
LONGENECKER and ASSOCIATES

G. William Hannaman, Ph.D., P.E.

EXPERIENCE SUMMARY

Dr. Hannaman holds a Professional Engineering Registration with over 30 years of experience in solving electrical and nuclear engineering safety and operation problems for a wide range of nuclear reactor types, process plants and industrial facilities using reliability and probabilistic risk assessment (PRA) techniques. Dr. Hannaman has provided profitable returns in various technical and project management positions with Westinghouse Electric Corporation, General Atomics, NUS Corporation, Science Applications International Corporation, and Data Systems and Solutions. He has published numerous technical papers and reports on human reliability, risk assessment, aging failures, reactor safety, design and operation. Developed and applied human reliability assessment (HRA) methods to consider the impact of operator interactions before and during accident conditions in risk models. Experience includes data collection from operational records and training simulators, database development, analysis and integrating the results into risk and reliability studies to identify cost effective management priorities for enhanced design, safety, operation, and maintenance in a wide range of facilities.

DETAILED EXPERIENCE

2005 to present, Consulting Engineer (SAIC, Granite)

2003 to 2005, Senior Staff Engineer, Science Applications International Corporation

1999 to 2003, Senior Staff Engineer, Data Systems & Solutions

1988 to 1999 Senior Staff Engineer, Science Applications International Corporation

Recent Projects

- Develop human factor implementation plans for new reactor design certification.
- Support Fire PRA updates in the human reliability analysis area as part of the EPRI/NRC methodology development project.
- Provide safety reviews on design documents, drawings and process flow diagrams for the Bluegrass Demil
- Evaluate operating history leading to recent electrical fires and recommend actions to restore electrical stability to the Umitilla Depot's aging internal electrical distribution system as part of the US Demil effort. Review and recommend updates to EHS requirements for hazardous jobs in the facility.
- Support preclosure risk assessment for Yucca Mountain Project by developing fire scenarios that threaten damage to spent fuel containers for facility design as part of the Licensing Submittal.
- Plan, Project Manage and Perform on EPRI projects in the following areas:
 - Developed process to support monitoring and evaluation of aging conditions on electronic I&C boards in control and protection circuits in nuclear power plants.
 - Developed guidelines for a simplified trip monitor that includes aging based failure rates for use in generation risk modeling.
 - Advisor for development of EPRI HRA calculator.
 - Linked trip monitor results to quantification of lost Mwe for component life cycle evaluations based on aging failures.
 - Provided PRA of Spent Fuel Bolted Cask Designs - initiating events, HRA and data evaluations in phases for loading testing and on pad aging including quantitative evaluation of associated job hazards, and fire scenarios.
 - Developed a procedure for addressing HRA in fire PSAs with Sandia National Lab collaboration.

- Upgraded Monte Carlo Simulation software (STEIN) for evaluating impact of NDE measures on structural integrity of steam generators under 10CFR50 Appendix B and ISO-9000 QA plans.
- Developed lesson plans for training Human Reliability Analysts as a basis for supporting human factors engineering.
- Consulted on methods for evaluation of organizational factors.
- Provided input to HRA and data sections for the ASME PSA standard (RA-S-2002)
- Provided an HRA upgrade evaluation to PSA (ANO-1) and supported presentation to NRC in response to significance determination process (SDP) finding for a postulated fire using simulator observations, etc.
- Provided an evaluation of safety relief valve failure probability assuming a use based failure rate during a core heat up scenario as one element in response to an SDP request by NRC in for evaluation of steam generator tube integrity.
- Independent safety reviewer for CANDU plant PSA in Romania. - Peer review of PSA modeling results to recommend changes and upgrades following ASME PSA standard to meet IAEA certification. Also provided HRA training and system and sequence evaluations.
- Developed uncertainty analysis tools for quality of glass/ nuclear waste mixtures for DOE/Bechtel.

Dr. Hannaman has recent direct project experience in the following areas – Human Factors Engineering, human reliability assessment, PRA, I&C, and risk informed applications, Steam generator tube integrity assessment for LERF sequences, risk management, reliability database development, RAM analysis, HRA/PSA certification and oversight committees.

Areas of recent technical experience:

Human Factors

Prepared and reviewed implementation HFE plans to meet Chapter 18 requirements in advanced reactor designs. Developed over riding Human Factors Engineering Implementation Plan which summarizes eleven key implementation plans, analyses, and evaluations required in NURE-0711 r2 which are issued as licensing topical reports. These are:

- Operating experience review
- Functional requirements analysis
- Function allocation and task analysis
- Staffing and qualifications
- Human reliability analysis
- HSI design implementation
- Procedure design
- Training design
- Human factors verification and validation
- Design implementation
- Human performance monitoring.

HFE activities also include: Responding to requests for additional information (RAIs), participation in Regulatory Audits, Identification of precursor plants and information to determine HFE issues from operating experience reviews and interviews with plant personnel in Japan and US, preparation of licensing topical reports, evaluation of software management and quality planning for digital controls. Provided inputs to the HFE issue tracking system and developed a data collection system for operating experience reviews. Provided presentations on topics related to HFE and digital systems in professional society meetings.

Human Reliability Assessment

- Planned and documented level I human reliability assessments (HRAs) for four utilities IPEs (BWR and PWR).
- Developed and delivered a weeklong training course on HRA/Human Factors to Eletronuclear in Brazil.
- Supported update of VC Summer IPEEE fires assessment as HRA task leader under SAIC and VCS quality assurance programs. Evaluated risk of using fire emergency procedures for the current control room configuration using NUREG/CR 4772, &1278 and EPRI-TR-100259.
- Contributor to development of ASME PSA standard HRA and data sections.
- Instructor on the subject of human reliability for Argonne National Labs Inter-regional Training Course on Prevention and Management of Accidents at Nuclear Power Plants
- Managed 3-year project to extract data from events to enhance human reliability for activities during less than full power operation in Both BWR and PWRs and develop human factor improvement areas . Reviewed the operator event data collection programs, updated the Systematic Human Action Reliability Procedure (SHARP), presented examples and information at EPRI's human reliability assessment workshop, and applied SHARP1 on specific accident sequences (e.g., Interfacing System Loss of Coolant Accidents that lead to LERF).
- Developed procedures, guidelines and project instructions for performing HRA in two PRAs.
- Supported use of control room training simulators in HRA studies for six utilities including Hope Creek (using NUPRA software) and Laguna Verde (BWRs).

Steam Generator Integrity Assessment

- Evaluate primary safety valve reliability with use based changes in the failure rate under severe accident conditions given a leaking SG tube.
- Compare EDF COMPRIS software code with STEIN to identify areas for enhancement in addressing primary water stress corrosion (PWSCC) aging through the use non-destructive (NDE) test measures.
- Product manager for establishing EPRI web site for SG SGDSM for maintaining and updating a quality assured (10CFR50) electronic database containing data from tests on pulled SG tubes to support burst and leak rate correlations. The secure web site developed under an ISO-9000 and 10CFR50 approved quality program supports data searches.
- Product manager for development of the STEIN Monte Carlo software code for use in evaluating Steam Generator ODSCC NDE measurement results to predict impact of aging on operational assessment and condition monitoring criteria.
- Developed methodology using Monte Carlo Simulation of uncertainties for assessing margin between an allowed I¹³¹ dose and a predicted accidental release from degraded steam generator tubes.

PRA and Risk Informed Applications

- For Entergy Operations, ANO-1 detailed fire assessment and simulation mockup, assisting in update of PRAs for ANO-2 (accident sequence review to identify issues for risk informed applications), and Waterford nuclear power plants (ISLOCA and ATWS support).
- Applied time dependent integration of system recovery assumptions and human reliability models with thermal hydraulic transient output to produce estimates of large early release frequencies in severe accidents for use in evaluating the risk of operating steam generators with degraded tubes.
- Supported Entergy (ANO2) and SCE (SONGS) in evaluating the extension of PSA and human reliability during severe accidents to support risk informed evaluation of steam generator tube integrity including review of SAMGs, EOPs, plant interfaces, and simulator training. Presentations on results given to NRC.

- Performed multi-compartment fire risk analysis in support of the IPEEE at Quad Cities.
- For CEQA contributed to guidelines for PRA application during the NPR-MHTGR design process. Provide mini PRA study for the Environmental Impact Statement for the NPR-MHTGR for DOE.

Risk management

- Supported development of methodology for blending risk-informed PSA with deterministic rules to demonstrate compliance with NRC's regulations governing steam generator operation.
- Developed qualitative risk assessment methodology and delivered training course on qualitative safety assessments including consideration of HRA for non-reactor facilities as part of a Sandia National Labs project to comply with DOE orders 5480.23, 5481.1B, and standards 1027-92 and 3009-94.
- Applied methodology on two facilities (Rocket launch and Accelerator). Results support safety documentation suitable for a facility safety analysis report in a risk-based format.
- For DOE used PRA and HRA methods to support reviews of DOE reactor projects and facility operations at Rocky Flats, Savannah River, and Hanford.

Reliability Database development

- Establish a reliability and safety database for use during the MHTGR design process for CEQA.
- Applied data based mechanical reliability aging models for safety relief valves using test demands and flow conditions to improve risk assessment results.

Ram Analysis

- Supported the MHTGR conceptual design through incorporation of applicable operational experience, development of technical position papers to demonstrate that lessons learned from previous operating experience were considered in the advanced design, and updated safety, availability, and plant capacity factor reports working with Stone and Webster Availability Assessment team. This involved building reliability block diagrams for various systems to evaluate reliability and risk.

Oversight projects

- Served as secretary on senior review committee to evaluate selection criteria for the NPR-MHTGR containment.
- Project manager for independent reviews of PSA/HRA and human factors for Union Fenosa on a Spanish Reactor to identify cost effective risk reduction upgrades for control room interface.
- Review of a spent fuel processing design for a DOE site.
- Performed review of human reliability assessments in the IPEs to verify met vulnerability requirements.
- Performed independent safety reviews of safety analysis reports and risk assessments including analysis of spray leaks during tank transfer operations, and evaluation of two different pump system operating lifetimes for Westinghouse Hanford using FMECAs, fault trees, aging models and data evaluations.
- Performed independent review of INEEL's ISLOCA methodology.

1981 to 1988, Senior Executive Engineer, NUS Corporation

- Principle Investigator for EPRI projects included development of a human reliability analysis framework, (SHARP), human cognitive reliability (HCR) models, and international HRA benchmark projects.
- Project leader for integration of HRA models to support simulator training, and model verification studies involving collection of data at control room simulators (e.g., for boiling water

reactors (BWR's) at ComEd, PP&L, and PE). Supported use of simulator data gathering for verification of BWR EOPs.

- Technology transfer of HRA/PRA methods to clients performing in US and internationally (e.g., EdF) via: (1) seminars, (2) reviews of PRAs and HRAs, (3) HRA task definition and supervision of analysts and (4) guidebook development such as PRA procedures guide and HRA guidelines for specific projects (5) performing benchmark comparisons, (6) performing analysis, (7) reviewing work, (8) planning risk related projects, and (9) recommending programs.
- Evaluated use of newly designed symptom based procedures in response to steam generator tube rupture and small break LOCAs to identify key operator actions for PRA modeling.
- Probabilistic risk accident analysis of fires for the Limerick BWR.
- Detailed safety reviews of design concepts such as the advanced modular gas turbine reactor.

1974 to 1981 Staff Engineer, General Atomics

- Performed probabilistic safety analysis, reliability and availability assessments and evaluations on all of GAs operating and proposed plant designs to identify areas for improvement.
- Developed and operated a computerized data base system of component and system reliability measures to analyze Fort St. Vrain availability experience as a way of improving new designs, including the Gas Turbine-HTGR, steamer, fusion designs and others.
- Lead engineer for Chemical and Process System Analysis Group on a 6-man-year effort to collect data and develop reliability evaluation methods including reliability block diagrams for process system hazard analysis reliability allocations, reliability predictions, availability, and maintainability quantification on proposed coal liquefaction systems.
- Provided training seminars on probabilistic risk assessment for PRA practitioner training and for shift technical advisors.
- Performed system reliability analysis to support qualification of reactor protection, control, heat removal, main power systems, circulators and support systems for the large HTGR.
- Team member and key author of the PRA study known as the Accident Initiation Progression Analysis.
- Established and maintained component and system reliability data bank supporting quantification of event- tree/fault-tree scenario frequencies and uncertainties (e.g., Diesel Generators, Pumps, Motors, Valves, etc).
- Developed and applied probabilistic operator models and common-cause failure models in PRAs.

1970 to 1974, Graduate Assistant and Senior Reactor Operator, Iowa State University

- Obtained licenses for reactor operator and senior reactor operator through the NRC on a university training reactor, with over 100 startups and shutdowns.
- Taught lab courses and helped prepare and present training course for Duane Arnold Energy Center operators in support of NUS training.

1965 to 1970, Supervisor, Westinghouse Electric Corporation Apparatus Repair Division

- Planned repairs and directed maintenance crews on chemical, utility and industrial sites and in repair plants for over 10,000 unique electric power system equipment failures.
- Designed and implemented an I&C temperature protection system for a large electrical motor, and developed design of a transformer oil storage and transfer system.
- Developed procedures, criteria, and equipment for testing, welding, and evaluating insulation and mechanical structures for serviceability and, if needed on the basis of predicted failures, applied methods for repairing, balancing and testing electrical and mechanical apparatus

including electric motors, breakers, controls, transformers, generators, turbines compressors, magnets, static flue gas capture systems, etc.

- While in Westinghouse's Graduate Student Program performed rotating assignments in manufacturing facilities for transformers and apparatus repair.

EDUCATION

BS, Electrical Engineering, Iowa State University, 1965

MS, Nuclear Engineering, Iowa State University, 1971

PhD, Nuclear Engineering, Iowa State University, 1974

MISCELLANEOUS

Professional Associations and Memberships:

State of California - Professional Nuclear Engineering Registration NU 1948 Since 1982

Member American Nuclear Society -

Technical Program Chairman for ANS embedded topical meetings - "Risk Management...Now more than ever," 2003, and "Advanced Nuclear Installation Safety," 2000. Assistant Technical Program Chairman for Risk Management -Expanding Horizons 1992. Human Factors Division, Executive Committee, 1987. Safety Division Program Committee 2000-present. San Diego Section chairman 1979. San Diego Section executive committee, various years. Organized and chaired numerous technical sessions for ANS. Paper reviewer for Nuclear Technology.

Member of Institute of Electrical and Electronics Engineers

Corresponding member of the Nuclear Engineering Subcommittee SC-5 on human factors and reliability responsible for standards on reliability methods. 2000–present. SC-5 Committee member on Reliability 1976 to 1980, SC-7 Committee member on Human Performance 1984-1986.

Society for Risk Analysis

Executive committee of Southern California Chapter in 1989. Organized and chaired technical session at PSAM II.

Patents, Selected Publications, and Awards:

- Elected to Sigma XI, the research honor society in 1973
- Elected to National Academy of Sciences 6-member panel on cooperation with USSR on reactor safety to identify needs and means for enhancing reactor safety. 1987
- Elected to Strathmore's Who's Who 1996-05
- Outstanding technical paper awards in ANS Meetings (e.g., ANS Midwest student conference 1974 and ANS summer meeting Human Factors Division 85, 88, and 93, Power Division 2006).
- Toastmaster CTM and ATM levels and Toastmaster of the year for Area 17 District 5 1999-2000
- Academic credit for
Reliability Assurance, UCLA 1975
Global Business Management, University of Phoenix 1998.

Author on over 50 reports and 25 papers.

Selected Reports

Hannaman G. W. and D. Wilkinson, "Evaluating the Effects of Aging on Electronic Instrument and Control Circuit Boards in Nuclear Power Plants," EPRI, Palo Alto, CA, 2005. Product ID # 1011709.

With Najafi, B. et. al., EPRI/NRC-RES Fire PRE Methodology for Nuclear Power Facilities: Volume 1 Summary and Overview, Volume 2, Detailed Methodology, EPRI, Palo Alto, CA and US NRC RES Rockville MD: 2004 EPRI TR-1008239 and NUREG/CR-6850.

Canavan, K and G. W. Hannaman, "Guide for Constructing a Nuclear Power Plant Generation Risk Model," Draft EPRI Report, August 2003.

With Canavan, K. et. al, "Probabilistic Risk Assessment (PRA) of Bolted Storage Casks: Quantification and Analysis Report," EPRI, Palo Alto, CA 2003, 1002877.

Hannaman, G. W. and I. B. Wall, "Lesson Plans for Human Reliability Assessments in PSAs," EPRI 1003329 June 2002.

Hannaman G. W (DS&S), V. Durbec and C. Bauby (EdF), "Feasibility Study for the Integration of EDF's models for PWSCC into EPRI's STEIN code," Joint EDF and DS&S Report to EPRI, May 19, 2002.

Hannaman G. W. and S. A. Flegler, "Evaluation of HCR Methodology Implementation in PSA and Control Room Human Factors Review for José Cabrera Nuclear Power Plant," EPRI, Palo Alto, CA, April 2000, 1000028.

Hannaman, G. W., B. W. Johnson, and Maureen K. Coveney, "Methodology For Steam Generator Condition Monitoring and Operational Assessment, Applying Monte Carlo Simulation," SAIC-97/1078, SAIC, San Diego, CA Dec 1998.

E. Fuller, E. Rumble, G. W. Hannaman, and M Kenton, "Risk Assessment Methodology for Complying with NRC Regulations on Steam Generator Tube Integrity: Diablo Canyon as an Example Plant" LR EPRI 550-7, Sept. 1997.

Hannaman G. W., M. Lloyd, B. Putney, G. Klopp, B. Johnson, A. Farruk, E. Fuller, and G. Pod "PSA Support For Steam Generator Degradation Specific Management" SAIC-1326, EPRI 550-7, March 1996.

Hannaman, G. W. "Transforming PRA Results into Performance-based Criteria for PWR Steam Generator Inspections and Management" White paper on EPRI project 550-07, March 1995.

Otis, M. D. D. A. Bradley and G. W. Hannaman, Technical Basis for Considering Uncertainties in I131 Release and Dose Limits for a Postulated Accident. EPRI TR-103878. EPRI, Palo Alto, CA March 1996.

NSAC 154 "ISLOCA Evaluation Guidelines," HRA methodology, EPRI, Palo Alto, CA Sept. 1991.

Hannaman G. W. A.J. Spurgin and Y. D. Lukic, Human Cognitive Reliability Model for PRA Analyses. EPRI Project 2170-3, NUS Report 4531, October 1984.

Hannaman W., and A. Spurgin, "Systematic Human Action Reliability Procedure (SHARP)," EPRI NP-3583 June 1984.

Hannaman G. W. GCR-Data Bank Status Report, US DOE Report GA-A-14839, General Atomic Co, July 1978.

HTGR Accident Initiation and Progression Analysis Phase II, (co-authored with K. N. Fleming, et al.). USDOE Report, GA-A-15000, General Atomic Co., April 1978.

Selected Papers

Hannaman. G. W., "Selecting Probability Models for Human Reliability Analysis," PSA'05, International Topical Meeting on Probabilistic Safety Analysis, San Francisco, 2005.

Hannaman, G. W., "Safety Valve Reliability Assessments for PSAs," PSA 2002, ANS Probabilistic Safety Topical Meeting, Detroit Oct, 2002.

Johnson, B., G. W. Hannaman, and M. A. Stutzke, "Operating Reactor Safety, Regulation and the Real World," in ANS Proceedings Operating Reactor Safety Topical Meeting, Oct. 11-14, 1998.

Fuller, Ed, E. Rumble, G. W. Hannaman, and M. A. Kenton, " Assessment of Risks from Thermal Challenge to Steam Generator Tubes During Hypothetical Severe Accidents," in ANS Operating Reactor Safety Topical Meeting Oct. 11-14, 1998.

Mahn J. A., G.W. Hannaman, P. M. Kryska, "Qualitative Methods for Assessing Risk" 1995 ASME conf., 1995.

Hannaman, G. W. and Avtar Singh, "Human Reliability Database for In-Plant Application Of Industry Experience," PSAM II, 1993

Hannaman G. W. and A. Singh "Assessments and Applications to Enhance Human Reliability and Reduce Risk during Less Than Full Power Operations" of EPRI, ANS Risk Management embedded topical, June 1992.

Hannaman G. W. "Human Reliability Methods for Enhancing Performance," in Risk Management Expanding Horizons Hemisphere Publishing, New York, 1991.

Hannaman G. W. and D.H. Worledge, "Some Developments in Human Reliability Analysis Approaches and Tools", Reliability Engineering and System Safety, Elsevier Publishers Ltd. England, V22 pg 235-256, 1988.

Hannaman G. W., F. S. Dombek, B. Y. O. Lydell, and Y. D. Lukic, "Using Risk Analysis to Improve Testing and Maintenance". Forth IEEE Conference on Human Factors and Power Plants. Monterey CA. June 1988.

Hannaman G. W., G.R. Crane and D.H. Worledge "Application of a Human Reliability Model to Operator Response Measurements" in PSA and Risk Management PSA'87, Zurich, Switzerland, September 1987.

Hannaman G. W., F.S. Dombek and P. Moieni "A PRA-Based Human Reliability Catalog", for Probabilistic Safety Assessment and Risk Management PSA'87, Zurich, Switzerland, September 1987.

Hannaman G. W. et. al. "Applications of Human Reliability Models to Structure Measurements of Human Performance in Simulations" Job Performance Measurement Technologies Conference, DOD, Wash., D.C. 3/87.

Hannaman G. W. "The Role of Frameworks, Data, and Judgment in Human Reliability Analysis", Nuclear Science and Engineering. North Holland Publishing Company, NEDEA 98L93, May 1986.

Crane G. and G. W. Hannaman, "Realistic Operator Response Measurements: Inputs to La Salle PRA", V 5, International Topical Meeting on Nuclear Reactor Safety No. 700106, ANS, La Grange Park, IL, Feb. 1986.

"Synthesis of Experience Data for Risk Assessment and Design Improvement of Gas-Cooled Reactors" (with A.P. Kelly), Proceedings of Probabilistic Analysis of Nuclear Reactor Safety, American Nuclear Society, IL, May 1978.

"Probabilistic Risk Assessment of HTGR's" (with Fleming, Houghton, and Joksimovich), Reliability Engineering, Applied Science Publishers, Ltd., England (1981) pp. 17-25.

Treatment of Operator Actions in the HTGR Risk Assessment Study, GA-A-15499, Winter ANS Dec.1979