

BWR Vessel Inspection for Taiwan Power using Navigator™ Scanner

by Randy M. Plis and David A. Brunner

Abstract

In the nuclear power generation industry, In-Service Inspections (ISI) of reactor vessels are required to be performed every 10 years. The purpose of the ISI is to monitor any changes since the previous inspection in order to confirm the continued integrity of the reactor pressure boundary. Baseline inspections are performed at the vessel's manufacturing facility without access difficulties. ISI's, however, are performed in place, and consequently have significant physical access restrictions. To overcome these restrictions, and to provide the ALARA and quality benefits of automated imaging, ABB AMDATA has developed the Navigator™ Scanner. Its first field use was to perform the second 10 year ISI of BWR reactor vessels at Taiwan Power Company's (TPC) Chin Shan Nuclear Power Station Units 1 and 2. The results of the inspections exceeded expectations, detecting previously unobserved manufacturing flaws, and experiencing the benefits of simultaneous ultrasonic and eddy current imaging.

Introduction

ABB NDE Services, a division of ABB Combustion Engineering Nuclear Power (CENP), was contracted by Taiwan Power Company (TPC) to conduct a 20th year In-Service Inspection of the BWR Reactor Vessel at Chin Shan Unit 2.

ABB NDE Services provided the field service using a UNIX RISC based IntraSpect™ imaging system. The inspection also involved the first field use of a Navigator™ automated scanner. Both the IntraSpect and Navigator are NDE products provided from ABB AMDATA, another division of ABB CENP. The inspection of Unit 2 was completed in November 1997. Following the success of Unit 2's inspection, ABB was also contracted to perform the ISI of Chin Shan Unit 1 at its next outage.



Navigator at Chin Shan Unit 2 traveling between the reactor vessel OD and mirror insulation

Inspection Requirements

The requirements for reactor pressure vessel (RPV) inspections are contained in the American Society of Mechanical Engineers (ASME) Code, Section XI, Rules for In-Service Inspection of Nuclear Power Plant Components. These rules require the RPV to be inspected every 10 years. It is up to the owner utility to determine the inspection strategy (i.e., OD, ID or both) in order to meet these rules.

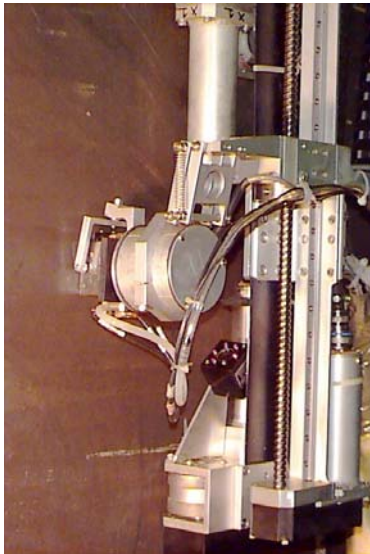
The purpose of the inspection for a Boiling Water Reactor is to ultrasonically examine both a circumferential and longitudinal weld in its beltline region. A minimum of 90% coverage of each weld is required. In the case of both Chin Shan units, access to the vessel is obstructed by mirror insulation, leaving a minimum gap of 7" (18 cm) to perform the inspection.

The BWR vessels at Chin Shan are 5" thick carbon steel with 3/16" thick stainless steel cladding on their ID. The detection flaw size of interest is 0.25" (i.e., calibrated on 0.25" side drilled holes at 1/4T, 1/2T & 3/4T).

Equipment Capabilities

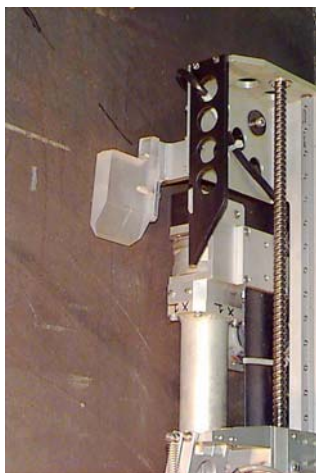
As a result of the physical obstructions and narrow access, ABB AMDATA designed and built a trackless Navigator scanner to perform this application. The Navigator included onboard cameras and inclinometers to visually locate and confirm the orientation of target welds.

The Navigator included a remotely controlled skewing device to direct the probes to any desired orientation irrespective of scanner position.



Skewing Device on Navigator

The Navigator also included an onboard reference block so that the scanner did not need to be periodically retrieved from the vessel to perform calibration checks.



Onboard Cal Check Block

A mockup of the vessel and its access and obstructions was built and used for training and mobilization at ABB's Windsor facility.



Navigator on BWR OD mockup plate observed by Design Engineer, Jay Baldwin

The Navigator was integrated with the following ABB AMDATA imaging and control system equipment as part of the mobilization efforts to prepare for the inspection:

- IntraSpect/UX-EX
- GA-1003
- Umbilical Cabling
- Monitors
- Inclinometer Displays
- Skewing Device Controller
- Joystick
- External Optical Drive

The IntraSpect/UX-EX (I/UX-EX) is RISC based UNIX system. It provides up to 4 channels of ultrasonics (UT), and 2 channels of Eddy Current (ET) at the same time. The system includes an HP workstation, a data acquisition system (DAS), color printer, keyboard, mouse, etc.

The GA-1003 is a 3 axis, servo based, scan controller. Although the Navigator is an X-Y style scanner, its X-drive wheels can be individually controlled to enable it to literally spin on a dime, if necessary.

A custom 300' long umbilical cable was manufactured for this application. It included 6 UT cables, 2 ET cables, 1 couplant supply line, 3 motor/encoder cables, 2 inclinometer cables, and 2 video cables.

Black & white monitors were added in association with the onboard cameras. This

allowed operators to view both the travel direction of the scanner, as well as to observe the NDE probe.

Inclinometer displays provided a digital readout of the Navigator's orientation. As the Navigator is able to spin in circles and travel upside-down, such additional feedback is extremely beneficial.

The skewing device controller is a separate box which allows an operator to manually manipulate the probe orientation, if necessary. Skewing direction (CW or CCW), speed and digital readouts are provided by the control box.

A 3-axis joystick is used in conjunction with the Navigator. It is used to manually drive the 2 X-axis motors (independently if desired as well as the Y-axis motor). The joystick also contains an E-stop for additional safety purposes.

Lastly, an external optical drive is provided for copying and/or archiving purposes. Its capacity per diskette is 2.6 GBytes.

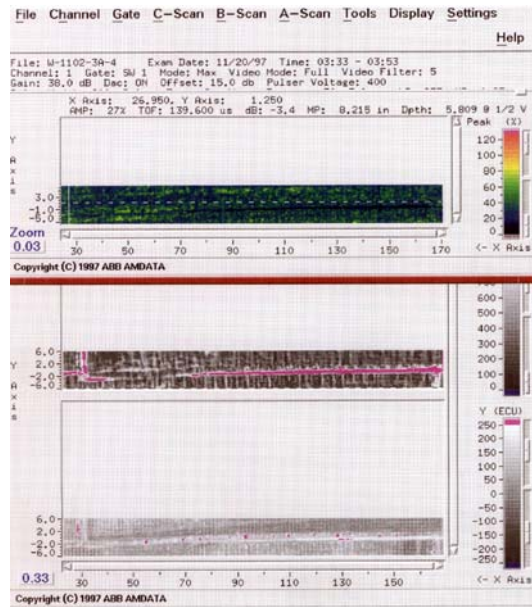


IntraSpect/UX-EX RISC Based System

These preparations paid off as the first use of the Navigator and ABB's BWR ISI service both performed extremely well.

Inspection Results

The inspection was conducted using ABB AMDATA's combined ultrasonic and eddy current imaging system: the IntraSpect/UX-EX. The actual inspection involved 3 channels of UT, and 1 channel of ET. In conjunction with the ultrasonic images, the operators found the additional view of eddy current imaging to be very beneficial in both locating welds, and the intersections of welds.



Chin Shan UT/ET Data Display

The Unit 2 inspection was based upon 5 man crews, working 2 shifts over a period of 4 1/2 days. This compared to an available first-use window of 10 days. ABB custom designed and built triplex probes, and also generated the inspection procedure for TPC approval.

Considering that the vessel was baseline inspected at its factory, and that this was the second 10-year ISI, the Chin Shan Unit 2 vessel had previously been inspected a minimum of 2 times. Surprisingly, ABB NDE Services' inspection detected numerous previously unrecorded indications. The indications were determined to be volumetric and associated with the welding process. All of these original manufacturing imperfections were determined to be smaller than the ASME Code rejectable flaw size.

Conclusions

The first field use of the Navigator was exceptionally successful. It accomplished all of its design objectives. The ASME target of 90% coverage was exceeded by inspecting 100% of each weld. Furthermore, its application by an experienced ABB crew resulted in the BWR ISI being completed in record time.

TPC was "exceptionally pleased" with the inspection service, and will have ABB return to perform the 20 year ISI for Chin Shan Unit 1 in February 1998.

Acknowledgments

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- ABB AMDATA: Jay Baldwin, Design Engineer

Additional Information

For additional information regarding the IntraSpect imaging system or the Navigator, please contact Randy Plis at 860-688-2400 extension 56. For additional information regarding BWR ISI or other NDE inspection services, please contact Rick Kusy at 860-688-2400, extension 23.