

## STEAM BENCH EXPERIMENTS

(DETAILED SPECIFICATION SHEETS ON EACH BENCH ARE AVAILABLE ON REQUEST)

### INTRODUCTION

Steam is widely used in industry for power generation, heating and many other processes requiring high temperatures. Consequently, the topic of vapour power systems is a major part of the thermodynamics syllabus.

Cussons steam equipment has been carefully designed and manufactured from the highest quality materials to meet the needs of the educational establishments throughout the world in teaching the technology of steam in thermodynamics courses.

All the various experiments detailed here reflect modern manufacturing practice and their design incorporates the safety features necessary to minimise any risk in operation.

Cussons steam benches have been designed to allow experiments to be carried out on one piece of equipment by a small group of students.

Experience has shown that the modular form of construction is the most versatile and the benches can generally be supplied as “stand alone” units or where more than one bench has been ordered, simply interlinked to form a continuous system (see Fig. 1).

### THE STEAM BENCH SYSTEM CONSISTS OF:

#### P7670 STEAM BOILER BENCH

A steam boiler bench is a service unit designed to provide a steam supply to a series of Cussons steam benches. When used in conjunction with the Separating and Throttling Steam Bench (P7672) and the Condenser Bench (P7675), experiments may be conducted in:-

- Boiler operation and behaviour
- Boiler evaporation capacity
- Boiler heat loss and efficiency

The general construction of benches comprises of welded steel frames fitted with adjustable feet together with steel front and back panels. To enable customers to test with one bench, then at a later date take on additional units linked together to form a complete system utilising a common steam supply and service system, each bench comes complete with the following standard features: -

An interconnecting back panel and student work surface.

A set of four stainless steel flexible hoses complete with aluminium-clad lagging for steam, blowdown, drain and water services.

Steam for conducting all experiments may be supplied by a Cussons Steam Boiler Bench, a Cussons Steam Plant or the clients own steam line, but in each case a maximum working pressure and temperature of 10.34 bar and 235°C is recommended.



### P7671 PRESSURE/TEMPERATURE STEAM BENCH

This bench includes a 2-pen continuous chart recorder tracing the variations in pressure and temperature. It allows students to become familiar with the presentation of such data on a typical process recorder used in industry. Students can then:-

- Investigate the relationship between temperature and pressure of saturated steam
- Compare the experimental observations with data published in recognised steam tables



### P7672 SEPARATING AND THROTTLING CALORIMETER STEAM BENCH

Separating and throttling calorimeters are used to determine the dryness fraction or quality of steam passing through the steam main. Using this bench students can:-

- Measure the dryness fraction of the steam supply by:-
  - using the separating calorimeter
  - using the throttling calorimeter
  - using both separating and throttling calorimeters together



### P7673 LAGGING EFFICIENCY STEAM BENCH

Lagging is applied to pipes carrying hot fluids as a means of reducing heat loss to the surrounding environment by both radiation and convection, and to protect personnel from contact with high surface temperatures. On this bench students can:-

- Investigate the efficiency of two types of lagging widely used in industry
- Compare the heat loss from these lagged pipes with that from two unlagged pipes with different surface finish



### P7674 EJECTOR STEAM BENCH

A common use for steam ejectors is as simple vacuum pumps where they have the advantage of being inexpensive and small, and with no moving parts are much more economical to operate than mechanical pumps. On this apparatus students are able to:-

- Investigate the efficiency of an ejector as a water pump
- Measure the heat transfer of steam to cooling water



### P7675 CONDENSER BENCH

Condensers are heat exchanging devices commonly used in industry to convert exhaust steam to water for subsequent re-use. This apparatus enables student to:-

- Demonstrate the operation of the condenser
- Investigate the heat transfer coefficient of condenser tubes under varying conditions of inlet and outlet pressures and rate of cooling water flow
- Demonstrate that condensing steam in a closed system will produce a vacuum



### P7676 STEAM ENGINE STEAM BENCH

A steam engine utilises the energy contained in steam under pressure. The energy released when steam expands in an engine cylinder is made to produce rotary motion suitable for driving machinery. On this bench the students can:-

- Demonstrate the method of testing a steam engine
- Measure brake horse power, steam consumption, and various efficiencies for a single cylinder engine with a variable load at constant speed



### P7677 WATER TREATMENT STUDIES BENCH

Raw water supplied for steam raising plant contains impurities which are harmful to the equipment and it therefore requires treatment to minimise these detrimental effects. This bench has a dual function, it can be used either as:-

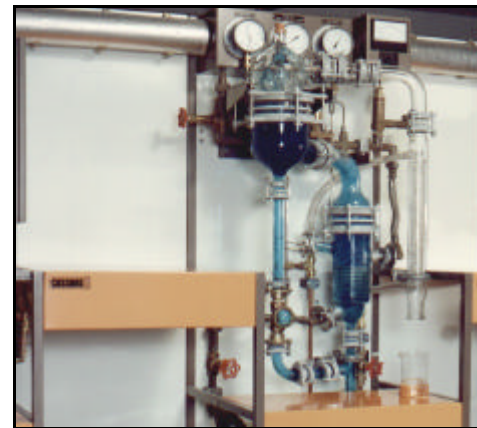
- An experimental bench to demonstrate the basic principles of water treatment by filtration and chemical means and enable students to carry out individual experiments and analysis of sample on varying types of water  
OR
- A service module to supply treated water to a steam boiler bench



### P7678 PROCESS CONTROL STEAM BENCH

Steam has many uses in process engineering. The steam heating circuit on this bench supplies steam to a process fluid circuit designed so that the various processes can be clearly observed. Students can therefore:-

- Demonstrate, visually the use of steam in a natural circulation (thermosyphon) reboiler for the heating of other fluids and the distillation process
- Verify the change of rate of recirculation with increase in boiling temperature
- Verify the choice of process steam pressure to suit the required process temperature



### P7681 NOZZLE STEAM BENCH

The purpose of a nozzle in steam applications is to convert the internal energy of the steam into kinetic energy and this is achieved by expanding it from higher to a lower pressure. The ultimate efficiency of this conversion process depends upon the shape (or profile) of the nozzle. With four different nozzles the experiments which can be carried out are:-

- The variation of pressure along a nozzle profile as a function of back pressure
- The effect of back pressure on the mass rate of flow
- A comparison of theoretical and actual throat pressures and rates of flow
- Determination of critical pressure ratio for choked flow
- Calculation of velocity through length of nozzles of various forms
- Study of the effects of friction in a parallel nozzle
- Study of shock wave formation with nozzle divergence and at nozzle outlet
- Measurement of state of entry to the nozzle and subsequent calculation



### P7682 PIPE CLOSURE KIT (ESSENTIAL ITEM)

The pipe closure unit is designed to close the open ends of the service pipes on the steam bench and provide a means of blowing down the system and automatically discharging condensate from the steam main. It comprises pipework connecting the steam main to the blowdown, a steam trap and isolating valve, a direct bypass line with isolating valve and drain plug, together with blanking plugs for water supply and drainage lines.

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