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May 23, 2001

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-0001

SUBJECT: Oconee Nuclear Station - Unit 2
Docket No. 50-270
Response to Request for Additional Information
Request to use an Alternative to ASME Boiler and
Pressure Vessel Code, Section XI in accordance with 10
CFR 50.55a(a)(3)(ii), (RR-01-06, RAI)

By letter dated May 7, 2001, Duke Energy Corporation (DEC) submitted a request, pursuant to 10 CFR 50.55a(a)(3)(ii), to use alternatives to the requirements of the ASME Boiler and Pressure Vessel Code, Section XI, Subsections IWA-4170(d), IWA-4500(e)(2), and IWA-4533, 1992 Edition with no addenda for Oconee Unit 2. The May 7, 2001 submittal was replaced in its entirety by letter dated May 22, 2001, in response to a NRC request to revise the original proprietary boundaries. Other revisions were incorporated into the May 22, 2001 submittal.

Attachments A, B, and C to this letter provide responses to a request for information received from the NRC on May 22, 2001.

Questions regarding this request may be directed to Robert Douglas at (864) 885-3073.

Very truly yours,

William R. McCollum,
Oconee Site Vice President

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Attachments:

A - Response to RAI, Request for Alternate Number 01-06, Revision 2
B - Excerpts from EPRI's NMAC Boric Acid Corrosion Guidebook
C - Excerpts from EPRI Report, TR-103354, "Temperbead Welding Repair of Low Alloy Pressure Vessel Steels: Guidelines"

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**RESPONSES TO RAI
REGARDING THE USE OF AN ALTERNATIVE TO
ASME CODE REQUIREMENTS CRDM NOZZLE WELD REPAIR
OCONEE NUCLEAR STATION, UNIT 2
DUKE ENERGY COMPANY**

1. **NRC Question:**

For the proposed alternative item 5, it states that "the volumetric and surface inspections be performed after the welds are completed and conditions have reached near ambient temperatures." What is the maximum temperature for "near ambient temperatures?"

DEC / Framatome ANP Response:

The maximum temperature allowed by procedure for post-weld volumetric and surface inspections is 125°F.

2. **NRC Question:**

On page 10 of the submittal, there is a discussion on using an enhanced visual examination during the welding process. This examination was not included in the proposed alternative to IWA-4170(d)/NB-5245. Is this enhanced visual part of the proposed alternative to IWA-4170(d)/NB-5245?

DEC / Framatome ANP Response:

It was intended that the UT procedures described would serve as the proposed alternative to IWA-4170(d)/NB-5245, because of the superiority of the UT examinations to the code required progressive PT examinations in detecting delayed underbead hydrogen cracking. In addition, the described enhanced visual examinations will provide another means to insure weld quality. Used together these methods will

provide assurance that unacceptable indications in the new pressure boundary welds can be detected.

3. **NRC Question:**

Reference 2, "EPRI's NMAC Boric Acid Corrosion Guidebook," was used for an example calculation. Provide a copy of Reference 2.

DEC / Framatome ANP Response:

Reference 2, EPRI's "NMAC Boric Acid Corrosion Guidebook," contains more than 200 pages. Two pages from this document were used in the example calculation. These pages are included as Attachment B.

4. **NRC Question:**

On page 10 of the submittal, there is a discussion on the machined flaws in a mock-up used to demonstrate the effectiveness of the proposed UT alternative. Discuss and compare the UT responses of the machined flaws with the UT responses associated with the flaws found in the CRDM-to-vessel weld prior to the repairs.

DEC / Framatome ANP Response:

Different ultrasonic examination techniques and search units were used for the pre-repair and post-repair configuration inspections. A direct comparison of the UT responses using the different techniques and search units is difficult to make. The examination techniques for the new pressure boundary welds have been developed and qualified for the detection of reflectors within the weld material, the nozzle base material, as well as the RV closure head HAZ. The signal response from reflectors, where the ultrasound propagates through Inconel weld metal, has a reduced signal to noise ratio as compared to the response from reflectors where the

ultrasound propagates only within the base material of the nozzle, such as the pre-repair inspections. The signal-to-noise ratios of the demonstration reflectors were lower than the signal-to-noise ratio of the flaws within the nozzle prior to the repair. However, the demonstration using reflectors within the weld mockup provides adequate resolution of planar type reflectors above the weld noise.

5. **NRC Question:**

On page 11 of the submittal, it states that a post-weld heat soak between 450-550 degrees F is required (IWA-4532.2(d)). In the same paragraph the licensee states that preheat temperature of 300 degrees F will be maintained during the post-weld soak for four hours. Will the 450-550 degrees F soak be performed? If so, how long will the area be at temperature? When will the 300 degree post weld heat soak be performed? What will be the total time after welding before performing the UT examination? The PT examination?

DEC / Framatome ANP Response:

Request for Alternative 01-07 proposed an alternative of 300 degrees F to the 450 to 550 degrees F post-weld heat soak required by IWA-4532.2(d). The alternative was justified by noting that the 450 to 550 degrees F post-weld heat soak requirement was to assure that no delayed cold cracking in the ferritic steel HAZ occurs. The weld consumables used consisted of bare wire with no hygroscopic flux. The alternative preheat temperature of 300 degrees F was maintained during the post-weld soak for four hours. The combination of the low moisture absorbing weld process and maintaining the post-weld soak temperature at 300 degrees F for four hours significantly reduced the possibility of hydrogen induced cracking.

As noted, the 300 degrees F post-weld heat soak temperature was maintained for four hours. Cool-down of the area lasted

six hours. The time between the end of the welding operations and the beginning of the UT examinations varied depending on the CRDM nozzle. However, the minimum elapsed time between the end of the welding operation and the beginning of the UT examinations was 45 hours. This time included the post-weld heat soak period and the cool-down period. The time between the end of the welding operations and the beginning of the PT examinations varied depending on the CRDM nozzle. However, the minimum elapsed time between the end of the welding operation and the beginning of the PT examinations was 55 hours. This time includes the post-weld heat soak period and the cool-down period.

Based on the above information, DEC proposes a partial deviation from the requirements of Section XI, 1992 Edition, IWA-4533. The requirement of IWA-4533 is to provide an ambient post-weld soak of 48 hours. DEC proposes a partial alternative to IWA-4533 by providing a post-weld heat soak of 300 degrees F for four hours in accordance with IWA-4500(e)(2) followed by a six hour cool-down to a temperature of 125 degrees F, followed by a post-weld ambient hold of at least 35 hours until the ultrasonic examinations are initiated. DEC believes this partial alternative provides an acceptable level of quality and safety when compared to the code requirements.

6. **NRC Question:**

On page 11 of the submittal, it states that EPRI tests show gas mixtures (argon and moisture) as high as +60 degrees F dew point will produce a hydrogen concentration per deposited weld metal of 4.6 ml/100g. Provide a copy of EPRI report.

<u>DEC / Framatome ANP Response</u>:

The subject EPRI Report, TR-103354, "Temperbead Welding Repair of Low Alloy Pressure Vessel Steels: Guidelines,"

dated December 1993, contains over 200 pages. The pertinent section of the report is provided as Attachment C.

7. **NRC Question:**

On page 15 of the submittal, the 48-hour hold time is to verify the absence of cold cracking in the HAZ. How wide (inches, grains) is the ferritic steel HAZ for the proposed welding process? How effective is the proposed UT technique in finding cracks the width/depth of the HAZ, perpendicular to the welding direction (weld rod movement)?

DEC / Framatome ANP Response:

The depth of the ferritic steel HAZ is about 0.07 inch for this welding process as measured on sectioned samples. The weld repair examination technique was demonstrated using machined reflectors in the calibration block and a weld mockup. The examination techniques are the same for the detection of perpendicular and parallel oriented flaws located in the ferritic steel HAZ, i.e. 0° & 45° longitudinal wave search units. The demonstration included reflectors located in the ferritic steel material 0.15 inch below the weld interface to demonstrate identification of underbead cracking. The UT examination techniques have demonstrated the capability to penetrate the weld material and detect machined reflectors in the HAZ. The examination techniques are considered qualified to detect indications of underbead cracks in the ferritic steel HAZ.

8. **NRC Question:**

On page 14 of the submittal, the sentences in the two paragraphs being called proprietary are nearly identical to sentences used by the staff's in the evaluation of Oconee Unit 1, dated January 8, 2001. The wording is in the public

domain. Therefore, the staff cannot accept this as proprietary information.

DEC / Framatome ANP Response:

The proprietary designation of the second sentence in the last paragraph of page 14 has been removed in the revision two submittal of the request.

The second sentence in the second to last paragraph on page 14 is still designated as proprietary in revision two of submittal. In the context used in this submittal these words define the important physical location of the new design and hence is considered proprietary. In other contexts which are not discussions of the new design, mention of the ID bore of the CRDM nozzle is not proprietary.

9. **NRC Question:**

On page 8 of the submittal, the GTAW process is singled out as being proprietary. On pages 11 and 12, there are open discussions on GTAW; and on page 14, part of the justification for this relief request is the remote GTAW process. The GTAW process is not a proprietary process; therefore, the staff cannot accept it as proprietary information. The application of the GTAW may be proprietary but not the process.

DEC / Framatome ANP Response:

The proprietary designation has been removed from discussions on the GTAW process in revision 2 of the relief request.

NRC Question:

In the submittal it is stated that the welding was qualified without preheating. The question is, was there actually preheating prior to welding and if so, where? If no preheating prior to welding, we need to discuss this why not.

DEC / Framatome ANP Response:

The PQR's included in Attachments C and D to Request for Alternate 01-06, revision 1, show that a dissimilar metal weld using the GTAW temperbead process without a post-weld soak of 48 hours had been qualified for ASME Code Case N-606-1. These PQR's were provided for justification of elimination of the ambient temperature post-weld soak. These PQR's were not the PQR used for the Oconee Unit 2 repairs. The actual new pressure boundary weld used a pre-heat temperature of 300 degrees F in accordance with IWA-4500(e)(2).

DUKE ENERGY CORPORATION

Excerpts from EPRI
"NMAC Boric Acid Corrosion Guidebook"

Example B-1. Corrosion of Reactor Vessel Shell at Damaged Cladding

Situation:

During inspection of the reactor vessel during a refueling, it is determined that the cladding has been damaged at a local area such that the low-alloy steel pressure vessel shell material is exposed to the primary coolant. The diameter of the damaged area is 2.5 inches, and the damage extends 0.25 inch below the bottom of the cladding. Is the current damage acceptable, and will this damage result in rapid corrosion which will require frequent inspections?

Analysis:

Paragraph NB-3332.1 of Section III of the ASME Code permits a hole in the vessel shell of $0.2\sqrt{Rt}$ without the need for any reinforcement (37). For the reactor vessel shell with an inside radius of 86.65 inches and a wall thickness of 8.625 inches, the maximum diameter of an unreinforced hole is $0.2\sqrt{86.65'' \times 8.625''} = 5.47$ inches. Since the damaged area is only 2.5 inches in diameter, the current degradation is acceptable.

The corrosion rate of the low-alloy steel vessel shell at the damage location can be determined from the data in Figure 4-2.

- For refueling conditions, the corrosion rate can be taken as 0.015 in/yr for aerated water at a conservative 140°F.
- For startup conditions with low oxygen concentration, the corrosion rate can be taken as 0.010 in/yr.
- For operating conditions with very low oxygen concentration, the corrosion rate can be taken conservatively as 0.001 in/yr.

For a thirty-year remaining life, a one-month refueling outage every year, and a two-week startup period after each outage, the predicted corrosion at end of life would be:

$$\Delta_{max} = 30\text{ yr}\left[\frac{4\text{wk}}{52\text{wk}} \times 0.015\text{in/yr} + \frac{2\text{wk}}{52\text{wk}} \times 0.010\text{in/yr} + \frac{46\text{wk}}{52\text{wk}} \times 0.001\text{in/yr}\right]$$

$$= 0.073\text{ inch} \qquad \text{(B-1.1)}$$

Frequent inspections of the damaged location are not required since the diameter of the damaged area is much less than the allowable diameter of an unreinforced hole and the predicted corrosion rate is very low.

Notes:

1. This calculation assumes that the damaged area is remote from penetrations or stress concentrations.

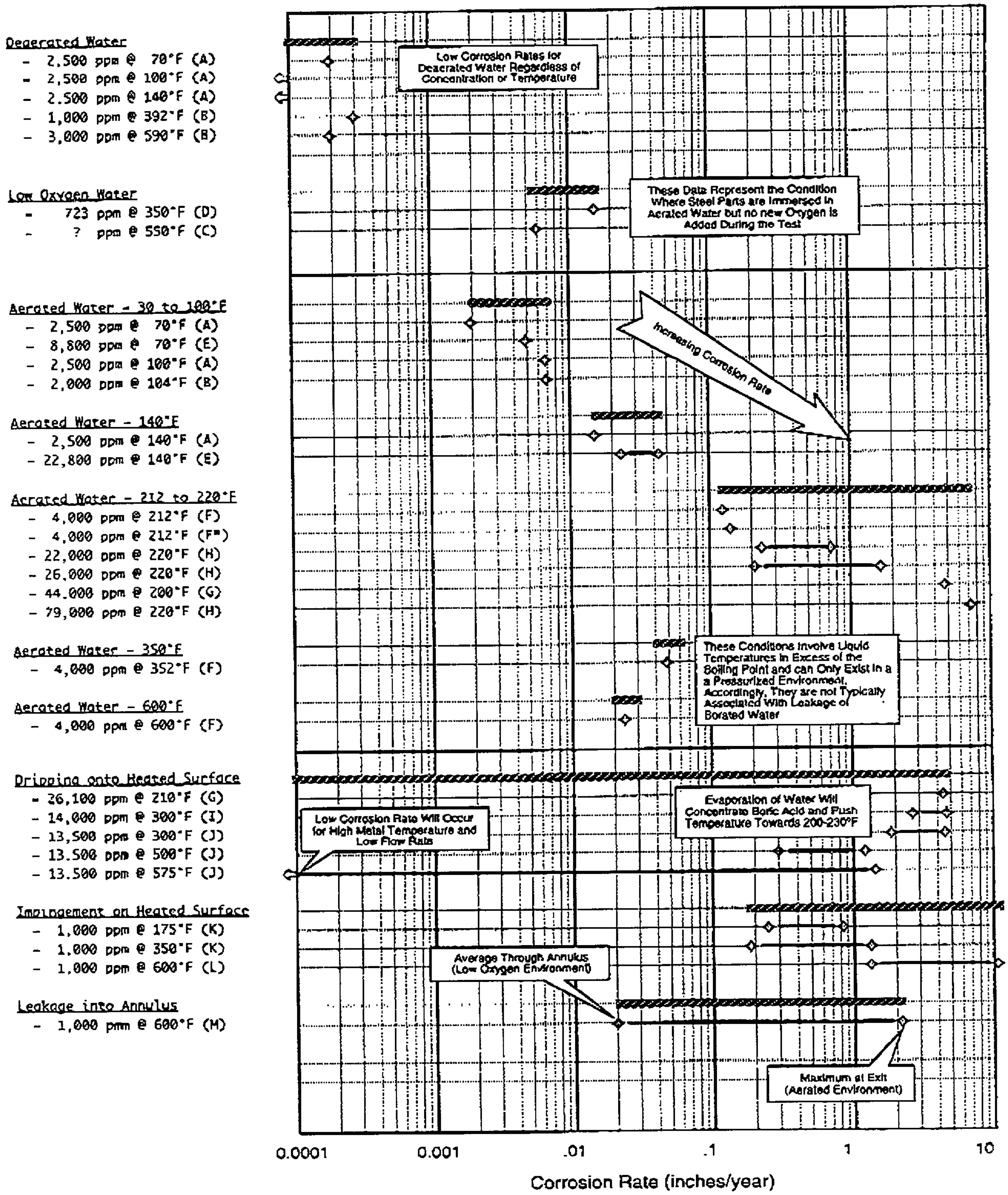

Figure 4-2
Summary of Corrosion Test Data

DUKE ENERGY CORPORATION

Excerpts from EPRI Report, TR-103354, "Temperbead Welding Repair of Low Alloy Pressure Vessel Steels: Guidelines"

REPORT SUMMARY

Temperbead Welding Repair of Low Alloy Pressure Vessel Steels: Guidelines

Optimum use of temperbead weld repair of low alloy pressure vessel steels permits welding on low alloy steel without the need for postweld heat treatment, thus saving significant repair costs and making some otherwise impractical repairs feasible. The results of this study support easing the ASME Code requirements for the temperbead process in order to make the procedure easier and cheaper to use.

INTEREST CATEGORIES

Nuclear plant corrosion control
Nuclear component reliability
Maintenance
Engineering and technical support

KEYWORDS

Maintenance
Materials
Repair
Replacement
Welding

BACKGROUND Earlier EPRI-supported research on the temperbead repair of pressure vessel steels resulted in ASME Code Case N-432 authorizing use of gas-tungsten arc welding temperbead repair. However, code restrictions limited its use, and specified welding parameters did not give adequate control.

OBJECTIVE To develop temperbead welding procedures that can be used for controlled deposition; to obtain data on resulting weld properties that justify lower preheat temperatures, a reduced number of weld layers, and elimination of the postweld hydrogen bake.

APPROACH The project team developed temperbead welding procedures that give controlled results in all welding positions. Using these procedures, the team evaluated the microstructure, hardness, and mechanical properties of the resulting welds under varying preheat temperatures, weld layer thickness, and atmospheric moisture conditions to evaluate welding parameters.

RESULTS The project results showed that properly done temperbead weld repair provides excellent weld integrity without postweld heat treatment. It was also shown that the preheat temperature could be reduced from the presently mandated 300°F to 200°F or less and that the postweld hydrogen bake could be eliminated. These results have already been used to obtain an ASME Code change allowing a reduction in the postweld bake temperature from 450°F to 300°F, equal to the currently required preheat temperature, thus significantly facilitating the repair. Additional relaxation is in progress with the ASME Code committees.

EPRI PERSPECTIVE The results of this work will make it much easier for utilities to repair low alloy pressure vessel steel components using the temperbead process. A conventional postweld heat treatment at approximately 1125°F is often completely impractical in a reactor pressure vessel. This work will make it possible to use temperbead welding repair in wider applications and significantly reduce cost and outage time for a repair. The data in the report will add confidence in the use of the process and should lead to further, more realistic relaxation of codes and regulatory requirements. Use of earlier versions of EPRI-developed temperbead technology saved approximately $18 million at the Vermont Yankee Plant.

Temperbead Welding Repair of Low Alloy Pressure Vessel Steels: Guidelines

TR-103354

Research Project C104-02
Final Report, December 1993

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Table 2-2
SFA 5.28 ER 80S-B2 Low Alloy Steel Filler Metal

C	Cr	Mo	Mn	Si	S	P	Ti
0.10	1.32	0.48	0.57	0.59	0.010	0.010	0.01

2.4.2 Diffusible Hydrogen Levels At Various Shielding Gas Dewpoint Temperatures

In preparation of diffusible hydrogen data to present to the ASME Code, it was realized that definitive data related to various shielding gas dewpoints needed to be generated. The RRAC began a second battery of diffusible hydrogen tests aimed at establishing hydrogen levels for shielding gas ranging from a dewpoint of -60F to +60F. Such tests were directed at determination of diffusible hydrogen levels associated with poor shielding gases. The tests employed the same ER80S-B2 filler wire utilized for the severe environment testing. Additionally, a 150F preheat was employed. The lower preheat temperature was utilized to be consistent with future programmatic goals targeted at preheat temperature reduction.

The various hydrogen levels were created by bubbling welding grade argon (-70F dewpoint) through a cylinder of water. A second cylinder and a needle valve were used to mix argon with the argon which had been bubbled through water to create specific shielding gas dewpoints. Figure 2-12 provides a photograph of the mixing cylinders and dewpoint meter. Utilizing the cylinders, shielding gas dewpoints were established from -60F to +60F. The lower (negative) shielding gas dewpoint represents little or no moisture, while the higher (positive) dewpoint represents a shielding gas laden with moisture. The results of the testing are presented in Section 2.5.2.

2.4.3 Off-the-Shelf Filler Wires

The two batteries of diffusible hydrogen tests were believed to be sufficient (along with diffusion calculations described in Section 2.5.4) to go to the ASME Codes for relaxation of the post-weld heat treatment requirement. However, the RRAC decided to perform diffusible hydrogen measurements on a number of other off-the-shelf filler wires (GTAW & SMAW) to determine hydrogen levels for more than one filler wire. This would help to gain an understanding of the diffusible hydrogen levels expected using different wires from various suppliers. The filler wires tested included the following GTAW wires[2]:

[2] Wire manufactures along with the chemistry for each wire utilized in this project can be found in Appendix A.

The significance of the measurements obtained from the tests discussed herein is that extremely low hydrogen contents are produced by the GTAW process. The welding process is, to quote Linnert, a "hydrogen-free" welding process which should produce relatively small levels of diffusible hydrogen if precautions such as preheating, removal of wire and surface contaminants, and proper shielding gas are taken (4).

2.5.2 Diffusible Hydrogen Levels At Various Shielding Gas Dewpoint Temperatures

The results of the diffusible hydrogen measurements carried out employing shielding gas dewpoints from -60F to +60F are presented in Figure 2-13. The maximum measured diffusible hydrogen level (measured at +60F) was 4.6ml/100g H_2. The level decreased with decreasing dewpoint temperature until a minimum diffusible hydrogen level of 1.86ml/100g H_2 was reached at a dewpoint of -15F. Between -15F and -60F the diffusible hydrogen content remained essentially constant at 1.86ml/100g H_2.

Two important points should be realized from these results. First, and most important, the maximum level of diffusible hydrogen recorded even under adverse (+60F shielding gas dewpoint) conditions was 4.6ml/100g H_2. This value falls in the "extra low" hydrogen content range as specified by AWS. Under shielding gas conditions where the gas is laden with moisture far exceeding those conditions that a competent welder would use, a diffusible hydrogen content in the extra low content range was recorded. Based on these results, one could conclude that shielding gas is a minor contributor to the level of diffusible hydrogen.

The second point realized from the testing is the minimum (or base level) average diffusible hydrogen content of the wire itself is 1.86ml/100g H_2. This conclusion is based on the test results from a dewpoint of -15F to -60F. Other low alloy steel GTAW filler wires may produce either lower or higher results. However, due to the improved processing capabilities of wire manufacturers in recent years, it was felt that the diffusible hydrogen levels would be on the same order as those recorded for the ER80S-B2 wire. The following section addresses a number of other types of wires and the diffusible hydrogen levels that can be expected.

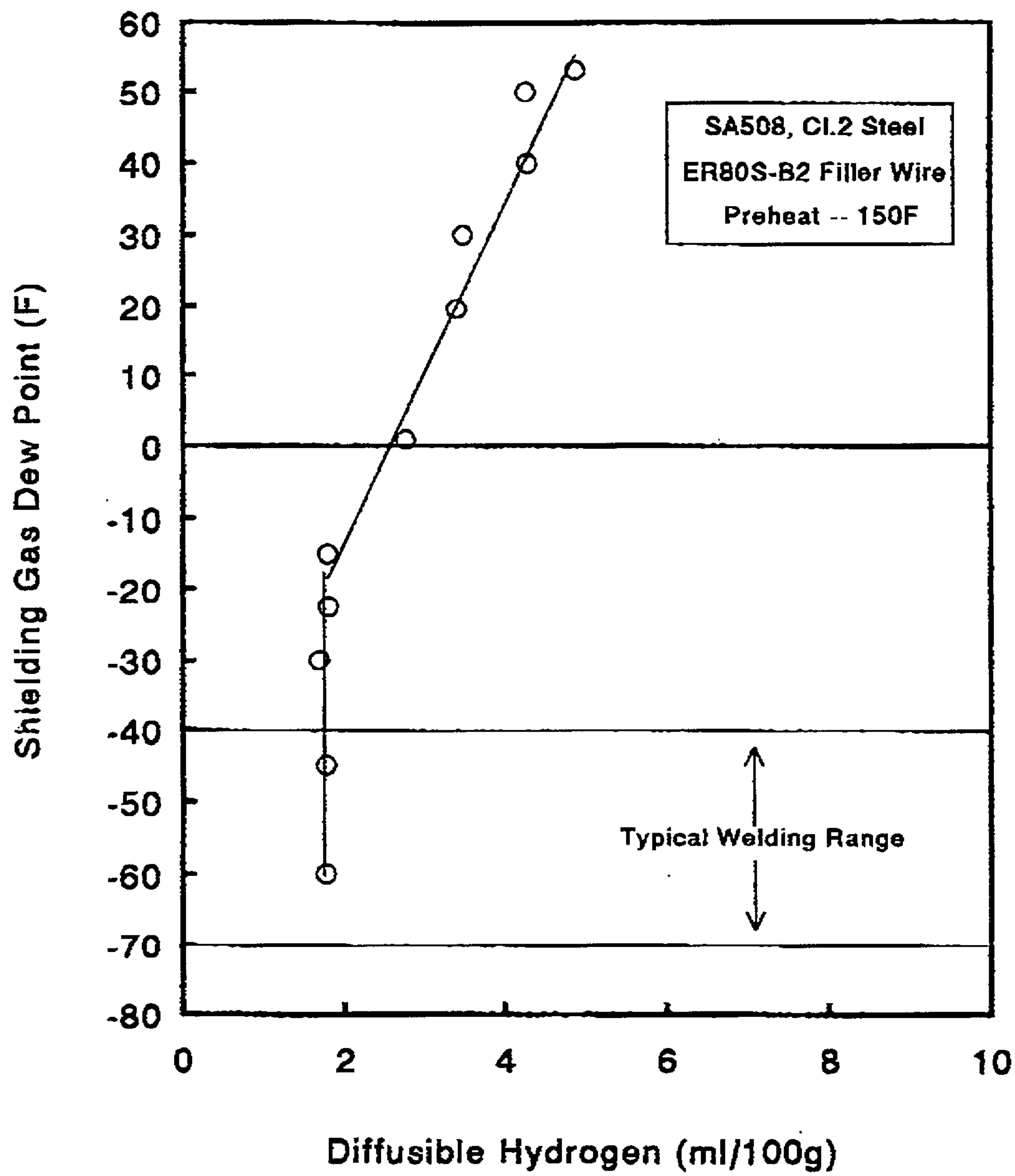

Figure 2-13
Diffusible Hydrogen Levels at Various Shielding Gas Dewpoint Temperatures