U.S. NUCLEAR REGULATORY COMMISSION

REGION V

Report No. 50-275 Docket No. 50-275

License No. DPR-76

Licensee: Pacific Gas and Electric Company
77 Beale Street, Room 1435
San Francisco, California 94106

Facility Name: Diablo Canyon Unit No. 1

Inspection at: Diablo Canyon Site, San Luis Obispo County, California

Inspection conducted: July 1-22, 1983

Inspectors:	G. Hernandez, Reactor Inspector	8/5/83 Date Signed
	W. Wagner, Reactor Inspector	8/5/83 Date Signed
	J. Crews, Technical Assistant to the Administrator	8/5/83 Date Signed
	A. Johnson, Enforcement Officer	8/5/83 Date Signed
	M. Mendonca, Resident Inspector	8/5/83 Date Signed
	J. Carlson, Senior Resident Inspector	8/5/83 Date Signed
	P. Morrill, Reactor Inspector	8/5/83 Date Signed
Approved by:	D. F. Kirsch, Chief, Reactor Projects Sec. No. 3	8/5/83 Date Signed

Summary:

Inspection during the period of July 1-22, 1983 (Report No. 50-275/83-26)

Areas Inspected: Special announced inspection by regional and resident inspectors of the circumstances and facts relating to the licensee's discovery of apparent less than minimum code allowable wall thickness at or adjacent to welds in the reactor coolant system (RCS), which was initially identified in Licensee Event Report (LER) 83-006. The inspection involved 184 inspection-hours by seven NRC inspectors.

Results: No items of noncompliance or deviations were identfied.

DETAILS

1. Individuals Contacted

a. Pacific Gas and Electric Company (PG&E)

G. Maneatis, Executive Vice President Facilities and Electric Resources Development
J. Schuyler, Vice President Nuclear Power Generation
R. Etzler, Field Construction Manager
D. Rockwell, Assistant Project Superintendent
R. Twiddy, Site Quality Assurance Manager
J. Shiffer, Manager Nuclear Operations
W. Raymond, Technical Assistant to the Vice President, Nuclear Power Operation
F. Dodd, Senior Metallurgical Engineer
S. Skidmore, Manager of Quality Assurance

b. Bechtel Corporation (Bechtel)

C. Dick, Project Management Team Member
H. Friend, Project Completion Manager

2. Background

On May 9, 1983 Pacific Gas and Electric Company (the licensee) representatives called the Region V staff to report that ultrasonic examination (UT) of RCS Weld Number WIB-RC-2-17 (in the Unit 1 RCS cold leg of loop No. 2) might be below specified minimum wall thickness. The licensee personnel committed to examine the remaining RCS girth welds in Unit 1 at that time. This telephone call was followed up with a LER (No. 83-006) dated May 23, 1983.

On June 22, 1983 a member of the licensee's staff verbally informed the NRC that based upon additional ultrasonic measurements it appeared that minimum wall requirements might not be met in approximately nine additional weld areas. Members of the Region V inspection staff arrived at the Diablo Canyon site the following day and examined the latest information related to this issue. At the NRC exit meeting on June 23, 1983 the licensee committed to conduct a detailed investigation and to submit a report documenting these activities. This report (dated July 1, 1983) was submitted to the Region V office by PG&E letter "Schuyler to Martin" dated July 5, 1983.

On June 29, 1983 the NRC contracted with Parameter, Inc. to conduct independent UT examinations of the subject RCS welds and to assess the adequacy of this technique for thickness measurements in this piping. During the week of July 5, 1983, three Parameter, Inc. personnel conducted these examinations which were documented in a report (dated July 14, 1983) and forwarded by a letter "Foley to Morrill" dated July 14, 1983.

Subsequently, Region V conducted a public meeting on July 14, 1983 in the Region V offices to discuss the licensee's July 1, 1983 report with members of the licensee's staff, members of the Independent Verification Program, representatives of the Governor of the State of California, and representatives of the joint intervenors. A transcript of that meeting was taken which was subsequently distributed to all parties to the Diablo Canyon licensing proceedings along with the Parameter Report, dated July 14, 1983.

Examinations of license records and measurements in progress had been examined on June 23-24, June 29 - July 1, July 7-8, July 12-13, and July 20-21, 1983 by the Region V staff. This report documents these inspection activities and the conclusions of the Region V staff.

3. Documents reviewed by the NRC included:

Westinghouse Specification No. G676341, Rev. 1, dated 4-11-67 "Reactor Coolant Seamless Pipe"

Westinghouse Specification No. G676342, Rev. 2, dated 4-6-67 "Reactor Coolant Cast Fittings"

Westinghouse Specification No. 676496, Rev. 0, dated 3-13-67 "Reactor Coolant Piping - Field Erection"

American Standard ASA B-31.1, 1955 Edition, Section 122 "Thickness of Pipe"

PG&E Deviation Report No. 39, written 10-7-70 and closed on May 5, 1971, to evaluate the effect of pipe spool marking depth on minimum wall thickness requirements

PG&E Procedure TG 83-01, Rev. 0, dated 6-29-83 "Temporary Procedure - RCS Piping Wall Thickness Measurements"

Mechanical measurement data for welds 1-1, 1-2, 1-4, 1-8, 1-11, 1-16, 2-1, 2-2, 2-17, 3-9, 3-13, 4-2, 4-16

PG&E Specification No. 8752 for Field Erection of RCS Piping (Wismer/Becker Specifiction)

PG&E Procedure N-UT-2, Rev. 0, dated 1-1-83, "UT Thickness Measurement Examination Procedure"

Southwest Fabricating & Weld Co. As-Built Drawings for pipe spools containing welds 1-1, 1-2, 1-11, 1-16, 2-1, 2-2, 2-17, 3-9, 4-16

Cameron Iron Works Data Sheets documenting minimum outside diameter, maximum inside diameter, maximum and minimum wall thickness measurements for pipe involved in RCS welds 1-1, 1-2, 1-11, 1-16, 2-1, 2-2, 2-17, 3-9, 4-16

Southwest Fabricating & Welding Company drawing no. SO.7524 Sheet Q giving details of shop and field weld tolerances for machining

4. Evaluation of Reactor Coolant System (RCS) Piping Wall Thickness

(a) Examination of Shop Manufacturing and Fabrication Records

The inspector reviewed records generated during fabrication of the reactor coolant loop (RCL) piping. This was to determine the adequacy of the quality assurance program during fabrication, and to establish whether or not minimum wall was maintained prior to the pipe being received at the jobsite. Specific records reviewed and the general results are described below.

Westinghouse Equipment Specification G-676341, "Reactor Coolant Seamless Pipe" listed the requirements that the suppliers (vendors) were responsible to meet during fabrication of RCS piping; this included dimensional requirements for inside and outside diameters (I.D. and O.D. respectively), and minimum wall thicknesses.

Cameron Iron Work Material Certifications provide dimensional measurements of the O.D., I.D. and wall thickness. Based on this data the inspector verified that the dimensional requirements of Westinghouse Specification G-676341 were met. These verifications were made for the hot leg, crossover leg and cold leg piping.

Southwest Fabricating and Welding Company (Southwest) as-built drawing for fabricated spool piece number PGE DC-663219-167-3 was examined. The inspector verified that minimum wall met the drawing requirements and was correctly approved for construction.

The inspector also reviewed a Southwest document addressing final inspection, prior to shipment, of 8 pipe sections and 4 elbows. This document stated that "dimensions were checked throughout and were within allowable tolerances".

Westinghouse records show that numerous inspections were performed by Westinghouse of their reactor coolant piping vendors. One memo stated that mechanical readings at the shop and field are compatible.

PG&E weekly inspection reports were written by PG&E inspectors during fabrication at Cameron and Southwest. These reports indicate that RCS pipe dimensions were checked and found acceptable.

PG&E QA Audit of Southwest verified that as-built dimensions conform to appropriate specifications.

(1) Cameron Iron Works, Inc.

During the manufacturing process at Cameron Iron Works Inc., measurements were taken and documented on each pipe section and heat number manufactured. These measurements consisted of

outside diameter, minimum and maximum inside diameter, and minimum and maximum wall thickness. The measurements were taken at distances of one inch and two feet from each end of the pipe section.

Westinghouse E Specification No. G-676341 specified acceptance criteria for maximum and minimum inside diameter, minimum wall thickness and minimum outside diameter for each size of pipe manufactured (i.e., for nominal inside diameters of 27.5 inches, 29 inches and 31 inches).

The inspector examined the data documented by Cameron Iron Works for the pipe sections containing weld numbers: weld 1-1 (field weld), weld 1-2 (shop weld), weld 2-1 (field weld), weld 2-2 (shop weld), weld 1-11 (shop weld), weld 1-16 (shop weld), weld 2-17 (shop weld, weld 3-9 (field weld), and weld 4-16 (shop weld). The data recorded and documented by Cameron demonstrates compliance with dimensional acceptance criteria specified in Westinghouse E Specification No. G-676341.

The inspector also performed independent calculations of wall thickness remaining based on counterboring for the shop and field welds. The counterboring and shop welding was performed by Southwest Fabrication and Welding Company (see next subsection).

This calculation was performed using the following equation:

$$\text{Wall Thickness} = \frac{\text{(Minimum Outside Diameter)} - \text{(Maximum Specified Inside Diameter)}}{2}$$

Data for the minimum outside diameter was obtained from data recorded by Cameron Iron Works. The maximum inside diameter data was obtained from Southwest Drawing No. 80.7524, Sheet Q and Westinghouse E Specification No. G-676341. The Southwest drawing specifies weld preparation dimensions, counterbore dimensions, and tolerances.

The results of the inspector's calculations indicated that minimum wall thickness criteria were complied with in all cases. The results of these calculations were compared to the mechanically measured minimum wall thickness presented in Table V-1 of the PG&E Report on "Investigation of Reactor Coolant Pipe Weld Thickness at Diablo Canyon", transmitted to the NRC Region V on July 5, 1983. The results of the independent calculations, performed using worst case conditions, appeared consistent with the wall thickness obtained and documented by PG&E, and demonstrated compliance with the Westinghouse minimum wall thickness acceptance criteria.

(2) Southwest Fabricating and Welding Co.

This company machined the counterbore on the pipe sections manufactured by Cameron and completed the shop welds. The

documentation indicates that the machining operations were performed as specified on Southwest detail sheet Q. Southwest has documented, by letter to Westinghouse, dated July 19, 1983, that wall thickness was checked with micrometers to verify that the minimum thickness specified on the detail sheet and sheet Q was satisfied and, further, that since this check was only to verify that thickness was adequate, actual thicknesses were not recorded. Southwest also states, in that letter, that in-service inspection preparation of welds was performed on the shop welds of the 31 inch inside diameter crossover legs while all other shop welds were furnished in the "as-welded" condition.

(3) Source Inspection Document Review

The inspector examined representative records of source inspections, performed by PG&E, of Southwest Fabricating and Cameron Iron Works. These records documented that PG&E inspectors made dimensional spot-checks and verified wall thicknesses of selected pipe spools.

The records documented that on pipe (4153 cold leg) was found to be less than minimum wall thickness in one location. It was subsequently repaired by welding and reinspected by Cameron.

(4) Westinghouse Electric Company

As Nuclear Steam Supply System supplier, Westinghouse furnished the RCS piping including a quality control release form with each piece. On these forms Westinghouse documented acceptance of dimensional records. However, the dimensional records were not included with the documentation package on shipment. PG&E, therefore based their acceptance on the documentation supplied by Westinghouse indicating that Westinghouse had accepted the dimensional records.

(b) Examination of Records of Field Erection and Welding of Reactor Coolant System Piping

Records of the erection and welding of the reactor coolant system (RCS) piping for Unit 1 were examined. Specific records which were examined included documentation for field weld numbers WIB-RC-1-1, 2-1 and 3-1.

The records indicated that weld fitup was examined and "signed-off" by three parties (Wismer & Becker, the California Code Inspector, and PG&E) for weld number 2-1. For Welds 1-1 and 3-9 the records indicated an additional sign-off of weld fitup by Westinghouse.

The records also indicated that measurements were recorded by Wismer & Becker inspectors of the pipe wall thickness after weld fitup. These measurements were recorded for each quadrant of the weld. According to PG&E General Construction Department personnel,

these measurements involved the placement of a mechanic's straight edge axially spanning the weld preparation area, with the depth of pipe wall determined by measurement from the straight edge to the top surface of the weld preparation land area at the root of the weld. The records indicated (with the exception of two quadrant measurements for weld 2-1, where the recorded value was not legible) wall thickness in each instance to be in excess of the minimum design wall thickness.

The inspector performed an independent calculation, using the data described above and the minimum allowed land thickness from drawing Sheet Q, to verify the wall thickness at the measured locations. The minimum allowed land thickness was 0.055 inches. Summing these dimensions indicates that the wall thickness remained above the specified minimum wall thickness in all locations measured by Wismer and Becker.

The records examined also included the logs of PG&E inspectors involved with inspection and surveillance of grinding of finished welds in the RCS during the period of early March 1975 through mid-May 1975. These records indicated essentially daily surveillance over this grinding activity. The records also contained acceptance criteria, established by PG&E's Engineering Department, for the grinding of the outside diameter of the welds. These criteria included the requirement that "...weld crowns should be ground smoothly down to the height of +1/16 inch max.,-0 inch min. from the adjacent pipe surface level...." The criteria also specified that grinding should be confined to the weld metal. The records indicated that this grinding was performed in preparation for ultrasonic inspection of the welds.

(c) Examination of Pacific Gas and Electric Company Deviation Report No. 39.

The inspector examined the subject deviation report. The report documents that, following receipt of the RCS piping spools at the warehousing area, PG&E became concerned that the observed depth of spool identification marking indentations may infringe on specified minimum wall thickness requirements.

Using ultrasonic wall thickness measurements PG&E rejected spool 1-1. The Westinghouse site manager made arrangements to measure wall thickness using state of the art optical and ultrasonic equipment. Optical measurements verified that wall thickness exceeded the specified minimum.

During these measurements a conflict developed between the data obtained ultrasonically and optically. The theory was advanced that the Type 316 SST material, used for the RCS pipe, was not homogenous in all heats thus causing the ultrasonic wave velocity to vary between heats.

When the UT instrument was calibrated to a known thickness of a specific heat number the material thicknesses (measured

ultrasonically) exceeded minimum wall specifications. However, data taken indicate that, even by calibrating the instrument to a specific heat, a difference of 2.0% to 4.5% existed between micrometer (mechanical measurement) data and UT data.

Westinghouse conducted an evaluation of the UT technique applied to extruded stainless steel material. The conclusions were: (a) the UT equipment used initially by PG&E was not accurate in the 2.5 inch range; and (b) the UT equipment must be calibrated on the same heat number (material) as the piece to be tested. The findings of this evaluation indicate that a sonic velocity difference of almost 4% existed from one heat number to the other. Furthermore, discussions with an industry expert indicated that sonic velocity variances of up to 10% had been observed, mainly due to the differences experienced by material in the heat treatment and stress level.

Examination of this Deviation Report indicates that Ultrasonic examination techniques were not a sufficiently reliable means for measuring wall thickness in this type of material.

(d) Examination of Ultrasonic Test Procedure

The inspector examined PG&E procedure no. N-UT-2, Rev. 0, dated January 1, 1983, titled "UT Thickness Measurement Examination Procedure." This procedure was utilized in the calibration of instruments and examination of the RCS piping.

The calibration section requires that an appropriate calibration block be used of the same material (material having similar chemical analysis, mechanical properties and microstructure) and product form (material manufactured by casting, rolling or forging for plate, etc.) as the material to be measured.

Furthermore the calibration section requires (following calibration to a step wedge), that the response of an intermediate thickness should not deviate by more than 1% of the range under test.

Discussions with licensee representatives involved in the UT process indicated that compliance with the above 1% criteria could not be consistently obtained.

The inspector questioned the validity of the ultrasonic measurement technique as applied to the RCS piping for the following reasons:

- The response of the UT instrument to an intermediate thickness could not be consistently maintained within 1% of the range under test.

- Data obtained in the resolution Deviation Report No. 39, in 1971, indicated that the ultrasonic method of wall thickness measurement was not reliable when applied to RCS piping.

- The material used in the calibration of the instrument potentially had a far different microstructure than the material under test. The sensitivity of the UT technique to different material heat numbers was amply demonstrated in the resolution of Deviation Report No. 39 in 1971.

- Use of a step wedge for calibration doesn't adequately provide a product form calibration standard since the material under test had a curved surface.

For the above reasons the inspector considers that the licensee had inappropriately placed a high degree of reliance on the RCS thickness measurements obtained by the ultrasonic nondestructive testing methods utilized in the identification and verification of the potential deviations from specified minimum wall thickness criteria.

(e) Verification of Mechanical and Ultrasonic Measurements

On July 1, 12 and 13, 1983, mechanical and ultrasonic measurements were observed and verified by an NRC inspector on five Reactor Coolant System girth welds. The licensee had previously identified nine Reactor Coolant System girth welds as being potentially below minimum wall in certain areas.

Mechanical measurements were performed on the inside and outside diameters of each weld area. The measurements were made at the horizontal and vertical axis of the pipe weld area, at the licensee identified minimum wall area, (as determined by ultrasonic examination) and at points selected by the NRC inspector. Ultrasonic thickness measurements were then performed for comparison with the mechanical measurements. The welds examined were welds Nos. 1-1, 2-1, 2-2, 2-17 and 3-9. For weld no. 3-9 the minimum wall point was determined to be in the heat affected zone of the weld.

The inspector observed that while the ultrasonic thickness measurements of the vertical and horizontal axis of each weld were consistent with previous licensee ultrasonic data, in most cases the previously identified licensee minimum wall point could not be relocated. In almost all cases a new minimum wall point was recorded.

The following tabulation is a comparison of minimum wall mechanical measurements obtained during the NRC inspection, with the data reported by the licensee in their report entitled, "Investigation of Reactor Coolant Pipe Weld Thickness at Diablo Canyon", dated July 1, 1983.

Weld No.	Required Minimum Wall Thickness	NRC Observed minimum wall data	PG&E Reported minimum wall data
1-1	2.335	2.382	2.413
2-1	2.335	2.405	2.433
2-2	2.335	2.342	2.341
2-17	2.215	2.222	2.223
3-9	2.495	2.503	2.560

The mechanical measurements observed and verified by the NRC inspector indicated that the wall thickness was above minimum wall requirements for the five welds measured. The variations in the minimum wall data between the NRC and the licensee obtained data is attributed to the different persons taking the data, the cramped quarters involved in obtaining the data, and the difficulty of relocating the same spot on the RCS piping.

(f) Analysis of Mechanical Wall Thickness Measurements

The inspector performed an independent conservative verification of wall thickness by using the PG&E measurements of minimum outside diameter and the maximum allowed inside diameter (Drawing Sheet Q) to verify adequate wall thicknesses, in accordance with the following equation.

$$\text{Wall Thickness} = \frac{OD - ID}{2}$$

Where

OD = minimum recorded outside diameter
ID = maximum allowed inside diameter at bottom of weld land on counterbore (reference Drawing Sheet Q)

At one location at weld no. 3-9, the minimum measured outside diameter (at location 30°) was reported to 36.138 inches which was less than the 36.20 inches as specified in Westinghouse Specification No. G-676341. However, the mechanical measurements taken by the licensee and the NRC inspector (at this location) indicated that the minimum wall was 2.503 inches, which is greater than the required wall thickness of 2.495 inches. At another location on this pipe the licensee's data identified another point on the outside diameter which appears to be less than the required outside diameter. This point was reported as 36.167 inches, however the mechanical measurements at that location indicated a minimum wall thickness of 2.561 inches.

5. Open Item

As a separate issue, the licensee has been requested to provide additional information regarding any instances where ultrasonic wall thickness measurements were used for quality acceptance in stainless steel piping systems. This area will be further examined in a subsequent inspection (50-275/83-26-01).

6. Conclusion

Based on the foregoing information the inspectors concluded that there is reasonable assurance that RCS piping wall thickness meets or exceeds design requirements.