Nuclear Reactor Coolant Removal Monitored by Measuring Hydrogen Off-Gas

NNC Limited is using Systech 542 programmable gas analysers to monitor hydrogen off-gas in test rig for Dounreay Fast Breeder Reactor decommissioning.

Decommissioning nuclear reactors is not only a matter of dealing safely with the radioactivity issues, non-nuclear contamination can be equally difficult to remove safely and economically. NNC Limited is currently developing a system to remove alkaline metal coolant contamination from the Dounreay Fast Breeder Reactor (DFR), which has been kept under care and maintenance since shut down in 1977. The mixture of sodium and potassium metal in alloy form (NaK), used as a coolant, not only contains a high level of radionuclides but is also a fire risk since sodium and potassium are both water and air sensitive. One of the options for decommissioning is to drain the bulk NaK from the reactor system and deal with the residues remaining using the Water Vapour Nitrogen (WVN) process.

The coolant residues remaining after draining form small pools and a surface coating over all exposed steel surfaces in both the reactor vessel and the cooling system. The problem to be solved is to remove these residues without the generation of excess hydrogen concentrations or pressure pulses from unstable reactions and to convert the entire residue to hydroxide. The hydroxide can then be flushed out with a water rinse and final dismantling can commence.

The process in development by NNC passes low concentration water vapour carried by nitrogen over the contaminated surfaces to react with the alkaline metals. This reaction produces hydrogen, which is measured using a Systech 542 programmable gas analyser. NNC acquired its first Systech 542 in 1994 since when a number of design changes have been made by Systech design engineers to meet the specific needs of the development programme.

The water vapour reacts with the coolant to produce potassium hydroxide and sodium hydroxide, plus hydrogen. The amount of hydrogen produced, an indication of the amount of contaminant remaining, is measured using two Systech 542 programmable gas analysers. Both have 2 alarms that can be set to high or low level. NNC use the alarms on both analysers as a high level and a high high level such that in the event of high or very high hydrogen concentration automatic trip levels can be set. The analyser also has settable analogue outputs that are recorded on a data logging system. Since NNC are generally interested in low levels of hydrogen but also need to record the high levels, the analogue output ranges of the two instruments are different, one on high sensitivity and the other on low.

NNC are currently running a test rig at its Warrington facility to test the effectiveness of the process under operating conditions and to determine operational parameters that can be transferred to a full-scale unit. Systech 542 analysers, used to monitor the progress of the decontamination process and to control the safe venting of hydrogen to atmosphere, are required to be accurate and stable at both high and very low concentrations of hydrogen. In the decontamination process, the most critical application, the Systech 542 is used to measure levels as low as 10 ppm of hydrogen in nitrogen. At these exceptionally low concentrations, instrument drift can become a major problem. At Warrington, drift of 20 ppm, due to changes in ambient environmental conditions between day and night, has been observed. In the NNC rig, effect of instrument drift is minimised by running the 542's auto-zero programme at predetermined intervals.

Described by Brian Fletcher, NNC's consultant engineer, as the most important element in the system, the Systech 542 programmable gas analysers are proving to be a key component in the development of the process for the safe decontamination of reactor system components from the Dounreay Fast Breeder Reactor.

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