

# Non-intrusive sensing of condensate drain line blockage in HVAC systems.

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## I. THE TECHNOLOGY

### A. Dielectric Constant

The SOS Switch operates by sensing an electrical property of water called Dielectric Constant.

When a non-electrical conducting material is placed between the two parallel metal plates of a capacitor, the capacitance value will usually increase. The ratio of the capacitance before and after the material is placed between the two plates, is equal to the dielectric constant of the center material.

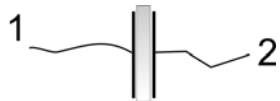


FIGURE 1. TYPICAL CAPACITOR ARRANGEMENT WITH 2 PARALLEL METAL PLATES (1) AND (2) WITH A DIELECTRIC MEDIUM LOCATED BETWEEN.

The dielectric constant of a vacuum is 1.00, dry air is 1.0006, and de-ionized water is 80.

TABLE I  
DIELECTRIC CONSTANTS OF TYPICAL MATERIALS

Material	Dielectric Constant
Vacuum	1.00
Air	1.0006
Dry wood	1.5 – 5.0
Paper	2.0 – 3.0
Teflon®	2.1
Polyethylene	2.3
Paraffin wax	2.5
Polystyrene	2.6
Polycarbonate	2.8
Rubber	3.0 – 4.0
Celluloid	4.0
Quartz	4.0 – 5.0
Mica	4.5 – 8.0
Formica	4.7
Pyrex® glass	4.8
Bakelite®	5.0
Porcelain	5.0 – 6.0
Window glass	7.0 – 8.0
De-ionized water	80

increase the capacitance when inserted between the capacitor plates. Other types of materials do not significantly affect the capacitance. Dielectric constants of other common materials are shown in TABLE 1 DIELECTRIC CONSTANTS OF TYPICAL MATERIALS.

### B. Practical Application

I have conceived, developed, proven, and patented a practical application of dielectric / capacitive sensing for use in the HVAC industry.



FIGURE 2. DIVERSITECH SAFETY OVERFLOW SWITCH (SOS™).

The Safety Overflow Switch™ or SOS™ by DiversiTech uses a sensor which has been made by curving the metal plates of a special clip-on capacitor. These plates are clipped onto the polyvinyl chloride (PVC), cross-linked polyvinyl chloride (cPVC), or other plastic / non-conducting rigid drain line pipe.

When there is little or no water present inside the drain line the dielectric constant is very low; near that of air or the PVC plastic of the pipe.



FIGURE 3. SOS™ SENSOR WITH THREE ROUNDED PLATES. ELECTRODE #1 (2 PLATES) AND ELECTRODE #2 FUNCTION AS THE CAPACITOR PLATES, AND THE WATER IN THE DRAIN PIPE AS THE DIELECTRIC.

As the pipe fills with water, the dielectric constant and the capacitance increase.



FIGURE 4. SOS™ SENSOR IS ACTIVATED WHEN THE DRAIN PIPE IS COMPLETELY FULL OF WATER.

The SOS Switch compares the capacitance value from the

Water and objects containing mostly water dramatically

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sensor to a reference value, and if that value is exceeded, the SOS Switch opens and turns the AC compressor off.

### C. Sensitivity

The SOS™ is not sensitive to just water. It detects the changing dielectric constant of the material within the unique clip. For example, the skin of the human finger is thin and the human blood under the skin makes a nice electrical conductor. The outside surface area of the human body is also large compared to the scale of the SOS™. The act of touching a human finger to a metal surface will cause a sizable capacitance change. Touching the center electrode of the SOS causes it to sense the added capacitance and, like water in the PVC, will cause the SOS™ to trip to the off position.

## II. THE SAFETY OVERFLOW SWITCH

### A. Reliability and Installation

The SOS™ detects water and is not significantly affected by debris which can foul mechanical type switches.

The SOS Switch does not have moving parts or touching electrical contact points that may be subject to failure from corrosion, acid, and vibration.

The SOS™ does not require tees, penetrations or cutting into the drain line in any way. There is nowhere for system air to leak out or blow-by the switch and a vent is not normally required. The SOS™ simply snaps onto existing PVC condensate drains.

The SOS™ is designed to work on 24VAC UL class II HVAC/R circuits which are, by their design, current limited and over current protected. The SOS™ is wired in series with the existing contactor control circuit and adds a simple overflow switch function; critical system controls such as temperature regulation and safety limits are unaffected by proper installation of the SOS™.

### B. Power Supply and Operation

The SOS™ is efficient and smart. It tests the water level 120 times each second (at the start of each AC power cycle) (60 sets of complete positive and negative cycles = 120).

The SOS™ is wired in series with the contactor. Since the SOS™ draws a very small fraction of an Amp, it does not cause the contactor to energize; the contactor simply passes all of the voltage to the SOS™.

At the beginning of each AC power cycle, the line voltage is zero. As the voltage rises the SOS™ sensor circuitry starts to operate. If it detects that there is no water present, it shorts itself out and passes the power to the load (compressor contactor). Since the switch is closed and the power consuming part of the SOS™ is shorted out, the SOS™ does not draw any power for the rest of the power cycle.

If the sensor detects that there is water, it remembers and tests for a few more cycles. If the water remains, the switch never turns on and the system is locked out.

### C. Circuitry and Switching

The SOS™ uses modern surface mount technology and

components similar to other high reliability electronic systems such as computers and telephone equipment. Safety margins of the key components far exceed the current levels required to operate typical HVAC contactors and control equipment ensuring long life and trouble free operation.

Cycle testing normally required on a switch with mechanical contacts which can arc, weld or break does not even apply to the SOS switch which doesn't even have any contacts to burn out or moving floats to hang up.

### D. Lockout

Once tripped, the SOS™ locks out the HVAC system until the problem is solved. A handy yellow LED located on the SOS switch top helps the homeowner or technician locate the problem area. The LED indicates "check drain" before condensate buildup becomes a problem.

Additionally, there are no moving parts in the SOS™ to foul, hang-up or arc-out as might be found in other level sensor type switches. Once the SOS™ detects a problem, the load is locked out until the power off reset or reset button is pressed.

The lock-out feature further helps by preventing on-off-on type problems that can lead to the failure of mechanical float switches and compressor overload and restart failures.

### E. Manufacturing

While nothing is 100.00000000% perfect, DiversiTech utilizes systems that include automatic testing of every SOS™ built prior to packaging. The test system functionally tests the units on plastic tubing, with a varying water level and an actual HVAC contactor load to ensure consistent operation and sensitivity.

All SOS™ manufactured by DiversiTech are subject to sampling on a MIL Spec Quality Inspection Plan by our team of independent quality inspectors. Each inspector, in addition to re-testing completed units for QA, has the authority to stop shipments of any product that falls outside of quality requirements.

Product qualification tests included lab testing over temperatures which exceed those ever seen in actual operation from below freezing to over 160F with the switch subjected to under and over voltage and excessive current and load conditions.

**C. Barry Ward** has been designing and commercializing products since the mid-1970s.

Previously with other HVAC component manufacturers, he has been with DiversiTech since 1999. He has over ten United States and foreign Letters Patent.

Mr. Ward is and has been a member of various product development and robotics design organizations.