Table of Contents

Go To Technical Menu

REF: Engine Mechanicals - Sub-07C

Differential Pressure

Vacuum pressure (negative) and air pressure (positive) are the terms that describe the amount of molecules of a gas in a given unit of space. [1)]
More molecules inside the engine than outside = inside air pressure.
Less molecules inside the engine than outside = inside is vacuum pressure.

Image two scenarios:

1. The case is sealed (closed to atmosphere).
    - The pistons just compress and relax the fluid in the case.
2. The case has a huge passage that allows the fluid to pass into and from the atmosphere.

Which takes more power to cycle?
Possibly the second.
Because the 1st, as the pistons use power to compress the fluid;
That power is returned as the pistons rise from the stored energy in the compressed fluid pushing pistons up.

That may be what's really happening for the most part in our bikes.
Obviously, the breather opening is too restrictive to allow so much flow that the case pressure stays more constant.
That restriction is on purpose to lessen the pumping losses by being closer to #1 than to #2.

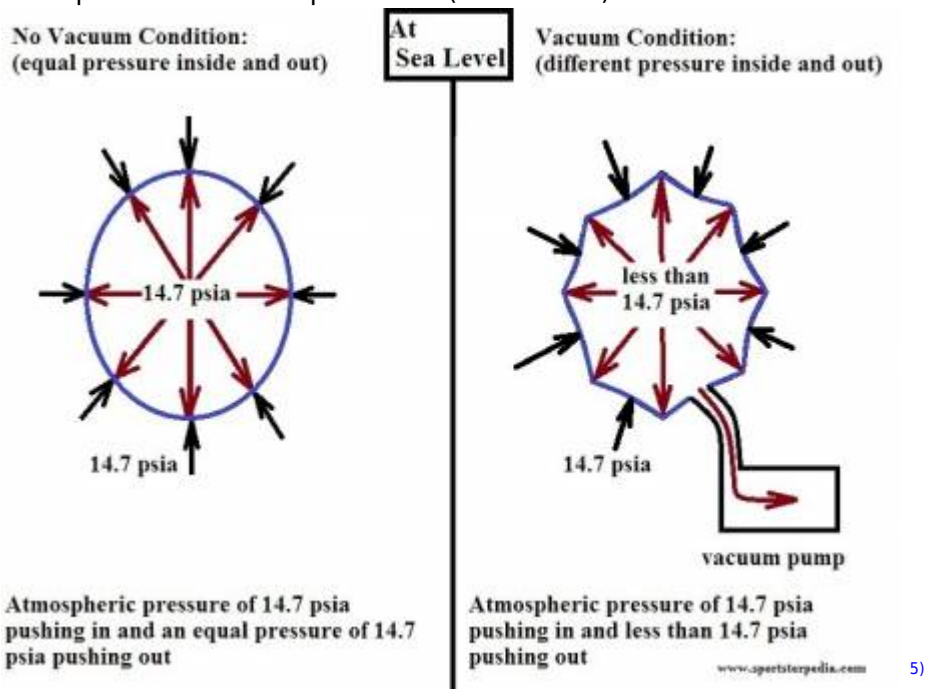
As the vacuum increases, the pumping losses decrease and the fluid is less dense. [2)]
On the flip side, less dense fluid can't suspend as much liquid (possibly resulting in more liquid drag).

Below is some terminology for vacuum measurements. [3)]
PSIG - (pounds per square inch (gauge):
Gauge pressure is pressure measured relative to ambient atmospheric pressure (approximately 14.7 PSIA).
PSIA - pounds per square inch (absolute):
Absolute pressure is measured relative to high vacuum (0 PSIA).
PSIV - pounds per square inch (vacuum):
Vacuum pressure is measured relative to ambient atmospheric pressure.
PSID - pounds per square inch (differential):
Differential pressure is pressure measured relative to a reference pressure.
If the reference pressure is one atmosphere the differential pressure range is equal to gauge pressure range.

The earth's atmosphere exerts a pressure upon us, known as the atmospheric pressure, which can be measured in a number of ways. [4)]
At sea level, the standard pressure is 14.7 psia or 29.92“ of mercury (Hg) or 760 mm of mercury (Torr).
Because the barometric pressure varies, the above “sea level” pressures are used as a reference point.
There is 14.7 psia pressure being exerted on us by the atmosphere, but there is also 14.7 psia inside of us pushing out.
(given the fact that for every action there is an equal but opposite reaction)
Thus, we do not feel discomfort from the atmospheric pressure.
Another way to state this is that there is no differential pressure between the inside and outside of our bodies.

The term “vacuum” is used to describe the zone of pressure below atmospheric pressure.
Vacuum is a negative gauge pressure, usually referenced to the existing standard barometric pressure where the equipment will operate.
This means vacuum is a differential reading between the surrounding atmospheric pressure and the pressure in the system evacuated.
In all instances when given a vacuum condition, the question should be asked, at what elevation the pump will operate.
(since the barometric pressure varies with altitude above or below sea level)

Example of differential pressures (or Vacuum):

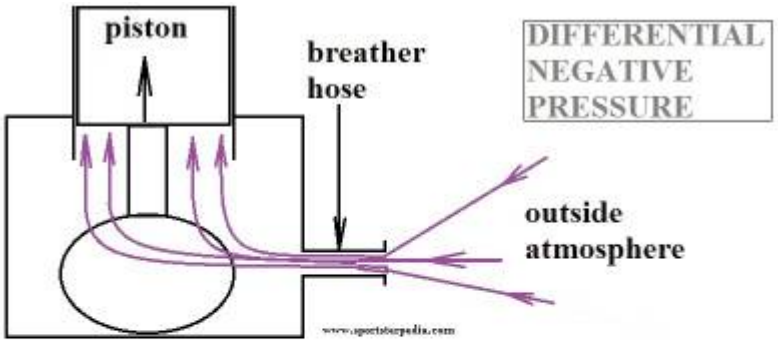


[5)]

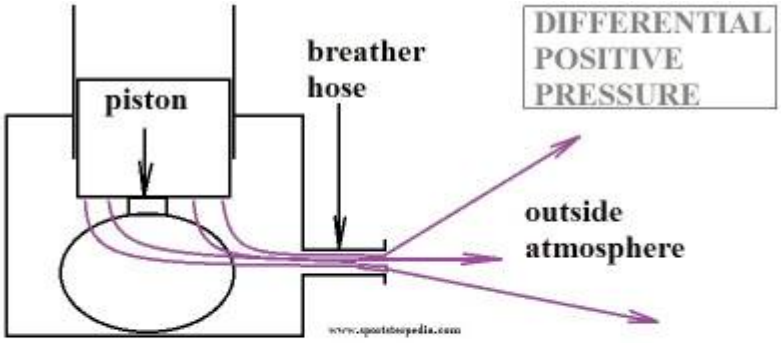
The breather valve is necessary to keep the imbalance in the crankcase (from the 45° arrangement) at bay.
The 57-76 timed breather mechanically closes after the pistons have began rising (upstroke). This creates a calculated amount of vacuum in the crankcase.
The 77-up one way valve closes when the upstroke begins. It's not mechanical. Vacuum pulls it closed.
The forces are simple in that during upstroke, a negative pressure is pulled inside.
The outside air has a higher pressure than the inside air does.
So the outside air tries to enter the engine.

57-76; By the time the timed breather closes, a certain amount of outside air has been pulled back into the crankcase. This lowers the amount of vacuum that is created by the full upstroke. 77-up; When the one way breather closes, it keeps outside air from entering the crankcase and the entire upstroke event creates vacuum.
So 77-up engines create more vacuum from the breather valve itself than their earlier counterpart. If the one way breather valve stays open or doesn't seal fully, higher air pressure and lower vacuum pressure cycle in and out with piston positions.
This is similar to a person coughing and inhaling then coughing again etc. but very much faster than that.

Differential pressure as it applies to the Sportster breathing system:



With the piston rising, air is pulled up under the piston. The pulled air pressure is higher than the atmosphere outside the engine. We refer to this as a vacuum condition inside the engine. If there were no breather valve inline, atmosphere would be pulled into the engine. Also expressed as a negative pressure. Also measured with a vacuum gauge. [6)]

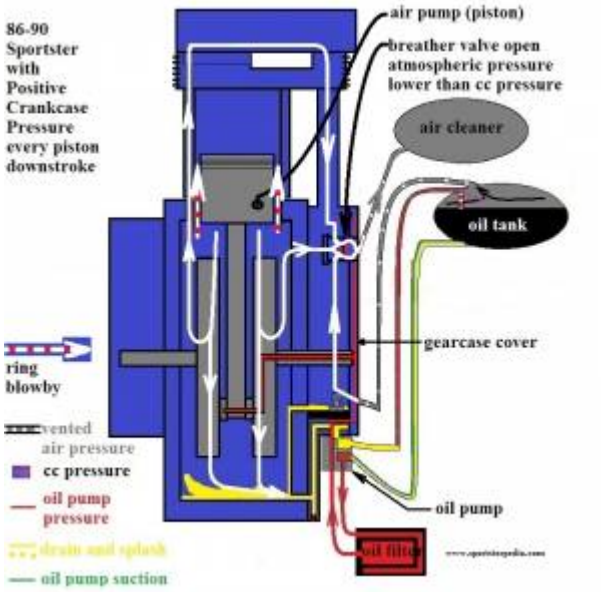


With the piston falling, air is pushed by the piston. The pushed air pressure is higher than the atmosphere outside the engine. We refer to this as a pressure condition inside the engine. With / without the breather valve inline, air is pushed out of the engine. Also expressed as a positive pressure. Also measured with a PSI gauge.

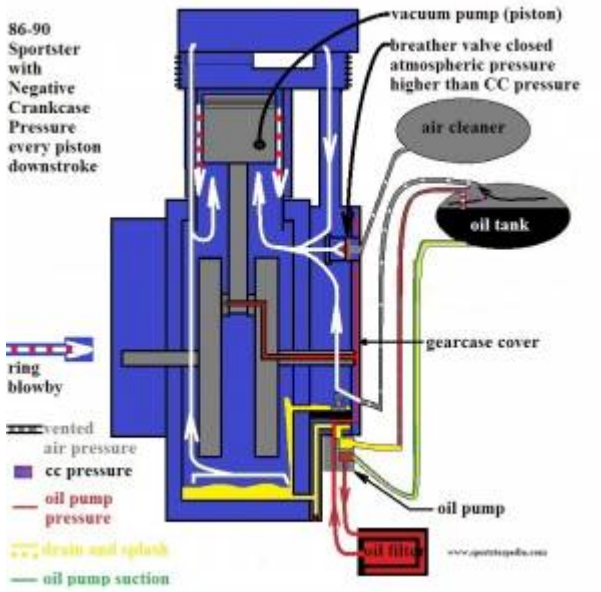
Applying the same principles, you can see the relation of positive and negative crankcase pressure in the Sportster engine.
Every piston upstroke and downstroke reverses crankcase pressure from positive to negative forces.
The pistons act as an air pump and then a suction pump respectively.

Below are drawings exampling positive and negative (vacuum) forces inside the engine.

86-90 models with cam chest breather vents:

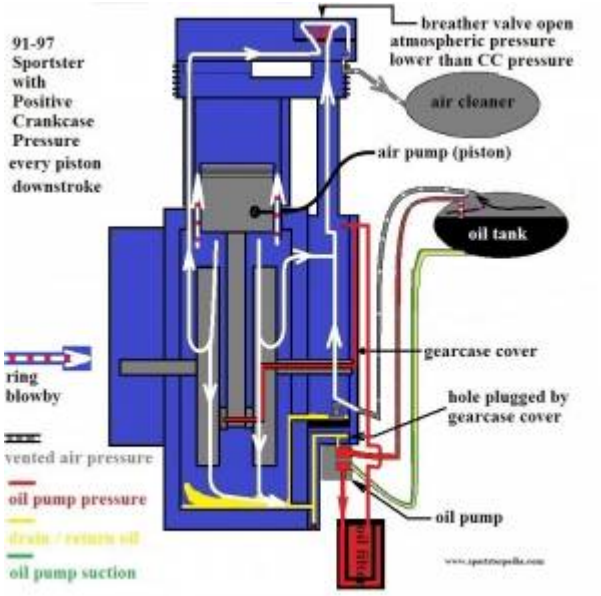


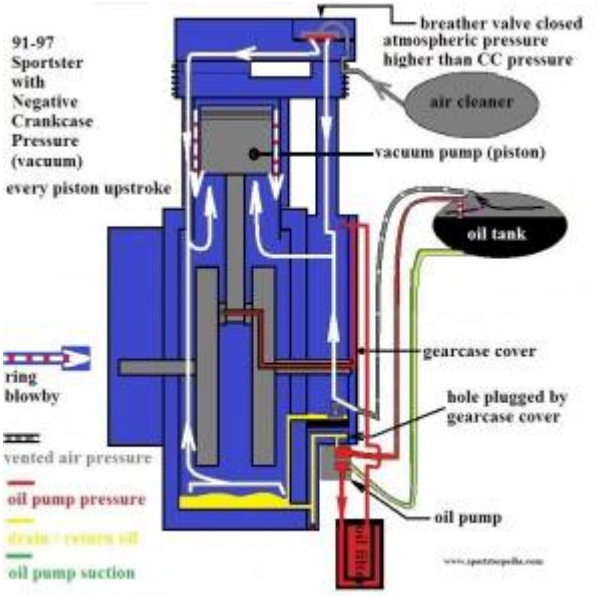
7)



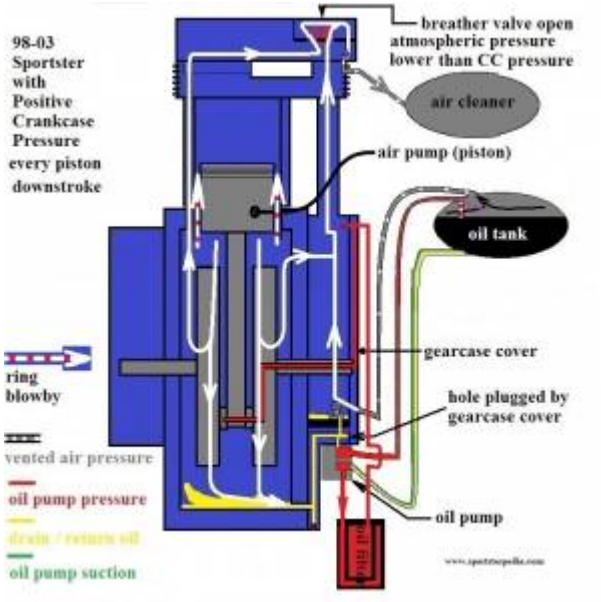
8)

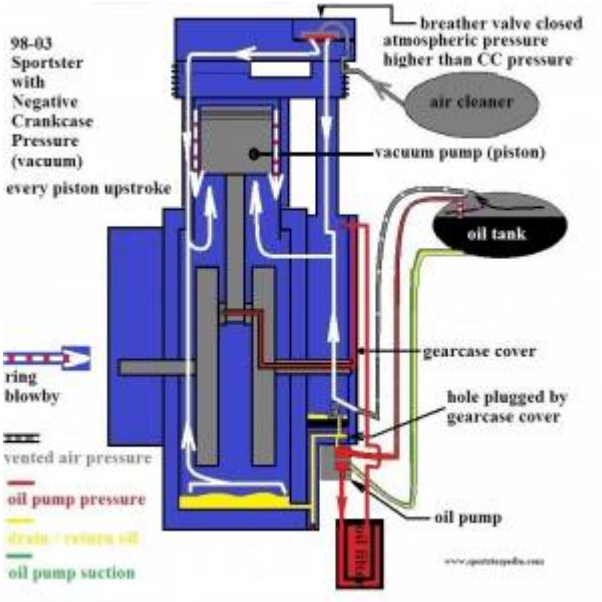
91-97 models with head breather vents:



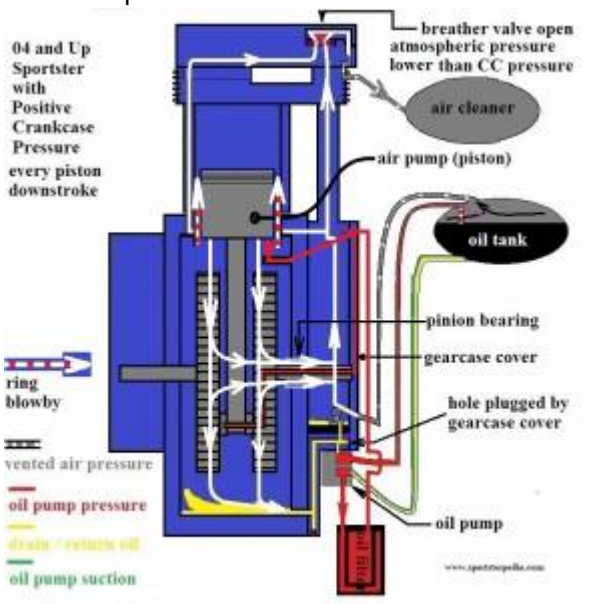


98-03 models with head breather vents:

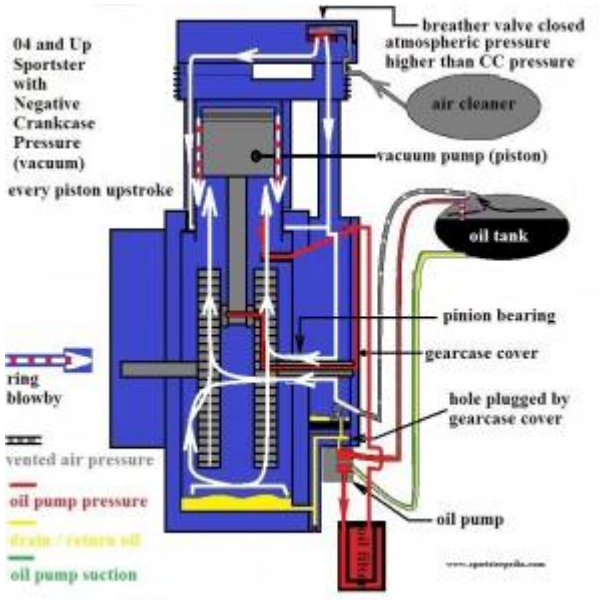




04 and Up models with head breather vents:



9)



10)

Go To Technical Menu

1)

Dr Dick of the XLFORUM
https://www.xlforum.net/forum/sportster-motorcycle-forum/sportster-motorcycle-era-specific-and-model-specific/ironhead-sportster-motorcycle-talk-1957-1985/122424-breather-diagrams/page4?t=1204854&page=4

2)

Dr Dick of the XLFORUM
https://www.xlforum.net/forum/sportster-motorcycle-forum/sportster-motorcycle-era-specific-and-model-specific/ironhead-sportster-motorcycle-talk-1957-1985/122424-breather-diagrams/page3?t=1204854&page=3

3)

https://www.setra.com/blog/vacuum-pressure-what-is-it-how-do-you-measure-it

4)

https://www.dekkervacuum.com/resource-library/knowledge-database/technical-data/what-is-vacuum/

5) 7) 8) 9) 10)

drawing by Hippysmack

6)

photo by Hippysmack