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Embedded sensors system to monitor cemented waste drums

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Abstract. BAM (Federal Institute for Materials Research and Testing) is developing an electronic measurement system to be placed inside a waste drum, which will be filled with concrete. The goal of this measurement system is to monitor the process of hardening and the evolution of the concrete itself over time to indirectly identify potential defects such as corrosion or cracking. The measured parameters are humidity, temperature, and pressure. In this regard, particular attention was given to the design of the electronic board's enclosure, to allow the sensors to measure the state of the concrete without being in direct contact with it. In the scope of the European Commission's project of PREDIS, the supply of power to the battery-less sensors and the data acquired by such sensors are transmitted through the metallic waste drum by an innovative wireless technology developed by VTT (Technical Research Centre of Finland Ltd) in order to ensure long-term operation, while keeping the integrity of the sealed container.

The sensing system is made of a chain of small units, called SensorNodes. Each SensorNode includes two off-the-shelf sensors, with one for relative humidity and temperature and one for pressure and temperature. A SensorNode is designed to have a unique identifier, in order to be connected to other units while being uniquely discoverable by a standard communication protocol. In this way, a distributed matrix of measurement points is created.

One of the most challenging tasks in designing a measurement system to run in a harsh environment (such as hardening concrete) is to let the sensors sense the external environment without damaging the sensors themselves. In order to keep the external environment away from the electronic board while still letting the sensors measure the concrete behaviour, holes have been drilled through the lid and covered from the inside with a layer of porous membrane. The membrane's pores allow water and gas particles to pass through and let the enclosed air equilibrate with the external environment. With the help of the developed sensors, monitoring concrete in cemented waste drums will be possible. The derived data will also serve as the basis for ongoing modelling approaches for digital twins within the PREDIS project. Overall, the sensors provide a means of enabling safe nuclear waste management through advanced monitoring.

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