Acoustical Capacity Meter
Acoustical Volume Meter

- **Acoustical Capacity Meter**
  (Combustion Chamber Capacity Meter)

- **Acoustical Volume Meter**
  (Density Meter)
When the loudspeaker placed in the sound source chamber is driven by a sinusoidal signal (sine wave) as shown in the right figure, for the capacity \( V_1 \) of the sound source chamber and \( V_2 \) (the capacity \( V_0 \) including space in the attachment plus the capacity \( V \) of the object (the combustion chamber in the figure), ultra small changes in volume (\( \Delta V \)) and pressure (sound) with the same absolute value, but of opposite phase, will occur inside each chamber. The degree of change is inversely proportional to the capacity. These pressure changes are detected by electret condenser microphones, and the capacity \( V_2 \) is calculated from the ratio of the pressure change. The capacity \( V \) can be obtained by subtracting \( V_0 \) (space in the attachment) from \( V_2 \).

Now precision measurement under dry conditions is possible for any shape of object.
When the loudspeaker placed in the sound source chamber is driven by a sinusoidal signal (sine wave) as shown in the right figure, for the volume $V_1$ of the sound source chamber and $V_2$ (the volume of space in the attachment plus the space between the measurement enclosure and the object), ultra small changes in volume ($\Delta V$) and pressure (sound) with the same absolute value, but of opposite phase, will occur inside each chamber. The degree of change is inversely proportional to the capacity. These pressure changes are detected by electret condenser microphones and the volume $V_2$ is calculated from the ratio of the pressure change.

The volume ($V$) of the object can be obtained by subtracting $V_2$ from $V_0$ (space in attachment plus empty space in the measurement chambers).

The target volume is calculated based on a comparison with a Reference Standard. First, the volume of the Reference Standard is measured, with the results providing the parameters for measuring the target. Once the calibration process is completed, the target volume can be measured repeatedly. Currently, to improve measurement precision, two or three Reference Standards are used for calibration. For example, for measuring target volume of approximately 100 cm$^3$, a measurement precision at $\pm 0.1$ cm$^3$ can be achieved.

**Measurement Principle**

When the loudspeaker placed in the sound source chamber is driven by a sinusoidal signal (sine wave) as shown in the right figure, for the volume $V_1$ of the sound source chamber and $V_2$ (the volume of space in the attachment plus the space between the measurement enclosure and the object), ultra small changes in volume ($\Delta V$) and pressure (sound) with the same absolute value, but of opposite phase, will occur inside each chamber. The degree of change is inversely proportional to the capacity. These pressure changes are detected by electret condenser microphones and the volume $V_2$ is calculated from the ratio of the pressure change.

The volume ($V$) of the object can be obtained by subtracting $V_2$ from $V_0$ (space in attachment plus empty space in the measurement chambers).

\[
\frac{P \times V^\gamma}{P_0} = \text{const.} \quad (\gamma \text{ is the ratio of specific heat for air, approx. 1.4)}
\]

\[
\frac{\Delta P_1}{P_0} = \gamma \frac{\Delta V}{V_1} \quad \frac{\Delta P_2}{P_0} = \gamma \frac{\Delta V}{V_2}
\]

$p$: Pressure in the chamber (atmospheric pressure)
$\Delta P$: Small pressure changes in space in the attachment plus the space between the measurement enclosure and the object
$V_2 = V_1 \frac{\Delta P_1}{\Delta P_2}$ ($V_1$ : const.)

\[
V = V_0 - V_2 \quad (V_0 : \text{const.})
\]
### Specifications

<table>
<thead>
<tr>
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<th>Acoustical Capacity Meter (Combustion Chamber Capacity Meter)</th>
<th>Acoustical Volume Meter (Density Meter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity/volume measurement: repeat precision</td>
<td>±0.05 cm³ ¹</td>
<td>±0.1 cm³ ²</td>
</tr>
<tr>
<td>Required measurement time</td>
<td>Approx. 2 seconds (When number of analysis points is 1024. Units: one-second steps)</td>
<td></td>
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<tr>
<td>Measurement frequency</td>
<td>15 to 99 Hz (variable, depends on the object)</td>
<td></td>
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<tr>
<td>Numbers of analysis points</td>
<td>256 to 4,096 points (variable, in a power-of-two. Initial value: 1,024 points)</td>
<td></td>
</tr>
<tr>
<td>Reference chamber: acoustic pressure in measurement tank</td>
<td>Approx. 94 to 134 dB (1 to 100 Pa rms)</td>
<td></td>
</tr>
<tr>
<td>Reference chamber: internal dimension, capacity</td>
<td>φ90 mm x 91 (H) mm V: nearly equal to 570 cm³</td>
<td></td>
</tr>
<tr>
<td>Controller</td>
<td>Connected to a computer through a USB cable. 54 (H) x 150 (W) x 170 (D) mm, approx. 400 g</td>
<td></td>
</tr>
<tr>
<td>Consumption current</td>
<td>5 V, approx. 475 mA (approx. 2.4 VA)</td>
<td></td>
</tr>
<tr>
<td>Available OS</td>
<td>Microsoft Windows XP/Vista</td>
<td></td>
</tr>
</tbody>
</table>

#### Accessories
- Connection cable, USB cable
- AC adapter
- Software (CD-ROM)

#### Options
- Connection cable, USB cable
- AC adapter
- Software (CD-ROM)

- Reference standards
  - For calibration, at least two reference standards are needed.
  - 0 to 120 cm³ (in 5 cm³ increments)
  - Manufactured according to the capacity of the object.
- Spark plug hole adapter
  - (for assembled engines)

- Reference standards
  - For calibration, at least two reference standards are needed.
- Measurement enclosure
  - Manufacture the enclosure according to the dimensions of the target object.

¹ When a volume of 50 cm³ is measured under standard environmental conditions (20 °C, 50 %) (for a cylinder head)
² When a volume of 100 cm³ is measured under standard environmental conditions (20 °C, 50 %)

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