Company name	Kyushu EPCO
Date of occurrence	18, December, 2007
Unit name	Genkai 1
Event	Inspection of the Inner Surfaces of Welded Locations of the Primary Coolant Outlet and Inlet Nozzles of Steam Generators
International Nuclear Event Scale (INES)	Not applicable
Status of report	Final report

Status when event occurred

The eddy current flow detection test (hereinafter referred to as “ECT”) was conducted on the inner surfaces of welded locations of the primary coolant outlet and inlet nozzles of all steam generators (hereinafter referred to as “SG”) in the 25th periodic inspection in accordance with the “Implementation of inspections of inner surfaces of welded locations of outlet and inlets nozzles of steam generators” (November 13, 2007) instructed by the Nuclear and Industrial Safety Agency (NISA) and the Ministry of Economy, Trade and Industry (METI).

As a result of ECT, significant signal indications were found at three locations with respect to the welded locations of the inlet nozzle of A-SG. No abnormality was found in the outlet nozzle of A-SG and outlet and inlet nozzles of B-SG.
The ultrasonic test (hereinafter referred to as “UT”) was conducted for the parts showing significant signal indications in ECT of the welded locations of the inlet nozzle of A-SG and the depth of the flaws was identified, but no significant signal indication was found.
Furthermore, a full investigation of these locations was conducted and as a result, extremely shallow cracks on the surfaces were identified.
Moreover, it was confirmed that these locations satisfied the design board thickness, even when these cracks are taken into consideration.

Summary of examination of cause

1. Inspection results
(1) ECT result
Significant signal indication was found in the axial direction at three locations of the welded locations of the inlet nozzle of A-SG; locations at 9 degrees in circumferential direction (No.1), at 130 degrees (No.2) and 344 degrees (No.3). (Circumferential direction angle is measured setting the starting point (0 degrees) at the highest point of the nozzle, then going around clockwise viewing the nozzle from the water chamber.)
(2) UT result
UT was conducted for the parts showing significant signal indications in ECT of the welded locations of the inlet nozzle of A-SG. However, no significant signal indication was found nor was it estimated that the

depth of indications is extremely shallow.

(3) Crack depth inspection result

As for the three locations where significant signal indication was found in ECT results, grinding of 0.6 mm, 0.5 mm and 0.8 mm was performed at locations No.1, No.2 and No.3 respectively. ECT was conducted after the grinding and since no significant signal indication was found, it was concluded that the cracks were extremely shallow about 1 mm in depth. So as to assure the procedure, an additional grinding was performed to have sufficient margin in the detection accuracy of ECT.

It was confirmed that the board thickness after the additional grinding satisfied the design board thickness of 75 mm, which is the indicated value in the application form for the construction plan approval.

2. Cause investigation

Cause of cracks at the welded locations of the inlet nozzle of A-SG with respect to the locations where significant signal indication was found from ECT was investigated.

As for cracks of the welded locations of the nozzle, it was confirmed through SUMP observation that the cracks have occurred along the dendrite border and have characteristics of stress corrosion cracking in the primary water environment (hereinafter referred to as “PWSCC”).

Machining marks made at the production phase were observed on the inner surfaces of welded locations welded with 600 type nickel base alloy.

Through interview inspections regarding machining conditions and through mockup tests conducted to investigate the cause of Mihama Unit No. 2, it was estimated that the residual stress has exceeded 300 MPa, which is the threshold level in occurrence of PWSCC.

It was confirmed that there was no repair welding at the production phase or peticuliar production/operation history.

Cause of event

It is assumed that PWSCC occurred due to the primary water environment and high stress from the high residual stress, which occurred on inner surfaces of the welded location, since machining (grinding) was conducted on the welded location of the inner nozzle welded with 600 type nickel alloy at the production phase of the replacement SG.

Measures to prevent recurrence

(1) Removal of cracks

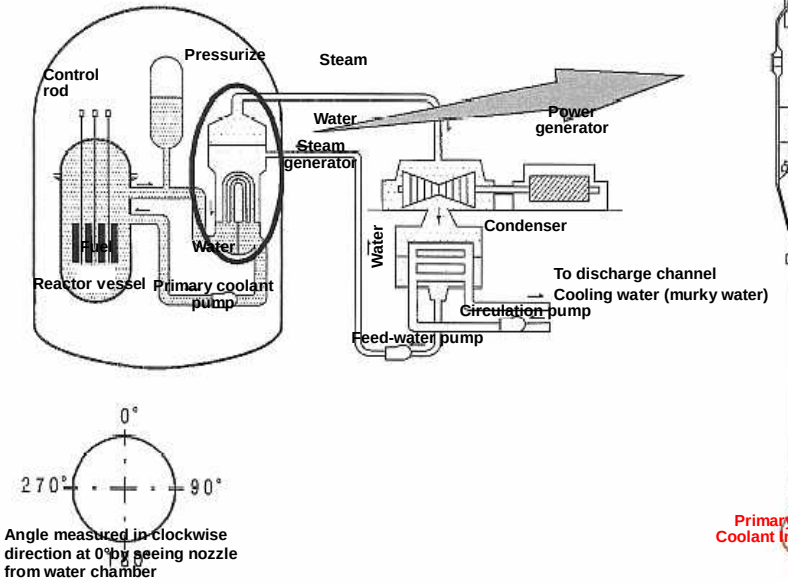
As for locations where significant signal indication was found in ECT, grinding was performed until no significant signal indication was found in ECT for the depth investigation and, furthermore, an additional grinding was conducted considering the investigation accuracy of ECT.

(2) Ultrasonic shot peening (USP) treatment

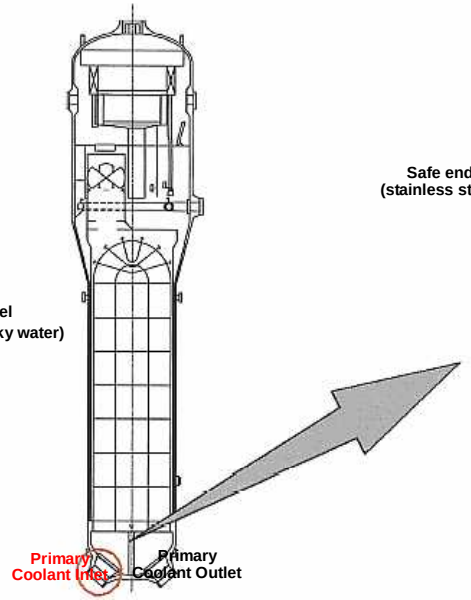
As a preventive maintenance measure, USP was applied to mitigate residual stress, which was planned to be conducted in this periodic inspection.

General chart of inlet nozzle of steam generator of Genkai Nuclear Power Plant Unit 1

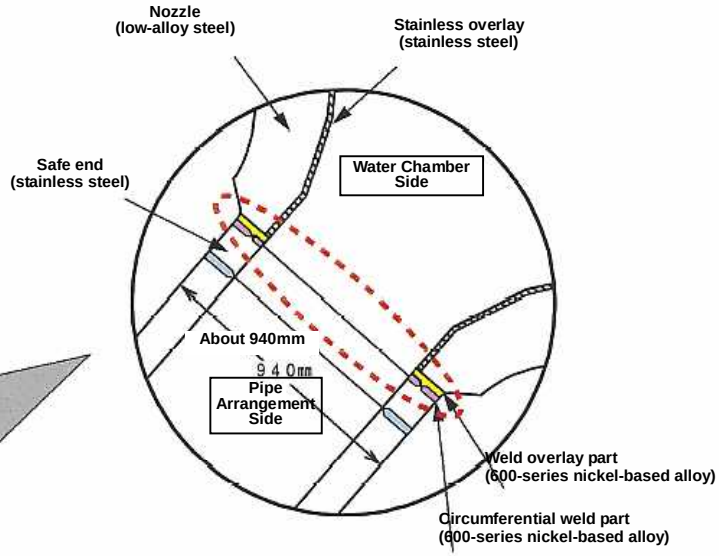
Schematic System Illustration



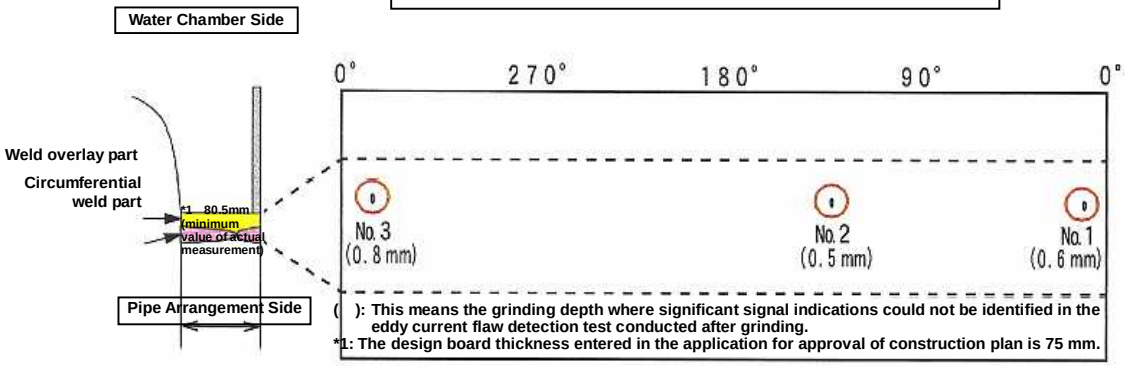
Schematic Illustration of A Steam Generator



Locations Inspected



Results of Eddy Current Flaw Detection Test of Inlet Nozzle of A Steam Generator



( ): This means the grinding depth where significant signal indications could not be identified in the eddy current flaw detection test conducted after grinding.

*1: The design board thickness entered in the application for approval of construction plan is 75 mm.

Inspection Results of Welded Locations of Outlet and Inlet Nozzles

Inspected locations			Eddy current flaw detection test *2		Ultrasonic flaw detection test *3
			Circumferential direction position	Axial direction length	Indicated depth
A steam generator	Inlet side	No.1	9°	5mm	Not identifiable
		No.2	130°	4mm	Not identifiable
		No.3	344°	4mm	Not identifiable
	Outlet side	—	No indication from eddy current flaw detection test		
B steam generator	Inlet side	—	No indication from eddy current flaw detection test		
	Outlet side	—	No indication from eddy current flaw detection test		

*2 Eddy current flaw detection test: This is a method for detecting flaws of objects to be tested from changes in electromagnetic induction during the passage of an eddy current on the surface of the material.

*3 Ultrasonic flaw detection test: This is a method for detecting flaws of material bodies by utilizing the nature of echoing flaws in a discontinuous manner during the transmission of ultrasonic sound wave through the material body.