REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR:8101060425 DOC.DATE: 80/12/24 NOTARIZED: NO DOCKET #
FACIL:STN-50-528 Palo Verde Nuclear Station, Unit 1, Arizona Publi 05000528
STN-50-529 Palo Verde Nuclear Station, Unit 2, Arizona Publi 05000529
STN-50-530 Palo Verde Nuclear Station, Unit 3, Arizona Publi 05000530
AUTH.NAME AUTHOR AFFILIATION
VAN BRUNT,E.E. Arizona Public Service Co. MA/1
RECIP.NAME RECIPIENT AFFILIATION
SPENCER,G.S. Region 5, San Francisco, Reactor Construction & Engineer

SUBJECT: Revised final deficiency rept,originally reported on 800612, re undersized structural steel fillet welds.Suppls original final rept w/corrections & addl info re "Analysis of Safety Implications" Section.

DISTRIBUTION CODE: B019S COPIES RECEIVED:LTR 1 ENCL 1 SIZE: 23
TITLE: Construction Deficiency Report (10CFR50.55E)

NOTES:Standardized Plant. 05000528
Standardized Plant. 05000529
Standardized Plant. 05000530

	RECIPIENT ID CODE/NAME		COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME		COPIES LTTR	COPIES ENCL
ACTION:	A/D LICENSNG	04	1	1	MIRAGLIA,F.	05	1	1
	LEE,J.	06	1	1	KERRIGAN,J.	07	1	1
INTERNAL:	AD/RCI/IE	17	1	1	AEOD	18	1	1
	ASLBP/J.HARD		1	1	D/DIR HUM FAC	15	1	1
	DIR,DIV OF LIC		1	1	EDO & STAFF	19	1	1
	EQUIP QUAL BR	11	1	1	HYD/GEO BR	22	1	1
	I&E	09	1	1	LIC QUAL BR	12	1	1
	MPA	20	1	1	NRC PDR	02	1	1
	OELD	21	1	1	PROC/TST REV	13	1	1
	QA BR	14	1	1	REG FILE	01	1	1
	RUTHERFORD,W.IE		1	1	STANDRDS DEV	21	1	1
EXTERNAL:	ACRS	16	16	16	LPDR	03	1	1
	NSIC	08	1	1				

JAN 7 1981

TOTAL NUMBER OF COPIES REQUIRED: LTTR 40 ENCL 40

ARIZONA PUBLIC SERVICE COMPANY

P. O. BOX 21666 · PHOENIX, ARIZONA 85036

December 24, 1980
ANPP-16958-BSK/JAR

U. S. Nuclear Regulatory Commission
Region V
Walnut Creek Plaza - Suite 202
1990 North California Boulevard
Walnut Creek, California 94596

Attention: Mr. G. S. Spencer, Chief
Reactor Construction and
Engineering Support Branch

Subject: A 50.55(e) Potentially Reportable Deficiency Relating to Undersized Structural Steel Fillet Welds
Final Report, Revision 1
File: 80-019-026
D.4.33.2

Reference: (1) Telephone Conversation between R. Haynes and B. S. Kaplan on June 12, 1980 (DER 80-3)

(2) Interim Report, ANPP-15741, dated June 26, 1980

(3) Final Report, ANPP-16191, dated August 25, 1980

Dear Sir:

Attached, is Revision 1 of the final written report of the potentially reportable deficiency, under 10CFR50.55(e), relating to fillet welds for structural steel undersized with respect to AWS D1.1 and AISC minimum weld requirements. Revision 1 contains corrections to the "Analysis of Safety Implications" section and provides additional information. Therefore, Revision 1 supplements the original final report.

The structural fillet welds referenced in this report, even though undersized with respect to the minimum requirements of AWS D1.1-75 and AISC, are sufficient to handle the design loadings while providing an adequate safety margin for crack prevention. The structural fillet welding referenced herein will be accepted without repair.

Very truly yours,

E. E. Van Brunt

E. E. Van Brunt, Jr.
APS Vice President
Nuclear Projects
ANPP Project Director

B019 S/1

EEVBJr/BSK:skc
Attachment

8101060425

S

cc: Victor Stello, Jr., Director
Office of Inspection and Enforcement
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

A. C. Gehr
Snell & Wilmer

J. A. Roedel
R. L. Robb
D. B. Fasnacht
W. E. Ide
J. M. Allen
A. C. Rogers
J. A. Brand
W. H. Wilson
W. G. Bingham
W. J. Stubblefield
R. L. Patterson
R. W. Welcher
D. R. Hawkinson

FINAL REPORT, REVISION 1

POTENTIAL REPORTABLE DEFICIENCY 50.55(e)

ARIZONA PUBLIC SERVICE COMPANY (APS)

PVNGS UNITS #1, #2 AND #3

II. Analysis of Safety Implications - Supplementary Information

A. Bechtel Field Structural Welding

Bechtel's Materials and Quality Services Department (M&QS) has determined that structural welding performed by Bechtel Construction forces utilizing Bechtel Welding Procedures P1-A-Lh (structural) and P1-A-C (structural) will produce equivalent or better fillet welds than the test results reported in "Evaluation of Structural Fillet Weld Samples for Underbead Cracking " (see Attachment A, Final Report, Revision 0) and PQR 705 (Attachment B, Revision 1).

1. M&QS, to date, has not found cracking in PQR coupons or in special tests. Refer to Attachment A, Revision 0 and Attachment B, Revision 1.

   Attachment A, Revision 0, includes test data for undersized fillets welded per WPS P1-A-Lh (structural) which uses E-7018 (low Hydrogen) electrodes. Attachment B, Revision 1, includes test data for undersize fillets welded per WPS P1-A-C (structural) which used E-6010 (cellulosic) electrodes.

2. Attachment C entitled "Technical Review for Palo Verde Project", Job No. 10407 (F. C. Breismeister, dated May, 1980) includes substantial data on undersized fillet welds performed on heavy (5/8" and 1-1/8") A-36 steel with no preheat using E-6010 electrodes. It is evident from this report that undersized fillets, welded with E-6010 electrodes under very adverse conditions, did not crack

3. AWS D1.1, Table 2.7, expresses the minimum single pass fillet weld size for prequalified joints. However, smaller fillets may be qualified in accordance with AWS D1.1, Paragraph 5.2.

4. The undersize fillet welds noted in this final report are sufficient to handle the design loadings, based on the allowable stresses provided in the Project Design Criteria.

5. Visual examination of the production welds has not revealed any cracking either in the weld metal or at the toes of the fillets. These are the most likely locations at which cracking might occur.

6. The aforementioned reports and PQR document the worst conditions for any structural fillet welded connections. No cracking has been found to date in the test conditions or at the reporting jobsites; therefore, M&QS believes that it is highly unlikely that cracking will occur.

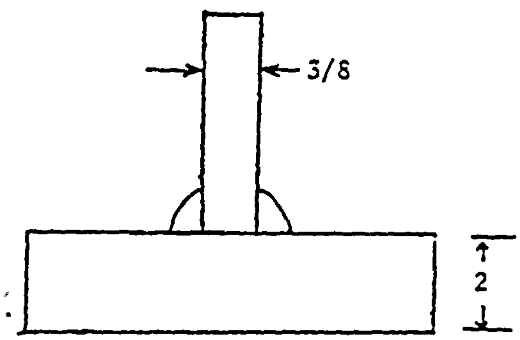
BECHTEL
WELDING PROCEDURE QUALIFICATION RECORD — PQR NO. 705

Procedure Specification: P1-A-c (Structural) — Date: October 12, 1979
Welding Process(es): Shielded Metal-Arc — Location: San Francisco, California
Material Specification: SA-36 to SA-36
ASME P-No. 1 to P-No. 1 — O.D. --- — O.D. Range Qualified ---
Thickness: 2 to 3/8 inch, 1/4 inch fillet — Thickness Range Qualified: 1/4 and smaller single pass fillets for all thicknesses

Filler Metal Specifications:
ASME SFA/AWS A5.1 — AWS Classification E6010 — F-No. 3 — A-No. 1
ASME ______ — AWS Classification ______ — F-No. ______ — A-No. ______

Filler Metal Chemistry	---		
Electrode Dia.	5/32	Wire Dia.	---
Consumable Insert	---	Trade Names	Lincoln 5P
Tungsten Type	---		
Shielding Gas	---	Flow Rate	---
Purge Gas	---	Flow Rate	---
Flux Classification	---	Flux Name	---
Position of Groove	2F and 3F		
Welding Direction	3F Uphill		
Backing Strip	---		
Current and Polarity	DCRP		
Amperage	95-120		
Voltage	24-30		
Single or Multiple Arc	Single		
Travel Speed	4 ipm.		
Multiple Pass Per Side	No		
Preheat Temperature Minimum	60F		
Maximum Interpass Temperature	---		
Oscillation Width	N.R. inch(es), Dwell --- sec.		
Oscillation Frequency	--- cpm.		

JOINT DESIGN



HEAT TREATMENT: Temp. None — Time ---

Reduced Section Tensile Tests	Specimen No.	Width	Thick. or Dia.	Area Sq. In.	Load Lbs.	UTS psi	Remarks
	None	in.	in.				
		in.	in.				
		in.	in.				
		in.	in.				

Guided Bend Tests	Type & Position	Result	Type & Position	Result
	None			

Other: Six macrosections from each coupon were examined and found acceptable to ASME Section IX and AWS D1.1, 1972 and 1979.

Mechanical Testing By: None — Lab. No. 1079-3
Welder's Name: A. D. Calija
Test Conducted By: F. Breismeister

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of Section IX of the ASME Code and AWS D1.1.

Recorded on New Form: June 6, 1980 — Reviewed By: [signature]
Original WPS, Rev., Entity: P1-A-c (Structural)/ Rev. 3/BPC — Approved By: [signature]

Other Designations

10407

Bechtel National, Inc.
Engineers — Constructors
Fifty Beale Street
San Francisco, California
Mail Address P. O. Box 3965, San Francisco, CA 94119

To: D. S. Parker

Date: June 13, 1980

Subject: Low Preheat Welding HVAC Supports
Palo Verde Project, Job 10407-002

From: F.C.Breismeister

Of: R&E/M&QS

At: 50/16 x 4211

Copies: B. D. Hackney
B. M. Macleod
R. A. Manley
N. J. Thakur
DCC (272152)

M&QS has been requested to provide a technical review of HVAC support installation welding. The attached document reviews this subject at the Palo Verde jobsite and a similar but different situation reported by another architect/engineer. It is concluded that the low preheat welding at Palo Verde is not a cause for concern. No additional corrective action appears necessary.

Project has reviewed the draft and accepted it without comment. This final report should be transmitted to Project promptly.

If any one has questions, please contact the writer at (415) 768-4211.

F. C. Breismeister

FCB/sla

ATTACHMENT C

LOW PREHEAT WELDING OF HVAC SUPPORTS

A Technical Review For

Palo Verde Project

Job No. 10407

By: F. C. Breismeister

Research and Engineering

Materials and Quality Services Department

Bechtel National, Inc.

Approved: B. D. Hackney

B. D. Hackney, Assistant Manager
Materials and Quality Services Department

San Francisco

May, 1980

TABLE OF CONTENTS

Section		Page
	ABSTRACT	iii
1.0	INTRODUCTION	1
2.0	CONCLUSIONS AND RECOMMENDATIONS	1
3.0	DISCUSSION	2
	3.1 Codes and Qualifications	2
	3.2 Underbead Cracking	2
	3.3 Metallurgical	3
	3.4 Welding	3
	3.5 Qualification Test	4
	3.6 As-Built Condition	4
APPENDIX 1	Waldinger Welding Procedure Qualification Records and Test Plate Certified Material Test Reports ...	5
APPENDIX 2	Critique of Waterford HVAC Installation Report....	6
APPENDIX 3	Palo Verde Steel Compositions....................	

ABSTRACT

HVAC support installation at the Palo Verde jobsite has been reviewed with emphasis on the metallurgical and welding engineering concerns related to E6010 welding electrodes and low preheat. Fundamental principles, as-built details, and AWS D1.1 Structural Welding Code qualifications are reviewed. A related, but different situation reported in the public record is also reviewed. Conclusions are drawn, and recommendations offered.

1.0 INTRODUCTION

The HVAC (Heating, Ventilating and Air Conditioning) installer, Waldinger Corporation, had been using E6010 electrodes for depositing single pass 3/16 fillet welds, and two pass 5/16 inch fillet welds, without preheat. The fillet welds were to structural steel columns and beams, and to embedments. The HVAC support members were 1/4 inch thick or less, frequently unistrut formed from 12 gage carbon steel. The A-36 structural steel was mostly 3/4 inch thick, some were 1-1/8 inch thick and 15 welds were made to 2-3/4 inches thick carbon steel.

A Quality Assurance Finding (QAF), S7923, was written because these joints were not preheated in compliance with the AWS D1.1 Structural Welding Code, which requires that the preheat temperature be based on the thickness of the thickest part at the point of welding. Waldinger has conducted tests in accordance with the AWS D1.1 Code which qualify the 3/16 inch and 5/16 inch fillet welds. The 3/16 inch weld sizes have also been increased to 5/16 inch using E7018 electrodes. These welds were inspected and found to be acceptable. There was no cracking.

Waldinger was the subject of a related, but different incident at the Waterford project reported to the NRC by another Architect/Engineer. That report indicated there were no cracks in the as-built condition, but found a (remote) possibility that cracks might have occurred, and caused extensive corrective action to be initiated.

This technical review has been made to justify the corrective action conducted at the Palo Verde jobsite, to identify questionable features of the Waterford report, which, if more thoroughly reviewed might have led to more positive conclusions in that report.

2.0 CONCLUSIONS AND RECOMMENDATIONS

The data and fundamental principles have been reviewed and the following conclusions result.

1) The 3/16 inch single pass fillet welds and the 5/16 inch two pass fillet welds made without preheat by Waldinger have been qualified as required by the AWS D1.1 Structural Welding Code.

2) There were no cracks in the as-built installation and none are anticipated.

3) The steel used at Palo Verde has a low carbon equivalent composition, and low hardenability, and is unlikely to have cracks.

4) The steels welded at Palo Verde do not require preheat to avoid cracking when the engineering specified weld sizes are made.

5) Additional corrective action is not necessary.

3.0 DISCUSSION

3.1 Codes and Qualifications

Installation of HVAC ductwork and supports has referenced the AWS D1.1 Structural Welding Code as a matter of convenience rather than as a technical necessity or on the basis of an engineering analysis. The Bechtel specification could have referenced other recognized codes or standards for the purposes of welding procedure and performance qualification. The AWS D9.1 standard for welding sheet metal could be referenced, and would be significantly less restrictive regarding welding preheat and weld sizes. Other codes such as the ASME Sections I, III and VIII and the ANSI Standards B31.1 and B31.3 governing the installation welding of pipe supports permit welding carbon steels such as A36 (SA36) without preheat.

The AWS D1.1, Table 4.2 requirement for preheat is recognized as arbitrary, and provision is made by D1.1 in Section 5 for qualification of welding procedure specifications using other preheat requirements. The HVAC installer has qualified such WPSs and copies are in Appendix 1. These qualification records meet the documentation requirements and bring the installation into code compliance.

Questions were raised regarding the adequacy of welding qualifications being performed on 1-1/8 inch thick plate, when the as-built condition contains welds on plate up to 2-3/4 inches thick. Thicker plate was thought to cause more rapid weld cooling rates and thus be more susceptible to heat-affected zone (HAZ) cracking. This is sometimes true. However, for moderately low heat-input required for these small fillet welds, even one inch thick plate behaves essentially as an infinitely thick plate during the significant part of the weld thermal cycle. This was demonstrated by Nippes, et. al. at R.P.I. and reported in the Welding Journal (1943, p. 384S).

3.2 Underbead Cracking

Concerns have been expressed regarding the possibility for underbead cracking based on a report by another Architect/Engineer regarding a related application. That report concluded there was a possibility for underbead cracking to have occurred although there was no objective evidence of any cracking in actual welds. A technical critique of that report is in Appendix 2. The several overly conservative features (high carbon equivalent and water induced rapid cooling) in that test program and the failure to provide a base metal weldability base line in the critical tests indicates that the final conclusions of that report were not fully justified. Underbead cracking requires a hydrogen potential source in the weld area, a susceptible microstructure, and restraint. Underbead cracking in thick structural steel, welded by cellulosic electrodes, is avoided by the low hardenability of the base metal and sufficiently slow weld cooling rates which preclude the formation of the susceptible microstructures (principly martensite).

3.3 Metallurgy

A hardened weld HAZ consisting chiefly of martensite is necessary for underbead cracking. In plain structural steel, both high carbon, and high manganese are necessary for the base material to be sufficiently hardenable to be crack susceptible. The compositions of structural steel and the embedded steel used at Palo Verde as bases for the HVAC supports, do not have sufficient hardenability to achieve the susceptible martensitic microstructure with the weld cooling rates likely to be experienced. The compositions of the largest structural wide-flange beams, and a sample of embed plates are shown in Appendix 3. The highest carbon equivalent, most crack susceptible composition of these steels, was used for the successful qualification test shown in Appendix 2. The use of the most susceptible steel with a carbon equivalent of 0.53 for qualification of 3/16 inch fillet size is significant because this represents the worst case composition. The amount of data in Appendix 3 was limited by the timeliness of retrieval of boxed records. Experience shows this data to be representative of the spectrum of carbon steel compositions provided to other projects. The highest carbon equivalent in a survey of two dozen plates on another project was 0.49. It is unlikely that the composition of any structural steel at Palo Verde was significantly higher than that used for the PQR test plate.

3.4 Welding

The base metal hardenability needs to be coupled with the weld HAZ thermal cycle cooling rates in determining whether a crack susceptible microstructure is developed. These cooling rates are dependent upon weld geometry, heat input (weld size), preheat, and thickness. Rapid cooling is most likely to cause cracking. Cooling can be sufficiently slowed by preheat, or welding heat input when the other variables are fixed. In this case the welding heat inputs (weld sizes) were sufficient to slow cooling to less than the critical rate so that preheat was not required.

The first pass of fillet welds, or a single pass fillet weld, represents the most rapid (severe) cooling conditions anticipated during installation. The fillet weld HAZs cool more rapidly than butt welds HAZs. The 1-1/8 inch thick base plate used in the qualification tests was more than adequate to achieve infinite plate heat-sink cooling rates. The 5/16 inch fillet weld first pass is the smallest weld bead to be made, and represents the worst case for heat input, i.e., the most rapid cooling rates. The second pass tempers the first and it cools more slowly than a 3/16 inch single pass fillet weld. A 3/16 inch fillet weld represents the most severe condition for a single pass weld. Both the single pass 3/16 inch fillet weld and the two pass 5/16 inch fillet weld have been qualified as shown in Appendix 1. These tests are conservative as regards welding technology.

3.5 Qualification Tests

The Waldinger Corporation qualification tests, reported in Appendix 2, were conservative regarding the base material composition and the welding conditions used. Both welding and composition represented the worst cases for any installation or as-built condition. No cracks were found. As no cracks were found in the qualification cross-section examinations, it is unlikely and improbable that any cracks would be present in the original as-built condition.

3.6 As-Built Condition

The original as-built conditions of single pass 3/16 inch fillet welds and 5/16 inch two pass fillet welds were examined and found to be crack free. Subsequently, additional E7018 weld metal was added to the 3/16 inch fillet weld. The welds were examined prior to the additional welding and no cracks were found. The welds were examined after E7018 welding and no cracks were found. The additional welding would effectively temper the HAZ of the first 3/16 inch fillet weld and further reduce its susceptibility for cracking. (The first pass HAZ of the 5/16 inch fillet was also tempered by its second pass.) The additional E7018 welding was not technically necessary, but has provided a conservative margin for satisfactory service. This also brought the as-built weld size into compliance with AWS design requirements.

The visual examinations performed on the fillet welds provide a good indication of the weld quality. Cracking of restrained fillet welds is most likely to occur through the weld metal. Weld metal cracks were not found. The next most likely location is at the toe of fillet welds because in plates which are effectively less than an infinite heat sink, this is the location of most rapid cooling and therefore the location of the most crack susceptible microstructure. No cracks were found in the toe location which is readly inspectable. For thick plate, cracking is as likely to occur at the fillet toe as under the bead. No cracks were found at the toe of these thick plate welds, which also provides a significant indication that there would be no cracks under the bead. The fundamental requirements expressed in D1.1 is that the preheat must be sufficient to prevent crack formation. The AWS D1.1 requirements for fillet sizes also appear related to avoidance of cracking. As cracking has not occurred, the fundamental requirements have been met.

APPENDIX 1

Waldinger Corporation Welding Procedure Qualification Records

Test Plate Certified Material Test Reports

THE WALDINGER CORPORATION

FORMERLY IOWA SHEET METAL CONTRACTORS, INC.

WELDING PROCEDURE QUALIFICATION TEST RECORD (80-88-D)

R.2 (5-24-80)

PROCEDURE SPECIFICATION

Material specification ....ASTM A-36....

Welding process ....Shielded Metal Arc....

Manual or machine ....Manual....

Position of welding ....Horizontal....

Filler metal specification ....AWS A5.1-69....

Filler metal classification ....E6010 F-3....

Weld metal grade ....N/A....

Shielding gas ....N/A.... Flow....NA....

Single or multiple pass ....Single & Multiple

Single or multiple arc ....Single....

Welding current: DC Reverse Polarity....

Welding progression ....N/A....

* Preheat temperature ....None Required....

Postheat treatment ....None....

Welder's name ....George Gonzales....

GROOVE WELD TEST RESULTS

Reduced-section tension test

Tensile strength, psi:

1. N/A
2. N/A

Guided-bend test

Root		Face	
1	N/A	1	N/A
2	N/A	2	N/A

Radiographic-Ultrasonic Examination N/A

Fillet test results

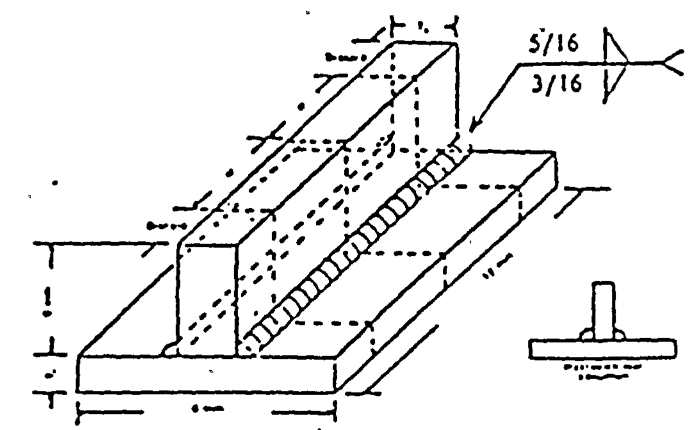
Min Size Multiple Pass Macroetch				Max Size Single Pass Macroetch			
1	S	3	S	1	S	3	S
2	S			2	S		

Laboratory Test No. F-TWC-BPC-80-88

S = Satisfactory

WELDING PROCEDURE

Pass no.	Elect. size	Welding Current Amperes	Welding Current Volts	Speed of travel	Joint Detail
				IPM	
3/16	1/8"	100-105	22-24	5to6	
5/16	3/32"	70-75	21-23	4to5	
5/16	1/8"	100-105	22-24	5to6	



$*T_1$ = 1-1/8" $*T_2$ = 5/8"

* We the undersigned, certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of 5B of AWS D1.1, Structural Welding Code.

*No preheat was utilized in performing this PQR

Manufacturer or Contractor ....The Waldinger Corp.

Authorized by [illegible]

Welding Engineering Supervisor

Date ....May 12, 1980....

Form No. SQC-09/03-28-77.

THE WALDINGER CORPORATION

FORMERLY IOWA SHEET METAL CONTRACTORS, INC.

WELDING PROCEDURE QUALIFICATION TEST RECORD (80-88-0) R.2 (5-24-80)

PROCEDURE SPECIFICATION

Material specification ASTM A-36
Welding process Shielded Metal Arc
Manual or machine Manual
Position of welding Vertical
Filler metal specification AWS A5.1-69
Filler metal classification E6010 F-3
Weld metal grade N/A
Shielding gas N/A Flow NA
Single or multiple pass Single & Multiple
Single or multiple arc Single
Welding current DC Reverse Polarity
Welding progression Uphill
* Preheat temperature None Required
Postheat treatment None
Welder's name George Gonzales

GROOVE WELD TEST RESULTS

Reduced-section tension test
Tensile strength, psi:
1 N/A
2 N/A

Guided-bend test

Root	Face
1 N/A	1 N/A
2 N/A	2 N/A

Radiographic-Ultrasonic Examination N/A

Fillet test results

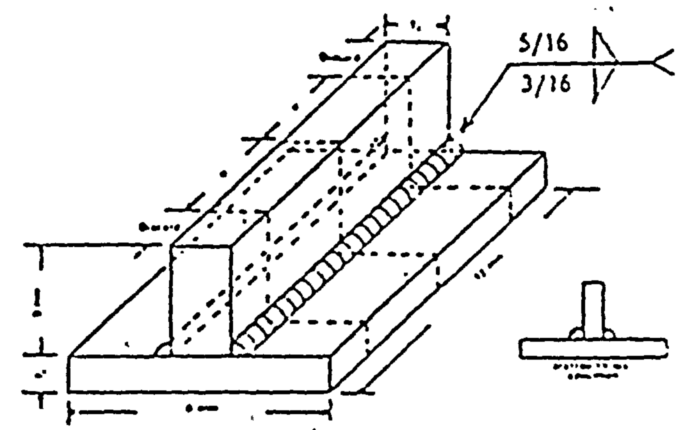
Min Size Multiple Pass Macroetch		Max Size Single Pass Macroetch	
1 S	3 S	1 S	3 S
2 S		2 S	

Laboratory Test No. F-TWC-BPC-80-88

S = Satisfactory

WELDING PROCEDURE

Pass no.	Elect. size	Welding Current Amperes	Welding Current Volts	Speed of travel	Joint Detail
				IPM	
3/16	1/8"	95-100	22-24	4 to5	
5/16	3/32"	65-70	20-22	4 to5	
5/16	1/8	95-100	22-24	5 to6	



*T1 = 1-1/8" *T2 = 5/8"

* We the undersigned, certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of 5B of AWS D1.1, Structural Welding Code.

*No preheat was utilized in performing this PQR

Manufacturer or Contractor The Waldinger Corp.
Authorized by [signature]
Welding Engineering Supervisor
Date May 19, 1980

Form No. SQC-09/03-28-77.

THE WALDINGER CORPORATION

FORMERLY IOWA SHEET METAL CONTRACTORS, INC.

WELDING PROCEDURE QUALIFICATION TEST RECORD (80-88-B) R.2 (5-24-80)

PROCEDURE SPECIFICATION

Material specification ASTM A-36
Welding process Shielded Metal Arc
Manual or machine Manual
Position of welding Overhead
Filler metal specification AWS A5.1-69
Filler metal classification E6010 F-3
Weld metal grade N/A
Shielding gas N/A Flow NA
Single or multiple pass Single & Multiple
Single or multiple arc Single
Welding current: DC Reverse Polarity
Welding progression N/A
* Preheat temperature None Required
Postheat treatment None
Welder's name George Gonzales

GROOVE WELD TEST RESULTS

Reduced-section tension test
Tensile strength, psi:
1 N/A
2 N/A

Guided-bend test

Root	Face
1 N/A	1 N/A
2 N/A	2 N/A

Radiographic-Ultrasonic Examination N/A

Fillet test results

Min Size Multiple Pass Macroetch
1 S 3 S
2 S

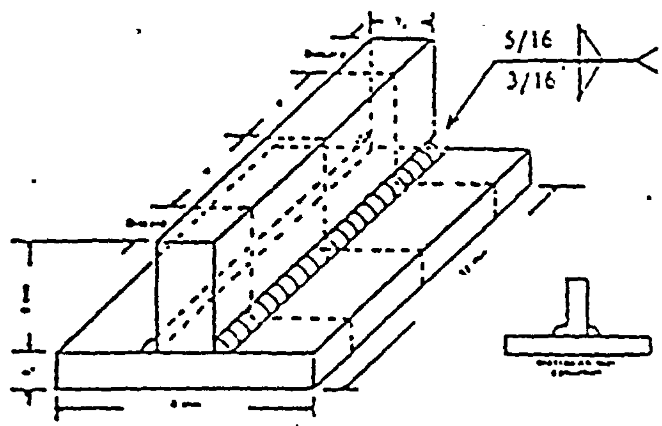
Max Size Single Pass Macroetch
1 S 3 S
2 S

Laboratory Test No. F-TWC-BPC-80-88

S = Satisfactory

WELDING PROCEDURE

Pass no.	Elect. size	Welding Current Amperes	Welding Current Volts	Speed of travel IPM	Joint Detail
3/16	1/8	95-100	22-24	5to6	
5/16	3/32"	70-75	21-23	4to5	
5/16	1/8	100-105	22-24	5to6	



$^*T_1$ = 1-1/8" $^*T_2$ = 5/8"

* We the undersigned, certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of 5B of AWS D1.1, Structural Welding Code.

*No preheat was utilized in performing this PQR

Manufacturer or Contractor The Waldinger Corp.
Authorized by [signature]
Welding Engineering Supervisor
Date May 27, 1980

Form No. SQC-09/03-28-77.

2401 Bell Avenue / P.O. Box 1612 / Des Moines, Iowa 50321 / 515/284-1911

THE WALDINGER CORPORATION

FORMERLY IOWA SHEET METAL CONTRACTORS, INC.

WELDING PROCEDURE QUALIFICATION TEST RECORD (80-88-A) R.2 (5-24-80)

PROCEDURE SPECIFICATION

Material specification ASTM-A-36
Welding process Shielded Metal Arc
Manual or machine Manual
Position of welding Flat
Filler metal specification AWS A5.1-69
Filler metal classification E6010 F-3
Weld metal grade N/A
Shielding gas N/A Flow N/A
Single or multiple pass Single & Multiple
Single or multiple arc Single
Welding current: DC Reverse Polarity
Welding progression N/A
* Preheat temperature None Required
Postheat treatment None
Welder's name George Gonzales

GROOVE WELD TEST RESULTS

Reduced-section tension test
Tensile strength, psi:
1 N/A
2 N/A

Guided-bend test

	Root		Face
1	N/A	1	N/A
2	N/A	2	N/A

Radiographic-Ultrasonic Examination N/A

Fillet test results

Min Size Multiple Pass Macroetch
1 S 3 S
2 S

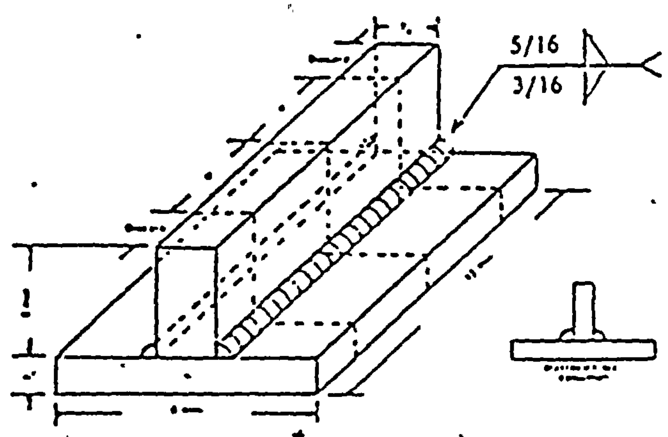
Max Size Single Pass Macroetch
1 S 3 S
2 S

Laboratory Test No. F-TWC-BPC-80-88

S = Satisfactory

WELDING PROCEDURE

Pass no.	Elect. size	Welding Current Amperes	Volts	Speed of travel	Joint Detail
				IPM	
3/16	1/8"	100-105	22-24	5to6	
5/16	3/32"	70-75	21-23	4to5	
5/16	1/8"	100-105	22-24	5to6	



*T_1 = 1-1/8" *T_2 = 5/8"

* We the undersigned, certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of 5B of AWS D1.1, Structural Welding Code.

*No preheat was utilized in performing this PQR

Manufacturer or Contractor The Waldinger Corp.
Authorized by [signature]
Welding Engineering Supervisor
Date May 17, 1980

Form No. SQC-09/03-28-77.

...ACT NO	P. O. DATE	PURCHASE ORDER NO.
		1A3506 11/09/79

SHIPPERS NO.	MILL ORDER NO.	INVOICE NO.
T00073 12 11 79	CD24805	156-72844

VEHICLE IDENTITY 32906

...Y WORKS
...Y, INDIANA 46402

...PH T RYERSON & SON INC
... BOX 8000-A
...ACCOUNTS PAYABLE
...GO ILL 60680

SHIP TO
JOSEPH T RYERSON & SON INC
EAST PLANT A SPAN
8300 S STEWART
CHICAGO ILL

WE HEREBY CERTIFY THAT THE CHEMICAL ANALYSES AND/OR TEST RESULTS SHOWN IN THIS REPORT ARE CORRECT AS CONTAINED IN THE RECORDS OF THE COMPANY.

by: [signature]
A. BELKIN
MGR QUALITY ASSURANC

DATE 12-14-79

...TE CARBON ASTM A36-75 AND ASME SA36-SUMMER 1979
...ENDA DTD 6/30/79 JT RYERSON SPEC 3533-F DTD
... 7/77 BEND TEST PER S14

...I 5 T/R TO JT RYERSON & SON INC TEST REPORT DIVISION ATTN TEST
...PORT SUPERVISOR PO BOX 8000-A CHICAGO ILL 60680

53308383
RT 51395

MATERIAL DESCRIPTION: THICKNESS SECTION	WIDTH, DIA. OR FT./WT.	LENGTH	QUANTITY	WEIGHT	HEAT NO.	TEST OR PIECE IDENTITY	YIELD PT. PSI	TENSILE STR. PSI	ELONGATION % IN 8"	ELONGATION % IN 2"	% RED. OF AREA	BEND
1 1/8"	84.000"	360	2	19296	088383		42000	78000		25.0		OK
							45700	73500	27.0			OK

MAY 09 1980
SUB CONTRACT
BY H G S

TYPE	C	MN	P	S	SI	CU	NI	CR	MO	SN	AL	N	V	B	TI	CB	CO
LCA1	23	115	014	024	05												

3405 74-002539

01.000.0772 (REV.7-70)

Test Report

CONTRACT NO.	P.O. DATE	PURCHASE ORDER NO.		
	10/31/79	1A3073		
	SHIPPERS NO.		MILL ORDER NO.	INVOICE NO.
	P11576 11/14/79		CD95620	107-A5686
	VEHICLE IDENTITY	20635 ILL		

SOUTH WORKS
CHICAGO, ILL. 60617

WE HEREBY CERTIFY THAT THE CHEMICAL ANALYSES AND/OR TEST RESULTS SHOWN IN THIS REPORT ARE CORRECT AS CONTAINED IN THE RECORDS OF THE COMPANY

D. R. FREESE
CHIEF METALLURGIST
DATE 11/15/79

JOSEPH T RYERSON & SON INC
P.O BOX 8000-A
ATTN ACCOUNTS PAYABLE
CHICAGO ILL 60680

SHIP TO:
JOSEPH T RYERSON & SON INC
SOUTH WHSE D SPAN
16TH & ROCKWELL ST.
CHICAGO ILL

PLATE CARBON
ASTM A36-75 AND ASME SA36-SUMMER 1979 ADDENDA DTD 6/30/79 JT
RYERSON SPEC 3533-F DTD 8/12/77 DEMO TEST PER S14
MILL RA/SN CERTIFIED T/R 5 T/R TO JT RYERSON & SON INC TEST
REPORT DIVISION ATTN TEST REPORT SUPERVISOR PO BOX 8000-A CHICAGO
ILL 60680

4286 1559
CT 51026

THICKNESS GA.SECTION	WIDTH DIA. BILLET WT.	LENGTH	QUANTITY	WEIGHT	HEAT NO.	TEST OR PIECE IDENTITY	YIELD PT. PSI	TENSILE STR. PSI	ELONGATION % IN 8"	IN 2"	% RED. OF AREA
5/8X84		240 IN	11	39303	181539		44220	72550	25.0		
							46530	73390	24.0		

OTHER INFO---PT#CC3A20663--

MAY 09 1980

NO.	TYPE	C	MN	P	S	SI	CU	NI	CR	MO	SN	AL	N	V	B	TI	CB	CO
539	LAT	22	90	010	016													

APPENDIX 2

Critique of Waterford Report

On HVAC Installation

BACKGROUND

At the Waterford Project, Waldinger used E6011 electrodes for HVAC installation without preheat. The Architect/ Engineer evaluated the situation and concluded the welds could not be accepted. No cracks were found in the as-built condition, even with destructive incremental grinding. The recommendation to replace the welds appears to be based on special tests not representative of the as-built condition.

TEST PROGRAM

Longitudinal underbead cracking tests were made on a special steel which was not representative of compositions at Waterford, (nor representative of steel at Palo Verde). The hardenability expressed as carbon equivalent was significantly higher. The carbon, manganese and silicon content were all within the ASTM A36 range but at or near the upper limits. (The carbon equivalent of this steel was 0.08 higher than the steels of interest at Palo Verde, and for this reason alone the Waterford special tests are not meaningful for Palo Verde.) It is unlikely for all elements to be at the composition upper limits.

UNDERBEAD CRACKING TEST

This underbead cracking test was developed principally to determine base metal susceptibility to cracking. For the test to be valid in evaluations of welding parameters and variables, the base metal must be shown capable of producing crack free welds. This validation was not done for the Waterford tests. The 1-5/16 inch thick test results are anomalous because the lower preheat (50F) showed less cracking than the higher preheat (78F). The lack of cracking on the 3/4 inch thickness could be due to welding on a different, more weldable section, caused by segregation and lack of inclusions, and does not validate the test of welding variables.

WELD COOLING RATES

The longitudinal underbead cracking test is not valid for direct evaluation of welding because the weld HAZ cooling rates are significantly more rapid than experienced in fabrication or installation at the same preheat and heat input. This was demonstrated at Battelle by Williams et. al. The longitudinal underbead cracking test specimen is placed in a pan of water which conducts heat away more rapidly than would a continuous steel plate. The result is that hardened microstructures are more frequently produced in steels of low hardenability which would otherwise be insensitive to underbead cracking. This has been explained by another Battelle investigator, Voldrich, "It should be remembered that the amount of

of cracking obtained by this technique is relatively great, because of the severity of the welding conditions and is therefore not directly indicative of the amount of cracking that may be obtained in production welding. The relatively drastic cooling rate was used in order to obtain cracking in the steels with the lower carbon and manganese contents."

The reported test welding conditions used are confusing. On page 2 it states that the welding parameters used are shown in Table 2. Table 2 shows 1/8 and 5/32 electrodes and approximately five inches per minute travel speed. The page 2 text states only 1/8 inch electrodes were used. The standard Battelle underbead cracking test uses 1/8 inch diameter electrodes and 10 inches per minute travel speed. It is not clear how this test was conducted. Another reason why the standard test is not representative of welding conditions at Palo Verde is because the travel speed is too fast to produce a useful weld size. The required 10 inches per minute travel is too fast to produce a 3/16 inch fillet with SMAW electrodes of the small diameters used for installation welding. Thus, the standard underbead cracking test is not relevant to installation, and is useful only for screening base material.

HARDNESS

The last paragraph of the Waterford report places undue emphasis on HAZ hardness values over RC35.5. Stout and Doty state that there is no satisfactory correllation between maximum HAZ hardness and the weldability of a steel in fabrication and for service performance, because too many other factors play a role. Hardness data are often of value in supplementing the results of other tests.

AS-BUILT CONDITION

Review of the other tests and examinations indicates there was little cause for concern. Although five of six hardness tests on material from the Waterford site were over RC35.5, no cracks were found in the longitudinal underbead cracking tests on these materials. No cracks were found in the installation welds visually or during incremental grinding.

In the Waterford report, insufficient emphasis has been placed on the actual materials used and installation at the Waterford site. The jobsite materials did not show underbead cracks in the tests. The as-built condition did not show cracks. The incremental grinding is a more effective investigative tool than is indicated in this report. Most craftsmen and laboratory technicians can identify a crack while grinding. It is unlikely that a significant crack would have been missed during incremental grinding.

APPENDIX 3

Palo Verde

Structural Steel Compositions

Product Form and Heat Number	C	Mn	Si	P	S	Carbon Equivalent
W36X300						
J86162	0.23	1.04	NR	0.009	0.021	0.49
J86159	0.22	1.00		0.031	0.030	0.47
J85691	0.21	0.97		0.013	0.034	0.45
K63416	0.21	1.01		0.017	0.024	0.46
J74212	0.20	1.04		0.021	0.024	0.46
K63057	0.23	0.91		0.014	0.016	0.46
H70471	0.24	1.07		0.014	0.026	0.51
K63419	0.23	1.00		0.022	0.027	0.48
W27X177						
1815131	0.22	0.76	NR	0.004	0.014	0.41
67D467	0.22	0.84	0.062	0.005	0.025	0.43
676715	0.24	0.83	0.058	0.005	0.017	0.45
Plates						
1R1539	0.22	0.90		0.010	0.016	0.45
D88383*	0.23	1.15	0.05	0.014	0.024	0.53

*PQR Test Plate