

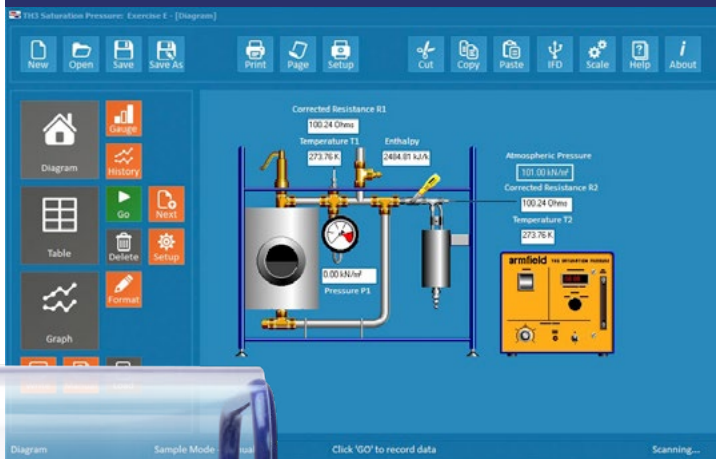
The Armfield Saturation Pressure Apparatus has been designed to introduce students to how the temperature of water behaves at its boiling point with variation in the absolute pressure.

The TH3 offers all the features of a Marcet Boiler and adds the capability of determining the quality of wet steam, thus enhancing the understanding of the underlying thermodynamic principle.

Saturation curves can be obtained by the student and compared with published steam tables. The quality of steam exiting the apparatus can be determined using a throttling calorimeter connected at the point of discharge.

**OFFERS ALL THE FEATURES OF A MARCET BOILER
DATA LOGGING**

TH3 use of the steady flow energy equation screen



Experimental Content

- ▶ Study the behaviour of water during the transition between liquid and vapour phases
- ▶ Investigate the behaviour of water at temperatures around the vapour point over a range of pressures
- ▶ Study the change in vapour point with increasing pressures and to watch the fluid behaviour using a sight glass set into a pressure vessel
- ▶ Understanding the principles of saturation pressure measurement
- ▶ Measure the saturation pressure of water using a pressurised vessel
- ▶ Examine the effect of unsteady conditions on measurement accuracy
- ▶ Investigate the accuracy of saturation data obtained using basic equipment
- ▶ Compare laboratory data with published steam tables
- ▶ Determine the quality of steam exiting a pressurised vessel
- ▶ Make use of a throttling calorimeter in conjunction with the Steady Flow Energy Equation, in order to calculate the enthalpy of the escaping steam
- ▶ Determine the quality of the steam using standard reference tables

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URL: <http://www.armfield.co.uk/th3>

Applications

ChE ME CE IP

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Description

A bench top unit designed to introduce students to the characteristics of saturated water vapour.

The apparatus is equivalent to a Marcet Boiler, with an additional throttling calorimeter and a pipe loop, which enables saturated steam to be returned to the base of the boiler as condensate.

Pure water in the boiler is heated to its boiling point using a pair of cartridge heaters with variable power control. A sight glass on the front of the boiler enables the internal processes to be observed, namely boiling patterns at the surface of the water, and also permits the water level in the boiler to be monitored.

Saturated steam leaving the top of the boiler passes around the pipe loop before condensing and returning to the base of the boiler for reheating. The operating range of the boiler and loop is 0 - 7 bar. The top limb of the pipe loop incorporates a Platinum Resistance Thermometer (PRT), temperature sensor and an electronic pressure sensor to measure the properties of the saturated steam. A filling point on the top limb enables the loop to be filled with pure water and permits all air to be vented safely before sealing the loop for pressurised measurements.

A vapour offtake, with isolating valve, enables steam from within the loop to be passed through a throttling calorimeter, the purpose of which is to demonstrate how the dryness fraction of the saturated steam in the loop can be determined.

The steam expands to atmospheric pressure as it is throttled and a second PRT temperature sensor measures the temperature of the steam following expansion.

The apparatus is designed for safe operation with a pressure relief valve set to operate if the pressure rises above the working pressure and a Bourdon gauge that remains operational when power is disconnected from the electrical console.

All power supplies, signal conditioning, circuitry etc. are contained in an electrical console with appropriate current protection devices and an RCD for operator protection. Readings from the sensors are displayed on a common digital meter with selector switch and all corresponding signals are routed to an I/O port for connection to a PC using an optional parallel interface/educational software package.

Key Features

- ▶ Measurement of the relationship between temperature and pressure of the saturated vapour in the loop
- ▶ Convenient control of heat input to the boiler using variable power control
- ▶ Sight glass in the boiler enables observation of the boiling patterns in the water
- ▶ Safe operation with pressure relief valve and permanent indication of system pressure
- ▶ Pressure and temperatures measured can be logged using a PC (not supplied). Optional teaching software is available for data logging

Detailed experimental capabilities

Teaching exercises will enable students to become familiar with the following topics:

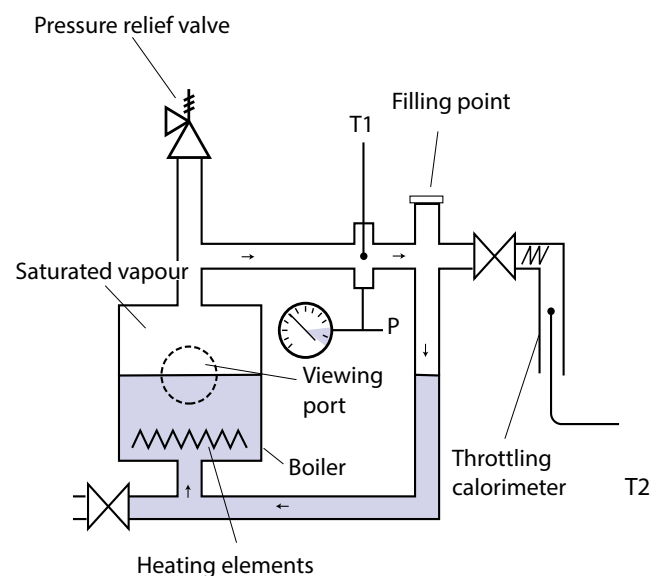
Saturation loop:

- ▶ Observation of the patterns of boiling at the surface of the water
- ▶ Measurement of the temperature of saturated steam over the range of pressures 0 - 7 bar and comparison of the saturation curves obtained with those published in steam tables
- ▶ The concept of a saturation line
- ▶ The describing equation and linearisation
- ▶ Gauge and absolute pressures
- ▶ Temperature scales
- ▶ The characteristic behaviour of a two phase fluid
- ▶ The effect of rate of response on the accuracy of measurement

Throttling calorimeter:

- ▶ Determination of the condition of the wet steam (quality of the steam) produced by the Saturation Pressure Apparatus at different operating pressures
- ▶ Use of the steady flow energy equation
- ▶ The two property rule
- ▶ Use of steam tables
- ▶ The difference in enthalpy between phases - enthalpy of vaporisation

Boiler sight glass and system pressure gauge



TH3: Schematic diagram of apparatus

TH3 Throttling calorimeter and steam discharge safety system



Safety features include RCD

Requirements

Scale



Electrical supply: Single phase

- ▶ TH3-A: 220-240V/1ph/50Hz, 6A
- ▶ TH3-B: 120V/1ph/60Hz, 13A
- ▶ TH3-G: 220-240V/1ph/60Hz, 6A

Initial fill with distilled/deionised water (three litres) and replenish as consumed

Overall dimensions

Saturation Pressure Apparatus

Length	0.670m
Width	0.290m
Height	0.580m

Electrical Console

Length	0.290m
Width	0.225m
Height	0.215m

Packed and crated shipping specifications

Volume	0.26m ³
Gross weight	30Kg

Instructional capabilities

- ▶ Understanding saturation curves and the characteristics of a two phase fluid
- ▶ Understanding the origin and use of steam tables
- ▶ Using a throttling calorimeter to determine the quality of wet steam

Optional accessories

TH-DTA-ALITE:

Educational software for TH1-TH5 on a USB key complete with data logger (a PC running Windows 7 or later, with a USB port is required)

Ordering specification

- ▶ A bench top unit comprising a boiler vessel and pipe loop with a pressure relief valve to limit the operating pressure to eight bar. A sight glass on the front of the boiler enables the boiling patterns to be observed and a Bourdon type gauge indicates the pressure in the apparatus at all times for safe operation
- ▶ A throttling calorimeter mounted adjacent to the pipe loop enables the condition of the saturated steam to be determined by measuring the temperature of the steam following throttling to atmospheric pressure. Temperatures in the pipe loop and inside the throttling calorimeter are measured using PRT sensors and pressure in the loop is measured using an electronic pressure sensor
- ▶ An electrical console houses the necessary electronics with current protection devices and an RCD for operator protection. A digital meter with selector switch displays all sensor measurements. Corresponding signals are routed to an I/O port for connection to a PC. An optional interface device and educational software package is available
- ▶ The boiler is heated by a pair of 500 W electric heating elements with variable power control and overtemperature protection
- ▶ A comprehensive instruction manual is included with a range of fully detailed laboratory teaching exercises

Recommended instruments

Accurate barometer: (to determine the absolute pressure)

The TH range for the study of Thermodynamics

- TH1: Temperature Measurement and Calibration
- TH2: Pressure Measurement and Calibration
- TH3: Saturation Pressure
- TH4: Recycle Loops
- TH5: Expansion Processes of a Perfect Gas
- TH6: Film & Dropwise Condensation Demonstration Unit

Ordering codes

TH3-A
TH3-B
TH3-G

Armfield standard warranty applies with this product

Knowledge base

- > 28 years expertise in research & development technology
- > 50 years providing engaging engineering teaching equipment

Benefit from our experience, just call or email to discuss your laboratory needs, latest project or application.

Aftercare

Installation
Commissioning
Training
Service and maintenance
Support: armfieldassist.com