



**Global Nuclear  
Network Analysis, LLC**

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## **Edward A. Rodriguez, PE**

Mr. Edward A. Rodriguez is a registered professional engineer providing consulting engineering services to private industry and government organizations through Global Nuclear Network Analysis, LLC, a woman-owned, limited liability company situated in Santa Fe, New Mexico.

Mr. Rodriguez has over 33 years experience in diverse areas, including the US Department of Energy (DOE) Nuclear Weapons Program administered by the National Nuclear Security Administration (NNSA), US Department of Defense (DOD) Navy Submarine Nuclear Propulsion Program, and DOE nuclear reactor programs. His demonstrated proficiency in diverse scientific and engineering fields, include;

- Structural Dynamics
- Pressure Vessel Design
- High-Explosives Engineering
- High-Velocity Penetration Mechanics
- Explosive Blast Load Structural Design
- Fatigue and Fracture Mechanics
- Weapons Effects/Response
- Thermal Shock and Stress Analysis
- Numerical Hydrodynamics
- Shock Wave Physics

Mr. Rodriguez has published extensively and given numerous presentations in the above diverse areas, which deal directly with transient (dynamic) and catastrophic events, including explosive blast loading, fragment generation and penetration, fracture and fatigue, pressure vessel design, and probabilistic structural analysis. Current consulting activities include:

- **BECTHEL NATIONAL, INC., US Department of Energy, Waste Treatment and Isolation Plant, Richland, WA** – Providing expertise in gaseous deflagration, detonation, and deflagration-to-detonation transition (DDT) in the overall design and analysis of piping transfer systems and pressure vessels for the waste vitrification plant. Performing computational modeling of gaseous detonations utilizing CTH hydrocode and structural dynamics modeling with TeraGrande.
- **THEOFANOUS AND COMPANY, INC., Santa Barbara, CA** – Member of a team studying analytical and numerical methods for design and analysis of structures subjected to simulated terrorist attack modes on reinforced concrete (civil) structures, including both explosive blast and impact (missile) loadings. Applying hydrodynamic methods for solution of blast loading functions.
- **LOS ALAMOS NATIONAL LABORATORY, WEAPONS ENGINEERING TECHNOLOGY DIVISION, Los Alamos, NM** – Providing engineering research and development, numerical and theoretical analytical support, and technical reviews associated with weapon design and weapons effects. Developing a “Confinement vessels Cookbook” that will provide design engineers with the necessary tools for design and analysis of a blast containment chamber to the rules of the ASME Code, Section VIII, Div. 3 and Code Case 2564.
- **KOBE STEEL, LTD., Kobe, Japan** – Providing technical expertise for design and analysis of high-explosive blast containment chambers supporting Chemical Weapons Demilitarization (CWD).
- **PAULIN RESEARCH GROUP, Houston, TX** – Consulting engineering on independent technical review and analysis of pressure vessel system subjected to gaseous events. Performing high-fidelity modeling of blast loads in large reactor chambers for chemical process.

Recently completed consulting activities include (with completion date):

- **UNIVERSITY OF CALIFORNIA AT SANTA BARBARA, Center for Risk Studies and Safety** – Member of a team studying analytical and numerical methods for design and analysis of structures subjected to simulated terrorist attack modes on reinforced concrete (civil) structures, including both explosive blast and impact (missile) loadings (March 2010).
- **U.S. DEPARTMENT OF ENERGY (DOE) - NATIONAL NUCLEAR SECURITY ADMINISTRATION (NNSA)** – Served on the NNSA, NA-54 Technical Independent Peer Review (T-IPR) for the conceptual design of the Radioactive Liquid Waste Treatment Facility (RLWTF) at the Los Alamos National Laboratory, in Los Alamos, NM (January 2010).
- **ADVANCED TECHNOLOGIES AND LABORATORIES INTERNATIONAL, INC., Germantown, MD** – Providing expert safety analysis review, under ASME Code Section XI, of commercial nuclear power plants for License Renewal Applications (LRA) from various utilities (December 2009).
- **SANDIA NATIONAL LABORATORIES, Livermore, CA** – Providing technical expertise for Peer Review of the Explosive Destruction System (EDS) supporting Chemical Weapons Demilitarization (CWD) for non-stockpiled chemical munitions (November 2009).
- **SAVANNAH RIVER SITE, Aiken, SC** – Providing subject matter expertise to WSMS/URS on deflagration, detonation, and deflagration-to-detonation transition (DDT) of vapor cloud explosions (VCE) in waste reprocessing facility (March 2009).
- **ENERGY RESEARCH, INC., Rockville, MD** – Providing subject matter expertise for the US Nuclear Regulatory Commission (NRC) in explosive blast load analysis methods for supporting calculations meeting the requirements of Regulatory Guide 1.91, *Evaluations of Explosions Postulated to Occur on Transportation Routes near Nuclear Power Plants* (February 2009).
- **U.S. DEPARTMENT OF ENERGY (DOE) - NATIONAL NUCLEAR SECURITY ADMINISTRATION (NNSA)** – Served on the NNSA, NA-54 Technical Independent Peer Review Team (T-IPR) for the conceptual design of the Pit Disassembly and Conversion Facility (PDCF) at the Savannah River Site in Aiken, NC (December 2008).
- **ARES CORPORATION, San Francisco, CA** – Provided expertise through numerical and theoretical hydrodynamic analysis of a hypothetical explosion occurring inside a vacuum-arc-remelt (VAR) furnace and corresponding blast loads impinging on the facility building. This effort was accomplished for the US Department of Energy, National Nuclear Security Administration's (NNSA) site, National Energy Technology Laboratory in Albany, OR (August 2008).
- **DOMINION ENGINEERING, INC., Reston, VA** – Provided engineering analysis and subject matter expertise in the design of gaseous detonation events, including design and analysis methods in accordance with the ASME Boiler and Pressure Vessel Code (February 2008).

## EDUCATION

Mr. Rodriguez received his BS degree in Civil Engineering (1977) from the University of Massachusetts (Amherst, MA) and MS degree in Mechanical Engineering (1981) from the University of Connecticut (Storrs, CT). He has also accomplished post-graduate work both at Rensselaer Polytechnic Institute (Hartford Graduate Center) and the University of New Mexico in Albuquerque, NM.

## EXPERIENCE

**From 2006 to 2008**, prior to engaging in consulting engineering, Mr. Rodriguez retired after 17 years with Los Alamos National Laboratory, in Los Alamos, NM, where he was most recently, Division Director for the Weapons Engineering Technology Division. He directed a \$65-70M budget with 285 technical engineering staff in Los Alamos and the Nevada Test Site (NTS), supporting nuclear weapons stockpile effort through experimental and analytical assessment. As Division Director, Mr. Rodriguez was responsible for:

- Subcritical underground experiments at the Nevada Test Site,
- Hydrodynamics experiments of weapon-like assemblies,
- High-explosive (HE) engineering R&D including HE pressing and machining operations,
- Application of numerical computations for structural dynamics and hydrodynamic analysis of all LANL nuclear weapons systems,
- Experimental shock and vibration facility supporting the stockpile weapons systems,
- Engineering R&D of polymeric substances

**From 2000 to 2005**, Mr. Rodriguez was Deputy Group Leader and then Acting Group Leader in the Engineering Sciences and Applications Division, supervising 120 engineering staff members and technicians providing research and development (R&D) of stockpiled nuclear weapon subjected to flight environments, including dynamic structural response and weapons effects, through application of numerical, theoretical, and experimental methods (Budget \$30.5M).

**From 1996 to 2005**, Mr. Rodriguez was the Primary Lead Engineer for the W88 Warhead System; Pit Certification POC, and Lead Structural Engineer for the DynEx Program directing engineering design and analysis efforts utilizing hydrodynamics and structural dynamics numerical methods.

- Responsible for structural dynamic analyses of the W88 weapon system utilizing ABAQUS/Standard, ABAQUS/Explicit, DYNA-3D, and LS-DYNA to support engineering assessments for normal and abnormal environments.
- Responsible for development of numerical hydrodynamic models, with the Sandia National Laboratories (SNL) code CTH, to model and describe the explosion dynamics and pressure pulse associated with internal detonations of the DynEx vessel system.
- Led technical effort of coupling the hydrodynamics shock-wave (blast) pressure to the structural dynamics response of structures. Utilized high-fidelity modeling techniques for large-scale massively parallelized computation.
- Developed high-velocity fragment penetration and blast response criteria leading to design/analysis methodology being employed at LANL, utilizing theoretical, analytical, and numerical hydrodynamics methods.

**From 1991 to 1996**, Mr. Rodriguez was Project Leader/Systems Engineer in direct charge of a \$3.5M Flammable Gas Program at the Hanford Site in Richland, WA. He directed a team of 15 engineers in support of safety analyses, which included numerical modeling and simulation, and experimental testing. Project Leader and lead structural engineer for the Safety Assessment for Hydrogen Mitigation of Hanford Waste Tank 241-SY-101.

- Responsible for structural dynamic/thermal analyses of hydrogen deflagrations of underground radioactive waste tanks using ABAQUS/Explicit finite element code.

- Mechanical engineering support for the Topaz-II Russian Space Nuclear Reactor safety assessment. Evaluated shock and vibration ground tests. Developed material failure model based on liquid-metal embrittlement (LME) of coolant loops.
- Project Engineer responsible for conducting failure analyses of the Russian PUREX chemical vessel explosion at Tomsk-7 Radiochemical Nuclear Facility in Tomsk, Russia. Theoretical assessment determined vessel and building failure to explosion overpressure.
- Senior mechanical/structural engineer responsible for technical design and safety guidance to DOE for the Heavy Water Reactor (HWR) and the Modular High Temperature Gas-cooled Reactor (MHTGR) designs slated to become the New Production Reactor (NPR) for tritium.

**From 1977 to 1991**, prior to his career at Los Alamos National Laboratory, Mr. Rodriguez spent 15 years, at the Electric Boat Division of General Dynamics, in Groton, CT. He was responsible for design and analysis of the Trident submarine reactor plant's contractor furnished equipment (CFE), including pressure vessel components, condensers, seawater pumps, and reactor compartment pressure hull. Structural evaluation included use of linear and non-linear dynamics, theoretical solutions, and experimental testing.

- Lead senior engineer performing structural design and analysis of submarine reactor plant structures for the TRIDENT class ballistic-missile and the LOS ANGELES class fast-attack nuclear submarines. Performed static/dynamic analyses of structures using linear/non-linear finite element methods, including ABAQUS, STAGSC-1, and ADINA. Performed fluid-structure interaction analyses using the Underwater Shock Analysis (USA) code coupled with a structural dynamics code.
- Lead structural engineer in design/analysis of submarine components. Heat transfer and fracture mechanics analyses of pressure vessels subjected to thermal transients, mechanical loadings and underwater shock. Developed a mathematical expression based on creep and stress relaxation test data for commercially pure titanium at room temperature. Finite Element Analysis (FEA) modeling confirming creep characteristic of titanium and applying results to the SEAWOLF fast-attack submarine design.
- Through extensive testing and numerical simulation, developed a creep and stress-relaxation model for commercially pure titanium (CP-Ti) at room temperature, which was eventually utilized in the design and analysis of the Trident submarine components.

## **PROFESSIONAL MEMBERSHIP & LEADERSHIP**

- Mr. Rodriguez has been an Associate Editor for the ASME *Journal of Pressure Vessel Technology* (JPVT) since 2006.
- Mr. Rodriguez received the PVP2009 Outstanding Technical Paper from the High Pressure Technology Technical Committee for co-authoring a paper with Dr. Joseph E. Shepherd, California Institute of Technology, titled, "*Gaseous Detonations in Piping Systems Partially Filled with Liquid.*"
- Mr. Rodriguez became a Fellow of the American Society of Mechanical Engineers (ASME) in 2009 and is a recognized expert within ASME Codes and Standards, including;
  - Active member of Section III, Div. 1, Working Group on Design Methods (WGDM) providing expertise on strain-based design and analysis criteria and elastic-plastic failure.
  - Active member of Section VIII, Div 3, Sub-Group on High Pressure Vessels (SG-HPV).
  - Vice-Chairman of the *Task Group on Impulsively Loaded Vessels* under Section VIII, Div. 3 that provide design guidance for impulsively (explosive blast) loading of containment vessels. The effort under this Task Group has recently been adopted as ASME Code Case No. 2564.
  - Chairman-elect for 2011 ASME Section VIII, Division 3 Task Group on Impulsively Loaded Vessels,

- 2005 R&D 100 Award co-winner with Southwest Research Institute (SwRI) for collaboration on development of the NESSUS Probabilistic Analysis Code
- 2002 LANL Distinguished Performance Award - DynEx Design/Analysis Team
- 2001 LANL Distinguished Performance Award - Octave Design Team
- Active member of the Pressure Vessel Research Council (PVRC), Subcommittee on Dynamic Analysis, where structural design rules and guidance on methodologies for engineering design criteria for blast loaded vessels was published in two seminal reports under the Welding Research Council (WRC). Mr. Rodriguez is a past Chairman of the Committee on Piping, Nozzles, and Vessels of PVRC.
- Member of American Institute of Aeronautics and Astronautics (AIAA), and
- Member of American Society for Metals (ASM).

### **ACCREDITATIONS**

- Registered Professional Engineer, State of Connecticut
  - P.E. License # 12404

### **SECURITY CLEARANCE**

- Department of Energy (DOE) - Q (1991 to Present)
- Department of Defense (DoD) - Secret (1977 - 1991)

## PUBLICATIONS

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Duffey, T. A. and Rodriguez, E. A., "Plastic Instabilities in Statically and Dynamically Loaded Spherical Vessels," Proceedings of the 2010 ASME Pressure Vessel and Piping Conference, American Society of Mechanical Engineers, Bellevue (Seattle), Washington, PVP2010-25230, July 18-22, 2010.

Rashid, J. Y. R., James, R. J., Theofanous, T. G., Nickell, R. E., Rodriguez, E. A., Nakafuji, G. T., "Failure Analysis and Risk Evaluation of Lifeline Structures Subjected to Blast Loadings and Aircraft/Missile Impact," International Workshop on Structures Response to Impact and Blast (IWSRIB), Technion, Israel, November 2009.

Shepherd, J. E., Akbar, R., Rodriguez, E. A., "Gaseous Detonations in Piping Systems Partially Filled with Liquid," Proceedings of the 2009 ASME Pressure Vessel and Piping Conference, American Society of Mechanical Engineers, Prague, Czech Republic, PVP2009-77734, July 26-30, 2009.

Nickell, R. E., Rodriguez, E. A., "Design Rules for CWD Vessels Subject to Extreme Design-Basis Internal Detonation Loads," Presented at 12<sup>th</sup> International Chemical Weapons Demilitarization Conference, (CWD-2009), Stratford-Upon-Avon, United Kingdom, May 18-21, 2009.

Rodriguez, E. A., Nickel, R. E., and Pepin, J. E., "Design Considerations for Blast Loads in Pressure Vessels," Los Alamos National Laboratory, LA-UR-07-2754, 19<sup>th</sup> International Conference on Structural Mechanics in Reactor Technology, August 12-17, 2007, Toronto, Canada.

Rodriguez, E. A., and Romero, C., "Hydrodynamic Modeling of Detonations for Structural Design of Containment Vessels," Los Alamos National Laboratory, LA-UR-06-0448, PVP-2006-ICPVT11-93737, The 11th International Conference of Pressure Vessel Technology and the 2006 ASME Pressure Vessels and Piping Conference, Vancouver, British Columbia, Canada, July 23-27, 2006.

Rodriguez, E. A., Riha, D. S., Thacker, B. H., Fleming, J. B., and Walker, J. D., "Verification and Validation Model for the Design of a Blast Containment Vessel: Part II Model Validation," 47<sup>th</sup> AIAA/ASME/ASCE/AHS/ASC Structure, Structural Dynamics, and Materials Conference, Newport, RI, May 1-4, 2006.

Mullin, S. A., Walker, J. D., Thacker, B. H., Rodriguez, E. A., and Leslie, P. O., "Verification and Validation Model for the Design of a Blast Containment Vessel: Part I Validation Experiments," 47<sup>th</sup> AIAA/ASME/ASCE/AHS/ASC Structure, Structural Dynamics, and Materials Conference, Newport, RI, May 1-4, 2006.

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Riha, D. S., Fleming, J. B., Thacker, B. H., Mullin, S. A., Walker, J. D., Weiss, C. E., Rodriguez, E. A., and Leslie, P. O., "Verification and Validation for a Penetration Model Using a Deterministic and Probabilistic Design Tool," *Hypervelocity Impact Symposium 2005 (HVIS)*, Lake Tahoe, Ca, October 9-13, 2005.

Riha, D. S., Fleming, J. B., Thacker, B. H., Mullin, S. A., Walker, J. D., Weiss, C. E., Rodriguez, E. A., and Leslie, P. O., "Modeling Impact and Penetration using a Deterministic and Probabilistic Design Tool," 22<sup>nd</sup> International Symposium on Ballistics (ISB), Vancouver, BC, Canada, November 14-18, 2005.

Thacker, B. H., Anderson, M. A. Senseny, P., Rodriguez, E. A., "The Role of Nondeterminism in Computational Model Verification and Validation," *International Journal of Materials and Product Technology*, Vol. 25, Nos. 1/2/3, 2006.

Thacker, B. H., Doebbling, S. W., Hemez, F. M., Anderson, M. C., Pepin, J. E., Rodriguez, E. A., "Concepts of Model Verification and Validation," Los Alamos National Laboratory and Southwest Research Institute, LA-14167-MS, December 2004.

Rodriguez, E. A., and Duffey, T. A., "Fracture-Safe and Fatigue Design Criteria for High Strain-Rate Loading in Pressure Vessels," Welding Research Council, Pressure Vessel Research Council, WRC Bulletin No. 494, New York, NY, August 2004.

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Thacker, B. H., and Rodriguez, E. A., "Verification and Validation Plan for Dynamic Experimentation Containment Vessels," Southwest Research Institute, San Antonio, TX, and Los Alamos National Laboratory, Los Alamos, NM, DV-PRO-202, December 2002.

Thacker, B. H., Rodriguez, E. A., Pepin, J. E., and Riha, D. S., "Uncertainty Quantification of a Containment Vessel Dynamic Response Subjected to High-Explosive Detonation Impulse Loading," *Proceedings of the IMAC-XXI Conference on Structural Dynamics*, Presented at the International Modal Analysis Conference (IMAC) in Kissimmee, FL, February 3-6, 2003.

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Burkett, M. W., Rodriguez, E. A., Wall, G. D., and Meier, J. K., "Abnormal Detonation Effects in Confinement Vessels (U)," Los Alamos National Laboratory, Report No. LA-CP-02-57, DynEx :00-090(S), February 2002.

Rodriguez, E. A., and Burkett, M. W., "Fragmentation and Fragment Penetration Design Criteria for HSLA-100 Steel Confinement Vessels (U)," Los Alamos National Laboratory, Report No. LA-CP-02-58, DynEx:00-089(S), February 2002.

Thacker, B. H., Riha, D. S., Rodriguez, E. A., and Pepin, J. E., "Uncertainty Quantification of Complex Numerical Models for Weapon Certification," *Presented at 6<sup>th</sup> U.S. National Congress on Computational Mechanics, Symposium on Probabilistic Mechanics*, Dearborn, MI, August 1-4, 2001.

Duffey, T. A., and Rodriguez, E. A., "Remaining Life of Containment Vessels for Repeated Explosive Testing," *Proceedings of the 2001 ASME Pressure Vessels and Piping Conference*, American Society of Mechanical Engineers, Atlanta, GA, Los Alamos National Laboratory, Report No. LA-UR-00-5424, July 2001.

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Thacker, B. H., Riha, D. S., Rodriguez, E. A., and Pepin, J. E., "Application of Probabilistic Methods to Weapon Reliability Assessment," American Institute of Aeronautics and Astronautics (AIAA), Presented at 42<sup>nd</sup> AIAA Structures, Structural Dynamics and Materials Conference, SDM 2001, Seattle, WA, April 16-19, 2001.

Duffey, T. A., and Rodriguez, E. A., "Computer Code Verification and Validation (V&V) in Support of HSLA-100 Steel Confinement Vessel Design," Los Alamos National Laboratory, Report No. LA-13804-MS, DynEx:00-088, March 2001.

Rodriguez, E. A., Bingham, K. L., Duffey, T. A., "Comparison of ASME Code and Confinement Vessel Program Performance Assurance System (PAS)," Los Alamos National Laboratory, Report No. LA-13803-MS, DynEx:00-087, March 2001.

Rodriguez, E. A., Borch, N. R., and Duffey, T. A., "Fracture Safe Design for HSLA-100 Steel Confinement Vessels," Los Alamos National Laboratory, Report No. LA-13802-MS, DynEx:00-086, March 2001.

Duffey, T. A., Rodriguez, E. A., "Dynamic vs. Static Pressure Loading in Confinement Vessels," Los Alamos National Laboratory, Report No. LA-13801-MS, DynEx:00-084, March 2001.

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Rodriguez, E. A., and Girrens, S. P., "Forum Discussion on Probabilistic Structural Analysis Methods," *Proceedings of the IMAC-XIX Conference on Structural Dynamics*, Kissimmee, FL, Los Alamos National Laboratory, Report No. LA-UR-00-5033, February 2001.

Rodriguez, E. A., Pepin, J. E., Thacker, B. H., and Riha, D. S., "Probabilistic Structural Response of a Valve Assembly to High Impact Loading," *Proceedings of the IMAC-XIX Conference on Structural Dynamics*, Kissimmee, FL, Los Alamos National Laboratory, Report No. LA-UR-00-5009, February 2001.

Pepin, J. E., Rodriguez, E. A., Thacker, B. H., and Riha, D. S., "Probabilistic Structural Response with Geometric Uncertainties under Collapse Loading," *Proceedings of the IMAC-XIX Conference on Structural Dynamics*, Kissimmee, FL, Los Alamos National Laboratory, Report No. LA-UR-00-5008, February 2001.

Rojas, S. P., Rodriguez, E. A., Idar, E. S., and Burkett, M. W., "Simulating the Penetration of High Density Projectiles into HSLA-100 Steel (U)," *Presented at 3rd Joint Classified Ballistic Symposium*, Los Alamos National Laboratory, Report No. LA-CP-00-131, San Diego, CA, May 1-4, 2000.

R. M. Dolin and E. A. Rodriguez, "Bayesian Inference Techniques In A Decision Analysis Framework To Determine Valve Reliability," *Presented at the Third Tri-Laboratory Engineering Conference on Modeling and Simulation*, Livermore National Laboratory, Livermore, CA., Los Alamos National Laboratory, Report No. LA-UR-99-2403, November 1999.

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Rodriguez, E. A., et al., "Physics-Based Damage Predictions for Simulating Testing and Evaluation (T&E) Experiments," Los Alamos National Laboratory, LA-UR-97-4877, November 1997.

Davidson, R. F., Walsh, M. L., Rodriguez, E. A., "EPIC Hydrodynamic Code Modeling of Hanford Site HLW Tank 241-SY-101 for Bounding Hydrogen Detonation," Los Alamos National Laboratory, Report No. LA-UR-96-1956, January 1996.

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Sullivan, L. H., et. al., "A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland, Washington" Los Alamos National Laboratory, LA-UR-93-3196 (March 1995).

Voss, S. S., Rodriguez, E. A., "Russian Topaz II System Test Program (1970-1989)," *Proceedings of the 10th Annual Symposium on Space Nuclear Power*, Albuquerque, NM, January 1994, Los Alamos National Laboratory, Report No. LA-UR-93-3398 (December 1993).

Rodriguez, E. A., "Fracture Mechanics Fundamentals for Leak-Before-Break Criteria of the Department of Energy Heavy Water Reactor," Los Alamos National Laboratory, Report N-7:92-08, NPR/SPO (1992)

Sammataro, R. F., et. al., "Heavy Water-New Production Reactor (HW-NPR) Deterministic Severe Accident Success Criteria," General Dynamics Corporation, Electric Boat Division, Report No. NPRW-DSAC91-4 (April 1991).

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Rodriguez, E. A., "Creep and Stress Relaxation Characteristics of Commercially Pure Titanium at Room Temperature," General Dynamics Corporation, Electric Boat Division, Nuclear Engineering Division Report (1987).

Rodriguez, E. A., "Finite Element Method for the Evaluation of Stress Distribution Within a Four Inch INCONEL Elbow Due to In-Plane Bending and Internal Pressure," General Dynamics Corporation, Electric Boat Division, Report from Dept. 471, (1985).