FLIGHT SAFETY FOUNDATION, INC.
5510 Columbia Pike, Arlington, VA 22204 USA
(703) 820-2777

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EVACUATION SLIDES . . .

HISTORY & NEW TECHNOLOGY

The following was prepared by Sharon Barthelmess, Safety Specialist, FAA (Federal Aviation Administration), Office of Aviation Safety

Aircraft accident experience has resulted in many new safety considerations for emergency evacuation slides. These include aluminized coating for inservice slide materials and a reassessment of slide strength and heat resistance requirements in new slide production. James Summer *, presently employed by Eastern Aero Marine, presented a history of the inflatable evacuation slide during a symposium held in October 1980 at the Federal Aviation Administration Technical Center (FAATC). The following article highlights Summer's presentation and includes a discussion of FAA and Boeing research and evacuation slide tests.

HISTORY OF THE INFLATABLE EVACUATION SLIDE

Aircraft were relatively small and low to the ground in the early days of air transport. In the event of an emergency evacuation, passengers would simply take a large step to the ground. As aircraft became larger the height of the doorsill to the ground increased so a knotted rope was provided for escape. Additional increases in aircraft size and doorsill height rendered the knotted rope practically useless.

About this time a coal man was observed delivering coal from his truck down thru a cellar window via a metal coal chute. The observer thought this could be applied to the emergency evacuation of an aircraft and the fabric escape chute was developed.

These chutes were made from coated fabrics, had a flat sliding surface with turned up sides to contain the evacuee, hardware at the upper end to attach the chute to the doorsill and several sets of webbing handles on each side at the lower or ground end. The chutes were stowed on or adjacent to the door. In case of an emergency the door was opened, the hardware on each side of the chute was attached to the mating hardware on the doorsill and the remainder of the chute was thrown/pushed out the aircraft. It was expected that two husky men would be the first to leave the aircraft by shinning down the hanging chute. These two men would grab a set of handles on opposite sides of the chute and walk away from the aircraft until the chute was fully extended. They would then throw their weight against the handles to hold the chute taut and two additional men would slide down the chute and grasp the remaining handles and assist in holding the chute taut for the remainder of the evacuees.

* *Summer is a twenty-year veteran engineer of Air Cruisers and American Safety Inflatables.*

The fabric chute was an improvement over the knotted rope but still had many drawbacks. They include: the length of time required to engage the chute and position the holders; the pile ups that occurred at the end because evacuees rarely landed on their feet; the inability of the holders to maintain a nearly constant sliding angle; the hesitancy of the evacuees to use the chute, and the improbability of having the holders support the chute with an engine fire overhead.

The individual who constructed the fabric chutes, was also an inflatables engineer. Having basically designed the inflatable airline rafts and life vests as we know them today, he began thinking about using an inflatable structure to replace the fabric chute.

The material available at that time was a natural rubber coated cotton or the newly developed nylon fabrics which could be purchased in a 36 inch useable width. If a tube was made of this width fabric it would be approximately 12 inchs in diameter. That would not be wide enough to slide on, however, if two widths of fabric were joined together a tube of approximately 24 inches in diameter could be fabricated. A tube of this diameter would be wide enough to slide on and would support the accompanying loads. Since it is difficult to maintain position on a curved surface a longitudinal tube was placed along the longitudinal axis on either side of the support tube to form a trough and to prevent the evacuee from sliding off the side of the tube. These tubes were approximately 12 inches in diameter to get full utilization from the 36 inch wide fabric.

A fabric girt was installed at the sill end with the same hardware as was used on fabric chutes. This girt was of two piece construction and was laced together so the slide could be detached from the aircraft while inflated for use as a flotation device in a water ditching.

Handles were installed at the lower end to permit use as a fabric chute should the inflation system malfunction. Additional handles were placed on the top of the slide to permit re-entering the aircraft and lines were fastened along the sides of the structural tube for flotation device hand holds.

Since natural rubber has a high friction factor and prevented evacuees from sliding, single side coated nylon fabric strips were cemented onto the sliding surface with the uncoated or nylon side up. The width and lengths of these strips were adjusted to obtain the required exit velocity.

The idea worked and led to the development of the inflatable slide. An acceptable method for inflating the slide however, still had to be developed.

The first commercial sale of an inflatable slide was during 1956. It had a volume of 110 cubic feet, was approximately 275 inches long and inflated in 25 seconds. Adjusting the regulator and adding tighter controls to the aspirators reduced the inflation time to 13 seconds.

The B-707 was the second sale followed closely by the DC-8 and CV-880/990. All these slide designs had one thing in common. Each one was designed exactly the same. Only the length and consequently the inflated volume, stored gas requirements and inflating times varied.

SLIDE IMPROVEMENTS

Although the slides were performing as originally designed - to get people off the aircraft in a hurry - experience showed that a large portion of the evacuations were of a precautionary nature. If an evacuee was injured, and the aircraft was intact (no fire, etc.), the injured evacuee filed a law suit. As the law suits piled up, the industry trend was to design a slide which would buckle under the weight of an evacuee and let them scramble/crawl off with no minor injuries. So the second generation of slide evolved in 1960 to 1962.

These slides were fabricated as a rectangular tubular structure having a fabric sliding surface and a built-in break point. The fabric sliding surface reduced the possibility of a catastrophic failure due to a spike heel puncturing the sliding surface.

In previous slides the sliding surface was on an inflated tube. If, in this case, a spiked heel punctured the sliding surface it also punctured the inflatable structure. The air integrity and, consequently, the structural support of the slide was lost.

This breaking effect of the slide and gentle deposit of the evacuee on the ground took valuable time and slowed the possible evacuation rate, so a third generation of slide evolved about 1965. This third generation slide had a curved or hooked lower end. It was strong, did not buckle and, when necessary, incorporated decelerating devices at the lower end to rotate an evacuee from a prone position to a sitting position. It provided an exit velocity slightly faster than a walk. This generation of slide is the current model although it has been modified to permit two lanes of evacuees. By adding a second tubular frame on top of the basic structure the slide/raft was developed.

STRUCTURAL CLOTH

Early inflatable equipment was fabricated from cotton, coated with an elastic substance such as natural rubber, and later, neoprene. The fibrous surface and low strength of the cotton cloth required heavy cotton threads and thick coatings in order to obtain the required strength and air-holding properties for any given inflatable design.

As synthetic fibers became available, nylon was substituted for the original cotton cloth. The greater strength of nylon permitted the use of lighter yarn for the same strength coated fabric and the less fibrous nature of the nylon yarn permitted use of a thinner elastic coating. The result was a large weight and bulk savings over the cotton based fabrics.

A new cloth made from "Kevlar" is now available which is lighter, stronger, more puncture and tear resistant and less flammable than nylon. This material can also be natural rubber, neoprene and/or polyurethane coated to obtain the desired air-holding properties.

Since "Kevlar" is highly flame resistant, it does not require additional quantities of flame retardants to be added to the coating compound, as is the case with nylon fabrics. The demonstrated higher strength, lower weight and bulk, less toxicity and greater resistance to heat flux of neoprene-coated "Kevlar" fabrics, when compared to various coated nylon fabrics, makes it an excellent candidate for the coated fabric for use on evacuation equipment.

SLIDING ANGLES

A review of potential sliding angles revealed that the optimum line of sight sliding angle for normal sill heights is approximately 36 degrees. For other than normal sill heights, the line of sight angle increases or decreases as the sill height increases or decreases, respectively.

As the line of sight angle increases beyond approximately 45 degrees, the speed of sliding increases fairly rapidly. At approximately 48 degrees, the evacuees have a tendency to hesitate before entering the slide because of its steep appearance.

As the line of sight sliding angle decreases below approximately 32 degrees, the speed of sliding decreases until, at approximately 28 degrees; evacuees may have to assist their descent by pushing with their arms and legs. As the line of sight sliding angle decreases below approximately 22 degrees, evacuees using the slide can run off it as they would from a ramp.

Each particular evacuation slide must be tailored to meet a compromise set of usable line of sight sliding angles, based on the expected variation of sill heights for its related aircraft door.

B-767 EVACUATION SLIDE

The passenger escape slide for the new Boeing 767 transport is being tested at the company's 747/767 final assembly facility in Everett, Washington. The test rig can be raised or lowered to simulate collapse of the main or the nose landing gear, or both. The slide will also undergo hot and cold chamber tests, be deployed outdoors in manmade crosswinds and in a pond to simulate ditching. The slide will undergo a total of 620 tests.

FAA TECHNICAL CENTER RESEARCH

As a result of the DC-10 accident on March 1, 1978 at Los Angeles International Airport, the FAA Technical Center has developed new and extensive tests to better measure the resistance of slide materials to radiant heat from fires.

Several evacuation slides failed when the DC-10 overran the departure end of the runway and the crew initiated an evacuation. One slide (slide/raft) failure was attributed to radiant heat from a fire that was located 15-20 feet away.

The FAA's full-scale test employed a 30 foot by 30 foot fuel fire. Inflated slides were placed 15 or 20 feet away from the edge of the fire. Various instruments and viedo/movie cameras recorded the behavior of the slides while subjected to the fire's radiant heat. The tests were performed at daybreak during minimum wind conditions. The FAA fire safety branch used the initial loss of air pressure in the slides as the moment of failure during the tests because a slide loses its safety capabilities at that time. After laboratory and full-scale tests, the FAA found that the addition of an aluminized coating doubled the heat resistance of uncoated slide material presently in use.

In the full-scale testing at 15 feet, urethane/nylon lasted 17 seconds before bursting from radiant heat, while neoprene/nylon lasted 28 seconds. The aluminized-coated urethane/nylon took 64 seconds until initial pressure loss.

The aluminized paint used in the research was developed by the B. F. Goodrich Corporation exclusively for the tests. The prototype laboratory test used a small pressurized cylinder which was covered by a piece of the material to be tested. The material was then placed close to a radiant heat source, and the heating rate was calibrated with a calorimeter. The Center's findings, monitored by leading commercial aircraft and evacuation slide manufacturers, will be forwarded to the FAA's Office of Airworthiness, which sets safety standards for aircraft.

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