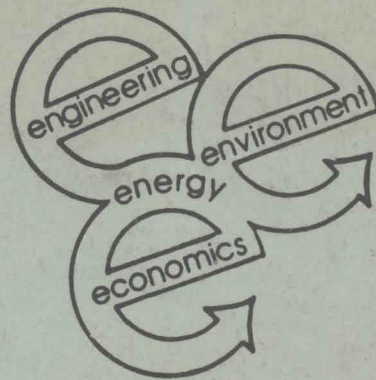


**1988**  
**21st Annual**  
**Frontiers of Power Conference**



Co-Sponsored by:  
**Engineering Energy Laboratory**  
and  
**School of Electrical and Computer Engineering**

**October 10-11, 1988**

A University Extension Program  
Oklahoma State University  
Stillwater, Oklahoma 74078

**P R O C E E D I N G S**

**1988**

**21st ANNUAL**

**F R O N T I E R S   O F   P O W E R  
C O N F E R E N C E**

**October 10-11, 1988**

**Co-Sponsored by:**

**THE ENGINEERING ENERGY LABORATORY**

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**THE SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING**

**OKLAHOMA STATE UNIVERSITY**

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## **PREFACE**

### **1988 FRONTIERS OF POWER CONFERENCE**

This Proceedings is a compilation of the papers presented at the Twenty-first Annual Frontiers of Power Conference sponsored by the Engineering Energy Laboratory and the School of Electrical and Computer Engineering, with the support of the electric utilities in this area.

This Conference is the outgrowth of the research on energy conversion and storage started in 1961, and actively sponsored starting in 1964, by six electric utilities in this area. These six utilities were:

- \*Oklahoma Gas & Electric Company, Oklahoma City, Oklahoma
- \*Public Service Company of Oklahoma, Tulsa, Oklahoma
- \*Arkansas Power & Light Company, Little Rock, Arkansas
- \*Kansas Gas & Electric Company, Wichita, Kansas
- \*Empire District Electric Company, Joplin, Missouri
- \*St. Joseph Light & Power Company, St. Joseph, Missouri

This original research resulted in the establishment of an Annual Conference starting in 1963, on Energy Conversion and Storage. This Conference was held annually through 1965, and essentially stressed direct energy conversion. About 1965, the number of national Conferences dealing with direct energy conversion increased rapidly, so the OSU Conferences on Energy Conversion and Storage were not held in 1966 or 1967. The support by utilities continued throughout this time.

The School of Electrical and Computer Engineering felt there was continuing need for a forum whereby the electric utilities, electric power equipment manufacturers, the universities, and government agencies could discuss and examine the technology that was relevant to the needs of the electric power industry in solving the problems confronting them. Therefore, the Conference was reinstituted with a new name, a broadened scope and held in 1968, as the Frontiers of Power Technology Conference. With the continued support of the electric power industry, it was again possible to hold the Conference this year.

A special acknowledgment is made to the authors and moderators for their contribution, as the Conference would not be possible without them.

Dan Lingelbach, Professor Emeritus  
School of Electrical and  
Computer Engineering &  
Conference Director  
Stillwater, Oklahoma 74078  
October 1988

#### **MEMBERS OF THE PROGRAM COMMITTEE FOR THIS YEAR'S CONFERENCE:**

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**John C. Zink**, Director, Production Services, Public Service Company of Oklahoma, Tulsa, Oklahoma

# Chaos and Order in the Electric Utility Future

## Keynote Speaker

JOELLYN K. MURPHY



Joellyn K. Murphy became the Vice President of Regulatory and Business Policy at Public Service Company of New Mexico in 1984. She joined the company in 1981 as Manager of the Rates and Regulation Department.

Ms. Murphy came to New Mexico from Washington, D.C. where she served as Deputy Director of the Bureau of Land Management. Her other positions in Washington included that of Budget Director for the Environmental Protection Agency and Director of the Coastal Energy Impact Program for the Department of Commerce.

A native of Pasadena, California, Ms. Murphy attended Stanford University where she received both a B.A. and an M.B.A. She also served a five-year term on the Board of Trustees of Stanford.

She is the President of the Santa Fe Center, a non-profit corporation that sponsors executive forums on issues at the nexus of public policy and private action.

At Public Service Company of New Mexico, Joellyn Murphy's insight and vision have contributed significantly to the company's innovative stance in the industry.

## Banquet Speaker

WILLIAM L. HUGHES



Dr. William L. Hughes is the President of InEn Corporation in Stillwater, Oklahoma and Emeritus Professor of Electrical and Computer Engineering at Oklahoma State University. He is presently the Vice President for Academic Affairs at the South Dakota School of Mines and Technology in Rapid City, South Dakota. He came to OSU from Iowa State University in 1960 as the Head of the School of Electrical Engineering, the position he held until 1976. Dr. Hughes founded the OSU Engineering Energy Laboratory in 1975 and directed it until July 1987.

Dr. Hughes received his B.S. Degree from South Dakota School of Mines and Technology and his M.S. and Ph.D. Degrees from Iowa State University. His major research interests have been in the areas of renewable energy systems,

electromagnetic radiation and visual information systems. As a member of BOSTID (Board of Science and Technology in Development) of the National Academy of Sciences since 1983, Dr. Hughes has served as Chairman of several international teams in the areas of renewable energy, energy conservation, and the role of computers in development. He has been a delegate of the U.S. State Department in several countries around the world.

Dr. Hughes has authored or coauthored two textbooks, over fifty technical papers, and has contributed to five engineering handbooks. His research efforts have also resulted in thirteen U.S. Patents. He is a Fellow of the IEEE and is a member of numerous distinguished professional organizations and honor societies.



## Moderator

### JESS A. REED



Jess A. Reed joined The Empire District Electric Company in February 1951 as an Engineer. He was promoted to Meter Shop Superintendent in 1957 and became System Supervisor in 1959. In 1970 he was named Superintendent of T&D and remained in that position until 1977 when he became General Superintendent. He was elected to the position of Vice President - T&D in 1978 and in 1984 was elected to his present position of Senior Vice President - Operations. He also serves as a member of the Company Board of Directors. As Senior Vice President, Jess is responsible for the Production Department; T&D Engineering; T&D Construction, Operation, and Maintenance; and System Operations Department.

He graduated from the University of Missouri in 1951 with

a Bachelor of Science Degree in Electrical Engineering and is a Registered Professional Engineer.

Jess is a member of the Operating Committee for the MOKAN Power Pool where he recently completed a two-year term as Chairman of that committee. He serves on the Edison Electric Institute Labor Relations Committee and also on the EEI Interconnection Committee. He is also a member of the Southwest Power Pool and National Society of Professional Engineers. In the community he is a member of the Kiwanis Club, Missouri Southern State College Lionbackers, the Southwest Chapter of Missouri Society of Professional Engineers, and Twin Hills Country Club. He is a member of the First United Methodist Church where he serves on the Board of Trustees.



# Moderator

## CARL M. MULLEN



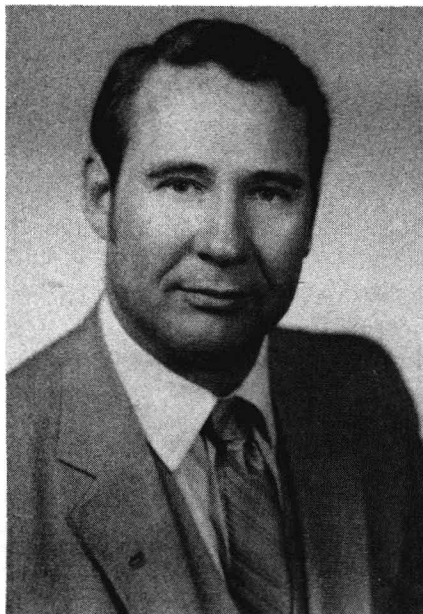
Carl M. Mullen is the Manager of Engineering, Corporate Headquarters of the Oklahoma Gas and Electric Company in Oklahoma City, Oklahoma. He was previously Manager of Purchasing. He has had experience in the Western Region Distribution Engineering Department as an Engineer, an Area Engineer, and a District Engineer.

He received his B.S. in Electrical Engineering from the University of Oklahoma in 1964 and served as an officer in the U.S. Navy for five years.

He is a Registered Professional Engineer, a member of the Institute of Electrical and Electronics Engineers, and the National Society of Professional Engineers.

## Moderator

### CHESTER L. JONES



Chester L. Jones, Manager of Operations, Oklahoma Gas and Electric Company, Oklahoma City, Oklahoma is a Registered Professional Engineer in the State of Oklahoma, member of Southwest Power Pool Engineering and Operating Committee, Chairman of Oklahoma University Power Advisory Board, member of Oklahoma State University Frontiers of Power Executive Committee, member of Advisory Council of the Transmission and Substation Design and Operating Symposium at the University of Texas at Arlington, Chairman of Executive Accident & Prevention Committee, and member of the Budget and Revenue Requirement Committees.

Chester worked for OG&E in the summers of 1955, 1956, and 1957. He worked part-time from September 1957 until graduation in May 1960,

at which time he went to work as a graduate Electrical Engineer in the Western Division in Oklahoma City where he was assigned to the South District, South Broadway, North District and then returned to the South Broadway offices. He was appointed West District Area Engineer in 1965 and North District Area Engineer in 1966. He was promoted to Shawnee Division Engineer at Shawnee in 1967, Northern Division Engineer at Enid in 1968, and Western Division Engineer in Oklahoma City in 1974. He was then promoted to Western Division Superintendent in 1978, Manager of T&D in 1982, and Manager of Operations in 1987.

Chester attended Oklahoma City public schools and he graduated from Oklahoma University with a Bachelor's Degree in Electrical Engineering in 1960.

## Moderator

### JOHN C. ZINK



Dr. John C. Zink, Director, Production Services, Public Service Company of Oklahoma, Tulsa, Oklahoma is a Registered Professional Engineer in Texas, Oklahoma, and California. He is a member of the American Nuclear Society and the National Society of Professional Engineers.

Dr. Zink was Director, Research and Development, Central and South West Services, Inc., Dallas, Texas, from 1984 to 1988. He was with Public Service Company of Oklahoma, Tulsa, Oklahoma, from 1975 to 1984 as Manager, Corporate Communications; Manager,

Material Management Improvement Program; Manager, Nuclear Licensing; Manager, Nuclear Fuel; and Supervisor, Nuclear Engineering. Dr. Zink was an Assistant Professor of Nuclear Engineering at the University of Oklahoma, Norman, Oklahoma, from 1970 to 1975. He was also affiliated with the Kerr-McGee Corporation, and the U.S. Army Nuclear Effects Laboratory.

Dr. Zink is a native of Indianapolis, Indiana. He received his B.S., M.S., and Ph.D. Degrees in Nuclear Engineering from the University of Notre Dame.

# Development and Verification of an Advanced Technique for Evaluation of Electro Hydraulic Fluid Systems

FRED R. EWING



Fred R. Ewing's career represents a total of 17 years in Turbine-Generator Service, with increasing emphasis on control systems and unit startup issues which constitute the basis of this paper.

Joining Westinghouse Power Generation Service Division in 1971, Mr. Ewing was first involved in erection of large turbines. By 1973 he had focused his technical speciality in balancing and control systems, with primary responsibility in unit startup.

From 1976 to 1985, Mr. Ewing served as Southeast Region Mechanical Engineer, administering a field service group in balancing and controls. In 1985, he was appointed manager for balancing work to coordinate field techniques for the division.

Mr. Ewing is currently Southeast Region Resources Manager and has taken the lead in developing advanced techniques for inspection and evaluation of EH Fluid Systems.

## DONALD P. ERSTAD



Donald P. Erstad, Startup Engineer, Westinghouse Power Generation Service Division, has centered his engineering specialty on control systems and startup. His extensive involvement in unit problems during startup has been the basis for his contribution to the EH Fluid System Evaluation Program now underway.

Mr. Erstad's ability to join in the development effort is further supported by his 20 year

career in the Control Systems for the U. S. Air Force and by his 6 years with Rockwell in manufacturing engineering for missile controls and guidance systems.

He is currently the Region Startup Engineer and is continuing on special assignment to expand valve system analyzer capabilities in testing internal and external valves and components vital to total system upgrade.

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# DEVELOPMENT AND VERIFICATION OF AN ADVANCED TECHNIQUE FOR OVERALL ELECTRO-HYDRAULIC FLUID SYSTEM EVALUATION AND RESTORATION

F.R. Ewing, Region Resource Manager

D.P. Erstad, Startup Engineer

Westinghouse Electric Corporation  
Power Generation Service Division

## Abstract

Aging electro-hydraulic fluid systems (see figure 1) exhibit internal cumulative, multiple point leakage that is difficult to locate. This condition can cause low pump cycle time, increased wear on pumps, high fluid temperature, system degradation and loss of back-up capability when one pump is incapable of supplying the fluid volume needed to maintain system pressure. Low fluid pressure can cause valves to drift from open toward closed and, in the case of back seated valves, can cause steam erosion on valve components. Degradation is not readily apparent since unit output is not affected until the problem has progressed to the verge of causing trip and shutdown.

Current industry practice involves routine preventive maintenance of critical valves but may not address certain conditions in systems that are still operational. At the same time, the aging process continues and system operating conditions are further deteriorated.

Responding to this situation, Westinghouse has been developing the means for comprehensive evaluation of the Electro-Hydraulic (EH) Fluid System.

Development objectives were focused on inspection and evaluation in two modes:

- Troubleshooting to identify and quantify problem areas in systems that had evidenced degradation through deterioration in cycle time
- Preventive maintenance in scheduled outages to promote availability and reliability

The evaluation methods were designed to minimize turbine downtime through minimum disassembly and to yield accurate estimates of EH fluid system performance by duplicating operating conditions.

Initial development criteria also recognized that the test equipment must be versatile, adaptive to a wide range of system configurations; transportable, rugged enough to withstand shipment site to site without damage or degradation of accuracy; self-standing, except for in-plant power source; and capable of withstanding the extremes of power plant environment.

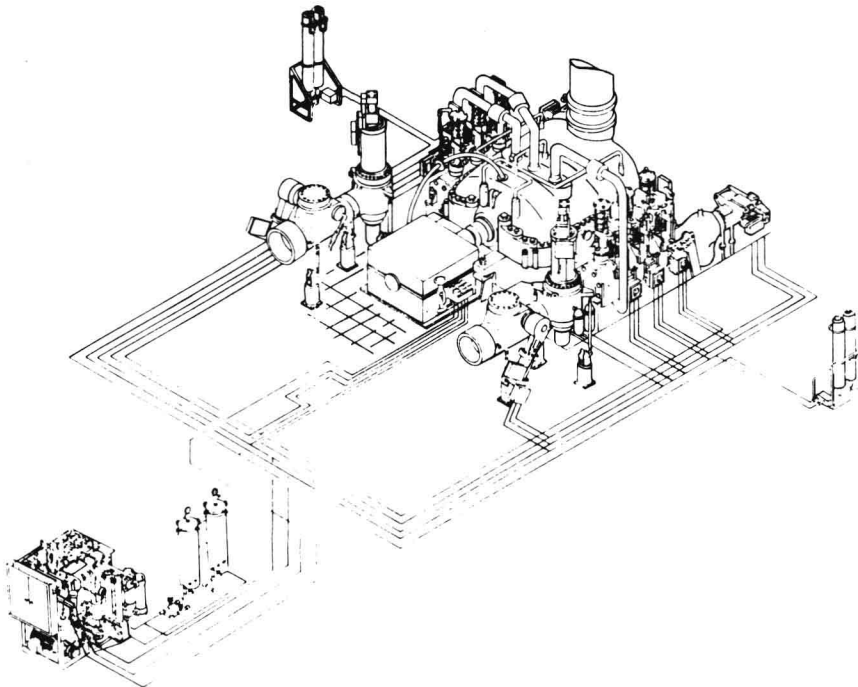


Figure 1. Electro-Hydraulic (EH) Fluid System

Now developed, the integrated EH system test assembly is designed to detect points of internal leakage in aging systems. Prototype testing has demonstrated capability that meets the full set of development objectives, along with the flexibility to test individual components or the total EH fluid system (see figure 2).

Westinghouse has conducted field applications at two utilities on three occasions. In some cases, these tests have identified malfunctioning components and internal leaks while, in other cases, components scheduled for preventive maintenance were verified to be fully serviceable.

Conducting EH fluid system evaluation while other outage work is in progress provides an efficient approach to system analysis, along with the opportunity to repair or replace long lead time items. Thus, early identification of problems provides system integrity and thus reduces the potential for trip and shutdown. At the same time, this inspection capability facilitates outage maintenance as it provides opportunity to schedule spare parts procurement and perform shop and on-site repair.

### Industry Status: Background

Experience in service to power generation systems has shown a need for comprehensive evaluation of EH fluid systems, performed with minimum disassembly in the initial stage of a maintenance outage. Thus, any corrective measures required can be taken without extending unit downtime.

While EH fluid systems are subject to malfunction through aging as a function of maintenance practice and deterioration of key components, these conditions may go undetected until incidents occur during post-outage startup.

In some cases, EH fluid system conditions have continued to deteriorate to the point that they cause a unit trip.

Cycle time is one of the few outward symptoms that alert operators to actual operating conditions in the EH fluid system.

Further, current practice in outage maintenance of EH fluid systems is typically limited to routine removal of a prescribed number of valves for shop inspection and repair, concurrent with outage maintenance of the turbine-generator. This approach does not address the actual condition of each valve on the system, nor does it respond to the potential for deterioration in other system components, such as pumps and actuators.

In the event of a difficulty in startup or during on-line operation, the lack of a method for comprehensive system evaluation presents a very real dilemma. In the effort to minimize downtime, maintenance teams are forced to practice random troubleshooting, to replace or repair components that appear to be the most likely source of the difficulty and to return the unit to service without a thorough investigation of system conditions.

Recognizing these problems, Westinghouse Power Generation Service Division has developed the evaluation tools, techniques and procedures to test the integrity and function of the overall EH fluid system. Service verification tests have been completed; and initial field trials have been conducted. Performance to date indicates that development objectives for accurate and repeatable evaluation have been achieved.

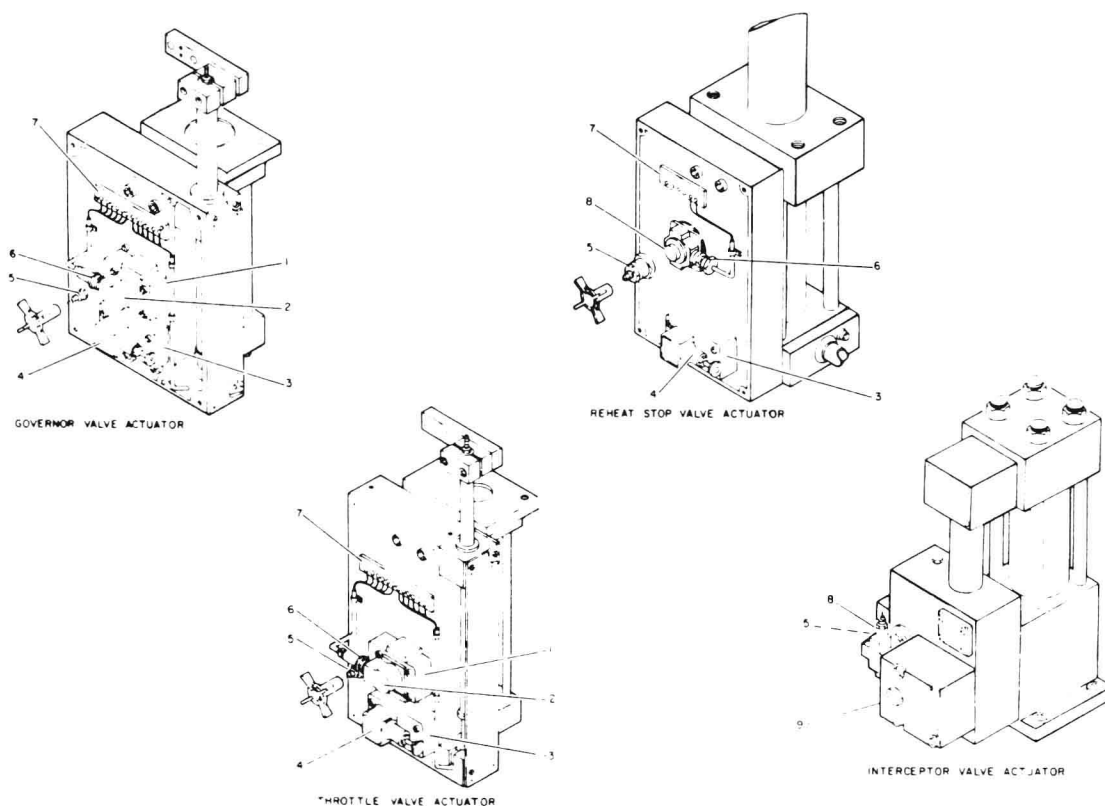


Figure 2. EH Valve Actuators