ENGINEERING ETHICS: THE LITHIUM-ION BATTERY FLAMMABILITY DILEMMA

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INTRODUCTION

The field of engineering takes mathematical and scientific principles and uses them to solve real world issues. With countless new technologies and heavy research, the field is always changing. Because of the developing nature of engineering, an engineer will be faced with many ethical issues in his or her career.

ABOUT ENGINEERING ETHICS

Engineering is all about improving the lives of other people. However, it is not always clear on what improves lives. These dilemmas have many viewpoints and approaches from which one can look at it. Each angle provides insight on what can be perceived as right or wrong. Therefore, it can be very hard to decide what is in the best interest of the public. William Marcy, executive director of the Murdough Center for Engineering Professionalism/National Institute for Engineering Ethics stated, “Ethics are opportunities for a healthy debate. It’s a chance to really see different ways to look at a problem. You do that when you create something but also when you look at the moral implications of that creation. Being ethical isn’t always about cut and dry answers but getting yourself to actually consider the possibilities” [1]. William Marcy also teaches a course on engineering ethics to about 600 students at Texas Tech University. He provides his class with controversial cases involving engineering ethics. Understanding and being able to apply the engineering code of ethics is an essential part of education for all aspiring engineers. By utilizing the code of ethics, engineers will be able to make wise choices when they encounter ethical issues in the workplace in the future [1].

According to Tim Healy of Santa Clara University, there exists four elements of ethical reasoning: the components include perception of a moral problem, assumption of universality and impartiality, application of action-guiding rules and principles, and the obligation to right action. These pieces, however, tend to over simplify any ethical dilemma and each element possesses issues. For example, the first ingredient of an ethical dilemma is perception. However, everybody perceives things differently. What one person sees as a moral problem, another person may look over. In the second item, the problem arises with the assumption of impartiality because it is human nature to be subjective and biased. The third part, applying rules and principles, has issues because there is no set of rules in life to live by when encountered with ethical issues. Lastly, obligation to right of action is not always true. Many scenarios can transpire that do not require action [2].

Despite the difficulty and unlikelihood, there are many case studies that exhibit all elements of an ethical issue. Many of these situations are hypothetical and are constructed to meet this criteria. Many others are real world scenarios that have been oversimplified and lack detail. The real world is more complex and is not as clear cut as many of these case studies. However, these case studies serve as great examples to teach engineering ethics [2].

HYPOTHETICAL SCENARIO

Suppose a large automobile company has just filled five chemical engineering internship positions. More excitingly, the company recently unveiled its first vehicle powered completely from a lithium-ion battery. The car was a big hit with consumers and the automobile company was making millions of dollars in sales. The chemical engineering interns were given a task to find ways to improve upon the battery for the next model of the lithium-ion vehicle. In order to do this, the interns needed to focus on the original lithium-ion battery used in the first car and calculate ways to optimize its performance and durability. However, what the interns discovered while researching the battery troubled them. Occasionally, the battery will overheat and spontaneously cause fires.

BACKGROUND INFO ON LITHIUM-ION BATTERIES

In addition to cars, lithium-ion batteries are found in many other everyday applications. Lithium-ion batteries first were found in consumer products. Everything from laptop computers, power tools, and cell phones use lithium-ion batteries. One may have noticed that cell phones become very hot when used excessively. Most phones will prompt the user for discontinued use for an interval of time, in order for the phone to cool down. If the phone did not disable itself when overheating, there would be a potential fire hazard that would arise. Perhaps if lithium-ion battery powered cars had this mechanism, then the previous scenario would become irrelevant.

In the past, every automobile has been powered by a lead-based battery and gasoline. One may wonder why there is a push to go from lead-based batteries to lithium-ion batteries when lithium-ion batteries are much more expensive. Lithium-ion batteries have a much greater energy
density and an even greater power density. This allows for a smaller, lighter weight, and higher-performing battery system. These systems are much more efficient than their predecessor [3]. Lead-based batteries in cars are only responsible for the headlights, interior lights, and ignition, while lithium-ion batteries do much more. The lithium-ion battery is also used as a traction power source in electric vehicles [4]. Because of the lithium-ion battery’s capabilities, the vehicles using them tend to be much more fuel efficient or even run completely on battery power depending on the make and model of the vehicle.

THE CAUSES

The causes of these spontaneous fires in lithium-ion batteries originate from a combination of chemical and electrical hazards. Despite being engineered to protect the environment, lithium-ion batteries can be dangerous when malfunctioning. Inside the battery, there are chemical substances that are not intended to be released. When they are released due to mechanical damages, however, spillage and gas emission occur. Both events possess flammable properties [5].

In addition to the chemical hazards, there are also dangers that exist electrically. Clearly, a current flow exists through the battery. The current flow creates heat. This idea is described as the Joule effect. The battery prepares for this and has a thermal management system. However, the heat given off has the potential to exceed the cooling effect of the thermal management system. This creates local hotspots and causes the battery to overheat [5].

If the chemical and electrical hazards of the lithium-ion battery are combined, thermal run-away is the result. Toxic or harmful gas emission, ejection of parts, and fire are all possible consequences of thermal run-away. For thermal run-away to occur, there must be a short circuit (which is very possible). The short circuit causes a chain reaction much like the domino effect. The short circuit will increase the Joule effect. Then the Joule effect will increase the battery temperature. At a certain temperature, the organic solvent is able to leave the cell through a vent. This leak is very likely to induce a fire [5].

BACK TO THE SCENARIO

In the hypothetical scenario, the interns of the large automobile company had deduced these causes from their research on the first model’s lithium-ion battery. The interns then turn to the management of the company and present their results. The management, horrified by the results, now face an ethical dilemma. No cases of the batteries catching fire have been reported yet and the company is making huge profits. The question becomes, “Should the big automobile company make a recall of the lithium-ion battery car because of the fire risk when there has been no reported incidents and possibly damage future sales of the vehicle?” The big automobile company can easily state that the interns’ report was inaccurate and untrue. However, that action would be against the National Society of Professional Engineers’ (NSPE) Code of Ethics.

ETHICS

NSPE’s Code of Ethics states that engineering impacts the quality of life for all people. Therefore, it is imperative that all engineers follow a set of ethical guidelines. The first fundamental canon relates closely to this scenario. It reads, “Engineers, in the fulfillment of their professional duties, shall hold paramount the safety, health, and welfare of the public” [6]. This canon is very useful in the decision making of this scenario. It explicitly states the course of action that the big automotive company should take.

This scenario is also tied closely to the American Institute of Chemical Engineers (AICE) code of ethics. In the AICE code of ethics it is stated that engineers should, “formally advise their employers or clients...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” [7]. Clearly, the spontaneous igniting nature of the lithium-ion battery puts the public’s health in jeopardy. Therefore the large automobile company should announce a recall on the lithium-ion batteries to keep the public safe and the company ethically sound.

Both codes of ethics are particularly useful in the hypothetical scenario. They both show that in order to be ethical, the company must announce a recall on the lithium-ion batteries to keep the public safe and continue car sales and proceed as if no new information had been presented to them.

CASE STUDY: DUTY TO WARN

In 1989, a 77 year old pedestrian suspension bridge collapsed when 40 people were on the bridge making it swing back and forth. Five people died, and dozens were injured. Seven years prior to the collapse, an engineer was evaluating the structural integrity of the bridge. He advised the county to apply a protective layer to the cables to prevent rust. The county blatantly ignored his request and proceeded to take no action. Victims and relatives sued the county for their negligence in maintaining the bridge. Claiming that they failed to warn the public of the potential danger and collapse of the bridge. The courts ruled in favor of the county [8]. However engineers should take note of this incident to avoid similar happenings in the future. In the hypothetical situation stated previously, the big automobile company should take this case study into account when considering whether or not to act on the results that the interns found. If they do not want to become at risk for lawsuits and potentially
harm the public, then they should announce a recall on their product and risk future sales and profit.

**CASE STUDY: EXCEEDING POLLUTION LIMITS**

An environmental engineer for Wolfog Manufacturing named, Marvin Johnson, is responsible for gauging the pollution levels of water and air in a nearby lake. His findings must be reported to the Department of Natural Resources where they have set limits on pollution levels that must be abided. In his last report, it was found that the pollution levels had slightly exceeded the limit set by the Department of Natural Resources. Marvin Johnson presented his findings to his supervisor, Edgar Owens; Owens pointed out that reconfiguring the pollution control parts of the plant would cost over $200,000 and that the company simply could not afford such a large payment. Also, he pointed out that advertising the high pollution would substantially decrease tourism in the area and have negative effects for many people [9]. However, many other people would believe that these findings should be brought to light. These people include tourists and people who use the lake for recreational use. Relating back to the previously described scenario involving lithium-ion batteries and their flammability, the big automobile company should take interest in this case. The pollution limit scenario describes two sides of an ethical dilemma in which both taking action and not taking action come with negative consequences. For example, if the big automobile company does not take action, the owners of the lithium-ion battery powered car are put at risk for potential injury and death. However if the major automobile company does take action, future sales and profits will most likely be diminished.

**CASE STUDY: REQUESTED TO FALSEFY DATA**

Stephanie Simon was an environmental engineer for Company XYZ. Her job was to measure the size of oil spills and report them to her manager, Adam Baines. However, Baines disagreed with many state regulations that became stricter over the past few years. He argued that Company XYZ was well off before the rules were tightened and that the regulations were superfluous and unnecessary. Therefore, Stephanie Simon knew Adam Baines would be upset that her report stated that a chemical spill was so large that it must be reported. As expected, Baines became enraged at the report and told Simon to go back to her desk and “rework those numbers until it comes out right.” The moral Simon knew it was against the code of ethics to falsify data and refused to take part. Instead, Simon wrote a memo regarding her conversation with Baines and she handed him her letter of resignation [10]. The big automobile company described previously would most likely have a vested interest in this scenario. Falsifying data is a breach in the code of ethics. Many employees may disagree if the company falsifies the interns’ results. This would cause negative consequences for the company including resignations and bad publicity.

**CONCLUSION**

For the hypothetical scenario originally stated regarding the lithium-ion battery powered car and its ability to spontaneously catch on fire, it should be clear what the big automobile company should do in order to act ethically. According to all the codes of ethics, the canons within them, and the case studies used as examples, the big automobile company should sacrifice its future sales and announce a recall on previously sold cars, in order to decrease the public safety risk to its original level.

In general, if an engineer is faced with an ethical dilemma in the workplace, it is suggested and recommended that he or she consult the NSPE code of ethics and his or her engineering discipline’s code of ethics. The engineer will find guidelines and standards of behavior that will result in the protection of the public welfare, safety, and health.

**REFERENCES**

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**ADDITIONAL SOURCES**


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