TD1006

Marcet Boiler

User Guide

TecQuipment has taken care to make the contents of this manual accurate and up to date. However, if you find any errors, please let us know so we can rectify the problem.

TecQuipment supply a Packing Contents List (PCL) with the equipment. Carefully check the contents of the package(s) against the list. If any items are missing or damaged, contact TecQuipment or the local agent.

DB/0311

TecQuipment

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Introduction

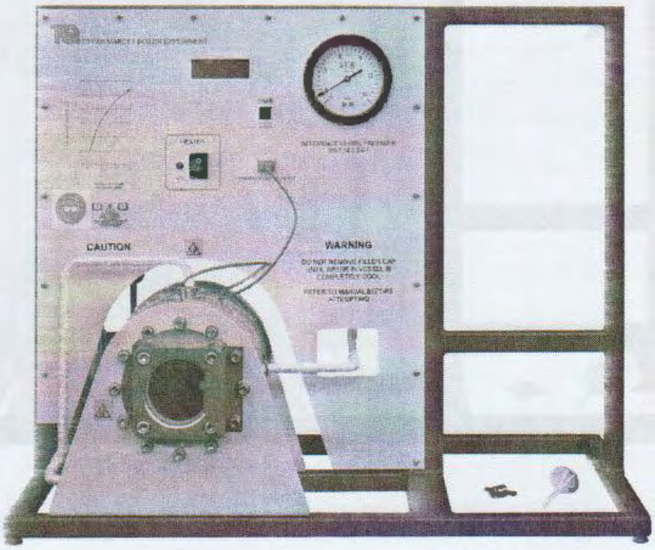

Figure 1 Marcet Boiler Apparatus

VDAS ***This product works with VDAS®***

During the nineteenth Century, an English-born scientist - Francois Marcet, experimented in Switzerland with steam pressures. His experiment found that water boiled (producing steam) at different pressures. It would boil more easily (need less heat energy) at lower pressures than at high pressures. This disproved the normally accepted rule that water boils at 100°C, as the process also depends on pressure.

Water is of course the most plentiful liquid available, so physicists, chemists and engineers of thermodynamics need to know how it behaves under different conditions. Knowing accurately when it will boil (or change state from liquid to gas) is one of the most important pieces of information they need.

TecQuipment's Marcet Boiler apparatus (TD1006) is a simple-to-use, fundamental experiment. It uses a sealed boiler to show the relationship between temperature and pressure of saturated steam. You can use it to produce results that compare with textbook results found by experiments started by Marcet and other famous scientists. This guide also shows how to predict pressures and temperatures for saturated steam by graphical method and by using the Antoine Equation.

Description

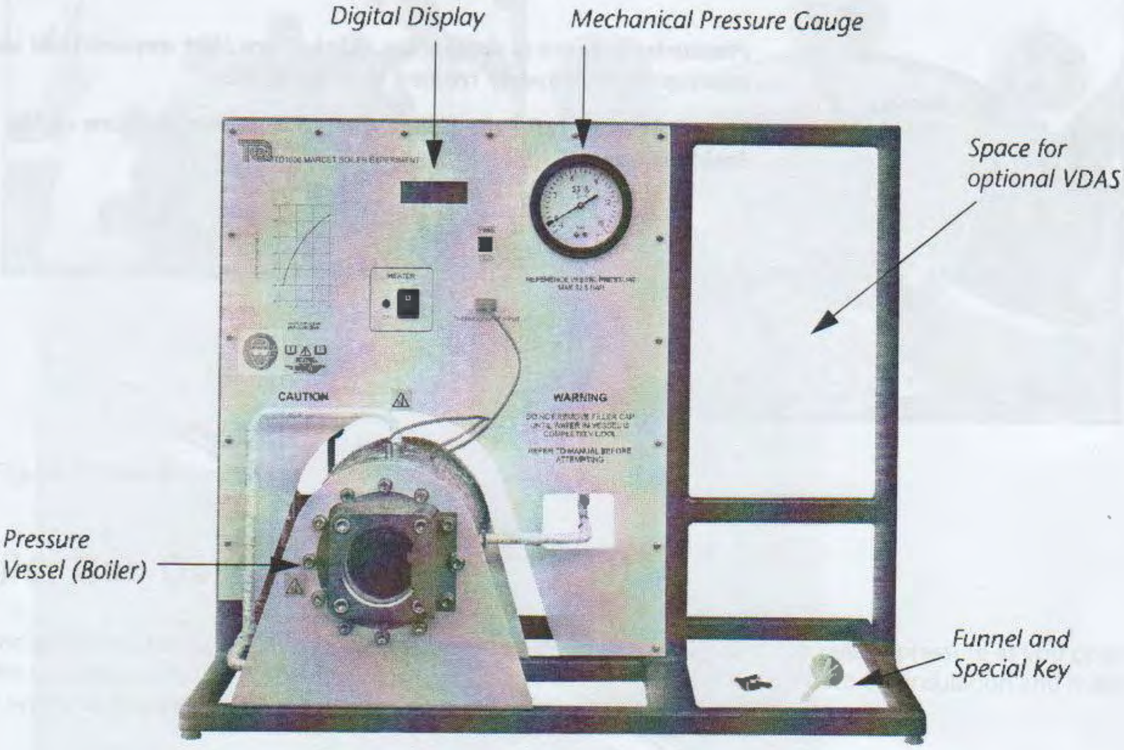

Figure 2 The Marcet Boiler Apparatus

Figure 2 shows the main parts of the Marcet Boiler apparatus. A compact, bench-mounting frame holds a pressure vessel (boiler) and a back panel. The frame also has a space for the frame-mounted version of TecQuipment's optional VDAS.

TecQuipment make the boiler to comply with international regulations for safe use by students (see **Pressure Vessel Design**). It has a clear viewing window so students can see the boiling process. A thermocouple measures the temperature of the steam in the boiler. A pressure sensor measures the pressure in the boiler. Both sensors connect to a digital display in the back panel. The display shows the temperature and pressure in traditional values of °C and bar (absolute), and also Kelvin and kilo Pascals (kPa) (absolute). The digital display produces warning notices when the pressure and temperature become too great.

The over pressure warning shows: OVER RANGE.

The over temperature warning shows: WARNING - HEATER IS TOO HOT.

Inside the boiler, an electric heater heats the water. The heater has a thermal switch to help prevent overheating. If the heater temperature becomes too great the thermal switch disconnects power to the heater until it cools down. The heater lamp goes off when this happens.

A mechanical pressure gauge also shows the boiler pressure (gauge pressure). TecQuipment use a mechanical gauge because this is good engineering practice - for safety it visually displays pressure, independent of batteries or electrical supplies (which could fail).

The boiler has a specially-made filling cap with a special key for safety (see **The Filler Cap Design**), and a drain valve to allow draining of the water. It also has a pressure relief valve for safety and to prevent damage to the equipment from overpressure.

WARNING

Pressurised steam is dangerous. Make sure that anyone that uses this equipment is properly trained and supervised.

Never drain or refill the boiler when it is under pressure or the water inside is hot.

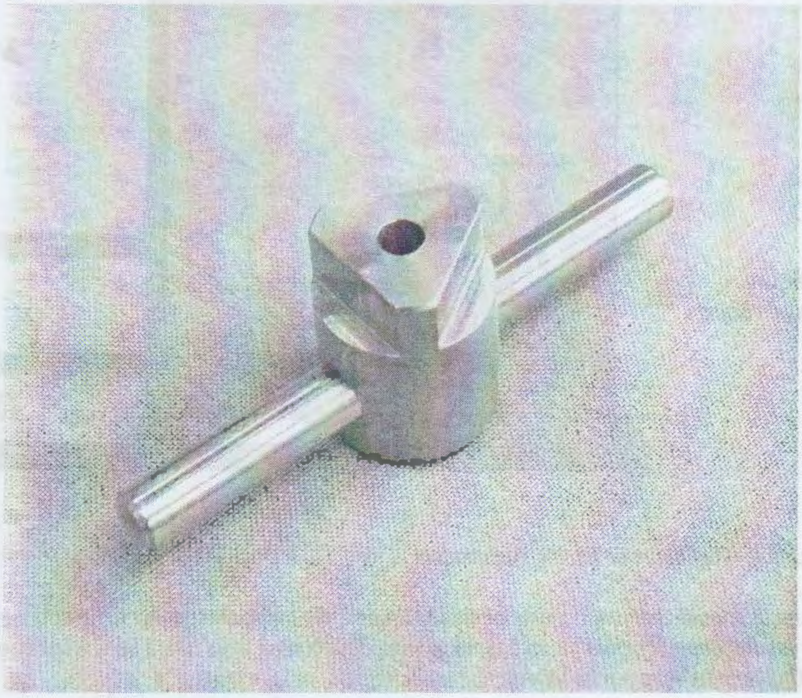

Figure 3 The Special Key

Pressure Vessel Design

The pressure vessel has less than 2 Litres capacity, so it is exempt from the European Pressure Equipment Directive (PED) for steam generators. The directive shows that vessels of this size do not need CE marking.

TecQuipment design and test the vessel according to SEP (sound engineering practice), using the PED as a guide. The rear cover plate of the vessel shows information about its rating (see Figure 4).

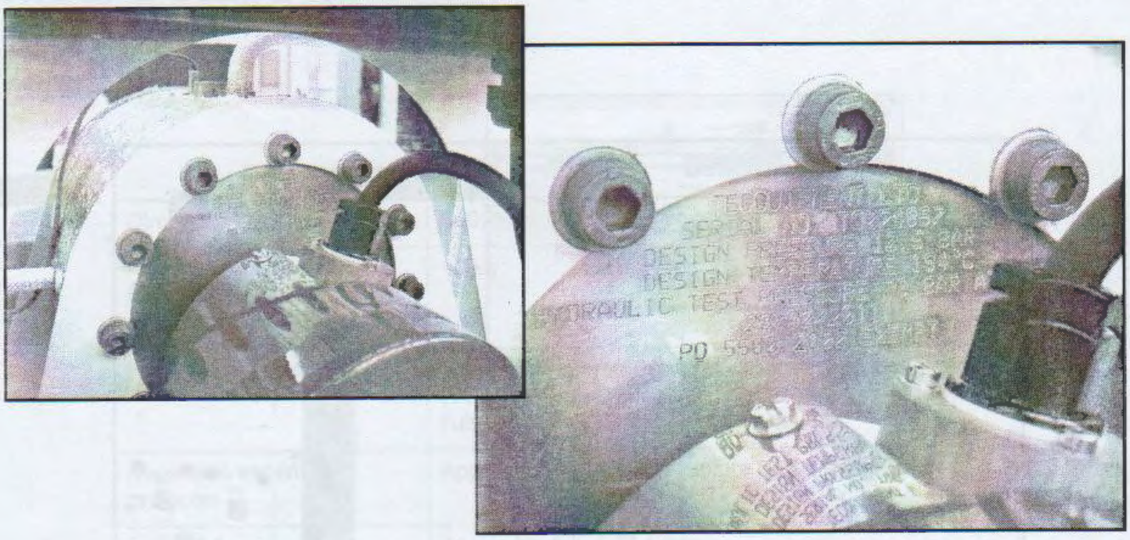

Figure 4 Rear of Vessel

The Filler Cap Design

For additional safety, the filling hole has an extra small 'weep hole' that can relieve pressure as you open the cap. However, this is a safety measure only and will allow water vapour into the insulation and make it wet and may eventually damage it.

CAUTION — *Do not continue to open the filler cap if the vessel is under pressure. Check the pressure gauge before you open the filler cap.*

WARNING — ***Do not remove the filler cap completely when the vessel is under pressure. Hot steam and water will spray out from the filling hole, causing serious injury.***

Versatile Data Acquisition System (VDAS)

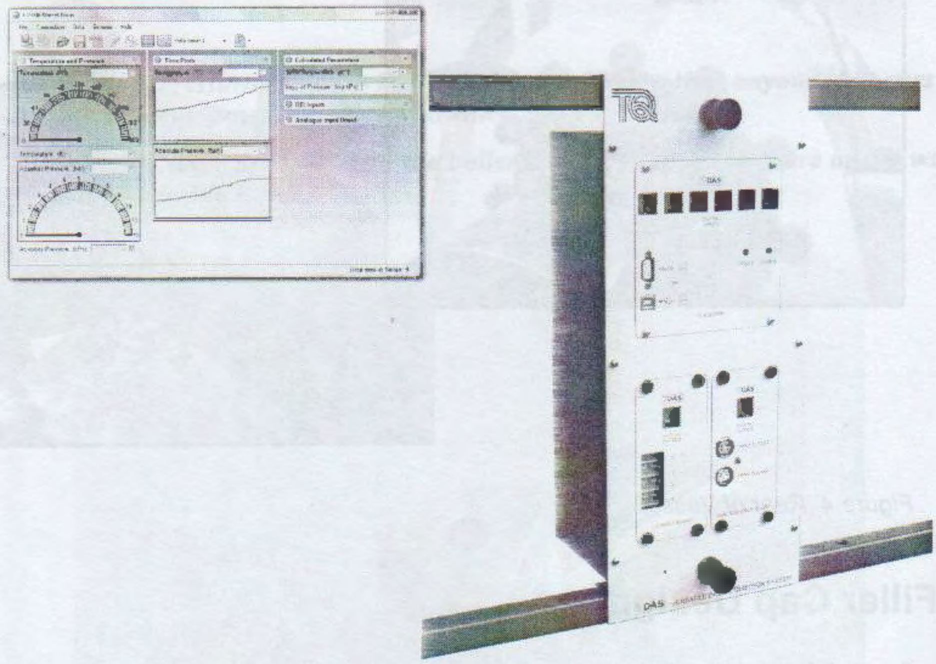

Figure 5 The VDAS Hardware and Software

TecQuipment's VDAS is an optional extra for the Marcet Boiler apparatus. It is a two-part product (Hardware and Software) that will:

- automatically log data from your experiments
- automatically calculate data for you
- save you time
- reduce errors
- create charts and tables of your data
- export your data for processing in other software

NOTE *You will need a suitable computer (not supplied) to use TecQuipment's VDAS.*

Technical Details

Item	Details
Dimensions	640 mm high x 800 mm wide x 410 mm front to back
Nett Weight (without water and the optional VDAS)	40 kg
Pressure Relief Valve	Set to start opening at approximately 12.5 bar absolute (11.5 bar gauge) Fully open at 13.5 bar (12.5 bar gauge)
Maximum experiment pressures	Approximately 10 bar absolute (9 bar gauge)
Boiler Volume	Approximately 1.75 Litres
Maximum experiment temperature	Approximately 180°C
Electric Heater thermal cut-out	Approximately 185°C
Electrical Supply (Determined by order)	220 VAC to 240 VAC at 5 A or 110 VAC to 120 VAC at 10 A 50 Hz to 60 Hz
Fuse	20 mm F6.3 A

Noise Levels

The noise levels recorded at this apparatus are less than 70 dB (A).

Installation and Assembly

The terms **left**, **right**, **front** and **rear** of the apparatus refer to the operators' position, facing the unit.

NOTE

- *A wax coating may have been applied to parts of this apparatus to prevent corrosion during transport. Remove the wax coating by using paraffin or white spirit, applied with either a soft brush or a cloth.*
- *Follow any regulations that affect the installation, operation and maintenance of this apparatus in the country where it is to be used.*

Location

The Marcet Boiler uses a bench area of 800 mm x 410 mm and is 640 mm high. Use it in a clean, well-lit laboratory or classroom type area. Put it on the top of a solid, level workbench or desk top. Allow room for a suitable computer if you are to use the optional VDAS.

WARNING ***The apparatus is heavy (see Technical Details). Ask someone to help you move or lift it.***

CAUTION *Make sure you have a suitable water drain system nearby that can accept water temperatures of up to 100°C.*

Assembly

1. See Figure 7. Use the two lengths of high temperature hose (steam hose) to connect the drain and pressure relief connections at the back of the equipment to your water drain system.

WARNING

The high temperature hoses have a steel wire lining. Take care when handling as the steel wires can stick out from the hose ends.

Do not shorten the hoses. Their length helps to cool the water or steam that leaves the boiler before it reaches the drain.

2. Make sure you securely connect the hoses to your drain system. Make sure the ends of the hoses are not submerged in water. Make sure the drain system is below the equipment to allow water to drain away by gravity.
3. Connect the thermocouple plug to its socket on the back panel.
4. Fill the boiler with deionized water (see **Filling the Boiler**).
5. Connect the equipment to the electrical supply (see **Electrical Connection**).
6. If you have the optional VDAS, see **Connection to VDAS**.

7. The apparatus is now ready for the experiments.

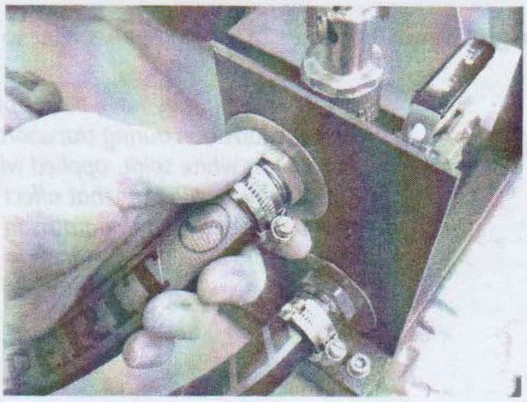

Figure 6 Connect Pipes (Supplied)

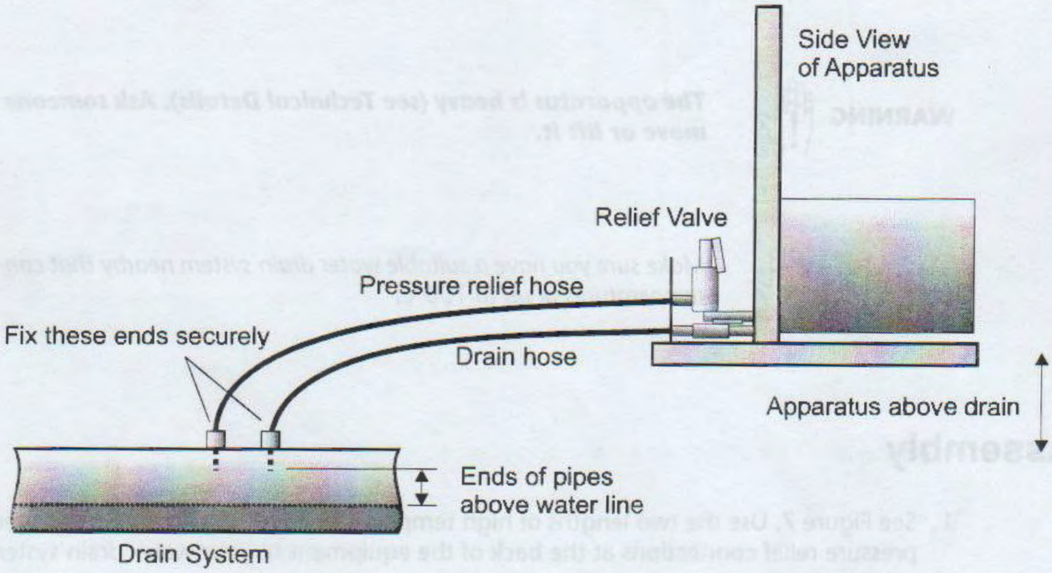

Figure 7 Water Drain Pipes

Filling the Boiler

WARNING

Never drain or refill the boiler when it is under pressure or the water inside is hot.

Only allow trained staff to use the special filler cap key. These staff should be trained to understand the dangers of steam.

If you cannot find the key or it is damaged - never try to use other tools to open the filler cap. Contact TecQuipment for a replacement.

CAUTION

Always use the funnel to fill the boiler. If you do not use the funnel, water will leak into the insulation.

1. Switch off the electrical supply and make sure the boiler is cool and not under pressure.
2. Use the special key to undo the filler cap fully and remove it from the boiler.
3. Check the 'O' ring seals on the filler cap and in the filling hole. If they are damaged or flattened, replace them (TecQuipment supply spares with the equipment).
4. Fit the small funnel (supplied) to the filling hole.

Figure 8 Use the Funnel (Supplied)

5. Make sure you have shut the drain valve at the back of the boiler (handle at right angle to the pipe).
6. Pour clean, low mineral content (deionized) water into the boiler until you can see it reach the 'MAX' level marker in front of the viewing window. You may use clean rainwater if deionized water is not availabe.
7. Refit the filler cap tightly, taking care not to damage the 'O' ring seals around it.
8. Keep the special key in a safe place, out of the reach of untrained people.

Electrical Connection

Use the cable supplied to connect the Marcet Boiler to the electrical supply.

WARNING ***Connect the Marcet Boiler to the electrical supply through a switch, circuit breaker or plug and socket. The apparatus must be connected to earth.***

These are the colours of each individual conductor:

GREEN AND YELLOW:	**EARTH E OR ⏚**
BROWN:	**LIVE L1 or Hot 1**
BLUE:	**NEUTRAL**

Connection to VDAS

1. Put the VDAS-F (frame mounted interface) into the space to the right of the frame.
2. Connect its electrical supply lead to the socket on the back of the Marcet Boiler.
3. Connect the 'VDAS Digital Output' socket on the Marcet Boiler back panel to any of the six 'Digital Input' sockets of the VDAS interface.
4. Refer to the VDAS User Guide for more details.

Theory

Notation

Symbol	Description	Units
p	Pressure	bar, $N.m^{-2}$ or Pa absolute or gauge where shown
T	Temperature	°C or K where shown
A, B and C	Antoine Coefficients	-

Useful Notes and Unit Conversions

The correct scientific units for pressure are Newtons per square metre ($N.m^{-2}$), or Pascals (Pa) where:

$$1\ N.m^{-2} = 1\ Pa = 0.00001\ bar$$

Many textbooks use the ***absolute*** values for pressure and temperature for the steam tables, where the pressure is with respect to absolute zero (a vacuum) and the temperature is in Kelvin, where 0 Kelvin is absolute zero (-273 °C).

Other textbooks may use ***Gauge Pressure.*** This is the pressure that normal mechanical gauges show, it is with respect to normal atmospheric pressure. When the gauge shows zero pressure, it is actually at atmospheric pressure.

Saturation, Vapour Pressure, Dryness and Superheated Steam

Textbooks use several terms when describing steam and boiling.

Saturation describes the amount of ***heat energy*** in the fluid or gas. A saturated fluid has enough energy to change state (into a gas or vapour). Saturated steam has enough energy to condense. Saturated steam is that which is at a temperature near to the boiling point of the water that it comes from.

Vapour pressure describes the ***pressure*** at which the fluid changes state into a gas or vapour. When clean water is saturated at normal atmospheric pressure it will boil, as this is its vapour pressure.

The Marcet Boiler experiment should show that you need to add more heat energy (make the water hotter) to make it boil as the pressure increases in the boiler. Alternatively, you should see that the vapour pressure increases with applied temperature.

Dryness is a quality of steam or water vapour. If the steam has 5% water by mass, then it has a dryness fraction of 0.95. Steam in contact with water in a boiler is usually 95% dry. 100% dry steam has no water content.

Superheated steam is at a higher temperature than the boiling point of the water that it comes from.

What is Boiling?

Textbooks say:

A liquid boils when its saturated vapour pressure is equal to the atmospheric pressure.

When you add heat energy to liquid (in this case water), it causes the molecules of the water to vibrate with kinetic energy. At some point (corresponding to the vapour pressure), some molecules vibrate with enough energy to change state into vapour molecules, forming bubbles of steam in the water.

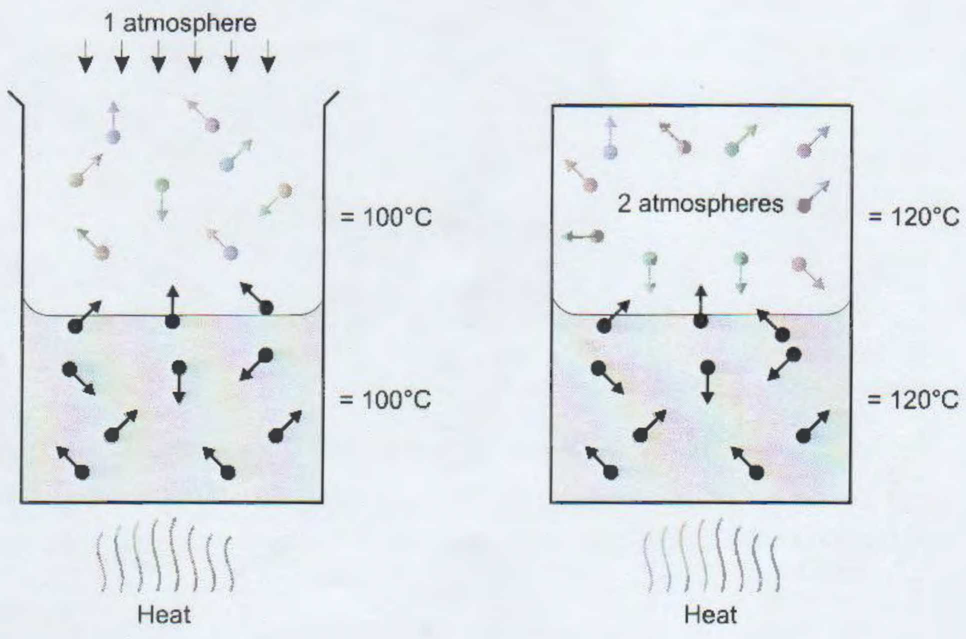

Figure 9 Boiling

The vapour molecules are less dense than the water molecules and rise to the water surface (under normal gravity conditions). If the pressure above the water is low enough, the vapour molecules (steam) will leave the water and move around in the area above the water. The steam remains as steam until it loses its energy and condenses back to water. The water and the steam just above it are both at a similar temperature and pressure (the boiling point or vapour pressure).

When exposed to atmosphere, and with enough applied heat, the water and vapour immediately above will remain in this state at 100°C until the water has entirely boiled away into steam (assuming that excess steam has moved away or risen from the immediate area of the water).

If the pressure above the water is too high, it restricts the vapour molecules from forming until they absorb enough heat energy. In this case the water will not boil until the molecules have reached a higher temperature (corresponding with a higher vapour pressure). This happens when boiling water in an enclosed vessel. Initially, steam leaves the water and gathers in the area above the water, slowly increasing the pressure in the vessel. At some point the increased pressure restricts more steam from being produced until more heat energy is applied. This results in a nett increase in temperature of both the liquid and steam, so the process continues with steadily increasing pressure. Therefore, a continued pressure increase in a sealed vessel needs a continued heat source.

Removing the heat source stops production of the steam and the pressure slowly drops as the steam condenses back into the liquid.

Things that Affect Boiling Point

School children learn that water boils at 100°C (or 373 K). However, early scientists including Marcet discovered that several factors affect the boiling point:

- ***Pressure*** - as described earlier, water boils more easily (at lower temperatures) at lower pressures. It will boil at roughly 26°C at 0.03 bar (near vacuum) and at roughly 180°C at 10 bar (ten atmospheres).

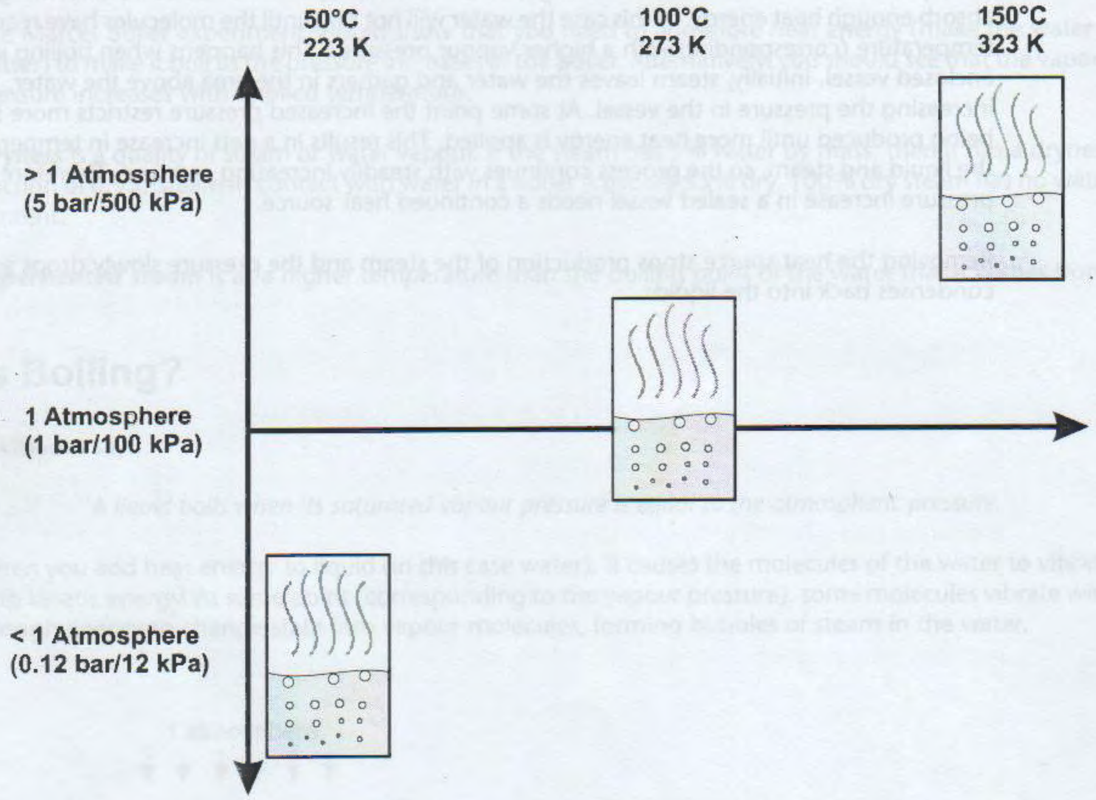

Figure 10 Pressure and Temperature

- ***Water quality*** - clean, pure water boils more easily (at lower temperatures) than dirty or salty water. Sea water at a salinity (salt content) of 35 $g.kg^{-1}$ boils at 100.56 °C. Adding salt to water to increase its boiling point is known as ***boiling point elevation***. However, you must add large quantities to change the boiling point by only a few degrees.

- The ***boiler material (inner surface finish)*** - a French scientist (Gay-Lussac) found that water boiled at a higher temperature in a glass vessel than in a metal vessel, by a difference of just over 1°C. Marcet did experiments using glass vessels that had previously contained acid, which had affected the glass inner surface. The water then boiled at 105°C.

- ***Air content*** - water can contain air particles, especially when it has been shaken, forced out of an outlet at high pressure, or poured from a height. Scientists have found that removing air from water increases its boiling point. Less air gives a higher boiling temperature.

From these factors, pressure is the most important, as most practical applications boil water in enclosed vessels to produce and capture steam, causing a pressure change.

Steam Tables

Absolute Pressure p (kPa)	Temperature T (K)	Temperature T (°C)	Log Pressure (log kPa)	1000/T (1000/K)
100	372.6	99.6	2	2.68
200	393.2	120.2	2.3	2.54
300	406.5	133.5	2.477	2.46
400	416.6	143.6	2.6	2.40
500	424.8	151.8	2.7	2.35
600	431.83	158.83	2.78	2.32
700	437.97	164.97	2.845	2.28
800	443.4	170.4	2.9	2.25
900	448.38	175.38	2.954	2.23
1000	452.91	179.91	3	2.21
1100	457	184	3.0	2.19

Table 1 Typical Steam Table Data

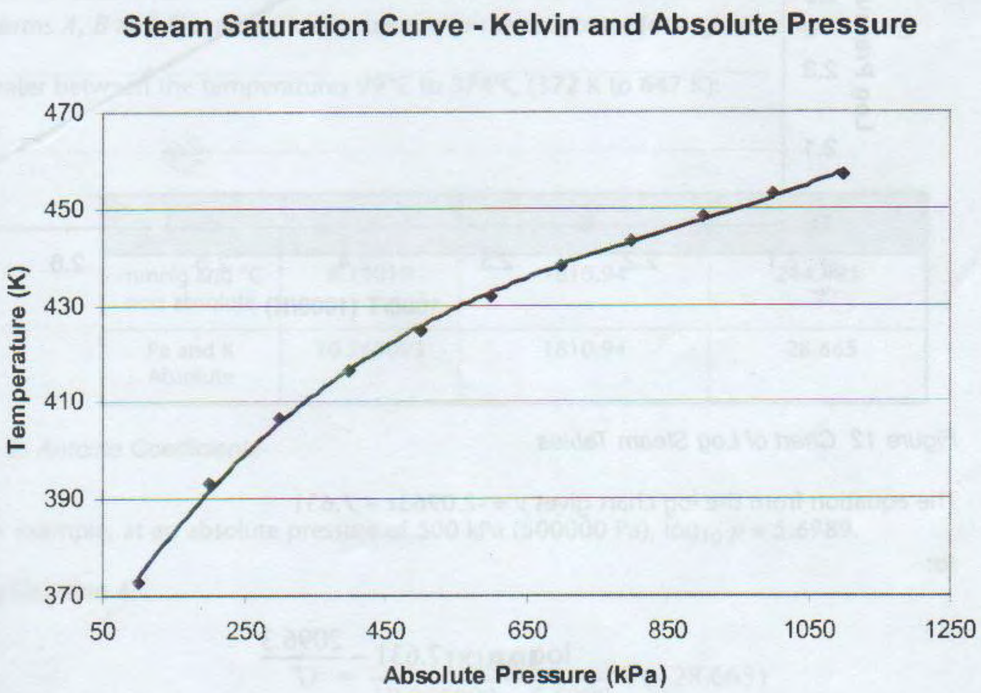

Figure 11 Steam Saturation Curve from Steam Tables

Table 1 shows typical data from published steam tables. Figure 11 shows a chart based on the typical data, showing how pressure of saturated steam in an enclosed vessel increases with its temperature. This is often called the ***steam saturation curve***.

Steam tables can only be accurately produced from actual experiments, as you cannot use simple equations to relate the variables over the full range. However, you can use simple equations to predict variables with reasonable accuracy over limited ranges.

Graphical Method

Note how ***over the range of temperature and pressure*** shown, you can create a chart of log pressure over $1000/T$. This should give linear results as in Figure 12, allowing you to check your results (as incorrect values will not fit along the line). It will also give an equation (gradient and intercept) for the line of this chart, which you can use to create a formula. This formula will give an approximate value of pressure or temperature for any given temperature or pressure over a given range.

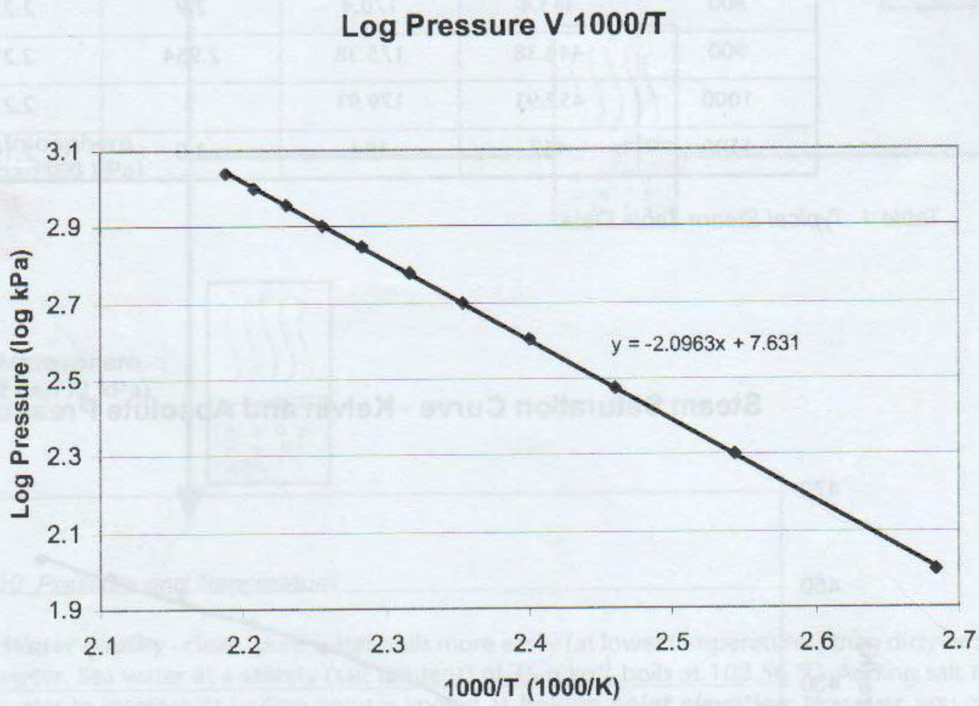

Figure 12 Chart of Log Steam Tables

The equation from the log chart gives $y = -2.0963x + 7.631$

so:

$$\log_{10} p = 7.631 - \frac{2096.3}{T} \qquad (1)$$

Alternatively:

$$T = \frac{-2096.3}{\log_{10}p - 7.631} \qquad (2)$$

Where p is in kPa (absolute) and T is in Kelvin.

NOTE *Just as with the Antoine equation (see later), this equation will only work accurately over the range of temperatures and pressures shown.*

Antoine Equation

In the late 19th century, a French researcher (Antoine) proposed an equation that linked the vapour pressure (p) and temperature (T) of pure substances. Equation 3 shows its basic form.

$$\log_{10}p = A - \frac{B}{C + T} \qquad (3)$$

alternatively:

$$T = \frac{B}{A - \log_{10}p} - C \qquad (4)$$

The terms A, B and C are coefficients unique to the substance for a given range.

For water between the temperatures 99°C to 374°C (372 K to 647 K):

Units	A	B	C
mmHg and °C non absolute	8.14019	1810.94	244.485
Pa and K Absolute	10.265093	1810.94	-28.665

Table 2 Antoine Coefficients

So for example, at an absolute pressure of 500 kPa (500000 Pa), $\log_{10} p = 5.6989$.

Using Equation 4:

$$T = \frac{1810.94}{10.265093 - 5.6989} - (-28.665)$$

$$T = \frac{1810.94}{4.566193} - (-28.665)$$

$$T = 396.59734 - (-28.665)$$

$$T = 425.26 \text{ K}$$

Which compares well with the value in Table 1 at 500 kPa.

Alternatively, at a temperature of 393.2 K, using Equation 3:

$$\log_{10} p = 10.265093 - \frac{1810.94}{-28.665 + 393.2}$$

$$\log_{10} p = 10.265093 - \frac{1810.94}{364.535}$$

$$\log_{10} p = 10.265093 - 4.9678$$

$$\log_{10} p = 5.297293$$

$$p = 198286.4329 \text{ Pa (198 kPa)}$$

Which again compares well with the value in Table 1 at 393.2 K.

Experiment

Useful Notes

Safety

This unit is safe to use, but you must obey sensible procedures when using.

WARNING

Never drain or refill the boiler when it is under pressure or the water inside is hot.

Check for any obvious leaks or damage to the boiler before using.

Keep the special key safe and only allow properly trained people to use it.

Do not touch the pressure relief valve, the boiler or its pipework unless it has cooled down and you are told to do so in this manual.

Clean up any water spills immediately.

Never work alone, always work in pairs.

WARNING

Wear eye protection when using this equipment.

Safety Protocols

The TD1006 has temperature and pressure safety systems (see **Description** and **Technical Details** sections) to protect the equipment and the user:

- The maximum experiment levels are 10 bar absolute pressure (0 to 9 bar gauge) and 180°C.
- The digital display warns the user of over pressure and temperature.
- The electric heater thermal trip operates when it gets too hot.
- The pressure relief valve opens if the pressure gets too high.

NOTE

The first three safety protocols give good warning and help prevent the conditions that cause the primary safety device (the pressure relief valve) to operate.

If the pressure relief valve does open at full pressure, it can cause a loud and unexpected 'bang'.

Mechanical Pressure Gauge

This gauge is for reference only, to show any pressure in the boiler if your local electrical supply breaks and the normal digital display stops working. Always use the digital display of pressure for your readings.

Water Levels

Make sure that you can see the water level between the MIN and MAX levels in the viewing window at all times during the experiment. If the water level drops too low, the heater will become too hot and may be damaged.

CAUTION

Only switch on the heater when you can see the water level in the viewing window.

Switch off the heater if you cannot see the water level in the viewing window.

Experiment

Aims

- To observe the boiling process at different pressures.
- To prove that steam pressure in a closed vessel increases with its temperature.
- To show that the Marcet boiler experiment gives results that compare well with published steam tables.
- To compare actual results with theory and prove the relationship between temperature and pressure for saturated steam and the theoretical equations that link the two variables.

Procedure

1. Fill the boiler with water as shown in **Filling the Boiler** on page 11.
2. Create a blank results table similar to Table 3. Alternatively, if you have the optional VDAS, start the software and select the TD1006 layout. The software will automatically create a results table for you when you start taking readings.

NOTE *The timed data capture in VDAS may be useful for this experiment (refer to the VDAS User Guide).*

3. Switch on the heater.
4. Note the temperature as the boiler heats up. When it reaches just above 90°C, carefully hold the pressure relief valve open (pull the lever up) until the temperature reaches 100°C and then release it.

NOTE *This helps to purge unwanted air from the area above the water.*

If you do not do this correctly, the pressure in the vessel will rise due to the expansion of the air content (not steam), giving false readings.

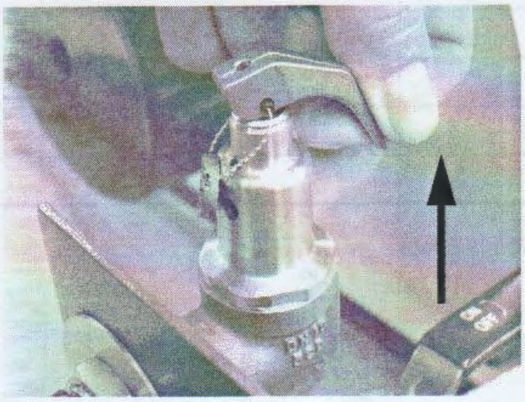

Figure 13 Lift the Pressure Relief Valve

5. Start recording the temperatures and pressures at 0.5 bar intervals or every ten seconds if you use VDAS timed data capture.
6. As the pressure increases, note the size of the water vapour bubbles inside the boiler.
7. When the pressure reaches 10 bar absolute (9 bar gauge) stop the test and switch off the heater.
8. When you switch off the heater, note the relatively fast drop in pressure when you remove the heat flow.

Absolute Pressure p (kPa)	Temperature T (K)	Log Pressure (log kPa)	$1000/T$ (1000/K)	Theoretical T (K)

Table 3 Blank Results Table

Results Analysis

What did you note about the size and quantity of the water vapour bubbles as the pressure changed?

Use either the graphical method or the Antoine equation to predict the temperatures for your recorded pressures.

NOTE

For your graphical method chart, you must start your x (horizontal) axis from 0 and interpolate your results back to the vertical line to find the intercept.

Alternatively, VDAS charting or spreadsheet software may automatically calculate the intercept and gradient for you.

Compare your theoretical temperatures with the actual temperatures to confirm the theory.

Now create a chart of recorded temperature (in Kelvin or °C) against absolute pressure (in kPa). Add to your chart the typical values from textbooks and compare the curves.

If there are differences, can you explain them?

Results

These results are typical only. Actual results may be slightly different - determined by local conditions such as water quality.

You should note the size and quantity of the water vapour bubbles decreases as steam pressure increases. This suggests that the increased pressure restricts the size and formation of the bubbles, as discussed in the theory.

Your actual results and those from theory should all compare well with textbook values, showing that you can accurately predict steam pressures or temperatures for a given range.

Any differences may be due to different water quality, slight instrument errors (expect better than 5% accuracy for both the temperature and pressure sensors) and results taking errors (when not using VDAS). If you did not correctly hold the pressure relief valve open until 100°C as described in the procedure, expect to see errors in the early readings, as the pressure recovers over an offset due to any trapped expanding air.

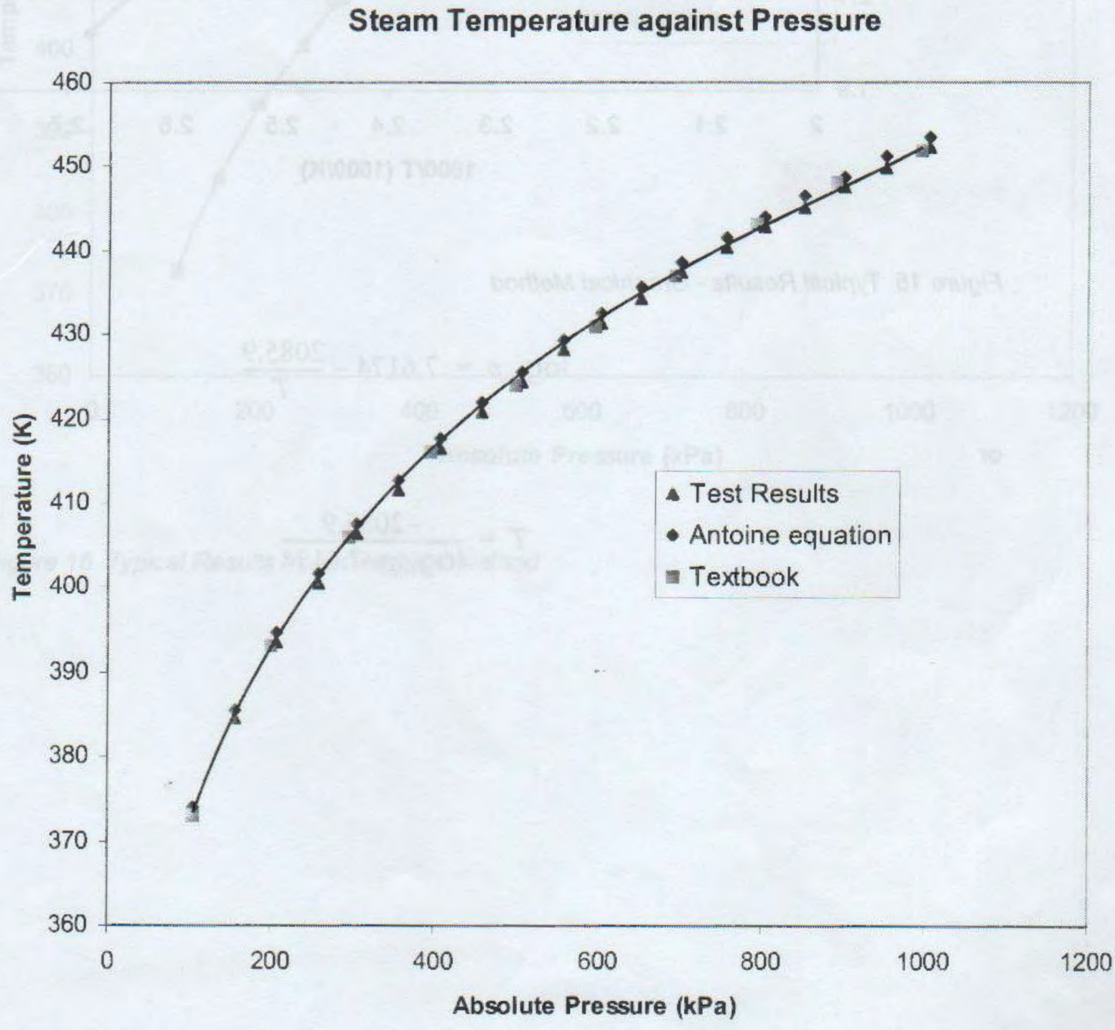

Figure 14 Typical Results With Antoine Equation

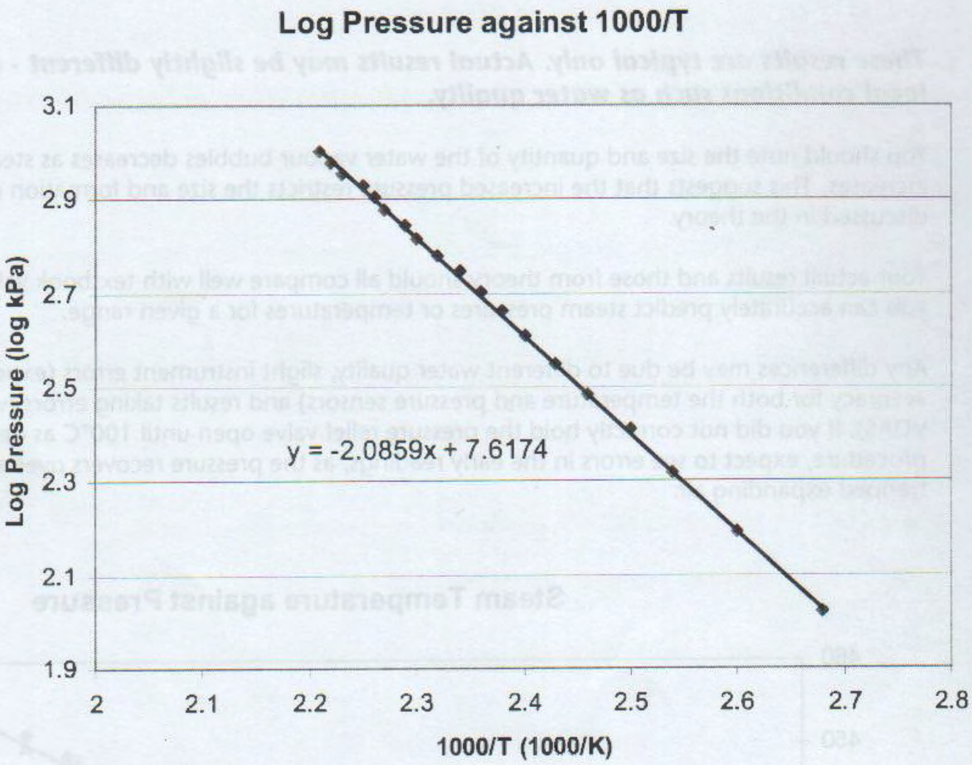

Figure 15 Typical Results - Graphical Method

$$\log_{10}p = 7.6174 - \frac{2085.9}{T}$$

or

$$T = \frac{-2085.9}{\log_{10}p - 7.6174}$$

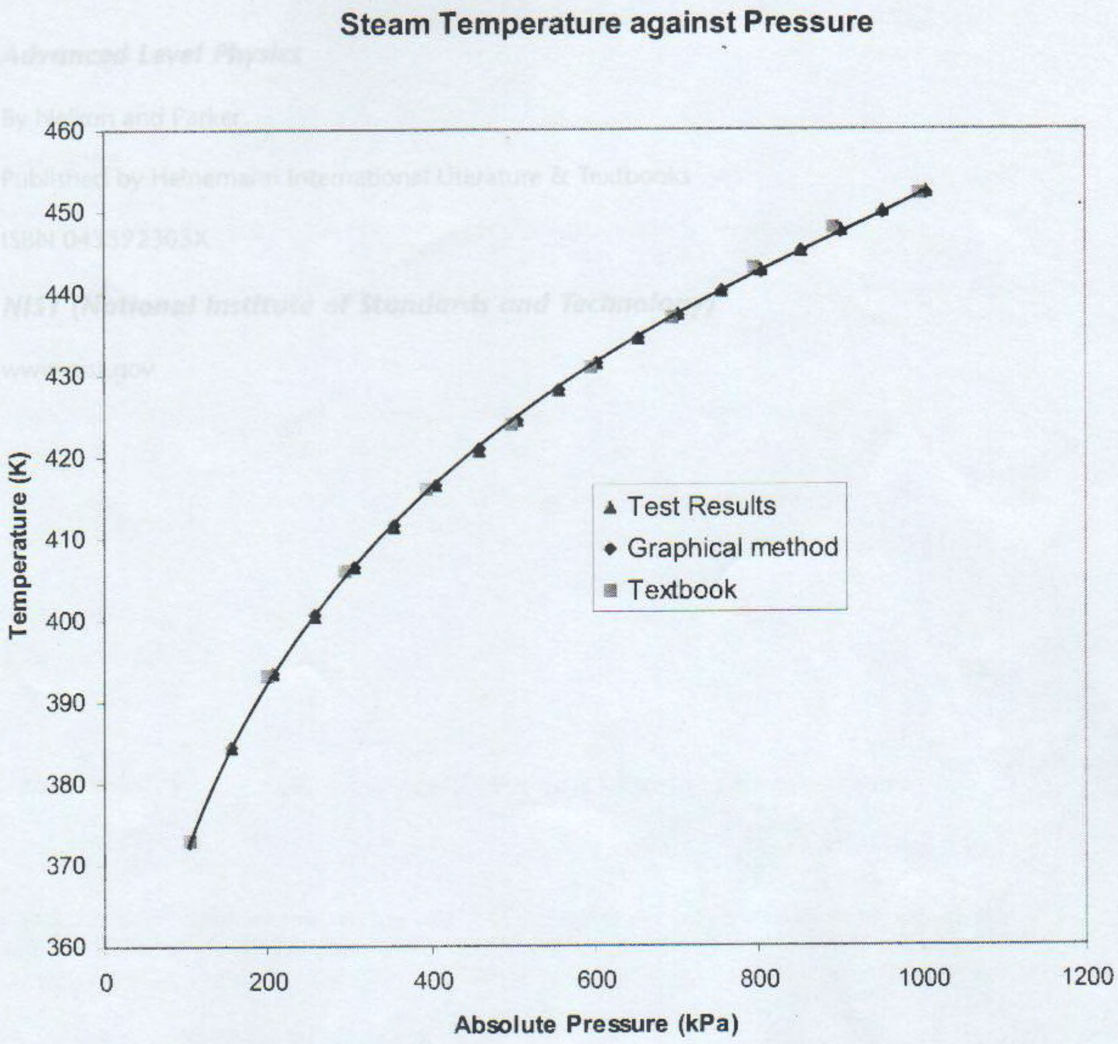

Figure 16 Typical Results from Graphical Method

Useful Textbooks and Resources

Advanced Level Physics

By Nelkon and Parker

Published by Heinemann International Literature & Textbooks

ISBN 043592303X

NIST (National Institute of Standards and Technology)

www.nist.gov

Maintenance, Spare Parts and Customer Care

Maintenance

General

Regularly check all parts of the apparatus for damage, renew if necessary.

When not in use, remove the filler cap and store the apparatus in a dry, dust-free area, covered with a plastic sheet. If the apparatus becomes dirty, wipe the surfaces with a damp, clean cloth. Do not use abrasive cleaners.

Regularly check all fixings and fastenings for tightness, adjust where necessary.

NOTE *Renew faulty or damaged parts with an equivalent item of the same type or rating.*

Water Stains

WARNING ***Only allow qualified people to service this equipment.***

If you use clean deionized water, the inside of the boiler should remain clear. However, should the window become too discoloured for you to see the water level clearly, you may remove it to clean it. To do this:

1. Make sure the boiler is cool and not under pressure.
2. Disconnect the electrical supply.
3. Remove the two screws that hold the red level indicator.

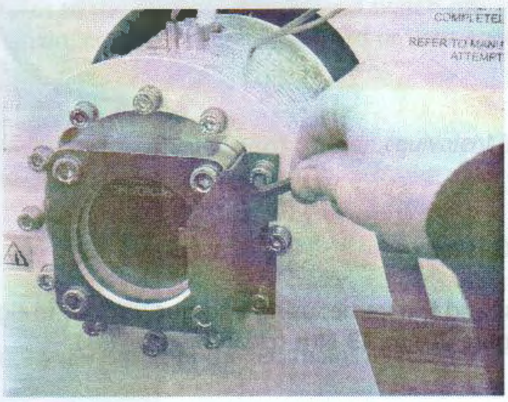

Figure 17 Remove the Two Screws that Hold the level Indicator

4. Remove the four screws that hold the window frame.

5. Carefully lift away the window frame complete with the glass and the gasket.

6. Clean the glass using hot soapy water.

7. Check the glass and all fixing screws for any damage. Contact TecQuipment if you see any damage and do not refit the glass.

8. Check the two sealing gaskets - one between the glass and boiler and one between the glass and the frame. Replace them if you can see any damage.

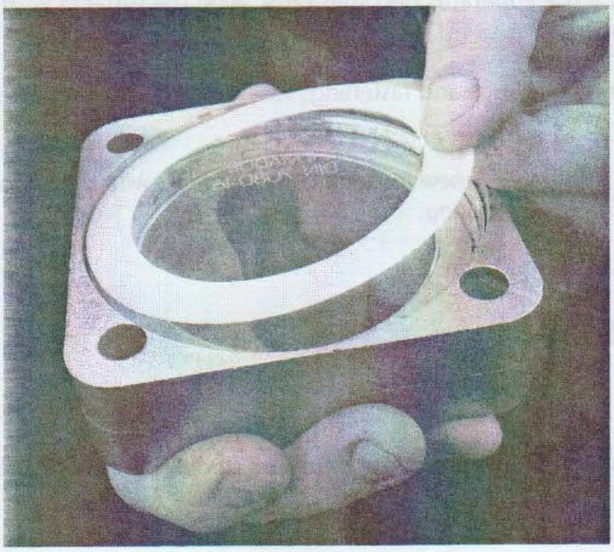

Figure 18 Gasket Between Glass and Boiler

9. A third gasket surrounds the glass, separating the glass from the frame (see Figure 19). This gasket is not a seal.

Figure 19 Third Gasket

10. Refit the glass and the frame, using a torque wrench to tighten the four frame screws in the right order (see Figure 20) to **33 Nm** (clean dry threads).

11. Carefully test the boiler up to its maximum conditions and check for leaks.

WARNING

If in doubt - contact TecQuipment.

When retesting after cleaning, take extra care in case of errors or leaks.

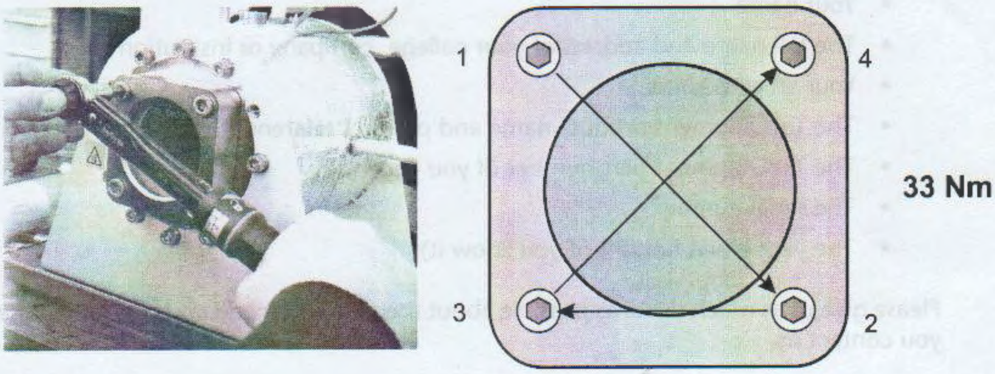

Figure 20 Tighten the Four Screws in Order Diagonally

Electrical

WARNING

Only a qualified person may carry out any electrical maintenance.

Obey these procedures:

- Assume the apparatus is energised until it is known to be isolated from the electrical supply.
- Use insulated tools where there are possible electrical hazards.
- Confirm that the apparatus earth circuit is complete.
- Identify the cause of a blown fuse before renewing.

To renew a broken fuse

- Isolate the apparatus from the electrical supply.
- Renew the fuse.
- Reconnect the apparatus to the electrical supply and switch on.
- If the apparatus fails again, contact TecQuipment Ltd or your agent for advice.

NOTE

Renew faulty or damaged parts with an equivalent item of the same type or rating.

Fuse Location

At the side of the equipment, forming part of the IEC mains inlet.

Spare Parts

Check the Packing Contents List to see what spare parts we send with the apparatus.

If you need technical help or spares, please contact your local TecQuipment agent, or contact TecQuipment direct.

When you ask for spares, please tell us:

- Your name
- The full name and address of your college, company or institution
- Your email address
- The TecQuipment product name and product reference
- The TecQuipment part number (if you know it)
- The serial number
- The year it was bought (if you know it)

Please give us as much detail as possible about the parts you need and check the details carefully before you contact us.

If the product is out of warranty, TecQuipment will let you know the price of the spare parts.

Customer Care

We hope you like our products and manuals. If you have any questions, please contact our Customer Care department:

Telephone: +44 115 954 0155

Fax: +44 115 973 1520

Email: **customer.care@tecquipment.com**

For information about all TecQuipment products visit: **www.tecquipment.com**