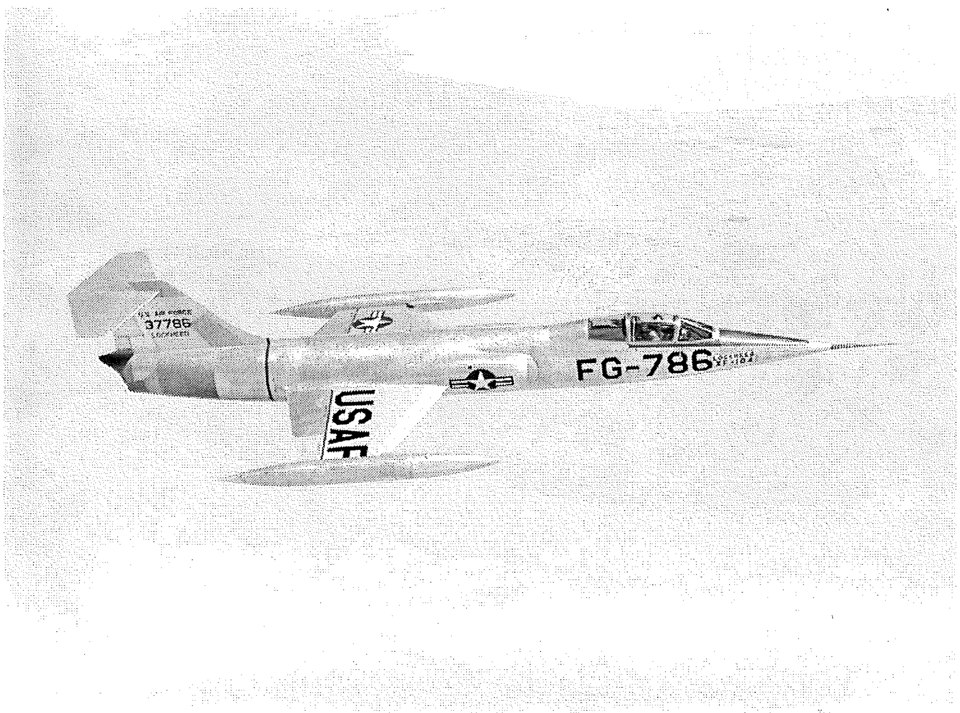
The SURE Project



Lecture – 4/10

STARFIGHTER
UTILIZATION
RELIABILITY
EFFORT

LECTURE
4

A TEST PILOT'S REVIEW OF F-104 ACCIDENTS

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REFERENCES

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2. Lockheed-California Company Fighter Newsletter No. 65-5, Dated 18 June 1965.

3. Lockheed-California Company Fighter Newsletter No. 8-65, Dated 20 August 1965.

4. T.O. 1F-104A-1, "F-104A and F-104B Flight Manual".

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FOREWORD

In no other profession in the world is the health and well-being or misfortune of a member as avidly reported from one to another -- as among fighter pilots. Far from being a morbid fascination with pain and death, the instinctive search of knowledge for self-preservation dictates an investigation of all facets connected with an esteemed member's unlucky encounter.

The prime motivation of a fighter pilot is to train and live for that split second of squeezing the trigger that culminates in proving that he is the world's best. In order to live until that supreme moment, the possibility of a "pilot-error" accident must be tenaciously evaded. A major aspect of the struggle is to gain invaluable pilot experience from the unforeseen pitfalls that our comrades do not escape.

In spite of the unforgiving aspect of flying that occasionally causes the loss of one of us, there is always a gain if we learn, if we remember and if we apply the lesson for which someone else has already paid a high price.

In this lecture I have compiled some selected F-104 accidents with my personal comments which are based only on the broad general assumption of what occurred during the accident. If this lecture has the effect of preventing even one accident -- my objective will be achieved.

For the purpose of emphasizing the lessons contained in these accident briefs, I have grouped them into the following categories:

I. Split Flap Problems

II. Approach and Landing Accidents

III. Mid-air Collisions

IV. Attempted Landings on Unprepared Surfaces

V. Ejection After Landing vs. Remaining In Aircraft

VI. Engine Compressor Stalls

VII. Power Stuck at Full Throttle or T_2 Reset

VIII. No Afterburner Operation On Attempted Takeoff

IX. Open Nozzle Failures

X. Open Canopies During Flight

XI. Nosewheel Lift-off During Takeoff Roll

XII. Crosswind Landing Problems

XIII. Low-level Acrobatics

XIV. Pilot Disorientation

XV. Exceeding Aircraft Limitations

Accident Review No. IA

Aircraft was on final approach for landing when the pilot transmitted he had roll-trim problems and would go-around. The aircraft made uncontrollable left rolls and crashed two-thirds of the way down the runway and a quarter mile to the left while going away from the runway at about a 45 degree angle. The pilot did not eject.

Investigation showed asymmetrical trailing edge flap condition caused by a right hand flap actuator internal failure. The right trailing edge flap was found 36 degrees down and left trailing edge flap full up.

Accident Review No. IB

Pilot making simulated flame-out patterns with hi-key at 25,000 feet. On second pattern, pilot lowered flaps to takeoff position but apparently only right trailing edge flaps lowered. Flaps were recycled without effect. Aircraft entered uncontrolled roll to left. Pilot tried to counteract roll by full right aileron and rudder with afterburner. A 360 degree turn was accomplished, however rate of roll was uncontrollable and increasing. Pilot ejected successfully.

Investigation showed left trailing edge flap failed to extend because its motor failed to operate and interconnecting system failed structurally.

Accident Review No. IC

Instructor and student had been practicing simulated flame-out approaches. Last aircraft radio call advised he was turning on initial approach. Witnesses state aircraft made normal left turn then began rolling to the right, making a complete roll before contacting ground. Evidence in wreckage indicated split flap condition caused loss of control. No ejection attempt by either pilot.

Comments

An asymmetrical flap condition is truly the most difficult aircraft lateral control problem short of total loss of the control system. Dependent upon the degree of asymmetry between flaps, aircraft speed and configuration and available control authority, the aircraft may or may not be controllable. For this reason, we designed the asymmetry detection system to stop the trailing edge flaps from getting too far out of symmetry. However, you should understand the design of this detection system so you will still be prepared for the possibility of an asymmetrical condition. So first let me explain the important points of TCTO 1F-104-844 and TCTO 1F-104-2033.

The asymmetry detector provides protection for wing trailing edge flap only. Leading edge flaps are not protected, since we believe that a leading edge flap asymmetry condition will be fully controllable. Therefore, if you move the flap lever after the detector has deactivated the trailing edge system, the leading edge flaps will probably operate normally. The asymmetry detector is designed to sense actuator movement only and does not sense actual flap position. The detector system will operate any time flap actuators become more than $5.5^{\circ} \pm 1^{\circ}$ and, in certain conditions, as high as 10° out of synchronization. Detector actuation will be effected by the following conditions:

A. Failed flex drive shaft.

B. Failed or jammed flap actuator.

C. Excessive drive slack in:
(1) Flap actuator
(2) Flap actuator to BLC valve drive
(3) BLC valve linkage

D. Excessive friction within BLC valve and/or linkage.

E. Incorrect installation and/or rigging of detector system.

F. Any combination of the above conditions that will permit actuator system to become unsynchronized the required amount.

An investigation of the aileron/rudder limiting circuits shows the electrical circuit differences between models. When F-104A/B/C/D detector switch deenergizes the trailing edge flap circuit, it also deenergizes the aileron limiter circuit and the pilot has full aileron travel available. This does not occur in F/RF/TF-104G(MAP) and TF-104G aircraft. To obtain full aileron travel in these models you must either pull the rudder limiter circuit breaker or lower the landing gear.

So now you can see that with aircraft without the asymmetry detection system and even those with the detection system, <u>it is possible</u> to encounter an asymmetric condition of varying degree when the flap system malfunctions.

The handbook* gives you the procedures for aircraft with and without the asymmetry detection system. It should be realized that the main task you must accomplish, with a split-flap condition, is the best possible analysis you can make of all control aspects for a possible landing. If the aircraft becomes uncontrollable due to a split flap malfunction, there is only one

*T.O. F/RF/TF-104G(MAP)

procedure -- ejection! And by all means you should do your best to hold the aircraft as level as possible and eject in this attitude. Our portrayal of bank angle effect in our discussion on ejection* shows you the importance of this requirement.

The points for you to consider in your evaluation of the controllability of the aircraft are:

1. Positions of trailing edge flaps: It will probably be impossible for you to determine exactly the position of each trailing edge flap. However, you can narrow down their approximate positions by taking into account their last known position and what flap selection you made just prior to the asymmetric condition. Experience has shown that asymmetric conditions between the Up and Take-off position are usually controllable to the extent that a well planned approach and landing is possible. Experience has also shown that for the malfunctions between the Take-off and Land positions, the aircraft might become laterally uncontrollable. This is because of the effect of BLC. For example, if one trailing edge flap stops shortly after starting from Take-off, toward the Land position, at about 20°, and the other flap continues to around 30°, the combination of split flap plus the increasing lift effect of BLC operation, makes the aircraft laterally uncontrollable. To eliminate, as much as possible, the effect of BLC, you should retard the throttle to idle. This will help in controlling the aircraft for ejection, but obviously precludes any attempt to fly and land.

2. Configuration of aircraft: For aircraft with tip tanks that have the 30 inch inboard vane, you will have degraded aileron effectiveness at landing speeds.** Therefore, consideration should be given to jettisoning these tanks. Also, if an immediate landing has to be made and fuel is still remaining in any external tanks, jettison of the stores will decrease the weight and make approach and landing that much safer.

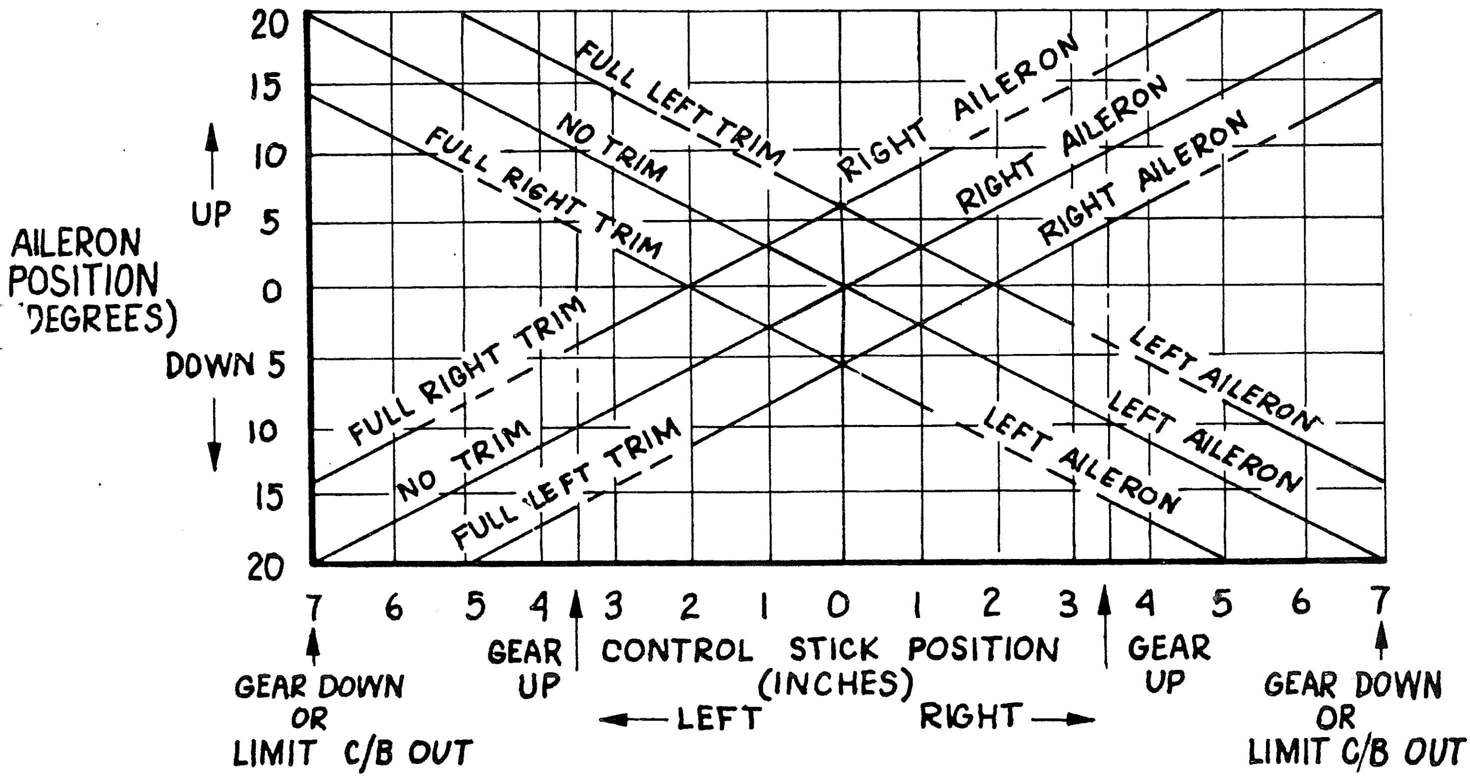
3. Airspeed: The normal reaction with an asymmetry problem is to increase speed. This obviously increases aileron effectiveness <u>but</u> it also increases the imbalance by increasing the lift on the down trailing edge flap. So you should search for the best control effectiveness airspeed in the best available landing configuration.

*SURE Lecture "A Critique of Selected F-104 Emergency Operating Procedures".
**SURE Lecture "An Analysis of F-104 Aircraft Limitations and Operating Restrictions".

4. Control Authority: As pointed out previously, on F-104A/B/C/D aircraft you will automatically have full $\pm$ 15° of available aileron throw anytime the asymmetry detector unit deenergizes the trailing edge flap circuit. This does not occur on the F/RF/TF-104G (MAP) and TF-104G aircraft. So I want you to study this next plot which will make clear to you the available aileron throw with various trim positions.

AILERON POSITION VERSUS CONTROL STICK POSITION AT TRIM CONDITIONS

F/RF/T F-104G CF-104/D F 104 J/DJ



If you study this graph, you will see the various limitations on available aileron throw with landing gear up and down.

You will notice that with the landing gear up, there is a control stick mechanical stop that limits you to 3.5 inches of stick throw left and right and $\pm$ 10° of available aileron throw at a no trim condition. With the landing gear down, or the limit circuit breaker out, there is 7 inches of stick throw, left and right, and $\pm$ 20° of available aileron throw at a no trim condition.

Now, I want to give you an example of how an understanding of this plot will help you. Suppose you have made a normal take-off and the landing gear comes up and at about 300 knots, you raise the flap handle from Take-off position to Up. Let's assume that the left trailing edge flap raises to Up, but the right trailing edge flap stops at about 10° down. In a short time, the right wing would start lifting in a left roll. Since you would still be in A/B and accelerating, you are above landing gear extension speed and the limit circuit breaker, as you know, is in a difficult to reach position. Therefore, your first reaction would be to move the control stick to the right to stop the left roll. <u>But</u>, you would quickly reach the 3.5 inch limit of stick travel with the right aileron only 10° up and the left aileron 10° down. Is this your maximum aileron travel under these conditions? No! Why not?

Well, if you're the type of pilot I am, the instant that the aircraft started rolling left, you would start using right control stick, and if this did not keep the wings level, you would instinctively push the trim button as if your life depended on it. Would this help you? Well, let's look at the graph. If you moved the stick to the right, until you were stopped by the control stick mechanical stop, the aileron displacement would be as I explained before -- right aileron 10° up and left aileron 10° down. But now with the aileron trim movement, we move straight up on the graph from the 10° up displacement point to over 15° up for the right aileron and the same increase in left aileron down movement. In other words, you increase the aileron throw by over 50% in both directions. So use all the trim available to assist you when the landing gear is up and the limit circuit breaker is in. Then when you have time and opportunity - either pull the limit circuit breaker or lower the landing gear for the full $\pm$ 20° of aileron authority.

Taking into account the above factors and using the dash one procedure, I recommend the following landing technique.

1. Glide path: Attempt to fly a straight line glide path with little or no change in pitch attitude that would aggravate the lateral control problem.

2. Airspeed: Maintain your best airspeed for control right down to the runway and touchdown without "flaring" the aircraft.

3. Touchdown: Lower and hold the aircraft nose on the runway while immediately bringing throttle to idle and slowing the aircraft with speed brakes and drag chute deployment at proper speed.

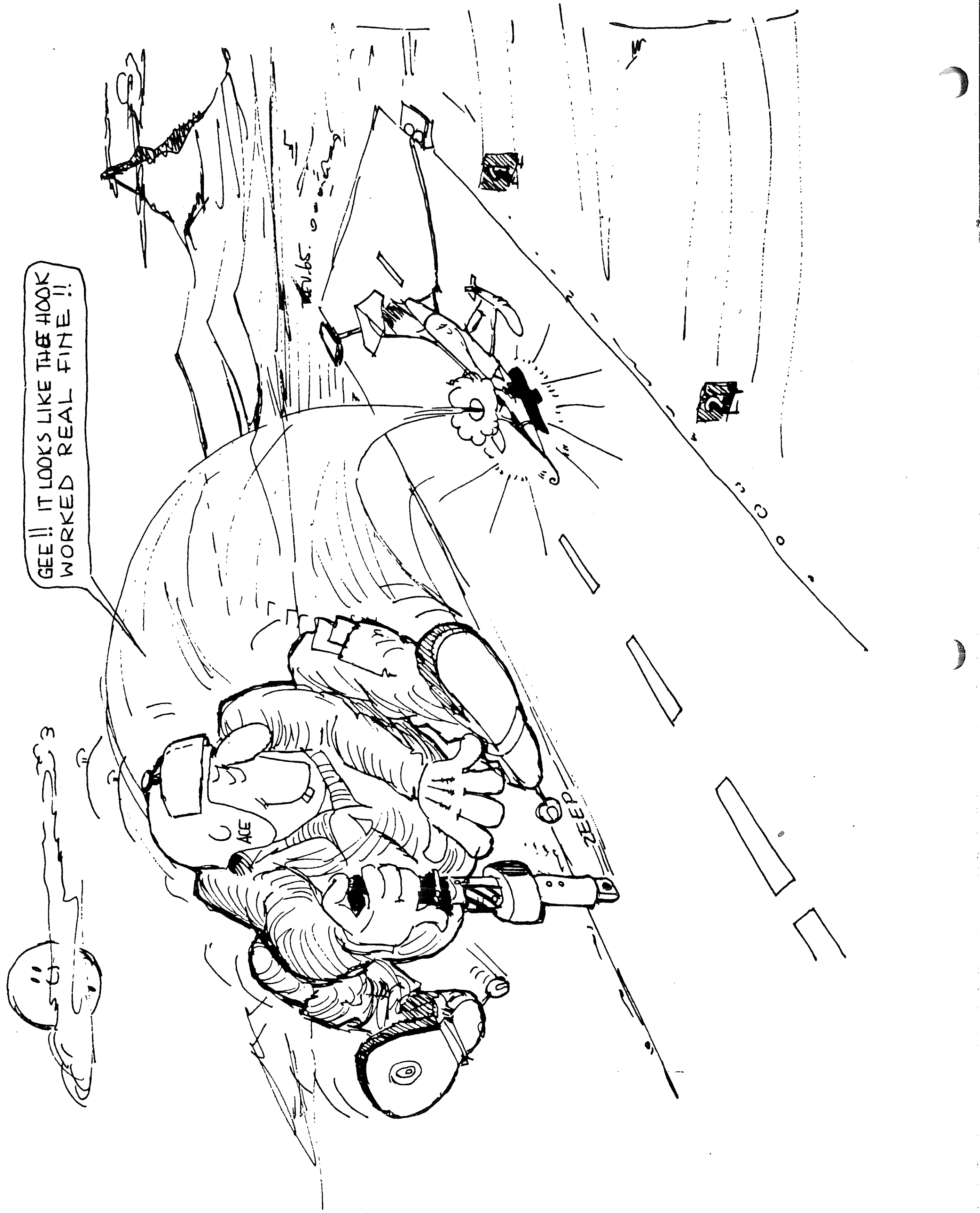
4. Landing roll: Use normal after landing procedure but be fully prepared for barrier engagement in case of drag chute or normal brake system failure.

Accident Review No. IIA

Pilot on ferry flight had been erroneously briefed that there would be a lack of drag chute repacking facilities at a planned fuel stop. Therefore, an attempt was made to land aircraft close to approach end of runway to utilize the entire length of runway, without the drag chute. Due to bad visibility, however, pilot did not see a sharp rise in the overrun and contacted the overrun heavily on the main gear. Impact jarred loose the hook which engaged the barrier cable. Aircraft came to a stop after a very short roll-out. The landing gear and the fuel cell area above the landing gear were extensively damaged. Pilot was uninjured.

Comments

Overruns, in many cases, are nothing more than treacherous traps. I have always advocated using normal approaches and touchdowns whenever possible. If the landing requires the drag chute for normal stopping -- I use it. There's always plenty of time to look for someone to repack it. The chute is easier to repack than it is to recock the barrier.


GEE!! IT LOOKS LIKE THE HOOK WORKED REAL FINE!!
ZEEP
ACE

Accident Review No. IIB

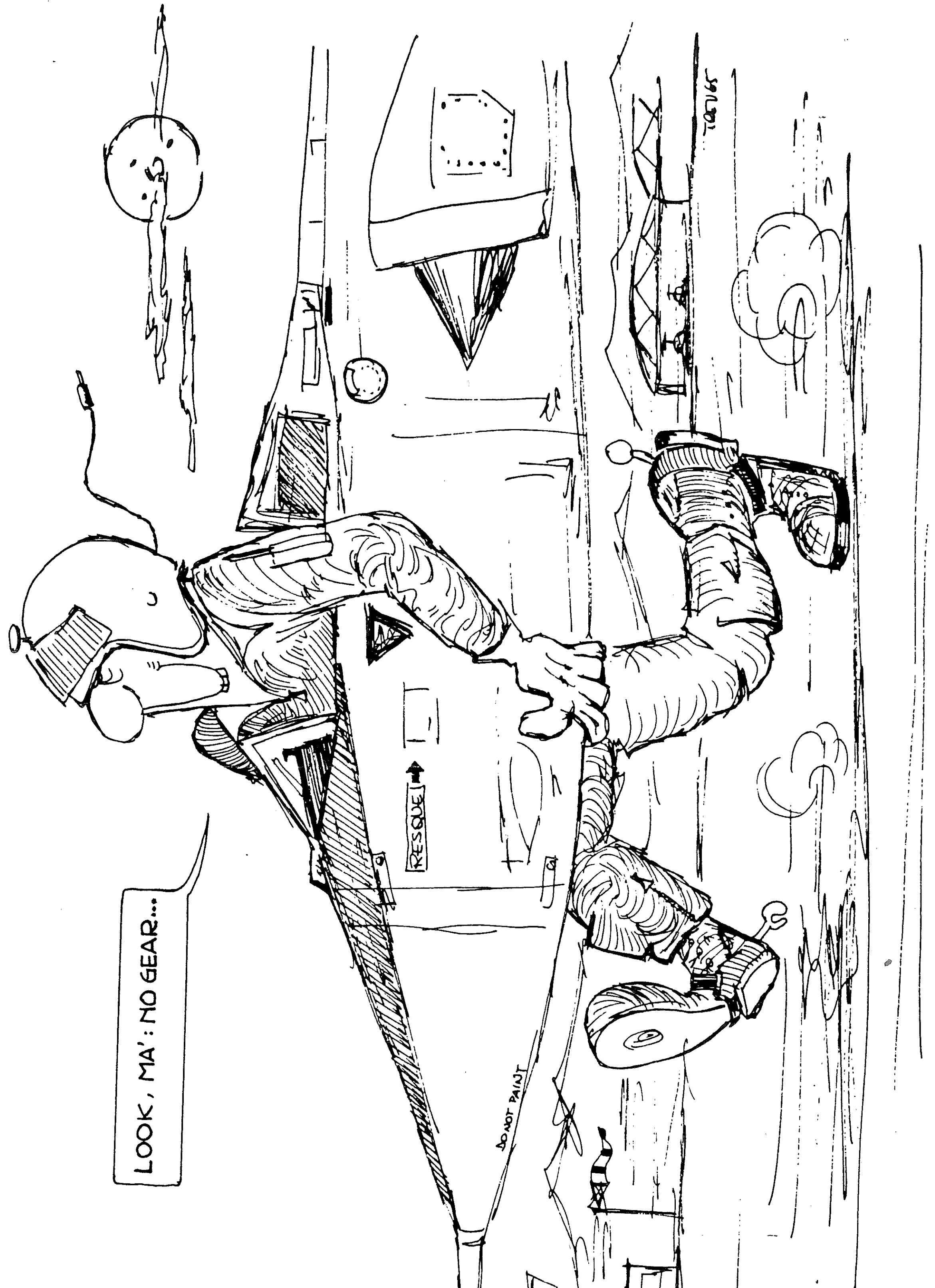
A student and instructor pilot had completed a Mach 2 run in the F-104 transition phase training and aircraft was on final landing approach. Landing was planned as takeoff flap landing, however, the right main gear contacted an approach light. Immediately after contact, the IP initiated a go-around and declared an emergency.

Aircraft was checked in-flight by another pilot who stated that the right main gear was not locked. The instructor landed the aircraft and shortly after touchdown the right main gear collapsed. Aircraft left the runway on the right side, skidded over the grass area between runway and taxiway and came to rest between other F-104 aircraft in front of the hangar. Both pilots were uninjured.

Comments

No one but another instructor pilot is ever appreciative of the tasks and difficulties, together with the overwhelming responsibility, that goes along with that back-seat "rocking-chair". For hour after hour, he must endure the stumbling efforts of his student and hope to hell he catches all the mistakes! In this case the IP missed by just that fraction that can be deadly. But you will notice that once he assumed command he did an excellent job of flying and his proficiency, along with good judgment, resulted in the non-injury of two valuable pilots and the recovery of a repairable aircraft.

In my back-seat experience, I have continuously noticed that the canopy gives you a false perspective as to your height above ground. Normally, as you approach the runway, it appears that you are lower to the ground than you really are. This is a "safe" perspective from the viewpoint that it makes you come over the end of the runway slightly higher than you do when flying from the front cockpit. But don't become so immune to this perspective that you start discounting it and think -- "Well we look a little low, but it's probably just this rear cockpit perspective". Remember, in all probability the student might be thinking -- "Well, I look a little low, but if I'm too low the IP will take over". Add these two thoughts together and you've got a short landing.


LOOK, MA': NO GEAR...
RESQUE
DO NOT PAINT

Accident Review No. IIC

Aircraft made a belly landing with landing flaps and BLC operating. Pilot believed he had put the gear down. However, the cockpit gear handle was found in the UP position and camera records show that landing gear was up during the final approach. Pilot uninjured. Aircraft repaired.

Comments

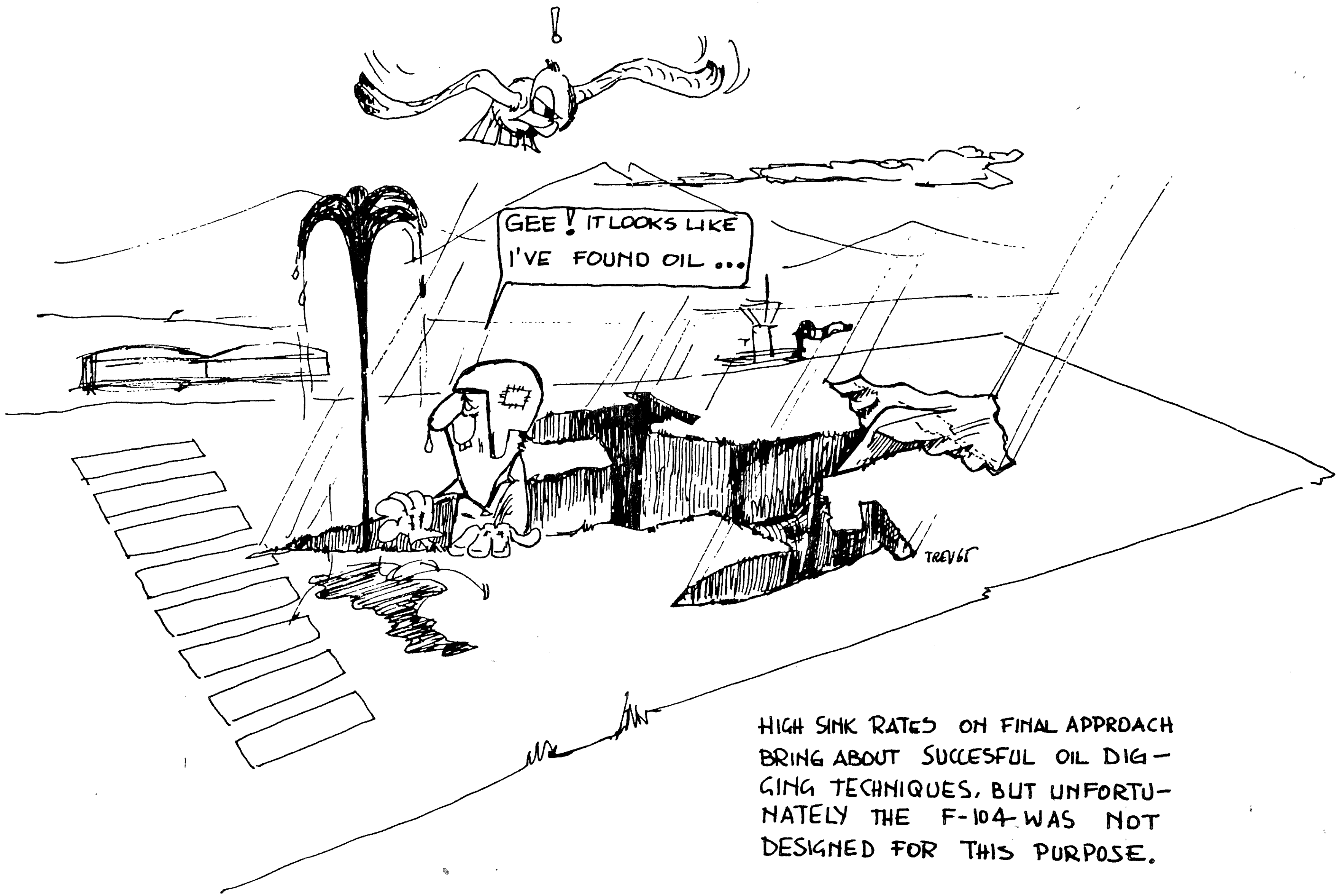
As with all aircraft, the F-104 is not immune to being landed "gear-up", even with its well designed warning system. In order to cover the predictable regimes of flight, we have designed the warning system to operate as follows:

1. Configuration; landing gear lever UP - flaps in any position.

2. Flight Condition; altitude at 10,000 feet ± 1500 feet, IAS 220 knots ± 15 knots.

3. Signal Operation; under the above conditions, if the throttle is retarded below 100% RPM, the warning tone will sound and the red light will illuminate in the gear handle. As throttle is advanced above approximately 95% RPM, the warning tone ceases and the light in the gear handle goes out.

Even with the most ingenious warning devices, it is still up to the pilot to not forget to "put the gear down!" You can hear many variations of the base-leg transmission such as "three green", "three rollers", "wheels down" and you name it. My first instructor started me on a habit that has never failed me yet. It's the base-leg call of "gear down <u>and</u> locked!" The natural emphasis on the "and locked" part of the phrase makes you double check all the indications. At least it does for me and it might for you.



HIGH SINK RATES ON FINAL APPROACH BRING ABOUT SUCCESFUL OIL DIGGING TECHNIQUES, BUT UNFORTUNATELY THE F-104 WAS NOT DESIGNED FOR THIS PURPOSE.

Accident Review No. IID

Aircraft was left at a transient base with an unresolved engine malfunction. The engine had flamed out repeatedly in run up tests and once while taxiing. Regardless of this past history, the pilot took off for a test flight. Shortly after takeoff the engine flamed out and the pilot attempted a dead engine landing. At the time of touchdown in a properly executed approach, the aircraft appeared to regain power as though it attempted to go around, however, the aircraft continued on the ground, through the barrier, before coming to rest approximately 1/4 mile off end of the runway.

The aircraft was a total loss and the pilot received fatal injuries.

Comments

It sure looks like this was a case of a very good pilot who exercised very poor judgement. Never, in my most courageous moments would I attempt to test fly an aircraft with a recurring, but unresolved malfunction, such as intermittent flameout. Removing and replacing the engine is all too cheap and much safer!

Accident Review No. IIE

Pilots in a two-place aircraft were making simulated flameout landings. On the fifth approach, sink rate was excessive. Pilot advanced throttle, but felt no response. Impact to the right of runway sheared the nose gear. Rear pilot ejected safely after initial impact. Aircraft skidded 3,000 feet and caught fire. Front pilot climbed out when aircraft stopped.

Investigation disclosed normal engine operation at time of impact and the speed brakes were extended.

Accident Review No. IIF

Aircraft landed hard and short from a simulated flameout approach. All three gears collapsed on contact with runway. Aircraft skidded, caught fire, and sustained substantial damage. Pilot uninjured.

Comments

Practice of emergency flight conditions is extremely essential to the training and welfare of all 104 pilots. But, carrying the practice conditions to such an extent as these two examples, resulted in unexpected conclusions - - I'm sure. A complete discussion of the recommended SFO pattern is contained in the SURE Lecture - "A Critique of Selected F-104 Emergency Operating Procedures".

Accident Review No. IIIA

A flight of four aircraft were participating in a large formation fly-by. The flight was in diamond formation for a pass by the reviewing stands. The left wing of the aircraft to the left of the lead struck a very high radio station antenna. Collision ruptured the left tip tank and sprayed fuel over the area, however, the aircraft maintained its position in the formation. Flight passed reviewing stands on a south heading and was turning right to a southwest heading in a 30 degree bank, when the aircraft in slot position overtook and crashed into the lead aircraft. Both aircraft caught fire and crashed. Neither pilot ejected.

The pilot who collided with the radio antenna returned safely to base.

Comments

A very old established rule of formation flying is -- "Don't take your eyes off the lead aircraft". The very short time that the slot man apparently took to look at the damaged aircraft was all the situation needed to result in this mid-air collision.

Mid-air collisions in formation generally result from:

1. Inattention to lead aircraft.

2. Visibility problems
   - A. Sun glare
   - B. Bright lights (night flying) or lack of lights giving wrong perspective
   - C. Weather
   - D. Cockpit obstructions
     - (1) Mirrors, gunsights, etc.
     - (2) Structural members
     - (3) Glare from radar scope and instrument lighting

3. Misjudgement
   - A. Closing rate
   - B. Reaction time of aircraft

4. Loss of control
   - A. System malfunction
   - B. Aerodynamic effects

5. Physiological effects
   - A. Vertigo/disorientation
   - B. Physical condition

Formation flying is team work to the highest degree. Wingmen must have confidence in their leaders -- confidence that is earned and never betrayed.

Accident Review No. IIIC

Two aircraft were on a formation flight and making practice GCA approaches. On a previous practice GCA, the wingman was observed to hold a good but close position. During field circuit there was discussion between the pilots regarding the technique involved. On next approach, at approximately 225 feet altitude, the aircraft collided. Marks on the wreckage indicated the wing aircraft collided with the lead aircraft from the right. Wingman attempted ejection but was unsuccessful. Pilot in lead aircraft was apparently knocked unconscious at impact and did not eject.

Comments

As stated previously, the wingmen must have unshakable confidence in the leader, but the leader has to depend on the integrity of the wingmen. There is no place, or requirement, in a formation for a person whose personal ego overrides practical considerations of safety.

Accident Review No. IIIB

Two F-104's were engaged in a formation transition flight above 28,000 feet. In attempting a cross-over maneuver, the rear aircraft contacted the forward aircraft.

The forward aircraft broke into two pieces at fuselage station 310. Pilot lost consciousness after collision, but found out later that he was hanging on the deployed parachute. He sustained head injuries and does not remember ejecting.

The seat was found intact in the wreckage and the lap belt had been manually opened.

The pilot of the other aircraft had to abandon his aircraft because damage was such that a safe landing was impossible. He connected the lanyard and ejected at 8,000 feet, air speed 280 to 300 knots, and landed without injury.

Comments

As discussed in the previous comments, it appears that this wingman misjudged the closure rate until too late.

Accident Review No. IVA

At 35,000 feet an afterburner light was attempted, resulting in engine flameout. Pilot subsequently reported unable to airstart the engine and was attempting a landing on an emergency dry lake. Last transmission from pilot at 1,000 feet indicated he would land short of the lake. Aircraft touched down smoothly in "clean" configuration, then struck a two foot rise causing aircraft disintegration and explosion.

Accident Review No. IVB

The fire warning light came on during a night training flight. Pilot apparently attempted a gear up landing on a sandy beach. The aircraft was in a slightly nose high attitude at less than normal landing speed when impact occurred. The pilot was fatally injured and the aircraft destroyed.

Accident Review No. IVC

Shortly after takeoff at approximately 1,000 feet, pilot transmitted he was experiencing some kind of engine stall. The aircraft reached an altitude of 2,500 feet and during this climb was observed to emit two balls of fire and black smoke. The aircraft then started to descend, the cockpit canopy left the aircraft at approximately 300 feet. The aircraft continued until striking a sandbar in a river in a nose high attitude. Aircraft was destroyed and pilot fatally injured.

Comments

I have compiled these three accidents to make one point: "Don't attempt a landing on an unprepared surface".

Accident Review No. VA

Aircraft was in landing configuration following a training mission. Witnesses stated some type of control difficulty was experienced just prior to touchdown, since left wing was low and then the right, while attempting to make initial contact with runway. Touchdown was accomplished about 1,400 feet beyond the approach end of runway in a right wing low attitude. Aircraft veered to the right, leaving the runway at approximately the 2,350 foot marker and continued out into the turf and sand area where it spun around 180° about the right main landing gear. The right main gear failed sometime after touchdown.

Both pilots apparently ejected intentionally after aircraft was on ground and were fatally injured.

The aircraft was repairable. It is the consensus of investigating personnel, that had the occupants remained with the aircraft, they would have survived.

Accident Review No. VB

Pilot was flying standard landing pattern. Aircraft hit 15 to 20 feet short of overrun. Main gear was knocked back and nose gear was broken off. The aircraft bounced up about 50 feet, hit the runway approximately 1,500 feet from initial contact, slid to the left, and went off runway approximately 8,500 feet from initial contact. The aircraft stopped after 9,800 feet parallel to and 20 feet from the runway. Pilot was uninjured and aircraft repairable.

Accident Review No. VC

During a night two plane GCA approach the aircraft fell behind leader and descended below glide path. The pilot advanced the throttle for a go-around, but aircraft continued to settle and contacted the runway sharply. The landing gear collapsed and the aircraft slid 6,000 feet sustaining major damage. The pilot was not injured and the aircraft was repairable.

Accident Review No. VD

During a night GCA formation landing, aircraft touched down on a rough section of asphalt about 600 feet down the runway. The right main gear failed at touchdown or very shortly thereafter. Aircraft skidded off the runway on the right pylon tank and GAR-8 missile. Nose gear collapsed, left main gear remained extended. Aircraft sustained major damage. No injuries to pilot.

Comments

This survey points out a very important consideration of remaining with the aircraft rather than ejecting after touchdown. The statistics indicate that if you are at or below touchdown speed and the aircraft leaves the runway, you are much better off staying in the cockpit and doing all you can to slow down and stop the aircraft, instead of ejecting -- right at the marginal edge of the envelope of the seat.

Accident Review No. VIA

After takeoff number 2 aircraft experienced a muffled thud as throttle was retarded to military. The flight was passing through 2,000 feet at 350 KIAS. At this time, the pilot experienced loss of thrust and rumbling in the engine. The pilot attempted to relight afterburner, but was unsuccessful. He then noticed the afterburner nozzle was open and actuated the emergency closure device, and reported the nozzles were closing. RPM had decreased to 70% and oil pressure indicated 20 PSI with the throttle at military. Pilot ejected successfully.

Comments

It appears that misinterpretation of the engine problem resulted in the pilot initiating the wrong procedure. Remember to read all the engine gauges before you make a decision as to the procedure needed. In this case, it seems that the pilot mistook a compressor stall as an open nozzle failure.

Accident Review No. VIB

After takeoff pilot brought throttle from A/B to military. He immediately felt a chug in the engine and RPM dropped to 85%. Normal stall clearing procedures were used without success. RPM continued to drop slowly to 70%. Pilot ejected successfully at 2,000 feet.

Comments

When you correctly analyze the engine problem and the recommended procedures fail, there is only one step left -- and this pilot took it.

Accident Review No. VIIA

After 45 minutes of flight, pilot radioed that throttle had stuck at military power setting. Radio transmissions did not indicate concern on the part of the pilot, who was highly experienced in jet aircraft. While turning to final approach for landing, aircraft appeared to stall and crashed short of runway. Pilot did not eject.

Investigation revealed main fuel shutoff switch and valve closed. Wing flaps were retracted even though flap handle was in the down position.

Accident Review No. VIIB

Aircraft was number 2 in a flight of three F-104's. Shortly after takeoff the pilot noticed excess RPM and poor response to throttle movement. Reducing the throttle to idle resulted in a reduction of RPM to only 101%. Remaining in the wing position, the flight entered a simulated flameout pattern. At the low key position, number 2 turned on a wide base leg and descended to final at 260 KIAS. Touchdown was made at the 400 foot mark at 200 KIAS. Drag chute deployed at 170 KIAS, blossomed and then failed. With 2,000 feet remaining at 150 KIAS, the right tire blew, and the pilot was unable to direct the aircraft into the barrier. The aircraft continued to the right, departing the runway, at which time all gear failed. Pilot abandoned the aircraft, but engine continued to run even though stop-cocked, until ground crew personnel activated the main fuel shutoff switch. Major damage to aircraft.

Comments

Landing with a stuck throttle or 100% RPM or full T_2 reset has been successfully accomplished and is not overly difficult. Utilize the speed brakes, landing gear, and flaps to keep airspeed down to landing approach speed. When the runway is definitely made, then the Main Fuel Shutoff Switch may be actuated and landing performed.

In our simulated flights for this condition, we discovered that at the normal base leg point to turn to final, it will take almost 100% to maintain a normal pattern if you have landing gear, land flaps and speed brakes out. Therefore by pulling "g's" on the aircraft you should be able to arrive at this point to make an approach safely to the threshold and <u>then</u> actuate the Main Fuel Shutoff Switch. The sudden stoppage of fuel will cause loud bangs like a compressor stall and, of course, be prepared for the loss of electrical power as the engine unwinds.

Accident Review No. VIIIA

Pilot took off with clean aircraft but needed 6,500 feet to become airborne in a nose high attitude. After leaving ground, aircraft did not gain any altitude. About one mile beyond end of runway aircraft crashed at a flat angle. The pilot did not make any attempt to eject.

Investigation disclosed the nozzle indicator reading 6.5 with the angle of attack indicator stuck in the red area.

Accident Review No. VIIIB

Power fluctuations were observed by ground personnel during takeoff roll, and afterburner did not light. Aircraft was barely airborne at 9,500 feet, main gear tires struck barrier trigger. In stalled condition, aircraft settled back to ground 2,200 feet past overrun. Parts of gear were sheared, tanks ruptured. Aircraft slid to stop, and pilot freed himself from cockpit. He was uninjured in crash, but later died from burns sustained in the ensuing fire.

Accident Review No. VIIIC

On takeoff the A/B did not light when advanced to sector burning. Throttle was retarded to military then advanced to full A/B with no subsequent light-off. Takeoff continued and aircraft became briefly airborne, then went through a factory one quarter mile off the end of the runway.

Student ejected successfully at approximately 35 feet. No ejection attempt was made by the instructor pilot who was fatally injured.

Accident Review No. VIIID

On takeoff aircraft used full length of runway, lifted off and was airborne for approximately 3,000 feet, then settled back on belly and slid for 1,000 feet. Power loss caused by lack of A/B. Small fire extinguished successfully. Pilot received minor injuries.

Accident Review No. VIIIE

On takeoff A/B did not light. Pilot was informed that nozzle was seen to open but no afterburner light. Aircraft lifted off at 5,000 feet marker, then settled back on the runway -- apparently losing and gaining thrust during takeoff. Aircraft was destroyed. Pilot received fatal injuries, when he ejected at a very low level after ground contact in a pitch, yaw and roll attitude.

Comments

No matter how persistent we have been in saying "Don't try it -- you'll never make it!", it seems there's always someone around who tries it regardless of our advice. The Dash One is very firm in its procedure to abort. General Electric has always been very adamant that the aircraft will not fly in this condition. My final word on this is -- "Don't be another foolish statistic -- if the A/B won't light on takeoff -- ABORT!"

I have included two photographs of the instruments that show the normal instrument condition and the situation with no afterburner light. My recommendation is to study them. They can literally mean life -- or death.

Condition:

1. Throttle in full Afterburner position.
2. No Afterburner operation.

Comment: Even though the RPM indicates 100%, your key recognition points in this case are -

1. EGT is low - definitely below the normal temperature limiting point.
2. Nozzles are at full opening on ramp cam but not in normal A/B position.
3. Due to nozzle position, the fuel flow is substantially below normal.

Condition:
1. Throttle in full Afterburner position.
2. Full Afterburner thrust.

Comment: Besides the "kick-in-the-pants" and the 100% RPM, your key recognition points are -
1. EGT is at the temperature limiting level - indicating full thrust.
2. Nozzles are at the normal A/B position.
3. Fuel Flow is at the high level for Military Power fuel flow indication.

Accident Review No. IXA

When throttle was reduced from A/B to military at 35,000 feet, the A/B nozzle failed to close. Override switch was actuated without effect. A/B relight could not be obtained. Tip tanks jettisoned and straight in approach initiated. Touchdown was made at 200 knots, 2,500 feet down the runway. Drag chute was deployed at 190 knots and failed. Heavy braking caused left main tire to fail and aircraft departed the runway shearing left main gear on an approach light. Prior to completely stopping, the nose gear folded. Pilots were uninjured and aircraft was repairable.

Comments

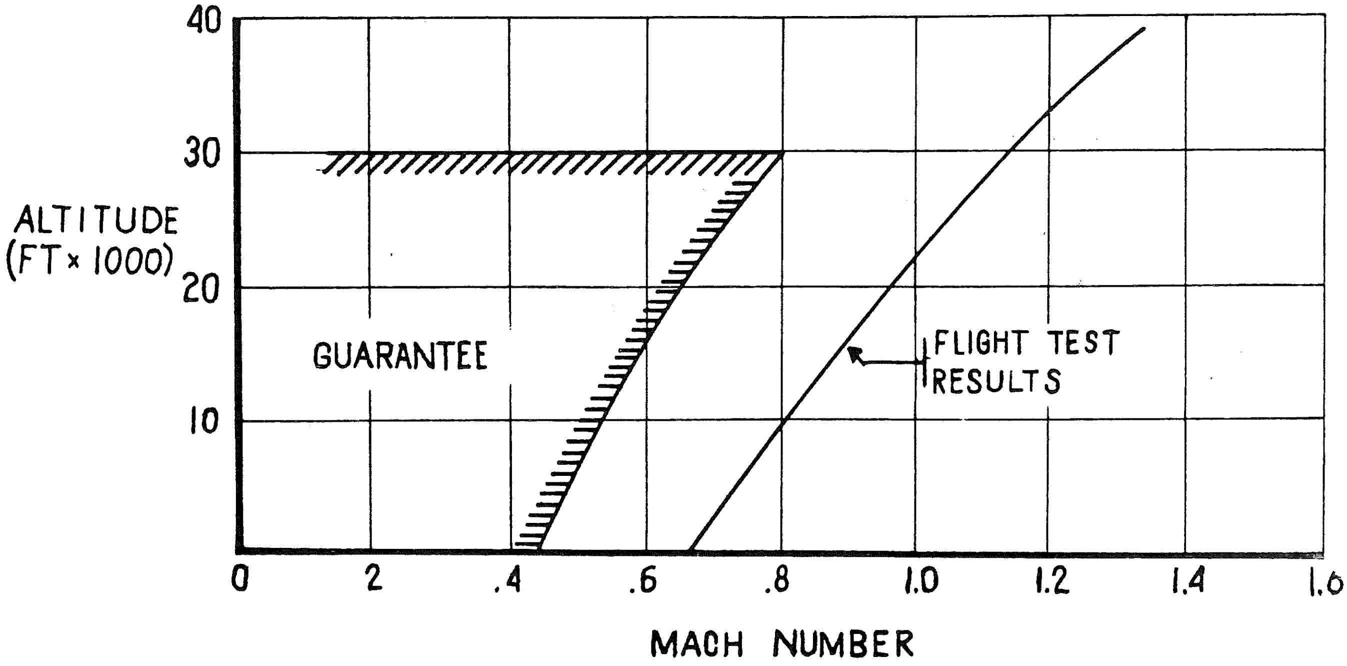
Open nozzle failures, I am happy to say, appear to be on the wane. Increased engine reliability, better inspections, and the addition of nozzle locks are all working in our favor. However, until all three factors are on all 104's, you should be prepared for the possibility of a nozzle failure.*

As I pointed out before, pilots and engineers at Lockheed and General Electric have worked for years to improve the reliability of the engine and necessary emergency systems. But all our effort goes down the drain *if you do not use the emergency system*!

To give you more confidence in the Emergency Nozzle Closure System, I am including a plot from General Electric that displays the envelope of operation. A study of this envelope will keep you from making a bad mistake, such as pulling the Emergency Nozzle Closure handle at a Mach No. and Altitude at which it cannot operate and then erroneously thinking it is inoperable and pushing the handle back in. This, of course, could easily lead you to a false conclusion and a needless emergency when you slowed down to within the guaranteed operation envelope.

*See SURE Lecture "A Crititque of Selected F-104 Emergency Operating Procedures".

Proven Limits For Emergency Nozzle Closure System



You can see from our plot that there is a huge, safe envelope of flight operation for climb, cruise and landing in which the Emergency Nozzle Closure System will give you the best "guaranteed" operation possible, if the emergency system is operating normally. Between that area and the actual flight test results data line is a highly possible and probable area in which the Emergency Nozzle Closure System may operate and close the nozzles to the emergency position. Beyond that line is an area in which the nozzles will probably not close to the emergency position (when you pull the handle). If you pull the handle in that flight regime and slow down to the flight test or guaranteed area, then the nozzles will close to the emergency position.

My firm recommendation to you, whenever you have a nozzle open failure, is to definitely follow the handbook procedure and <u>use your Emergency Nozzle Closure System</u>.

Accident Review No. XA

Immediately after takeoff, at 500 feet, the canopy flew open and the aircraft began to lose altitude. The wingman advised the pilot he was at low altitude and should eject. The pilot ejected unsuccessfully. Aircraft crashed and was destroyed.

Accident Review No. XB

Student pilot took off on transition flight with IP chase. At 1 1/2 miles from runway, canopy departed aircraft. As IP passed student, he observed the missing canopy and radioed instructions that were never acknowledged or carried out. Aircraft made continually descending 180 degree turn and crashed. Pilot did not attempt ejection. Aircraft destroyed.

Investigation of wreckage disclosed extensive FOD in engine area and engine in compressor stall at time of crash.

Comments

Information from the field has disclosed the following two conditions that can exist when the canopy is not locked on takeoff or comes open in flight.

1. Canopy in full open position or against in-flight refueling boom:
   - A. In this condition, there will probably be no ill effect on engine operation unless material that was resting on cockpit glare shield is ingested. Pilot experiences indicate it is impossible to re-close the canopy due to air loads.
   - B. Control of the aircraft is very difficult due to aerodynamic effects of canopy. Landing is possible, however.

2. Canopy beyond restraining lock and overcentered on hinge with contact against left side of fuselage:
   - A. In this condition, all past experiences indicate that the angle of attack vane is deflected and shaker actuation is experienced. Also, in all probability there will be damage to the canopy and the engine will stall due to resultant FOD as breakage material is ingested in the left inlet duct.

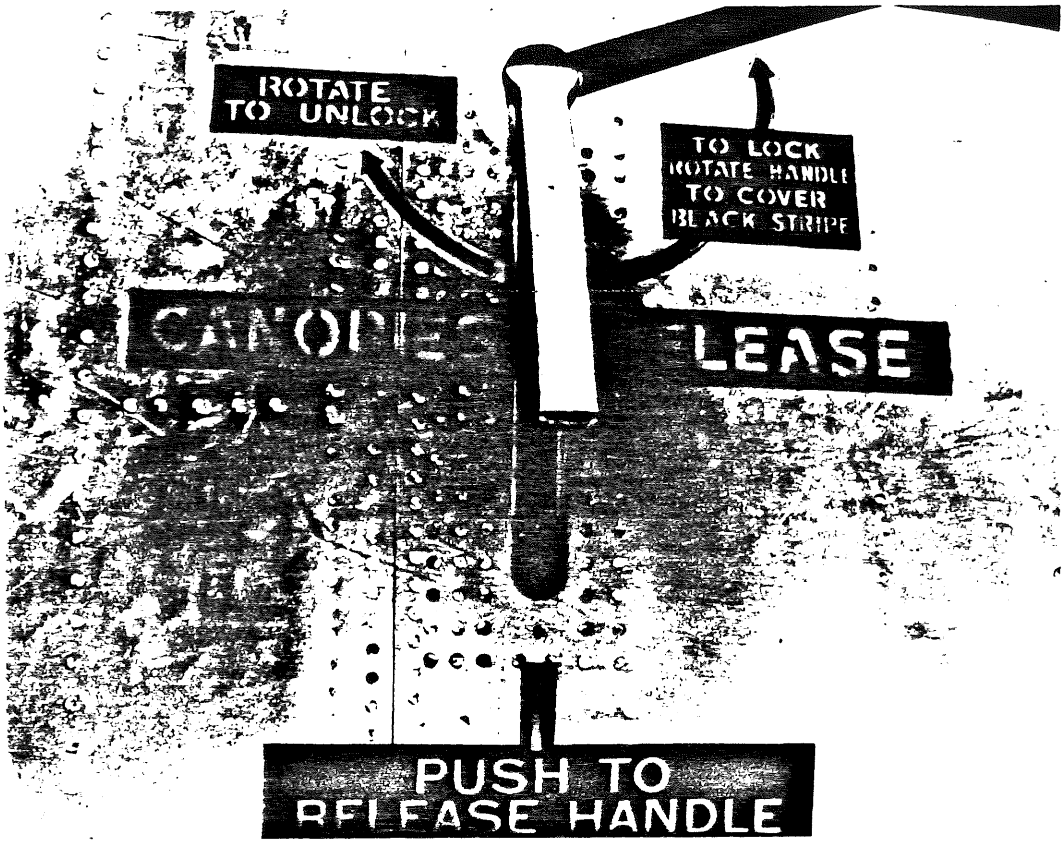
In any case, you are in an emergency condition with the canopy open in flight. And while there have been reports of canopy glass failure in flight, no reports have been received of the canopy coming unlocked in flight, if it was properly locked on the ground.

Since there is a possibility of snatching the interior canopy locking handle and missing the canopy brackets with the hooks, I am enclosing pictures of the right and wrong ways. Always check --

1. Exterior Locking Lever - Secured.

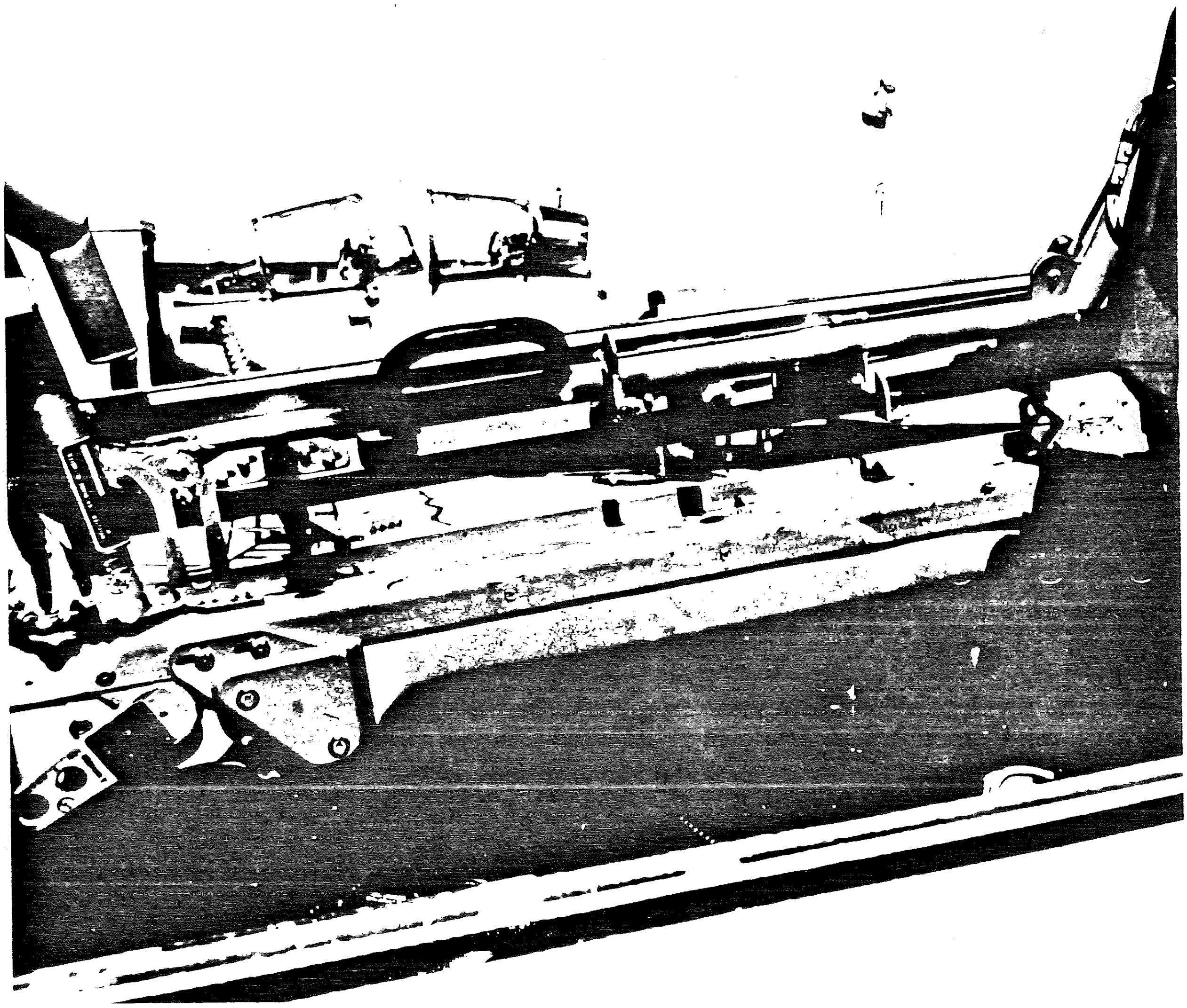
2. Rotate canopy locking handle slowly and visually check hooks overcenter on brackets.

3. Warning Light - Out.


ROTATE
TO UNLOCK
TO LOCK
ROTATE HANDLE
TO COVER
BLACK STRIPE
LEASE
PUSH TO
HANDLE


ROTATE
TO UNLOCK
TO LOCK
ROTATE HANDLE
TO COVER
BLACK STRIPE
CANOPIES
RELEASE
PUSH TO
RELEASE HANDLE

OPEN



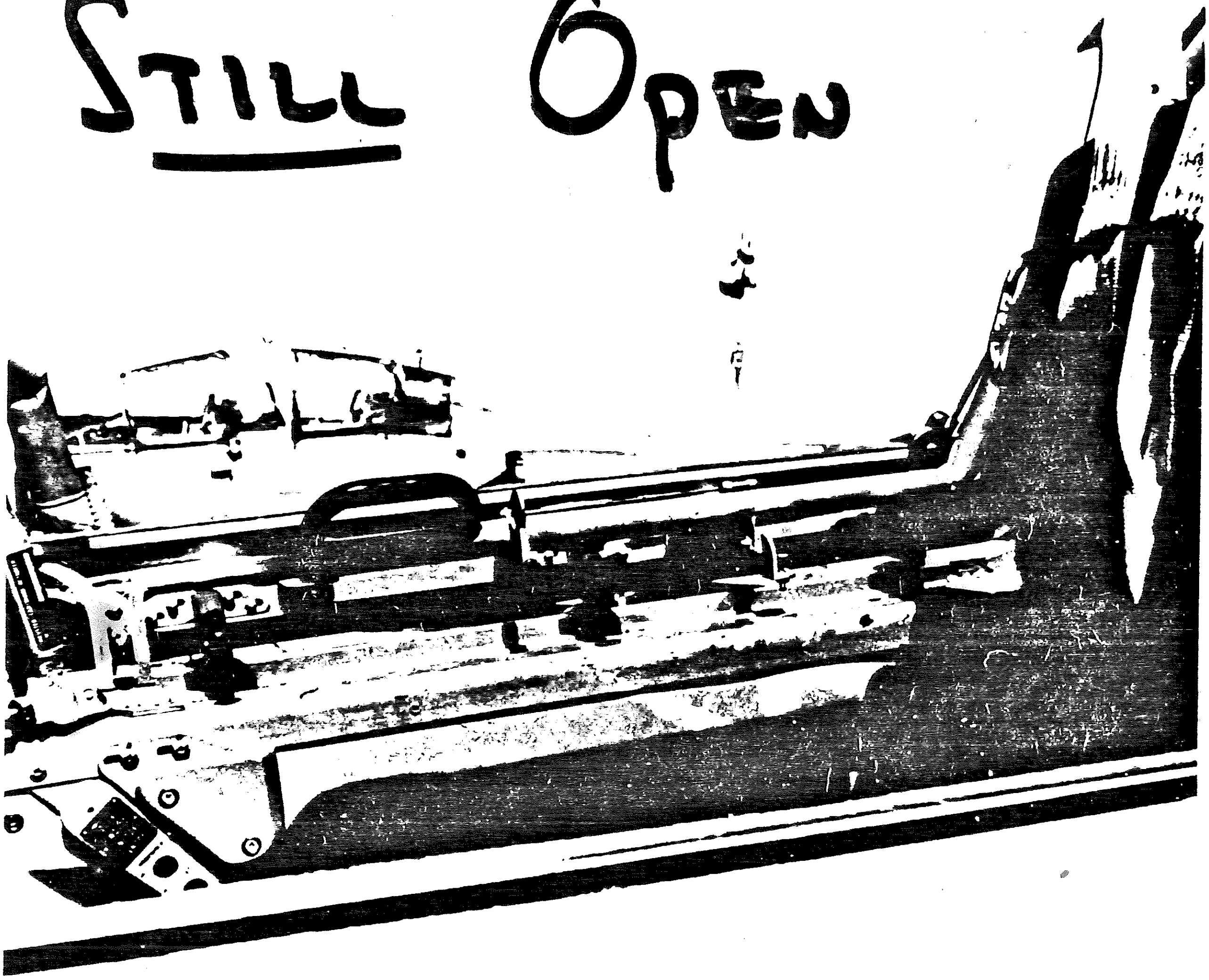
Condition:

1. Internal Locking Lever - Forward/unlocked position.
2. Canopy is in normal part-open position.

Comment: Your key recognition points are -

1. Canopy locking brackets are resting on lifter cams.
2. hooks are cocked to rear and level with canopy sill.
3. Canopy unsafe light is illuminated.

STILL OPEN



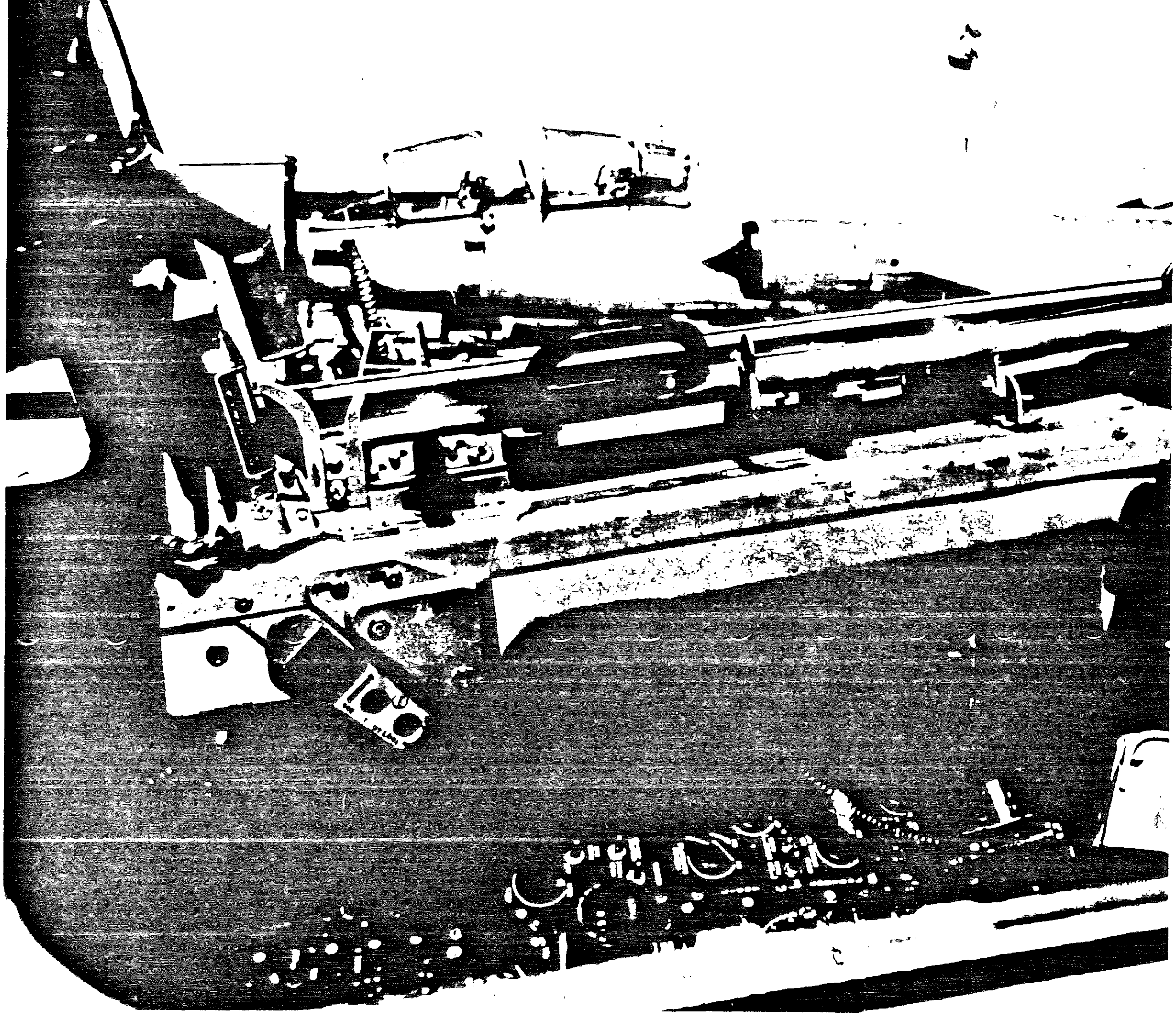
Condition:

1. Internal Locking Lever - Aft/locked position.
2. Canopy is not locked.

Comment: Your key recognition points are -

1. Canopy locking brackets are resting on top of overcentered hooks.
2. Lifter cams have lowered below canopy sill.
3. Canopy unsafe light is still illuminated.

LOCKED



Condition:

1. Internal Locking Lever - Aft/locked position.
2. Canopy is locked.

Comment: Your key recognition points are -

1. Canopy hooks are overcentered and locked on canopy brackets.
2. Canopy is flush with sill and there is no opening.
3. Canopy unsafe light is not illuminated.

Accident Review No. XIA

The pilot reported that aircraft acceleration was normal up to 150-160 knots. The nose lifted, but only to a level attitude. The stick was moved to full aft position at 180 knots, but nose failed to lift higher. When airspeed reached 200 knots IAS the flight was aborted with 3500-4000 feet of runway remaining. The throttle was stop-cocked, anti-skid brakes turned off, and arresting hook lowered. Aircraft engaged barrier at 175 knots. The drag chute was not deployed.

This barrier engagement ran out the barrier chain for 965 feet, which is 68 feet short of maximum. Aircraft ran beyond overrun onto graveled area; however, the nose gear failed short of end of overrun and aircraft continued on its nose for 126 feet. Pilot uninjured and aircraft repairable.

Comments

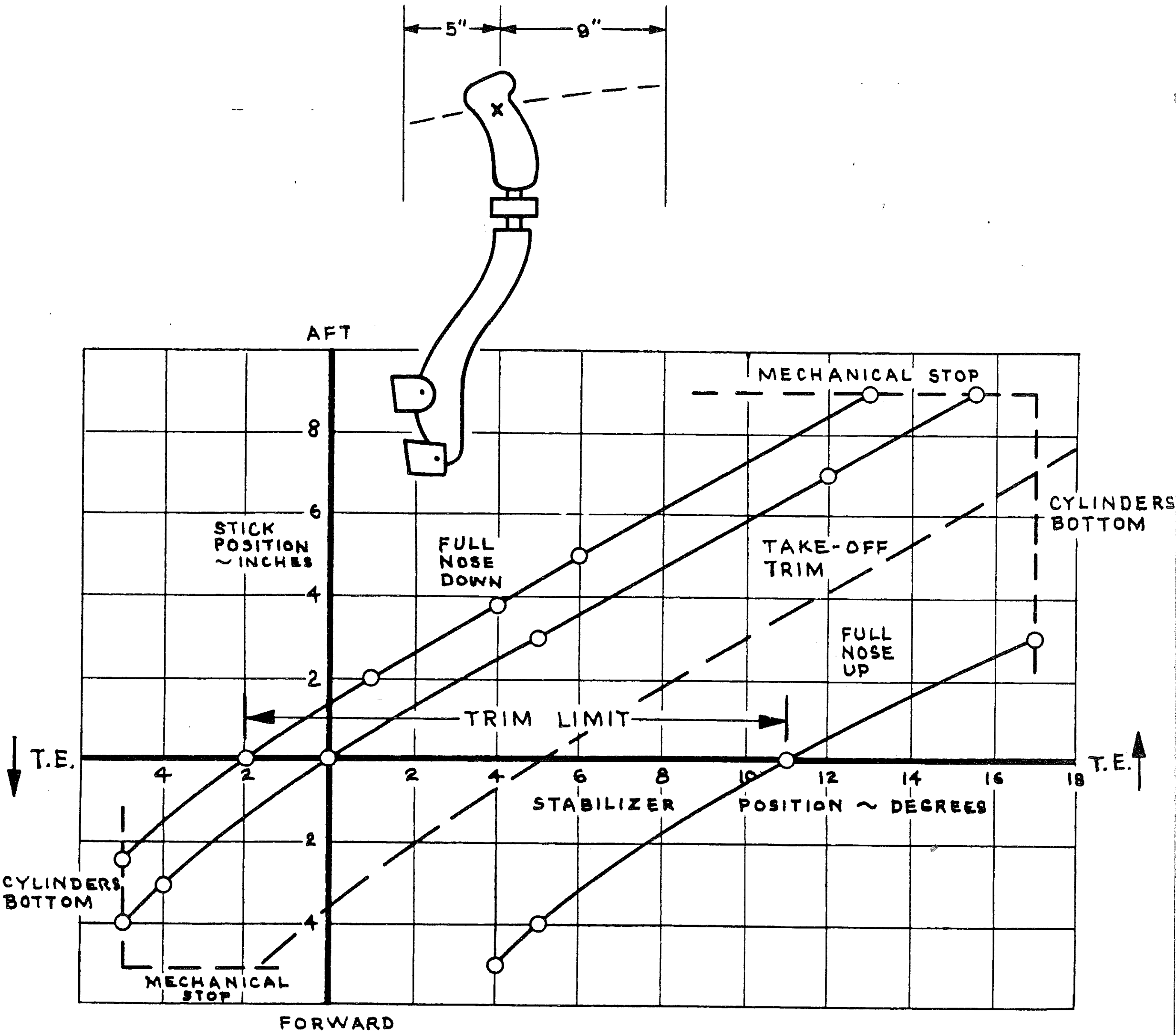
To our consternation, reports have been coming in of pilots reporting difficulty in rotating the aircraft on takeoff. Our research of this indicates it is a combination of factors rather than just one item. From the engineering flight tests made on nosewheel lift-off and aircraft take-off speeds, we found that the determination of these speeds was based on two factors:

1. Trim position.
2. C. G. and weight effects.

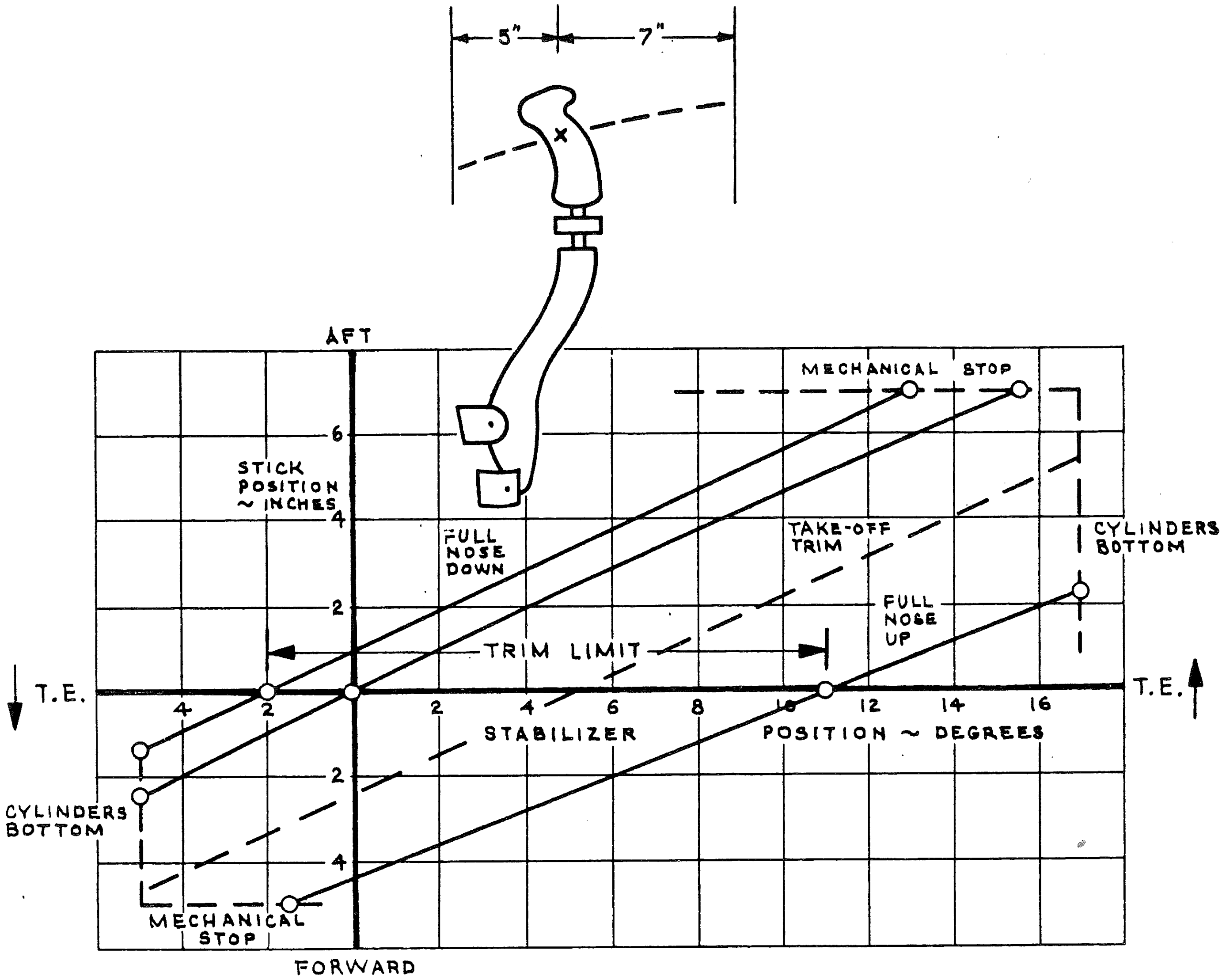
We have prepared some plots and charts to explain these factors and I also want to discuss the recommended pilot procedure on control stick movement so that no doubt remains in your mind as to the positiveness of nosewheel liftoff and aircraft rotation.

1. Trim position: In order that you may know exactly the relationship of the trimmed position of the stabilizer in relation to the available stick throw (and stabilizer movement), I have included two plots that cover all models of F-104s. From these plots you can quickly see two main points:

   A. The more forward you trim away from takeoff position, the less available aft stick (and nose up) movement.
   B. The more aft you trim away from takeoff position, the less available forward stick (and nose down) movement.



HORIZONTAL STABILIZER POSITION VERSUS
CONTROL STICK POSITION AT VARIOUS TRIM CONDITIONS
F-104 A/B/C/D



HORIZONTAL STABILIZER POSITION VERSUS
CONTROL STICK POSITION AT VARIOUS TRIM CONDITIONS
F/RF/TF-104G, MAP & CONSORTIUM, CF-104/104D F-104J/DJ

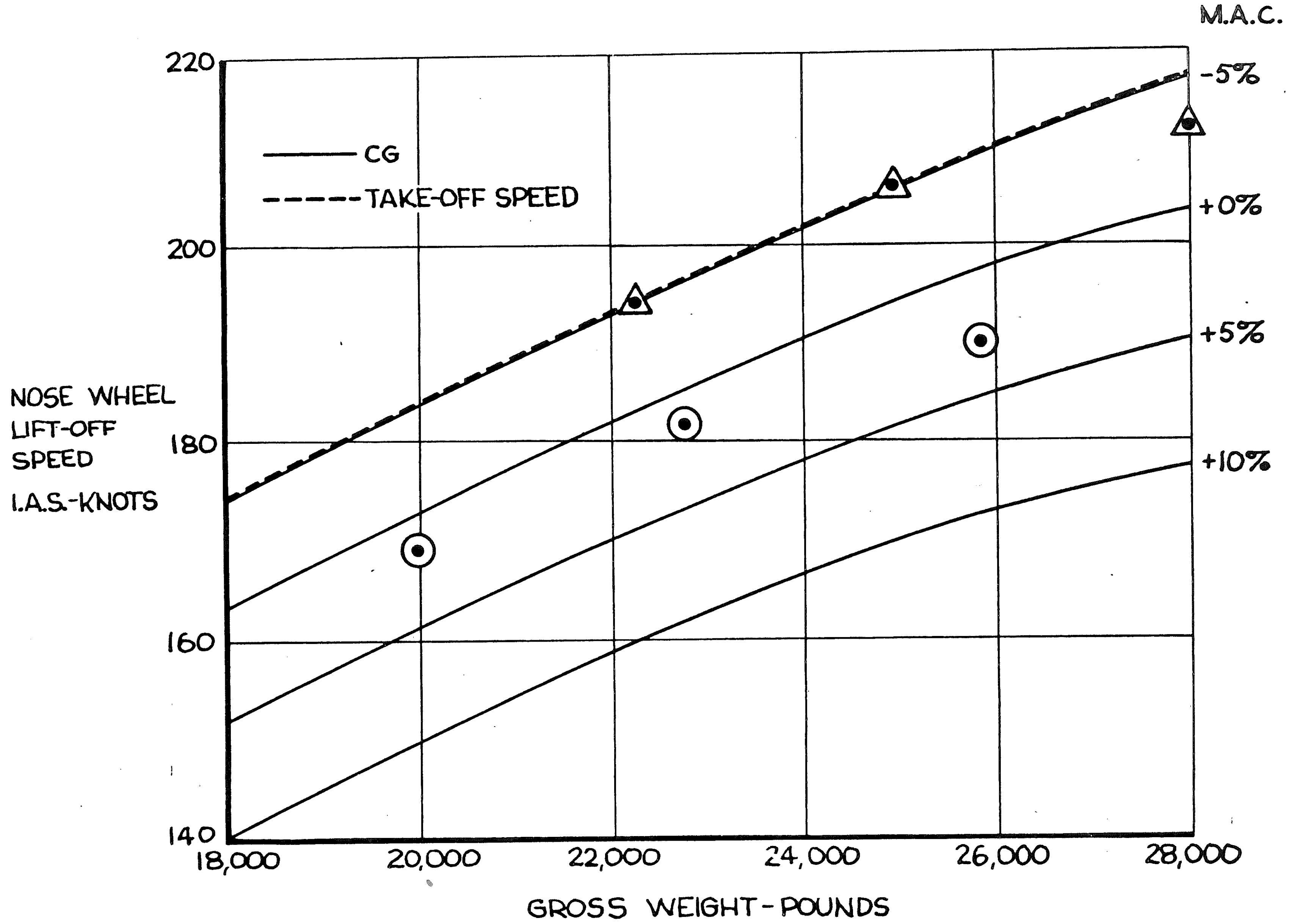
Obviously then, it is very important for all models of F-104s that you set your trim, as per handbook procedure, and leave it alone till you need it.

For those F-104s that have the interconnection between Autopilot and Stability Augmentation System, it is possible to encounter a trim shift due to the following checks:

A. Autopilot engaged and Altitude Hold selected. This procedure may, in all likelihood, cause a falsely referenced signal to engage the Auto Trim and drive the stabilizer away from the takeoff setting.
B. Pitch damper turned off. Due to a pitch down shift in the Stability Augmentation System, this procedure will cause a shift away from the takeoff position.

Therefore, all checks such as these should be made prior to the setting of trim for takeoff.

2. <u>C. G. and Weight Effect</u>: To show the interrelation of C. G. and weight, I have included a plot that is based on data expanded from Flight Test Results. This plot shows nosewheel lift-off speed and take-off speed for various weights and C. G.'s. As you examine this graph, you will see that Nosewheel Lift-off Speed is plotted vs. Gross Weights and the aircraft C. G. is represented in percent Mean Aerodynamic Chord Lines. Also included is one line that represents take-off speed and generally is only 1 to 2 knots airspeed above the -5% C. G. line. Now let's look at a few different configurations and C. G. s and discuss the nosewheel lift-off and take-off speeds. On the graph, the dots with circles represent the weights for clean, tip tanks and tip tanks plus pylon tanks. The C. G. s are +1.5%, +1.5% and +3.0% respectively. We can now calculate, from this graph, the nosewheel lift-off and take-off speeds for each configuration. First, for the clean configuration at 20,000 lb. gross weight, we go up the gross weight line to the C. G. position of +1.5% then read to the left a nosewheel lift-off speed of around 170 knots. By continuing on up the gross weight line to the take-off speed line, then reading left, we find a take-off speed of around 184 knots. Using this same procedure on the other two configurations you will notice that as the weight increases, the nosewheel lift-off speed increases slightly but there is always a spread of 15-20 knots between nosewheel lift-off and take-off speeds. Now let's look at the configurations of clean with a 2,000 lb. centerline store, tips with a 2,000 lb. centerline store, and the maximum gross weight of tips and pylons with a 2,000 lb. centerline store. These C. G. s are represented by the dots with triangles. Since the clean and tip tank configurations with the 2,000 lb. centerline store have a C. G. of -5%, the nosewheel lift-off speed is the <u>same</u> as the take-off speed. For the all up gross weight with a centerline store, there is a small difference between lift-off and take-off speed.


M.A.C.
-5%
+0%
+5%
+10%
CG
TAKE-OFF SPEED
NOSE WHEEL
LIFT-OFF
SPEED
I.A.S.-KNOTS
220
200
180
160
140
18,000
20,000
22,000
24,000
26,000
28,000
GROSS WEIGHT - POUNDS

3. Pilot Technique: During the early F-104 test program, specific tests were conducted evaluating nosewheel lift-off characteristics. In conducting these tests, various stabilizer application techniques were employed in which the amount of stabilizer deflection, rate of input, and speed at application were all varied. Some tests consisted of applying full stabilizer at speeds as low as 100 knots and maintaining full stick until nosewheel lift-off occurred. In no case did aircraft fail to rotate. In fact, very consistent results were obtained showing that nosewheel lift-off speed varied with weight and C. G.

An important difference was noted between single and two-place aircraft, however. The basic weight of two-place aircraft is considerably less than that for single-place aircraft, and, in addition, normally has a more aft C. G. Both of these differences contribute to the fact that two-place aircraft will rotate earlier for common configurations. As a result, when pilots complete training in two-place aircraft and advance to single-place aircraft, they can reasonably expect a 15 to 20 knot increase in nosewheel lift-off speed.

The final conclusion is that the best takeoff procedure is to begin rotation of aircraft at 20 knots below the normal computed takeoff airspeed. In so doing, takeoff attitude and airspeed are reached smoothly and simultaneously.

In the case of cross-wind takeoffs, it is recommended to follow the handbook procedure and increase the rotation and lift-off speed as spelled out in the Dash One.

4. We at Lockheed have not flown any tests for nosewheel lift-off under adverse weather conditions for heavy rain or snowy slush on the runway. Therefore, the exact amount of degrading effect that "water-planing" will have on raising the nosewheel is unknown.

Also, all of our tests were flown with proper nosewheel strut extension and the exact effect of a lowered or "collapsed" strut is unknown.

The pilot was attempting a landing in a strong crosswind condition. After making a smooth touchdown, the aircraft again became airborne due to a strong crosswind, and with lateral control swiftly diminishing, the pilot ejected while the aircraft was in a 30 degree left bank. The altitude of the aircraft has been estimated by eye witnesses to have been under ten feet at the time of ejection.

The pilot was aided by the fact that he ejected into the wind, which greatly accelerated the opening sequence of the chute. He came to rest a short distance from the runway after one full swing under his chute, and was unhurt. He resumed flying the next day.

The aircraft which was moving at about 150 KTS at the time of pilot abandonment, fell back to the runway and continued rolling for several hundred feet before it left the runway and sheared the nose and right main gears in the rough. Aircraft repairable.

Comments

I think that most fighter pilots will agree with me when I say that crosswind landings are the roughest challenge to our flying skill. A landing, in itself, is a skillful, precision maneuver -- but when you add a healthy, gusting crosswind -- you have a real problem. I would like to point out the recommended technique in the handbook.*

CROSSWIND LANDING

> Wind drift may be compensated for by crabbing or the wing-down method, or a combination of both. In strong crosswinds the wing-down or a combination of the two methods is more suitable. Increase touchdown speed 5 knots for each 10 knots of direct crosswind. The most important things to remember are to lower the nose immediately after touchdown and engage the nosewheel steering before deploying the drag chute. The drag chute may be deployed in 90-degree crosswinds of 20 knots, or 45-degree crosswinds of 30 knots, provided nosewheel steering is engaged.

This excerpt contains the main points to consider on crosswind landings, except a few recommendations I would like to make.

1. Wing-down is the most effective input to maintain the straight path on approach, except that at touchdown there is a tendency to bounce on the down wing landing gear and this causes a wing-up condition that is immediately aggravated by the crosswind.

*T. O. 1F/RF/TF-104G(MAP)-1, Dated 15 January 1965.

2. Crabbing is very effective but, unfortunately, the rudder will hold its effect only for a short time. Then the directional stability of the long fuselage takes over and even with full rudder the aircraft will slowly straighten out and will not hold the crabbed position.

3. I recommend an approach that combines the best of both techniques. If you hold a wing-down on the approach to flare, you can more easily maintain directional control. Then at the flare point I start smoothly bringing in the crab and levelling the wings to prevent any bounce. A landing completely in a crabbed attitude is OK as the gear span is not wide and you don't build up large twisting moments. I keep the nose low and lower it immediately after touchdown and get on the nosewheel steering.

4. A very important recommendation I would like to make is to use only take-off flaps when landing in strong, gusting cross-winds. Take-off flaps make the aircraft easier to handle than do landing flaps in strong crosswinds because of the BLC effect. For example, on an approach with land flaps, BLC and a wing lowered into the wind, the tendency during flare usually is to bounce on the upwind gear. This causes the upwind wing to rise and results in less lift on the downwind wing. The situation is further aggravated and the landing difficulties increased because the aircraft wants to turn away from the wind. The upwind wing has increased lift, the fuselage is blocking airflow over the downwind wing thus spoiling the BLC effect and the situation will rapidly get out of hand. My experience has been that in severe crosswinds, take-off flap landings are much easier.

5. At touchdown, I positively retard the throttle to idle and extend the speed brakes. As I go through the procedure to engage the nosewheel steering, I bring up the flaps to decrease the lift and put more weight on the landing gear. When I deploy the drag chute I brace myself for the possibility of being yawed directionally into the crosswind due to the weathervaning of the drag chute. If the yaw from the drag chute cannot be controlled by nosewheel steering, the drag chute should immediately be jettisoned. However, as pointed out in the Handbook, you should expect difficulty in releasing the drag chute when it is weathervaned to the aircraft and it might take more than one pull to jettison it. Therefore, in consideration of all factors, sometimes I do <u>not</u> use the drag chute in excessively strong crosswinds.

Accident Review No. XIIIA

The aircraft was on a delivery flight from plant to squadron base. Pilot took off and executed a left hand turn out from the field. He flew over the runway at approximately 1000 feet and began his loop which reached 7,000 to 8,000 feet altitude. On descent, he cut afterburner and began pulling out. Aircraft struck ground to the right of the runway and exploded on impact. Pilot did not eject.

Ground personnel believe they saw kicker actuated twice during descent.

Accident Review No. XIIIB

Pilot was practicing low level acrobatics. While performing a loop, witnesses stated that aircraft spun out at top. Pilot had been practicing acrobatics for demonstration purposes. Pilot ejected after loss of control. Ejection and seat operation was normal, but initiated at too low an altitude. Aircraft was destroyed and pilot fatally injured.

Comments

All low level maneuvers in the 104 should be carefully planned and practiced to perfection. A most important characteristic to consider is the high wing loading of the aircraft in regard to low level maneuvering.

A complete discussion of low altitude maneuvers in the F-104 would be too long and technical to be included in this lecture. However, I would like to make some strong points about low level acrobatics and airshows. In my opinion, there is no opportunity or any requirement in military flying to learn the intricate, complex details of low level, airshow-type acrobatics -- unless you're on an assigned team. The following rules are what I recommend if you are going to attempt low level acrobatics for airshows.

1. Make a careful study of practical, realistic maneuvers that can be performed in the aircraft.
2. Practice.
3. Concentrate on smoothness of performance.
4. Practice.
5. Never overextend yourself and always have a "margin of safety".
6. Practice.
7. Always fly to a point that is below your proven limit.
8. Practice. Practice. Practice.

Accident Review No. XIVA

Weather was low overcast. Pilot took off on a low level mission with a chase plane. Shortly after entering clouds, pilot radioed the chase that he would climb above clouds. Aircraft crashed soon afterward. Aircraft cut a 450 yard path through trees prior to ground impact point. Wreckage was found strewn 1800 yards from impact point, in line of flight. Cause undetermined. Pilot did not eject.

Accident Review No. XIVB

Pilot took off to fly a low level training flight.

Immediately after takeoff, the tower asked the pilot whether he could carry out a check of some recently reported snow showers north of base. The pilot consented and complied with the request, reporting the weather as "heavy snow showers ---- going right down to the ground". The aircraft crashed shortly after this transmission, impacting the ground in a left wing low attitude of 5 degrees and about 5 to 15 degrees nose down. Strip analysis of the Main Attitude Indicator showed that the readings on the indicator coincided with the attitude in which the aircraft contacted the ground. Pilot did not eject. Aircraft destroyed.

Accident Review No. XIVC

Aircraft flying No. 2 in two ship flight, VFR, at 1000 feet over 800 foot hills. No. 1 pilot pulled up into clouds at 1200 feet, turned left with No. 2 following. No. 1 levelled off and flew straight to establish separation in clouds. No. 2 apparently lost altitude in left turn and flew into hill. Pilot did not eject. Aircraft destroyed.

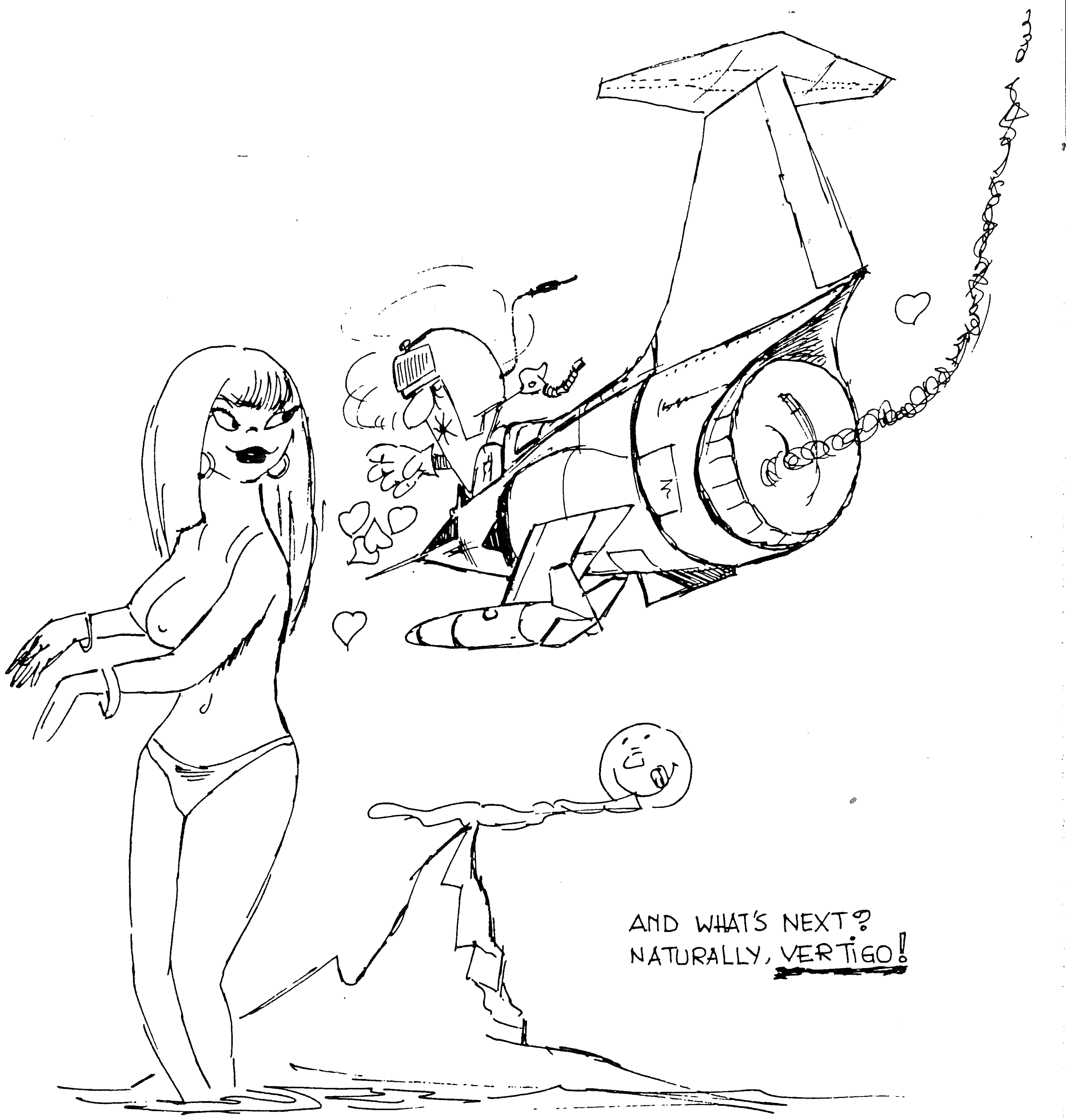
Accident Review No. XIVD

Aircraft was leading two ship low level mission through rainstorm in area where hills were 1000 feet elevation. No. 2 pilot noted heavy rain settling over hills and took evasive action to the right. No. 2 pilot saw ball of fire and no parachute. Assumed aircraft flew into hill. Pilot did not eject. Aircraft destroyed.

Comments

One of the cardinal rules for flight in weather conditions is, "Fly instruments -- and don't attempt to also fly by visual contact!" Any diversion to your attention in instrument conditions should be disregarded.

Vertigo and disorientation are as deadly an enemy as that fighter coming in on your tail -- use your intelligence and skill to overcome one so you can shoot down the other.


AND WHAT'S NEXT?
NATURALLY, VERTIGO!

Accident Review No. XVA

Two-place aircraft was on a routine training flight and carried no external tanks or stores. Through confusion between the two pilots aboard, the landing flaps were inadvertently selected at 36,000 feet and Mach 1.4. When the IP realized what had happened, he immediately returned the flap lever to the UP position. However, the left hand flap was torn loose and struck the empennage surfaces causing the aircraft to enter uncontrolled gyrations.

The IP ejected at high altitude and speed. He suffered broken leg and head injury. Student had difficulty reaching seat ejection ring due to high negative "g" forces, finally was able to grasp it with one finger and eject at a very low altitude. He suffered a dislocated finger. Aircraft was destroyed on impact.

Comments

Operation of the aircraft beyond the flight tested limitations as listed in the handbook will result in failure as in this case. Do not gamble on the limitations -- we've already tested them to the maximum.