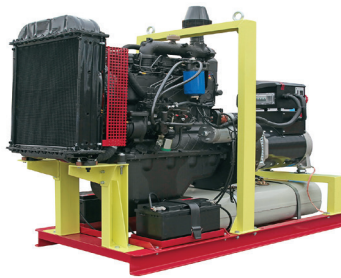


## Improving Mission Critical Cooling Systems With More Reliable Level Sensing

*CAP-300 Coolant Level Sensors raise the bar on reliability where dependable performance is mission-critical and operational downtime is money lost.*



*Any well-designed diesel electrical power generator or motor can be made more reliable with new Gems CAP-300 coolant level sensors. An easy change with long term benefits.*



### Why reliable coolant level sensing is important

The choice of coolant level sensor may seem like an insignificant detail when designing complex machinery such as emergency generators and cranes, but if this sensor fails, the operator has no warning of dangerously low coolant levels. Emergency generators may fail to start when your customer needs them the most, and machinery can overheat to the point of breakdown, requiring expensive repairs and even more expensive downtime.

All power generating systems produce prodigious amounts of heat, requiring dependable cooling systems to operate. Typical cooling systems use water-based fluids, fans and radiators to dissipate heat and keep equipment within safe operating temperatures. While cooling systems may take different design paths based on application needs, they all share the same basic method of moving a fluid through a closed loop to transfer heat. Assuring that the fluid is actually there in sufficient volume to keep the system from overheating is critical, which brings us back to the coolant level sensor, a component which is often taken for granted but can cause operations to grind to a halt if it fails.

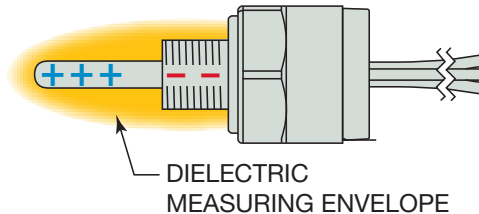
Diesel systems are built to last, and built to produce. They are typically found in large and complex equipment that represents a significant business investment and an integral part of either daily operations or emergency back-up systems. Failing to start when needed, or being rendered inoperable for even a day, can cost the end user thousands of dollars in lost productivity, damage the manufacturer's reputation, and even endanger lives.

Generator sets are particularly sensitive to failure issues. Emergency generators often sit unattended and non-operational for months at a time, only called into action when external power is cut off and immediate, reliable operation is needed to keep hospitals, cell phone towers, and businesses across the world functioning. Equally challenging, a gen-set may be the only source of power to keep remote installations operating, far from any maintenance staff or drop-in replacements.

## Common points of weakness

The most reliable fluid level sensors used in today's cooling systems utilize capacitance technology. Most of these capacitance coolant level sensors do an adequate job when first installed, but are subject to several weaknesses in the face of time and real-world use. Our survey of the diesel power industry has made it clear that one of the prime reasons for a diesel power system to become inoperable is still due to coolant sensor failure.

Capacitance level sensors function by measuring the difference in capacitance value between two different dielectrics: air and coolant. The electrode of the sensor and surface of the sensor housing form the plates of a capacitor, while the space between them is the dielectric. When that space is occupied by air, the capacitance value is lower than when it is occupied



by a water-based coolant. That difference is evaluated by a high frequency electronic system and converted into a corresponding output switch actuation. These switch actuations trigger other actions within an Electronic Control Unit (ECU) or Body Control Unit (BCU) to trigger a warning light or record a diagnostic error code.

Over time, however, sensor probes can accumulate a coating of minerals and other elements found in the water/coolant mixture. As coatings grow, the sensor's ability to measure the dielectric degrades and can cause false readings on the presence or absence of coolant in the loop.

Likewise, coolant formulation and mix ratios can change over time, as coolant is substituted or degraded over years of service. When the blend changes, so does the capacitance of the liquid in the coolant loop. Sensors tuned to a narrow frequency range can lose efficiency and give false readings simply because of a change in the brand of coolant or the proportion of water in the mix.

## Raising the bar on coolant level sensor reliability

Gems has spent two years developing a new capacitive coolant sensor based on input from leading manufacturers of emergency generators, remote power supplies, trucks, trains, and off-highway vehicles about their biggest frustrations with coolant level sensors. The result is our new CAP-300 series, which addresses four primary weaknesses of the older sensors on the market:

1. Probe Coating
2. Frequency Sensitivity
3. Size
4. Build Quality

**Probe Coating:** These sensors spend their life submerged in water-based fluid. The electrode and body of the sensor form the two capacitor plates, but over time the probe becomes coated with minerals and other elements found in the water/coolant additive mixture. As coatings grow, the sensor's ability to measure the dielectric becomes degraded, making accurate reporting of fluid presence unreliable. Some sensor designs surround the probe with a perforated guard, which can also trap coolant fluid in contact with the probe and produce a false reading.

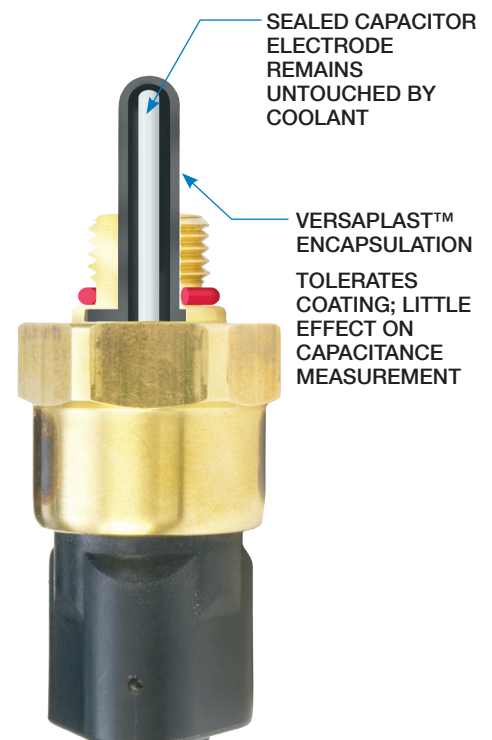
The CAP-300 line of coolant level sensors solves the coating problem by completely encapsulating the probe in a frequency-transparent, inert plastic housing. Being completely sealed, no fluid contacts the capacitive probe. While the plastic housing can still accumulate some coating of its own over time, in most cases it is frequency-transparent, like the housing. (A highly conductive coating can still interfere.)



*Emergency backup power generator outside of a hospital. Also found serving major office and industrial buildings.*



*One of three diesel generators providing shipboard electrical service on USNS Catawba.*







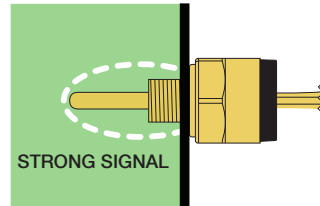
Long days of work and a limited harvesting season make coolant sensor integrity essential.

**Frequency Sensitivity:** Coolant sensors are frequency adjusted to measure the dielectric between air and coolant. Coolant formulation and mix ratios often change over time, altering the conductivity of the liquid and placing it outside of the zone which the sensor was tuned to. A sensor that worked fine in a brand new installation with manufacturer-specified coolant is no longer quite so reliable when the coolant is substituted or degraded over years of service.

**The “Goldilocks Syndrome” found with common coolant sensors:**

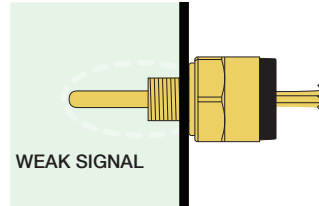
**Just Right**

In new systems the coolant conductivity is matched to the sensor’s frequency range “sweet spot”.



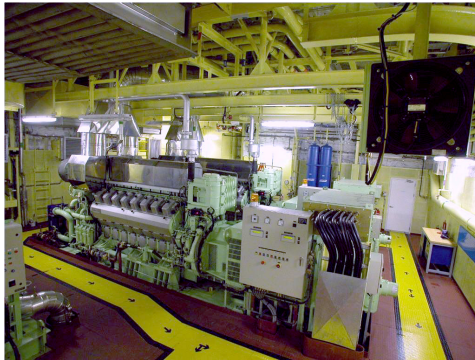
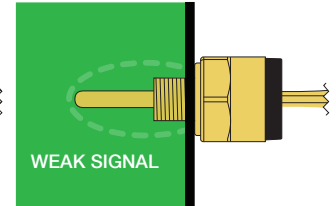
**Too Dilute**

The coolant conductivity falls out of sensor’s tuned frequency range; sensor performance is compromised.

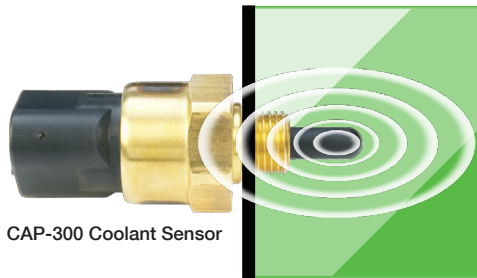


**Too Concentrated**

Coolant conductivity exceeds sensor’s tuned frequency range; sensor performance is again compromised.



Power generator on an off-shore oil rig. A long way from home, system reliability is paramount.

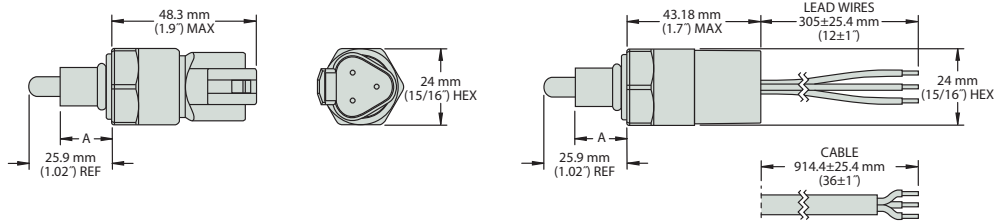


CAP-300 Coolant Sensor

The circuitry built into CAP-300 sensors utilizes a broader frequency range than other sensors. Out of the box, CAP-300 sensors operate with a wide range of coolants, and the broad frequency range makes CAP-300 sensors better prepared to successfully contend with changes in coolant mixture concentrations, and the resulting differences in conductivity.

**Size:** Size isn’t as universal a problem as probe coating and frequency sensitivity, but some coolant sensors have quite long probes (as long as 4 inches), and these can present design limitations and installation problems.

CAP-300 sensors are compact, starting with a probe that protrudes into radiator cavities less than 0.5” for most models within the series, and the body length is just 2 inches. Combined with the short probe length, the CAP-300 series are among the easiest coolant sensors to design with and to install.



**Build Quality:** Our approach to build quality goes beyond basic physical integrity, and encompasses operational integrity. The environments in which coolant sensors must operate include a battery of forces that will degrade the sensor over time if they are not protected against. These include water, dust, shock, vibration, humidity, thermal shock, electromagnetic fields, electrostatic discharge, power transients and more. CAP-300 Series level sensors have gone through exhaustive testing and achieved prominent approvals and certifications. These include **IP6K9K, CE, IP67, RoHS.**

[More CAP-300 performance testing on the following page..](#)

## Conclusion

There has never been a time when more reliance was placed on diesel power. In the area of power generation, more and more people depend on the reliability of this equipment to provide electricity while off the grid, and to minimize the impact of emergencies. Coating, changeable coolant blends, and the rugged environments this equipment operates in have made coolant level sensors a weak link in producing the kind of reliable operation that remote and mission critical systems require. Now, manufacturers have a better option; specifically designed, manufactured, and tested to address all of these issues. The CAP-300 series of level sensors truly raises the bar, and provides a greater degree of reliability and longevity than was previously achievable in this sensor class.

## Performance Tests

### Ingress protection

**IPX7 (Submergence):** PER IEC60529 †

**IP6K9K (High pressure, high temp wash down, in-organic dust intrusion):** per DIN 40050-9 †

**External Vacuum:** -1 PSIG †

**Vibration:** per MIL-STD-202G Method 204D

**Shock:** per MIL-STD-202G Method 213B

**Drop:** 1.2M Concrete with protective cap (all orientations) †

**Salt Spray:** 96 Hours at 35°C

### Humidity

**Operating:** 48 hours †

**Storage:** 240 hours at 96% RH

**Thermal shock:** -40°C to 125°C air to air shock, six hour cycle repeated five times

### Electromagnetic compatibility

#### Radiated immunity per ISO 11452-2

- 200MHz-1GHz: 140 V/m
- 1GHz-2GHz: 50 V/m

**Radiated immunity per ISO 11452-5:** 10kHz-1MHz: 140V/m

**Conducted immunity/RF injection per IEC 61000-4-6:** 150kHz-80MHz: 10V/m

**Burst immunity to signal ports per IEC 61000-4-4:** ±1kV, 5/50 TR/Th ns, Rep Rate 5kHz

**Burst immunity to DC power lines per IEC 6100-4-4:** ±2 kV, 5/50Tr/Th ns, Rep Rate 5kHz

**Audio frequency immunity per MIL-STD-461E, CS101:** 30Hz-150 kHz, using curve 2 to the power lines only

**Magnetic field immunity per IEC 6100-4-8:** Test limit: 30 A/m

**Bulk current injection per IOS11452-4 (Pending):** 1 mHz-400MHz at a level of 120mA

#### Electrostatic discharge per SAE J1113/13:

±8kV for direct contact and +/-15kV for air discharge, sensor must function during “power up mode” and after “package and handling” test

#### Input Power Transient Immunity:

- ISO 7637-2: Rev 2002
- Test Pulses 1, 2A, 2B, 3A, 3B, 4, 5A.

**Conducted Emissions per CISPR 25, Rev Aug-2002:** Class III levels. Over limit from 70-108 MHz

#### Radiated Emissions per CISPR 25: Rev Aug-2002:

- 150kHz to 54MHz
- Class III levels

**Radiated Emissions to ISO 13766, Rev May-2006:** 30kHz to 1GHz; Meets narrowband requirement

#### Far Field Emissions:

- CISPR 11:2003. 30MHz – 230MHz; Over limit from 67-230 MHz
- CISPR 25:2002. 230MHz - 1GHz

† Results Pending