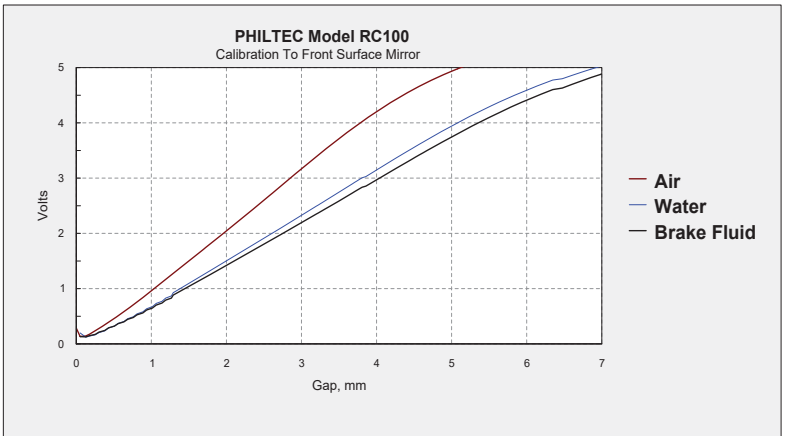
Philtec Application Note

No. 86
Sep 2026

Measurements in Cryogenic Fluids

When a sensor is submersed in a fluid, light rays diverging from the probe tip are more collimated than they would be in air. This increases the operating range of the sensor. The degree of collimation is proportional to **the ratio of the refactive index of the fluid to that of the calibration medium (air or water).**

For example, this chart shows the output function of a model RC100 sensor in three different fluids: air, water and DOT 5 silicone brake fluid. The fluids increase the operating range by approximately 30%. To be precise, the sensor must be calibrated in the same medium in which the measurements will be made.



CRYOGENIC FLUIDS

Liquid fueled rockets burn pressurized cryogenic fluids via two turbopumps that mix the fuel with an oxidizer to create thrust. They are:

the OTP - Oxygen Turbopump
the FTP - Fuel Turbopump

Many companies have used Philtec's FODS (Fiber Optic Displacement Sensors) for rotor dynamics measurements in the testing phase of these pumps. This table lists the refractive indices of the various fluids in use at the present time.

Medium	Refractive Index
Vacuum	1.00000
Air	1.00004
Liquid Helium	1.026
Liquid Hydrogen	1.0974
Liquid Nitrogen	1.2053
Liquid Oxygen	1.221
Methane (LCH4)	1.286
Water at 35°C	1.3316
Propane (LPG)	1.34
Kerosene	1.44

Philtec sensors have been used to monitor speeds and rotor displacements in a variety of pressurized fluids, such as:

- Liquid Hydrogen, -300°F, 1000 psi max. pressure
- Liquid Oxygen, -297°F, 5000 psi max. pressure
- Liquid Methane, -297°F, 7500 psi max. pressure

At the factory, sensors are calibrated in air or water at ambient pressure. The XY calibration data is then mathematically corrected for performance in the operating fluid.

CALIBRATIONS AND DATA CONVERSION TO CRYOGENIC FLUIDS

Calibrations

Depending upon the refractive index of the cryo fluid, the sensor will be calibrated in air or water: whichever is closer to the cryo fluid's index.

For example,

- If the medium is liquid hydrogen (1.0974 Index), calibration in air is the best approximation.
- If the medium is liquid methane (1.286 index), calibration in water is the best approximation.

Data Conversions with Calibration in Air

The XY calibration data (x = mm, Y = Volts) are corrected for performance in the cryo fluid to be used. Using this formula, the operating range is extended in the fluid.

- **mm (Cryo) = mm (Air) x RI Cryo Fluid**

Data Conversions with Calibration in Water

LOX and LCH4 are two fluids with reflective indices slightly lower than RI of water. Compared to the operating range in water, the range in these fluids are shortened in the cryo fluids.

MAPPING EXAMPLE , CALIBRATION IN WATER

mm in H20	mm in LOX*	mm in LCH4**	Volts
0.000	0.000	0.000	1.23
1.016	0.931	0.981	0.86
2.032	1.863	1.962	1.94
3.047	2.794	2.943	3.23
4.063	3.726	3.924	4.47
5.080	4.658	4.906	5.44

Formula *

RI LOX / RI H_2O = 1.221 ÷ 1.332

Formula **

RI LCH4 / RI H_2O = 1.286 ÷ 1.332