion in gas turbine emissions are:

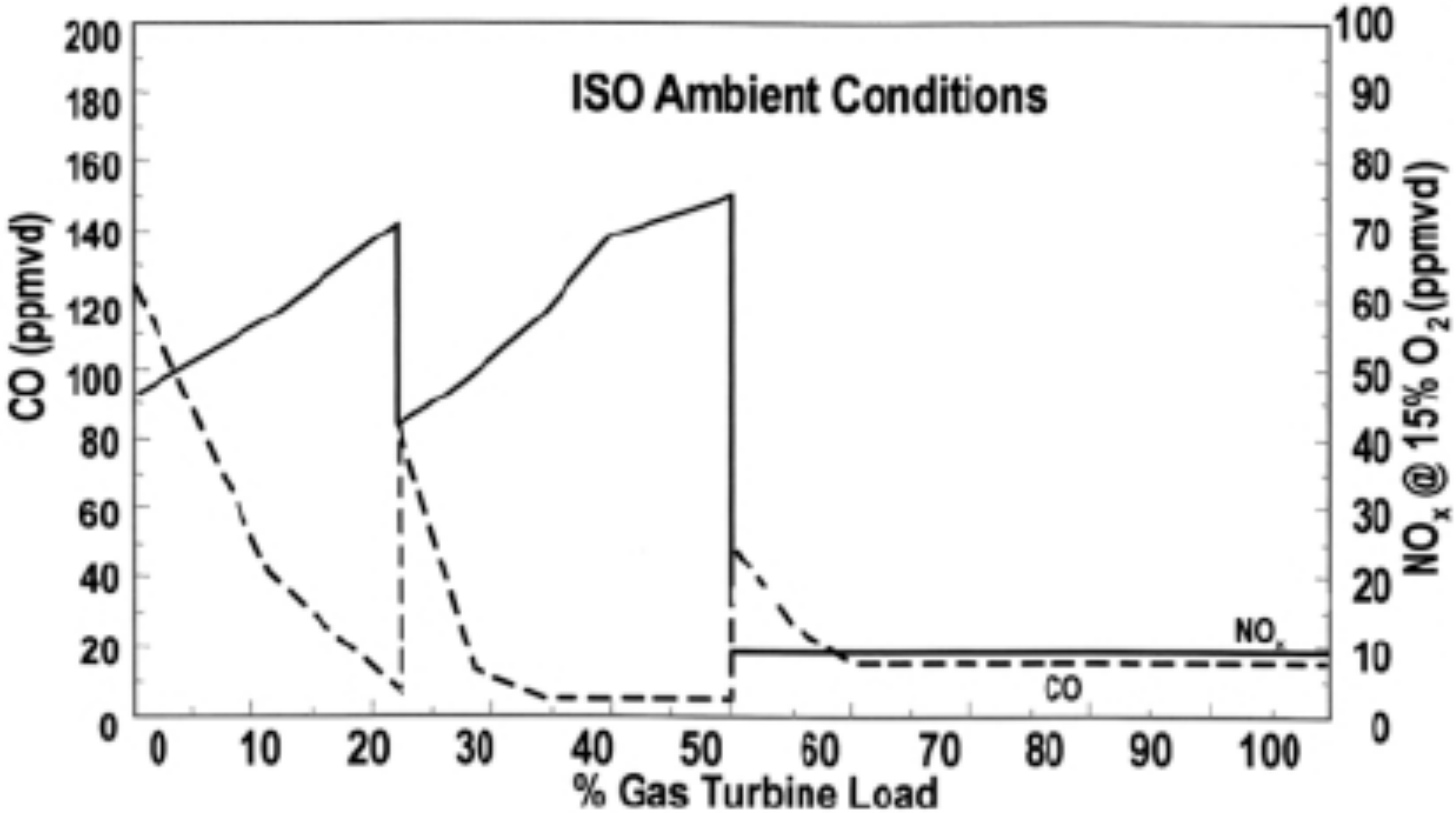
- Oxides of nitrogen (NO and NO_2, collectively called NO_x)
- Carbon monoxide (CO)
- Unburned hydrocarbons or UHCs (usually expressed as equivalent methane [CH_4] parti-cles and arise from incomplete combustion)
- Oxides of sulfur (SO_2 and SO_3) particulates.

Emissions Control Methods

There are three principal methods for controlling gas turbine emissions:

- Injection of a diluent such as water or steam into the burning zone of a conventional (diffusion flame) combustor
- Catalytic clean-up of NO_x and CO from the gas turbine exhaust (usually used in conjunction with the other two methods)
- Design of the combustor to limit the formation of pollutants in the burning zone by utilizing "lean-premixed" combustion technology

Typical Emissions on Natural` Gas

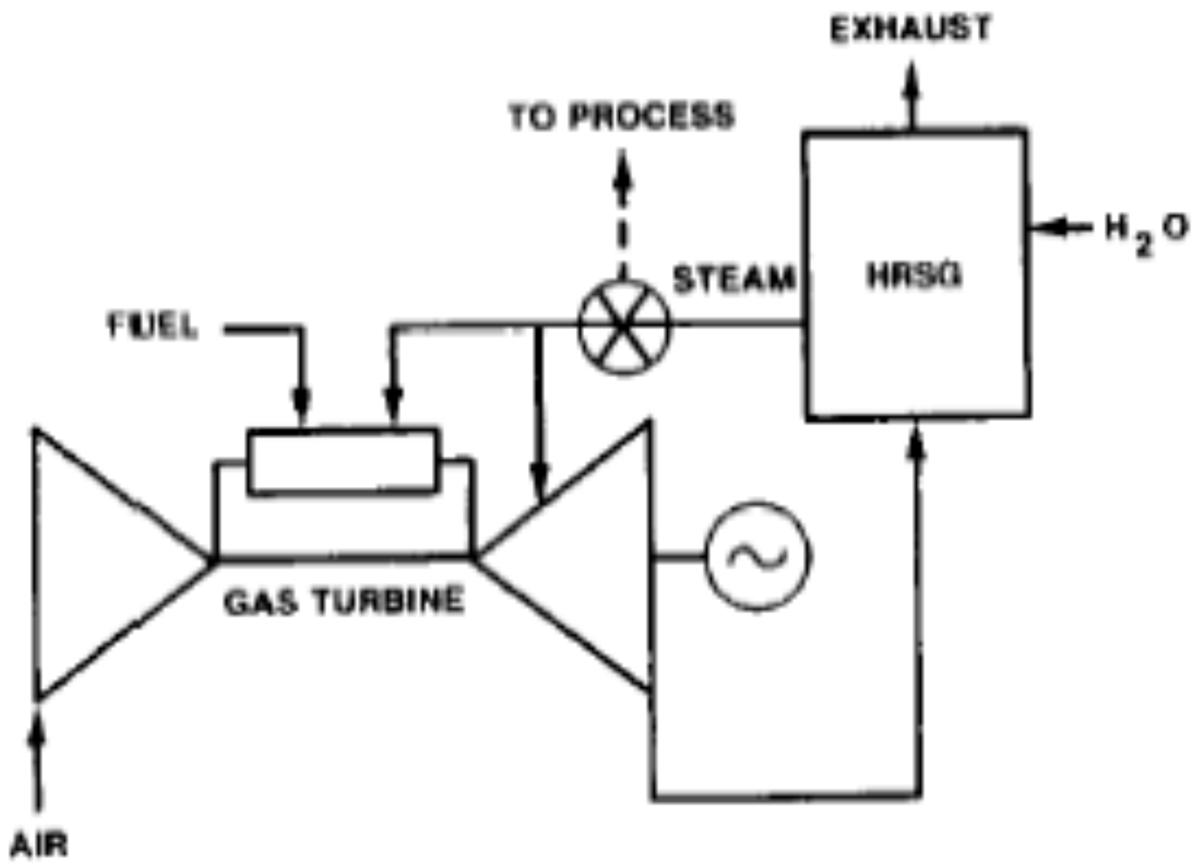


Emissions of a Fr 6B w/DLN combustor, 9 ppmvd NO_x & 25 ppmvd CO

Typical GT Fuels

- Natural gas
  - Synthesis gas
  - CNG
  - Medium and low BTU gases
  - Gasified coal or bio-mass (Syngas)
- Liquid Fuel
  - LNG
  - Distillates
  - Residual oil
  - Crude Oil

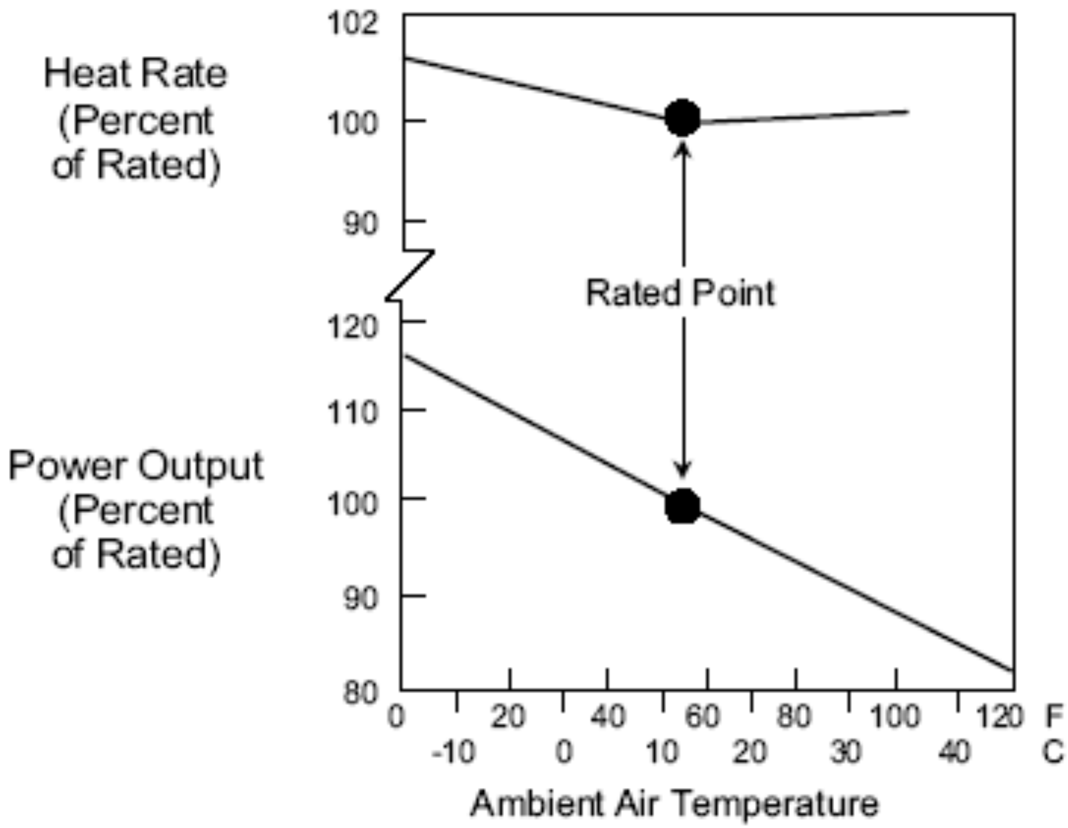
Waste Heat Recovery
Steam to Process



Combined Cycle

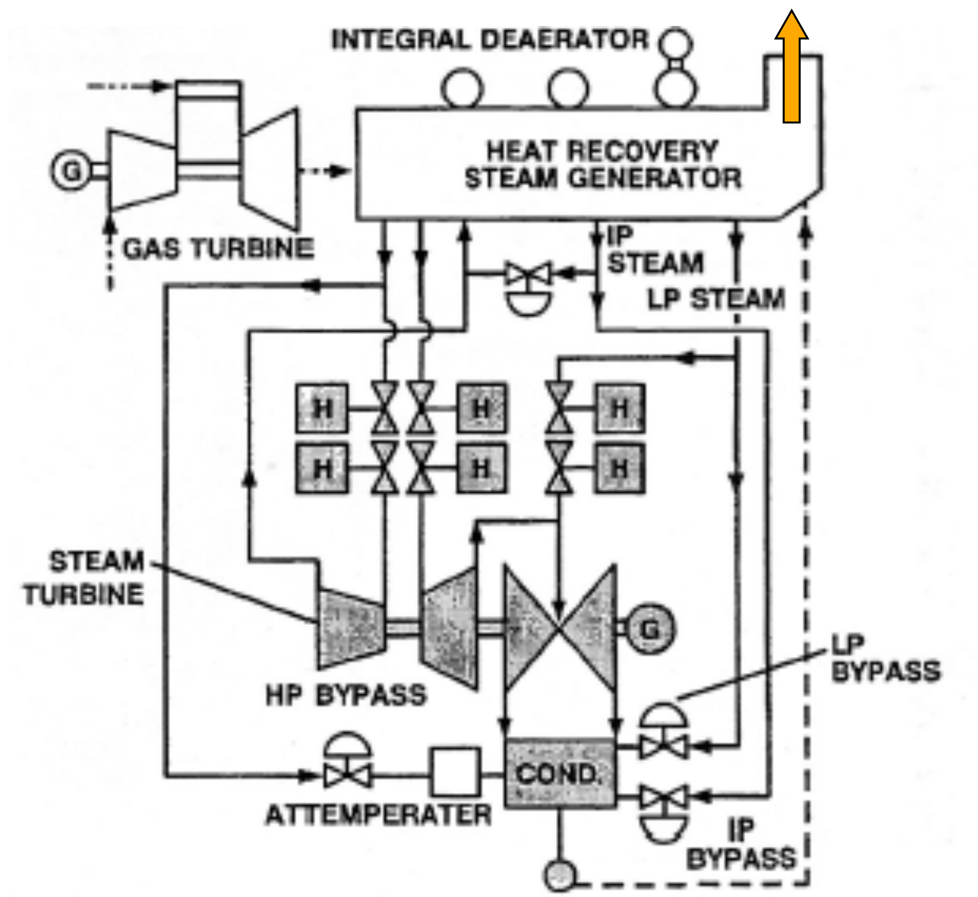
- Simple cycle operation consists of burning fuel to generate shaft work to drive a pump, compressor or generator.
- Combined cycle operation consists of harnessing the energy in the hot exhaust gases to make steam in a heat recovery boiler. Or the heat may be used in a process such as drying bricks.
- The steam can be used for process heat or expanded in a conventional steam turbine to drive a pump, compressor or generator

Ambient Temperature Effects



GT Combined Cycle

3 – pressure level



GT Application Considerations

- Selection of a GT is based on several factors
  - Output power required
  - Fuel type & availability
  - Heat rate – fuel consumption
  - Ambient conditions – high or low ambient temperature, elevation, dust laden environment, site constraints, geography
  - Process heat requirements – combined heat & power
  - Redundancy – reliability & availability requirements
  - Duty cycle – base load, intermediate load or peaking service
  - Aero-derivative or heavy industrial machine
  - Local emissions criteria