GUIDELINE TO INCORPORATE STANDARDS IN SENIOR DESIGN PROJECTS

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Senior Design Project reports will include the following sections:

(1) A section entitled “Survey of Related Standards” in the chapter “Introduction” where literature survey is also presented. This section will review applicable standards for your senior design project by also listing specific standards in the references. Note that this will initially be carried out when the design project problem is defined and literature survey is conducted, but before the actual design work has started. It may be revised and enhanced later as the project develops.

(2) A section entitled “Standards Used in the Project” will be included in the “Design Experience” chapter. As this will be written towards the end of the design development, the section will include specific standards actually used. Standards, codes, specifications and technical regulations that were used in the project will be described in this section and they will be clearly listed in the reference list. Additionally, excerpts of standards used may be included as sections of the appendix in senior design reports.

Standards can be considered in two categories: (1) System level and (2) component level.

SYSTEM-LEVEL STANDARDS

Examples of system level standards include standards developed for elevators, escalators, turbines, wind turbines, boiler and pressure vessels, piping systems, pumps, conveyors, cranes, hoists, engines, vehicles, aircraft, robots, fuel cell vehicle safety, A/C systems, nuclear reactors, and so on.

Senior design projects that develop systems for competitions are bound by the rules and guidelines of the competition rules. Those teams should include a copy of the current rules as a section in the appendix, and state that their design complies with the required rules and regulations. However, a general review of their field for the availability of related major standards and summarizing them in a section will show the reader team’s understanding of the field in terms of applicable standards.
Any special design code or standard that may be important in your design may also be searched and included in this section. Depending on the nature of the project, this may be a special standard applicable to your project established by the FDA, EPA, USDOE, AWEA, SAE, ASME, NHTSA, IEEE, HFES, and others.

As safety standards are sometimes issued or classified separately in some instances, a search focusing on “safety standards specifically developed for your system” may reveal valuable information to design a safe system. Similarly, standards on ergonomics as developed by ISO, ANSI, and HFES should be searched for systems for which human factors and ergonomics are critical.

Hence, whatever may be the topic of your senior design project, each team is required to conduct a survey on the availability of relevant standards for the system, and later design the system so that the final developed system is in compliance with the rules listed in the standards.

**COMPONENT-LEVEL STANDARDS**

Component-level standards apply to every element used in the design and perhaps over 95% of the parts used in any design implicitly use standards at the component level even if it is not acknowledged explicitly. Note that federal and state regulations also require that many standards are applied; otherwise, many components cannot be sold legally on the market.

For instance, all of the engineering materials listed in mechanical design textbooks are standard components as their coded names reveal: ASTM, AISI, SAE, UNS, ASM, ASTM, AA, NIST, AISC and others have developed standard designations to identify materials. For instance, when steels AISI 4140, SAE 1080, and UNS G10350 are used, you can claim that component level standards are used in the form of standard materials.

Note that almost entirety of the material, appendices, majority of the tables and charts in your Mechanical Design book are direct excerpts from various standards established by ASME, SAE, ASME, AGMA, ANSI, ISO, and so on. This is often acknowledged as a footnote in a table, figure or page.

Standard components from reputable companies such as Timken, SKF, Boston Gear and others also form a basis of standards at the component level. Note that almost every component selected from reputable companies use a number of standards (materials, parts, special codes developed by ASME, ISO, ANSI, etc.) and they themselves become standard. For instance, AGMA gear selection procedure itself is a standard published by AGMA. Hence, many components used in design, such as gears, bearings, belts, chains, shafts, brakes, clutches, nuts and bolts, screws, materials used, computer controller boards, computer languages used (ANSI C, for instance),
safety guidelines, safety signs and labels developed and incorporated into the senior design project, are likely to be already in compliance with the standards developed by one of the SDOs (Standard Developing Organizations), and should be clearly identified and listed in the senior design report.

Below is a list of various Standards Developing Organizations (SDOs) that is covered in our design courses, textbooks and previous senior design projects:

**STANDARD DEVELOPING ORGANIZATIONS (SDOs) FOR MECHANICAL ENGINEERING**


NSPE National Society of Professional Engineers: Code of Ethics for Engineers, Ethics Resources for Case Studies, Board of Ethical Review Cases

NCEES National Council of Examiners for Engineering and Surveying: FE CBT Exam, PE License

US/SI US and International System of Units

ASTM American Society for Testing and Materials

AGMA American Gear Manufacturers Association

ABMA American Bearing Manufacturers Association

AISI American Institute of Steel Institute

ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers

NAPE National Association of Power Engineers

SAE Society of Automobile Engineers: Oil, Lubricants, Steel Standards, Aerospace, Automotive

UNS Unified Numbering System

ANSI American National Standards Institute

ISO International Organization of Standardization

AISI American Iron and Steel Institute

ASM International: American Society of Metals: Materials, Composites

ASTM American Society for Testing and Materials

AA Aluminum Association

UTS Unified Thread Standard

UNC Unified Coarse Thread Standard

UNF Unified Fine Thread Standard

UNEF Unified Extra Fine Thread Standard

NIST National Institute of Standards and Technology: Materials, Energy, Electronics, Manufacturing, Nanotechnology, Transportation

AWS American Welding Society
FCC Federal Communications Commission
CE Conformité Européenne (European Conformity)
IEEE Institute of Electrical and Electronics Engineers
IFR International Federation of Robotics
ISTA International Safe Transit Association
HFES Human Factors and Ergonomics Society
FDA Food and Drug Administration
USDA United States Department of Agriculture
AISC American Institute of Steel Construction
NHTSA National Highway Traffic Safety Administration
AWEA American Wind Energy Association
LEED Leadership in Energy and Environmental Design
USGBC United States Green Building Council
USEPA United States Environmental Protection Agency
USDOT United States Department of Transportation
USDOE United States Department of Energy
AASHO American Association of State Highway and Transportation
USDOL Occupational Safety and Health Administration

ASME Organized Competitions:
- ASME Human Powered Vehicle Challenge (HPVC)
- ASME Robots for Relief
- ASME IAM3D Challenge International Additive Manufacturing

SAE Organized Competitions:
- SAE Formula Race Car, Mini Baja Race
- SAE Aero Design East, SAE Aero Design Brasil
- SAE Supermileage Competition

NASA National Aeronautics and Space Administration Organized Competitions:
- NASA Robotic Mining Competition (RMC)
- NASA Green Aviation Challenge
- NASA Great Moonbuggy Race


BattleBot Robot Combat Competitions: An American company that has received international acclaim for their BattleBot competitions. Competitions take place in different categories including lightweight, middleweight and heavyweight robots.

Shell Eco-marathon - Shell Organized Competitions: Shell organizes the Shell Eco-marathon competitions where entrants can compete either in Prototype or UrbanConcept class. Cars can
utilize either an internal combustion engine (fueled by petrol, diesel, natural gas or ethanol) or electric mobility unit powered by hydrogen fuel cells or lithium-based batteries.

AN OVERVIEW OF STANDARDS COVERED IN MECHANICAL DESIGN COURSES

Mechanical Engineering Design I and II courses introduce several standard practices and design codes throughout the courses. These include the use of material specifications as recommended by ASTM, AISI, SAE, UNS, ASM, ASTM, AA, NIST, AISC, and others.

The following standards introduced by AGMA for gears are covered in class: Gear tooth systems for spur gears, standard pressure angles, standard addendum and dedendum, standard and coarse diametral pitch and modules, tooth proportion formulas for bevel gears, standard tooth proportions for helical gears, recommended pressure angles and tooth depths for worm gears. Gear design nomenclature is used as introduced in ANSI/AGMA 2001-C95 and continued in ANSI/AGMA 2001-D04 (strength values, reliability factors, dynamic factor, etc.). Spur gear geometry factor is defined by AGMA Standard 908-B89.

AGMA gear design procedure developed by the American Gear Manufacturers Association as referenced by ANSI/AGMA 2001-D04 and ANSI/AGMA 2101-D04 is covered in class in detail and students use the AGMA procedure to design several gears to develop gearboxes that have different design requirements for each team in class projects. In cases where gear catalogs have not yet adopted the most recent AGMA procedure for gear selection, students are asked to select gears as the catalog at hand recommended, and then verify the selection independently applying the most recent AGMA procedure covered in class.

Bevel gear rating equations, stress and strength formulas, geometry factor, dynamic factor, bending factor, contact stress cycle factor, hardness ratio, reliability factor, allowable contact stress numbers for steel and iron gears, allowable contact stress numbers for iron gears and steel gears, etc. are adopted from ANSI/AGMA 2003-B97 Standard.

Chain horsepower ratings and ANSI chain numbers are covered as defined in ANSI B29.1-1975 and B29.9-1958. Wire rope data is introduced as proposed by the American Steel and Wire Company. Minimum factors of safety recommended for wire ropes were adopted from ANSI A17.1-1978, maximum allowable bearing pressures of ropes on sheaves were used as recommended in the Wire Rope User’s Manual published by AISI, 1979.

Welding design and specification symbols of welding details are covered as recommended by the American Welding Society (AWS).
SAE grades and ISO class standards established for bolts and screws are covered in design classes. Acme threads as defined by ASME/ANSI B1.5-1998 are introduced as a screw thread profile used commonly in power screws.

ABMA standards and classification plans for ball bearings, roller bearings, and spherical roller bearings are taught in the class. Timken and SKF, which are the largest bearing manufacturers in the world, are introduced in the class and their online catalogs are used for bearing selection in design projects.

Since senior design project topics vary considerably, each design utilizes appropriate standards needed for the topic. As several of the teams design systems to participate in professional-society-organized competitions, their rules and standards are largely defined by the rules of the competition. In recent years, several teams developed their senior design projects to participate in the following competitions:

- ASME Human Powered Vehicle Challenge (HPVC)
- ASME Robots for Relief
- ASME IAM3D Challenge International Additive Manufacturing
- SAE Formula Race Car
- SAE Mini Baja Race
- SAE Aero Design East
- SAE Aero Design Brasil
- SAE Supermileage Competition
- MATE ROV Underwater Robotics Competition (MATE: Marine Advanced Technology Education Center, ROV: Remotely Operated Underwater Vehicle)
- BattleBot Robot Combat Competitions in Three Categories: Lightweight, Middleweight and Heavyweight Robots
- Shell Eco-marathon: Prototype or UrbanConcept Categories. Each with either an internal combustion engine or electric mobility unit powered by hydrogen fuel cells or lithium-based batteries
- NASA Robotic Mining Competition (RMC)
- NASA Green Aviation Challenge
- NASA Great Moonbuggy Race

**SEARCH OF STANDARDS THROUGH FIU LIBRARIES**

FIU Libraries subscribe to a number of standards (including ASTM) and continue to add new standards as they receive new requests and their budget allows. Students are encouraged to conduct a search through the “FIU Libraries” domain to reach specific standards.