UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
TEXAS UTILITIES GENERATING COMPANY, et al.	)	Docket Nos. 50-445 and 50-446
	)	
(Comanche Peak Steam Electric Station, Units 1 and 2)	)	(Application for Operating Licenses)

AFFIDAVIT OF W.E. BAKER,
M.D. MUSCENTE, J.D. STEVENSON, AND
R.E. LORENTZ, JR. REGARDING ALLEGATIONS
INVOLVING AWS AND ASME CODE PROVISIONS

We, W.E. Baker, M.D. Muscente, T.D. Stevenson, and R.E. Lorentz, being first duly sworn do depose and state as follows:*

(Baker) My name is William E. Baker. I reside in Granbury, Texas. I am the Senior Project Welding Engineer employed by Brown & Root, Inc. at Comanche Peak. My educational and professional qualifications are attached to Applicants' Rebuttal Testimony Regarding Allegations of D. Stiner and H. Stiner Concerning Weave Welding, Welding of Misdrilled Holes, Downhill Welding, and Weld Rod Control, previously filed in this proceeding.

(Muscente) My name is Mathew D. Muscente. I reside in Houston, Texas. I am the manager of Materials Engineering for Brown & Root, Inc. My educational and professional qualifications are attached to Applicants' Rebuttal

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* Except as otherwise indicated each affiant attests to all parts of this affidavit.

Testimony Regarding Allegations of D. Stiner and H. Stiner Concerning Weave Welding, Welding of Misdrilled Holes, Downhill Welding, and Weld Rod Control, previously filed in this proceeding.

(Stevenson) My name is John D. Stevenson. I reside in Cleveland, Ohio. I am the President and Managing Partner of Stevenson and Associates. My educational and professional qualifications are attached (Attachment A).

(Lorentz) My name is Roy E. Lorentz, Jr. I reside in Chattanooga, Tennessee. I am a metallurgical engineer specializing in welding. My educational and professional qualifications are attached (Attachment B).

In overview fashion, this affidavit will respond, in part, to CASE's allegations that the AWS Code contains ten specific provisions not addressed in the ASME Code, and accordingly, that welding at CPSES in accordance with the ASME Code is unacceptable. Specifically, this affidavit will address those provisions which relate primarily to welding as opposed to weld joint design. Those provisions which specifically relate to weld joint design will be addressed in later testimony regarding design. In addition, this affidavit addresses a related concern raised by the Board regarding downhill welding, weave welding, preheat requirements and cap welding.

The process of making acceptable welds entails at least three distinct but interrelated activities, viz., (1) design of the weld joint, (2) development and qualification (testing) of a welding procedure to assure that the weld joint (and others with similar important parameters) can be welded so as to meet the design strength requirements, and (3) training and qualification of welders to assure that they are capable of welding with the procedure developed.

With regard to design of the weld, both the AWS and ASME Codes contain some requirements in this area (e.g., AWS D1.1 Code Section 2, Design of Welded Connections, and ASME Code, Appendix XVII). However, neither code provides all the details necessary to design a weld joint, and both codes rely on the designer to assure that the weld joint is designed to meet the design and operating loads. To do this, the designer uses numerous reference sources and his skill as an engineer to provide a proper design which, pursuant to Appendix B to 10 CFR Part 50 and other regulatory requirements, goes through several review and approval stages before acceptance. It must be understood that the AWS Code is primarily a fabrication code and not a design code. However, specific and complete design details are not included in either code.

After the weld joint is designed, a procedure to perform the weld must be developed or obtained. This process is discussed in detail later in this affidavit.

Finally, the welder must be capable of welding the joint using the procedure. This entails a training and qualification process in conformance with applicable Code requirements to assure that the welder is qualified. While the basic philosophies of the ASME and AWS Codes as they apply to developing welding procedures differ somewhat, both codes include requirements for welding procedures that will result in welds that are adequate for their intended uses.

The ASME Code requires that all welding procedures used for the fabrication and installation of components and their supports be qualified by test pursuant to the requirements of Section IX of the ASME Code. In order to satisfy these ASME requirements, each manufacturer or installer performing Code welding must conduct tests necessary to qualify each welding procedure.

On the other hand, the AWS Code provides for the use of either prequalified welding procedures (i.e., not requiring qualification testing prior to their use) or welding procedures which are qualified by test. In short, the ASME Code allows welding only with procedures based on

qualification testing, while the AWS Code allows welding with welding procedures qualified by testing or with prequalified procedures.

The difference in philosophy between the AWS Code and ASME Code stems from the fact that the AWS Code covers structural welding in general along with specific requirements for use in the construction of buildings, bridges and architectural tubular structures. Thus, although its provisions for prequalification are generally applicable to any steel structure, the drafters of the AWS Code have acknowledged the limitations of that Code in stating that "when using the Code for other structures, owners, architects and engineers should recognize that not all of its provisions may be applicable or suitable to their particular structure." (AWS D1.2, Commentary on Structural Welding Code, Section 1.1.) (It should be noted that in any event, the AWS Code is not applicable to pressure retaining boundaries such as pressure vessels or piping systems (AWS D1.1, Section 1.1.1).)

Thus, with the prequalified procedures in the AWS Code, welding may be performed without qualification testing. However, the AWS Code recognizes that if prequalified procedures are not applicable, or if the user prefers not to use prequalified procedures, then the user must qualify procedures by test.

In qualifying welding procedures in accordance with the requirements of Section IX of the ASME Code (as well as Section 5 of the AWS D1.1 Code), a draft welding procedure is first written describing the precise status of certain variables specified in Section IX of the ASME Code (essentially the same specified in the procedure qualification section of the AWS Code). A test plate or pipe is prepared and welded in strict accordance with the draft welding procedures. Mechanical tests are then performed in accordance with the requirements of Section IX of the ASME Code to determine if the welding process and parameters are acceptable and adequate to produce welds that will withstand design and operating loads.

The tests are performed using specimens removed from the test plate or pipe. Each test has a separate purpose in determining whether the weld produced using the welding procedure is structurally sound and capable of withstanding design and operating loads. The tests required by the ASME Code, Section IX (which are essentially the same as endorsed by AWS) are as follows:

1. Tension tests, used to determine ultimate tensile strength, yield strength and ductility (reported as % elongation and/or % reduction of area);

2. Guided bend tests, used to determine the degree of soundness and ductility of groove weld joints;

3. Charpy V-Notch Impact or Drop Weight tests, used to determine the notch-toughness of the weldment (these tests are only performed when fracture toughness is specified in NF-2311, or for integral attachments, when required by other sections of the ASME Code); and

4. Fillet-weld tests, used to determine the size, contour, and degree of soundness of fillet welds (This test is used to qualify welding procedures when only fillet welds are to be produced using that procedure).

If acceptable results are obtained from the testing, the procedure has been qualified and a Procedure Qualification Record (PQR) is prepared listing the specified parameters used for the welding in the form of essential and non-essential variables. ASME Section IX specifies essential and non-essential variables for each welding process. An essential variable is a change in a welding condition which will affect the mechanical properties of the weldment (for example, a change in base metals, welding process, filler material or weld rod, and preheat requirements). If an essential variable is changed, then new welding procedure qualification tests must be performed. A non-essential variable is a change in a welding condition which will not affect the mechanical properties of a weldment (such as joint design, and cleaning). A change in a non-essential variable would not require requalification of the procedure, but the procedure would have to be evaluated, and, if appropriate, amended to include this change.

(Baker) All welding procedures qualified by test pursuant to the ASME Code for use at CPSES follow the requirements of Section IX of the ASME Code. This includes following requirements regarding test procedures, essential and non-essential variables, testing of specimens, and all other aspects which could affect the procedure qualification process. While many welding procedures at CPSES are qualified pursuant to the ASME Code, the AWS Code is also used at CPSES for some welding of non-ASME components (such as some cable-tray supports and some building structures). In addition, the AWS Code is frequently used by designers and engineers at CPSES as a reference (along with numerous other industry documents) in performing tasks such as design, design review or verification of weld parameters.

(All Affiants) If a welding procedure is qualified by test in accordance with each provision of Section IX of the ASME Code, use of that procedure will produce welds that are structurally sound and as adequate for their intended use as welds produced using either prequalified procedures of the AWS Code or procedures qualified by test in accordance with the AWS Code.

The ASME Code and its qualification test procedures were developed only after thorough, rigorous and complete review, testing, analyses and study by literally thousands of engineers, scientists and other highly skilled and

qualified professionals. Further, prior to its adoption this qualification test process set forth in Section IX of the ASME Code received significant and extensive peer review and critique. Finally, the qualification test procedure has withstood the test of time and has proven time and time again that using it will produce welds which are adequate for their intended purpose and every bit as sound as welds produced pursuant to prequalified AWS procedures or procedures qualified by test pursuant to the AWS Code.

CASE has alleged that the AWS Code includes certain provisions not considered by the ASME Code or used at CPSES, i.e., (1) "Preheat requirements for welds on plates over 3/4-inch thick," (2) "Drag angle and work angles (which limit the space allowed for the welder to function," (3) "Beta factor for tube-to-tube welds," (4) "Multiplication factor and reduction factors for skewed "T" weld joints," (5) "Limitations on angularity for skewed "T" joints," (6) "Calculations for punching (actually a reduction factor for the weld) shear on step tube joints," (7) "Lap joint requirements," (8) "Design procedure for joint of tube to tube with Beta equal to 1.0," (9) "Limitation on weld sizes relative to plate thickness," and (10) "Calculation for effective throat of flare bevel welds." (This last item was closed out by the Board's Memorandum and Order of December 28, 1983 at p. 41).

Of the nine items noted above which are still open, four items (4, 5, 6 and 8, above) deal primarily with weld joint design and will be discussed in testimony regarding design which will be filed at a later date. With regard to the remaining five open items (1, 2, 3, 7 and 9, above), we have evaluated these five items which CASE has characterized as AWS Code provisions and found that not all five are AWS Code provisions. In evaluating the items we first examined the applicable AWS Code to find out if there were any AWS Code provisions related to the item. Next we examined the applicable ASME Code provisions to determine if and how the corresponding AWS Code provision (if any) had been taken into consideration. Finally, we checked to assure that the applicable procedures at CPSES took into consideration the relevant provisions.

With respect to Item 1, "preheat requirements for welds over 3/4-inch thick," the AWS D1.1 Code addresses preheat requirements for prequalified procedures in Subsection 4.2, "Preheat and Interpass Temperature Requirements." (If procedures are to be qualified by test pursuant to the AWS Code, the preheat requirements specified in subsection 4.2 need not be used.) For these prequalified procedures, Table 4.2 establishes preheat requirements based on the type of material and the welding process used. For example, for

shielded metal arc welding with low hydrogen electrodes on A36 rolled shapes and A500 Grade B structural tubing, the requirements are as follows:

Thickness (inches)	Minimum Temperature
Up to 3/4	None
Over 3/4 thru 1-1/2	50°F
Over 1-1/2 through 2-1/2	150°F
Over 2-1/2	225°F

Subsection NF-4611 of the ASME Code also addresses preheat requirements based on various properties, as follows:

> The need for and temperature of preheat are dependent on a number of factors, such as the chemical analysis, degree of restraint of the parts being joined, elevated temperature, physical properties and material thickness. Some practices used for preheating are given in Appendix D as a general guide for the materials listed by P-Numbers of Section IX. It is cautioned that preheating suggested in Appendix D does not necessarily ensure satisfactory completion of the welded joint and that the preheat requirements for individual materials within the P-Number listing may be more or less restrictive. The Welding Procedure Specification for the material being welded shall specify the minimum preheating requirements under the welding procedure qualification requirements of Section IX. [Emphasis supplied.]

In short, while Appendix D of the ASME Code, Section III, provides guidance for preheat requirements (very similar to that provided in the corresponding sections of AWS), the Code states that during welding procedure qualification, the preheat requirements which have been actually tested and produce acceptable welds are the ones to be specified in the applicable procedures.

(Baker) Qualification of procedures in accordance with the ASME Code has resulted in preheat requirements in the applicable CPSES welding procedures that in all cases either meet or exceed those preheat requirements set forth in the AWS Code.

(All Affiants) In sum, CASE's allegation that preheat requirements set forth in the AWS Code are not adequately considered at CPSES is without merit.

With regard to Item 2, "Drag Angle and Work Angle" (which limit the space allowed for the welder to function), contrary to CASE's allegation, neither the AWS nor ASME Codes refer to, or in any way mention "drag angle" or "work angle" requirements or restrictions. In its February 1, 1984, Answer to Applicants' Motion for Reconsideration, CASE provides some clarification of its concern and states in the attached Affidavit of Jack Doyle that the weld designer must take into consideration the welder's drag and work angles. For support, CASE references the Welding Handbook, Seventh Edition, Volume 2. It should be noted that this Handbook in no way states or implies that the drag angle or work angle of a welder should be an explicit design consideration. Regardless of the weld design, the skilled welder assumes the proper drag and work angle for the job. Indeed, that very portion of the Welding Handbook referenced by CASE and attached to the Doyle Affidavit states that proper work

orientation of the weld rod (e.g., drag and work angle) are "automatically taken into account" by the trained welder. In short, the welder's very basic training provides this information as well as the precautions a welder has to take to make successful welds.

(Baker) Where the area which surrounds the weld of concern is limited so as to potentially adversely impact a welder's ability to maintain proper weld orientation, as a matter of practice at CPSES welders are used who have practiced and been tested in these configurations. For example, on piping where space limitations may require welding using a mirror without directly seeing the weld, welders are trained and tested in this configuration to assure that the weld is performed correctly. Many times mock-ups of the configuration (including simulating the limited space) are constructed to provide precise conditions the welder will encounter. A qualification listing and matrix of the "specially" qualified welders is maintained.

(All Affiants) In any event, CASE's stated concern regarding improper work angle and drag angle is that it may cause slag entrapment, porosity and undercut. These defects are no different than potential concerns regarding any other weld. Because of welder training and qualification, coupled with inspections and surveillance of the Welding Engineering

Department and QA/QC, there is reasonable assurance that any problems regarding slag entrapment, porosity and undercut will be detected and corrected, as necessary.

In sum, CASE's allegations concerning drag angle and work angle are without merit.

With regard to Item 3, "Beta Factor for Tube-to-Tube Welds," the Beta Factor (the ratio of the diameters of two adjoining tubes) is referenced in Section 10 of AWS D1.1 Code, subsection 10.12.5, 10.13.5 and Figure 10.13.5. In essence, these references provide that if the Beta Factor is greater than 1/3 for tube-to-tube (circular) connections and greater than 0.8 for box (rectangular) connections, the weld procedure used must be qualified by test (the greater the Beta factor, the more likely that stresses at the joint will be higher). In short, where the likelihood of greater stresses is present, the Beta Factor is used in the AWS Code to indicate that qualification of a procedure by test is required. Significantly, the ASME Code requires that all weld procedures be qualified, without consideration of the likelihood of greater stresses.

In any event, in Mr. Doyle's testimony (CASE Exhibit 669, Vol. I, p. 112), he states as his concern that the Beta factor limit of 1/3 should apply to shielded metal arc fillet welds used when welding trunions to pressure boundary piping. Since such a trunion would be an "integral

attachment" to the piping, the AWS Code does not apply and the weld must be designed to the applicable pressure boundary subsection in ASME, i.e., NB, NC, or ND. AWS D1.1 (as stated in paragraph 1.1.1) clearly does not apply to this case (i.e., pressure boundary piping) and Mr. Doyle's concerns are unfounded.

(Baker) It should be noted that in addition to the qualification of these procedures by testing, CPSES also has performed additional generic testing on equal sized box connections (B=1.0) to assure that penetration depth and minimum throat requirements (the major concerns for these welds) are adequate for rectangular beam welds.

(All Affiants) From the foregoing, CASE's concerns regarding AWS Code requirements concerning Beta Factor are without merit.

With regard to Item 7, "Lap joint requirements," Subsection 8.8 of the AWS D1.1 Code provides lap joint requirements for building structures. These requirements are the same as those set forth in Paragraphs XVII-2431, 2452.3(c), 2453.1, 2452.9 and 2283.1(c) of Appendix XVII of the ASME Code (mandatory to CPSES welding in conformance to ASME requirements). (Subsection 9.10 of the AWS D1.1 Code provides corresponding lap joint requirements for bridges, subjected to continuous dynamic loading.)

In short, the ASME Code requirements for lap joints (with which applicable welding at CPSES complies) are the same as related requirements in the AWS Code. Accordingly, CASE is not correct in stating that the ASME Code and applicable welding at CPSES does not adequately consider lap joint requirements as noted in the AWS Code.

With regard to Item 9, "Limitation on weld size relative to plate thickness," limitations are addressed by AWS D1.1 Code in Subsections 2.7 (fillet welds) and 2.10 (partial penetration groove welds). These subsections basically provide that with regard to fillet and groove welds, welds to be made without qualifying the applicable procedure by test shall conform to the minimum size requirements of Tables 2.7 and 2.10.3, respectively. These requirements are identical to or less stringent than those required at CPSES by the ASME Code in Appendix XVII, Table XVII-2452.1-1.

In sum, the limitations on weld size relative to plate thickness set forth in the AWS Code are considered in the ASME Code and factored into applicable procedures at CPSES. Accordingly, CASE's allegation that this AWS Code provision was not adequately considered is incorrect.

In its January 3, 1984, Memorandum and Order at pp. 6-7, the Board requested that additional testimony be provided as to the requirements of both the AWS and ASME Codes

concerning weave welding, downhill welding, preheat and cap welding. The specific requirements, if any, in each Code regarding these issues and how CPSES factors these requirements into its procedures are set forth below:

1. Weave Welding

Neither the AWS nor ASME Code establishes specific requirements limiting weave or oscillating pattern welding. Accordingly, there are no specific Code requirements.

It should be noted, however, that for shielded metal arc welding (the welding of concern) bead width is listed as a supplementary essential variable in Section IX of the ASME Code when impact properties are specified, and a nonessential variable when not specified. In either case, while applicable CPSES welding procedures set an upper limit on bead width, the bead width can vary below that limit without impacting the procedure.

(Baker) As stated in previous testimony, CPSES welding procedures have limited bead width to four times the core diameter of the weld rod being used. Other industries which comply with the Codes and perform qualification tests of procedures generally use bead widths in excess of four times the rod core diameter, up to and including eight times the rod core diameter. In

sum, although there are no specific Code requirements regarding bead width (other than considering it as a supplementary essential or non-essential variable, as stated above), relevant procedures at CPSES limit the bead width to four times the rod core diameter.

2. Downhill Welding

(All Affiants) Neither the ASME nor AWS Codes exclude use of downhill or uphill welding. However, the ASME Code and the AWS Code specify that the direction of travel must be listed.

(Baker) At CPSES, Brown & Root welding procedures state that in all instances the direction of progression will be upward. Other contractors, in a few instances, have performed qualification testing using downward progression, and downhill welding by those contractors is thus permissible. In short, direction of travel is considered at CPSES and is appropriately factored into welding procedures.

3. Preheat Requirements

(All Affiants) Code requirements concerning this area and how they are addressed at CPSES are discussed above in relation to CASE's concern regarding "preheat requirements for welds on plates over 3/4 inch thick."

4. Cap Welding

Cap welding is not terminology common to welding. The usual reference is a cover pass or a reinforcement pass. There are no additional Code requirements regarding cap welding; Code requirements for other welding apply equally to cap welding. Indeed, the AWS Code (1975 Revision) specifically endorses it as follows:

> Additional weld material to compensate for any deficiency in size shall be deposited using an electrode preferably smaller than that used for making the original weld, and preferably not more than 5/32 in. (4.0 mm) in diameter. The surfaces shall be cleaned thoroughly before welding. [Section D1.1, subsections 3.7.1].

To the extent that CASE is concerned that new weld material cannot be placed on an old weld without some adverse structural impact, CASE's concern is without merit. Neither Code provides any restrictions in this area, or even requires its consideration as an essential or non-essential variable. Such practice occurs daily when a welder takes a lunch break during a weld, or stops in the middle of a weld due to crew change or even to change a weld rod. In all such instances the welder simply follows his procedure to complete the weld. This would require actions such as cleaning the weld surface and assuring that preheat requirements, if any, are met (in most instances $60^{\circ}F$).

(Baker) It should be noted that CASE's concern apparently stems from the fact that some fillet welds in the plant were found to be approximately 1/16 inch below the minimum size specified in the ASME Code. These welds were subsequently corrected by following appropriate welding procedures that consisted of, among other things, cleaning the weld, assuring preheat requirements were being met, welding the additional pass and obtaining a final QC visual inspection. It should be noted that in no instance did any welder or QC inspector report a crack in any of the welds.

(All Affiants) Specifically, CASE's concerns appear to be that the minimum size of the weld may have resulted in miscellaneous cracks (caused by external loading on the undersized weld), internal cracking or underbead cracking which would be aggravated when additional material is used to build up the weld.

In the first instance, the welds were designed to resist extensive and substantial seismic loading well in excess of any external loading that likely did occur from the time that the welds were made until they were built up. In this regard, it should be noted that even with undersized welds, the AWS Code states that the weld is still acceptable even if undersized 1/16 of an inch for 10 percent of the weld length (AWS Code, Sections

8.15.1.6 and 9.25.1.6). The ASME Code added this provision to Subsection NF in the winter 1983 addenda. Accordingly, CASE's speculation that miscellaneous weld cracks may have formed due to external loading on these welds is without merit.

As to CASE's concerns that internal cracking may have formed because the welds were undersized in the first instance is also without a supporting basis. Indeed, it is well known and a very basic principle of welding that the primary reason for internal cracking is not an undersized pass, but rather a weld pass that is too thick.

As to CASE's concerns that because the welds may have been slightly undersized there is a substantial problem with underbead cracking, this position is again without any supporting basis. Especially when using low hydrogen electrodes (used at CPSES), underbead cracking is not a problem with the mild or low carbon structural steels such as used for the bulk of the fabrication of pipe supports at CPSES, including those supports on which the undersized welding referenced by CASE occurred. These steels contain only carbon and manganese as alloying elements (.29% maximum carbon) and

do not form the martensite grain structure in the heat affected zone of the base material that is necessary to promote underbead cracking.

The high strength, low alloy steels which contain varying amounts of chromium, vanadium, zirconium, nickel and phosphorous (and thus could result in formation of martensite in the heat affected zone) are only used for special applications at CPSES. Where these materials are used, specific welding procedures are utilized containing special preheats (300^{o} - $400^{o}F$) and post weld heat treatment to prevent weld shrinkage and martensite formation, necessary to cause underbead cracking.

To summarize the above, to prevent underbead cracking, only low hydrogen type electrodes are utilized for the welding of any low or mild carbon steels or high strength low alloy structural steels. Further, the bulk of the pipe support fabrication employs carbon steels not susceptible to underbead cracking problems. For those special items utilizing steels which may be subject to underbead cracking, welding procedures are utilized which contain the necessary preheat or post weld heat treatment requirements to eliminate the metallurgical conditions which are necessary for underbead cracking to occur. In short, CASE's concerns regarding underbead cracking are totally without merit.

In sum, the concerns regarding cracking raised by CASE are without technical merit. In any event, it must be remembered that no cracks were identified by either the welders or QC inspectors for any of the undersized welds. If cracks had been a problem, at least some of them would have been detected and reported.

In short, to the extent that CASE is concerned with welding over previously welded joints, such concerns are completely groundless.

William E. Baker

William E. Baker

Sworn to before me this 2nd day of April 1984.

Notary Public

Mathew D. Muscente

Sworn to before me this 2nd day of April 1984.

Notary Public

John D. Stevenson

John D. Stevenson

Sworn to before me this 4th day of April 1984.

Deborah A. Miller

Notary Public

My Commission Expires 14, 1986

Roy E. Lorentz, Jr.

Roy E. Lorentz, Jr.

Sworn to before me this 2nd day of April 1984.

Catherine D. Smith

Notary Public

My Commission Expires 3/13/88

PROFESSIONAL QUALIFICATIONS OF JOHN D. STEVENSON

EXPERIENCE:

PRESIDENT - MANAGING PARTNER

Since November 1981, Dr. Stevenson has managed and has served as President and Senior Consultant to Stevenson & Associates. The firm specializes in high technology consulting and forensic engineering associated with failure analysis of structural and mechanical systems; extreme loads; and nonlinear, dynamic, probabilistic and high temperature analyses.

VICE-PRESIDENT - GENERAL MANAGER
1976 - 1981

As Vice-President, Dr. Stevenson managed and served as Senior Engineering Consultant to the Cleveland Offices of Woodward-Clyde Consultants and Structural Mechanics Associates specializing in areas of high technology applicable to the structural-mechanical design and analysis of structures, systems and components. Prior to this time, the consulting group he headed provided similar services as a Division of Davy-McKee Co. Dr. Stevenson also served as Corporate Manager of Engineering Quality Assurance for Davy-McKee Co.

ASSOCIATE PROFESSOR
1974 - 1976

Case Western Reserve University, CWRU, Dr. Stevenson served as Director of a program in Design for the Extreme Load Environment and held a joint appointment in the Departments of Civil Engineering and Mechanical Design. He also conducted a number of seminars on Nuclear Facility Seismic, Quality Assurance, Scheduling and Manpower Requirements and Design of Mechanical and Electrical Equipment and Distribution Systems including supports for Heavy Industrial Facilities.

CONSULTANT
1973 - 1974

Westinghouse Nuclear Energy Systems, Pittsburgh, Pennsylvania.

As a Consulting Engineer for Westinghouse Nuclear Energy Systems, Dr. Stevenson acted as an advisor to the

Technical Director on the Executive Vice-President for Nuclear Power Staff. He performed evaluations of balance of plant requirements associated with nuclear power plant design and constructed and represented Westinghouse on a number of Industry Committees associated with nuclear power.

CONSULTANT
1972 - 1973

Westinghouse Water Reactor Divisions, Pittsburgh, Pennsylvania.

As an Advisory Engineer for the Westinghouse Standard Plant Project, Dr. Stevenson acted as a consultant to the Manager of the Westinghouse Standard Plant Project. In this capacity he had responsibility for determining interface requirements with site-related design parameters and set envelope requirements for the standard plant design. He was responsible for nuclear island PSAR text developments and AEC licensing requirements associated with the standard plant layout development.

ADJUNCT PROFESSOR
1970 - 1972

University of Pittsburgh, Pittsburgh, Pennsylvania.

As a member of the Civil Engineering Facility of the University of Pittsburgh, Dr. Stevenson was particularly active in the areas of structural dynamic response to earthquake, tornado, missile and fluid jet effects as well as reliability and risk analysis and optimum design of structural systems. Dr. Stevenson was responsible for the development of a graduate study program for the study of structural design and analysis for the extreme load environment.

MANAGER STRUCTURAL SYSTEM ENGINEERING
1968 - 1970

Westinghouse PWR Systems Division, Pittsburgh, Pennsylvania.

Dr. Stevenson had overall responsibility within Westinghouse for the development and approval of structural design criteria and layout used in the design of the six nuclear power stations for which Westinghouse had prime design and construction responsibility for product

line management of design and development of support structures for major nuclear components.

LEAD ENGINEER
1966 - 1968

Westinghouse PWR Systems Division, Pittsburgh, Pennsylvania.

As Lead Engineer, Dr. Stevenson was responsible for liaison with the various architect-engineer-constructor firms which performed the detailed structural design and construction of turnkey plants, and as such he was responsible for design review and approval. Dr. Stevenson was active in representing Westinghouse structural design policy before the Atomic Energy Commission and Advisory Committee on Reactor Safeguards.

GRADUATE STUDENT
1963 - 1966

Case Institute of Technology, Cleveland, Ohio.

Worked towards a Ph.D. in Structures with emphasis on computer applications and risk analysis applied to structural design.

RESEARCH ENGINEER
1962 - 1963

I.I.T. Research Institute, Chicago, Illinois.

Responsibilities included integrated radiation, structural and operational analysis and minimum cost design of nuclear blast resistant underground structures.

ASSISTANT PROFESSOR
1957 - 1962

Virginia Military Institute, Lexington, Virginia.

Courses in structural design of concrete and steel structures were taught to Civil Engineering undergraduates.

John Hopkins University, Baltimore, Maryland - (Part-Time) Research Assistant.

Responsibilities included report editing and research in the location, type quantity and packaging of low level solid atomic wastes.

FIELD ENGINEER
1956 - 1957

McDowell Construction Co., Cleveland, Ohio.

Field Engineer responsible for technical supervision and engineering field modifications to construction of a Sintering Plant for U.S. Steel Corp. Youngstown Works.

Dr. Stevenson has been particularly active in the review and evaluation of design adequacy of structures, equipment and equipment supports in nuclear power plants and other industrial facilities. Particular projects where he personally performed such evaluations include the following:

Nuclear Power Plants:

Indian Point Units 2 & 3
H.B. Robinson
R.E. Ginna
Point Beach
Dresden 2
Monticello
D. C. Cook
Palisades
Oyster Creek
Millstone
South Texas Project
Conn. Yankee
Maine Yankee
Fessenheim - France
Cordoba - Argentina
Milhama - Japan

Other Industrial Facilities:

Tokamac Fusion Test Facility
Purex Facility
Hanford
Rocky Flats Processing Facility
Centrifuge Plant
Granger Soda Ash Plant
LMFBR
Hercules Polypropalene Plant
Shuichang Steel Complex
Touss Oil Fired Power Station
Hanford Coal Fired Power Station
Addy Ferro Silicate Plant
Killen Coal Fired Power Station

EDUCATION:

B.S. - Civil Engineering -
Virginia Military Institute, 1954

AEC Institute on Nuclear Engineering -
Purdue University, Summer 1960

M.S. - Civil Engineering -
Case Institute of Technology, 1962

Ph.D. - Civil Engineering -
Case Institute of Technology, 1968

PROFESSIONAL:

1. Member: American Society of Civil Engineers
   Chairman: Nuclear Standards Committee - Technical Council on Codes and Standards
   Member: Executive Committee, Technical Council on Codes and Standards
   Member: Structural Division Committee on Nuclear Safety
   Member: Structural Division Committee on Nuclear Structures and Materials

2. Member: American Society of Mechanical Engineers
   Chairman: Task Committee on Seismic Functional Qualification of Mechanical Components (Pumps and Valves)
   Member: Subgroup on Design of ASME BPVC-Section III-Div. 1 Nuclear Components
   Member: Subcommittee on Qualification of Mechanical Components in Nuclear Service

3. Member: Nuclear Standards Management Board of ANSI representing ASCE

4. Member: U.S. Representative International Standards Committee SC 85/3/7 on Seismic Criteria for Nuclear Plants

5. Member: AISC, American Institute of Steel Construction Committee on Specifications for Structural Steel in Safety Class Nuclear Structures

6. Member: U.S. Representative International Atomic Energy Agency Working Group on the Development of Seismic Design Standards

7. Registered Professional Engineer: Virginia, Pennsylvania, and Ohio

8. Winner: Moiseiff Award - ASCE, 1971

Dr. Stevenson's codes and standards activities also include being an organizing member in 1971 of the Subgroup NF which prepared the ASME Code rules on component supports. He personally was responsible for the initial draft of Appendix XVII for design of linear supports.

PUBLICATIONS INCLUDE THE FOLLOWING:

1. Stevenson, J.D., "Criteria and Design of Pressurized Water Reactor Coolant System Support Structures - State-of-the-Art," First International Conference on Structural Mechanics in Reactor Technology, Berlin, Germany, September 1971.

2. Stevenson, J.D., "Seismic Design of Small Diameter Pipe and Tubing for Nuclear Power Plants," Proc. 5th World Conference on Earthquake Engineering, Rome, June 1973.

3. Stevenson, J.D. and LaPay, W.S. "Amplification Factors to be Used in Simplified Seismic Dynamic Analysis of Piping Systems," Proc. Pressure Vessel and Piping Conference, ASME, June 1974.

4. Bergman, L.A. and Stevenson, J.D., "The Effects of Support Stiffness Upon the Response of Piping Systems," Presented at ASME National Congress on Pressure Vessels and Piping, June 1979.

5. Gorman, M. and Stevenson, J.D., "Probability of Failure of Piping Designed to Seismically Induced Emergency and Faulted Condition Limits," 5th SMIRT Conference, Berlin, Germany, August 1979.

6. Stevenson, J.D., "Nuclear Standards Applicable to the Civil-Structure Design of Nuclear Power Plants." Proceedings of Specialty Conference on Experience with the Implementation of Construction Practices, Codes Standards, and Regulations in Construction of Power Generating Facilities, Pennsylvania State University, September 1981.

7. Moses, F., and Stevenson, J.D., "Reliability Based Structural Design," Journal of the Structural Division, ASCE, Vol. 96, No. ST 2, Proc. Paper 7072, February 1970.

8. Stevenson, J.D. (Editor), "Proceedings of Second ASCE Speciality Conference on Structural Design of Nuclear Power Plant Facilities," New Orleans, December 1975.

9. Stevenson, J.D., and Moses, F., "Reliability Analysis of Frame Structures," Journal of the Structural Division, ASCE, Vol. 96, No. ST 11, Proc. Paper 7692, November 1970.

10. Stevenson, J.D., and Abrams, J.I., (Editors) "Proceedings of Symposium on Structural Design of Nuclear Power Plant Facilities," University of Pittsburgh, 1972.

11. Stevenson, J.D., "Standards - Status and Development in the Nuclear Industry," Proceedings of ASCE Specialty Conference on Design of Nuclear Plant Facilities, Boston, April 1979.

12. Stevenson, J.D., Chairman, Editing Bcard, Structural Analysis and Design of Nuclear Plant Facilities, ASCE Manuals and Reports on Engineering Practice - No. 58, American Society of Civil Engineers, August 1980.

Professional Qualifications
of
Roy E. Lorentz, Jr.

Professional Experience

From 1940 -- Metallurgist with Combustion Engineering, Inc. working on welding developments, metallography, failure analysis, nondestructive testing, material selection, production equipment development, and metallurgical application, including technical support for all groups of company including sales, engineering, production, international operations, etc.

Held successive positions as Project Leader Supervisor, Production Metallurgist, Manager Fabrication Metallurgy, Manager of Metallurgical Research and Development 1968 to 1973, and Director of C-E Power Systems Chattanooga Metallurgical and Materials Laboratory, until retirement from C-E in 1981.

From May 1981 -- Metallurgical Consultant to Chattanooga Concerns and the Metal Properties Council.

Memberships

American Welding Society, American Society for Metals, American Society for Testing Materials, Pressure Vessel Research Committee, ASME Boiler & Pressure Vessel Code, Metal Properties Council. Offices held include past Chairman Chattanooga Sections AWS & ASM, Past District Director AWS. Past member National Nominating Committees AWS & ASM. Honors include 1962 AWS Adams Memorial Lectureship. 1962 Award Certificate. Active member of ASME -- Subcommittee of Welding -- Chairman of its Materials Subgroup -- and Subgroup on Plates.

Publications

April 66 Metal Progress "Should Pressure Vessels Be Heat Treated?", 1966 Chapter 9 in Book "Combustion Engineering", on "Materials Metallurgy", AWS Welding Handbook Chapters on "Chromium Iron & Steels", "Pressure Vessels", "Nuclear Vessels", "Clad Steels". AWS Journal 1957 on "Fabrication of Nuclear Reactor Vessels", ASTM Nondestructive Testing Symposium 1942 Book Chapter -- and many others.

Personal

B.S. Metallurgical Engineering - University of Illinois - June 1939. M.S. Metallurgical Engineering - Lehigh University - June 1940. Employed as Welder during college summers. Member Brainerd United Methodist Church and its Board of Trustees, Member Brainerd Kiwanis Club.

ATTACHMENT 1

1. In 1963 awarded certificate of ASME "In Appreciation of his Outstanding Leadership in the Development of Standards and Codes as a member of Subcommittee on Welding of the Boiler and Pressure Vessel Committee from October, 1949."

2. In 1962 awarded certificate of AWS "Adams Lecture for the year 1962 under the Title of Utilization of Quenching and Tempering for Improvement in Properties of Low Alloy Steels in Heavy Thicknesses for Welded Construction and who was selected in recognition of his attainments in the science and art of welding."

3. Co-author of American Welding Society Handbook Chapter 51 "Pressure Vessels and Boilers", Chapter 88 "Nuclear Power", Chapter 95 "Clad Metals", of book Combustion Chapter on "Metallurgy", of Welding Research bulletin 82 (October 1962) on "Arc Welding of Thick Cross Sections." ASME Paper 59-A-318 (January 1960), "The Eddystone Research Story", Chapter 5 (titled "Factors Affecting Weldability in Fabrication" of Book -- Weldability of Steels - by Stout and Doty (1971)).

4. Presented technical talks to AWS-ANS in May, 1963, New York and in previous years to various Society, University and Government organizations. (See Attachment 2).

5. Past Chairman AWS and ASM Chattanooga Section (and other offices). Past member National Nominating Committee of AWS and ASM. Past Southeastern District Representative AWS. Member Tau Beta Pi, Sigma Xi.

ATTACHMENT 2

1. Welding Design and Fabrication Per ASME Section IX and other Codes -- Presented (For Technical Seminars, Inc.) in Albuquerque, N.M., February 1983.

2. Fabrication and Inspection of Power Plant Components -- W. R. McDearman and R. E. Lorentz, Jr. -- Presented at INCO Power Conference 1978

3. Quenched and Tempered Heavy Section Steels -- Presented in Moscow, USSR, November 1976.

4. Metallurgical Problems and Solutions Pertaining to Nuclear Components -- Presented in Moscow, USSR, November 1976.

5. Temper Embrittlement of 2¼ Cr-1 Mo Steel - Panel Participation, Dallas, Texas, September 1974.

6. Fabrication of Heavy Thickness, Low Alloy Steel Pressure Vessels, Presented at Petroleum Division Conference, ASME, Los Angeles, California, September 1964.

7. Quenched and Tempered Heavy Section Steels, by R. E. Lorentz, Jr., and W. L. Harding -- Presented at 23rd Annual Petroleum Mechanical Engineering Conference, Dallas, Texas, September 1968.

8. Evaluation of Ni-Cr-Mo Quenched and Tempered Alloy Steel For Nuclear Reactor Pressure Vessels, by J. V. Alge, U.S. Steel, R. E. Lorentz, Jr., C.E. Inc., E. Landerman, West. Elect. Corp. -- Presented at ASME -- 21st Annual Petroleum Mechanical Engineering Conference, New Orleans, Louisiana, September 1966.

9. Fabrication of High-Strength Heavy-Wall Pressure Vessels, by M. W. Davis and R. E. Lorentz, Jr.-- Presented at Midwest Welding Conference, Chicago, Illinois, February 1966.

10. Panel member University of Illinois short course on Welding Engineering -- Presented "Residual Stresses and Relief", December 1960.

11. Presented technical talk at ASME National Metals Engineering Conference Workshop on "The Application of Metals in Heavy Sections - Quality Control", May 1959.

12. Presented talk to Atlanta Section of ASM on "Fabrication of Nuclear Reactor Pressure Vessels", February 1959.

13. Talk to Oak Ridge AWS Section on "Fabrication of Nuclear Reactor Pressure Vessels and Heat Exchanger Equipment", February 1959.

14. Talk to ASME and AWS Sections of Providence, Rhode Island on "Pressure Vessels and Piping", November 1958.

15. Talk to AWS Northern New York Section at Albany, New York on "Fabrication Problems in the Manufacture of Reactor Vessels", November 1958.

16. Talk to Western Welding, Brazing and Heat Treating Conference at Menlo Park, California on "Fabrication of Nuclear Power Reactors and Auxiliary Equipment", March 1958.

17. With Dr. L. W. Smith, presented talk at ASME Annual Meeting, New York on "Metallurgical Design and Fabrication Problems in Pressure Vessels for Nuclear Power", December 1957.

18. Talk to AWS National Spring Meeting in Philadelphia, Pennsylvania on "Welding Problems in Pressure Vessels for Nuclear Reactors", published in AWS Journal, September 1957.

19. Talk to Annual Southern Metals Conference at Jacksonville, Florida, on "New Horizons in the Welding of Pressure Vessels for Nuclear Reactors", May 1957.

20. Talk to Welding Engineers Conference of the U.S. Navy, Washington, D.C. on "Fabrication of AISI Type 430 Stainless Steel Pressure Vessels." Published in Brochure of Bureau of Ships Welding Engineers Conference at U.S. Naval Research Laboratory, May 1956.

21. Similar talks previous years including teaching of classes.