Ethics — Examining Your Engineering Responsibility

Deborah L. Grubbe, P.E.
Operations and Safety Solutions, LLC

Engineering ethics frequently has nothing to do with technology and everything to do with communication, thought and decision-making patterns, and conflicts around time and money.

Ethics is referenced in many engineering curricula, yet few universities require chemical engineering students to attend a formal ethics course. And although ethics underpins consistent achievement of safety, environmental, and business outcomes, many corporate training classes mention the subject only briefly. We continue to see failures, workplace deaths, and product-related deaths and injuries, and hear of large firms being fined or prosecuted for not self-reporting safety or environmental issues.

Ethics is defined by the Oxford Dictionary as: "the moral principles that govern a person's or a group's behavior" *(1)*. Good ethics could also be described as the appropriate execution of an engineer's professional responsibility. Harris, *et al.,* describe engineering ethics as an amalgam of complex concepts: professionalism, standards, risk management, liability, competence, truth, societal protection, trust, reliability, honesty, cost/benefit, attitude, organization, obligation, whistleblowing, regulation, and the law *(2)*. Ethics is sometimes clearly black and white and easy to understand; often, though, ethics comes in many shades of gray.

What kinds of chemical engineering mistakes might result in fatalities? An incorrect calculation or an unrealistic assumption? Could you lose your job over using the wrong safety factor in a design? Perhaps. However, the underlying causes of many serious incidents are not technical, and may have little or nothing to do with technology. For example:

• You do what your boss tells you to do, even if it is against your better engineering judgment.

• You tell your boss about a condition that could be dangerous under certain conditions, and when your boss says everything is fine, you remain silent and do not revisit the subject.

• You act contrary to a legal hold order and destroy evidence related to pending litigation, because you are afraid that you will lose your job, or worse yet be prosecuted for something you have written.

The underlying issues often involve conflicts that arise in the execution of engineering work; money and time are often at the root of the conflict. Serious incidents are frequently the result of ignoring common sense.

As the profession continues to expand, many chemical engineers are in areas of practice where the rules are not always clearly laid out and the lines are not always bright. New fields and new research areas, such as nanotechnology, structural biology, genetics, and tissue engineering, are exciting and full of promise. However, they present potential ethical dilemmas for which we not only do not have answers, but we do not even know the questions.

The issues around ethics can sometimes be double-sided — you can be "damned if you do and damned if you don't." These situations require you to search deep within yourself to decide on the best path, as there may be no good way out. The secret is to not land in this position in the first place. That avoidance takes clear thinking, good analysis, and forethought. We hope this article will pique your interest in an area of our profession where people tend to not spend a lot of thought time, and that it will help you frame your thinking about ethics. You will not become an expert in ethics by reading this article, but it will help you become better prepared.

Since each situation is unique, ethics is best taught through case studies. This article first examines several well-known incidents — the collapse of suspended walkways (skywalks) at the Hyatt Regency Kansas City, the space shuttle Challenger and Columbia disasters, and the BP Texas City refinery explosion — with a focus on the incidents' nontechnical causes.

Definitions

Ethics: The basic concepts and fundamental principles of decent human conduct. It includes study of universal values such as the essential equality of all men and women, human or natural rights, obedience to the law of land, concern for health and safety and, increasingly, also for the natural environment.

Leadership: The activity of leading a group of people or an organization or the ability to do this. Leadership involves:

1. establishing a clear vision,
2. sharing that vision with others so that they will follow willingly,
3. providing the information, knowledge and methods to realize that vision, and
4. coordinating and balancing the conflicting interests of all members and stakeholders.

Organizational Culture: The values and behaviors that contribute to the unique social and psychological environment of an organization. Organizational culture includes an organization's expectations, experiences, philosophy, and values that hold it together, and is expressed in its self-image, inner workings, interactions with the outside world, and future expectations. It is based on shared attitudes, beliefs, customs, and written and unwritten rules that have been developed over time and are considered valid. Also called corporate culture, it's shown in:

- the ways the organization conducts its business, treats its employees, customers, and the wider community,
- the extent to which freedom is allowed in decision-making, developing new ideas, and personal expression,
- how power and information flow through its hierarchy, and
- how committed employees are towards collective objectives.

Professional Responsibility: Legal and moral duty of a professional to apply his or her knowledge in ways that benefit his or her client, and the wider society, without causing any injury to either.

Source: www.businessdictionary.com

Skywalk collapse

On July 17, 1981, two suspended walkways in the Hyatt Regency Kansas City collapsed during a party (Figure 1), killing 116 people and injuring 214. At fault were the structural support rods that held the two suspended walkways at the second floor and the fourth floor.

During the investigation of the incident, the original design was proven to be adequate. However, the structural engineer in charge of the support rods was deemed to be negligent in verifying the steel shop drawings when they came back from the vendor. What ensued at the time was a series of court cases around engineering negligence, or failure to verify, and a vigorous debate around who is accountable for the design *(3)*. The ethical lapse was assuming that the shop drawings were correct, and failing to verify that the drawings fulfilled the intent of the design.

The Kansas City skywalk collapse was a wake-up call to the civil engineering community, and it provides important ethical lessons for chemical engineers. The work processes that we in the chemical process industries (CPI) follow are very similar to those followed by civil engineers. A client outlines requirements for the final product, engineers make assumptions at the beginning of the design process, and, as more detail becomes available, the original assumptions are verified to ensure that the product will function as intended and that the safety margins are not exceeded. The same issues about assumptions with respect to variation or unintended changes and about failure to verify designs apply to many incidents that involve chemical engineers.

The structural engineer who had accountability for the skywalks had his license to practice revoked in several states, which damaged his professional reputation and severely limited his earning potential. Was the little bit of

▲ **Figure 1.** Two suspended walkways in the Hyatt Regency Kansas City collapsed as dozens of party-goers dancing on them caused them to sway and vibrate — subjecting them to a larger-than-expected dynamic load. Source: MatDL: Failure Cases Wiki, http://matdl.org/failurecases/File%253AHyatt.3.jpg.html time he saved by not reviewing the vendor's shop drawings worth this level of loss? The answer to that question must be no.

Unfortunately, some engineers do not fully consider the potential ramifications of their actions or lack of action. In the case of the space shuttle Challenger, one engineering manager did think through his actions, specifically those he did *not* take.

Challenger explosion

On Jan. 28, 1986, the space shuttle Challenger was destroyed and seven astronauts died in an explosion of the orbiter's main tanks (Figure 2). The physical cause of the disaster was the failure of an elastomeric O-ring in one of the solid rocket boosters (SRB) 73 seconds into launch; the resulting heat plume melted a support, and the SRB pivoted and breached the liquid-hydrogen and liquid-oxygen tanks, resulting in an explosion. As in many incidents, organizational and work process failures underpinned the physical failure, and engineers were involved in the organizational decisions, discussions, and work processes.

Chemical engineer Allan J. McDonald was one of those engineers. (See the Profile on pp. 31–32). McDonald was contractor Morton Thiokol's senior management representative at the Kennedy Space Center on the morning of the launch and in the days leading up to it. In his book, *Truth, Lies and O-Rings: Inside the Space Shuttle Challenger Disaster (4),* McDonald eloquently details (among other things) the prelaunch meetings and teleconferences during which numerous assumptions were made about who knew what and when they knew it, as well as the post-launch investigations and other activities that are less well-known.

During discussions on the evening before the launch, it was clear that NASA preferred to launch, and the Thiokol team felt pressured to tell NASA why it *could* launch — rather than what the risks with the solid rockets were and whether they were safe. The temperature was well below the lowest temperature the boosters had ever experienced, but there was no conclusive evidence that the temperature was too cold; such data did not exist. Morton Thiokol's engineers recommended not launching, but senior management reversed the engineering recommendation and told NASA to proceed with the launch as planned. McDonald would not sign the launch consent form, because he thought they were taking risks that they did not have to take; as a result, his boss in Utah signed the document instead. At 6 am on launch day, icicles were so thick on the Challenger that McDonald mused to himself, "… I doubt we will launch today."

In the days following the disaster, McDonald was demoted from his position as director of the space shuttle solid rocket motor project and given a non-job as head of scheduling in the hopes that he would quit and leave the company. That action proved to be shortsighted and not well thought through. As a critical and knowledgeable party, McDonald was intimately involved in the investigations, and his testimony, both before Congress and before the Rogers Commission, was crucial. Eventually, an act of Congress reinstated him to lead the redesigned solid rocket motor program at Morton Thiokol because his knowledge and his ethical behavior were essential to the successful fixes needed by the NASA space shuttle program. (This has been the only time that the U.S. Congress directly intervened in the employment of a citizen by a government contractor.)

McDonald stood by his principles and his best judgment. He may have temporarily lost his job, but he never lost his self-respect, his reputation, or his personal integrity. The careers of many others, at Thiokol and at NASA, were ruined.

What would have happened if all of the Thiokol engineers and managers had stood together and said to NASA: "The situation looks suboptimal. We don't have the data, but we know we have problems with the O-rings at cold temperatures, and we think the risk is too high, based on our knowledge and experience?"

If the Thiokol thinking had been squared up, and the engineering voice had been heard, would NASA have backed off? Or was the pressure to launch, the so-called "go fever," inside of NASA so strong that it would ignore what

▲ **Figure 2.** On Jan. 28, 1986, the space shuttle Challenger and her seven-member crew were lost when a ruptured O-ring in the right solid rocket booster caused an explosion soon after launch. This photograph, taken a few seconds after the accident, shows the space shuttle main engines and solid rocket booster exhaust plumes entwined around a ball of gas from the external tank. Source: NASA.

looked like a serious launch hurdle? Had the decision criteria already been identified, and was there a plan for how to address the issue, or were the decisions made *ad hoc*?

And, who was making the decisions? The ultimate decision-makers were the engineers and managers sitting in their offices hundreds of miles away from the Kennedy Space Center. Was the engineering voice being appropriately considered by the NASA managers (who were engineers themselves)? Who were those managers listening to?

Inside Thiokol, it appeared that the only manager actually listening to the engineers was McDonald. His senior management seemed to be more concerned about what NASA wanted than what was technically most correct. "It was the classic case where good technical judgment and common sense seemed to have yielded to the philosophy that the 'customer is always right,'" McDonald stated. In hindsight, clearly the NASA managers should have postponed the launch due to the unknowns concerning the unanswerable questions they were asking the Morton Thiokol engineers.

Ethics in Academic Research

Students, faculty, and staff in the academic community face unique ethical situations related to their research activities. Students who conduct laboratory research for credit may be tempted to enhance raw data or to toss out data that do not fit the desired pattern. Graduate students often have to deal with issues related to authorship, reproducibility of results, and plagiarism. Faculty who live by the publish-or-perish rule may feel pressured to submit papers to journals before they are fully vetted.

Although the open nature of the Internet facilitates copy-and-paste plagiarism, the web is helping to educate many people about the poor publishing behaviors of some authors. For instance, Retraction Watch (http://retractionwatch.com) is a popular, well-referenced blog whose tagline is "Tracking retractions as a window into the scientific process." It focuses on the science and technology fields, and has over 9,000 subscriptions. Each entry includes the name, institution, and department of all parties involved in the paper, as well as the issues of concern (*e.g.,* plagiarism, fabricated data, etc.) — on the web for all to see. Naming and shaming is one strategy for addressing these issues in a very public manner. Learning occurs very quickly for those who do not want their name or their department's name showing up on this website.

Additionally, the National Academy of Engineering (NAE) carries out a variety of projects related to ethics in academic research. These include studies, symposia, and public information activities on subjects ranging from ethics education to emerging technologies and engineering ethics. The NAE currently supports the Online Ethics Center, a popular resource for information on science, engineering, and research ethics. For more information, visit www.nae.edu/default.aspx?id=20676&FilterCategID=85.

The issues surrounding NASA's safety culture (the pressure to launch) and technical management communication were not fully resolved in the time between the 1986 loss of Challenger and 2003, when, sadly, both contributed to the space shuttle Columbia incident.

Columbia disintegration

On Feb. 1, 2003, the space shuttle Columbia disintegrated upon re-entry over east Texas, killing seven astronauts. A piece of insulating foam broke off the external fuel tank 82 seconds into the launch and struck the shuttle's left wing, creating a hole in the wing's leading edge. During re-entry, hot gases entered the wing and the control equipment, melted the internals, and destroyed the wing's support structure, causing the orbiter to break apart.

The NASA flight engineers knew on the second day of the flight that there had been a late foam hit and had asked for pictures of the orbiter eight different times during the 16-day flight. They were worried because although this piece of foam was estimated to weigh only about 0.75 kg, when traveling at nearly a thousand km/hr, it had a high potential to cause damage, depending on where it struck the orbiter *(5)*.

The Mission Management Team (MMT), which handled all the day-to-day mission activities, was being managed by the second-in-command. The launch had been delayed for various reasons, and the team's regular, more-experienced manager asked to be released from his duties due to a pending family vacation that now coincided with the flight window. Because this flight was viewed as a very routine mission — there would be no space walks, no scheduled rendezvous, no satellite launch, and no International Space Station repairs — the leave request was approved.

The new MMT manager did not respond to the engineers' repeated requests for pictures, which were discussed during the mission management meetings, nor did she request a sanity check on the computer analysis that indicated the foam strike was not a serious problem. Foam damage was not looked at as a potential loss-of-crew/loss-of-mission (LOC/LOM) issue, so it did not receive as much consideration as it should have.

The NASA shuttle program communications structure hindered the engineers' efforts to get their messages to the decision-makers in an effective way. When the engineers were not successful in getting the MMT's attention, they resorted to sharing their thoughts with each other through email. (Many of these email messages, which were made public during the investigation, were quite blunt and to the point.)

Unfortunately, the people who saw the emails during the mission did not escalate these serious concerns. There are many reasons why that did not happen. It could have been an inability to see foam as an LOC/LOM issue. Some engineers believed their concerns were being blocked by the MMT. Additionally, the engineering staff did not have quick access to those at the top of the NASA organization.

As with the Challenger launch, the pressure to keep moving forward — that go fever — seemed to hamper management's ability to stop and think differently about the new information coming in. The thinking was very narrowly channeled along one potential outcome, and no one seemed to step back and say, "Let's take a break and think about this persistent request some more."

Also, as in the Challenger incident, the communication and decision-making patterns were inadequate for the situation. How do communications get so deeply channeled? How could a group of managers, who obviously had good intentions, think so narrowly about the questions being put in front of them? What would an engineer's professional responsibility have looked like in this situation? Perhaps an engineer could have helped the MMT members rethink their assumptions about foam. Perhaps a quick force calculation would have prompted them to reconsider. In the next case, we see yet again that incomplete communications can cause loss of life.

Refinery explosion

On March 23, 2005, an explosion at the BP Texas City refinery (Figure 3) killed 15 people and injured more than 170. During startup, flammable liquid hydrocarbons being pumped into a tower overflowed into an overhead pipe, which ran down the side of the tower to pressure relief valves. Three relief valves opened, discharging a large quantity of flammable liquid to a blowdown drum with a vent stack open to the atmosphere. The blowdown drum and stack overfilled and released a geyser-like plume of volatile liquid. The liquid evaporated as it fell to the ground, forming a flammable vapor cloud, which was ignited when an idling diesel pickup truck backfired.

The BP Refineries Independent Safety Review Panel, also known as the Baker Panel, was modeled after the Columbia Accident Investigation Board. Its report *(6)* contained ten recommendations that have implications for all CPI operations. Much has been written about the incident, the investigation, and the Baker Panel's recommendations. Here, we focus on communications, specifically as related to shift handover, teamwork, and startup procedures.

All who died were inside portable work trailers, which disintegrated in the pressure wave. They did not know that the unit right next to them was starting up that day, because no one told them. Additionally, there was a 6-min delay between the lifting of the column's relief valves and the explosion. Normally, that would have been plenty of time to sound an emergency evacuation alarm and empty the trailers; but that did not happen, either.

The shift handover between the night operations crew and the daytime operations crew was essentially nonexistent, because the night operator left before his day-shift counterpart arrived. The shift notes in the log book were very brief and left many items open to interpretation, but it was clear that the column was being started up. About three hours before the explosion, the supervisor had to leave the site to address a family medical emergency. The startup was not stopped or put on hold. Like NASA's go fever, the push for production and to move ahead took priority over everything else. The departing supervisor did not appoint an acting supervisor to cover his decision-making authority; he just left the site. This is yet another example of poor teamwork, communication, and professionalism.

This column had experienced startup issues in the past. It had come close to overflowing numerous times before, yet these instances were not effectively followed up with any preventative actions. Additionally, the startup procedures were written and accessible, but they did not outline what was considered to be normal practice. No one corrected this deviation, and the operators continued to violate the procedures every time this column was started.

What would have happened if the trailers had not been put near operating units? Why were site procedures violated in placing those units there, and why did someone sign the temporary placement permit? Were the engineers aware of the hazards being introduced? Why was this not checked by one of the supervisors? What would have happened if the day operator refused to continue the startup because the information in the log was unclear? What would have happened if the departing night supervisor had asked someone to cover for him for the duration of the startup? Was a safety review conducted prior to column startup? Why did not someone insist that required work be done?

Loss of life has serious repercussions, even for people

▲ **Figure 3.** The overfilling of a tower being started up set in motion a chain of events that led to a vapor cloud explosion and fire at the BP Texas City refinery. Source: U.S. Chemical Safety and Hazard Investigation Board.

who may have had little to do with the actual event. Within two years of the explosion, every person in the chain of command, from the operator to the supervisor, to the refinery manager, to the senior executives, and including the company CEO, was in a different job or had left the company.

After the incident, many engineers in many companies began asking questions about what they needed to do differently because of what happened at Texas City. This thinking is a start. However, it is not enough to stop there. Each of us has a continuing professional responsibility to figure out what needs to happen where we work and to make the needed changes.

The AIChE Code of Ethics

Members of the American Institute of Chemical Engineers shall uphold and advance the integrity, honor and dignity of the engineering profession by:

- Being honest and impartial and serving with fidelity their employers, their clients, and the public;
- Striving to increase the competence and prestige of the engineering profession;
- Using their knowledge and skill for the enhancement of human welfare.

To achieve these goals, Members shall:

- Hold paramount the safety, health and welfare of the public and protect the environment in performance of their professional duties.
- Formally advise their employers or clients (and consider further disclosure, if warranted) if they perceive that a consequence of their duties will adversely affect the present or future health or safety of their colleagues or the public.
- Accept responsibility for their actions, seek and heed critical review of their work and offer objective criticism of the work of others.
- Issue statements or present information only in an objective and truthful manner.
- Act in professional matters for each employer or client as faithful agents or trustees, avoiding conflicts of interest and never breaching confidentiality.
- Treat fairly and respectfully all colleagues and co-workers, recognizing their unique contributions and capabilities.
- Perform professional services only in areas of their competence.
- Build their professional reputations on the merits of their services.
- Continue their professional development throughout their careers, and provide opportunities for the professional development of those under their supervision.
- Never tolerate harassment.
- Conduct themselves in a fair, honorable and respectful manner.

Source: www.aiche.org/about/code-ethics

Learning from the commonalities

Even though these events happened many years apart and in different industries, they all have, at their roots, inadequate nontechnical communication and thought patterns. Another common element is familiar to chemical engineers — unsteady-state operation.

Consider the space shuttle incidents. The astronauts did not die in space; they died going up or coming down. Each of the shuttle disasters occurred during unsteady-state operations, as did the refinery explosion. Before the hotel skywalks collapsed, they were subjected to a larger-than-expected dynamic (unsteady-state) load, as dozens of party-goers dancing on them caused them to sway and vibrate.

How can we learn from these incidents and share the lessons with students and other engineers? For one, universities could bring in lecturers to discuss their experiences. Undergraduate and continuing education could address such topics as: the hazards associated with unsteady-state operations and the extra cautions required; the importance of nontechnical issues and their potential to cause loss of life and property; and how to identify these issues in advance, so that there is enough time to successfully negotiate and take positive steps to mitigate a disaster in the making.

The remainder of this article offers some advice on how to avoid potentially difficult situations and what you might do if you find yourself in one.

The role of the senior engineer, manager, or faculty advisor

Senior engineers, managers, department heads, faculty advisors, and others in leadership positions play a critical role in ensuring that the team and the organization can openly discuss issues of concern. They establish the culture of their teams through their everyday behaviors — by what they pay attention to and what they do when something goes wrong.

Some senior people, through their actions and/or words, either intentionally or unintentionally, stifle dissent and open conversation, thereby impeding the easy and early resolution of ethical issues. By making it difficult for someone with bad news to come forward, they can create a serious impediment to ethical decision-making and ethical behavior. Furthermore, if a senior team member is known to bend the truth to his or her advantage, that may not only harm the team, but it may also land people in legal trouble if it involves the violation of a law or a regulation. Some chemical company executives, for example, have been prosecuted and imprisoned for falsifying environmental reports.

The employees of one organization breathed a collective sigh of relief upon hearing an executive of the company say, quite publicly, “Good news is bad news delivered early enough to attempt a fix.” However, that relief was short lived, ending the first time a manager was rebuffed for delivering bad news to that executive. Word spread, and bad news stopped flowing up. This seriously hampered the senior management team from learning about issues in a timely manner. And, it affected not just that one executive, but the entire company.

Finding yourself between a rock and a hard place

Have you ever felt that your job or position was threatened because you disagreed with your supervisor? Have you ever been asked to revise the language of a report to downplay unfavorable conclusions? Have you ever been forced to do something that you knew was fundamentally wrong or even illegal? Have you cheated on an exam? Have you been tempted to invent data to strengthen research results? Has your principal investigator inadequately defined the requirements for authorship among your lab team members?

Hopefully, you have never been in any of these positions and will never have to deal with these questions. If you do face such a difficult situation, you have three basic options: take action quickly, take action later, or take no action.

The first option — raising any issues as they occur — attempts to reach a good outcome while circumstances are somewhat within your control. If you let the situation evolve before taking action — in effect, choosing the second option — you may have to be ready to accept whatever happens next, as the situation may become bigger than you can easily influence. You may be labeled a troublemaker or incompetent, and your reputation may suffer. You are willing to accept that, though, because you believe that is better than being labeled a conspirator later if you stay silent.

The third option is to wait, hope nothing bad happens, be careful about what you say to people, and deal with any consequences later. Experience teaches that difficult situations never get better or go away by themselves. They continue to grow and draw in more and more people. If you choose to claim you are innocent, other investigations may prove you wrong or guilty of bad assessments. Unfortunately, as this option plays out, the course of events will spiral further and further out of your control, and any punishments may be even worse than those for the other options. Remember, too, that conspiracy to cover up certain situations or information is considered obstruction of justice, which is a crime. An engineer involved in the Deepwater Horizon incident was indicted for erasing text messages in violation of a legal record-hold order *(7)*.

If you find yourself in an ethical dilemma and have decided to take action, either immediately or after a short period of time, consider the following points. Thinking through these issues should help you develop a satisfactory action plan.

• Realize the situation you are in and analyze it calmly. Anticipate what may happen. Consider what other people may do.

• Do you have any allies, or are you alone? Do others share your situation? If you know others are also concerned, you may be able to act together or support one another. There is usually power in numbers.

• What is the source of the pressure you are feeling? How high up in the organization is it coming from? If the issue originates at a senior level and you are very junior, your career progress may stall if you take action publicly. If your conscience is the source of your pressure, have you verified that your understanding of the situation is correct? In other words, are you seeing reality as it truly exists? You would not want to take action if you are incorrect.

• Is there a legal implication to any action or inaction? It is important to understand whether the situation is purely a matter of ethics, or if a legal statute or regulation is (allegedly) being violated. What is the legal penalty or sentence for action or inaction? It might be wise to consult an attorney with expertise in the area in question.

• What is your personal situation — *e.g.,* your family needs, career goals, etc.? Do you need the job? Are you the sole earner in your family? What is the status of your savings? How many months can you afford to be unemployed? How easily would you be able to find another position? How much risk are you willing or able to take?

• How strong is your support network inside and outside of work? Name the individuals who can support you in your professional and your personal lives. You will need people you respect to offer guidance, support, and constructive opinions during this time.

• Who can you trust? Why? Do they trust you similarly? Knowing this information will enable you to make the best decisions about what to say to whom. You may find that the only people you can trust are people outside of your company.

• Are you clear about what motivates you? If you are going to put your career and your family’s well-being at risk, be sure you understand *why* you are going through this. Share your thinking with your significant others so you can benefit from their support.

• Do you have clear lines that you will not cross? If you think in a very black-and-white manner, it may be more difficult for you to consider other options or other people’s views of the situation. Be sure you have a clear understanding of why you are being inflexible in your thinking.

• How important is your reputation to you versus your titled position? This is an individual decision, and it needs to be thought about carefully. You may find yourself attempting to hang onto your job title, only to become involved, in the worst case, in a lawsuit where your firm may not defend you.

• How marketable are your skills and experience? If your skills are very marketable, you may be able to afford to take a bit more risk. If you feel your skills are not marketable, maybe you should start to do something about that now.

• What are your organization's mechanisms for addressing these types of issues? Many firms have a hotline, a corporate ombudsman, and/or other processes for reporting ethics violations. Although these are usually said to be confidential, information may leak out — no human system is totally foolproof when it comes to confidentiality. Some firms (under the guise of management accountability) gather your information and route it back to your organization for investigation by the very people you are trying to avoid. Many institutions say they will protect whistleblowers, but in reality, they often ostracize them and shuffle them off to the side.

If you feel uncomfortable speaking internally, consider retaining private, outside counsel. It may cost you a few hundred dollars to gain some advice, but you will also obtain an additional perspective on your options. The U.S. Occupational Safety and Health Administration (OSHA) has a formal whistleblower program for issues related to workplace health and safety (see sidebar). If you plan to call OSHA, be sure you have thought through the considerations outlined here, as you may not have control over the situation once you file a formal complaint.

An important consideration in every situation is this: *You* want to be able to make your own decisions, not have other people make decisions for you. You want to have the sense of power that comes from being in control of some part of the situation. You also want to have a clear view of what may happen to you and to your position as a result of any action you take or do not take.

Finally, and most importantly, make sure that your thinking is clear and that you take time to outline all the what-ifs that may arise. Be sure you get out ahead of the situation, rather than playing catch-up from behind.

An action plan

Next, the considerations discussed in the previous section need to be translated into an action plan for addressing a situation involving engineering ethics or ethical undertones. The following steps can serve as an outline.

1. Do your homework. Understand the situation, the relevant law, your thinking, and your options. Know where your support lies. Be certain of your reasoning, your environment, and your facts.

2. Understand the consequences of your thinking and your plan of action. Should you act now? Act Later? Do Nothing? Leave now?

3. Appreciate that your professional reputation is the only thing you own. No matter one's role in the chemical engineering profession, no matter how large or small one's job or company, we exist in a small world where reputation and word of mouth are very important to future prospects. Your reputation will be very difficult to rebuild if it is damaged. For example, one industrial executive switched careers after he was involved in a serious incident and was unable to find work as an engineering manager.

4. Decide on your course of action. Be sure to have a safety net and a backup plan that you can set into motion, if necessary, and that your support system is in place. Realize that some people may no longer feel comfortable speaking with you, out of guilt or from fear of association.

5. Execute your plan in a methodical way. Sometimes the hardest part of carrying out a plan is waiting for someone else to make his or her move. Do not rush the process, as doing so could cause other problems.

6. Consider implementing your backup plan if things are not going well. Factors outside of your control may send events in an unpredictable direction. Always have other options available, if possible.

Sadly, serious ethical breeches usually have long tentacles and can affect many innocent people. If you believe you can make the situation better, see your plan through. If you feel you need to get out, then exit as soon as you are able, as these situations rarely improve.

What is AIChE doing?

The AIChE Academy, the Institute's new portal to education and training resources for chemical engineers and the companies they work for, offers an eLearning course

The OSHA Whistleblower Protection Program

Encompassing the whistleblower provisions of more than 20 statutes, the U.S. Occupational Safety and Health Administration's (OSHA) Whistleblower Protection Program protects employees who report violations of various workplace safety, environmental, nuclear, pipeline, food safety, financial reform, and securities laws (among others).

Employers may not retaliate against workers who, for example, participate in safety and health activities, report a work-related injury, illness or fatality, or report another type of violation of the statutes.

Employees who believe they have been retaliated against (*e.g.,* demoted, suspended, denied a promotion, fired, threatened, etc.) can file a complaint with OSHA.

For more information, visit the OSHA website, www.whistleblowers.gov, and download the fact sheet "Your Rights as a Whistleblower" at www.osha.gov/OshDoc/data_General_Facts/whistleblower_rights.pdf.

entitled "Professional Ethics and Excellence for Chemical Engineers." Also available are several archived webinars and conference presentations related to ethics. For more information, visit www.aiche.org/academy and search for "ethics."

AIChE's Licensure and Professional Development Committee (LPDC) is studying various educational components with respect to licensure, ethics, and professional responsibility. Each state and U.S. territory has its own engineering licensure laws, and the licensing process is managed through a board in each jurisdiction. Many states require ethics courses as part of continuing professional development (CPD). CPD is required in most states to renew one's P.E. license. Remember, though, that ethical questions arise regardless of whether you are licensed, and holding a license does not guarantee ethical decision-making. (If you are interested in participating in the LPDC effort, contact the author.)

An internal AIChE Ethics Committee serves as an adjudicating body when a member files an ethical complaint against another member. This internal review is highly confidential and involves senior Institute leaders. The committee has the power to revoke the membership and ban for life an individual who is found to have violated the AIChE Code of Ethics.

The Society for Biological Engineering (SBE) has partnered with the American Physiological Society on a National Science Foundation (NSF)-funded project related to ethics in biological publishing. The goal of the project is to develop, field-test, and widely disseminate a set of teaching modules focused on building graduate student skills in publication ethics.

Additionally, an AIChE team is studying the development of a learning community to assist members in understanding and in obtaining guidance on ethical issues. The National Society of Professional Engineers (NSPE) does this through the NSPE Board of Ethical Review, which renders nonbinding guidance to NSPE members who submit a formal query to it. The board is a team of peers that evaluates about 12 cases per year, and disseminates opinions to the NSPE membership to further member education. It is not a court of law, and it does not address legal issues pertinent to the complaint, as that is the purview of the state board or licensing entity.

Conversations with leaders of other engineering and scientific societies indicate that there are many needs and opportunities around education and communication of ethical tenets and concepts. Multiple efforts are underway in many other places, and AIChE believes it is crucial to leverage all applicable efforts.

Closing thoughts

Whether you view ethics as the red-face test — the situation would cause you embarrassment if others knew about it — or the tone at the top — the unspoken rules and norms by which an organization operates — the subject of ethics is critical to your professional career. The long fingers of ethical issues reach into industry, government, private consulting, and academia. Thus, it is important to understand how ethical issues can arise in all of these work environments and how you might be affected.

AIChE, supported by funds raised through the AIChE Foundation's 2013 Gala, has started a comprehensive effort to support its members in addressing the needs of ethical practice. It will be incumbent on us as professionals to behave in a way that engenders the public's trust. Education is your first step, and there are many resources to help you learn. Thank you for committing your attention and your personal energy to ensuring that chemical engineering is always considered an ethical profession that places public safety and welfare first in everything we do. CEP

Literature Cited

1. "Oxford English Dictionary," 3rd ed., Oxford Univ. Press, U.K. (2005).
2. **Harris, Jr., C. E., *et al*,** "Engineering Ethics — Concepts and Cases," 4th ed., Wadsworth, Belmont, CA (2009).
3. **Deutsch, J. B.**, "744 South Western Reporter," 2nd series, Duncan and Gillum vs. Missouri Board for Architects, Professional Engineers and Land Surveyors, Missouri Court of Appeals, Eastern District, Division Three, MO (1988).
4. **McDonald, A. J., and J. R. Hansen**, "Truth Lies and O-Rings – Inside the Space Shuttle Challenger Disaster," University Press of Florida, Gainesville, FL (2009).
5. **Gehman, Jr., H. W., *et al*,** "Columbia Accident Investigation Board, Report – Volume 1," National Aeronautics and Space Administration, Washington, DC (2003).
6. **Baker, III, J. A., *et al*,** "The Report of the BP U.S. Refineries Independent Safety Review Panel," Houston, TX (2007).
7. **Steffy, L.,** "Case of BP's Kurt Mix — A Cautionary Tale for All Employees," *Forbes Online*, www.forbes.com/sites/lorensteffy/2014/06/16/case-of-bps-kurt-mix-a-cautionary-tale-for-all-employees/ (June 16, 2014).

DEBORAH L. GRUBBE, P.E., is the owner and President of Operations and Safety Solutions, LLC (Email: deb@opsandss.com), a consultancy that specializes in enhancing returns from both hard and soft assets. She has held corporate director roles in safety, operations, and engineering at DuPont, and in 2006 and 2007 led BP to its two safest years on record. From 2003 to 2012, she was a member of the NASA Aerospace Safety Advisory Panel. She is an Emeritus Member of the Center for Chemical Process Safety (CCPS), a former Director of AIChE, and the immediate past chair of the AIChE Institute for Sustainability. Grubbe obtained a BS in chemical engineering from Purdue Univ. and attended the Univ. of Cambridge on a Churchill Fellowship. She is a licensed professional engineer, a chartered engineer in the U.K., and a Fellow of both AIChE and IChemE. She was named Engineer of the Year in Delaware in 2002, and in 2010 received an Honorary Doctorate in Engineering from Purdue Univ. for leading safety in the process industries and for her work in supporting faculty diversity.

Acknowledgments

The author sincerely appreciates Allan J. McDonald for his review and input to this article.