
USER MANUAL

# VerCal

## OXYGEN BOMB CALORIMETER

The VerCal is an advanced bomb calorimeter engineered for accurate determination of the heat of combustion and calorific value of a wide range of fuels and materials. Combining cutting-edge technology with a user-friendly interface, it delivers precise and consistent results, making it an ideal choice for laboratories and industrial settings. Its robust design and versatile functionality ensure reliable performance across various applications, supporting research, quality control, and energy analysis with ease.

TABLE OF

# CONTENTS

ADVANCED HEAT OF

# COMBUSTION ANALYSIS

# ADVANCED HEAT OF COMBUSTION ANALYSIS

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1

ASTM D240 - IP 12

**Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb CalorimeterThis test method is utilized to determine the heat of combustion of liquid hydrocarbon fuels, which range in volatility from light distillates to residual fuels.**

2

ASTM D4809 - ASTM D2382 (Obsolete)

**Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)This test method is designed to determine the heat of combustion of hydrocarbon fuels with a precision intended for aviation turbine fuels. The allowable difference between duplicate determinations is specified to be approximately 0.2%. A wide range of volatile and non-volatile materials can be analyzed, particularly where higher precision is required.**

3

ASTM D5865 - ASTM D3286 (Obsolete)

**Standard Test Method for Gross Calorific Value of Coal and CokeThis test method is employed to determine the gross calorific value of coal and coke by utilizing an adiabatic bomb calorimeter.**

4

ISO 1716

**Reaction to Fire Test for Building ProductsThis method determines the heat of combustion of building products at a constant volume using a bomb calorimeter.**

CONTROL

# ELEMENTS AND ACCESSORIES

# CONTROL ELEMENTS AND ACCESSORIES


*Figure 1:* *Front Panel*


*Figure 2:* *Rear Panel*

# CONTROL ELEMENTS AND ACCESSORIES


Figure 3: **Right Panel**


Figure 4: **Left Panel**



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# CONTROL ELEMENTS AND ACCESSORIES


**Figure 5:** *Top Panel*

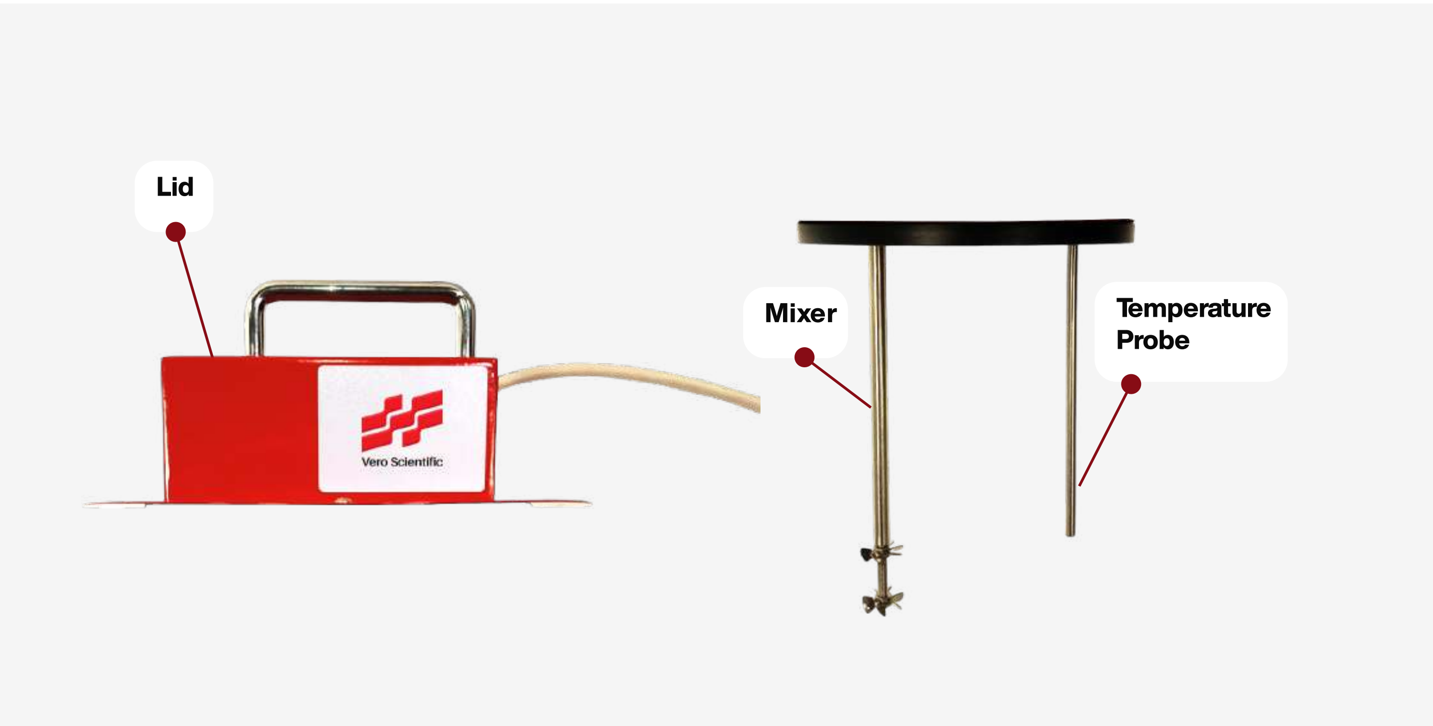


**Figure 6:** *Lid, Mixer, Temp. Probe*

# CONTROL ELEMENTS AND ACCESSORIES

**Figure 7:** *Calorimeter Jacket*


**Figure 8:** *Oval Bucket*



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# CONTROL ELEMENTS AND ACCESSORIES

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Figure 9: Ignition Electrodes

Figure 10: Combustion Capsule

Figure 11: Oxygen Combustion Vessel

Figure 12: Oxygen Vessel Parts

SAFE AND EFFICIENT

# PREPARING THE OXYGEN BOMB

# SAFE AND EFFICIENT PREPARING THE OXYGEN BOMB

- A sample cup should be tarred.
- A sample should be weighed to the nearest 0.0001 g (0.1 mg)
- A fuse wire should be attached.
- The fuse wire should be positioned so that it touches the top of a solid pellet.
- The fuse wire should not be buried in a powdered or granulated sample.
- The fuse wire may touch a liquid sample or be positioned appropriately.

The head should be loaded into the bomb cylinder:

A: The head should be placed into the cylinder.

B: The cap should be screwed on as far as it will go and then backed off slightly. It should not be over-tightened.

C: The Oxygen Fill Connection should be placed onto the oxygen filling inlet.

D: Using the bomb lifter, the bomb should be positioned partway into the bucket.

E: The ignition wires should be attached to the terminals on the bomb head.

F: Efforts should be made to avoid getting fingers wet.

G: The bomb should be lowered the rest of the way into the bucket.

H: The bomb should sit on the embossed circle at the bottom of the bucket.

I: The bomb should be observed to ensure that no oxygen leaks are present.

J: Do NOT proceed if bubbles are observed coming from the bomb.

*Oxygen Filling Unit*

MEASUREMENT OF

# HEATING VALUE PROCESS

# MEASUREMENT OF HEATING VALUE PROCESS

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## PRECAUTIONS

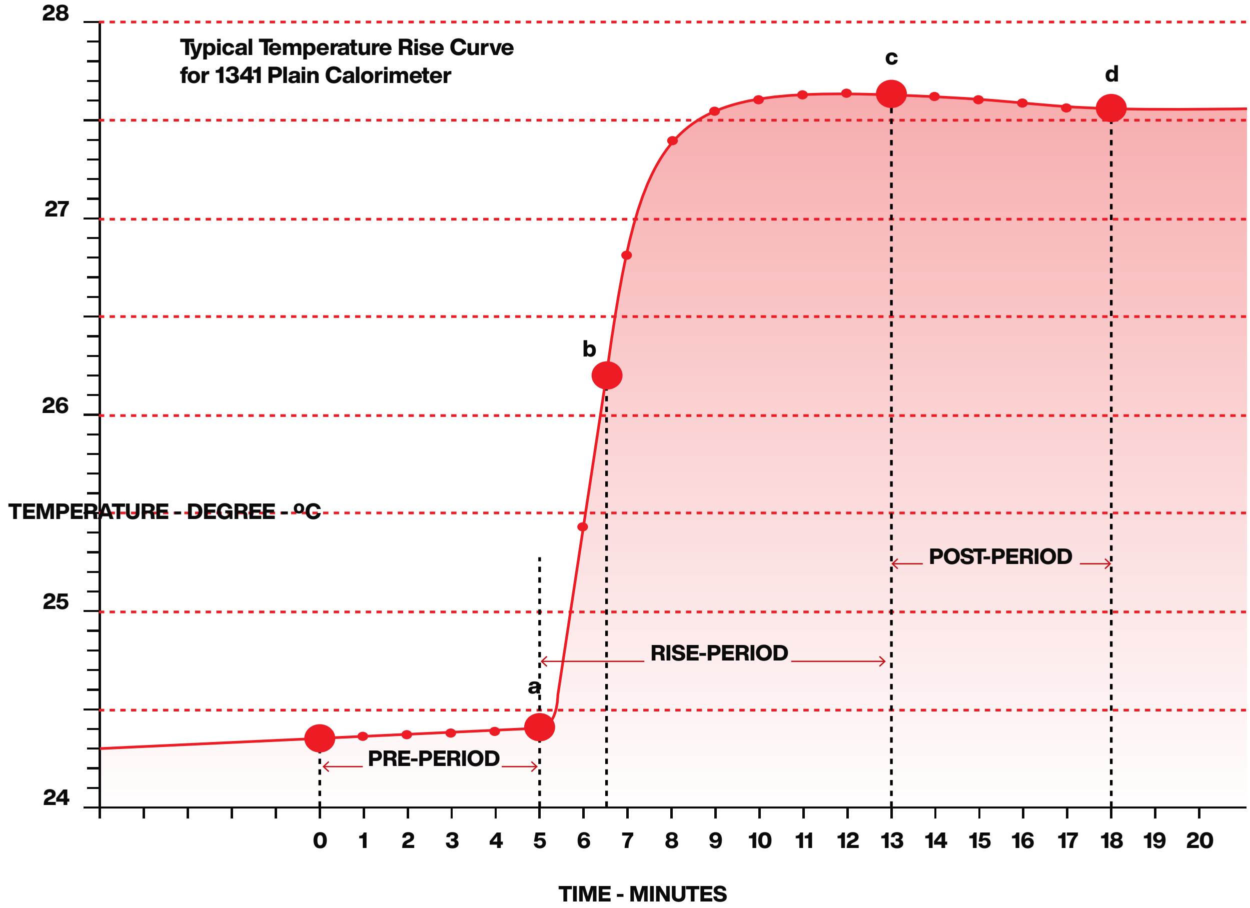
1. A sample that will react explosively or weighs more than 1.5 grams should not be placed in the bomb. A sample size of less than 1.1 grams is typically recommended.
2. The bomb should not be overcharged with oxygen. The initial charge should not exceed 40 atm (519 psig), with the usual charging pressure being 30 atm.
3. The bomb should be completely submerged, and the electrodes should be attached before firing.
4. The area around the bomb should be cleared during firing, and the bomb should not be handled until the water temperature reaches a steady state.

## OPERATING THE CALORIMETER

All operations required to test a sample or to standardize the calorimeter should proceed step-by-step as follows:

1. The sample should be prepared and the oxygen bomb charged as described in the section Preparing the Sample.
2. The calorimeter bucket should be filled by first taring the dry bucket on a solution or trip balance. Then, 2000 (+/- 0.5) grams of water should be added. Distilled water is preferred; however, demineralized or tap water containing less than 250 ppm of dissolved solids is acceptable. The water temperature should be approximately 1.5°C below room temperature, though this can be adjusted to suit the operator's preference. It is not necessary to use exactly 2000 grams; however, the amount selected must be duplicated within +/- 0.5 grams for each run. Alternatively, the bucket can be filled using an automatic pipette or any other volumetric device if the repeatability of the filling system is within +/- 0.5 ml, and the water temperature is maintained within a 1°C range.
3. The bucket should be placed in the calorimeter. The lifting handle should be attached to the two holes in the side of the screw cap, and the bomb should be partially lowered into the water. The bomb should be handled carefully during this operation to avoid disturbing the sample. The two ignition lead wires should be inserted into the terminal sockets on the bomb head. The wires should be oriented away from the stirrer shaft to prevent entanglement in the stirring mechanism. The bomb should be lowered completely into the water, ensuring that its feet span the circular boss at the bottom of the bucket. The lifting handle should then be removed, and any water droplets should be shaken back into the bucket. Gas bubbles should be checked for.

# MEASUREMENT OF HEATING VALUE PROCESS




4. The cover should be set on the jacket. The stirrer should be turned by hand to ensure that it runs freely, and then the unit should be turned on.
5. The stirrer should be allowed to run for 5 minutes to reach equilibrium before starting a measured run. At the end of this period, the time should be recorded on the timer, and the temperature should be noted.
6. Temperatures should be read and recorded at one-minute intervals for 5 minutes. Then, at the start of the 6th minute, the next step should be performed.
7. The operator should stand back from the calorimeter and fire the bomb by pressing the ignition button. Caution: The head, hands, or any other parts of the body should not be positioned over the calorimeter when firing the bomb. The operator should continue to stand clear for 30 seconds after firing.
8. The bucket temperature will begin to rise within 20 seconds after firing. This rise will be rapid during the first few minutes and then slow as the temperature approaches a stable maximum, as shown by the typical temperature rise curve below. While it is not necessary to plot a similar curve for each test, accurate time and temperature observations must be recorded to identify the specific points required for calculating the calorific value of the sample.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9. The time required to reach 60 percent of the total rise should be measured by estimating the temperature at the 60% point and observing the time when the temperature reading reaches that point. If the 60% point cannot be estimated before ignition, temperature readings should be taken at 45, 60, 75, 90, and 105 seconds after firing. The 60% point should then be identified by interpolating between these readings after the total rise has been measured.

10. After the rapid rise period (approximately 4 or 5 minutes after ignition), temperatures should be recorded at one-minute intervals until the difference between successive readings remains constant for five minutes. Typically, the temperature will reach a maximum and then drop very slowly. However, this is not always the case, as a low starting temperature may lead to a slow, continuous rise without reaching a maximum. As previously mentioned, the difference between successive readings should be noted, and the readings should continue at one-minute intervals until the rate of temperature change becomes constant over a period of 5 minutes.

11. After the last temperature reading, the motor should be stopped, and the cover should be lifted from the calorimeter. The thermistor shaft and stirrer should be wiped with a clean cloth. The bomb should be lifted out of the bucket, the ignition leads should be removed, and the bomb should be wiped with a clean towel.

12. The knurled knob on the bomb head should be opened to release the gas pressure before attempting to remove the cap. This release should proceed slowly over a period of no less than one minute to avoid entrainment losses. Once all pressure has been released, the cap should be unscrewed. The head should then be lifted out of the cylinder and placed on the support stand. The interior of the bomb should be examined for soot or other evidence of incomplete combustion. If such evidence is found, the test must be discarded.

13. All interior surfaces of the bomb should be washed with a jet of distilled water, and the washings should be collected in a beaker.

14. All unburned pieces of fuse wire should be removed from the bomb electrodes. The wire should be straightened and its combined length measured in centimeters. This length should be subtracted from the initial length of 10 centimeters, and the result should be entered on the data sheet as the net amount of wire burned. Alternatively, the correction in calories can be found on the card of the 45C10 fuse wire.

15. The bomb washings should be titrated with a standard sodium carbonate solution using methyl orange or methyl red as the indicator. A 0.0709N sodium carbonate solution is recommended for this titration to simplify the calculation. his solution is prepared by dissolving .ams of aCOater and diluting to one liter.
NaOH or KOH solutions of the same normality may also be used.

CALCULATING THE

# THE HEAT OF COMBUSTION

# CALCULATING THE HEAT OF COMBUSTION

## ASSEMBLY OF DATA

The following data should be available at the completion of a test:

$a$ = time of firing

$b$ = time (to nearest 0.1 min.) when the temperature reaches 60 per cent of the total rise

$c$ = time at beginning of period (after the temperature rise) in which the rate of temperature change has become constant

$t_a$ = temperature at time of firing

$t_c$ = temperature at time c

$r_1$ = rate (temperature units per minute) at which the temperature was rising during the 5-min. period before firing

$r_2$ = rate (temperature units per minute) at which the temperature was rising during the 5-min. period after time c. If the temperature was falling instead of rising after time c, r is negative and the quantity -r (c-b) becomes positive and must be added when computing the corrected temperature rise

$c_1$ = milliliters of standard alkali solution used in the acid titration

$c_2$ = percentage of sulfur in the sample

$c_3$ = centimeters of fuse wire consumed in firing

$W$ = energy equivalent of the calorimeter, determined under standardization

$M$ = mass of sample in grams

### Temperature Rise

Compute the net corrected temperature rise, t, by substituting in the following equation:

$$t = t_c - t_a - r_1 (b-a) - r_2 (c-b)$$

# CALCULATING THE HEAT OF COMBUSTION

## THERMOCHEMICAL CORRECTIONS

**Compute the following for each test:**

$e_1$ = Correction in calories for heat of formation of nitric acid
.lkali was used for the titration.

$e_2$ = Correction in calories for heat of formation of sulfuric acid SO
.

$e_3$ = **Correction in calories for heat of combustion of fuse wire**
hen using Parr Cel-chromium fuse wire, or
hen using o. uge iron fuse wire.

Gross Heat of Combustion

**Compute the gross heat of combustion, Hg, in calories per gram by substituting in the following equation:**

$$t = t_c - t_a - r_1 (b-a) - r_2 (c-b)$$

$$H_g = \frac{tW - e_1 - e_2 - e_3}{m}$$



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## *Conversion to Other Bases*

*The calculations described above provide the calorific value of the sample with moisture, as it existed when the sample was weighed. For instance, if an air-dried coal sample was tested, the results will be expressed in terms of heat units per weight of the air-dry sample. This can be converted to a moisture-free or other dry basis by determining the moisture content of the air-dry sample and using conversion formulae published in ASTM Method D3180 and other references on fuel technology.*

*The calorific value obtained from a bomb calorimeter test represents the gross heat of combustion of the sample. This includes the heat produced during combustion, as well as the heat released when the newly formed water vapor condenses and cools to the temperature of the bomb. In nearly all industrial operations, this water vapor escapes as steam in the flue gases, and the latent heat of vaporization contained within it is not available for useful work. The net heat of combustion, which is obtained by subtracting the latent heat from the gross calorific value, is therefore an important figure in power plant calculations.*

*If the percentage of hydrogen (H) in the sample is known, the net heat of combustion, Hn, in Btu per pound can be calculated as follows:*

Example:

a = 1:44:00 = 1:44.0

b = 1:45:24 = 1:45.2

c = 1:52:00 = 1:52.0

$t_a$ = 24.428 + 0.004 = 24.432 ºC

$t_c$ = 27.654 + 0.008 = 27.662 ºC

$r_1$ = + 0.010 ºC / 5min. = + 0.002 ºC / min.

$r_2$ = + 0.004 ºC / 5min. = + 0.01 ºC / min.

$c_1$ = 23.9 ml.

$c_2$ = 1.02% Sulfur

$c_3$ = 7.6 cm. Parr 45C10 wire

W = 2426 calories / ºC

m = 0.9936 grams

t = 27.662 - 24.432 - (0.002) (1.4) - (-0.001) (6.6) = 3.234 ºC

$e_1$ = 23.9 calories

$e_2$ = (13.7) (1.02) (0.9936) = 13.9 calories

$e_3$ = (2.3) (7.6) = 17.5 calories

$$H_g = \frac{(3.234)(2426) - 23.9 - 13.9 - 17.5}{0.9936}$$

= 7841 calories / gram

= (1.8) (7841) = 14,114 Btu / lb

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As Vero Scientific, we provide advanced measurement technologies, preventive maintenance solutions, and cloud-based analytics for oil and fuel analysis. Our mission is to empower industries with precise, reliable, and sustainable solutions.