

EDEXCEL HNC/D
PLANT and PROCESS PRINCIPLES

OUTCOME 1
THERMODYNAMIC SYSTEMS
TUTORIAL 1

1 Operating and testing of plant

Safe operating procedures: pre start-up checks; start-up; running and shutdown procedures; permit to work; emergency procedures

Testing procedures: performance monitoring (eg collation of data and results, flow variables such as temperature, pressure, volume flow, abnormal conditions, quality control, corrective action); performance testing (eg comparison of measured results with accepted norms for criteria such as power, efficiency, heat loss, power factor, slip)

This tutorial covers general information and detail is provided in the case studies which should be downloaded separately.

WHAT IS PLANT?

This seems a simple question but before we commence to talk about procedures for safe operation we should be clear about what type of plant this covers. The forms of plant are large and varied. Here is a list of the main types.

COMPRESSORS

- Reciprocating
- Multi/single stage
- Centrifugal
- Axial Flow
- Screw
- Vane
- Lobe

STEAM BOILERS

- Power generation
- Process Steam and Water
- Gas/Oil/Solid Fuel/Nuclear
- Combustion Plant
- Fuel Pulverisers

STEAM TURBINES

- Power generation
- Reaction
- Impulse
- Pass Out
- Back Pressure
- Lubrication System

STEAM POWER PLANT

- Economisers
- Feed Heaters
- De-aerators
- De-superheaters
- Pre-heaters
- Regenerators
- Cooling Systems
- Cooling Towers
- Feed Pumps
- Water Treatment
- Drain and Air Traps

PROCESS PLANT

- Chemical Vessels
- Heat Exchangers
- Oil Refineries

ENGINES

- Diesels
- Petrol
- Marine

COMPRESSOR PLANT

- Cooling Systems
- Interstage Coolers
- After Coolers
- Receivers
- Drain Traps

GAS TURBINES

- Multi-stage compression and Expansion
- Intercoolers
- Inter-stage Reheater
- Combustion Chambers
- Re-heaters
- Exhaust Gas Heat exchangers

ELECTRICAL

- Generator
- Motors
- A.C.
- D.C.
- Switch Gear
- Transformers

FLUID POWER

- Hydraulic Power Plant
- Pneumatic Power Plant

PIPE WORK SYSTEMS

- Steam/Water/Gas/Oil/Chemicals

It would be impractical to go into the specific safety and running routines for all plant operation but there are many common features and probably students are best taught with case studies and assignments to produce the relevant information for plant specific to their areas of employment.

There are standards regarding the construction, materials and safety of such systems. The main standard is BS1553 which covers the symbols for pipes and plant items connected with the pipe work. The main symbols are shown on the attached sheets and should be learned.

GENERAL PROCEDURES

There are many things common to plant in general that you will find reoccurring in the case studies accompanying this tutorial.

MANAGING

When a major item of plant has been constructed such as a small power station, from the start managers and consultants should prepare a detailed plan and schedule for commissioning, operation, planned outages and emergency outages.

Before starting commissioning managers and consultants review:

- drawings
- specifications
- plans

During the critical final phase of commissioning, specialists in the field conduct performance tests to assure that equipment is functioning as specified and ensure that the plant systems are ready for operation. They also:

- Prepare plant documentation.
- Train the plant operators and maintenance crew.
- Establish and set the normal range for all plant variables (pressure, temperature, flow rate and so on)
- Preparation of operation and maintenance manuals.
- System descriptions and operating instructions.
- Integrated operating instructions.

The start-up manager must perform the following duties.

- Establishes a contractor release schedule and packages.
- Schedules test witnesses and monitoring.
- Sets safety and environmental standards.

On-site field engineers conduct:

- Component testing.
- Flushing.
- Chemical cleaning.
- Steam blowing.
- Initial equipment operation system facility tests such as performance, emissions, and noise control.

When the facility is operational, start-up and commissioning experts train power plant personnel to operate and maintain the new plant or system. They provide direct instruction about the balance of plant systems and coordinated vendor training for control systems, turbine generators, and the water treatment.

PLANNED OUTAGES

When any item of plant is to be taken off line for scheduled maintenance the outage must be managed correctly to avoid excessive costs resulting from the affect the outage has on the operation of the business concerned. The ideal time to conduct the maintenance is at a time when the whole system is closed such as in the summer vacation period. The plan must also take full account of the safety implications to those working on the plant and those affected by the outage.

STANDBY PLANT

If an outage cannot be conducted during a period of complete shut down, standby plant is needed to take over the operation. This is common in power stations where for example, three feed pumps each capable of providing $\frac{1}{2}$ of the required flow rate are connected in parallel so that at any one time, one is isolated and available to takeover from one of the others if it requires maintenance.

SHUTTING DOWN

Plant being taken out of service must be shut down according to a prepared schedule of procedures. This schedule is drawn up before and during the commissioning period. Some important points depending on the type of plant are:

- Obtain a permit to work.
- Obtain a certificate of clearance for flammable or dangerous substances if applicable.
- Arrange standby operation.
- Take off load and disconnect.
- Reduce speed, flow and so on in prescribed manner.
- Isolate the system.
- Display notices to prevent anyone tampering while you are working.
- Speed control to avoid critical speeds for vibration.
- Lubrication pumps to be switched off after movement stops.
- Conduct a controlled cooling of the system.
- Coolants turned off and isolated only when appropriate.
- Lock out all isolating valves.
- Place warning signs at appropriate places.
- Check for electrical safety and remove fuses or lock out the supply.
- Check for pressure.
- Flush out fumes.

PERMITS

Relevant permits should always be obtained when taking any item of plant out of operation as the knock on affect could be disastrous and costly if the work is not scheduled and not conducted by competent people using the correct safety procedures. This will depend on the nature of the plant and the type of fluids used. Clearly if toxic or explosive fluids are used, stringent safety procedures must be followed.

NOTICES and LOCK DOWN

Notices and lockdown features should be used to ensure that no one switches anything on or off that would endanger those working on the outage or in the rest of the complex. A prime example of what can go wrong was a major explosion and fire on a North Sea gas rig when a gas compressor was taken off line and stripped down but other operators did not know that a crucial safety feature had been removed and started pumping gas.

EMERGENCIES

Operators need to be conversant with the procedures to be followed in emergencies of all kinds including emergency shut down of plant. Many types of plant such as gas turbine power plant usually have automated start up and shut down systems and emergency shut down is a case of hitting the right switch.

START UP AFTER OUTAGE

Procedures for bringing plant back on line are very much the reverse of those for shutting it down.

- Obtain relevant permits to bring back on line.
- Check pipes.
- Check electrical connections.
- Check safety devices and interlocks.
- Purge pipes.
- Slow warm up.
- Jacking pumps used for lubricants on heavy duty rotodynamic machinery.
- Check lubricant flow, temperature and pressure.
- Gradually raise pressure.
- Avoid critical speeds.
- Check operating values against correct values.
- Complete job sheet and hand over to the operators.
- Connection to power grid if appropriate using correct procedures.

NORMAL RUNNING and PERFORMANCE MONITORING

Plant should be monitored to see that the correct variables are maintained within scheduled parameters. In modern plant most of this is done with automated systems in which the upper and lower values are programmed and automatic adjustments are made. In older plant the controls are manual but alarms should be fitted to make the operators aware when the variable goes outside the allowed limits. Typical parameters to be monitored and controlled are:

Pressures and Vacuums
Speed
Power Level
Power Factor
Flue gas content
Lubricants
Vibrations

Temperatures
Flow rates
Voltage and current
Flue Draft (vacuum)
Fluid levels
Coolants

In addition monitoring of contaminants and quality of things like the lubrication oil, feed water, coolants and so on will give an early warning of something going wrong and allow corrective action.

OVERALL PERFORMANCE

The overall performance of a plant should be monitored by management. This includes things like efficiency, quantities and outages. Overall performance should be compared to required values and average values over a period to see if changes have occurred.

Useful information may be found at the following web sites.

<http://www.hse.gov.uk/offshore/circulars/tchosd26.htm>

<http://shippai.jst.go.jp/en/Search?fn=1&dt=0&op=0&so=0&vt=0&kw=Education&st=1&nct=TZ00000025>

<http://www1.control.com/1026222160/index.html>

<http://www.peci.org/ftguide/ftct/boilers.htm>

You should now download the case studies and complete them.