

Lesson Plan – Introduction to ASTM F3239 Standard Specification for Aircraft Electric Propulsion Systems

<https://polytechnic.purdue.edu/aircraft-electric-propulsion>

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| Title: | Introduction to the standard specification for the Standard Specification for Aircraft Electric Propulsion Systems, ASTM F3239-22a |
| Instructional Goal: | <p>The goal of the two lesson modules is to increase student knowledge of the relationship between electric or hybrid-electric aircraft propulsion technologies and the applicable standards related to design and airworthiness. This module focuses on airworthiness requirements for aircraft electric propulsion systems. The companion website is divided into three areas: Materials, Assessments, and Resources. There are three informational videos in the Materials section of the companion website: Introduction to Airworthiness, Terminology in ASTM F3239, and Requirements in ASTM F3239. The Assessments section of the website contains multiple choice assessments and answer keys for each of the four videos in the Materials section. Please check for updated versions of this standard and for associated changes.</p> <p>There are two goals for the students in this module:</p> <p>Locate the applicable airworthiness requirements reference standards for the following systems of an electric propulsion engine.</p> <ul style="list-style-type: none">- Energy distribution- Control and indication- Hazard mitigation- Powerplant installation <p>Determine connections to FAA regulations in Title 14 Code of Federal Regulations Part 23 and FAA Advisory Circulars.</p> |
| Learning Standards: | N/A |
| Performance Objectives: | Given a list of systems, the student shall correctly identify which airworthiness requirements are located in ASTM F3239. |

Given a particular system, the student shall correctly identify the appropriate airworthiness requirements required in the ASTM F3239 or other standards.

Given a list of terms, the student shall correctly identify the appropriate definition.

Instructional Resources: Access to FAA and ASTM documentation.

ASTM F3239 Standard Specification for Aircraft Electric Propulsion Systems

FAA Title 14 CFR Part 23 AIRWORTHINESS STANDARDS: NORMAL CATEGORY AIRPLANES

FAA Title 14 CFR Part 33 AIRWORTHINESS STANDARDS: AIRCRAFT ENGINES

FAA Title 14 CFR Part 35 AIRWORTHINESS STANDARDS: PROPELLERS

ASTM F3060 Standard Terminology for Aircraft

Student Characteristics: Post-secondary adults with an interest in aircraft.

Delivery Method: Online or in-person

Lesson Outline

Introduction: The purpose of this module is to familiarize students with available industry standards related to the airworthiness of aircraft electric propulsion systems.

The student will be provided with multiple resources such as videos, assessments, and activities. The videos are an introduction and do not replace in-depth study of the standards or regulations. The videos should be previewed by the instructor to determine how the video may be used in one of more classes. Depending on the

course objectives, these materials may be adjusted to fit the needs of courses in technical, engineering, and general science or design courses.

Content: See the associated website for instructional videos, assessments, and activities. The transcription for each of the videos is on the website in the Materials section. By clicking on each of the videos, the viewer may select from three options of video and transcript as shown in this figure.



Closing: This module introduces the student to the use of standards for the airworthiness of aircraft electric propulsion systems. It is not a comprehensive module on the airworthiness process, airworthiness requirements, or aircraft certification.

Assignments/Activities: These are sample ideas for student activities and assignments that may be completed in class or as homework, and either by one student or in groups. The activities are not designed to be appropriate for all courses at all levels. Based on the instructional level and goals of the course, the instructor may choose to modify these activities or may choose to develop their own activities.

A. Students will create a list of electric aircraft currently certificated or under development, identify the engine and aircraft type options, and the country of origin. This list should be developed by using internet sources that are cited in the text and are listed on a “List of References”. A suggested format for this assignment is a table (with column headings such as engine,

aircraft type options, engine type options, country of origin, certificating body, and citation) that the student creates with a reference list for each cited source at the bottom of the table. An appropriate cover sheet or descriptive title should be a part of the assignment that is turned in to the instructor or shared in class.

B. Students will list the current uses of electric aircraft and their projected uses. This list should be developed by using internet sources that are cited by the students and are listed on a “List of References”. A suggested format for this assignment is a table (engine, aircraft type options, country of origin, certificating body, and citation that leads to the reference list) that the student creates with a reference list attached. An appropriate cover sheet or descriptive title should be a part of the assignment that is turned in to the instructor or shared in class.

C. Students will compare and contrast the differences between the following sets of terms:

- a) electric engine and electric propulsion system
- b) energy distribution systems and energy storage system
- c) capacity and usable energy capacity
- d) hazard identification and hazard mitigation.

A short, descriptive answer is acceptable for each of the four pairs of terms. A suggestion for completing this assignment is that the student create a table with columns for: each of the pairs of terms, comparisons, contrasts, and a summative example. A row on the table should be devoted to each of the four pairs of terms. Sources should be cited and available in a reference list. An appropriate cover sheet or descriptive title should be a part of the assignment that is turned in to the instructor or shared in class.

D. Students will search the Title 14 Code of Federal Regulations for the definition and explanation of “airworthy” and “airworthiness”. Find the definitions of these terms and write them down. Find the definition of “certificated” and write it down. What is a “certificated aircraft”? Students should start with 14 CFR Part 3a (as of June 2025) that states, “*Airworthy* means the aircraft conforms to its type design and is in a condition for safe operation.” What is the certification process? What is a certificated aircraft? What does Title 14 CFR Part 23 say about

certification? What does AC 23-16A have to say about certification?

Is there a video (or videos) from the FAA that explains these terms? Is there a video from other sources that explains these terms? How would you determine which video(s) are accurate or complete?

An appropriate cover sheet or descriptive title should be a part of the assignment that is turned in to the instructor or shared in class.

E. Students will investigate sources to develop and provide answers to these questions. What electric aircraft have you heard of before this class? Is electric propulsion always the best answer for moving people or cargo? Why or why not? Explain. This answer may require the student to use multiple sources, which should be cited and referenced.

F. Students will investigate sources to develop and provide answers to these questions. What does Title 14 CFR cover? [Clue: it covers more than just civilian aircraft.] Why does it matter? What is a Federal Regulation? Explain briefly. An appropriate cover sheet or descriptive title should be a part of the assignment that is turned in to the instructor or shared in class.

G. Students will investigate sources to develop and provide answers to these questions. Do all electric aircraft have propellers? Are the propellers always in the front or the back of the aircraft or on the top of the fuselage or on the wings or on the tail? What is meant by “pusher” propellers versus “puller or tractor” propellers? Are there other types of propellers used in current electric aircraft? How many propellers are on each of the electric aircraft that are certificated in the US? In the EU? In other countries (such as Japan, China, Russia, Kenya, Canada, Argentina, among other possibilities)? An appropriate cover sheet or descriptive title should be a part of the assignment that is turned in to the instructor or shared in class.

After viewing the videos and doing some number of activities, the students will develop and provide a list of questions that remain in

their minds related to electric propulsion. A quick exercise would be to develop a list of these questions (using brainstorming techniques, or one idea on a sticky note for each student, or a group activity) and then ask questions about how the students might go about finding answers to these questions. The instructor may share the final list with the class. This exercise may provide a way for instructors and students to connect these questions to other courses in their degree curriculum.

Assessment: See the four sets of assessment questions on the website. Any one of the assignments may be an option for a summative assessment.

Answer Key:

1. Introduction to Airworthiness Requirements for Electric Propulsion:

Q1: What is one major reason flying on commercial airlines continues to be safe?

B. Commitment to standard construction and maintenance procedures

Q2: What does the ASTM F3239 standard specifically address?

A. Airworthiness requirements for electric and hybrid-electric propulsion systems

Q3: Which organization certifies civilian aircraft in the United States?

B. Federal Aviation Administration (FAA)

Q4: Which category of civilian aviation is specifically linked to FAA Title 14 CFR Part 23?

B. General aviation

Q5: How do industry standards relate to FAA oversight?

A. They support compatibility and standardization but do not replace FAA oversight

Q6: What kind of documents does the FAA publish to guide airworthiness beyond regulations?

C. Advisory circulars, airworthiness directives, and service bulletins

Q7: What role do consensus standards play in aviation certification?

A. They provide additional guidance to complement FAA regulations

Q8: Who governs the FAA?

B. U.S. Department of Transportation

Q9: What is one key benefit of using industry standards in aviation?

C. They help maintain high safety standards through uniform procedures

Q10: Why might students be advised to ask their instructor about state aviation laws?

A. Because aviation regulation may vary across U.S. states

2. Terminology in ASTM F3239

Q1: What are the first three sections typically found in ASTM standards?

A. Scope, Referenced Documents, Terminology

Q2: Which standard contains comprehensive definitions for airworthiness-related terms?

B. ASTM F3060

Q3: What is the main function of an electric engine within the propulsion system?

B. Provide thrust for propulsion

Q4: Which of the following is NOT explicitly listed as a component of an electric propulsion system in ASTM F3239?

C. Avionics system

Q5: Why is standardized terminology important in the aviation industry?

B. It facilitates communication with clarity and precision

Q6: What component in an electric propulsion system is equivalent to a fuel tank in a gasoline-based system?

C. Energy Storage System (ESS)

Q7: Which of the following best defines the Energy Distribution System (EDS) in electric propulsion?

A. It delivers energy from the source to the electric engine

Q8: What issue is highlighted by the term “quantity” in the context of standardized definitions?

C. Inconsistent interpretation of what and when to measure

Q9: What is the practical reason battery manufacturers restrict full access to usable energy capacity?

A. To prolong battery life

Q10: How are “capacity” and “usable energy capacity” different in electric propulsion systems?

B. Usable energy capacity is a subset limited by design

3. Requirements in ASTM F3239

Q1: What is one reason why ASTM F3239 includes references to other standards in the powerplant installation section?

B. To build on existing requirements without duplicating details

Q2: In both gasoline and electric propulsion systems, what is a shared requirement for the oil system?

C. It must be independent and maintain a safe operating temperature

Q3: What condition must the energy distribution system be able to support to meet F3239 requirements?

B. Maximum continuous power for at least 30 minutes

Q4: Why must multiple electric engines have independent energy distribution systems?

A. To maintain redundancy and safety during operation

Q5: According to the video, what determines where energy system independence begins and ends?

A. Guidance provided in FAA advisory circulars

Q6: What types of systems are discussed in the hazard mitigation section of the standard?

C. Protection against fire, lightning, and ice

Q7: Why is it important to define what the pilot can replace in energy storage systems?

C. It ensures pilot actions don't compromise system safety

Q8: What does the video emphasize about the similarity of requirements between gasoline and electric systems?

B. Many core requirements remain the same despite the energy source

Q9: Why does the video compare standards to “puzzle pieces”?

A. Each contributes to a complete system of aviation safety

Q10: What is one key takeaway the video wants learners to leave with?

C. A working knowledge of standards improves aviation safety awareness