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Space systems — Structural design — Loads and induced environment

Systèmes spatiaux — Conception des structures — Charges et environnement induit

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Foreword

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International Standard ISO 14622 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Space systems — Structural design — Loads and induced environment

1 Scope

This International Standard defines the principles used to determine loads and the induced environment during the service life of a space flight vehicle and its components, taking account of the notions of probability, combined loads, corresponding safety factors and lifecycle.

2 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

2.1
space flight vehicle
combination of the launch system elements which leave the ground, i.e. the launch vehicle and the space vehicle(s) placed in orbit by the launch vehicle

2.2
launch vehicle
one or more space flight vehicle stages capable of launching one or more space vehicles and placing them in orbit

2.3
space vehicle
integrated group of subsystems and units capable of performing functions in space

NOTE Spacecraft is synonymous with space vehicle.

2.4
launch system
system including the space flight vehicle and corresponding installations, the ground equipment, hardware, software, procedures, services and personnel required for operations

2.5
load
response of a space flight vehicle to excitations encountered during its service life

2.5.1
static load
quasi-static load
load whose magnitude and direction are independent of time, or load which vary slowly and for which the dynamic response of the structure is not significant

NOTE This load can be induced by:

— steady winds;

— aerodynamic forces;

— thrust (constant or with slow variations);

— manoeuvres;

— spin stabilization.

2.5.2
transient load
load whose magnitude or direction varies with time and for which the dynamic response of the structure is significant

NOTE This load can be induced by:

— gusts;

— engine ignition or shutdown;

— separation;

— orbital docking;

— physical impact;

— deployment of appendages.

2.5.3
shock load
load applied in the form of shocks or percussion and for which the structure's dynamic response is significant

NOTE This load can be induced by:

— shockwave phenomena;

— pyrotechnic systems;

— physical impacts by deployed appendages;

— explosions.

2.5.4
oscillating load
load whose amplitude or direction varies within a frequency range for which the structure's dynamic response is significant

NOTE This load can be induced by:

— POGO effect;

— buffeting;

— vortex shedding due to ground wind;

— flutter;

— acoustic environment;

— rotation of parts;

— combustion instabilities in solid propellant stages.

2.5.5
limit load
maximum load that can be expected during the lifetime and in the presence of the environment

2.5.6
yield load
limit load multiplied by the yield safety factor J_E (2.10.1)

2.5.7
ultimate load
limit load multiplied by the ultimate safety factor J_R (2.10.2)

2.5.8
acceptance load
proof load
load applied during acceptance testing and which is equal to the limit load multiplied by an acceptance factor J_P

2.5.9
qualification load
load applied during the qualification tests and which is borne by the structure without failure or collapse

2.5.10
failure load
load determined experimentally and for which the structure fails, collapses through instability or exhibits excessive deformation

2.6 Pressure

2.6.1
limit pressure
maximum pressure differential that can be expected in service and in the presence of the environment (see 3.2.4) and includes:

— the operating pressure (due either to propellant combustion or to pressurisation);

— transient pressure;

— hydrostatic pressure;

— external pressure.

2.6.2
yield pressure
limit pressure multiplied by the yield safety factor J_E (2.10.1)

2.6.3
ultimate pressure
limit pressure multiplied by the ultimate safety factor J_R (2.10.2)

2.6.4
proof pressure
differential pressure applied during the proof pressure test and which is equal to the limit pressure multiplied by the proof pressure factor J_P (2.5.8)

2.6.5
hydrostatic pressure
pressure at a level below the liquid level in the tank, which is induced by the height of liquid above this level, plus quasi-static accelerations

2.6.6
transient pressure
pressure that varies with time and for which the characteristic variation time is of the same order of magnitude as the structure's significant time constant

2.7 Thermal definitions

2.7.1
calculated thermal flux
heat flux evaluated in the most unfavourable heat exchange condition

NOTE See 3.2.5.

2.7.2
design temperature
temperature of the structure once subjected to the harshest combination of load, pressure and temperature

2.8 Material properties

2.8.1
Young's modulus
E
constant ratio between the stress and the resulting strain

NOTE The average value of the Young's modulus determined at the design temperature shall be taken into consideration.

2.8.2 Allowable stresses

2.8.2.1
σ_E
uniaxial yield stress corresponding to 0,2 % residual strain (metallic materials only)

2.8.2.2
σ_R
uniaxial ultimate strength stress

NOTE 1 σ_R and σ_E have a statistical definition: they are equal to a value which has a 90 % probability of being exceeded, with a 95 % confidence level for unmanned space vehicles. In the case of manned space vehicles and/or launch vehicles, the values are 99 % and 95 % respectively.

NOTE 2 σ_R and σ_E correspond to the condition of the material when the structure is in service at the design temperature.

2.9
strength
ability of the structures to withstand the loads (or pressures) and the environment encountered during their service lifetime

2.10
safety factor
coefficient by which the limit load (or pressure) is multiplied so as to account for any inaccuracies in the known statistical distribution of the load (or pressure) and strength value

NOTE These inaccuracies are due to:

— the limited number of observations or tests used to estimate these distributions;

— calculation inaccuracies.

EXAMPLE If F represents the estimated statistical distribution of loads (or pressures) and R the estimated statistical distribution of strengths and that, relative to these estimated distributions, F_1 is the limit load and R_1 the allowable strength (ultimate or yield strength), the corresponding safety factor is:

$$J = \frac{R_1}{F_1}$$

2.10.1
safety factor at yield strength
J_E
ratio between the load (or pressure) at the material yield strength and the limit load (or pressure)

NOTE This factor can only be applied to metal structures.

2.10.2
ultimate safety factor
J_R
ratio between the allowable ultimate load (or pressure) and the limit load (or pressure)

NOTE A different approach can be used for defining a safety value when one has extensive experience of a given field of application. In this case, the authority will choose and set values for the safety factors.

2.11 Lifetime

2.11.1
envelope lifetime
lifetime of a structure determined on the basis of the structure having been subjected to the most unfavourable combination of events (load cycles, thermal cycles, etc.)

2.11.2
nominal lifetime
most probable lifetime determined by the authority on the basis of the envelope lifetime

2.11.3
design lifetime
lifetime used for designing structures, and in particular, for the damage tolerance studies

2.11.4
service lifetime
maximum period between the end of acceptance testing and the end of the structure's flight

3 Determination of loads and the induced environment

3.1 General input data

3.1.1 System inputs

To determine the loads, a space system shall be defined by:

— design trajectory;

— geometry;

— inertial data (masses, centre of gravity, inertia, unbalance);

— aerodynamic characteristics (global, local, distributed);

— thermal and thermo-optical coefficients;

— stiffness values (global, local);

— modal characteristics;

— propulsion characteristics;

— functional data concerning the control subsystem, the separation and jettison subsystems and the subsystems for deployment of appendages and other on-board devices.