geometry. For example, some characteristics of these test rods are not typical of PWR rods. There are also indications that test conditions have led, e.g., to a relatively uniform azimuthal cladding temperature distribution, and hence the burst data are not typical of in-pile rod bundle behavior. Also, some FR-2 (German) and FLASH 01 (French) data were not consistent.

Finally, this session also featured papers that presented limited data for fission products, particularly volatiles, released when a fuel rod bursts upon exposure to a LOCA-type accident sequence. However, cladding and LOCA conditions as may occur in a power reactor were not well reproduced in these tests.

Session IV

A tentative discussion is given of the core damage at TMI-2 based on a postulated accident progression made by the Nuclear Safety Analysis Center as deduced from a limited amount of recorded data. This analysis suggests that: fuel rod failure began some 30 min after the start of core uncovery; a first core disruption occurred after the core quench resulting from the brief restart of a coolant pump; 40 to 70% of the entire core inventory of volatile fission products was released in <50 min; no reliable data exist on rate or timing of hydrogen production; a new core disruption was noted $\frac{1}{2}$ h after restart of high pressure injection; local temperatures remained below the melting point of UO_2, Zircaloy, and cladding fuel eutectic solutions.

To date the consequences of TMI-2 do not appear to have precipitated any plans for major modifications to current U.S. fuel design.

Session V

This session on fuel behavior models and codes included ten papers and dealt with the modeling of specific phenomena and with a description of integral codes. These include: RAPTA-1, SPARA, CARATE, COMETHE, TESOA, CANSWEL-2, and MABEL 2A. Two approaches are used: the deterministic model uses a single-rod model with corrections for bundle effects; the second employs statistical methods. Neither approach yet appears quite capable of modeling the whole core.

The code RAPTA-1 (Soviet Union) is designed to model LWR fuel element behavior for a wide range of transients, including fuel element behavior up to the point of cladding failure in a LOCA. The code considers two modes of cladding deformation—tensile stress induced ballooning and compressive stress induced collapse. Computations for transients (LOCA, PCM, etc.) in VVER- and RBMK-type reactors showed the fuel element response is strongly affected by the rod geometry, strength anisotropy, oxygen dissolution, and oxidation of the cladding. Cladding by Zr–1% Nb is found not to be superior to Zircaloys.

The SPARA code (Italy), which is calibrated against in-pile data on center fuel temperatures and fission gas release in the CIRENE elements and diametral plastic strains measured on internally pressurized cladding tubes, is used to analyze fuel element behavior in the CIRENE prototype reactor under LOCA conditions. The code can also treat degenerate accidents, such as channel blockage.

Experiments tend to confirm that, in general, LWR Zircaloy cladding failure is a strong function of the cladding azimuthal temperature and stress distributions. To treat these effects, the code CARATE (Germany) used azimuthal nodalization combined with locally applicable creep and burst models. However, although experiments suggest azimuthal cladding failure strain is a very strong function of the cladding azimuthal temperature distribution, this code shows failure strain is strongly dependent on both the temperature ramp and the azimuthal temperature distribution. Also, the strong influence of oxygen uptake on cladding deformation and burst are not explicitly modeled in the code. The code is targeted for modification in the near future to include axial nodalization, whereby axial extension and the form of ballooning defects can be studied. This should further enhance the current state of the art on the modeling of cladding failure in LWRs during LOCA, RIA, etc. conditions.

A review is given of modifications made to the COMETHE code since its presentation in 1976 at the Committee on the Safety of Nuclear Installations specialists' meeting in Spätind, Nord Torpa, Norway. This important and well benchmarked LWR code now allows for: grain growth, fission gas release models, tunneling effect, axial fuel/cladding interaction, variable fuel plasticity temperature, and Zircaloy cladding failure criteria. The extensive experience with this code is used to identify important characteristics of cladding, fuel pellet, fuel rods, and power history, as relevant to safety-related fuel behavior.

Finally, the CANSWEL-2 code is designed to model the effects of hot spots on the deformation of Zircaloy cladding as pertains to conditions in a PWR LOCA. It treats azimuthal nonuniformities in clad thickness and temperature and models rod interaction with nearest neighbors.

A. R. Wazzan, who received a BS in chemical engineering in 1959, an MS in aeronautical engineering in 1961, and a PhD in engineering science in 1963 from the University of California at Berkeley, has been a professor in the Department of Chemical, Nuclear, and Thermal Engineering at the University of California at Los Angeles (UCLA) since 1962. He is the author of many review and research articles on physics of fluids, physics of solids, modeling of fission gas behavior in irradiated oxide and carbide fuels, and most recently he is a coauthor with a team from Electricité de France of a series of articles in Nuclear Engineering and Design *on the thermal-hydraulic characteristics of pressurized water reactors during commercial operation. Since July 1, 1981, he has been an associate dean in the School of Engineering and Applied Science at UCLA.*

Radiation Chemistry of Hydrocarbons

Editor	G. Földiak
Publisher	Elsevier/North-Holland, Inc. (1982)
Pages	476
Price	$83.00
Reviewer	Joseph Silverman

The radiation chemistry of hydrocarbons has been the subject of hundreds of scientific articles, but until this year only two slim volumes have been published on this important subject: *Radiolysis of Hydrocarbons*, edited by A. V. Topchiev (1963) and *Aspects of Hydrocarbon Radiolysis*, edited by T. Gäumann and J. Hoigné (1968). Both remain useful sources of information and ideas, although they were incomplete even at the time of their publication.

The new book by Professor Földiak and his colleagues is comprehensive as well as up to date. It contains a fine introductory chapter on the fundamental physical and chemical effects following the deposition of energy from ionizing radiation and the experimental methods of measuring these effects. In the closing chapter, Földiak makes a penetrating analysis of the status of research in this field and of the industrial implications and applications. Between these two chapters are five others consisting of well-written, brief descriptions of a large body of experimental information, along with numerous tables, figures, and references. Qualitative explanations and correlations are offered at appropriate points, and there are some efforts to present unifying models, but the principal value of this book is to be found in its wealth of experimental information.

There are some minor flaws in this fine work. A reactor engineer might be disappointed to find only ten references to the radiation chemistry of the terphenyls. A polymer chemist should look elsewhere for detailed information on the chemical effect of ionizing radiation on polyolefins and polymerizable hydrocarbons. The section on the radiation chemistry of methane omits references to some of the most important electron spin resonance studies performed at 1.6 to 4 K. An author index would have been useful. In almost all other respects the book meets the worthy objectives of its Hungarian authors. They have produced a work of enduring value that belongs on the bookshelf of every radiation chemist.

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Proceedings of the 36th Industrial Waste Conference—Purdue University

Editor	John M. Bell
Publisher	Butterworth Publishers, Inc., Woburn, Massachusetts (1982)
Pages	997
Price	$69.95
Reviewer	Stephen G. Margolis

This is a collection of 95 papers in 20 categories. Other than a passing reference (in the keynote address) to the Three Mile Island radiation release, the question of nuclear waste management is not specifically mentioned in any of the 95 papers. Its principal value to nuclear engineers, then, is to give a background perspective on industrial wastes generally.

Primarily, the papers concern the treatment of wastes produced chronically by the process industries. These wastes are produced in large volumes by a mind-boggling variety of industries. The wastes considered include swine waste, poultry carcasses, heavy metals, the explosives TNT and RDX, paper mill effluents—in short, a panoply of biological, chemical, and physical pollutants that have in common *only* the *absence* of radioactivity.

One paper, "Emergency Response to a Major Agricultural Chemical Warehouse Fire," by Ryckman et al. (pp. 212-223) deals with the procedures used in an acute incident—a warehouse fire—which required evacuation of a downwind area and a major postfire cleanup effort ($500 000 and 250 000 gal of contaminated water). The paper concludes that the incident was resolved with no injuries, no lasting environmental impacts, and no litigation. This is in sharp contrast to the typical acute nuclear incident. In the chemical fire cited, the key ingredients for successful resolution of the incident appear to have been timely action by a state authority, a cleanup consultant, and an insurance company, all having unquestioned jurisdiction and all located within 50 miles of the incident site.

Can nuclear engineers learn anything from this collection of papers? It appears that the way to stay off the network news is to take action that is timely, local, and informed.

Stephen G. Margolis is a professor in the Department of Electrical and Computer Engineering at the State University of New York at Buffalo. His 13 years of industrial experience were with Westinghouse Bettis, ASEA-ATOM, and EG&G Idaho. He had 12 years of university teaching experience, is the author of numerous papers, and is a coauthor (with Roger Mayne) of Introduction to Engineering.

Radiochemistry, Hot Atoms, and Physical Chemistry
[Vol. II of the Collected Papers of Willard F. Libby (deceased)]

Editor	Leona Marshall Libby
Publisher	Geo Science Analytical and the University of California at Los Angeles (1982)
Pages	540
Price	$15.00
Reviewer	Jeffrey I. Steinfeld

The publications of the late W. F. Libby are being edited by his widow, Leona Marshall Libby, in a series of paperbound volumes. In this volume, his papers on radiochemistry and physical chemistry are collected. Included are brief reminiscences by W. G. McMillan and John A. McCone, 31 papers on hot-atom and radiation chemistry, 53 additional papers on a wide variety of topics in physical chemistry, and transcripts of 14 unpublished lectures.

A collection of this type cannot, of course, serve as a definitive scholarly presentation of any of the wide variety