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PRINCIPLE AND APPLICATIONS OF EJECTION SEAT IN AERONAUTICS

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ABSTRACT

Almost since the first days of flight, man has been concerned with the safe escape from an aircraft, which was no longer flyable. Early escape equipment consisted of a recovery parachute only. As aircraft performance rapidly increased during World War II, it became necessary to assist the crew members in gaining clear safe separation from the aircraft. This was accomplished with an ejector seat, which was powered by a propellant driven catapult - the first use of a propulsive element in aircrew escape Since then, this collection of componentry has evolved through several generations into today's relatively complex systems, which are highly dependent upon propulsive elements. Ejection seats are one of the most complex pieces of equipment on any aircraft, and some consist of thousands of parts. The purpose of the ejection seat is simple: To lift the pilot straight out of the aircraft to a safe distance, then deploy a parachute to allow the pilot to land safely on the ground

Key words: Safe ejection, Air Pilot Safety

Introduction

During the first days of flight man has been concerned with the safe escape from an aircraft which was no longer flying capacity. During Early days escape equipment consisted of only recovery parachute. As aero planes performance rapidly increased during World War II, it became necessary to assist the people in the crew in gaining clear safe separation from the plane. This was accomplished with an ejector seat which was powered by a propellant driven catapult –It was the first use of a propulsive element in aero plane cabin escape. From then onwards , this collection of parts of machine or vehicle has evolved through several generations into today's relatively complex systems which are highly dependent upon propulsive elements. Ejection seats are one of the most complex pieces of equipment on any jet plane, and some consist of thousands of parts. The purpose of the ejection seat is to lift the pilot straight out of the aircraft to a safe distance, then deploy a parachute to allow the pilot to land safely on the ground

The first operational use of a propulsive element to assist an airplane cabin to escape from an aircraft apparently occurred during World War II. The first country to find the ejection system was Germany as it is known that approximately 60 successful ejections were made from German aircraft during World War II. however, that the first plane ejection seat was designed and tested successfully with a dummy in 1910 by **J. S. Zerbe** in Los Angeles, California. The one year before the first parachutist successfully, jumped from an aircraft. Other than Germany another country involved in initial ejection seat work was Sweden. In early stages experiments were made by SAAB in 1942 using propellant powered seats. On 8 January 1942 the first ejection system was successful. A successful live ejection was made on 29 July 1946.At the end of World War II both the British people and Americans acquired German and Swedish ejection seats and data. This information and equipment added force to their efforts. On 24 July 1946 the first live flight test in England occurred. When Mr. Bernard Lynch ejected from a Meteor III aircraft at 320 mph IAS at 8,000 feet, using a prototype propellant powered seat. First Sergeant Larry Lambert ejected on 17 August 1946 from a P61B at 300 mph IAS at 7,800 feet to become the first live in-flight US ejection test.

3. BASIC COMPONENTS

It is essential to understand how an ejection seat works, you must first be familiar with the basic components in any ejection system. Everything has to perform properly in a split second and in a specific sequence to save a pilot's life. It could cause death even one piece of critical equipment malfunctions. Like all seats, the basic anatomy of ejection seat's consists of the bucket, back and headrest. Everything else is built around these main components.

Here are key devices of an ejection seat:

- **Catapult**
- **Rocket**
- **Restraints**

- **Parachute**

At the early stages propulsive element has been called a gun or catapult and, is in essence, a closed telescoping tube arrangement containing a propellant charge to forcibly extend the tubes, thereby imparting the necessary separation velocity to the "ejector seat" and its contents .The rocket is a propulsive device in the seat. The catapult is used as the initial booster to get the seat mass clear of the cockpit, while the rocket motor came on line, once clear of the cockpit, to act in a sustainer mode. For the cabin member the restraint system is the protective devices to avoid injury while ejecting the seat. The Harness straps can be tightened and the body position can be adjusted. To reduce injury from the forces encountered during ejection. The lifting devices of leg and arm and leg restraints are provided to prevent limb injuries due to windblast forces. The limb restraints do not require the cabin crew to hook up as they enter the aircraft and do not restrict limb movement during normal flight operations. Parachute helps to land safely on ground.

Bucket – It was situated at the lower part of the ejection seat that contains the survival equipment.

Canopy - It is often seen on military fighter jets. This is the clear cover that encapsulates the cockpit of some planes.

Catapult - With this ballistic cartridge the most ejections are initiated.

Drogue parachute - It designed to slow the ejection seat after exiting the aircraft. This small parachute is deployed prior to the main parachute.

Egress system – Egress system refers to the entire ejection system, including seat ejection, canopy jettisoning and emergency life-support equipment.

Environmental sensor - It tracks the airspeed and altitude of the seat.

Face curtain - Attached to the top of some seats, pilots pull this curtain down to cover his or her face from debris. It also holds the pilot's head still during ejection.

Recovery sequencer - It controls the sequence of events during ejection.

Rocket catapult - It is a combination of a ballistic catapult and an under seat rocket unit.

Underseat rocket – In some seats there have a rocket attached underneath to provide additional lift after the catapult lifts the crewmember out of the cockpit.

Vernier rocket –It is attached to a gyroscope, this rocket is mounted to the bottom of the seat and controls the seat's pitch.

zero-zero ejection - The ejection on the ground when the aircraft is at zero altitude and zero airspeed is known as zero-zero ejection .

Basic equations:

Forces and G's - Newton's second law states that the force on a body is defined as the product of mass and acceleration. It is represented in an equation as

Force = Mass * Acceleration [F=M*A]

In terms of the G the acceleration is usually measured, or gravity, force equivalent. one experiences 1 G of acceleration. A rocket assisted seat has a G rating of 5-10, while one pure catapult seat would be in the 10-20 G range.

G's and speed – Incase to determine the speed of the seat at any point in time, one solves the Newton equation knowing the force applied and the mass of the seat or occupant system. There are other factors that are needed are the time for the force to be applied and the initial velocity present . This all works together in the following equation:

Speed (final) = Acceleration * Time + Speed (initial)

[V(f) = AT + V(i)]

At the start initial velocity may involve the climb or sink rate of the aircraft, but most likely involves velocity resulting from a previous ejection force. According to recent facts, in most current seats, the ejection in a two step process where an explosive catapult removes the seat from the aircraft then a rocket sustainer gives final separation. In order to solve this seat system, the Newton equation would be solved twice. Once with a Velocity(initial) of zero for the catapult and a second time where the initial velocity would be the speed at which the seat left the catapult.

Seat speed, aircraft speed, & aircraft size - The above parameters like force, mass, time, and seat sequencing, need to be considered when the system is applied to an operating aircraft. The seat speed needs to be high enough to give a reasonable separation distance between the occupant and the airplane or aircraft. But at the same time, the operating time needs to be short enough to move the person out of danger and allow all actions to take place. But as speed goes up and time goes down, the G force may become excessive. Consequently distance and time have to be balanced to provide a system that will operate swiftly, provide adequate separation, and not to impose an undue G load on the seat occupant.

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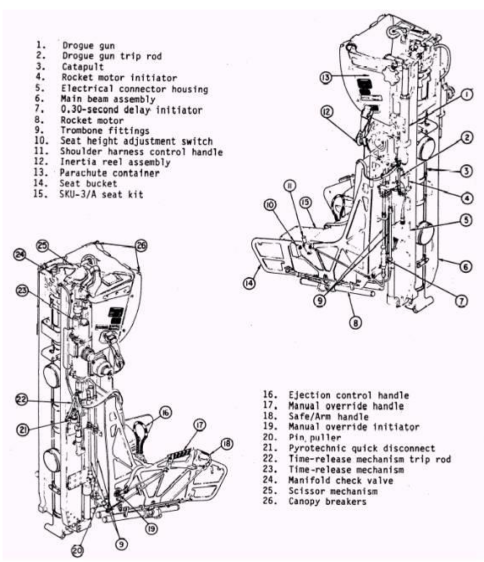
This relationship is given in the following equation:
Distance = 1/2 * Acceleration * Time^2 + Speed (initial) * Time

[D = 1/2AT^2 + V(i)T]

Pilot size & weight:
There are seat mass, equipment mass and pilot or occupant mass The mass of seat is composed of the seat itself, any pyrotechnics that eject with it, the survival kit, and the parachute.

These weights can vary highly. Since the Martin Baker H-7 seat as installed in the F-4 phantom they were as follows, seat = 88 kg, survival kit = 18 kg, and parachute = 9 kg. Well, by looking at the McDonnell Douglas ACES II seat, the seat weight drops to about 68 kg with the other factors remaining essentially constant. For some seats used in aircraft, weight is even less as the survival kit may be deleted since the aircraft is only used for flight test or over land where rescue is immediately available. On Depending the aircraft and the occupant that may be 14-22 kg of weight.

Figure:



Line diagram of ejection seat(3)

CONCLUSION:

Ejection seat has been evolved into a complicated system with the subsystems. Seat improvement has improved the chances of survival, and expanded boundary limits for successful ejection. And the incidence of ejection injuries is reduced by employing a complex acceleration profile. The profile is impulsive and of high amplitude at the beginning and end of the acceleration period, while relatively smooth and of low amplitude during the interposed major time segment.

The controllable propulsion systems will be used by the next generation of escape systems to provide safe ejection over the expanded aircraft flight performance envelopes of advanced aircraft. And the continued research will only make better the capability of future ejection systems. The current research efforts are being directed toward solving the problems associated with high speed and high altitude ejections. Legitimately we can expect that in the future more advanced ejection seats will evolve which will be more safer and will save many valuable lives.

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