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Weld Evaluation Project Component Inspection and Examination Process

Department of Energy
Weld Evaluation Project
TVA Watts Bar Nuclear Plant Unit 1

Donald A. Armour

Idaho National Engineering Laboratory

U.S. Department of Energy • Idaho Operations Office

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WELD EVALUATION PROJECT COMPONENT INSPECTION AND EXAMINATION PROCESS

DEPARTMENT OF ENERGY WELD EVALUATION PROJECT TVA WATTS BAR NUCLEAR PLANT UNIT 1

Donald A. Armour

November 1987

U.S. Department of Energy
Idaho Operations Office

ABSTRACT

The United States Department of Energy/Weld Evaluation Project (DOE/WEP) was formed in December 1985 as the result of an interagency agreement between the DOE and the Tennessee Valley Authority (TVA). The project was assigned by the DOE to EG&G Idaho, Inc., for implementation. The DOE/WEP was tasked to perform an independent evaluation of the documented TVA welding program and the as-constructed weld quality with respect to the TVA-performed safety-related welds at the Watts Bar Nuclear Plant Unit 1 (WBNP-1). This is one of ten reports describing the plan, processes, implementation, and results of the DOE/WEP at the plant. This report describes the component inspection and examination process and the training and certification of inspection personnel.

ACKNOWLEDGMENTS

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DEFINITIONS

Certification	Written testimony of qualification.
Characterization	Activities required (a) to determine size of a discontinuity for final acceptance and status of the inspection attribute or (b) to provide information required to evaluate the significance of the observed discrepancy.
Incomplete fusion	The lack of coalescence during the melting of filler material to the base material.
Nonrelevant indications	Indications found during nondestructive examination(s) (NDE) that are not characteristic of, but could mask, relevant indications. Nonrelevant indications are usually the result of a surface condition that retains excessive amounts of the examination medium. Examples are coarse ripples, grooves, and abrupt ridges and valleys of weld surfaces.
Qualification	Demonstrated skill, training, knowledge, and experience required for personnel to properly perform the duties of a specific job.
Slag	Nonmetallic solid material. By-product of flux used to prevent, dissolve, or facilitate removal of oxides and other undesirable surface substances.
Ultrasonic thickness gauge	A material thickness measuring instrument that transmits ultrasonic waves into a material and precisely measures the time for the wave to bounce off the back surface and return to the instrument. This time is translated into material thickness and displayed on a digital readout. Example: Krautkramer-Branson, Inc., D-Meter Thickness Gauge DM-2.
Deviation or deviant weld	Deviation or deviant weld denotes a condition that does not meet the applicable code inspection acceptance criteria for the weldment specified by the engineer. These terms are used before an evaluation of the condition has been performed in accordance with other applicable code provisions to determine the acceptability of the condition.

WELD EVALUATION PROJECT COMPONENT INSPECTION AND EXAMINATION PROCESS

1. INTRODUCTION

The United States Department of Energy/Weld Evaluation Project (DOE/WEP) was formed in December 1985 as the result of an interagency agreement between the DOE and the Tennessee Valley Authority (TVA) to provide the TVA with an independent assessment of the quality of safety-related welding performed by the TVA during construction of the Watts Bar Nuclear Plant Unit 1 (WBNP-1). The DOE/WEP was conducted by EG&G Idaho, Inc., as contractor to the DOE.

The specific objectives of the DOE/WEP were to:

1. Assess compliance of the TVA's documented weld program to the requirements in the WBNP Final Safety Analysis Report (FSAR)[1] and amendments through February 1, 1986.
2. Assess applicable TVA employee concerns (ECs) and quality documents to determine if they identify quality problems with the TVA-performed, safety-related welds.
3. Evaluate the TVA's as-constructed plant weld status by conducting an examination of the plant welds, evaluating the results, and when deviations[a] were determined to be unacceptable, analyzing and concurring with the TVA's corrective action proposals for these deviations.
4. Provide the TVA with a statement of the compliance of the plant welds with applicable construction welding codes.

This is one of ten reports describing the plan, processes, implementation, and results of the DOE/WEP at the WBNP-1. The assessment to meet Objective 1 was accomplished with the completion of the report, "Weld Program Review."[2] The other eight reports are listed as References 3 through 10. In addition to the Weld Program Review cited above, these reports delineate: the program organization and work scope, the formation of homogeneous groupings of welds, the formation of the weld/component data base, the data bases for weld reinspection results and status reports, the processes of suitability for service engineering evaluation, the generic problem analysis of deviations found during the examinations, an aggregate assessment of weld reinspection results, and a final summary.

A weld inspection program was developed to assess the weld quality of components[a] at the WBNP-1. This program included a training and certification program to ensure compliance with the requirements for inspection personnel in accordance with the American Society of Mechanical Engineers document ANSI/ASME NQA-1.[11] The actual weld inspection activities were preceded by a selection of a required number of components from a bounded component population as described in Reference 4. The components were field verified by a walkdown to determine the accessibility/inspectability of inspection characteristics required of the component. The components found inaccessible were documented and removed from consideration. Walkdowns continued until the required number of components were achieved.

Following the walkdown process, the accessible components were identified to the DOE/WEP Technical Program organization, who prepared examination packages (EP) for each component. These EPs specified the inspection activities required for each component.

Following the EP preparation, the EPs were transmitted to the DOE/WEP Inspection/Examination (IE) organization. The EPs were then assigned to inspectors qualified to perform the

a. *Deviation* or *deviant weld* denotes a condition that does not meet the applicable code inspection acceptance criteria for the weldment specified by the engineer. These terms are used before an evaluation of the condition has been performed in accordance with other applicable code provisions to determine the acceptability of the condition.

a. A component is defined for structures as a logical assembly of parts that have a common function. Examples of structural components are pipe supports, pipe hangers, ladders, platforms, and structural members identified by drawing detail or mark number. A component is defined for piping as a welded joint.

required examinations. The specified examinations and document reviews (as required) were performed, at which time all acceptable and deviant conditions were documented. The EPs were then transferred to the DOE/WEP Configuration Management organization for further processing.

Reported deviant weld conditions underwent a suitability for service engineering evaluation (SSEE) as described in Reference 7. When required for SSEE, deviant conditions were characterized by the TVA personnel. The characterizations performed by the TVA were witnessed and documented by the DOE/WEP I/E organization.

Section 2 of this report describes the training and certification of the DOE/WEP inspection personnel. The inspection procedures are discussed in Section 3; the inspection process in Section 4. Appendix A consists of the WEP Standard Practices applicable to the examination process. Appendix B contains a report of the qualification of inspection procedures.

2. TRAINING AND CERTIFICATION

The training and certification program was developed to ensure compliance with the requirements for inspection personnel in accordance with ANSI/ASME NQA-1.[11] This program is detailed in Standard Practice (SP) WEP 4.1.2 (Appendix A).

2.1 Knowledge Assessment

Nondestructive examination (NDE) as defined by SP WEP 4.1.2 includes the following test methods: liquid dye penetrant testing (PT), magnetic particle testing (MT), radiographic testing (RT), ultrasonic testing (UT), and visual testing (VT). Examination Level II candidates seeking certification in these NDE methods were required to complete knowledge assessment examinations before receiving any DOE/WEP sponsored training. The knowledge assessment examinations were administered for each NDE test method to identify the strengths and weaknesses of each candidate. The results of an individual's examination indicated the type of training required prior to the administration of certification examinations. Individuals whose examination results were too low were not considered for certification.

As a prerequisite, applicants for visual inspection certification were required to possess a current Certified Welding Inspector (CWI) certificate, issued by the American Welding Society (AWS).

2.2 Personnel Training

All candidates were trained, as recommended by SNT-TC-1A,[12] to ensure a clear understanding of the principles and procedures in those areas of NDE for which certification was sought. The following describes the training performed to fulfill the program objectives:

- A minimum of 4 hours of Nuclear Construction Issues Group NCIG document NCIG-03[13] training was provided to each candidate who sought a certification in visual inspection. This was to ensure that the visual weld acceptance criteria of NCIG-01[14] were clearly understood.
- Ultrasonic thickness measurement training was provided to all visual examiners to provide an evaluation method for determining actual material thickness using an ultrasonic thickness gauge.
- For examiners seeking certification to SP WEP 3.2.15 (Appendix A), 15 hours of training describing the techniques used to obtain characterization data for weld discontinuities using UT methods were provided. For the purpose of this training, characterization of weld discontinuities is defined as a determination of a discontinuities depth, length, height, orientation, and classification of its geometric shape (e.g., planar, cylindrical, or spherical). When sufficient data were available, further description of discontinuity type was made (e.g., crack, lack of fusion).
- During the course of the project, update training was provided on an as-needed basis to ensure uniformity in drawing weld symbol interpretations, drawing notes, and inspection applications.
- Training records were maintained in each examiner's certification file by the I/E Training and Certification Group.

2.3 Personnel Certification

All DOE/WEP I/E personnel were certified in accordance with SP WEP 4.1.2 (Appendix A) in those NDE methods for which qualification requirements were met. The DOE/WEP Level III examiners responsible for the administration of qualification activities were certified in accordance with SP WEP 4.1.2 by a DOE/WEP approved independent outside agency (Hellier & Associates Inc.). The SP WEP 4.1.2 was written in accordance with the provisions of SNT-TC-1A,[12] and ANSI/ASME NQA-1.[11]

2.4 Background Verification and Certifying Authority

An outside agency (Corporate Strategies Inc.) performed a background verification on all the DOE/WEP I/E examiners. The Certifying Authority or his authorized representative verified the training, education, and work experience of each candidate for certification.

Because of varying company policies, verification of training and previous certifications was not always possible. In such instances, verification of

previous employment, where credit for training and certification had been claimed, was deemed sufficient.

Evidence of a candidate deliberately falsifying information pertaining to education, training, or experience, would have automatically disqualified him from the certification process.

Documented evidence of training, education, and experience provided by the candidate was maintained by the I/E Training and Certification Group.

The Certifying Authority (DOE/WEP Project Manager) issued certification document(s) upon the written recommendation of an NDE Level III examiner. The Level III examiners recommendation was based upon personal knowledge and a thorough review of support qualification records that a certification candidate had met all of the requirements established by SP WEP 4.1.2 (Appendix A).

2.5 Quarterly Monitoring of Inspectors

Each calendar quarter, a monitoring of each Level II examiner was performed in one of the examination methods in which the individual was certified. The monitoring activity consisted of a Level III, or designated Level II examiner, performing an overview of the individual during performance of an examination. Particular attention was given to the use of inspection tools, procedure compliance, and documentation requirements. This activity was documented on an Inspector Certification Status Report.

2.6 Inspection Overcheck

To ensure the accuracy of examination and examiner performance, a 5% overcheck was performed weekly of the DOE/WEP inspections. Overchecks were performed by the DOE/WEP Level III examiners and consisted of selecting and independently reexamining the component, then comparing examination results and documentation with the original examination. If a deviation was identified, the Level III examiners and I/E Manager discussed the deviation to determine its significance. The original examiner was then interviewed to state his position on the deviant finding. If, as a result of the final interview, corrective action was required, full documentation was provided in an Overcheck Report.

2.7 Electronic Data Base

An electronic data base was maintained for each certified individual to avoid a lapse in certifications. The data base contained the following certification data:

- Method and level of each certification
- Expiration date of certification(s)
- Expiration date of visual acuity examinations
- Audit status in each test method (quarterly monitoring).

3. INSPECTION PROCEDURES

The reinspection scope of work necessitated specialized procedures in order to effectively assess the weld quality at the TVA's WBNP-1. The following describes the primary activities performed by the I/E organization during the inspection process.

3.1 Development of Procedures

The DOE/WEP I/E procedures were generated to reflect the TVA's commitments as established by their FSAR. The DOE/WEP procedures paralleled the TVA procedures with respect to acceptance criteria for each examination method, with the following exceptions:

- SP WEP 3.2.15 (Appendix A)—Characterization of weld discontinuities using UT methods, which was written to distinguish specific types of weld discontinuities identified by the DOE/WEP Assessment Plans (APs), was added
- NCIG-01[14]—The AWS D1.1 alternate visual inspection acceptance criteria was used.

Examination procedures for MT, PT, and UT were separately qualified by a DOE/WEP Level III examiner. Documentation of the limitations of these demonstrated activities were maintained in the DOE/WEP's Procedure Qualification files. Procedural limitations for each nondestructive method were clearly identified in each NDE procedure.

3.2 Scope of Procedures

The established DOE/WEP examination procedures and acceptance criteria are set forth in WEP Standard Practices, which are in Appendix A of this report (Appendix A is on microfiche attached to the inside back cover of this report.) The procedures and acceptance criteria are:

For VT examination, SP WEP 3.2.3 contained the acceptance criteria that were used. The acceptance criteria were in three appendixes:

- Appendix A of SP WEP 3.2.3 addresses the ASME Code Section III, Division 1;[15] ASME Code Section VIII, Divisions 1 and 2;[16] and ANSI B31.1[17] and B31.5.[18]
- Appendix B of SP WEP 3.2.3 addresses AWS D1.1[19] in Category 1 structures including pipe hangers, cable tray supports and duct supports. Appendix B of SP WEP 3.2.3 is used when it is determined that NCIG-01[14] requirements are not appropriate because of structural design.
- Appendix C of SP WEP 3.2.3 addresses the NCIG-01 acceptance criteria as applied to Category 1 structures including pipe hangers, cable tray supports, duct supports, and attachments.

For PT examination, SP WEP 3.2.4 contained the acceptance criteria that were used. The acceptance criteria were in two appendixes:

- Appendix A of SP WEP 3.2.4 addresses the ASME Code Section III, Division 1; ASME Code Section VIII, Divisions 1 and 2; and ANSI B31.1
- Appendix B of SP WEP 3.2.4 addresses AWS D1.1.

For MT examination, SP WEP 3.2.5 contained the acceptance criteria that were used. The acceptance criteria were in two appendixes of SP WEP 3.2.5:

- Appendix A SP WEP 3.2.5 addresses the ASME Code Section III, Division 1 and ANSI B31.1 and ANSI B31.5
- Appendix B SP WEP 3.2.5 addresses AWS D1.1.

For RT examination, SP WEP 3.2.6 contained the acceptance criteria that were used. The acceptance criteria were in two appendixes of SP WEP 3.2.6:

- Appendix A of SP WEP 3.2.6 addresses the ASME Code Sections I,[20] III, and VIII and ANSI B31.1
- Appendix B of SP WEP 3.2.6 addresses AWS D1.1.

For UT examination, SP WEP 3.2.7 contained the acceptance criteria to AWS D1.1. SP WEP 3.2.9 contained acceptance criteria for the ASME Code Sections I, III, and VIII and ANSI B31.1.

4. INSPECTION PROCESS

The sequence and responsibilities of inspection activities are described in SP WEP 3.2.10 (Appendix A).

The DOE/WEP examinations were those required by the original TVA inspection, with the following exceptions:

- NCIG-01—Alternate acceptance criteria to AWS D1.1, which is allowed within the provisions of the AISC Specification[21] and AWS D1.1.
- PT/MT—In most cases, carbon steel component surfaces had been painted. As a result of paint removal operations, possible paint entrapment and surface metal smearing occurred, thus possibly enclosing some surface discontinuities. In these instances, whenever the TVA originally performed PT examinations, the DOE/WEP elected to utilize the MT examination method because of its ability to pick up slight subsurface discontinuities. The report transmitted to the TVA by KGT-201-86 (see Appendix B) provides a documented study of the investigation performed by the DOE/WEP and the TVA that supports the DOE/WEP's position on use of MT versus PT after paint removal.
- The UT examinations (not originally required) were performed to assess the existence of specific subsurface discontinuities identified by the DOE/WEP APs.

4.1 Prerequisites for Inspection

Before preparation and inspection of EPs, the selected components were field verified by a walkdown performed by the DOE/WEP I/E and the TVA representatives to determine accessibility for the required inspection/examination activities. This process identified the accessibility of each component. For inaccessible items, the I/E representative documented the reason for inaccessibility. Accessible items were tagged with a DOE/WEP identification tag to uniquely identify the component and preempt any further rework or reconfiguration of the item during the inspection period.

The accessible components were identified to the DOE/WEP Technical Program organization, who prepared EPs for each component. The EPs identified the inspection activities required and contained all relevant documentation/information required to perform these activities (i.e., location/design drawings, applicable design notes and the DOE/WEP inspection forms, etc.). The inspection requirements for each component were established by the DOE/WEP assessment plans, which identified the specific concern, bounded the sample population, and established the evaluation methods required to address the concern.

Following EP preparation, the DOE/WEP I/E reviewed EPs for completeness and assigned them to examiners whose qualifications were appropriate for the required inspection.

4.2 Inspection and Examination Activities

Inspection personnel performed the required inspection activities and documented the results on the applicable DOE/WEP inspection forms contained within the associated EPs. All examination related deviant conditions were documented on the DOE/WEP deviation reports (DRs), which were maintained with the associated EPs. Upon completion of inspections, the EPs were transmitted to the DOE/WEP Configuration Management for further processing.

When performing visual inspection of welds, weld attributes such as weld quality, size, length, location, profile and general surface condition were evaluated. When surface slag was identified, the examiner evaluated the slag to the acceptance criteria and documented the condition, if rejectable. All other inspection attributes were not evaluated until the slag was removed. Slag removal was performed by the examiner unless an inordinate amount of work was required, in which case the TVA craft performed the removal operation. After slag removal, the examiner completed the weld inspection.

When cracks, arc strikes with indeterminate depth, and potential nonrelevant indications were observed, a DOE/WEP Level III examiner was notified for confirmation of the condition. All suspect cracks received an exploratory MT or PT examination as determined by the DOE/WEP Level III.

Additional relevant data, such as welds missing in their entirety because of configuration; or welds missing in their entirety not as a result of configuration, weld type not corresponding to the design drawing, or inaccessibility, was provided for clarification and engineering consideration. This information was provided on the DOE/WEP inspection records. Clarification of these type conditions was documented on the associated DRs.

If, during the course of the inspection/examination process, a portion of the weld was determined to be inaccessible, it was identified as such on a Deviation Report. Doing so excluded that portion of the weld from the required inspection/examination process. Typical cases of weld inaccessibility were:

- Access was insufficient to perform visual inspection within 24 in. of the surface to be examined and angle of the examination surface not less than 30 degrees
- Welds covered by structural members
- Welds covered by a portion of structural member.

The DOE/WEP I/E reviewed the TVA's performance of radiography and previously radiographed film to the original acceptance criteria. Film quality (i.e., density, penetrameters, artifacts and geometric unsharpness) was reviewed to the requirements of SP WEP 3.2.6 (Appendix A).

As a result of this review, a number of welds were requested by the DOE/WEP to be reradiographed in which the DOE/WEP I/E witnessed the TVA personnel performing the radiography and verified that the proper techniques were utilized.

The deviant weld conditions reported during inspections underwent a suitability for service engineering evaluation to determine the weld/component capability to perform its intended function. When pressure boundary welds revealed conditions such as cracks, linear indications, nonrelevant indications, unacceptable rounded indications, arc strikes with indeterminate depth, and incomplete fusion, such conditions were characterized to determine significance for the suitability for service engineering evaluation. On structural applications, incomplete fusion and cracks were characterized, when applicable.

Characterization consisted of alteration of the existing weld by weld metal removal, such as grinding, filing, and burring to determine the orientation and depth of the discontinuity. Characterization activities were performed by the TVA personnel and witnessed by the DOE/WEP I/E. These activities were documented and incorporated in the associated EPs. The performance and documentation of this activity was performed in accordance with SP WEP 3.2.16 (Appendix A).

5. REFERENCES

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13. Nuclear Construction Issues Group "Training Manual for Inspectors of Structural Welds at Nuclear Power Plants Using the Acceptance Criteria of NCIG-01," Rev. H, NCIG-03, June 1985.

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18. The American Society of Mechanical Engineers, "Refrigeration Piping," ANSI B31.5-1966.

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20. The American Society of Mechanical Engineers "Power Boilers," *ASME Boiler and Pressure Vessel Code*, Section I, 1971 through Summer 1971 Addenda.

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APPENDIX B

QUALIFICATION OF INSPECTION PROCEDURES FOR PREVIOUSLY PAINTED COMPONENTS

Idaho National Engineering Laboratory

EG&G Weld Evaluation Project
Interim Office Building
Tennessee Valley Authority
Watts Bar Nuclear Power Plant Site
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August 2, 1986

Mr. F. E. Laurent
Tennessee Valley Authority
Watts Bar Nuclear Power Plant Site
P. O. Box 800
Spring City, TN 37381

QUALIFICATION OF INSPECTION PROCEDURES FOR PREVIOUSLY PAINTED COMPONENTS - KGT-201-86

Dear Mr. Laurent:

Attached for your information is a report of the qualification activities performed by Weld Evaluation Project (WEP) for the inspection procedures used to inspect components which have been painted and then cleaned using the Tennessee Valley Authority (TVA) cleaning process.

Very truly yours,

Kent G. Therp, Manager
Weld Evaluation Project

bmr

Attachment:
As Stated

cc: R. E. Tiller, DOE-ID
J. O. Zane, EG&G Idaho (w/o Attch.)

bcc: G. R. Archibald
A. E. Bradford
T. L. Bridges
W. S. Burkle
C. O. Doucette
F. C. Fogarty
D. M. Grigg
R. J. Wade
Central Files
K. G. Therp File

Mr. Kent G. Therp
Project Manager
EG&G Weld Evaluation Project
Tennessee Valley Authority
Watts Bar Nuclear Power Plant Site
P.O. Box 800
Spring City, Tennessee 37381

July 23, 1986

Dear Mr. Therp;

In response to your inquiry concerning the effect of paint removal upon the detectability of weld defects by visual, penetrant, and magnetic particle examination, an investigation addressing this issue was conducted under my direction at the Watts Bar Nuclear Power Plant site. The following summarizes this investigation.

Introduction

In order to assess the effect which paint removal might have upon weld defect detection, a comparison was made of the detectability of Copper-Ferrite dilution cracking in welded test plates before and after a paint removal procedure had been performed. Copper-Ferrite dilution cracking is characteristically very fine and difficult to detect visually, and hence representative of a weld defect which could be expected to be easily affected by surface working during paint removal.

Test Specimens

Five ASTM A-36 steel plate specimens were prepared, each approximately twelve (12) inches by six (6) inches by one-half (0.5) inch

thick. A single vee groove butt weld was produced in the center of each plate by the SMAW process using E-7018 electrodes. Each weld was divided into segments two inches in length and two of these segments in each weld were selected for crack implantation. Copper-Ferrite dilution cracking was induced in each of the two selected segments. Each specimen was assigned a sample identification number, and each was examined using an alternating current yoke and dry magnetic particles. A transparent tape transfer record was made of all particle indications for each direction of magnetization. Since liquid dye penetrant materials are difficult to remove from capillary voids (such as the cracks produced in the sample plates) and these materials could potentially interfere with subsequent coating application, an initial liquid dye penetrant examination was not performed.

Initial Visual Examination

Copper-ferrite dilution cracks tend to form fine, branched indications which vary significantly in length and width. Many of these cracks are not consistently detectable during visual examination, depending upon the orientation of the crack and the crack's reflective characteristics. In order to ensure that crack detection comparisons were based upon a reliable and consistent frame of reference, an effort was made to determine which of the sample weld crack indications could be repeatedly and consistently detected. Fifteen AWS CWI qualified individuals visually examined each of the five test plates and produced a detailed sketch of detected crack locations and orientations. Each examiner's sketch was compared to

the previously obtained magnetic particle tape transfer record for the appropriate sample segment. Those cracks which were most consistently reported by all fifteen examiners were selected for use as reference cracks in comparing detectability before and after paint removal.

Five of the examiners were available to participate further in the investigation, and the crack sketches produced by these individuals were used as the comparative baseline.

Coating Application

Each of the five plates was sandblasted in preparation for coating application. Five paint systems commonly used at Watts Bar were then applied by brushing in strict accordance with TVA written procedures. The paint systems applied, and the average applied coating thickness of each were as follows:

Sample No.	Primer	Thickness	Topcoat	Thickness
B1	Zinc Chromate	1.4 mils	Enamel	3.9 mils
B2	TNEMEC	1.9 mils	Enamel	3.5 mils
B1	TNEMEC	1.8 mils	Carboline 305	5.2 mils
B1	Carbozinc 11	4.4 mils	Carboline 305	11.0 mils
B1	Carbozinc 11	3.4 mils	N/A	N/A

Each sample was afforded a fourteen day dry and cure time. After curing, the welds were visually examined to determine if any cracking was visible through the paint. None was detected.

Coating Removal

Coating removal was accomplished in compliance with TVA Procedural requirements, which involve the application of solvents in combination with manual and power wire brushing.

Visual Reexamination

After coating removal, the five AWS CWI qualified individuals performed a visual reexamination of the samples. Each examiner produced a detailed sketch of the location and orientation of cracks detected. By comparing the sketches to the original magnetic particle transfer record, and the sketches of crack locations produced prior to coating, the frequency with which each of the recorded reference cracks had been redetected was determined. In all cases the reference cracks were redetected and were recorded without significant change.

Magnetic Particle Examination

An alternating current yoke dry powder magnetic particle test was applied to each sample segment, and transparent tape transfers of all particle indications were obtained for each direction of magnetization. Comparisons were made of magnetic particle tape transfer records obtained before and after coating removal. The results were identical.

Liquid Dye Penetrant Examination

A liquid dye penetrant examination was applied to each test plate using a solvent removed visible dye penetrant and nonaqueous wet developer. A twenty minute dwell time was observed prior to penetrant removal and developer application. This examination method failed to reveal eighty percent (80%) of the reference cracks.

Cross-Sections

Each of the welds was cross-sectioned through various crack locations to determine certain physical characteristics such as crack width, to determine if any smearing or working of the metal surrounding the crack openings had occurred, and to determine the extent to which the paint may have entered and occluded reference cracks.

Based upon laboratory reports and the writer's own examination of the samples, crack widths were determined to be in the range of from one to ten thousandths of an inch (.001" to .010") wide at the crack opening to the surface. A layer of disturbed metal was observed which partially sealed the crack opening. Laboratory examinations indicate that this layer was on the order of one or two metal grains in thickness. No paint was detected in any of the crack voids.

Conclusion

The visual and magnetic particle examination of welds which have been involved in a coating removal operation is reliable. No significant

degradation in crack detectability was noted. All reference cracks detected by magnetic particle examination were also detected by visual examination.

Test results suggest that the liquid dye penetrant examination method is not reliable in the detection of discontinuities after paint removal. It is suspected that this is primarily the result of the partial smearing of the weld surface metal across discontinuity openings. In a further investigation, a test weld containing copper-ferrite dilution cracking was liquid penetrant tested both before and after sandblasting. Prior to sandblasting, the cracks were readily detected; After sandblasting, crack detectability was significantly reduced. This would suggest that surface preparation also contributes to smearing.

The original records and the plate sample remnants used for this investigation are being retained and are available for inspection. Please advise if you have further questions concerning weld examination after paint removal.

Very truly yours;

William S. Burkle

E13 860725 369

TECHNICAL REPORT

REPORT NO.: M86-86-0282

SHEET NO.: 1 of 1 sheets

DATE OF REPORT: 7/22/86

LOCATION: Central Laboratories - PSC - Chattanooga

SUBJECT: WELD CRACKING EVALUATION PROJECT, WATTS BAR NUCLEAR PLANT

COPIES SENT TO: Gary Pitzle, RIMS, Lab Files, W. Robertson

PREPARED BY: Paulette Brown/DLF CHECKED BY: Rebecca Goins APPROVED BY: H. A. Taff

On July 7, 1986, five welded test plates (Figures 1 - 5) were submitted to the Metallurgical Laboratory Section with a request to perform the following:

a. Perform magnetic particle testing (NDE) to reveal cracking in the welds and document the cracking.

b. Record the extent of the cracking in the copper weld bead metallographically.

c. Examine the cracks for paint deposit (spray and hand application), and, if found, measure the depth of the paint penetration in the cracks.

d. Measure the depth and width of the cracking in the weld.

e. Document the disturbed layer of metal at the weld surface that was caused by hammering.

Cracking could easily be observed in the copper weld beads after the magnetic particle test (Figures 1 - 5). Cross-sections of the welds were examined metallographically to document the depth and nature of the cracks (Figures 6 - 16). A thin layer of disturbed metal was found on the surface of the weld beads as expected, but this layer was only 2-3 grains deep.

Energy dispersive X-ray analysis (EDX)*, in conjunction with the scanning electron microscope, was used to determine the composition of the deposit in the cracks as well as the paints. It was determined that the deposit was composed of calcium and silicon. This did not compare primarily with the composition of the paints which had a high titanium content nor the primer which had a high zinc content. The calcium and silicon may be part of the flux used in the welding operation; therefore, no measurements were made of the crack deposits.

Scanning electron micrographs showing typical appearance of representative cracks are shown in Figures 17 and 18. The sample with deposits detected in the cracks (B4-3) is shown in Figure 18b.

Table I lists the depth and width of a representative crack in each area viewed metallographically. Arrows in the macrographs (Figures 6 - 16) indicate the crack measured.

If any additional information is required, please refer to Metallurgical Laboratory Report No. M86-86-0282.

*EDX analysis is a semiquantitative technique which uses no standards.

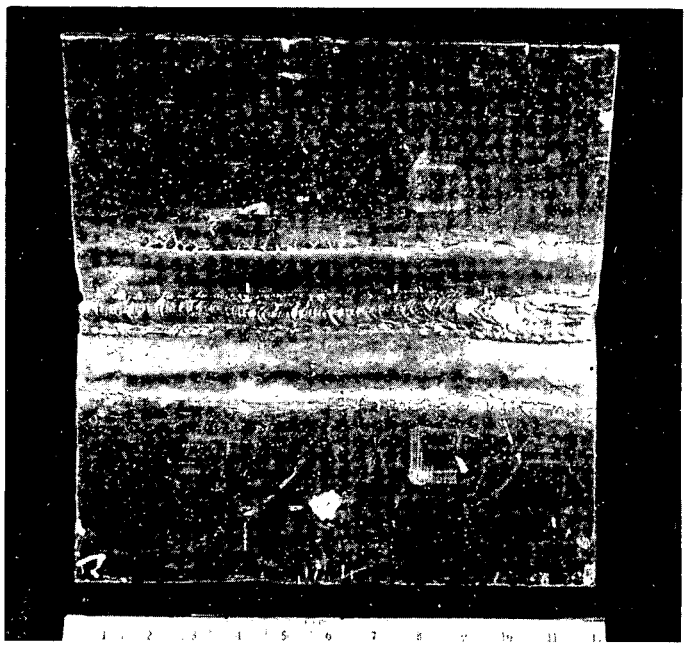
PDB:DLF:SAV (0628)
Attachments: Figures 1 - 18
Table I

TABLE I

Dimensions of Cracks* in Copper Weld Bead for Report No. M86-86-0282

Weld Sample	Depth of Crack, inches	Width of Crack, inches
B1-1	0.1493	Top = 0.0039 Bottom = 0.0019
B1-3	0.1985	Top = 0.0019 Bottom = 0.0059
B2-1	0.0511	Top = 0.0010 Bottom = 0.00393
B2-3	0.0884	Top = 0.0039 Bottom = 0.0010
B3-1	0.1670	Top = 0.0059 Bottom = 0.01376
B3-2	0.0845	Top = 0.0019 Bottom - 0.0019
B4-1	0.2378	Surface = 0.0098 Bottom = 0.0019
B4-3	0.1513	Top = 0.0059 Bottom = 0.0010
B4-5	0.1572	Top = 0.0098 Bottom = 0.00589
B5-1	0.1493	Top = 0.0059 Bottom = 0.0079
B5-4	0.0983	Top = 0.0019 Bottom = 0.0039

*Cracks that were measured are indicated by arrows in Figures 6 - 16.



As-received photograph of weld plate (left) and closeup view showing cracks revealed by magnetic particle testing (below). Closeup view shows areas where weld was sectioned for microscopic examination of the cracks.

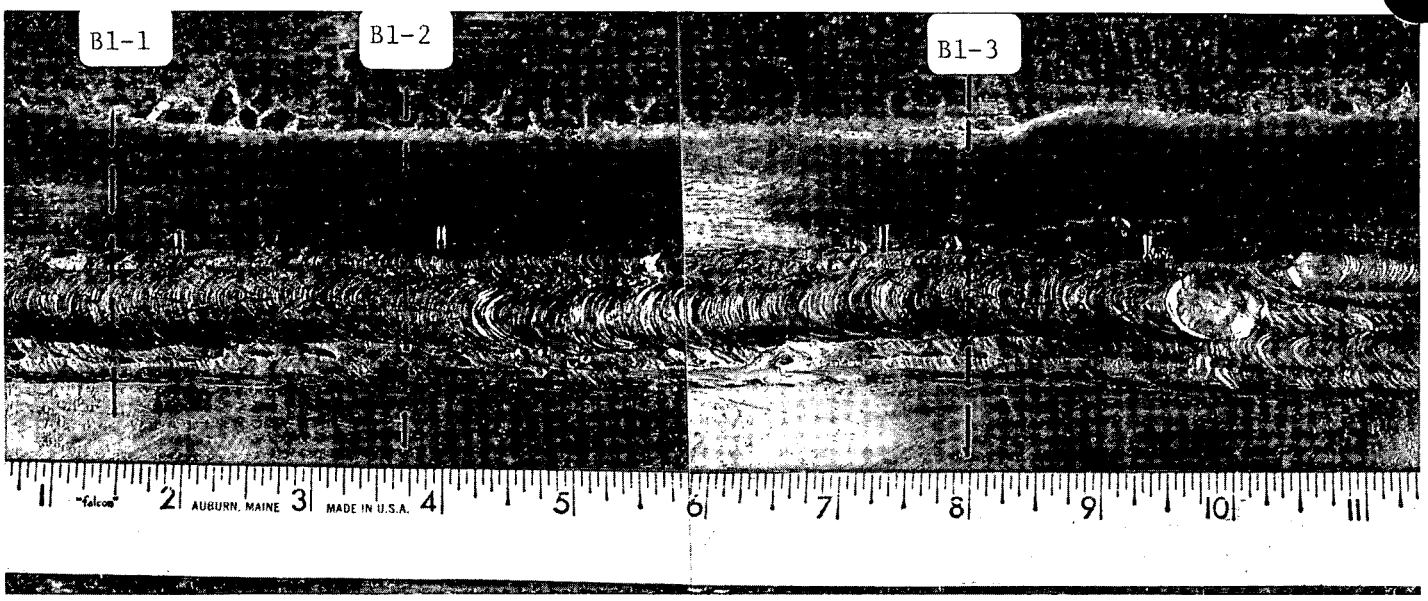
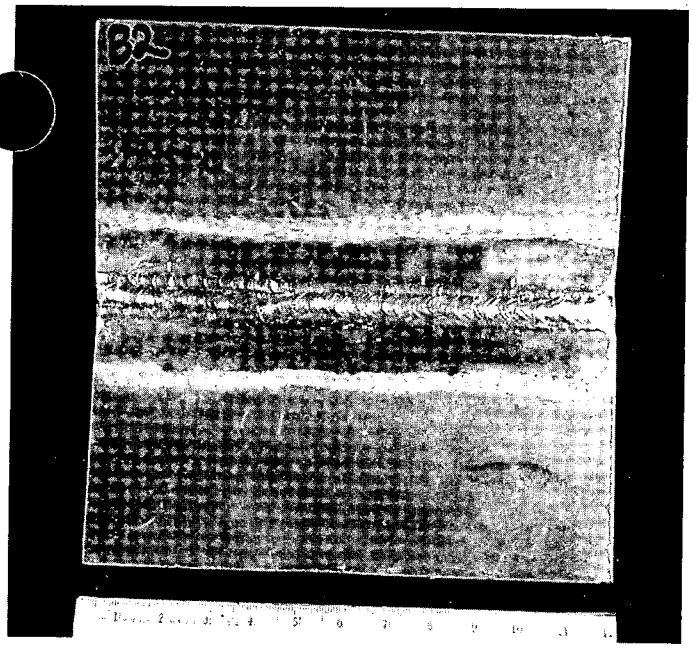


Figure 1 - Weld Plate "B1," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant, M86-86-0282.



As-received photograph of weld plate (left) and closeup view showing cracks revealed by magnetic particle testing (below). Closeup view shows areas where weld was sectioned for microscopic examination of cracks.

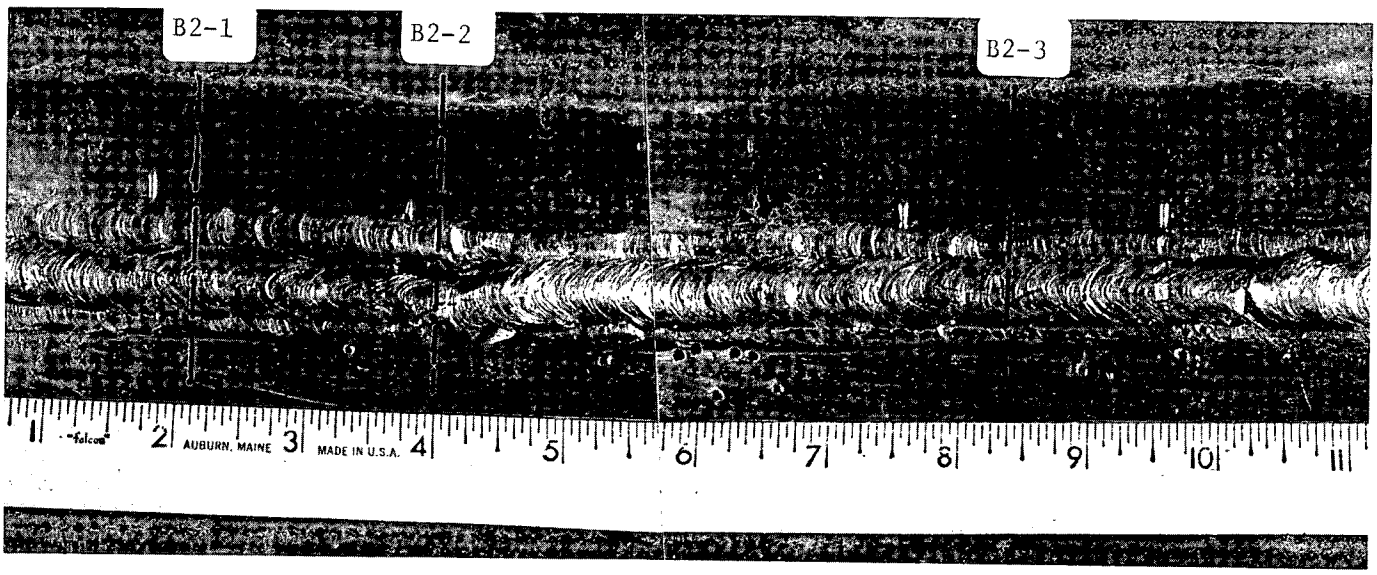
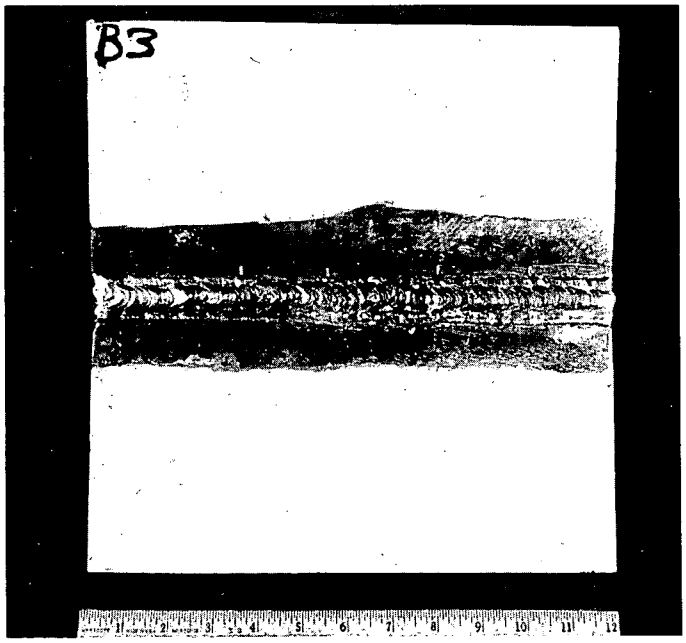


Figure 2 - Weld Plate "B2," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant, M86-86-0282.



As-received photograph of weld plate (left) and closeup view showing cracks revealed by magnetic particle testing (below). Closeup view shows areas where weld was sectioned for microscopic examination of cracks.

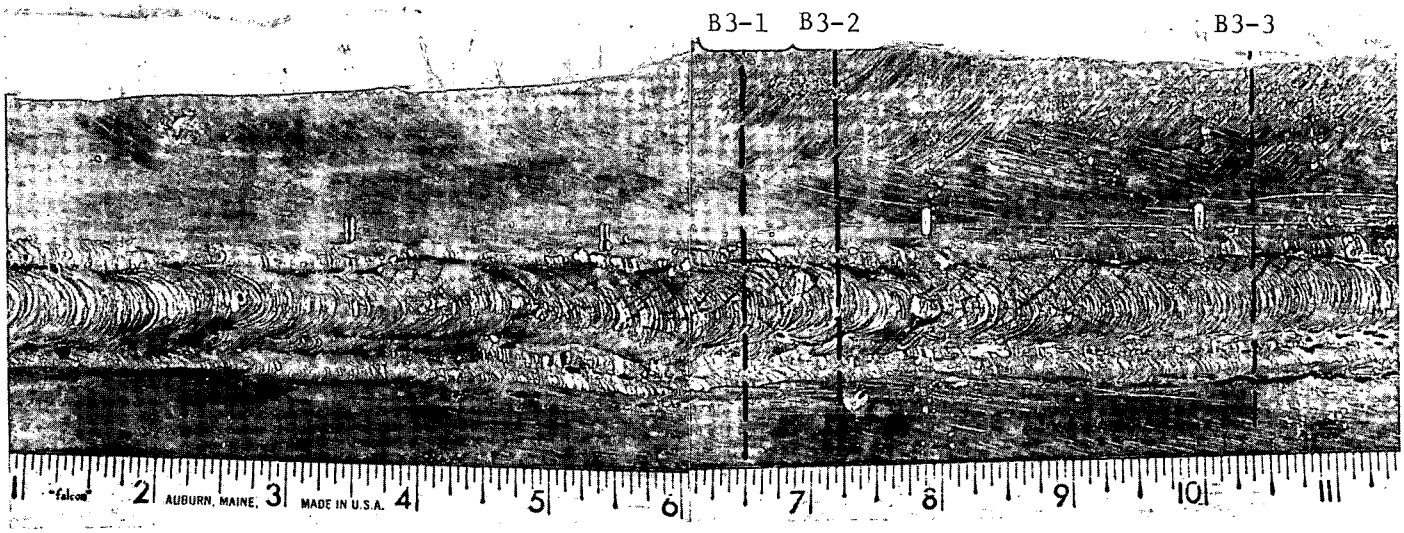
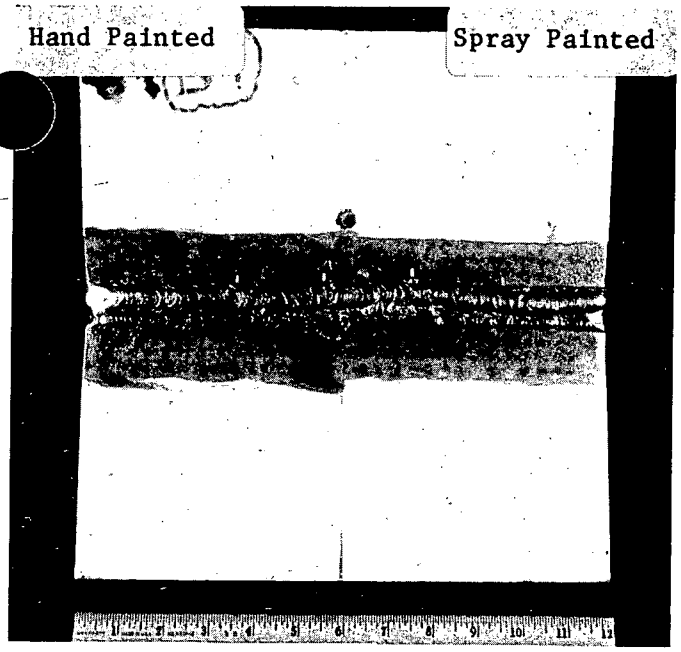


Figure 3 - Weld Plate "B3," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant, M86-86-0282.



As-received photograph of weld plate (left) and closeup view showing cracks revealed by magnetic particle testing (below). Closeup view shows areas where weld was sectioned for microscopic examination of cracks.

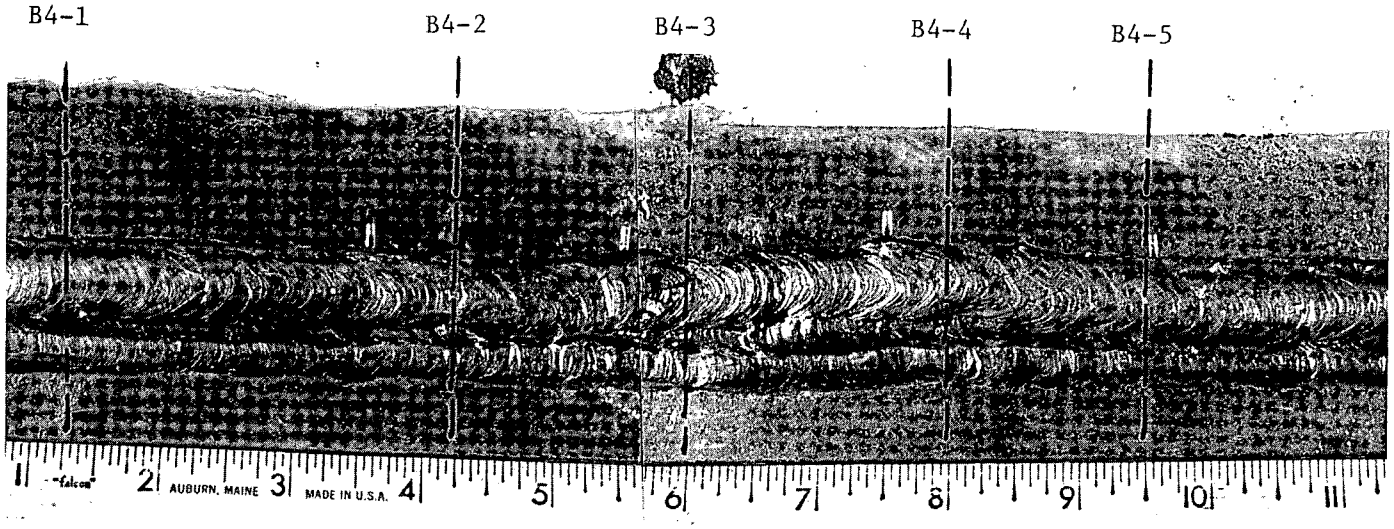
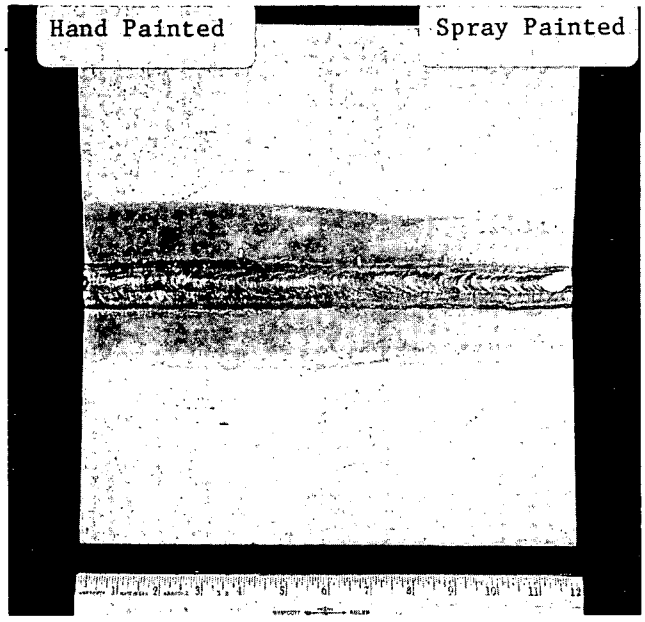


Figure 4 - Weld Plate "B4," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant, M86-86-0282.



As-received photograph of weld plate (left) and closeup view showing cracks revealed by magnetic particle testing (below). Closeup view shows areas where weld was sectioned for microscopic examination of cracks.

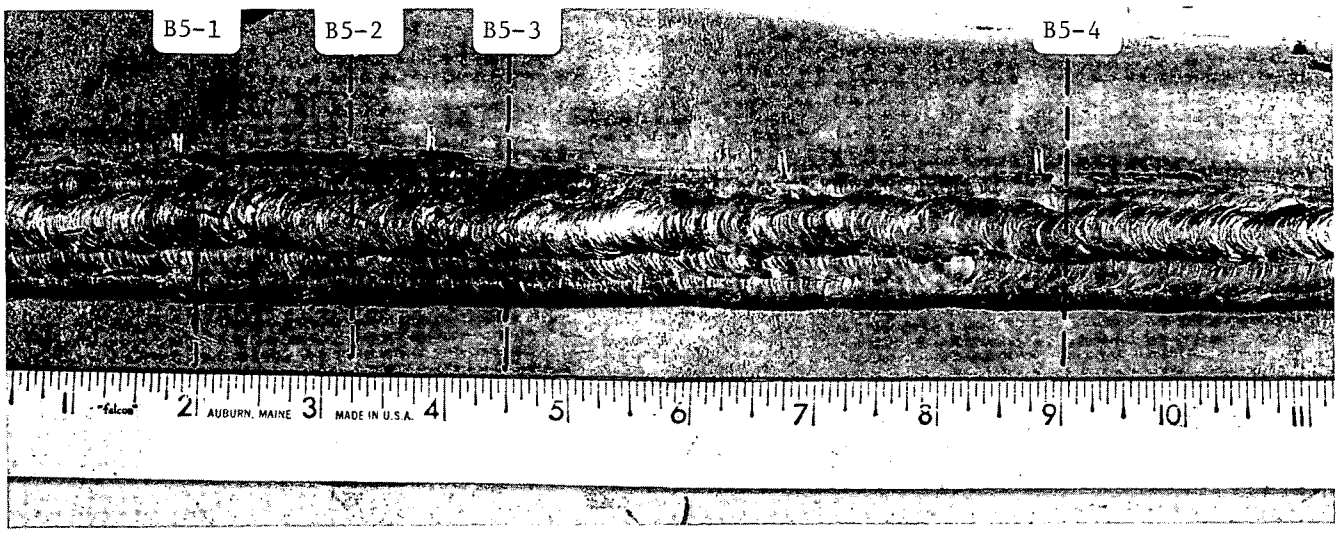
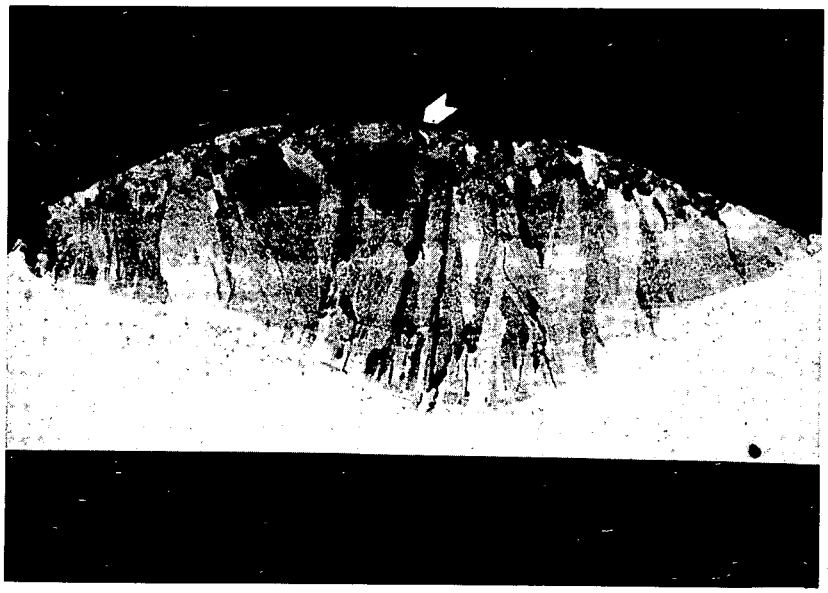


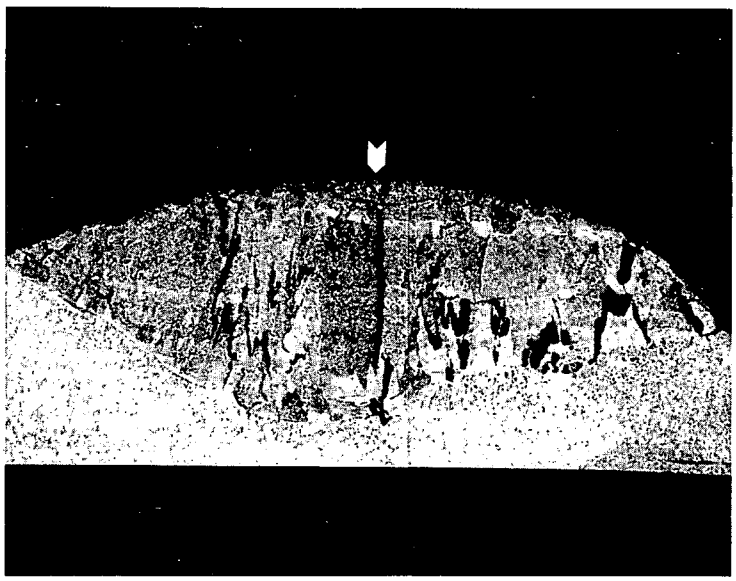
Figure 5 - Weld Plate "B5," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant, M86-86-0282.



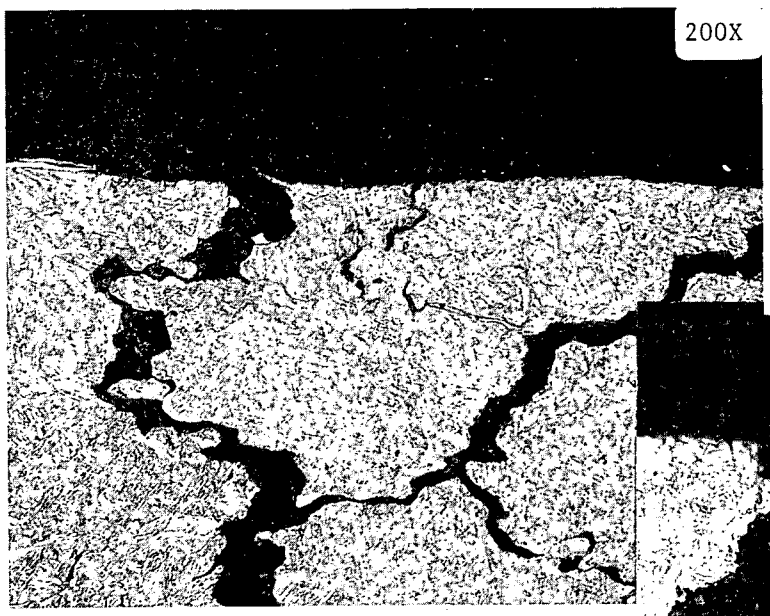
Macrograph of weld cracking, arrow indicates area where crack measurements were made (∿7X).

Micrograph of the cracking at the weld surface showing shallow disturbed layer (200X).

Figure 6 - Weld Area "B1-1," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant - M86-86-0282.



Macrograph of weld cracking, arrow indicates area where crack measurements were made (∿7X).



Micrographs of the cracking at the weld surface showing shallow disturbed layer.

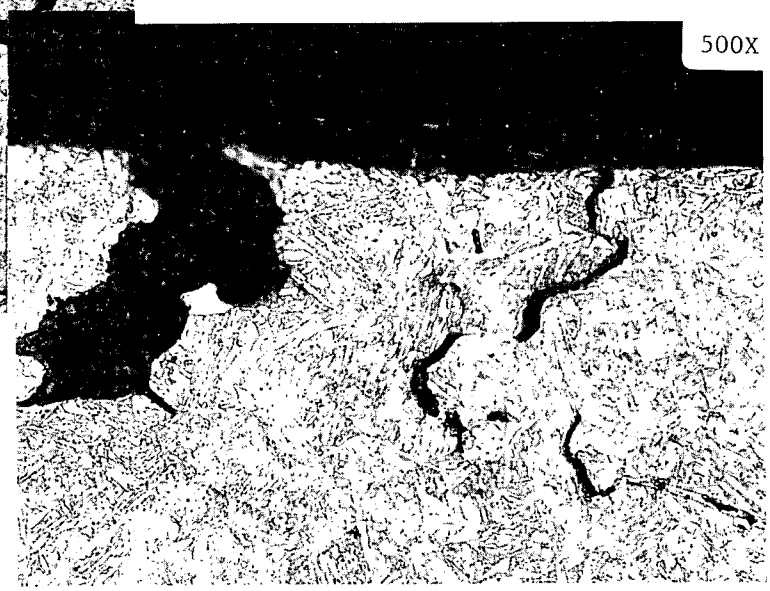
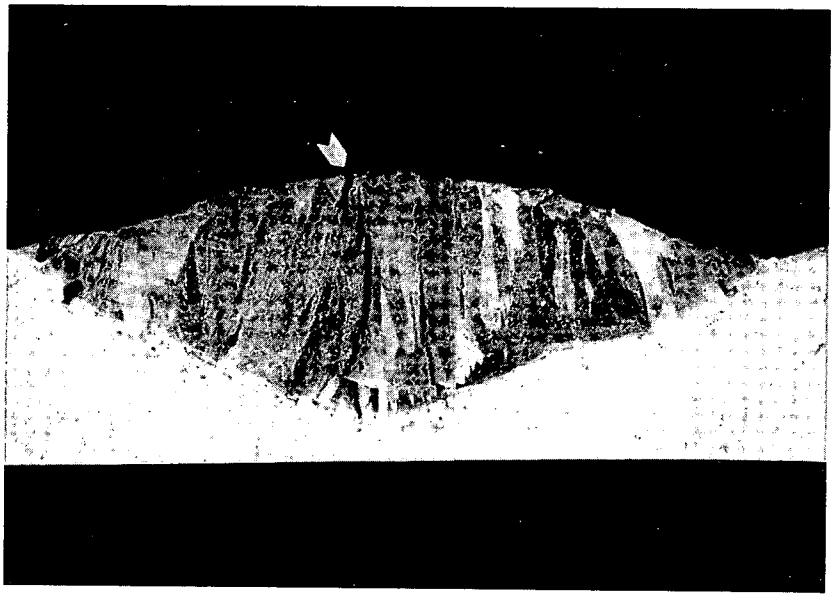
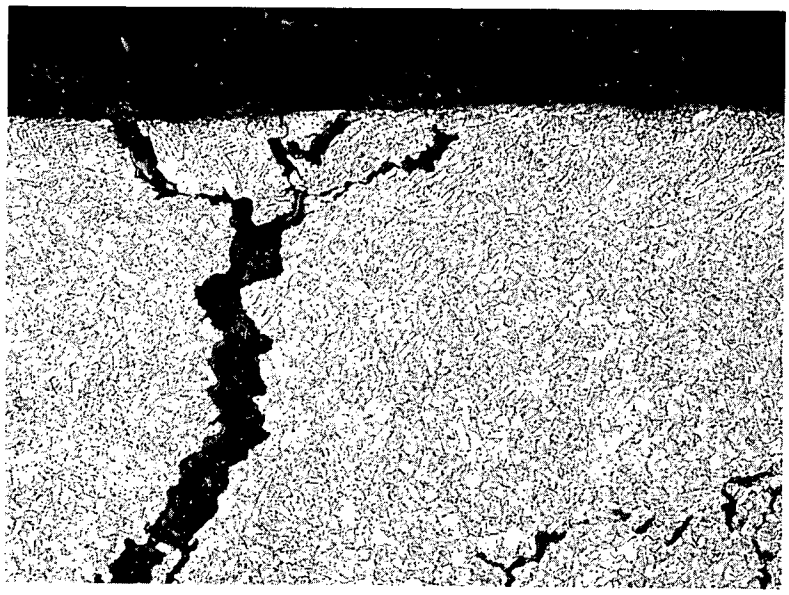


Figure 7 - Weld Area "B1-3," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant - M86-86-0282.

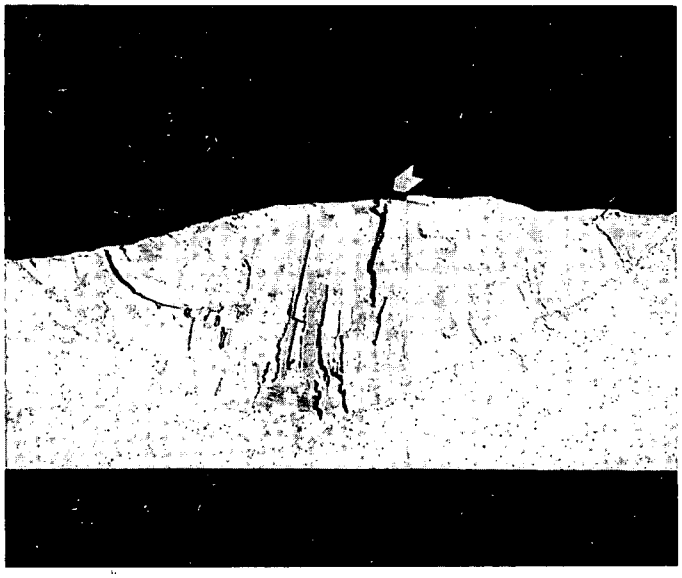


Macrograph of weld cracking, arrow indicates area where crack measurements were made (∿7X).

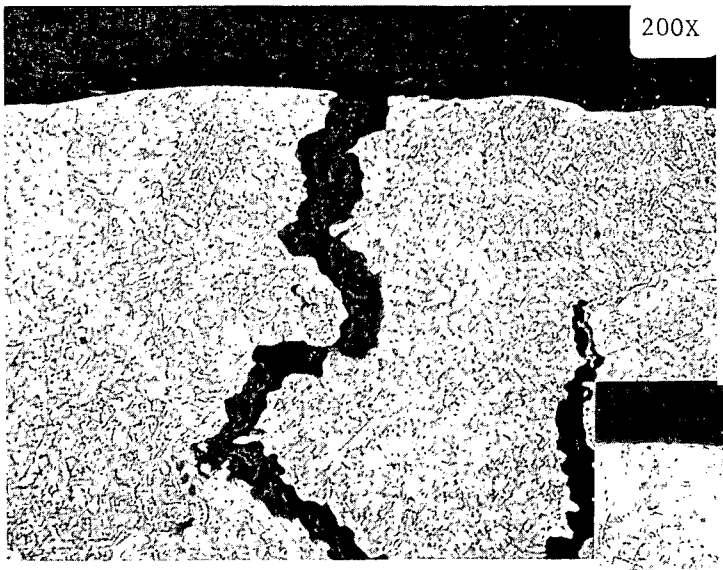


Micrograph of the cracking at the weld surface showing shallow disturbed layer (200X).

Figure 8 - Weld Area "B2-1," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant - M86-86-0282.

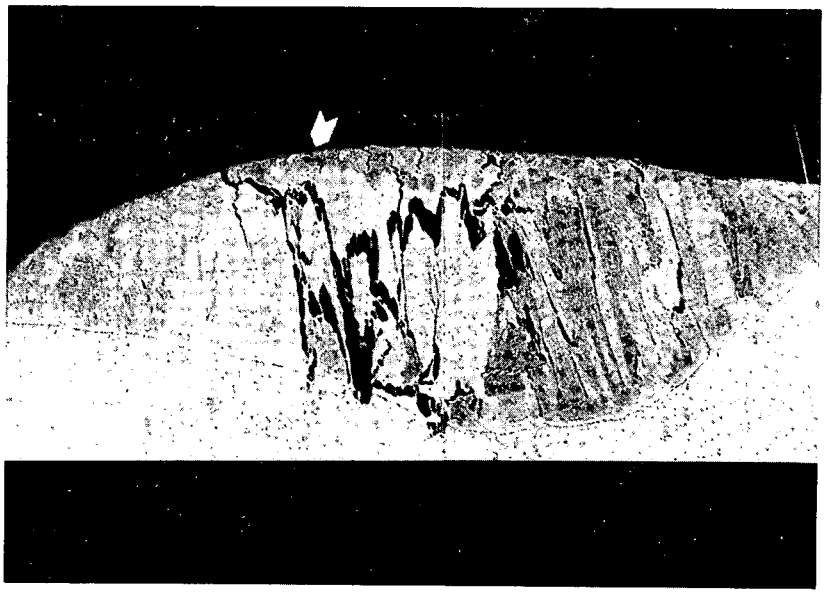


Macrograph of weld cracking, arrow indicates area where crack measurements were taken (∿7X).



Micrographs of the cracking at the weld surface showing shallow disturbed layer.

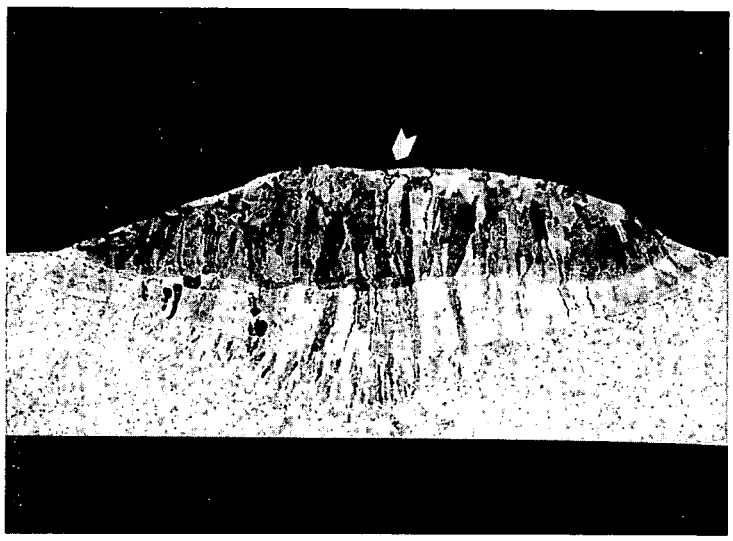
Figure 9 - Weld Area "B2-3," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant - M86-86-0282.



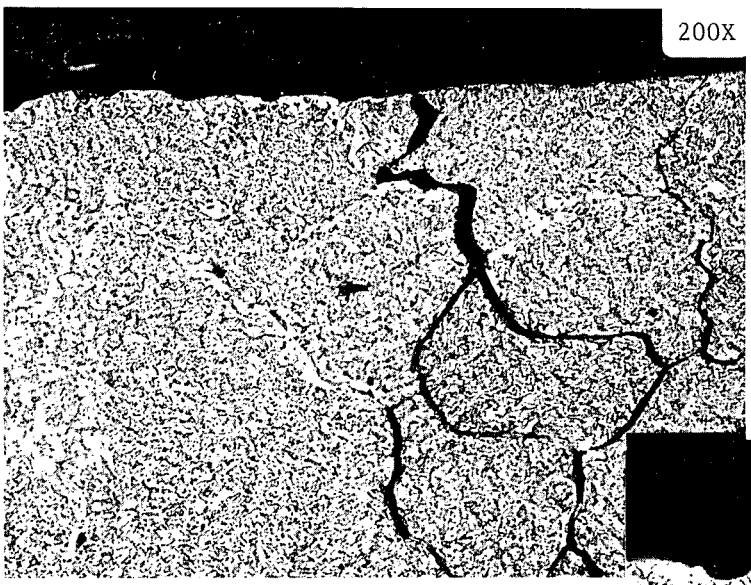
Macrograph of weld cracking, arrow indicates area where crack measurements were made (∿7X).

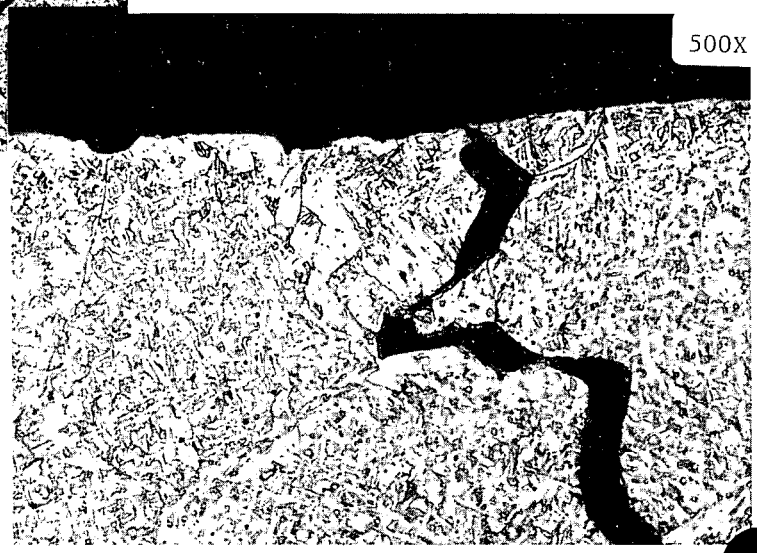
Micrograph of the cracking at the weld surface showing shallow disturbed layer (200X).

Figure 10 - Weld Area "B3-1," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant - M86-86-0282.



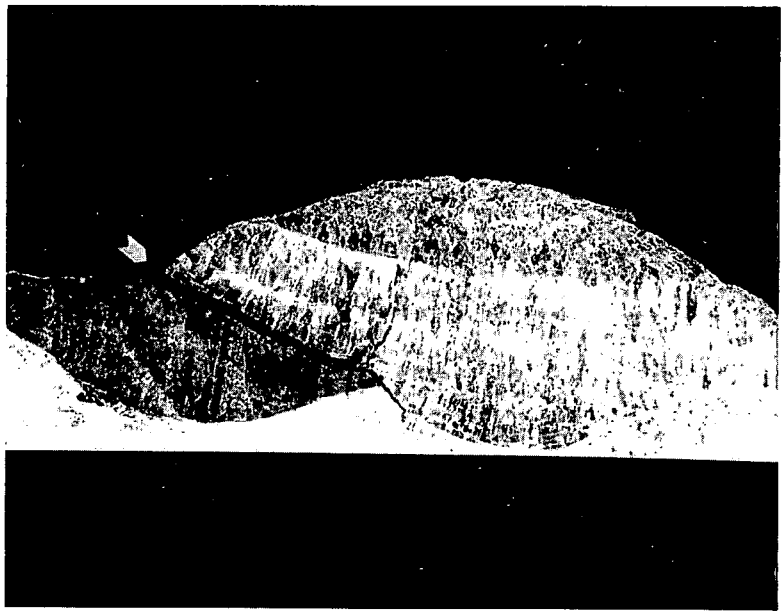
Macrograph of weld cracking, arrow indicates area where crack measurements were made (∿7X).



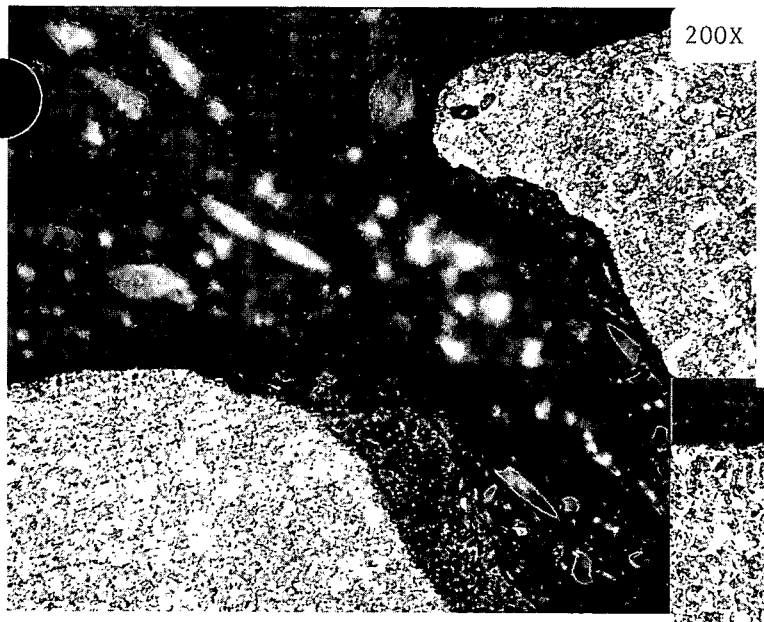


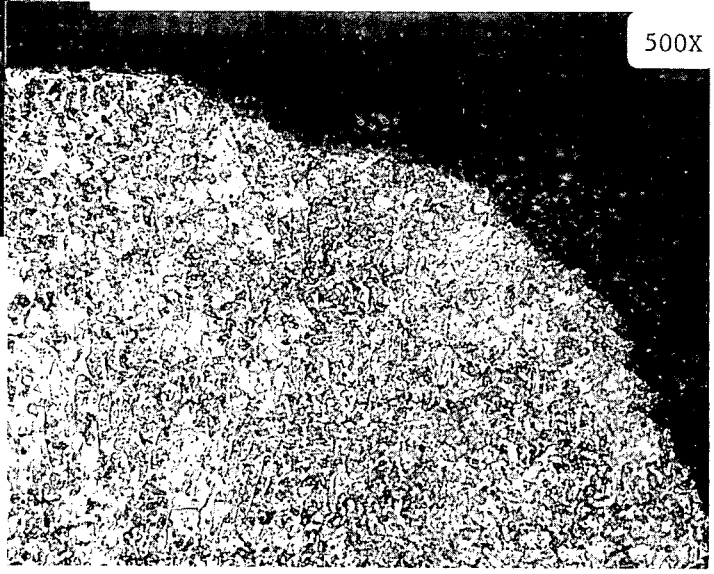
Micrographs of the cracking at the weld surface showing shallow disturbed layer.

Figure 11 - Weld Area "B3-2," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant - M86-86-0282.



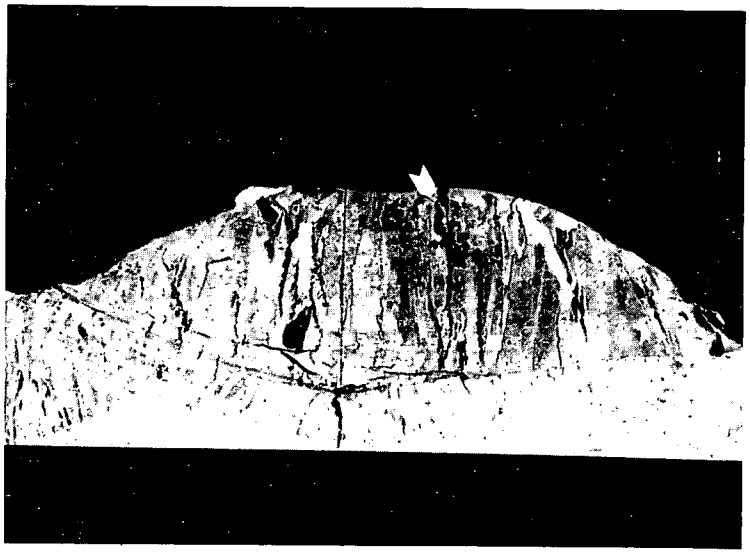
Macrograph of the weld cracking, arrow indicates area where crack measurements were made (∿7X).



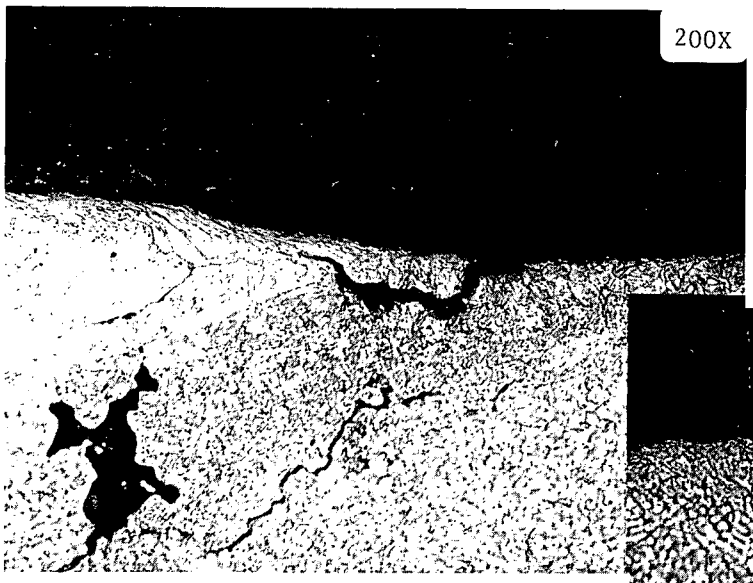


Micrographs of the cracking at the weld surface showing shallow disturbed layer.

Figure 12 - Weld Area "B4-1," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant - M86-86-0282.

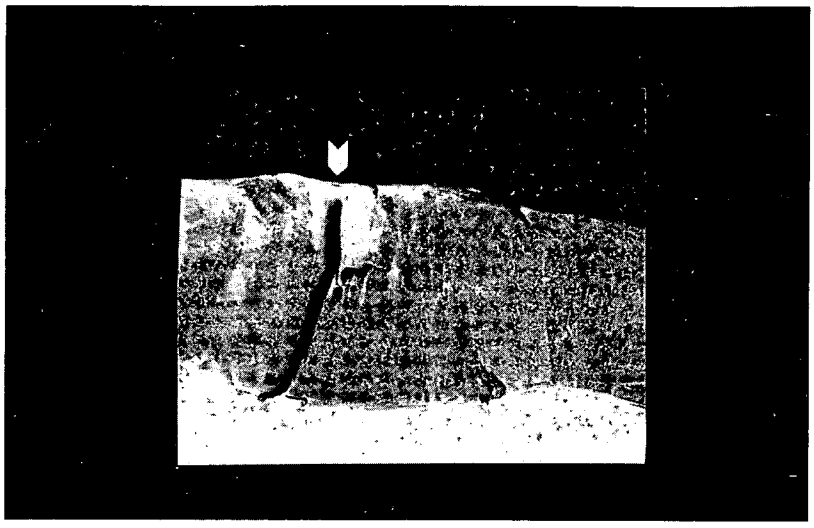


Macrograph of weld cracking, arrow indicates area where crack measurements were made (∿7X).

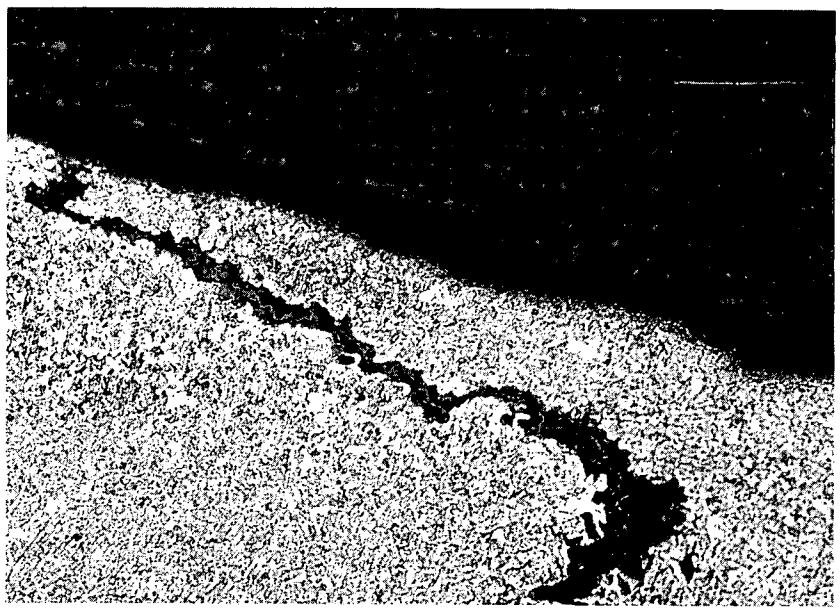


Micrographs of the cracking at the weld surface showing shallow disturbed layer.

Figure 13 - Weld Area "B4-3," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant - M86-86-0282.

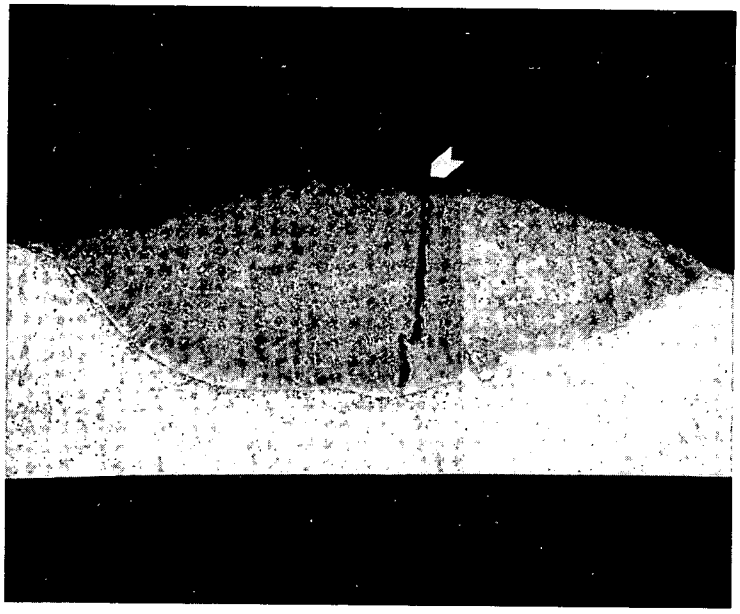


Macrograph of weld cracking, arrow indicates area where crack measurements were made (∿7X).

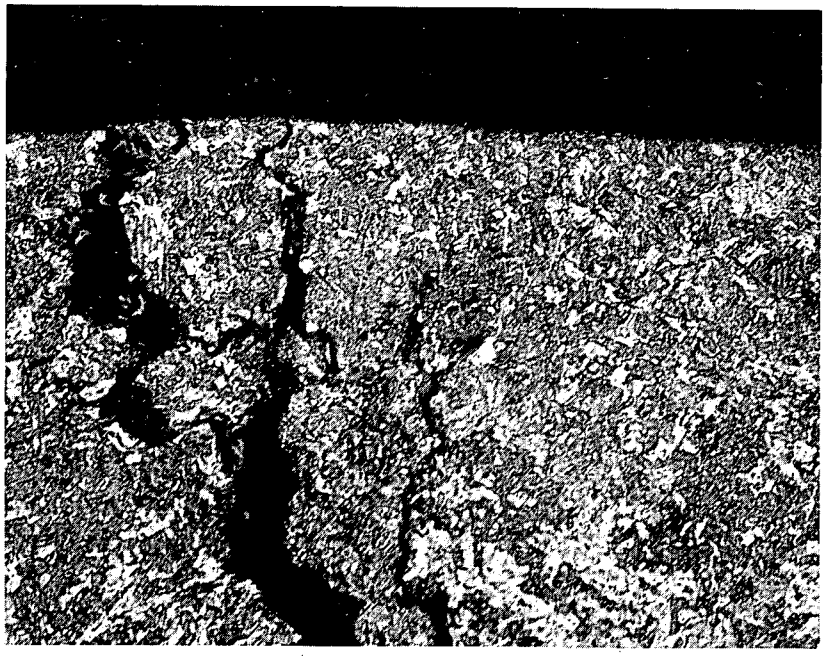


Micrograph of the cracking showing shallow disturbed layer (200X).

Figure 14 - Weld Area "B4-5," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant - M86-86-0282.

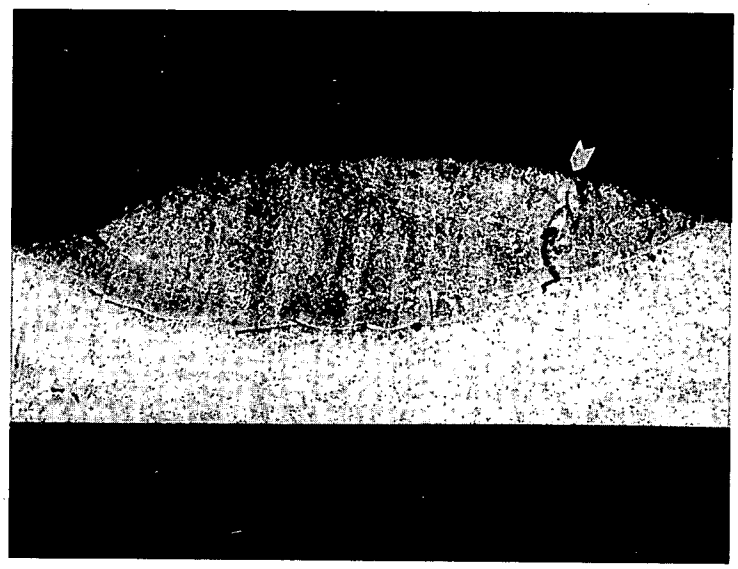


Macrograph of weld cracking, arrow indicates area where crack measurements were made (∿7X).

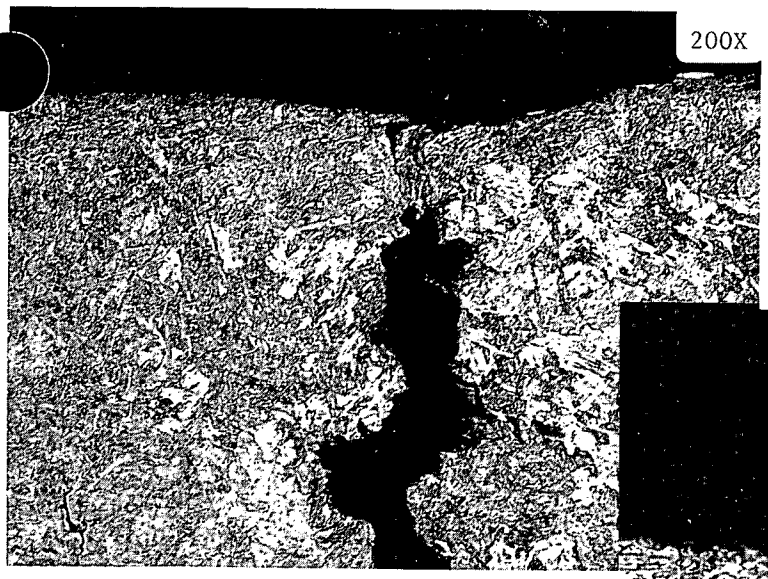


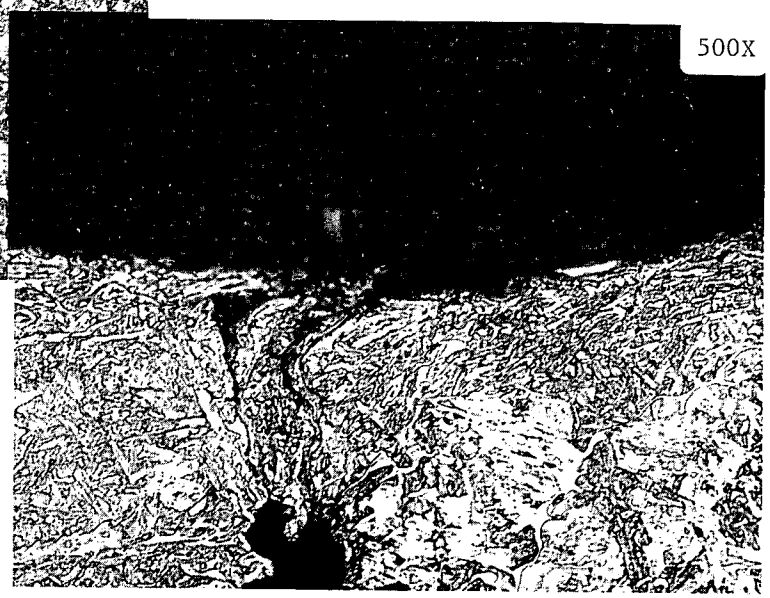
Micrograph of the cracking at the weld surface showing shallow disturbed layer (200X).

Figure 15 - Weld Area "B5-1," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant - M86-86-0282.



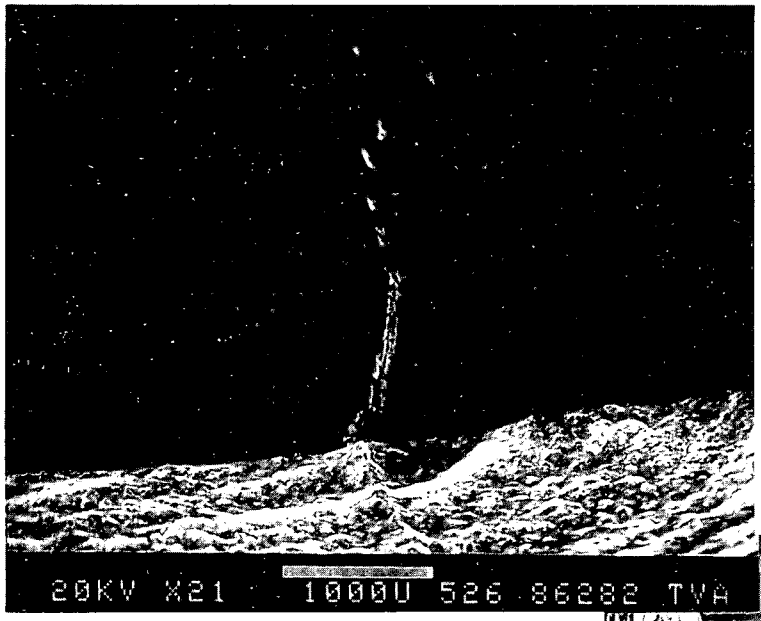
Macrograph of weld cracking,arrow indicates area where crack measurements were made (∿7X).





Micrographs of the cracking at the weld surface showing shallow disturbed layer.

Figure 16 - Weld Area "B5-4," Weld Cracking Evaluation Project, Watts Bar Nuclear Plant - M86-86-0282.



Scanning electron micrographs showing large crack in sample B4-5 cross section.

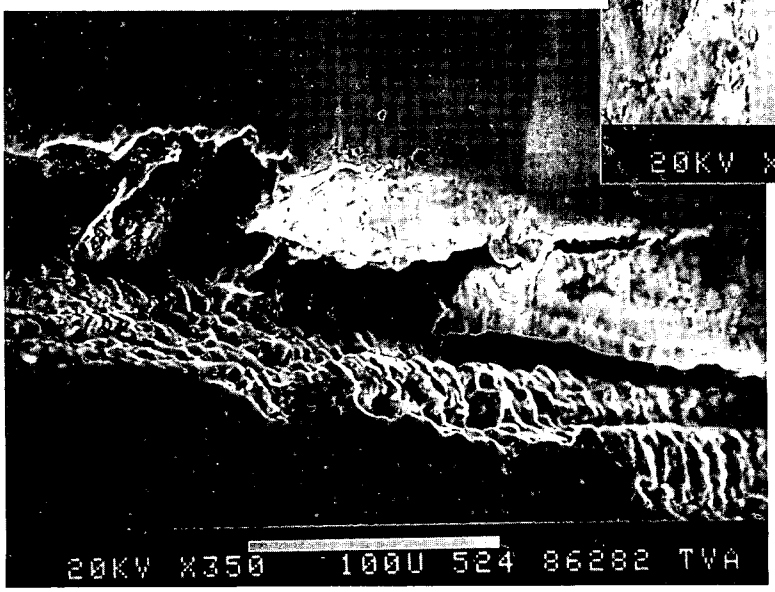
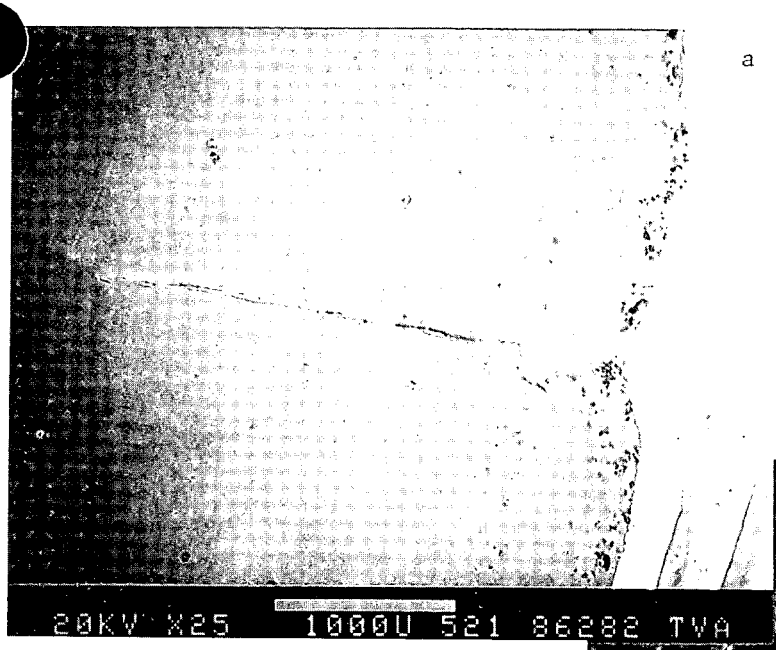
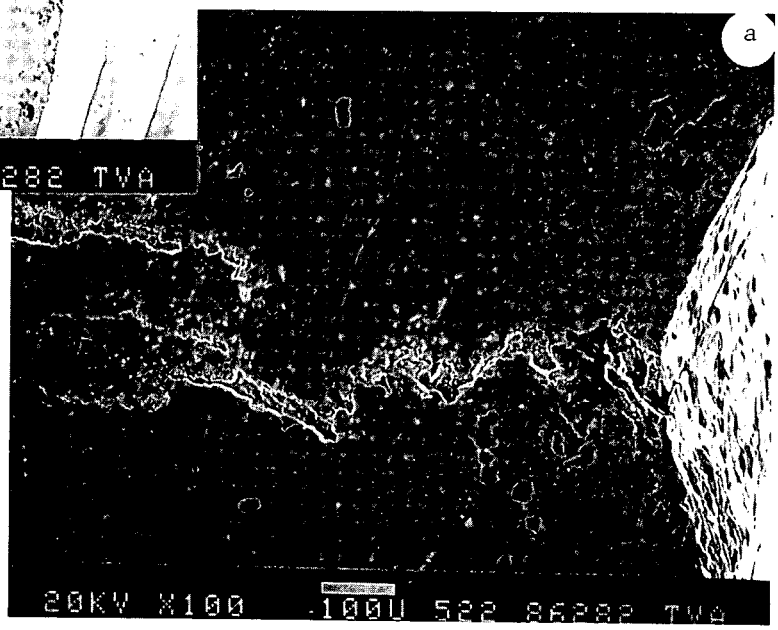


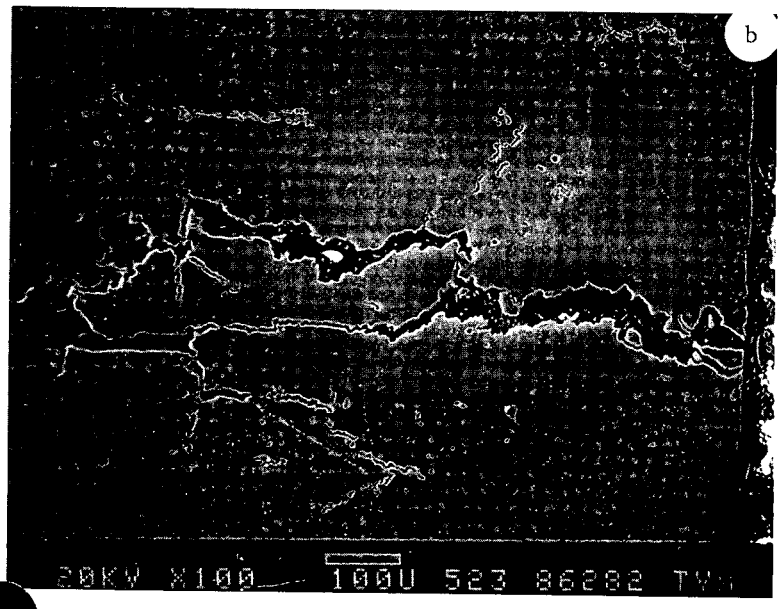
Figure 17 - Scanning Electron Micrographs, Weld Cracking Evaluation Project, Watts Bar Nuclear Plant - M86-86-0282.



a

a. Scanning electron micrographs of large crack in sample B5-1.





b. Scanning electron micrograph (at left) of sample B4-3 showing evidence of deposits in crack, which appear to be welding flux rather than paint.

Figure 18 - Scanning Electron Micrographs, Weld Cracking Evaluation Project, Watts Bar Nuclear Plant - M86-86-0282.

APPENDIX A

APPLICABLE DOE WELD EVALUATION PROJECT STANDARD PRACTICES

APPENDIX A

APPLICABLE DOE WELD EVALUATION PROJECT STANDARD PRACTICES

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EG&G Idaho, Inc. STANDARD PRACTICE DOE Weld Evaluation Project	Title: VISUAL EXAMINATION METHODS AND ACCEPTANCE CRITERIA	No.: WEP 3.2.3 Rev 13 Page 1 of 23 Date: 06/02/87
	Approved:	REVISIONS: Vertical line, right margin
Reviewed By:		See DRR 686

1. PURPOSE AND SCOPE

1.1 To establish Visual Testing (VT) Methods and Acceptance Criteria for the examination of welds and acquire other pertinent data at Watts Bar Plant Unit 1, Department of Energy Weld Evaluation Project.

1.2 This procedure incorporates, the VT requirements specified in the ASME Section III Division 1, ASME Section VIII Divisions 1 and 2, ANSI B31.1, ANSI B31.5, AWS D1.1, and NCIG-01 (References 4.1 through 4.6).

2. RESPONSIBILITY AND PRACTICE

2.1 The Inspection/Examination (I/E) Manager shall be responsible for compliance with this procedure.

The Level III shall be responsible for the content of this procedure and subsequent revisions.

The designated Supervisor shall be responsible to ensure that only certified personnel perform examinations to this procedure.

Personnel performing examinations to this procedure shall be certified to the requirements of Standard Practice (SP) WEP 4.1.2, and shall perform the required examinations in accordance with this procedure. This procedure shall be present during the performance of an examination.

2.2 Examination Requirement

2.2.1 Direct visual examination may usually be made when access is sufficient to place the eye within 24 inches of the surface to be examined, at an angle of not less than 30° with the surface to be examined.

2.2.2 The area under immediate examination shall be illuminated, if necessary, with a flashlight or other auxiliary lighting. Lighting shall be considered adequate when the inspector can resolve a black line 1/32 inch wide or less on an 18% neutral grey card placed on the surface being inspected.

2.2.3 Remote visual examinations may have to be substituted for direct examination in some cases. Remote visual examination may use visual aids such as mirrors, borescopes, fiber optics, cameras, or other suitable instruments. Such systems shall have a resolution capability at least equivalent to that obtainable by direct visual observation.

2.2.4 During the performance of visual examinations, the inspector shall use the appropriate examination tools.

2.2.5 A UT thickness measurement shall be taken in accordance with SP WEP 3.2.8 when the inspector deems it necessary to determine actual material thickness and other mechanical means of inspection are impractical.

2.2.6 Refer to SP WEP 3.2.16, Reference 4.11, for confirmation of cracks, arc strikes with indeterminate depth, nonrelevant indications, and, evaluation/removal of slag.

2.2.7 Inspection through paint may be performed per the Examination Package requirements. Visual Examination shall be limited to: weld size, weld profile, and weld length and location. Examination attributes related to weld quality shall be N/A'd.

2.3 Acceptance Criteria

For determination of the appropriate acceptance criteria, the inspectors shall use the acceptance criteria referenced in the examination package, which was developed according to SP WEP 3.1.8.

Appendix E, Relevant Data, shall be used for Inspector Observations only, and is not considered part of the examination.

2.4 Documentation

2.4.1 Process variables and results of the examination shall be documented on the applicable documents as defined in SP WEPs 3.1.8 and 3.2.2.

2.4.2 Attachments 1 (Form WEP 302), 2 (Form WEP 303), 3 (Form WEP 305) and/or 4 (Form WEP 328) shall be used to document examination results, as appropriate for the specific acceptance criteria.

2.4.3 As required, other relevant data shall be documented on the appropriate Weld Evaluation Project (WEP) visual forms.

3. DEFINITIONS

3.1 Inspector Observation--Specific observations which have been requested from the inspector.

4. REFERENCES

4.1 American Society of Mechanical Engineers (ASME), Nuclear Power Plant Components, Section III-Division 1, Boiler and Pressure Vessel Code, 1971 Edition through Summer 1973 Addenda.

4.2 American Society of Mechanical Engineers (ASME), Section VIII, Pressure Vessels, Divisions 1 and 2, 1971 Edition with Summer 1973 Addenda through the 1974 Edition with Summmer 1976 Addenda.

4.3 ANSI B31.1, Power Piping, American National Standard Institute Code for Pressure Piping, 1973 through Winter 1973.

4.4 ANSI B31.5-1966 (USASI B31.5-1966), Refrigeration Piping, USA Standard Code for Pressure Piping, Published by American Society of Mechanical Engineers, 1966.

4.5 AWS D1.1, Structural Welding Code, American Welding Society, Inc., 1972 through 1974 Addenda as modified by TVA Specification G29.

4.6 Visual Weld Acceptance Criteria for Structural Welding at Nuclear Power Plants, NCIG-01, May 1985, Revision 2.

4.7 Standard Practice WEP 4.1.2, "Training, Qualifying, and Certifying Personnel for Visual and Nondestructive Examinations."

4.8 Standard Practice WEP 3.1.8, "Preparation of the Examination Package."

4.9 Standard Practice WEP 3.2.2, "Reporting Deviations to TVA."

4.10 Standard Practice WEP 3.2.8, "Ultrasonic Thickness Measurement."

4.11 Standard Practice WEP 3.2.16, "Surface Conditions and Characterizing Weld/Hadware Discrepancies."

ATTACHMENT 1

Form WEP 302
Rev. 8/86a

VISUAL EXAMINATION RECORD FOR ASME/ANSI WELDS

Page __ of __

Examination Package No: _____
Component Identification No: _____

Reference Document:
Standard Practice No. _____
Revision Date _____

Attribute	Acceptance Criteria	Accept/ Reject
Cracks	1.1	
Overlap	1.1	
Undercut	1.1	
Lack of Fusion	1.1	
Incomplete Penetration	1.1	
Slag	1.1	
Visible Porosity	1.1	
Weld Spatter	1.1	
Arc Strikes	1.1	

Attribute	Acceptance Criteria	Accept/ Reject
Coarse Ripples	2.1	
Grooves	2.1	
Abrupt Ridges	2.1	
Valleys	2.1	
Minimum Section Thickness	2.2	
Taper	2.3	
Maximum Offset	3.1	
Reinforcement	4.1 4.2 4.3 4.4	
Fillet/Socket Weld Size	5.1 5.2	

Refer to indicated paragraph(s) of Standard Practice 3.2.3, Appendix A for acceptance criteria.

Relevant Data		
Inaccessible	See Appendix E	

Reviewed and Approved by: _____ I/E Supervisor _____ Date

ATTACHMENT 2

Form WEP 303
Rev. 8/86a

VISUAL EXAMINATION RECORD FOR AWS D1.1 WELDS
IN CATEGORY I STRUCTURES

Page __ of __

Examination Package No: _____

Component Identification No: _____

Reference Document:
Standard Practice No. _____
Revision Date _____

1986 SVS Used Yes ____ No ____		Accept/Reject				
Attribute	Acceptance Criteria	Weld No.	Weld No.	Weld No.	Weld No.	Weld No.
Cracks						
Lack of Fusion						
Craters						
Undercut						
Porosity						
Fillet Weld Profiles						
Undersize Welds						
Oversize Welds						
Reinforcement						
Overlap						
Piping Porosity						
Material Thickness						
Arc Strikes and Weld Spatter						
Relevent Data						
Inaccessible	See Appendix E					

Refer to indicated paragraph(s) of Standard Practice 3.2.3, Appendix B for acceptance criteria.

Reviewed and Approved by: _____ _____
I/E Supervisor Date

ATTACHMENT 3

Form WEP 305
Rev. 8/86a

VISUAL EXAMINATION RECORD FOR NCIG-01 WELDS

Page __ of __

Examination Package No: _____
Component Identification No: _____

Reference Document:
Standard Practice No. _____
Revision Date _____

1986 SVS USED Yes __ No __		Accept/Reject				
Attribute	Acceptance Criteria	Weld No.	Weld No.	Weld No.	Weld No.	Weld No.
Cracks	1.2.2.1					
Weld Size	1.2.2.2					
Incomplete Fusion	1.2.2.3					
Overlap	1.2.2.4					
Underfilled Craters	1.2.2.5					
Weld Profiles	1.2.2.6					
Undercut	1.2.2.7					
Porosity	1.2.2.8					
Weld Length and Location	1.2.2.9					
Arc Strikes	1.2.2.10					
Surface Slag and Weld Spatter	1.2.2.11					
Relevant Data						
Missing Welds	See App. E					
Missing Welds Due to Configuration	See App. E					
Inaccessible	See App. E					
Weld Type	See App. E					

NDE Required Yes _____ No _____

Welders ID: _____

Refer to indicated paragraph(s) of Standard Practice 3.2.3, Appendix C for acceptance criteria.

Reviewed and Approved by: _____ _____
I/E Supervisor Date

ATTACHMENT 4

WEP Form 328
Rev. 8/86a

Page __ of __

VISUAL EXAMINATION RECORD FOR THREADED STUD WELDS

Examination Package No: _____ Reference Document: _____
Component Identification No: _____ Standard Practice No: _____
Revision Date _____

Attribute	Acceptance Criteria	Accept/Reject			
		Weld Number	Weld Number	Weld Number	Weld Number
360° Flash	1.1				
*Inaccessible	See App. E				
		Weld Number	Weld Number	Weld Number	Weld Number
360° Flash	1.1				
*Inaccessible	See App. E				
		Weld Number	Weld Number	Weld Number	Weld Number
360° Flash	1.1				
*Inaccessible	See App. E				
		Weld Number	Weld Number	Weld Number	Weld Number
360° Flash	1.1				
*Inaccessible	See App. E				

Refer to indicated paragraph of Standard Practice 3.2.3 Appendix D for acceptance criteria.

* Relevant Data

Reviewed and Approved by: _____ I/E Supervisor _____ Date

APPENDIX A

ASME SECTION III, DIVISION 1
ASME SECTION VIII, DIVISIONS 1 AND 2
ANSI B31.1 AND B31.5 PIPING WELD ACCEPTANCE CRITERIA

All welds requiring visual examination shall be examined for the following items

- o Weld defects (cracks, porosity, slag, etc.)
- o Contour and finish of the weld surface
- o Offset in final welded joints
- o Reinforcement
- o Leg and throat size for fillets.

1. <u>Weld Defects</u>

1.1 All welds and adjacent base material shall be free of cracks, undercut in excess of 1/32 inch (does not encroach on the required section thickness), lack of fusion, incomplete penetration (when full penetration is required), slag, visible porosity, weld spatter, and arc strikes. Overlap is unacceptable if subsequent NDE is required and the overlap condition may mask an unacceptable indication.

2. <u>Contour and Finish of the Weld Surface</u>

2.1 The surfaces of welds are sufficiently free from coarse ripples, grooves, abrupt ridges, and valleys to perform the required nondestructive examination without masking possible discontinuities.

2.2 <u>Pipe Welds</u>

The weld and adjacent surfaces shall be examined for minimum wall violations. Minimum wall thickness shall not be less than nominal minus 12.5%.

<u>All Other Welds</u>

The minimum wall thickness shall be as specified in the Examination Package.

EXCEPTIONS: The following components are not classified as pressure vessels. There is no minimum design section thickness. There shall be no punctures or ground areas that penetrate the full thickness of the material.

- o Reactor well
- o Spent fuel pool
- o Transfer canal
- o Fuel cast area

2.3 When components of different outside diameters, offset ends, or of different thicknesses are welded together, there shall be a gradual transition between the two surfaces. The length of the transition may include the weld. The slope of the transition shall have a length-to-offset ratio of not less than 3 to 1.

3. Maximum Allowable Offset in Double Welded Joints

3.1 The maximum offset of the finished weld shall not be greater than the applicable amount listed in Table 1, where t is the nominal thickness of the thinner section of the joint.

TABLE 1. DIRECTION OF JOINTS

Section Thickness (inch)	Longitudinal[a,b]	Circumferential[c]
Up to 1/2, inclusive	1/4t	1/4t
Over 1/2 to 3/4, inclusive	1/8 inch	1/4t
Over 3/4 to 1-1/2, inclusive	1/8 inch	3/16 inch
Over 1-1/2 to 2, inclusive	1/8 inch	1/8t
Over 2	Lesser of 1/16t or 3/8 inch	Lesser of 1/8t or 3/4 inch

a. This column also applies to joints in spherical vessels, heads, and joints between cylindrical shells and hemispherical heads.

b. In longitudinal joints, the middle lines of the adjoining thicknesses is in alignment within these tolerances.

c. This column applies to all welds made per the requirements of ASME Section III, Subsection CC, except that 1/4 inch is the maximum allowable offset.

4. Reinforcement

4.1 For double-welded butt joints, the reinforcement listed in column 1 of Table 2 shall apply separately to both inside and outside surfaces of the joint.

4.2 For single-welded butt joints, the reinforcement listed in column 2 of Table 2 shall apply to the inside surface and the reinforcement listed in column 1 shall apply to the outside surface. The reinforcement shall be measured from the higher of the abutting surfaces involved.

4.3 Weld sizes for branch connections and integral attachments shall be in accordance with the design drawings.

NOTE: Weld bevel preparation areas shall be completely consumed with weld metal unless otherwise specified by the design drawings.

4.4 Vessels, Pumps and Valves--The finished surface of welds may be flush with the base material or may have reasonably uniform crowns, the maximum on each side not to exceed the values in the appropriate column in Table 3.

TABLE 2. WELD REINFORCEMENT

Material Nominal Thickness (inch)	Maximum Reinforcement (inch)	
	Column 1	Column 2
Up to 1/8, inclusive	3/32	3/32
Over 1/8 to 3/16, inclusive	1/8	3/32
Over 3/16 to 1/2, inclusive	5/32	1/8
Over 1/2 to 1, inclusive	3/16	5/32
Over 1 to 2, inclusive	1/4	5/32
Over 2	Greater of 1/4 inch or 1/8 of weld width in inches	5/32

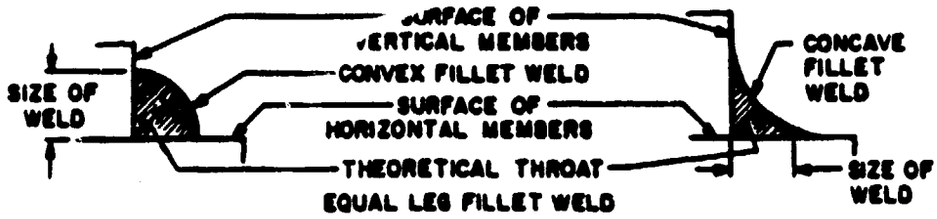
TABLE 3. WELD REINFORCEMENT

Nominal Thickness (inches)	Maximum Reinforcement (inches)		
	ASME III Division 2	ASME III Division 1	ASME I and VIII-1
Up to 1/2, inclusive	3/32	3/32	1/16
Over 1/2 to 1, inclusive	1/8	3/32	3/32
Over 1 to 2 , inclusive	3/16	1/8	1/8
Over 2 to 3, inclusive	--	5/32	5/32
Over 3 to 4, inclusive	--	7/32	5/32
Over 4 to 5, inclusive	--	1/4	5/32
Over 5	--	5/6	5/32

5. Leg and Throat Size for Fillets (Socket Welds)

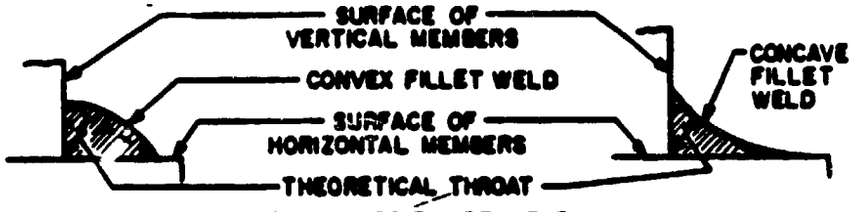
5.1 Fillet welds may vary from convex to concave provided that the size meets the minimum requirements of Figure 1A.

5.2 The fillet weld size for socket welds shall be as shown in Figure 2A.



EQUAL LEG FILLET WELD

NOTE: THE "SIZE" OF AN EQUAL LEG FILLET WELD IS THE LENGTH OF THE LARGEST INSCRIBED RIGHT ISOSCELES TRIANGLE. THEORETICAL THROAT = 0.7 x SIZE.

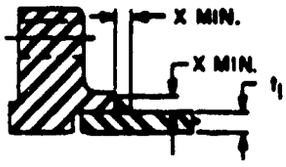


UNEQUAL LEG FILLET WELD

NOTE: FOR UNEQUAL LEG FILLET WELDS, THE SIZE OF THE WELD IS THE LEG LENGTHS OF THE LARGEST RIGHT TRIANGLE WHICH CAN BE INSCRIBED WITHIN THE FILLET WELD CROSS SECTION.

Figure 1A. Fillet weld dimensions.

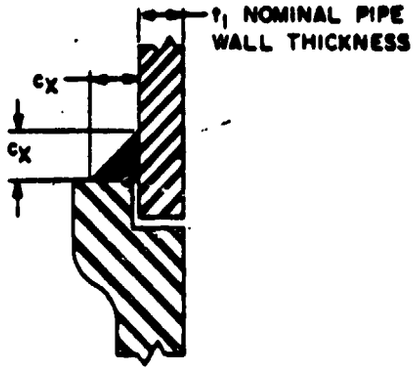
SIZE OF FILLET WELDS



SOCKET WELDING FLANGE

t_1 = NOMINAL PIPE WALL THICKNESS
X MIN. = 1.4 t_1 OR THICKNESS OF THE HUB, WHICHEVER IS SMALLER BUT NOT LESS THAN 1/8 in.

WELDING DETAILS FOR SOCKET-WELDING FLANGES



c_x MIN. = 1.09 t_1 BUT NOT LESS THAN 1/8 in.

(not permitted for connections over 2-inch nominal pipe size for Class 1 components)

Seal welds on threaded joints have all exposed threads removed entirely or the exposed threads are completely covered with weld.

Figure 2A. Fillet weld dimensions.

APPENDIX B

AWS D1.1 ACCEPTANCE CRITERIA FOR STRUCTURAL WELDS IN CATEGORY I STRUCTURES INCLUDING PIPE HANGERS, CABLE TRAY SUPPORTS, AND DUCT SUPPORTS

1. Acceptance Criteria

1.1 Welding Completed After February 13, 1981

Prior to examination, welds shall be preferably in the as-welded condition. All welds shall be free from slag, paint, rust or other extraneous material that may interfere with the examination process. A weld shall be acceptable by visual inspection if the inspection shows that:

1.1.1 The weld has no cracks.

1.1.2 Thorough fusion exists between adjacent layers of weld metal and base metal.

1.1.3 Craters are filled to the full cross-section of the weld.

1.1.4 Undercut does not exceed 1/32 inch.

1.1.5 The sum of the diameters of the piping porosity in fillet welds does not exceed 3/8 inch in any linear inch of weld and does not exceed 3/4 inch in any one-foot length of weld.

1.1.6 The face of fillet welds may be slightly convex, flat, or slightly concave. The convexity shall not exceed the value (0.1S + 0.06 inch) where S is the actual leg size of the fillet welds in inches. These requirements do not apply to outside or boxed corners.

1.1.7 A fillet weld in any single continuous weld shall be permitted to underrun the nominal fillet size required by 1/16 inch without correction, provided that the undersized portion of the weld does not exceed 10% of the length of the weld. On web-to-flange welds or girders, no underrun is permitted to the ends for a length equal to twice the width of the flange.

1.1.8 Fillet welds should be limited to 1/8 inch larger than the leg size specified. Maximum fillet weld size shall be 3/16 inch larger than specified.

1.1.9 Groove welds shall be made with slight or minimum reinforcement. Butt and corner joint reinforcement shall not exceed 1/8 inch in height and shall have a gradual transition to the adjacent base metal surface. The 1/8 inch maximum reinforcement does not apply to T

joints. The contour of T joints where reinforcing fillets are not required shall have a gradual transition into both members. Fillet weld criteria of Section 1.1.7 shall apply to reinforcing fillet welds required on T joints.

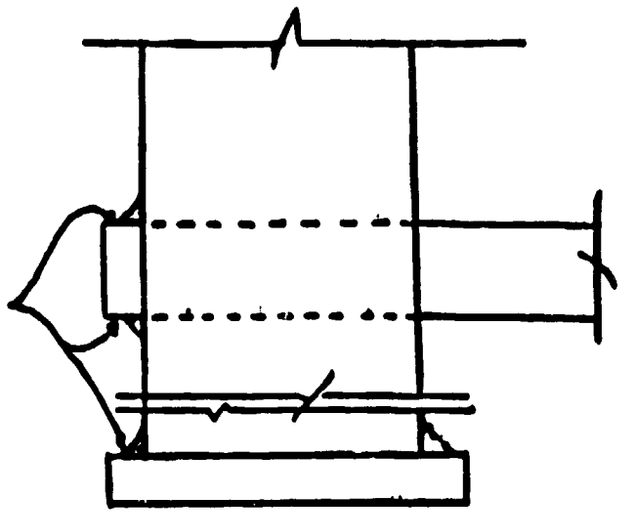
Flare bevel groove welds shall be welded out at least flush with the outside surface of the base material unless otherwise stated on the drawing.

1.1.10 All welds shall be free from overlap.

1.1.11 Complete joint penetration groove welds in butt joints shall have no piping porosity.

1.1.12 Undercut on nonstressed members as shown in Figure 1B, shall not be cause for rejection. Nonstressed members shall be specifically identified by OE.

1.1.13 Where mechanical means, such as grinding, burring, etc., were used for surface conditioning and/or corrective action to meet workmanship requirements, reduction of base material thickness will be additive to the amount of undercut. The total of the two conditions will be evaluated to the acceptance requirements for undercut.



Undercut at locations shown by arrows shall not be cause for rejection.

Figure 1B. Undercut on Nonstressed Members.

1.2 Welding Completed Prior to February 13, 1981

The requirements of Section 1.1 apply to work completed prior to February 13, 1981, except as follows:

1.2.1 Cable Tray Supports

a. Undercut on stressed members shall not exceed 1/32 inch in depth except that undercut of an additional 1/32 inch (1/16 inch total depth) and 1/4 inch length, not to exceed 10% of the run, is acceptable. All welds are to be considered in stressed members unless identified otherwise by OE.

b. Allowable minimum fillet weld sizes are shown on drawings revised under Watts Bar Nuclear ECN 2688.

c. Weld sizes specified to be 3/8 inch or less shall not be more than twice the specified size. Weld sizes specified to be greater than 3/8 inch shall not be more than 3/8 inch larger than the specified size.

d. Random weld spatter and arc strikes are acceptable if cleaned by wire brushing and are visually free of cracks.

1.2.2 Pipe Hangers

a. Weld sizes specified to be 3/8 inch or less shall not be more than twice the specified size. Weld sizes specified to be greater than 3/8 inch shall not be more than 3/8 inch larger than the specified size.

b. Random weld spatter and arc strikes are acceptable if cleaned by wire brushing and are visually free of cracks.

1.2.3 Duct Supports

a. Undercut on stressed members shall not exceed 1/32 inch in depth except that undercut of an additional 1/32 inch (1/16 inch total depth) and 1/4 inch length, not to exceed 10% of the run, is acceptable. All welds are to be considered in stressed members unless identified otherwise by OE.

b. A minimum permissible structural fillet weld size is 3/16 inch. Undersize of 1/16 inch is allowed for fillet welds over 3/16 inch in size.

c. Weld size specified to be 3/8 inch or less shall not be more than twice the specified size. Weld sizes specified to be greater than 3/8 inch shall not be more than 3/8 inch larger than the specified size.

d. Random weld spatter and arc strikes are acceptable if cleaned by wire brushing and are visually free of cracks.

1.2.4 Other Installed Work

a. Weld sizes specified to be 3/8 inch or less shall not be more than twice the specified size. Weld sizes specified to be greater than 3/8 inch shall not be more than 3/8 inch larger than the specified size.

b. Undercut on stressed members shall not exceed 1/32 inch in depth except that undercut of an additional 1/32 inch (1/16 inch total depth) and 1/4 inch length, not to exceed 10% of the run, is acceptable. All welds are to be considered in stress members unless identified other by OE.

c. Random weld spatter and arc strikes on stainless steel and carbon steel are acceptable if cleaned by wire brushing and are visually free of cracks. Weld spatter on all other materials shall be evaluated.[1]

1. G-29 Series, TVA Process Specification for Welding Heat Treating, Nondestructive Examination, and Allied Fabrication Operations, Section C.

APPENDIX C

NCIG-01 ACCEPTANCE CRITERIA

1. ACCEPTANCE CRITERIA

1.1 Measurement Units

Table 1 identifies the smallest measurement units the Inspector will use when inspecting the listed weld attributes. When measuring and recording dimensions of the weld attributes listed in Table 1, these dimensions shall be rounded off to the nearest significant unit.

TABLE 1. MEASUREMENT UNITS

Weld Attribute	Reference Section	Smallest Measurement Unit (Significant Unit--Inches)
Fillet Weld Size	1.2.2.2	1/16
Incomplete Fusion	1.2.2.3	1/8
Weld Overlap	1.2.2.4	1/8
Undercut Depth	1.2.2.7	1/32
Surface Porosity	1.2.2.8	1/16
Weld Length	1.2.2.9	1/8 or 1/4
Weld Location	1.2.2.9	1
Slag	1.2.2.11	1/4

1.2 Acceptance Criteria

1.2.1 These Acceptance Criteria are to be used for the acceptance inspection of welds in the uncoated condition.

1.2.2 A weld shall be acceptable by visual inspection, subject to the following:

1.2.2.1 Weld Cracks--The weld shall have no cracks.

1.2.2.2 Fillet Weld Size--A fillet weld shall be permitted to be less than the size specified by 1/16 inch for 1/4 the length of the weld. Oversized fillet welds shall be acceptable if the oversized weld does not interfere with mating parts.

1.2.2.3 Incomplete Fusion--In fillet welds, incomplete fusion of 3/8 inch in any 4-inch segment, and 1/4 inch in welds less than 4 inches long, is acceptable. For groove welds, incomplete fusion is not acceptable. For fillet and groove welds, rounded end conditions that occur in welding (starts and stops) shall not be considered indications of incomplete fusion and are irrelevant.

1.2.2.4 Weld Overlap--Overlap is acceptable provided the criteria for weld size and fusion can be satisfied. When fusion in the overlap length cannot be verified, an overlap length of 3/8 inch in any 4 inch segment, and 1/4 inch in welds less than 4 inches long, is acceptable.

1.2.2.5 Underfilled Craters--Underfilled craters shall be acceptable provided the criteria for weld size are met. Craters which occur outside the specified weld length are irrelevant provided there are no cracks.

1.2.2.6 Weld Profiles

1.2.2.6.1 The faces of fillet welds may be convex, flat, or concave, provided the criteria for weld size are met.

1.2.2.6.2 The faces of groove welds may be flat or convex.

1.2.2.6.3 Convexity of fillet and groove welds are not criteria for acceptance and need not be measured.

1.2.2.6.4 The thickness of groove welds is permitted to be a maximum of 1/32 inch less than the thinner member being joined.

1.2.2.6.5 Flare bevel grooved welds shall be welded out at least flush with the outside surfaces of the base material unless otherwise stated on the drawing with the exceptions provided in Paragraph 1.2.2.6.4.

1.2.2.7 Undercut

1.2.2.7.1 For material 3/8 inch and less nominal thickness, undercut depth of 1/32 inch on one side for the full length of the weld, or 1/32 inch on one side for 1/2 the length of the weld and 1/16 inch for 1/4 the length of the weld on the same side of the member, is acceptable. For members welded on both sides where undercut exists in the same plane of a member, the cumulative lengths of undercut shall be limited to the lengths of undercut allowed on one side. Melt-through that results in a hole in the base metal is unacceptable.

1.2.2.7.2 For materials greater than 3/8 inch nominal thickness, undercut depth of 1/32 inch for the full length of the weld and 1/16 inch for 1/4 the length of the weld on both sides of the member is acceptable. When either welds or undercut exist only on one side of the member or are not in the same plane, the allowable undercut depth of 1/32 inch may be increased to 1/16 inch for the full length of the weld.

1.2.2.8 Surface Porosity--Only surface porosity whose major surface dimension exceeds 1/16 inch shall be considered relevant. Fillet and groove welds which contain surface porosity shall be considered unacceptable if:

1.2.2.8.1 The sum of diameters of random porosity exceeds 3/8 inch in any linear inch of weld or 3/4 inch in any 12 inches of weld; or

1.2.2.8.2 Four or more pores are aligned and the pores are separated by 1/16 inch or less, edge to edge.

1.2.2.9 Weld Length and Location--The length and location of welds shall be as specified on the detail drawing, except that weld lengths may be longer than specified. For weld lengths less than 3 inches, the permissible underlength is 1/8 inch and for welds 3 inches and longer the permissible underlength is 1/4 inch. Intermittent welds shall be spaced within 1 inch of the specified location.

1.2.2.10 Arc Strikes--Arc strikes and associated blemishes are acceptable provided no cracking is visually detected.

1.2.2.11 Surface Slag and Weld Spatter--Slag whose major surface dimension is 1/8 inch or less is irrelevant. Isolated surface slag that remains after weld cleaning and which does not exceed 1/4 inch in its major surface dimension, is acceptable. (Slag is considered to be isolated when it does not occur more frequently than once per weld or more than once in a 3 inch weld segment.) Spatter remaining after the cleaning operation is acceptable.

APPENDIX D

VISUAL EXAMINATION OF AWS D1.1 THREADED STUD WELDS

1. Acceptance Criteria

1.1 All studs shall show a 360° Flash.[1]

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1. The expelled metal around the base of the stud is designated as flash. It is not a fillet weld such as those formed by conventional arc welding. The expelled weld metal, which is excess to the weld required for strength, is not detrimental but, is essential to provide a good weld. The stud weld flash may have none fusion on its vertical leg and overlap on its horizontal leg; and it may contain occasional small shrink fissures or discontinuities that usually form at the top of the weld flash with essentially radial or longitudinal orientation, or both, to the axis of the stud. These types of discontinuities are acceptable.

APPENDIX E

RELEVANT DATA

Relevant Data	Description	Documentation
Missing Weld[1]	Welds missing in their entirety and not a result of configuartion.	Form WEP 305[1]
Welds Missing Because of Configuration[1]	Welds missing in their enitrety because of configuration.	Form WEP 305[1]
Weld Type[1]	Weld type is not the same as called out on the design drawing or as modified by the design notes.	Form WEP 305[1]
Inaccessible[2]	When welds or portions of welds are inaccessible because of configuration.	Form WEP 302[2] Form WEP 303[2] Form WEP 305[2] Form WEP 328[2]

1. A Deviation Report (DR) shall be generated in accordance with Standard Practice 3.2.2 when this type of condition exists. The DR number shall be indicated in the appropriate block of the applicable form. If no DR is generated, N/A the block.

2. Inaccessible welds shall be processed in accordance with Standard Practice 3.2.10. The DR number shall be indicated in the "Accessible" block on the appropriate form. If no DR is generated, N/A the block.

1. PURPOSE AND SCOPE

1.1 This procedure defines the requirements for solvent removable penetrant examination of ASME Section III, Division 1, ASME Section VIII Divisions 1 and 2, ANSI B31.1, and AWS D1.1 when required. (See References 4.1 through 4.4.)

1.2 This procedure and its applicable Appendices, when used with the Examination Packages developed according to Reference 4.5, shall constitute the written procedure. Controlled copies of each procedure shall be readily available to the nondestructive examination personnel for their reference and use.

2. RESPONSIBILITY AND PRACTICE

2.1 Inspection/Examination

2.1.1 The Inspection/Examination (I/E) Manager shall be responsible for compliance with this procedure.

The Level III shall be responsible for the content of this procedure and subsequent revisions.

The designated Supervisor shall be responsible to assure that only certified personnel perform examinations to this procedure.

Personnel performing examinations to this procedure shall be certified to the requirements of Reference 4.6 and shall perform the required examination in accordance with this procedure. This procedure shall be present during the performance of an examination.

2.1.2 Perform required liquid penetrant (PT) examinations per the procedure details and acceptance criteria called out in the Examination Package, as developed according to Reference 4.5.

2.2 Descriptions of Method

Liquid penetrant examination is a nondestructive examination method that provides for detection of discontinuities, which are open to the surface of nonporous ferrous and nonferrous materials.

2.3 Method

2.3.1 A solvent removable color contrast penetrant shall only be used with this procedure.

2.3.2 Penetrant materials used in this procedure shall be analyzed for sulfur and halogen content not to exceed 1% by weight or 1000 ppm.

2.3.3 Certification of test results for each batch of penetrant material shall be obtained from the supplier.

2.4 Materials

2.4.1 Liquid penetrant materials to be used in accordance with this procedure shall be as follows:

a. Spotcheck Penetrant, type SKL-HF/S

b. Spotcheck Cleaner/Remover, type SKC-NF/ZC-7B

c. Spotcheck/Zyglo Developer, type SKD-NF/ZP-9B.

2.5 Process Requirements

2.5.1 Surfaces to be examined may be in the as-welded, as-rolled, as-cast, or as-forged condition.

2.5.2 Prior to PT examination, the surface to be examined and adjacent area within 1 inch shall be cleaned and free of any rust, scale, welding flux, spatter, grease, paint, oily film, dirt, or other extraneous material that could obscure openings or otherwise interfere with the examination.

2.5.3 The temperature of the penetrant materials and surfaces to be examined shall be between 40-125°F (4-52°C). Actual temperatures shall be taken by use of calibrated contact thermometers or calibrated pyrometers. The temperature, thermometer/pyrometer number and calibration date shall be recorded on the examination checklist.

2.5.4 Drying after cleaning of the surfaces to be examined shall be accomplished by normal evaporation. Drying time shall be a minimum of 5 minutes.

2.5.5 Application of Penetrant

Penetrant shall be applied by brushing or spraying including 1/2 inch on each side of the weld for ASME Section III, Class I butt welds and attachment welds. For all other welds, apply penetrant to the weld zone only. Keep all examination surfaces wetted for a minimum of 10 minutes not to exceed a maximum of 30 minutes, except for casting, which may be wetted for a minimum of 5 minutes not to exceed a maximum of 30 minutes.

2.5.6 Removal of Penetrant

Penetrant shall be removed by wiping with a lint-free cloth or absorbent paper, repeating the operation until most traces of penetrant have been removed. Then, lightly moisten with solvent/remover a lint-free cloth or absorbent paper and wipe the surfaces until all remaining traces of excess penetrant have been removed. Care shall be taken to minimize removal of penetrant from discontinuities with excess solvent/remover. Allow surfaces to dry for a minimum of 5 minutes and no more than 10 minutes.

2.5.7 Application of Developer

2.5.7.1 Prior to application of the developer, the solution shall be agitated to ensure dispersal of the particles in suspension.

2.5.7.2 The developer shall be applied by spraying a uniform thin coating over the entire surface being examined.

2.6 <u>Examination</u>

2.6.1 Observe the surfaces being examined during the application of the developer to detect the nature of any indications which tend to bleed out.

2.6.2 Final interpretation and evaluation of indications shall be made after a minimum of 7 minutes and within 30 minutes after application of the developer.

2.6.3 If the surface being examined is of sufficient area to preclude complete examination within the prescribed time, the area of interest shall be examined in suitable increments.

2.6.4 Adequate lighting shall be provided for easy observation of the indication; lighting may be considered adequate for evaluation of the test when the inspector can resolve a black line 1/32 inch wide or less on an 18% neutral gray card placed on the surface being inspected.

2.7 Nonrelevant Indications

2.7.1 Any indication which is believed to be nonrelevant shall be regarded as a defect and shall be reexamined to verify whether or not actual defects are present. In some cases surface conditioning may be required prior to reexamination. Nonrelevant indications and broad areas of pigmentation which would mask indications of defects are unacceptable.

2.8 Relevant Indications

2.8.1 Relevant indications are those with mechanical discontinuities. Linear indications are those indications in which the length is more than three times the width. Rounded indications are indications which are circular or elliptical with the length less than three times the width.

2.9 Post Cleaning

2.9.1 After examination is complete, remove penetrant material as soon as possible by flushing the area with solvent/remover and wiping it clean. This may have to be repeated several times.

2.10 Documentation

2.10.1 Attachment 1 (Form WEP 306) shall be used to document examination results and process variables.

2.11 Acceptance Criteria

2.11.1 For determination of the appropriate acceptance criteria, the inspectors shall use the acceptance criteria referenced in the examination package, which was developed according to Reference 4.5.

3. DEFINITIONS

None.

4. REFERENCES

4.1 American Society of Mechanical Engineers (ASME), Nuclear Power Plant Component, III and V, Boiler and Pressure Vessel Code, 1971 Edition through Summer 1973 Addenda.

4.2 American Society of Mechanical Engineers (ASME) Section VIII, Pressure Vessels, Divisions 1 and 2, 1971 Edition with Summer 1973 Addenda through the 1974 Edition with Summer 1976 Addenda.

4.3 ANSI B31.1, "American National Standards Institute Power Boilers," 1971 through Summer 1973.

4.4 AWS D1.1, Structural Welding Code, American Welding Society, Inc., 1972 through 1974 Addenda.

4.5 Standard Practice WEP 3.1.8, "Preparation of the Examination Package."

4.6 Standard Practice WEP 4.1.2, "Training, Qualifying, and Certifying Personnel for Visual and Nondestructive Examination."

The Weld Evaluation Project (WEP) hereby certifies that the above Nondestructive Examination Procedure has been qualified by actual demonstration.

Level III Examiner

ATTACHMENT 1

Form WEP 306
Rev. 3/86

LIQUID PENETRANT EXAMINATION
CHECKLIST

Reference Document:
Standard Practice No. _____
Revision Date _____

Examination Package No. _____

Unit No. _____
Weld No. _____
Weld class _____
Material _____
Diameter _____
Thickness _____
Dwg. No./Weld Map _____

Penetrant time _____
Cleaner time _____
Developer time _____
Developer removed yes __ no __
Penetrant Lot No. _____
Cleaner Lot No. _____
Developer Lot No. _____

Temperature of part _____
Thermometer/pyrometer No. _____
Thermometer/pyrometer Cal Due Date _____

Group No. _____
WEP Reviewer _____ Date _____ Inspector/Level _____ Date _____

IDENTIFICATION OF AREA EXAMINED
(Record size, shape, and location of all rejectable indications)

If reference sketch is used, record Sketch No. _____ and attach to this report.

Accept _____ Date _____ / Reject _____ Date _____

Remarks

APPENDIX A

ACCEPTANCE CRITERIA
FOR ASME SECTION III, ASME SECTION VIII, AND ANSI B31.1 WELDS

1. Acceptance Criteria

1.1 Only indications with major dimensions greater than 1/16 inch shall be considered relevant.

1.2 The following relevant indications are unacceptable:

1.2.1 Any cracks or linear indications.

1.2.2 Rounded indications with a dimension of greater than 3/16 inch.

1.2.3 Four or more rounded indications in a line separated by 1/16 inch or less, edge-to-edge.

1.2.4 Ten or more rounded indications (greater than 1/16 inch) in any 6 square inches of surface with the major dimension of this area not to exceed 6 inches with the area taken in the most unfavorable location relative to the indications being evaluated.

2. Acceptance Criteria for Base Materials

2.1 The following relevant indications are not acceptable in materials for which a liquid penetrant examination is required by P.S.4.M.5.1:

2.1.1 Any linear indications greater than 1/16-inch long for materials less than 5/8-inch thick, greater than 1/8-inch long for material from 5/8-inch thick to under 2 inches thick, and 3/16-inch long for material 2 inches thick and greater.

2.1.2 Rounded indications with dimensions greater than 1/8-inch for thicknesses less than 5/8-inch and greater than 3/16-inch for thicknesses 5/8-inch and greater.

2.1.3 Four or more indications in a line separated by 1/16-inch or less edge to edge.

2.1.4 Ten or more indications in any 6 square inches of area whose major dimension is no more than 6 inches with the dimensions taken in the most unfavorable location relative to the indications being evaluated.

3. Report

3.1 Identify all examination reports to permit positive correlation with the material or part examined.

3.2 Identify the equipment and examination medium in sufficient detail to permit duplication of the examination at a later date.

3.3 Provide a sketch, chart, or marked-up drawing to show coverage and orientation, if necessary, for clarity and/or to permit duplication of the examination.

APPENDIX B

ACCEPTANCE CRITERIA FOR AWS D1.1 WELDS

1. Acceptance Criteria for AWS D1.1 Welds

   1.1 The weld has no cracks.

   1.2 Thorough fusion exists between weld metal and base metal.

   1.3 The sum of diameters of piping porosity does not exceed 3/8 inch in any linear inch of weld nor does it exceed 3/4 inch in any 12 inch length of weld.

2. Report

   2.1 Identify all examination reports to permit positive correlation with the material or part examined.

   2.2 Identify the equipment and examination medium in sufficient detail to permit duplication of the examination at a later date.

   2.3 Provide a sketch, chart, or marked-up drawing to show coverage and orientation, if necessary, for clarity and/or to permit duplication of the examination.

   2.4 If necessary, record size, shape, and location of all rejectable/reportable indications in the form of sketches or photographs and written descriptions. All photographs used to supplement the sketches and written descriptions shall include a scale or other length standard by which approximate dimension can be determined.

PATS-1381 (Rev. 11/85)

EG&G Idaho, Inc. STANDARD PRACTICE DOE Weld Evaluation Project	Title: DRY MAGNETIC PARTICLE EXAMINATION METHODS AND ACCEPTANCE CRITERIA	No.: WEP 3.2.5 Page 1 of 13 Date: 07/25/86
	Approved:	REVISIONS: Vertical line, right margin
Reviewed By:	LEVEL III	

1. PURPOSE AND SCOPE

1.1 To establish dry magnetic particle examination (MT) Methods and Acceptance Criteria for the examination of welds at Watts Bar Nuclear Plant Unit 1 (WBN-1), Tennessee Valley Authority (TVA) Weld Evaluation Project (WEP).

1.2 This procedure and its applicable Appendices, when used with the Examination Packages developed according to Reference 4.1, shall define the requirements for dry magnetic particle examination of welds and, when required, the adjacent base material, according to ASME Section III, Division 1, AWS D1.1, ANSI B31.1, and ANSI B31.5. (See References 4.2, 4.3, 4.4, and 4.5.)

2. RESPONSIBILITY AND PRACTICE

2.1 Description of Method

This method involves magnetizing the area to be examined, followed by applying particles of the ferromagnetic examination medium to the surface. The particles will be retained on the surface at cracks and other discontinuities due to leakage in the magnetic field. The patterns will be characteristic of the type of discontinuity present.

2.2 The Inspection/Examination Manager shall be responsible for compliance with this procedure.

The Level III shall be responsible for the content of this procedure and subsequent revisions.

The designated Supervisor shall be responsible to assure that only certified personnel perform examinations to this procedure.

Personnel performing examinations to this procedure shall be certified to the requirements of Reference 4.6 and shall perform the required examination in accordance with this procedure. This procedure shall be present during the performance of an examination.

DRR WEP 382

2.3 Examination Requirements

2.3.1 Surface Preparation

2.3.1.1 Dry magnetic particle examination shall not be done on the surface of parts whose temperature exceeds 600°F (316°C).

2.3.1.2 Surfaces may be examined in the as-welded, as-rolled, as-cast, or as-forged condition providing that surface irregularities will not mask indications of unacceptable discontinuities.

2.3.1.3 The surface to be examined and any adjacent area within at least 1 inch (25 mm) of the surface to be examined shall be dry and free from any dirt, grease, lint, scale, welding flux, spatter, oil, or other extraneous matter that would interfere with the examination.

2.3.3 Sequence of Operation--Examination shall be done by the continuous method; that is, the magnetizing current remains on while the examination medium is being applied and while excess of the examination medium is being removed.

2.3.4 Examination Medium (Dry Powder)--Dry powder shall be used as the inspection medium. This material shall be of high permeability and low retentivity and of suitable sizes and shapes to produce readily magnetic particle indications. It should be of a color that will provide adequate contrast with the background of the surface to be inspected.

2.3.5 Demagnetization--Demagnetization following examination is not required.

2.3.6 Orientation of Discontinuities--Whatever method is used to produce the magnetic flux, the maximum sensitivity will be to the linear discontinuities perpendicular to the lines of flux. Each area shall be examined at least twice, with the line of flux in one case approximately perpendicular to the lines of flux in the other.

2.3.7 Examination Coverage--Examinations shall be conducted with sufficient overlap to assure 100% coverage at the established test sensitivity (Attachment 1). For ASME Section III, Class 1 welds, the examination area shall include at least 1/2 inch of the base material on each side of the weld.

2.3.8 Equipment

2.3.8.1 Acceptable commercial power sources

Yokes	Model	
Parker Probe	DA-200	DRR
Magna Flux	P-920	WEP
Magna Flux	P-90	382

2.3.8.2 Acceptable commercial powder for use is Magnaflux No. 8A red.

2.3.9 Equipment Calibration

2.3.9.1 Each piece of magnetizing equipment shall be calibrated at least once a year, or after each time it has been subjected to major electrical repair, periodic overhaul, or damage. DRR WEP 382

2.3.9.2 Equipment with ammeters--The unit's meter readings shall be compared to those of a control test meter with shunt or current transformer arrangement, connected so as to monitor the output current. The accuracy of the entire control test meter arrangement shall be verified annually by means traceable to a national stanadard. Comparative readings shall be taken at a minimum of three output levels encompassing the useable range.

2.3.9.3 Tolerance--The unit's meter reading shall not deviate by more than +10% of full scale, relative to the actual current value as shown by the test meter.

NOTE: When half-wave current is involved, the direct current test meter readings must be doubled for calibration.

2.3.9.4 Yokes--The magnetizing force of yokes shall be calibrated by determining their minimum lifting power. Each alternating current electromagnetic yoke shall have a lifting power of at least 10 lb at the maximum pole spacing at which it will be used.

NOTE: A calibration lift shall be performed prior to examination.

2.3.10 Inspection Medium Application and Removal--The dry powder shall be applied by lightly dusting a small quantity over the surface and then removing the excess with a gentle air stream. The air stream shall be controlled so that it does not disturb or remove the lightly held powder patterns.

NOTE: Lighting--Adequate lighting shall be provided for easy observation of the indication; lighting may be considered adequate for evaluation of the test when the inspector can resolve a black line 1/32 inch wide or less on an 18% neutral grey card placed on the surface being inspected.

2.4 Technique

2.4.1 Yoke Technique

2.4.1.1 This method should be used only to detect discontinuities which actually come to the surface.

2.4.1.2 Alternating or direct current electromagnetic yokes or permanent magnet yokes shall be used and shall meet the requirement of Paragraph 2.3.8.1.

NOTE: Except for materials 1/4 inch or less in thickness, alternating current yokes are superior to direct or permanent magnetic yokes of equal lifting power for the detection of surface cracks.

2.4.1.3 The minimum pole spacing shall be 3 inches; the maximum pole spacing shall be 6 inches.

2.4.2 Prod Technique

2.4.2.1 Magnetization shall be accomplished by portable prod type electrical contacts pressed against the surface in the area to be examined. To avoid arcing, a remote control switch, which may be built into the prod handles, shall be turned on after prods have been properly positioned and to be turned off before they are removed. DRR WEP 382

2.4.2.2 Prod spacing shall be a maximum of 8 inches for the M/F P-920 and 6 inches for the M/F P-90. Shorter spacing may be used to meet the limitation of geometry of dimensions of the area being examined, or to increase the sensitivity, but prod spacing less than 3

inches usually is not feasible due to banding of the particles around the prods. The prod tips shall be kept clean and dressed and the contact areas of the test surface shall be free from dirt, oil, scale, etc., to minimize electrical arcing. If a source of magnetizing current with an open circuit voltage of over 25 V is used, lead, steel or aluminum, rather than copper-tipped prods, are recommended to avoid copper penetration. DRR WEP 382

2.4.2.3 Direct or rectified magnetizing current shall be used at a minimum of 100 and a maximum of 125 amp/inch of prod spacing for sections 3/4-inch thick or greater. For sections less than 3/4-inch thick, amperage shall be 90 to 110 amp/inch of prod spacing.

2.5 Evaluation of Indications

2.5.1 Mechanical discontinuities at the surface will be indicated by the retention of the examination medium. All indications are not necessarily defects or discontinuities, since certain metallurgical discontinuities and magnetic permeability variations may produce similar indications which are not relevant to the detection of unacceptable discontinuities.

2.5.2 Nonrelevant Indications--Any indication which is believed to be nonrelevant shall be regarded as a defect and shall be reexamined to verify whether or not actual defects are present. Surface conditioning may precede the reexamination. Nonrelevant indications which would mask indications of defects are unacceptable.

2.5.3 Relevant Indications--Relevant indications are those which result from unacceptable mechanical discontinuities. Linear indications are those indications in which the length is more than three times the width. Rounded indications are indications which are circular or elliptical with the length less than three times the width.

2.6 Acceptance Criteria--For determination of the appropriate acceptance criteria, the inspectors shall use the acceptance criteria referenced in the examination package which was developed according to Reference 4.1.

2.7 Documentation

2.7.1 Process variables and results of the examination shall be documented on the applicable documents as defined in Reference 4.1 and 4.7.

2.7.2 Attachment 2 (Form WEP 307) shall be used to document examination results.

3. DEFINITIONS

None.

4. REFERENCES

4.1 Standard Practice WEP 3.1.8, "Examination Package Preparation."

4.2 American Society of Mechanical Engineers (ASME), Nuclear Power Plant Components, Section III-Division 1, Boiler and Pressure Vessel Code, 1971 through Summer 1973 Addenda.

4.3 AWS D1.1 Structural Welding Code, American Welding Society, Inc., 1972 through 1974 addenda.

4.4 ANSI B31.1, Power Piping, American National Standard Institute Code for Pressure Piping, 1973 through Winter 1973.

4.5 ANSI B31.5 (USASI B31.4-1966), Refrigeration Piping, USA Standard Code for Pressure Piping, Published by American Society of Mechanical Engineers, 1966.

4.6 Standard Practice WEP 4.1.2, "Training, Qualifying, and Certifying Personnel for Visual and Nondestructive Examination."

4.7 Standard Practice WEP 3.2.2, "Identifying and Reporting WEP Nonconformances."

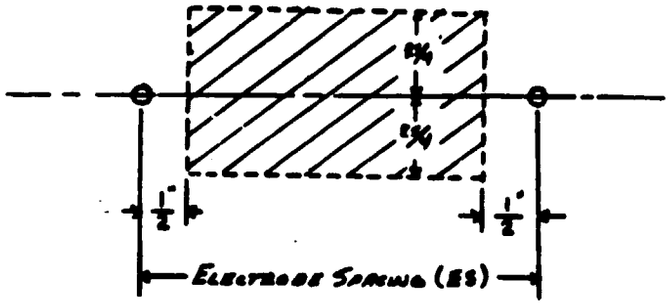
WEP hereby certifies that the above Nondestructive Examination Procedure has been qualified by actual demonstration.

Level III Examiner

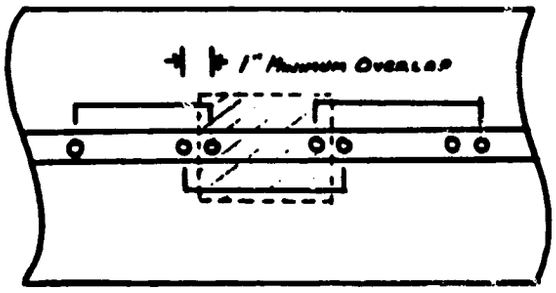
ATTACHMENT 1

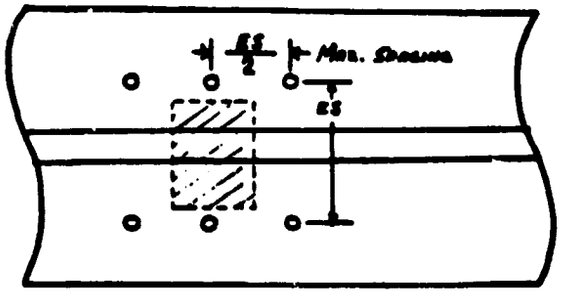
EXAMINATION COVERAGE ELECTRODE PLACEMENT

INSPECTION AREA



TYPICAL INSPECTION TECHNIQUE





ATTACHMENT 2

Form WEP 307
Rev. 3/86

DRY MAGNETIC PARTICLE EXAMINATION CHECKLIST

Page 1 of 1

Reference Document:
Standard Practice No. _____
Revision Date _____

Examination Package No. _____

Unit No. _____	Test Method _____	Powder Brand _____
Dwg. No./Weld Map _____	Pole Spacing _____	Powder Color _____
Weld No. _____	Current Amperage _____ Type _____	Coverage % _____
Material _____	Lifting Power _____	Batch No. _____
Diameter _____	Equipment Type _____	Comments: _____
Thickness _____	Equipment No. _____	_____
Component Type _____	Cal. Lift _____	_____
Weld class _____	Date _____	_____

Group No. _____
WEP Reviewer _____ Date _____ Inspector/Level _____ Date _____

IDENTIFICATION OF AREA EXAMINED
(Record size, shape, and location of all rejectable indications)

If reference sketch is used, record Sketch No. _____ and attach to this report.

Accept _____ Date _____ / Reject _____ Date _____

Remarks

INDEX OF APPENDICES

Weld Acceptance Criteria For ASME Section III ANSI B31.1, and B31.5 . . . . . APPENDIX A

Acceptance Criteria for AWS Welds . . . . . APPENDIX B

APPENDIX A

WELD ACCEPTANCE CRITERIA FOR ASME SECTION III, ANSI B31.1 AND ANSI B31.5

1. Acceptance Criteria for Welds

1.1 Only indications with major dimensions greater than 1/16 inch shall be considered relevant.

1.2 The following relevant indications are unacceptable:

1.2.1 Any cracks or linear indications.

1.2.2 Rounded indications with dimension greater than 3/16 inch.

1.2.3 Four or more rounded indications in a line separated by 1/16 inch or less, edge-to-edge.

1.2.4 Ten or more rounded indications (greater than 1/16 inch) in any 6 square inches of surface with the major dimension of this area not to exceed 6 inches, with the area taken in the most unfavorable location relative to the indications being evaluated.

2. Acceptance Criteria for Base Materials

2.1 Only indications with major dimensions greater than 1/16 inch shall be considered relevant.

2.2 The following relevant indications are not acceptable in materials for which a magnetic particle examination is required by P.S.4.M.5.1[1]:

2.2.1 Any linear indications greater than 1/16-inch long for materials less than 5/8-inch thick, greater than 1/8-inch long for materials from 5/8-inch thick to under 2-inch thick, and 3/16-inch long for materials 2-inch thick and greater;

2.2.2 Rounded indications with dimensions greater than 1/8 inch for material thicknesses as less than 5/8 inch and greater than 3/16 inch for material thicknesses 5/8 inch and greater;

---

1. G-29 Series, TVA Process Specification for Welding Heat Treating, Nondestructive Examination, and Allied Fabrication Operations, Section M.

2.2.3 Four or more indications in a line separated by 1/16 inch or less, edge-to-edge;

2.2.4 Ten or more indications in any 6 square-inch area whose major dimension is no more than 6 inches with the dimensions taken in the most unfavorable location relative to the indications being evaluated.

3. Records

3.1 Identify all test records to permit positive correlation with the material or part examined.

3.2 Identify the equipment and examination medium in sufficient detail to permit duplication of the examination at a later date.

NOTE: Record calibration due dates of equipment used (equipment with ammeters, light meters, etc).

3.3 Provide a sketch, chart or marked-up drawing to show coverage and orientation, if necessary, for clarity and/or to permit duplication of the examination.

3.4 Record size, shape, and location of all rejectable/reportable indications in the form of sketches or photographs and written descriptions. All photographs used to supplement the sketches and written descriptions shall include a scale or other length standard by which approximate dimension can be determined.

APPENDIX B

ACCEPTANCE CRITERIA FOR AWS WELDS

1. Acceptance Criteria

1.1 The following discontinuities are unacceptable for welds evaluated to the requirements of AWS D1.1 Structural Welding Code Sections 8 and 10.

1.1.1 Cracks

1.1.2 Discontinuities exceeding the values of Table 1 and its accompanying notes. The following definitions apply to Table 1:

a. Aligned indication--Three or more indications oriented such that the middle indications touch a line drawn through the two indications at either end.

b. Indication Accumulation--(IA) - The sum of the greatest dimensions of all aligned indications.

c. Weld Size--Leg length of a fillet, the base material thickness for a full penetration butt weld, the bevel depth for a partial penetration weld, or the bevel depth plus the fillet leg length of a fillet-reinforced butt or tee weld.

1.1.3 Any indication 3/32 inch or greater, closer than three times its greatest dimension from the end of a weld.

TABLE 1. SIZE LIMITATIONS OF DISCONTINUITIES

Weld Size (W)	Maximum Indication Size Allowable (inch)	For Aligned Indications the Maximum IA in a Length (L)[a,b]	
		IA (inch)	L (inch)
0 to 1/4-inch inclusive	3/32	1/8	3/4
Greater than 1/4 inch to 1/2 inch inclusive	5/32	1/4	1-1/2
Greater than 1/2 inch to 3/4 inch inclusive	/16	1/2	3
Greater than 3/4 inch to 1-1/8 inch	1/2	3/4	4-1/2
Greater than 1-1/8 inch	3/4	W	6W

a. For welds with a total length, s, less than L, the maximum IA shall be s/L x weld size.

b. An aligned indication 3/32-inch or greater separated by less than three times its greatest dimension from an adjacent indication shall be evaluated as one continuous indication.

1.1.4 Independent of the requirements of Sections 1.1.2 and 1.1.3, discontinuities having a greatest dimension of less than 3/32 inch, if the sum of their greatest dimensions exceeds 3/8 inch in any linear inch of weld.

2. Records

A record shall be kept of each examination and shall contain the following information:

Identification of weld(s) that are examined
Disposition of area examined
Type of magnetizing current
Examiner and SNT-TC-1A level
Date of examination
Record calibration due date of equipment used (equipment with ammeters, etc.)

1. PURPOSE AND SCOPE

1.1 This Standard Practice (SP) defines the requirements for volumetric examination of pipe and structural welds by radiographic examination at the Department of Energy (DOE) Weld Evaluation Project (WEP) at the Tennessee Valley Authority (TVA) Watts Bar Nuclear Plant Unit 1 (WBN-1).

1.2 This SP is limited to the performance of radiographic examinations using radioactive isotopes. All radiographic operations shall be conducted to an approved Radiation Safety Program as defined by the Nuclear Regulatory Commission (NRC) and radiography activities shall be immediately terminated when there is an intrusion of the Radiation Area by nonradiography personnel or when safety procedures are violated.

1.3 This SP and its applicable appendices, when used with the examination packages (EPs) developed according to Reference 4.1, shall define the requirements for radiographic examination of welds according to ASME Sections I, III, and VIII; ANSI B31.1; and AWS D1.1 (References 4.2 through 4.6). Acceptance criteria for ASME Sections I, III, VIII and ANSI B31.1 are found in Appendix A; acceptance criteria for AWS D1.1 welds are found in Appendix B.

2. RESPONSIBILITY AND PRACTICE

2.1 Description of Method

Radiographic examination is a nondestructive examination (NDE) method for the volumetric examination of material and components and is based on the differential absorption of radiation as recorded on radiographic film.

2.2 The Inspection/Examination Manager shall be responsible for compliance with this procedure. DRR WEP 385

The Level III shall be responsible for the content of this procedure and subsequent revisions.

The designated Supervisor shall be responsible to ensure that only certified personnel perform examinations to this procedure.

Personnel performing examinations to this procedure shall be certified to the requirements of Reference 4.7 and shall perform the required examination in accordance with this procedure. This procedure shall be present during the performance of an examination. DRR WEP 385

2.3 Equipment and Materials

2.3.1 Radiation Source--Radioisotope sources, either Iridium 192 or Cobalt 60, shall be used and shall be of a sufficiently small physical size to comply with geometric unsharpness requirements.

2.3.2 Film--Radiographs shall be made using medium or low speed film of high contrast and low graininess (Type 1 or 2, Table 2 of ASTM Recommended Practice SE-94, as contained in Reference 4.8).

2.3.3 Penetrameter

2.3.3.1 Penetrameters shall be fabricated of radiographically similar material to the material or weld metal to be examined and shall meet the requirements of ASME SE-142 (as contained in Reference 4.8).

2.3.3.2 For ASME or ANSI welds, penetrameter thickness shall be in accordance with Tables 1, 2, 3, or 4, as applicable, with the additional requirement that penetrameters 5 through 10, as applicable, shall also contain a slit 1/4 inch long and .010 inch wide.

2.3.3.3 For structural (AWS) welds, penetrameters shall conform to details shown in Figure 1.

2.3.3.4 Penetrameters shall be identified by permanently attached lead numbers. The numbers shall indicate for (a) ASME penetrameters, the penetrameter thickness in accordance with Tables 1, 2, 3, or 4, as applicable, or (b) AWS penetrameters, the minimum thickness of steel on which the penetrameter may be used.

2.3.4 Screens--Intensifying screens, other than fluorescent type, may be used.

2.3.5 Shims

TABLE 1. THICKNESS AND IDENTIFICATION OF PENETRAMETERS REQUIRED FOR GIVEN WELD THICKNESS TO THE REQUIREMENTS OF ASME SECTION VIII (Divisions I and II)

Thickness Range (inches)	Source Side Penetrameter Thickness (inches)	Penetrameter Designation	Essential Hole	Film Side Penetrameter Thickness (inches)	Penetrameter Designation	Section VIII Essential Hole
Up to 1/4, inclusive	0.005	5	2T or slit	0.005	5	2T
Over 1/4 through 3/8	0.0075	7	2T or slit	0.0075	7	2T
Over 3/8 through 1/2	0.010	10	2T or slit	0.010	10	2T
Over 1/2 through 5/8	0.0125	12	2T	0.010	10	2T
Over 5/8 through 3/4	0.015	15	2T	0.012	12	2T
Over 3/4 through 7/8	0.0175	17	2T	0.015	15	2T
Over 7/8 through 1	0.020	20	2T	0.017	17	2T
Over 1 through 1-1/4	0.025	25	2T	0.020	20	2T
Over 1-1/4 through 1-1/2	0.030	30	2T	0.025	25	2T
Over 1-1/2 through 2	0.035	35	2T	0.030	30	2T
Over 2 through 2-1/2	0.040	40	2T	0.030	30	2T
Over 2-1/2 through 3	0.045	45	2T	0.035	35	2T
Over 3 through 4	0.050	50	2T	0.040	40	2T
Over 4 through 6	0.060	60	2T	0.050	50	2T
Over 6 through 8	0.080	80	2T	0.060	60	2T
Over 8 through 10	0.100	100	2T	0.080	80	2T
Over 10 through 12	0.120	120	2T	0.100	100	2T
Over 12 through 16	0.160	160	2T	0.120	120	2T
Over 16 through 20	0.200	200	2T	0.160	160	2T

TABLE 2. THICKNESS AND IDENTIFICATION OF PENETRAMETERS FOR RADIOGRAPHIC EXAMINATION OF WELDS TO THE REQUIREMENTS OF ANSI B31.1 AND ASME SECTION I

Material Thickness Range (inches)	Source Side Penetrameter Thickness (inches)	Penetrameter Designation	Essential Hole		Film Side Penetrameter Thickness (inches)	Penetrameter Designation	Essential Hole	
			Designation	Diameter			Designation	Diameter
Up to 1/4, inclusive	0.010	10	4T	0.040	0.005	5	4T	0.020
Over 1/4 through 3/8	0.012	12	4T	0.050	0.005	5	4T	0.020
Over 3/8 through 1/2	0.015	15	4T	0.060	0.005	5	4T	0.020
Over 1/2 through 5/8	0.015	15	4T	0.060	0.008	8	4T	0.035
Over 5/8 through 3/4	0.015	15	4T	0.060	0.009	9	4T	0.036
Over 3/4 through 7/8	0.017	17	4T	0.070	0.010	10	4T	0.040
Over 7/8 through 1	0.017	17	4T	0.070	0.010	10	4T	0.040
Over 1 through 1-1/4	0.020	20	4T	0.080	0.015	15	4T	0.060
Over 1-1/4 through 1-1/2	0.030	30	4T	0.090	0.017	17	4T	0.070
Over 1-1/2 through 2	0.035	35	2T	0.090	0.017	17	4T	0.070
Over 2 through 2-1/2	0.040	40	2T	0.080	0.017	17	4T	0.070
Over 2-1/2 through 3	0.045	45	2T	0.090	0.020	20	4T	0.080
Over 3 through 4	0.050	50	2T	0.100	0.030	30	2T	0.090
Over 4 through 6	0.060	60	2T	0.120	0.035	35	2T	0.100
Over 6 through 8	0.080	80	2T	0.160	0.045	45	2T	0.120
Over 8 through 10	0.100	100	2T	0.200	0.060	60	2T	0.120
Over 10 through 12	0.120	120	2T	0.240	0.060	60	2T	0.120
Over 12 through 16	0.160	160	2T	0.320	0.080	80	2T	0.160
Over 16 through 20	0.200	200	2T	0.400	0.080	80	2T	0.160

TABLE 3. PENETRAMETER REQUIREMENTS FOR RADIOGRAPHY OF CIRCUMFERENTIAL BUTT WELDS IN ITEMS SUCH AS PIPE, FITTINGS, TUBING, AND NOZZLES (ASME Sections I and III, and ANSI B31.1

Single-Wall Thickness Range (inches)	Penetrameter		Penetrameter	
	Designation	Thickness (inch)	Designation	Diameter (inch)
0 to 0.375	10	0.0100	4T	0.040
Over 0.375 to 0.625	12	0.012	4T	0.048
Over 0.625 to 0.875	15	0.015	4T	0.060
Over 0.875 to 1.00	17	0.017	4T	0.068
Over 1.00 to 1.50	25	0.025	2T	0.050
Over 1.50 to 2.50	30	0.030	2T	0.060
Over 2.50 to 3.00	35	0.035	2T	0.070
Over 3.00 to 4.00	40	0.040	2T	0.080
Over 4.00 to 6.00	50	0.050	2T	0.100

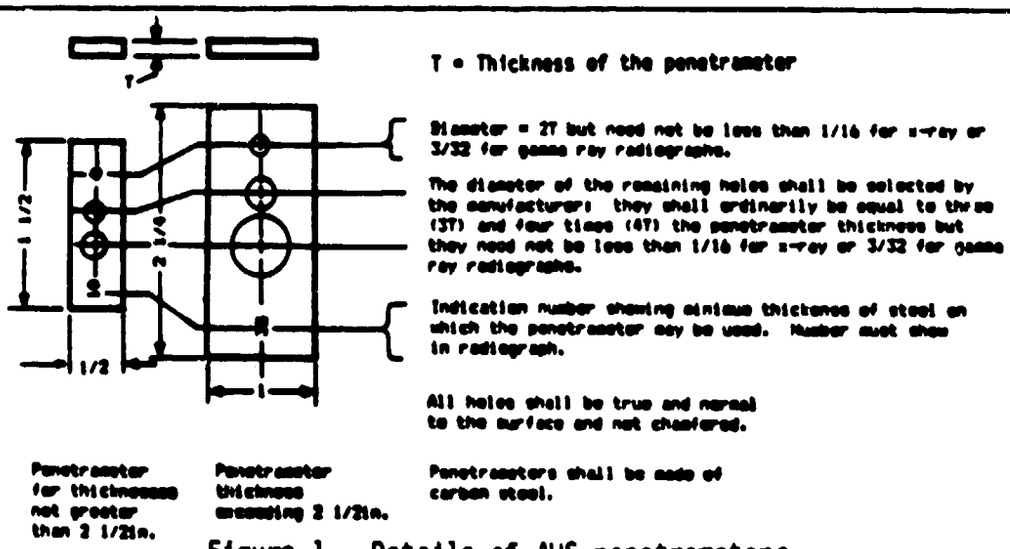


Figure 1. Details of AWS penetrameters.

TABLE 4. THICKNESS AND IDENTIFICATION OF PENETRAMETERS REQUIRED FOR GIVEN WELD THICKNESS TO THE REQUIREMENTS OF ASME SECTION III.

Thickness Range (inches)	Source Side Penetrameter Thickness (inches)	Penetrameter Designation	Essential Hole	Film Side Penetrameter Thickness (inches)	Penetrameter Designation	Essential Hole
Up to 1/4, inclusive	0.005	5	2T or slit	0.005	5	2T
Over 1/4 through 3/8	0.0075	7	2T or slit	0.005	5	2T
Over 3/8 through 1/2	0.010	10	2T or slit	0.005	5	2T
Over 1/2 through 5/8	0.0125	12	2T	0.005	5	2T
Over 5/8 through 3/4	0.015	15	2T	0.007	7	2T
Over 3/4 through 7/8	0.0175	17	2T	0.010	10	2T
Over 7/8 through 1	0.020	20	2T	0.010	10	2T
Over 1 through 1-1/4	0.025	25	2T	0.015	15	2T
Over 1-1/4 through 1-1/2	0.030	30	2T	0.017	17	2T
Over 1-1/2 through 2	0.035	35	2T	0.020	20	2T
Over 2 through 2-1/2	0.040	40	2T	0.020	20	2T
Over 2-1/2 through 3	0.045	45	2T	0.025	25	2T
Over 3 through 4	0.050	50	2T	0.030	30	2T
Over 4 through 6	0.060	60	2T	0.035	35	2T
Over 6 through 8	0.080	80	2T	0.045	45	2T
Over 8 through 10	0.100	100	2T	0.060	60	2T
Over 10 through 12	0.120	120	2T	0.060	60	2T
Over 12 through 16	0.160	160	2T	0.080	80	2T
Over 16 through 20	0.200	200	2T	0.080	80	2T

2.3.5.1 Shims shall be of a material radiographically similar to the item being radiographed. Shim size shall exceed the penetrameter size by at least 1/8 inch on three sides.

2.3.5.2 Shims shall be used when the weld reinforcement and/or backing strip is not removed. The shim thickness shall be selected so that the total thickness being radiographed is the same as the total weld thickness, including the backing strip.

2.3.6 Film Holders--Film holders or cassettes may be of a commercial variety and shall be maintained without light leaks or defects which will mar the radiographs.

2.3.7 Collimators--Collimators may be used to improve directionality of radiation beam and to reduce backscatter.

2.3.8 Identification Markers--Lead markers shall be used to produce a radiographic image on the film to identify the weld and location of indications.

2.4 Examination Requirements

2.4.1 Surface Preparation--Welds to be radiographed shall be prepared as follows: the weld ripples or weld surface irregularities, both inside and outside, shall be removed by a mechanical process to such a degree that the resulting radiographic contrast cannot mask or be confused with the image of an unacceptable discontinuity. Also, the weld surface shall merge smoothly into the adjacent material surface. Weld root concavity and weld reinforcement shall be in accordance with the requirements of TVA Process Specification 3.M.3.1 (R3) (Reference 4.9).

2.4.2 Film Identification

2.4.2.1 ASME/ANSI--Radiographs shall be plainly and permanently marked with the weld number, plant, unit, system, and exposure date. The marking is not required to be a radiographic image.

2.4.2.2 AWS--Radiographs shall have the weld number appear as a radiographic image on each film adjacent to the weld. This number shall be permanently marked on the material adjacent to the weld. The plant, unit, system, and exposure date shall be preprinted on the film

no less than 3/4 inch from the edge of the weld or shall be indicated by lead figures on the steel (see Figures 2 and 3).

2.4.3 Film Location Markers--At least two film location markers shall appear as a radiographic image on each radiograph. The location of the marker(s) shall be placed on the base metal using either a low stress stencil, vibratory pencil, paint marker, or other approved marking method such that a defect appearing on a radiograph may be accurately located. In addition to the requirement above, AWS markers shall be placed directly over the location numbers marked on the steel. The marking shall also provide evidence on the film that complete coverage of the weld has been obtained.

2.4.4 Penetrameters

2.4.4.1 General Requirements--Penetrameters shall be placed on the side nearest the radiation source so that the plane of the penetrameter is normal to the radiation beam. When it is

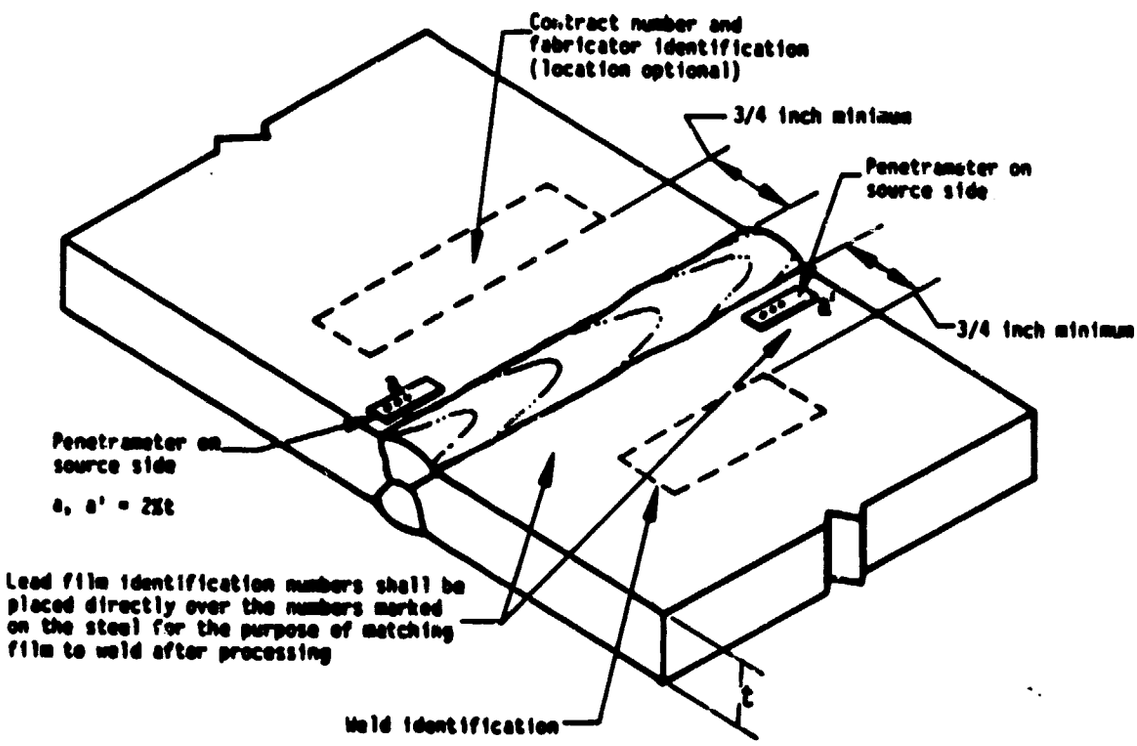


Figure 2. Radiograph identification and penetrameter location on approximately equal thickness joints.

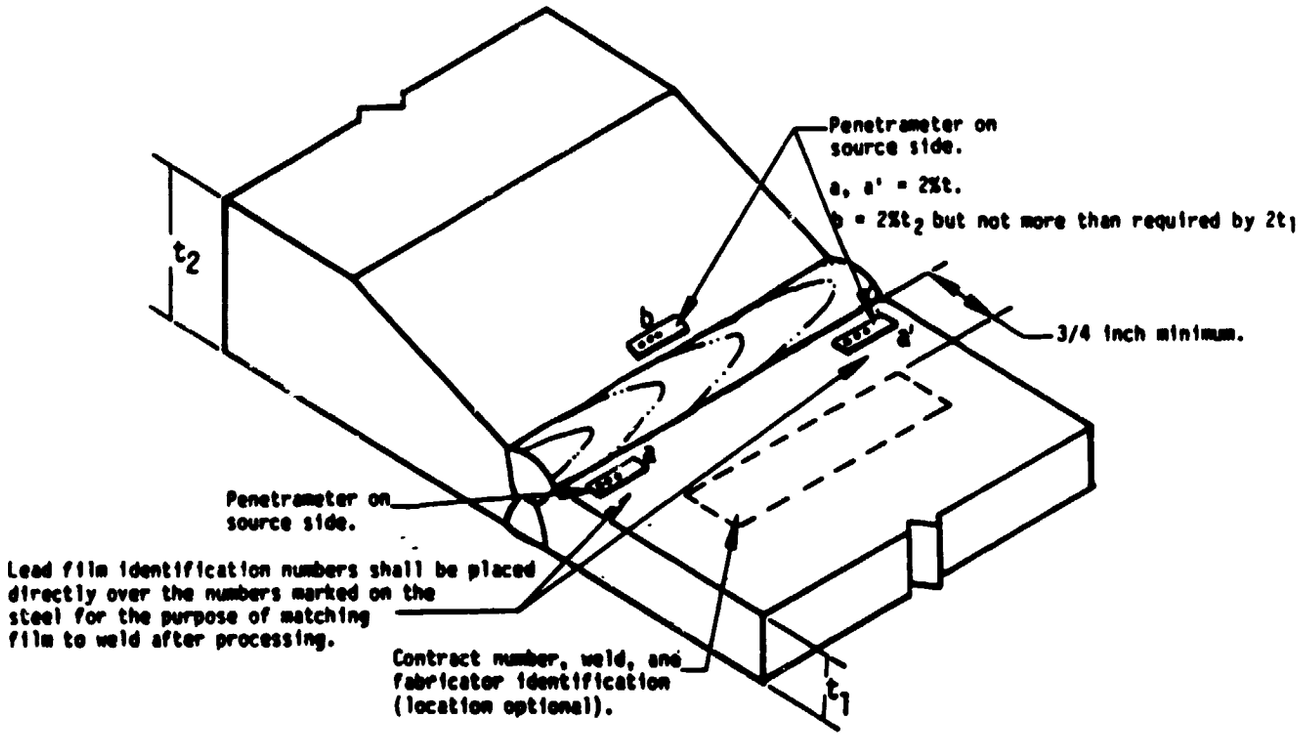


Figure 3. Radiograph identification and penetrameter location on transition joints.

physically impractical to locate the penetrameter on the source side, except as noted in Paragraphs 2.5.1.2 and 2.5.2, it may be placed on the film side of the joint with a lead letter "F", 1/2 inch in height, placed adjacent to the penetrameter.

2.4.4.2 ANSI/ASME Welds

2.4.4.2.1 Number of Penetrameters--At least one penetrameter image shall appear on each film, with the exception that when the source is placed on the axis of the object and the complete circumference is radiographed with a single exposure, at least three uniformly spaced penetrameters shall be employed.

2.4.4.2.2 Placement of Penetrameter--Source or film side penetrameters shall be placed adjacent to the weld.

2.4.4.2.3 Selection of Penetrameters--ASME penetrameter, shall be selected based on Tables 1, 2, 3, or 4, depending on the thickness of the weld including the reinforcement being examined.

2.4.4.2.4 Sensitivity--The radiograph must show the images of the penetrameter outline, identifying numbers and designated hole from Tables 1, 2, 3, or 4, as applicable. A smaller hole than designated may be used.

2.4.4.3 AWS Welds

2.4.4.3.1 Number of Penetrameters--Two or more penetrameters shall be used for each radiograph on a film 10 inches or more in length. Only one penetrameter need be used for radiographs on films less than 10 inches in length.

2.4.4.3.2 Placement of Penetrameters--Penetrameters shall be placed on the side of the work nearer the radiation source and adjacent to the weld (see Figures 2 and 3).

2.4.4.3.3 Selection of Penetrameters--AWS penetrameters shall be used and selected based on the thickness of the thinner of the parts being joined.

2.4.4.3.4 Sensitivity--The radiograph must show the image of the smallest hole (2T).

2.4.5 Radiographic Density

2.4.5.1 Measurement--The transmitted film density through the radiographic image of the body of

the appropriate penetrameter and the area of interest shall be measured with a densitometer that has been verified by comparison with a calibrated step wedge film traceable to a national standard.

2.4.5.2 ASME/ANSI Welds

2.4.5.2.1 The film density through the area of interest shall not be less than 2.0 nor more than 4.0 for single film viewing and 2.6 minimum for composite viewing of double film exposures. Each film of a composite set shall have a minimum density of 1.3.

2.4.5.2.2 The film density through the area of interest shall not vary by more than -15 to +30 percent from the density through the penetrameter. Two penetrameters may be used: one in the lightest area and one in the darkest area; when this is done, the intervening densities between the penetrameters shall be considered acceptable. It is not necessary that these two penetrameters be normal to the radiation source.

2.4.5.3 AWS Welds

2.4.5.3.1 The film density shall not be less than 1.5 nor more than 4.0. However, it is preferred to have densities between 2.5 to 3.5.

When weld transitions in thickness are radiographed, and the ratio of the thicker weld section to the thinner weld section is 3 or greater, radiographs should be exposed to produce a density of 3.0 to 4.0 in the thinner section. When this is done, densities of less than 1.5 will be accepted in the thicker section. Except for

this condition, densities outside the maximum and minimum limits specified above shall be cause for rejection of the film. Penetrameters on transition joints shall be positioned as shown in Figure 3.

2.4.6 Geometric Unsharpness

2.4.6.1 Object-to-Film Distance--The object-to-film distance shall be the minimum possible; when practical, the film shall be shaped to the contour of the object.

2.4.6.2 Source-to-Object Orientation--The source shall be positioned normal and centered, as possible, to the test object.

2.4.6.3 Source-to-Object Distance

2.4.6.3.1 ASME/ANSI Welds--Source-to-object distance shall not exceed that length such that the maximum geometric unsharpness is 0.020 inch for material thickness up to 4 inches and 0.050 inch maximum for material over 4 inches. In special cases where geometrical limitations make it impossible to attain the above, a special procedure shall indicate the attainable; however, under no circumstances shall geometrical unsharpness exceed 0.070 inch.

Geometrical unsharpness equals source size times thickness, divided by source-to-object distance:

$$Ug_{max} = \frac{Ft}{D}$$

where

F = source size, inches [the maximum effective dimension (diameter) of the radiating source (or focal spot) in the plane of the distance D from the weld].

ORR WEP 385

t = thickness, in inches, of the weld being radiographed, assuming the film is placed against the weld. Otherwise, it is the thickness of the weld, plus the space between the film and the weld.

D = distance, in inches, from the source of radiation to the weld surface.

2.4.6.3.2 AWS Welds--The source-to-object distance shall be no less than six times the maximum thickness of the weld, less any gap between the weld and film.

Film shall not be interpreted where the rays penetrate the weld at any angle greater than 26-1/2 degrees from a line perpendicular to the weld surface. The 26-1/2 degrees equals one half the source-to-film distance along the weld from the point on the film directly beneath the source.

2.4.7 Backscatter--Backscatter shall be checked by use of a lead letter "B" at least 1/16 inch thick and 1/2 inch high attached to the back of the film holder. If the image of the "B" appears on the radiograph, the scattered radiation is objectionable and the radiograph is unacceptable.

2.4.8 Film Processing--All film shall be processed either manually or by machine in accordance with ASTM E94-68 (as contained in Reference 4.8).

2.4.9 Film Quality Requirements--All film shall be free from mechanical, chemical, or other processing defects that could interfere with proper interpretation of radiographs such as:

a. Fogging
b. Processing defects such as streaking, watermarks, or chemical stains
c. Scratches, finger marks, crimps, static marks, dirtiness, smudges, or tears

d. Loss of detail due to poor screen-to-film contact
e. False indications due to defective screens or internal faults.

2.4.10 Film Viewing--Viewing facilities shall provide subdued background lighting of an intensity that will not cause troublesome reflections, shadows, or glare on the radiograph. Equipment used to view radiographs for interpretation shall provide a light source sufficient for the essential penetrameter hole to be visible for the specified density range. The viewing conditions shall be such that light from around the outer edge of the radiograph or coming through low density portions of the radiograph does not interfere with interpretation.

2.5 Radiographic Techniques

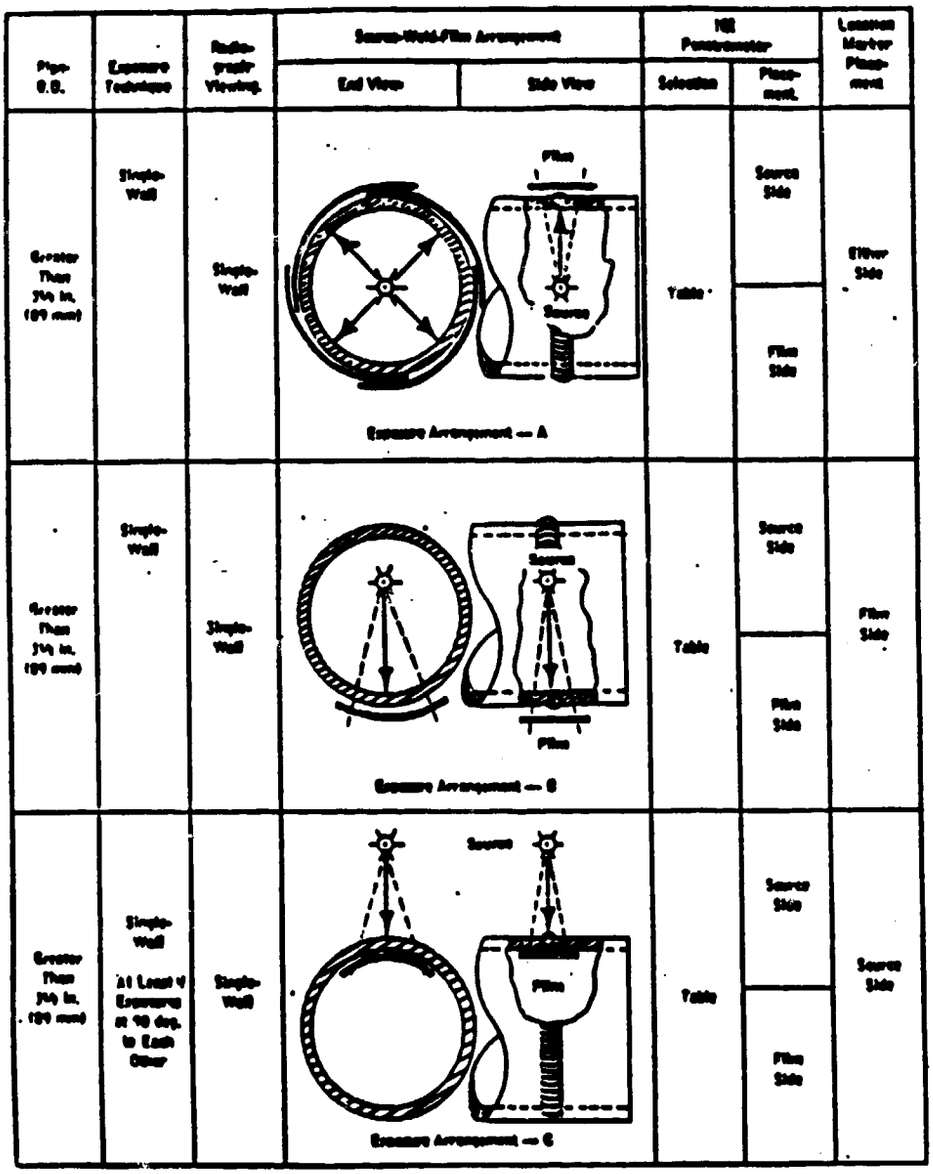
2.5.1 Single Viewing

2.5.1.1 ASME/ANSI Welds--Radiographic examination of ASME/ANSI welds, except as permitted in Paragraph 2.5.2, shall be performed for single wall viewing. For circumferential butt welds, the radiation may pass through one or both walls. Refer to Figures 4 and 5 for typical technique arrangements.

2.5.1.2 AWS Welds

a. When complete testing is specified, the entire length of the weld in each designated joint shall be inspected.

b. When spot testing is specified, the number of spots in each designated category of welded joint to be radiographed in a stated length of weld shall be as indicated in the design specification. Each spot radiograph shall show at least 4 inches of weld length. If a spot radiograph shows discontinuities that require repair, as defined in Appendix B, two adjacent spotsshall be inspected. If discontinuities requiring repair are shown in either of these, the entire

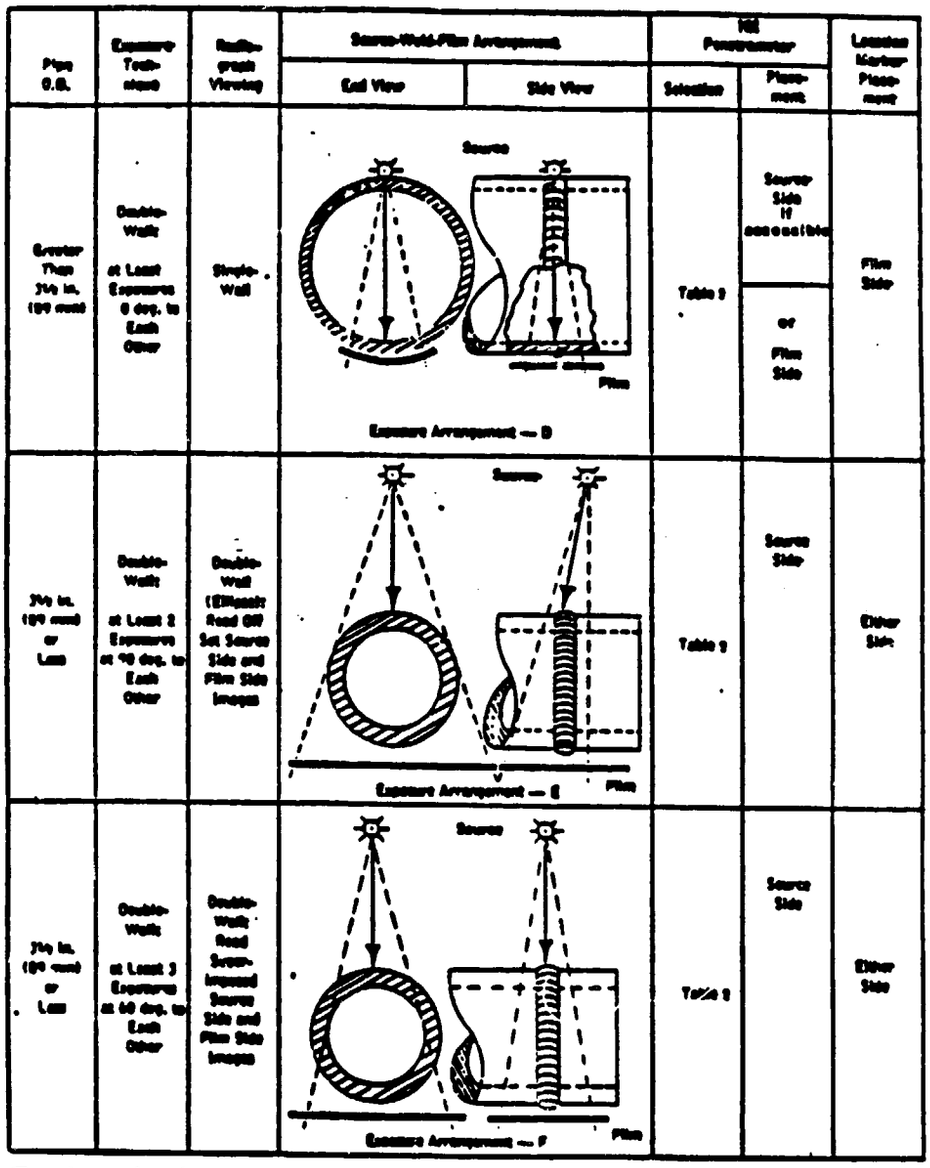


The above sketches are suggested techniques. Other exposure arrangements may be made provided they comply with the requirements of this standard.

Figure 4. Single-wall radiographic techniques.

length of weld in that welded joint shall be tested radiographically.

2.5.2 Double Viewing--For ASME/ANSI circumferential butt welds with an outside diameter of 3-1/2 inches or less, a radiographic technique may be used in which radiation



The above sketches are suggested techniques. Other exposure arrangements may be made provided they comply with the requirements of this standard.

Figure 5. Double-wall radiographic techniques.

passes through two walls and the weld in both walls is viewed for acceptance on the same film. Refer to Figure 5 for typical technique arrangements.

2.6 Documentation--Attachment 1 (Form WEP 311) shall be used to document examination results and process variables.

2.7 Acceptance Criteria--For determination of the appropriate acceptance criteria, the inspectors shall use the acceptance criteria referenced in the examination package, which was developed according to Reference 4.1.

3. DEFINITIONS

None.

4. REFERENCES

4.1 Standard Practice WEP 3.1.8, "Preparation of the Examination Package."

4.2 American Society of Mechanical Engineers (ASME), Power Boilers, Section I, 1971 through Summer 1971 addenda.

4.3 American Society of Mechanical Engineers (ASME), Nuclear Power Plant Components, Section III-Division 1, Boiler and Pressure Vessel Code, 1971 through Summer 1973 Addenda.

4.4 American Society of Mechanical Engineers (ASME), Rules for Construction of Pressure Vessels, Section VIII-Divisions 1 and 2, 1971 through Winter 1972 addenda.

4.5 ANSI B31.1, Power Piping, American National Standard Institute Code for Pressure Piping, 1973 through Winter 1973.

4.6 AWS D1.1 Structural Welding Code, American Welding Society, Inc., 1972 through 1974 Addenda.

4.7 Standard Practice WEP 4.1.2, "Training, Qualifying, and Certifying Personnel for Visual and Nondestructive Examination."

4.8 American Society of Mechanical Engineers (ASME), Nondestructive Testing, Section V, Boiler and Pressure Vessel Code, 1977 Edition, July 1, 1977.

4.9 TVA Process Specification 3.M.3.1 (R3), Specifications for Radiographic Examination of Welded Joints, February 9, 1983.

WEP hereby certifies that the above Nondestructive Examination Procedure has been qualified by actual demonstration.

Level III Examiner — Date 8/9/86

APPENDIX A

ACCEPTANCE CRITERIA FOR ASME SECTIONS I, III, VIII, AND ANSI B31.1

1. Sections of weld that are shown by radiography to have any of the following types of discontinuities are unacceptable.

   1.1 Any type of crack or zone of incomplete fusion or penetration.

   1.2 Any elongated indications, such as slag or tungsten, which has a length greater than 1/4-inch for thickness (t) up to 3/4-inch, 1/3 t for thickness from 3/4 to 2-1/4 inches, or 3/4-inch for thickness over 2-1/4 inches. DRR WEP 385

   1.3 Any group of indications in line that have an aggregate length greater than t in a length of 12 t except when the distance between the successive imperfections exceeds 6L, where L is the length of the longest imperfection in the group. DRR WEP 385

   1.4 Porosity in excess of the following:

      a. The total area of porosity as determined from the radiographic film shall not exceed 0.06 T square inch in any 6-inch length of weld, where T is the thickness of the weld. If the weld is less than 6 inches long, the total area of porosity shall be reduced in proportion.

      b. The maximum pore dimension shall be 20% of T or 1/8-inch, whichever is less, with the exception that an isolated pore separated from an adjacent pore by a minimum of 1 inch may be 30% of T or 1/4-inch, whichever is less.

      c. Dark images of a generally circular or oval shape shall be interpreted as porosity.

      d. In any 1-inch length of weld or 2 T, whichever is less, porosity may be clustered to a concentration of four times that permitted by 0.06 T. Such clustered porosity shall be included in the porosity in the 6-inch length of weld which includes the cluster.

      e. Aligned porosity shall be acceptable providing the summation of the diameters of the pores is no more than T in a length of 12 T or 6 inches, whichever is less, provided each pore is separated by a distance of at least six times the diameter of the largest adjacent pore. Aligned porosity indications shall be counted in the total

area of permissible indications in any 6-inch length of weld.

f. Permissible porosity indications for weld thicknesses intermediate to those shown in Table A-1 may be evaluated either by comparison to the next thinner material or by calculation. Permissible porosity for greater thicknesses shall not exceed 0.06 T square inch in any 6-inch length of weld.

g. The typical porosity indications in ASME Section III, Appendix VI; Section VIII, Division I, Appendix IV; or Section VIII, Division 2, Appendix VIII, may be used as a guide for comparison of acceptable porosity.

1.5 Internal root weld conditions are acceptable only when the density change as indicated in the radiograph is not abrupt. Elongated indications on the radiograph at either edge of such conditions shall be unacceptable as provided in Section 1 of Appendix A. DRR WEP 385

2. Base metal indications detected during examination shall have the following acceptance criteria:

2.1 Castings shall meet the acceptance criteria of Severity Level 2 of the reference radiographs on SE-71, SE-446, SE-186, or SE-280, as applicable, for the thickness being radiographed, except Category D, E, F, or G defects shall be unacceptable.

2.2 All other base materials shall meet the criteria of Paragraph 1.

3. If the exact location of an indication detected during examination cannot be determined, the indication shall be assumed to be in the weld rather than the base metal.

4. That portion of longitudinal weld seams which appears on the radiograph of circumferential weld seams shall be evaluated to the acceptance criteria for either the circumferential weld seal or the applicable ASME material specification.

TABLE A-1. MAXIMUM PERMISSIBLE POROSITY INDICATIONS IN RADIOGRAPHS PER 6-INCH LENGTH OF WELD

Weld Thickness (inches)	Total Area of Permitted Porosity (inch)	Large			Medium			Fine		
		Approximate Fraction	Decimal Value	Number	Approximate Fraction	Decimal Value	Number	Approximate Fraction	Decimal Value	Number
1/8	0.0075	--	--	--	--	--	--	1/64	0.014	49
1/4	0.015	--	--	--	3/128	0.025	31	1/64	0.0138	100
1/2	0.030	3/32	0.100	4	1/32	0.031	40	3/128	0.0195	101
3/4	0.045	1/8	0.125	4	1/32	0.034	50	3/128	0.024	99
1	0.060	1/8	0.125	5	5/128	0.039	50	1/32	0.0275	101
1-1/2	0.090	1/8	0.125	7	3/64	0.048	50	1/32	0.034	99
2	0.120	1/8	0.125	10	7/128	0.055	51	5/128	0.039	100
2-1/2	0.150	1/8	0.125	12	1/16	0.061	51	3/64	0.044	99
3	0.180	1/8	0.125	15	1/16	0.068	50	3/64	0.048	99
3-1/2	0.210	1/8	0.125	17	5/64	0.073	50	7/128	0.052	99
4	0.240	1/8	0.125	20	5/64	0.078	50	7/128	0.055	101

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APPENDIX B

ACCEPTANCE CRITERIA FOR AWS D1.1 WELDS

1. The following discontinuities are unacceptable for welds required to be evaluated to the requirements of Section 8, Design of New Buildings, and Section 10, Design of New Tubular Structures, of the AWS Structural Welding Code.

   1.1 Cracks

   1.2 Discontinuities exceeding the values of Table B-1 and the accompanying notes. The following definitions apply to Table B-1:

   Aligned Indications--Three or more indications oriented such that the middle indications touch a line drawn through the two indications at either end.

   Indication Accumulation (IA)--The sum of the greatest dimension of all aligned indications.

   Weld Size--Leg length of a fillet, the base material thickness for a full penetration butt weld, the bevel depth for a partial penetration weld, or the bevel depth plus the fillet leg length of a fillet reinforced butt or tee weld.

   1.3 Any indication 3/32 inch or greater closer than three times its greatest dimension from the end of a weld.

   1.4 Discontinuities having a greatest dimension of less than 3/32 inch if the sum of their greatest dimension exceeds 3/8 inch in any linear inch of weld.

TABLE B-1. SIZE LIMITATIONS OF DISCONTINUITIES

Weld Size (W)	Maximum Indication Size Allowable (inch)	For Aligned Indications the Maximum IA in a Length L[a,b]	
		IA (inch)	L (inch)
0 to 1/4 inch, inclusive	3/32	1/8	3/4
Greater than 1/4 inch to 1/2 inch, inclusive	5/32	1/4	1-1/2
Greater than 1/2 inch to 3/4 inch, inclusive	5/16	1/2	3
Greater than 3/4 inch to 1-1/8 inches	1/2	3/4	4-1/2
Greater than 1-1/8 inch	3/4	W	6W

a. For welds with a total length (S) less than L, the maximum indication accumulation (IA) shall be S/L times weld size.

b. An aligned indication 3/32 inch or greater separated by less than three times its greatest dimension from an adjacent indiction shall be evaluated as one continuous indication.

ATTACHMENT 1

Form WEP 311 RADIOGRAPHIC EXAMINATION CHECKLIST Reference Document:

Rev. 3/86 Standard Practice No. ____

Examination Package No. _____ Revision Date _____

WELD DATA

Weld No. _____ Dwg. No. _____ Weld Procedure No. _____

Material Type _____ Thickness _____ System _____

Joint Type: Open Butt ___ Fillet ___ Other ___ Backing Ring ___ Const. Insert ___

TECHNIQUE DATE

Source: Ir192 ____ Co60 ____ ☐ Isotope S/N _____ Eff. Source Size _____

Exposure _____ Curie-Minutes ☐ Source Strength _____ Ci ☐ Exp. Time ____ Min

☐ Source to Film Distance _____ in; Geometric Unsharpness _____

Film: Type _____, Size _____, Number in Cassette _____

Shim: Type _____, Thickness _____

Screens: Type _____, Thickness: Front ____ Back ____ Interscreen ____

Penetrameters: Size _____, Hole _____ Source Side ____ Film Side ____

Technique: Single Wall-Single Viewing ____ Double Wall-SV ____ Double Viewing ____

Exposure Arrangement: A B C D E F (Per Figures 4 & 5 of RT Procedure)

Date Radiographed _____ NOTE: For others sketch on back.

Remarks _____ (Use Back if Necessary)

Radiographer _____ Level ___ EGAA Verification by _____ Level ___

INTERPRETATION

Film View	Accept	Reject	Incomplete Fusion	Incomplete Penetration	Root Concavity	Root Convexity	Shrinkage	Crack	Slag Inclusion	Tungsten Inclusion	Porosity	Undercut	Surface	Burn Through	Film Artifact	Remarks

Interpretation by _____ Level _____ Date _____

EG&G Idaho, Inc. STANDARD PRACTICE DOE Weld Evaluation Project	Title: AWS ULTRASONIC EXAMINATION METHODS AND ACCEPTANCE CRITERIA	No.: WEP 3.2.7 Rev 2 Page 1 of 18 Date: 02/02/87
	Approved:	REVISIONS: Vertical line, right margin
Reviewed By:		See DRR 591

1. PURPOSE AND SCOPE

1.1 This procedure defines the requirements for ultrasonic examination of structural groove welds between the thicknesses of 5/16 inch and 8 inches inclusive for new buildings in accordance with AWS D1.1, (Reference 4.1).

1.2 This procedure and its applicable appendices, when used with the Examination Packages developed according to Reference 4.2, shall constitute the written procedure. Controlled copies of each procedure shall be readily available to the nondestructive examination personnel for their reference and use.

1.3 Variations in testing procedure, equipment or acceptance standards not included in this Standard Practice may be used if required by material or configuration. Variations shall be approved by a Level III examiner.

2. RESPONSIBILITY AND PRACTICE

2.1 Description of Method

Ultrasonic examination is a nondestructive method in which a beam of high frequency sound waves, that are introduced into the material being tested, are used to detect surface and subsurface flaws.

2.2 The Inspection/Examination Manager shall be responsible for compliance with this procedure.

The Level III shall be responsible for the content of this procedure and subsequent revisions.

The designated Supervisor shall be responsible to ensure that only certified personnel perform examinations to this procedure.

Personnel performing examinations to this procedure shall be certified to the requirements of Reference 4.3 and shall perform the required examination in accordance with this procedure. This procedure shall be present during the performance of an examination.

2.3 Equipment and Materials

2.3.1 The ultrasonic test instrument shall be of the pulse-echo type. It shall generate, receive, and present on a cathode ray tube (CRT) screen pulses in the frequency range from one to six megahertz (MHz). The presentation on the CRT screen shall be the "video" type, characterized by a clean, crisp trace.

2.3.2 Each ultrasonic unit shall be certified for general operational performance at a minimum time interval of 12 months with a method approved by the instrument manufacturer.

2.3.2.1 The horizontal linearity of the test instrument shall be within ±5% over the linear range which includes 90% of the sweep length presented on the CRT screen for the longest sound path to be used. The horizontal linearity shall be measured by the techniques prescribed by Section 7.9 of ASTM E317 (Reference 4.4) except that the results may be tabulated rather than graphically presented.

2.3.2.2 Test instruments shall include internal stabilization so that after warmup, no variation in response greater than ±1 dB occurs with supply voltage change of ±15% nominal or, in the case of battery powered instruments, over the battery charge operating life. There shall be an alarm or meter to signal a drop in battery voltage prior to instrument shutoff due to battery exhaustion.

2.3.2.3 The test instrument shall have a calibrated gain control (attenuator) adjustable in discrete 1 or 2 dB steps over a range of at least 60 dB. The accuracy of the gain control settings shall be with ±1 dB.

2.3.2.4 The dynamic range of the instrument's CRT display shall be such that a difference of 1 dB of amplitude can be easily detected on the CRT.

2.3.3 Transducers

2.3.3.1 Straight beam search unit transducers shall have an active area of not less than 1/2 inch^2 nor more than 1 inch^2. The transducer shall be round or square. Transducer frequency shall be 2 to 2.5 MHz.

2.3.3.2 Angle beam search units shall consist of a transducer and an angle wedge. The unit may be comprised of the two separate elements or may be an integral unit.

2.3.3.3 The transducer frequency shall be between 2 and 2.5 MHz, inclusive.

2.3.3.4 The transducer crystal may vary in size from 1/2 to 1 inch in width and from 1/2 to 13/16-inch in height (see Figure 1).

2.3.3.5 Each search unit shall be marked to clearly indicate the frequency of the transducer, nominal angle of refraction, and index point. The index point location is determined by setting the transducer in position D on the IIW block and moving the transducer until the signal from the radius is maximized. The point on the transducer which is in line with the line on the calibration block is indicative of the point of sound entry (see Figure 4).

2.3.3.6 The search unit shall produce a sound beam in the material being tested within ±2° of the following proper angles: 70°, 60°, or 45°. The following procedure shall be used to determine sound path angle (see Figure 4):

2.3.3.6.1 Set the transducer in position B on International Institute of Welding (IIW) block for angles 40° through 60°.

2.3.3.6.2 Set the transducer in position C on IIW block for angles 60° through 70°.

2.3.3.6.3 Move the transducer back and forth over the line indicative of the transducer angle until the signal from the radius is maximized. Compare the sound entry point on the transducer with the angle mark on the calibration block.

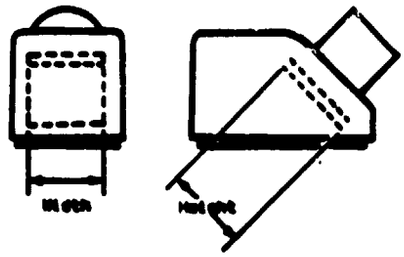


Figure 1. Transducer crystal.

2.3.3.7 The dimensions of the search unit shall be such that the closeness of approach to the weld reinforcement shall not exceed the requirements of 2.3.3.7.1. The search unit shall be positioned for maximum indication from the 0.06 inch diameter hole in the IIW calibration block.

2.3.3.7.1 The minimum allowable distance, X, between the toe and the search unit and the edge of the IIW block shall be as follows:

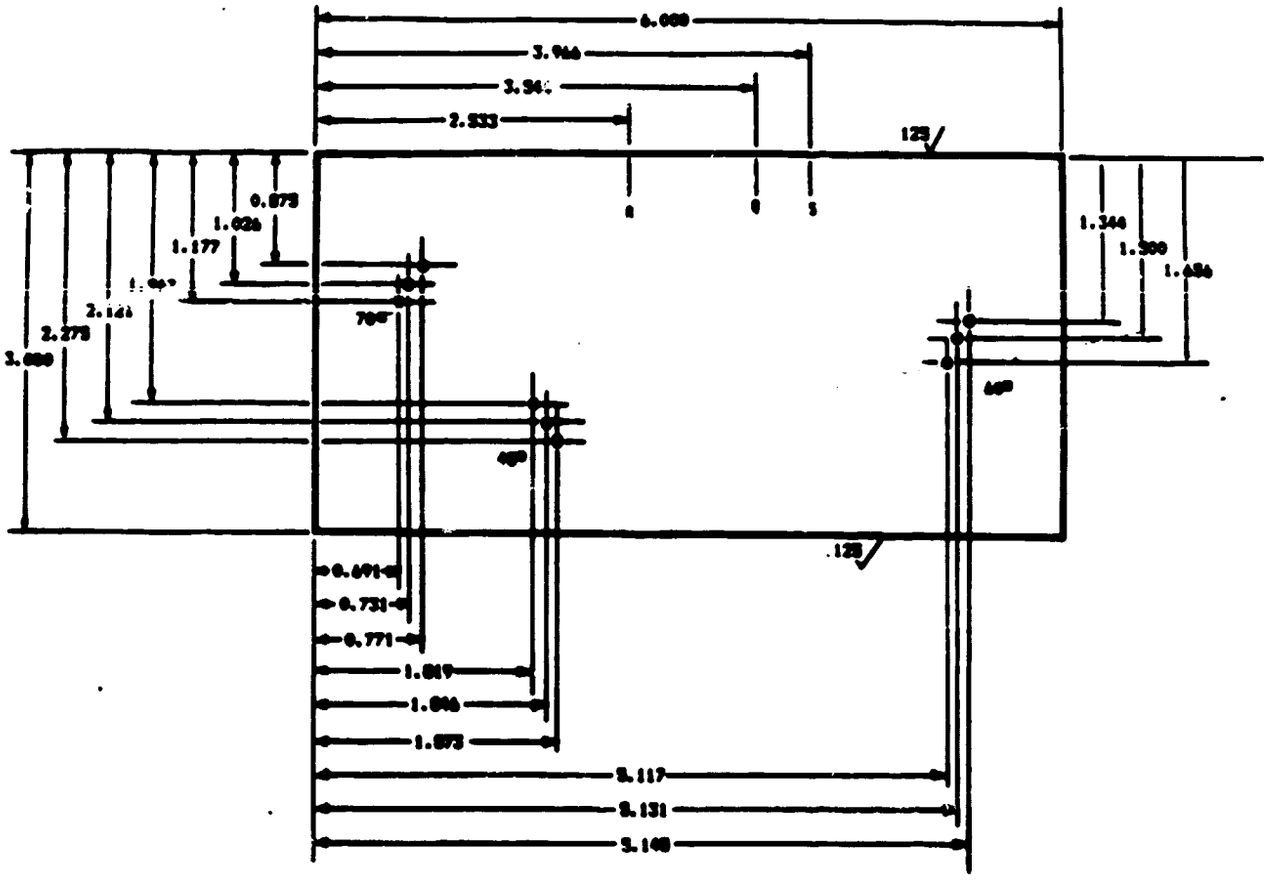
for 70° transducer, X = 2 inches
for 60° transducer, X = 1-5/8 inches
for 45° transducer, X = 1 inches.

2.3.3.8 The combination of search unit and instrument shall resolve three holes in the resolution test block shown in Figure 2. The resolution shall be evaluated with the instrument controls set at normal test settings and with indications from the holes brought to mid-screen height. Resolution shall be sufficient to distinguish at least the peaks of indications from the three holes. The transducer shall be positioned on the resolution block Q for 70° angle, position R for 60° angle, position S for 45° angle. Use position F for straight beam on the IIW block shown in Figure 4.

2.3.3.9 Internal reflections from the search unit, with a screen presentation higher than the horizontal reference line, appearing on the screen to the right of the such entry point shall not occur beyond 1/2-inch equivalent distance in steel when the sensitivity is set as follows: 20 dB more than that required to produce a maximized horizontal reference line height indication from the 0.05-inch diameter, hole in the IWW reference block.

2.3.4 Couplant

A couplant shall be used between the search unit and the metal. The couplant shall be a commercial grade with suitable wetting characteristics for ultrasound transmission into the test medium or calibration block.



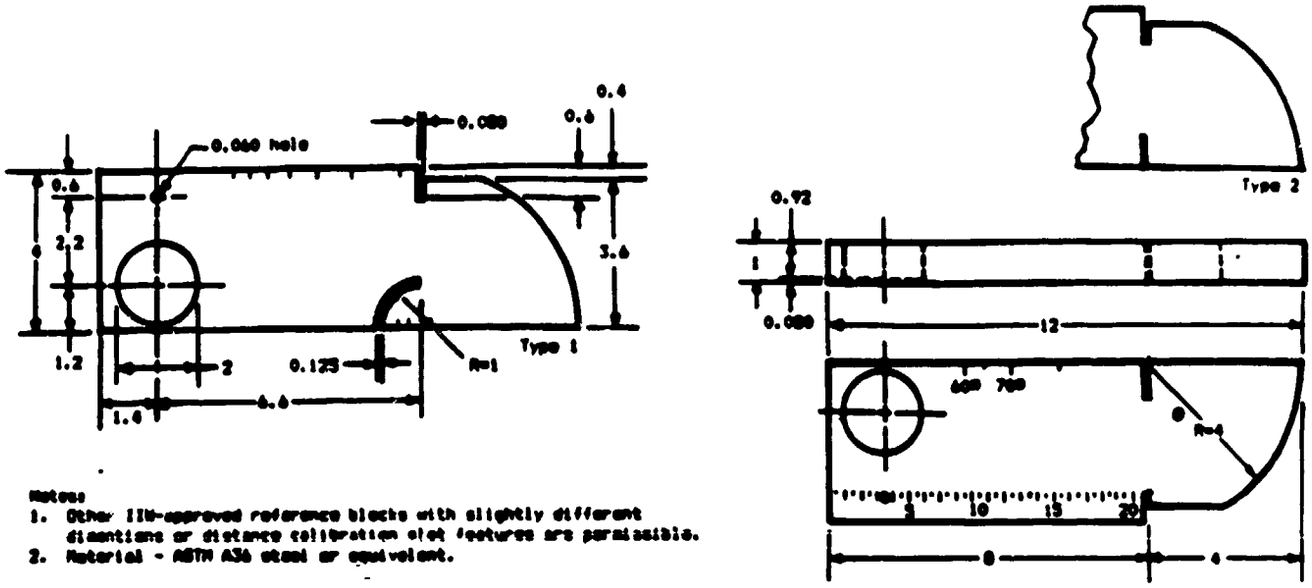
Notes
1. The test block is 3 in. x 1 in. Finish all over to a maximum of 125 in. rms.
2. Material - ASTM A36 or equivalent.
3. 1/16 in. diameter holes are to be drilled at 90 degrees to the surface.
4. Degree lines are to be scribed on the surface as shown.
5. Degree numbers are to be stamped on the surface as shown.

Figure 2. Resolution test block.

2.4 Calibration

2.4.1 Calibration Standard

2.4.1.1 The IIW ultrasonic reference block shown in Figure 3 shall be the standard used for both distance and sensitivity calibration. See Figure 4 for applications.



Notes:
1. Other IIW-approved reference blocks with slightly different dimensions or distance calibration slot features are permissible.
2. Material - ASTM A36 steel or equivalent.

Figure 3. International Institute of Welding (IIW) ultrasonic reference blocks.

2.4.1.2 The use of a "corner" reflector for calibration purposes is prohibited.

2.4.2 Equipment Calibration

2.4.2.1 The instrument's gain control (attenuator) shall meet the requirements of 2.3.2.3 and shall be checked for correct calibration at two-month intervals.

2.4.2.2 Horizontal linearity shall be checked by the technique prescribed in 2.3.2.1 after each 40 hours of instrument use.

2.4.2.3 With the use of an approved calibration block, each angle beam search unit shall be checked after each eight hours of use to determine that the contact face is flat, that the sound entry point is correct, and that the beam angle is within the permitted $\pm 2°$ tolerance. Search units which do not meet those requirements shall be corrected or replaced.

2.4.3 Standardization

2.4.3.1 Calibration for sensitivity and horizontal sweep (distance) shall be made by the ultrasonic operator just prior to and at the

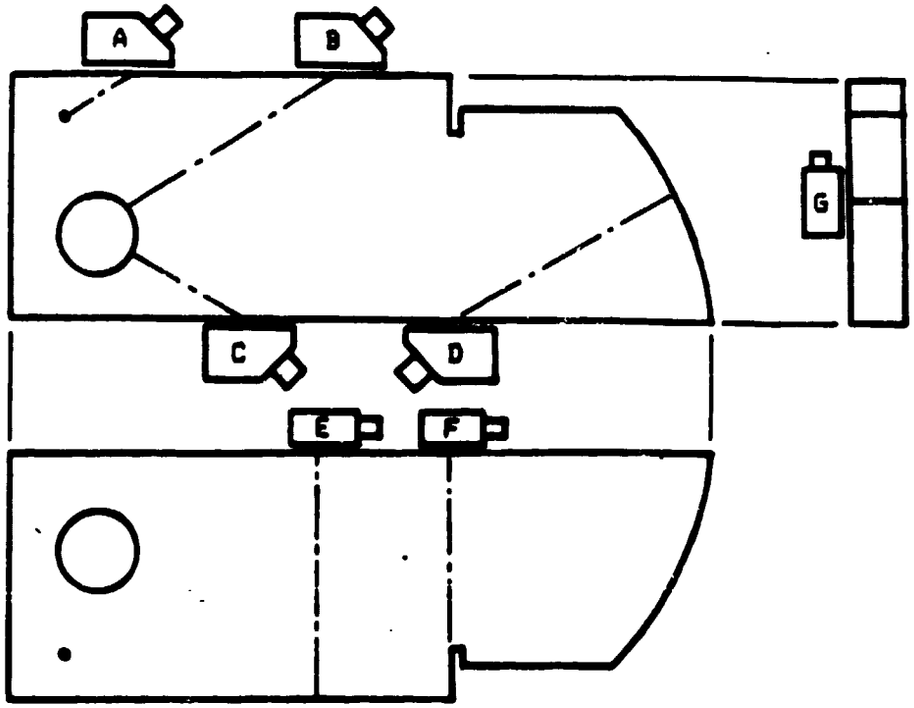


Figure 4. IIW block.

locations of testing of each weld and at intervals of 30 minutes as testing proceeds. Recalibration shall be made each time there is a change of operators, when transducers are changed, when new batteries are installed, or when equipment operating from a 110-volt source is connected to a different power outlet.

2.4.3.2 Calibration for straight beam testing shall be performed as follows:

a. The horizontal sweep shall be adjusted for distance calibration to present the equivalent of at least two plate thicknesses on the CRT screen. The transducer shall be set at position G on the IIW Block.

b. The sensitivity shall be adjusted at a location free of indications so that the first back reflection from the far side of the place will be 50 to 75% of full screen height. The transducer shall be set at position G on the IIW block. For this purpose, the reject (clipping) control shall be turned off.

2.4.3.3 Calibration for angle beam testing shall be performed as follows:

a. The horizontal sweep shall be adjusted to represent the actual sound path distance by using acceptable distance calibration block shown in Figure 3. This distance calibration shall be made using either the 5-inch scale or 10-inch scale on the CRT screen, whichever is appropriate, unless joint configuration or thickness prevents full examination of the weld at either of these settings The search unit is positioned at D on the IIW block, as shown in Figure 4, and the instrument adjusted to attain indications at 4 inches and 8 inches on type 2 block or 9-inches on type 1 block.

b. The sensitivity shall be adjusted by the use of the gain control (attenuator) so that a horizontal reference level trace deflection results on the CRT screen with the maximum indication from the 0.06-inch diameter hole in the IIW block. The transducer is positioned at A on the IIW, as shown in Figure 4, block and adjust for a maximized signal from the .06 inch hole to attain a horizontal reference line height indication. The basic sensitivity in decibels then becomes the zero reference level for discontinuity evaluation and shall be recorded on the ultrasonic test reports under reference level "b". See Attachment A for a sample ultrasonic test report form.

2.5 Testing Procedure

2.5.1 A "Y" accompanied with a weld identification number shall be clearly marked on the base metal adjacent to the weld at the left end of each weld that is ultrasonically tested. This identification number serves as an orientation direction for weld discontinuity location and as the report number on the report form.

2.5.2 All surfaces to which a search unit is applied shall be free of weld spatter, dirt, grease, oil (other than that used as a couplant), and loose scale and shall have a contour permitting intimate coupling. Tight layers of paint need not be removed unless the thickness exceeds 10 mils.

2.5.3 The entire base metal through which ultrasound must travel to test the weld shall be tested for laminar reflectors using a straight beam search unit conforming to the requirements of 2.3.3.1 and calibrated in accordance with 2.4.3.2. If any area of base metal exhibits total loss of back reflection and is located in a position that would interfere with the normal weld scanning procedure, the following alternative weld scanning procedure shall be used.

2.5.3.1 The area of the laminar reflector and its depth from the surface shall be determined and reported on the ultrasonic test report.

2.5.3.2 If part of a weld is inaccessible to testing in accordance with the requirements of Table 1, due to laminar content recorded in accordance with 2.5.3.1 the testing shall be conducted (a) using an alternative scanning pattern shown in Figure 5, or (b) by first grinding the weld surfaces flush to make total weld areas accessible to ultrasonic testing, or both.

2.5.4 Welds shall be tested using an angle beam search unit conforming to the requirements of 2.3.3.2 than 2.3.3.9 with the instrument calibrated in accordance with 2.4.3.3 using the angles as shown in Table 1. Following calibration and during testing, the only instrument adjustment permitted is in the sensitivity level adjustment with the calibrated gain control or attenuator. Sensitivity shall be increased from the reference level for weld scanning in accordance with Table 2 as applicable.

2.5.4.1 If mechanically possible, all welds shall be scanned from both sides on the same face for longitudinal and transverse discontinuities. The following scanning pattern or patterns shall be used.

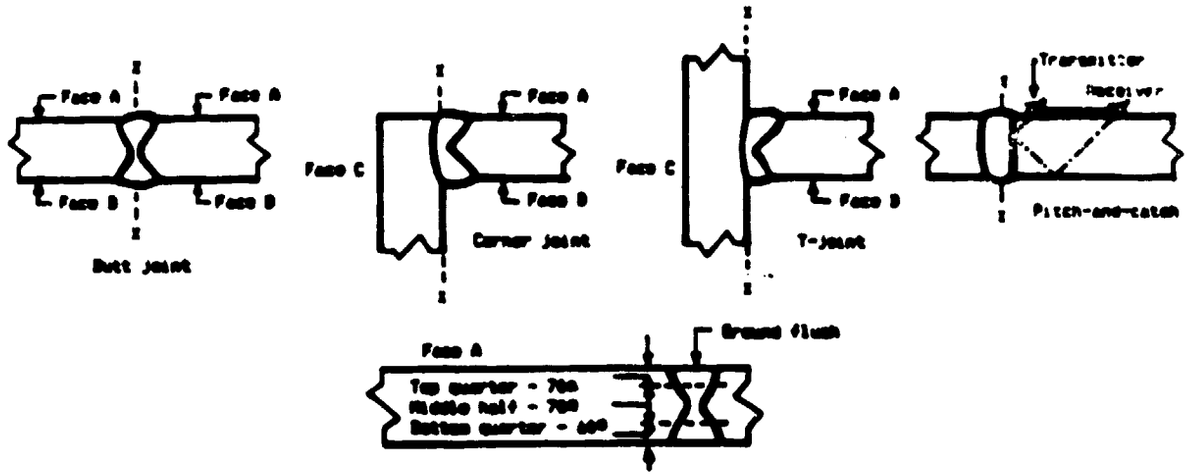
a. Scanning pattern for longitudinal discontinuities:

Scanning movement A: rotation angle a = 10°
Scanning movement B: scanning distance b shall be such that the section of weld being tested is covered

TABLE 1. TESTING ANGLE

Procedure Chart

Weld Type	Material Thickness (inches) 5/16 to 1-1/2[a]	1-1/2 to 1-3/4[a]	1-3/4 to 2-1/2[a]	2-1/2 to 3-1/2[a]	3-1/2 to 4-1/2[a]	4-1/2 to 5[a]	5 to 6-1/2[a]	6-1/2 to 7[a]	7 to 9[a]
Butt	1 0	1 F	1G or 4 F	1G or 5 F	6 or 7 F	8 or 10 F	9 or 11 F	12 or 13 F	12 F
T	1 0	1 F or XF	4 F or XF	5 F or XF	7 F or XF	10 F or XF	11 F or XF	13 F or XF	-- --
Corner	1 0	1 F or XF	1G or 4 F or XF	1G or 5 F or XF	6 or 7 F or XF	8 or 10 F or XF	9 or 11 F or XF	13 or 14 F or XF	-- --
Electrogas and electroslag	1 0	1 0	1G or 4 1[b]	1G or 5 P1 or P3	6 or 7 P3	11 or 15 P3	11 or 15 P3	11 or 15 P3	11 or 15[b] P3



NOTES:

1. All examinations shall be made from Face A unless otherwise noted on this table.
2. All butt welds shall be tested from both sides of the weld from Face A unless otherwise noted on this table.
3. All examinations shall be made in Leg I where possible or otherwise specified in this table.

TABLE 1. (continued)

4. Examinations in Leg II shall be made only to satisfy provisions of this table or when necessary to test weld areas made inaccessible by an unground weld surface or interference with other portions of the weldment.

5. A maximum of Leg III shall be used only where thickness or geometry prevents scanning of complete weld areas and heat affected zone in Leg I or Leg II.

6. On tension welds on bridges, the top quarter of thickness must be tested with the final leg of sound progressing from Face B toward Face A. The bottom quarter of thickness must be tested with the final leg of sound progressing from Face A toward Face B: i.e., the top quarter of thickness shall be tested either from Face A in Leg II or from Face B in Leg I at the contractor's option, unless otherwise specified in the contract documents.

7. Root areas of single groove weld joints which have backing strips not requiring removal by contract shall be tested in Leg I, and Face A shall be that face opposite the backing strip. (Grinding of the weld face may be necessary to permit complete scanning of the weld and heat affected zone.)

8. Procedure 6, 6, 8, 9, 12, 14, or 15 must be followed when testing welds which have been ground flush. The need for grinding may either be to satisfy contract requirements, or to provide a suitable surface for testing from Face A. Face A on both connecting members or butt welds must lie in a single plane.

Procedure Legend

	Area of Weld Thickness				Area of Weld Thickness		
Number	Top Quarter (degrees)	Middle Half (degrees)	Bottom Quarter (degrees)	Number	Top Quarter (degrees)	Middle Half (degrees)	Bottom Quarter (degrees)
1	70	70	70	9	70 G A	60	45
2	60	60	60	10	60 B	60	60
3	45	45	45	11	45 B	70[b]	45
4	60	70	70	12	70 G A	45	70 G B
5	45	70	70	13	45 B	45	45
6	70 G A	70	60	14	70 G A	45	45
7	60 B	70	60	15	70 G A	70 A B	70 G B
8	70 G A	60	60				

a. Required only where CRT referenced height indication of discontinuity is noted in fusion zone which searching at scanning level with primary procedures selected from first column.

b. Use 15 or 20 inch screen distance calibration.

TABLE 1. (continued)

LEGEND:

X Check from Face "C".

G Grind weld face flush.

O Not required.

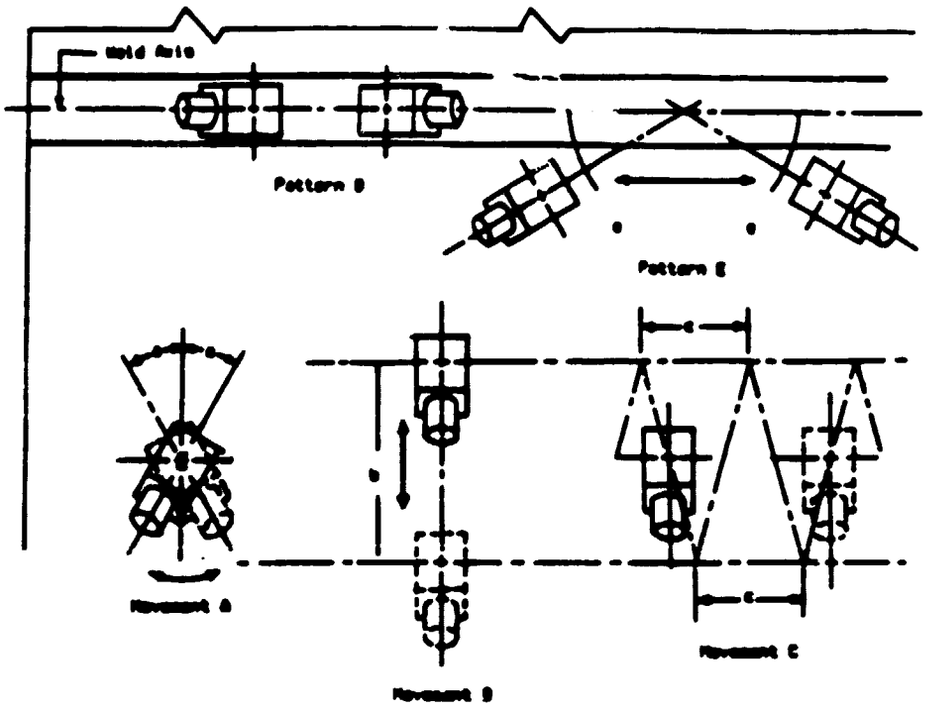
A Face The face of the material from which the initial scanning is done (on T- and corner joints, follow above sketches).

B Face Opposite the "A" face (same plate).

C Face The face opposite the weld on the connecting member or a T- or corner joint.

P Pitch and catch shall be conducted for further discontinuity evaluation in only the middle half of the material thickness with only 45° or 70° transducers of equal specification, both facing the weld. (Transducers must be held in a fixture to control positioning--see sketch.) Amplitude calibration for pitch and catch is normally made by calibrating a single search unit. When switching to dual search units for pitch and catch inspection, there should be assurance that this calibration does not change as a result of instrument variables.

F Further evaluate fusion zone indications with either 70°, 60° or 45° transducer--whichever sound patch is nearest to being perpendicular to the suspected fusion surface.



Notes:
1. Testing patterns are all symmetrical around the weld axis with the exception of pattern B which is conducted directly over the weld axis.
2. Testing from both sides of the weld axis is to be made wherever mechanically possible.

Figure 5.

TABLE 2. SCANNING LEVELS

Sound Path (inches)[a]	Above Zero Reference (dB)
To 2-1/2 (64 mm)	14
Greater than 2-1/2 to 5 (64 to 127 mm)	19
Greater than 5 to 10 (127 to 254 mm)	29
Greater than 10 to 15 (254 to 381 mm)	39

a. This column refers to sound path distance; NOT material thickness.

Scanning movement C: progression distance c shall be approximately one-half the transducer width.

NOTE: movements A, B, and C are combined into one scanning pattern.

a. Scanning patterns for transverse discontinuities:

Scanning pattern D: when welds are ground flush
Scanning pattern E: when weld reinforcement is not ground flush
Scanning angle e = 15° maximum.

NOTE: the scanning pattern is to be such that the full weld section is covered.

2.5.4.2 The testing angle shall be as shown in Table 1 and the transducer size must conform to 2.3.3.4.

2.5.5 Evaluation of Indication

2.5.5.1 When a discontinuity signal appears on the screen the transducer shall be positioned for maximum signal response. The gain control (attenuator) shall be adjusted to determine the number of decibels needed for the discontinuity signal to equal the reference level response. Record the Indication Level (A) in dB and Reference Level (B) in dB on test report (Attachment 1, Form WEP 323).

2.5.5.2 The "Attenuation Factor" "C" on the test report is attained by subtracting 1 inch from the sound path and multiplying the remainder by 2. This factor shall be rounded out to the nearest dB value. Fractional values less than 1/2 dB shall be reduced to the lower dB level and those of 1/2 or greater increased to the higher level.

2.5.5.3 The "Indication Rating" "D" on the test report (Attachment 1) is obtained by using the following:

With instruments with gain control, use formula A-B-C = D.

With instruments with attenuation control, use formula B-A-C = D.

The "Indication Rating" "D must show a plus (+) or minus (-) sign unless "D" is equal to zero.

2.5.5.4 The length of a discontinuity as entered under "Indication Length" on the test report shall be determined by locating points at each end at which the indication amplitude drops 6 dB and measuring between the point from the center of the transducer at one end to the center of the transducer at the other end.

2.6 Documentation

2.6.1 Only those discontinuities which are rejectable shall be recorded on Form WEP 323, (Attachment 1), and shall be identified under the heading, "Defect Evaluations."

2.6.2 Each rejectable discontinuity shall be indicated on the weld by a mark directly over the discontinuity, for the entire length. The depth from the surface and type of discontinuity shall be noted on near by base metal.

2.7 Qualification

2.7.1 The testing procedure and equipment qualification shall be acceptable when a successful calibration can be performed on an appropriate test block.

2.8 Acceptance Criteria

2.8.1 Any weld discontinuity shall be accepted or rejected based on the defect rating and length in accordance with Table A-1, Appendix A, (Acceptance Criteria for AWS D1.1 Welds for New Buildings).

3. DEFINITIONS

None.

4. REFERENCES

4.1 AWS D1.1, Structural Welding Code, American Welding Society, Inc., 1972 through Summer 1974 addenda.

4.2 Standard Practice WEP 3.1.8, "Examination Package Preparation."

4.3 Standard Practice WEP 4.1.2, "Training, Qualifying, and Certifying Personnel for Visual and Nondestructive Examination."

4.4 ASTM E317, Standard Practice for Evaluating the Performance Characteristics of Ultrasonic Pulse-Echo Testing Systems Without the Use of Electronic Measuring Instruments, American Society of Testing and Materials.

APPENDIX A

ACCEPTANCE CRITERIA FOR AWS D1.1 WELDS FOR NEW BUILDINGS

TABLE A-1. MINIMUM ACCEPTANCE LEVELS
(decibels)

	Weld Thickness and Transducer Angle (inches)													
Reflector	5/16 to 3/4	Greater than 3/4 to 1-1/2	Greater than 1-1/2 to 2-1/2			Greater than 2-1/2 to 4			Greater than 4 to 6			Greater than 6 to 8		
Severity	70°	70°	70°	60°	45°	70°	60°	45°	70°	60°	45°	70°	60°	45°
Large Reflector	+8	+3	-1	+2	+4	-4	-1	+1	-7	-4	-2	-9	-6	-4
Small Reflector	+9	+4	+1	+4	+6	-2	+1	+3	-5	-2	0	-7	-4	-2
Minor Reflector	+10	+5	+3	+6	+8	0	+3	+5	-3	0	+2	-5	-2	0

NOTES:

1. Discontinuities which have a more serious rating than those of minor reflectors shall be separated by at least 2L, L being the length of the larger discontinuity. Discontinuities not separated by at least 2L are considered to be one discontinuity whose length is determined by the combined length of the discontinuities plus their separation distance.

2. Discontinuities which have a more serious rating than those of minor reflectors shall not begin at a distance smaller than 2L from weld ends carrying primary tensile stress, L being the discontinuity length.

3. Discontinuities detected at scanning levels in the root-face areas of complete joint penetration double V-groove welds, double J-groove welds, double U-groove welds, and double bevel-groove welds shall be evaluated at an acceptance level 4 dB[a] more sensitive than prescribed in this table when such welds are designated on design drawings as "tension welds".

TABLE A-1. (continued)

4. Electroslag and electrogas welds--discontinuities which exceed 2 inches (51 mm) in length and occur in the middle half of such welds are to be evaluated at n acceptance level 6 dB more sensitive than the above levels.

a. Add +4 dB to the number in the table.

Large reflector	Any discontinuity, REGARDLESS OF LENGTH, having a more serious rating (smaller number) than this level shall be rejected.
Small reflector	Any discontinuity, longer than 3/4 inch (19.0 mm) having a more serious rating (smaller number) than this level shall be rejected.
Minor reflector	Any discontinuity, longer than 2 inch (51 mm) in length and having a more serious rating (smaller number) than this level shall be rejected.

Scanning Levels

Sound Path Distance (inch)	Sound Path Distance (mm)	Above Zero Reference (dB)
To 2-1/2	63.5	+14
Greater than 2-1/2 to 5	63.5 to 127	+19
Greater than 5 to 10	127 to 254	+29
Greater than 10 to 15	254 to 381	+39

ATTACHMENT 1

Form WEP 323
Rev. 9/86

ULTRASONIC TEST REPORT

Reference Document: _____
Standard Practice No. _____
Revision Date: _____

Examination Package No. _____
Group No. _____ WEP Reviewer _____

REPORT OF ULTRASONIC EXAMINATION OF WELDS

Project _____ Unit _____ Material _____

Weld Identification _____
Material Thickness _____
Weld Joint AWS _____
Welding Process _____
Remarks _____

Line number	Indication number	Transducer angle	Leg*	Decibels: Indication level a	Decibels: Reference level b	Decibels: Attenuation factor c	Decibels: Indication rating d	Defect: Length	Defect: Angular Distance (sound path)	Defect: Depth from "A" surface	Defect: Distance From X	Defect: Distance From Y	Discontinuity evaluation	Remarks
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														

NOTES:
1. In order to attain "Rating D"
   (A) With instruments with gain control, use the formula: a - b - c = d
   (B) With instruments with attenuation control, use the formula: b - a - c = d
   (C) "A + OR" sign must accompany the "D" figure unless "D" is equal to zero.
2. Distance from X used in describing the location of a weld discontinuity in a direction perpendicular to the weld reference line. Unless this figure is zero, "A + OR" sign must accompany it.
3. Distance from Y is used in describing the location of a weld discontinuity in a direction parallel to the weld reference line. This figure is attained by measuring the distance from the "Y" end of the weld to the beginning of said discontinuity.
4. Make a separate report following repairs. (Suffix report no. with R1, R2, etc.).

* Use Leg I or II.

Inspector _____ Level _____ Date _____

1. PURPOSE AND SCOPE

1.1 This Standard Practice (SP) defines the requirements for ultrasonic (UT) examination of welds in accordance with ASME Section I, III, and VIII and ANSI B31.1 (References 4.1 through 4.4). The UT examination will take place at the Department of Energy (DOE) Weld Evaluation Project (WEP) at the Tennessee Valley Authority (TVA) Watts Bar Nuclear Plant Unit 1 (WBN-1).

1.2 This SP and its applicable appendices, when used with the Examination Packages (EPs) developed according to Reference 4.5, shall constitute the written procedure. Controlled copies of each procedure shall be readily available to nondestructive examination (NDE) personnel for their reference and use.

2. RESPONSIBILITY AND PRACTICE

2.1 Description of Method--Ultrasonic examination is an NDE method in which beams of high frequency sound waves, introduced into the material being tested, are used to detect surface and subsurface flaws.

2.2 The Inspection/Examination Manager shall be responsible for compliance with this procedure.

The Level III shall be responsible for the content of this procedure and subsequent revisions.

The designated Supervisor shall be responsible to assure that only certified personnel perform examinations to this procedure.

Personnel performing examinations to this procedure shall be certified to the requirements of Reference 4.6 and shall perform the required examination in accordance with this procedure. This procedure shall be present during the performance of an examination. DRR WEP 383

2.3 Equipment/Materials

2.3.1 Ultrasonic Flaw Detector

2.3.1.1 Pulse-echo ultrasonic equipment generating frequencies over the range of 1-5 MHz shall be

used. A nominal frequency of 2.25 MHz shall be used for all examinations unless factors such as material grain size require the use of other frequencies.

2.3.1.2 The instrument shall provide linear vertical presentation within ±5% of the full screen height (base line to maximum calibrated screen height).

2.3.1.3 The equipment shall have a calibrated attenuator (gain control) accurate to ±2 dB or 20% over its range. The range shall be sufficient to allow comparison of indications beyond the viewable portion of the cathode ray tube display.

2.3.1.4 The instrument shall be checked at each use for vertical linearity and amplitude control accuracy and a record maintained to document the calibration. Instructions for instrumentation checks are given in Attachment 2.

2.3.2 Transducer

2.3.2.1 Straight beam search units should have a diameter not less than 3/4 inch and not more than 1-1/8 inches, with a transducer frequency of 2.25 MHz.

2.3.2.2 Angle beam search units shall consist of a transducer and an angle wedge. The unit may be comprised of two separate elements or be an integral unit, with a transducer frequency of 1.0, 2.25, or 5.0 MHz. The transducer may vary in size from 1/2 inch to 1 inch in width, and 1/2 inch to 13/16 inch in height. The search unit shall produce a sound beam in the material being tested within ±2° of the following allowable angles: 45°, 60° or 70°.

2.3.3 Couplant--Any commercial grade couplant having good wetting characteristics will provide for the transmission of ultrasound from the search unit to the test material.

On stainless steel and all ASME Section III welds, the total sulfur-halogen content of the couplant shall not exceed 1% weight.

2.3.4 Calibration Block

2.3.4.1 The flat calibration block shall be as shown in Figure 1.

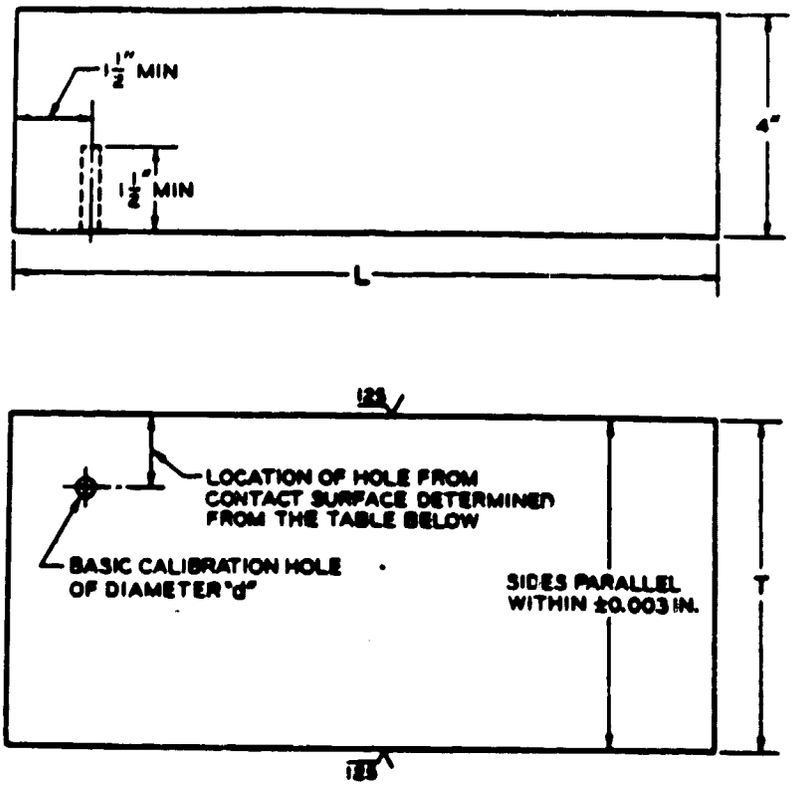


Figure 1. Calibration Block.

L = Length of block determined by the angle of search unit and the vee-path used.
T = Thickness of basic calibration block (see table below).
d = Diameter of side-drilled hole (see table below).
t = Nominal production material thickness.

Nominal Material Production Thickness (t) (inches)	Calibration Block Thickness (T) (inches)	Hole Location	Hole Diameter (d) (inches)
Up to 1 inclusive	3/4 or t	1/2 T	3/32
Over 1 through 2	1-1/2 or t	1/4 T	1/8
Over 2 through 4	3 or t	1/4 T	3/16
Over 4 through 6	5 or t	1/4 T	1/4
Over 6 through 8	7 or t	1/4 T	5/16
Over 8 through 10	9 or t	1/4 T	3/8
Over 10	t	1/4 T	See Note 1

Note 1: For each increase n thickness of 2 inches or a fraction thereof, the hole diameter shall increase 1/16-inch.

Note 2: For block sizes over 3 inches in thickness (T), the distance from the hole to the end of the block shall be 1/2 T minimum.

2.3.4.2 The material of the block shall be of similar metallurgical structure and have the same or equivalent P-number (ASME Section IX, QW 420) as the material to be examined. P-numbers 1, 3, 4, and 5 shall be considered equivalent.

2.3.4.3 For examination of circumferential welds or any longitudinal welds with a contact surface curvature of 20 inches in diameter or less, the calibration block contact surface shall also be curved.

2.3.4.3.1 The diameter of the part to be examined shall be no less than 90 percent nor more than 150 percent of the calibration block diameter.

2.3.4.3.2 Listed below are six curved blocks which will cover a 0.94- to 20-inch-diameter range.

Block Diameter (inches)	Contact Surface Diameter (inches)
1.04	0.94 - 1.56
1.7	1.56 - 2.6
2.9	2.6 - 4.3
4.8	4.3 - 7.2
8.0	7.2 - 12.0
13.33	12.0 - 20.0

2.4 System Calibration--The following calibration shall be performed prior to use in the thickness range under examination.

2.4.1 Straight Beam Calibration

2.4.1.1 A distance-amplitude correction (DAC) curve shall be constructed when examining material of 1 inch or greater thickness.

2.4.1.2 The curve shall be constructed as follows using the basic calibration block:

a. The search unit shall be positioned to obtain a maximum response from the calibration hole at 1/4 T. This is the primary reference response.

b. The signal shall be adjusted to produce a response of 1/2 of full scale on the cathode ray tube.

c. Without changing the gain control, the maximum response from the calibration hole at 3/4 T shall be determined.

d. The points representing the response from 1/4 T and 3/4 T shall be joined by a straight line extended to include the complete test range (Figure 2).

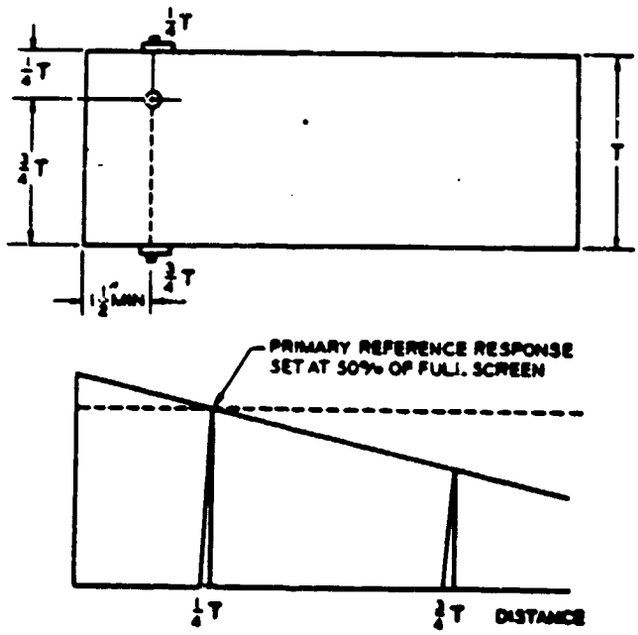


Figure 2. Typical distance amplitude correction curve; straight beam method.

2.4.2 Angle Beam Calibration--A DAC curve shall be constructed as follows using the basic calibration block:

a. The search unit shall be placed as near as possible to the calibration hole and positioned for maximum response. The approach distance shall not be less than 2 inches or 3/8 node, whichever is less.

b. The response shall be adjusted using the gain control to produce a response of 75 percent of full screen height. This is the primary reference response.

c. Without changing the gain control, the search unit shall be positioned at other locations covering the examination distance range to be used.

d. The corresponding responses shall be noted on the cathode ray tube screen.

e. These points shall be connected with a smooth curve (see Figure 3 for a typical example).

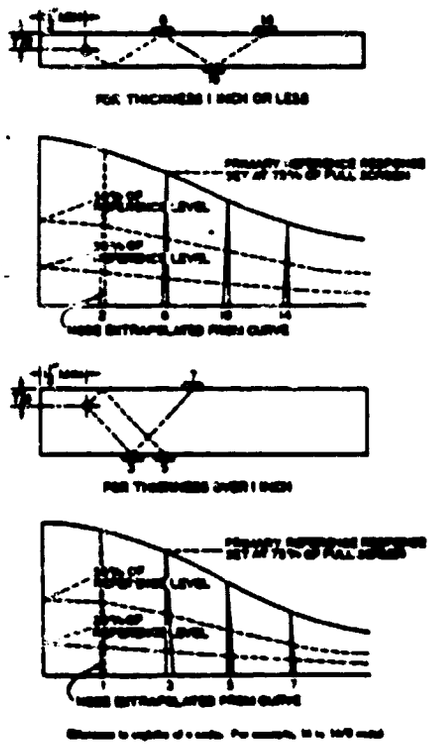


Figure 3. Typical distance amplitude correction curve; angle beam method.

2.5 Testing Procedure

2.5.1 Surface Preparation--All surfaces within the search unit contact area shall be free of irregularities, loose foreign matter, or coatings which interfere with free movement of the search unit or impair the transmission of ultrasonic vibrations. The weld surface shall be finished so it cannot mask or be confused with reflections from defects, and should merge smoothly into the surfaces of the adjacent base materials.

2.5.2 Calibration Check--A calibration shall be performed prior to and at the finish of each examination or series

of similar examinations, every 4 hours during the examination, and when examination personnel are changed. The sweep and distance amplitude correction values recorded satisfy the following requirements.

2.5.2.1 Sweep Range Correction--If a point on the DAC curve has moved on the sweep line more than 10% of the sweep reading or 5% of full sweep, whichever is greater, correct the sweep range calibration and note the correction in the Ultrasonic Examination Report (Form WEP 321). If reflectors are recorded on the data sheets, those data sheets shall be voided and a new calibration shall be recorded. All recorded indications since the last valid calibration or calibration check shall be reexamined with the corrected calibration and their values shall be changed on the data sheets.

2.5.2.2 DAC Correction--If a point on the DAC curve has decreased 20% or 2 decibels of its amplitude, all data sheets since the last calibration or calibration check shall be marked void. A new calibration shall be made and recorded and the area covered by the voided data shall be reexamined. If any point of the DAC curve has increased more than 20% or 2 dB of its amplitude, all recorded indications since the last valid calibration or calibration check shall be reexamined with the corrected calibration and their values shall be changed on the data sheets.

2.5.3 Extent and Method of Examination

2.5.3.1 The entire volume of base metal through which the sound will travel during angle beam examination of the weld shall be examined by the straight beam method to detect reflectors which would interfere with the angle beam examination. (This examination shall be used only to locate areas which would interfere with angle beam examination and shall not be used as an acceptance examination.)

2.5.3.2 The entire volume of the weld and heat-affected zone shall be examined to detect, locate, and evaluate defects oriented both parallel and perpendicular to the weld.

2.5.3.2.1 Where practical, the weld shall be examined from both sides by the angle beam method.

2.5.3.2.2 Where geometry or base metal reflectors do not permit angle beam examination from both sides (from either or both surfaces), a combination of angle beam and straight beam examination or straight beam examination from two perpendicular directions shall be used.

2.5.4 Base Material Search--Prior to initial angle beam examination, the base material through which the angle beam will travel will be scanned with a straight beam search unit to detect laminar reflectors which might affect interpretation of angle beam results. Scanning shall be accomplished at a gain setting that gives an initial back reflection amplitude of 75% to 85% of screen height from the component.

2.5.5 Angle Beam Scan

2.5.5.1 The reference level for monitoring defects shall be the primary reference level corrected for distance (Paragraph 2.4.2).

2.5.5.2 The rate of search unit movement for examination shall not exceed 6 in./second unless calibration is verified at scanning speed.

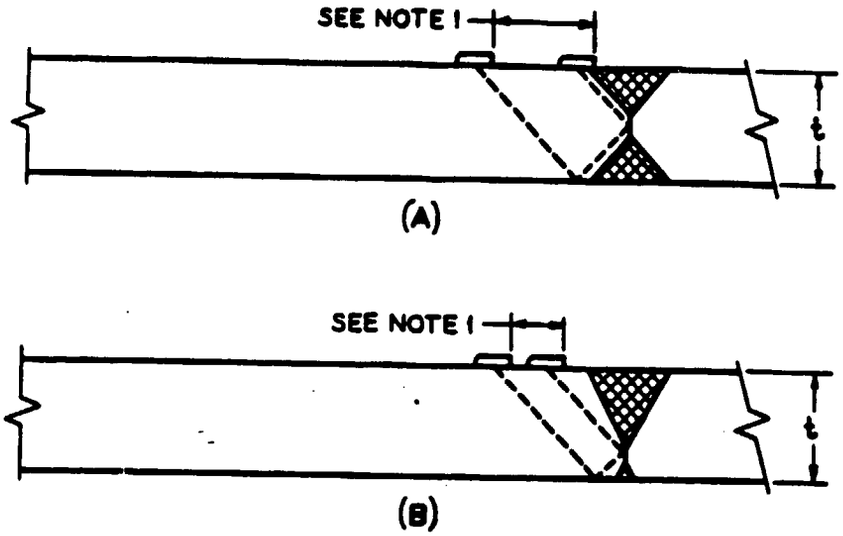
2.5.5.3 Scanning shall be performed at a gain setting of 6 dB above the reference level.

2.5.5.4 Defects parallel to the weld shall be detected as follows:

a. The angle beam search unit shall be placed on the contact surface with the beam approximately perpendicular to the weld.

b. The search unit shall be moved laterally and longitudinally so that the beam passes through the entire volume of weld metal in two different approaches. Each pass of the search unit shall overlap a minimum of 10 percent of the transducer width.

c. Double welded joints may be examined using two search units to detect lack of penetration (Figure 4).



[1] The search units position will vary because the search units must be located in relationship to the sound beam travel.

Figure 4. Typical double search unit technique for detecting lack of penetration in double welded joints.

2.5.5.5 Defects perpendicular to the weld shall be detected as follows:

a. Two search units shall be placed astride the weld.

b. They shall form an angle of less than 45 degrees with the weld (Figure 5).

c. The search units shall be manipulated such that the entire volume of weld metal is examined. Each pass of the search unit shall overlap a minimum of 10 percent of the transducer width.

d. Alternatively, if the weld surface is suitably prepared, one search unit may be placed on the weld with the beam parallel to the weld. The unit shall be manipulated such that the entire volume of weld metal is examined.

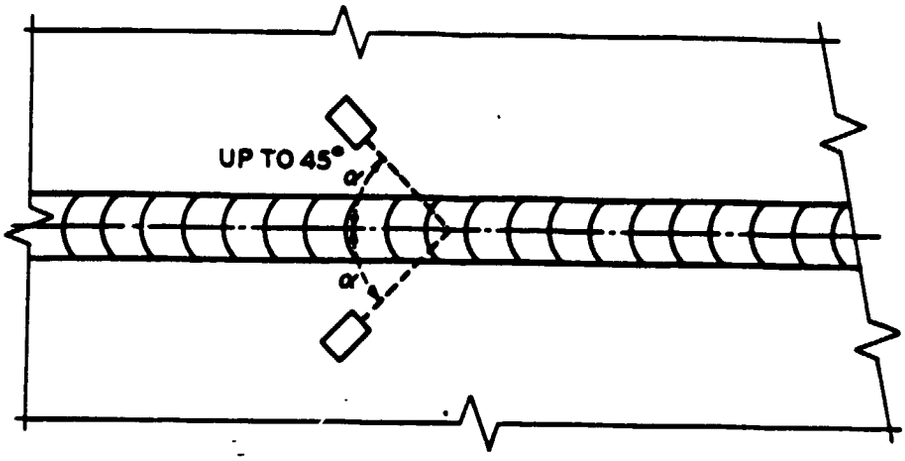


Figure 5. Typical two search unit technique for detecting transverse discontinuities.

2.5.5.6 Reflectors producing a response greater than 20 percent of the reference level shall be evaluated with the gain control at the reference level.

2.5.5.7 The reflectors shall be evaluated to determine their shape, identity, and location in relation to the acceptance criteria in Appendix A.

2.5.6 <u>Straight Beam Search</u>

2.5.6.1 Straight beam scanning may be required when angle beam scanning cannot be performed from both sides of weld.

2.5.6.2 When possible, scanning shall be performed at a gain setting of twice (6 dB) the primary reference level.

2.5.6.3 The weld shall be scanned by moving the search unit along and across a sufficient contact area to examine the entire weld. Each pass of the search unit shall overlap a minimum of 10 percent of the transducer width.

2.5.6.4 Penetration of the sound beam shall be verified by obtaining a back reflection from a parallel surface opposite to the contact surface. Alternatively, the back reflection may be obtained on a metallurgically similar material using approximately the same sound travel distance.

2.5.6.5 Reflectors which produce a response greater than 20 percent of the reference level shall be evaluated with the gain control at the reference level.

2.5.6.6 The evaluation shall be sufficient to determine the shape, identity, and location of the reflectors in relation to the acceptance criteria of Appendix A.

2.5.7 Documentation--The Ultrasonic Examination Report (Form WEP 321, Attachment 1) shall be used to document examination results and process variables.

2.5.8 Acceptance Criteria--For determination of the appropriate acceptance criteria, inspectors shall use the acceptance criteria referenced in the examination package which was developed according to Reference 4.5.

2.6 Variations in testing procedure, equipment and acceptance standards included in this SP as an Appendix may be used when configuration or material require. Variation shall be approve by a Level III Examiner before use.

2.7 Procedure and equipment qualification shall be acceptable when a satisfactory calibration on the appropriate calibration block is performed for each examination. Calibration information shall be included in the examination package.

3. DEFINITIONS

None.

4. REFERENCES

4.1 American Society of Mechanical Engineers (ASME), Power Boilers, Section I, 1974 Edition.

4.2 American Society of Mechanical Engineers (ASME), Nuclear Power Plant Components, Section III-Division 1, 1974 Edition.

4.3 American Society of Mechanical Engineers (ASME), Pressure Vessels, Section VIII, 1974 Edition.

4.4 American National Standards Institute (ANSI), Power Piping, 1973 Edition through Summer 1974 addenda.

4.5 Standard Practice WEP 3.1.8, "Preparation of the Examination Package."

4.6 Standard Practice WEP 4.1.2, "Training, Qualifying, and Certifying Personnel for Visual and Nondestructive Examination."

APPENDIX A

ACCEPTANCE CRITERIA FOR ASME SECTION I, III, VIII AND ANSI B31.1

1. Discontinuities are unacceptable if the amplitude exceeds the reference level, and discontinuities have lengths which exceed:

   A. 1/4 inch for t up to 3/4 inch, inclusive

   B. 1/3t for t from 3/4 inch to 2 1/4 inches, inclusive

   C. 3/4 inch for t over 2 1/4 inches

   where t is the thickness of the weld being examined; if a weld joins two members having different thicknesses at the weld, t is the thinner of these two thicknesses.

2. Where discontinuities are interpreted to be cracks, lack of fusion, or incomplete penetration, they are unacceptable, regardless of discontinuity or signal amplitude.

3. Record all responses with an amplitude greater than reference level except for ASME Section VIII where all responses greater than 50 percent of the reference level are documented.

ATTACHMENT 1

Form WEP 321
Rev. 5/86

ULTRASONIC EXAMINATION REPORT

Page __ of __

Examination Package No. _____ Reference Document: _____
Group No. _____ Standard Practice No. _____
WEP Reviewer _____ Date _____ Revision Date _____

Weld No. _____ Unit _____ System _____
Material _____ Thickness _____
Weld Configuration _____
Equipment: Make _____ Model _____ S/N _____
Transducer: Type _____ Frequency _____ Size _____ Angle ____°
Calibration Block: Material _____ ID No. _____
Couplant: _____

Location and Identification Sketch

Weld Acceptable _____ Weld Rejectable _____

UT Technician _____ Level _____ Date _____

ATTACHMENT 1

Form WEP 321
Rev. 5/86

ULTRASONIC EXAMINATION REPORT

Page __ of __

AMPLITUDE LINEARITY CHECK	
LARGER INDICATION % FULL SCREEN	SMALLER INDICATION % FULL SCREEN
100	
90	
80	40
70	
60	
50	
40	
30	
20	

AMPLITUDE CONTROL		LINEARITY	
INITIAL INDICATION % FULL SCREEN	dB CONTROL CHANGE	FINAL INDICATION % FULL SCREEN	
		ACTUAL	REQUIRED
80	−6		32 - 48
80	−12		16 - 24
40	+6		64 - 96
20	+12		64 - 96

REFLECTION TYPE: ☐ SHOE FACE ☐ CAL BLOCK SERIAL NO. _____ INSTRUMENT SERIAL NO. _____

ATTACHMENT 2

INSTRUCTIONS FOR INSTRUMENTATION CHECKS

1. Amplitude Linearity--Position an angle-beam search unit as shown in Figure 6 so that indications can be observed from both the 1/2-and 3/4-T holes in a suitable calibration block. Adjust the search unit position to give a 2 to 1 ratio of amplitudes between the two indications, with the larger set at 80% of full-screen height. Without moving the search unit, adjust the sensitivity (gain) to successively set the larger indication from 100% to 20% of full-screen height, in 10% increments (or 2 dB steps if a fine control is not available), and read the smaller indication at each setting. The reading must be 50% of the larger amplitude, within 5% of full-screen height. The settings and readings must be estimated to the nearest 1% of full screen.

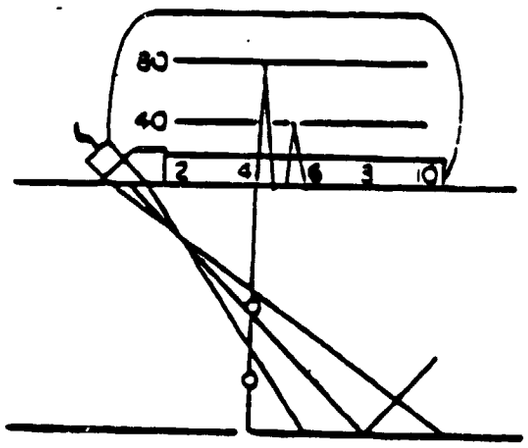


Figure 6. Linearity.

2. Amplitude Control Linearity--Position an applicable search unit on a wedge or suitable calibration block such that an indication from a back surface or calibration hole or notch is peaked on the screen. With the increases and decreases in attenuation, shown in the following table, the indication must fall within the following specified limits. Estimate the readings to the nearest 1% of full screen. Record linearity checks on Form WEP 321.

Indication (Percent of Full Screen)	dB Change[a]	Indication Limits (Percent of Full Screen)
80	-6 dB	32-48
80	-12 dB	16-24
40	+6 dB	64-96
20	+12 dB	64-96

a. Minus (-) denotes decrease in amplitude; plus (+) denotes increase.

APPENDIX B

PROCEDURE FOR THE DETECTION OF PARTIAL PENETRATION SQUARE GROOVE BUTT WELD JOINTS IN FIRE PROTECTION PIPING SYSTEMS

Scope

This procedure details the requirements and specifies the technique to be employed for detecting partial penetration square groove butt weld joints in fire protection piping systems, using manual ultrasonic examination methods.

Procedure

Weld Surface Preparation. Each weld to be tested shall have a 1-inch circumferential length of weld reinforcement prepared by flush grinding.

Instrument Linearity. Instrument horizontal and vertical linearity shall be confirmed prior to testing.

Horizontal Linearity. Using a 1/4 inch x 5 MHz pulse-echo longitudinal wave transducer, establish a minimum of 10 Cathode Ray Tube (CRT) reflections (back reflection and nine multiple reflections) from the 1-inch thickness of the International Institute of Welding (IIW) block.

Using the sweep delay control, position the first reflection at increment zero (0) on the CRT time base.

Using the sweep length control, position the tenth reflection at increment 9 on the CRT time base.

The latter adjustment will alter the position of the first reflection. Adjust first the sweep length and then the sweep delay control until the first and tenth reflections are simultaneously positioned and aligned at increments zero and nine, respectively.

Observe the positions of the intermediate reflections. These should align at increments 1, 2, 3, 4, 5, 6, 7, and 8, exactly.

Vertical Linearity. Using a 1/4 inch x 5 MHz pulse-echo longitudinal wave transducer, establish 2 reflections on the CRT using any convenient IIW Block reflectors.

Adjust the gain control and the position of the transducer on the IIW block until one reflection is adjusted to 40% full-screen height (FSH) in amplitude, and the other to 20% FSH.

Holding the transducer steady in position, increase the instrument gain by 6 decibels (dB). The 40% FSH reflection should rise to 80% FSH. The 20% FSH reflection should rise to 40% FSH.

Longitudinal Wave Time Base Calibration. The thickness of the (pipe) parent metal is to be determined prior to the application of shear wave tests, and the parent metal on both sides of the weld shall be examined to ensure the absence of laminar reflectors. Calibration for longitudinal wave tests shall be accomplished as follows:

Place a 1/4 inch x 5 MHz transmit-receive (T-R) transducer on the 1-inch thickness of the IIW Block.

Establish 2 CRT reflections and adjust the first reflection to increment 0, using the sweep delay control.

Adjust the second reflection to increment 10 on the CRT, using the sweep length control.

The latter adjustment will alter the position of the first reflection. Adjust first the sweep delay and then the sweep length control until the two reflections are simultaneously positioned and aligned at increments 0 and 10, respectively.

Using only the sweep delay control, reposition the first reflection so that it aligns with increment 10 instead of increment 0. This will roughly establish a 1-inch screen range.

Place the transducer on a 0.3-inch-thick step in a calibrated step wedge.

Using first the sweep delay and then the sweep length control, adjust the resulting reflections so that they align with increments 3, 6, and 9. This provides fine adjustment of the 1-inch screen range calibration.

Place the transducer on the pipe adjacent to the weld being tested.

Read the pipe thickness within 0.02 inch directly from the CRT, and record this dimension.

Repeat the thickness reading on the opposite side of the weld.

Scan both sides for laminar reflectors (in the test area only).

Shear Wave Time Base Calibration. Connect a 1/4 inch x 2.25 MHz x 45° shear wave pulse-echo transducer to the test instrument.

Place the transducer on the IIW Block near the index point marking so that a reflection is obtained from the 4-inch radius of the block (quadrant). Move the transducer forward and backward while observing the amplitude of the reflection from the quadrant. At the point at which the movement results in the maximum signal height (amplitude), the sound exit point is indicated directly opposite the index point marking on the block. Ensure that the exit point is marked on the transducer.

Place the transducer on the IIW block so that a reflection is obtained from the 2-inch diameter plastic-filled hole.

Move the transducer forward and backward while observing the amplitude of the reflection from the hole. At the point at which the movement results in the maximum signal amplitude, the central beam angle of the shear wave is indicated on the block directly opposite the sound exit point mark on the transducer. This angle should be 45° ± 2°.

Position the transducer on the IIW Block to obtain two simultaneous reflections from the 2-inch and 4-inch quadrants of the block.

Move the transducer forward and backward until the amplitude of the two refections is maximized.

Hold the transducer steady in position. Using the sweep delay, adjust the reflection from the 2-inch quadrant until it aligns with increment 0 on the CRT.

Using the sweep length control, adjust the reflection from the 4-inch quadrant to increment 10 on the CRT.

The latter adjustment will alter the position of the first reflection. Adjust first the sweep delay and then the sweep length control until the two reflections are simultaneously positioned and aligned at increments 0 and 10, respectively.

Using <u>only</u> the sweep delay control, reposition the reflection from the 2-inch quadrant so that it aligns with increment 10 instead of increment 0. This will establish a 2-inch screen range. Each minor increment on the CRT will have a value of 0.040 inch.

<u>Mock-Up Standardization</u>: Select a mock-up specimen that has the same nominal wall thickness as the weld which is to be tested.

Place the transducer on the mock-up so that a reflection is obtained from the bottom corner of the pipe edge at 1/2 node.

Adjust the instrument gain control so that the maximized reflection from the bottom corner is 100% FSH.

Using a china marker crayon, or similar, place a vertical mark on the CRT that coincides with the bottom corner reflection position. Label this line with a "B."

Reposition the transducer to obtain a reflection from the pipe edge top corner at 1 full node.

Place a vertical mark on the CRT that coincides with the position of the top corner reflection. Label this line with a "T."

Repeat this procedure to obtain a reflection from the bottom corner of the pipe edge at 1-1/2 inch node, and mark the screen accordingly.

Repeat this procedure to obtain a reflection from the top corner of the pipe edge at 2 Node, and mark the screen accordingly.

Test Application. Apply couplant to the test area and scan across the weld while observing the CRT.

If no CRT reflections occur, the weld is a full penetration weld.

If reflections occur at CRT positions corresponding to both "B" and "T," the weld is a partial penetration square butt weld.

Indications occurring at position "B" only shall be observed while scanning from both sides of the weld.

Indications at "B" that are visible only when scanning from one side of the pipe do not indicate a partial penetration square butt weld.

Indications at "B" that are visible when scanning from both sides of the pipe may indicate a partial penetration weld, or may indicate internal root reinforcement.

Generally, root reinforcement will shift the indication to the right of the "B" to a significant degree. Straight scan can be used to verify root reinforcement.

Verification. This procedure was verified by actual demonstration on mock-up samples.

R. A. Vasek LEVEL III
Approved

APPENDIX C

PROCEDURE FOR MEASURING DEPTH OF WELD PENETRATION IN AUSTENITIC STAINLESS STEEL VEE GROOVE WELDS

Scope

This procedure details the requirements and the techniques to be employed for the measurement of depth of weld penetration in austenitic stainless steel vee groove welds, using the ultrasonic test method (UT).

Test Surface Preparation. Prior to test, the weld shall be ground flush in a minimum of three spots about the pipe circumference. The circumferential length of each spot shall be a minimum of 1 1/2 inch.

Procedure

Longitudinal Wave Testing. Each prepared test spot shall have the depth of weld penetration determined using longitudinal wave testing.

1. Connect a 1/4-inch diameter, 5-MHz transmit-receive (T-R) transducer to the UT instrument.

2. Calibrate the CRT time base to obtain a 1-inch screen range, per Standard Practice WEP 3.2.9.

3. Place the transducer on the prepared test area directly over the approximate weld center and observe the CRT.

4. Manipulate the transducer on the weld while observing the CRT. When the minimum CRT time base reading is obtained, record this value as the weld depth of penetration.

Shear Wave Testing. In order to ensure that planar root reflectors do not exist which would not be detected by longitudinal wave tests, each prepared spot shall also be examined using shear waves.

1. Mark the position of the approximate weld centerline directly on the test specimen. This line will be a datum (reference) point for future measurements.

2. Connect a 1/4-inch, 2.25-MHz, 45 degree Pulse-Echo shear wave transducer to the UT instrument.

3. Calibrate the CRT time base to obtain a 2-inch screen range, per Standard Practice WEP 3.2.9.

4. Place the transducer on the pipe at approximately 1/2-skip or 1-1/2-skip distance from the weld centerline.

5. Manipulate the transducer while observing the CRT. Record the metal path distance of any reflections that appear on the CRT, along with the corresponding probe exit point distance from the weld centerline.

6. Place the transducer on the pipe on the opposite side of the weld at approximately 1/2-skip or 1-1/2-skip distance from the weld centerline.

7. Manipulate the transducer while observing the CRT. Record the metal path distance of any reflections that appear on the CRT, along with the corresponding probe exit point distance from the weld centerline.

Reflector Evaluation.

1. Disregard all shear wave reflectors that are detectable from only one side of the weld. These reflectors shall be considered nonrelevant for the purposes of this examination.

2. Calculate the depth and projected surface position of each shear wave reflector that was detectable from both sides of the weld.

3. Using a full-scale drawing of the weld joint, plot the position of each relevant reflector.

4. Reflectors that appear to be planar root shall be noted.

5. When planar root reflectors are detected, the weld depth of penetration data obtained using longitudinal wave tests shall be considered void.

Verification. This procedure was verified by actual demonstration or mock-up samples.

Approved LEVEL III

APPENDIX D

PROCEDURE FOR MEASURING THICKNESS WITH A PULSE-ECHO FLAW DETECTOR

Scope. This procedure specifies the technique for thickness measurements using a pulse-echo flaw detector.

Equipment. Test shall be made using a pulse-echo flaw detector with a digital display. Transducers may be either 1/4 inch x 5 MHZ, for thinner sections, or 3/8 inch x 2.25 MHZ, for thicker sections, straight beam.

The calibration block shall have the same nominal acoustic velocity as the test material. The block may be a step wedge of varying thickness whose range includes the thickness of the test material whose thickness is measured with a calibrated precision mechanical instrument. Instrument horizontal linearity shall be confirmed prior to and at the end of each shift of testing.

Horizontal Linearity. Using a 1/4 inch x 5 MHz pulse-echo longitudinal wave transducer, establish a minimum of 10 CRT reflections (back reflection and 9 multiple reflections) from the 1-inch thickness of the International Institute of Welding (IIW) block.

Using the sweep delay control, position the first reflection at increment 0 on the CRT time base.

Using the sweep length control, position the tenth reflection at increment 9 on the CRT time base.

The latter adjustment will alter the position of the first reflection. Adjust first the sweep length and then the sweep delay control until the first and tenth reflections are simultaneously positioned and aligned at increments 0 and 9, respectively.

Observe the positions of the intermediate reflections. These should align at increments 1, 2, 3, 4, 5, 6, 7, and 8, exactly.

Procedure. Select one calibration block thinner than the material to be tested and one thicker.

Place the transducer on the thinner calibration section. Adjust the sweep and delay controls to display the back reflection at a convenient area of the CRT. Using the gain reject and damping controls, obtain a sharp signal about 80% full screen height.

Adjust the gate controls to obtain a digital readout. Use the zero adjust to set the digital to the known thickness.

Place the transducer on the thicker calibration section and use the material calibration control to adjust the digital to the known thickness.

Alternate between the thicker and the thinner calibrations while adjusting the controls to obtain the proper readings.

The instrument will now measure thicknesses between the calibration points.

The gain control may be adjusted during testing to obtain a signal of the proper amplitude.

Documentation. The thickness readings, the calibration standard and the instrument identification shall be recorded on Form WEP 302 or other forms as required by examination package instructions.

Qualifications. This procedure is qualified at each use by satisfactory calibration.

Approved LEVEL III

PATS-1361 (Rev. 11/85)

EG&G Idaho, Inc. STANDARD PRACTICE DOE Weld Evaluation Project	Title: PERFORMANCE OF EXAMINATION	No.: WEP 3.2.10 Rev 3
		Page 1 of 3
		Date: 10/06/86
	Approved: Kenta Thy	REVISIONS: Vertical line, right margin
Reviewed By:		

1. PURPOSE AND SCOPE

To specify the methods used to record the results of physical plant inspections, review of associated records, and transfer of inspection data. These inspections will be used in support of the Department of Energy (DOE) Weld Evaluation Project (WEP).

2. RESPONSIBILITY AND PRACTICE

2.1 Project Administration and Control (PAC) will notify Inspection and Examination (I/E) that Examination Packages are ready for inspection. DRR WEP 505

2.2 Upon notification per 2.1 above, the I/E Manager is responsible for:

a. Scheduling work to be performed

b. Obtaining the EP from Configuration Management (CM).

2.3 The I/E inspectors are responsible for performing inspections as specified in the EP. Prior to performing the inspection, the inspector shall re-estimate the component accessibility to ensure that the weld(s) specified in the EP are 100% accessible. If the welds are estimated as inaccessible, Standard Practice 3.1.7, the inspector shall not perform the inspection.

If during the inspection activity, results indicate that a portion of the component/weld(s) is inaccessible, the inspector shall complete the inspection as stated in the Examination Package.

2.4 When mutually agreed upon and documented by WEP and TVA, I/E inspectors may inspect welds when portions of the weld(s) are inaccessible. For those portions of the weld(s) deemed inaccessible, the inspector shall prepare a Deviation Report, Standard Practice 3.2.2.

2.5 The Inspector will record the results of the completed examination on the Examination Record Form as follows:

a. If the attribute is acceptable, stamp and date the Examination Record Form.

b. If the attribute is unacceptable, stamp and date the Examination Record Form with the D-stamp and prepare a Deviation Report, for all rejected items resulting from the examination process.

c. If the attribute(s) is not applicable to the examination, the spector shall mark the accept/reject box with an "N/A" and initial and date. For multiple attributes, cross through from corner to corner and initial and date. DRR WEP 505

2.6 The I/E Supervisor will review the completed Examination Package for:

a. Completeness and accuracy of Examination Record Form

b. Inspector is qualified and certified to perform examination.

2.7 Once the I/E Manager or designee has approved the Examination Record Form, the package will be transferred to Configuration Management.

2.8 Transfer of Inspection Data

2.8.1 Transfer of inspection data shall be performed by the original inspector. When this is not possible, the Inspection/Examination Supervisor or Level III shall perform this function.

2.8.2 Prior to the transfer of inspection data, the inspector shall become familiar with the inspection requirements (acceptance criteria) at the time the original inspection was performed. If there is no observed change in the inspection requirement, the inspector shall stamp-off the corresponding attribute on the appropriate form and date the stamp impression with the date of the transfer. If the inspection requirements have changed since the original inspection, the inspector shall review the inspection data and determine acceptance or rejection based on the examination procedure in effect on the day of the review/transfer. If during the review of inspection data the inspector determines there is no objective evidence that inspection requirements (acceptance criteria) have been satisfied, the inspector shall re-examine the hardware for that attribute.

2.8.3 If activities require reexamination the activity shall be identified by an asterisk and the note "reexamined" shall be added to the examination record.

2.8.4 The words "Inspection Data Transfered," form number and form revision date shall be added to the top of the original examination record.

3. DEFINITIONS

3.1 D-stamp--Identifies rejected items.

4. REFERENCES

4.1 Standard Practice WEP 3.1.7, "Weld Accessibility Assessment."

4.2 Standard Practice WEP 3.2.2, "Reporting Deviations to TVA."

1. PURPOSE AND SCOPE

To detail the requirements and technique to be used for characterization of weld discontinuities using the ultrasonic test method employing conventional A-scan equipment. Characterization shall include a determination of a discontinuity's depth, length, height, and orientation, and a classification of a discontinuity as either planar, cylindrical, or spherical. Characterization may also include further description of a discontinuity as to its metallurgical nature, i.e., slag, lack of fusion, etc., when sufficient data are available to enable such determination to be made. Characterization shall be accomplished using both longitudinal and shear wave scans. Discontinuity dimensions and orientation shall be derived by the use of amplitude drop (dynamic probe) techniques.

2. RESPONSIBILITY AND PRACTICE

2.1 General

2.1.1 The Inspection/Examination Manager shall be responsible for compliance with this procedure.

2.1.2 The Level III Examiner shall be responsible for the content of this Weld Evaluation Project Standard Practice (WEP SP 3.2.15) and its subsequent revisions.

2.1.3 The designated Supervisor shall ensure that only certified personnel perform examinations to this procedure.

2.1.4 Personnel performing examinations to this SP (WEP 3.2.15) shall be certified to the requirements of SP WEP 4.1.2.

2.1.5 This SP (WEP 3.2.15) shall be present during the performance of an examination and the required examinations performed in accordance with it.

2.2 Test Specimen Marking

2.2.1 The weld centerline shall be physically marked on the test specimen.

2.2.2 Prior to scanning, the test specimen thickness is to be determined, and a calculation shall be made of the half and full-skip distances for each of the nominal angles to be used during examination.

2.2.3 A line shall be physically marked at the half-skip distance on the test specimen, parallel to the weld axis, measured from the inside-opposite joint preparation edge (weld toe or root). This will be the forward scan point.

2.2.4 A line shall be physically marked at the full-skip distance on the test specimen, parallel to the weld axis, measured from the outside-near joint preparation edge (weld toe or root). This will be the rear scan point.

2.2.5 A line shall be physically marked on the test specimen, perpendicular to the weld axis, which will serve as the X-datum. The position chosen for the X-datum shall be adequately described and reported on the test record to enable positive relocation.

2.3 Longitudinal Wave Scanning

2.3.1 The entire base metal volume between the rear scan line and the weld toe shall be scanned using a longitudinal wave transducer to detect laminar reflectors.

2.3.2 The depth of all base material reflectors shall be recorded, and the length, width, shape, and distance from the X-datum of each such reflector shall be determined using the 6 dB drop (half amplitude drop) technique, and shall be recorded on Form WEP 337, Ultrasonic Test Report (Attachment 1).

2.3.3 If the weld volume to be examined is accessible for longitudinal wave examination, such examination shall be made. The depth of all reflectors shall be recorded, and the dimension of each reflector shall be determined and recorded on Form WEP 337, using the 6 dB drop technique. Additionally, the reflective and characteristic of each discontinuity shall be recorded (i.e., specular or faceted) along with the distance of the discontinuity from the X-datum.

2.4 Shear Wave Scanning

2.4.1 The vertical beam profile of each shear wave transducer to be used for characterization shall be established and plotted. This plot is to be constructed using the .060-inch diameter side-drilled hole in the IIW block, and shall include the beam leading edge, beam center, and beam trailing edge. The leading and trailing edges are to be plotted at the 20-decibel (dB) drop points (see sample of Composite Plot Figure 1).

2.4.2 The weld to be examined shall be drawn, full-scale and cross-sectional, on a transparent plastic grid (see sample, Figure 1). If the weld is to be scanned in the second leg, an identical but inverted (mirror image) sketch of the weld shall also be drawn.

2.4.3 The entire weld volume shall be scanned using shear waves. The weld shall be scanned by moving the transducer exit point between the forward and rear scan lines. A minimum of 50% overlap between traverses shall be maintained.

2.4.4 Gain settings for initial scanning shall be established by positioning the transducer such that the beam passes through the weld joint. The gain setting will be such that grass just begins to uniformly appear across the sweep.

2.4.5 The weld shall be scanned from both sides and all accessible surfaces. The length of all discontinuities detected shall be determined using a 6-dB drop technique, and the discontinuity distance from the X-datum shall be recorded. A plan-view, scaled sketch of each discontinuity shall be produced using on Form WEP 337.

2.4.6 The depth, height, and orientation of the most reflective area of each discontinuity shall be determined and recorded. Depth is to be determined using the central beam. Height and orientation data shall be obtained using the 20-dB drop technique for specular reflectors, and by using the maximum amplitude drop technique for faceted reflectors.

2.4.7 The characteristic of the reflection shall be recorded as being either specular or faceted.

2.4.8 Each discontinuity will be classified as being either cylindrical, spherical, or planar. This is to be accomplished by moving the transducer forward and backward, toward and away from the discontinuity, while observing the CRT display. The reflection from planar discontinuities will remain constant in amplitude; the reflection from cylindrical or spherical discontinuities will rapidly decrease in amplitude. To distinguish between cylindrical and spherical reflectors, move the transducer in a short arc around the discontinuity. Spherical discontinuities will remain essentially constant in amplitude, whereas the amplitude of cylindrical discontinuities will rapidly vary.

2.4.9 If a discontinuity reflection can be obtained from more than one side, an attempt may be made to further characterize the discontinuity. Generally, planar indications are cracks, lack of fusion, and lack of penetration. A discontinuity that has a specular reflection when scanned from one side, and a faceted reflection when scanned from the opposite side, will be a lack of fusion. Cracks tend to be faceted on both sides. Lack of penetration is specular and can be detected from both sides of a joint. A planar root discontinuity detectable from only one side of the joint will normally be mismatch. Lack of fusion is occasionally cylindrical when it lies between beads (interbead). However, it will produce a specular reflection. Slag, which is also a cylindrical discontinuity, will produce a faceted reflection from all sides. Porosity tends to be spherical in most instances.

2.4.10 Using the beam profile and transparent overlay of the weld cross-section (see sample of Beam Profile Figure 2), plot the top, center, and bottom of each detected discontinuity. A copy of the composite plot for each discontinuity detected shall be attached Form WEP 337, Ultrasonic Test Report.

2.4.11 Evaluate each discontinuity based upon its orientation and position in the weld joint, along with its reflective characteristic and shape. Report the evaluation of each discontinuity using on Form WEP 337.

2.4.12 Reference shall be made to the WEP examination package. Discontinuities that have been characterized shall be compared to the sought condition(s) listed in the examination package, and, if identical, shall be recorded using a Discrepancy Report (DR; Form WEP 313) according to SP WEP 3.2.2; discontinuities that can be characterized that do not represent the sought condition referred to by the examination package shall be recorded using TVA-supplied Form 999, and submitted to TVA for evaluation. DRR WEP 516

2.4.13 Discontinuities that cannot be characterized shall be recorded using a DR (Form WEP 313) according to SP WEP 3.2.2.

3. DEFINITIONS

None.

4. REFERENCES

4.1 Standard practice WEP 4.1.2, "Training, Qualifying, and Certifying Personnel for Visual and Nondestructive Examination."

4.2 Standard Practice WEP 3.2.2, "Reporting Deviations to TVA."

ATTACHMENT 1

Form WEP 337
Rev. 08/86a

ULTRASONIC TEST REPORT

Examination Package No.: _____
Component Identification No.: _____

Reference Document:
Standard Practice No.: _____
Revision Date _____

Test Item Description:

Weld Number:

Date of Test:

PLAN VIEW

WELD TOP VIEW

DISCONTINUITY NUMBER:

SURFACE:

SIDE:

TRANSDUCER SERIAL NUMBER:

TRANSDUCER ELEMENT SIZE:

TRANSDUCER FREQUENCY:

X-DATUM DISTANCE:

DISCONTINUITY LENGTH:

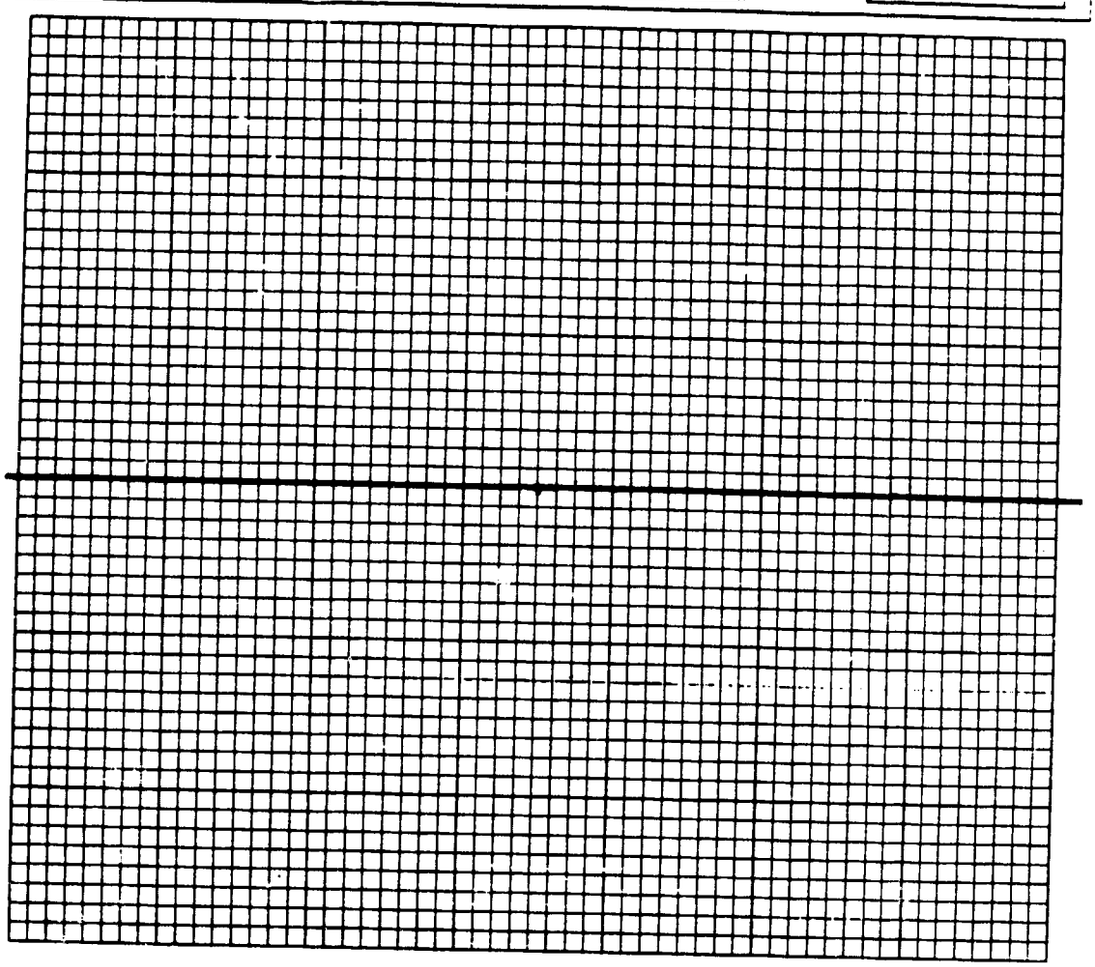
REFLECTION CHARACTERISTIC:

EVALUATION:

EXAMINER: _____

TEST ITEM IDENTIFICATION:

DISCONTINUITY NUMBER: DATE:



BEAM BOUNDARY INTERCEPT DATE	LEADING EDGE SOUNDPATH	
	LEADING EDGE SURFACE DISTANCE	
	CENTRAL BEAM SOUNDPATH	
	CENTRAL BEAM SURFACE DISTANCE	
	TRAILING EDGE SOUNDPATH	
	TRAILING EDGE SURFACE DISTANCE	
MAXIMUM AMPLITUDE DROP DATA	CENTRAL BEAM SOUNDPATH #1	
	CENTRAL BEAM SURFACE DISTANCE #1	
	CENTRAL BEAM SOUNDPATH #2	
	CENTRAL BEAM SURFACE DISTANCE #2	

Figure 1. Composite plot.

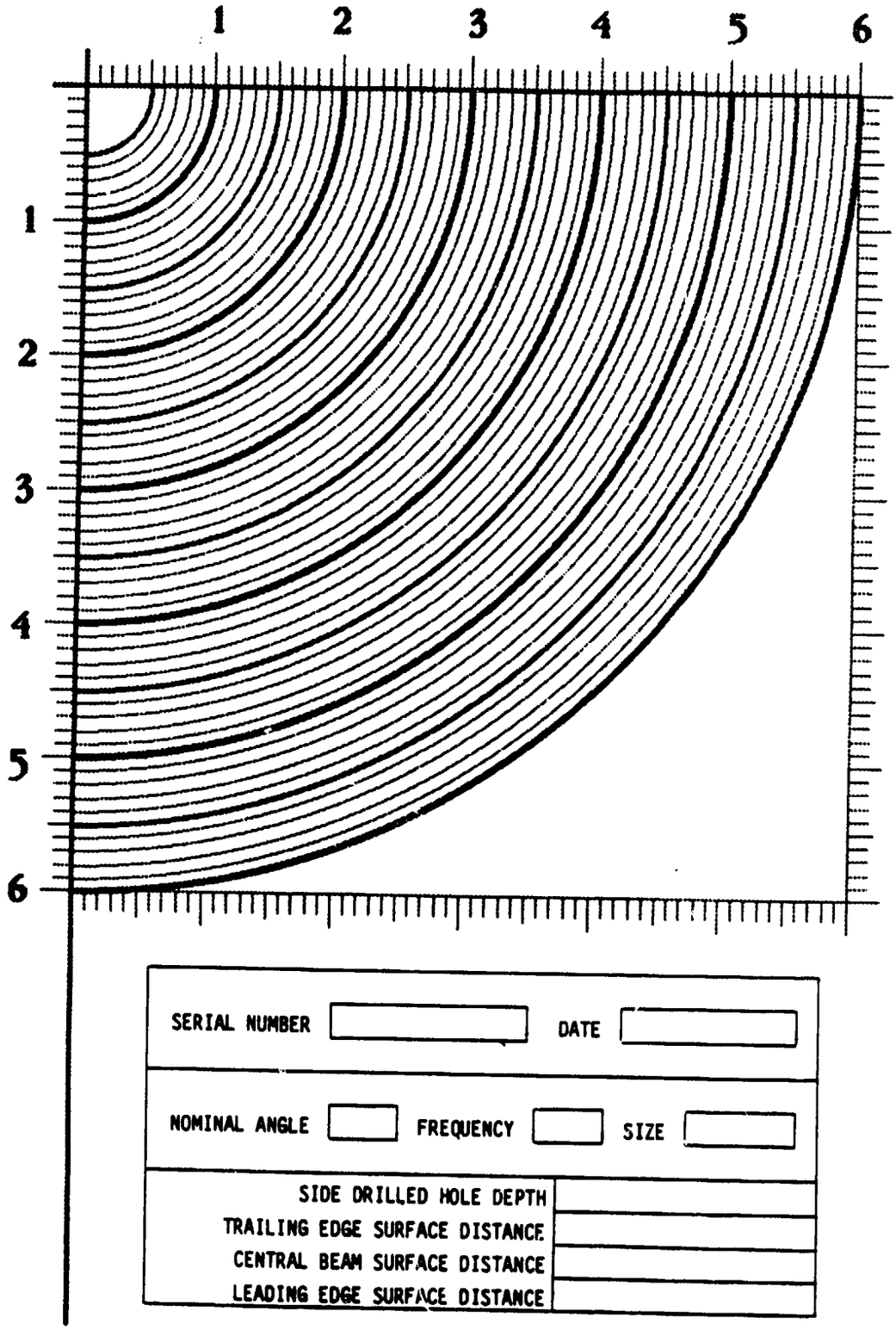


Figure 2. Beam profile.

1. PURPOSE AND SCOPE

The purpose of this procedure is to define the process used to

- o Correct weld surface conditions which prevent the determination of final acceptance or status of certain weld attributes such as arc strikes with indeterminate depth, and potential non-relevant indications
- o Remove surface slag
- o To provide specific instructions to confirm the presence of visual cracks
- o Characterize discrepant conditions for engineering analysis.

2. RESPONSIBILITY AND PRACTICE

2.1 Responsibility

2.1.1 The Weld Evaluation Project (WEP) Level III examiner shall identify the method for characterization of discrepancies.

2.1.2 The Inspection/Examination (I/E) Manager shall be responsible for compliance with this procedure.

2.1.3 Personnel implementing this Standard Practice (SP) shall be certified to the requirements of SP WEP 4.1.2.

2.1.4 This procedure shall be present during the performance of activities described in this procedure.

2.2 Procedure

2.2.1 Confirming Presence of Cracks, Arc Strikes with Indeterminate Depth, and Nonrelevant Indications

2.2.1.1 When conditions such as cracks, arc strikes with indeterminate depth, and potential

nonrelevant indications exist, the WEP Level II shall notify a WEP Level III for confirmation of the condition. (All suspect cracks will receive an information PT or MT examination. The method of examination will be determined by the WEP Level III.)

2.2.2 Characterization and Examination Preparation/Data Analysis (EP/DA) Notification

2.2.2.1 The WEP Level III shall notify a Tennessee Valley Authority (TVA) representative when subject indications are confirmed and concur with actions to be taken to characterize the discrepant condition. If concurrence cannot be reached, the issue will be elevated to management for resolution. DRR WEP 465

2.2.2.2 The WEP Level III shall notify EP/DA to prepare additional examination instructions to cover the activities as described in this procedure.

NOTE: TVA will process Maintenance Requests (M/Rs) to authorize such activities.

2.2.3 Removal of Surface Slag

2.2.3.1 If during the performance of visual examination the WEP Level II identifies surface slag conditions, he shall evaluate the slag condition to the appropriate acceptance criteria and document the condition (accept/reject) on the appropriate examination WEP form.

If the slag condition is rejectable, all other inspection activities, such as weld quality, size, and profile, etc., shall not be performed until the surface slag removal operations are complete.

2.2.3.2 The WEP Level II shall remove all rejectable surface slag unless removal operations are inordinate. In such cases, the WEP Level II shall notify the appropriate TVA craft interface for the removal of the slag.

2.2.3.3 After slag removal operations are complete, the WEP Level II shall examine the weld in accordance with the appropriate acceptance criteria.

2.3 Examination/Activities Described in Appendices A and B

2.3.1 After or during work operations, weld(s)/hardware shall be reexamined as directed by the appropriate Appendices and associated forms in this procedure.

2.3.2 Document such examinations as follows.

2.3.2.1 Removal of nonrelevant indications:

A. Activities as described in Appendix A shall be documented on Form WEP 334, Record for Removal of Nonrelevant Indications (Attachment 1).

B. If a relevant indication is determined to be rejectable, a Deviation Report (DR) shall be generated in accordance with Standard Practice 3.2.2.

2.3.2.2 Arc strikes and characterizing welds/hardware discrepancies:

A. Activities as described in Appendix B shall be documented on Form WEP 336.

3. DEFINITIONS

Characterizing - Those activities required to determine size of a discontinuity to arrive at a final acceptance status of the inspection attribute or to provide information required to evaluate the discrepancy significance.

4. REFERENCES

4.1 Standard Practice 4.1.2 "Training Qualifying and Certifying Personnel For Visual And Nondestructive Examination."

4.2 Standard Practice 3.2.5, "Dry Magnetic Particle Examination Methods and Acceptance Criteria."

4.3 Standard Practice 3.2.4, "Liquid Penetrant Examination Methods and Acceptance Criteria."

4.4 Standard Practice 3.2.3, "Visual Examination Methods and Acceptance Criteria."

4.5 Standard Practice 3.2.2, "Reporting Deviations to TVA."

APPENDIX A

REMOVAL OF NONRELEVANT INDICATIONS

1.1 Examination Requirements/Evaluation

1.1.1 Weld(s) identified on form WEP 334 shall be reexamined by the WEP Level III or his Level II designee with the appropriate magnetic particle or liquid penetrant examination method, in accordance with Standard Practice 3.2.4 or 3.2.5 respectively.

1.1.2 The WEP Level III shall evaluate the nonrelevant indication and determine the amount of metal to be removed. Metal shall not be removed beyond what is necessary to eliminate the nonrelevant indications, thus avoiding removal of any relevant indication that may be present.

NOTE: Metal removal shall be performed by TVA, with direction and appropriate interfaces from the WEP and TVA representative. DRR WEP 465

1.1.3 After completion of metal removal, the WEP Level III or his designated Level II shall reexamine the weld. The WEP Level III shall determine relevancy/acceptability. If a nonrelevant condition still exists, activities 1.1.1 through 1.1.3 shall be repeated.

1.1.4 After relevancy/acceptability has been determined, the weld shall be reexamined for weld size/profile in accordance with the appropriate appendix of Standard Practice 3.2.3 and documented on the appropriate WEP visual examination form.

APPENDIX B

REMOVAL OF ARC STRIKES
AND CHARACTERIZING WELDS/HARDWARE DISCONTINUITIES

1.1 Examination Requirements

1.1.1 Review the description of activities to be performed on WEP Form 336 Item 1.

1.1.2 After the appropriate activities have been performed, a WEP Level II shall reexamine/inspect the hardware with the NDE method described in Form 336 Item 1.

Compete item 2 if affected activities have been reexamined.

NOTE: Work operations shall be performed by TVA.

ATTACHMENT 1

Form WEP 334 RECORD FOR REMOVAL OF NONRELEVANT INDICATIONS Page __ of __
Rev. 8/86

Examination Package No.: _____
Component Identification No. : _____

Reference Document: _____
Standard Practice No.: _____
Revision Date: _____

NDE METHOD _____

Attribute	Activity	Weld Number	Weld Number	Weld Number	Weld Number
Reexamination performed	Para. 1.1.1	yes ___ no ___	yes ___ no ___	yes ___ no ___	yes ___ no ___
Weld metal removal	Para. 1.1.2	yes ___ no ___	yes ___ no ___	yes ___ no ___	yes ___ no ___
Reexamination performed	Para. 1.1.4	yes ___ no ___	yes ___ no ___	yes ___ no ___	yes ___ no ___
MT/PT weld Accept/Reject	Para. 1.1.4	*	*	*	*
VT weld size/ profile Accept/Reject	Para. 1.1.5	*	*	*	*

LEVEL III _____ Date _____

* See Examination Report WEP Form _____ Rev. _____.

Review and approved _____ Date _____
I/E Manager

ATTACHMENT 2

Form WEP 336
Rev. 8/86

RECORD FOR REMOVAL OF ARC STRIKES AND CHARACTERIZING WELD/HARDWARE DISCREPANCIES

Page __ of __

Examination Package No.: _____
Component Identification No.: _____

Reference Document: _____
Standard Practice No: _____
Revision Date: _____

1. Description of Activities to be Performed

_____

WEP Preparer _____ Date _____

2. Effected activities reexamined Yes _____ No _____

See examination Report WEP Form _____ Rev. _____

Inspector _____ Date _____

1. PURPOSE AND SCOPE

1.1 This document sets forth the minimum requirements for the training and certification of personnel engaged in the Nondestructive Examination of welds at the Department of Energy Weld Evaluation Project, Tennessee Valley Authority Watts Bar Plant Unit 1.

1.2 Nondestructive Examination as defined by this Standard Practice includes the Liquid Dye Penetrant Test Method, Magnetic Particle Test Method, Radiographic Test Method, Ultrasonic Test Method, and Visual Test Method.

1.3 Where applicable, this Standard Practice conforms with the American Society for Nondestructive Testing Document SNT-TC-1A, "Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing," and constitutes a written practice for the qualification and certification of personnel in accordance with the provisions of SNT-TC-1A.

1.4 Certification where used in this Standard Practice shall mean Weld Evaluation Project certification unless otherwise specified.

2. RESPONSIBILITIES AND PRACTICE

2.1 Levels of Certification

2.1.1 This Standard Practice (SP) recognizes three levels of personnel certification in each test method. (Please note restrictions pertaining to Visual Test certification as described in Paragraph 2.1.4.) Each of the three levels reflects a differing degree of knowledge, skill, and experience. Level I shall be considered the lowest attainable, and Level III the highest attainable certification level.

2.1.2 The capabilities of personnel for the various levels of certification shall be substantially as follows:

a. A Nondestructive Examination (NDE) Level I individual shall be capable of performing NDE methods for which they are certified, in accordance with an established method and technique, under the direct supervision of an NDE Level II or III examiner. A Level I examiner is not authorized to make any product disposition (i.e., accept or reject parts).

b. An NDE Level II individual shall be thoroughly familiar with the scope and limitations of the method for which they are certified and shall be capable of independently performing the following activities: .

1. Exercising assigned responsibility for on-the-job training and guidance of NDE Level I personnel

2. Performing or directing the performance of NDE, including setting up equipment, calibrating equipment, and applying appropriate techniques established by NDE Level III personnel

3. Interpreting and evaluating NDE results with respect to applicable codes, standards, and specifications, and reporting results in accordance with acceptance and reporting criteria established by NDE Level III personnel.

c. An NDE Level III individual shall be capable of independently performing the following activities:

1. Interpreting specifications and codes with regard to determining the NDE requirements and acceptance criteria and the means by which these requirements can be most economically and effectively accomplished

2. Establishing NDE methods and techniques

3. Performing or directing the performance of NDE in accordance with established methods and techniques

4. Interpreting, evaluating, and reporting NDE results

5. Establishing training and qualification criteria for certifying NDE Level I and II candidates

6. Implementing training and qualification criteria.

2.1.3 Within each of the three levels of certification and for each test method, there may exist restrictions pertaining to the type of equipment and/or process for which an individual is qualified. The existence of such restriction(s) shall be stated on the certification documentation. An example of these restrictions are as follows:

a. Film Interpretation--Individuals may be certified in the Radiographic Test Method (RT) with the restriction that they are authorized only for the interpretation of radiographs, and/or monitoring the performance of others engaged in producing radiographs.

b. Yoke Testing--Individuals may be certified in the Magnetic Particle Test Method (MT) with the restriction that they are limited to the performance of MT using an alternating current yoke.

c. Solvent Removable Penetrants--Individuals may be certified in the Liquid Dye Penetrant Test Method (PT) with the restriction that they may use only solvent removable liquid dye penetrants and nonaqueous developers.

2.1.4 nly individuals certified as NDE Level II or III in the Visual Test Method (VT) will be permitted to perform visual examination of welds at the Weld Evaluation Project (WEP) site.

2.1.5 Ultrasonic Test Method (UT) thickness gaging shall not be considered an UT test method since the purpose of the test is material thickness measurement and not the identification and evaluation of discontinuities. Level II Visual Inspectors may be certified for UT thickness measurement after appropriate training and practical examination by a Level III Examiner. The training and examination requirements shall be defined in the test procedure.

2.2 Certifying Authority

2.2.1 The WEP Project Manager is the Certifying Authority and shall be responsible for certifying the compliance of NDE personnel in meeting the applicable minimum requirements for qualification and certification as stated within this SP.

2.2.2 The Certifying Authority shall sign the certification documents upon the written recommendation of an NDE Level III individual who shall have made such recommendation based upon his personal knowledge that a certification candidate has met all of the pertinent requirements established within this SP. This shall be ascertained by a thorough review of supporting qualification records.

2.2.3 The Certifying Authority or his authorized representative shall verify the claimed training, education, and work experience of each candidate for certification.

a. The training, education, and work experience to be verified shall be that listed by the candidate on Form WEP 400, WEP Nondestructive Examination Personnel Survey Form (Attachment 1).

b. A verification of documentation of claimed education, training, and work experience shall be completed for each certification candidate prior to certification.

c. Due to varying company policies, verification of training and previous certifications may not be possible. In such instances, verification of previous employment where credit for training and certification are claimed shall be sufficient.

A completed verification report shall be maintained in the candidates' personnel certification record file.

d. Evidence that a candidate has deliberately falsified information pertaining to claimed education, training, or experience shall disqualify him from consideration for certification.

e. When provided all documented evidence of training/education/experience shall be maintained on file.

2.3 <u>Prerequisites for Certification</u>

2.3.1 All candidates for certification shall meet the following prerequisites as appropriate for the method(s) and certification level(s) for which certification is sought.

a. Prerequisites for Radiographic Testing, Ultrasonic Testing, Magnetic Particle Testing, and Liquid Dye Penetrant Testing Certification

1. Candidates shall have sufficient training and experience as recommended by SNT-TC-1A (Reference 4.1) to ensure a clear understanding of the principles and procedures of those areas of NDE for which certification is sought. Applicants shall meet the minimum requirements as specified in Table 1, Qualification Requirements for NDE Examiners for each NDE method/level for which certification is sought.

2. Applicants shall be specifically trained in the safety aspects of the NDE method for which certification is to be issued.

3. Applicants for Level II certification must be high school graduates or the equivalent and shall have received sufficient organized training in the principles and practices of the particular NDE method to satisfy the minimum training requirements as stated in Table 1.

4. Applicants for certification to Level III shall meet the following requirements of the particular NDE methods:

   - Graduation from a four-year accredited college or university with a degree in Engineering or Science, plus one year of experience in nondestructive testing in an assignment comparable to that of an NDE Level II in the applicable test method.

   - Completion with a passing grade of at least two years of engineering or science study at an accredited university, college, or technical school, plus two years experience in nondestructive testing in an assignment at least comparable to that of an NDE Level II in the applicable test method.

Four years experience in an assignment at least comparable to that of NDE Level II in the applicable testing method.

- o The above requirements may be partially replaced by experience as a certified NDE Level II, or in assignments at least comparable to NDE Level II in methods other than that for which certification is sought.

5. Credit for initial experience may be gained simultaneously in two or more disciplines. The applicant must spend at least 25% of his work time on each discipline for which experience is being claimed.

6. Applicants for certification to Visual Level II shall meet the following requirements:

   - o One year of satisfactory performance as a Level I in the corresponding inspection or test category or class; or
   - o High school graduation plus three years of related experience in equivalent inspection or testing activities; or
   - o Completion of college level work leading to an associate degree in related discipline plus one year related experience in equivalent inspection or testing activities; or
   - o Graduation from a four-year college plus six months of related experience in equivalent inspection or testing activities.

7. Applicants for certification to Visual Level III shall meet the following requirements:

   - o Six years of satisfactory performance as a Level II in the corresponding inspection or test category or class; or
   - o High school graduation plus ten years of related experience in equivalent inspection or testing activities; or high school graduation plus eight years of experience in equivalent inpection or testing activities with at least two years as a Level II and with at least two years associated with nuclear facilities--or, if not, at least sufficient training to be acquainted with the relevant quality assurance aspects of a nuclear facility; or

- o Completion of college level work leading to an associate degree and seven years related experience in equivalent inspection or testing activities with at least two year of experience associated with nuclear facilities--or, if not, at least sufficient training to be acquainted with the relevant quality assurance aspects of a nuclear facility; or

- o Graduation from a four-year college plus five years of related experience in equivalent inspection or testing activities with at least two years of this experience associated with nuclear facilities--or, if not, at least sufficient training to be acquainted with the relevant quality assurance aspects of a nuclear facility.

b. Prerequisites for Visual Testing Certification

1. Candidates for Visual Test Certification shall hold valid American Welding Society (AWS) Certified Welding Inspector Certification per AWS QC1 (Reference 4.2).

2. Candidates for Visual Test Certification shall have successfully completed specific training in the use and interpretation of visual inspection codes or standards pertinent to WEP.

3. The WEP Level III Visual Examiner may be certified under the provisions of Reference 4.3.

c. Prerequisites for all methods of NDE certification

1. Applicants shall be examined to ensure the adequacy of their natural or corrected vision. A report of this examination shall be made using Form WEP 402 Visual Acuity Record Form (Attachment 2). Reexaminations shall be performed every twelve months.

2. The eye examination shall ensure corrected or uncorrected near distance visual acuity in at least one eye, such that the applicant is capable of reading a minimum of Jaeger J-1 letters at a distance of not less than 12 inches, or a minimum of Ortho-Rater No. 8 or similar test pattern. Personnel shall also receive an examination to ensure corrected or uncorrected far distance visual acuity, in at

TABLE 1. QUALIFICATION REQUIREMENTS FOR NDE EXAMINERS,[a] LEVELS I AND II

	Training Hours		Experience Months		Examination Questions					
					General[b]		Specific[b]		Practical[c]	
	Levels									
NDE Method	I	II[d]	I	II[d]	I	II	I	II	I	II
Radiographic (RT)	12[e]	40[e]	3	9	40	40	20	20	--	--
	20[f]	40[f]	3	9	40	40	20	20	--	--
Magnetic Particle (MT)	8[e]	4[e]	1	3	30	30	20	15	--	--
	12[f]	8[f]	1	3	30	30	20	15	--	--
Ultrasonic (UT)	24[e]	40[e]	3	9	40	40	20	20	--	--
	40[f]	40[f]	3	9	40	40	20	20	--	--
Liquid Dye Penetrant (PT)	4[e]	4[e]	1	2	30	30	20	15	--	--
	4[f]	8[f]	1	2	30	30	20	15	--	--
Electromagnetic (ET)	8[e]	8[e]	1	9	30	30	15	15	--	--
	12[f]	8[f]	1	9	30	30	15	15	--	--
Visual[g]	--	4	--	--	--	40	--	20	--	--

a. Training, experience, and examination requirements meet the recommendations of SNT-TC-1A, 1980 Edition.

b. General and Specific examinations shall, as a minimum, consist of the number of questions listed in their respective columns above.

c. Practical examinations shall be as specified by Paragraph 2.4.1(c).

d. Applicants qualified directly to Level II with no time at Level I: The sum of the training hours for Level I and Level II shall apply and the sum of the experience months for Level I and Level II shall apply.

e. Completion with a passing grade of at least 2 years of engineering or science study in a university, college, or technical school.

f. High school graduation or equivalent.

g. Level II shall be the minimum certification level.

least one eye, equal to or better than 20/30 as determined by Snellen Test. The examination shall be administered by qualified personnel and records shall be maintained for the period of certification. Applicants shall also be capable of distinguishing contrast between colors used in the methods for which qualified, such as demonstrated by Ischihara Color Test Plate examinations or other methods.

3. If corrective lenses are required, this restriction must be noted on the certification documentation. Corrective lenses worn during NDE activities shall be clear. Sunglasses or darkened lenses shall not be worn during the performance of NDE except that properly shaded filters shall be worn if directly observing an arc welding operation.

d. Knowledge Assessment

1. All candidates for certification are required to complete Form WEP 400, Nondestructive Examination Personnel Survey (Attachment 1).

2. Level I and Level II candidates shall complete a qualification screening test prior to receiving any WEP-sponsored training and prior to NDE certification.

3. The following criteria shall be applied during the evaluation of the qualification screening test:

   - Individuals failing to satisfactorily achieve an acceptable score of 60% or more in any single part for which they indicate prior NDE Level II certification (see Part I of Form WEP 400, Attachment 1) shall receive a minimum of 40 hours of additional training by WEP in the applicable method prior to WEP certification examination. This shall be in addition to that training specified by Paragraph 2.3.1.a.2 of this document.

   - Individuals satisfactorily achieving an acceptable score of more than 60% and up to 70% in any single part for which they indicate prior NDE Level II certification (see Part I of Form WEP 400, Attachment 1) shall receive a minimum of 12 additional

hours of training by WEP in the applicable method, prior to WEP certification examination. This shall be in addition to that training specified by Paragraph 2.3.1.a.2 of this document.

- Individuals satisfactorily achieving an acceptable score of more than 70% and up to 80% in any single part for which they indicate prior NDE Level II certification (see Part I of Form WEP 400, Attachment 1) shall receive a minimum of 8 hours of training by WEP in the applicable method, prior to WEP certification examination. This shall be in addition to that training specified by Paragraph 2.3.1.a.2 of this document.

- Individuals satisfactorily achieving an acceptable score of more than 80% in any single part for which they indicate prior NDE Level II certification (see Part 1 of Form WEP 400, Attachment 1) shall not be required to receive additional training prior to WEP certification examination in the applicable methods. This shall not, however, constitute a waiver of Paragraph 2.3.1.a.2.

- Each candidates' score for each of the four parts of the Qualification Screening Test shall be recorded by direct marking on the form.

- A completed Form WEP 400 and the Qualification Screening Test shall be maintained in the candidates' personnel certification record file.

2.4 Certification Examinations

2.4.1 Candidates for certification Levels I and II shall demonstrate their qualification by successfully completing general, specific, and practical examinations as defined in this SP. These examinations shall enable the NDE Level III Examiner to determine if the applicant is familiar with the NDE method, the limitations of the method, the equipment required to perform the method, and is able to interpret and evaluate the results.

a. General--The written general examination shall cover the basic NDE principles relative to the NDE level and NDE method for which certification is sought. The number of questions shall, as a minimum, be as specified by Table 1.

b. Specific--The written specific examination shall include questions concerning the equipment, operating procedures, and NDE techniques that the applicant may encounter in his specific assignment. The specific examination shall also cover the applicable WEP NDE standards. Questions for Levels I and II shall be prepared or approved by an NDE Level III Examiner. The number of questions shall, as a minimum, be as specified by Table 1.

c. Practical--An appropriate practical examination shall be administered to demonstrate proficiency in selecting and performing applicable NDE method(s), and interpreting, evaluating, and recording the results of the examination(s). Samples or production items used for the practical examination shall be approved by the NDE Level III examiner, and a list of at least ten test variables and ten procedural requirements shall be satisfactorily completed by the NDE Level III examiner.

2.4.2 Examination questions shall be prepared and maintained in an electronic data base system which permits the generation of a unique examination for each certification candidate.

2.4.3 Applicants for certification to NDE Level III shall demonstrate their qualification by successfully completing an examination consisting of the following:

a. Basic Examination (required only once when more than one method examination is taken)

1. Twenty questions relating to an understanding of the SNT-TC-1A document

2. Fifteen questions relative to applicable materials, fabrication, and product technology

3. Fifteen questions similar to published Level II questions for appropriate NDE methods.

b. Method Examination (for each method)

1. Thirty questions relating to fundamentals and principles which are similar to published ASNT Level III questions for each method

2. Fifteen questions relating to application and establishment of techniques and procedures which are selected from, or are similar to, the published ASNT Level III questions for each method

3. Twenty questions relating to the capability for interpreting codes, standards, and specifications relating to the method.

c. Specific Examination (for each method)

1. Twenty questions relating to specifications, equipment, techniques, and procedures applicable to the employer's product(s) and methods employed, and to the administration of the employer's written practice.

2.4.4 The following applies to examinations administered for NDE Level III examiners by outside agencies, when the Level III examiner has valid national ASNT Level III certifications:

a. Examinations administered by ASNT

1. Candidates shall provide evidence of satisfactory completion of ASNT Level III Examination(s) for the test methods for which certification is sought.

2. When ASNT administers the basic and method examinations, and grades on a pass or fail basis, the minimum grade for the specific examination shall not be less than 80%.

b. Examinations administered by other outside agencies

1. An outside agency may be engaged to administer training and/or NDE Level III examinations. In such instances, WEP shall retain the responsibility for certification.

2. WEP shall ensure that training and/or examination services meet or exceed the requirements listed within this SP.

3. Minimum grade requirements for examinations administered by an outside agency shall be in accordance with this SP.

4. Examination results shall be included in WEP personnel certification records.

2.4.5 The individual and composite percentile grade for examinations shall be weighted and computed as outlined in Paragraph 2.4.7 for NDE Levels I and II, and Paragraphs 2.4.4 or 2.4.8 as applicable, for NDE Level III. Weighting factors assigned to NDE examinations shall total 1.0 and shall not be changed to fit the capabilities of an applicant.

2.4.6 Personnel failing to attain the required grade must wait at least 30 days before retest or show evidence of having received suitable additional training, as determined by the NDE Level III Examiner.

2.4.7 An NDE Level III Examiner shall be responsible for the administration and grading of examinations for NDE Level I and II personnel.

a. The passing grade for each Level I or II general, and specific, shall be 70% or greater. The practical shall be 70% or greater on the test variable and 70% or greater on the procedure variable.

b. A composite grade of 80% or greater is required and shall be computed as follows:

1. General exam score X weighting factor of 0.4, plus

2. Specific exam score X weighting factor of 0.3, plus

3. Practical exam score X weighting factor of 0.3, for a total of 80 or greater.

2.4.8 The responsibility of the administration and grading of examinations for NDE Level III shall be as designated by the Certifying Authority.

a. The passing grade for each Level III basic, specific, and method examination shall be 70% or greater.

b. A composite grade of 80% or greater is required and shall be computed as follows:

1. Basic exam score X weighting factor of 0.4, plus

2. Specific exam score X weighting factor of 0.2, plus

3. Method exam score X weighting factor of 0.4 for a total of 80 or greater.

2.5 Certification documentation shall be issued to each individual satisfactorily meeting the requirements for certification.

2.5.1 Certification documents shall include the following information:

a. Name of certified individual

b. The level of certification and test method for which certified

c. Any restrictions relating to the certification

d. The signature of the responsible NDE Level III Examiner and the Certifying Authority

e. Date of certificate expiration.

2.5.2 The certification in the form of a wallet card (Attachment 4) shall be as shown by Form WEP 403, Specimen Certificate of Qualification, Attachment 3 and Form WEP 404, Specimen Certification Wallet Card, Attachment 4.

2.5.3 Certification in the form of a wallet card (Attachment 4) shall be maintained on the person of the certified individual at all times while engaged in the performance of NDE activities.

2.5.4 It shall be the responsibility of the Inspection/Examination Manager to ensure that no individual is assigned to perform NDE work in method(s) for which he is not certified.

2.5.5 A monitoring activity shall be performed by the NDE Level III Examiner or his authorized representative to ensure that NDE is being performed in strict accordance with procedural requirements and by properly certified personnel.

a. The monitoring activity shall be conducted by randomly selecting and observing scheduled NDE activities.

1. Certified Level I and Level II individuals shall be monitored on a quarterly basis.

b. Monitoring shall be recorded using an NDE Level III Examiners Monitor Log, as shown in Attachment 5.

c. Any irregularities in adherence to applicable procedural requirements or in the certification status of individuals performing NDE shall be noted in the NDE Level III Examiners Monitor Log (Attachment 5), and shall be referred to the Certifying Authority and I/E for disposition. The individual involved shall have his certification immediately suspended pending the outcome of the disposition by the Certifying Authority.

d. Should an individual not be available for quarterly production monitoring in a particular NDE method for which he is certified and the six month period is about to lapse, he may instead be monitored based upon the performance of an examination of a suitable test specimen selected by the NDE Level III Examiner.

e. At the end of each quarterly monitoring period, a copy of the NDE Level III Examiners Monitor Log, Attachment 5, shall be placed in the personnel certification file of each candidate.

2.6 Recertification

2.6.1 All levels of NDE personnel shall be recertified by examination every three years.

2.6.2 NDE personnel may be reexamined at any time at the discretion of the Certifying Authority.

2.7 Termination

Certifications shall be revoked upon the termination of employment, or for other just cause as determined by the Certifying Authority. Certification may be reinstated within six months of the termination date provided the individual successfully passes a monitoring (outlined in Paragraph 2.2.5), by the Level III in each method sought for reinstatement.

2.8 Training and Certification Records

Records which contain evidence of the applicable training, qualification, experience, education, and physical examination for each individual who has been certified in one or more NDE methods shall be maintained by the Training and Certification Group. Records shall also be maintained which document training received subsequent to certification.

2.8.1 These records shall specify the following:

a. Name of certified individual

b. Level of certification and test method

c. Educational background and experience

d. Statement of satisfactory completion of training

e. Record of visual acuity

f. Current examination copy(s) or evidence of successful completion of examinations

g. Composite grade(s)

h. Qualification Screening Test.

2.8.2 An electronic data base shall be established and maintained which includes the following certification data:

a. Name(s) of certified individuals

b. Methods and levels of certifications for each individual

c. Expiration date of certification for each individual for each test method.

d. Expiration date of visual acuity examinations for each certified individual

e. Audit status of each individual in each test method for which certified.

2.8.3 On a monthly basis, a data base search and sort shall be performed and individuals shall be identified who will require recertification and/or visual acuity reexamination within 30 days of expiration date.

3. DEFINITIONS

3.1 Qualification--Demonstrated skill, training, knowledge, and experience required for personnel to properly perform the duties of a specific job.

3.2 Certification--Written testimony of qualification.

3.3 Training--The program developed to impart the knowledge and skills necessary for qualification.

3.4 Outside Agency--A company or individual that provides NDE Level III services and whose qualifications to provide these services have been reviewed by the employer that engages the company or individual.

4. REFERENCES

4.1 Recommended Practice SNT-TC-1A, American Society for Nondestructive Testing (ASNT), 1980 Edition.

4.2 Standard for Qualification and Certification of Welding Inspectors, AWS QC1.

4.3 Quality Standard Practice 2.5, "Training, Qualification, and Certification of Inspection Personnel, Quality Division Standard Practices Manual, EG&G Idaho, Inc.

ATTACHMENT 1

(Doc 0279A)

Form WEP 400
Rev. 4/86

WEP NONDESTRUCTIVE EXAMINATION PERSONNEL SURVEY FORM

Page 1 of 3

Instructions: This form is designed to assist the WEP Level III Examiner in recording and assessing the work experience, training, and education of a candidate for certification. Please complete each part of the form by supplying the requested information. If you should have any questions, please contact the NDE Level III Examiner.

Name _____ Date _____

Part I Work Experience Survey

Attach copies of supporting certification documents if available			NDE Experience (months)					Certification Level				
Date	Employer	Reference	VT	RT	UT	MT	PT	VT	RT	UT	MT	PT

ATTACHMENT 1 (continued)

Form WEP 400
Rev. 4/86

Name _____ Date _____ Page 2 of 3

Part II Training Survey

Please list all NDE training completed

Date	Method VT	RT	UT	MT	PT	Hours	Training Organization

Attach copies of supporting documentation

ATTACHMENT 1 (continued)

Form WEP 400
Rev. 4/86

Name _____ Date _____ Page 3 of 3

Part III Educational Level Survey

Date	Institution or School	Major	Degree	Diploma

ATTACHMENT 2

Form WEP 402
Rev. 4/86

VISUAL ACUITY RECORD FORM

This is to certify that the visual acuity of _____
has been examined and conforms with the following visual acuity criteria:

NOTE: Circle either natural or corrected vision, as applicable.

___ Natural or corrected near vision in at least one eye such that individual is capable of reading a minimum Jaeger Number 1 (or equivalent) type and size letters at a distance of not less than 12 inches on a standard Jaeger eye chart. The ability to perceive an Ortho-Rater minimum of 8 or similar test pattern is also acceptable.

___ Natural or corrected far distance visual acuity of 20/30 or better.

___ Capable of distinguishing and differentiating contrast between colors used in the methods.

Are corrective lenses required for inspection duties? __ Yes __ No

_____
Signature Date

_____
Title

State License or Registration No. _____

Visual acuity examinations shall be conducted only by Licensed Physicians, Optometrists, or Registered Nurses.

ATTACHMENT 3

SPECIMEN CERTIFICATE OF QUALIFICATION

Department of Energy

Weld Evaluation Project

Tennessee Valley Authority
Watts Bar Nuclear Plant

PRESENTS THIS

CERTIFICATE

TO

_____

having satisfied all of the qualification requirements
listed in _____ is hereby
certified as a

_____

The above individual is authorized to perform examinations for DOE/WEP within the qualification of this certification providing this certification is contained on the status report list published monthly by the DOE/WEP Training Coordinator.

This certification subject to the following restrictions:

Training Coordinator	**Level III Examiner**	**Manager, DOE/WEP**
Dated	Certificate Expiration Date	**Certificate No.**

ATTACHMENT 4

SPECIMEN CERTIFICATION OF QUALIFICATION--WALLET CARD

U.S. Department of Energy • Tennessee Valley Authority

WELD EVALUATION PROJECT
DOE/WEP

NONDESTRUCTIVE EXAMINATION

hereby certifies

_____

as NDE Level _____ in the following nondestructive examination methods.

	Examination Method Expiration Date
☐ Radiography	_____
☐ Magnetic Particle	_____
☐ Ultrasonic	_____
☐ Liquid Penetrant	_____
☐ Eddy Current	_____
☐ Visual	_____

Certificate No. _____

DOE/WEP Level III Examiner _____

DOE/WEP Project Manager _____

DOE/WEP NONDESTRUCTIVE EXAMINATION CERTIFICATION

Eye Examination Expiration Date _____

Restrictions: _____

_____

_____

_____

ATTACHMENT 5

Form WEP 405 Rev. 4/86

NDE Level III EXAMINERS MONITOR LOG

Examiner Name	Method	Level	Audit Date	Location	Certification	Performance	Remarks
	RT- UT- MT- PT- VT-						
	RT- UT- MT- PT- VT-						
	RT- UT- MT- PT- VT-						
	RT- UT- MT- PT- VT-						
	RT- UT- MT- PT- VT-						
	RT- UT- MT- PT- VT-						

Log for Period _____ to _____ NDE Level III Examiner Signature _____