

**ANNUAL REPORT OF THE CENTER
FOR ENERGY AND COMBUSTION RESEARCH**

University of California, San Diego

July 1, 1995 – June 30, 1996

1. SUMMARY OF ACTIVITIES AND PLANS FOR THE COMING YEAR

This center, previously known as the UCSD Energy Center, was given its new name in 1986 to underscore the close link on campus between energy and combustion research. Approximately twenty faculty and professional staff members are affiliated informally with CECR.

Since its origins, the center has focused on basic problems in finding new sources of energy and the social, environmental, economic, and political consequences of energy consumption, including combustion. Studies range from investigations into the fundamental nature of energy and combustion to practical applications in energy conservation and production, as well as pollution control.

Current research includes flame theory, combustion in turbulent flows, asymptotic methods in combustion, fire research, reactions in boundary layers, other areas of combustion and fluid dynamics. Three specific new grants are for "Stretched Diffusion Flames in von Karman Swirling Flows," from NASA, "Development and Demonstration of Micropilot Diesel/Natural Gas Combustion System Optimized for High Efficiency and Low Emission," a subcontract from BKM, Inc. for the South Coast Air Quality Management District, and an equipment grant to purchase a new Phase Doppler Particle Analyzer, from the Office of Naval Research.

The Center for Energy and Combustion Research has brought together researchers from Germany, France, Spain, Japan, Norway and Korea for brief periods of study and of exchange of ideas during this period.

Plans for the 1996-97 academic year include further emphasis on the fluid dynamics of reacting flows relevant to propulsion and on chemical aspects of propulsion and energy problems. Proposals have been submitted to the Air Force Office of Scientific Research for research on, "Fundamentals of Acoustic Instabilities on Liquid-Propellant Rockets Under Transcritical Conditions", and to NASA on, "Scientific Support for a Proposed Space Shuttle Droplet Burning Experiment", for example. In addition, plans are under way for seeking a large grant for a Center for the Simulation of Turbulent Reactive Systems for ASCI - National Labs, jointly with researchers from the San Diego Supercomputer and the Department of Chemistry at UCSD.

2. ACADEMIC AND PUBLIC SERVICE

A. Membership

It is necessary to distinguish between CECR "members" and "affiliates". "Members" are those who are involved in CECR on a day-to-day basis and who actively participate in CECR programs and research. These include: The Director and Associate Directors, Active Adjunct and Emeritus Professors, and Researchers who are employed full-time by CECR research grants. "Affiliates" are regular faculty members who participate in some CECR projects but who also have other activities and projects not part of CECR.

Faculty Members:

Forman A. Williams - Director
PhD, Engineering Science
Professor of Engineering Physics and Combustions

Robert J. Cattolica - Associate Director
PhD, Engineering Physics
Professor of Engineering Physics

K. Seshadri - Associate Director
PhD, Engineering Science
Professor of Chemical Engineering and Fluid Mechanics

Abraham L. Berlad 6/30/95
PhD, Chemical Physics
Adjunct Professor of Combustion Science

Alvin S. Gordon
PhD, Chemistry
Adjunct Professor of Engineering Chemistry

Paul A. Libby
PhD, Aeronautical Engineering
Professor Emeritus of Fluid Mechanics

Stanford S. Penner
PhD, Physical Chemistry
Professor Emeritus of Engineering Physics

Norbert Peters
PhD, Mechanical Engineering
Adjunct Professor of Mechanical Engineering

M. Simnad
PhD, Materials Science
Adjunct Professor of of Materials Science and Engineering,
Nuclear Engineering and Energy Technologies

Affiliate Faculty Members:

D.J. Benson
PhD, Mechanical Engineering
Associate Professor

J.C. Lasheras
PhD, Mechanical and Aerospace Engineering
Associate Professor of Fluid Mechanics

D.R. Miller
PhD, Chemical Engineering
Professor of Chemical Engineering

M. Meyers
PhD, Physical Metallurgy
Professor of Materials Science

V.F. Nesterenko
PhD, Physics
Associate Professor of Materials Science

K. Nomura
PhD, Mechanical Engineering
Assistant Professor of Mechanical Engineering

S. Sarkar
PhD, Mechanical Engineering
Associate Professor

B. Researchers

Jong Soo. Kim
PhD, Engineering Physics
Assistant Project Scientist
(until 6/3/96)

Shui-Chi Li
PhD, Mechanical and Aerospace Engineering
Assistant Research Scientist

Kurt O. Lund
PhD, Engineering Science
Assistant Research Scientist

C. Visiting Researchers and Scholars

CECR participants interact extensively abroad on energy and combustion issues. There is continuing joint research with investigators at Cambridge University in England, RWTH Aachen in Germany, Université de Provence in Marseilles, France, The University of Tokyo and Ishikawajima-Harima Heavy Industries in Tokyo, Japan and elsewhere. Renowned scientists from throughout the United States and abroad, specializing in energy and combustion research, regularly visit UCSD and participate in CECR programs through formal lectures, research activities and informal discussions. Visitors from the last year include:

VISITOR	AFFILIATION
Clemens Brinkheimer	RWTH Aachen, Aachen, Germany
Michel Champion	ENSMA, Poitiers, France
Paul Clavin	Universite Aix Marseilles, Marseilles, France
Ritsu Dobashi	The University of Tokyo, Tokyo, Japan
Adelbert Grudno	RWTH Aachen, Aachen, Germany
Osamu Habara	The University of Tokyo, Tokyo, Japan
Øyvind Hovde	Norwegian Institute of Technology, Trondheim, Norway
Hideaki Kobayashi	Tohoku University, Sendai, Japan
Amable Liñán	Ciudad Universitaria, Madrid, Spain
Akira Matsushita	Japanese Patent Office, Tokyo, Japan
Masato Mikami	Yamaguchi University, Yamaguchi, Japan
Norbert Peters	RWTH Aachen, Aachen, Germany
Jun'ichi Sato	Ishikawajima-Harima Heavy Industries, Tokyo, Japan
Juan Esteban Garcia Schafer	Universidad Politecnica de Madrid, Madrid, Spain
William A. Sirignano	University of California, Irvine
Mitch Smooke	Yale University, New Haven, CT
Chae Hoon Sohn	Seoul National University, Seoul, South Korea
Otto Sonju	Norwegian Institute of Technology, Trondheim, Norway
Akira Toda	The University of Tokyo, Tokyo, Japan
Tord Peter Ursin	Norwegian Institute of Technology, Trondheim, Norway

D. Seminars

CECR sponsors a general series of seminars and public lectures in its areas of activities. A listing of these seminars is given in the following tables.

Seminar Speaker	Date	Topic
William E. Anderson	July 11, 1995	"Combustion Instability Mechanisms in Liquid Rocket Engines"
Juan Estaban García Schäfer	August 18, 1995	"Stability of Longitudinal Oscillations in a Solid Propellant Rocket Motor"
Hideaki Kobayashi	August 21, 1995	"High-Pressure Turbulent Premixed Flames"
M.G. Velarde	August 22, 1995	"Droplet Motions: From Drag to Thrust"
Amable Liñán	August 23, 1995	"The Role of Fluid Dynamics in the Attachment of Diffusion Flames"
Paul Ronney	August 25, 1995	"Buoyancy Effect on Propagating Chemical Front"
Paul Clavin	August 25, 1995	"Dynamics of Planar Detonation Fronts"
Kozo Saito	November 17, 1996	"How are Buoyancy Controlled Laminar Pool Fires Anchored?"
Joseph Rom	January 9, 1996	"On the Acceleration of Projectiles in the in-tube Chemical Accelerators"
Antoni K. Oppenheim	February 1, 1996	"Inverse Problem in Combustion Revisited"
William Whitemore	February 27, 1996	"Review of Neutron Therapy of Brain Tumors and Skin Melanomas"
Ken Schultz	February 29, 1996	"Inertial Fusion"
Verena Moser	March 8, 1996	"Large Eddy Simulation of Premixed Turbulent Combustion Using a Capturing Tracking Hybrid Scheme"
Jim Riley	April 26, 1996	"Modeling Subgrid-scale Chemistry in Turbulent Reacting Flows"
William Sirinano	May 16, 1996	"Stability of Injected Liquids"
Valentino Tiangco	May 30, 1996	"Review of Biomass Energy Conversion Systems"
Katja Lindenberg	May 30, 1996	"Nonclassical Kinetics on Diffusion - Limited Reactions in Restricted Geometries"

CECR Special Seminar Series

CECR had special seminar series in the Winter of 1996 which featured invited speakers who are outstanding scientists in their fields. It focused on energy technologies, conservation, environmental impacts and policies.

Seminar Speaker	Date	Topic
Professor S.S. Penner Applied Mechanics and Engineering Sciences, UCSD	January 8, 1996	"Commercialization of Fuel-Cells"
Professor Massoud Simnad Applied Mechanics and Engineering Sciences, UCSD	January 16, 1996	"The Worldwide Status of Nuclear Energy and Nuclear Proliferation"
Dr. Thomas Schneider Executive Scientist Electric Power Research Institute	January 22, 1996	"Impact on the Utility Industry of the Changed Environment"
Professor William Nierenberg Director Emeritus, SIO, Cal Space Institute	January 29, 1996	"Global Climate Changes and Fossil Fuel Utilization"
Professor Kenneth Train Economics UC Berkeley	February 6, 1996	"Incentives for Appliance Efficiency in a Competitive Energy Industry"
Professor Anthony Sebald Electrical/Computer Engineering UCSD	February 12, 1996	"The Use of Intelligent Systems for Managing Energy Conservation"
Dr. Charles Baker International Thermonuclear Reactor Program (ITER)	February 20, 1996	"The Future of Fusion Energy"
Dr. K.R. Sridhar The University of Arizona	March 11, 1996	"Solid Oxide Electrolysis"

F. Contribution to Graduate or Undergraduate Teaching Programs

CECR personnel participated in teaching the following courses:

- 119A Thermodynamics Systems
Examination of entropy production and energy costs in power plant cycles; component and cycle efficiencies; economic costs and constrained optimization to minimize fuel costs for fixed power output.
- 119B Energy: Non-Nuclear Energy Technologies
Oil recovery from tar sands and oil shale. Coal production, gasification, liquefaction. The hydrogen economy. Energy storage systems. Techniques for direct energy conversion. Solar energy utilization. Energy from windmills. Tidal and wave energy utilization. Hydroelectric power generation. Hydrothermal energy. Geothermal energy from hot rocks. Electrical power production, transmission, and distribution.
- 119C Energy: Nuclear Energy Technologies
A brief survey of energy demands and resources. Available nuclear energy, physical background – thermal dynamics – atomic and nuclear physics; fission and fusion processes, physics of fission reactions – engineering aspects – safety and environmental effects, fusion, scaling laws, and start-up criteria – laser fusion, magnetic confinement – equilibrium instability.
- 211 Introduction to Combustion
Fundamental aspects of flows of reactive gases, with emphasis on processes of combustion, including the relevant thermodynamics, chemical kinetics, fluid mechanics, and transport processes. Topics may include deflagrations, detonation, diffusion flames, ignition, extinction, and propellant combustion.
- 213 Mechanics of Propulsion
Fluid mechanics, thermodynamics, and combustion processes involved in propulsion of aircraft and rockets by air-breathing engines, and solid and liquid propellant rocket engines; characteristics and matching engine components; diffusers, compressors, combustors, turbines, pumps, nozzles.

Graduate Students

NAME	ADVISOR	DATES
David Farley	R.J. Cattolica	1991 - 1996
John Hewson	F.A. Williams	1991 - present
Øyvind Hovde	F.A. Williams	1995 - present
Nenad Ilincic	K. Seshadri	1992 - 1995
Thomas Primosch	F.A. Williams	1995 - 1996
Ingrid Smedvig	F.A. Williams	1996 - present
Alexander Telengator	F.A. Williams	1995 - present
Dietmar Trees	K. Seshadri	1992 - 1996
Lenny Truett	K. Seshadri	1994 - present
Tord Ursin	F.A. Williams	1995 - 1996
Bai-Li Zhang	F.A. Williams	1992 - present

Post-Graduate Researchers

PGR	ADVISOR	DATES
Nenad Ilincic	F.A. Williams	1995 - 1996
Dietmar Trees	K. Seshadri	1996 - present

G. University-Industry Activities

Faculty and staff members associated with the UCSD Center for Energy and Combustion Research continue to be associated with various university-industry activities. In particular, there have been significant interactions with Solar Turbines and with BKM Inc. Joint seminars with Solar Turbines were held both at their San Diego facility and at UCSD. Many discussions of possible joint projects were pursued. Both experimental and computational joint research was pursued with BKM. In particular, spray measurements by PDPA were performed, and diesel-engine combustion computations with the KIVA code were pursued. These university-industry interactions are increasing.

3. ADMINISTRATION

A. Appointments

Director:	Forman A. Willaims
Associate Director:	Robert Cattolica
Associate Director:	K. Seshadri

B. Advisory Committee

Dr. Harold Agnew
Former Chief Executive Officer
General Atomics

Dr. Alan C. Kolb
Chairman and Chief Executive Officer
Maxwell Laboratories, Inc.

Dr. R.A. Figueroa
Program Manager
Research, Development and Demonstration
SDG&E

Mr. Dave Esbeck
Vice President, Engineering
Solar Turbines Inc.

Dr. Charles Baker
ITER Program
UCSD

Dr. S.S. Penner
Director Emeritus
CECR

4. FACILITIES AND SPACE

Unlike most ORU's, CECR has not been assigned independent space or facilities. Instead, CECR space comes entirely from AMES, and CECR is dependent on AMES for adequacy of its space. In AMES, space is assigned to individual professors, according to their needs, as justified by the sizes of their programs and the number of associates working with them.

A. Laboratories

The CECR laboratory space thus is, in fact, the laboratory space assigned by AMES to the CECR director and the two CECR associate directors. This space comprises B12, B14, B16 and B17 in Engineering Building Unit II and consists, in total, of 6000 sq. ft. This space currently is adequate for the existing CECR laboratory research activities. If one or more of the large umbrella proposals discussed later had been funded, then it would have been only marginally sufficient. However, unless such increased funding becomes a reality, the CECR laboratories should best remain restricted to their currently occupied space.

The CECR laboratory facilities include three gas-chromatographic systems for measurements of concentrations of stable chemical species, a laser-Doppler velocimeter for velocity measurements in reacting flows, an argon-ion laser system for measurement of particle sizes and number densities by Mie scattering, and a phase-Doppler particle analyzer for measurements of fuel sprays. Laser spectroscopic capabilities include Rayleigh, Raman, and fluorescence spectroscopy using pulsed lasers with advanced detection systems for both one-dimensional and two-dimensional imaging. In addition, there is a laminar coflow diffusion-flame apparatus and a number of counterflow combustion systems for measurement of diffusion-flame, premixed-flame, fuel-spray, and catalytic-combustion processes. Computer systems for computation of flame structures with full chemistry and for extraction of histories of droplet and flame diameters from video or photographic records are available. Droplet-trajectory and droplet-combustion facilities with photographic recording are in place, and a turbulent-jet flame apparatus is under construction, as is a solid-propellant combustion facility and a high-pressure combustion chamber.

B. Offices and Conference Rooms

Professors who are members of CECR have their own offices (Engineering Building Unit II, rooms 256, 555, 557, 558, 559 and 560) and offices for their graduate students, postdoctoral researchers and visitors (Engineering Building Unit II, rooms 561, 563, 564, 566, 570 and 571), all provided by the AMES department. The AMES space allotment to the CECR director is made on the same basis as the allotment to other faculty, without any special consideration of CECR. In Engineering Building Unit II, the CECR administrative office 554, the CECR secretary office and mail, FAX, copy and utility room, 565, all are taken from the CECR director's allotment, reducing his space for students and researchers and leading him to house them in his laboratory. Unlike the Fusion Energy Research Center, for example, no conference room or laboratory space has been assigned to CECR.

Office space was sufficient when CECR was housed in Urey Hall. Upon moving to Engineering Building Unit II, subject to the AMES space formula, CECR lost four offices and experienced uncomfortable overcrowding, which likely was one factor in the eventual resignation of Professor A.L. Berlad from his Adjunct Professorship and membership in CECR. An ORU of this type cannot function well without some special space assigned for administration, conference, library, etc.; most other ORU's have such space. Unfortunately, AMES does not have sufficient space to offer centers special space allotments. It would therefore be helpful if CECR could be assigned four offices, independent of AMES, without reducing AMES space. This would provide the Center with a base from which to carry on its operations.

5. FINANCIAL DATA

SUPPORT EXPENDITURES OF ENGINEERING EDUCATIONAL UNIT OR PROGRAM

Category	Fiscal Year 1995-1996	Energy & Combustion Research
FUNDS AWARDED		
Business/Industry	15,250	0
EBU2 Funds	972,188	0
Federal	0	0
Foreign	0	0
Other	47,330	0
Private	0	0
State	57,917	0
State/Research		
TOTAL FUNDS	1,092,685	
EXPENSES		
SALARIES		
Faculty	0	0
Research	246,771	0
Part-Time Asst*	0	0
Teaching Asst.	0	0
Grad Research Stud	58,651	0
Readers	0	0
Staff	31,474	0
General Asst.	48,744	0
Benefits	41,857	0
RATF	17,173	0
Supplies/Expense	119,336	0
Travel	63,586	0
Equipment	38,111	0
Stipend	0	0
Fees	0	0
Overhead	243,073	0
Assessment Fees	880	0
TOTAL EXPENSE	909,656	
Recharge Income	6,750	
95/96 INTEREST	340	
95/96 ACTIVITY	190,119	

1995/1996 ACADEMIC YEAR PERSONNEL AND STUDENTS

	Energy & Combustion Research			
	HEAD COUN		FTE	RATIO /FAC
	FT	PT		
Administrative	0	0	0.00	///////
Faculty (tenure)	3	0	3.00	///////
Faculty (non-tenure)	0	0	0.00	///////
*Other Faculty	0	4	1.90	///////
Student Teaching Assistants/Readers	0	11	1.00	0.20
Student Research Assistants/Fellow	1	6	3.98	0.81
Technicians/Specialists	0	5	0.50	0.10
Office/Clerical Employees	1	3	1.80	0.37
Others (Researchers, PGRS)	2	2	3.50	0.71
Managerial Employees	0	0	0.00	0.00
Undergraduate Students	28	0	0.00	5.71
Graduate Students	4	0	0.00	0.82

CENTER FOR ENERGY AND COMBUSTION RESEARCH 1995/1996 FISCAL YEAR REPORT
 FUNDS AWARDED / EXPENDITURES

PI	FUND	AGENCY/ACCT NAME	O'HEAD	ADM FEE	SALARIES		BENEFITS		SUPPLIES EXPENSE	TRAVEL	EQUIP	STIPEND		TOTAL EXPENSE	AWARDS	RECH INC	STIP INC	TOTAL FUNDS					
					ACAD	STAFF	G/A/S	BENE				RATF	FEES						STIP				
Libby	22419A	DOE DEF03-86ER13527	24,502	0	40,856	0	1,122	0	3,081	3,226	0	0	0	72,787	55,000	0	0	55,000					
Libby/Williams	22422A	DOE DEF03-87ER13685	36,882	0	44,056	0	8,543	0	12,086	3,599	415	0	0	110,334	137,639	0	0	137,639					
Lund	19900A	CalSpace #CS-33-95	0	0	9,505	0	1,073	0	75	0	0	0	0	16,159	16,159	0	0	16,159					
Lund	40555A	Advanced Silicon Mils	0	480	1,385	0	404	373	3,021	0	4,406	0	0	10,069	12,000	0	208	12,208					
Lund	66850A	Conferences/Exp	0	0	0	0	0	0	2,409	0	0	0	0	2,409	6,750	0	0	6,750					
Lund/Seshadri	53078A	PHI Appld Physed Sci	0	400	0	0	0	0	498	0	0	0	0	400	10,000	0	0	10,000					
Penner	22459A	DOE DEF03-93ER30213	129	0	0	0	0	0	795	0	0	0	0	627	0	0	0	0					
Penner	45139A	Energy Res Fdn	0	0	0	0	0	0	-139	795	0	0	0	656	0	0	0	0					
Penner	78605A	EG&G Idaho	2,469	0	8,947	0	262	0	2	0	0	0	0	11,680	0	0	0	0					
Seshadri	22581A	NIST 60NANB3D1435	1,970	0	753	0	58	0	1,009	818	0	0	0	5,870	0	0	0	0					
Seshadri	23010A	ARO DAAH1-95-1-0108	12,767	0	11,167	0	695	0	5,680	1,190	3,045	0	0	41,016	80,000	0	0	80,000					
Seshadri	23022A	ARO DAA103-90-G-0084	0	0	0	0	0	0	0	0	0	0	0	0	-0	0	0	0					
Williams	19900A	CECR General Funds	0	0	30,812	0	8,051	0	2,613	0	0	0	0	41,476	41,758	0	0	41,758					
Williams	21374A	NSF CTS 92-14888	9,070	0	11,301	0	798	0	2,436	559	0	0	0	27,211	0	0	0	0					
Williams	22523A	AFOSR F49620-93-1-0380	807	0	0	0	0	0	1,413	186	9,447	0	0	11,853	0	0	0	0					
Williams	22523B	AFOSR Fees	0	0	0	0	0	0	4,802	0	0	0	0	4,802	0	0	0	0					
Williams	22523B	AFOSR Stipends	0	0	0	0	0	0	16,200	0	0	0	0	16,200	0	0	0	0					
Williams	23244A	NASALeRC NAG 3-1081	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Williams	23291A	NASA NAG3-1248	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Williams	31000A	ONR N06014-94-1-0679	75,309	0	85,737	662	11,391	9,240	23,495	10,237	276	0	0	233,957	75,000	0	0	75,000					
Williams	31340A	NSF CTS 95-26410	8,091	0	0	0	77	0	7,774	2,080	3,101	0	0	27,058	265,000	0	0	265,000					
Williams	31802A	AFOSR F49620-94-1-0166	40,995	0	53,421	0	8,509	0	6,759	12,492	5,751	0	0	127,927	115,935	0	0	115,935					
Williams	31917A	NASA/Lew NAG 3-1689	6,150	0	8,746	0	288	0	132	0	276	0	0	18,605	40,000	0	0	40,000					
Williams	31920A	NASA NCC 3-407	24,114	0	26,848	0	532	7,560	7,904	10,868	11,394	0	0	90,366	90,000	0	0	90,000					
Williams	39426A	UC Presti dents Office	0	0	2,700	0	54	0	19,754	13,074	0	0	0	35,582	36,330	0	0	36,330					
Williams	43130A	Ishikawa Jima UC/Fdn	0	0	0	0	0	0	409	1,390	0	0	0	1,799	0	0	110	110					
Williams	47292A	GA Schol/Fnd #1365	0	0	0	0	0	0	1,360	0	0	0	0	1,360	0	0	22	22					
Williams	60826A	Student Design	0	0	0	0	0	0	0	0	0	0	0	0	11,000	0	0	11,000					
Williams/Li	26924A	UCLLNL B264086	0	0	0	0	0	0	0	0	0	0	0	0	-136	0	0	-136					
Williams/Libby	22508A	AFOSR F49620-92-1-0184	-182	0	0	0	0	0	-3,437	3,072	0	0	0	-547	0	0	0	0					
Williams/Libby/	31817A	AFOSR F49620-96-1-0106	0	0	0	0	0	0	0	0	0	0	0	0	107,000	0	0	107,000					
ENERGY & COMBUSTION RESEAR															11,092,685	6,750	340	1,099,775					
TOTAL															909,656	0	0	0	909,656	11,092,685	6,750	340	1,099,775

E. Publications of CECR Researchers

1. Members Publications List

Abraham L. Berlad

S.S. Penner and A.L. Berlad, "Fundamental Combustion Research in Support of Industrial Applications," *Energy – The International Journal*, Vol. 20, No. 4, pp. 311-324, (1995).

Robert J. Cattolica

D.R. Farley and R. J. Cattolica, "Electron-Beam Fluorescence Measurements of Density and Rotational Temperature in a Simulated Martian Atmosphere," *Rarefied Gas Dynamics*, Vol. II, p. 1425-1432, Oxford University Press, Oxford, 1995.

R. J. Cattolica, "Quenching Effects on Laser-Fluorescence Measurements of OH Rotational Temperature in H₂/O₂/Ar Flames," *Combustion Science and Technology*, Vol. 112, pp. 1-13, 1996.

David R. Farley and Robert J. Cattolica, "Electron-Beam Fluorescence from the $A^2\Pi_u - X^2\Pi_g$ and the $B^2\Sigma_u - X^2\Pi_g$ Transitions of CO₂⁺. *Journal of Quantitative Spectroscopy and Radiative Transfer*," Vol. 56, No. 1, pp. 83-96, 1996 .

David R. Farley and Robert. J. Cattolica, "Multipole Line Strengths for Linear Hund's Case (a) Molecules," *Journal of Quantitative Spectroscopy and Radiative Transfer*, Vol. 56, No. 5, pp. 753-760, 1996.

Alvin S. Gordon

S.C. Li, A.S. Gordon and F.A. Williams, "A Simplified Method for the Computation of Burke-Schumann Flames in Infinite Atmospheres," *Combust. Sci. Technol.* 104 (1995), 75-91. From Submitted. (Changed title from, "Effect of Carbon Hydrogen Ratio on Fuel Height").

John C. Hewson

J.C. Hewson and M. Bollig, Reduced Mechanisms for NO_x Emissions from Hydrocarbon Diffusion Flames, The Twenty-sixth Symposium (International) on Combustion, The Combustion Institute, 1996.

M. Bollig, H. Pitsch, J.C. Hewson, and K. Seshadri, Reduced n-Heptane Mechanism for Nonpremixed Combustion, The Twenty-sixth Symposium (International) on Combustion, The Combustion Institute, 1996.

J. C. Hewson, Reduced Mechanisms for Hydrocarbon and Nitrogen Chemistry in Diffusion Flames, CECR Report 95-01, 1995.

Jong Soo Kim

Kim, J. S., Williams, F. A. and Ronney, P. D., "Diffusional-Thermal Instability of Diffusion Flames," *Journal of Fluid Mechanics* 327, 273-301, (1996).

Kim, J. S., "Diffusional-Thermal Instability of Diffusion Flames in the Premixed-Flame Regime," *Combustion Science and Technology* 118, 27-48 (1996).

Kim, J. S. and Williams, F. A., "Acoustic-Instability Boundaries in Liquid-Propellant Rockets: Theoretical Explanation of Empirical Correlation," *Journal of Propulsion and Power* 12-3, 621-624 (1996).

Kim, J. S., "Effects of Turbulence on Linear Acoustic Instability: Spatial Inhomogeneity," *Liquid Rocket Engine Combustion Instability, Progress in Astronautics and Aeronautics Vol. 169* (Vigor Yang Ed.), AIAA, Washington D.C., pp. 431-454 (1995).

Sohn, C. H., Chung, S. H., Kim, J. S. and Williams, F. A., "Acoustic Response of Droplet Flames to Pressure Oscillations," *AIAA Journal* 34-9, 1847-1854 (1996).

Im, H. G., Law, C. K., Kim, J. S. and Williams, F. A., "Response of Counterflow Diffusion Flames to Oscillating Strain Rates," *Combustion and Flame* 100, 21-30 (1995).

Shui-Chi Li

S.C. Li and F.A. Williams, "Nitramine Deflagration: Reduced Chemical Mechanism for Primary Flame Facilitating Simplified Asymptotic Analysis", *Journal of Propulsion and Power* 12, 302-309 (1996).

Paul A. Libby

Maury, F.A. and Libby, P.A., "Nonpremixed flames in stagnating turbulence. Part I - The $k - \epsilon$ theory with equilibrium chemistry for methane-air system," *Combustion and Flame* Vol. 102, 341-356 (1995).

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