BOARD OF WATER SUPPLY

CITY AND COUNTY OF HONOLULU
630 SOUTH BERETANIA STREET
HONOLULU, HI 96843

RECEIVED
SAFE DRINKING
WATER BRANCH
OCT 11 2012

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October 10, 2012

Ms. Joanna Seto, Chief
Safe Drinking Water Branch
Department of Health
State of Hawaii
919 Ala Moana Boulevard, Room 308
Honolulu, Hawaii 96814-4920

Dear Ms. Seto:

Subject: Urethane Grout Material Found in Board of Water Supply Reservoirs

On August 13, 2012, during routine chlorination of our reservoirs, Board of Water Supply (BWS) personnel discovered noticeable quantities of a cellophane, gel-like material floating on the water surface in our Aina Haina 395 Reservoir No. 2. Efforts to remove the material through the reservoir overflow line proved unsuccessful. In response, BWS secured the reservoir on August 15, 2012, and initiated an investigation into the origin and cause of the floating material.

The purpose of this letter is to notify you of this incident and discuss the findings of our investigation to date. The BWS also contracted Dr. Robert G. Tardiff, an expert in estimating health risks to chemicals in drinking water, to evaluate the health impact of the material in the water. A copy of his resume and his toxicologic safety evaluation are attached.

Aina Haina 395 Reservoir No. 2

The Aina Haina 395 Reservoir No. 2 is a 300,000 gallon concrete tank that serves all areas mauka of Halapepe Street, mauka of Paniolo Place and mauka of the intersection of Hao and Liwai Streets in upper Aina Haina Valley. The facility was repaired for cracks and leaks in the reservoir's concrete wall from June 28, 2012 to July 5, 2012. The project involved using a polymeric formulation (i.e. urethane grout) called De Neef Hydro Active Flex LV (Flex LV) and De Neef Hydro Active Flex SLV (Flex SLV) to seal the cracks. Both products contain the same active ingredient that when in contact with water, polymerizes into a foam urethane grout used specifically for sealing cracks in potable water storage and distribution structures. Both products are applied to cracks under pressure, are National Sanitation Foundation (NSF) Standard 61 approved, and, according to the product manufacturer, may be applied while the reservoir is in service.

Water for Life . . . Ka Wai Ola

Both Flex LV and SLV products are two-chemical component systems designed to form a urethane polymer upon contact with water. The active ingredient in both the Flex LV and SLV is a chemical called 4,4'-diphenylmethane diisocyanate (CAS No. 101-68-8). The polymer is formed by mixing appropriate amounts of 4,4'-diphenylmethane diisocyanate with dibutyl phthalate (CAS No. 84-74-2). The latter compound serves as a catalyst to accelerate the polymerization of the diisocyanate, a curing and hardening process that occurs within less than a half hour. The resulting urethane polymer is not water soluble, according to its manufacturer. The manufacturer also indicates that the Flex LV may be used with and without addition of the catalyst (dibutyl phthalate). The Material Safety Data Sheets (MSDS) for these chemicals are attached as background information.

The total amount of material floating in the reservoirs could not be estimated with certainty. However, the presence is visible to the eye. Based on work start date of June 28, 2012 and the August 15, 2012 reservoir shut down date, we believe the material could have been floating in the water for at least 45 days.

BWS records indicate that four other reservoirs were repaired using the same pressure application technique as Aina Haina. The reservoirs are:

1. Barbers Point 215 No. 3
2. Waialae Iki 1300
3. Moanalua 405 No. 2
4. Woodlawn 705

All of these tanks were secured as a precautionary measure and visually inspected for any crack sealant debris. Of these reservoirs, only Barbers Point 215 Reservoir No. 3 was found to have noticeable amounts of debris floating on the water surface. The debris looked like thin sheets of amber-colored cellophane. We found no evidence of any debris in Waialae Iki 1300, Moanalua 405 No. 2 and Woodlawn 705. All of these reservoirs will be cleaned, inspected and tested prior to placement back into service.

Barbers Point 215 Reservoir No. 3

Barbers Point 215 Reservoir No. 3 is a three million gallon concrete reservoir that serves the Leeward Coast from Ewa to Makaha. The tank is one of three reservoirs that sits on the Barbers Point 215 Reservoir site located on Old Farrington Highway about 0.5 mile mauka of the Kalaeloa Boulevard interchange. The facility was repaired for cracks and leaks from December 27, 2011 to January 23, 2012.

The BWS contacted the De Neef product manufacturer who believed that the floating material was most likely the polymerized diisocyanate. In the presence of water, the diisocyanate will polymerize, albeit slowly (approximately an hour without using the catalyst and in less than 30 minutes when the catalyst is used with the product).

Toxicological Assessment

At this point, the BWS sought outside guidance in determining whether the floating material might pose a health risk to consumers. The BWS retained the services of Dr. Robert G. Tardiff and provided him with the MSDS that we have attached for you. He agreed to assist the BWS with this matter.

Based on the information described above, Dr. Tardiff reached the following conclusions:

1. The exposures to the material in question would have been relatively brief (a few days to a few weeks). Thus, the initial concern should focus on the possibility of acute toxicity.

2. Three chemical contaminants were evaluated, the polymerized diisocyanate, the diisocyanate by itself and dibutyl phthalate.

   a. The polymerized diisocyanate is very inert and does not undergo changes in the human body. Consuming the polymer in tap water poses little to no risk of illness because the polymer molecule is too large to be absorbed from the stomach to other parts of the body.

   b. Based on the amount of diisocyanate used and large amount of water in the reservoir, very low concentrations of up to 10 µg/L or parts per billion (ppb) could have been in the water. The U.S. Environmental Protection Agency uses a metric called Margin of Exposure (MoE) to compare and assess the health effects of chemicals by exposure through inhalation, ingestion and skin contact. The MoE for 10 ppb of diisocyanate is 125,000 less than the Occupational Safety and Health Administration (OSHA) safe limit for this chemical in the workplace converted for ingestion. MoE values of 1,000 indicate no adverse health effects. This means 10 ppb of diisocyanate in water is 125,000 times safer than the safe limits allowed in the workplace.

   c. Based on the amount of dibutyl phthalate used and large amount of water in the reservoir, very low concentrations of up to 10 µg/L or ppb could have been in the water. The MoE for 10 ppb of dibutyl phthalate is 3,120,000 less than the OSHA safe limit for this chemical in the workplace converted for ingestion. This means 10 ppb of dibutyl phthalate in water is 3,120,000 times safer than the safe limits allowed in the workplace.

3. Finally, no evidence was found to indicate that exposure to these compounds has the ability to cause any risk of genetic toxicity, impacts to pregnancy or cancer.

In summary, Dr. Tardiff concluded that the amount of sealant material exposed to the water supply posed no significant threat to public health or to the safety of the water supply. Dr. Tardiff has expressed interest in sharing the bases for these findings, and BWS would be pleased to arrange a conference call to discuss his assessment with the Department of Health (DOH). He will also be in Honolulu on October 17 and 18, 2012 and will be available to meet with the DOH.

BWS Action in Response to Incident

In response to this incident, our policy now requires all water storage, pumping, and treatment facilities undergoing repair or renovation work be performed only when the facility is not in operation serving water to the distribution system, unless approved by the Manager and Chief Engineer.

BWS is serious about protecting public health and safety and will be reviewing its construction management policies and procedures to ensure this incident is not repeated.

Our investigation into this matter is continuing, and we will keep you abreast of our findings as they become available. If you have any questions, please call me at 748-5061.

Very truly yours,

ERNEST Y. W. LAU, P.E.
Manager and Chief Engineer

Attachments

CURRICULUM VITAE

ROBERT G. TARDIFF, Ph.D., Fellow A.T.S.

SUMMARY OF QUALIFICATIONS

Over thirty years of experience and leadership in the fields of strategic risk management, toxicological interpretations and research, in risk analysis / safety evaluation, regulatory affairs, and risk communication. Counsel to diverse clients including corporate executives of Fortune 500 companies, trade associations, state regulatory agencies, and attorneys. Extensive experience in program management.

Scientific Evaluations

Performs detailed examinations of health data (toxicological, epidemiological, and clinical) for numerous compounds present in air, drinking water, foods (as contaminants, natural substances, or additives), consumer products (including pesticides and inks), medical devices, the workplace, and waste products. Estimates the degree of risk or safety (including diverse forms of pathology to several target organs and developing organisms) to human health from known or anticipated exposures to chemicals under varying durations of exposure (from brief to lifetime). Engages in the characterization and modeling of human exposure (including internal dosimetry) to individual chemicals and mixtures under a wide range of circumstances, and aggregates all sources of exposure into a holistic understanding of effective doses. Examines toxicity and other data for the formulation of more than 1000 material safety data sheets (MSDS). Critically evaluates modes of toxic actions of several classes of compounds and demonstrates their application for regulatory decision making. Performs comparative risk assessments of chemical agents, complex sites such as manufacturing facilities, watersheds, chemical & waste treatment technologies, and hazardous waste disposal facilities. Evaluates the health significance of occupational exposures to chemicals.

Regulatory Affairs

Structures major science-policy studies (dealing with drinking water, food chemicals, and air pollutants) serving as bases for regulations. Structures scientific arguments to support regulatory decisions brought by private parties. Critically reviews agency criteria documents and health advisories to determine the strength of scientific evidence and interpretations that underlie regulatory policies. Advises private-sector clients on regulatory compliance under federal statutes including CAA, CERCLA, CWA, FD&CA, FHSA, FIFRA, FQPA, OSHA, SARA, SDWA, and SWA. Renders guidance on regulatory compliance with statutes and regulations of some states (*e.g.*, California's Proposition 65, California's Toxics Hot Spots Bill, school-purchase laws, & waste-disposal laws). Develops detailed scientific constructs for use in risk assessments (*e.g.*, severity of injuries, less-than-lifetime exposures, and mixtures). Advises on scientific & regulatory requirements for registration of pesticides in the United States and in Western Europe. Constructs flexible approaches to the regulation of drinking water contaminants. Reviews regulatory proposals for scientific integrity and policy implications. Determined the feasibility of a systematic process for the replacement of pesticidal inerts with less toxic substitutes. Estimates the relative health benefits from the proposed lowering of select occupational exposure limits and from the application of technologies to reduce toxic emissions from mobile and stationary sources. Advises corporate executives on elements of environmental and occupational health programs.

International Collaboration

Participates as an expert in international groups—the World Health Organization, the United Nations Environmental Program, the International Agency for Research on Cancer, Health Canada, and the Scientific Group on Methodologies for the Safety Evaluation of Chemicals—charged with developing consensus on the hazards and risks of environmental substances and with identifying means of disseminating such information to governmental agencies throughout the world.

Consulting

Provides scientific strategic risk management counsel to industry, trade associations, law firms, and federal and state agencies. Constructs strategies for comparing the risks of alternative products, compliance, research, and presentations of data. Reviewed and evaluated risk assessment activities of the leading federal health agency. Provides guidance on product registrations. Estimates health risks of contaminants in air, water, food, consumer products, and workplace. Provides guidance about regulatory proposals and compliance with regulations. Examines the scientific merits of litigations. Provides real-time evaluations to health and waterworks officials confronted with chemical spills in sources of potable water. Provides insights into risk communications to workers and the community and risk management to corporate executives. Evaluates the risks of proposed and existing waste control & minimization technologies such as incinerators and other waste treatment facilities leading to major reductions in the costs of construction, maintenance, and remediation. Oversaw corporate toxicology for large chemical corporation, including integration with industrial hygiene and occupational medicine. Provides risk communication planning and execution from script preparation to media involvement to counseling. Engages in litigation support such as causation analysis, exposure assessment, and expert testimony.

Management

Oversees and directs multi-disciplinary staffs of several professionals (at one time, oversaw over 200 volunteer committee members). Identifies problems, set priorities, and craft solutions. Fosters professional development through continuing education, on-the-job training, and encouragement to contribute to extramural professional activities. Recruits scientists at all levels. Develops and implements marketing plans, including the writing of proposals, leading to extensive business awards. Structured and implemented research plans. Managed certification programs providing evaluations of toxicological safety and regulatory compliance.

Academic and Tutorial Instruction

Prepared and delivers formal lectures on toxicology, risk assessment, and their central role in the resolution of health risk problems. Organizes conferences and workshops on scientific methods and their application to decision making. Tutors professionals throughout their careers on the appropriate use of science (toxicology, risk assessment, and related scientific areas) in decision making.

Research

Established and directed a laboratory research enterprise that pioneered toxicity testing of complex mixtures of organic compounds. Developed tools for risk characterization: One by which to assess health risk from exposures to toxicants; another to employ severity of toxic lesions in risk estimation and priority setting; another to amalgamate the risks of carcinogens and non-carcinogens in the same mixtures; and another to model the degree of hazard present in a facility that uses chemicals. Develops toxicity testing approaches and protocols, select laboratories, conduct quality assurance audits, and oversees performance of studies.

PROFESSIONAL EXPERIENCE

Principal and President, *Toxicological Consultative Services, LLC*	1987-present
Chairman and CEO, *The Sapphire Group. Inc.*	2010 - 2012
President and CEO, *The Sapphire Group, Inc.*	1997 - 2010
Sr. Vice President, Risk Sciences & Management Practice EA Engineering, Science, & Technology, Inc. (Silver Spring, MD)	1992 - 1996
Director, *RiskFocus*, Versar, Inc. (Springfield, VA)	1988 - 1992
Principal, Environ Corporation (Arlington, VA)	1984 - 1988
Director of Risk Assessment, Life Systems/ICAIR (Arlington, VA)	1983
Executive Director, Board on Toxicology and Environmental Health Hazards, National Academy of Sciences/National Research Council (Washington, DC)	1977 - 1983
Chief, Toxicological Assessment Branch, Office of Research and Development, U.S. Environmental Protection Agency (Cincinnati, OH)	1970 - 1977
Research Toxicologist, Water Supply and Sea Resources Program, Department of Health, Education, and Welfare (Cincinnati, OH)	1968 - 1970

EDUCATION

Ph.D., Pharmacology/Toxicology, University of Chicago, Chicago, Illinois, 1968 (Kenneth P. DuBois, graduate mentor)

A.B., Biology, Merrimack College, North Andover, Massachusetts, 1964

CME credit, Intensive Bioethics Course, Georgetown University, Washington, DC, 2010

Admitted unconditionally to **M.A.** Program in Bioethics and Health Policy at Loyola University of Chicago (IL), November 2010. Courses 2011: Principles of Health Care Ethics; Religion Bioethics; Clinical Bioethics; Bioethics & the Law; Organizational Ethics I: Business, Professionalism, & Justice [GPA ' 3.753].

CME: Emerging Frontiers in Biotechnology, Medicine, and Regulatory Science. Georgetown University. June 2011.

PROFESSIONAL CERTIFICATION

Fellow of the Academy of Toxicological Sciences, 1987-2012

AWARDS

U.S. Public Health Service Predoctoral Traineeship, 1964-1968

U.S. E.P.A. Scientific and Technological Achievement Award: Health Effects, 1981

Certificate of Appreciation and Recognition from Journal of Environmental Pathology and Toxicology in appreciation for significant contributions made to the advancement of knowledge in the field of pathology and toxicology as a member of the Editorial Board, 1990

Society for Risk Analysis Fellow, granted 1992 for lifetime

Certificate of Appreciation from USEPA Science Advisory Board for Service on Environmental Health Committee, 1989

Certificate of Appreciation for Outstanding Service from the U.S. National Academies, Board on Environmental Studies and Toxicology, 1999-2000

PROFESSIONAL AFFILIATION

Academy of Toxicological Sciences (co-founder; Board of Directors 1981-1986; Professional Standards Evaluation Board 1987-1988; Board of Directors 1990-1995; Secretary-Treasurer 1990–1993; President 1994–1995)

American Association for the Advancement of Sciences (1980-2009)

American College of Toxicology (Board of Directors, one term; Finance Committee, 1988-1990; Nominating Committee, 1988), 1980-1995

American Society for Pharmacology and Experimental Therapeutics, 1981-1992

American Water Works Association, 1999-2008

Council of Scientific Society Presidents, 1993-1997

Environmental Mutagen Society, 1980-1994

International Scientific Group on Methodologies for the Safety Evaluation of Chemicals (Executive Committee, 1987-1997)

International Society for Regulatory Toxicology & Pharmacology: Member; Board of Directors 2003-2010)

New York Academy of Sciences, 1971-1993

Sigma Xi, 1968-1988

Society for Risk Analysis: Member, co-founder; President-Elect 1993; President 1993-1994; Council 1980-1982, 1986-1988, 1995; Publications Committee 1989-1990; Chairman of Publications Committee 1995; Advisory Board 2002); Program Committee 2000-2005, 2009; Membership 2007-2009; Ad Hoc Committee on New Approaches to Regulatory Review, 2009

Society of Toxicology, 1972-present: Technical Committee (two terms); SOT Endowment Fund Board, 2009-2013.

EDITORIAL RESPONSIBILITIES

Archives of Environmental Health

Environmental Carcinogenesis Reviews (Journal of Environmental Science and Health)

International Journal of Toxicology, Editorial Board (1997-2007)

International Scientific Group on the Methodologies for the Safety Evaluation of Chemicals, Editor-in-Chief (1987 - 1995)

Journal of Environmental Pathology and Toxicology (1977-1984)

Journal of Applied Toxicology (1998-2007)

Journal of Health, Risk, & Society (1998-2007)

Journal of Food and Chemical Toxicology, Editorial Board (2007-2010)

Regulatory Toxicology and Pharmacology (2002-present)
Risk Analysis, An International Journal (1988-1991)
Toxicology and Environmental Health Series, Lewis Publishers
Referee, Critical Review of Toxicology (12(4), 982; Collection "Toxicology assessment of organic compounds in drinking water."

ACADEMIC ACTIVITIES

Judge, Georgetown University, McDonough School of Business, Business and Public Health Residency, Health Care Track, March 2011
Lecturer in "Toxicology and Risk Assessment," Department of Pharmacology, College of Medicine, Howard University, 2003-2006
Adjunct Associate Professor, Institute for Health Policy Analysis, Georgetown University Medical Center, 1983-1989
Adjunct Associate Professor of Toxicology, Medical College of Virginia, 1979-present
Distinguished Visiting Lecturer, University of Alabama Medical School, 1979-1982
Applied Toxicology. Graduate course at University of Cincinnati, Department of Environmental Health, Division of Toxicology, 1975-1977
Recognition, Evaluation and Control of Occupational Hazards (NIOSH Special Course 549), lecture: "Chemical Carcinogens"
Graduate Seminars on the Environment (University of Cincinnati/U.S. Environmental Protection Agency), lecture: "Hazards from Exposure to Toxic Chemicals in the Laboratory"
Eighth Annual Laboratory Animal Medicine Conference: Hazard Containment in Animal Facilities, University of Cincinnati, lecture: "Our Legal Responsibilities"
Industrial Hygiene and Toxicology Course, lecture: "Principles of Toxicology"
Bioassay Seminar, Environmental Protection Agency, lecture: "Cellular Bioassay Systems"
Workshop on Industrial Toxicology, Thomas Jefferson University, lecture: "Toxicological Problems with Water Supplies"
John Wiley Jones Symposium on Environmental Aspects of Cancer, Rochester Institute of Technology, 1979, lecture: "Chemical Carcinogens: Sources of Exposure and Assessment of Risks"

COMMITTEE ACTIVITIES

Society of Toxicology (invited), Endowment Fund Board, 2009-2013.
Society of Toxicology (invited), Inter-organizational Advisory Committee on Human Health and Disease, 2010-2011.
Society for Risk Analysis, Committee to Evaluate Draft Recommendations to OMB on New Approaches to Regulatory Analysis and Review, 2009.
ILSI Risk Assessment Methodologies Workshop on Approaches to Weight-of-Evidence Evaluation in Risk Assessment (invited), Baltimore, MD, December 2006.
National Academy of Sciences-National Research Council. Member of Subcommittee on Toxicological Risks to Deployed Military Personnel. 2002-2004. [*Review of Army's*

Technical Guides on Assessing and Managing Chemical hazards of Deployed Personnel, 2004].

Toxicology Excellence for Risk Assessment (TERA). Committee Member of Workshop on Risk Characterization of 66 mm Non-Lethal Grenade. May 21-23, 2002.

Toxicology Excellence for Risk Assessment (TERA). Committee Member of Workshop on Non-Lethal Weapons Risk Characterization. 2001-2002.

National Academy of Sciences-National Research Council. Member of the Subcommittee on Risk Assessment of Flame-Retardant Chemicals. 1999-2000.

International Life Sciences Institute Workshop on Research on Disinfection Byproducts. Moderated session on haloacetonitriles. October 1998.

Expert Working Group on the Health Risks of Drinking Water Chlorination By-Products. Health Canada, 1997. [C.J. Mills et al., Workshop Report. Health Risks of Drinking Water Chlorination By-Products: Report of an Expert Working Group. CDIC, vol. 19, no. 3, 1998.]

International Life Sciences Institute Workshop Organizing Committee on Potential Health Effects of Water Disinfection Byproducts: Current Research Findings, 1995.

National Advisory Board of the National Institute of Chemical Studies (Charleston, West Virginia), 1994-present.

EPA Expert Committee to Assist Environmental Criteria and Assessment Office (ECAO, Cincinnati, OH), 1990-1991.

EPA Drinking Water Subcommittee of the Science Advisory Board, Chair, 1986; Co-Chair, 1985-1989

EPA Environmental Health Committee of the Science Advisory Board, member, 1985-1989

NIH/DHHS Ad Hoc Technical Review for SBIR [Small Business Incentive Research] Grant Applications, member, 1986-1987

NAS/NRC Committee on the Evaluation of Cyclamate for Carcinogenicity, member, 1984-1985

United Nations Environmental Programs: International Register of Potentially Toxic Compounds (IRPTC), member of Scientific Committee, 1979-1983

NATO/CCMS Committee on Safe Drinking Water, member, 1977-1980

Committee on U.S. Manpower in Toxicology (administered by Yale University for NIEHS and the Society of Toxicology), member, 1979-1981

World Health Organization Panel on Haloforms in Drinking Water, member, 1979-1980

International Joint Commission for the Great Lakes Science Advisory Board, member, 1979-1981

DHEW Committee to Coordinate Environmental Research Program, liaison representative, 1977-1983

National Institute for Environmental Health Sciences Council, liaison representative, 1977-1983

NAS/NRC Committee on Toxicology, member, 1975-1977

NAS/NRC Committee to Review "Principles and Procedures for Evaluating the Toxicity of Household Substances," Chair, 1976

Technical Committee of the Society of Toxicology, member, 1974-1976; co-chairman, 1976-1977; Chairman, 1977-1978

Cancer Assessment Group of U.S. Environmental Protection Agency, staff toxicologist, 1976-1977

NAS/NRC Committee to Establish EPA Policy on Toxicity Testing of Environmental Chemicals and participant in Chronic Toxicity Panel, 1972

Panel on Agenda of NCI Interagency Collaborative Group on Carcinogenesis, member, 1975-1976

NCI Interagency Collaborative Committee on Carcinogenesis, liaison representative, 1975-1978

DHEW Ad Hoc Working Group on Asbestos Carcinogenesis Protocols (reporting to NIEHS), consultant, 1974-1975

NCI Sub-Task Group on Carcinogen Testing, member, 1974-1975

NCI Sub-Committee on Aquatic Carcinogens, consultant, 1974-1978

NAS/NRC Water Panel to Set Drinking Water Standards for Human Space Flight, member, 1972

EPA Sub-Committee on Toxicology for the Review of Federal Drinking Water Standards, co-chair, 1972-1974

EPA Committee for the Review of Federal Drinking Water Standards, member, 1970-1974

U.S. Army Medical R&D Command Program on Toxicological Research and Evaluations, consultant, 1971-1977

Council on Laboratory Animal Management for the National Environmental Research Center of EPA in Cincinnati, Chairman, 1971-1975

Committee on Hazardous Materials of EPA's Environmental Research Center (Cincinnati), chair, 1976-1977

Council of American College of Toxicology, member, 1981; secretary, 1983-1984

Organizing Committee for Society for Risk Analysis, member, 1980-1981

CDC External Peer Review of Exposure Data from the Love Canal, member, 1981

EPA External Peer Review Committee on Risk Assessment Methodology, member, 1979-1982

New York Health Department Expert Panel on the Evaluation of Health Risks at the Binghamton State Office Building, member, 1980-1981

EPA Task Force on Assessment Risks to Human Reproduction and Development of the Human Conceptus from Exposure to Environmental Substances, member, 1980-1981

CONFERENCE PARTICIPATION

Participation in Society for Risk Analysis Symposium "Emerging Risks of Synthetic Biology." George Washington University, Washington, DC, February 2012.

Presentation (co-author: M. L. Carson) of paper "Estimation of Safe Levels in Drinking Water for Perfluorooctanoic Acid (PFOA) Using State of the Art Approaches" at European Society for Risk Assessment as part of Conference on Risk, Governance, and Accountability, London, England, June 2010.

Chair (invited) of Risk Assessment Session of European Society for Risk Assessment as part of Conference on Risk, Governance, and Accountability, London, England, June 2010.

Participation (invited) in TERA Workshop: Beyond Science and Decisions, March 2010, including preparation and presentation of case study proposal for future development. Chair (invited) of Work-Group on Non-linear Dose-response for Mutagenic Carcinogens, 2010-2011.

Presentation of paper: "Weight of Evidence (WoE) Approach for Safe Levels of Exposure to Perfluorooctanoic Acid (PFOA) Risk in Drinking Water." Toxicology Forum, Aspen, Colorado, July 2009.

Presentation of paper: "Internal Dosimetry Model for Safe Levels of Acrylamide in Humans." Toxicology Forum, Aspen, Colorado, July 2009.

Presentation (co-authors: B Silverstein and C. Kirman) of paper: Retrospective Assessment of Worker Exposure to NTA. American Industrial Hygiene Conference and Exposition, June 2009.

Co-Chair of "Assessing Dose-Response and Risk for Controversial Chemicals" Session at the annual meeting of the Society for Risk Analysis, Boston, December 2008.

Presentation of paper: "Retrospective Assessment of Workers Exposure to NTA" at meeting of American Industrial Hygiene Association, Toronto, Canada, May 2009.

Presentation (invited) of paper: "Chlorination byproducts: What are the health risks?" At a symposium on Disinfection Byproducts during the World Aquatic Conference, Cincinnati, Ohio, October 3, 2007.

Co-Chair of "Low-Dose Extrapolation" Session at the annual meeting of the Society for Risk Analysis. December 2007.

Chair of Session "Acrylamide in food: The Roles of Laboratory Rodents, The Press, and Warning Labels in Risk Analysis" at the Annual meeting of the Society for Risk Analysis. December 2005.

Chair of Session "Mode of Action and Life-Stage": at the Annual meeting of the Society for Risk Analysis. December 2005.

Presentation of paper "Identification of key decision points in dose-response assessment for 2,3,7,8-TCDD under USEPA's final guidelines for carcinogen risk assessment" (Co-author ' C.R. Kirman) at annual meeting of the Society for Risk Analysis, Orlando, FL, 5-7 December 2005.

Presentation of paper "Adaptation and application of a physiologically-based-pharmacokinetic model for naphthalene to chronic human health risk assessment" (Co-authors: L.M. Sweeney, C.R. Kirman, T.F. Long) at annual meeting of the Society for Risk Analysis, Palm Spring, CA, December 6-8, 2004.

Presentation on the weight-of-evidence for non-linearity of the cancer dose-response curve for dioxins in humans. Presented to the NAS/NRC Committee to Review EPA's Assessment of the Health Implications of Exposure to Dioxin (on behalf of the Chlorine Chemistry Council), Washington, DC, 22 November 2004.

Presentation of poster "Probabilistic cancer risk assessment of workers exposed to creosote during pressure treatment of wood" (Co-authors, T.F. Long. C.R. Kirman, and J.H. Butala) at annual meeting of the Society of Toxicology, Baltimore, MD, March 2004 [The Toxicologist, abstract 750].

Participation (invited): TechTrends Global Gateway for Science and Technology Conference. Presented "Chemical Risks: A Vital Part of the Foundation for Homeland Security." Wilmington, DE, 22-24 April 2003.

Participation (invited): "Applying Biomarkers to Occupational Health Practice." Presented "Biomarkers and Risk Management" and chaired Risk Management session. Sponsored by NIOSH/NORA, Santa Fe, NM, 28-29 March 2003.

Participation (invited; co-author L. Wikstrom) Risk and Safety Associated with a Reentry Chlorine Concentration of 10 mg/L. Sponsored by the National Spa and Pool Institute, Dallas, TX, Oct. 30 - Nov. 1, 2002.

Presentation (co-authors R.P. Hubner and C.G. Graves) "Estimation of health risks to swimmers from exposures to chloroform and chlorine in chlorinated swimming pools." Poster at Annual Meeting of International Society of Exposure Analysis, Charleston, South Carolina, 2001.

Participation (invited) in Risk and Governance: An International Symposium. Sponsored by the Society for Risk Analysis, Warrenton, VA, 21-25 June 2000.

Participation (invited) in MTBE Route to Route Extrapolation Issues Specialty Workshop: Status of MTBE Research in Relation to the Adequacy of the PBPK Models. Sponsored by USEPA, Research Triangle Park, NC, 24 May 2000.

Presentation (invited) "Balancing Risk, Benefits, Tradeoffs" at Symposium: Comparative Risk: Balancing Risk and Benefits of Fish Intake. Annual Meeting of the Society for Risk Analysis, Atlanta, Georgia, 6-8 December 1999.

Presentation (invited) "Review of Board of Water Supply Data, Assessment of Drinking Water Quality in Village Park and Royal Kunia (Oahu, Hawaii)" at meeting of the Hawaii Department of Health and Honolulu Board of Water Supply, Oahu, Hawaii, 20 October 1999.

Participation (invited) as peer-reviewer on arsenic and barium hazard evaluations and risk estimations. Sponsored by Toxicology Excellence in Risk Assessment, Cincinnati, OH, 14-15 June 1999.

Presentation (invited) "Carcinogenicity and dose-response relationship of methyl-tertiary-butyl ether (MTBE)" at the US Environmental Protection Agency Conference on Drinking Water and Health, Sarasota, FL, 26-27 February 1999.

Participation (invited) as peer-reviewer on acrolein, acrylamide, and acrylonitrile hazard evaluations and risk estimations for Health Canada. Sponsored by Toxicology Excellence in Risk Assessment, Cincinnati, Ohio, Nov. 16-17, 1998.

Presentation (invited) "M*t*BE health data review and estimate of safe drinking water levels" at 14th Annual Conference on Contaminated Soils, Amherst, MA, October 22, 1998.

Presentation (invited) "Developing a Prevention and Emergency Response Program" as part of the American Petroleum Institute's Conference "Managing Risk at the Speed of Light: Crisis Management, Emergency Response, and Communication". Dallas, TX, 6 October 1998.

Participation (invited) in the peer-review of the Toxicological Profile of Toluene for the Agency for Toxic Substances and Disease Registry, Atlanta, GA, July 1998.

Presentation (invited) "MtBE health benefits outweigh health risks" at the Southwest Focused Ground Water Conference of the national Ground Water Association, Anaheim, CA, June 3-4, 1998.

Presentation (invited) "An overview of the relationship between toxicology and epidemiology in risk assessment" in IBC's Environmental Health Forum on Characterizing Human Risk, Washington, D.C., 14 - 15 May 1998.

Participation (invited) as panelist at UCLA Workshop on MTBE. February 28, 1998.

Presentation (invited) "Risk-Based Decision-Making as part of Environmental Risk Management in the Private Sector in the Ideas Conference of Pennsylvania's 21st Century Environment Commission. Harrisburg, PA, February 4-5, 1998.

Presentation (invited) "Toxicology and risk analysis: Antagonism or symbiosis or synergy?" at the annual meeting of the Society for Risk Analysis, Washington, D.C., 10 December 1997.

Presentation (invited) "Analysis of the ETS Exposure Monitoring Study: Distribution of Exposures to Selected ETS Chemicals among Workers" at the Society for Risk Analysis 10th Annual Symposium Health Risk Assessment: Current Issues, Monterey, CA, October 8, 1997.

Presentation (invited) "Chronic Health Risks of MTBE in Water" at the OFA/WSPA/AMI Workshop on MTBE in Groundwater, Los Angeles, CA, June 1997.

Presentation (invited) "EPA's Proposed Cancer Risk Assessment Guidelines: Chloroform as a Case Study" at the TAPPI International Environmental Conference & Exhibit, Minneapolis, MN, 6 May 1997.

Presentation (invited; co-authors: F.O. Hoffman and S. Kaplan) Beyond the Domain of Direct Observation: How to Specify a Probability Distribution that Represents the "State of Knowledge" about Uncertain Inputs. Second Workshop on "When and How Can You Specify a Probability Distribution If you Don't Know Much?" Sponsored by the University of Virginia, Charlottesville, VA, 12-140March 1997.

Chair of Session "Topics in Risk Analysis" at the 31st Annual Symposium of the Washington Operations Research/Management Science Council (WORMSC), Arlington, VA, 18 November 1996.

Presentation (invited) of paper "Water Disinfection: Microbial vs. Chemical Risks" at The Second Annual Cummings Colloquium on Environmental Law, entitled *Risk in the Republic: Comparative Risk Analysis and Public Policy*, sponsored by Duke University Law School and the Research Triangle Chapter of the Society for Risk Analysis, 15-16 November 1996.

Presentation (invited) of paper "Health Benefits of Oxygenates in Fuels" to the Committé des Applications des Académies des Sciences de la France, Paris, 2 October 1996.

Presentation of paper (R.G. Tardiff, S.R. Baker, J.S. LaKind, and E.J. Burger) "Comparing the Health Risks and Benefits of Methyl-tertiary-Butyl Ether (MTBE) in Reformulated Gasoline (RFG) and Winter Oxyfuels in the U.S." at the Annual Meeting of the European Society for Risk Analysis, University of Surrey, England, June 1996.

Presentation (E.A., McKenna, J.S. LaKind, D.F. Bodishbaugh, R.P. Hubner, A.H. Kim, D.F. Ludwig, B.S. Suedel, and R.G. Tardiff) of paper "Comparing Ethylene Glycol (EG) and Propylene Glycol (PG) Using Toxicity as a Basis for Risk Management Decisions" at the Annual Meeting of the European Society for Risk Analysis, University of Surrey, England, June 1996.

Participation in Panel on "MTBE: Risks in a Regulatory Context" at the Toxicology Forum, Washington, DC, 20 February 1996.

Presentation (M. Raybourn, A. Kim, U. Vedagiri, co-authors) of paper "Use of Risk-Based Screening to Rank Sites for USAF 15th ABW Installation Restoration Program" at the Second World Congress of the Society of Environmental Toxicology and Chemistry, Vancouver, B.C., Canada, November 5-9, 1995.

Presentation of Paper "Predictive Toxicology, Mixtures, and Risk Assessment Approaches" at the ILSI Workshop *Disinfection Byproducts in Drinking Water: Critical Issues in Health Effects Research* Chapel Hill, North Carolina, October 23-25, 1995.

Participation in Panel "Priorities for Research" at the ILSI Workshop *Disinfection Byproducts in Drinking Water: Critical Issues in Health Effects Research* Chapel Hill, North Carolina, October 23-25, 1995.

Presentation (L.G. Williams, E. Fendick, J. LaKind, B. Stern, J.A. Strand, co-authors) of paper "Risk-Based Site-Specific Water Quality Criteria for Treated Mine-Tailings Effluent" at the Second World Congress of the Society of Environmental Toxicology and Chemistry, Vancouver, B.C., Canada, November 5-9, 1995.

Chair (M. Dourson, co-chair) of symposium "Role of Toxicology in Tomorrow's Risk Assessment Practices" at the Seventh International Congress of Toxicology, Seattle, Washington, July 2-6, 1995.

Presentation (S.R. Baker, M.S. Gray, B.R. Stern, co-authors) of poster "Comparing and Balancing of Human Health Risks for Infectious Agents and Disinfection Byproducts in Tap Water" at the Annual Meeting of the American Water Works Association, Anaheim, California, June 19-22, 1995.

Presentation (M.L. Kunkle. I. MacFarlane, & R. Newman, co-authors) of paper "Data Collection for Ambient Air Exposure at a Former Manufactured Gas Plant" at the Annual Meeting of the Society for Risk Analysis, Baltimore, Maryland, December 5-7, 1994.

Presentation (invited) of paper "Protecting Human Health: Keeping Science in Risk Assessment and Balance in Risk-Based Regulations" at the 1994 Conference of the American Society of Civil Engineers entitled *National Water Resources Regulation - Where is the Pendulum Now?*, Washington, DC, January 31, 1994.

Presentation (invited) of paper "FDA's Latest Estimations of Cancer Risks from Aflatoxins in Processed Foods: What Significance?" at the Annual Convention of the Peanut Butter and Nut Processors Association, Tucson, AZ, January 17, 1994.

Presentation (B.Goldstein, E. Dickason, and L. Morrisey, co-authors) of paper "Communications of risk due to community and workplace petroleum exposure" at the International Conference of the Royal College of Physicians on Volatile Organic Compounds, London, England, September 27-28, 1993.

Presentation (S.R. Baker, and T.B. Piccin, co-authors) of paper "The Valdez Air Health Study - Proven Approach to Community Risk Assessment of Toxic Air Emissions" at the Annual Meeting of the Air and Waste Management Association, Denver, CO, June 16, 1993.

Presentation (G.F. Hoffnagle and B.D. Goldstein, co-authors) of paper "Design of the 'Valdez Air Health Study'" at Annual Meeting of the Society for Risk Analysis, San Diego, CA, December 10-12, 1992.

Presentation (S.R. Baker and T.B. Piccin, co-authors) of paper "The Influence of Human Activities on Estimates of Human Doses" at Annual Meeting of the Society for Risk Analysis, San Diego, CA, December 10-12, 1992.

Presentation (B.D. Goldstein and S.R. Baker, co-authors) of paper "Estimations of Human Health Risks from VOCs in Valdez" at Annual Meeting of the Society for Risk Analysis, San Diego, CA, December 10-12, 1992.

Presentation (M.A. Silkowski and J.H. Driver, co-authors) of paper "Methods to Assess Potential Consumer Exposures to Chemical Mixtures: A Case Study" at the Annual Meeting of the Society for Risk Analysis, San Diego, CA, December 10-12, 1992.

Presentation of invited paper "Chlorine Dioxide in Drinking Water: A Current Perspective" at CMA, AWWARF, & EPA 2nd International Symposium Chlorine Dioxide: Drinking Water Issues, Houston, Texas, May 7-8, 1992.

Presentation of invited paper "Risk Assessment: Benzene as an Illustration" at 7th Annual Course *New Directions in Risk Assessment* presented by the International Society for Risk Analysis, Arlington, VA, April 13-14, 1991.

Testimony before the Consumer Products Safety Commission on "CPSC's Proposed Guidelines for Determining Chronic Toxicity Issued under the Labeling of Hazardous Art Materials Act (LHAMA), Bethesda, MD, October 17, 1991.

Presentation (B.G. Goldstein, G.F. Hoffnagle, S.R.Baker, co-authors) of paper "Measurement of Exposure to Benzene and Other Volatile Petroleum Constituents of Community Residents of Valdez, Alaska" at the 1st Annual Meeting of the International Society of Exposure Analysis, Atlanta, GA, November 18-22, 1991.

Presentation (J.H. Driver, M.E. Ginevan, S.R. Baker, and R.L. Mikkelsen, co-authors) of paper "The Valdez Air Health Study - Integrated Monitoring, Modeling, and Human Activity Pattern Analyses to Assess Health Risks" at the 84th annual meeting of the Air and Waste Management Association, Vancouver, B.C., Canada, June 16-21, 1991.

Presentation (Whitmyre, G.K., M.E. Ginevan, J.H. Driver, R.G. Tardiff, and S.R. Baker) of paper "Analysis of the Impact of Exposure Assumptions on Risk Assessment" at the 84th Annual Meeting & Exhibition of the Air & Waste Management Association, Vancouver, BC, June 16-21, 1991.

Presentation (J.H. Driver, M.E. Ginevan, S.R. Baker, and R.L. Mikkelson, co-authors) of paper "The Valdez Air Health Study—Integrated Monitoring, Modeling, and Human Activity Pattern Analysis to Assess Health Risks" at 84th Annual Meeting & Exhibition of Air & Waste Management Association, Vancouver, B.C., Canada, June 16-21, 1991.

Presentation of invited paper "Risk Assessment and the 1990 Amendments to the Clean Air Act—A Scientist's Perspective" at the Environmental Law Seminar of Holland & Hart, Denver, CO, December 11, 1990.

Presentation of invited paper "Setting International Health Standards for the Environment including the Workplace" at the Fifth Professional Conference on Industrial Hygiene, Vancouver, BC, Canada, 23-26 October 1990.

Presentation of paper "Risk Assessment in the Practice of Industrial Hygiene" at the Professional Development Course on "Fundamentals of Risk Assessment for the Workplace Environment" at the Fifth Professional Conference on Industrial Hygiene, Vancouver, BC, Canada, October 23-26, 1990.

Organization of Professional Development Course on "Fundamentals of Risk Assessment for the Workplace Environment" at the Fifth Professional Conference on Industrial Hygiene, Vancouver, BC, Canada, October 23-26, 1990.

Presentation (S.R. Baker, G.K. Whitmyre, and M.E. Ginevan, co-authors) of invited paper "Analysis of the Impact of Exposure Assumptions on Risk Assessment and Risk Management," Annual Meeting of the Society for Risk Analysis, New Orleans, Louisiana, October 8-10, 1990.

Presentation (M.E. Ginevan, co-author) of paper "Risk Assessment for Groundwater Contaminants: Reducing Uncertainty with Improved Analytic Techniques," Edison Electric Institute, Washington, D.C., July 19, 1990.

Participation in Workshop on Methods for the Estimation of Cross-Species Differences in DNA Damage and Repair in the Context of Pharmacokinetic Mechanisms, SGOMSEC Workshop No. 8, Research Triangle Park, North Carolina, March 19-23, 1990.

Presentation ©. Cubbison, C. DeRosa, P.Y. Lu, C. Bast, and S. Brown, co-authors) of paper "Estimation of Chronic No-Effect Levels by Analogy to Acute Toxicity," Annual Meeting of the Society of Toxicology, Miami Beach, Florida, February 12-16, 1990.

Testimony (S.R. Baker, co-author) before the U.S. Environmental Protection Agency concerning evaluation of the carcinogenicity of styrene in regard to EPA's proposed regulation of styrene under the Safe Drinking Water Act, July 13, 1989.

Presentation of invited lecture "Risk Assessment and Policy Development for Regulation of Toxic Substances," Department of Biomedical Sciences, The Virginia-Maryland Regional College of Veterinary Medicine, Blacksburg, Virginia, 9 November 1989.

Presentation of invited paper "Assessment of Risks from Chemical Carcinogens: Can the Approach Be Radically Different from That for Ionizing Radiation?" Session on Risk Analysis of Toxic Materials: Radiation and Chemicals, Annual Meeting of the Society for Risk Analysis, San Francisco, California, October 29-November 1, 1989.

Presentation of invited paper "Community Risk Assessment," Environmental Compliance Conference/Exposition, Chicago, Illinois, April 19, 1989.

Presentation (S.H. Youngren, co-author) of paper "Reducing Uncertainty in Risk Assessment: Exposure Assessment," Annual Meeting of the Society for Risk Analysis, Washington, D.C., October 30 - November 2, 1988.

Presentation of invited paper "Health Risk Assessments," 1988 Washington Conference on Risk Assessment, Center for Energy and Environmental Management, Washington, D.C., September 22-23, 1988.

Presentation of invited paper "Impact of Right-to-Know Legislation on Tort Liability," Meeting of Cleveland Chapter, Federal Bar Association, Cleveland, Ohio, 4 May 1988.

Presentation ®. Scofield, R. Powell, M. Conklin, R. Machado, S. Youngren, E. Fechner, and M. Gough, co-authors) of paper "Multipathway Risk Assessment Methodology Compatible with California Decision Tree and US EPA Superfund Guidelines," Fifth National RCRA/Superfund Conference & Exhibition on Hazardous Wastes & Hazardous Materials, Las Vegas, Nevada, April 19-21, 1988.

Project Director, Session Chair, Workshop on Male Reproductive Toxicity, Georgetown University Institute for Health Policy Analysis, Washington, D.C., January 1988.

Rapporteur, Panel on Determination of Carcinogenic Potency, Conference on Regulation of Pesticides, Washington, D.C., 1987.

Presentation (J.V. Rodricks, co-author) of invited paper "Use of Risk Information in Environmental Standard Setting," Meeting of the Air Pollution Control Association, Washington, D.C., October 27, 1987.

Presentation of invited paper "Candidate and Substance Selections: California, NTP, and IARC," Joint Meeting of the Cosmetics, Toiletries, and Fragrances Association and the Proprietary Association on California's Proposition 65, Washington, D.C., September 1987.

Presentation of invited paper "In Vitro Methods of Toxicity Evaluation: Implications for Assessing Risks and Safety to Human Health," International Scientific Congress on Alternative Methods to the Use of Animals in Experiments, Versailles, France, May 1987.

Presentation of paper “Reducing Risks in the Insurance Industry” at Symposium IV. “Applied Risk Assessment and Management” during the Seventh Annual Meeting of the American College of Toxicology, 18 November 1986.

Project Director, Workshop on Immunotoxicology, Georgetown University Institute for Health Policy Analysis, Washington, D.C., 1986.

Presentation R. Harris, co-author) of invited paper "Risk Assessment," American Water Works Association National Drinking Water Issue Convocation, Annapolis, Maryland, June 1986.

Presentation of invited paper "Assessment of Health Risks of Hazardous Wastes: Approaches and Selected Examples," Conference on Environmental and Health Risk Assessment, Alexandria, Virginia, 28-29 October 1985.

Presentation (invited) “Relating Risk Assessment to Risk Management” at Chemical Information Program for Hawaii State Legislators, Honolulu, Hawaii, 5 December 1984.

Participation in panel "What are the Trade-Offs for a Safer Environment?" 1984 National Issues Forum on Difficult Choices about Environmental Protection, Birmingham, Alabama, 25 October 1984.

Participation in Workshop on Methods for Assessing the Effects of Mixtures of Chemicals, SGOMSEC Workshop No. 3, University of Surrey, England, 15-19 August 1983.

Presentation of invited paper “Application of Toxicological Data to the Assessment of Risk to Human Health” at the International Conference on Ground Water Contamination with Organo-Chlorine Compounds of Industrial Origin, Milan, Italy, 16-29 January 1983.

Organizing Committee Member, Rapporteur, Workshop on Toxicity Assessment on Mixtures of Chemicals, 1983.

Participation (organizer, rapporteur) in Workshop on Quantitative Estimation of Risk to Human Health from Chemicals, SGOMSEC Workshop No. 2, Rome, Italy, June 12-16, 1982.

Session Chairman, International Conference on Safety Evaluation and Regulation of Chemicals, 1982.

Symposium Co-Chairman, American Chemical Society Symposium on Assessing Health Risks from Chemicals, Washington, DC, 1982.

Moderator, Scientific Panel on Cause-Effect Relationships in Health Risk Cases, Symposium on Law, Science, and Technology in Health Risk Regulation II, 1981.

Organizing Committee Member, International Workshop on the Analysis of Actual vs. Perceived Risks, Society for Risk Analysis, Washington, DC, 1981.

Panelist, National Library of Medicine Symposium on Information Transfer in Toxicology, Bethesda, Maryland, 1981.

Panelist, American Academy of Environmental Engineers Seminar on Development and Assessment of Environmental Quality Standards, 1981.

Organizing Committee Member, Rapporteur, Reproductive Toxicity Workshop of Scientific Group on Methodologies for the Safety Evaluation of Chemicals, 1981.

Organizing Committee Member, Oak Ridge National Laboratory Symposium on Health Risk Analysis, 1980.

Presentation of a paper "A U.S. National Overview on the Policy of Toxic Substances" to the Satellite Session of the Thames/Potomac Seminars *Water Quality: Non-Point Pollution and Toxic Concerns*, Washington, DC, 19 April 1978.

Presentation (V.F. Simmon, L. Hedden, D. Poole, co-authors) of paper "Mutagenic Assay with *bis*-(2-Chloroisopropyl) Ether" at Second International Conference on Environmental Mutagens, Edinburgh, Scotland, July, 1977.

Presentation (V.F. Simmon, and L. Hedden, co-authors) of paper "Mutagenic Assays with bis (2 Chloroisopropyl) Ether" at Second International Conference on Environmental Mutagenesis, Edinburgh, Scotland, July, 1977.

Presentation (P.M. Gallagher, S.W. Glasser, and J.C. Loper, co-authors) of paper "Evaluation of Organics from New Orleans Drinking Water by Bacterial Mutagenesis" at the meeting of the American Society of Microbiology, New Orleans, Louisiana, May, 1977.

Presentation to Congressional Subcommittee on Oversight and Investigations, Committee on Interstate and Foreign Commerce, "Health Risks of Carbon Tetrachloride in Cincinnati Drinking Water," 13 April 1977.

Presentation (T.A. Jorgenson, C.J. Rushbrook, and G.W. Newell, co-authors) "Study of the Mutagenic Potential of *bis*-(2-Chloroethyl) and *bis*-(2-Chloroisopropyl) Ethers in Mice by the Heritable Translocation Test" at the Sixteenth Meeting of the Society of Toxicology, Toronto, Canada, March, 1977.

Presentation (G.P. Carlson, co-author) "Subacute Effects of Brominated Benzenes on Xenobiotic Metabolism" at Sixteenth Annual Meeting of the Society of Toxicology, Toronto, Canada, March, 1977.

Presentation (V.F. Simmon and K. Kauhanen, co-authors) "Mutagenic Assays with *bis*-(2-Chloroethyl) Ether" at First International Congress on Toxicology, Toronto, Canada, March 1977.

Presentation (C.C. Smith, co-author) of paper "Metabolic Characteristics of l,2,4-Trichlorobenzene" at First International Congress on Toxicology, Toronto, Canada, March 1977.

Presentation (G.P. Carlson, co-author) of paper "Alteration of Xenobiotic Metabolism by Chlorinated Benzenes" at the Fifteenth Annual Meeting of the Society of Toxicology, Atlanta, Georgia, 14-18 March 1976.

Presentation " Screening and prioritization strategies" at USEPA Advanced Fossil Fuel Research Advisory Committee, Research Triangle Park, NC, 13 November 1975.

Presentation (F.C. Kopfler, R.G. Melton, and J.L. Mullaney, co-authors) of paper "Human Exposure to Water Pollutants" at Division of Environmental Chemistry and the American Chemical Society, Philadelphia, Pennsylvania, 6-11 April 1975.

Presentation (J.J. Clary, co-author) of paper "Absorption, Distribution, and Excretion of Orally Administered $^{133}BaCl_2$ in Weanling Male Rats" at the Thirteenth Annual Meeting of Society of Toxicology, Washington, D.C., March 10-14, 1974.

Presentation of paper "Organic Compounds in Drinking Water--Are Standards Necessary?" at the Water Quality Technology Conference, American Water Works Assn., Cincinnati, Ohio, December 2-5, 1973.

Presentation (M. Deinzer, co-author) of paper "Toxicity of Organic Compounds in Drinking Water" at the Fifteenth Water Quality Conference. University of Illinois, Champagne-Urbana, 7-8 February 1973.

Presentation (K.P. DuBois, co-author) of paper "Inhibitory effect of Cytoxan and other alkylating agents on hepatic microsomal enzymes" at Sixth Annual Meeting of the Society of Toxicology, Atlanta, GA, 23-25 March 1967.

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COMMUNITY SERVICE

St. Paul Leadership Forum, Catholic Diocese of Arlington (VA), 2010 - 2011

Parish Finance Council, St Thomas á Becket Church, 2006-2012 [Chair, 2010 - 2012]

Parent-Teacher Organization, OLGC Grade School, President, 1989 -1990

Parent-Teacher Organization, OLGC Grade School, Vice-President, 1988-1989

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BOOKS/CHAPTERS (2/2012)

Long, T.F., M.L. Gargas, R.P Hubner, and R.G. Tardiff. The Role of Risk Assessment in Redeveloping Brownfield Sites. In: Todd S. Davis, Ed. Brownfields: *A Comprehensive Guide to Redeveloping Contaminated Property.* Second Edition, Chapter 21. Chicago: American Bar Association, pp. 281-326, 2002.

R.A. Lindthurst, P. Bourdeau, and R.G. Tardiff, Eds. *Methods to Assess the Effects of Chemicals on Ecosystems.* [SGOMSEC 10]. Chichester, John Wiley & Sons, 1995.

R.G. Tardiff, P.H.M. Lohman, and G.N. Wogan, Eds. *Methods to Assess DNA Damage and Repair: Interpsecies Comparisons.* [SGOMSEC 8]. Chichester: John Wiley & Sons, 1994.

R.G. Tardiff, Ed. *Methods to Assess Adverse Effects of Pesticides on Non-Target Organisms.* [SGOMSEC 7]. Chichester: John Wiley & Sons, 1992.

R. G. Tardiff and B. Goldstein, Eds. *Methods to Assess Exposure of Human and Non-human Biota.* [SGOMSEC 5]. Chichester: John Wiley & Sons, 1991.

E.J. Burger, Jr., R.G. Tardiff, A.R. Scialli, and H. Zenick, Eds. *Sperm Measures and Reproductive Success.* New York: Alan R. Liss, 1989.

R.G. Tardiff and J.V. Rodricks, Eds. *Toxic Substances and Human Risk.* New York: Plenum Publishing, 1988.

E.J. Burger, R.G. Tardiff, and J.A. Bellanti, Eds. *Environmental Chemical Exposures and Immune System Integrity.* Princeton, N.J.: Princeton Scientific Publishing, 1987.

J.M. McGinnis, J.C. Bailar, and R. G. Tardiff, Eds. *Determining Risks. Report of the Task Force on Health Risk Assessment.* Washington, D.C.: U.S. Department of Health and Human Services, 1986.

D.A. Okun, R.H. Harris, and R.G. Tardiff, Eds. *Water Quality Considerations in Source Selection.* Oakland, Cal.: East Bay Municipal Utility District, 1985.

J.V. Rodricks and R.G. Tardiff, Eds. *Assessment and Management of Chemical Risks.* ACS Symposium Series No. 239. Washington, D.C.: American Chemical Society, 1984.

V.T. Covello, W.G. Flamm, J.V. Rodricks, and R.G. Tardiff, Eds. *The Analysis of Actual vs. Perceived Risk.* New York: Plenum Publishing, 1983.

Tardiff, R.G. Problems and issues in toxicology. Pp. 9-13 in H.R. Witschi, Ed. *The Scientific Basis of Toxicity Assessment.* Developments in Toxicology and Environmental Science Series, Vol. 6. New York: Elsevier/North Holland Biomedical Press, 1980.

H.F. Kraybill, C.J. Dawe, J.C. Harshbarger, and R.G. Tardiff, Eds. *Aquatic Pollutants and Biologic Effects with Emphasis on Neoplasia.* Annals of the New York Academy of Sciences, Vol. 298. New York: N.Y. Academy of Sciences, 1977.

Kopfler, F. C., R. G. Melton, J. L. Mullaney, and R. G. Tardiff. Human exposure to water pollutants. In: Fate of Pollutants in the Air and Water Environments. Advances in Science and Technology, Vol. 8, pp. 419-434, 1977. New York: John Wiley & Sons, Inc.

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PUBLICATIONS (11/2011)

Tardiff, RG, and ML Carson. Derivation of a reference dose and drinking water equivalent level for 1,2,3-trichloropane. *Food and Chemical Toxicology* **48**, 1488-1510, 2010

Kimbrough, RD, CA Krouskas, ML Carson, TF Long, CJ Bevan, and RG Tardiff. Human intake of persistent chemicals from contaminated soils: PCDD/Fs and PCBs. Regul Toxicol Pharmacol **57**:43-54, 2010

Tardiff, RG, ML Gargas, CR Kirman, ML Carson, LM Sweeney. Estimation of Safe Dietary Intake Levels of Acrylamide for Humans. *Food and Chemical Toxicology* **48**, 658-667, 2010

Sweeney, L.M., C.R. Kirman, M.L. Gargas, and R.G. Tardiff. Development of a Physiologically-based Toxicokinetic Model of Acrylamide and Glycidamide in Rats and Humans. *J Food and Chemical Toxicology*, **48**, 668-685, 2010.

Tardiff, R.G., M.L. Carson, C.J. Bevan, L.M. Sweeney, C.R. Kirman, Y. Tan, M. Andersen, and M.L. Gargas. Derivation of a drinking water equivalent concentration and maximum contaminant level (MCLG) for perfluorooctanoic acid (PFOA. A persistent water soluble compound. *Food and Chemical Toxicology*, **47**, 2557-2589, 2009.

Gargas, M.L., C.R. Kirman, L.M. Sweeney, and R.G. Tardiff. Acrylamide: Considerations of species differences and non-linear processes in estimating risk and safety for human ingestion. *J. Food Chem Tox*, **47**: 760-768, accepted for publication January 2009.

Tardiff, R.G., M.L. Carson, and M.E. Ginevan. Updated Weight of Evidence for an Association Between Adverse Reproductive and Developmental Effects and Exposure to Disinfection Byproducts. *J. Regul. Tox. Pharm.* **45**: 185-205, 2006.

DeBord, D.G., R.E. Savage, Jr., H. Drexel, C. Freeman, J. Groopman, M. Jayjock, M. McDiarmid, M. Morgan, R. Santella. P. Shulte, G. Talasks, R.G. Tardiff, and C. Viau. A summary of of the workshop applying biomarkers to occupational health practice. J. Occup. Environ. Hyg. 1(5): D57-D60, 2004.

Long, T.F., C.R.Kirman, J.H. Butala, and R.G. Tardiff. Probabilistic cancer risk assessment of workers exposed to creosote during pressure treatment of wood. *Toxicologist* **78**(S-1): 155, 2004 [abstract no. 750].

Tardiff, R.G., R. P. Hubner, and C. G. Graves. Harmonization of thresholds for primary skin irritation from results of human repeated insult patch tests and results of laboratory animal skin irritation tests. (Short communication). *J. Applied Toxicology* **23**: 279-281, 2003.

Graves, C.G., Matanoski, G.M., and R. G. Tardiff. 2001. Weight of evidence for an association between adverse reproductive and developmental effects and exposure to disinfection byproducts: A critical review. *Regul. Toxicol. Pharmacol.* **34**: 103-124.

Graves, C.G., M.E. Ginevan, R.A. Jenkins, and R.G. Tardiff. Doses and lung burdens of environmental tobacco smoke constituents in nonsmoking workplaces. *Int J Exposure Anal Environ Epidemiology* **10(4)**:365-377, 2000.

Graves, C.G., G.M. Matanoski, and R.G. Tardiff. Carbonless copy paper and workplace safety: A review. *J Regulatory Toxicology and Pharmacology* **32**: 99-117, 2000.

Tardiff, R.G. Risk Analysis for the Workplace. In: R.L. Harris, L.J. Cralley, and L.V. Cralley, Eds. *Patty's Industrial Hygiene and Toxicology*, Third Edition, Volume 3, Part A, Chapter 46. New York: John Wiley and Sons, Inc., pp. 2151-2198, 2000.

Hubner, R.P., and R. G. Tardiff. Registration of Pesticides in the U.S.: Understanding the Process. In: M. L. Miller, Ed. *Pesticides Law Handbook*, Government Institutes, Rockville, Maryland, 1999.

Lakind, J.S., E.A. McKenna, R.P. Hubner, and R.G. Tardiff. A review of the Comparative Mammalian Toxicity of Ethylene Glycol and Propylene Glycol. *Critical Reviews in Toxicology* **29**(4): 331-365, 1999.

LaKind, J.S., C.G. Graves, M.E. Ginevan, R.A. Jenkins, D.Q. Naiman, and R.G. Tardiff. Exposure to Environmental Tobacco Smoke in the Workplace and the Impact of Away-from-Home Exposure. *Risk Analysis* **19**(3): 349-358, 1999.

LaKind, J.S., R.A. Jenkins, D.Q. Naiman, M.E. Ginevan, C.G. Graves, and R.G. Tardiff. Use of Environmental Tobacco Smoke Constituents as Markers for Exposure. *Risk Analysis* **19**(3): 359-373, 1999.

LaKind, J.S., M.E. Ginevan, D.Q. Naiman, A.C. James, R.A. Jenkins, M.L. Dourson, S.P. Felter, C.G. Graves, and R.G. Tardiff. Distribution of Exposure Concentrations and Doses for Constituents of Environmental Tobacco Smoke. *Risk Analysis* **19**(3): 375-390, 1999.

Stern, B.R., and R. G. Tardiff. Risk Characterization of Methyl *Tertiary* Butyl Ether in Tap Water. *Risk Analysis* **17**:6, 1997.

Fawell, J., et al., and R.G. Tardiff. Disinfection Byproducts in Drinking Water: Critical Issues in Health Effects Research. *Environmental Health Perspectives* **105**(1): 108-109, 1997.

Tardiff, R.G. Risk Analysis in Industrial Hygiene. In: R.L. Harris, L.J. Cralley, and L.V. Cralley, Eds. *Patty's Industrial Hygiene and Toxicology*, Third Edition, Volume 3, Part A. New York: John Wiley and Sons, Inc. 1994.

Tardiff, R.G. Protecting Human Health: Keeping Science in Risk Assessment and Balance in Risk-Based Regulations. In H. Holme (ed.) Proceedings of ASCE 1994 Conference "National Water Resources Regulation—Where is the Pendulum Now?" New York: American Society of Civil Engineers, 1994, pp 96-106.

Goldstein, B.D., O.E. Dickason, L. Morresey, and R.G. Tardiff. Communication of Risk Due to Community and Workplace Petroleum Exposure. *Indoor Environment* **3**: 96-102, 1994.

Whitmyre, G.K., J.H. Driver, M.E. Ginevan, R.G. Tardiff, and S.R. Baker. Human Exposure Assessment I: Understanding the Uncertainties. *Toxicology and Industrial Health* **8**(5): 297-320, 1992.

Whitmyre, G.K., J.H. Driver, M.E. Ginevan, R.G. Tardiff, and S.R. Baker. Human Exposure Assessment II: Quantifying and Reducing the Uncertainties. *Toxicology and Industrial Health* **8**(5): 321-342, 1992.

Driver, J.H., R.G. Tardiff, L. Sedik, R.C. Wester, and H.I. Maibach. *In Vitro* Percutaneous Absorption of [^{14}C] Ethylene Glycol. *J. Exposure Analysis and Environmental Epidemiology* **3**: 277-284, 1993.

Youngren, S.H., and R.G. Tardiff. Reducing uncertainties in risk assessment: Exposure assessment. Pp. 575-588 In C. Zervos, K. Knox, L. Abramson, & R. Coppock, Eds. *Risk Analysis Prospects and Opportunities*. New York: Plenum Press, 1991.

Nigg, H.N., R.C. Beier, O. Carter, C. Chaisson, C. Franklin, T. Lavy, R.G. Lewis, P. Lombardo, J.F. McCarthy, K.T. Maddy, M. Moses, D. Norris, C. Peck, K. Skinner, and R. G. Tardiff. Chapter 2. Exposure to pesticides. Pp. 35-130 In S.R. Baker and C.F. Wilkinson, Eds. *The Effects of Pesticides on Human Health*. Princeton, N.J.: Princeton Scientific Publishing, 1990.

Tardiff, R. G., and V. Snoeyink. Chapter 7. Activated carbon and air stripping. In *Comparative Health Effects Assessment of Drinking Water Treatment Technologies. Report to Congress.* Submitted by the U.S. Environmental Protection Agency, Washington, D.C., November 1988.

Scofield, R, R. Powell, M. Conklin, R. Machado, S. Youngren, E. Fechner, M. Gough, and R.G. Tardiff. Multipathway risk assessment methodology compatible with California decision tree and U.S. EPA Superfund guidelines. In *Proceedings of the Fifth National Conference on Hazardous Wastes and Hazardous Materials, Held in Las Vegas, Nevada, April 19-21, 1988.*

Brown, S.L., S. Brett, M. Gough, J. Rodricks, R.G. Tardiff, and D. Turnbull. Review of Interspecies risk comparisons. *J. Reg. Toxicol. Pharmacol.* **8**: 191-206, 1988.

Tardiff, R.G., and M. Gough. Estimating health risks at hazardous waste sites: Decisions and choices despite uncertainty. In *Hazardous Waste Site Management: Water Quality Issues.* Washington, D.C.: National Academy Press, 1988.

Tardiff, R.G., and J.V. Rodricks. Comprehensive risk assessment. In *Toxic Substances and Human Risk.* New York: Plenum Publishing, 1988.

Rodricks, J.V., and R.G. Tardiff. Use of risk information in environmental standard-setting. In *Managing Environmental Risks. Proceedings of an APCA International Specialty Conference, Washington D.C., October 1987.* Pittsburgh: Air Pollution Control Association, pp 1-12, 1988.

Tardiff, R.G., and S.H. Youngren. Public health significance of organic substances in drinking water. Pp. 405-436 in *Organic Carcinogens in Drinking Water: Detection, Treatment, and Risk Assessment.* New York: John Wiley and Sons, 1987.

Tardiff, R.G., and S.H. Rieth. Risk assessment strategy. Pp. 1437-1458 in *1987 Annual Conference Proceedings of the American Water Works Association, Vol. 2.* Denver: American Water Works Association, 14-18 June 1987.

Rodricks, J.V., V. Frankos, D. Turnbull, and R.G. Tardiff. Risk assessment for effects other than cancer. Pp. 61-74 in *Food Protection Technology.* Chelsea, MI: Lewis Publishers, 1987.

Tardiff, R.G. Reducing risks in the insurance industry. *J. Am. Coll. Toxicol.* **6**(2): 167-170, 1987.

Tardiff, R.G. Chapter 4. Determining risk levels. In H.W. de Koning, Ed. *Setting Environmental Standards. Guidelines for Decision-Making.* Geneva: World Health Organization, 1987. 105 pp.

Tardiff, R.G. and S.H. Youngren. Trihalomethanes: Health risks revisited. *Water Res. Quart.* **4**(1): 13-15, 1985.

Rodricks, J.V., and R.G. Tardiff. Animal research methods and dose response assessment. Appendix D. In *Risk Assessment and Risk Management Methods: The State-of-the-Art.* Washington, D.C.: National Science Foundation, December 1984.

Rodricks, J.V., and R.G. Tardiff. Risk assessment: How it's done and how it might be. *Chemtech*, July 1984: 394-397.

Rodricks, J.V., and R.G. Tardiff. Conceptual basis for risk assessment. Pp. 3-12 in *Assessment and Management of Chemical Risks.* ACS Symposium Series No. 239. American Chemical Society: Washington, D.C., 1984.

Muir, W., and R.G. Tardiff. Priority risk assessment. *Risk Analysis* **3**(1): 5-7, 1983.

Mann, T., R.L. Dixon, R. Eliasson, J.B. Kerr, C. Lutwak-Mann, A. Massoud, J. Parazek, and R.G. Tardiff. Effects of chemicals on male reproductive function in mammals. In *Methods for Assessing the Effects of Chemicals on Reproductive Functions.* SCOPE Report No. 20, Prepared by the Scientific Group on Methodologies for the Safety Evaluation of Chemicals. New York: John Wiley and Sons, 1983.

Tardiff, R.G. Application of toxicological data to the assessment of risks to human health. In *Ground Water Pollution with Organo-Chlorine Compounds of Industrial Origin, 1983.*

Rodricks, J.V., and R.G. Tardiff. Biological bases for risk assessment. Pp. 77-84 in *Safety Evaluation and Regulation of Chemicals.* Basel: Karger, 1983.

Hayes, A. W., T. Fedorowski, T. Balazs, W. Carlton, B. Fowler, M.R. Gilman, I. Heyman, B.A. Jackson, G.L. Kennedy, R.E. Shapiro, C.C. Smith, R.G. Tardiff, and C.S. Weil. Correlation of human hepatotoxicants with hepatic damage in animals. *Fund. Appl. Toxicol.* **2**: 55-66. 1982.

Tardiff, R.G., M. Robinson, and N.S. Ulmer. Subchronic oral toxicity of $BaCl_2$ in rats. *J. Environ. Pathol. Toxicol.* **4**: 267-276, November, 1980.

Coleman, W.E., and R.G. Tardiff. Contaminant levels in animal feeds used for toxicity. *Arch. Environ. Contam. Toxicol.* **8**: 693-702, 1979.

Lingg, R., W. Kaylor, S. Pyle, and R.G. Tardiff. Thiodiglycolic acid: A major metabolite of *bis*-(2-chloroethyl) ether. *Toxicol. Appl. Pharmacol.* **47**: 23-24, 1979.

Simon, G.S., R.G. Tardiff, and J.F. Borzelleca. Failure of hexachlorobenzene to induce dominant lethal mutations in the rat. *Toxicol. Appl. Pharmacol.* **47**: 415-419, 1979.

Tardiff, R.G. In vitro methods of toxicity evaluation. *Ann. Rev. Pharmacol. Toxicol.* **18**: 357-370, 1978.

Simon, G.S., R.G. Tardiff, and J.F. Borzelleca. Potential mutagenic and adverse male reproductive effects of 1,2,3,4-tetrabromobutane: A dominant lethal study in the rat. *Toxicol. Appl. Pharmacol.* **44**: 661-664, 1978.

Simmon, V.F., K. Kauhanen, and R.G. Tardiff. Mutagenic activity of chemicals identified in drinking water. Pp. 249-258 in *Progress in Genetic Toxicology.* New York: Elsevier/North Holland, 1977.

Loper, J.C., D.R. Lang, C.C. Smith, R.S. Schoeny, F.C. Kopfler, and R.G. Tardiff. *In vitro* mutagenesis and carcinogenesis testing of residual organics in drinking water. Pp. 405-417 in O. Hutzinger, I. Van Lilyveld, and B. Zoeteman, Eds. *Aquatic Pollutants: Transformation and Biological Effects.* 1978.

Tardiff, R.G. Introduction. Pp. 1-9 in National Research Council. *Principles and Procedures for Evaluating Household Substances.* Washington, D.C.: National Academy Press, 1977.

Smith, C.C., R.D. Lingg, and R.G. Tardiff. Comparative metabolism of haloethers. *Ann. N.Y. Acad. Sci.* **298**: 111-123, 1977.

Simmon, V.F., and R.G. Tardiff. Mutagenic activity of drinking water concentrates. *Mutat. Res.* **38**(6): 389-390, 1976.

Tardiff, R.G. Health effects of organics: Risk and hazard assessment of ingested chloroform. Paper No. 5-2 in *Proceedings of the 96th Annual Conference of American Water Works Association, Vol. 2. Water Technology and Research.* New Orleans, Louisiana, 20-25 June 1976.

Carlson, G.P., and R.G. Tardiff. Effects of halogenated aromatic hydrocarbons on the metabolism of foreign organic compounds. *Toxicol. Appl. Pharmacol.* **3**(2): 383-394, 1976.

Tardiff, R.G., G.P. Carlson, and V.F. Simmon. Halogenated organics in tap water: A toxicologic evaluation. Pp. 213-227 in R.L. Jolley, Ed. *The Environmental Impact of Water Chlorination. Proceedings of the Conference on the Environmental Impact of Water Chlorination.* (CONF-751096, UC 11, 41, 48). Oak Ridge National Laboratory, Oak Ridge, Tennessee, October 22-24, 1975.

Carswell, J.K., E. Coleman, J. Glass, F. Kopfler, K. Kropp, R. Lingg, O.T. Love, V. Maxson, R. Melton, M. Robinson, C. Slocum, B. Smith, A. Stevens, J. Symons, R. G. Tardiff, and M. Whitsell. Evaluation of the carbon chloroform extract and methylene chloride soluble portion of the carbon alcohol extract. EPA Staff Report. *J. Am. Water Works Assoc.* **67**(5): 281-284, May 1975.

Tardiff, R.G., *et al.* Overview. Pgs. 3-21 in National Research Council. *Geochemistry and the Environment, Vol. 1. The Relation of Selected Trace Elements to Health and Disease.* Washington, D.C.: National Academy of Sciences, 1974.

Tardiff, R.G. Health standards for metals in drinking water bases and ongoing research. In *Proceedings of the Environmental Health Seminars.* Environmental Sciences Center, Oregon State University, Nov. 2, 1972.

Winton, E.F., R.G. Tardiff, and L.J. McCabe. Nitrate in drinking water. *J. Am. Water Works Assoc.* **63**(2): 95-98, 1971.

Tardiff, R.G., and L.J. McCabe. Rural water quality and the need for improvement. In *Proceedings of the Second Water Quality Improvement Seminar, San Francisco, California, August, 1968.* ASAE Publication Proc-268. St. Joseph, Michigan: American Society of Agricultural Engineers, 1968.

Tardiff, R.G., and K.P. DuBois. Inhibition of hepatic microsomal enzymes by alkylating agents. *Arch. Int. Pharmacodyn. Therap.* **177**(2): 445-456, 1969.

Tardiff, R.G., and K.P. DuBois. Inhibitory effect of Cytoxan and some other alkylating agents on hepatic microsomal enzymes. *Toxicol. Appl. Pharmacol.* **10**(2), 1967. (Abstract of paper presented at Annual Meeting of Society of Toxicology, Atlanta, Georgia, March 1967).

* * * * *

REPORTS (2/2012)

Tardiff, R.G. and M. L. Carson. Safety Evaluation of Surgical Powder-Free Synthetic Elastomer Glove for Submission to US FDA. Prepared for Hutchinson-Santé, Paris, France, April 2011.

Tardiff, R.G. Questions raised about the Criticality of risk analysis and risk management in offshore oil drilling. Society for Risk Analysis Risk Newsletter, 30(1), 2010, pp. 1 and 3.

Tardiff, R.G. Questions raised about the criticality of risk analysis and risk management in offshore oil drilling. Risk Newsletter 10 (3): 1-3, August 2010.

Tardiff, R.G., and M. L. Carson. Estimation of the "Maximum Allowable Daily Dose" (MADL) for the reproductive and developmental toxicity of chloroform and dichloroacetic acid pursuant to the criteria of California's Proposition 65. Prepared for the Chlorine chemistry Division of the American Chemistry Council, December 2009.

Tardiff, R.G., M.L. Carson, and R.P. Hubner. Estimated exposures and health risks of MTBE and Benzene in Drinking Water of a Maryland community, Report prepared for Carroll Independent Fuel Company, November 2009.

Kirman, C.R., and R.G. Tardiff, Updated cancer risk assessment for creosote wood treatment workers. Report prepared for Creosote Council, August 2007.

Kirman, C.R., and R.G. Tardiff, Updated non-cancer risk assessment for creosote wood treatment workers. Report prepared for Creosote Council, August 2007.

Tardiff, R.G. and R.P. Hubner. Product Safety Standard Operating Procedure. Report prepared for Johns Manville Corporation, February 2007.

Tardiff, R.G. Comments on and insights concerning "Bladder cancer and exposure to water disinfection by-products through ingestion, showering, & swimming in pools" (Villanueva, et al. Am J Epid. 165(2): 148-156, 2007). Report prepared for the Chlorine Chemistry Council of the American Chemistry Council, February 2007.

Tardiff, R.G., Gargas, M.L., and C. Kirman. Recommendations for Deriving a Public Health Goal for 1,2,3-Trichloropropane in Drinking Water. Report prepared for Dow AgroSciences, April 2006.

Tardiff, R.G., and R.P. Hubner. Waimanalo Gulch Landfill: Evaluation of Gravity Scores for "Potential for Harm" applied to The Hawaii Department of Health in its Penalty Calculation. Prepared for Waste Management of Hawaii, 15 September 2006.

Tardiff, R.G., C.R. Kirman, and T.F., Long. Weight-of-evidence for the modes-of-action from two therapeutic topical uses of salicylic acid. Report prepared for L'Oréal USA to satisfy scientific requirements of the European Commission (2001), 23 December 2005.

Tardiff, R.G., C.R., Kirman, and F. Jay Murray. Recommendations for deriving a public health goal for 1,2,3-trichlopropane in drinking water. Report prepared for the Office of Health Hazard Assessment, California Department Environmental Protection, State of California, on behalf of an industry coalition, December 2005.

Tardiff, R.G., C.R. Kirman, and F. Jay Murray. Comments on the proposal to establish a specific regulatory level posing no significant risk (NSRL) for acrylamide and amend Title 22, California Code of Regulations, Section 12705(b). Report submitted to the Office of Health Hazard Assessment, California Department Environmental Protection, State of California, on behalf of the Industry Acrylamide Coalition, 17 August 2005.

Tardiff, R.G. Oxygenates (MTBE and ethanol) in automotive fuels: Health benefits and safety/risks. Report prepared for the Maryland Legislature, Annapolis, MD, on behalf of Lyondell Corporation, 16 February 2005.

Tardiff, R.G. Comments offered to the Committee to "Review EPA's Risk Assessment of the Health Implications of Exposure to Dioxin." Report prepared on behalf of the Chlorine Chemistry Council, November 2004.

Silverstein, B.D. And R.G. Tardiff. Qualitative and quantitative analysis of assorted products of PQ Corporation for crystalline silica (quartz) following modification of manufacturing process. Report (confidential) prepared for Pepper Hamilton, LLP, Philadelphia, PA, February 2004.

Tardiff, R.G. and R.J. Bull. Review of cancer data used to support USEPA's proposed Stage 2 Disinfectants and Disinfectant Byproducts Rule (40CFR Parts 141, 142, 143; 18 August 2003). Report prepared for Chlorine Chemistry Council, January 2004.

Graves, C.G., and R.G. Tardiff. Review of reproductive and developmental health effects data used to support USEPA's proposed Stage 2 Disinfectants and Disinfectant Byproducts Rule (40CFR Parts 141, 142, 143; 18 August 2003). Report prepared for Chlorine Chemistry Council, January 2004.

Tardiff, R.G., and C. Kirman. Comments on NTP-CERHR Expert Panel Report (June 2004) on the Reproductive and Developmental Toxicity of Acrylamide. Prepared for the Snack Food Association, August 2004.

Hubner, R.P., B. Silverstein, and R.G. Tardiff. Indoor Air Quality Survey. Report prepared for at PQ Corporation, May 2004.

Tardiff, R.G., Gargas, M.L., and C. Kirman. Cancer Risk Assessment For Creosote Wood Treating Workers. Report prepared for Creosote Council, March 2004

Tardiff, R.G., Gargas, M.L., and C. Kirman. Non-cancer Risk Assessment for Creosote Wood Treating Workers. Report prepared for the Creosote Council, March 2004.

Tardiff, R.G. and B.D. Silverstein. Reconstruction of subchronic doses of nitrilotriacetic acid (NTA) in workers formulating detergents. Report prepared for confidential client. August 2003.

Hubner, R.P., B. Silverstein, and R.G. Tardiff. Worker Health and Safety Recommendations. Prepared for the Eaton Corporation's Fluid Power Automotive Fluid Connectors Facility in Forest City, North Carolina, August 2003.

Tardiff, R.G. and R.P. Hubner. Evaluation of the Safety and Suitable Purity of K-Flex® 500, K-Flex® 800, K-Flex® DP, and K-Flex® DE for Use in Food Contact Applications Under the Food, Drug, & Cosmetic Act. Prepared for a confidential client, April 2003.

Tardiff, R.G. and R.P. Hubner. An investigation of drinking water for pesticidal chemicals associated with birth defects and other childhood illnesses: Characterization of the health significance of those active pesticidal ingredients measured in groundwater on Oahu. Report prepared for the Honolulu Board of Water Supply, August 2002.

Tardiff, R.G. Assessment of the genetic toxic potential of Tall Oil and Tall Oil Fatty Acids. Report prepared for MeadWestvaco, July, 2002.

Tardiff, R.G. Bromodichloromethane: An update of carcinogenicity data, their significance for the health of humans consuming chlorinated tap water, and their significance for drinking water standards. Report prepared for the Chlorine Chemistry Council, July 2002.

Tardiff, R.G. and R.P. Hubner. An Investigation of Drinking Water for Pesticidal Chemicals Associated with Birth Defects and Other Childhood Illnesses. Prepared for the Honolulu Board of Water Supply, Honolulu, Hawaii, November 2002.

Tardiff, R.G., Gargas, M.L., and C. Kirman. Comments on NSF's Draft (7/15/02) of PGBE Oral Risk Assessment Regarding NOAEL/NOEL. Prepared for the American Chemistry Council, August 2002.

Tardiff, R.G., Gargas, M.L., and C. Kirman. Comments on NSF's Draft (7/15/02) Oral Risk Assessment for PGBE Regarding Uncertainty Factors (UF). Prepared for the American Chemistry Council, August 2002.

Tardiff, R.G., Hubner, R.P., and C.G. Graves. Development of Targeted Documentation on the Proper Understanding of the Significance of Chronic Disease Tracking Information. Prepared for the American Chemistry Council, August 2002.

Hubner, R.P., B. Silverstein, and R.G. Tardiff. Critical Examination of the Role of "T-69" in Thyroid Toxicity and Experimental Approaches to Characterize Safety to Workers and Users. Prepared for a private client, April 2002.

Tardiff., R.G., R.P. Hubner. Reevaluation of potential human health risk and action levels for 1,2,3-trichloropropane (TCP) in drinking water in Hawaii. Report prepared for Hawaii Department of Health, November 2001.

Hubner, R.P., B. Silverstein, and R.G. Tardiff. An investigation of indoor bioaerrosols at the Fidelity Investments Corporation located at 1900 K Street, Washington, DC. Sapphire Group report prepared for Fidelity Investments Corporation, Boston, MA. November 2001.

Tardiff, R.G., Gargas, M.L., and C. Kirman. A critical evaluation of the scientific support for health-protective limits for vinyl chloride monomer (VCM) used in polyvinyl chloride (PVC) plastics. Sapphire Group report prepared for Occidental Chemical Corporation, October 2001.

Long, T.F., M.L. Gargas, and R.G. Tardiff. A *Class Based Evaluation Level* analyis for oligomeric cyclic ethers from thermoplastic urethane materials used in potable water systems. Sapphire Group report prepared for the American Plastics Council, Arlington, VA. September 2001.

Tardiff, R.G.., and R.P. Hubner. An investigation of drinking water for pesticidal chemicals associated with birth defects and other childhood illnesses. Phase 1: Identification of candidate pesticides for analysis. Sapphire Group Report prepared for the Honolulu Board of Water Supply, June 2001.

Tardiff, R.G., and R.P. Hubner. Toxicologic assessment of compounds Identified from thermal processing of CustomKote On-Demand paper. Sapphire Group report prepared for Mead Corporation. May 2001.

Tardiff, R.G. Estimation of the health risks and safety from exposures to chlorine and chloroform for swimmers in pools. Sapphire Group report prepared for the National Association of Gas Chlorinators, the Chlorine Chemistry Council, and the California International Chemical Company, Inc., November 2000.

Tardiff, R.G., and R. P. Hubner. Comments on USEPA's Proposed Acute Exposure Guideline Levels (AEGLs for Hydrogen Sulfide. Sapphire Group report prepared for the American Petroleum Institute and BPI, Inc., March 2000.

Tardiff, R.G. Characterization of the health hazards and virtually safe dose of t-butyl Alcohol (TBA) in the Workplace. Sapphire Group report prepared for Dow Corning Corporation, November 1999.

Tardiff, R. G., Stern, B.R., and N. McGrory. Disinfection byproducts (DBP) and cancer hazards and/or risks to human health: Update since State I DBP negotiations under the Safe Drinking Water Act. Sapphire Group report prepared for the Chlorine Chemistry Council, 1999.

Tardiff, R.G. A critical assessment of select human toxicity studies of H_2S in relation to setting limits on H_2S in workplace atmospheres. Sapphire group report to the American Petroleum Institute, June 1999.

Tardiff, R.G., and C.G. Graves. Peer review of draft NIOSH hazard review: Carbonless copy paper (dated 18 February 1999). Sapphire Group report to the national Institute of Occupational Safety and Health, commissioned by the Carbonless-copy paper manufacturers, June 1999

Tardiff, R.G., R.P. Hubner, S.A. Galik, N. McGrory, and J. Lowenstein. Disinfection byproducts (DBP) and reproductive hazards and/or risks to human health: Update since State I DBP negotiations under the Safe Drinking Water Act. Sapphire Group report prepared for the Chlorine Chemistry Council, July 1999.

Tardiff, R.G., R.P. Hubner, S.A. Galik, N. McGrory, and J. Lowenstein. Disinfection byproducts (DBP) and developmental hazards and/or risks to human health: Update since State I DBP negotiations under the Safe Drinking Water Act. Sapphire Group report prepared for the Chlorine Chemistry Council, July 1999.

Tardiff, R.G. and M. Christian. Submission to the California Environmental Protection Agency on methyl-tertiary-butyl ether (MTBE) with regard to reproductive and developmental toxicity for consideration under the Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). Sapphire Group submitted to California EPA and commissioned by the Oxygenated Fuels Association, November 1998.

Tardiff, R.G., and R.P. Hubner. The interpretation of findings from standardized tests for dermal irritancy: A brief perspective. Sapphire Group report to the National Institute of Occupational Safety and Health commissioned by the Carbonless-Copy Paper Manufacturers, July 1998.

Tardiff, R.G., and C.G. Graves. Multiple Chemical Sensitivity: A brief perspective on its plausibility as a human disease. Sapphire Group report to the National Institute of Occupational Safety and Health commissioned by the Carbonless-Copy Paper Manufacturers, May 1998.

Tardiff, R. G. Bromodichloromethane (BDCM): Background information related to fetal loss. Sapphire Group report prepared for the Chlorine Chemistry Council, February 1998.

Tardiff, R.G., G.F. Craun, R.P. Hubner, H. Pastides, and A.R. Scialli. Comments to California Environmental Protection Agency Regarding its Draft "High Priority" Proposal for Chloroform as a Reproductive and Developmental Toxicant under the Safe Drinking Water and Toxic Enforcement Act of 1986. Sapphire Group report prepared for the Chlorine Chemistry Council, November 1997.

Tardiff, R.G. Evaluation of the Virtually Safe Dose of TBA in Drinking Water. Sapphire Group report prepared for ARCO Chemical Corporation, August 1997.

Tardiff, R.G., R.P. Hubner, and J.S. LaRocco. Detailed Evaluation of Toxicity Data of Mead's Carbonless Paper and of Ingredients Used to Manufacture Mead's Carbonless Copy Paper. Sapphire Group Report prepared for Mead Corporation, June 1997.

Tardiff, R.G. Chloroform: Research Findings Support Risk Assessment. *Drinking Water and Health* (A publication of the Public Health Advisory Board of the Chlorine Chemistry Council, Alexandria, VA) **3**(5), Winter 1997.

Tardiff, R.G. An Evaluation of the Health Significance of Chlordane Approaches to Minimize Risk to Human Health. Report prepared for the Board of Water Supply, Honolulu, Hawaii, December 1997.

Tardiff, R.G. An Evaluation of the Health Significance of Dieldrin in Drinking Water and Approaches to Minimize Risk to Human Health. Report prepared for the Honolulu Board of Water Supply, Honolulu, Hawaii, December 1997.

Tardiff, R.G., S. Youngren, and B. Stern. Evaluation of the Significance of Inhalation of Chloroform Present in the Air of Pools and Spas in Compliance with California's Proposition 65. EA Report prepared for the Chlorine Chemistry Council, 1996.

Kim, A., and R.G. Tardiff. Estimation of Risk-Based Concentrations of Formaldehyde in Ambient Air. EA Report prepared for International Paper Company, October 1996.

Hubner, R.P, J.S. LaKind, A. Kim, and R.G. Tardiff. A Toxicological Review and Risk Assessment of Four Ethylene Glycol Ethers: Ethylene Glycol Methyl Ether, Ethylene Glycol Ethyl Ether, Ethylene Glycol Butyl Ether, and Diethylene Glycol Butyl Ether. EA Report prepared for ARCO Chemical Company, October 1996.

Tardiff, R.G., and B. Stern. Examination of Chloroform as a Candidate for Reassessment Using EPA's Proposed Implementation Strategy for Reevaluating Existing Assessments Using the Final Revised Carcinogen Risk Assessment Guidelines. EA Report prepared for The Chlorine Chemistry Council, September, 1996.

Tardiff, R.G., and N. Stahkiv. Dichloroacetic Acid (DCAA): Carcinogenicity/Chronic Toxicity Evaluation with Consideration of Modes of Action. EA Report prepared for the International Life Sciences Institute, August 1996.

Tardiff, R.G., J. M. Symons, and M. Gray. Comments on National Primary Drinking Water Regulations: Enhanced Surface Water Treatment Requirements. EA Report prepared for The Chlorine Institute, August 1996.

Tardiff, R.G. and B. Stern. Evaluation of EPA's Proposed Cancer Risk Assessment Guidelines Using Chloroform as a Case Study. EA Report prepared for The Chlorine Chemistry Council, August, 1996.

Tardiff, R.G. (with S. Baker, L. McKenna, C. Graves, and B. Stern). Critical Review of the USEPA Proposed Guidelines for Carcinogen Risk Assessment. EA Report prepared for submission to the U.S. Environmental Protection Agency, Washington, DC., August, 1996.

Tardiff, R.G. (with R.P. Hubner, A. Kim, and J.S. LaKind). A Toxicological Review and Risk Assessment of Eight Propylene Glycol Ethers: PG Methyl Ether, PG Ethyl Ether, PG –Propyl Ether, PG –Butyl Ether, PG *t*-Butyl Ether, Dipropylene Glycol Methyl Ether, Dipropylene Glycol –Propyl Ether, and Dipropylene Glycol –Butyl Ether. EA Report prepared for ARCO Chemical Company, 26 July 1996.

Tardiff, R.G. (with J.S. LaKind and R.P. Hubner). Ethylene Glycol: Scientific Rationale for Continued Listing on EPA's Toxic Release Inventory (TRI). EA Report prepared for ARCO Chemical Company, 29 February 1996.

Tardiff, R.G. (with J.S. LaKind, R.P. Hubner, and B. Suedel). Comparative Toxicity and Environmental Impacts of Ethylene Glycol and Propylene Glycol: A Review. EA Report prepared on behalf of ARCO Chemical Company as Appendix A of an amicus brief submitted to the Ohio State Court, 15 February 1996.

Tardiff, R.G. (With S. Baker, J. LaKind, and B. Stern). Decision Support Document on Health Benefits and Health and Safety Associated with the Use of Methyl tertiary Butyl Ether (MTBE) in Gasoline). EA Report prepared for ARCO Chemical Company, December 1995.

Tardiff, R.G., C. Graves, A. Kim. Risk Assessment of *Intersept*®. First Edition in Compliance with EU Guidance. EA Report Submitted on behalf of Interface Research Corporation, Atlanta, GA, and Interface Europe, Ltd., Yorkshire, UK, 1995.

Graves, C.G., R.G. Tardiff, and G.F. Craun. Epidemiology of the Possible Association between Drinking Water Chlorination and Reproductive and Developmental Toxicity. EA Report prepared for the Chlorine Institute, December 1994.

Graves, C.G., R.G. Tardiff, and G.F. Craun. Evaluation of the Epidemiology Studies on the Possible Association between Drinking Water Chlorination and Cancer. EA Report prepared for the Chlorine Institute, December 1994.

Tardiff, R.G., M. Gray, B.R. Stern, S.R. Baker. Balancing Health Risks in the Regulation of Disinfectants of Drinking Water: Disinfection Chemical Byproducts versus Microbial Pathogens. EA Report prepared for the Chlorine Institute, December 1994.

Tardiff, R.G. and B.R. Stern. Critical Evaluation of EPA's Rationale for MCLs and MCLGs for Halogenated Acetic Acids as Stated in the Agency's Criteria Document and the Federal Register Proposal to

Regulate Disinfectants and Disinfection Byproducts. EA Report prepared for the Chlorine Institute, December 1994.

Tardiff, R.G. and B.R. Stern. Critical Evaluation of EPA's Rationale for Bromate MCLG as Stated in Its Criteria Document and in the Federal Register Proposal to Regulate Disinfectants and Disinfection Byproducts. EA Report prepared for the Chlorine Institute, December, 1994.

Tardiff, R.G. and B.R. Stern. Critical Evaluation of EPA's Rationale for Chloramine MRDLG as Stated in Its Criteria Document and in the Federal Register Proposal to Regulate Disinfectants and Disinfection Byproducts. EA Report prepared for the Chlorine Institute, December, 1994.

Tardiff, R.G. and B.R. Stern. Critical Evaluation of EPA's Rationale for Chlorine MRDLG as Stated in Its Criteria Document and in the Federal Register Proposal to Regulate Disinfectants and Disinfection Byproducts. EA Report prepared for the Chlorine Institute, December, 1994.

Tardiff, R.G. and B.R. Stern. Critical Evaluation of EPA's Rationale for Trihalomethanes MCLGs and MCLs as Stated in Its Criteria Document and in the Federal Register Proposal to Regulate Disinfectants and Disinfection Byproducts. EA Report prepared for the Chlorine Institute, December, 1994.

Tardiff, R.G. and M. Gray. Critical Evaluation of EPA's Rationale for the MCLG for *Cryptosporidium* as Stated in Its Criteria Document and in the Federal Register Proposal to Regulate Disinfectants and Disinfection Byproducts. EA Report prepared for the Chlorine Institute, December, 1994.

Tardiff, R.G., A. Kim, and S.H. Youngren. Evaluation of Acrylamide Co-Polymers and DADM Polymers for Private GRAS Affirmation for Use in Protein Recovery in Accordance with the provisions of the Food, Drug, & Cosmetics Act (FDCA). EA Report prepared for Chemtall Inc., December, 1994.

Baker, S.R., J. LaKind, T. Piccin, B. Stern, S. Youngren, L. Wakefield, and R.G. Tardiff. Human Health Risk Assessment of Manufactured Gas Plant Residuals and Other Chemicals at Baltimore Gas and Electric Company's (BGE) Spring Gardens Facility: Part I Onsite Risk Assessment. EA Report for the Baltimore Gas Company, August 29, 1994.

Tardiff, R.G., A. Kim, and S.H. Youngren. Evaluation of Acrylamide Co-Polymers for Private GRAS Affirmation as Retention Aids & De-Inkers in Paper Production in Accordance with the provisions of the Food, Drug, & Cosmetics Act (FDCA). EA Report prepared for Betz Laboratories Inc. and Chemtall Inc., August 1994.

Piccin, T.B. and R.G. Tardiff. Estimation of Benzene Cancer Risks in Valdez, Alaska, as a Result of Installing Vapor Control Technology at Alyeska's Marine Loading Terminal. EA Report for the Alyeska Pipeline Service Company, July 1994.

Tardiff, R.G., and Leslie Wakefield. Safety Evaluation of FRIGC FR-12 for Use as a refrigerant in automobiles air conditioning systems. EA Report prepared for Intermagnetics Inc. as part of a petition to USEPA. June 1994.

Tardiff, R.G. and J.S. LaKind. Modelled Predictions of Disinfection Byproducts for the Baltimore Water Supply System after Implementation of Zebra Mussel Control. EA Report prepared for KCI Engineers and the City of Baltimore Water Supply, February 1994.

Tardiff, R.G., and S.T. Cragg. The Relevance of the Carcinogenicity Data for Methyl-Tertiary-Butyl Ether (MTBE to the Estimation of Cancer Risk in Humans. EA Report prepared for ARCO Chemical Company, July, 1993.

Tardiff, R.G., and T.B. Piccin. Evaluation of Employees' Benzene Exposure at the Alyeska Marine Terminal, Valdez, Alaska. EA Report Prepared for the Alyeska Pipeline Service Company, July 1993.

Tardiff, R.G., and S.H. Youngren. Safety Evaluation of Intersept® for Selected Uses. Third Edition. EA Report Prepared for Interface Research Corporation, March 1993.

Tardiff, R.G. Balancing Chemicals and Microbiological Risks: Non-Cancer Health Risks of Chlorine Disinfection of Drinking Water. EA Report for the Chlorine Institute, February 1993.

Tardiff, R.G. Balancing Risks from Chemical Carcinogens & Water-Borne Infectious Microbes: A Conceptual Framework. EA Report for the Chlorine Institute, January 1993 (Revised May 1993).

Tardiff, R.G. Balancing Chemicals and Microbiological Risks: Weight-of-Evidence for Cancer Risks of Chlorine Disinfection of Drinking Water. EA Report for the Chlorine Institute, January 1993 (revised May 1993).

Tardiff, R.G., B.D. Goldstein, G. Hoffnagle, T. Piccin, P.L. Roney, L. Wakefield, M.A. Silkowski, and S.R. Baker. Valdez Air Health Study, Vols I and II. EA report prepared for the Alyeska Pipeline Service Company, June 1992.

Tardiff, R.G. Evaluation of Scientific Merits of Claims Made in Case of Ken Richards v. Eaton Corporation (Kearney, Nebraska). Report prepared for Eaton Corporation, March 1992.

Roney, P.L., G.K. Whitmyre, and R.G. Tardiff. Submission for Certification of Cationic Polyacrylamide for Use as a Drinking Water Additive. RiskFocus report prepared for the Chemical Manufacturers Association, June 1991.

Roney, P.L., G.K. Whitmyre, and R.G. Tardiff. Submission for Certification of Anionic and Nonionic Polyacrylamide for Use as a Drinking Water Additive. RiskFocus report prepared for the Chemical Manufacturers Association, June 1991.

Roney, P.L., G.K. Whitmyre, and R.G. Tardiff. Submission for Certification of Poly (Diallyldimethylammonium Chloride) for Use as a Drinking Water Additive. RiskFocus report prepared for the Chemical Manufacturers Association, June 1991.

Roney, P.L., G.K. Whitmyre, and R.G. Tardiff. Submission for Certification of Epichlorohydrin-Dimethylamine for Use as a Drinking Water Additive. RiskFocus report prepared for the Chemical Manufacturers Association, June 1991.

Roney, P.L., J. Levy, and R.G. Tardiff. Comments to New Jersey Department of Environmental Protection Draft Regulations for Cleanup Standards. RiskFocus report prepared for Allied Signal Corporation, August 1991.

Tardiff, R.G., and J.H. Driver. Evaluation of the Exposure to Aniline to Ascertain Compliance with California's Proposition 65. RiskFocus report prepared for the Writing Instrument Manufacturers Association, March 1991.

Tardiff, R.G., and M.E. Ginevan. Comments on EPA's Proposed Regulation of Pentachlrophenol under the Safe Drinking Water Act and its Amendments. RiskFocus report prepared for the Edison Electric Institute, March 1991.

Roney, P.L., J.H. Driver, and R.G. Tardiff. Factors Related to the Interpretation of Chronic Toxicity Data for Ceterizine. RiskFocus report prepared for Pfizer Inc., March 1991.

Roney, P.L., J.H. Driver, and R.G. Tardiff. Evaluation of the Chemical Safety of Ethyl Acrylate for Users of Liquid Paper Pen and Ink Correction Fluid. RiskFocus report prepared for the Gillette Medical Evaluation Laboratories, October 1990.

Tardiff, R.G., P.L. Roney, M.E. Ginevan, & S.N. Miller. Re-Analysis of Potential Human Health Risk from the Pesticide DBCP in Tap Water and Approaches to Setting Action Levels for Less-Than-Lifetime Exposures to Pesticides in Potable Water in Hawaii. RiskFocus report prepared for the Department of the Navy, September 1990.

Tardiff, R.G. Response to Issues Related to EPA's Proposed Regulation of 24 Substances Under the Safe Drinking Water Act and Its Amendments. RiskFocus report prepared for the Edison Electric Company, September 1990.

Tardiff, R.G., J.H. Driver, and P.L. Roney. Guideline for the Evaluation of the Chemical Safety of Writing Instruments and Their Components for Users of Those Instruments. RiskFocus report prepared for the Writing Instrument Manufacturers Association, August 1990.

Tardiff, R.G., M.E. Ginevan, and E.B. Ilgren. Assessment of the Health Risks of Inhaling Nickel Compounds Present in Ambient Air. RiskFocus report prepared for Pacific Gas and Electric Company, August 1990.

Roney, P.L., J.H. Driver, and R.G. Tardiff. Summary of the Proposed Mechanisms of Carcinogenicity of Chromium Compounds. RiskFocus report prepared for Occidental Chemical Corporation, June 1990.

Marzulli, F., and R.G. Tardiff. Carcinogenic Potential of Soluble and Insoluble Chromium Compounds. RiskFocus report prepared for Occidental Chemical Corporation, June 1990.

Tardiff, R.G., P.L. Roney, and M.E. Ginevan. A critical Examination of the Evidence for a Threshold for Cancer Risk in Humans from Trivalent Inorganic Arsenic. RiskFocus report for the Edison Electric Institute, February 1990.

Driver, J.H., and R.G. Tardiff. Evaluation of the Chemical Safety of Trace Elements for Users of Golden Road Correction Fluid Stationary Products. RiskFocus report for the Gillette Company, February, 1990.

Driver, J.H., and R.G. Tardiff. Evaluation of the Safety of Ethylene Glycol Monomethyl Ether and Ethylene Glycol Monoethyl Ether for Users of Writing Instruments. RiskFocus report prepared for Sanford Corporation, December 1989.

Driver, J.H., and R.G. Tardiff. Evaluation of the Chemical Safety of Trichloroethylene for Users of Liquid Correction Fluid. RiskFocus report prepared for The Gillette Company, December 1989.

Driver, J.H., M.E. Ginevan, F.N. Marzulli, and R.G. Tardiff. Evaluation of the Chemical Safety of 1,4-Dioxane for Users of Liquid Paper Pen and Ink Correction Fluid and Thinner for Correction Fluid. RiskFocus report prepared for The Gillette Company, December 1989.

Driver, J.H., M.E. Ginevan, F.N. Marzulli, and R.G. Tardiff. Evaluation of the Chemical Safety of 1,4-Dioxane for Users of Correction Pen. RiskFocus report prepared for The Gillette Company, December 1989.

Roney, P.L., and R.G. Tardiff. Evaluation of the Possible Reproductive Toxicity and Risks from Occupational Exposure to Compounds Used at Occidental Chemical Corporation's Niagara Falls Plant. RiskFocus report prepared for Occidental Chemical Corporation, November 1989.

Driver, J.H., M.E. Ginevan, and R.G. Tardiff. Evaluation of the Chemical Safety of 1,4-Dioxane for Users of Writing Instruments. RiskFocus report for the Writing Instrument Manufacturers Association, November 1989.

Roney, P.L., S. Noren, M.E. Ginevan, F. Marzulli, and R.G. Tardiff. Evaluation of the Chemical Safety of *o*-Aminotoluene for Users of Writing Instruments. RiskFocus report for the Writing Instrument Manufacturers Association, November 1989.

Roney, P.L., J.H. Driver, M.E. Ginevan, F.N. Marzulli, and R.G. Tardiff. Evaluation of the Chemical Safety of Auramine for Users of Writing Instruments. RiskFocus report prepared for The Gillette Company, November 1989.

Roney, P.L., J.H. Driver, N. Snider, M.E. Ginevan, F.N. Marzulli, and R.G. Tardiff. Evaluation of the Chemical Safety of Benzyl Violet 4B for Users of Writing Instruments. RiskFocus report prepared for The Gillette Company, November 1989.

Driver, J.H., G. K. Whitmyre, and R.G. Tardiff. Evaluation of the Chemical Safety of Ethylene Dichloride for Users of Liquid Paper Pen and Ink Correction Fluid and Thinner and Correction Fluid. RiskFocus report prepared for The Gillette Company, November 1989.

Driver, J.H., and R.G. Tardiff. Evaluation of the Chemical Safety of di(2-Ethylhexyl) Phthalate for Users of Writing Instruments. RiskFocus report prepared for The Gillette Company, October 1989.

Roney, P.L., M.E. Ginevan, R.G. Tardiff. Evaluation of the Chemical Safety of Auramine for Users of Writing Instruments. RiskFocus report prepared for the Writing Instrument Manufacturers Association, October 1989.

Roney, P.L., S. Noren, M.E. Ginevan, F. Marzulli, R.G. Tardiff. Evaluation of the Chemical Safety of Formaldehyde for Users of Writing Instruments. RiskFocus report prepared for the Writing Instrument Manufacturers Association, October 1989.

Roney, P.L., N. Snider, M.E. Ginevan, R.G. Tardiff. Evaluation of the Chemical Safety of Benzyl Violet 4B for Users of Writing Instruments for Compliance with California's Proposition 65. RiskFocus report prepared for the Writing Instrument Manufacturers Association, October 1989.

Whitmyre, G.W., J.H. Driver, M.E., Ginevan, R.G. Tardiff, and J.F. Borzelleca. Evaluation of the Scientific Basis for Derivation of Safe Levels of Exposure to Ethylene Oxide (EtO) via Human Consumption of Fumigated Spices. RiskFocus report prepared for Durkee-French Foods, Inc., October 1989.

Driver, J., M.E. Ginevan, R.G. Tardiff. Evaluation of the Chemical Safety of 1,4-Dioxane for Users of Writing Instruments. RiskFocus report prepared for the Writing Instrument Manufacturers Association, October 1989.

Driver, J.H., P.L. Roney, M.E. Ginevan, R.G. Tardiff. Evaluation of the Chemical Safety of Monoethyl Ether for Users of Writing Instruments. RiskFocus report prepared for the Writing Instrument Manufacturers Association, October 1989.

Driver, J.H., M.E. Ginevan, R.G. Tardiff. Evaluation of the Chemical Safety of di(2-Ethylhexyl) Phthalate for Users of Writing Instruments. RiskFocus report prepared for the Writing Instrument Manufacturers Association, October 1989.

Roney, P.L. and R.G. Tardiff. Evaluation of Trichloroethylene (TCE) and Perchloroethylene (PCE) for Potential to Cause Encepahlopathies. RiskFocus report prepared for Occidental Chemical Corporation, October 1989.

Driver, J.H., P.L. Roney, M.E. Ginevan, R.G. Tardiff. Evaluation of the Chemical Safety of Monoethyl ether for Users of Writing Instruments. RiskFocus report prepared for the Writing Instrument Manufacturers Association, August 1989.

Tardiff, R.G., P.L. Roney, and T. Nelky. Chemical and Toxicological Evaluation of Dynalith. RiskFocus report prepared for Eaton Corporation, August 1989.

Tardiff, R.G. Response to Issues Related to EPA's Proposed Regulation of 38 Substances Under the Safe Drinking Water Act and Its Amendments. RiskFocus report prepared for the Edison Electric Company, August 1989.

Roney, P.L., and R.G. Tardiff. Scientific Evaluation of the Public Health Significance of Airborne Levels of Carbon Disulfide. RiskFocus report prepared for Hazel, Thomas, Fiske, Beckhorn, & Hanes, May 1989.

Whitehouse, J., T. Nesky, P.L. Roney, and R.G. Tardiff. Chemical Analysis for PCB on Surfaces on Santa Cruz Ranch. RiskFocus report prepared for Pillsbury, Madison, & Sutro, May 1989.

Driver, J.H., M.E. Ginevan, N. Owen, F. Marzulli, and R.G. Tardiff. Evaluation of the Cancer Risks of β-Butyrolactone for Users of Writing Instruments for Compliance with California's Proposition 65. RiskFocus report prepared for Weil, Gotshal, and Manges, March 1989.

Driver, J.H., M.E. Ginevan, M. Alford, and R.G. Tardiff. Scientific Evaluation of the Public Health Significance of Airborne Levels of Chloroform from Mallinckrodt's St. Louis Plant (St. Louis, MO). RiskFocus report prepared for Mallinckrodt, Inc., March 1989.

Driver, J.H., M.E. Ginevan, M. Alford, and R.G. Tardiff. Scientific Evaluation of the Public Health Significance of Airborne Levels of Methyl Isobutyl Ketone from Mallinckrodt's St. Louis Plant (St. Louis, MO). RiskFocus report prepared for Mallinckrodt, Inc., March 1989.

Driver, J.H., M.E. Ginevan, M. Alford, and R.G. Tardiff. Scientific Evaluation of the Public Health Significance of Airborne Levels of Toluene from Mallinckrodt's St. Louis Plant (St. Louis, MO). RiskFocus report prepared for Mallinckrodt, Inc., March 1989.

Tardiff, R.G. Safety Evaluation of Intersept® for Selected Uses, Second Edition. RiskFocus report prepared for Interface Research Corporation, 1989.

Roney, P.L., S. Noren, M.E. Ginevan, F. Marzulli, and R.G. Tardiff. Evaluation of the Chemical Safety of Michler's Ketone for User's of Writing Instruments. RiskFocus report prepared for the Writing Instrument Manufacturers Association, December 1988.

Driver, J.H., P.L. Roney, M.E. Ginevan, and R.G. Tardiff. Evaluation of the Health Consequences of Exposures to Trichloroethylene and Other Compounds in Tap Water of Residents of Dublin, Pennsylvania. RiskFocus report prepared for Skadden, Arps, Slate, Meagher, & Flom, November 1988.

Driver, J.H., E. Guida, and R.G. Tardiff. Evaluation of Exposures and possible Health Consequences Associated with Occupational Exposures to "Clean-All-D." RiskFocus report prepared for Weil, Gotshal, and Manges, October 1988.

Brown, S. L., R. G. Tardiff, and R. Putzrath. Health Risk Assessment of Chemical Mixtures. Environ report prepared for the ECAO, Environmental Protection Agency, June 1988.

Brown, S. L., R. G. Tardiff, and B. Seidman. Health Risk Assessment of Less-than-Lifetime Exposures to Chemicals. Environ report prepared for the ECAO, Environmental Protection Agency, June 1988.

Tardiff, R.G., D. Turnbull, S. Brett, and A. Clevenger. Critical Evaluation of Carcinogenicity and Epidemiology Studies of Crystalline Silica. Environ report prepared for Manville Corp., February 1988.

Tardiff, R.G., B. Seidman, and D. Turnbull. 2,4-Diaminotoluene Release by Polyesterurethane Foam: An Assessment of the Carcinogenic Risk to Humans. Environ report prepared for C.R. Bard, Inc., December 1987.

Brown, S., M. Kaplan, N. Rachman, and R.G. Tardiff. Use Classification of Inert Ingredients in Pesticide Formulations. Environ report prepared for EPA's Office of Policy, Planning, and Evaluation, December 1987.

Tardiff, R.G., D. Turnbull, V. Frankos, and S. Brown. Assessment and Ranking of Chemicals for Acute and Other Short-Term Exposures. Environ report prepared for EPA's Environmental Criteria and Assessment Office, December 1987.

Brown, S. L., and R.G. Tardiff. Aquatic Toxicity of Formaldehyde and Phenol in Big Creek. Environ report prepared for Bryan, Cave, McPheeters, & McRoberts, August 1987.

Turnbull, D., M. Ginevan, and R.G. Tardiff. Illustration of Uncertainty in Determining Acceptable Levels of Human Exposure to Chemicals. Environ report prepared for the Chemical Manufacturers Association, August 1987.

Tardiff, R.G., and D. Turnbull. Assessment of Potential Risks to "Solvent Sniffers" from the Use of Allyl Isothiocyanate as a Denaturant. Environ report prepared for Gillette Company, June 1987.

Gough, M., J.V. Rodricks, and R.G. Tardiff. Dioxin: A Critical Review of Its Distribution, Mechanism of Action, Impacts on Human Health, and the Setting of Acceptable Exposure Limits. Environ report prepared for National Council of Paper Industry for Air and Stream Improvement, Inc., May 1987.

Gough, M., J.V. Rodricks, and R.G. Tardiff. Dioxin and Its Human Health Significance. Environ report prepared for National Council of the Paper Industry for Air and Stream Improvement, Inc., May 1987.

Fishbein, L., D. Turnbull, and R.G. Tardiff. Examination of the Occurrence in Food of the Chemicals Regulated under California's Safe Drinking Water and Toxic Enforcement Act of 1986. Environ report prepared for the Grocery Manufacturers Association, April 1987.

Scofield, R., R. Powell, and R.G. Tardiff. Potential Health Risks from Former Manufactured-Gas Plant Sites: Toxicity and Chemical Property Profiles. Environ report prepared for Pacific Gas & Electric Co., Southern California Edison, and Southern California Gas Company, March 1987.

Powell, R., R. Scofield, and R. Tardiff. Potential Health Risks from Former Manufactured-Gas Plant Sites: Exposure Assessment. Environ report prepared for Pacific Gas & Electric Co., Southern California Edison, and Southern California Gas Company, January 1987.

Turnbull D., and R.G. Tardiff. Safety Evaluation of Hexazinone. Environ report prepared for Hawaii Sugar Planters Assn., December 1986.

Tardiff, R.G., J. Storm, D. Turnbull, and V. Frankos. Examination of the Severity of Toxic Effects and Recommendation of a Systematic Approach to Rank Adverse Effects. Environ report prepared for the Environmental Protection Agency, September 1986.

Tardiff, R.G., and D. Turnbull. Assessment of Possible Health Risk Associated with Eighteen-Month Exposure to Ethylene Oxide Released to the Atmosphere from the Salinas Plant of McCormick & Co. Environ report prepared for McCormick & Co., August 1986.

Tardiff, R.G., and D. Turnbull. Assessment of Possible Health Risks Associated with Exposure to Ethylene Oxide Released to the Atmosphere from the Salinas Plant of McCormick & Co. Environ report prepared for McCormick & Co., January 1986, and June 1986 Supplement.

Scott, M., and R.G. Tardiff. Modeling of Human Exposures to Ethylene Oxide from Air Emissions at McCormick & Co.'s Schilling Plant. Environ report prepared for McCormick & Co., January 1986.

Harris, R.H., R.G. Tardiff. S. Reith, S. Youngre, D.A. Okun. Water quality considerations in the selection of sources of additional Water for EBMUD. Report prepared for EBMUD, January 1985.

Tardiff, R.G., and D. Turnbull. Analysis of Potential Human Health Risk and Approaches to Setting Action Levels for Pesticides in Drinking Water. Environ report prepared for Honolulu Board of Water Supply, Hawaii Department of Health, and Hawaii Office of Environmental Quality Control, December 1985.

Tardiff, R.G., D. Turnbull, and R. Scofield. Analysis of Potential Carcinogenic Risk of Isophorone. Environ report prepared for Union Carbide Agricultural Products Company, December 1985.

Tardiff, R.G., D. Turnbull, and C. St.Hilaire. Factors Influencing Interspecies Extrapolation of Carcinogenicity Data. Environ report for Chemical Manufacturers Association, December 1985.

Tardiff, R.G., and S.H. Youngren. Trihalomethanes: Health Risks Revisited. Water Research Quarterly, AWWA Research Foundation, October-December, 1985.

Tardiff, R.G., and D. Turnbull. Analysis of Health Risks of Nitrosocarbaryl from Registered Uses of Carbaryl. Environ report prepared for Union Carbide Agricultural Products Company, Inc., November 1985.

Tardiff, R.G., and V. Frankos. Acrylonitrile: Research Plan to Reduce Major Uncertainties in Assessing Risk to Human Health. Environ report prepared for the Standard Oil Company of Ohio, October 1985.

Tardiff, R.G. Evaluation of Possible Future Health Risks to Occupants of Hanover Townhouses, Lexington, Kentucky. Environ report prepared for Marathon Oil Company, October 1985.

Tardiff, R.G. Evaluation of the Health Hazards and Regulatory Status of Chlorine Dioxide as a Disinfectant of Potable Water. Environ report prepared for Delta Management Group (Silver Spring, MD), September 1985.

Rodricks, J.V., R.G. Tardiff, and D. Turnbull. Review and Evaluation of Office of Toxic Substances Draft Risk Assessment on 1,3-Butadiene. Environ report prepared for the Chemical Manufacturers Association, May 1985.

Highland, J., R.G. Tardiff, D. Turnbull, and R.J. Jaeger. A Risk Analysis Developing Safe Levels of Toxicants in Soils at the Kearny Works AT&T Technology Systems. Environ report prepared for AT&T Technology Systems, March 1985.

Harris, R.H., R.G. Tardiff, S. Reith, S. Youngren, and D.A. Okum. Water Quality Consideration in the Selection of Source of additional Water for the East Bay Municipal Utility District. Environ report prepaed for East Bay Municipal Utility District (Oakland, CA), January 1985.

Putzrath, R. and R.G. Tardiff. Comparison of the Fate of Free and Particulate-Associated Pollutants after Inhalation. Environ report prepared for the Health Effects Institute, December 1984.

Tardiff, R.G., and R. Putzrath. Hypersusceptability to Air Pollutants: Glucose-6-Phosphate Dehydrogenase Deficiency and the Risk of Hemolysis from Oxidants. Environ report prepared for the Health Effects Institute, October 1984.

Tardiff, R.G., G. Wrenn, and J.V. Rodricks. Peer Review of the U.S. Environmental Protection Agency's 1984 Exposure Assessment Initiative. Environ report prepared for EPA's Office of Research and Development, September 1984.

Rodricks, J.V., R.G. Tardiff, and D. Turnbull. Review of Risk Assessments Contained in EPA's Preregulatory Assessment of 2-Methoxyethanol, 2-Ethoxyethanol, and Their Acetates. Environ report prepared for Chemical Manufacturers Association, March 1984.

Tardiff, R.G., D. Turnbull, J.S. Schlesinger, and T.S. Totah. Health Risk Assessment of Inhaled Volatile Organic Compounds from Proposed Treatment of Contaminated Groundwater. Environ report prepared for Pratt & Whitney Aircraft, March 1984.

Tardiff, R.G. Mutagenicity Testing of *o*-, — and *p*-Cresol. Life Systems, Inc., report prepared for the Chemical Manufacturers Association's Cresols Task Force, October 5, 1983.

Tardiff, R.G., and B.B. Jaffe. Mathematical Models and Safety Factors. Life Systems, Inc., report to EPA's Office of Toxic Substances, November 1982.

Tardiff, R.G. Toxicologic Evaluation of Contamination of Potable Water by Chloroethylenes, Chloroethenes, and Carbon Tetrachloride. Report prepared for Pratt & Whitney Aircraft, August 1980.

Tardiff, R.G., T. Balazs, B. Fowler, M. Gilman, A. W. Hayes, I. Heyman, B. Jackson, G. Kennedy, R. Shapiro, C. Smith, C. Weil. Qualitative relationship of hepatic toxicity in man and laboratory animals. Report of the Society of Toxicology Technical Committee, Washington, D.C., 1979.

Mullaney, J.L., and R.G. Tardiff. Literature Review and Bibliography of Mammalian Toxicology of Select Munitions. Water Supply Research Laboratory, Environmental Protection Agency, National Environmental Research Center, Cincinnati. Springfield, Virginia, NTIS (Report PB-243-566) 1976.

Tardiff, R.G., and J.L. Mullaney. Mammalian Toxicology of Class B Munitions, A Literature Review. Water Supply Research Laboratory, Environmental Protection Agency, NERC, Cincinnati. Report to the U.S. Army Biomedical Research Laboratory, March, 1975.

Tardiff, R.G., *et al.* National Reconnaissance Survey: Analysis of Tap Water from 5 U.S. Cities for Volatile Organics Compounds, a Staff Report. Cincinnati, Health Effects Research Laboratory, Environmental Protection Agency, November, 1975.

Tardiff, R.G., and J.L. Mullaney. The Compounds in the "MUST" WasteWater as They Relate to Hazards in the Product Water: A Toxicity Evaluation. Water Supply Research Laboratory, Environmental Protection Agency NERC, Cincinnati. Report to the U.S. Army Biomedical Research Laboratory, October, 1973.

DuBois, K.P., K. Yam, R.G. Tardiff, and F.K. Kinoshita. Inhibition of the Development of Hepatic Microsomal Detoxification Enzymes by X-Irradiation. Toxicity Laboratory, Univ. of Chicago. Report to the School of Aerospace Medicine, U.S.A.F., December 1966.

Tardiff, R.G., and K.P. DuBois. Modification of the Radiation-Induced Increase in Adenosine Triphosphatase Activity of the Spleen by Various Chemical Agents. Toxicity Laboratory, Univ. of Chicago. Report to the School of Aerospace Medicine, Aerospace Medical Division, U.S.A.F., June, 1966.

Tardiff, R.G., and K.P. DuBois. Further Studies on the Effects of Various Drugs on the Adenosine Triphosphatase Activity of the Hematopoietic Tissues of Rats Exposed Repeatedly to Cobalt-60 Gamma Radiation. U.S.A.F. Radiation Laboratory Quarterly Progress Report No. 58, January 15, 1966.

Tardiff, R.G., and K.P. DuBois. Studies on the Effects of Various Drugs on the Adenosine Triphosphatase Activity of the Hematopoietic Tissues of Rats Exposed to Cobalt-60 Gamma Radiation. U.S.A.F. Radiation Laboratory Quarterly Progress Report No. 56, July 15, 1965.

Tardiff, R.G., and K.P. DuBois. Further Studies on the Adenosine Triphosphatase Activity of the Hematopoietic Tissues of Rats Exposed to Cobalt-60 Radiation. U.S.A.F. Radiation Laboratory Quarterly Progress Report No. 55, April 15, 1965.

Tardiff, R.G., and K.P. DuBois. Application of Radiation-Induced Changes in Adenosine Triphosphatase Activity of Hematopoietic Tissues to a Study of Chronic Gamma Radiation and the Influence of Various Factors on Acute Radiation Injury. U.S.A.F. Radiation Laboratory Quarterly Progress Report No. 54, January 15, 1965.

* * * * *

NATIONAL RESEARCH COUNCIL REPORTS DIRECTED AND MANAGED

National Research Council. *Drinking Water and Health, Vol. 5.* Washington, D.C.: National Academy Press, 1983. 157 pp.

National Research Council. *Research Briefings for the Office of Science and Technology Policy, the National Science Foundation, and Selected Federal Departments and Agencies.* Washington, D.C.: National Academy Press, 1983.

National Academy Council, Herbicides and birth defects in the Republic of Vietnam. Report prepared by R. G. Tardiiff, 1982, pp. 73.

National Research Council, Committee on Response Strategies to Unusual Chemical Hazards. *Assessment of Multichemical Contamination. Proceedings of an International Workshop held April 28-30, 1981, in Milan, Italy.* Washington, D.C.: National Academy Press, 1982.

National Research Council. *Drinking Water and Health, Vol. 4.* Washington, D.C.: National Academy Press, 1982. 299 pp.

National Research Council, Committee on Response Strategies to Unusual Chemical Hazards. *Plans for Clinical and Epidemiologic Follow-up after Area-wide Chemical Contamination.* Washington, D.C.: National Academy Press, 1982.

National Research Council, Panel on Quality Criteria for Water Reuse. *Quality Criteria for Water Reuse.* Washington, D.C.: National Academy Press, 1982.

National Research Council, Steering Committee on Identification of Toxic and Potentially Toxic Chemicals for Consideration by the National Toxicology Program. *Strategies to Determine Needs and Priorities for Toxicity Testing, Vol. II. Development.* Washington, D.C.: National Academy Press. 1982.

National Research Council, Steering Committee on the Identification of Toxic and Potentially Toxic Chemicals for Consideration by the National Toxicology Program. *Strategies to Determine Needs and Priorities for Toxicity Testing, Vol. I. Design.* Washington, D.C.: National Academy Press, 198l.

National Research Council. 1980. *Drinking Water and Health, Vol 2.* Washington, D.C.: National Academy Press, 1980. 393 pp.

National Research Council. *Drinking Water and Health, Vol. 3.* Washington, D.C.: National Academy Press, 1980. 415 pp.

National Research Council and Institute of Medicine, Committee for a Study on Saccharin and Food Safety Policy. *Saccharin: Technical Assessment of Risks and Benefits.* Washington, D.C.: National Academy of Sciences, 1978.

National Research Council. *Drinking Water and Health.* Washington, D.C.: National Academy of Sciences, 1977. 939 pp.

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Toxicologic Safety Evaluation: Urethane Grout Material Present in Honolulu Board of Water Supply Reservoirs

Prepared for

Honolulu Board of Water Supply (BWS)
Honolulu, Hawaii

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October 2012

INTRODUCTION AND BACKGROUND —

As reported by BWS, on August 13, 2012, during routine chlorination of the reservoirs, Board of Water Supply (BWS) personnel reportedly discovered quantities, noticeable to the naked eye, of a cellophane, gel-like material floating on the water surface in the Aina Haina 395 Reservoir No. 2. The total amount of material floating in the reservoirs could not be estimated with certainty. Based on contractor records, BWS estimated that the floating material might have been in the reservoir water for as much as 45 days. Efforts to remove the material through the reservoir overflow line proved unsuccessful. This reservoir was removed from tap water storage service on August 15, 2012, and BWS initiated an investigation into the origin and cause of the floating material.

BWS reported having examined other concrete storage tanks for tap water, and finding the one at Barbers Point 215 Reservoir No. 3 (3 million gallon capacity) to also have noticeable amounts of debris floating on the water surface. The debris looked like thin sheets of amber-colored cellophane, and appeared to be of the same magnitude as that observed in the Aina Haina 395 Reservoir.

In September, BWS contacted Dr. Robert G. Tardiff of *Toxicologic Consultative Service, LLC* [TCS] seeking a toxicologic safety evaluation to determine whether the floating material in Aina Haina 395 Reservoir No. 2 and in the Barber's Point 215 No. 3 reservoir might have either caused injury to consumers of tap water or risk of injury to consumers of the ingredients of the grout material. Subsequently, BWS contracted with TCS to carry out that evaluation.

BWS reported that the Aina Haina 395 Reservoir No. 2 is a 300,000 gallon concrete tank that serves several areas on Oahu; and Barbers Point 215 No. 3 is a 3 million gallon concrete tank also serving several areas on Oahu. BWS also represented that these facilities are currently under contract to repair cracks and leaks in reservoir walls. BWS further noted that the project scope-of-work specifies using a polymeric formulation called De Neef Hydro Active Flex LV (Flex LV) and De Neef Hydro Active Flex SLV (Flex SLV) to seal the cracks. According to Materials Data Sheets (MSDS) provided to TCS by BWS and obtained from the product manufacturer, both products contain the same active ingredient that when in contact with water polymerizes into a foam urethane used specifically for sealing cracks in potable water storage and distribution structures. Both products are applied to cracks under pressure, are approved by the National Sanitation Foundation (NSF) Standard 61 for contact with tap water via this application, and, according to the product manufacturer, may be applied while a reservoir fully contains tap water.

According to documentation from the manufacturer, the active ingredient in both the Hydro Active Flex LV and Hydro Flex SLV is a chemical called <u>4,4'-DiphenylMethane Diisocyanate</u> (CAS No. 101-68-8; this compound is used in a wide array of commercial products). The foam urethane polymer is formed by mixing specified amounts of 4,4'-diphenylmethane diisocyanate with <u>dibutyl phthalate</u> (CAS No. 84-74-2; used to accelerate polymerization; present widely in cosmetics). The latter compound serves as a catalyst to accelerate the polymerization of the diisocyanate, a curing and hardening process that occurs within less than a half hour, according to its manufacturer. The resulting urethane polymer is not water soluble, according to its manufacturer. The manufacturer also indicates that the Flex LV may be used with and without addition of the catalyst (*i.e.*, dibutyl phthalate).

APPROACH AND METHOD —

To undertake this prescribed toxicologic safety evaluation of the floating material and its two ingredients in each of the two reservoirs considered herein, the following methodology was employed.

A cornerstone of this evaluation is a principle that the "dose makes or does not make the poison." Some level of dose or dose rate is needed to produce adverse events to tissues and organs of the body. The human body has numerous defense mechanisms that will allow an exposed individual to suffer no adverse effect. Some of these include the rate of elimination through excretory organs, metabolism of an otherwise toxic dose to a non-toxic dose, inability or limited ability to be absorbed from the point of contact such as the gastro-intestinal tract or skin, and detoxification via macromolecular (e.g., protein) binding. Clearly if no exposure existed, no risk of injury, however transient, can exist; and even if some exposure has occurred, the dose may prove insufficient to alter adversely even a single cell.

Thus the method of evaluation includes first an estimation of possible durations of consumption and possible doses of the chemicals in question that might have been received by BWS consumer of its tap water from either of the two subject tanks. Next, the toxic potency of each chemical of interest is determined from scientific observations of assorted types and/or from definitions of safety from authoritative organizations.

Once values from each step are obtained, they are compared to estimate a Margin of Exposure (MoE)[1] that allows one to judge whether a possibility of injury might have been present or may occur post exposure. This methodology has been used widely in toxicological assessments of short-term exposures to chemicals in drinking water and other media.

1. *Estimation of Possible Dose and Dose Rate to Polymer and Monomers*

The exposures to the material in question would have been relatively brief (a few days to a few weeks, likely less than 45 days, according to reports from the BWS subcontractor). When evaluating the safety of a chemical in drinking water, such durations are generally referred to as "short-term," or as "acute" in toxicological parlance. Given the magnitude of the volume of water in Aina Haina and Barbers Point reservoirs and the relatively small proportion of the floating material observed, had there been any consumption of the material, it would likely have been intermittent, that is, not every day of the 45-day duration, based on the BWS representation of the use pattern of water from these two tanks. Indeed, since water in the tanks was drawn from their bottom and the material observed was at or near the top of the water levels, it is quite likely that none of the material reached the distribution system. Thus the probability that customers served by these tanks would have consumed these materials or would have had their skin come into contact with the material in question appears to be relatively small. No empirical evidence indicates that the polymer and its two monomers were present in any consumer's tap water originating from either tank.

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[1] Formerly described by regulatory agencies, non-governmental organizations (NGO), and others as "margin of safety" or MoS.

Nonetheless, the floating material was quite likely the diisocyanate polymer that had been incorrectly formulated from the two monomeric constituents, a conclusion consistent with the manufacturer's certification that the diisocyanate monomer alone will polymerize within approximately one to two hours upon coming into contact with water; and it is known that the grouting was performed when the tanks were filled with water. In this scenario, 10 μg/L (ppb) of the polymer is assumed to be the highest likely concentration of the polymer in the Aina Haina and Barbers Point reservoir water, given the amount of material used to fill cracks and the large water volume of each of the two reservoirs. That assumption is based on the following considerations.

For the Aina Haina reservoir, BWS has been provided with crude estimates of the cumulative dimensions of the multiple cracks filled with the grout products as 360 linear ft, 1/16 inch wide, and 12 inches deep (from limited records provided by BWS's subcontractor). Upon inspection of the grouted cracks, it appeared to BWS representatives that only a small fraction of the applied grout was missing among the cracks, suggesting that as an upper-bound perhaps as much as 10% of the grout applied was released into the tank water and polymerized therein. It is our understanding that this estimate may have a somewhat low degree of confidence.

The amount of grout material that was estimated to have been used for the cracks in the Aina Haina reservoir was 120 pounds (approximately 60 kg), based on records from the BWS subcontractor; however, this estimate also has a low degree of confidence because of limitations in data collection. Relying upon this limited information, the amount of polymer that might have been released into the tank water may have been as high as 10% of the amount administered or six kilograms of polymer into 300,000 gallons (= approximately 1.2 million liters) of water. That amount is approximately equivalent to a concentration of approximately 4 to 8 μg/L (ppb) of polymer in the Aina Haina tank. However, no empirical data are available to verify this estimated value. Despite the presence of considerable uncertainties in this estimation, relying on a concentration of 10 ppb remains a reasonable upper-bound value.

For the Barbers Point reservoir, BWS has been provided with crude estimates of the cumulative dimensions of the multiple cracks filled with the grout products as 240 linear ft, 1/16 inch wide, and 12 inches deep (from limited records provided by the BWS subcontractor). Upon inspection of the grouted cracks, it appeared to BWS representatives that only a small fraction of the applied grout was missing among the cracks, suggesting that as an upper-bound perhaps as much as 10% of the grout applied was released into the tank water and polymerized. It is our understanding that this estimate may have a somewhat low degree of confidence.

The amount of grout material that was estimated to have been used for the cracks in the Barbers Point reservoir was approximately 250 pounds (approximately 125 kg), based on records from the BWS subcontractor; however, this estimate also has a low degree of confidence because of limitations in data collection. Relying upon this limited information, the amount of polymer that might have been released into the tank water may have been as high as 10% of the amount administered or 12.5 kilograms of polymer into 3 million gallons (= approximately 12 million liters) of water. That amount is equivalent to a concentration of approximately 0.5 to 3 μg/L (ppb) of polymer in the water of the Barbers Point tank.

However, no empirical data on the Barbers Point repair are available to verify this estimated value. Despite the presence of considerable uncertainties in this estimation, relying on a concentration of 10 ppb remains a reasonable upper-bound value.

One might hypothesize that not only was the polymer present in the Aina Haina and Barbers Point tanks but also that each of the monomers might have been present. Facts about the chemistry of the diisocyanate monomer make that a virtual impossibility after one to two hours in which the diisocyanate came in contact with the water in each tank. However, dibutyl phthalate is water soluble and would be unlikely to polymerize by itself in water. Note that no empirical evidence indicates that either compound was present in water of either Aina Haina or Barbers Point tanks.

For purposes of examining the hypothetical, albeit likely unrealistic, possibility that either monomer might have been present in the water contained in the Aina Haina and Barbers Point tanks and so as to estimate the Margins of Exposure for each, it is assumed the maximum concentration of each could have been no more than 10 µg/L, based on the information described above in this section of the report.

2. *Characterization of Acute Toxic Potency for the Polymer and its Two Monomers*

Since the chemical contaminant in question was most likely the polymerized diisocyanate, consumption of the polymer in tap water should pose little risk of systemic illness, because the size of a polymer molecule such as this one would be too large to be absorbed from the GI tract into the circulation, thereby providing no risk to other tissues in the body. However, in large enough doses, the diisocynate polymer may cause irritation of the bowel, accompanied by nausea, vomiting, abdominal pain, and diarrhea. These symptoms would be transient; since polymer molecules are quite large, they would pass through the digestive tract and be excreted with other normal waste products. Furthermore, the physical nature of the diisocyanate polymer would be such that intestines would be unable to break down the polymer into its monomeric state, making it unlikely that monomer toxicity would occur.

4.4'-DiphenylMethaneDiisocyanate has been used widely in occupational situations; most human exposures have been via inhalation and skin contact, and not via ingestion. This compound is not acutely toxic to humans or laboratory animals. However, long-term inhalation has been shown to cause asthma, hypersensitivity, and irritation of the upper respiratory tract in workers. In chronic rodent inhalation studies, this compound has been described as having insufficient data to identify it as a carcinogen in laboratory animals or humans. In this lifetime study, a threshold for non-neoplastic toxicity has been reported to be a chronic inhalation level of 0.19 mg/m^3. It also has been tested for the possibility of causing genetic abnormalities, but the findings were inconclusive. The compound has been tested in a standard protocol by inhalation for maternal and fetal toxicity, and a threshold level below which no adverse developmental effects were found was an inhalation dose of 9 mg/m^3. This compound has been shown by inhalation to be absorbed via the lungs; and because of its chemical reactivity, it combines with proteins, a process that can act as a detoxification event (WHO, 2000).

The Occupational Safety and Health Administration (OSHA) has set a safe level of exposure to diisocyanate in the air of workplaces of 0.2 mg/m^3 to protect against the most sensitive toxic effects, namely skin irritation and pulmonary sensitization. This standard applies to exposure durations of 8 hours per day, 5 days per week, for 35 years.

Dibutyl Phthalate also has been studied to define its toxic potential. Acute exposures to the undiluted chemical can cause mild irritation to the eyes and upper respiratory tract. For humans, this compound is defined as having "low" acute toxicity; that is, large doses (e.g., grams, not milligrams or micrograms) are needed to elicit even mild and transient effects. When ingested in high doses (grams), this compound has been reported to cause nausea, dizziness, sensitivity to light, redness of the eyes, and transient kidney inflammation (OSHA, 2012). Dibutyl Phthalate, at high doses, was shown to have produced anatomic malformations in laboratory animals; and California has listed it as a "suspected teratogen" under its 1986 Proposition 65 statute.

The Occupational Safety and Health Administration (OSHA) has set a safe level of exposure to dibutyl phthalate in the air of workplaces of 5.0 mg/m^3 to protect against the most sensitive toxic effects, namely skin irritation and nausea. This standard applies to exposure durations of 8 hours per day, 5 days per week, for 35 years.

TOXICOLOGIC EVALUATION —

This step entails comparing the estimated ingestion exposure values for the compounds of interest to toxicologically relevant reference values, in this case authoritative values aimed at protecting humans exposed repeatedly and chronically to these compounds. The only authoritative values are those promulgated by the Occupational Safety and Health Administration (OSHA) to protect workers over their working lifetime (35 years), called 8-hr Threshold Limit Value (TLV). It is important to recognize that OSHA's TLVs already have a margin of safety incorporated within them. No health standards were found to address the ingestion of the polymer and its two monomers over a relatively brief period of time (i.e., few days to a few weeks) by any US regulatory agency. Since the OSHA values are expressed as inhalation doses, they must be converted to ingestion doses, a process described below for each compound of interest. In addition, since neither compound is cumulative in the body, it is defensible to use total aggregate dose to the comparisons.

The comparison method uses a metric referred to as a Margin of Exposure (MoE) which has been relied upon by the US Environmental Protection Agency (EPA) and other agencies and organizations. The MoE is derived by dividing the imputed safe level of exposure by the estimated dose.

The resulting MoE is judged in this circumstance to generate values that reflect the magnitude of the extension of an original level of safety imposed by the authoritative body (OSHA in this case). Professional practice in toxicology holds that the larger the MoE the greater the confidence in the safety of the estimated exposures and doses. For instance, an MoE of at least 1,000 would provide a high confidence that those exposed would experience no adverse effects during the time of ingestion of a compound of interest or thereafter.

For the Diisocyanate Polymer, the MoE is infinity, because no reference value is available and because by qualitative understanding it appears highly unlikely that ingesting 10 ppb of the polymer for brief periods of time will produce any adverse effects in consumers.

For the Diisocyanate Monomer, the OSHA standard (inhalation and skin contact) is 0.2 mg/m^3 which is unlikely to cause toxic injury for exposures of 8 hours per day/5 days per week for 35 years; this translates into a daily dose of 2.0 mg/person per day (assumes 10 m^3 per day) and weekly dose of 50 mg/person; and a total lifetime dose of 17,500 mg (=17,500,000 µg) [this compound is not bioaccumulative]. Hypothetically, If the water containing diisocyanate had reached a consumer of that water at a concentration of 10 µg and if that consumer had drunk two liters of that water per day for 7 days, the individual would have received a total dose of 140 µg per person. Thus, the MoE between these values is roughly <u>125,000</u>, a value which strongly supports the unlikelyhood that any acute toxicity is likely to be manifest. No scientific evidence indicates or suggests that this compound at 10 ppb in water is capable of producing adverse health effects after cessation of exposure.

For Dibutyl Phthalate, the OSHA standard (inhalation and skin contact) is 5.0 mg/m^3 which is unlikely to cause toxic injury for exposures of 8-hours per day/5 days per week for 35 years; this translates into a daily dose of 20.0 mg/person per day (assumes 10 m^3 per day) and weekly dose of 100 mg/person; and a total lifetime dose of 437,500 mg (=437,500,000 µg) [this compound is not bioaccumulative]. Hypothetically, If the water containing dibutyl phthalate had reached a consumer of that water at a concentration of 10 µg and if that consumer had drunk two liters of that water per day for 7 days, the individual would have a total dose of 140 µg per person. Thus the MoE between these values is roughly <u>3,120,000,</u> a value strongly supporting the unlikelyhood that any acute toxicity is likely to occur. No scientific evidence indicates or suggests that this compound at 10 ppb in water is capable of producing adverse health effects after cessation of exposure.

CONCLUSIONS —

Based on the information described above, the following conclusions were reached:

1. Since the chemical contaminant in question was most likely the polymerized diisocyanate, consumption of the polymer in tap water should pose little or no risk of systemic illness, because the size of a polymer molecule such as this one would be too large to be absorbed from the GI tract into the circulation, thereby providing no risk to other tissues in the body.

2. If hypothetically the diisocyanate monomer were present at 10 ppb in the tap water of these tanks for a brief period of time, the MoE between these values is roughly <u>125,000</u> which is sufficiently large to conclude that no acute toxicity is likely to have occurred and that forms of delayed toxicity will occur among the consumers of the BWS water.

3. If hypothetically the dibutyl phthalate may have been present at 10 µg/L in the tap water of these tanks for a brief period of time, the MoE between these values is roughly <u>3,120,000,</u> a value which is sufficiently large to conclude confidently that no acute toxicity is likely to have occurred and that no forms of delayed toxicity will occur among the BWS consumers.

4. Confidence is somewhat low for the estimated concentrations and amounts of the chemicals in the water of the two tanks. Confidence is high with respect to the estimates of the safe

reference doses of the polymer and two monomers. Hence, the degree of confidence for the overall safety evaluation is at least moderate or somewhat better.

In summary, based on very large margins of exposure estimated for the chemicals in question, the amount of sealant material present briefly in two water tanks posed no significant threat to public health or to the safety of the water supply both at the time of the event and thereafter.

REFERENCES —

OSHA [Occupational Safety and Health Administration], 2012. Occupational Safety and Health Guiddeline for Dibutyl Phthalate. Washington, DC. Available at www.osha.gov/sltc/healthguidelines.

WHO [World Health Organization], 2000. Diphenylmethyl Diisocyanate. Concise International Chemical Assessment Document 27. Geneva, Switzerland.

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CONSTRUCTION CHEMICALS, INC.

MATERIAL SAFETY DATA SHEET

HYDRO ACTIVE® FLEX CAT ACTIVATOR

Rev. 09/08

SECTION 1: PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: HYDRO ACTIVE® Flex Cat Activator

MANUFACTURER: *de neef* Construction Chemicals Inc.
ADDRESS: 5610 Brystone Drive
Houston, TX 77095
PHONE: (800) 732-0166 (7am-5pm CST Weekdays)
FAX: (713) 849-3340
WEBSITE: www.deneef.com

EMERGENCY PHONE: CHEMTREC (800) 424-9300 (Anytime)
Outside US: 1-703-527-3887

SECTION 2: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW:

DANGER: CORROSIVE! CAUSES CHEMICAL BURNS

APPEARANCE AND ODOR:
Clear to slightly amber liquid with a slightly musty / amine odor.

REACTIVE:
Avoid acids, chlorine and oxidizers.

POTENTIAL HEALTH EFFECTS

EYES:
Can cause severe eye irritation. Prolonged exposure to eyes can cause severe chemical burns. Uncontrolled vapor exposure may cause severe pain or serious damage to eye.

SKIN:

Can cause severe skin irritation. Prolonged exposure to skin can cause severe chemical burns. Exposure can cause latent severe burns. Heated product may cause thermal burns if contacted.

INGESTION:

Small amounts may cause injury.

INHALATION:

Prolonged or repeated high level exposures may cause severe irritation of respiratory passages and/or lung congestion.

SECTION 3: HAZARDOUS INGREDIENTS

Name	CAS NO.	% wt/wt
Cocoalkyldimethylamine	61788-93-0	15%-40%
Di-N-Butyl Phthalate	84-74-2	15%-40%

SECTION 4: FIRST AID MEASURES

EYES: Immediately flush eyes gently with water for at least 15 minutes, while holding open upper and lower lids. Immediately seek medical attention.

SKIN: Immediately wash thoroughly with mild soap and water. If available, use an appropriate decontamination skin cleanser. Remove contaminated clothing and wash before reuse. Destroy contaminated shoes. Immediately obtain medical attention.

INGESTION: SEEK IMMEDIATE MEDICAL ATTENTION! DELAYED TREATMENT MAY RESULT IN FATALITY. Do not induce vomiting. If victim is fully conscious, dilute stomach contents with large amounts of milk or water. Never give anything by mouth to an unconscious person. Immediately call a physician.

INHALATION: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Immediately get medical attention.

SECTION 5: FIRE-FIGHTING MEASURES

FLASH POINT:
CC >266˚F (>130˚C)

EXTINGUISHING MEDIA:
Dry Chemical, CO_2, Foam or Water Fog

SPECIAL FIRE FIGHTING PROCEDURES:
A MSHA/NIOSH approved self-contained breathing apparatus should be worn. Do not scatter material with high pressure water streams.

HAZARDOUS DECOMPOSITION PRODUCTS:
Fire or intense heat will decompose the product into Butene, Butanol & Phthalic Anhydride.

SECTION 6: ACCIDENTAL RELEASE MEASURES

ACCIDENTAL RELEASE MEASURES:
Where exposure level is known, wear approved respirator suitable for the level of exposure. If exposure level is unknown, wear approved, positive pressure, self-contained respirator. In addition to the protective clothing in section 8, wear impermeable boots. Prevent from reaching waterways.

CLEAN-UP PROCEDURES:
Remove sources of ignition. Dike and contain the spill with inert material (i.e., sand, earth, sawdust) and transfer liquid and solid diking material to separate containers for recovery or disposal. Wash floor area with hot water solution. Remove contaminated clothing and wash before reuse. Wash affected skin areas with soap and water. Keep spills out of all sewers and bodies of water.

SECTION 7: HANDLING AND STORAGE

HANDLING:
Avoid skin and eye contact. Wash thoroughly after handling. Keep product away from heat and open flame. Handle in accordance with good hygiene and safety procedures. Avoid contact with eyes, skin, and clothing. Wash thoroughly after handling. Since empty containers contain product residue and can be dangerous, follow all hazard warnings and precautions even after container is emptied. Keep away from sources of ignition.

STORAGE:
Maintain storage temperatures between 65°F to 86°F (18°C to 30°C). Do not allow product to freeze. Do not use if previously frozen. Store in original closed containers in a cool, dry, well-ventilated area. Store separately from all combustible, organic and oxidizable materials. Keep from contact with oxidizing materials. Containers should be kept tightly closed and stored in a dry well-ventilated place

SECTION 8: EXPOSURE CONTROLS/ PERSONAL PROTECTION

Dibutyl Phthalate:
OSHA PEL-TWA: 5 mg/m^3

Cocoalkyldimethylamine:
Exposure limits not established.

ENGINEERING CONTROLS:
Local exhaust: preferred. Mechanical may be necessary if working at elevated temperatures or in enclosed areas.

SECTION 8: EXPOSURE CONTROLS/ PERSONAL PROTECTION (CONTINUED)

RESPIRATORY PROTECTION:

Use an appropriate NIOSH/MSHA approved respirator for exposure to contaminated atmosphere. A NIOSH/MSHA approved self-contained breathing apparatus or air-supplied respirator is recommended if the concentration exceeds the capacity of cartridge respirator. WARNING: Air purifying respirators do not protect workers in oxygen-deficient atmospheres.

EYE PROTECTION: Safety goggles or face shield

SKIN PROTECTION: Protective gloves: Rubber or plastic depending upon degree of potential exposure, additional personal protective equipment may be required, such as chemical boots and full protective clothing.

WORK HYGIENIC PRACTICES:
Use good hygiene practices when handling this material including changing and laundering of work clothes after use.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE: Clear amber liquid

ODOR: Musty, amine odor

ODOR THRESHOLD: Not available

PHYSICAL STATE: Liquid

pH: 13

MELTING PT: 39°F (4°C)

FLASH POINT: >266°F (>130°C)

EVAPORATION RATE: Not available

FLAMMABILITY: Non-flammable

UPPER FLAMMABILITY LIMITS: Not applicable

LOWER FLAMMABILITY LIMITS: Not applicable

VAPOR PRESSURE: Not available

SPECIFIC GRAVYITY (H_2O=1): 1.01

BULK DENSITY: 8.5-8.6 lbs/gal

SOLUBILITY (H_2O): None

PARTITION COEFFICIENT: Not available

AUTO-IGNITION TEMPERATURE: Not available

VISCOSITY: 5-16 cps @ 77°F

DECOMPOSITION TEMPERATURE: Not available

SECTION 10: STABILITY AND REACTIVITY

STABILITY:
Stable under normal conditions.

CONDITIONS TO AVOID (STABILITY): High temperatures

INCOMPATIBILITY (MATERIAL TO AVOID):
Liquid Chlorine, Oxidizers, Acids

HAZARDOUS DECOMPOSITION OR BY-PRODUCTS:
Fire or intense heat will decompose the product into Butene, Butanol & Phthalic Anhydride.

HAZARDOUS POLYMERIZATION:
Explosive polymerization at 118°C when mixed with liquid chlorine.

SECTION 11: TOXICOLOGICAL INFORMATION

CARCINOGENICITY:
IARC: Group 3 (not classifiable as to its carcinogenicity in humans)
EPA: Group D

ACUTE TOXICITY

D-N-Butyl Phthalate
LD50 Oral 8,000 mg/kg (rat)
LC50: 25,000mg/m^3 (mice) Di-N-Butyl Phthalate

Cocoalkyldimethylamine
LD50: 1400 mg/kg (rat)

SECTION 12: ECOLOGICAL INFORMATION

ECOLOGICAL INFORMATION:
Does not Bioaccumulate (All Ingredients)
Biodegrade to 40% - 0% in 28 days (Dibutyl Phthalate)

SECTION 13: DISPOSAL CONSIDERATIONS

Waste Disposal Method
Waste disposal should be in accordance with existing federal, state and local environmental

control laws.

Empty Container Precautions
Empty containers retain product residue; observe all precautions for product. Do not heat or cut empty container with electric or gas torch because highly toxic vapors and gases are formed. Do not reuse without thorough commercial cleaning and reconditioning. If container is to be disposed, ensure all product residues are removed prior to disposal. Dispose of per local, state and federal guidelines as required by your specific local. This product <u>in its cured foam state</u> is inert and non-toxic.

SECTION 14: TRANSPORT INFORMATION

At quantities greater than 30 lbs, this material must be labeled RQ: Di-N-Butyl Phthalate

<u>Land Transport (DOT)</u>
Proper Shipping Name: Amines, liquid, corrosive, n.o.s. (contains fatty acid derived amines). Marine pollutant (Alkyl (C12-C14) dimethylamine)
Hazard Class or Division: 8
UN Number: UN2735
Packing Group: III
Hazard label: Corrosive, Marine pollutant

<u>Air Transport: (ICAO/IATA)</u>
Proper Shipping Name: Amines, liquid, corrosive, n.o.s. (contains fatty acid derived amines)
Hazard Class or Division: 8
UN Number: UN2735
Packing Group: III
Hazard label: Corrosive

<u>Sea Transport: (IMO)</u>
Proper Shipping Name: AMINES, LIQUID, CORROSIVE, N.O.S. (CONTAINS FATTY ACID DERIVED AMINES) MARINE POLLUTANT- (ALKYL (C12-C14) DIMETHYLAMINE)
Hazard Class or Division: 8
UN Number: UN2735
Packing Group: III
Hazard label: Corrosive, Marine pollutant

SECTION 15: REGULATORY INFORMATION

U.S. FEDERAL REGULATIONS:

All components in this product are either listed on or exempt from the TSCA inventory.

WHMIS:
All components are listed on the CEPA Domestic Substances List (DSL)

Ingredient Disclosure List (IDL), the following components are on the list:

Di-N-Butyl Phthalate	84-74-2

NFPA HAZARD CLASSIFICATION:
HEALTH: 3 FLAMMABILITY: 1 REACTIVITY: 0

SECTION 16: OTHER INFORMATION

PREPARATION INFORMATION:
September 2008
This MSDS is on a three year review cycle. If the date on this sheet is older than three years please contact *de neef* Construction Chemicals Inc. for an updated MSDS.

DISCLAIMER:
All information appearing herein is based on manufacturer and/ or recognized technical sources. While the information is believed accurate *de neef* Construction Chemicals Inc. makes no representations as to the accuracy or sufficiency of the information.

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CONSTRUCTION CHEMICALS, INC.

MATERIAL SAFETY DATA SHEET HYDRO ACTIVE® FLEX LV Rev. 04/09

SECTION 1: PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: HYDRO ACTIVE® FLEX LV

MANUFACTURER: *de neef* Construction Chemicals Inc.
ADDRESS: 5610 Brystone Drive
Houston, TX 77095
PHONE: (800) 732-0166 (7am-5pm CST Weekdays)
FAX: (713) 849-3340
WEBSITE: www.deneef.com

EMERGENCY PHONE: CHEMTREC (800) 424-9300 (Anytime)
Outside US: 1-703-527-3887

SECTION 2: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: (ERG CODE 171)

APPEARANCE AND ODOR: Clear to amber liquid with a slightly musty odor.

REACTIVE: Product will polymerize when exposed to water.

POTENTIAL HEALTH EFFECTS

EYES: Causes irritation with symptoms of reddening, tearing, stinging, and swelling. May cause temporary corneal injury. Vapor or aerosol may cause irritation with symptoms of burning and tearing. Product may polymerize in eye.

CHRONIC EYE: Prolonged vapor contact may cause conjunctivitis

SKIN:
Causes irritation with symptoms of reddening, itching, and swelling. Persons previously sensitized can experience allergic skin reaction with symptoms of reddening, itching, swelling, and rash. Contact with skin can cause product to polymerize. Cured material is difficult to remove. Contact with MDI can cause discoloration.

CHRONIC SKIN: Prolonged contact can cause reddening, swelling, rash, and, in some cases, skin sensitization. Animal tests on MDI indicate skin contact alone may lead to an allergic respiratory reaction.

INGESTION:
May cause irritation; Symptoms may include abdominal pain, nausea, vomiting, and diarrhea. Carcinogenicity: No Carcinogenic substances as defined by IARC, NTP and/or OSHA

SECTION 2: HAZARDS IDENTIFICATION (Continued)

INHALATION:
Diisocyanate vapors or mist can irritate (burning sensation) the mucous membranes in the respiratory tract (nose, throat, lungs) causing runny nose, sore throat, coughing, chest discomfort, shortness of breath and reduced lung function (breathing obstruction).

CHRONIC INHALATION
As a result of previous repeated overexposures or a single large dose, certain individuals may develop sensitization to diisocyanates (asthma or asthma-like symptoms).

SECTION 3: HAZARDOUS INGREDIENTS

Name	CAS NO.	% wt/wt
4,4'-Diphenylmethane Diisocyanate	101-68-8	3% - 4%

SECTION 4: FIRST AID MEASURES

EYES: Immediately flush eyes gently with water for at least 15 minutes, while holding open upper and lower lids. Product reacts with moisture in eye! Immediately seek medical attention.

SKIN: Remove contaminated clothing. Blot or brush the product away, prior to washing the exposed area with water. The cured product on the skin is rarely a cause of irritation (If it does, seek medical attention). The process of trying to remove the cured product may cause irritation.

INGESTION: SEEK IMMEDIATE MEDICAL ATTENTION! DELAYED TREATMENT MAY RESULT IN FATALITY. Do Not Induce Vomiting. Rinse mouth out with water. Aspiration of material into the lungs due to vomiting can cause chemical pneumonitis which can be fatal.

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CONSTRUCTION CHEMICALS, INC.

MATERIAL SAFETY DATA SHEET HYDRO ACTIVE® FLEX LV Rev. 04/09

SECTION 4: FIRST AID MEASURES (continued)

INHALATION: Move to an area free from further exposure. Get medical attention immediately. Administer oxygen or artificial respiration as needed. Asthmatic symptoms may develop and may be immediate or delayed up to several hours. Extreme asthmatic reactions can be life threatening.

SECTION 5: FIRE-FIGHTING MEASURES (ERG CODE 171)

FLASH POINT & METHOD USED:
ASTM D93 >270°F (>132°C)

EXTINGUISHING MEDIA:
Dry Chemical, CO_2, Foam or Water Fog

SPECIAL FIRE FIGHTING PROCEDURES:
Do not scatter material with high pressure water streams. Firefighters should wear NFPA compliant structural firefighting protective equipment, including self-contained breathing apparatus and NFPA compliant helmet, hood, boots and gloves. Avoid contact with product. Decontaminate equipment and protective clothing prior to reuse. During a fire, isocyanate vapors and other irritating, highly toxic gases may be generated by thermal decomposition or combustion. Exposure to heated diisocyanate can be extremely dangerous Closed container may forcibly rupture under extreme heat or when contents are contaminated with water (CO2 formed). Use cold-water spray to cool fire-exposed containers to minimize the risk of rupture. Large fires can be extinguished with large volumes of water applied from a safe distance, since reaction between water and hot diisocyanate can be vigorous.

HAZARDOUS DECOMPOSITION PRODUCTS:
Fire or intense heat will decompose the product into CO_2, CO, Hydrogen Cyanide, Oxides of Nitrogen, Isocyanates, Isocyanic Acid, and dense black smoke.

SECTION 6: ACCIDENTAL RELEASE MEASURES (ERG CODE 171)

ACCIDENTAL RELEASE MEASURES: Where exposure level is known, wear approved respirator suitable for the level of exposure. If exposure level is unknown, wear approved, positive pressure, self-contained respirator. In addition to the protective clothing in section 8, wear impermeable boots.

CLEAN-UP PROCEDURES: Remove sources of ignition. Stop and contain / dam the spill. Absorb spill with inert material (vermiculite / diatomaceous earth). Shovel material into appropriate container for disposal.

SECTION 7: HANDLING AND STORAGE

HANDLING:
Do not breathe vapors, mists, or dusts. Use adequate ventilation to keep airborne isocyanate levels below the exposure limits. Wear respiratory protection if material is heated, sprayed, used in a confined space, or if the exposure limit is exceeded. Warning properties (irritation of the eyes, nose and throat or odor) are not adequate to prevent overexposure from inhalation. This material can produce asthmatic sensitization upon either single inhalation exposure to a relatively high concentration or upon repeated inhalation exposures to lower concentrations. Individuals with lung or breathing problems or prior allergic reactions to isocyanates must not be exposed to vapor or spray mist. Avoid contact with skin and eyes. Wear appropriate eye and skin protection.
Wash thoroughly after handling. Do not breathe smoke and gases created by overheating or burning this material. Decomposition products can be highly toxic and irritating. Store in tightly closed containers to prevent moisture contamination. Do not reseal if contamination is suspected.

STORAGE:
Keep in manufacturer's sealed nitrogen packed pail. Maintain storage temperatures between 65°F to 86°F (18°C to 30°C).

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

4,4'- Diphenylmethane Diisocyanate:

ACGIH PEL-TWA:	0.005 ppm
NIOSH Ceiling:	0.02ppm at 10 minutes
OSHA PEL (vacated)CEILING:	0.02 ppm, 0.2mg/m^3

ENGINEERING CONTROLS:
Normal room ventilation is usually adequate under normal use. Local exhaust should be used to maintain levels below the TLV whenever MDI is heated, sprayed, or aerosolized. Standard reference sources regarding industrial ventilation (e.g., ACGIH Industrial Ventilation Manual) should be consulted for guidance about adequate ventilation. To ensure that published exposure limits have not been exceeded, monitoring for airborne diisocyanate should become part of the overall employee exposure characterization program.

INHALATION:
Diisocyanate vapors or mist at concentrations above the TLV or PEL can irritate (burning sensation) the mucous membranes in the respiratory tract (nose, throat, lungs) causing runny nose, sore throat, coughing, chest discomfort, shortness of breath and reduced lung function (breathing obstruction). Persons with a preexisting, nonspecific bronchial hyper reactivity can respond to concentrations below the TLV or PEL with similar symptoms as well

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION (continued)

as asthma attack or asthma-like symptoms. Exposure well above the TLV or PEL may lead to bronchitis, bronchial spasm and pulmonary edema (fluid in lungs). Chemical or hypersensitivity pneumonitis, with flu-like symptoms (e.g., fever, chills), has also been reported. These symptoms can be delayed up to several hours after exposure. These effects are usually reversible.

CHRONIC INHALATION
As a result of previous repeated overexposures or a single large dose, certain individuals may develop sensitization to diisocyanates (asthma or asthma-like symptoms) that may cause them to react to a later exposure to diisocyanates at levels well below the TLV or PEL. These symptoms, which can include chest tightness, wheezing, cough, shortness of breath or asthmatic attack, could be immediate or delayed up to several hours after exposure. Extreme asthmatic reactions can be life threatening. Similar to many non-specific asthmatic responses, there are reports that once sensitized an individual can experience these symptoms upon exposure to dust, cold air or other irritants. This increased lung sensitivity can persist for weeks and in severe cases for several years. Sensitization can be permanent. Chronic overexposure to diisocyanates has also been reported to cause lung damage (including fibrosis, decrease in lung function) that may be permanent.

RESPIRATORY PROTECTION:
Airborne MDI concentrations greater than the ACGIH TLV-TWA (TLV) or OSHA PEL-C (PEL) can occur in inadequately ventilated environments when MDI is sprayed, aerosolized, or heated. In such cases, respiratory protection must be worn. The type of respiratory protection selected must comply with the requirements set forth in OSHA's Respiratory Protection Standard (29 CFR 1910.134). The type of respiratory protection available includes (1) an atmosphere-supplying respirator such as a self-contained breathing apparatus (SCBA) or a supplied air respirator (SAR) in the positive pressure or continuous flow mode, or (2) an air-purifying respirator (APR). If an APR is selected then (a) the cartridge must be equipped with an end-of-service life indicator (ESLI) certified by NIOSH, or(b) a change out schedule, based on objective information or data that will ensure that the cartridges are changed out before the end of their service life, must be developed and implemented. The basis for the change out schedule must be described in the written respirator program. Further, if an APR is selected, the airborne diisocyanate concentration must be no greater than 10 times the TLV or PEL. The recommended APR cartridge is an organic vapor/particulate filter combination cartridge (OV/P100).

EYE PROTECTION: Safety goggles or face shield

SKIN PROTECTION: Use gloves; wear protective clothing to prevent skin contact. In cured form, the product is difficult to remove from skin and hair.

WORK HYGIENIC PRACTICES: Use good hygiene practices when handling this material including changing and laundering of work clothes after use.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE: Clear to amber
ODOR: Slightly musty odor
ODOR THRESHOLD: Not available
PHYSICAL STATE: Liquid
pH: Neutral
MELTING PT: <- 4°F (<- 20°C)
FLASH POINT (CC):>270°F (>132°C)
EVAPORATION RATE: Not available
FLAMMABILITY: Non-flammable
UPPER FLAMMABILITY LIMITS: Not applicable
LOWER FLAMMABILITY LIMITS: Not applicable
VAPOR PRESSURE:0.0006 mm Hg @ 40°C
SPECIFIC GRAVITY (H_2O=1): 1.15
BULK DENSITY: 8.7-9.2 lbs/gal
SOLUBILITY (H_2O): None
PARTITION COEFFICIENT: Not available
AUTO-IGNITION TEMPERATURE: Not available
DECOMPOSITION TEMPERATURE: <212°F(<100°C)
VISCOSITY: 400-800 cps @ 72°F

SECTION 10: STABILITY AND REACTIVITY

STABILITY: Contact with moisture or temperatures above 350° F (177° C) will cause polymerization.

CONDITIONS TO AVOID (STABILITY): Will polymerize with heat and/or moisture.
INCOMPATIBILITY (MATERIAL TO AVOID): Amines, Strong Bases, Alcohols, Copper Alloys, Liquid Chlorine. Water- until ready to react.

HAZARDOUS DECOMPOSITION OR BY-PRODUCTS: Fire or intense heat will decompose the product into CO_2, CO, Hydrogen Cyanide, Oxides of Nitrogen, Isocyanates, Isocyanic Acid, and dense black smoke.
During normal polymerization CO_2 is produced.

HAZARDOUS POLYMERIZATION: During normal polymerization CO_2 is produced.

SECTION 11: TOXICOLOGICAL INFORMATION

CARCINOGENICITY:

4,4'-Diphenylmethane Diisocyanate
IARC: Group 3 (not classifiable as to its carcinogenicity in humans)
EPA- CBD
MAK: 4

SECTION 11: TOXICOLOGICAL INFORMATION continued

ACUTE TOXICITY
4,4'-Diphenylmethane Diisocyanate
Oral LD50 (rat) >5800 mg/kg
Inhalation LC50 (rat) : 14ppm/4hrs
Dermal LD50 (rabbit) : >16 mL/kg

SECTION 12: ECOLOGICAL INFORMATION

Does not Bioaccumulate (All Ingredients)
Biodegrade to 0% in 28 days (4,4'- Diphenylmethane Diisocyanate)
Biodegrade to 70% compressive strength in 80 years (cured foam state)

SECTION 13: DISPOSAL CONSIDERATIONS

Waste Disposal Method
Waste disposal should be in accordance with existing federal, state and local environmental control laws. Incineration is the preferred method.

Empty Container Precautions
Empty containers retain product residue; observe all precautions for product. Do not heat or cut empty container with electric or gas torch because highly toxic vapors and gases are formed. Do not reuse without thorough commercial cleaning and reconditioning. If container is to be disposed, ensure all product residues are removed prior to disposal. Dispose of per local, state and federal guidelines as required by your specific local. This product in its cured foam state is inert and non-toxic.

SECTION 14: TRANSPORT INFORMATION

Not regulated by DOT, ITA, or IMO

SECTION 15: REGULATORY INFORMATION

U.S. FEDERAL REGULATIONS

Ingredient	TSCA	CERCLA RQ	SARA 302	SARA 313
4,4'- Diphenylmethane Diisocyanate	Yes	5000 lbs	No	Yes

TSCA: All ingredients are listed in or exempt from the TSCA Master Inventory File

WHMIS:
All ingredients are listed on the CEPA Domestic Substances List (DSL)

Ingredient Disclosure List (IDL), the following components are on the list:

4,4'- Diphenylmethane Diisocyanate	101-68-8

SECTION 16: OTHER INFORMATION

NFPA HAZARD CLASSIFICATION:
HEALTH: 2 FLAMMABILITY: 1 REACTIVITY: 1
HMIS:
HEALTH: 2 FLAMMABILITY: 1 PHYSICAL HAZARD: 1

PREPARATION INFORMATION:
April, 2009
This MSDS is on a three year review cycle. If the date on this sheet is older than three years please contact *de neef* Construction Chemicals Inc. for an updated MSDS.

DISCLAIMER:
All information appearing herein is based on manufacturer and/ or recognized technical sources. While the information is believed accurate *de neef* Construction Chemicals Inc. makes no representations as to the accuracy or sufficiency of the information.

de neef

CONSTRUCTION CHEMICALS, INC.

MATERIAL SAFETY DATA SHEET HYDRO ACTIVE® FLEX SLV Rev. 05/09

SECTION 1: PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: HYDRO ACTIVE® FLEX SLV

MANUFACTURER: *de neef* Construction Chemicals Inc.
ADDRESS: 5610 Brystone Drive
Houston, TX 77095
PHONE: (800) 732-0166 (7am-5pm CST Weekdays)
FAX: (713) 849-3340
WEBSITE: www.deneef.com

EMERGENCY PHONE: CHEMTREC (800) 424-9300 (Anytime)
Outside US: 1-703-527-3887

SECTION 2: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: (ERG CODE 171)

APPEARANCE AND ODOR: Clear to amber colored liquid with a slightly musty odor.

REACTIVE: Product will polymerize when exposed to water.

POTENTIAL HEALTH EFFECTS

EYES: Causes irritation with symptoms of reddening, tearing, stinging, and swelling. May cause temporary corneal injury. Vapor or aerosol may cause irritation with symptoms of burning and tearing. Product may polymerize in eye.

CHRONIC EYE: Prolonged vapor contact may cause conjunctivitis

SKIN:
Causes irritation with symptoms of reddening, itching, and swelling. Persons previously sensitized can experience allergic skin reaction with symptoms of reddening, itching, swelling, and rash. Contact with skin can cause product to polymerize. Cured material is difficult to remove. Contact with MDI can cause discoloration.

CHRONIC SKIN: Prolonged contact can cause reddening, swelling, rash, and, in some cases, skin sensitization. Animal tests on MDI indicate skin contact alone may lead to an allergic respiratory reaction.

INGESTION:
May cause irritation; Symptoms may include abdominal pain, nausea, vomiting, and diarrhea. Carcinogenicity: No Carcinogenic substances as defined by IARC, NTP and/or OSHA

SECTION 2: HAZARDS IDENTIFICATION (Continued)

INHALATION:
Diisocyanate vapors or mist can irritate (burning sensation) the mucous membranes in the respiratory tract (nose, throat, lungs) causing runny nose, sore throat, coughing, chest discomfort, shortness of breath and reduced lung function (breathing obstruction).

CHRONIC INHALATION
As a result of previous repeated overexposures or a single large dose, certain individuals may develop sensitization to diisocyanates (asthma or asthma-like symptoms).

SECTION 3: HAZARDOUS INGREDIENTS

Name	CAS NO.	% wt/wt
4,4'-Diphenylmethane Diisocyanate	101-68-8	7%-11%

SECTION 4: FIRST AID MEASURES

EYES: Immediately flush eyes gently with water for at least 15 minutes, while holding open upper and lower lids. Product reacts with moisture in eye! Immediately seek medical attention.

SKIN: Remove contaminated clothing. Blot or brush the product away, prior to washing the exposed area with water. The cured product on the skin is rarely a cause of irritation (If it does, seek medical attention). The process of trying to remove the cured product may cause irritation.

INGESTION: SEEK IMMEDIATE MEDICAL ATTENTION! DELAYED TREATMENT MAY RESULT IN FATALITY. Do Not Induce Vomiting. Rinse mouth out with water. Aspiration of material into the lungs due to vomiting can cause chemical pneumonitis which can be fatal.

SECTION 4: FIRST AID MEASURES (continued)

INHALATION: Move to an area free from further exposure. Get medical attention immediately. Administer oxygen or artificial respiration as needed. Asthmatic symptoms may develop and may be immediate or delayed up to several hours. Extreme asthmatic reactions can be life threatening.

SECTION 5: FIRE-FIGHTING MEASURES (ERG CODE 171)

FLASH POINT & METHOD USED:
ASTM D93 > 266°F (>130°C)

EXTINGUISHING MEDIA:
Dry Chemical, CO_2, Foam or Water Fog

SPECIAL FIRE FIGHTING PROCEDURES:
Do not scatter material with high pressure water streams. Firefighters should wear NFPA compliant structural firefighting protective equipment, including self-contained breathing apparatus and NFPA compliant helmet, hood, boots and gloves. Avoid contact with product. Decontaminate equipment and protective clothing prior to reuse. During a fire, isocyanate vapors and other irritating, highly toxic gases may be generated by thermal decomposition or combustion. Exposure to heated diisocyanate can be extremely dangerous Closed container may forcibly rupture under extreme heat or when contents are contaminated with water (CO2 formed). Use cold-water spray to cool fire-exposed containers to minimize the risk of rupture. Large fires can be extinguished with large volumes of water applied from a safe distance, since reaction between water and hot diisocyanate can be vigorous.

HAZARDOUS DECOMPOSITION PRODUCTS:
Fire or intense heat will decompose the product into CO_2, CO, Hydrogen Cyanide, Oxides of Nitrogen, Isocyanates, Isocyanic Acid, and dense black smoke.

SECTION 6: ACCIDENTAL RELEASE MEASURES (ERG CODE 171)

ACCIDENTAL RELEASE MEASURES: Where exposure level is known, wear approved respirator suitable for the level of exposure. If exposure level is unknown, wear approved, positive pressure, self-contained respirator. In addition to the protective clothing in section 8, wear impermeable boots.
CLEAN-UP PROCEDURES: Remove sources of ignition. Stop and contain / dam the spill. Absorb spill with inert material (vermiculite / diatomaceous earth). Shovel material into appropriate container for disposal.

SECTION 7: HANDLING AND STORAGE

HANDLING:
Do not breathe vapors, mists, or dusts. Use adequate ventilation to keep airborne isocyanate levels below the exposure limits. Wear respiratory protection if material is heated, sprayed, used in a confined space, or if the exposure limit is exceeded. Warning properties (irritation of the eyes, nose and throat or odor) are not adequate to prevent overexposure from inhalation. This material can produce asthmatic sensitization upon either single inhalation exposure to a relatively high concentration or upon repeated inhalation exposures to lower concentrations. Individuals with lung or breathing problems or prior allergic reactions to isocyanates must not be exposed to vapor or spray mist. Avoid contact with skin and eyes. Wear appropriate eye and skin protection.
Wash thoroughly after handling. Do not breathe smoke and gases created by overheating or burning this material. Decomposition products can be highly toxic and irritating. Store in tightly closed containers to prevent moisture contamination. Do not reseal if contamination is suspected.

STORAGE:
Keep in manufacturer's sealed nitrogen packed pail. Maintain storage temperatures between 65°F to 86°F (18°C to 30°C).

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4,4'- Diphenylmethane Diisocyanate:

ACGIH PEL-TWA:	0.005 ppm
NIOSH Ceiling:	0.02ppm at 10 minutes
OSHA PEL (vacated)CEILING:	0.02 ppm, 0.2mg/m^3

ENGINEERING CONTROLS:
Normal room ventilation is usually adequate under normal use. Local exhaust should be used to maintain levels below the TLV whenever MDI is heated, sprayed, or aerosolized. Standard reference sources regarding industrial ventilation (e.g., ACGIH Industrial Ventilation Manual) should be consulted for guidance about adequate ventilation. To ensure that published exposure limits have not been exceeded, monitoring for airborne diisocyanate should become part of the overall employee exposure characterization program.

INHALATION:
Diisocyanate vapors or mist at concentrations above the TLV or PEL can irritate (burning sensation) the mucous membranes in the respiratory tract (nose, throat, lungs) causing

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION (continued)

INHALATION: (continued)
runny nose, sore throat, coughing, chest discomfort, shortness of breath and reduced lung function (breathing obstruction). Persons with a preexisting, nonspecific bronchial hyper reactivity can respond to concentrations below the TLV or PEL with similar symptoms as well as asthma attack or asthma-like symptoms. Exposure well above the TLV or PEL may lead to bronchitis, bronchial spasm and pulmonary edema (fluid in lungs). Chemical or hypersensitivity pneumonitis, with flu-like symptoms (e.g., fever, chills), has also been reported. These symptoms can be delayed up to several hours after exposure. These effects are usually reversible.

CHRONIC INHALATION
As a result of previous repeated overexposures or a single large dose, certain individuals may develop sensitization to diisocyanates (asthma or asthma-like symptoms) that may cause them to react to a later exposure to diisocyanates at levels well below the TLV or PEL. These symptoms, which can include chest tightness, wheezing, cough, shortness of breath or asthmatic attack, could be immediate or delayed up to several hours after exposure. Extreme asthmatic reactions can be life threatening. Similar to many non-specific asthmatic responses, there are reports that once sensitized an individual can experience these symptoms upon exposure to dust, cold air or other irritants. This increased lung sensitivity can persist for weeks and in severe cases for several years. Sensitization can be permanent. Chronic overexposure to diisocyanates has also been reported to cause lung damage (including fibrosis, decrease in lung function) that may be permanent.

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SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION (continued)

EYE PROTECTION: Safety goggles or face shield

SKIN PROTECTION: Use gloves; wear protective clothing to prevent skin contact. In cured form, the product is difficult to remove from skin and hair.

WORK HYGIENIC PRACTICES: Use good hygiene practices when handling this material including changing and laundering of work clothes after use.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE: Clear to amber colored
ODOR: Slightly musty odor
ODOR THRESHOLD: Not available
PHYSICAL STATE: Liquid
pH: Neutral
MELTING PT: <- 4°F (<- 20°C)
FLASH POINT (CC):>266°F (>130°C)
EVAPORATION RATE: Not available
FLAMMABILITY: Non-flammable
UPPER FLAMMABILITY LIMITS: Not applicable
LOWER FLAMMABILITY LIMITS: Not applicable
VAPOR PRESSURE: Not available
SPECIFIC GRAVITY (H_2O=1): 1.15
BULK DENSITY: 9.0-9.15 lbs/gal
SOLUBILITY (H_2O): None
PARTITION COEFFICIENT: Not available
AUTO-IGNITION TEMPERATURE: Not available
DECOMPOSITION TEMPERATURE: <212°F(<100°C)
VISCOSITY: 150-250 cps @ 72°F

SECTION 10: STABILITY AND REACTIVITY

STABILITY: Contact with moisture or temperatures above 350° F (177° C) will cause polymerization.

CONDITIONS TO AVOID (STABILITY): Will polymerize with heat and/or moisture.
INCOMPATIBILITY (MATERIAL TO AVOID): Amines, Strong Bases, Alcohols, Copper Alloys, Liquid Chlorine. Water- until ready to react.

HAZARDOUS DECOMPOSITION OR BY-PRODUCTS: Fire or intense heat will decompose the product into CO_2, CO, Hydrogen Cyanide, Oxides of Nitrogen, Isocyanates, Isocyanic Acid, and dense black smoke.
During normal polymerization CO_2 is produced.

HAZARDOUS POLYMERIZATION: During normal polymerization CO_2 is produced.

SECTION 11: TOXICOLOGICAL INFORMATION

CARCINOGENICITY:

4,4'-Diphenylmethane Diisocyanate
IARC: Group 3 (not classifiable as to its carcinogenicity in humans)
EPA- CBD
MAK: 4

ACUTE TOXICITY
4,4'-Diphenylmethane Diisocyanate
Oral LD50 (rat) >5800 mg/kg
Inhalation LC50 (rat) : 14ppm/4hrs
Dermal LD50 (rabbit) : >16 mL/kg

SECTION 12: ECOLOGICAL INFORMATION

Does not Bioaccumulate (All Ingredients)
Biodegrade to 0% in 28 days (4,4'- Diphenylmethane Diisocyanate)
Biodegrade to 70% compressive strength in 80 years (cured foam state)

SECTION 13: DISPOSAL CONSIDERATIONS

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Waste disposal should be in accordance with existing federal, state and local environmental control laws. Incineration is the preferred method.

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SECTION 14: TRANSPORT INFORMATION

Not regulated by DOT, IATA, or IMO

SECTION 15: REGULATORY INFORMATION

U.S. FEDERAL REGULATIONS

Ingredient	TSCA	CERCLA RQ	SARA 302	SARA 313
4,4'- Diphenylmethane Diisocyanate	Yes	5000 lbs	No	Yes

TSCA: All ingredients are listed in or exempt from the TSCA Master Inventory File

WHMIS:
All ingredients are listed on the CEPA Domestic Substances List (DSL)

Ingredient Disclosure List (IDL), the following components are on the list:

4,4'- Diphenylmethane Diisocyanate	101-68-8

SECTION 16: OTHER INFORMATION

NFPA HAZARD CLASSIFICATION:
HEALTH: 2 FLAMMABILITY: 1 REACTIVITY: 1
HMIS:
HEALTH: 2 FLAMMABILITY: 1 PHYSICAL HAZARD: 1

PREPARATION INFORMATION:
May 2009
This MSDS is on a three year review cycle. If the date on this sheet is older than three years please contact *de neef* Construction Chemicals Inc. for an updated MSDS.

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