

Standard

Space Systems – Flywheel Rotor Assemblies

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Space Systems – Flywheel Rotor Assemblies

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Abstract

This standard establishes baseline requirements for the design, fabrication, test, inspection, storage, and transportation of a flywheel rotor assembly used in a spaceflight flywheel system for energy storage and/or attitude control. These requirements when implemented on a particular system will assure a high level of confidence in achieving safe and reliable operation.

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Foreword

This Standard establishes baseline requirements for the design, fabrication, test, inspection, storage, and transportation of a flywheel rotor assembly used in a spaceflight flywheel system for energy storage and/or attitude control. These requirements when implemented on a particular system will assure a high level of confidence in achieving safe and reliable operation.

The development effort of this Standard was one of the major activities of the Flywheel Rotor Safety and Longevity (FRSL) Working Group which was formed in June 2000 with the emphasis on inclusion of aerospace prime companies, flywheel rotor suppliers, university researchers and all interested government agencies. James Chang is the Chairman of this Working Group. Jennifer Ratner is the Secretary and David Christopher is the Technical Advisor. Kerry McLallin and Jerry Fausz are the government sponsors.

At the time of document preparation, the members of the AIAA Flywheel Rotor Safe-Life Standards Working Group were:

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The above consensus body approved this document in June 2004.

The AIAA Standards Executive Council (Mr. Phil Cheney, chairman) accepted the document for publication in October 2004.

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1 Scope

This document establishes a top level certification standard for the design, analysis, material selection and characterization, fabrication, test and inspection of the flywheel rotor assembly (FRA) in a flywheel used for energy storage and/or attitude control in manned and unmanned space systems. This standard, when implemented on an FRA in a particular flywheel system, can assure a high level of confidence in achieving safe and reliable operation. This document may also be applicable to flywheel systems used in aircraft, mobile, stationary and subterranean applications if appropriate changes are agreed to between the responsible authority and the flywheel developer.

This document applies specifically to FRAs in flywheels used in space flight applications. The standard is applicable to the parts in the FRA, which rotate under normal operating conditions. Included are rim, hub and/or shaft, and other associated rotating parts such as the rotating bearing components and the motor generator rotor.

This document does not include verification requirements applicable to the system level of the flywheel. At the flywheel system level, the qualification and acceptance test requirements specified in MIL-STD-1540 are applicable.

2 Applicable Documents

The following documents contain provisions which, through reference in this text, constitute provisions of this standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

MIL-STD-1540	<i>Military Standard, Test Requirements for Launch, Upper-Stage, and Space Vehicle</i>
MIL-STD-1629	<i>Failure Modes and Effects Criticality Analysis</i>
MIL-HDBK-5	<i>Military Handbook, Metallic Material and Elements for Aerospace Vehicle Structures</i>
MIL-HDBK-17	<i>Defense Department Handbook, Polymer Matrix Composites</i>
MIL-HDBK-340	<i>Military Handbook, Test Requirements For Launch, Upper Stage & Space Vehicles</i>
CINDAS/USAF	<i>Aerospace Structural Metals Handbook</i>
CINDAS/USAF	<i>Damage Tolerance Design Handbook</i>

3 Vocabulary

3.1 Abbreviations and Acronyms

FRA	Flywheel Rotor Assembly
I_p	Polar Mass Moment of Inertia
I_t	Transverse Mass Moment of Inertia
K_{IC}	Plane Strain Fracture Toughness
K_{ISCC}	Stress Intensity Threshold for Stress-Corrosion Cracking
KPP	Key Process Parameter

MDS	Maximum Design Speed
MEOS	Maximum Expected Operating Speed
MoS	Margin of Safety
NDE	Nondestructive Evaluation
NDI	Nondestructive Inspection
NDT	Nondestructive Test
S-N	Stress-Life Curve
ϵ -N	Strain-Life Curve
T _g	Glass Transition Temperature
VDT	Visual Damage Threshold

3.2 Terms and Definitions

For the purposes of this document, the following terms and definitions apply. In the event of a conflict, the definitions listed below take precedence.

“A” Basis Allowable

the mechanical strength value which at least 99% of the population of values are expected to fall above, with a confidence level of 95%

“B” Basis Allowable

the mechanical strength value which at least 90% of the population of values are expected to fall above, with a confidence level of 95%

Acceptance Tests

the required formal tests conducted on hardware items to ascertain that the materials, manufacturing processes, and workmanship meet specifications

Allowable Load (Stress or Strain)

the maximum load (stress or strain) that can be accommodated by a structure (material) without rupture, collapse, or detrimental deformation in a given environment

NOTE Allowable loads (stress or strain) commonly correspond to the statistically based minimum ultimate strength, buckling strength and yield strength as applicable.

Catastrophic Failure

a structural failure event due to rotor separation, or the rupture or collapse of other FRA components, or assembly

Composite Material

a combination of materials differing in composition of form on a macro-scale in which the constituents retain their identities in the composite, i.e., they do not dissolve or otherwise merge completely into each other although they act in concert

NOTE Normally, the constituents can be physically identified and exhibit an interface between one another.

Damage Tolerance

the ability of a fracture critical part to resist failure due to the presence of cracks during the required service life time, i.e., life factor X service life. For composite parts, the term crack also includes delaminations, defects due to manufacturing, and in-service damage, such as surface cuts and abrasions.