



Well Test Design and Analysis

Instructors: Christine Ehlig-Economides, Ph.D.

Course Discipline: Reservoir Engineering

Course Level: Intermediate

Course Length: 5 days

Course CEUs: 4.0

Course Description

This 5-day course will provide a comprehensive view of pressure transient test design and interpretation. The emphasis is on understanding how well and reservoir parameters of practical interest can be quantified from well tests. Well parameters causing productivity loss include near wellbore damage and limited entry; those stimulating productivity include hydraulic fracturing and well deviation, the latter including horizontal wells. Reservoir parameters include vertical and horizontal permeability, natural fractures, and reservoir boundary characterizations. The course begins with a brief derivation of the models used for pressure transient analysis and hands on interpretation basics. The test design module describes a wide variety of test types and acquaints participants with forward simulation using commercial software providing a rich analytical model catalog. Then basic analysis is extended to include gas reservoirs and the effects of heterogeneity due to natural fractures. Next the emphasis turns to characterizing vertical and lateral reservoir limits and how the latter relates to seismic data interpretation. Then both pressure transient and production data analysis are considered for horizontal and hydraulically fractured wells. Finally, we examine multiwell and interference testing. Participants are invited to bring data for the class to consider on the last day if not before.

Who should attend

Engineers and geoscientists interested in well and reservoir evaluation from well tests and production data.

Course Content

- Learn how well test models are derived and computed
- Experience how to simulate pressure transient test behavior and how to design well tests.*
- Experience how to process, quality check, diagnose, and analyze pressure transient data.
- Understand the behavior of well and reservoir response patterns observed in well test, what well and reservoir parameters can be quantified, and how to quantify them from pressure transient data*

*Using commercial software (Ecrin suite by Kappa Engineering)



CHRISTINE A. EHLIG-ECONOMIDES
Instructor

PROFESSIONAL EXPERIENCE:

President (EPT-International, 2014 to present)

Consultant for Sinopec and PetroKing, training for ENI in Milan and Mozambique, for Petrogroup in Colombia.

Full Professor (University of Houston, September, 2014 to present)

William C. Miller Chair; working with faculty to grow with the new undergraduate program and starting work to develop an industry consortium for research about shale oil and gas, invited instructor for Technion and University of Cyprus.

Full Professor (Texas A&M University, June, 2004 to September, 2014)

Albert B. Stevens Endowed Chair; developing new research and education in energy engineering; director of new Center for Energy, Environment, and Transportation Innovation of the Crisman Institute.

Full Professor (University of Houston, September, 2003 to May 2004)

Global Account Manager (Schlumberger Global Client Accounts, Houston, Texas, July, 1999 to August, 2003)

Coordinate Schlumberger participation for the Shell international accounts; provide reservoir engineering consulting for numerous other global projects involving US – based international companies

Adjunct Professor (University of Houston, January, 2000 to August, 2003)

Director of the Petroleum Engineering Program which offers the MS Degree in Petroleum Engineering; providing part-time support to this program for faculty and student recruiting, student advising; teaching (Reservoir Engineering and Pressure Transient Testing), and other functions.

Area Manager, Latin America North (Schlumberger Reservoir Technologies, Caracas, Venezuela, September, 1997 to July, 1999)

Schlumberger Reservoir Technologies provides integrated reservoir characterization and reservoir management. The Latin American North Area includes Peru, Ecuador, Colombia, Venezuela, and Trinidad.

Technical and Marketing Manager, Production Enhancement (Schlumberger Oilfield Services, Sugar Land, TX, July, 1996 to September, 1997)

The Production Enhancement business development is directed toward assisting Schlumberger customers to identify opportunities to enhance production in existing wells and in producing reservoirs. Responsibilities include establishing a technical ladder for professionals involved in production engineering services, developing a marketing plan for the production enhancement service, coordinating training, and recruiting personnel.

Technical Advisor (Anadrill Schlumberger, Sugar Land, TX, July, 1995 to July, 1996)

Reservoir engineering specialist in multidisciplinary team assigned to develop reentry and multilateral well strategies for Anadrill; responsible for developing tools to design the reservoir

portion of single or multiwell trajectories that optimize Net Present Value while accounting for a reservoir model and drilling and completion costs.

Technical Advisor (Schlumberger International Coordination, Houston, TX, Jan. 1993 to the July, 1995)

Providing technical input and training to commercial, marketing, engineering, and research groups on applications for integrated services and identifying ways to better address industry needs, with an emphasis on production and reservoir engineering; acting as project coordinator for selected projects; participating in multidisciplinary reservoir characterization studies; assisting international operations as needed.

Visiting Professor (Stanford University, spring quarter of 1995)

Taught graduate level course on Well Testing for Prof. Roland Horne, who is on sabbatical leave.

Visiting Professor (University of Houston, spring of 1994)

Taught Master's level course on Integrated Reservoir Characterization

Project Leader, Reservoir Dynamics (Etudes et Productions, Schlumberger, Clamart, France, June 1990 Dec. 1992)

Provided functional specifications and managed implementation of applications on an integrated reservoir modeling workstation. Applications included integrated interpretation of seismic and well test data, reservoir fluid flow simulation project management, integration of formation test pressures in correlation of open hole logs and seismic cross section display, compartmentalized reservoir model for integrated interpretation of well test and formation test data, and a module for using openhole and cased hole saturation data integrated with other data for generation of capillary pressure and relative permeability input to reservoir simulation and for time-dependent volumetric saturation mapping.

Section Manager, Reservoir Engineering (Schlumberger Well Services, Houston, TX, January 1988 to June 1990)

Managed a team of 7 professionals in the development of a state-of-the-art methodology for transient test design and interpretation, the STAR (Schlumberger Transient Analysis and Report) product implementation, and the specification for ZODIAC (Zoned Dynamic Interpretation), both now in commercial use.

Section Head, Layered Reservoir Testing (Schlumberger Perforating and Testing, Houston, TX, August 1986 to January 1988)

Managed the work of 4 professionals in the development of the Well Management System, reservoir engineering software for the interpretation of layered reservoir tests and single well simulation applications.

Developed analytical models for layered reservoirs, and methods for interpretation of field data.

Section Head, Dynamic Reservoir Description (Flopetrol Johnston Schlumberger, Melun, France, September 1983 to August 1986)

Managed 3 professionals to develop new models and techniques for testing layered reservoirs and interactive software for production log interpretation.

Developed comprehensive analytical model for layered reservoir system, and participated in design, data acquisition, and interpretation of successful layered reservoir tests.

Head, Petroleum Engineering Department (University of Alaska, Fairbanks, AK, 1981-83)
Assistant Professor of Petroleum Engineering (University of Alaska, 1980-83)
Responsible for designing curricula, courses, laboratories, and for recruiting faculty for the B.S. and M.S. programs in Petroleum Engineering at the University of Alaska, Fairbanks. Also responsible for managing expenditures and securing additional funding for faculty and graduate student research.

Taught courses in oil well design and production, formation evaluation, reservoir engineering, numerical simulation, and waterflooding.

Conducted research on interference testing with constant pressure producing wells, analysis of interference and conventional well tests in elongated reservoirs, and custom generated type curves using source and Green's functions.

Acting Assistant Professor of Petroleum Engineering (Stanford University, Stanford, CA, 1979-80)

Taught undergraduate laboratory courses in fluid properties and core analysis and taught, with Professor H.J. Ramey, Jr., the graduate level course in advanced natural gas engineering.

Program Manager (Stanford Geothermal Program, Stanford University, 1978-80)

Managed \$400,000 per year DOE contract on geothermal energy research.

Organized the Annual Stanford Workshop on Geothermal Reservoir Engineering, and weekly seminars involving many prominent speakers. Wrote the quarterly and annual project reports for the DOE.

Research Assistant (Petroleum Engineering Department, Stanford University, 1976-78)

Conducted bench scale research on temperature effects on absolute permeability. Wrote Ph.D. dissertation on new and comprehensive well test procedures for wells flowing at constant pressure.

Engineer (Shell Development, summers 1977, 1979, Shell Oil, summer 1981)

Participated in research on experimental determination of 3-phase relative permeabilities for oil-water-steam systems, and on determination of properties of steam foam as a displacing medium.

Developed computer simulation for pattern steam flood for a heavy oil lease in California.

Research Assistant (Water Resources Section, Kansas Geological Survey, Lawrence, KS, 1974-76)

Developed computer simulations for groundwater reservoir modeling. Developed mathematical solutions for the convection-diffusion equation in two dimensions.

COURSES TAUGHT:

Pressure Transient Analysis (graduate course at UH and TAMU and short course)

Reservoir Engineering (undergraduate/graduate course at UH and short course)

Production Engineering (undergraduate/graduate course at UH and short course)

Energy Resources, Use, and Importance to Society (undergraduate course at TAMU)

Energy and Sustainability (undergraduate/graduate course at TAMU)

Introduction to Petroleum Engineering (graduate course at UH)

Short courses for PEMEX, Yukos, Sibneft, Conoco Norway, PDVSA, PetroChina, ENI, KNOC, SOECOR

HONORS AND AWARDS

Phi Kappa Phi (University of Kansas)
Standard Oil of California Fellowship (Stanford University)
Sigma Xi (National Honor Research Society)
Outstanding Faculty Award (Univ. of AK, Fairbanks; School of Mineral Industry), 1983
SPE Distinguished Achievement Award for Petroleum Engineering Faculty, 1982
Alaska SPE Engineer of the Year, 1982
SPE Formation Evaluation Award, 1995
SPE Distinguished Member in 1996
Lester C. Uren Award in 1997
SPE Distinguished Lecturer, 1997-98
National Academy of Engineering, 2003
SPE Anthony Lucas Gold Medal, 2010

PROFESSIONAL SOCIETIES AND ACTIVITIES

Elected Member of the US National Academy of Engineering, 2003
Member of Society of Petroleum Engineers of AIME
Member of American Association of Petroleum Geologists
Member of American Society for Engineering Education
Member American Chemical Society Petroleum Research Fund Advisory Board, 2013
Member of the NAE Membership Policy Committee, 2012-2014
Treasurer, Texas Academy of Medicine Engineering Science and Technology 2011-2012
Member of NRC Board on Energy and Environmental Systems (BEES), 2010-present
Member, SPE Program Committee for Applied Technology Workshop, 2012-2103.
Member of EPA Science Advisory Board Oil Spill Research Strategy Review Panel, 2011
Member NAS Committee on America's Energy Future, 2007-2009
Co-Chairperson of the SPE Dual Career Workshop Steering Committee, 2007
Technical Program Committee Chairperson for the SPE ATCE, 2006
Member of Technical Program Committee for the Russian Oil and Gas Technical Conference and Exhibition, 2006
Co-Chairperson of the SPE Middle East Colloquium on Petroleum Engineering Education, 2006
Member of Executive Committee for SPE Digital Conference, 2006
SPE Technical Editor, 2004-present
Workshop Presenter for Expanding Your Horizons, 2001 and 2002
Member of SPE Ferguson Award Committee, 1999-2001
Member of SPE Forum Coordination Committee, 1999-2000
Member of SPE Forum Series Coordinating Committee, 1999
Forum liaison for South American Forum, 1999, 2000
SPE Distinguished Lecturer, 1997-98
Chairperson of SPE Cultural Diversity Committee, 1994-95
Member of SPE *Ad Hoc* Task Force on Diversity/Governance, 1995
Executive Editor for *SPE Formation Evaluation*, 1995-96
Co-chairperson of Steering Committee for SPE Rocky Mountain Forum on Horizontal Well Evaluation and Performance Assessment, 1995

Member of Steering Committee for SPE European Forum on Evaluation, Development and Management of Layered Reservoirs, 1995

Member of Steering Committee for Colloquium for Petroleum Engineering Education, 1995

Member of Steering Committee for SPE European Forum on Well Testing, 1992

SPE Editorial Review Committee Chairman, 1991-93

SPE Technical Editor, 1982-86

Member of Technical Program Committee for 1983 SPE Western Region Conference

Member of Technical Program Committee for 1987 SPE Low Permeability Symposium

Member Visiting Committee for the University of Texas Petroleum Engineering Department

EDUCATION

B.A.	1971	Math-Science, cum laude Rice University
M.A.T.	1974	Mathematics Education University of Kansas
M.S.	1976	Chemical Engineering University of Kansas
Ph.D.	1979	Petroleum Engineering Stanford University

PUBLICATIONS

Textbook:

Economides, M.J., Hill, A. Daniel, and Ehlig-Economides, C.A., Zhu, Ding: *Petroleum Production Systems Second Edition*, PTR Prentice Hall, Englewood Cliffs, NJ, 2012.

Ehlig-Economides, C.A., Aghara, S., Kavscek, A., Pisupati, S., and Toossi, R.: *Live Energy*, prototype iBook funded by NSF TUES Phase-II Grant number 1022932.

Engineering Education

1. Ehlig-Economides, C.A., Talreja, R., Ezrailson Mariotti, C.: "Reading, Writing - Energy: An NSF CCLI Project to Enhance a Freshman Core Curriculum Natural Science Course," Poster Paper presented at the American Society of Engineering Education Annual Meeting, Pittsburgh, PA, June 2008.
2. Yalvac, B., Brooks, L.A., Ehlig-Economides, C.A.: "Research on the Evolution of College Instructors' Perspectives of Teaching and Learning," paper presented at the American Society of Engineering Education Annual Meeting, Pittsburgh, PA, June 2008.
3. Brooks, L.A., Yalvac, B., Ehlig-Economides, C.A.: "The Influence of Apprenticeships of Observation on STEM Recitation Instructors' Practices and Epistemological Flexibility," to be presented at the 2009 AERA Annual Meeting in a Poster Session titled, "College and University Posters".
4. Yalvac, B., Ehlig-Economides, C.A., Brooks, L.A., and Smith, D.: "An International, Interdisciplinary, and Dynamic Approach to Teaching Energy Utilization and Sustainability," paper Q863SM, International Symposium on Engineering Education and Educational Technologies in Orlando, Florida, July 10th - 13th, 2009.
5. Ehlig-Economides, C., Aghara, S. K., Pisupati, S. V., Toossi, R., Kavscek, A. R., Ayar, M., Binks-Cantrell, E., Gilman, D. R., Smith, D. L., Robinson, T. A., & Yalvac, B., "Live energy: An initiative for teaching energy and sustainability topics with the most up-to-

date and relevant content", *Proceedings of the 2012 American Society for Engineering Education (ASEE) Annual Meeting*, vol. , (2012), " " Proceedings Publication.

6. Yalvac, B., Ayar, M., Ehlig-Economides, C.A.: "An Emergence of A Community-of-Practice: Five Engineering Faculty Co-Authoring An Electronic-and-Dynamic Textbook Material in Energy Sustainability" presented at the AERA 2012 Conference.

Energy, Environment, and Transportation

1. Ehlig-Economides, C.A., Barrufet, M., Longbottom, J.R., and Velu, B.P.: "Unconventional Uses for Unconventional Oil," SPE 97338 presented at the 2005 SPE International Thermal Operations and Heavy Oil Symposium held in Calgary, Alberta, Canada, 1–3 November 2005.
2. Adekoge, A., Barrufet, M., and Ehlig-Economides, C.A.: "GTL Plus Power Generation: The Optimal Alternative for Natural Gas Exploitation in Nigeria," SPE 10523 presented at the International Petroleum Technology Conference held in Doha, Qatar, 21–23 November 2005.
3. Adekoge, A., Barrufet, M., and Ehlig-Economides, C.A.: "Integrated GTL Power-Generation Technology: The Optimal Solution to Natural Gas Exploitation in Nigeria," SPE 105966, presented at the 30th Annual SPE International Technical Conference and Exhibition in Abuja, Nigeria, July 31-August 2, 2006.
4. Akinnikawe, A., Tokan-Lawal, A., Longbottom, J.R., Azcarate, F., Ehlig-Economides, C.A.: "Dualmode Transportation – Impact on the Electric Grid," Paper Number: 08-1326, presented at the Transportation Research Board Conference, Washington, D.C., January 2008.
5. Ehlig-Economides, C.A., and Longbottom, J.R.: "Dual Mode Vehicle and Infrastructure Alternatives Analysis," Texas Department of Transportation Report 0-5827-1, October 2007.
6. Akinnikawe, O., and Ehlig-Economides, C.A.: "Reducing the Green House Gas Emissions from the Transportation Sector," paper J259JY, International Symposium on Energy Engineering, Economics and Policy in Orlando, FL, July 10-13, 2009.
7. Srivatsan, Jagannath Saiyee, Linke, Patrick, Ehlig-Economides, Christine: "Seawater Desalination Using Excess Heat from GTL Proces," SPE 124462, presented at the 2009 SPE Annual Technical Conference and Exhibition held in New Orleans, Louisiana, USA, 4–7 October 2009.
8. Alenzi, Naser, Liao, Wei-Ssu, Cremer, Paul S., Sanchez-Torres, Viviana, Wood, Thomas K., Ehlig-Economides, Christine, Cheng, Zhengdong: "Photoelectrochemical hydrogen production from water/methanol decomposition using Ag/TiO₂ nanocomposite thin films," *International Journal of Hydrogen Energy* 1-8, 2010.
9. Alenzi, Naser, Liao, Wei-Ssu, Cremer, Paul S., Sanchez-Torres, Viviana, Wood, Thomas K., Ehlig-Economides, Christine, Cheng, Zhengdong: "Photoelectrochemical hydrogen production from water/methanol decomposition using Ag/TiO₂ nanocomposite thin films," *International Journal of Hydrogen Energy* 11768-11775, 35, 2010.

Drilling Engineering

1. Song, G., Hu, Z., Sun, K., Ma, N., Economides, M.J., Samuel, R., and Ehlig-Economides, C.A.: "An Innovative Ultradeepwater Subsea Blowout Preventer (SSBOP) Control System Using Shape Memory Alloy Actuators," *ASME JERT* 33101-3 September, 2008.
2. Ma, N., Hu, Z., Samuel, R., Ehlig-Economides, C.A., and Song, G.: "Design and Performance Evaluation of an Ultradeepwater Subsea Blowout Preventer Control System Using Shape Memory Alloy Actuators," SPE 101080, presented at the 2006 SPE

Annual Technical Conference and Exhibition held in San Antonio, Texas, U.S.A., 24–27 September 2006.

Production Engineering

1. Ehlig-Economides, C.A., Tomic, S., and Economides, M.J.: “Foolproof Completions for High-Rate Production Wells,” SPE 111455, presented at the SPE International Symposium and Exhibition on Formation Damage Control held in Lafayette, Louisiana, U.S.A. 13–15 February 2008.
2. Tomic, S., Ehlig-Economides, C.A., Economides, M.J., and Vincent, M.C.: “New Flux Surveillance Approach for High Rate Wells,” SPE 115689, presented at the SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 21–24 September 2008.
3. Zhang, Y., Ehlig-Economides, C.A., Han, G., Tomic, S., and Economides, M.J.: “Inflow Performance for a Hydraulic Fracture in a Deviated Well,” SPE 119345, presented at the SPE Hydraulic Fracturing Technology Conference held in The Woodlands, Texas, USA, 19–21 January 2009.
4. Zhang, Y., Morangiu-Porcu, M., Ehlig-Economides, C.A., Tomic, S., and Economides, M.J.: “Comprehensive Model for Flow Behavior of High-Performance Fracture Completions,” SPEPO, November 2010.
5. Marongiu-Porcu, M. Naha, S. Norman, D. Ehlig-Economides, C. A. : “Field Data Validation of a General Model for High-Performance Fractures in Deviated High-Rate Wells,” SPE 135188, presented at the SPE Annual Technical Conference and Exhibition held in Florence, Italy, 19–22 September 2010.
6. Mohamed, I.M., Nasralla, R.A., Sayed, M.A., Marongiu-Porcu, M., and Ehlig-Economides, C.A.: “Evaluation of After-Closure Analysis Techniques for Tight and Shale Gas Formations,” SPE 140136, presented at the SPE Hydraulic Fracturing Technology Conference and Exhibition held in The Woodlands, Texas, USA, 24–26 January 2011.
7. Morangiu-Porcu, M., Economides, M.J, and Ehlig-Economides, C.A.: “Global Model for Fracture Falloff Analysis,” SPE 144028 presented at the SPE North American Unconventional Gas Conference and Exhibition held in The Woodlands, Texas, USA, 14–16 June 2011.
8. Xue, H., and Ehlig-Economides, C.A.: “Permeability Estimation from Fracture Calibration Test Analysis in Shale and Tight Gas,” Paper URTEC 1569587 presented at the Unconventional Resources Technology Conference held in Denver, Colorado, USA, 12-14 August 2013.
9. Ahmed, I.A., and Ehlig-Economides, C.A.: “Investigation of Created Fracture Geometry through Hydraulic Fracture Treatment Analysis,” Paper URTEC 1574483 presented at the Unconventional Resources Technology Conference held in Denver, Colorado, USA, 12-14 August 2013.
10. Tovar, F.D., Lee, K.J., Gonzales, S.E., Hwang, Y.S., del Busto, A.M., Aderibigbe, A.A., Economides, M.J., and Ehlig-Economides, C.A.: “Horizontal Hydraulic Fracture Design for Optimal Well Productivity in Anisotropic Reservoirs with Different Aspect Ratios ,” Paper URTEC 1565038 to be presented at the Unconventional Resources Technology Conference held in Denver, Colorado, USA, 12-14 August 2013.
11. Marongiu-Porcu, M., Retnanto, A., Economides, M. J., & Ehlig-Economides, C.: “Comprehensive Fracture Calibration Test Design,” SPE 168634, presented February 4, 2014. Society of Petroleum Engineers. doi:10.2118/168634-MS
12. Zhang, T., Pang, W., Du, J., He, Y., He, Q., Liu, H., Ehlig-Economides, C. A.: “Actual and Optimal Hydraulic Fracture Design in a Tight Gas Reservoir,” SPE 168613 (2014, February 4), submitted for journal publication, Society of Petroleum Engineers. doi:10.2118/168613-MS

Reservoir Engineering and Horizontal and Multibranch Wells

1. Ehlig-Economides, C.A., and Spath, J.: "Waterflood Infill Well Pattern Strategies for Horizontal and Multibranch Wells," SPE 35209 presented at the Permian Basin Oil Recovery Conference held in Midland, TX, 27-29 March, 1996.
2. Ehlig-Economides, C.A., Mowat, G.R., and Corbett, C.: "Techniques for Multibranch Well Trajectory Design in the context of a Three-Dimensional Reservoir Model," SPE 35505 presented at the European 3-D Reservoir Modelling Conference in Stavanger, Norway, 16-17 April 1996.
3. Ehlig-Economides, C.A., Chan, K.S., and Spath, J.: "Production Enhancement Strategies in Strong Bottom Water Drive Reservoirs," SPE 36613 presented at the 1996 SPE Annual Conference and Exhibition, Denver, Colorado, Oct. 6-9.
4. Fernandez, Belkis, Ehlig-Economides, C.A., and Economides, M. J.: "Multibranch Injector/Producer Wells in Thick Heavy Crude Reservoirs," SPE 53950, presented at the 1999 SPE Latin American and Caribbean Petroleum Engineering Conference held in Caracas, Venezuela, April 1999.
5. Ehlig-Economides, C.A., Fernandez, B.G., Gongora, C.A.: "Global Experiences and Practice for Cold Production of Moderate and Heavy Oil," SPE 58773, presented at the SPE international Symposium on Formation Damage Control, Lafayette, LA, February 2000.
6. Ehlig-Economides, C.A., Taha, M., Marin, H.D., Novoa, E. and Sanchez, O.: "Drilling and completion Strategies in Naturally Fractured Reservoirs," SPE 59057 presented at the SPE International Petroleum Conference and Exhibition in Mexico, Villahermosa, February 2000.
7. Ehlig-Economides, C.A., and Economides, M.J.: "Single Well Reservoir Management – the Ultimate Multibranch Well Challenge," SPE 59447 alternate paper for the SPE Asia Pacific Conference on Integrated Modeling for Asset Management, Yokohama, April 2000.
8. Ehlig-Economides, C.A., Fernandez, B., and Economides, M.J.: "Multibranch Injector/Producer Wells in Thick Heavy Crude Reservoirs," *SPEREE*, June 2001
9. Ehlig-Economides, C. A., and Economides, M. J.: "Accelerating Oil Recovery with - Mode Production," *World Oil*, November 2000.
10. Guerithault, Raphael, and Ehlig-Economides, C.A.: "Single-Well Waterflood Strategy for Accelerating Oil Recovery," SPE 71608 presented at the Annual Technical Conference and Exhibition, October, 2001.
11. Terez, Ivan E., and Ehlig-Economides, C.A.: "Horizontal Wells in Thermal Applications for Displacement and Gravity Drainage," SPE/CIM 78974, presented at the International Thermal Operations and Heavy Oil Symposium and International Horizontal Well Technology Conference held in Calgary, Alberta, Canada, November 2002.
12. Song, Bo, Economides, Michael J., Ehlig-Economides, Christine: "Design of Multiple Transverse Fracture Horizontal Wells in Shale Gas Reservoirs," SPE 140555, presented at the SPE Hydraulic Fracturing Technology Conference and Exhibition held in The Woodlands, Texas, USA, 24–26 January 2011.
13. Song, Bo, Ehlig-Economides, Christine: "Rate-Normalized Pressure Analysis for Determination of Shale Gas Well Performance," SPE 144031, prepared for presentation at the SPE North American Unconventional Gas Conference and Exhibition held in The Woodlands, Texas, USA, 12–16 June 2011.
14. Chaudhary, A.S., Ehlig-Economides, C.A., Wattenbarger, R.: "Shale Oil Production Performance from a Stimulated Reservoir Volume," SPE 147596 prepared for presentation at the SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 30 October–2 November 2011.

15. Ehlig-Economides, C.A., and Economides, M.J.: "Water as Proppant," SPE 147603, prepared for presentation at the SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 30 October–2 November 2011.
16. Ehlig-Economides, C.A., Ahmed, I., Apiwathanasorn, S. Lightner, J., Song, B., Vera, F., Xue, H., and Zhang, Y.: "Stimulated Shale Volume Characterization: Multiwell Case Study from the Horn River Shale: II. Flow Perspective," paper SPE 159546 presented at the SPE Annual Technical Conference and Exhibition held in San Antonio, Texas, USA, 8-10 October 2012.
17. Wei, P., Ehlig-Economides, C. A., Juan, D., Ying, H., & Song, B.: "Intelligent Rate Transient Analysis for Forecasting Behavior of Shale Gas Wells," SPE 1921855, presented August 28, 2014. Society of Petroleum Engineers. doi:10.15530/urtec-2014-1921855
18. Zhang, Y., & Ehlig-Economides, C.: "Accounting for Remaining Injected Fracturing Fluid in Shale Gas Wells," SPE 189299 presented August 28, 2014. Society of Petroleum Engineers. doi:10.15530/urtec-2014-1892994
19. Yan, C., Luo, G., & Ehlig-Economides, C. A.: "Systematic Study of Bakken Well Performance Over Three Well Completion Design Eras," SPE 171566, presented September 30, 2014. Society of Petroleum Engineers. doi:10.2118/171566-MS
20. Sorek, N., Moreno, J. A., Rice, R., Luo, G., & Ehlig-Economides, C.: "Optimal Hydraulic Fracture Angle in Productivity Maximized Shale Well Design," SPE 170965 presented October 27, 2014. Society of Petroleum Engineers. doi:10.2118/170965-MS

Layered Reservoir Testing

1. Ehlig-Economides, C.A., and Ayoub, J.A.: "Vertical Interference Testing Across a Low Permeability Zone, *SPEJ*, Oct., 1986.
2. Ehlig-Economides, C.A., and Joseph, J.A.: "A New Test for Determination of Individual Layer Properties in a Multilayered Reservoir," *SPEFE*, Sept., 1987.
3. Ehlig-Economides, C.A.: "Well Testing in Layered Reservoirs, " *Trans.*, International Seminar on North Sea Oil and Gas Reservoirs, Trondheim, Norway, Dec., 1986.
4. Ehlig-Economides, C.A., Joseph, J.A., Erba, M., and Vik, S.A.: "Evaluation of Single-Layer Transients in Multilayered System, SPE paper No. 15860, Oct., 1986.
5. Ehlig-Economides, C.A.: "Testing and Interpretation in Layered Reservoirs," *JPT*, Sept., 1987.
6. Ayestaran, L., Ehlig-Economides, C.A., Shah, P.C., Kuchuk, F.J., Nicolson, B., and Wittmann, M.: "Layered Reservoir Testing," *The Technical Review*, V. 35, no. 4 (October 1987) 4-11.
7. Ehlig-Economides, C.A.: "Model Diagnosis for Layered Reservoirs," *SPEFE*, Sept. 1993.
8. Sui, W., Zhu, D., Hill, A.D., Ehlig-Economides, C.A: "Determining Multilayer Formation Properties from Transient Temperature and Pressure Measurements," SPE 116270, presented at the 2008 SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 21–24 September 2008.
9. Sui, W., Zhu, D., Hill, A.D., Ehlig-Economides, C.A: "Model for Transient Temperature and Pressure Behavior in Commingled Vertical Wells," SPE 115200, presented at the 2008 SPE Russian Oil & Gas Technical Conference and Exhibition held in Moscow, Russia, 28–30 October 2008.
10. Sui, W., Zhu, D., Hill, A.D., Ehlig-Economides, C.A.: "Determining Multilayer Formation Properties from Transient Temperature and Pressure Measurements in Commingled Gas Wells," SPE 131150 to be presented at the CPS/SPE International Oil & Gas Conference and Exhibition in China held in Beijing, China, 8–10 June 2010.

11. Sui, Weibo, Ehlig-Economides, Christine, Zhu, Ding, Hill, A. Daniel: "Determining Multilayer Formation Properties from Transient Temperature and Pressure Measurements," accepted for publication in *Petroleum Science and Technology*.

Pressure Transient Testing

1. Ehlig-Economides, C.A., and Ramey, H.J., Jr.: "Transient Rate Decline Analysis for Wells Produced at Constant Pressure," *SPEJ*, Feb., 1981.
2. Ehlig-Economides, C.A., and Ramey, H.J., Jr.: "Pressure Buildup for Wells Produced at a Constant Pressure," *SPEJ*, Feb., 1981.
3. Ehlig-Economides, C.A., and Ansari, J.A.: "Interference Effects Among Wells Produced at Constant Pressure," SPE paper No. 11715, March, 1983.
4. Ehlig-Economides, C.A., and Economides, M.J.: "Pressure Transient Analysis in an Elongated Linear Flow System," *SPEJ*, Dec., 1985.
5. Wagner, P.B., Economides, M.J., and Ehlig-Economides, C.A.: "Custom Type-Curve Generation for Pressure Transient Analysis of Elongated Linear Flow Systems," *Rev., Inst. Fr. du Pet.*, 39, No. 6, Nov.-Dec., 1984.
6. Joseph, J.A., Ehlig-Economides, C.A., and Kuchuk, F.J.: "The Role of Downhole Flowrate and Pressure Measurements in Reservoir Testing," SPE paper No. 18379, Oct., 1988.
7. Ehlig-Economides, C.A.: "Use of the Pressure Derivative for Diagnosing Pressure-Transient Behavior," *JPT*, Oct., 1988.
8. Ehlig-Economides, C.A., Joseph, J.A., Ambrose, R.W., and Norwood, C: "A Modern Approach to Reservoir Test Interpretation," *JPT*, Dec., 1990.
9. Ehlig-Economides, C.A., Ambrose, R.W., and Joseph, J.A.: "Pressure Desuperposition Technique for Improved Late-Time Transient Diagnosis," SPE paper No. 20550, Sept., 1990.
10. Veneruso, A., Ehlig-Economides, C.A., and Petitjean, L.: "Pressure Gauge Specification Considerations in Practical Well Testing," paper No. SPE 22752, presented at the 1991 SPE Annual Conference and Exhibition, Dallas, Texas, Oct. 6-9.
11. Ehlig-Economides, C.A.: "Integrating Transient Well Test Data with Field Wide Simulation of Fluid Flow in Heterogeneous Reservoirs," paper No. SPE 22371, presented at the SPE International Meeting on Petroleum Engineering, Beijing, China, March 24-27, 1992.
12. Deruyck, B., Ehlig-Economides, C.A., and Joseph, J.A.: "Testing Design and Analysis," *The Oilfield Review*, V. 4, no. 2 (April 1992) 28-45.
13. Veneruso, A.F., Ehlig-Economides, C.A., and Akmansoy, A.-M.: "Computer Based Downhole Data Acquisition and Transmission in Well Testing," presented at the SPE Annual Technical Conference and Exhibition, Washington, D.C., 1992.
14. Brown, P.A. and Ehlig-Economides, C.A.: "Use of Downhole Flowmetering Technique for Improved Drillstem Test Interpretation," presented at the SPE Annual Technical Conference and Exhibition, Washington, D.C., 1992.
15. Ehlig-Economides, C.A.: "Computation of Test Area of Investigation in Nonradial Geometries," H.J. Ramey, Jr., Memorial Volume, *SPE Advanced Technology Series*, 1995.
16. Ehlig-Economides, C.A., Hegeman, Peter, and Vik, Sven: "Guidelines Simplify Well Test Interpretation," *OGJ*, July 18, 1994.
17. Ehlig-Economides, C.A., Hegeman, Peter, and Clark, Gavin: "Three Key Elements Necessary for Successful Testing," *OGJ*, July 25, 1994.
18. Ehlig-Economides, C.A., Hegeman, Peter, and Clark, Gavin: "Modern Testing Meets Wide Range of Objectives," *OGJ*, Aug. 1, 1994.

19. Mayerhofer, M.J., Ehlig-Economides, C.A., and Economides, M.J.: "Pressure-Transient Analysis of Fracture-Calibration Tests," *JPT*, March, 1995.
20. Ehlig-Economides, C.A., Fan, Yong, and Economides, M.J.: "Interpretation of Fracture Calibration Tests in Naturally Fractured Reservoirs," SPE paper No. 28690, presented at the SPE International Petroleum Conference & Exhibition of Mexico, Veracruz, Mexico, 1994.
21. Ehlig-Economides, C.A., and Spivey, John: "Intuition and Well Test Interpretation," *Harts E&P*, October 2000.
22. Ehlig-Economides, C.A., and Wells, K.L.: "Average Reservoir Pressure from a Horizontal Well Pressure Buildup Test," paper SPE 10096 presented at the International Petroleum Technology Conference held in Doha, Qatar, 21–23 November 2005.
23. Ehlig-Economides, C.A., Nduonyi, M. Abiazie, J.: "Test Design for Vertical Permeability Determination from a Conventional Pressure Buildup Test," SPE 102779, presented at the 2006 SPE Annual Technical Conference and Exhibition held in San Antonio, Texas, U.S.A., 24–27 September 2006.
24. Ehlig-Economides, C.A., Valko, P., and Dyashev, I.: "Pressure Transient and Production Data Analysis for Hydraulic Fracture Treatment Evaluation," SPE 101832, presented at the 2006 SPE Russian Oil and Gas Technical Conference and Exhibition held in Moscow, Russia, 3–6 October 2006.
25. Economides, M.J., Ehlig-Economides, C.A., and Tosic, S.: "Application of Pressure Transient and Production Data Analysis for Hydraulic Fracture Treatment Evaluation" SPE 106382, presented at the 2007 SPE Hydraulic Fracturing Technology Conference held in College Station, Texas, U.S.A., 29–31 January 2007.
26. Sui, W., Mou, J., Bi, L., Deng, J., and Ehlig-Economides, C.A.: "New Flow Regimes for Well Near Constant Pressure Boundary," SPE 106923, presented at SPE Europec/EAGE Annual Conference and Exhibition held in London, United Kingdom, 11–14 June 2007.
27. Ehlig-Economides, C. A., Martinez Barron, H., Okunola, D.: "Unified PTA and PDA Approach Enhances Well and Reservoir Characterization," SPE 123042 to be presented at the SPE Latin American and Caribbean Petroleum Engineering Conference in Cartagena, Colombia, 31 May–3 June 2009.
28. Tao, Q., Ehlig-Economides, C.A., and Ghassemi, A.: "Modeling Variation of Stress and Permeability in Naturally Fractured Reservoirs Using Displacement Discontinuity Method," ARMA 09-047, presented at the 43rd US Rock Mechanics Symposium and 4th U.S.-Canada Rock Mechanics Symposium, held in Asheville, NC June 28th – July 1, 2009.
29. Tao, Q., Ehlig-Economides, C.A., and Ghassemi, A.: "Investigation of Stress-Dependent Fracture Permeability in Naturally Fractured Reservoirs Using a Fully Coupled Poroelastic Displacement Discontinuity Model," SPE 124745, presented at the SPE Annual Technical Conference and Exhibition held in New Orleans, Louisiana, USA, 4–7 October 2009.
30. Tao, Q., Ghassemi, A., and Ehlig-Economides, C.A.: "Pressure Transient Behavior for Stress-Dependent Fracture Permeability in Naturally Fractured Reservoirs," SPE 131666, to be presented at the CPS/SPE International Oil & Gas Conference and Exhibition in China held in Beijing, China, 8–10 June 2010.
31. Ortiz, R., E., Tran, T., Sinurat, P., and Ehlig-Economides, C.A.: "Integration of Pressure Buildup Deconvolution with the Rate-Normalized Pressure," SPE 128436, presented at the SPE North Africa Technical Conference and Exhibition held in Cairo, Egypt, 14–17 February 2010.
32. Ehlig-Economides, C.A., Anchliya, A., and Song, B.: "Pressure Falloff Test Interpretation for Leakage Detection during CO₂ Injection in a Deep Saline Aquifer," SPE

131675, to be presented at the SPE EUROPEC/EAGE Annual Conference and Exhibition held in Barcelona, Spain, 14–17 June 2010.

33. Apiwathanasorn, S., and Ehlig-Economides, C.A.: "Evidence of Reopened Microfractures in Production Data Analysis of Hydraulically Fractured Shale Gas Wells," paper SPE 162842 presented at the SPE Canadian Unconventional Resources Conference held in Calgary, Alberta, Canada, 30 October–1 November 2012.
34. Ehlig-Economides, C.A., and Vera, F.E.: "Diagnosing Pressure-Dependent-Permeability in Long-Term Shale Gas Pressure and Production Transient Analysis," Paper URTEC 1573545, to be presented at the Unconventional Resources Technology Conference in Denver, Colorado, USA, 12-14 August 2013.
35. Tovar, R. A., & Ehlig-Economides, C. A.: "Improved Reservoir Description from Pressure Transients," SPE 170719, presented October 27, 2014. Society of Petroleum Engineers. doi:10.2118/170719-MS

Reservoir Engineering

1. Ehlig-Economides, C.A., and Economides, M.J.: "Pressure and Temperature Dependent Properties of the Rock-Fluid Systems in Petroleum and Geothermal Formations," SPE paper No. 9919, March, 1981.
2. Ostermann, R.D., Ehlig-Economides, C.A., and Owolabi, O.O.: "Correlations of the reservoir Fluid Properties of Alaska Crudes," SPE paper No. 11703, March, 1983.
3. Ehlig-Economides, C.A., Ebbs, Don and Meehan, D. Nathan: "Factoring Anisotropy into Well Design," *The Oilfield Review*, V. 2, no. 4 (October 1990) 24-33.
4. Ehlig-Economides, C.A.: "Applications for Multiphase Compartmentalized Material Balance," paper No. SPE 27999, presented at the University of Tulsa Centennial Petroleum Engineering Symposium held in Tulsa, Oklahoma, August 1994.
5. Ehlig-Economides, C.A.: "Engineering Applications for Integrated Reservoir Characterization," paper No. SPE 29994, prepared for presentation at the SPE International Meeting on Petroleum Engineering, Beijing, China, Nov., 1995.
6. Mathur, A.K., Ning, X., Ehlig-Economides, C.A., Economides, M.J.: "Hydraulic Fracture Stimulation of Highly Permeable Formations: The Effect of Critical Fracture Parameters on Oilwell Production and Pressure," paper No. SPE 30652, presented at the SPE Annual Technical Conference & Exhibition held in Dallas, TX, October, 1995.
7. Manrique, J.F., Bjornen, K., and Ehlig-Economides, C.A.: "Systematic Methodology for Effective Perforation and Fracturing Strategies," paper No. SPE 38630, presented at the SPE Annual Technical Conference and Exhibition in San Antonio, TX, October, 1997.
8. Ehlig-Economides, C.A., and Economides, M.J.: "Recipe for Success in Ultradeep Water," paper No. SPE 77625, presented at the SPE Annual Technical Conference & Exhibition held in San Antonio, TX, October, 2002.
9. Briceño, M.C., Peralta, J.A., Silva, R.J., Rismyhr, O., Zerpa, L.B., and Ehlig-Economides, C. A.: "Horizontal and Deviated Wells Water Disposal Injection Experiences in a Venezuelan Heavy Oil Reservoir in the Orinoco Belt and Future Injection Practices," SPE paper no. 84377, prepared for SPE Annual Technical Conference & Exhibition held in Denver, CO, October, 2003.
10. Serpen, E., Laine, E., and Ehlig-Economides, C.A.: "Effects of Geostatistical Heterogeneity on Lateral Flow Behavior," EAGE 66th Conference & Exhibition — Paris, France, 7 - 10 June 2004.
11. Serpen, E., Laine, E., and Ehlig-Economides, C.A.: "Effect of areal Heterogeneity on Waterflood Performance between Parallel Horizontal Wells," SPE Paper No. 90346, SPE International Petroleum Conference in Mexico held in Puebla, Mexico, 8–9 November 2004.

12. Anchliya, A., and Ehlig-Economides, C.A.: "Aquifer Management to Accelerate CO₂ Dissolution and Trapping," paper SPE Journal 2012.
13. Economides, M.J., Ehlig-Economides, C.A.: "Sequestering Carbon Dioxide in a Closed Underground Volume," SPE 124430, presented at the 2009 SPE Annual Technical Conference and Exhibition held in New Orleans, Louisiana, USA, 4–7 October 2009.
14. Ehlig-Economides, Christine, Economides, Michael J.: "Sequestering carbon dioxide in a closed underground volume," *Journal of Petroleum Science and Engineering*, 123–13, 70, 2010.
15. Ehlig-Economides, Christine, Economides, Michael J.: "Reply to: Open or closed? A discussion of the mistaken assumptions in the analysis of carbon sequestration," *Journal of Petroleum Science and Engineering* 111–11, 74, 2010.
16. Akinnikawe, Oyewande, Chaudhary, Anish, Vasquez, Oscar, Enih, Chijioke, and Ehlig-Economides, Christine A.: "Increasing CO₂-Storage Efficiency through a CO₂-Brine Displacement Approach," SPE 139467 presented at the SPE International Conference on CO₂ Capture, Storage, and Utilization held in New Orleans, Louisiana, USA, 10–12 November 2010, accepted for publication in *SPE Journal*.
17. Lee, K., Moridis, G. J., & Ehlig-Economides, C. A.: "Oil Shale In-Situ Upgrading by Steam Flowing in Vertical Hydraulic Fractures," SPE 169017 presented April 1, 2014. Society of Petroleum Engineers. doi:10.2118/169017-MS
18. Lee, K., Moridis, G. J., & Ehlig-Economides, C. A.: "A Comprehensive Simulation Model of Kerogen Pyrolysis for the In-situ Upgrading of Oil Shales," SPE 173299 presented February, 2015, Society of Petroleum Engineers. doi:10.2118/173299-MS

Geothermal Reservoir Engineering

1. Daneshi, A., Ehlig-Economides, and Ramey, H.J., Jr.: "The Effect of Temperature Level on Absolute Permeability of Unconsolidated Silica and Stainless Steel," *Geoth. Res. Council Trans.*, **2**, 1978.
2. Ehlig-Economides, C.A., Economides, M.J., and Miller, F.G.: "Interference Between Wells in a Fractured Formation," *Geoth. Res. Council Trans.*, **4**, 1980.
3. Ehlig-Economides, C.A., and Economides, M.J.: "Analysis of a Geothermal Well Test in a Predominantly Linear Flow System," *Proc., Int. Conf. on Geoth. Energy*, May, 1982.
4. Economides, M.J., Ehlig-Economides, C.A., Dunze, J.F., and Lofgren, B.: "A Fieldwide Reservoir Engineering Analysis of the Pilgrim Springs, Alaska, Geothermal Reservoir," *Proc., Eighth Stanford Workshop on Geoth. Res. Eng.*, Dec., 1982.
5. Thoram, S., and Ehlig-Economides, C.A.: "Heat Transfer Applications for the Stimulated Reservoir Volume," SPE 146975 prepared for presentation at the SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 30 October–2 November 2011.

Natural Gas Hydrates

1. Ehlig-Economides, C.A., and Combellick, P.: "Natural Gas Hydrates - A Frozen Treasure," *The Northern Engineer*, **13**, No. 1, Spring, 1981.
2. Collett, T.S., and Ehlig-Economides, C.A.: "Detection and Evaluation of the In-Situ Natural Gas Hydrates in the North Slope Region, Alaska," SPE paper No. 11673, March, 1983.
3. Godbole, S.P., Kamath, V.A., and Ehlig-Economides, C.A.: "In-Situ Natural Gas Hydrates in Alaska," *SPE*, Feb., 1988.

Groundwater Modeling

1. Ehlig, C.A.: "Comparison of Numerical Method for Solution of the Diffusion-convection Equation in One and Two Dimensions," *Finite Elements in Water Resources*, W.G. Gray, G.F. Pinder, and C.A. Brebbia, editors, Pentech Press, London, p. 1.91-1.102.
2. Ehlig, C.A., and Halepaska, J.C.: "A Numerical Study of Confined-Unconfined Aquifers Including Effects of Delayed Yield and Leakage," *Water Resources Research*, **12**, Dec., 1976.

Patents

1. Ehlig-Economides, C.A.: "Property Determination for Multilayer Formation," US Patent # 4,803,873, 1989.
2. Ehlig-Economides, C.A.: "Characterizing the Layers of a Hydrocarbon Reservoir," US Patent # 5,247,829, Sept. 5, 1993.