Chemical Engineers:
Trusted Voice on Technical Matters of Public Concern…or Not?

Process Safety and Loss Management Symposium
Societal Expectations Session, Wednesday October 31, 2007
Paper #556
57th Canadian Chemical Engineering Conference
Edmonton, Alberta

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Our Chemical Engineering profession is relatively new, a field that has grown from black art to a central science in 350 years. This rapid evolution has had a downside: the general public, taking for granted the benefits of chemistry, looks at the mounting evidence of environmental impacts and chronic health effects and assumes our field is out of control. We must get better at engaging in honest and open dialogue with the public on the challenges presented by manufacture of the products which the public requires. The rapid advances in process safety management in the past 20 years show that we are capable of merging technical solutions and management discipline to make a difference. As professionals, we must earn trust or we forfeit our credibility by default. The CIC's existing structure of constituent societies, subject divisions and local sections is called to provide leadership in taking a public stand on issues related to chemistry.

Introduction:

Over the past forty-plus years of my career, I've often mused about the fact that as engineers, we don't get to have a title prefixing our names as medical doctors do. We don't get elected in droves to public office at the municipal, provincial and federal levels as lawyers do. Even among our fellow engineering professionals, as chemical engineers, we are in a 10% minority. Our expertise is based on what is to most people a relatively abstract and bewildering science, abounding in infinite variability. That causes even other engineers to think of us as not really engineers!

History of Our Profession:

Although other professions date back several millennia, chemical engineering is very new, by comparison. The evolution of chemistry, as a modern science, from the black art of alchemy, took about 200 years, beginning about the middle of the 17th century. It was championed by a diverse and visionary group of individuals: Joseph Priestly, Henry Cavendish, Humphry Davy and John Dalton of England, Karl Wilhelm Scheele and Jons Jakob Berzelius of Sweden, Antoine-Laurent Lavoisier and Jacques Charles of France, Robert Boyle of Ireland, Benjamin Thompson of the United States, Friedrich Wöhler, Robert Bunsen and Eduard Buchner of Germany, Lorenzo Avogadro of Italy and Dmitri Mendeleev of Russia. Their developmental work formed the foundation of the science of chemistry.

The first generation of chemical process industries was small-scale batch production of fine and specialty chemicals. This did not require the special capabilities now associated with chemical engineering. In the early to mid 19th century, Germany was the leading chemical producing nation world-wide and the level of technology necessary came from the collaborative efforts of chemists and mechanical engineers as chemical manufacturing moved from laboratory-scale chemistry to batch production. Those "plants" were very small-scale by today's standards. Germany, in spite of having been early into chemical production, was a latecomer among industrialized nations in developing a chemical engineering profession, for that very reason.

In the late 19th and early 20th centuries, society's needs and quality of life expectations grew. This created demand for the same heavy industrial commodity chemicals: sulphuric acid, sodium hydroxide and chlorine, that are still in demand today. The contact process for the former and the electrolysis of sodium chloride brine for the latter two moved into the realm of technological demands that not even chemists and mechanical engineers in collaboration could handle.

Chemical engineers, with our unique disciplinary approaches of unit operations and reaction engineering filled the void. The trend to higher production capacities made continuous process capability an advantage, if not essential. These new plants required large-scale continuous reactors and continuous mass transfer devices never before in existence. Large-scale and continuous is where our chemical engineering profession really comes into prominence, eclipsing the pure chemists.

George Davis emerged from the British alkali industry with a unique way of looking at processing operations, emphasizing the underlying unity among seemingly different operations. He presented a series of twelve lectures on these unit operations in 1887 at what is now the University of Manchester. In 1901, he published this lecture series as his “Handbook of Chemical Engineering”. In 1915, the American, Arthur D. Little, made a pitch to the President of Massachussetts Institute of Technology to emphasize this unit operations approach as the foundation of North America’s first chemical engineering program.

Early in the 20th century, as petroleum products were required to fuel and lubricate the booming automobile era, chemical engineers came to the forefront to satisfy the requirements of the refining industry. To accommodate this accelerating demand, after MIT, university programs in chemical engineering were established early at Toronto, McGill and UBC, as well as at Pennsylvania and Tulane. Today, 20 post-secondary institutions in Canada offer bachelors’ and advanced level degrees in Chemical Engineering.

A later further evolutionary step in our profession was provided when Octave Levenspiel converged simple design methods, graphical procedures, and understanding of the fundamental capability characteristics of the major reactor types in a way that matched unit operations in its applicability. His launching of chemical reaction engineering made it the basic unified approach that now underlies the successful design and operation of large-scale batch and continuous chemical reactors.

Where We Find Ourselves Now:

Now let’s fast-forward across most of the 20th century. Not because it wasn’t important; quite to the contrary. The vast majority of the public, probably taking for granted the quality of life that chemistry has contributed, look at the mounting evidence of environmental impacts and chronic health effects and assume that we chemical professionals “drove it like we stole it” for 100 years! And, in general, we as a chemistry community, have been very ineffective in doing anything at all to correct the reputation we’ve developed.

How We Catch Up:

I had a personally educational experience nearly 25 years ago, a year before Bhopal, when I was production manager of a chemical pulp mill located in the downtown heart of a small town in northwestern Ontario. The rupture of one of our vaporizers and the resultant release of chlorine gas triggered a knee-jerk evacuation of 1,500 nearby residents. Our company knew we had to depart from the standard approach of having our communications officer speak to the press and public.

Being designated spokesman at a public meeting, I was overwhelmed by the feeling of being able to share my technical understanding to inform the public. It had nothing to do with being the centre of attention. It had everything to do with sharing my knowledge on a user-friendly basis with the intention of informing, not impressing. It connected back to a lesson learned from my Dad twenty years earlier and which carries ahead into exactly what I am talking about here and now. His advice was to use my God-given ability to get an education and then share what I knew with people less fortunate. Otherwise my education would have been a waste of time and effort. You never forget a message like that!

Our profession made a landmark commitment, just prior to the turn of the century, in 1997. It happened in London, England, at the 75th anniversary conference of the Institution of Chemical Engineers. A meeting of 18 heads of the profession from around the world, including our Canadian Society for Chemical Engineering, gave rise to the London Communiqué. It said "'we, the representatives of 18 societies representing chemical engineers worldwide and acting here in our personal capacities, subscribe to the following statement: the key challenge for our profession in the twenty-first century is: ‘to use our skills to improve the quality of life: foster employment, advance economic and social development, and protect the environment. This challenge encompasses the essence of sustainable development. We will work to make the world a better place for future generations’."

The Communiqué listed seven areas in which chemical engineers will specifically respond. That list included "engage in honest and open dialogue with the public on the challenges presented by manufacture of the products which the public requires." The Chemical Institute of Canada’s vision is that chemistry is central to the well-being of society. It must be recognized as benefiting every facet of life.

Sustainable improvement will only be achieved through public education on the importance and positive aspects of chemistry in everyday life. Knowledge and understanding are keys to avoiding harm and benefiting from the appropriate use of all chemicals. As chemical professionals, we are called to advance the principles and practices of the chemical sciences and engineering for the betterment of society, relative to the environment; health and safety and economy and energy.

In August 2003, the CIC issued a policy statement on “Taking a Public Stand on Issues Related to Chemistry”. This has been succinctly expressed by CIC Executive Director Roland Andersson in the May 2003 issue of ACCN. It is stated clearly on the Chemical Institute of Canada web site under “Vision and Values”. Now we must crisply focus on the need to identify the issues to be considered. Building from that, the CIC has since issued a direction statement entitled “Towards 2015”. This is the subject of CIC President Cathy Cardy’s article in the February 2007 issue of ACCN. The whole point is that CIC members are the experts and so the CIC and its members must become the reliable and accurate source of information on science matters and issues.

We, as scientists, must be trusted or lose credibility. Trust, as discussed by Stephen Covey, comes from the convergence of two core virtues: integrity and competence. Integrity means we have to be honest and competence means we have to know what we are doing, and be seen to know. To that I would add, in dealing with a field as misunderstood and intimidating as chemistry, both require the ultimate in transparency and the ability to communicate in ways that can be understood by our non-expert audience.

Call for Action:

Let's not ever think that is a "flavour of the year" with a priority that will fade. Consider this: in December 1965, after more than three years of intense renewal activity, the Second Vatican Council of the Roman Catholic Church came to a close. Among the core theme messages transmitted was the one entitled "To Men of Thought and Science", delivered by Cardinal Paul-Emile Leger, Archbishop of Montreal. The message, said, in part: "What other basic principle is there for men of science except to be sure your thought processes are reasoned and correct…and while possessing the truth, search…to renew it, deepen it and transmit it to others." Considering that's from over 40 years ago and originally written in Latin, it's astoundingly relevant! Our scientific community has been under scrutiny for a long time. People are waiting!

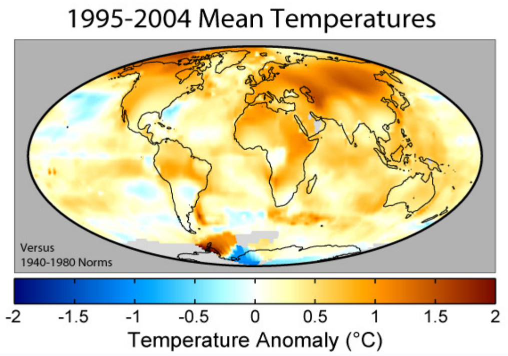
Now it's time to do something about it! Before we start to disseminate information, we need collect information on what issues are most critical to the public. I have my own personal top five priorities and just to get the thought process kick-started, here they are.

Making Chemical Process Plants Safer for Employees and the General Public

I am starting with Process Safety Management because that Division is hosting this presentation and because developments in that particular discipline form the template for other channels of endeavour. For the broader audience not so familiar, Process Safety Management is application of management principles and systems to the control of process hazards to prevent process-related loss. It has evolved from developing purely technical solutions to applying crisply focused management. In many countries, chemical engineering societies provide the organizational leadership to advance PSM. The third edition of CSChE 's "Process Safety Management" guide, published in 2002, is really a guide to applying chemical engineering discipline and methodology to increasing the performance efficiency of a process operation, in all its aspects.

We all gain when we make our operations and our communities safer for everyone. The gains we have made here in Process Safety Management in the past two decades, since the Bhopal incident, lay the foundation for enhancing the credibility of our voices in other areas of significant public concern.

Global Climate Change



This topic becomes extremely timely in the aftermath of former US Vice-President Al Gore's Nobel Prize. Climate change refers to the long-term variation in the Earth's global climate or in regional climates over time. In recent usage, especially in the context of environmental policy, the term "climate change" often refers only to changes in modern climate, including global warming, the rise in average surface temperature of the earth.

In is now known that the net trapping of radiant energy by greenhouse gases is the primary cause of global warming. Greenhouse gases are also important in understanding Earth's climate history. According to these studies, the greenhouse effect, which is the warming produced as greenhouse gases trap heat, plays a key role in regulating Earth's temperature. The greenhouse gases subject to the Kyoto Protocol include:

- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O)
- several groups of fluorinated gases
    - trichlorofluoromethane CFC-11 (CCl_3F)
    - dichlorodifluoromethane CFC-12 (CCl_2F_2)
    - monochlorodifluoromethane HCFC-22 ($CHClF_2$)
    - tetrafluoromethane (CF_4)
    - 1,1,2-trichloro-1,2,2-trifluoroethane ($C_2Cl_3F_3$)
- carbon tetrachloride (CCl_4)
- sulphur hexafluoride (SF_6)

Ozone depletion describes two distinct but related observations: a slow, steady decline of about 3 percent per decade in the total amount of ozone in Earth's stratosphere since around 1980; and a much larger, but seasonal, decrease in stratospheric ozone over Earth's polar regions during the same period. Both ozone depletion mechanisms strengthened as emissions of CFCs and halons increased. Chlorinated fluorocarbons, halons and other contributory substances are commonly referred to as ozone-depleting substances.

There is an abundance of information and disinformation in public circulation. This critical area is one in which our technical expertise can make a major contribution, when channelled constructively.

Agrochemicals Toxic and Health Effects on Producers and Consumers

Having grown up in rural southweastern Ontario, I have a first-hand perspective of the implications of this issue. My nephews are fourth generation apple growers so the roots run deep. The use of agrochemicals is unquestionably the major factor behind the increase in agricultural productivity since the start of the 20th century. We are talking about the various chemical products used in agriculture: insecticides, herbicides, fungicides, synthetic fertilizers and chemical growth agents. The significant downside is that many agrochemicals are toxic, and virtually all agrichemicals in bulk storage pose significant environmental and/or health risks in the event of accidental spills.

A case in point is dichlorodiphenyltrichloroethane, DDT, the first and arguably the best known organic pesticide in history. It was first produced in Germany in 1874 but its insecticidal properties were not discovered until 1937. It was used early in World War II to combat mosquitoes spreading malaria and typhus among both military and civilian populations, and also as an agricultural insecticide. Chemist Paul Hermann Müller of Geigy Pharmaceutical in Switzerland was awarded the Nobel Prize in Physiology in 1948 for his discovery of the high efficiency of DDT as a contact poison against several arthropods. It became widely used in apple production for the control of the codling moth, *Cydia pomonella*.

In 1962, allegations first arose that DDT caused cancer and through the principles of biological magnification, killed higher level organisms like birds. Extrapolation of its demonstrated tendency to accumulate in cow's milk would suggest the impact could reach to humans. DDT is moderately to slightly toxic to mammals and has caused chronic effects on the nervous system, liver, kidneys, and immune systems in experimental animals. It causes adverse reproductive effects in test animals although the evidence relating of carcinogenicity provides uncertain conclusions. DDT is very fat-soluble and is therefore found in fatty foods such as meat and diary products. Analysis of human fat shows that DDT can persist for many years.

The fallout was that DDT was banned for agricultural use worldwide, including the United States in 1972 and Canada in 1985. As a chemical industry and profession, we simply cannot afford 100 year cycles from discovery to total banning!

Safe Transportation of Toxic and Explosive Chemicals by Rail, Highway and Water

Living in the proximity of a chemical processing facility and having relatives and friends employed there is one thing. Quite another again is the exposure we can all have to mobile hazards as they pass through our communities or when we encounter them as we travel.

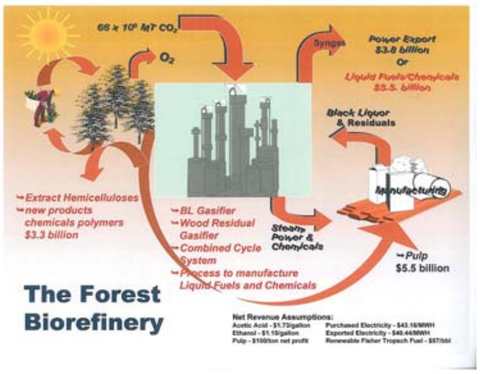
A dangerous good is any solid, liquid, or gas that can harm people, other living organisms, property, or the environment. The most widely applied regulatory scheme applied to such materials involves their transportation, since that poses the most significant exposure to the unsuspecting general public. The U. N. Economic and Social Council issues model regulations on the transportation of dangerous goods. Most regional and national regulatory schemes for hazardous materials are harmonized to a greater or lesser degree with the UN model regulation.

Dangerous goods may be radioactive, flammable, explosive, toxic, corrosive, biohazardous, an oxidizer, an asphyxiant, a pathogen, an allergen, or may have other characteristics that make them hazardous to health, safety, property or the environment during use or transportation. These materials are divided into nine classes on the basis of the specific chemical characteristics producing the risk.

Class 1: Explosives
Class 2: Gases
Class 3: Flammable liquids
Class 4: Flammable solids
Class 5: Oxidizing Agents & Organic Peroxides
Class 6: Toxic and Infectious Substances
Class 7: Radioactive Substances
Class 8: Corrosive Substances
Class 9: Miscellaneous Dangerous Substances

From the chemistry-based nature of these nine classifications, it becomes apparent that as chemical professionals, we stand at the forefront in our expertise and our capability for developing competence in dealing with such risks and in providing responsible and informed commentary to the general public. Even if we allow that in general, existing regulations are adequate, there is still a need for informed commentary to the public at the time incidents occur, to put the potential implications in perspective.

Future Potential of the Forest Biorefinery



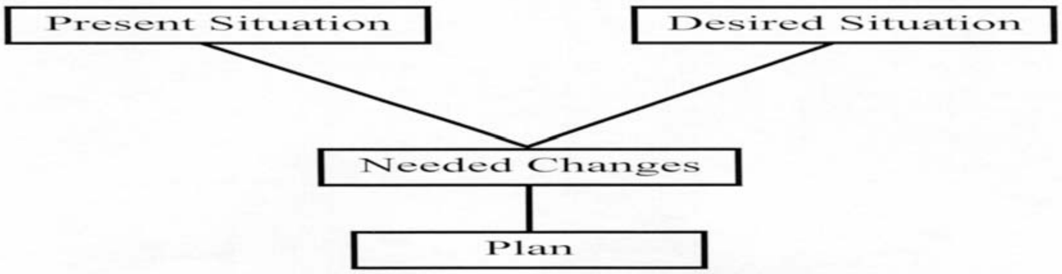
Now it is time to consider one that is mainly good news. A biorefinery is a facility that integrates biomass conversion processes and equipment to produce fuels, power, and value-added chemicals from biomass. The biorefinery concept is analogous to today's petroleum refinery, which produce multiple fuels and products from petroleum. Even since I began preparation of this paper, the scope of potential biorefinery technology has expanded from forest resources to agricultural byproducts and the potential for further growth is wide open.

Producing multiple products, a biorefinery takes advantage of the various components in biomass and their intermediates therefore maximizing the value derived from the biomass feedstock. A biorefinery could, for example, produce one or several low-volume, but high-value, chemical or nutraceutical products and a low-value, but high-volume liquid transportation fuel such as biodiesel or ethanol. Concurrently, it could generate electricity and process heat, through combined heat and power technology, for its own use and perhaps enough for sale of electricity to the local utility. The high-value products increase profitability, the high-volume fuel helps meet energy needs, and the power production helps to lower energy costs and reduce greenhouse gas emissions from traditional power plant facilities.

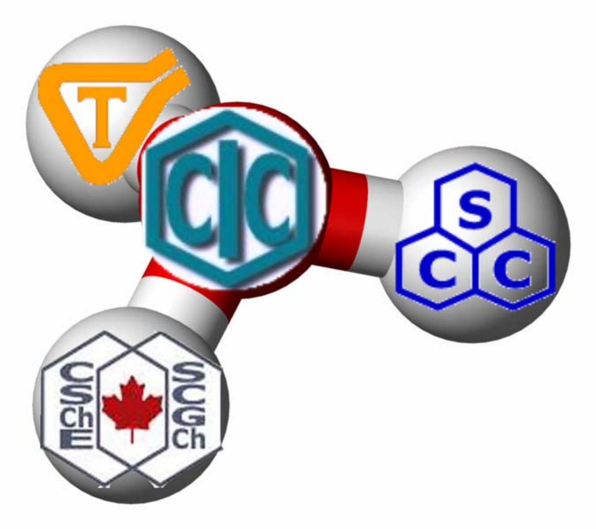
This is prime ground for intense public interest in the near future. We must become conversant in explaining and proactive in leading the way.

Moving Forward by Creating and Sharing Knowledge

Not everyone sees things the same way and certainly the general public, at large, does not see things they way we professional insiders do. But these five focus areas do exemplify the quality of life balance with risks that the public typically associates with our field of expertise. I am certain there are many others of concern, or at least potential concern So let’s find out!



Trustworthy communication begins with perceptive listening. We don't need to build an infrastructure to do that, because we already have one. The Chemical Institute of Canada has an established structure of three constituent Societies, 16 Subject Divisions and 23 Local Sections. Some of these bodies exist to specifically address one or more public priorities; all are ideally positioned to be our eyes and ears, open to public interests and concerns.



This whole process is about knowledge creation in society. It is similar to the challenge of overcoming cultural resistance to Process Safety Management except the audience and stage are much larger. Knowledge creation is essential! It's what makes people and communities smarter and more capable of dealing with the world around them.

Societal knowledge is "created" when difficult to explain tacit knowledge is converted to more shareable explicit knowledge. This is a 2-way process: both the audience and the presenter must learn from each other. There are two basic mechanisms we need to understand.

> Socialization, the conversion of tacit knowledge in one person to tacit knowledge in another person or group is what happens when people share experience by sharing impressions and mental models. More subtly, it is the process through which a community or stakeholder culture perpetuates itself, much to the frustration of change agents who are unable to recognize and manage it.
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> Externalization, the conversion of tacit knowledge in a person or group to explicit knowledge for the listener is the key to understanding. From that comes the opportunity to create new knowledge and understanding. This may be the softest of the four and certainly the least emphasized in our technical education process.

Wisdom is the ultimate level of understanding. We get there when we see enough patterns and trends that we are able to synthesize and then use them in novel ways. Wisdom is not easily passed from one person to another as it must be worked for. However, recognizing and valuing the wisdom in others will help define a framework for achieving it.

My challenge to the leaders and participants throughout this expert network is to get this “Taking a Public Stand on Issues Related to Chemistry” initiative rolling by asking, listening and letting us know what people need and want to know about. Let’s see if this works! Please give us your feedback!

Thanks very much for your interest. Now let’s take another step towards making a difference.

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Writer Biographical Information:

General Manager of Pope & Talbot Ltd. in Mackenzie, British Columbia, Tom hails from Charlotteville Township in the heart of the Carolinian Forest Region on Ontario's "South Coast", graduating from secondary school in Port Dover in 1965. His qualifications include B. A. Sc. (Chem. Eng.), Waterloo, 1970 and P. Eng. certification (BC and ON) supporting 35 years of experience in six Canadian kraft pulp operations, coast to coast. In April 1999, he was appointed general manager of the Mackenzie 235,000 tpy bleached chemical market pulp mill with 255 employees and gross annual sales of $200 million.

He has over 35 years of technical, engineering, operations and capital project experience in pulp and paper mills in three provinces. His career spans ever-increasing levels of responsibility: process engineer, maintenance & engineering manager, pulp production manager, paper production manager and general manager, primarily in kraft pulp manufacturing, supplemented with production responsibility for groundwood specialty paper.

He is a member of the Pulp and Paper Technical Association of Canada, where he has served on three committees, and also of the parallel TAPPI organization in the United States. He is a member of the C. S. Ch. E., which he currently serves as Director of Industrial Liaison for 2006-08.

He spent three and a half years as Chairman of the Board of CHMM-FM which saw the launch of a successful community radio station. He is District Coach Mentor Coordinator with the BC Hockey; is the Chairman and manufacturing industry spokesman on the Mackenzie Community Policing Committee, serves on the Chemical and Biological Engineering Industrial Advisory Council at UBC and is President of the B. C. Forest Industry Health Research Program.