Dissolved Oxygen and Hydrogen Analysis in Reactor Coolant Systems

Low service, durable and highly accurate analyzer offers real-time process control while withstanding high pressures and radiation to mitigate radiation exposure for personnel

Introduction

The success of any reactor coolant chemistry program depends on minimizing chemically corrosive environments that affect the integrity of the reactor coolant system (RCS). Program goals typically include: decreasing the total inventory of radioactive contaminants present in the system; reducing equipment repairs; increasing plant operating efficiency, and reducing exposure of nuclear plant personnel to ionizing radiation.

RCS piping and equipment corrosion is accelerated by the presence of small quantities of dissolved oxygen (DO). In some cases, dissolved hydrogen (DH) is introduced into the RCS to minimize the concentration of DO produced by radiolysis. The accurate knowledge of DH and DO levels in the RCS is therefore imperative to maintaining good process control.

A common method of reactor coolant DH analysis is by gas chromatography (GC). RCS DH measurements by GC have several pitfalls:

- It is a spot check analysis, yielding only a "snapshot" concentration in time.
- It requires at least one hour collecting the sample—a substantial exposure to a high radiation zone, and a high expense of technician time.
- Accuracy of the GC analysis relies heavily on the sampling technique of the individual performing the task.

Benefits of the Hach Solution

The use of an Orbisphere dissolved H_2/O_2 analyzer offers electric power utilities numerous benefits in comparison to GC or alternative sampling methods:

1. An on-line DO_2/DH_2 measurement system practically minimizes radiation exposure for personnel, hence adhering to ALARA (as low as reasonably achievable).
2. It provides nearly "real time" continuous process control.
3. It provides more accurate and consistent measurements than any other method, bench top or otherwise.

On-line analysis permits early recognition of possible trends toward out of tolerance conditions, preventing costly corrosion damage to RCS piping, components, and equipment. Continuous gas analysis provides data enabling faster plant degas, shutdown, and start-up.

The Orbisphere H_2/O_2 analyzer uses the Orbisphere superior gas measurement sensors: a unique thermal conductivity detector/membrane metering sensor for H_2, and the Orbisphere K1200 Luminescent Oxygen Sensor or the industry-standard electrochemical oxygen sensor. The sensors are made to withstand high pressures and radiation — rugged enough for many years of trouble-free service in reactor coolant measurements, as evidenced for over 20 years at nuclear plants around the world.

The sample is introduced to the sensors by means of ¼" or 6-mm stainless steel tubing leading into the Orbisphere model 32001 flow chambers. The sensors are integrated with the Orbisphere model 51x (including channel compensation for EC sensor version) nuclear services instrument, which calculates dissolved hydrogen (typically in units of cc/kg, but other choices are menu-selectable) and dissolved oxygen (typically in units of ppb). A full range of menu-configured analog and digital signals and alarms can be output continuously.

The measurement of RCS DH must be made at elevated pressures in order to keep all of the hydrogen in solution. Typically, the measurement is made at a pressure of about 4 to 5 bar absolute; pressure reduction valves and flow control devices are used to maintain optimum sample conditions.

Hach Solutions

Choose the electrochemical (EC) sensor solution if :

- You are looking for a true zero measurement with 0.1 ppb precision
- The sample pressure exceeds 20 bar

Otherwise, Hach strongly suggests the optical solution for lower maintenance and intervention.

Table 1: Solution with Optical O_2 Sensor

Component	Model	Description
Controller	511FK0 / P1C1P0N0	H_2 (TC) & O_2 (Optical) two-channel controller for nuclear services
O_2 Sensor	K1200 –S00	Optical oxygen sensor
H_2 Sensor	31250	Thermal conductivity hydrogen sensor with nitrogen purge
Flow Chamber	32001.010	Flow chamber in stainless steel with 6 mm fittings (2 required) *Also available: 32001.011 with ¼" fittings
Cables (xx = length in meters)	32505.xx 32510.xx 32548.xx	H_2 sensor cable O_2 sensor cable Pressure sensor cable
Accessory	29089	Pressure regulator and filter for H_2 sensor purge

Table 2: Solution with EC O_2 Sensor

Component	Model	Description
Controller	512AF0 / P1C1P0N0	H_2 (TC) & O_2 EC two-channel controller for nuclear services with inter-channel compensation
O_2 Sensor	A1100 –S00	EC oxygen sensor with Smart Capability: stainless steel
H_2 Sensor	31250	Thermal conductivity hydrogen sensor with nitrogen purge
Flow Chamber	32001.010	Flow chamber in stainless steel with 6 mm fittings (2 required) *Also available: 32001.011 with ¼"
Cable (xx = length in meters)	32505.xx 32505.xx	H_2 sensor cable O_2 sensor cable
Accessory	29089	Pressure regulator and filter for H_2 sensor purge

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