Encounters With Engineering Ethics: A Sample of Early Career Case Studies

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2024 IEEE Frontiers in Education Conference (FIE) | 979-8-3503-5150-7/24/$31.00 ©2024 IEEE | DOI: 10.1109/FIE61694.2024.10893075

***Abstract*—This research-to-practice full paper presents a series of brief engineering ethics case studies, all inspired by actual incidents recounted during interviews with early career engineers. Current ABET accreditation requirements include ethics-related outcomes for engineering graduates, and most engineering professional societies and employers maintain their own ethics codes. Yet we have limited knowledge about what kinds of ethical situations and issues are faced by practicing engineers, both in general and during early career phases. More nuanced understandings about the ethical dimensions of engineering work could inform training interventions designed to better prepare engineering graduates for workplace realities. This paper aims to bridge research and practice by presenting a series of brief case studies covering a variety of ethical situations encountered by early career engineers. The case studies are adapted from interviews conducted with a stratified sample of 29 technical professionals, all with at least one degree in engineering and 1-3 years of full-time work experience. The interviews were carried out as part of a larger mixed-methods research study investigating how engineering students and early career professionals perceive and experience ethics, social responsibility, and related concerns. The case studies presented in this paper were intentionally selected and developed to reflect different job roles and industry settings, as well as diverse ethical issues encountered by our participants. We present cases that reflect more commonplace or everyday situations that are "microethical" in nature, i.e., involving localized interactions among individual professionals. We also include some suggested scaffolds and resources for instructors seeking to use such cases in their teaching. We intend that this paper will be relevant and useful for instructors who want to bring early career ethics cases into their courses, as well as for those wishing to write short ethics case studies.**

Keywords*—case studies, early career, engineering practice, ethics

I. Background: Case-Based Learning

Case-based instruction belongs to the "active learning" family of pedagogical approaches, which by definition encourage students to "actively think about what they are doing" [1]. Fink additionally characterizes active learning by its emphasis on "doing", "observing", and "reflecting" [2]. Case-based approaches are an appealing active learning strategy because cases can be brought into existing courses and programs with relative ease, support a wide variety of learning outcomes, and potentially enhance student engagement and motivation.

Case-based instruction was first used at Harvard Law School in the 1870s to improve the ability of students to identify general principles from small collections of legal cases, while also learning to apply key legal principles and develop communication skills [3]. It became a dominant form of legal education, and in the 1920s and 1930s spread to many business schools. Case-based teaching has more recently gained popularity in many other fields, including teacher education [4], [5]. Medical schools have used similar teaching strategies since the 1950s and 1960s, but more typically using a "problem-based learning" (PBL) format where groups of students grapple with patient cases over multiple weeks and with extensive supplemental research and support [6]. In engineering education, evidence of growing interest in case-based approaches can be traced back to at least the late 1950s, as reflected in a series of period textbooks and case study collections (e.g., [7]-[9]).

Yet no matter the field or subject area, the core of case-based instruction is the *case*, as defined by Carroll and Rosson:

> Cases are narrative descriptions of a specific activity, event, or problem, drawn from the real world of professional practice. They provide models of practice to students and other novice practitioners. Cases incorporate vivid background information and personal perspectives

> to elicit empathy and active participation. They seek to engage the student in the drama of a real situation. Cases include contingencies, complexities, and often dilemmas to evoke integrative analysis and critical thinking. [10, p. 1]

While cases are usually self-contained and serve as primary instructional content, there are many different formats and types. *Case histories*, for example, give more comprehensive descriptions of events or situations, while *case problems* are usually open-ended simulations that allow for many different possible solutions or outcomes [11]. Other variations include whether a given case is: real, fabricated, or a mix of the two; presented using traditional prose and/or multimedia; paired with supplemental materials (data, interview clips, etc.); and intended for individual or group learning. Cases can also vary widely in terms of the associated instructional scaffolding, such as learning objectives, reflection or discussion prompts, quiz or assignment questions, instructor's guides, etc. Any given case may also reflect different stylistic preferences, a focus on specific topics or learning outcomes of concern, and field-specific considerations [3], [12].

One early advocate for case-based instruction in engineering characterized a case as "a written account of an engineering job as it was actually done, or of an engineering problem as it was actually encountered" [13]. He argued that cases should document actual jobs or problems, and noted that cases often involved both "quantitative relations" and non-technical factors. It is thus not surprising to find many cases that implicitly or explicitly engage with ethical issues such as safety and risk. For example, many texts have featured cases focused on engineering design, including failure case studies [14]-[18]. Other volumes intended for scientists and engineers have presented cases focused on environmental ethics [19] and environmental disasters [20]. Casting a wider net, the Online Ethics Center (OEC) has collected hundreds of cases, mini-cases, and case-related essays focused on engineering ethics and related topics [21]. Many textbooks on engineering ethics also utilize case-based approaches (e.g. [22], [23]), and Martin et al. have declared that "[c]ase studies are considered to be the most popular method to teach engineering ethics" [24, p. 47]. Hess and Fore [25] likewise identified "case study exposure" as one of the most common interventions found in their systematic review of literature on ethics education in engineering, only second in prevalence to engagement with ethics codes or rules.

Nonetheless, critics have leveled numerous critiques at the kinds of cases most often presented to engineers, including a perceived overemphasis on "disaster ethics" [26], concern about overly individualistic views of engineers reflected in many case studies [27], and a tendency for cases to more often focus on micro- rather than macro-ethical concerns [28]. Even more generally, Martin et al. point to a lack of research on case-based ethics instruction in engineering, arguing that we know little about "how cases are presented and the type of cases used (Yadav et al., 2007), how they should be taught (Davis and Yadav, 2014, 172), and what approach serves the achievement of which learning goals (Romkey, 2015)" [24, p. 1]. This paper primarily engages with the first of these three themes, namely by exploring resources, strategies, processes, and decisions associated with the "upstream" development of new ethics cases. As we detail below, this effort is grounded in our own empirical research focused on how early career engineers perceive and experience ethics in their work. We draw on data from a current, ongoing study, as well as previous efforts by our team and others to develop short cases and vignettes for both instructional and assessment purposes [29]-[32].

II. Methods

A. Data Collection

The cases developed in this work were selected from 29 interviews conducted with early-career engineers as part of a larger research project investigating how early-career engineers and engineering graduate students view and experience ethics, social responsibility, and related concerns [33]. The pool of interviewees had roughly equal numbers of participants identifying as men and women, and more than two-thirds identified as White. The most common degree held by interviewees was in mechanical engineering (about a third), with the remainder holding degrees in a wide variety of other engineering and technology disciplines. About two-thirds of our interviewees graduated from the same three universities and had been repeatedly surveyed and interviewed as part of a larger longitudinal study. The remaining one-third were newly recruited, surveyed, and interviewed to help increase the total number of participants representing the early career stage. A large majority of the interviewees received at least one degree from U.S.-based institutions and were practicing professionally in the U.S., most typically in large corporate organizations.

The interviews were semi-structured and approximately 60 minutes in length, on average. The interview protocol included questions that probed diverse dimensions of engineering ethics, including ethical situations encountered by the interviewee in professional settings, their definitions of concepts such as ethics and social responsibility, and their responses to specific ethical scenarios. A version of the interview protocol which was used by our research team in an earlier stage of this project can be found in [34]. The work described here used an interview protocol which was only slightly modified, largely to adapt the questions to interviewees who were in their first few years of professional practice or graduate school after completing their undergraduate studies. The interview protocol and broader research study was approved by our institutions' respective Institutional Review Boards. After the interviews were conducted, they were transcribed by a third-party machine transcription service and then reviewed and edited for accuracy and confidentiality by a member of our research team.

B. Selection and Development of the Cases

In prior work, our team identified critical incidents related to ethics among the early-career engineers who participated in this research study [35]. The critical incidents were identified by two members of our research team based on whether the ethical experience described by the interviewee included: 1) enough information so that it could be sufficiently understood, 2) a detailed description of the incident or experience, and 3) a clear impact on the interviewee indicated by a self-described change in viewpoint or behavior [35].

To select the cases developed here, we began with a table of the critical incidents identified in the previous work, which

This material is based upon work supported by the National Science Foundation under Grant Nos. 2024301 and 2130924. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

included 52 critical incidents drawn from the 29 transcripts. (The number of incidents exceeded the number of interviewees, as some interviewees identified more than one critical incident related to ethics over the course of their interview.) From this table, the same two researchers who had previously identified the critical incidents chose interviews to re-examine based on the incident's perceived potential utility in a classroom setting. The researchers then proposed example scenarios from these interviews for further development as case studies. These choices were based on considerations such as the amount of detail provided by the interviewee, whether the ethical situation described was sufficiently compelling or powerful to initiate in-class discussions and spark student interest, and variation among the proposed cases. These examples were each discussed with one or more other members of the research team for feedback on the suitability of the selections. Following these discussions, four ethical situations were formally written up as case studies.

Our case studies were developed in three parts: a longer case narrative describing the details of the case, a succinct one-paragraph version of the case, and a short instructor's guide with additional information and analysis, including suggested discussion prompts or follow-up questions that could be used by an instructor during a lesson or class. The case narratives were written following the structure for compelling case studies suggested by Atkinson [36], which includes: descriptions of the setting and characters, a plot with a clear conflict (defined broadly – not necessarily an interpersonal conflict), and a conclusion to the conflict. The shorter paragraph-length versions of the cases follows a format that might be more suitable for what Davis calls the "micro-insertion" of ethics cases into existing classes [37]. The discussion prompts and instructor's guides were collaboratively written by our research team, in part informed by our knowledge of current views and tensions in engineering ethics education and research, e.g. [25], [38], [39].

III. Case Studies

The first case below is inspired by our interview with "Bart." To develop a short version of his case, we first prepared a structured case summary (presented in Appendix A as a resource and sample). We then used this summary as inspiration for drafting the short version and instructor's guide presented here, while also periodically revisiting the original transcript to confirm specific details and pull relevant quotes. The other cases presented below reflect different stylistic choices, with varying amounts of detail and supporting material. Finally, it is worth noting that the assumed context for these cases is the U.S.

A. Chemical Quandary

1) Case: You are a chemical engineer working at a chemical waste treatment facility. Holding the title of "Chemist", part of your job involves analyzing waste samples to determine if they are within regulatory limits for emissions from the facility's incinerator. Since joining the company about two years ago, you've noticed increased corporate training and messaging around safety. After receiving a waste shipment, you discover that a sample from the tanker had very high amounts of chlorine, raising emissions concerns. You also test a separate sample taken from the mixing tank that feeds the incinerator, but are surprised to find it has a chemical composition that is likely within or nearly within permitted limits. The waste is already being processed, and shutting down the incinerator would cost your company time and money while possibly raising the ire of management. You suspect such discrepancies have been swept under the rug in the past. How would you handle this situation, and why?

2) Instructor's Guide: This case reflects a classic "balancing" challenge, using the language of reflexive principlism (see below). On one hand, someone in this type of situation might be concerned about the company's espoused safety culture, external regulatory requirements, and/or more general professional or moral commitments (e.g., the so-called paramountcy clause, or simply "doing what's right"). Regarding an individual's broader commitments, Bart underscored elsewhere in his interview the importance of "due diligence," being "honest in your work" and "do[ing] our jobs right." He also pointed out that negligence was often a factor in engineering disasters. On the other hand, this case involves ambiguity in terms of whether the waste was actually out of compliance; probable time, cost, and managerial pressures; and uncertainty about whether or how an emissions violation would be recorded or detectable, much less impactful in terms of increased pollution, fines levied against the company, etc.

Regarding how this situation actually played out, Bart reported that their team performed further modeling using historical data and worst-case assumptions about the chemical make-up. The results suggested that in previous situations they "did not violate our permit limits at any point," and thus felt that the current incineration process was likely also in compliance. Nonetheless, Bart noted that they reached this conclusion after "most of the […] problematic material had already gone through the incinerator." Thus, he felt that the only other possibility in terms of follow-up actions or remediation would be to "look into this issue into the future." Bart also reported feeling a sense of ethical resolution or closure with how this situation played out. While the staff's baseline procedure for handling the waste was "technically by the books," further verification helped "make sure that we were, that everything was correct." He also noted that this type of situation was relatively uncommon, as most of the time he felt the plant was operating in compliance with regulations.

Additional prompts to help facilitate discussion:

a) What specific ethical principles or guidelines are most relevant or applicable in this situation?

b) How might you approach the weighting or balancing of competing factors or principles relevant to this situation? Are some considerations more or less important than others, or perhaps even non-negotiable?

c) Does your formal job title ("Chemist") have any impact on your ethical obligations as a professional?

d) What process changes could you recommend to help prevent this type of situation from arising in the future?

B. Maladaptive Mentoring

1) Case: As an early career engineer working for a large company in the gas products industry, Sadie is in a rotational onboarding program and has been placed in a Project Manager role. As is standard practice in the company, she is assigned to work with a mentor to provide additional supervision and support separate from her primary manager. However, she is having difficulty working with her mentor. Despite feeling like she is doing the best she can, her mentor frequently expresses disappointment with Sadie's performance and provides little in the way of constructive feedback. Sadie is uncertain about what she should expect in a mentoring relationship given that this is her first job, and has lingering concerns about "what is acceptable in a work environment versus what's not." Consider:

a) What would you recommend Sadie do in this situation, and why?

b) In a series of interactions with her mentor over multiple weeks, Sadie tries to tactfully convey that his feedback is not helpful. Yet she sees little change in his behavior. What, if anything, do you think should she do next?

c) Sadie reports her growing dissatisfaction with the mentor to her primary manager. Yet after repeatedly expressing her concerns, the manager evades the topic or suggests he will take action but never seems to follow through. What, if anything, would you recommend she do next?

d) Another interviewee we spoke with ("Carly") described a similar situation, but with her primary supervisor rather than a mentor critiquing her work. Her supervisor even made comments suggesting that the company was losing money because of her. She feels this is unfair given that she has only been at the firm for six months and has received very little training. What should Carly do in this situation?

2) Instructor's guide: This case reflects tensions that engineers might encounter around how others perceive them and the quality of their work, potentially calling into question their competence as early career professionals. The issues encountered by Sadie and Carly also involve poor interpersonal experiences related to mentoring styles and relationships with superiors, which are important aspects of early career work. Despite her frustrations, Sadie was hesitant to speak up about the problems she experienced because, as she explained in the interview, she thought this environment was normal for an industrial plant. As an early career engineer, Sadie did not have much experience with the culture of engineering, or of other workplaces, so her negative experiences seemed like they might be normal despite the toll they were taking on her. Sadie described the challenge she felt when deciding whether to report her mentor, stating "I didn't want to lose my job. I didn't want to step on anyone's toes." While trying to advocate for herself, Sadie also had to navigate the potential repercussions of speaking up. Along similar lines, Carly described how she was unsure whether "just that one company that was like that, or if it's all engineering or like, if I should even be an engineer." She additionally described how she was "stressed out" and "dealing with imposter syndrome."

Nonetheless, some readers might wonder whether there was some validity to the criticisms directed at Carly and Sadie, even if communicated in ways that were unprofessional or lacking in collegiality. Indeed, many ethics codes uphold the importance of "offer[ing] honest criticism of technical work" while at the same time treating "all people fairly and with respect" and avoiding harassment of any kind [40]. Such situations could involve large gaps between how criticism is intended by superiors and how it is actually received by subordinates.

Ultimately, Sadie decided to raise concerns about her mentor with a supervisor and as a result no longer had to interact directly with that mentor. Her decision came after several months of negative experiences and asking more experienced coworkers for advice. While she did improve her work life by reporting the mentor, she also shared that the experience sparked a desire to improve conditions for future young engineers who may face similar challenges. In fact, she framed "mentoring younger engineers" as part of her own "ethical responsibilities." While Sadie's experience was initially localized and had negative impacts on her personal, her follow-up actions and advocacy could improve the culture of her workplace and the profession. Carly, on the other hand, ultimately left her job but remained in the profession. She reported that her new company provided adequate training and had an environment where she felt much more comfortable asking questions. She also mentioned having a supportive boss and sense that she "know[s] how to do the work." Finally, she noted that therapy had helped with processing her earlier negative experiences.

C. *Is the Customer Always Right?*

1) Case: Chad is a test engineer who does dynamic testing on satellite parts. While the company he works for advocates for workers to perform high quality work and be transparent, there are many times where the culture of the company and clients push engineers to rely on their professional judgement in order to abbreviate procedure, skip design steps, and extend working hours in order to meet a customer's timeline. Chad's most recent client has a soft deadline that is pushing his team to work past normal working hours and occasionally past the 12-hour maximum that his company recommends as a limit. Despite the needs of the client, Chad notices the long working hours are negatively affecting the quality of the team's work and their attention to detail is questionable. How do you recommend Chad and his team proceed while balancing the needs of all the stakeholders?

2) Instructor's Guide: In this scenario, Chad has to balance the needs of various stakeholders with competing priorities. The client wants the project completed in a timely manner and to be of sufficient quality. In his interview, Chad mentioned how sometimes "the customer specifically asks for corners to be cut of like various aspects of testing to be skipped," which highlights how important deadlines can be for the customers. The engineering team has to appease the client while also considering design constraints, work-life balance, professional responsibilities, employment law, and the needs of the company. Regardless of how Chad decides to proceed, at least one stakeholder will need to compromise in order to come to a solution. This compromise pulls at a variety of professional obligations that Chad has as an engineer such as being a faithful agent for his employer and client, ensuring high quality work (which could impact public safety, health, and welfare), and being a good team player. These issues are further compounded by Chad's employer fostering a culture where the customer's demands may take priority over the company's established procedures and the preferences of its engineers and other staff.

Additional prompts to help facilitate discussion:

a) If Chad agrees to meet the customer's deadline at the expense of his team's time and quality of work, what would be the impact? Conversely, if he decides to push back against the customer's deadline to allow his team to rest, what would be the impact? Or, can you think of any creative middle-way solutions to Chad's dilemma?

b) Chad mentioned how the culture of his workplace encourages engineers use their "professional judgement" to make decisions in order to meet a customer's timeline. What do you think about this type of work culture?

D. *To Drive or Not to Drive?*

1) Case: Brody studied manufacturing engineering and now works as a fabrication supervisor for a home appliance manufacturer. One day at work, there is an accident at the plant that leaves one of the operators injured on the production floor and in need of immediate medical attention. At the time, no one in the plant is trained and approved to drive the company ambulance, which would provide medical supplies and a mode of transportation not otherwise available to the injured operator. Brody could drive the ambulance himself but may face punishment for driving it without company approval, and he may also be cited by the authorities for opearting the ambulance without a proper certification on his driver's license. He could contact the on-call safety expert and ask them to drive, but that would likely require a significant amount of additional waiting time. What do you recommend Brody do in this situation?

2) Instructor's guide: This case is an example of some of the split-second decisions an engineer may need to make while balancing various priorities. The operator's health and safety are vitally important but, in this case, come at the expense of procedure and potentially with consequences for Brody. The severity of the injury was purposefully omitted from this case study to provide room for variability in how the case is framed and presented to students. The specificity of the situation may change what the appropriate response is and how students engage with this case. In the actual situation, the operator was bleeding severely, so Brody decided to drive the ambulance and did so without repercussions. However, if the operator had a less severe injury his response may have been different, and established protocols may have been observed. This case also raises questions of liability and responsibility for the employer and for Brody. Depending on the accident, a company may be liable for paying for medical treatment, rehabilitation, workman's compensation, and other costs associated with a workplace injury. Brody is not legally licensed to operate the ambulance, so it is debatable whether his actions are on behalf of the company or if he is acting in his personal capacity to help the injured coworker. If something bad were to happen while Brody is driving the ambulance, such as getting into an accident, the company could attempt to use him as a scapegoat and avoid legal culpability.

Additional prompts to help facilitate discussion:

a) Would driving the ambulance unapproved still be appropriate for a minor injury? How severe does the injury need to be before it is acceptable for Brody to break rules or laws?

b) Are there other non-emergency situations where not following protocol may be justifiable? What are some emergency situations where following protocol would be a priority?

IV. Instructor Resources

Based on our own experiences with developing and using cases such as those presented above, we offer some additional resources that may be relevant and helpful for other instructors and facilitators. First, ethical codes can provide important baseline principles which may apply in particular situations. Simply asking students to identify which parts of a given ethics code (or multiple) can be a productive exercise. While discipline-specific codes may be preferred in some settings, we especially recommend use of the NSPE code since it is one of the most comprehensive [41], and is also the default code associated with professional licensure in the U.S. The IEEE code is another worthy resource given that it is relatively brief and accessible [40]. Finally, the ASCE code is a notable source given that it was revised and reorganized in 2020 to feature an overarching preamble followed by specific responsibilities in a hierarchical stakeholder model [42].

We also recommend introducing an ethical decision-making framework to help scaffold student engagement with cases. One simple but effective option is the describe-analyze-evaluate (DAE) model adapted from the intercultural education field [43]. One main goal of this framework is to discourage participants from making premature assumptions, judgments, or conclusions. In the *describe* phase (focused on the "what"), participants are first asked to make sure they understand the basic facts of the case. Next, students are asked to *analyze* or *interpret* the case (focusing on the "so what") by exploring it from as many angles as possible. Sample prompts include: Who are the stakeholders, and what are their positions and interests? What ethical considerations or principles are most relevant or important? What other pressures, considerations, or priorities might be involved? Finally, participants are asked to evaluate the case (the "now what"), namely by recommending and justifying specific actions that could be taken. Instructors may also prefer to use other readily frameworks and processes for ethical decision-making, such as those featured in ethics textbooks, e.g. [44, Appendix II].

The Reflexive Principlism [45] framework is another useful resource, especially given that it addresses both principles and process. More specifically, it proposes a reflective and iterative process of specifying, balancing, and justifying four principles within the context of a specific case. The four principles are derived from Beauchamp and Childress' [46] work in biomedical ethics, namely: 1) nonmaleficence: avoiding causing harm; 2) beneficence: providing benefits to society or others; 3) autonomy: respecting the agency of individuals in decision-making; and 4) justice: distributing risks, benefits, and costs equitably among all individuals. Analysis of a given case using reflexive principilism includes specifying how each of the principles is reflected within the case for various stakeholders and balanced among each other as they evaluate potential solutions or actions. Instructors may also adopt elements of the SIRA framework [47], which includes scaffolding and interactive components along with the reflective analysis of reflexive principlism.

V. Conclusion

Engineering ethics case studies are a means of exposing engineering students to the types of ethical scenarios that they might encounter in everyday professional practice. In this paper, we report how we used interviews with practicing early-career engineers to develop four case studies with a particular emphasis on selecting cases that were relevant, plausible, and reflected "everyday" kinds of ethical concerns. In future work we hope to generate more evidence regarding the quality and utility of these cases, as well as their efficacy in developing ethics-related outcomes among students. We hope that this paper proves useful for instructors wishing to bring early career ethics cases into their courses, and for those wishing to develop their own ethics case studies.

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant Nos. 2024301 and 2130924. We also gratefully acknowledge the participants in our study for their willingness to share their experiences and stories with us.

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APPENDIX: CASE SUMMARY FOR "CHEMICAL QUANDARY"

SETTING: Bart works at Chemical Treatment Company X. The organization is international, but based largely in North America. The main focus of the company is to manage hazardous waste and environmental cleanup. At Bart's site, they focus on treating the waste from various clients using an incinerator. Bart's role in this operation is to analyze the chemical composition of the waste coming into the site and decide how to treat it optimally. Notably, since Bart's role involves consideration of regulatory limits and compliance, he expresses that there are many opportunities for ethical dilemmas and decision-making to occur. He describes that the company he works for was "previously not the greatest when it came to safety. And so you can see the company is very, trying very hard to shift toward a safety perspective, safer, safer perspective." He mentions that while this change is good, there are "remnants of the old kind of culture still kind of there as they're trying to work it out still." During his first six months with the company, he participated in training sessions on the importance of safety on a weekly basis, and is thus very familiar with the company's code of conduct and other relevant policies.

PLOT: A tank full of hazardous liquid was brought into the facility for treatment. After performing chemical tests on the samples pulled from the tanker, Bart noticed abnormally high chlorine content. When his team cross-checked with the data from the incinerator's feed tank itself (not the original sample), the numbers did not match. This discrepancy launched a process of working with the compliance teams and other chemical engineers to run calculations to determine if emissions remained within permit limits as the chlorine was fed into the incinerator. This process is longer and more costly to the company. But as Bart explained, had he and his coworker not flagged the sample, the potential permitting violation and its associated impacts might have easily been swept under the rug.

CHARACTERS: Bart has a chemical engineering bachelor's degree, and his official title in the company is chemist. He personally identifies as a chemical engineer, but admits that in his current role at Company X, he doesn't think he is considered an engineer. His motivations to call out the extreme chlorine level came from his ethical compass, as he explained that the issue might otherwise have easily been overlooked. He defines ethics as being closely related to honesty, and notes elsewhere that an ethical exemplar would be a person who is "straightforward and honest." In the engineering context, he believes that ethical engineers practice due diligence with everything that they work on and are honest in their work. He strongly values the safety and security of everyone on his team, and the impact his work has on the outside population.

CONFLICT: It was a difficult decision to make, as there were two separate sets of data: one that would be fine for compliance, and one that raised a red flag. While Bart followed all the correct procedures, the decision came after the fact, and put him in a compromising position to either blindly trust the better sample, or to raise a flag regarding his concern over the high level of chlorine. If the worst-case scenario was confirmed, it was not really clear how the issue would be solved or addressed.

CONCLUSION: Unfortunately, the source of the discrepancy was never fully determined. By the time the red flag was examined, most of the material from the tanker had gone through the incinerator. They simply verified the worst case scenario and modeled it through the incineration process to make sure that there was, strictly speaking, no likely violation of any permit limits. While it might not have been the safest or most conservative option, they felt that regulatory compliance was maintained and Bart suggested that such incidents should be examined and considered more seriously in the future.