Stephen B. Bram
Vice President

Consolidated Edison Company of New York, Inc.
Indian Point Station
Broadway & Bleakley Avenue
Buchanan, NY 10511
Telephone (914) 737-8116

April 12, 1988

Re: Indian Point Unit No. 2
Docket No. 50-247

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: Steam Generator Inservice Inspection: Followup Activity on Girth Welds

This letter provides a report of the results of the testing program undertaken to acquire further information regarding the properties of the heat-affected zone material in the steam generator girth weld. This program was described in our January 15, 1988 submittal.

The attached report documents the information that was discussed during a telephone conversation with the NRC staff on March 24, 1988. A Westinghouse WCAP containing detailed photographs is expected to be available in May, 1988.

Based on the results of phase 2 of our program, the criteria for acceptable conclusion of this program have been met. These results confirm with a high level of confidence the complete acceptability of the existing weld and alleviate the need for a mid cycle inspection of the steam generator girth weld.

Should you have any further questions, please contact us.

Very truly yours,

Attachment
cc: Mr. William Russell
Regional Administrator - Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406-1498

Ms. Marylee M. Slosson, Project Manager
Project Directorate I-1
Division of Reactor Projects I/II
U.S. Nuclear Regulatory Commission
Mail Stop 14B-2
Washington, DC 20555

Senior Resident Inspector
U.S. Nuclear Regulatory Commission
P.O. Box 38
Buchanan, NY 10511

A047
1/1

CHARPY TOUGHNESS AND BRITTLE TRANSITION TEMPERATURE
CHARACTERIZATION OF THE HAZ HARD ZONE OF THE IP-2 STEAM GENERATOR GIRTH WELD PRODUCED BY GLEEBLE WELD THERMAL CYCLE SIMULATION

1.0 INTRODUCTION

This document summarizes the results of the toughness evaluation program of the Gleeble weld thermal cycle simulated HAZ "high hardness zone" of the steam generator upper shell to transition cone weld at the Indian Point Unit 2 Station. The IP-2 steam generator girth weld heat affected zone was reported to have been subjected to circumferential cracking. The steam generator shell is fabricated from A302 B steel material. The results of the prior metallurgical evaluations conducted on the boat samples from the steam generator weld showed that the cracking was initiated at the ID surface pitting and propagated by fatigue mechanism. These studies also confirmed the presence of a thin hard zone adjacent to the fusion zone in the heat affected zone with an equivalent Rockwell "C" hardness level ranging from 34 to 39. The current program is undertaken to address the concerns resulting from the potential occurrence of the positioning of the HAZ cracking in the high hardness zone.

The primary objective of the current program is to evaluate the upper shelf toughness value and the brittle transition temperature (FATT) of the thin high hardness zone of the IP-2 steam generator weld by accurately reproducing the high hardness zone microstructure in bulk Charpy blanks utilizing Gleeble weld thermal cycle simulator.

The program was carried out in three phases. The first phase of the program identified the target microstructure with the required grain size and hardness level. The second phase of the program established the quench, temper and stress anneal weld thermal cycles on the Gleeble to accurately simulate the target high hardness zone microstructure of the weld HAZ in the Charpy blanks. Finally, the third phase of the program was involved in conducting Charpy toughness tests to establish the upper shelf toughness value and the fracture appearance transition temperature (FATT) of the high hardness zone. Brief review of the work carried out under each of the phases and the results are presented below.

2.0 TARGET MICROSTRUCTURE AND HARDNESS

The results of the metallographic examinations conducted on a boat sample containing the weld HAZ cracking from the IP-2 steam generator girth weld was utilized to establish the target microstructure. The results of the metallographic examinations showed that the high hardness zone is aproximately 0.02 inch thick with an equivalent Rockwell "C" hardness level ranging from 34 to 39.

The microstructure corresponded to lower bainite or slightly tempered lath martensite with an ASTM prior austenite grain size number of 5 1/2. The microstructure also revealed some grain boundary phase transformation indicating that the hard zone was heated above the A_1 temperature during the multipass welding operation.

The target microstructure was chosen to be 39 Rockwell "C" hardness maximum.

3.0 ESTABLISHING GLEEBLE WELD THERMAL CYCLES TO SIMULATE TARGET MICROSTRUCTURES

3.1 Test Material

A302-B grade steel material from a reactor vessel nozzle dropout of 20 year old plant was utilized for the test program. Oversize Charpy blanks (12 mm x 12 mm x 4 in) were machined from the 1/4 T location of the sheet material. Metallography, hardness survey and wet chemistry analyses were conducted on the material prior to the sample machining to ensure that the material properties and composition meets the specification requirements.

3.2 Duplication of Target Prior Austenite Grain Size

Tests were run in the Gleeble weld thermal cycle simulator with peak temperatures of 1100, 1200, 1250 and 1300 degrees C. Each sample was held at the temperature for five seconds and allowed to cool in still air. Metallographic examination was then carried out and the prior austenite grain size determined. The 1100 degrees C. and 1200 degrees C. maximum temperatures produced grain sizes smaller and larger respectively than that of the target structure. Tests were then performed with peak temperatures of 1100, 1125, 1150 and 1175 degrees C. to closely identify the desired maximum temperature. The test at 1150 degrees C. produced a prior austenite grain size of approximately ASTM 5 1/2 and was, therefore, adopted in subsequent tests. The hardness of the structure produced with the peak temperature was 453-515 HV1 (46-50 Rockwell "C" hardness).

3.3 Selection of Appropriate Tempering Temperature

To simulate a multipass weld HAZ structure, the as-quenched microstructure was tempered by subjecting the sample to a second thermal cycle in the Gleeble weld thermal cycle simulator. A number of short duration tempering operations were conducted at 500, 550, 575, 600, 650, 675, 700, 800 and 850 degrees C. and held at these for five seconds. Each sample was initially heated to 1150 degrees C. and held for five seconds to produce the desired grain size. Two samples underwent each thermal cycle so that one could be examined metallographically and the other would be postweld heat treated as described on the following page.

3.4 Postweld Heat Treatment

The postweld heat treatment (PWHT) operation conducted on the steam generator girth weld was simulated on each of the samples that underwent a two-step thermal cycle. The PWHT was conducted at 1000 degrees F. (540 degrees C.) for seven hours. This heat treatment reduced the hardness of each specimen over that of the as-tempered specimens. The sample that was tempered at 800 degrees C. gave the desired Rockwell "C" hardness (average of 38 and peak of 39), and had a microstructure of tempered martensite. This was considered most typical of the target structure and hardness and, therefore, 25 more samples were produced as described below.

3.5 Production of 25 Charpy "Blanks" With Target Microstructure and Hardness

Each sample was subjected to a two-step thermal cycle of 1150 degrees C. maximum temperature with a five second hold followed by a tempering operation at 800 degrees C. of five seconds. This two-step operation was conducted using the Gleeble weld thermal cycle simulator and, to ensure reproducibility, every sixth sample was taken and metallurgically examined. The microstructure and hardness were tested. Two batches of samples underwent the postweld heat treatment and one additional sample from each heat treatment taken was removed and the microstructure and hardness tested.

Twenty-five samples containing the target structure at the center of each 4 inch x 12 x 12 mm blank were produced ready for machining into ASTM Charpy V-notch specimens.

4.0 CHARPY TOUGHNESS TESTING

ASTM Charpy V-notch test specimens were machined with the V-notch positioned at the center of the high hardness zone, from the Gleeble test blanks. Charpy toughness testing was conducted at temperatures ranging from -300 degrees F. to plus 320 degrees F. The results of the Charpy toughness tests are tabulated in Table 1 and are graphically represented in Figure 1. As can be seen, the data in Figure 1 suggests an upper shelf toughness value of approximately 59 ft-lbs with a minimum upper shelf temperature of 76 degrees F. The fracture appearance transition temperature corresponded to approximately -115 degrees F. The data indicates that the high hardness zone possesses toughness properties comparable to those of the base metal material.

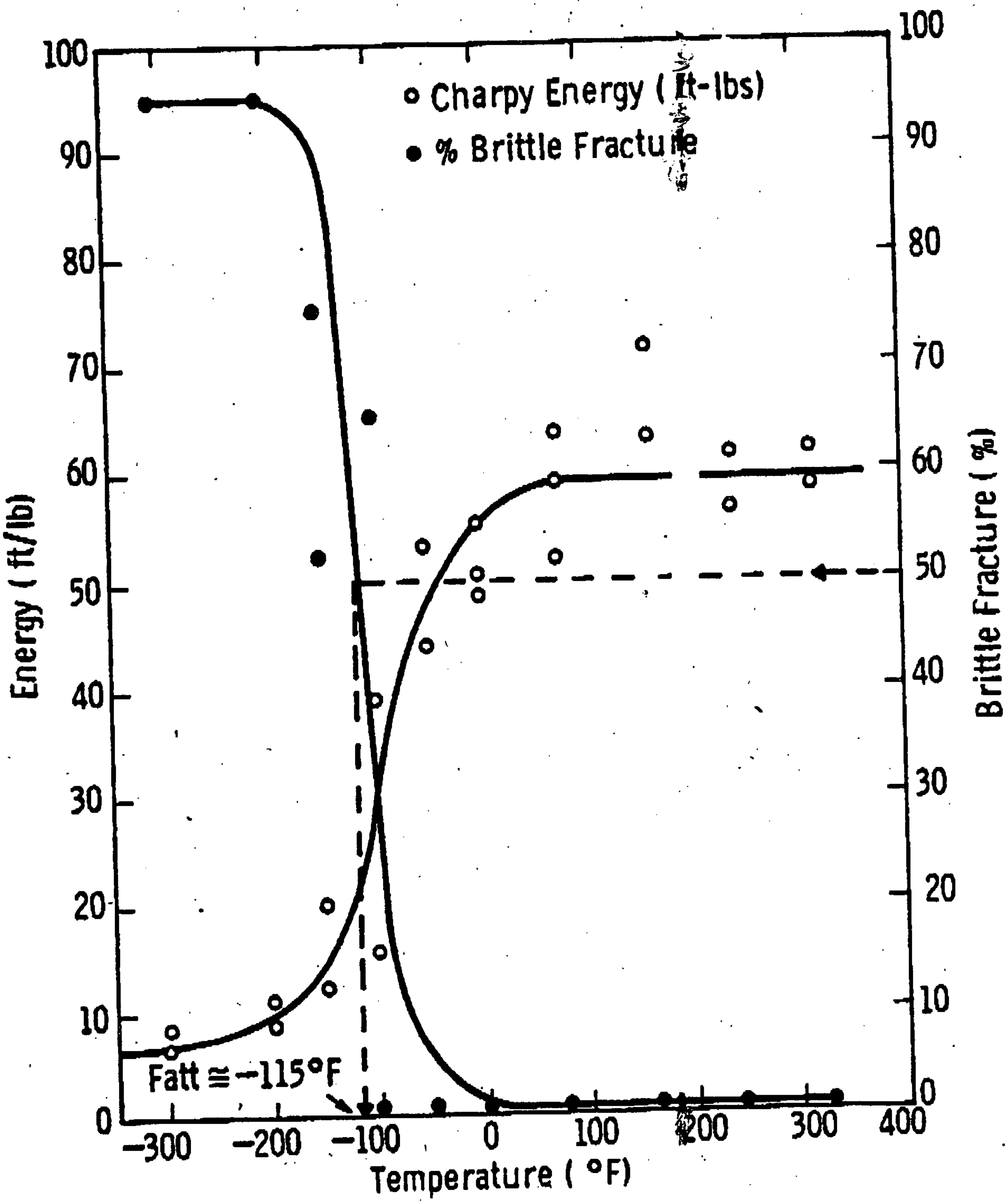

Fig. 1 – Charpy V-notch toughness test results of the gleeble simulated HAZ hard microstructure in A302-B steel.

G. Rao
t.g.- jd 3-24-88

TABLE 1

SUMMARY OF CHARPY V-NOTCH TOUGHNESS TEST RESULTS

SPECIMEN IDENTIFY	WIDTH (IN)	NOTCH THICK (IN)	TEST TEMP (F)	IMPACT STRENGTH (FT-LBS)	LATERAL EXPANSION (IN)	BRITTLE FRACTURE (%)
40	0.395	0.315	76	59.0	0.031	0
64	0.395	0.315	76	63.5	0.035	0
54	0.395	0.315	0	50.5	0.028	0
72	0.395	0.315	0	48.5	0.025	0
79	0.395	0.315	-100	15.5	0.005	65
34	0.395	0.315	-100	39.0	0.016	0
44	0.395	0.315	-200	11.0	0.000	95
62	0.395	0.315	-200	8.5	0.000	95
36	0.395	0.315	160	71.5	0.037	0
68	0.395	0.315	160	63.0	0.036	0
53	0.395	0.315	240	61.0	0.034	0
70	0.395	0.315	240	56.0	0.029	0
35	0.395	0.315	320	58.0	0.033	0
73	0.395	0.315	320	61.5	0.050	0
50	0.395	0.315	-150	12.0	0.002	75
69	0.395	0.315	-150	20.0	0.010	52
51	0.395	0.315	-50	53.0	0.027	0
81	0.395	0.315	-50	44.0	0.021	0
65	0.395	0.315	-300	6.5	0.000	95
76	0.395	0.315	-300	8.5	0.000	95
67	0.395	0.315	76	52.0	0.027	0
75	0.395	0.315	0	55.0	0.034	0