ANALYSIS AND MEASUREMENT SERVICES CORPORATION
AMS Technology Center
9119 Cross Park Drive
Knoxville, TN 37923 USA
Phone (865) 691-1756 • Fax (865) 691-9344
Email: info@ams-corp.com • www.ams-corp.com

Testing Program to Verify Optimum RTD Performance in a Nuclear Power Plant

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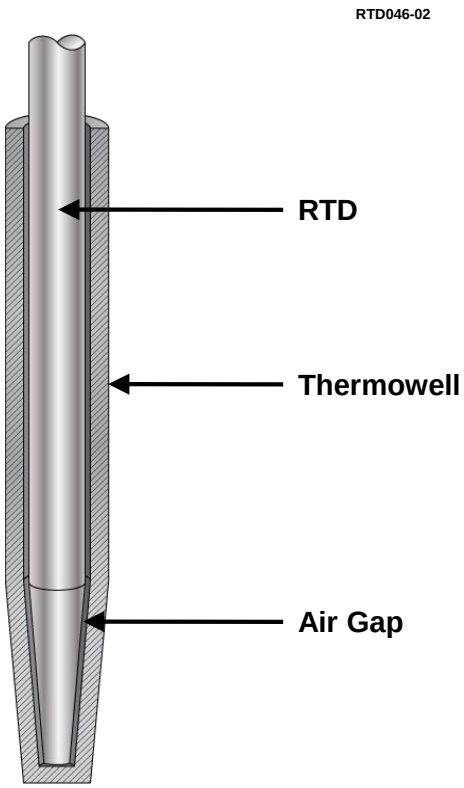

The following test program is designed to help nuclear power plants with Resistance Temperature Detector (RTD) performance verification. These tests shall be performed on new RTDs and/or new thermowells, or each time an RTD is removed and reinstalled in its thermowell. Also, the tests shall be performed after each period of extended outages (twelve months or more), especially if there is any reason to believe that the RTDs might have been disturbed during the outage.

Cable/Connector Tests

In addition to response time verification, the test program outlined here is necessary to verify that the wiring and connections in the RTD head, junction boxes, penetrations, and other electrical connections are free of any abnormalities which may cause problems during the in-situ response time testing using the Loop Current Step Response (LCSR) method. Sometimes an RTD is properly wired for steady-state performance and no problems may normally exist with the circuit. At the same time, the RTD may exhibit problems during the LCSR test when an electrical current is applied throughout the whole circuit. Experience has shown that occasionally the use of current during the LCSR test can reveal circuit problems that are not normally seen by conventional cable tests. These problems can interfere with successful LCSR testing of the RTD and may also be a problem otherwise. As such, it is important to verify that such problems are not present while the plant is at cold shutdown conditions, when it is easy to resolve such problems. The cold tests that are included in the test program not only verify proper installation for optimum response time during normal operating conditions, but also can reveal circuit/cable/connector problems that can interfere with LCSR testing of the RTDs.

Response Time

The response time of a thermowell-mounted RTD is very sensitive to the installation of the RTD into its thermowell. Laboratory and in-plant experience from more than twenty years of testing in nuclear power plants has shown that one mil (1/1000th of an inch) air gap between the tip of a thermowell and the RTD sheath can change the response time significantly.

In nuclear power plants, it is important to identify RTD response time problems and resolve them during an outage while the plant is at cold shutdown conditions. If not identified and resolved during an outage, RTD response time problems can cause major delays at critical path or even prevent the plant from proceeding toward power operation.

Cold Shutdown Tests

The tests at cold shutdown are performed at the ambient temperature and flow conditions after the RTDs are installed in their thermowells in the plant, their wiring is completed, and the primary coolant loops are filled. As the test results at cold shutdown will depend strongly on the water flow rate, it is desirable that all RTDs be tested at approximately the same flow rate. Stagnant room temperature water conditions or shutdown cooling (RHR) induced flow in the primary coolant loops are acceptable conditions for the cold shutdown tests. The shutdown cooling system or RHR system is normally operated to remove the heat from the core during the cold shutdown periods. It takes suction from one of the hot leg pipes and discharges to one or more of the cold leg pipes. The flow can be switched from one train to another if needed to change flow configurations during the cold shutdown tests.

The cold shutdown test data are analyzed on-site and the time constants and self heating results for all RTDs are inter-compared to identify the outliers (if any). These tests have proven useful in identifying gross installation problems with thermowell-mounted RTDs in nuclear power plants. Examples of problems that are encountered with thermowell-mounted RTDs which have been detected in the past by response time testing at cold shutdown include: bent RTDs, bent thermowells, RTD/thermowell mismatch, insufficient RTD-in-thermowell insertion due to dimensional or mechanical problems, dirt in the thermowell, and wiring problems that are not readily detectable by routine measurement of electrical loop and insulation resistances.

Note that the cold shutdown results are useful only for verification of proper installation and not for measuring the actual in-service response times of the RTDs. The in-service response times are measured at hot standby conditions as described below.

Hot Standby Tests

Since RTD response time depends on process temperature, pressure, and flow conditions, the actual in-service response times of the RTDs must be measured by in-situ testing at or near normal operating conditions using the LCSR and self-heating methods. For new or recently installed RTDs, these tests are performed at the end of the outage with the plant at hot standby. In most plants, the hot standby condition during which the tests are performed is referred to as "Mode 3." It is required in almost all plants that the response times of newly installed RTDs be measured at Mode 3 to verify that the response times are acceptable before the plant can proceed toward power operation.