Conservation of Energy, Mass... and Life?

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Conservation of energy (CoE) and conservation of mass (CoM) are both fundamental principles that apply to many aspects of chemical engineering design, analysis, and education. Chemical engineers know that in many cases, we cannot apply one without consideration of the other. Students in senior chemical engineering design classes are quick to cite CoE and CoM as important considerations in their projects. When asked about conservation of life, however, the response is more hesitant: conservation of life?

Conservation of life (CoL) is the prevention of serious human injury, property damage, and environmental harm *(1)*. CoL is a fundamental principle of chemical engineering design and application, although perhaps not as well recognized as CoE and CoM. CoL was first introduced to my knowledge by Lewis DeBlois, who was DuPont's first corporate safety manager and later president of the National Safety Council, when he wrote in 1918 *(2)*:

"... safety engineering, with its interests in design, equipment, organization, supervision, and education... bears as well a very definite and important relation to all other branches of engineering. This relation is so close, and its need so urgent, that I am convinced that some instruction in the fundamentals of safety engineering should be given a place in the training of every young engineer... Conservation of life should surely not be rated below the conservation of energy."

Today, CoL is represented in practice by the development of effective process safety programs to identify and evaluate process hazards (*e.g.,* toxicity, flammability, and reactivity); the elimination of these hazards when possible; and otherwise, the control and management of these hazards through use of multiple layers of protective safeguards.

As J. R. R. Tolkien wrote in *The Hobbit*, "It does not do to leave a live dragon out of your calculations…" Lack of awareness of or complacency regarding process hazards, as with dragons, can result in death and destruction at any time.

Many serious incidents, both in industry and academia, unfortunately remind of this far too often. For example, following the T2 Laboratories runaway reaction and explosion in 2009 *(3)*, the U.S. Chemical Safety and Hazard Investigation Board (CSB) recommended that AIChE and the Accreditation Board for Engineering and Technology (ABET) work together to include greater emphasis on process safety in undergraduate chemical engineering programs. The Beirut ammonium nitrate explosion is a more recent example *(4)*.

In industry, the importance of process safety is represented in the U.S. by regulations, such as the Occupational Safety and Health Administration (OSHA) Process Safety Management (29 CFR 1910.119); consensus codes and standards; and industry guidance developed by AIChE's Center for Chemical Process Safety (CCPS) and other organizations. Compliance with regulations should represent minimum essential practice: effective process safety programs manage the process hazards and risks that are present, which often requires going beyond regulatory requirements.

The primary focus of any process safety program is first to prevent fatalities and other injuries, and then to avoid significant property damage and environmental harm to provide overall safe and reliable operations. To achieve the desired process safety performance and consistent management of process hazards and risks, effective process safety programs are built on three interrelated foundations *(5)*: safety culture and leadership, process safety systems, and operational discipline (*i.e.,* correctly following required procedures and practices) (Figure 1). Like a three-legged stool, weakness in one of these areas can lead to poor process safety performance, incidents, and injuries.

CoL reflects the need for awareness and consistent application of process safety in chemical engineering education, design, and practice. If we recognize CoL as equally important to CoE, CoM, and other fundamental chemical engineering principles, implementation and continuous improvement of effective process safety programs will not be something else we have to do, it will inherently be a part of all that we do. CEP

Figure 1. Effective process safety programs are built on three key foundations. Source: Adapted from *(5)*.

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