University of Technology
Department of Materials Engineering
Fourth Grade
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Second semester- Fifth Lecture

5. Risk, safety and accidents

No duty of the engineer is more important than her duty to protect the safety and well-being of the public. Indeed, the codes of ethics of the professional engineering societies make it clear that safety is of paramount importance to the engineer.

5.1. Definition

Safety is at the same time a very precise and a very vague term. It is vague because, to some extent, safety is a value judgment, but precise because in many cases, we can readily distinguish a safe design from an unsafe one. It is impossible to discuss safety without also including a discussion of risk. Risk is a key element in any engineering design; it is impossible to design anything to be completely risk free. safety and risk are essentially subjective and depend on many factors:

- Voluntary vs. involuntary risk. Many consider something safer if they knowingly take on the risk, but would find it unsafe if forced to do so.
- Short-term vs. long-term consequences. Something that might cause a short-lived illness or disability seems safer than something that will result in permanent disability.
- Expected probability. Many might find a one-in-a-million chance of a severe injury to be an acceptable risk, whereas a 50:50 chance of a fairly minor injury might be unacceptable.
- Threshold levels for risk. Something that is risky only at fairly high exposures will seem safer than something with a uniform exposure to risk.
- Delayed vs. immediate risk. An activity whose harm is delayed for many years will seem much less risky than something with an immediate effect.

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5.2. Engineering & Safety

Since safety is an essential aspect of our duties as engineers, how can we be sure that our designs are safe? There are four criteria that must be met to help ensure a safe design:

- **First**, the minimum requirement is that a design must comply with the applicable laws. This requirement should be easy to meet, since legal standards for product safety are generally well known, are published, and are easily accessible.
- **Second**, a design must meet the standard of "accepted engineering practice." You can't create a design that is less safe than what everyone else in the profession understands to be acceptable.
- **Third**, alternative designs that are potentially safer must be explored.
- **Fourth**, the engineer must attempt to foresee potential misuses of the product by the consumer and must design to avoid these problems.
- **Finally**, once the product is designed, both prototypes and finished devices must be rigorously tested. This testing is not just to determine whether the product meets the specifications. It should also involve testing to see if the product is safe.

5.3. Designing & Safety

How should safety be incorporated into the engineering design process? Texts on engineering design often include some variation on a basic multistep procedure for effectively executing engineering designs. One version of this process is summarized as follows:

1. Define the problem. This step includes determining the needs and requirements and often involves determining the constraints.

2. Generate several solutions. Multiple alternative designs are created.

3. Analyze each solution to determine the pros and cons of each. This step involves determining the consequences of each design solution and determining whether it solves the problem.

4. Test the solutions.

5. Select the best solution.

6. Implement the chosen solution.

5.4. Accident

There are many ways in which accidents can be categorized and studied. One method is to group accidents into three types: procedural, engineered, and systemic.

- Procedural accidents are perhaps the most common and are the result of someone making a bad choice or not following established procedures.
- Engineered accidents are caused by flaws in the design. These are failures of materials, devices that don't perform as expected, or devices that don't perform well under all circumstances encountered.
- Systemic accidents are harder to understand and harder to control. They are characteristic of very complex technologies and the complex organizations that are required to operate them.