AIRSPEED INDICATOR

1. The airspeed indicator indicates the speed at which the airplane is moving through the air.
   a. Airspeed must not be confused with groundspeed, which is the speed at which the airplane is moving across the ground.

2. Principle of operation. The airspeed indicator (ASI) is a differential air pressure instrument which measures the difference between the total pressure (measured from the pitot line) and static pressure. This difference is called dynamic pressure.

   a. To measure the dynamic pressure, the ASI is constructed as a sealed case in which a diaphragm is mounted.
      1) The pitot line (total pressure) is connected to one side of the diaphragm.
      2) The static line is connected to the other side of the diaphragm.
   b. As the airplane moves, total (or impact) pressure becomes greater than static pressure, causing the diaphragm to expand.
      1) Expansion or contraction of the diaphragm moves the indicator needle by means of gears and levers.
   c. The airspeed dial may be calibrated to convert dynamic pressure into units of knots (kt.), miles per hour (mph), or both.
   d. The ASI is calibrated to display an airspeed representative of a given dynamic pressure only at ISA sea-level values; thus, it does not reflect changes in density altitude.
      1) The ISA is the International Standard Atmosphere.
      2) The standard atmosphere at sea level is a surface temperature of 59°F, or 15°C, and a surface pressure of 29.92 inches of mercury (Hg), or 1,013.2 MB.

3. The Three Kinds of Airspeed Useful for Pilots
   a. Indicated airspeed (IAS) is the direct instrument reading obtained from the ASI, uncorrected for variations in air density or installation and instrument errors.
      1) Your airplane’s Pilot’s Operating Handbook (POH) will list airspeed limitations and performance airspeeds based on IAS.
      2) The FARs and ATC will also use IAS for speed limitations.
b. **Calibrated airspeed (CAS)** is IAS corrected for installation and instrument errors.

1) Although manufacturers attempt to keep airspeed errors to a minimum, it is not possible to eliminate them along the entire airspeed operating range.
   a) Installation (position) error is caused by the static port(s) sensing erroneous static pressure. The slipstream flow causes disturbances at the static port(s) preventing true static pressure measurement.
   b) Also, at varying angles of attack, the pitot tube does not always point directly into the relative wind, which causes erroneous total (or impact) pressure measurement.

2) At certain airspeeds and with certain flap settings, the installation and instrument error may be several knots. This error is generally greatest at low airspeeds.

3) In the cruising and higher airspeed ranges, IAS and CAS are approximately the same.

4) To determine CAS, read the IAS and then correct it by using an airspeed calibration chart or table found in the airplane’s POH.
   a) **EXAMPLE:** The airspeed calibration table for a Cessna 152 is shown below.

<table>
<thead>
<tr>
<th>CONDITIONS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power required for level flight or maximum rated RPM dive.</td>
</tr>
</tbody>
</table>

**AIRSPEED CALIBRATION**

<table>
<thead>
<tr>
<th>FLAPS UP</th>
<th>KIAS</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
<th>110</th>
<th>120</th>
<th>130</th>
<th>140</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KCAS</td>
<td>46</td>
<td>53</td>
<td>60</td>
<td>69</td>
<td>78</td>
<td>88</td>
<td>97</td>
<td>107</td>
<td>117</td>
<td>127</td>
<td>136</td>
</tr>
<tr>
<td>FLAPS 10°</td>
<td>KIAS</td>
<td>40</td>
<td>50</td>
<td>60</td>
<td>70</td>
<td>80</td>
<td>85</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td></td>
<td>KCAS</td>
<td>44</td>
<td>52</td>
<td>61</td>
<td>70</td>
<td>80</td>
<td>84</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td>FLAPS 30°</td>
<td>KIAS</td>
<td>40</td>
<td>50</td>
<td>60</td>
<td>70</td>
<td>80</td>
<td>85</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td></td>
<td>KCAS</td>
<td>43</td>
<td>51</td>
<td>61</td>
<td>71</td>
<td>82</td>
<td>87</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
</tr>
</tbody>
</table>

c. **True airspeed (TAS)** is CAS corrected for density altitude. TAS is the true speed of an airplane through the air.

1) Because air density decreases with an increase in altitude, the airplane must be flown faster at higher altitudes to cause the same dynamic pressure to be measured in the ASI.
   a) Therefore, for a given TAS, IAS decreases as altitude increases.
   b) For a given IAS, TAS increases with an altitude increase.
2) TAS can be determined by various methods.
   
a) A flight computer can be used when CAS, outside air temperature (OAT), and pressure altitude are known.

b) Some airspeed indicators (called true airspeed indicators) have this function built in. With an adjusting knob, pressure altitude is set opposite OAT in the window at the top of the instrument, as in the illustration below.

   i) The TAS is then read under the needle. On the airspeed indicator shown below, the IAS is 153 kt. (inner scale) or 168 mph (outer scale), and the TAS is approximately 198 kt.

   ![Airspeed Indicator Illustration]

   c) A cruise performance chart in the airplane’s POH can be used to determine a planned, not actual, TAS.

   d) The following general rule may be used to approximate TAS: Add 2% to the IAS for each 1,000 ft. of altitude.

   i) EXAMPLE: Given IAS is 140 kt. and altitude is 6,000 ft., find TAS.

      Solution:
      
      \[
      \begin{array}{l}
      2\% \times 6 = 12\% (.12) \\
      140 \times .12 = 16.8 \\
      140 + 16.8 = 156.8 \text{ kt. (TAS)}
      \end{array}
      \]
4. Most airplanes use a standard color code on airspeed indicators to highlight vital airspeed ranges.

![Airspeed Indicator Diagram]

a. The **white arc** represents the flap operating range.
   1) The lower limit of the white arc is $V_{SO}$.
      a) $V_{SO}$ is the stalling speed or the minimum steady flight speed in the landing configuration.
      b) In small airplanes, $V_{SO}$ is the power-off stall speed in the landing configuration (i.e., flaps and landing gear down) at the maximum landing weight.
   2) The upper limit of the white arc is $V_{FE}$.
      a) $V_{FE}$ is the maximum flap extended speed.
      b) Operating with the flaps extended at higher airspeeds could result in severe strain or structural failure.

b. The **green arc** represents the normal operating range.
   1) The lower limit of the green arc is $V_{S1}$.
      a) $V_{S1}$ is the stalling speed or the minimum steady flight speed obtained in a specific configuration.
      b) In small airplanes, $V_{S1}$ is normally the power-off stall speed with the wing flaps and landing gear (if retractable) retracted at the maximum takeoff weight.
   2) The upper limit of the green arc is $V_{NO}$.
      a) $V_{NO}$ is the maximum structural cruising speed.
      b) You should not exceed $V_{NO}$ except in smooth air and then only with caution.

c. The **yellow arc** represents the caution range.
   1) The lower limit of the yellow arc is $V_{NO}$, and the upper limit is $V_{NE}$.
   2) You should fly at airspeeds within the yellow arc only in smooth air while using caution.

d. The **red line** is $V_{NE}$.
   1) $V_{NE}$ is the never-exceed speed.
   2) The never-exceed speed is the maximum speed at which the airplane can be operated safely and should never be exceeded intentionally.
   3) Operating at airspeeds above $V_{NE}$ could cause structural damage or failure.
5. **Other airspeed limitations.** Some other important airspeed limitations are not marked on the face of the airspeed indicator. These speeds are generally found on placards in view of the pilot and/or in the airplane’s POH.

   a. **Design maneuvering speed (\(V_A\))** is the maximum speed at which full, abrupt deflection of the controls may be made without overstressing the airplane.
      
      1) Your airplane should be flown at or below this airspeed when rough air or severe turbulence is expected.
      
      2) \(V_A\) varies with the airplane’s gross weight.

   b. **Landing gear operating speed (\(V_{LO}\))** is the maximum speed for extending or retracting the landing gear.

   c. **Best angle-of-climb speed (\(V_X\))** is important when a short-field takeoff is required to clear an obstacle. It will allow the pilot to gain the most altitude in a given distance.

   d. **Best rate-of-climb speed (\(V_Y\))** is the airspeed that will give the pilot the most altitude in a given period of time.

   e. **Best glide airspeed (\(V_{GLIDE}\))** is the airspeed that provides the best lift/drag (i.e., \(L/D_{MAX}\)) ratio angle of attack in a power-off glide. It will allow the airplane to glide the farthest.

6. The following list of performance speeds are for your review. These definitions, as well as the specific speeds for your airplane, need to be memorized. The letter V means velocity.

   - \(V_A\) -- design maneuvering speed
   - \(V_{FE}\) -- maximum flap extended speed
   - \(V_{LE}\) -- maximum landing gear extended speed
   - \(V_{LO}\) -- maximum landing gear operating speed
   - \(V_{NE}\) -- never-exceed speed
   - \(V_{NO}\) -- maximum structural cruising speed
   - \(V_R\) -- rotation speed
   - \(V_{S0}\) -- the power-off stalling speed or the minimum steady flight speed in the landing configuration (i.e., flaps and landing gear extended)
   - \(V_{ST}\) -- the power-off stalling speed or the minimum steady flight speed obtained in a specified configuration (i.e., flaps and landing gear retracted)
   - \(V_X\) -- speed for best angle of climb
   - \(V_Y\) -- speed for best rate of climb
   - \(V_{GLIDE}\) -- best glide speed