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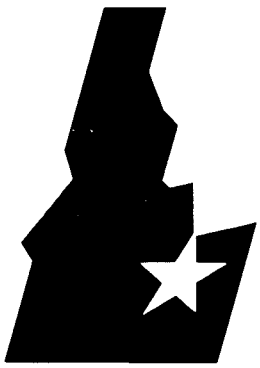
Weld Evaluation Project Organization and Work Scope

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

Susan M. Bradford



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WELD EVALUATION PROJECT ORGANIZATION AND WORK SCOPE

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

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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 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 organization of the DOE/WEP and the technical approach taken along with a description of the elements of the project and their relationship to each other. These elements are: (a) the initial weld program review, (b) the formation of homogeneous weld groups, (c) the preparation of group assessment plans, (d) the examination acceptance criteria determination, (e) the populating of weld groups, (f) the evaluation by examination, (g) the suitability for service engineering analysis; and (h) the generic problem analysis of deviations found during the examinations.

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WELD EVALUATION PROJECT ORGANIZATION AND WORK SCOPE

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 the 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 the 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 formation of homogeneous groupings of welds, the formation of the weld/component data base and data bases for weld reinspection results and status reports, the processes of component inspection and examination, the suitability for service evaluation engineering, the generic problem analysis of deviations found during the examinations, an aggregate assessment of weld reinspection results, and a final summary.

During the final part of construction of WBNP-1, the TVA management was apprised of numerous observations by employees of probable plant deficiencies that could affect the safe operation of WBNP-1. Investigation identified potential concerns regarding the quality of the plant. An independent contractor, Quality Technology Company (QTC), was engaged to investigate the employee concerns and maintain confidentiality for the employees. The outcome of the investigations pointed toward suspected weld-related problems. In order to evaluate these problems expeditiously and independently of the TVA, in October 1985, the TVA entered into an interagency agreement with the Department of Energy whereby the DOE, Idaho Operations Office (DOE/ID), and its contractor, EG&G Idaho, Inc., would perform the hands-on tasks of the Weld Evaluation Project.

This report describes the purpose and work scope of the Weld Evaluation Project as agreed upon between the TVA and the DOE/WEP. The organizational structure and responsibilities of the DOE/WEP personnel are presented in Section 2. The technical approach developed by the DOE/WEP to perform their task is summarized in Section 3 and discussed in more detail in the following sections. Section 4 discusses the weld program review conducted by the DOE/WEP. The formation of weld groups is discussed in Section 5 and assessment plans in Section 6. The examination acceptance criteria and training are presented in Section 7. The weld group population, evaluation by examination, suitability for service analysis, and generic problem analysis are discussed in Sections 8 through 11, respectively. A summary follows in Section 12.

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.

2. ORGANIZATION

The DOE/WEP was organized to accomplish the task agreed to by the TVA and DOE; the overall organizational structure is presented in Figure 1.

The DOE/ID Manager had overall responsibility for the activity for the DOE. The DOE/ID WEP Task Manager and Site Representatives provided primary direction to the Project Manager and also provided primary interface between the TVA and the DOE. The DOE/ID Site Representative provided day-to-day communication with the Project Manager in the areas of contract administration and technical assistance; and also provided interfaces between the TVA, the DOE, and the DOE/WEP.

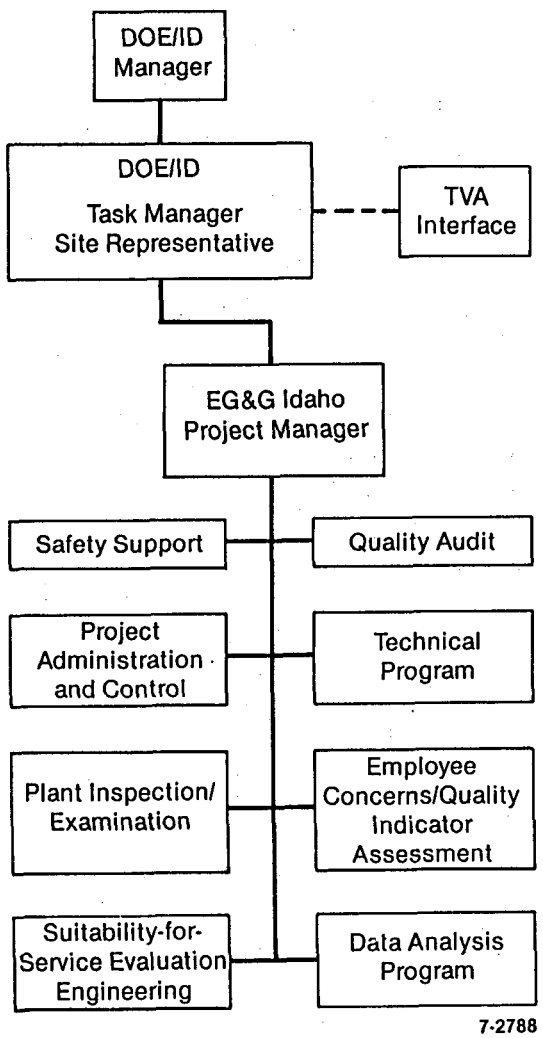

Figure 1. Weld Evaluation Project organization.

The TVA Welding Task Group Manager was the interface between the TVA and the DOE/WEP, facilitating day-to-day communications with the other TVA technical and administrative managers to expedite execution of the task, and ensuring appropriate information communication to the TVA Manager of Office of Engineering. The interface also ensured coordination of administrative needs for the DOE/WEP, including personnel security, dosimetry badges, and assembly of the TVA documentation required for the evaluation effort.

The DOE/WEP Project Manager provided direction to the project and to the subcontractor organizations engaged to support the task. The responsibilities and titles of the project organizations were changed periodically to reflect current needs of the project. The responsibilities of the organizations, as they existed the majority of time during performance of the project work scope, are discussed below.

The Project Administration and Control organization was responsible for processing and scheduling of reports; text processing, technical editing; secretarial and administrative support; preparation of the Project Management Plan and the Quality Assurance Program; project documentation revision; configuration management; examination/analysis package tracking and control; schedule preparation, status, tracking, and control; budget preparation, status, tracking, and control; issuance and maintenance of project Standard Practices; project communications; property administration; data base maintenance; and project contracts.

The Technical Program organization was responsible for the following: statistical program; populating groups; population verification; sample identification; examination/analysis package preparation; examination/analysis package review and closure; deviation report review and closure; document review/examination evaluation; repopulation of expansion and original group; closure of the prior TVA-accepted deviations; data base input and review; and project technical report review.

The Plant Inspection/Examination Program organization was responsible for weld accessibility verification (i.e., walkdown); plant examination; deviation reports; weld operation sheet review; control of measurement and test equipment; quality material receiving inspection; examination

surveillance and overchecks; and examiner training, qualification, and certification.

The Employee Concern-Quality Indicator Assessment organization was responsible for performance of the TVA welding program documentation evaluation and reporting; maintenance of the master list of the DOE/WEP-identified homogeneous groups; development of employee concern (EC)/quality indicator (QI) groups, criteria, and bases; homogeneous group establishment, bases, and boundaries; preparation of assessment plans and evaluation methods; engineering evaluation; document review/evaluation; group closures; and group closure statement/evaluation reporting.

The Suitability-for-Service Evaluation Engineering organization was responsible for review and concurrence with the TVA suitable-for-service analyses; review and concurrence with the TVA proposed corrective actions.

The Data Analysis Program organization was responsible for examination and documentation data analysis; generic problem analysis and reporting; project procedures for bounding populations containing components not in compliance with their applicable code.

The Safety Support organization was responsible for performing safety surveillance and training, and to verify project compliance with the TVA-safety requirements.

The Quality Audit organization was responsible for performing continuous, independent reviews, including audits and overchecks of the DOE/WEP activities to verify compliance with the Quality Assurance Program.[a]

The DOE/WEP prepared and issued a Project Management Plan[11] and a Quality Assurance Program.[12] The Project Management Plan defined the:

- The DOE/WEP organizational structure
- Objectives of the DOE/WEP suborganizations
- Scope of work
- Technical approach for accomplishing the objectives
- Control and reporting requirements for the DOE/WEP activities.

The Quality Assurance Program (QAP) was a management tool to assist in and ensure that the weld evaluation program was logically defined in accordance with nationally accepted quality assurance standards and was implemented as documented. The QAP implemented the requirements of the American Society of Mechanical Engineers ANSI/ASME NQA-1, "Quality Assurance Program Requirements for Nuclear Facilities,"[13] and supplements thereto that apply to the DOE/WEP. The Quality Assurance Program was divided into 18 elements that correspond to the 18 sections of ANSI/ASME NQA-1.

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a. Letter from R. E. Oswald to F. C. Fogarty, "Audit Overview, 70806, DOE/WEP Quality Audit Summary," REO-49-87, August 27, 1987.

3. TECHNICAL APPROACH

The DOE/WEP developed a technical approach to accomplish the evaluation of the required weld quality at WBNP-1. The details of the task performed by the DOE/WEP are described in the following sections and in the referenced reports. The guidelines for accomplishing the welding program evaluation activities were documented in the DOE/WEP Standard Practices Manual.[a] Highlights of the technical approach are discussed below and are shown in Figure 2.

The technical approach undertaken by the DOE/WEP was initiated with the identification of requirements in the FSAR relating to weld quality during construction. This was implemented by a detailed evaluation of the TVA weld program, the weld-related ECs, and quality assurance program documents. The weld program review, described in Section 4 and reported in Reference 2, was an initial evaluation of codes, standards, regulatory guides, and the TVA procedures and specifications related to welding and inspection activities associated with installation by the TVA for safety-related components at WBNP-1. The primary purpose of the review was to determine if there were areas of concern or document deficiencies that indicated potential weld deficiencies in the plant. The ECs were then evaluated to determine (a) the potential for problems with the welding at WBNP-1, and (b) the areas or nature of the concerns by category, such as welder certification, nondestructive examination (NDE) processes and procedures. Quality documents that pertained to the TVA weld program were reviewed. Those issues that indicated potential weld quality problems were incorporated into the program as QIs.

The resulting EC and QI issues were consolidated into homogeneous groups of welded components associated with the issues for evaluation.

Assessment plans were developed to direct the evaluation process of each group of welds. The assessment plans provided the definition of the group, the proposed method of evaluation, the extent of the evaluation, and the criteria for acceptance. Each group was then evaluated by the method that would appropriately resolve the problem area it was formed to address. The evaluation methods

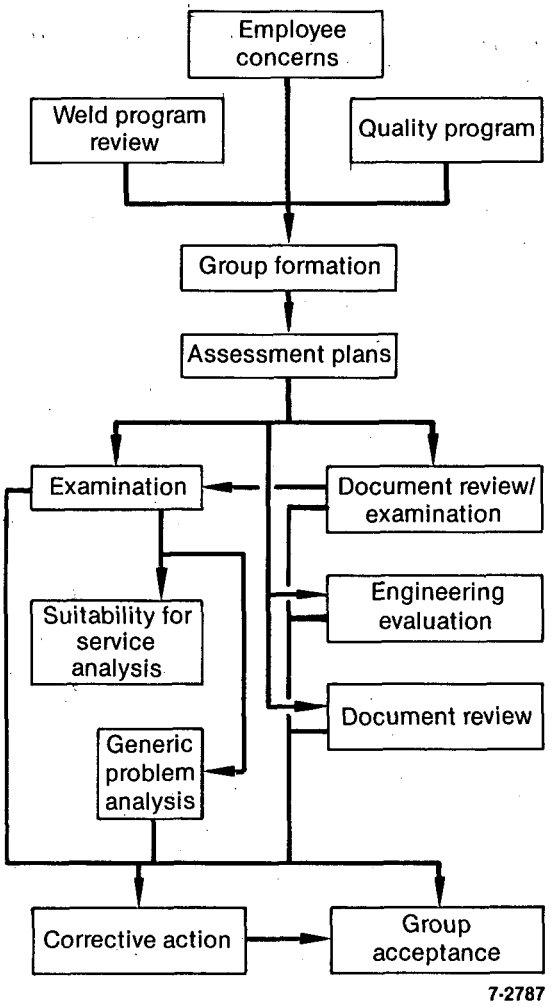


Figure 2. Technical approach selected by the DOE/WEP.

were document review, engineering evaluation, examination, or a combination of these methods.

If any weld group that was evaluated by examination contained a deviant weld condition, a suitability-for-service or engineering analysis was performed for each deviant weld by the TVA and reviewed by the DOE/WEP. This analysis was performed to demonstrate compliance with applicable code requirements, accounting for the effects of the deviations. A generic problem analysis (GPA) was also performed for welds to isolate and evaluate potential problem areas in the unsampled weld populations.

The TVA proposed corrective action when components with deviant welds were determined to be in noncompliance with the applicable codes.

a. The DOE/WEP Standard Practices Manual is a compilation of more than 60 written procedures adopted to delineate responsibilities and practices for accomplishing DOE/WEP functions and activities.

The DOE/WEP concurred with corrective actions, providing that the TVA would be in compliance with applicable code requirements upon completion of the proposed corrective action.

4. WELD PROGRAM REVIEW

The DOE/WEP assessed the compliance of the TVA's documented weld program requirements to ensure that they included all of the requirements of the codes, standards, specifications, and regulations referenced in the WBNP FSAR and amendments through February 1, 1986. The review was confined to welding and inspection activities associated with fabrication and installation of safety-related items performed by the TVA at WBNP-1. The programmatic review was divided into two areas: quality/regulatory guides and codes/standards. These areas were further categorized by the TVA organizations that performed safety-related welding and by time, i.e., from the date of the first safety-related weld (April 18, 1974) to February 1, 1986.

The quality/regulatory guides review included welding quality assurance requirements from American National Standards Institute (ANSI) standards (ANSI N45.2 and applicable daughter standards), the ASME Boiler and Pressure Vessel (B&PV) Code, Section III, NA-4000, and welding quality-related United States Nuclear Regulatory Commission (USNRC) regulatory guides. This review was performed to verify that the requirements related to welding activities and inspection were incorporated into the TVA quality assurance program documents, such as quality assurance manuals, program policies, and procedures.

The codes/standards review included all the applicable requirements that governed/implemented fabrication and inspection activities as established in the American Welding Society code AWS D1.1, ANSI B31.1 and B31.5, the ASME B&PV Code, Section III, and construction-related USNRC regulatory guides. This review was performed to verify that technical requirements related to inspection and welding activities were incorporated into the implementing documents, such as quality control instructions, procedures, and process specifications.

The codes, standards, and regulatory guides were reviewed to identify the criteria that were applicable to the welding inspection activities within the scope of the DOE/WEP evaluation. The applicable criteria were then organized into checklists for performing the review. The TVA documents that implemented the welding program were reviewed against those checklists to verify incorporation of the criteria into those documents. The results of the DOE/WEP review of the TVA weld program are reported in the "Weld Program Review."[2] If significant phases or areas of programmatic commitments to the FSAR had been found delinquent, groups of welded components would have been formed, as appropriate, to evaluate the as-constructed welds.

5. HOMOGENEOUS WELD GROUP FORMATION

In order to assess the overall TVA weld program implementation, the DOE/WEP evaluated the as-constructed plant weld quality of the TVA-performed, safety-related, WBNP-1 welded components and their associated weld inspection documents. All plant safety-related weld populations were assessed because the issues raised appeared to potentially affect all aspects of weld quality.

The DOE/WEP was asked by the TVA to review the employee concerns because of the number of concerns that indicated potential problems with welding at WBNP-1. Copies of the concerns as transcribed by the QTC were provided to the DOE/WEP for evaluation. It was found that the concerns could be grouped by the nature of the indicated problem, such as, but not limited to, welder certifications, weld filler material control, parent metal problems, and various weld quality problems.

The DOE/WEP chose to evaluate the quality documents (reports written during the construction of WBNP-1 that pertained to the TVA weld program and its implementation or both) as a source of information that could provide insight into weld problems in the plant, and aid in the resolution of the ECs associated with welding. Examples of the quality documents reviewed were Nonconforming Condition Reports, 10 CFR 50.55(e) Reports, and Conditions Adverse to Quality. Those issues that indicated potential weld quality problems were incorporated into the program as QIs.

Groups of welded components[a] were developed on the bases of information developed from employee concerns and quality indicators by the DOE/WEP. The DOE/WEP assessed the applicable TVA weld-related employee concerns and quality indicators to identify apparent or perceived quality problems with the TVA-performed, safety-related welding.

The ECs and QIs were placed within one of three designated groups for evaluation based on the amount of detailed information provided. The classification designations used for the groups formed directly as a result of these ECs and QIs, were *specific* and *special.*

Specific Group—A group formed to address a problem that could be isolated to a specific component or components and would be 100% evaluated.

Special Group—A group formed to address a specified problem that could not be isolated to specific components, but could be isolated to a certain type of component, configuration, area, system, etc., where quality could be assessed statistically.

General groups were formed to investigate the general plant welding quality and to determine if any safety-related issues existed that may not have been otherwise identified. A general group was a logically bounded division of the total population of welded components. The boundaries of the general groups were established in order to be able to evaluate components that should exhibit a homogeneous weld quality considering common:

- Welding personnel and organization
- Inspection personnel and organization
- Welding codes
- Welding procedures
- Inspection procedures.

Based on the above, the plant welds for the general groups were separated into three major categories and nine subcategories. See Table 1 for this detail. The ECs and QIs that describe the potential problem that could not be isolated to the specific and special definition were assigned to a general group.

If suspected weld quality problems could be associated with specific plant components, those components were evaluated. However, specific welds were not identified in a number of the ECs and QIs. Sampling techniques were therefore deemed appropriate for selecting which components in the special and general groups would be used to evaluate the potential weld quality problems. The criteria established was:

- The sampling technique must be carefully and rigorously applied
- The statistical method employed must have a high confidence level for accuracy of results

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 and hangers. A component is defined for piping as a welded joint.

Table 1. Original general group categories formed for overall evaluation of as-constructed plant welds

Piping			Time frame	Structural					HVAC duct
					Supports				
ASME small bore	ASME large bore	ANSI B31.1, B31.5		Civil	Pipe	I&C	Electrical	HVAC	
A	B	C	1986	D	F	G	I	K	M
≤ 2 in nominal pipe size	> 2 in nominal pipe size								
			Feb. 1981	———		———	———	———	
			1973	E		H	J	L	

Notes:

1. Time frame division indicates a change in the organization that inspected the welding, and other weld program changes implemented by the TVA in this time frame to upgrade construction welding. The changes could potentially have affected the homogeneity of weld quality.

2. A through M indicated DOE/WEP designation of the general groups.

- The weld population to which the sampling technique was applied must have been previously examined and accepted
- The sampling program must provide for expansion (up to 100% of the population, as appropriate for the observed data) when a potential or actual weld quality problem was revealed by the results of the initial sample.

The DOE/WEP elected to use the NCIG-02 "Sampling Plan for Visual Reinspection of Welds"[14] developed by Nuclear Construction Issues Group. The NCIG-02 is a valid random sampling plan, meets the above criteria, and was approved by the TVA for the reinspection efforts. Section 8 of this report further describes NCIG-02.

The ECs and QIs that identified the same or closely related potential quality problems were consolidated into one group that would address the issue.

Specific groups were excluded from any special or general group. The general groups were nonoverlapping. Some special groups overlapped into two or more general groups, or there group boundaries coincided with some general group boundaries. In the case of coincidence, that special group was evaluated using the results of those general groups.

Ninety-seven original groups of welded components were formed to evaluate the quality of the completed welding. Additionally, 18 new special groups were formed, as a result of the evaluation process, from additional data compiled at the completion of the TVA data base verification process, or because of a special request made by the TVA to

extend the evaluation beyond that originally required by the DOE/WEP program.

The "WEP Formation of Homogeneous Groupings of Welds" discusses in more detail the formation process used by the DOE/WEP to evaluate the employee concerns and quality indicators, and the development of the specific, special, and general groups.

6. ASSESSMENT PLANS

Assessment plans were prepared to direct the evaluation process for each group of welds. The assessment plan defined the issue that created the group, boundary of the group, method for evaluating the issue, and criteria for the issue being evaluated. The assessment plans provided direction during the course of the evaluation process and were the means by which the DOE/WEP documented and, thereby, provided objective evidence of the evaluation performed for each group.

The method of evaluation used to address the problem issue was an engineering judgment by the DOE/WEP, and was determined by the information available at the time the assessment plan was prepared. Assessment plans were revised, as necessary, to provide further direction of the assessment process whenever the initial assessment process would not answer the issue for which the group was formed, or if more information became available. The methods of evaluation were document review/examination, engineering evaluation, document review, or examination.

The extent of the evaluation performed was determined by the classification of the group: specific, special, or general.

Engineering evaluation was used when the quality issue could not be resolved using conventional NDE, or when examination or document review could not yield data appropriate to resolve the issues.

Document review was considered to be appropriate if used to supplement examination, or if the quality issue pertained to documentation. Document review was used when the issues in a specific or special group could be resolved by comparing those issues with national codes, standards, or other documents and records required to resolve the issue.

All components within specific groups were evaluated. Statistical sampling methods were used to select which welded components that would be evaluated in special and general groups.

The bulk of the DOE/WEP's evaluation performed was by examination because of the extent to which the issues challenged the quality of the as-constructed welding. In some instances, evaluation of welds that had been reported as having possible conditions that required a unique examination technique or method exceeding the original examination requirements.

For statistical validity, the assessment of any one group was independent of the assessment of any other group; the samples were independent and the conclusions were independent. In particular, assessments for special and general groups (sometimes considering different sets of attributes) were independent. Random samples from overlapping groups may have, by chance, contained one or more components in common. If so, the relevant data obtained from such a component was applied to each group for which the component was sampled. This independence of assessments ensured the statistical validity of the procedure for each group and did not impose constraints on the order in which the groups were evaluated.

7. EXAMINATION ACCEPTANCE CRITERIA AND TRAINING

The DOE/WEP evaluated the welds performed by the TVA utilizing the nationally recognized codes and standards established in the FSAR. The acceptance criteria were all the visual and NDE criteria specified by the TVA, excluding those original in-process examinations that could not be recreated.

For structural welding, the visual acceptance criteria were in accordance with American Welding Society, "Structural Welding Code-Steel, D1.1" (AWS D1.1)[15] using the NCIG-01 "Visual Weld Acceptance Criteria for Structural Welds at Nuclear Power Plants."[16]

The NCIG-01 is applicable when inspecting welds in nuclear power plant structures and supports that were designed and fabricated to the requirements of the American Institute of Steel Construction (AISC) Specification and AWS D1.1. The development of such acceptance criteria by the owner and the engineer falls within the provisions of the AISC Specification and AWS D1.1.

For piping, the visual acceptance criteria and the applicable NDE acceptance criteria, when required, were in accordance with the applicable code requirements: the ASME B&PV Code Section III,[17] ANSI B31.1,[18] and ANSI B31.5.[19]

The DOE/WEP Standard Practices incorporated the requirements from the governing codes into the following examination methods for structures and piping:

For visual testing (VT), the applicable examination methods and criteria were used from the following codes, as applicable: the ASME B&PV Code, Section III, Division 1;[17] the ASME B&VP Code, Section VIII, Divisions 1 and 2;[20] ANSI B31.1;[18] ANSI B31.5,[19] and AWS D1.1;[15] with NCIG-01.[16]

For liquid penetrant examination (PT), the examination methods and criteria were used from the following codes, as applicable: the ASME B&PV Code, Section III Division 1; the ASME B&PV Code, Section VIII, Divisions 1 and 2; ANSI B31.1; and AWS D1.1.

For dry magnetic particle examination (MT), the methods and criteria were used from the following codes, as applicable: the ASME B&PV Code, Section III, Division 1; AWS D1.1; and ANSI B31.1, and ANSI B31.5.

For ultrasonic examination (UT) the methods and criteria were used from the following codes, as applicable: ASW D1.1; ASME B&PV Code, Section I;[22] the ASME B&PV Code, Section III; the ASME B&PV Code, Section VIII; and ANSI B31.1.

For radiographic examination (RT) for film interpretation only, the following criteria were used from the following codes, as applicable: the ASME B&PV Code, Section I; the ASME B&PV Code, Section III; the ASME B&PV Code, Section VIII; ANSI B31.1; and AWS D1.1

NOTE: The DOE/WEP only interpreted the TVA radiograph film. When the review of the original radiographs was not adequate to determine if the welds were acceptable, re-radiographic examination was performed by TVA and witnessed by the DOE/WEP.

The DOE/WEP performed all visual and nondestructive examinations, except radiography. The DOE/WEP examiners were required to demonstrate the necessary skill, knowledge, and experience to properly perform the plant examinations. Visual and nondestructive examiner qualifications were based on the recommended practices of the American Society for Nondestructive Testing SNT-TC-1A.[23] Visual examiners were Certified Weld Inspectors (CWI) in accordance with American Welding Society QC1, with additional training to NCIG-01 and NCIG-03[21] in accordance with the DOE/WEP Standard Practices. The examiners were certified by the DOE/WEP for visual and NDE techniques in accordance with the DOE/WEP Standard Practices. The DOE/WEP inspection/examination qualification process is discussed in more detail in Reference 5.

8. WELD GROUP POPULATION

The TVA provided personnel that aided in data base identification and composition. Reviews of the TVA data bases were conducted to establish their sizes, contents, sorting capabilities, and the TVA computer mainframe space requirements. The appropriate sorts were requested to establish the general group populations for the DOE/WEP data bases. These populations were established and designed to contain all safety-related weld/components installed and designated as being completed for Unit 1 fuel load by the TVA Office of Construction. Separate populations were established for those welds/components that had been installed, modified, and/or repaired by the TVA Office of Nuclear Operations. These files were then considered *frozen* and access limited to the authorized DOE/WEP personnel.

Some of the populations identified were not set up in a manner that would enable direct sampling. These required additional effort (i.e., walkdowns, hand sorting, generation of weld maps) by the DOE/WEP to establish a data base for these populations. The general groups requiring the time line separation were populated by reviewing the dates on the installation records of the applicable components.

The DOE/WEP then verified the adequacy of these DOE/WEP data bases. An arbitrary sample of 64 components related to each category shown on Table 1 was walked down to field verify the completeness and the accuracy of the correlation between the data base, the TVA weld maps or drawings, and the component identification tags. The DOE/WEP performed sampling that verified these data bases utilizing the 95%/95% sampling methodology presented in NCIG-02.

For each special and general sample group, a list of a minimum of 200, or the entire population if less than 200, randomly selected components was generated. The number of randomly selected components was large enough to allow for removal of inaccessible components from the sample populations and to allow for possible expansion of the sample size. The sampling process was designed such that each component in the group had an equal chance for selection. An appropriate number of samples were identified to provide at least the minimum confidence/reliability levels (95%/95%). For an infinite-size population (2179 or more components), the sample consisted of the first 64 accessible components on that list. For finite-size populations, the sample size was adjusted to maintain selected statistical confidence (95%/95%).

Following generation of the randomly selected component list for each group, a walkdown of the selected components was performed to determine component accessibility. Components were defined as accessible when 100% of the welds were accessible for 100% of the attributes designated for examination by the assessment plan (100%/100%). This definition was used so that the suitability-for-service or engineering analysis conclusions could be reached without the use of probabilistic statements. Any component judged by the DOE/WEP to be inaccessible was replaced by the next accessible component on the random sample list. This process was continued until the required sample size was obtained for each group.

If more than 10% of the initially selected sample for a group was replaced because of inaccessibility, the DOE/WEP reviewed the sample population to determine if the exclusion of the inaccessible components biased the sample. Any observed bias was eliminated on a case basis either by selecting additional sample components that were accessible per the 100%/100% criterion or by applying a less restrictive accessibility criterion to the excluded original sample components. At the completion of the accessibility evaluation, the final list of the randomly selected accessible components in each group was generated and forwarded to the TVA. The TVA used these listings to assemble the documentation/records and drawings necessary for the DOE/WEP to prepare the examination packages.

The "WEP Weld/Component Data Base" report[4] discusses the process by which the DOE/WEP established and verified the DOE/WEP data base. The random selection process of components for population of the groups and the theory of the multiple stage sampling plan is also presented in the report.

9. EVALUATION BY EXAMINATION

An examination package was prepared by the DOE/WEP for each component designated for examination. Examinations and weld record reviews were conducted in accordance with the examination package.

That package provided the information such as the relevant attributes, acceptance criteria, examination methods, and location/detail drawings required for performing the examination. As the evaluation of a component progressed, all documentation pertaining to that evaluation (inspection record sheets, deviation reports, suitability-for-service or engineering analysis, etc.) was added to that package, so that by the completion of that evaluation, the examination package provided a complete record for that component.

Following the examination, the DOE/WEP reviewed all resulting deviations for prior identification and use-as-is dispositions by the TVA. Deviations with adequate technical justification were removed from the list of deviations found in the examination because of prior identification and resolution by the TVA. The deviations that remained were reported to the TVA for suitability-for-service or engineering analysis and for corrective action, as appropriate, in accordance with the applicable code. Deviant welds or conditions noted by the DOE/WEP that were not selected for examination as part of the DOE/WEP program were documented and reported to the TVA independently of the examination package related deviations.

Specific groups with assessment plans that designated evaluation by examination required 100% examination. That is, 100% of the population of the specific groups was examined and the weld quality was assessed by examining all the weld attributes. This was done because the results of these examinations would have to be used to evaluate an entire population without the benefit of any results of other populations. These welds/components were evaluated independently of specials and generals; doing so allowed the DOE/WEP to make a more definitive statement for compliance with FSAR construction codes for 100% of a bounded population with a suspected problem area. Figure 3 indicates the work plan and process for 100% examination.

Figure 4 shows the work plan for the three-stage multiple-sampling plan for statistically selected components utilized by the DOE/WEP. This plan had four scenarios for accepting populations based

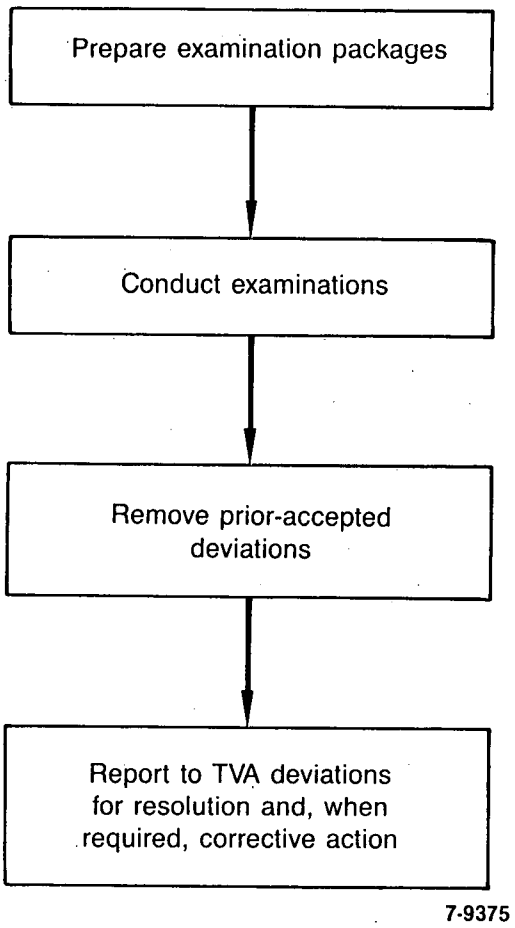
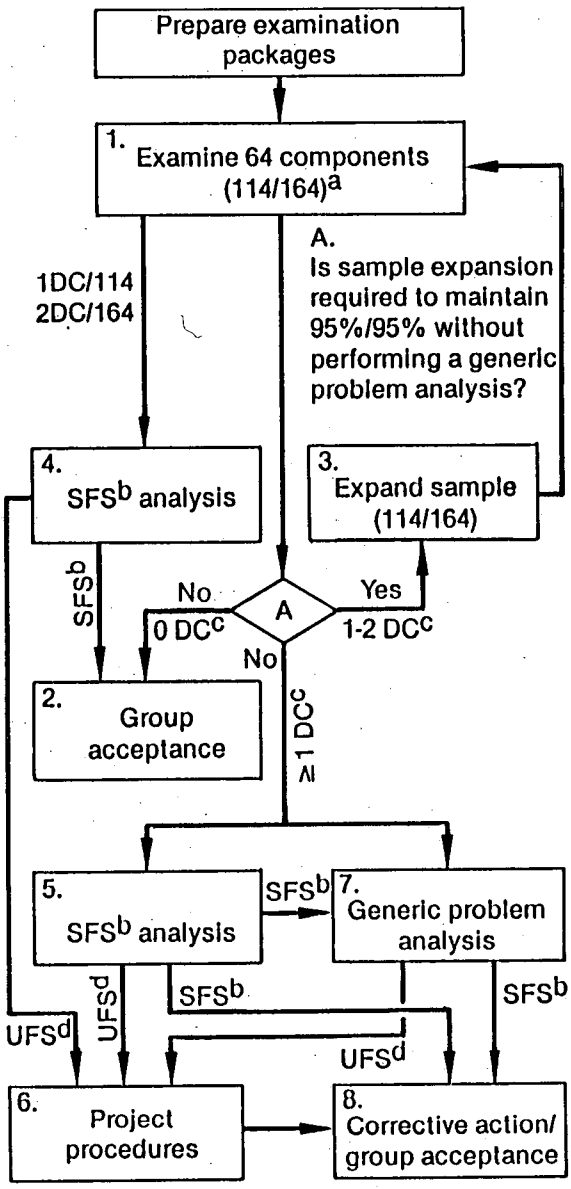


Figure 3. Work plan for evaluating weld quality by 100% examination.

on examination of components (Block 1) and analysis of results:

1. No deviant component was found after examination of the sample population (Block 2).
2. One or two deviant components that were evaluated as suitable for service as allowed by the applicable code, were found during the examination process. Additional components, up to 100, were examined to maintain the 95%/95% criterion (Blocks 3, 1, 4, and 2).
3. One or more deviant components were observed during the examination, but they were evaluated as being suitable for service as allowed by the applicable code, and generic problem analysis showed no



Notes:

a. Sampling expansion numbers (114/164) are based on an infinite population

b. SFS—Suitable-for-Service

c. DC—Deviant Component

d. UFS—Unsuitable-for-Service (defective component).

7-2790

Figure 4. Work plan for evaluating weld quality of statistically selected components.

potential for components in the unsampled population not to be in compliance with applicable code (Blocks 5, 7, and 8).

4. One or more deviant components that were evaluated unsuitable for service or could not be accepted in accordance with the applicable code were identified during the examination. Project procedures were then invoked to bound all of these potential unacceptable components, and corrective action plans were proposed by TVA for the unsuitable-for-service components and for those components that could not be accepted in accordance with the dispositioned suitable for applicable code (blocks 5 and/or 7, 6, and 8).

Project procedures (Figure 5) was the process used to determine if there were any additional unsuitable for service components in a population already evaluated as containing at least one such

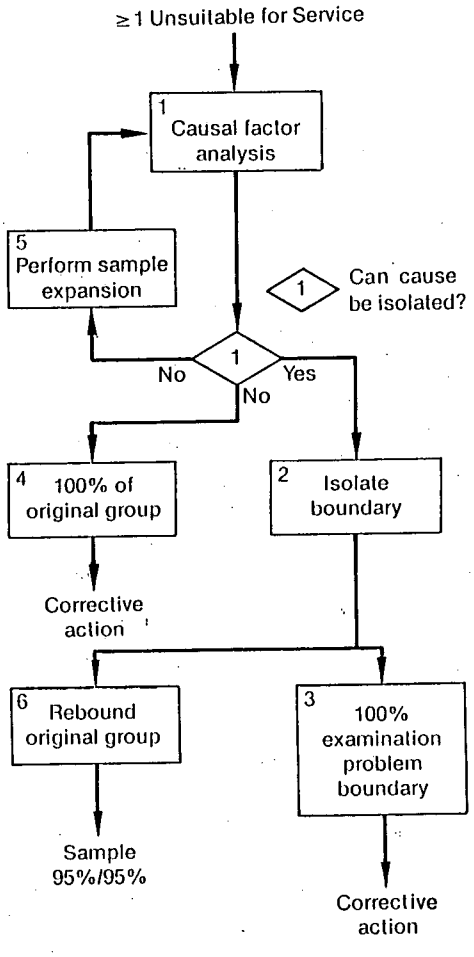


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Figure 5. Project procedures.

component. The weld configuration, weld procedure, welder, inspector, or other potential contributors were reviewed to determine a causal factor(s) for the initially unacceptable components (Block 1). If the causal factors could not be identified, there was an option to either initiate 100% examination of the original group (Block 4) or to examine additional components (Block 5) to the extent required to determine the cause(s). Once the causal factors were identified, the problem-area group was bound, an assessment plan was then developed, and examinations were performed (Blocks 3 and 6). For the isolated problem-area group, 100% examination of the components of the group was initiated (Block 3) and the original group from which the problem area group was removed (Block 6) was repopulated and examined to the extent required to maintain the 95%/95% criterion specified in NCIG-02. The 100% examination expansion process was terminated when a documented engineering judgement so justified.

For the problem-area group, the DOE/WEP reviewed and concurred with the TVA's corrective action proposals to establish acceptability of the group's components to the applicable code requirements.

10. SUITABILITY-FOR-SERVICE OR ENGINEERING ANALYSIS

The suitability-for-service (SFS) or engineering analysis was performed to establish acceptability of reported deviant weld conditions, based upon compliance with the applicable codes and standards. The TVA performed an analysis on all components that exhibited deviant conditions to determine if the deviations would result in an unacceptable condition. The DOE/WEP performed an independent review of this analysis to verify that:

- Design loads and load combinations and their sources were identified
- Design loads were reasonable
- Correct weld geometry and material conditions were used in the analysis, accounting for the weld deficiencies
- Stresses in welds were correctly and accurately calculated and combined
- The effects of the weld deficiencies on connected members were appropriately accounted for
- The computed stresses were evaluated using the appropriate code allowables
- The analysis conclusion was appropriate.

The DOE/WEP reviewed the as-constructed (AC) stresses to determine suitability for service and the final disposition of each identified deviation to ensure that the evaluations completed by the TVA were correct and in compliance with applicable codes. The basis for disposition of deviant welds is unchanged from the requirements of the original acceptance criteria of the codes and standards committed to by the TVA in the FSAR. If suitability for service could not be established, corrective action for the deviant component was required.

A discrepant item is suitable for service (SFS) when it was demonstrated by appropriate evaluations to be in compliance with the applicable codes and standards. For the DOE/WEP, a component with a deviant weld was SFS when an appropriate engineering evaluation demonstrated that the component would adequately perform its intended safety function for all postulated loading conditions and met the appropriate code. Where the engineering evaluation is a stress analysis accounting for the deviant condition, the calculated stresses must satisfy the stress criteria of the applicable design code as specified in the WBNP FSAR. An overstressed weld within a component does not affect SFS of the component when the stresses in all remaining members and welds of the component are determined to be below design allowables assuming failure of the overstressed weld.

The analysis was not intended to be an alternate criteria for meeting the specified requirements of the codes and standards committed to in the FSAR. Any welds that were found not meeting these requirements were dispositioned for corrective action to bring the component into compliance with the requirements of the original codes and standards. The ASME Code Section III components with deviant conditions to mandatory code requirements could not be dispositioned SFS without corrective action, unless code requirements were satisfied through agreement among the owner, applicable certificate holder(s), their respective authorized inspection agencies, and appropriate jurisdictional and/or regulatory bodies.

If suitability for service could not be determined, or if the components were found unsuitable for service (UFS), a corrective action plan prepared by the TVA and concurred by the DOE/WEP was required. The reason for the DOE/WEP review and concurrence of the proposed corrective action plan was to determine: if upon completion of the proposed corrective action plan, the TVA would be in compliance with the applicable code requirements and, as appropriate, the TVA commitments in the FSAR.

The "Suitability for Service Evaluation Engineering Process" report[7] discusses in more detail the DOE/WEP review and concurrence of the TVA SFS or engineering analysis for the identified deviations within the work scope of the DOE/WEP. Also discussed is the DOE/WEP's review and concurrence of the TVA's proposed corrective action plans.

11. GENERIC PROBLEM ANALYSIS

To provide a comprehensive evaluation of the achieved weld quality, it was further determined that the program should require a root cause and generic problem evaluation, hereinafter referred to as a generic problem analysis (GPA) when physical examination of a randomly sampled group of components from a homogeneous component population identified three or more deviant components. This analysis method was based on the methodology in NCIG-02; that is, a population is accepted if every discrepancy found is acceptable and the root cause analysis shows that there are no generic problems. The GPA was applied to those groups whose components were statistically selected (see Figure 6). The DOE/WEP generated procedures implementing the root cause analysis and generic problem evaluation criteria of NCIG-02. The GPA process also included analysis of defective components (components whose weld deviations cannot be accepted in accordance with the applicable code) through the implementation of WEP project procedures as previously discussed in Section 9.

The GPA was performed to assess the impact of potential deviations similar to the observed deviations on the unexamined components, to assess the ability of the unsampled components to be in compliance with the intended code, and to determine the need for further evaluation of nonexamined welds in a population to determine whether potential generic problems may exist in that population. Further evaluation was required when the following occurred:

- The frequency of a deviant attribute(s) exceeded a preset limit
- The application of the effects of the found deviations as applied to the higher stressed deviant components indicated a potential for welds in the unsampled population to be in noncompliance with the applicable construction code.

The weld examination records were reviewed to identify the deviant weld attributes and the number of times each attribute was examined for all components in each weld population (group). The ratio was then calculated of the number of times each attribute was found deviant to the number of times the attribute was examined. If these ratios were less than 0.05, and there were no deviant critical attributes (i.e., cracked welds or missing welds), the analysis was terminated on the basis that the deviation rate was within limits, the DOE/WEP considered acceptable.

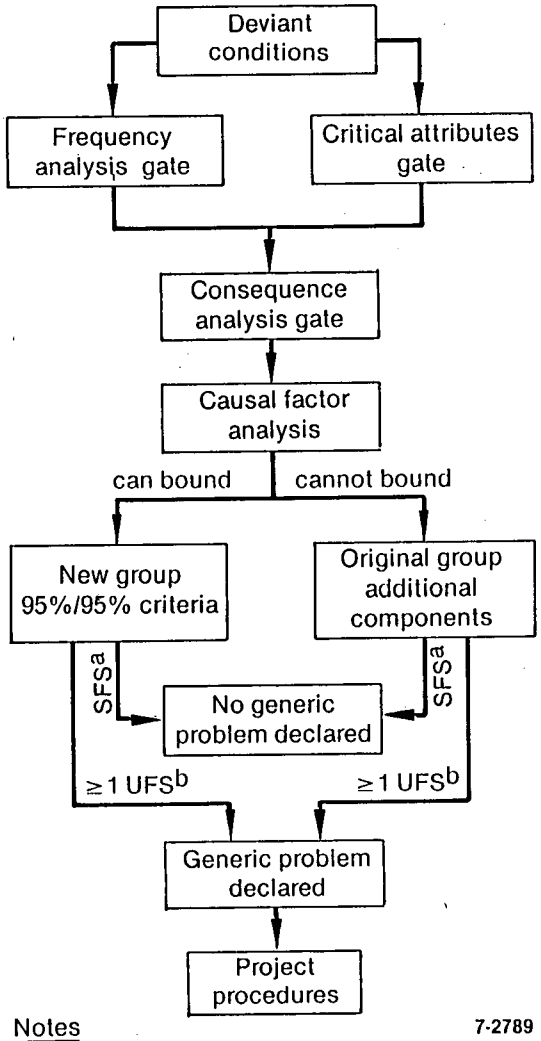

Figure 6. Work plan for generic problem analysis.

If any of these ratios were greater than or equal to 0.05, or the sample contained any deviant critical attributes, a consequence (significance) analysis was performed. The 5% frequency trip gate was established by an agreement between the TVA and the DOE/WEP, on the basis of conservatism.

For the consequence analysis, the TVA provided the as-designed (AD) and as-constructed (AC) stresses, based on the same loading conditions, for each deviant welded connection within the group.

For these connections, whose physical configuration was categorized, the highest AC/AD ratio was multiplied by the highest AD stress of the deviant welded connection in the category. If this product was less than or equal to 100% of the design allowable stress for each category, the procedure was terminated on the basis that the observed deviations within the sample would not cause components in the unsampled population to be in noncompliance with the applicable code if those deviations occurred similarly. For those categories that exceeded 100% of the design allowable stress, a causal factor analysis was performed to determine the potential root cause(s) of the deviations.

The weld configuration, the weld procedure used, the welder and/or inspector, or other potential contributors for all deviant attributes were evaluated to determine if a cause(s) for the deviations could be isolated and/or defined. If this causal factor analysis did not isolate the cause(s) of these deviations, no rebounding occurred and an additional random sample for the group, or an individual type component category, as appropriate, of a minimum of 30 components was selected. A SFS or engineering analysis was performed for any discrepancies identified during the examination of the additional components. If all the components were dispositioned as SFS, the population was accepted and declared to have no generic problem.

If the causal factors were determined, a random sample was selected from the boundary that included the causal factor(s) to determine if there was at least 95% confidence that 95% of the components met the appropriate code acceptance criteria. If there were no deviations identified during the examination of the new, rebounded group, or the resulting deviations were dispositioned as SFS, the population was declared to have no generic problem and was accepted.

If any deviant component that was analyzed as UFS was identified from the additional samples, a generic problem was declared and project procedures were implemented. The generic problem analysis process as described is presented in Figure 6. The project procedures process was described in Section 9 and the specific methodology is schematically presented in Figure 5.

The root cause and the generic problem analysis and project procedures process is discussed in more detail in "Generic Problem Analysis Process."[8]

12. SUMMARY

The Department of Energy/Weld Evaluation Project (DOE/WEP) was formed to evaluate the as-constructed welding quality of the Tennessee Valley Authority Watts Bar Nuclear Plant Unit-1 (WBNP-1) and to assess the documented welding program's compliance with the requirements of the WBNP FSAR. Employee concerns and quality documents were reviewed for potential quality problems and were assigned or related to specific or special weld groups to perform the evaluation. General groups were formed to provide insight into the overall as-constructed weld quality. Additional groups were formed to address potential or identified problems from the analysis of the original group evaluation results.

Assessment plans were prepared to direct the evaluation process, by document review, engineering evaluation, examination, or a combination of these methods. The welded components were evaluated utilizing the codes and standards established in the FSAR. If welded components that were evaluated by examination were found deviant, a suitability-for-service or engineering analysis was performed, and if appropriate, a generic problem analysis was performed for the groups containing those welded components. The data was gathered and reported in the WEP Aggregate Assessment of Weld Reinspection Results and the Weld Evaluation Project Final Report.[9,10]

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