Unit 3: Safety, Responsibility as an engineer - *Safety and risk - assessment of safety and risk - risk benefit analysis and reducing risk – Road, Rail & Fire safety – Electrical & Industrial Safety*

Safety – Responsibility as an Engineer

Civil Engineer Safety
•Things to look at before designing
•Location
•Load
•Environment
•Structural Engineers study damage to gain a better understanding of geological faults, to determine why structures fail
Personal Restraints
•Lap, Shoulder, Seat Bolsters
•Methods of Use and Purpose

Child Safety
•Switches
•Windows
•Child Locks
•Carseat
Collisions
•Airbags

•Design

•Ethical Engineering
Ergonomics
•Improves design of every-day products to make them safer and more efficient
•Human Engineers
•Ergonomists deal with anything involving people
•Take into account anatomy, physiology, and psychology to make working and life more comfortable
Ergonomics
•Products include:
•Specially Designed chairs with footrests
•Glare Reduction on Computer Monitors
•Gel wrist supports to reduce carpal tunnel syndrome

Safety and Engineering
•Ethics
•Well Being of Employees
•Well Being of the Engineer

Ethics

•Making products safe for all those in using environment

•Value human life more than money

•Have courage to admit your mistakes

•Point out all the problems you find in your design

Well Being of Employer

•When designing for an employer, you have to do everything in your power to prevent potential lawsuits

•Expensive settlements can cripple of destroy a small company or one just getting started.

•Damages to reputation can be more costly

Well Being of Engineer

•Whenever you design something, your career is at risk

•Too many small mistakes or one big one can cause you to lose your job

•Example: Engineer lost his license to practice structural engineering in Kansas City after collapse of Kansas City Hyatt Hotel.

Safety in the Aerospace Industry

•Millions fly commercial airlines everyday

•Engineers are responsible for safely getting these people where they want to go

•Aerospace and aeronautical engineers develop new technologies for aviation, defense system, and space exploration

Safety in the Aerospace Industry

Safety in the Aerospace Industry

•Engineers develop aircrafts including commercial, military fighter jets, helicopters, spacecrafts, missiles and rockets

Safety in the Aerospace Industry

•Many people are dependent on the quality and safety of these engineers' products

•Engineers are responsible for making sure these aircrafts run correctly and safely

Safety in the Aerospace Industry

•Engineers can be held accountable if something goes wrong

•Aerospace engineers are mostly responsible for the continued operational safety of aviation products

•Some aerospace engineers work on aircraft testing; others investigate crashes to determine causes and prevent future accidents

Chemical Engineering Safety

•Synthetic Materials

●How do they react to people? (Allergies)

●Tire failure from faulty synthetic rubber

•Fertilizers

●Do they harm the environment?

Nuclear Power

•Department of Energy (DOE)

•Three Mile Island (US 1979)

•Cheronbyl (Ukraine 1986)

Nuclear Waste

- Waste Cleanup
- Byproducts of Nuclear plants have been buried for a long time
- Spills could cause dramatic effects on the environment

Risk-Benefit Analysis

The ultimate purpose of a Risk -Benefit Analysis is to help determine if a product is worth the risk connected with using it (Martin & Schinzinger, 153). On top of all the assumptions and uncertainties that may go into any analysis, in many cases we cannot even express both sides of this equation in the same terms. In the case of the automobile for example, we might be trying to compare the benefit of personal transport to the loss of life from accidents. What's worse, in some cases the benefits accrue to one group while most of the risk falls on another (e.g. a powerplant) (Fleddermann, 67). This begs the question: “Under what conditions, if any, is someone in society entitled to impose a risk on someone else on behalf of a supposed benefit to yet others?”(Martin & Schinzinger, 154). In many cases the evaluation is based on such a broad cross section of society that they cannot practically be consulted directly. While Fleddermann says “It is important to be sure that those who are taking the risks are also those who are benefiting” (67), this is almost impossible to implement in many situations. Perhaps providing adequate information and ensuring an open debate will help all those involved make an informed decision and receive compensation when appropriate. The fact that sometimes the benefits or risks or both are displaced in time also complicates matters even more (Martin & Schinzinger, 153). Even with these problems, Risk -Benefit Analysis can still be a very useful tool, especially when used to compare alternative methods of providing the same benefit. For example, in the field of power generation, the benefits are assumed the same for alternative generating methods, and the costs or risks can be compared to determine the preferable option. In doing Risk - Benefit Analysis in situations concerning public safety, it often appears that capital costs are compared to a “dollar value” for a human life (e.g. fatalities on a certain stretch of highway versus the costs to improve that section). As mentioned above, this type of analysis can still be very useful in deciding priorities for spending limited resources. For instance, if reliable statistics were available on the umber of fatalities on different sections of highway along with the costs to improve these sections, one can use this to decide which section to improve first. However, care must be taken to present such analysis in a way that helps the public understand that the intent and the actions are to maximize the saving of lives. If presented poorly, it can look like, for instance, that the “value” of a human life is being assigned some fixed monetary value for engineering economic purposes. While “figures” are invaluable in making planning decisions, they can seem insensitive or mercenary if treated inappropriately. Too often these types of “figures” are interpreted in a negative light. As partial explanation for their use, and a warning, the U.S. National Highway Traffic Safety Administration noted “We have provided an estimate of some of the quantifiable losses in social welfare resulting from a fatality and can only hope that this estimate is not construed as some type of basis for determining the optimal' (or even worse, the ‘maximum') amount of expenditure to be allocated to saving lives.” (Martin & Schinzinger, 156) Engineers are often called to be part of the public process of examining costs and benefits in order to either improve regulations and standards or in litigation against those who have failed to do so. In all cases, the engineer should be wary of statistics and presentation methods, both in giving and receiving (Martin & Schinzinger, 159). Remember, meaningful and understandable information is what is required for informed consent.

Engineers are usually afforded more respect than an equally versed lay person (157). This reinforces their responsibility to declare biases or possible conflicts, to present data in a "friendly" and understandable way, and finally to avoid comments in areas outside their expertise

Design Safety

Gone are the days when a design engineer could focus mainly on improving a product's design functionality. With higher safety levels now both achievable and economical, the engineer's role in delivering design safety has broadened considerably.

At their disposal are a host of new objective analytic techniques to identify hidden hazards and potential problems, determine design countermeasures and remedies, and assess and categorize residual risk. But with these new tools comes a responsibility to manage the consequences of interjecting protective mechanisms and safety devices into a product's design and operation. Below is a rundown of the benefits, burdens, and opportunities of designing for safety.

Designing for Safety

In a simpler time, safety features and accessories intended to protect equipment operators were considered the responsibility of the user and owner, not the design engineer. But today, more stringent safety standards and rapid technological advances mean engineers can more easily ferret out a product's potential for failure and then design to prevent it. While these techniques provide management and customers assurance the products they use will help and not hurt, some design-safety mechanisms can cause problems if not used wisely.

It's not enough, for example, to simply add a safe-stop mechanism that shuts down just the part of a machine where the problem occurs so that once fixed, operation can quickly resume. That mechanism may require the addition of other safety features—like self-monitoring, redundancy, faults that fail safe—to work properly. Because such systems are commonly used in high-risk situations, they often require special attention.

The impact of a protective mechanism or safety device on other components must be considered to prevent secondary faults or errors, including the possibility that normal operation be resumed prematurely. Maintenance checks of the mechanism also are crucial as over time it may become inactive or unreliable without any warning.

> The growing importance of software to mechanical systems is placing other burdens on design engineers. Far too many programs exhibit unexpected bugs, lockups, memory errors, out-of-bounds errors, even excessive test errors or failures. Hence, effective software reviews should begin early enough in the development and design process so that errors can be fixed, including those difficult-to-find-and-solve design safety problems that often emerge much later.

Extended field-testing, not just bench testing, is needed to head off design safety problems before the customer has to experience them.

Backup Warnings

Safety warnings can be an effective supplement to engineering safety design. A warning can't prevent harm, however, unless clearly conveyed and tailored for the right stakeholder. Whereas warnings for users are designed to identify hazards and risks to help them avoid personal harm, the information provided to customers is meant to give them what they need to know to weigh any associated risks before they buy the product.

Getting the wording just right is crucial as warnings that raise too many alarms can trigger information overload that may undercut the original intent.

Safety Around the World

It's no longer enough to satisfy U.S. regulations and standards. In order to tap into international markets, businesses must broaden the design process to take into account the global regulatory landscape as well as the forces driving overseas consumer-products markets.

For their part, engineers must stay abreast of safety requirements abroad to determine the design and manufacturing impact on their work. For example, the European Union's RoHS (Restriction of Hazardous Substances) directive restricting lead-based alloys used for solder and plating requires U.S. and other non-EU manufacturers to engineer around new issues of connector reliability and performance, which could change the manufacturing process and create new avenues of failure to explore.

Many nations and international organizations such as the United Nations also are spearheading regulatory changes designed to eliminate barriers to trade. For example, the European Union's REACH (Regulation, Evaluation, Authorization, and Restriction of Chemical Substances) program is helping to bring about a global system for the classification, labeling, and packaging of chemicals and products that contain them to enable shipment of uniform products anywhere in the world.

The design-safety implications of this and other related programs have some engineers wondering whether it's time to begin proactively designing products and systems with worldwide safety trends in mind.

End of Service Life Issues

Engineers who do their jobs too well (i.e., design products that last and last), must face other complex issues. How should end-of-life disposal and recycling be approached for products with long service life when new product safety requirements can be passed into law at any future time? What kind of exculpatory documentation should be retained regarding safety analyses performed when they could potentially incriminate those involved with design and development at some future point? Where operational teamwork is required on a system, how can studies of operator interactions be performed to reveal design data without infringing on privacy or creating an appearance of bias?

Safety Requirements in software intensive industry

Rather than safety requirements, many industry and governmental standards and regulations typically concentrate on the specification of safety constraints. As defined in the following hierarchical list, safety constraints are clearly another way of specifying safety-related requirements:

• A requirement is any mandatory, externally observable, verifiable (e.g., testable), and validatable behavior, datum, characteristic, or interface.

 A constraint is any engineering decision (e.g., architectural mechanism, design decision, implementation technique) that has been selected to be imposed as a requirement.

− A safety constraint is any constraint that specifies a specific safeguard (e.g., architectural safety mechanism, safety design feature, safety implementation technique).

Safety constraints typically include things like requiring interlocks and physical barriers around moving parts, safeguards concerning electricity and the handling of toxic chemicals, and the mandatory placement of warning signs. A potential danger in the mandating of specific safeguards is that it may well be possible to architect a better system in which the associated hazards cannot occur and thus the mandated safeguards become unnecessary or inappropriate. In fact, the new system without the safeguards may be both cheaper and safer. For example, using magnets to keep refrigerator doors closed eliminated the need for installing safeguards to allow trapped children to open the previous locks from the inside.

5 SAFETY-CRITICAL REQUIREMENTS

The most common approach to dealing with safety during requirements engineering is to concentrate on the identification of safety-critical requirements. Unlike safety requirements which are a type of quality requirement, safety-critical requirements are typically functional, data, or interface requirements that must be properly implemented if hazards and their associated accidents are to be avoided or minimized. The completeness of safety-critical requirements (a potential source of accidents) can be addressed by considering all events in all modes (i.e., performing state and event completeness analysis) as well as performing I/O variable completeness analysis (e.g., all sensor input).

Many accidents are caused by problems with system and software requirements, and “empirical evidence seems to validate the commonly stated hypothesis that the majority of safety problems arise from software requirements and not coding errors” [Leveson1995]. Major accidents often result from rare hazards, whereby a hazard is a combination of conditions that increases the likelihood of accidents causing harm to valuable assets (e.g., people, property, and/or the environment). Most requirements specifications are incomplete in that they do not specify requirements to eliminate these rare hazards or mitigate their consequences. Requirements specifications are also typically incomplete in that they do not specify what needs to happen in exceptional “rainy day” situations or as a response to each possible event in each possible system state although accidents are often caused by the incorrect handling of rare combinations of events and states that were considered to be either impossible or too unlikely to worry about, and were therefore never specified. Even when requirements have been specified for such rare combinations of events and conditions, they may well be ambiguous (an unfortunately common characteristic of requirements in practice), partially incomplete (missing assumptions obvious only to subject matter experts), or incorrect, or inconsistently implemented. Thus, the associated hazards are not eliminated or the resulting harm is not properly mitigated when the associated accidents occur. Ultimately, safety related requirements are important requirements that need to be better engineered.

Consider for example an automatic subway system connecting terminals within an airport. There will be functional software requirements for starting and stopping the subway train, for accelerating and decelerating the trains between terminals, and for opening and closing the subway car doors. These requirements may be analyzed using use cases or using state transition diagrams. Clearly, while it is important to be able to travel between terminals and important to open the subway car doors at stops, it is also important to not open the doors when the subway is moving because people and their luggage can fall out, resulting in injury, death, and property damage. Similarly, accelerating or decelerating too fast can also cause people to fall and be injured. Thus, the software controlling subway train starting, stopping, accelerating, and decelerating as well as the software controlling the opening and closing of the doors is safety critical. Thus, the associated functional requirements are safety-critical, whereas the functional requirements concerning the announcement of arrival at a terminal are not safety critical. Actually, identifying functional, data, and interface requirements as either safety-critical and non-safety-critical is probably too gross of a categorization. When using hazard analysis to categorize safety risks into safety assessment levels (a.k.a., safety integrity levels), one often obtains a larger number of safety risk categories such as: very high risk, high risk, medium risk, low risk, and no risk. Requirements having no safety risks can be viewed as non-safety-critical, but requirements having higher categories of safety risks should probably not be grouped together and categorized as safety-critical. Instead, such requirements should be categorized by safety risk level, possibly as follows: very high risk safety can be referred to as safety-critical requirements, high risk safety requirements can be referred to as safety-important, medium risk requirements can be referred to as safety-significant, and low risk requirements can be referred to as safety-relevant. This allows different safety evidence assurance levels for the requirements. For example, functional, data, and interface requirements that are safety-critical may need to be specified using a formal specification language, whereas the lower levels may need successively less evidence to support safety certifications

Risk and Safety Management

Risk and Safety Management

The Risk Management and Safety Office is located in the Department of Human Resources. The Office provides oversight and protection of Commission assets through purchase of insurance, contractual transfer of risk, program and operational analysis, mitigation of insured losses, loss prevention and related program and policy development to minimize risk and loss potential. This Office is also charged with developing and implementing the Commission’s safety and health programs to reduce accidents and injuries through training, inspections and regulatory compliance.

Insurance programs

The Commission participates in the Montgomery County Self-Insurance Program (the "Program") for the purpose of economic pooling of risks and resources.The Program provides the Commission with insurance coverage for workers' compensation (Maryland State mandatory limits), comprehensive general liability, automobile coverage (first and third-party claims), professional liability, property and fire damage, boiler and machinery damage, data processing systems breakdown and blanket crime coverage.

The Commission has, in addition to the self-insurance coverage, further liability and property loss coverage through the direct purchase of commercial policies for claims arising out of the operation of a public airport, and loss or damage to antiques and other specific items of personal property.The Commission also has public official bond coverage for its public officials.

Safety and loss control programs

The following are examples of the services provided to Commission departments:

- Training in OSHA/MOSH compliance
- Safety and accident prevention consulting services
- Review all Commission contracts for contractor insurance compliance
- Receive and process insurance claims filed against the Commission
- Provide accident analysis information to departments
- Conduct risk analysis of exposures to loss

The mission of Risk Management and Safety of Auburn University is to protect people, the environment, property, financial, and other resources in support of Auburn University's teaching, research, outreach, and student services. This is accomplished by

- Understanding the needs and priorities of the university community and partnering with key stakeholders.
- Developing materials and resources to provide guidance to the university community.
- Providing education through training and consultation.
- Assisting the university community with regulatory compliance by identifying opportunities to improve the safety of the university community.
- Leadership through integrity, credibility and technical excellence.
- Providing quality services in a professional and responsive manner.

Introduction to Radiological Research

Radiological research at AU is governed by the Radiation Safety Committee and is directed by the Radiation Safety Officer. This document will help you identify the different policies, tools, forms, and manuals that you will need to carry out your research. If you have any questions please contact the Radiation Safety Officer.

Topic	Information	Link
Manuals	The Radiation Safety Manual must be available and reviewed annually.	• Radiation Safety Manual
Training	Radiation safety training is required prior to use.	• Contact the Radiation Safety Officer for training.
New User	AU requires that a New Radiation Worker form be submitted prior to initiation of work.	• New Radiation Worker Form
Materials License	A Radioactive Materials License must be obtained prior to the possession or use of any materials.	• Radioactive Materials License Application
Waste Disposal	All radiological waste must be disposed of properly. Information regarding disposal is located in the Radiation Safety Manual.	• Radiation Safety Manual • Radioactive Waste Disposal Sheet
Shipping Radioactive Materials and other hazardous materials	You may not ship radiological materials without approval from RMS staff. Only individuals who have completed an approved hazardous materials shipping course and are certified may ship these materials. Contact the Radiation Safety Officer for assistance.	• Radiation Safety Officer
Additional Information	The RMS website contains information, forms, and tools. *Note: radiological research often involves chemical s and biological. The applicable standards also need to be followed for these areas.*	• Radiation Safety Homepage

Introduction to Environmental Programs

AU Faculty and Staff with responsibility for chemicals and other hazardous materials must ensure that these materials are stored and/or used in conformance with AU procedures and environmental regulatory requirements. The following addresses the most commonly identified compliance issues. Additional information and guidance is available on the RMS Environmental Management webpage at https://cws.auburn.edu/rms/environmentalManagement.aspx

Topic	Information	Link
Chemical Waste Management	All chemical wastes must be properly labeled with the identity of the contents and include the word WASTE (ie, Waste Acetone). Waste containers must be clean, appropriately sealed to prevent release of contents, and placed in a designated waste accumulation area. The list of nonhazardous chemicals identifies chemicals which are appropriate for trash or drain disposal. All other chemicals must be managed through the AU Chemical waste management program.	• Hazardous Waste Management Guide • List of Chemicals Considered Nonhazardous for Disposal
CHEMATIX Waste Database	AU utilizes the CHEMATIX waste database for management of all chemical waste generated from university operations. Please contact the CHEMATIX administrator to obtain access to the system.	• Chematix website • Chematix User Guide
Used Oil	Containers of used oil must be labeled with the words "USED OIL", in good condition, and closed at all times when not adding waste.	• Used Oil Management
Waste Aerosol Cans	Spray cans containing product under pressure are hazardous materials. If an aerosol can becomes unusable so that the product cannot be removed by normal means or if the product is outdated, off spec or otherwise unusable/unwanted, the can should be disposed of through the RMS Waste Management program as a chemical waste.	• Aerosol Container Management
Universal Waste	Universal wastes include batteries, mercury containing lamps (i.e. fluorescent, metal halide), mercury containing equipment and pesticides. Universal wastes are a special class of hazardous wastes which require proper management.	• Universal Waste Management • Used Fluorescent Bulbs • Used Batteries

An **industrial safety system** is a countermeasure crucial in any hazardous plants such as oil and gas plants and nuclear plants. They are used to protect human, plant, and environment in case the process goes beyond the control margins. As the name suggests, these systems are not intended for controlling the process itself but rather protection. Process control is performed by means of process control systems (PCS) and is interlocked by the safety systems so that immediate actions are taken should the process control systems fail.

Process control and safety systems are usually merged under one system, called *Integrated Control and Safety System* (ICSS). Industrial safety systems typically use dedicated systems that are SIL 2 certified at minimum; whereas control systems can start with SIL 1. SIL applies to both hardware and software requirements such as cards, processors redundancy and voting functions.

Biohazardous Waste Management	Guidelines for proper management o f medical waste, biological waste and pathological waste are provided in the AU Medical Waste Guide. Additional guidance is available in the AU Biosafety Manual.	• Medical Waste Guide • Biological Safety Manual
Hazardous Materials Shipping and Receiving	The US Dept. of Transportation and Federal Aviation Administration require that all personnel who ship or receive hazardous materials receive appropriate training and certification. Please contact AU Hazardous Materials Management for assistance with shipping hazardous materials.	• HAZMAT Receiver Training
Additional Information	A general fact sheet is provided to assist AU Faculty and Staff with managing their environmental compliance responsibilities associated with hazardous materials.	• Critical Hazmat Compliance Issues

Industrial Safety Integration provides both training services and software solutions to meet the ever-increasing requirement to assess industrial safety. Industrial machinery risk analysis and risk reduction techniques can create a very complex matrix of solutions. Industrial Safety Integration can help your company make informed decisions that will help to keep your employees safe.

In India the construction industry is the second largest employer next to agriculture whereas it is next to the road accidents in our country. The annual turnover of the construction industry in India is about 4000 Billion Rupees, which is more than 6% of the National GDP employing a large work force. The construction works in NPCIL, are enormous. The number of fatalities occurring from construction work in the industry is quite disturbing and fall of person from height and through openings are the major causes for serious accidents.

For the last several years, NPCIL has been executing massive construction activity. During the past seven years, NPCIL has taken up construction of 8 reactors at 4 locations namely Tarapur, Kaiga, Rajasthan and Kudankulam. A faster pace of project execution with parallel construction activities in

civil, electrical, mechanical and other jobs for reducing the gestation period through mega package contract employing morethan 25,000 construction workers have been very successful. The mobile natureof work force poses challenge in ensuring that all of them are adequately trained.
After the completion of 2 units of Tarapurand one unit at Kaiga, at present the workforce at construction sites is about 12,000. While successfully completing projects under construction, NPCIL gained valuable experience in meeting several challenges in Industrial Safety management. Construction safety management indeed is a challenging task due to the dynamic nature of construction activity

1. coupled with involvement of unskilled, illiterate and mobile work force. Since the projects are located in remote regions of the country the surrounding population involved in construction activities is substantial. These personnel are generally from an agricultural background, speaking and understanding local languages only. This poses additional challenge due to limitation in communication. Construction hazards are rated as eight times more risky than those from manufacturing sector. NPCIL, proactively, has been conceiving, developing and implementing unique safety programs and mechanism to overcome this. The implementation of feedback mechanisms and developing wider appreciation of safety among executing agencies on a continual basis, since the inception of nuclear power programme, has indeed paid rich dividends in achieving higher appreciation of Industrial Safety requirements and effective implementation of the same in NPCIL. . With strong planning, effective implementation and continual training with focussed safety management a good safety record could be achieved comparable
to international level. The average Fatal Accident Frequency Rate (FAFR) in NPCIL during last five years is 0.22 incidents / 1000 employees /year as against an estimated value of 15.8 for Indian Construction Industries. In this context, it is worthwhile to mention that FAFR for construction industry in the US as per data published US Dept. of Labor for the year 2005 is 0.23. However, we are not complacent and efforts to achieve the next level of excellence are being invested on a structured manner. Therefore we need to focus on the following aspects,

- Innovation in the training methodologies to achieve higher effectiveness of training among the contractor employees.
- Developing and implementing Behaviour Based Safety Program to improve orientation of work force towards safety in work.
- Implementation of innovative engineering measures to strengthen the safety requirements at design stages to achieve safe working environment during construction.

- Training and certification, in Industrial Safety requirement, of line managers and others responsible for construction activity essentially to enhance their perception and appreciation for industrial safety. The role of line managers and safety professionals in preventing the safety-related incidences is quite important. Therefore, it is necessary that safety requirements are assured on regular basis by scrupulous field rounds and the deficiencies identified are attended to promptly. Further, the attributes and requirements to achieve effective management of safety right from the design stage to execution and operation must be identified and addressed appropriately through a structured program. To achieve this prime objective, it is imperative to recognize the important elements of the safety management system and strengthen the same at each stage.

In order to enhance the safety standards and safety culture it is imperative that the existing programs and processes in safety implementation is to be pursued religiously. Additionally, the following need to be taken up as a consolidated program.

a. Evolving and implementing engineering solutions such as safe access to work locations and mechanization
b. Industrial Safety clauses in contract conditions which are formulated need to be pursued for effective implementation.
c. Field surveillance through a structured checklist and prompt addressal of deficiencies.
d .Ensuring administrative control of construction activities through institution of work permits, height pass and other work procedures.
e. Encouraging the mock exercises by performing model and mock up for complex works.
f. Certification of line managers in Industrial safety.
i. Development of a pool of line managers having Industrial Safety diploma as a long term measure bring in still greater appreciation and regard for industrial safety.

Fire safety refers to precautions that are taken to prevent or reduce the likelihood of a fire that may result in death, injury, or property damage, alert those in a structure to the presence of an uncontrolled fire in the event one occurs, better enable those threatened by a fire to survive in and evacuate from affected areas, or to reduce the damage caused by a fire. Fire safety measures include those that are planned during the construction of a building or implemented in structures that are already standing, and those that are taught to occupants of the building.

Threats to fire safety are referred to as *fire hazards*. A fire hazard may include a situation that increases the likelihood a fire may start or may impede escape in the event a fire occurs.

Fire safety is often a component of building safety. Those who inspect buildings for violations of the Fire Code and go into schools to educate children on Fire Safety topics are fire department members known as *fire prevention officers*. The Chief Fire Prevention Officer or Chief of Fire Prevention will normally train newcomers to the Fire Prevention Division and may also conduct inspections or make presentations.

Key elements of a fire safety policy

- Building a facility in accordance with the version of the local building code
- Maintaining a facility and conducting yourself in accordance with the provisions of the fire code. This is based on the occupants and operators of the building being aware of the applicable regulations and advice.

Examples of these include:

- Not exceeding the maximum occupancy within any part of the building.
- Maintaining proper fire exits and proper exit signage (e.g., exit signs pointing to them that can function in a power failure)
- Compliance with electrical codes to prevent overheating and ignition from electrical faults or problems such as poor wire insulation or overloading wiring, conductors, or other fixtures with more electric current than they are rated for.
- Placing and maintaining the correct type of fire extinguishers in easily accessible places.

- Properly storing and using, hazardous materials that may be needed inside the building for storage or operational requirements (such as solvents in spray booths).
- Prohibiting flammable materials in certain areas of the facility.
- Periodically inspecting buildings for violations, issuing Orders To Comply and, potentially, prosecuting or closing buildings that are not in compliance, until the deficiencies are corrected or condemning it in extreme cases.
- Maintaining fire alarm systems for detection and warning of fire.
- Obtaining and maintaining a complete inventory of firestops.
- Ensuring that spray fireproofing remains undamaged.
- Maintaining a high level of training and awareness of occupants and users of the building to avoid obvious mistakes, such as the propping open of fire doors.
- Conduct fire drills at regular intervals throughout the year.

Fire code

In America, the **Fire code** (also **Fire prevention code** or **Fire safety code**) is a model code adopted by the state or local jurisdiction and enforced by fire prevention officers within municipal fire departments. It is a set of rules prescribing minimum requirements to prevent fire and explosion hazards arising from storage, handling, or use of dangerous materials, or from other specific hazardous conditions. It complements the building code. The fire code is aimed primarily at preventing fires, ensuring that necessary training and equipment will be on hand, and that the original design basis of the building, including the basic plan set out by the architect, is not compromised. The fire code also addresses inspection and maintenance requirements of various fire protection equipment in order to maintain optimal active fire protection and passive fire protection measures.

A typical fire safety code includes administrative sections about the rule-making and enforcement process, and substantive sections dealing with fire suppression equipment, particular hazards such as containers and transportation for combustible materials, and specific rules for hazardous occupancies, industrial processes, and exhibitions.

Sections may establish the requirements for obtaining permits and specific precautions required to remain in compliance with a permit. For example, a fireworks exhibition may require an application to be filed by a licensed pyrotechnician, providing the information necessary for the issuing authority to determine whether safety requirements can be met. Once a permit is issued, the same authority (or another delegated authority) may inspect the site and monitor safety during the exhibition, with the power to halt operations, when unapproved practices are seen or when unforeseen hazards arise.

List of some typical fire and explosion issues in a fire code

- fireworks, explosives, mortars and cannons, model rockets (licenses for manufacture, storage, transportation, sale, use)
- certification for servicing, placement, and inspecting fire extinguishing equipment
- general storage and handling of flammable liquids, solids, gases (tanks, personnel training, markings, equipment)

- limitations on locations and quantities of flammables (e.g., 10 liters of gasoline inside a residential dwelling)
- specific uses and specific flammables (e.g., dry cleaning, gasoline distribution, explosive dusts, pesticides, space heaters, plastics manufacturing)
- permits and limitations in various building occupancies (assembly hall, hospital, school, theater, elderly care, child care, prs that require a smoke detector, sprinkler system, fire extinguisher, or other specific equipment or procedures
- removal of interior and exterior obstructions to emergency exits or firefighters and removal of hazardous materials
- permits and limitations in special outdoor applications (tents, asphalt kettles, bonfires, etc.)
- other hazards (flammable decorations, welding, smoking, bulk matches, tire yards)
- Electrical safety codes such as the National Electrical Code (by the National Fire Protection Association) for the U.S. and some other places in the Americas
- Fuel gas code

Rail safety

“Australia requires a safe, secure, efficient, reliable and integrated national transport system that supports and enhances our nation’s economic development and social
and environmental well-being.” To achieve this vision, ATC committed to the following policy objectives:

•Economic
: To promote the efficient movementof people and goods in order to support sustainable economic development and prosperity.
•Safety:
To provide a safe transport system that meets Australia's mobility, social and economic objectives with maximum safety for its users.
•Social: To promote social inclusion by connecting remote and disadvantaged communities and increasing accessibility to the transport network for all Australians.
•Environmental: Protect our environment and improve health by building and investing in transport systems that minimise emissions and consumption of resources and energy.
•Integration: Promote effective and efficient integration and linkage of Australia’stransport system with urban and regional planning at every level ofgovernment and with international transport systems.
•Transparency: Transparency in funding and charging to provide equitable access to the transport system, through clearly identified means where full cost recovery is not applied.
Following on from these objectives, ATC agreedthat it would consider the options of establishing national frameworks for regulation for heavy vehicles, marine safety and rail to move towards establishing genuine national markets and a seamless regulatory framework.

The current rail safety regulatory framework
“The most compelling reasons for the Commonwealth, state and territory governments to commit to national consistency in regulations are: the contribution that consistency can make to the

effectiveness of the regulations; the efficiency of their administration and enforcement; and to the efficiency of the economy as a whole."

Australia's rail safety regulatory framework comprises:

•The safety outcomes desired and the policies to achieve these outcomes
•The 'rules' by which participants abide
•The standards to which participants adhere
•The institution or institutions that administer the rules
•The quality and quantity resources (staff and financial) made available by governments to undertake the regulatory task.

The safety outcomes desired by governments are succinctly articulated in the Victorian Department of Transport's submission as "to reduce risk to life and limb at affordable costs." To date, governments have best articulated their outcomes in the national model rail safety legislation. The objectives of the model rail safety Bill place a high value on the effective management and control of risk to improve safety in railway operations and to promote public confidence in the safety of rail transport.

Industry is in the process of preparing a national rail safety strategy, which should articulate industry's desired outcomes. This regulatory impact statement is primarily concerned with the unanswered questions of institutional arrangements. Of the components of the regulatory framework set out above, standards are industry responsibilities and governments have addressed the rules (legislation) extensively in recent years, although there is still room for improvement. Some work on institutional arrangements had been undertaken by the NTC, but was not concluded prior to commencing this regulatory impact statement. Institutional arrangements in rail safety regulation have been examined before. In 1999 ATC engaged consultant Booz Allen Hamilton to review the 1996 intergovernmental agreement. The review recommended, amongst other matters, the introduction of a single national regulator. The recommendation was not endorsed by ATC at the time. The 2006 Productivity Commission inquiry into road and rail freight infrastructure pricing found,

"There are efficiency gains to be obtainedfrom a single institutional framework for safety regulation of rail. The adoption of nationally consistent rail safety regulation legislation by July 2007 is, therefore, a priority. Gains from harmonisation would be compromised if jurisdictions legislate based on differing interpretations of the nationally agreed draft bill.

Electrical Safety

Electricity is a powerful source of energy that powers lights, tools, machinery and many other devices necessary for our day-to-day work. Electricity can also be a hazard causing injury or death. Experts in the electrical industry look to the National Electric Code (NEC) for the electrical safety standards on how to correctly assemble and maintain electrical circuits and the National Electric Safety Code (NESC) for the basic provisions for safeguarding persons from hazards when installing, operating or maintaining electric currents.

OSHA recognized the importance of the NEC and included the 1971 edition into Subpart K of the 29 CFR 1926 for the construction industry. They have since made updates, revised and clarified the standard to make it more flexible in order to eliminate the need for the constant revision to keep pace with the NEC, which is updated every 3 years. For the general industry, OSHA has dedicated 29 CFR

1910 Subpart S to electrical safety. On February 14, 2007, OSHA published a final rule revising the electrical installation standards found in Subpart S that are intended to reduce the risk of injury and death caused by unsafe electrical installations. This revised standard became effective on August 13, 2007.

Some of the requirements of sections 29 CFR 1910.303 through 1910.308 do not apply to all electrical installations. It can be difficult to determine which requirements apply to the installation based on the time period in which the equipment was built or last modified. To remedy this problem OSHA has developed an interactive eTool designed to assist employers determining what regulation applies to them based on the date of installation or modification of the equipment.

Electricity and Its Effects on the Body

In order for electricity to work, a complete circuit made of a conductor, a load or electricity-consuming device and a ground is needed. Electricity will flow through the conductor to the load and finally to the ground to complete the circuit. Electricity will follow the path of least resistance to ground—similar to water in a pipeline that flows out of a valve when it is opened. Electricity becomes dangerous when you become part of the circuit, because the closest path to ground may be through you, causing an electrical shock.

When you are shocked by electricity, your muscles contract. If the lungs are involved in the path of the circuit, voluntary respiration can be halted. If the heart is involved, fibrillation can occur resulting in heart failure. As little as 50 milliamperes can cause death. It is important to realize that an electrical shock may not be strong enough to cause a fatality but it could cause you to fall or jolt to dangerous surroundings. For details on the effects electricity has on the body, see table 1.

Qualified Personnel vs. Unqualified Personnel

The 29 CFR 1910 Subpart S identifies two types of people that may come in to contact with electrical equipment on a jobsite: qualified and unqualified. A qualified person is one who has been trained to avoid electrical hazards when working on or near exposed energized parts and is:

- Familiar with the safety-related work practices required in 29 CFR 1910.331-1910.335
- Able to distinguish exposed live parts of electrical equipment
- Knowledgeable of the skills and techniques used to determine the nominal voltages of exposed parts

An unqualified person is someone who has little or no training regarding electrical hazards. Even though unqualified persons may not be exposed to energized parts, training should still be provided so they can be familiar with any necessary electrical safety practice.

Electrical Safety Practices at Work

Safe work practices are used to prevent electrical shock or similar injuries by keeping workers away from energized equipment or circuits and by training qualified workers on the correct procedures when working on energized equipment or circuits. Prior to using or performing maintenance on electrical equipment, the employee should first determine if it is safe by checking the following:

- Make sure the electrical equipment is not located in a hazardous environment, such as a damp/wet location or where it is exposed to high temperatures and flammable liquids and gases
- Make sure current and safety devices, such as fuses, breakers and ground fault circuit interrupters (GFCI), have not been tampered with and are working correctly
- Make sure the power cord and plug do not have any defects, such as cuts in the insulation exposing bare wiring
- Know if the equipment has an emergency shutoff switch and where it is located prior to use
- Make sure there is sufficient space around the electrical equipment or circuit in order to maintain or operate
- Make sure all personal metal jewelry is removed prior to using or working on electrical equipment or circuits
- De-energize electrical equipment before testing or repairing in accordance with the Lockout Tagout standard 29 CFR 1910.147.

If de-energizing the electrical equipment or circuit will increase the potential for an electrical hazard or is necessary for testing and troubleshooting, the appropriate tools and personal protective equipment (PPE) must be used and worn for the specific parts of the body to be protected.

Insulated Tools

Insulated tools must be used when working on or near exposed energized live conductors. Only insulated tools that comply with the International Electrotechnical Commission standard 900 (IEC 900) and marked with the international 1000V rating symbol should be used. Not all tools with a plastic coating or plastic handles provide protection from electrical shock. It is important to inspect your tools before performing electrical work—not only to verify if the tools are rated for the job, but also to check for damage, wear and if they no longer provide adequate protection from electrical shock. Damaged or worn tools should be removed from service immediately.

Electrical Protective Equipment

Electrical protective equipment, also known as insulating equipment, includes items such as insulated blankets, matting, covers, line hose, gloves, sleeves, face shields and arc flash clothing. Blankets, gloves and sleeves are clearly marked with class and type, while clothing is labeled with an arc thermal performance value rating (ATPV) measured in calories per square centimeter (i.e. 65 cal/cm). The class refers to the maximum-use voltage. Insulating must not exceed maximum-use voltages (see table 2). The type refers to ozone resistance. Type I is not ozone resistant. Type II is ozone resistant. The ATPV rating cal/cm identifies the amount of energy that can be delivered to a point at a particular distance from an arc flash. The higher the number, the more protection the clothing offers.

Insulated equipment should be inspected prior to each day's use and immediately following an incident that may have caused damage. Damage consists of holes, tears, cuts, punctures, ozone cutting, embedded foreign objects, swelling, softening, hardening or any other defect. Once an insulated piece of equipment is removed from service, it may not be reused until it has been retested and certified. All electrically insulated equipment must also be retested and certified periodically. See table 3 for testing intervals.

Employee Training

Electrical safety is the responsibility of everyone on the jobsite. It is important to establish a hazard assessment program that includes employee training on electrical safety. Training employees on the basics of electrical safety should include its effects on the body, first aid procedures when someone is shocked, how to fight an electrical fire and how to identify hazards. Some do's and dont's that can assist in electrical safety training include:

DO'S

- Read and follow electrical equipment instruction manuals prior to using
- Use safety signs, barricades and tags to identify and protect electrical equipment
- Only use extension cords as a last resort
- Use waterproof cords in an outdoor application
- Contact a certified electrician when electrical repair is needed

DONT'S

- Overload outlets by using splitters
- Touch electrical equipment, including power cords with wet or damp hands
- Allow dirt, grease or dust to accumulate on electrical equipment
- Use temporary wiring in place of permanent wiring
- Use cords or equipment that are not properly grounded

SPUSA Pledge

Through the SPUSA pledge program young people are challenged to make a personal commitment to use science and technology in a socially responsible way, thereby, contributing to a safer, more just society. The pledge creates public discourse over the role of individual responsibility when selecting a career.

The pledge reads:

> *I promise to work for a better world, where science and technology are used in socially responsible ways. I will not use my education for any purpose intended to harm human beings or the environment. Throughout my career, I will consider the ethical implications of my work before I take action. While the demands placed upon me may be great, I sign this declaration because I recognize that individual responsibility is the first step on the path to peace.*

Univ of Leeds

Transmission Towers

George Randall is a civil engineer with over 10 years' experience in analysing transmission towers (pylons & communication towers) and poles that support wire. He is working for Elexis, an electricity company, on a project to install PCS antennae on existing pylons. This will involve extra weight being added to the towers and George is to calculate the stresses involved to work out where this weight is best placed in order to protect the integrity of the tower.

George has at his disposal software that can accurately model the behaviour of the towers and allow him to see how the tower would behave with the antennae in various positions and with the value of other variables changing. Using this programme George ascertains the optimum position for the antennae. Having done this he then uses the software to test how the tower will react under certain conditions with the new antennae in place.

George is working with lattice towers that are rectangular based and these have a problem with the narrow face not having sufficient leg spacing to resist a wind load on the wide face. There is a critical angle that produces maximum leg compression. In the 'old days' skewed wind angles would not be included in George's calculations: without software it took days to calculate one normal load case and do an analysis by hand; to consider skewed wind angles too was far too calculation-intensive. However, with software giving George the ability to study the phenomenon in detail, he feels that it is prudent to examine all wind angles and build for the worst case scenario.

The software indicates that under a certain wind speed and direction, the tower will fail: if the wind hits the wires at a skewed angle with a high enough speed, this will cause the legs of the tower to buckle. However, George calculates that guying the tower will help to brace it and reduce the leg loads to acceptable levels. George reports the results of his analysis to his boss, Fiona Linley, who is an electrical engineer. He outlines how, in his opinion, the tower will fail if the wind hits maximum design speed at the most critical direction but explains that guying it will counteract this effect.

Fiona says that George is to continue with the installation of the antennae in the position he recommends, and to ignore the oblique wind direction. A few years ago this would never have been taken into account anyway, plus the safety record of towers of this kind is excellent. She has had to come to a management decision about the issue of risk versus reward: the high winds are unlikely in her opinion and the guying is expensive to implement given that the chance of such a wind occurring is so low.

George does not know what to do. He knows that there has been no incidence of tower failure under high winds in his working lifetime. However, PCS antennae have only been introduced in the last 5 years, and there have been no high winds during this time to test whether towers are safe at high wind speeds. Moreover, it is George that will have to approve the plans as the civil engineer, not his boss and he feels that he will be responsible for any failure. Fiona is also due to retire in the next 2 years and so even if the tower does fail in its 50 year lifespan, she is not going to be around to take the blame for it. George, however, has a lot of his career still ahead of him.

George looks at the building regulations to see if they can give him answers about what he should do: if the regulations say that towers must be designed with oblique wind angles in mind then his dilemma is solved. However, while the regulations mention that "under extreme wind conditions, an oblique wind may require greater structural strength" than normal, this is only a suggestion or recommendation; the regulations do not state that reinforcing structures to account for oblique winds is a legal *requirement*. George considers approaching Fiona's boss, Tim Jackson, but having a background in business rather than engineering, he might not understand the complexities of the issue.

Questions

Imagine that you are George and you are genuinely concerned about the safety of the towers. You have to come to a decision about whether to do as Fiona says or not.

(i) What do you do first? What further lines of inquiry would you pursue to help you with your decision?

(ii) What decision do you make? Give three reasons why you think that this is the best course of action. Could you defend this decision ethically?

(iii) Does it make a difference to your decision that Elexis are affixing the new antennae purely for commercial benefits?

(iv) Would it make a difference to your decision if you knew that some of the antennae will be erected near residential areas?

(v) Who would be responsible if any of the towers failed?

Changes on the industrial scene

Changes in patterns of employment

43 The regulatory environment now has to cope with the increasing trend in industry and elsewhere to outsource work and hence risks, with changes in patterns of employment and with the fragmentation of large companies into autonomous organisations working closely together. For example, there have been dramatic increases in self-employment and home-working; small and medium size firms are now a major force in creating jobs. Moreover, many monolithic organisations have become a series of separate companies, eg the railways now operate as separate companies with different responsibilities for operating the track, the rolling stock and the networks.

Polarisation of approaches between large and small firms

44 Some of these changes have blurred legal responsibilities for occupational health and safety, traditionally placed on those who create the risks or on those best situated to take steps to control the risks. In certain industries it is often no longer easy to determine who may be in such a position. Though case law has in many instances clarified the situation, the fact remains that for many sectors the above factors make it more difficult to coordinate the adoption of measures for controlling risks. Many more players are involved, some with little access to expertise. There has in consequence been a growing demand by small firms for a reversion to prescriptive regulation, running counter to the self-regulatory approach – a demand resisted by large firms because they do not face the same problems and are comfortable with the self-regulatory approach. This has resulted in greater emphasis being placed on the need for clarity of the status and content of the guidance element of the architecture of regulation.

A growing perception that risks imposed on people should be justified

47 There is a growing propensity to scrutinise benefits brought about by industrial activity against potential undesirable side effects such as the risk of being maimed or killed or of environmental pollution. This is particularly true for risks: _ which could lead to catastrophic consequences; _ where the consequences may be irreversible, eg the release of genetically modified organisms; _ which lead to inequalities because they affect some people more than others, such as those arising from the siting of a chemical plant or a waste disposal facility; _ which could pose a threat to future generations, such as toxic waste.

48 This has already resulted in industry having less discretion on matters on which theypreviously had considerable freedom to decide which course of action to adopt, eg plans for modifying their plant within their own boundaries, what raw materials and processes they should use, or how the waste generated (or the plant itself at the end of its useful life) should be disposed of.

Noise at Work-Part 1

Nick Rafferty works for Wallcote Brothers, a small engineering firm that produces components for washing machines and other domestic appliances. Nick has been with the company 5 years and after completing his induction programme (6 week rotations in each of the company's departments) settles in their design division. He is a popular member of staff and combines a very sharp mind and an ability to solve problems with a relaxed and easygoing manner, which makes him popular with employees from all levels of the firm. This includes the 'shop floor team', with whom he occasionally shares an after-work pint.

Nick has recently been promoted to Team Leader of Design. Whilst he still reports to Henry Jarvis the Head of Design, Nick has the responsibility for managing a group of 20 employees comprising part of the shop floor team that manufactures washing machine drums. Nick's promotion initially made things a bit frosty with some his new team members as he changed from being their friend to being their supervisor at work. However, Nick has a natural management style which soon appeases any worries that any of the team had about the power going to his head.

Nick is called into Henry's office one day where Henry explains that all shop floor employees at Wallcote Brothers must undergo their regular audiometric surveillance. Most of Wallcote's employees work on a noisy factory floor. Health and Safety laws require that, among other things, companies must implement health surveillance programmes as a duty of care where their employees are exposed to health risks such as loud noise on a prolonged or regular basis.

EarsRUs, a private occupational health service, has been brought in to deliver the surveillance and Nick must inform his team that they are expected to undergo a hearing test. Nick announces in the team briefing the next morning that EarsRUs will be visiting the following week. He explains that the employees' hearing only will be monitored, and that the purpose of this is to ascertain whether Wallcote needs to take any further measures to protect its employees' health.

EarsRUs come in to the factory and conduct the tests. After these are complete they report their findings to Wallcote's Human Resources (HR) department. EarRUs are not at liberty to disclose confidential clinical information about the health of particular individuals which they gain as a result of administering the tests but they do update each employee's health record, stating whether they are fit or unfit for work. All of Nick's team are declared as fit for work. Although patient confidentiality means that Wallcote cannot access any particular employee's test results without that employee's written permission, they are entitled to see grouped anonymized results. This data identifies how many employees' hearing abilities fall within a particular range. Wallcote request such information after every health surveillance check, and do so on this occasion as a matter of routine.

On receipt of the information, the HR department compare this year's results to those from previous years. There is a small staff turnover at Wallcote, with around 85% of the workforce having 6 or more years of service. It is noticed that there is a significant proportion of staff whose hearing has deteriorated over the years, which indicates that there is a worrying trend developing. While all employees were declared fit for work, if the hearing loss trend continues, this may result in more serious long-term problems arising.

Tutor Notes

The tutor takes a facilitator role directing questions where necessary to generate discussion, allowing students to voice their own opinions and encouraging students to justify their answers. To begin the class, give each student part 1 of the scenario and give them time to **read the text**. **(5 minutes or less for this section)**

Next **split the students into groups** of 4-6 and get them to discuss the question. (These are ideal numbers but larger groups are workable. There should really be no more than five groups in a class and larger group sizes are preferable to greater numbers of groups so expand group sizes if necessary). Encourage students to move chairs or themselves around where possible so that group members can hear each other and so that the different groups are sufficiently distinct from one another. It is often useful to split up groups of friends and put students with people with whom they would not normally converse. While this might make the students awkward to begin with, it helps them to focus on the task and usually ensures that a broad range of opinions are represented within each group making the discussion livelier and more involved. **(10-15 minutes)**

After there has been some discussion bring the group together for a **group discussion**. Ask a member of each group to briefly summarise their answer to the question. The class discussion can begin by focusing on a point at which groups disagreed and ask them to comment further - why they gave that answer, why they think that the other groups are wrong etc. Discussion should flow but below are the main points that should be covered **(10-15 minutes)**:

What should Nick do? Nick really only has two options; either he can say nothing or he can come clean

- **Say nothing:** Because of the anonymised data, Nick cannot be certain that any of his team have damaged hearing. Admitting to Henry that he does not enforce the wearing of safety equipment can only harm Nick's reputation at work. He could start getting his team to wear their protection from now on and this would comply with the law and protect his team members from any further damage. Moreover, the members of his team also have a responsibility to wear their hearing protection. Nick has failed to enforce the use of earmuffs but the situation is not entirely his responsibility. Henry, however, may not see it this way so silence may be the best way to protect himself. However, Wallcote may be about to spend money on unnecessary safety equipment. The SMT will assume that safety equipment is currently being used and that the deterioration in employees' hearing indicates that more elaborate and expensive equipment is required.

- **Come clean:** As a supervisor Nick is in a position of responsibility and expected by Wallcote to behave professionally. This will entail being honest about how things are going on the shop floor, including at those times when honesty means Nick admitting some faults on his part. Because the company needs to plan its safety policy, Nick should inform them that employees rarely use their hearing protection. This information will allow the SMT to implement safety measures which are appropriate for the risks present and will have the effect of protecting the health of the employees more effectively in the long run. By doing this Nick will also demonstrate to Henry that he is honest. This will foster an atmosphere of trust and openness between them which will help their working relationship with benefit to Wallcote and possibly to Nick's future career prospects.

There is a strong ethical case for Nick coming clean but you could discuss how doing the right thing is often difficult - it may involve putting one's own interests below those of others, for example. In this case, Nick runs the risk of being disciplined for not implementing safety policies properly but this risk may be outweighed