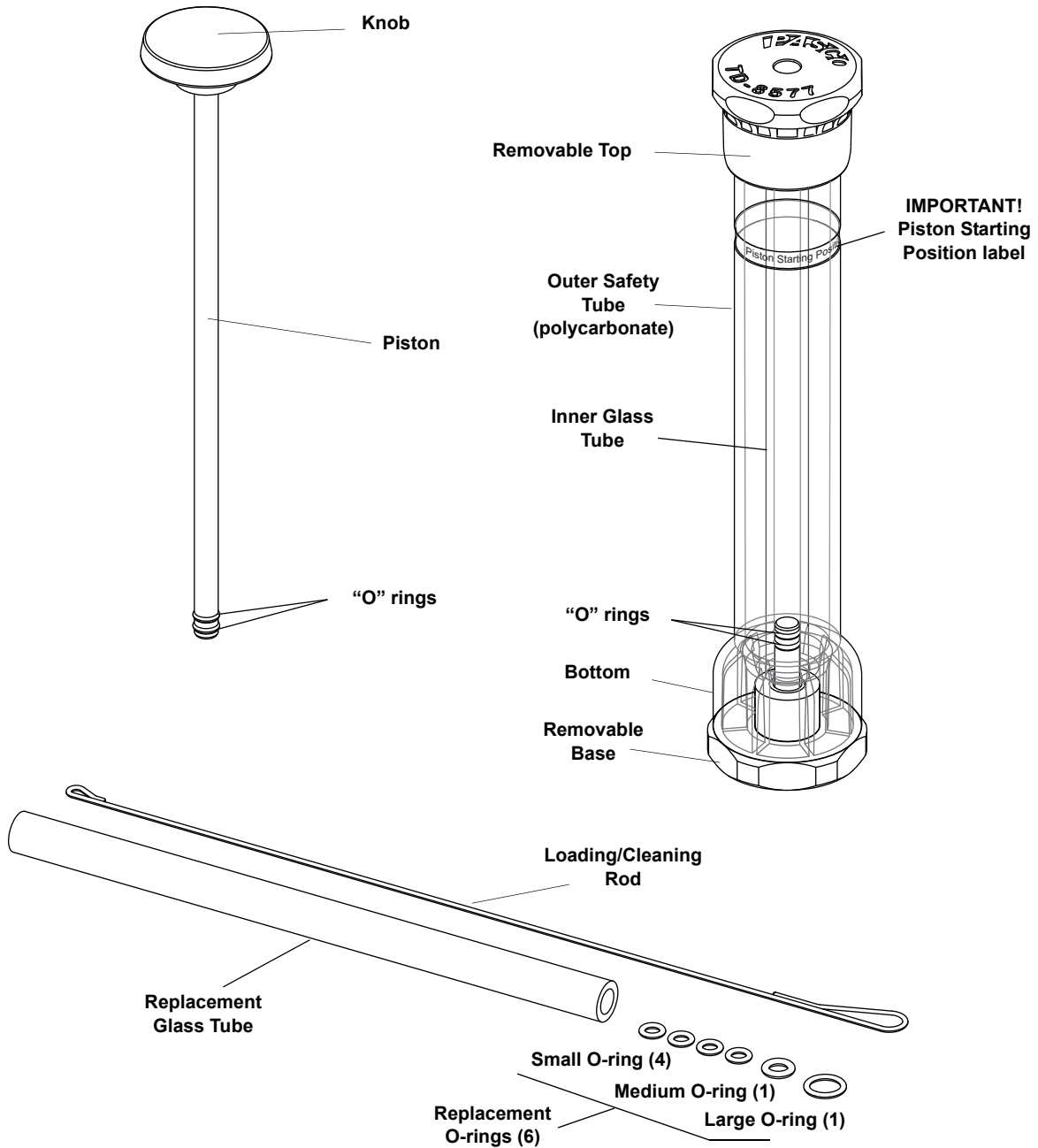


PASCO Compression Igniter

TD-8577



Included Equipment	Included Equipment
PASCO Compression Igniter	Replacement Glass Tube*
Loading/Cleaning Rod	Replacement O-rings* (6)
Lubricant, silicone compound, (2 packets), not shown	Material Safety Data Sheet for Lubricant
Additional Item Needed	Cotton, tissue paper, “flash paper”

* The TD-8498A Replaceable Glass Tubes includes two replacement tubes and twelve O-rings.

Introduction

The TD-8577 PASCO Compression Igniter (or “fire syringe”) illustrates what happens inside the cylinder of a diesel engine. It demonstrates the high temperatures produced during adiabatic compression of air by igniting a small amount of cotton, tissue paper, or magician’s “flash paper” inside a replaceable, thick-wall glass tube. The glass tube is encased in a polycarbonate safety tube that protects users from injury if the glass tube breaks. The piston has two rubber “O” rings at its end that provide a tight seal against the inside of the glass tube. When the piston is rapidly pressed down into the glass tube, the temperature inside the tube rises quickly.

The Compression Igniter comes with one replacement glass tube and six O-rings. The large O-ring is a replacement for the ring at the top of the inner glass tube. The medium O-ring is a replacement for the ring at the top of the piston rod where it joins the knob. The small O-rings are replacements for the rings on the end of the piston rod and for the rings on the post that is part of the removable base.

Theory

The compression of air inside a hollow cylinder is an *adiabatic process* since the compression is so fast that there is no time for thermal energy to leave or enter the cylinder.

For an adiabatic compression of gas, $PV^\gamma = \text{constant}$, where P is the pressure of the gas, V is the volume of the gas, and γ is the ratio of specific heats of the gas (specific heat at constant pressure divided by specific heat at constant volume)

Therefore, when the gas in the cylinder is at its original volume V_0 and pressure P_0 and then is compressed to a small volume V and pressure P ,

$$PV^\gamma = P_0V_0^\gamma$$

With the compression igniter, it is possible to compress the gas in the cylinder by a factor of about 15, so $V_0 = 15V$. With this assumption, the final pressure at maximum compression can be calculated in terms of the initial (atmospheric) pressure:

$$PV^\gamma = P_0(15V)^\gamma$$

$$P = 15^\gamma P_0$$

The quantity that is of interest is the final temperature: Is it high enough to ignite paper? To arrive at the temperature, assume that the gas is air and that it is an ideal gas. For an ideal gas,

$$P_0V_0 = nRT_0 \text{ and}$$

$$PV = nRT$$

The ignition temperature of paper is about 451 °F.

See the science fiction novel [Fahrenheit 451](#) by Ray Bradbury.

where n is the number of moles of gas, R is the gas constant, and T is the absolute (thermodynamic) temperature. Solving the initial equation for nR and substituting the expression into the final equation gives:

$$PV = \frac{P_0 V_0 T}{T_0}$$

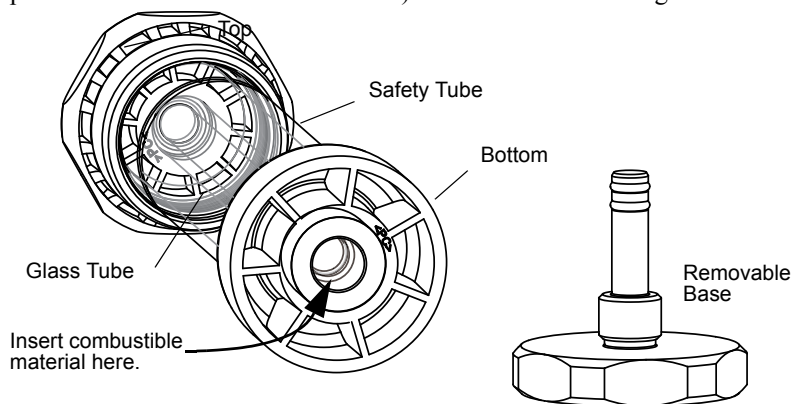
Solving for the final temperature, T , and substituting the final pressure, P , derived from the adiabatic equation and the final volume, V , which is $1/15$ the initial volume gives:

$$T = \frac{PV}{P_0 V_0} T_0 = \frac{15^\gamma P_0 V}{P_0 (15V)} T_0$$

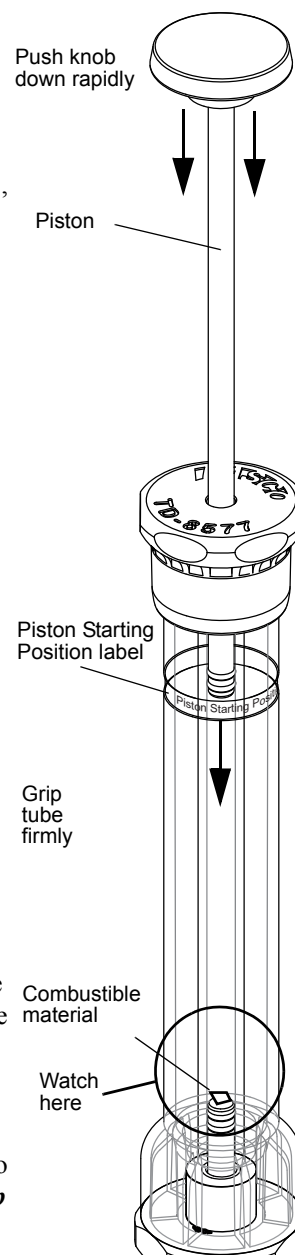
Simplifying this expression gives $T = 15^{(\gamma-1)} T_0$. For air, which is mainly diatomic, $\gamma = 1.4$, so this gives $T = 15^{0.4} T_0$. Assuming that the initial temperature is about $24\text{ }^\circ\text{C}$ (297 K), then $T = 15^{0.4} (297\text{ K}) = 877\text{ K}$. Converting to celsius, $T = 604\text{ }^\circ\text{C}$. Since $604\text{ }^\circ\text{C} = 1120\text{ }^\circ\text{F}$, the temperature is high enough to ignite paper.

Operation

1. Turn the removable base counterclockwise to unscrew it from the bottom of the igniter. Remove the base and set it aside.
2. Insert a small piece ($\sim 1\text{ cm}^2$) of tissue paper or a few strands of cotton fiber (e.g., pulled from the end of a cotton swab) into the bottom of the glass tube.



3. Use the loading/cleaning rod to push the material up into the lower part of the glass tube. Carefully remove the loading/cleaning rod without pulling the material out of the lower part of the glass tube.
4. **IMPORTANT:** Insert the piston into the top of the igniter and push it in far enough that the end of the piston lines up with or is slightly below the "Piston Starting Position" label on the outer tube 2.5 cm (1 inch) below the top.
5. Replace the removable base by screwing it clockwise into the bottom.
6. Place the base of the igniter on a sturdy horizontal surface and securely hold the tube with one hand. Make sure that the combustible material in the bottom of the glass tube is visible.
7. Watch the piece of combustible material at the bottom of the glass cylinder.
8. With the palm of your other hand, quickly slap down on the knob of the piston so the end of the piston goes down into the cylinder rapidly. **Slap it down and keep it down.**



Hints

- Do not ‘clump’ or compress the combustible material. Allow it to remain flat and spread out. The more surface area it has, the better.
- If the material does not ignite, try reducing the amount of material you put into the glass tube.
- If you are using a piece of tissue paper, remove the paper and tear it in half. Put one half of the paper back into the glass tube and try again.
- If you are using cotton and it does not ignite, reduce the number of strands of cotton and try again.
- After “firing” the Compression Igniter, remove the base and move the piston up and down in the cylinder to purge (remove) any combustion gases.

Maintenance

Cleaning

To remove fragments of burned material from the igniter, unscrew the removable base from the bottom of the igniter. Use the loading/cleaning rod to scrape any residue out of the lower part of the glass tube.

To clean the glass tube, remove the piston and the base. Use the loading/cleaning rod to push a small wad of tissue paper through the glass tube.

After cleaning, screw the removable base back into the bottom of the igniter. Do not use a wrench or other tool to tighten the removable base or the top. Instead, they should be only as tight as you can make them using your hand.

Lubrication

The “O” rings on the piston and the removable base are lubricated at the factory. If the “O” rings on the piston become dry, tear or cut the tip off the packet of lubricant. Squeeze a small drop (1 to 2 mm diameter) of lubricant onto an applicator (such as a toothpick, cotton-tipped swab, etc.), and rub the lubricant onto the two “O” rings. Store the open packet in a plastic bag or a small jar. CAUTION: Do not use a different lubricant than the kind provided.

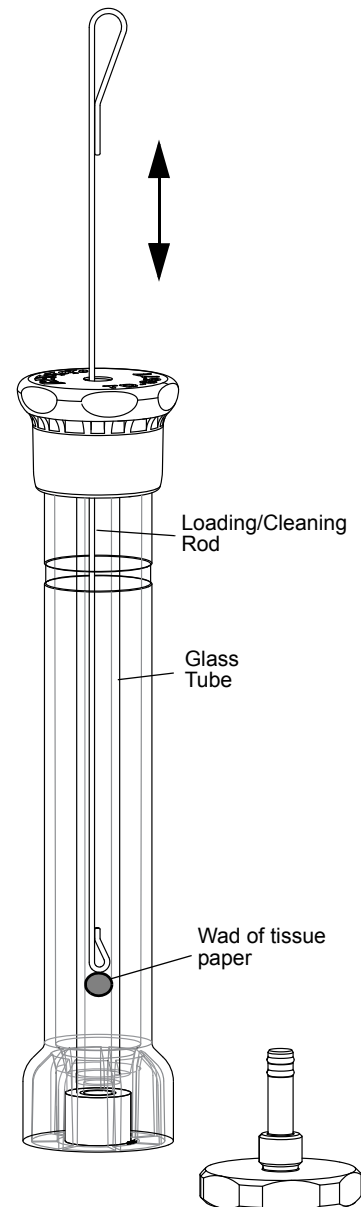
Storage

Store the compression igniter with the piston removed from the inner glass tube.

Caution

The inner cylinder in the Compression Igniter is thick-wall glass, but it can break if the Compression Igniter is dropped or if the piston is not far enough down into the glass tube when the igniter is used. Before using the igniter, be sure that the bottom of the piston is at least to the “Piston Starting Position” label.

Be careful when handling the Compression Igniter, and always store the igniter with the piston removed from the glass tube. The Compression Igniter is shipped with a replacement inner glass tube packed separately to minimize the possibility of damage during transit.

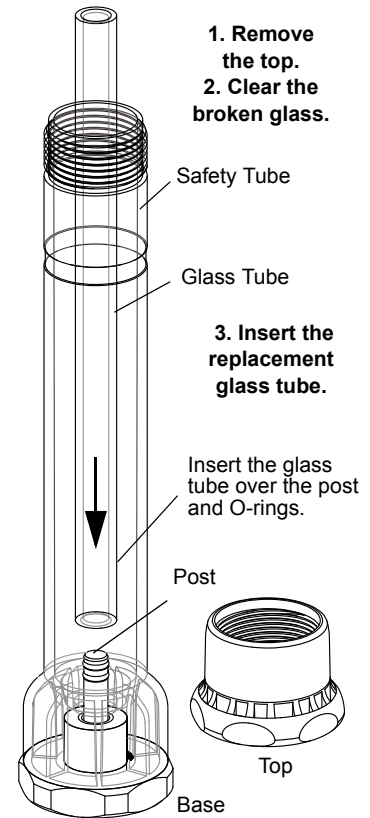


Replacing the Inner Glass Tube

If the glass tube in the Compression Igniter should break, replace it with the included replacement glass tube*.

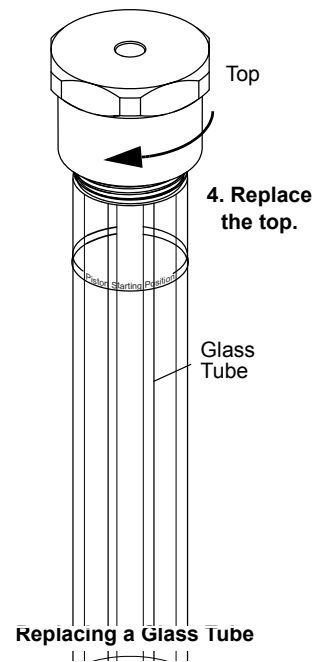
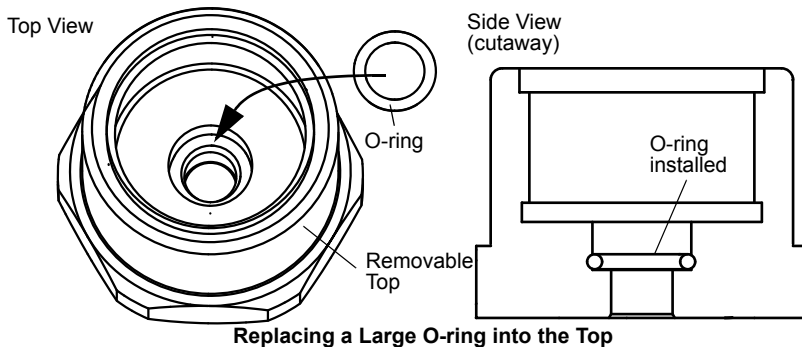
- Hold the igniter over a receptacle to catch any falling glass and remove the piston.
- Unscrew the removable base from the bottom, and unscrew the top from the safety tube.
- Carefully remove any broken glass from inside the safety tube and dispose of the glass properly.
- Check the condition of the O-rings and replace them if necessary. NOTE: If the O-rings show no abrasion damage, they do not need replacing.
- Screw the removable base into the bottom of the igniter. Leave the top off the igniter.
- Carefully insert the replacement glass tube into the igniter so that the bottom end of the glass tube fits over the post at the bottom of the igniter.
- Replace the top on the igniter. Be careful to line up the upper end of the inner glass tube with the hole in the top.

*The TD-8498A Replaceable Glass Tubes kit includes two more replacement tubes and twelve O-rings



Replacing a Large O-ring

- To replace the large O-ring in the top of the igniter, unscrew the top from the safety tube.
- Remove the old O-ring. (You may need to use a small, flat-blade screwdriver to remove the ring.)
- Place the replacement O-ring in the groove at the bottom of the hole. Make sure that the O-ring is flat against the bottom of the hole..



- Replace the top on the igniter. Line up the top end of the glass tube with the hole in the top and then turn the top clockwise to screw it onto the igniter.

Teacher and Technical Support

For assistance with any PASCO product, contact PASCO at:

Address: PASCO scientific
10101 Foothills Blvd.
Roseville, CA 95747-7100

Phone: +1 916 462 8384 (worldwide)
800-772-8700 (U.S.)

Web: www.pasco.com

Email: support@pasco.com

Specifications

Inside diameter of glass
tube = 0.797 cm

Compressible length of glass
tube = 18.308 cm

Compression ratio
(approximate) = 15 to 1

For more information about the PASCO Compression Igniter and the latest revision of this instruction sheet, visit the PASCO web site at www.pasco.com and enter TD-8577 in the Search window.

Limited Warranty

For a description of the product warranty, see the PASCO catalog.

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