

## THERMODYNAMICS LABORATORY— 5KW STEAM OIL FIRED POWER PLANT

### CUSSONS RECOMMENDED LABORATORY

Steam retains its position as a **key subject in thermodynamic teaching**. The study of a wide range of thermodynamic principles, an understanding of enthalpy and entropy, conversion of energy to work, energy balance etc are all covered by a working steam plant. Cussons 5kW steam plant is available for laboratory use, providing steam plant on a scale that not just supports teaching but also provides a genuine operational experience, applicable not just as direct experience for those entering the power sector, the chemical sector and the marine sector, but also as good operational experience for any engineer, who should know about plant operations. Plant is fully instrumented for teaching studies with data acquisition options for short lab periods.

The 5kW steam plant range is one of a coordinated range of steam, thermodynamic and other laboratories for supporting teaching in mechanical engineering that is available from Cussons Technology.

Please see [www.cussons.co.uk](http://www.cussons.co.uk) for additional information on any product, or contact [sales@cussons.co.uk](mailto:sales@cussons.co.uk)

NB: 10KW and 20 KW steam power plants also available, as well as Gas & Dual Fuel versions.

#### P7600 Steam Power Plant— 5 kW

Fully automatic oil fired steam boiler capable of evaporation rate of 320 kg/hr from and at 100°C and with a maximum working pressure of 10.3 bar (150 lb/in<sup>2</sup>) gauge. The boiler comprises a tubeless annular steam raising pressure vessel with extended surface area. A centrally mounted semi-forced draught burner firing vertically downwards into a double pass combustion chamber and incorporating flame failure safety warning light and control.



#### P7601 Tank set for Scheme 5-oil fired, with P7613 Water Treatment, and shown with optional items P7602 and P7604 additional instrumentation

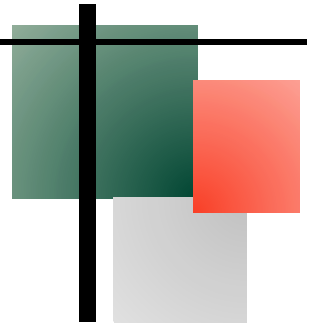
An oil fired boiler needs storage tanks for oil and feed water, which is provided by the basic P7601 tank set, (also including meters and pumps). Boiler water lost in the cooling tower must be made up by treated water from the P7613 water treatment system mounted on the same frame. P7602 and P7604 are options to provide additional instrumentation stations for the boiler and superheater systems, including basic flue gas analysis and flue draught and temperatures.

#### P7603 Super Heater for scheme 5—oil fired

Cussons P7671 Pressure/Temperature Steam Bench consists of a sturdy framework and panels of all steel construction, fitted with a student work surface, interconnecting back panel and adjustable feet. The steam bench includes a 2-pen chart recorder to provide a continuous recording of the process variables, namely temperature and pressure and gives students the opportunity to become familiar with the presentation of such data on a typical process recorder used in industry. The effect of changes of shape of the heat source on natural convection.

P7610 & P7611 provide flue materials for the boiler and superheater exhausts





## P7614 Steam Turbine & Condenser Set for scheme 5 steam plant

Cussons P7615 module is made up from a base plate supporting a steam turbine coupled to a dynamometer able to generate 5kW electrical output. The turbine includes use adjustable guide vane nozzles and a speed control governor. Steam exits the turbine to a condenser and condensate timer collection tank. The system is instrumented to show temperatures, pressures, turbine speed and dynamometer torque. The dynamometer control allows the turbine to be loaded or motored as desired.



**P7615 Cooling Tower** provides an evaporative cooling tower for the condenser heat exchanger. The cooling tower is supplied with a pump for operation adjacent to the building.

**P7616 Lab Design** provides a design service to engineer the steam plant into the laboratory available and to pinpoint the services required. **P7617 Installation Materials** includes the valves, pipes, brackets and cables needed for installation. **P7618 Installation Services** provides the labour and supervision to install the steam plant. **P7619 Commissioning Services** provides a commissioning service and equipment operation training.

## P7685 Data Acquisition System for Steam Power Plants C/W data Logger, PC & Printer



**Cussons P7672 Separating and Throttling Steam Bench** consists of a sturdy framework and panels of all steel construction, fitted with a student work surface, interconnecting back panel and adjustable feet.

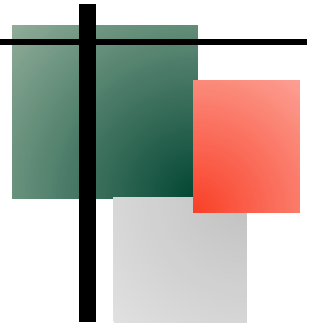
The steam bench includes an insulated separating calorimeter, equipped with a water level sight glass, connected via fixed orifice to a lagged throttling calorimeter which exhausts to a water cooled steam condenser. A mercury manometer is provided for measuring the pressure inside the throttling calorimeter and thermocouples are provided for measuring steam supply and temperatures which may be individually selected for display on an analogue temperature meter.

**Cussons P7673 Lagging Efficiency Steam Bench** consists of a sturdy framework and panels of all steel construction, fitted with a student work surface, interconnecting back panel and adjustable feet.

The steam bench incorporates four similar mild steel tubes, each connected to a common steam supply via an inlet regulating valve and a common blowdown line via an outlet valve. Two of the tubes are unlagged but have differing finishes, namely a painted finish and a chromium plated finish respectively.



**Cussons P7674 Ejector Bench** consists of a The principle of operation of an ejector is simple: a high velocity steam jet blows into the ejector throat and thereby produces a suction which draws a fluid into the throat at high velocity. The expanding cross section downstream of the throat causes the velocity head to be converted into a pressure head and the mixture of steam and water (or other fluid) emerge from the ejector at low velocity and higher pressure. Common use for steam ejectors is as a simple vacuum pump. They have the advantage of being inexpensive, small, have no moving parts to go wrong and are much more economical to operate than mechanical pumps in cases where exhaust steam can be put to effective use.



### **P7675 Condenser Bench**

Cussons P7675 Steam Bench Consists of a sturdy framework and panels of all steel construction, fitted with a student work surface, interconnecting back panel and adjustable feet.

The steam bench includes a water-cooled multi-tube condenser, a steam feed line to supply a regulated supply of steam at reduced pressure and a condensate tank complete with a sight glass. Cooling water flow rate is metered in the supply line and regulated by a control valve in the drain line. Bourdon type pressure gauges are provided from pressure indications and thermocouples are used to measure temperature, which may be individually selected for display on an analogue temperature meter.

### **P7576R Steam Engine Bench / P7676T Steam Turbine Bench**

Cussons P7576R Steam Engine Steam Bench consists of a sturdy framework and panels of all steel construction, fitted with a student work surface, interconnecting back panel and adjustable feet.

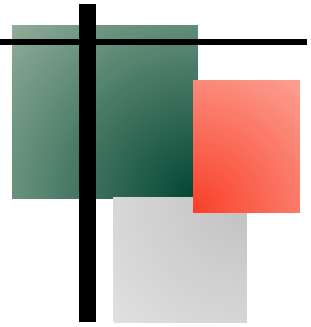
The steam bench comprises a robust single cylinder, double acting reciprocating steam engine driving a dynamometer which enables a calculable, variable resistive load to be easily imposed on the engine. The steam engine is supplied with steam from a steam header at a reduced pressure via an over speed trip solenoid valve and a displacement lubricator from which oil is displaced by droplets of condensed steam into the steam supply to lubricate the engine. Exhaust steam is cooled by a water cooled, coiled tube type condenser. Engine inlet and outlet steam pressures are indicated on 0-16 bar and -1 to 3 bar Bourdon tube pressure gauges respectively.



### **P7677 Water Treatment studies Bench**

This demonstrates the abilities and combined effects of the base exchange, de-alkalinising and de-mineralization units.

Raw water supplied for steam raising plant can contain impurities which can be harmful to the equipment, and it therefore requires treatment to minimise these detrimental effects. The bench has a dual function of demonstrating the basic principles of water treatment, and as a service module to supply treated water to P7670 Steam Boiler Bench.



## P7678 Steam Process plant Bench

Cussons P7678 Process Plant Steam Bench consists of a sturdy framework and panels of all steel construction, fitted with a student work surface, interconnecting back panel and adjustable feet.

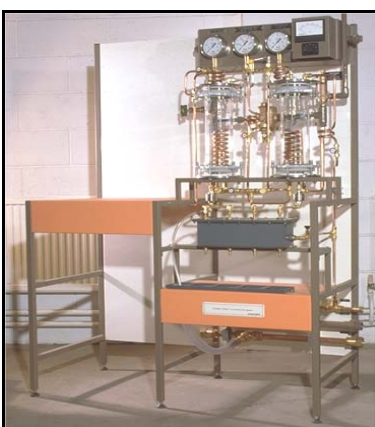
### PRINCIPLE EXPERIMENTS

- ◆ Demonstration of a thermosyphon reboiler, using water as the process fluid and steam as heating fluid.
- ◆ Demonstration of cumulative effect on thermosyphon reboiler boiling rate, and of the boiling off of process fluid lighter fractions.

## P7681 Nozzle Rig bench

Cussons P7681 Nozzle Steam Bench consists of a sturdy framework and panels of all steel construction, fitted with a student work surface, interconnecting back panel and adjustable feet.

The steam chest consists of an inlet chamber and an exhaust chamber with a test nozzle positioned in the wall common to the two chambers. Steam supply to the inlet chamber first passes through a steam separator to remove excess water content and the chamber is fitted with a throttling facility to enable the dryness of the inlet steam to be determined. Steam passes from the inlet chamber, through the test nozzle, into the exhaust chamber and finally into the surface condenser via a back pressure control valve.



## P7683 Double effect evaporator Bench

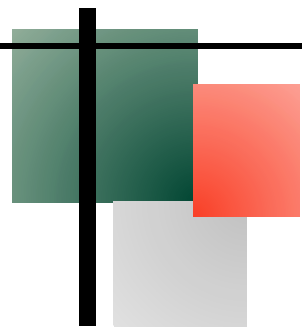
Cussons P7683 Double Effect Evaporator consists of a sturdy framework and panels of all steel construction, fitted with a student work surface. interconnecting back panel and adjustable feet.

The steam bench includes two evaporator vessels with interconnecting pipework and valves to allow single or double effect evaporation. The steam feed line includes a pressure reducing valve and safety relief valve. The steam used is measured by sub cooling the condensate and using collecting beakers. Bourdon type pressure gauges are provided for pressure indications and thermocouples are used to measure temperature, which may be individually selected for display on an analogue temperature meter.

## P8385 Combustion and Flue Gas Emissions Analyser

comprises of a carrying case which houses the various sensors, a heavy duty water trap, particulate and sulphur filters, an integral printer, gas and pressure connectors and a rechargeable battery and battery charger.





## ***Boiler Control Trainer***

### **P7665 Boiler Control Demonstration And Fault Simulator Unit**

An arrangement of up to date integrated circuits is used to simulate boiler pressure and burner control together with the sensing and control systems associated with modern boiler systems. The simulated boiler itself is constructed from a clear acrylic tank and thus the demonstration unit provides a clear visual appreciation of the operating characteristics of the various level controls i.e. float operated magnetic, reed or mercury switch or electronic system using electrode sensors. The operation of these level sensing devices can readily be investigated since they may be removed from the Demonstration Unit, dismantled and re-assembled, without the attendant problems which would occur on an operational boiler. These systems would not normally all be fitted in the same boiler but are included in this unit to give the student an appreciation of the characteristics of each system. Conversion of water from the boiler into steam is simulated so that the level sensors need to operate as in a true Boiler system.



### **P7667 boiler simulation software**

The P7667 allows students to investigate the operation of a steam generation plant.

Altering the system properties allows the user to simulate a wide range of boiler systems for periods up to 24 hours and adjustments to the operating parameters may be made whilst the simulation is running to allow the investigation of transients on the system.

Results from the simulation may be saved manually or automatically to allow subsequent viewing and printing. The results are saved in 'tabbed text' format to allow importing into spreadsheet programs that the student may be familiar with, such as Microsoft Excel, which will allow further analysis and production of graphs.

The software may be used in conjunction with Cussons P7665 Boiler Control Demonstration and Fault Simulation unit, which will interact with the simulation software and enables the introduction of faults into the operation of the system. This requires that interface cards be fitted to the P7665 and the PC to allow their interconnection.

## ***Sectioned Steam Plant Equipment***

**P2295 Sectioned Steam Trap**

**P2296 Sectioned Steam Separator**

**P2297 Sectioned Steam Ejector**

**P2298 Sectioned Pressure Relief Valve (steam)**

**P2299 Sectioned Condenser**

**P2300 Sectioned Steam Engine**

**P2301 Sectioned Steam Injector**

