Maximum Length of Dry-Pressure Hose

Introduction

In most scenarios, the maximum length of tubing for dry-pressure sensors will not affect the reading. Without leaks or stretching of the tubing, the only effect of adding length to the tube is a time delay. The time delay is the speed of sound through that medium. This paper will break down several principles and explain why, in most cases, maximum length ends up not being a concern.

Overview of Concepts

Beginning with what a dry-pressure sensor is reading: air. Air is for the most part an ideal gas as well as a fluid. The physics behind air as a fluid will also apply to other fluids such as water, but as water is not an ideal gas, air cannot be completely compared to water. Most notably, air is compressible where water is not.

There are four key ideas at play here, feel free to skip to the following section if detail is not needed.

Pascal's Law

Pascal's Law is also known as the principle of transmission of fluid pressure. It is the simplest of the three concepts and yet the most important for this note. In short, a fluid in a fixed container under pressure will show an equal force in all areas. That's to say that in a stable and closed system, fluid will exhibit equal pressure in all areas. So, in a long piece of tubing for a pressure sensor, the pressure at one end will be the same as the other in an ideal case.

Pressure Drop from Friction

Pressure will drop with the fluid's velocity when experiencing friction. In this case friction is from the pipe's surface. The amount of pressure loss due to the pipe will be determined by the rate the fluid passes through the pipe as well as how much friction the pipe has. The pipe's friction is related to size and material, with a larger pipe having less friction if the material stays the same.

Speed of Sound

Sound is a form of pressure moving through a medium, in this case fluid. Speed of sound is the maximum speed at which a change in pressure can propagate through a medium. In this note, that applies to how fast the dry-pressure sensor can detect changes in pressure. For air, the speed of sound is 343m/s (1125ft/s) at 20C (68F). Essentially, the time for a sensor to detect change in pressure is the speed of sound down the length of hose.

Atmospheric Pressure

Baseline air pressure that changes with altitude, all from gravity. For differential pressure this will cancel out unless pressure readings are very far apart from each other, but only in terms of elevation. For the most part this can be ignored in dry pressure readings. Atmospheric pressure does play a part in wet pressure readings in the form of "head", or pressure coming from the weight of the fluid, e.g. a column of water.

Maximum Length

NOTE

Wet Pressure

While wet pressure is mentioned, maximum length is only fully explored for dry pressure. Wet pressure is mentioned as it's an adjacent topic; showing where they are similar.

As long as the hosing is only for providing air to the sensor (near zero flow), sealed and rigid hosing, then the only real consideration is pressure propagation time. As long as the added time of reporting a change in pressure at the rate of the speed of sound is acceptable, then the maximum distance is significantly further than what is common.

Pascal's law applies for a sealed system, which may sound complicated, but this case just calls for tubing that doesn't deform under pressure nor leak. Senva's dry pressure products are limited to a few psi, which for most hosing is low enough that deformation is not expected.

Additional Notes

Wet Pressure

The physics here are the same, apart from the ideal gas law. However, water has a much higher viscosity, density, and has surface tension. There's enough differences that this app-note won't give any recommendations, but the principles shown above will help explain recommendations found elsewhere.

Electricity

For those electrically inclined, hose length is a similar exercise to that of voltage drop on long leads. Pressure can be thought as voltage and flow rate that of current. The friction of a pipe is similar to resistance of wire. That includes material and wire size with pipe material and diameter respectively. Sensing dry pressure is similar to a control electrical signal where current is near zero and thus there is almost no voltage drop. In that case, interference is more of a concern than voltage drop.