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Standard Specification for Design and Performance of Pneumatic-Hydraulic Unmanned Aircraft System (UAS) Launch System[1]

This standard is issued under the fixed designation F 2585; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers the design and performance of unmanned aircraft system (UAS) launch system operating via a closed-loop pressurized hydraulic or pneumatic system with a hydraulic recovery, or both.

1.2 In instances where the launcher and UAS manufacturer are the same entity, compliance with this specification is the responsibility of the UAS manufacturer where applicable.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Terminology

2.1 *Definitions:*

2.1.1 *acceleration envelope*—range of launch accelerations (that is, acceleration curves) that the UAS launcher is capable of generating.

2.1.2 *deployed configuration*—UAS launcher's physical geometry in which it is in neutral position and ready for launch operations. Any manufacturer-prescribed check-out tests have been completed when the UAS launcher is in deployed configuration.

2.1.3 *gaseous charging agent*—compressible fluid that is pressurized to store the energy required for launch.

2.1.4 *jerk*—first derivative of the acceleration curve with respect to time; also referred to as acceleration growth rate.

2.1.5 *launch actuator*—cylinder that accepts the gaseous charging agent or liquid charging agent during expansion of the gaseous charging agent to move a piston; transfers gas or fluid pressure into an accelerating force on the shuttle assembly.

2.1.6 *launch, or exit, velocity*—velocity of the UA upon release from the launcher; UAS take-off velocity.

2.1.7 *launch lock*—mechanism that secures the shuttle assembly into the launch position to counter the force from fully pressurized pre-launch accumulator(s).

2.1.8 *launch rail*—track upon which the shuttle assembly can be accelerated prior to UA take-off.

2.1.9 *launch system*—self-contained system capable of launching a UA at prescribed take-off conditions; also referred to as a launcher or catapult.

2.1.10 *launch weight*—maximum allowable UA take-off weight not including the weight of the shuttle assembly.

2.1.11 *liquid charging agent*—incompressible fluid that can be used to fill the pre-launch accumulators to move the piston.

2.1.12 *neutral position*—UAS launcher system state in which *(1)* any fluids inside the pre-launch accumulators and pre-charge accumulators (if available) are at equal pressures, or *(2)* the system does not apply a force on the launch lock mechanism.

2.1.13 *power transmission mechanism*—used to transfer the accelerating force from launch actuator to shuttle assembly (for example, a shuttle assembly ram, cable and pulley system, etc.); power transmission mechanism may not be necessary in designs in which the launch actuators moves the shuttle assembly directly.

2.1.14 *pre-charge accumulator(s)*—similar in design to the pre-launch accumulator; allows extra space for storing gaseous charging agent between launches at a pressure lower than operating pressure; also used to achieve desired pre-launch accumulator pressures despite fluctuations in ambient temperatures.

2.1.15 *pre-launch accumulator(s)*—stores the energy required for launch; typically consists of either *(1)* a cylinder with a piston separating fluids (gaseous charging agent and liquid charging agent) within which a compressible fluid (usually a gas) is pressurized by pumping an incompressible fluid (usually hydraulic) into the cylinder, or *(2)* a pressurized container (for example, bottle) holding the gaseous charging agent with no piston (examples of each are provided in Fig. 1).

2.1.16 *recovery*—method by which the shuttle assembly is returned upon release of the UAS.

2.1.17 *shuttle assembly*—platform that interfaces with both the UA and the launcher.

2.1.18 *stowed configuration*—UAS launcher's smallest volumetric physical geometry in which the UAS launcher can be transported or stored for later use.

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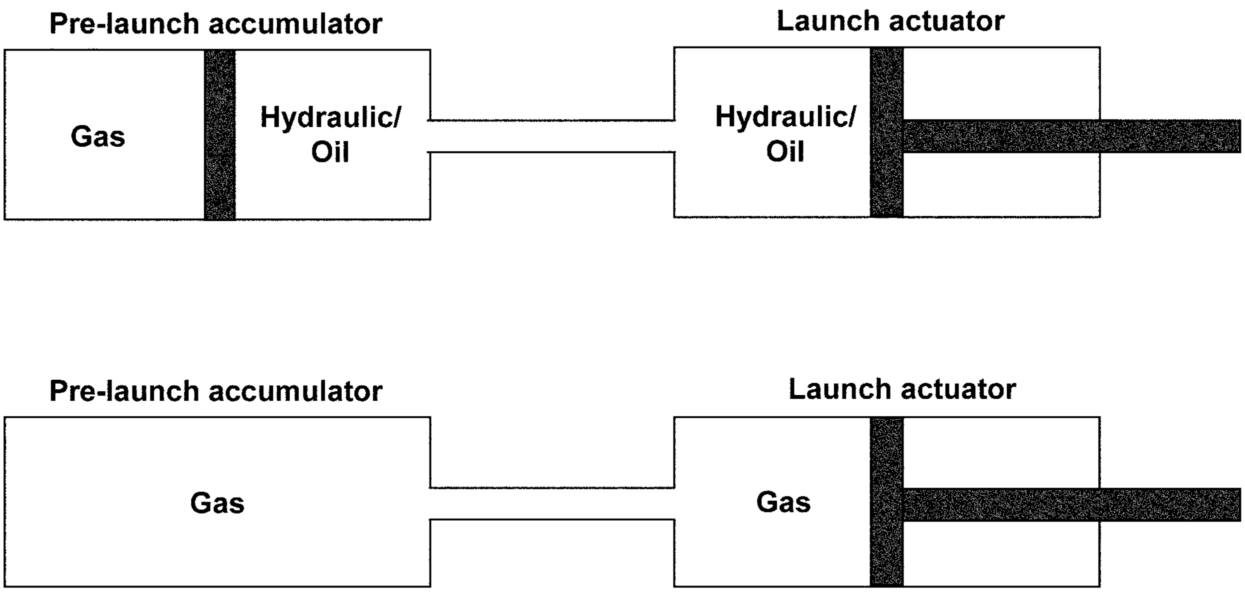

FIG. 1 Examples of Launcher Designs

2.1.19 *stroke*—distance traveled by the shuttle assembly as measured from start (pre-launch) to UA release.

2.1.20 *throw weight*—total weight to be accelerated by the UAS launcher; UA weight plus shuttle assembly weight.

2.1.21 *UA surrogate*—structure representative of the mass and support point dimensions of the UA; used to interface with the shuttle assembly during test launches.

2.1.22 *unmanned aircraft (UA)*—flight-capable portion of the unmanned aircraft system (UAS).

2.1.23 *velocity envelope*—range of launch velocities that the UAS launcher is capable of generating; a function of launcher acceleration and rail length.

2.1.24 *weight envelope*—range of launch weights that the UAS launcher is capable of accelerating to the required take-off velocity.

3. Design

3.1 The hydraulic or pneumatic launcher with hydraulic recovery, or both, shall include, but not be limited to, the following main components: pre-launch accumulator(s), launch actuator(s), shuttle assembly, launch rail, and launch lock.

3.2 *Accumulator(s), Launch Actuator(s), and Power Transmission Mechanism*:

3.2.1 Each pre-launch accumulator shall be capable of pressurization to accommodate the range of ambient temperatures within which the UA is rated to be launched.

3.2.2 Each pre-launch accumulator shall be capable of pressurization that exceeds the maximum required pressurization of the weight and velocity envelopes by 25 %.

3.2.3 The gas used as a charging agent shall be:

3.2.3.1 Non-combustible or have low combustibility (for example, nitrogen, air),

3.2.3.2 Non-toxic, and

3.2.3.3 Capable of pressurization via a compressor or gas bottle.

3.2.4 The liquid charging agent shall have a viscosity range with maximum fluctuation as a function of ambient temperature such that:

3.2.4.1 It can generate the required range of velocities within the velocity envelope, or

3.2.4.2 It can be heated to acceptable temperatures if ambient temperatures are shown to potentially increase viscosity to levels that adversely affect the velocity envelope.

3.2.5 The piping that transfers the liquid charging agent shall be designed to minimize cavitation and ensure smooth flow from the accumulators to the launch actuator.

3.2.6 The launch actuator shall transfer gas pressure from the pre-launch accumulator(s) into an accelerating force on the power transmission mechanism.

3.2.6.1 Indirectly (that is, pre-launch accumulator transfers pressure from compressed gas into fluid pressure and is connected to the launch actuator via hydraulic pipes, or hoses, or both), or

3.2.6.2 Directly (that is, pre-launch accumulator is connected to the launch actuator via pneumatic pipes, or hoses, or both).

3.2.7 Pressurization to control launch velocity shall be adjustable by one person via electronic or mechanical controls. Pressurization shall be displayed to the launcher operator via an electronic or standard pressure gauge.

3.2.8 The hydraulic recovery system shall be designed to:

3.2.8.1 Utilize the same actuators used to generate the accelerating force, or

3.2.8.2 Have dedicated actuators used for recovery only.

3.3 *Shuttle Assembly, Launch Rail, and Launch Lock*:

3.3.1 The shuttle assembly shall be securable in start (pre-launch) position using a launch lock mechanism when the UAS launcher is in neutral position.

3.3.2 The launch lock mechanism shall be capable of withstanding 1.5 times the force generated by fully-pressurized pre-launch accumulators.

3.3.3 Launch shall be initiated with the release of the launch lock, allowing for acceleration of shuttle assembly (piston in the case of ram design) and UA. Accelerating force generated by launch actuator(s) can act on shuttle assembly directly or via power transmission mechanism.

3.3.4 The force (that is, acceleration) delivered through a power transmission mechanism to the shuttle assembly:

3.3.4.1 Shall be constant, or

3.3.4.2 When this force is not constant, the launcher manufacturer shall provide the operator with data showing the launcher acceleration curve.

3.3.5 The launcher system shall include a measurement device(s) to monitor maximum velocity of the shuttle assembly (that is, UA exit velocity).

3.3.6 Shuttle assemblies that interface with various UA platforms shall interface with the launch rail via a common (that is, universal) design such that no structural reconfiguration of the launcher is required to launch a given UA platform provided that UA falls within the launcher velocity and weight envelopes.

3.3.7 The launcher shall be configurable so that it can be oriented azimuthally to accommodate adjustment for:

3.3.7.1 Local obstacles,

3.3.7.2 Prevailing wind direction, and

3.3.7.3 Operational requirements.

3.3.8 The launcher shall be configurable so that it can be oriented in elevation to ensure that the take-off path (angle) is consistent with the performance of the UA.

3.4 *General Design and Performance*:

3.4.1 The launch system manufacturer shall coordinate closely with the specific UAS manufacturers and operators before and during the design process to tailor the launch system to the specific UA performance, structural, and operational requirements to include the UA:

3.4.1.1 Mass,

3.4.1.2 Required take-off velocity,

3.4.1.3 Maximum acceleration loads, and

3.4.1.4 Launch angle.

3.4.2 Launchers shall be designed and classified as a function of their weight, velocity and acceleration envelopes. Various UA shall be accommodated by a single launcher if the launcher fulfills the UA requirements listed in 3.4.1.1 through 3.4.1.4.

3.4.3 Launcher operation shall not be dependent upon compatibility with the UAS command or control data link.

3.4.4 Any resulting recoil of the launcher during the launch process shall be reacted by:

3.4.4.1 Shock absorbers on the launcher platform,

3.4.4.2 Secure grounding to prevent launcher movement under recoil loads, or

3.4.4.3 Other methods demonstrated to be able to absorb recoil.

3.4.5 The launcher system shall be a "closed" system with the self-contained capability for:

3.4.5.1 Power,

3.4.5.2 Fluid compression, and

3.4.5.3 Autonomous monitoring of launcher status.

3.4.6 The launcher generator may be capable of providing excess electrical power to other UAS systems on a contingency basis.

3.4.7 Velocity envelopes shall be achieved without the requirements for rocket-assisted take-off (RATO) or other propulsive devices.

3.4.8 The launcher system shall be designed to support operations in night or low light conditions.

3.5 *Proof of Compliance*—The manufacturer(s) of the launcher shall coordinate with the UAS manufacturer and operator to obtain concurrence on an acceptable means of compliance with these specifications in accordance with Section 4. Compliance may be proven by conservative testing with the UA or a UA surrogate.

4. Testing

4.1 Each launcher that is designed and built to UAS manufacturer specifications shall be tested prior to delivery to the UAS manufacturer.

4.2 The results of any developmental or acceptance testing shall be presented to the UAS manufacturer upon launcher system delivery. Any system modifications based on test results shall be documented and noted at this time.

4.3 *Developmental Testing*:

4.3.1 Where applicable as determined by the launcher manufacturer, the following test procedures shall be developed and performed on a prototype launcher in order that the manufacturer may determine the appropriateness for use, of not only the components, but the entire system of a newly designed launcher.

4.3.1.1 Procedures to verify such design characteristics as relevant deflections, loads, and forces that are placed on both the launcher and the UA during operation.

4.3.1.2 Procedures to determine velocity, weight, and acceleration envelopes generated by nominal launcher operation.

4.3.1.3 Procedures to allow the manufacturer to determine such factors as component variability and certification requirements of components.

4.3.1.4 Procedure to determine operational limits and restart criteria related to environmental conditions (that is, criteria to determine when previously exceeded operational and environmental conditions have returned to acceptable levels for nominal launcher operation).

4.4 *Acceptance Testing*:

4.4.1 Where applicable as determined by the launcher manufacturer and UAS operator, the following test procedures shall be developed and performed to determine launcher performance prior to delivery.

4.4.1.1 *Pressurization Time*—The initial time required to pressurize the launcher from atmospheric or neutral position pressure to launch pressure.

4.4.1.2 *Reload Time*—The time to recharge the launcher for subsequent launches.

4.4.1.3 *Weight (Mass) Envelope*—The regime of acceptable UA launch masses from minimum to maximum.

4.4.1.4 *Velocity Envelope*—The regime of acceptable UA launch velocities from minimum to maximum.

4.4.1.5 *Acceleration*—The acceleration curves and maximum possible acceleration generated by the launcher.