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with

UKAEA *and* NUKEM

Special Nuclear TDR radar level measuring systems meet challenging requirements

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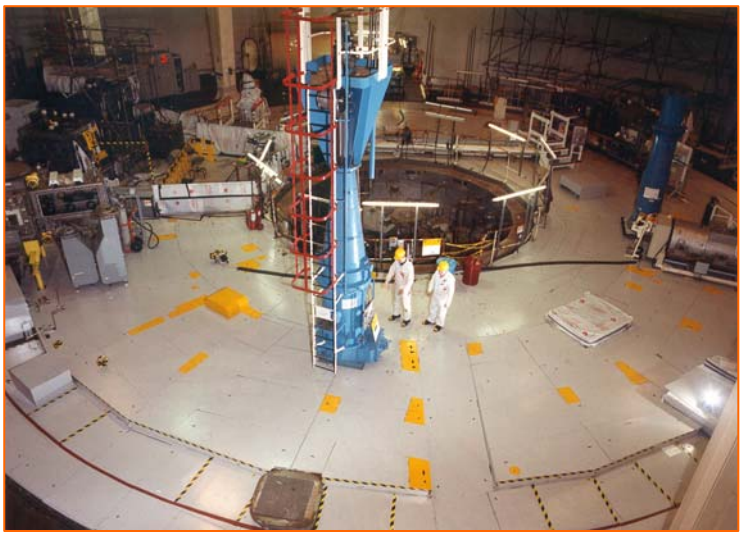
Restoring the 140-acre Dounreay site on the north coast of Scotland is one of the most complex nuclear decommissioning tasks in the world and the site's history in fast reactor and fuel cycle development presents significant decommissioning challenges. Key projects include dealing with liquid metal coolants from the Dounreay Fast Reactor (DFR) and Prototype Fast Reactor (PFR) and managing liquid and solid radioactive waste. It is estimated the clean-up will take until 2032 to complete at a cost of £2.9 billion. Decisions about when the site can be released for general use after that will be determined by a consultation on the preferred end state.

The special nuclear versions of the TDR systems have been installed to measure the levels in a range of vessels in the DFR containing toxic, hazardous and radiological inventory. Originally the vessels had been fitted with capacitance probes and ultrasonic level measuring systems, but over time the transducers had degraded, leading to false level readings and spurious trip signals.

To negate the potential exposure threat to operators due to potential failure of the level detectors, the decision was made to replace the existing systems with more reliable level control systems capable of operating in the harsh environments.



NUKEM Limited, one of the major sub-contractors on the Dounreay site, was contracted to provide a design solution for a liquid metal level measurement system for NaK hold/transfer vessels in the DFR sphere and on neutralisation vessels in the DFR IXP (Ion Exchange Plant). The NUKEM design

team were requested to undertake the work package due to their extensive knowledge of the DFR NaK plant and its operations. Numerous outputs from the specified instruments were required, providing process control and operator interfaces to ensure safe operations. The design involved looking into alternative level measurement systems which would be compatible with the high radiation, toxic chemical environment and provide the operators with a reliable remote readout of vessel status. The project was further complicated by the short timescales imposed so that the design, installation and commissioning could be completed within the plant shutdown window.

Having surveyed the various options open to them, NUKEM Limited deemed the Hycontrol system, based on their VF Series Guided Wave Radar transmitter, to be the best option for this application. These instruments work on the principle of Time Domain Reflectometry commonly known as TDR, originally developed for checking and locating damage along sub-sea telecommunication cables. The device sends low-power electromagnetic pulses of one nanosecond width along the instrument's probe. Upon reaching the surface of the vessel contents, the pulses are reflected back with a signal strength that is dependent on the dielectric constant of the medium being measured. The instrument measures the time between the emission and the reception of the signal, converting this into a 4-20 mA output current. Any weak or spurious signals are analysed and ignored by the electronics. In this application the analogue signal provides the operators with vessel level indication and an input to trip amplifiers to give high and low control and alarm functions.

TDR technology is ideal for such applications, offering exceptional long term accuracy of better than 3 mm over the unit's full measuring capabilities of 35 metres. The TDR unit is supplied pre-calibrated and has a very narrow measuring footprint, allowing it to work in enclosed spaces down to 50 mm diameter. Unlike a number of alternative level measuring technologies, TDR technology has the advantage of not being affected by process factors such as dust, foam, vapour, agitated and boiling surfaces whilst in parallel pressure, temperature and density variations also have no effect.

However from the outset it was clear to Hycontrol engineers that the standard units would need significant modifications. In addition to the nuclear environment, the application presented a number of engineering challenges, including restricted headroom above the vessels, narrow entry

points due to lead lining and highly corrosive vessel contents. Carrying out any vessel modifications was not an option.

The restricted headroom above the vessel entry points dictated that the stainless steel TDR probes had to be constructed in separate threaded sections and then screwed together as they were lowered into the vessels. The corrosive nature of some of the vessel contents mandated 316 stainless steel construction for the probes. Teflon spacers were fitted to the probes to ensure they stay parallel to the sides of the entry tubes without touching them.

The standard VF TDR units incorporate the processing electronics directly in the head of the unit. However in this application, due to the radiation levels immediately surrounding the vessels, these had to be situated 10 metres away outside the lead shielding, requiring the head to be connected to the wave guide by an umbilical cord.

Hycontrol's sales director Nigel Allen is justifiably proud of his company's achievements in this project and as he concludes: *"We were confident we could adapt the standard units to work in this application, although it certainly stretched the technology to its limits. We pride ourselves on being able to meet extreme level measuring problems but I have to admit this was one of the most challenging yet. In addition the required delivery time was very short in order to fit in with the plant shutdown. The units were assembled and calibrated at our plant in Redditch allowing rapid site installation."*

1) The fast reactors developed at Dounreay were unique in how they used liquid metals to transfer heat from the core to steam generators and produce electricity. The Dounreay PFR was a 250Mwe (600 MWth) sodium-cooled pool type fast reactor, with an inventory of 1,500 tonnes of sodium. It was shut down for decommissioning in March 1994 after 20 years of operation.

Site photographs courtesy of UKAEA

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