AEROSPACE

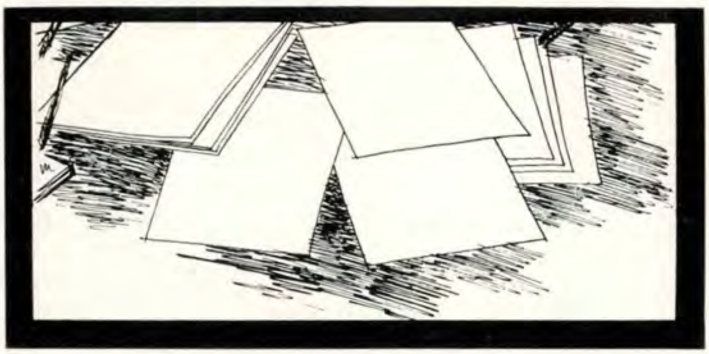
SAFETY

UNITED STATES AIR FORCE

DECEMBER 1963

EDITORIAL . . .

ACCIDENT RATES



Accident rates are an administrative device for keeping records on losses that are not attributable to fair wear and tear.

Accidents are arbitrarily divided into categories, usually on a basis of estimated manhours to repair or replace. Breakouts of this recording system include: major accidents, minor accidents, incidents, mishaps, one-time damage reports, and so on.

One reason for such categorizing is to encourage reporting of all happenings, either serious or of serious potential. Careful analysis of all such reports is one of the best means of avoiding many of the more costly types of accidents. Today, a state of the art has been reached at which, in some weapon systems, even one accident is not acceptable.

Diligent reporting, *in all cases,* to the Directorate of Aerospace Safety *is* one of the best prevention tools yet devised. Here, military weapon systems project officers, civilian specialists and industry representatives study reports, watch for trends, analyze for seriousness and, most important of all, make suggestions on prevention.

Comparison of rates between like organizations and with past years is an outgrowth of the record keeping system. But the rates in themselves are merely an index. And rates, per se, may be very misleading. A lower rate may be due to equipment modifications or revision in the accounting procedure. A unit may have a lower overall rate than for the previous reporting period, but the number of accidents that could have been prevented at unit level may be up. In such a case the prevention program has deteriorated, despite a lower rate.

For such reasons as this, rates, on the surface, are not true indexes to a unit's accident prevention program (except in the case of a rate of zero).

From a practical standpoint, no matter how far the rate has been reduced, accident prevention programs need emphasis so long as preventable accidents occur. Consider the pilot killed in the crash of a fighter that went through the barrier, the airman lost in an explosion in a missile silo, or the sergeant whose life was slammed from his body when his buddy's car hit a bridge abutment. The wives of these men get no solace from the fact that the rate was down for the year. If their husbands were lost in preventable accidents, to them the accident prevention programs were 100 per cent *failures.* This is also the way the programs should be considered by all who, in any way, were in a position to prevent such accidents.

Although in a competition conscious society the spotlight may shine on rates, the real gains will be made by diligent support and operation of all weapon systems, and the reporting of all potential accidents.

It's not how we keep the score, but how we play the game that determines whether we win or lose. ☆

Lieutenant General John D. Ryan
The Inspector General, USAF

•

Major General Bertram C. Harrison
Deputy The Inspector General, USAF

•

Brigadier General Jay T. Robbins
Director of Aerospace Safety

•

Colonel Charles L. Wimberly
Chief, Flight Safety Division

•

Colonel James F. Risher, Jr.
Chief, Ground Safety Division

•

Colonel George T. Buck
Chief, Missile Safety Division

IN THIS ISSUE

Accident Rates . . . IFC

Fallout 1

Needle In A Silo 2

Junk In The JP-4 . . . 7

Mystery In Pit X 12

Removing The White Stuff 14

CAT Again 17

A Hard Look At Aero Clubs 20

Check The MAN 22

FAA Advisories 23

If You Can Walk Away . 24

Aerobits 26

Missilanea 28

Well Done 29

FALLOUT

Nest 3
Migration Motel
(Fully Feathered)

Dear Editor:

I'm known to be a flyer of long standing and good repute, so in all modesty I feel able to write to you about an experience of mine which I think you might like to know about.

Well, last year, Ed, a few of us geese decided to fly from Comox, British Columbia (where I've seen quite a few of your honourable airframe drivers, by the way) to the area around the RCAF Station at Cold Lake, Alberta. If you've been to Comox or vicinity, Ed, you'll know that temperatures there run at a pretty comfortable level as a rule, and on this day it was +40°F. Just nice for flying, and I had my outer feathers in the full vent position and my inner down at part close. We had a nice enough trip across the Rockies, keeping to the passes as usual, but as we got east a bit, things began to get real cold. It took me by surprise, so sudden was the drop in temperature. Luckily, of course, I was able to adjust my inner down to the full snug setting and to lower my outer feathers to max close. Even so, the cold did get to me in the early stages and our flight leader looked back and honked out, "Lor luv a duck mate, why don't you plan ahead a bit and make sure you're properly covered for these temps?" You'd like our flight leader, Ed, his mother was mated to an English pheasant once and this goose has the weirdest accent.

Well, believe it or not, Ed, the surface temperature at Cold Lake turned out to be 40 below zero! S'fact! An eighty degree temp drop on one flight—a flight comparable to many that your jocks might make in these areas, by the way.

In talking this over, we got to mentioning as how we had sometimes seen American jocks staging through Comox (the RCAF place there) and as how we had often admired their bright plumage, but as far as we could see, the plumage looked fine for 40° above, but no damn good at all for anything a whole lot lower—especially if you consider an all night stint in the open such as might happen if it became necessary to leap out the nice cozy airframe for whatever reason.

Well, Ed, up here we like Americans. Especially the ones who fly. And we hate to see 'em start a "See Canada and Die" club (SCAD), so I thought I might just pass the word about our goose pimpling experience so you could maybe have your jox know what they could be up against on a trip through from, say Sunni Calli or Hamilton, to points north and east. And as I say, we love to see them.

We all enjoy reading your fine magazine, one of the best in the flying business. Happily, we get to see every issue, and since you're the Editor, we hope you get north of the line occasionally to see how we operate.

Cheers for now, and all the best to you and your staff.

Yours in Safety,

P.S. Some of the guys are trying to tell me that USAF stands for Ultra Skillful American Flyboy — is this true? If so, I'd like to join. ☆

Merry Christmas

AND A SAFE NEW YEAR

•
Chief, Education and Training Group
Colonel Jerome I. Steeves
Feature Editor
Amelia S. Askew

Editor
Major Thomas J. Slaybaugh
Art Editor
David Baer

Managing Editor
Robert W. Harrison
Staff Illustrator
SSgt Bill Foster

Volume Nineteen Number Twelve—USAF Recurring Publication 62-1

Finding the cause of a ballistic missile accident can be like searching for a . . .

. . . Needle in a SILO

How complex this can be is revealed in the following step-by-step description by a missile accident specialist who takes us along on a detailed investigation of a missile catastrophe. Length of this article dictates that it be divided into two parts, the second of which will appear in the January issue of Aerospace Safety.

You've just poured a tall cool drink and switched to channel four. As Sam Benedict makes his bombastic entrance, your telephone rings. The boss quietly tells you that an Atlas operational site has just launched a silo. It looks like the Aerospace Safety Accident Investigation Board (ASAIB) for the Atlas will have to be convened so start alerting the participants. If this were a "who done it" Mr Poe would probably flash back to the dastardly deed so why should we be any different?

First, visualize what happened as various eye witnesses described it. The site confidently approached completion of project "Long Reach" slightly ahead of schedule. Successful accomplishment of this PLX, loading of LOX and counting down through the commit sequence to the point of engine ignition, without ignition of course, would complete weeks of hard work. The site would be ready to assume its EWO function and a scheduled maintenance and inspection program would be initiated to keep the site in its ready state. In the launch control center were the five-man crew, the sector commander, a safety technician, an extra electrical power production technician, a three-man mobile calibration and maintenance team, and four "Long Reach" engineers, a total of 15 people.

The PLX was scheduled for 1000 hours, but thunderstorms in the area resulted in its being rescheduled for 1730 hours. About 10 minutes before this time, the sector commander went to the cap to visually check the area for thunderstorm activity. His observations were favorable and the command post was notified that conditions were suitable for conducting the PLX. A "Long Reach" Phase III message was initiated by the command post and the MCCC announced that the PLX would commence at 1730 hours.

A brief delay then occurred when it was discovered that the 480 VAC diesel generators were putting out excessive current. A power factor adjustment was made in the electrical power production equipment, which im-

Lt Col Charles W. Flanders, USAF (Ret.)

proved the situation, but current output was still slightly high.

The propellant loading exercise started at 1744 hours with no significant anomalies during the exercise. An apparently high vapor content in the silo was observed on the television monitors. A malfunction was indicated in the missile lift system near completion of the lift sequence; however, the launch platform continued to creep up and a launch platform *up and lock* indication signaled successful completion of the raise sequence. An autopilot or circuitry failure indication also occurred in the flight control system, but the exercise was declared successful. The abort sequence was entered at approximately 1757 hours.

The missile lift system drive down was accomplished and by 1805 the 40-horsepower hydraulic pump had dropped off the line and all lights were extinguished on the control station manual operating level. At 1806:50 the amber light indicating LOX drain illuminated. Events progressed routinely until 1817 when the LOX drain valve (L-16) indication on the LOX tanking panel changed from fully open (a green light) to not fully open, not fully closed. This was signified by extinguishment of the indicator light.

The safety technician and the ballistic missile analyst technician donned protective equipment to enter the silo and investigate the malfunction. At approximately 1822, before the technicians had left the launch control center, the green indicator light came on indicating that the LOX drain valve (L-16) was again fully open. The malfunction investigation was discontinued and LOX downloading proceeded. But a couple of minutes later, the L-16 valve indication again changed to an intermediate position and remained this way for the rest of the exercise. The technicians then entered the tunnel to the silo with their protective clothing and emergency breathing apparatus to investigate the malfunction.

Now events started to pile on top of each other. The technicians had reached the blast door at the silo level 2 entrance and found abnormal resistance in opening the door. The safety technician believed that the door was being held closed by over-pressure within the silo. Meanwhile, in the launch control center, sparks and flashes were observed on the level 8 TV camera monitor and the fire alarm for levels 7 and 8 was actuated. On the level 6A TV camera monitor, flames were observed rising from a lower level.

Evacuation alarms were sounded, the technicians were recalled from the tunnel and the fog spray system was actuated. The technicians made it back to the launch control center by approximately 1828, securing the blast and debris doors behind them. The missile LOX tank pressure gage rapidly decreased to zero, the missile fuel tank gage was indicating 53 psi, and the differential pressure gage was pegged out at 5 psi. During this hectic period the 48 VDC battery charger failed and 28 VDC missile reference power was lost. Complete electrical power failure occurred at 1828:32 hours. These unsettling experiences were followed shortly by an explosion within the silo followed by fires of varying intensity. (The fires burned for 19½ hours.) Flames reaching as high as 500 feet above the silo cap were accompanied by minor explosions and popping sounds.

Smoke and dust filled the launch control center. Visibility was severely limited even though the emergency lights went on when electrical power was lost. When field telephone contact was made with the fallback area, observers reported the extent of the fire and advised the launch control center that flames were obscuring the emergency exit and the security fence gate area. The normal entrance, however, was clear of fire. Donning emergency breathing apparatus, personnel evacuated the launch control center through the normal entranceway and scaled the security fence on the north side of the complex. With the exception of a few minor cuts and bruises, there were no injuries.

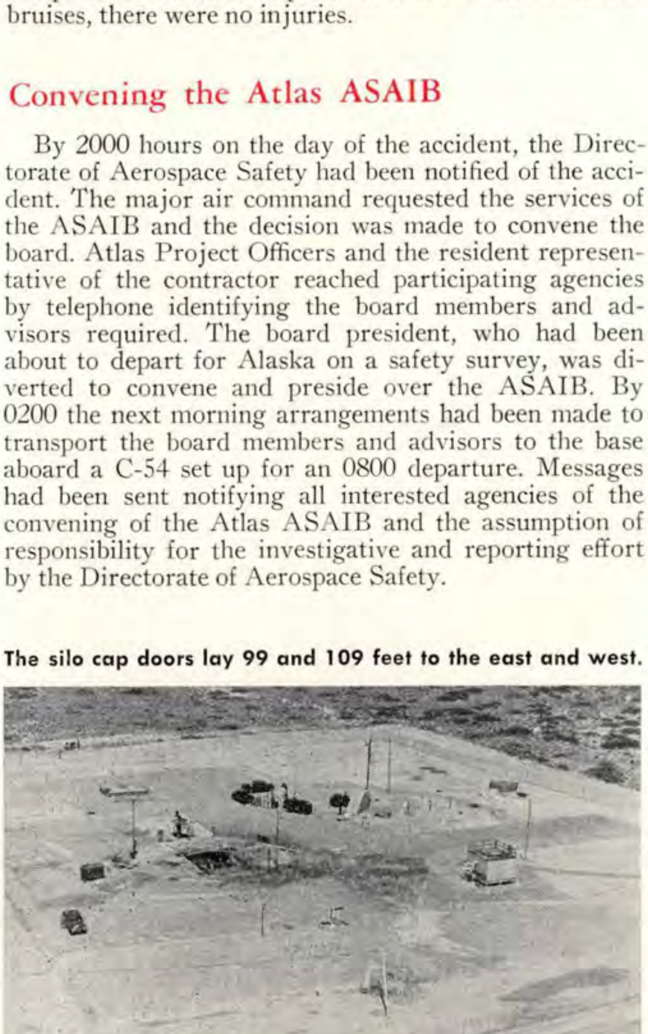
DEFINITIONS

- PLX — Propellant Loading Exercise
- EWO — Emergency War Order
- MCCC — Missile Combat Crew Commander
- BMAT — Ballistic Missile Analyst Technician
- GOX — Gaseous Oxygen
- LOX — Liquid Oxygen
- EOD — Explosive Ordnance Disposal

Convening the Atlas ASAIB

By 2000 hours on the day of the accident, the Directorate of Aerospace Safety had been notified of the accident. The major air command requested the services of the ASAIB and the decision was made to convene the board. Atlas Project Officers and the resident representative of the contractor reached participating agencies by telephone identifying the board members and advisors required. The board president, who had been about to depart for Alaska on a safety survey, was diverted to convene and preside over the ASAIB. By 0200 the next morning arrangements had been made to transport the board members and advisors to the base aboard a C-54 set up for an 0800 departure. Messages had been sent notifying all interested agencies of the convening of the Atlas ASAIB and the assumption of responsibility for the investigative and reporting effort by the Directorate of Aerospace Safety.

The silo cap doors lay 99 and 109 feet to the east and west.



The Investigation

The board and advisors arrived at the base at 1215 on the following day and the Atlas ASAIB convened at 1345. The squadron accident investigation board briefed

Needle in a Silo continued

the Atlas ASAIB on the status of their investigative effort. Applicable records were being impounded and interrogation of witnesses had begun. A contact officer and recorder from the base were assigned to the board along with required secretarial and administrative help. The base flight surgeon was assigned to the board as its medical member.

At 1500 the ASAIB began its examination of the site. What they saw was not reassuring: the silo cap doors lay 99 and 109 feet east and west of the silo cap. The silo was too hot for entry. Debris from the silo was distributed generally in a northwesterly direction.

Wreckage identification, photographing, plotting, and explosive forces analysis were started by the missile structure and subsystems group and the explosive materiel and fire pattern group at 1600 hours. This effort was carried out throughout the daylight hours until the task was completed on the tenth day. Investigators, using breathing equipment, entered the launch control center at 1620 hours. Oxygen content of the interior was found to be normal. Toxic gas sampling could not be accomplished due to inoperative test equipment.

The specialized investigative groups reported progress to the board president at 2100 hours. Priorities were established for the next day's investigative effort. Special support requirements were identified. Board operating procedures, administrative requirements and responsibilities of the members, advisors and support personnel were reviewed by the president. A daily time period was established for specialized group coordination meetings and for group leaders' meetings with the board president for progress reporting, coordination between groups, and direction of the investigative effort. At 2200 the board recessed and the first progress report dispatched to all involved and interested agencies. All Atlas F organizations were included as addressees as well as agencies specified in AFR 127-4.

Problems Arise

Now for some of the problems that arose during the month of activity required for this investigation.

Investigative and support personnel working at the complex required food, drinking water, communication with the base, lights for underground operations, breathing apparatus, coveralls and boots. The board was fortunate in the assignment of the base contact officer. He arranged with food service for iced water, coffee and meals to be delivered to the complex each day. Daily checks by the food service supervisor with the recorder assured adequate supply of these necessities at the site. The base contact officer also made arrangements for coveralls from personal equipment on a loan basis and sale of combat boots to those people needing them. Through the communications officer he provided a telephone at the security fence gate on the complex, another one at the launch control center entrance and an extension in the utility building which served as a work area for personnel at the site. A diesel generator and flood light unit provided lighting and emergency electrical power. Whatever was needed by the board for support of the investigative effort he managed to provide in a timely fashion. No avoidable delays were encountered even though some of the requirements could not be foreseen.

Top photo, note dust on floor of Level 1 of Launch Control Center. Following blast, investigators, using breathing equipment, entered Launch Control Center at 1620 hours. Oxygen content of Level 1 and Level 2 (below) was normal.

The first recorder assigned to the board was subject to conflicting duty requirements. He was shortly replaced by a new recorder who performed quite well even though he had no such previous experience. Careful selection of board support personnel as well as the members and advisors is vital to the successful and timely accomplishment of an accident investigation.

On the third day the industrial hygiene engineer sampled air within the launch control center. There were no toxic vapors present and the oxygen content was still normal. Aerial photos were taken of the silo cap and surrounding area to assist the wreckage plotting effort. The control officer who participated in this flight failed to establish a recognizable pattern for this photo effort. Consequently, most of those pictures which did not include a portion of the complex within the picture frame could not be correlated since the surrounding area presented no recognizable landmarks. Photo mapping is normally a highly satisfactory method of establishing a wreckage location diagram. However, personnel experienced in photo mapping techniques are needed to insure a usable product.

Investigators entered the tunnel between the launch control center and the silo. Dust similar to that found in the launch control center was found throughout the tunnel. The debris door and two blast doors were intact and there was no debris in the tunnel. Blast wall sealing material (lead wool) and the insulation on wiring in the cable trays was burned away adjacent to the blast door at the silo level 2 entrance.

At 1500 on the third day, a small fire had rekindled in the lower level of the silo and was controlled by the firefighting crew. Two B-52 air conditioning units were borrowed from the flight line and positioned to circulate cooled air through the silo to accelerate cooling of the interior to below ignition temperature. Later a purge air blower unit designed for circulating large volumes of air through the silo was located in the missile assembly and maintenance shops building and set up on the silo cap in place of the B-52 units. It was discovered that the purge air blower unit had been furnished to the squadron without operating, inspection and maintenance technical data.

The board president briefed the air division commander and staff personnel, and made a telephone briefing to Hq USAF on progress of the investigation. At this point he requested the Director of Aerospace Safety to have a technical consultant alerted to assist the board in hardware analysis as soon as the silo could be safely entered.

Concurrently, the launch operations and witness group was interrogating witnesses and analyzing testimony. The medical member was conducting human factors interviews for accomplishment of AF Form 711g. The maintenance, inspection, and records group was evaluating available records and searching for missing documents. The ground equipment and facilities group was reviewing base civil engineer records.

Silo Entered

By the fourth day the silo had cooled enough that a two-man hazard evaluation team, a missile safety Atlas project officer and an engineer could enter the silo and make an access inspection of all levels. Meanwhile, the industrial hygiene engineer collected dust deposit samples from the launch control center and forwarded them to the closest Area Environmental Health Laboratory for analysis.

Requests were made for technical assistance. These included an RP-1/LOX explosion expert to conduct an evaluation of the explosion source, its nature and the forces experienced. A technical consultant was sought from the Directorate of Aerospace Safety for hardware fracture analysis.

Control of site access and direction of the onsite investigation was assigned to the missile structure and subsystems group leader.

The board president provided a rough estimate of damage to the Air Staff.

Since control of news releases concerning board activities is a responsibility of the board president, procedures for releases were established with the base information services officer. The actual handling of such releases is best accomplished by utilizing the services of an experienced information services officer.

On the fifth day, a detailed gross personnel hazards inspection of the damaged silo was made. Site access procedures and detailed safety precautions for investigative operations within the silo were established.

It is significant that there was only one minor injury during the investigation. An investigator cut his hand on a cold chisel being used to cut a component loose from the missile remains. There were no reportable mishaps.

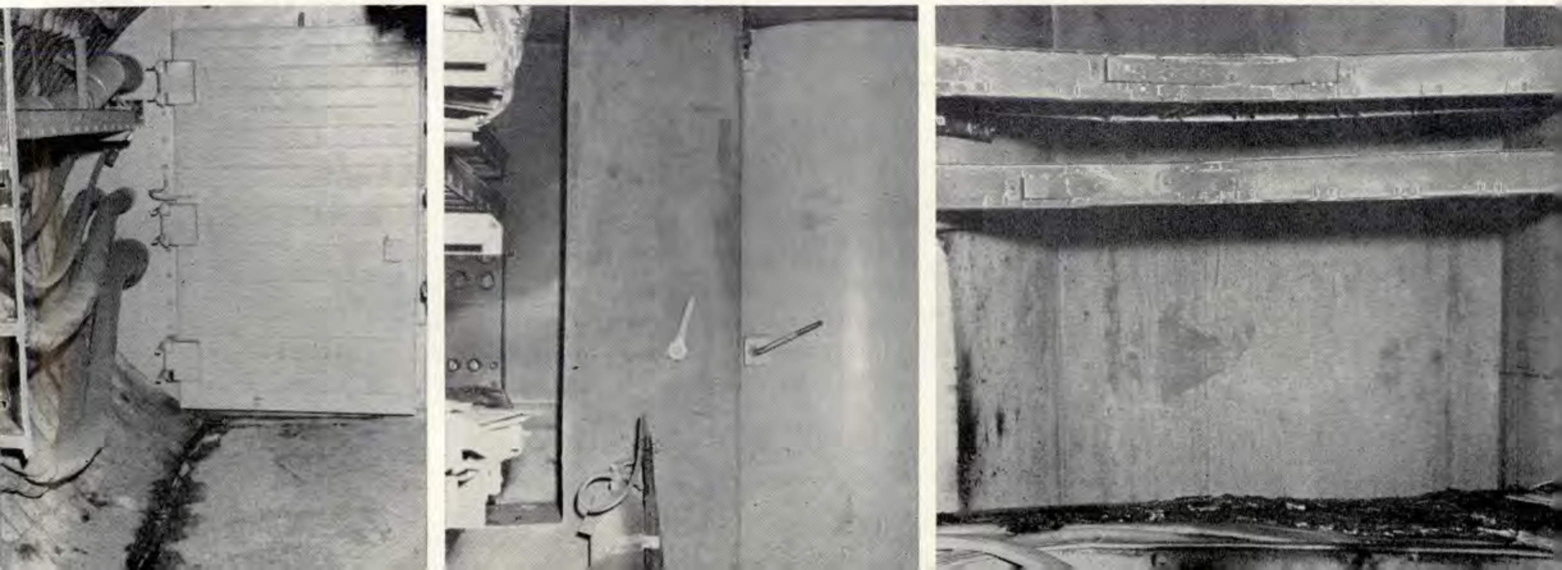
A crane and personnel bucket were placed on the silo cap for direct entry into the silo down to level 5. Field telephones were installed temporarily for communications between the silo cap and the various levels where investigators were working.

Detailed visual inspection and photographic coverage of the primary suspect areas were made within the silo. The local diesel technical representative and an electrician assisted board members in the identification and evaluation of silo components.

The Area Environmental Health Laboratory reported that dust deposit samples from the launch control center contained from two to five per cent lead by weight. The medical member of the ASAIB, the local flight surgeon, immediately established a testing program for all personnel who had been exposed to the fumes and dust within the launch control center. Blood and urine samples were taken for analysis. Laboratory reports revealed that there had been no harmful effects and there were no cases of lead poisoning.

Toward the end of the first day of investigation within

In photos below, left to right, we note that beyond the debris door in the tunnel there is dust and smoke, but no debris. Blast doors were still intact, but blast wall sealing material and wiring insulation were burned away at the silo entrance.



Needle in a Silo continued

the silo, a small flow of diesel engine generator lubricating oil was noted dropping down to the water below level 8. The silo interior was more like a Hollywood location for a science fiction thriller than anything you could associate with the Air Force. Even the sound effects were weird. Peculiar whistles, groans, crackings, gurglings, and the intermittent showering of small chunks of concrete spall made the investigators wonder if the whole mess was about to go into orbit.

Examination of the rubble at level 8 and the storage tanks showed an increased seepage of GOX and liquid oxygen from the broken line at the base of the LOX storage tank. Ground water seepage through silo wall spalled areas had increased and the water level below silo level 8 was rising. A pile of rubble near the LOX seepage area was still quite hot and temperature measurements indicated 500°F two to six inches below its surface. Close examination of the LOX seepage area was difficult due to poor lighting and fog rising off the vaporizing LOX. However, it could be seen that two pools of gel appeared to be forming below the broken LOX line. All personnel were withdrawn from the silo and hardware examination within the silo was suspended pending evaluation of this new hazard. Support equipment was moved outside the perimeter fence. An expert in LOX/hydrocarbon gel behavior was sent for to advise the ASAIB.

Arrangements were made with the photo lab to process each day's film and provide one print of each to the board by 1200 hours of the day following the shooting. This arrangement worked exceptionally well and gave the photo lab sufficient time to program its workload. There were no instances where prints were actually needed sooner than the following day. The prints were posted on display panels upon receipt, and personnel from the wing intelligence office familiar with the subjects involved reviewed each new group to establish the security classification of each print. The prints and negatives were controlled as if they were classified until security review established otherwise. This procedure virtually eliminated the possibility of inadvertent security violations.

With suspension of the in-silo portion of the investigation and the uncertainty of when, if ever, this phase of the investigation could be resumed, an analysis and evaluation session of the whole board was called. Based upon observations made at the site, comparison visits to other sites and current evaluation of maintenance records, the board recommended the following actions prior to further propellant loading exercises involving LOX at Atlas F sites:

- Repair, calibrate, activate and maintain GOX detectors in operable condition.

- Establish TV coverage of diesel engine generator rooms on silo levels 5 and 6 and require monitoring of these areas with TV during such exercises.

- Maintain all personal escape and emergency equipment listed on the equipment component list in operable condition and locate it appropriately for instantaneous use by each crewmember when required.

- Properly seal cable opening adjacent to tunnel blast doors and debris door.

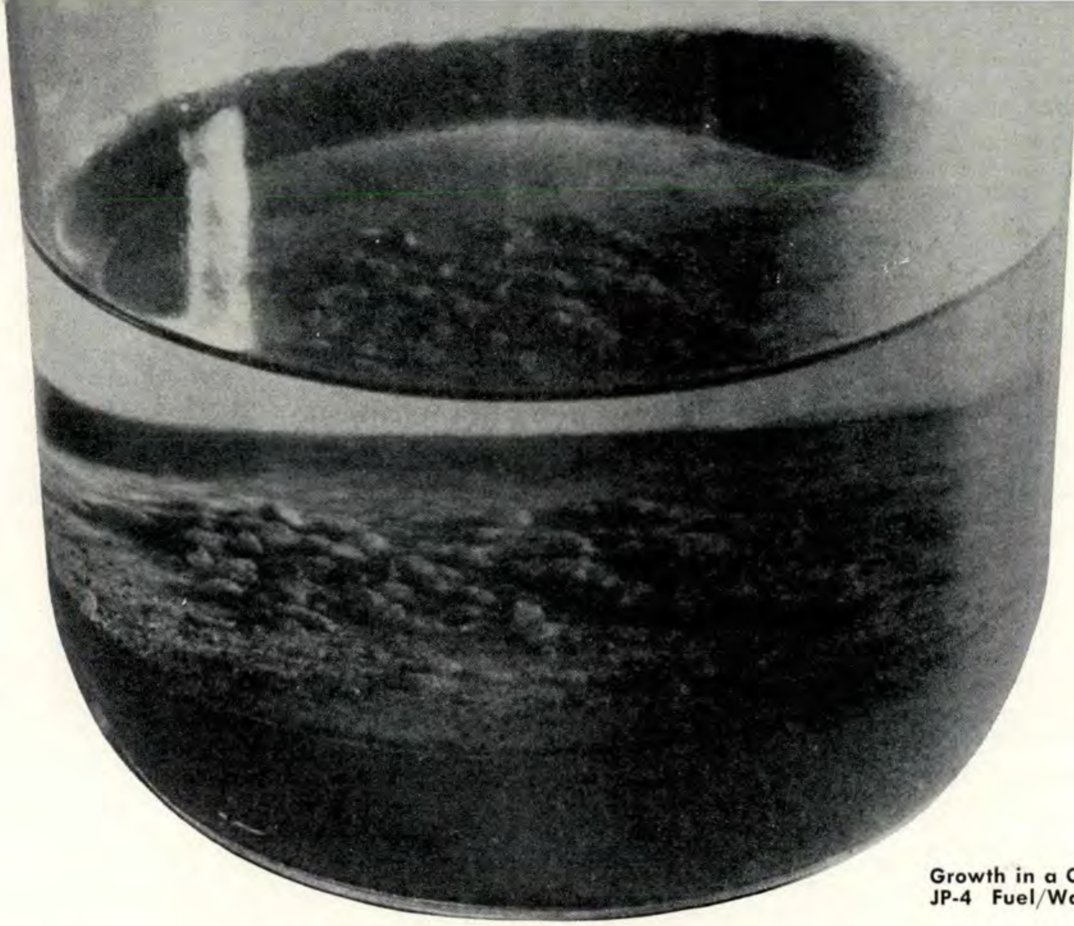
- Require an extensive housecleaning program around diesel engine generator units on silo levels 5 and 6. Remove all hydrocarbon residues and keep silo areas free of hydrocarbon materials such as fuels, oils, and hydraulic fluids.

- Establish procedures to insure entrance portal entrapment door cannot hinder or trap personnel in the launch control center when evacuation is required during electrical power loss. ☆

Next month the investigation continues.

The author, Lt Colonel C. W. Flanders, joined the Missile Safety Division on 1 November 1959 as a Ballistic Missile Project Officer and became an Atlas Project Officer with advent of the Atlas into the operational inventory. He retired 31 October 1963 and is now on the teaching staff of the Aerospace Safety Division at the University of Southern California teaching Missile Accident Prevention and Accident Investigation. While in the Air Force, he coauthored AFM 127-200, Missile/Space System Mishap Prevention and Investigation Manual.

Silo interior was more like a Hollywood science fiction set.



Growth in a Contaminated JP-4 Fuel/Water Sample.

For a thorough discussion of the effect of jet fuel contaminants on corrosion of fuel tanks, Aerospace Safety recommends careful reading of . . .

Junk in the JP-4

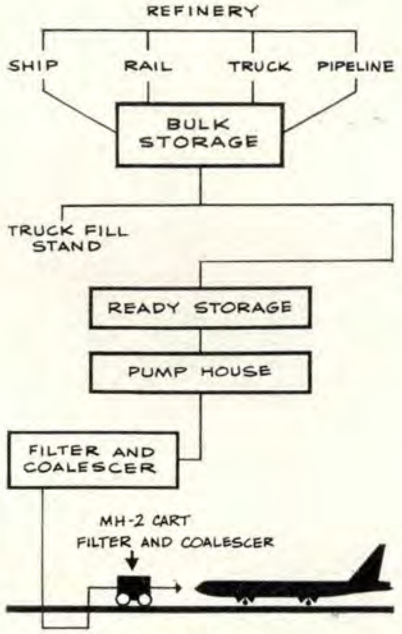
A. V. Churchill, ASD, Wright-Patterson AFB, Ohio

Integral fuel tank corrosion and other operational problems have been associated with microbiological growths and other jet fuel contaminants. The four major jet fuel contaminants — water, particulate matter, surfactants and microorganisms—are discussed, as well as other contributory factors, as to their possible role in the corrosion problem. Research and development programs, which have been initiated in an attempt to find the exact causes of corrosion and to reduce the severity of corrosion, are described.

Several incidents have occurred in both military and commercial turbine-powered aircraft where contaminants in jet fuel have resulted in severe operational problems. These contaminants appear to be associated with and affect the severity of fuel system filter plugging, fuel gage malfunctions and integral fuel tank corrosion. Although the role of each particular contaminant in these fuel system problems has not been adequately defined, substantial evidence is available to show that a reduction in concentration of any one contaminant or combination thereof reduces the seriousness of the problems.

Due to their nature, jet fuels are more likely to carry fine particles of rust, water and other foreign material in suspension to a much greater extent than aviation gasolines. Jet fuels also have a penetrating capacity and can dislodge existing rust and scale from the interior surfaces of tankers, pipelines, storage tanks and other handling equipment to a greater extent than is experienced with aviation gasolines. Modern jet fuel distribution systems are designed to provide and maintain strict standards of cleanliness for fuel delivered to the aircraft.

Figure 2 illustrates a typical jet fuel handling system. After leaving the refinery, the fuel is transferred by either ship, rail, truck or pipeline to a bulk storage facility. The storage facility is usually located at a base, but may be located at a terminal point in the distribution system to supply more than one base. From bulk storage the fuel is moved either to a ready tank storage system on the aircraft flight line or to a truck fill stand. From these storage points to the aircraft, the fuel is filtered twice to remove free water and particulate matter. Normally, fuel delivered to the aircraft contains no more than four milligrams of solid per gallon of fuel



Fuel Delivery

Junk in the JP-4 continued

and is free from any visible haze of dispersed or free water.

Although the above standards of cleanliness are, in most cases, achieved with current jet fuels and handling procedures, serious problems have appeared as a result of contaminated jet fuel. This article discusses the major jet fuel contaminants as to their possible role in the corrosion process as well as methods to control or eliminate these contaminants from jet fuel systems.

Background

The problem of microbiological sludge in jet fuels was first observed in the Air Force during the summer of 1956 when samples of contaminated jet fuel from various locations were examined. Results of this initial study indicated that microorganisms were present in the samples and that they live primarily in the water layer or at the fuel-water interface. This investigation and more recent ones have shown that these micro-organisms feed on hydrocarbons and produce slimes, mycelia mats, residues and stable emulsions. Figure 1 illustrates a contaminated jet fuel/water sample obtained from a base fuel facility.

The integral fuel tank corrosion problem was not observed in the Air Force until 1960 when the presence of corrosion, degradation of sealants and topcoatings, and fuel contaminants, including microrganisms, were detected in several operational aircraft. The same or similar type problems have been encountered in the other military services, in commercial airlines and in the Australian Air Force and Australian Airlines.

In aircraft, microbiological sludge usually exists in the form of green or brown slimes or mats. Under these mats degradation of the topcoating material and pitting corrosion of aluminum wing skin have been observed. Figure 3 illustrates microbiological and other contamination in a wing fuel tank. The sealant on the rivets is covered with light powdery mats of microbial growth and other contaminants. Heavy accumulation of growth is shown in lower right corner. A photomicrograph of corrosion is shown in Figure 4; the dark area is topcoating material while the light areas depict pits in the aluminum wing tank.

Analyses of sludge samples obtained from aircraft based at a tropical Air Force base showed that the sludges consisted of microorganisms, microbiological debris and metabolic products, breakdown products of the hydrocarbons, iron oxides, surfactants, chlorides, metal salts, water, silica and other extraneous material.

Inspection of commercial jet aircraft in late 1960 also revealed the presence of sludge in integral fuel tanks, and in some cases pitting corrosion had occurred under these mats of sludge. These cases of corrosion have been attributed to fuel contaminants, particularly microorganisms, iron oxide and/or water.

Contributory Factors and Possible Mechanisms

The exact mechanisms involved in the sludge and integral fuel tank corrosion problems are quite complex and are not quite clear at this time. However, several factors or combination of factors appear to be associated with and affect the severity of the operational problems. These are:

- Water and water-soluble salts.
- Solid contaminants.
- Surfactants.
- Microorganisms.
- Temperature and environmental conditions.
- Aircraft construction materials, treating methods and coating materials.
- Housekeeping of fuel handling systems.

These factors are discussed in detail below.

Water is a most serious hazard in jet fuel systems and is usually present in jet fuels as both dissolved and free or dispersed. In addition to causing direct damage by freezing out at points in the aircraft fuel system, the presence of water creates an environment for growth of microorganisms.

The solubility of water varies with temperature as shown in Figure 5. The solubility of water in parts per million in fuel is roughly equal to the fuel temperature in degrees F; for example, saturated fuel at 70°F will contain about 70 parts per million dissolved. However, this will vary to some extent, depending on the aromatic content of the fuel. Fuels are usually saturated with water due to handling procedures and atmospheric venting of tanks. Free water also is carried along with the fuel during handling unless proper steps are taken to eliminate it.

Particulate matter is present in jet fuels as iron rust, dust, lint, etc., and usually is removed readily by adequate settling times and proper filtration through filter/separators. Kerosene and JP-4 fuels are likely to carry more foreign matters in suspension than gasoline. Since the density and viscosity of jet fuels are higher, finely divided particles take longer to settle.

Water and particulate matter are removed in ground servicing facilities by filter/separator equipment. Solids are filtered out and water is removed by coalescing small droplets into larger ones. By the use of millipore filter equipment for determining amount of sediment in fuel, the allowable contamination limits which have been established for fuel delivered to aircraft are a maximum of four milligrams of solids per gallon of fuel and no excess water. (This limit, not yet published, resulted from an agreement between USAF, the Navy and NATO in

Fig III

Microbiological Contamination in an integral fuel tank.

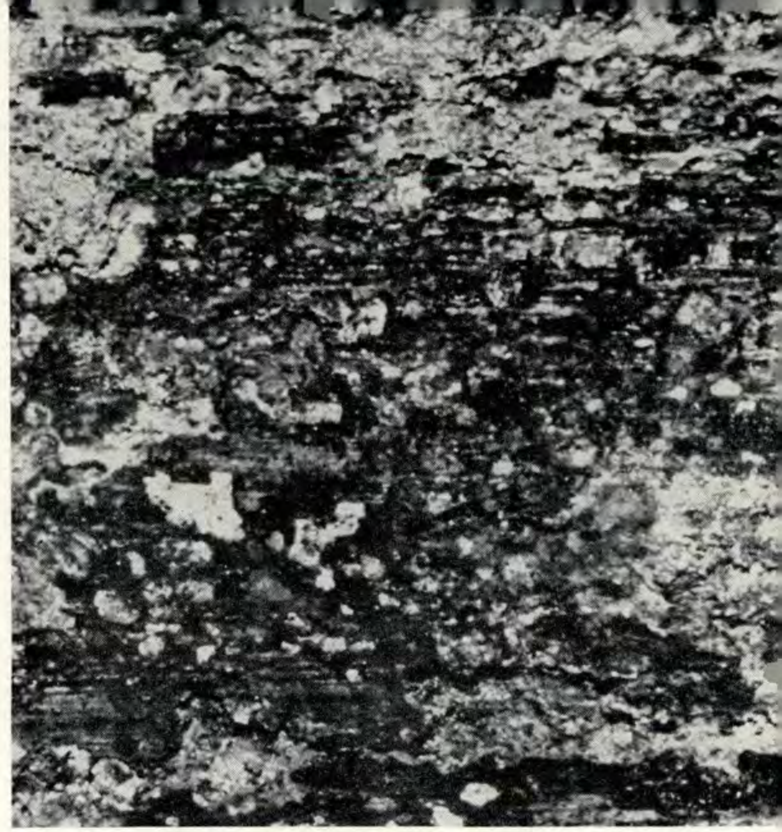


Fig IV

Brown Fungus Photomicrograph, Bright Medium Phase.

May 1963. This information should appear in the next revision of TO 42B-1-1 and Quality Control handbook MIL-HDBK-200.) If discrepancies are noted, immediate action is taken to locate and eliminate the source of contamination.

Surfactants, or surface-active materials, such as sulfonates, naphthenates and polyethylene glycols, may be present in jet fuels from numerous sources; namely, from residual refinery processes, from naturally-occurring materials, from carry-over of other products handled in a distribution system, and from other sources. These materials, when present in jet fuel in trace quantities, have been known to disperse particulate matter and water into the fuel and increase the difficulty of removal. In general, surfactants lower the interfacial tension between water and fuel, thereby impairing both the water settling characteristics of the fuel and the water coalescing ability of the filter/separators.

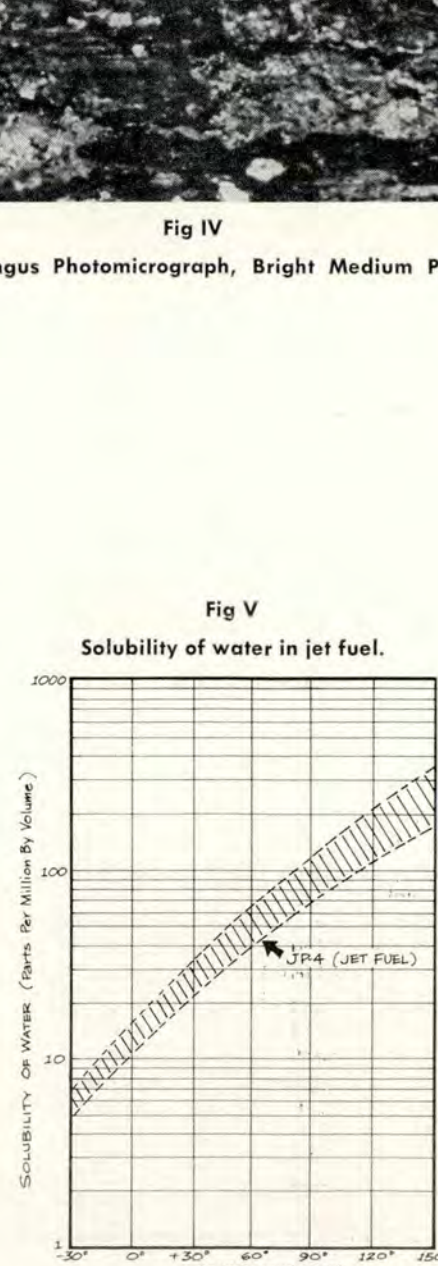
Jet fuel surfactant problems have been recognized in the field by both the military and commercial airlines. Inspections at an Air Force base two years ago showed that surfactants were present in fuel delivered to that base. These surfactants permitted gross contaminants to be pumped into the aircraft, thereby contributing to the severe corrosion and other operational problems occurring there. Although the recognition of the surfactant problem is relatively recent, a laboratory technique called the CRC Water Separometer has been developed for recognizing and evaluating this problem. This test method is being considered as a required test in jet fuel specifications to control the concentration of surfactants in jet fuels.

Microorganisms. Growths in the form of bacteria and fungi are present in most, if not all, jet fuel storage facilities. These bacteria and fungi are common microorganisms from air, soil and water that find their way into storage facilities and aircraft wing tanks. Several investigators have isolated numerous bacteria and fungi from jet fuel-water samples.

Of the fungi isolated, *Hormodendrum hordei* or *Cladosporium* appers to be the most predominant. A

Fig V

Solubility of water in jet fuel.



Junk in the JP-4

continued

photograph of three representative cultures of this fungus is shown in Figure 6, and a photomicrograph of this fungus is shown in Figure 7. Among the bacteria, the predominating groups of bacteria were identified as *Pseudomonas aeruginosa* and a *Bacillus sp*. Photomicrographs of these bacteria are shown in Figures 8 and 9. Figure 8 is a photomicrograph of a transparent bacterium identified as Psuedomonas aeruginosa; Figure 9 is a photomicrograph of a mucoid bacterium identified as a *Bacillus sp*. As one can note, these microorganisms are capable of forming slimes and mats along with other contaminants.

As with other living plants, these organisms must have a source of energy for growth and survival. They derive this energy by converting the elements carbon and hydrogen in their foods to carbon dioxide and water by a series of metabolic processes. Some forms may not oxidize carbon but use other elements as an energy source, such as nitrogen and sulfur. It is also known that these microorganisms readily require certain other elements, such as calcium, phosphorus, sodium, potassium, magnesium and iron in small concentrations, and that the need for proper hydrogen ion concentration is quite important since certain enzyme systems will function only at specified pH (amount of acid in the solution—as in a swimming pool) ranges.

Most microbiologists would agree that, in general, the oxidized metabolic products of microorganisms are quite capable of causing corrosion. Since biological oxidations are always involved in microbial metabolism, secretion of acids, oxygen consumption, carbon dioxide production and surface tension changes are some of the environmental changes that are known to accompany microbial growth. These changes, especially acid production, can constitute a dangerous situation with respect to corrosion of metal. Salts of organic acids may also play a significant role in the mechanism of corrosion.

From laboratory tests, as well as from inspection of aircraft, corrosion can result from microorganism attachment on aluminum specimens in an aqueous environment. It appears that the moisture holding properties and the formation of concentration cells at attachment points are the major factors in this type of corrosion.

Research work conducted by one of ASD's contractors strongly suggests that sulfide formation may be playing a major part in the corrosion process. Microscopic examination of corrosion pits in one of their simulated fuel tanks indicated the presence of sulfate reducers (*Desulfovibrio desulfuricans* or another species of *Desulfovibrio*) as well as other bacteria and fungi. Anaerobic corrosion by sulfate-reducers is widespread in the petroleum industry and much information has been published concerning the mechanism.

It is also strongly suspected that a symbiotic condition has been found to exist in fuel tanks between a bacteria and fungi and between various bacteria. For example, a possible mechanism of corrosion by iron bacteria has been proposed by C. H. Oppenheimer, which requires the action of sulfate-reducing bacteria. This involves the extraction of ferrous iron from the water by iron bacteria and its subsequent oxidation to ferric hydroxide. This type of growth results in tubercles, which as they increase in thickness, decrease oxygen diffusion until anaerobic conditions develop under the surface of the tubercle, allowing anerobic corrosion by sulfate-reducing bacteria to occur.

Research investigations also indicate that a symbiotic condition may exist between a bacterium, *Pseudomonas aeruginosa,* fungus and other aerobic or facultative organisms and the anaerobic sulfate-reducer, *Desulfovibrio*. The fungus filaments probably give rigidity to the structure and anchor it more firmly to the wing tank bottom and together with the other organisms provide anaerobic conditions and nutrients for the anaerobic sulfate-reducing organisms.

Temperature and Environment Conditions. Complex environmental factors affect the growth of microorganisms in turbine fuel distribution systems and in aircraft, and thereby affect the incidence of operational problems. Among these are increased fuel temperatures, pH of the water bottoms, nutritious salts in water bottoms, surfactant contamination, various fuel additives and possibly polysulfide sealing and topcoating materials. These particular variables are being studied in detail at the present time.

Fig VI

Colonies of Brown Fungus are shown in photo on Sabouraud's Agar.

Fig VIII

Photomicrograph is of Transparent Bacterium Dark Low Phase Contrast.

Aircraft Construction Materials, Treating Methods and Coating Materials. Present integral wing tank topcoating materials are not impervious to water, microbiological contamination and saline water. In view of these deficiencies, new materials

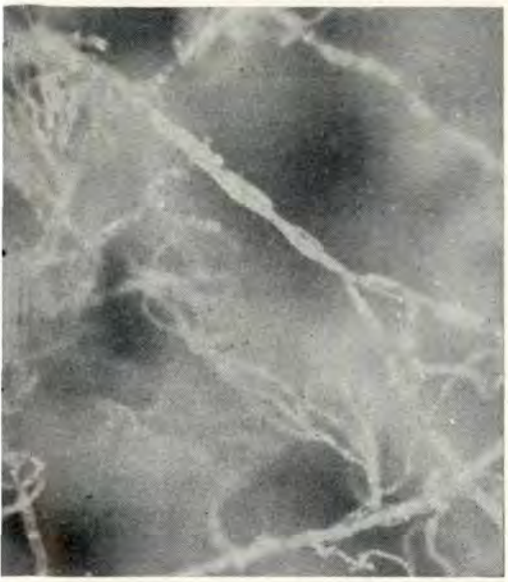


Fig VII
Above is an actual photograph, that shows integral fuel tank corrosion.

Fig IX
Another Photomicrograph is of Mucoid Bacterium Dark Low Phase Contrast.

are being developed and evaluated to afford better protection of aluminum from corrosion. Although the skin of these tanks has been treated for corrosion protection (anodized, alodined or iridited), these treatments have been inadequate for corrosion protection when the aluminum skin is exposed to the media afforded by the presence of water phase in the wing tank.

Housekeeping of Fuel Handling Systems. As mentioned earlier, free water and other contaminants are carried along with the fuel during handling unless proper steps are taken to eliminate them. This is accomplished by adequate tank settling times, proper design of tank roof drains, periodic draw-off of tank water bottoms, use of filter/separators, and draining of aircraft wing tank sumps.

As a result of inspections of several Air Force base fueling facilities, the following corrective measures have been recommended Air Force-wide:

1. Incorporate MH-2 Hose Filter carts as an extra filtering step.
2. Coat storage tanks and filter/separators.
3. Incorporate floating suction in storage tanks.
4. Enforce and revise existing handling procedures such as frequent filter element changes.
5. Revise fuel specifications with incorporation of Water Separometer Test and enforcement of "Clear and Bright" requirements.

Cleaning of the fuel must be a continuous process from the refinery to the aircraft since contamination can and does occur at any point in the distribution, storage and dispensing systems. The introduction of water in any part of the fuel system can result in the development of problem areas, particularly since microorganisms are considerably more prolific when water is present. Daily checks for water are made at bulk and operating storage tanks and in the aircraft wing tanks. All possible removal of water is accomplished daily if checks indicate excess accumulation.

Research and Development Programs

Research programs to date have been mainly concerned with the elimination or reduction of the various contaminants in fuel systems through proper maintenance and good fuel handling procedures, and through the use of suitable additives, both water-soluble and fuel-soluble. As discussed earlier, it is impractical to remove completely the problem of water and particulate matter in fuel storage systems and in aircraft wing tanks, particularly in tropical and semitropical climates. For this reason several promising inhibitors have been recommended for this application and further studies are in progress to assure their compatibility with fuel properties and fuel system materials.

The Air Force has found potassium dichromate to be quite effective in killing or controlling microorganisms in water bottoms. This material at a concentration of two per cent by weight in the water bottoms has been under service test since 28 May 1962 and is continuing. The present anti-icing additive, mixture of ethylene glycol monomethyl ether and glycerine, used in JP-4 jet fuel also appears to be quite effective as a biocide at concentrations ranging from 10 to 15 per cent in the water layer. The partition coefficient of this additive is such that aircraft sump drains contain 20 to 25 per cent additive. Laboratory studies as well as field surveys have shown the biocidal effectiveness of this inhibitor. Other biocides are being investigated for use in jet fuels.

An extensive program is underway to resolve contamination and corrosion problems associated with microorganisms, surfactants, particulate matter and water in jet fuels. Both contract and in-house research programs have been initiated to:

1. Determine the effect of microbial corrosion on the mechanical properties of materials used in fuel cell structures.
2. Examine mechanical techniques for killing, removing or controlling microorganisms found in fuels.
3. Develop techniques for rapid detection of microorganisms in fuels.
4. Investigate the role of fuel contaminants in the degradation of jet fuels, in sludge and slime formation, and in corrosion and/or deterioration processes on aircraft fuel systems.
5. Determine and demonstrate the feasibility of ultrasonically scanning an integral fuel tank to detect corrosion.
6. Evaluate present base fuel handling procedures to establish optimum fuel handling procedures.
7. Develop jet fuel system sealants and coatings capable of resisting microbiological deterioration or growth.
8. Evaluation of the performance of full-scale filter/separators in a controlled operational environment on contaminated fuel. ☆

THE MYSTERY OF

Pit X

Lt Col Paul L. Smith, Tactical Air Command

Flight time from liftoff to crash was approximately 30 seconds. The left wing struck the ground and the aircraft was destroyed. All crewmembers were lost.

In brief, this was the history of flight of a major aircraft accident which has had us shaking our heads and asking questions. The investigation team, aided by AMA experts and engine and aircraft company specialists, spent weeks searching for an answer to this one. We knew that propellers on two engines on one wing had been feathered prior to the crash and that neither had been shut down erroneously. We knew that both had lost power prior to being caged. These facts were verified by company specialists. However, a complete teardown of the engines by the manufacturer, supervised by AMA and base personnel, revealed no internal failure.

The engine fuel controls showed evidence of dirt and water content. However, when the system was checked the dirt and lint content did not prevent fuel from reaching the engines. Another blind alley; we had prior experience with engines operating with much more contamination than this aircraft contained.

The night of the crash we had taken samples from Pit X, which had refueled the aircraft, and sent them to Wright-Patterson for analysis. Additional samples were gathered from the crashed aircraft and from other aircraft that had refueled from the same pit before and after the accident. All of these came back indicating no excessive dirt. However, water had been found in one of the filters on the wrecked plane.

In checking, we found that no data were available to determine how much water in the fuel would cause an engine to flame out. Opinions varied to such an extent that no definite conclusions could be reached. We asked for permission to conduct local tests but were refused because we could not control the tests adequately to provide qualified results.

We knew that the pilot had shut down two engines. The only reason left was fuel interruption. This could occur due to water in large amounts being introduced into the engines. Our problem was how. In this particular aircraft, the wing construction is such that the bottom section of the fuel cell forms an integral part of the aircraft. It is milled in channels and in the cross rib construction it is possible to trap water behind many of these ribs in quantities that could cause an engine flameout if suddenly released into the baffle tanks. A modification requiring drilled passageways to be provided through these stiffeners had not been completed on the crashed aircraft. Plant flight test personnel were of the opinion that under certain circumstances of non-coordinated flight sufficient water could be introduced into the baffle tanks on one side of the aircraft to cause flameout of two engines.

As we started down this investigative alley, we ran into a new complication. Water had been found in this aircraft during a periodic inspection just before the fatal flight. The aircraft had been drained, sumps checked, then refueled from Pit X. Yet, fuel taken from other aircraft refueled from the same pit had checked O.K. This indicated that the water must have been trapped behind the ribs all the time. Our old heads didn't like the odds of losing two engines on one side under these conditions and said so, but all other possibilities had been eliminated.

We asked USAF for and received a thorough shakedown of our fuels handling, storage, and refueling operations. While the team had many helpful suggestions, they could find no action which they felt contributed to the accident. Shortly after this team left, the major air command came in with a sizeable team and went through the whole system again, really going into detail. They too had many suggestions but found no item that could have caused the accident.

We went back to the depot performing the modification. They reported that, in going through better than 50 per cent of the fleet, they still had found no serious problem with dirt, lint or water. So we went into a much more restrictive examination of our fuels procedures. Aircraft tanks were opened and cleaned. Inspection times were reduced on fuel filters. Sump drain procedures were tightened. And we found very little.

Oh, we had some very interesting fuels show up. We would get a quart of fuel which contained yellow water. We got dirt, and we got lint. But each fuel report we got back said "within tolerances." And we found only isolated instances. One tank here—another there. No pattern to go by. Then one day we got water across the board in one of our modified aircraft. There was so much of it that we literally had to pull the aircraft out of service while we drained and cleaned it. Samples were taken from Pit X again and again. They came out clean. No other instances of water.

About two weeks later we ran into another case of water across the board. This one occurred right after a very heavy wet snow. This aircraft had been refueled right after another aircraft had been defueled. And—you guessed it—it was Pit X. No other aircraft had been refueled from that pit on that day. We closed the pit. Then we defueled the aircraft. After taking 3/5 of a gallon of water out of the sumps on the fifth pogo, we really expected results. Less than a quart of water showed up in the fuel truck. We went over the pit with a fine tooth comb. *Nothing.* We put a pressure check on the line from the pit to the main fuel manifold. *Nothing.* We checked the defuel lines. *Nothing.* We checked the aircraft that had defueled into the pit. *Nothing.* The aircraft sump drain records were checked. No trouble until that day. And the modification had been completed.

Now we began to get orange water occasionally. After about four times, we had another couple of aircraft pulled due to too much water. Again, we asked for help. This time the team, while not finding excess water, came up with a look-see at the delivery system before it reached the base. There were some discrepancies which were remedied. However, the base system checked out again. The orange water, by the way, came from an additive to the fuel which was colorless until water came in contact with it.

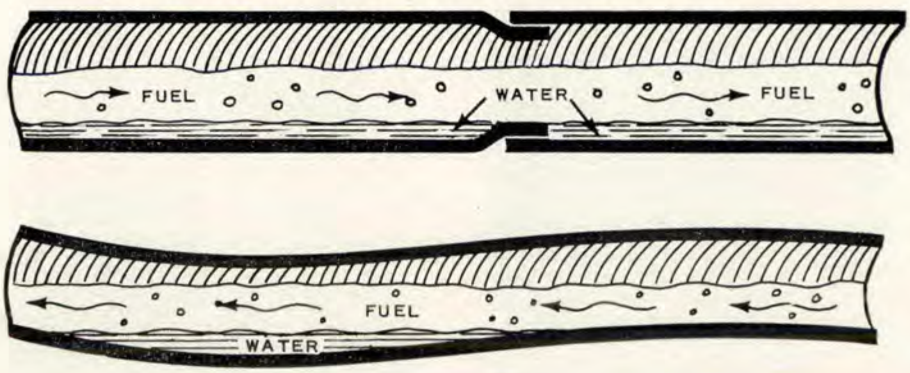
A related problem was fuel probes. The water was raising "Old Ned" with them. Fuel load is critical and we were having to stand down vital numbers of aircraft while we washed the corrosion off the probes. Then one day we had a big movement of aircraft and refueled several simultaneously. The next group on the pits resulted in really tremendous amounts of water in three birds. One had over 500 gallons of water in a total defuel of 3100 gallons. Again we howled for help. And back came the experts. No question about where the water came from. It had to be on our base. Yet, a water content reading from the tanks showed a perfectly reasonable reading. It couldn't happen.

We dug up a diagram of the entire system. From the tanks, a main manifold ran the length of the pits. While questioning the engineers about leaks (we didn't have any) we suddenly got the clue. That manifold held nearly 100,000 gallons of fuel. It hadn't been checked for 10 years although it was flushed weekly. How well was it flushed? We tripled that pressure and found the answer. Two pumps had pushed the fuel right over the top of the water which had accumulated in the bottom of the line since installation. When we put six pumps on the flushing job, we washed out over a thousand gallons of water. The fuels team estimated that some of it had been there for years.

We found that the procedures for flushing our big manifold were not right. That has now been changed. We also found how our lost bird could have gotten so much water. Any turbulence at any time in that manifold could result in a large slug of water being put into an aircraft.

We now have hose carts at each pit which will shut off fuel flow when water is present. We also have a lot of aircrews who are flying much easier now that they know where the water came from and that it probably won't happen again. To date it hasn't. It took nine months and a lot of hard work, but thanks to a couple of dedicated maintenance men, a unit safety officer, and a POL type who wouldn't give up, a really serious problem was solved. ☆

Below are two artists' illustrations showing how entrapped water can remain beneath the lower level of fuel in transfer manifolds of a base POL complex.



Removing the White Stuff

Lt Col Robert W. Heesen, Base Operations Officer, Kincheloe AFB, Michigan

In Michigan, when you have to keep runways open for F-106s, B-52s, T-33s, support aircraft, as a staging area for ADC target forces and as a recovery base for division fighters, you have to learn something about snow removal. In fact, in August we start checking out our snow removal equipment. Comparatively, Kincheloe has consistently had a clear runway when many other bases in the northern circuit haven't fared so well. I attribute this to the type of equipment we have and how it is used.

First of all we have a piece of equipment called the Sicard Airblast Sweeper. It has a large rotary metal sweeper with a tube that blows air behind the sweeper. Metal bristles dislodge the snow and the airblast blows it off to the side of the runway. However, when the runway is covered with ice, the bristles have no effect on dislodging the ice. Also, when the snow is soft or loose and packed a little the bristles don't have too much effect. In this case the best procedure is to use the snow plows and not the roll-over blade in the front but the drag blade in the center underneath the belly of the truck.

This drag blade is applied to the runway by hydraulic pressure and, as the vehicle moves along, the pressure does two things: it creates heat from friction and it flakes the ice and snow so that there are little wafer-thin pieces sticking up in the air. We run about four drag blade plows down the runway in echelon, followed by the Sicard Airblast Sweeper. When the sweeper bristles hit the little flakes of ice or packed snow they dislodge them and the blower blows them off to the side. The airblast sweeper by itself obviously wouldn't have too much effect, but when preceded by the drag blade it does a good job of removing most of the snow from the runway.

We find that a number of bases are reticent to use the airblast sweeper because they find that it just polishes the ice, but, as I described, the underbelly drag blade is the key to the whole thing.

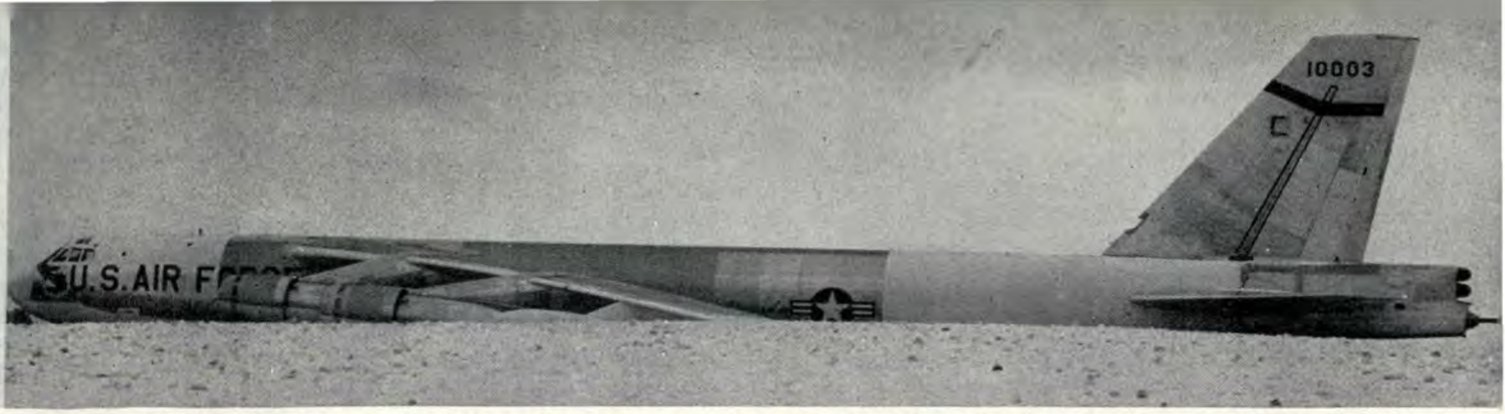
Two years ago we had very few cases of freezing rain or thin ice on the runway. Last year we were plagued with one freezing rainstorm after another, resulting in glaze ice on the runway which produced a runway condition reading of approximately 2 to 4 on the decelerometer. Our first attempt to improve traction was by the use of sand. The sand improved the braking action to about 10 or 11 on the decelerometer, but we found that the sand got into the struts and fairing doors on the F-106s and B-52s and was very difficult to get off. It also caused abrasions on the metal.

On the surface it would appear that sand would be easy to remove, but picture a B-52 that takes off on a sandy runway and goes 2000 miles and returns to the same base where the temperature is below zero. There is no possible way that you can wash that sand off. We can't put it in the garage, so to speak, and rinse the sand off because we do not have that capability out on the ramp at 20 degrees below zero. So, for maintenance reasons, we discontinued the use of sand.

Our next move then was to look into the possibility of using de-icer fluid. We had quite a bit of de-icer fluid available at our base (the type no longer used for aircraft) and we rigged a 5000-gallon tank truck with a spray bar behind. The spray bar is about 10 feet wide and when we get a glazed ice situation we run

The snow removal crews must be available at any hour.

Center drag blades are followed by the airblast sweeper.



Keeping first line aircraft ready for flight and runways open is a job that takes planning, equipment and know-how.

the spray tanker with about a 70 (water) 30 (alcohol) solution. We spray four strips down the center—four widths of the spray bar—for the first 3000 feet on the takeoff end and four widths down at the far end of the runway and then run back up the center with what we've got left in the truck. We found that 1000 gallons will effectively clean off about a 100-foot wide strip down the center of the runway. When conditions are just about right we go over this area, loosening the snow and ice with the drag blades, as I described before, and the airblast sweeper will sweep this off to the side and gradually widen the area down the center where there is no ice. Many times we've had conditions of 15-20 degrees below zero with a wet runway and we get a runway condition reading of WR 18 or 20 or even 24 even though the temperature is many degrees below freezing. When the airplanes start using the runway they tend to blast the water off and then we run the Sicard Airblast Sweeper over it. We are thus able to gradually dry the runway. If we get just a little bit of sun through the clouds, we've got a dry runway.

If you'll check the records you'll find that Kincheloe consistently has a better runway condition than most northern bases.

Of course, there are times when all the snow plows in the world are not going to get ahead of a heavy snowfall. Then you just have to sit tight and take your flight delays. When it stops snowing and the plows can get caught up, it's a matter of a couple of hours until we have a usable runway.

Another key to the whole thing is that somebody in operations has to monitor the snow removal because the snow plow operators are essentially truck drivers—knowledgeable people, but they don't understand aircraft operations. The Base Operations Officer logically should monitor snow removal and every time there is a remote possibility of a change in runway condition he should take a look at it and check it with his decelerometer. If he determines that the runway has sufficient ice to make operations unsafe, he should take action to get the underbody drag blades and the airblast sweeper to operate and get snow off the center of the runway.

Frequent, careful checking during periods of bad weather and coordinating a snow removal effort will get you ahead in the snow removal game. There are times when we would like to fly but we find that we must stop in order to get the runway safe for flying. In other words if we go ahead and fly and let our snow equipment idle at the end of the runway, we are doing nothing but wasting fuel and paying drivers to sit in a truck. Somebody, probably the Base Operations Officer, should make a decision to hold some aircraft in the air or on the ground and give the snow removal people that extra 30 minutes they need to get the runway cleared off enough to make it safe.

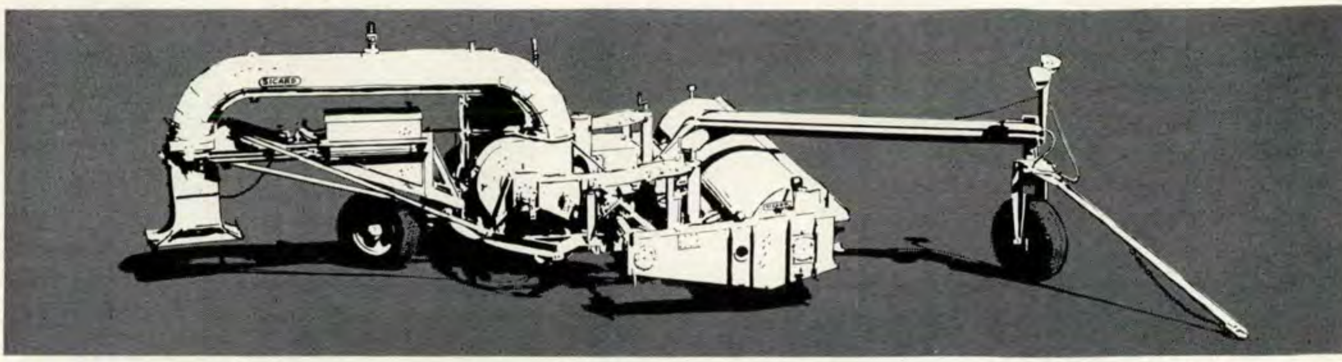
One problem with the Sicard Airblast Sweeper is that some of the snow thrown into the air falls back in the machinery. Occasionally, stops have to be made to clean snow out of the generators and other components.

We have attempted to operate these sweepers in such a manner that the snow will not be blown back into the sweeper itself, but found this impractical because you must start at the center of the runway and work to the sides.

With the crown of the runway higher in the center, any snow removal operation will be better if you start from the center and work to the side. A hazard in operating these drag blades is that centerline and narrow gauge lighting will be damaged by the blades. This we have come to accept because the lightweight pot metal of the centerline and narrow gauge lighting will break when a drag blade is run over it. The solution is centerline lighting that will take the pounding of the drag blades during winter snow removal operations.

Another problem in connection with snow removal is that low visibility during a heavy snow makes it difficult for snow plow operators to see where they are going, and many times they will run over the BAK 6 or BAK 9 arrestor barrier cables. We solved this by stapling pieces of light weight reflective cloth to the cable. The lights of the truck will shine on this and

Spray tanker is used for applying de-icer fluid at Kincheloe.



Above is the Sicard Airblast Sweeper, an item of specialized snow removal equipment used at Kincheloe AFB in winter.

the driver will see and turn prior to engaging the cable.

We've heard some rumors that the deicer fluid will seep through the runway and cause heaving and cracking, also severe flaking of the concrete on the surface. So far, we have had no indication of this. We've experienced normal wear and tear on the runway, what you would expect from the drag blades and use by aircraft. Drag blades will wear out rather rapidly when you use them as much as we do. The only thing you can do is go ahead and accept the expense of replacement of drag blades for the sake of getting a clear runway.

Another item in connection with drag blades and snow plows in general is that when used constantly, nuts, bolts, pins and various other items fall off. The driver won't notice—so now you have an FOD problem. We ask everyone who has reason to go out on the runways or taxiways to watch carefully for foreign objects, and to pick them up.

We also use an electro-magnetic sweeper about once every week or ten days to pick up the pieces of nuts, bolts and steel that fall off the snow removal equipment.

IN SUMMARY

The significant thing is to insist that operations and civil engineering personnel watch the runways carefully. When about half an inch of snow has fallen, start clearing it off; this way it won't get ahead of you very often. Use the roll-over blades in the front of the snow plows until the snow stops; then use the drag blades to get that layer of snow off the runway. Finally, sweep it off with a Sicard Airblast Sweeper. I think the most significant aspect of our actual removal program is the use of this sweeper, coupled with the drag blades of the snow plows, along with the use of the de-icer fluid, of course. De-icer fluid can get expensive, but when you thin it down 70/30, the cost drops. Sometimes you have to face the fact that if you're going to fly and you want to fly safely, it's a case of using a de-icer fluid and accepting the expense. In connection with the use of de-icer we have found that once we get the center cleaned off, 100-200 feet wide, it will last for days—until the next snowstorm. At times our runway has been clean and we've recovered too many airplanes for our parking capability, and other bases are not getting much traffic because they have bad runway braking action. We'd like to sell our procedures for the sole purpose of cutting down the parking problem at our base.

We check our runway the first thing in the morning, several times during the day, just after dark, around midnight, at 4:30 AM, about 6 AM, then start all over again. We do this because we find that conditions can change from icy to good in 20 minutes with a change in the temperature. It can also change from a good runway to a bad one in 10 minutes. If we don't make frequent checks we can expect to have an airplane in the barrier or off the end.

A lot of credit must be given to our roads and ground supervisor. He's been in the business for a number of years and trains our snow removal people.

One other recommendation: if any tests are to be run on snow removal equipment, these tests should be at an air base where airplanes are flying and not some place where there's just snow. Airplanes and vehicles on the runways and taxiways add mightily to the problem. And if you run any tests they should be at a place where they have the same conditions as where you are going to use the equipment; and if any one has equipment that looks good, bring it over—we'd be glad to try it out at our field. ☆

When the job is done right, safe winter operations result.

CAT AGAIN

CAT is back with fangs bared and claws outstretched, ready to slash the first intruder. Last winter it struck twice with devastating effectiveness. In each case a B-52 was the victim. Fortunately, there were several survivors to relate the details and enable the investigators to determine the cause of the accidents.

CAT (clear air turbulence) strikes both high and low. One B-52 was at 38,000 feet when the turbulence was first encountered. The violent jolt, in a mountain wave on the eastern side of the mountains, was the one that started the chain of events that resulted in structural breakup.

In the other case, the aircraft was on a low altitude training sortie when the mountain wave was encountered and structural breakup followed.

In both cases the pilots followed the prescribed flight manual procedures to get out of the area of severe turbulence, but to no avail, the damage had been done.

For years various guidance has been written on how best to avoid or get out of clear air turbulence once it is entered. Air Weather Service has conducted exhaustive studies on how to plot and predict such phenomena and is continuing its efforts in this area to provide better service to flight personnel.

The big question presented to the pilot is which way to go when he suddenly finds his lower bridgework bouncing off the canopy.

One recommendation is "slow down." Applying control forces to alter the course of the aircraft, at the same time that turbulence is being encountered, may just provide the last straw. The consensus is that, if course is to be altered, control movements must be gingerly made.

The most serious effect of CAT is, of course, structural breakup of aircraft. This happened to the aforementioned B-52s, an airliner over Indiana in 1960 and a C-47 over Montana in 1962. Lesser cases have resulted in compressor stalls, flameouts and injury to occupants.

In an effort to find a solution to this operational problem, Air Weather Service established a unit whose sole job was to forecast CAT. On 1 November 1961, the first daily CAT forecast was sent over the AWS teletype network. Starting 1 January 1962 CAT forecasts were made twice daily. The purple, greasepenciled CAT boxes over the outline surface map have become a familiar sight in local base weather stations.

How good are these forecasts? During the period from 1 December 1962 through 30 April 1963, a total of 8533 moderate or greater CAT reports were received for altitudes between 16,000 and 56,000 feet. Of these, 46 per cent were within forecast CAT zones (5 per cent of the 16,000- to 56,000-foot airspace).

The fact that many CAT reports come from areas outside the forecast zones indicates that there is much progress yet to be made in forecasting CAT. There may have to be adjustment in present thinking that turbulence intensity is greatest in the 30,000-foot area. U-2 pilots have reported turbulence above 60,000 feet, and X-15 pilots at 80,000 and above.

REVIEW

Turbulence stems primarily from convective currents or thunderstorms, mountain waves and wind shear. The latter two are the primary causes of clear air turbulence, which accounts for 75 per cent of all turbulence above 15,000 feet.

Turbulence is simply small-scale irregularities found within generally uniform air flow. These eddies exist and move in both the horizontal and vertical. They are similar to irregularities noticeable in rivers or streams,

CAT AGAIN continued

or about a stream of water flowing from a hose into quiet water.

Irregularities of wind flow vary in size, which accounts for the difference in aircraft reaction to them. The size and weight of the aircraft, the area and shape of the wing, the airspeed and similar factors all have a bearing on roughness experienced by an aircraft.

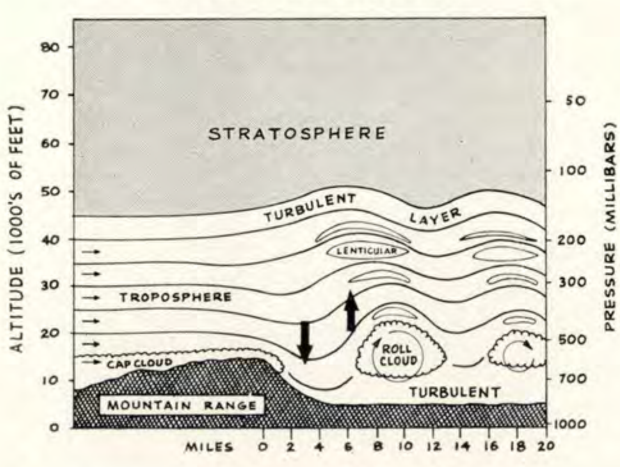
Most frequently CAT is associated with the mountain wave and jet stream. However, it can also be associated with a closed low aloft, a sharp trough aloft and an advancing cirrus shield.

MOUNTAIN WAVE

As the name implies, mountain wave turbulence occurs in mountainous areas and is associated with the wave formed by wind flowing over mountains. The wave occurs on the lee side of mountains when the wind flow component is perpendicular to the ridge line. It does not move as other systems do, but appears and disappears over the same range. The stronger the winds at the ridge level and the greater the vertical extent of the mountain range, the more intense the turbulence. A distinguishing feature of mountain wave CAT is the lens-shaped lenticular clouds below the turbulent layer.

Generally speaking, there are two types of turbulent layers associated with the mountain wave. The lower level turbulence is associated with the rotor clouds which exist on the lee side. This is not considered CAT; however, the higher level turbulence is in the CAT family. It averages about 5000 feet in thickness and is usually above the lenticular clouds. This turbulence can extend as much as 300 miles down wind from the mountain ridge.

Mountain Wave Turbulence

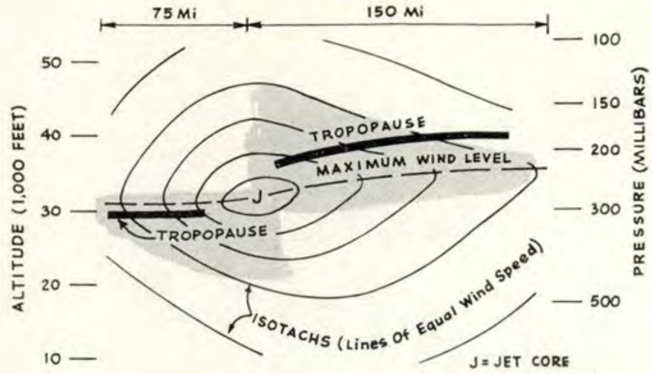


JET STREAM

Usually there are no tell-tale clouds by which to identify turbulence associated with the jet stream. Other forecasting problems are: turbulence may or

Jet Stream Turbulence

LOOKING DOWNSTREAM



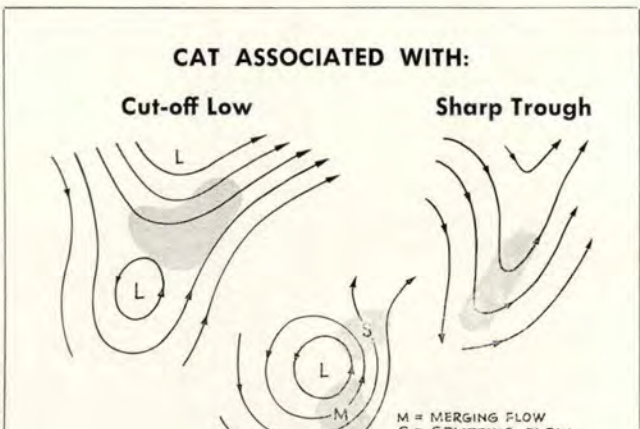
may not be present, areas of turbulence may change in intensity, maximum wind currents are not necessarily continuous and may merge or split into two or more currents and many wind maxima may occur on a given day. CAT increases with increased wind shear along either the horizontal or vertical plane.

OTHER CAUSES

A sharp trough aloft, especially one moving at more than 20 knots, may have turbulence in or near the trough line. Wind speeds may be rather low, compared with the speeds near the jet stream, but the winds on opposite sides of the trough may have 90 degrees or more difference in their direction. This may occur with no appreciable vertical shear.

Circulation around a closed low aloft may be accompanied by CAT. If the flow is merging or splitting, moderate or severe CAT can be encountered.

Also, to the northeast of a cut-off low aloft, significant CAT can be experienced.



COMBINATIONS

Any one of the above situations can produce moderate to severe clear air turbulence. However, the combination of any two or more of the conditions is almost certain to produce severe or even extreme CAT. A jet stream may be combined with a mountain wave, or be associated with merging or splitting flow. The 300-mb chart for 0000Z, 20 January 1961, just a little more than an hour prior to a B-52 crash in southeastern Utah, shows the merging flow of two jet streams which no doubt was associated with mountain waves in the area. The combination of these conditions undoubtedly resulted in the severe to extreme clear air turbulence which this B-52 encountered.

WHAT'S AHEAD

As stated initially, the consensus now is to avoid CAT forecast areas and, if CAT is encountered, slow down. Currently, there are no known sensors to detect CAT ahead of time, although there is considerable research being done on this problem. Large changes in windspeed (Doppler equipment helps identify here) and temperature are significant indications that the aircraft is approaching a potential CAT area. Pilot reports of CAT, as well as of negative CAT in CAT forecast areas, are a continuing requirement. (See Flip, En route Supplement, for reporting procedures.) Turbulence intensity is now measured by airspeed fluctuations: five to 15 knots for light, 15 to 25 knots for moderate, more than 25 knots for severe and rapid fluctuations in excess of 25 knots for extreme (Aerospace Safety, October 1962). However, recent experience in which structural aircraft damage occurred has shown that airspeed fluctuations are not as great in CAT as in convective turbulence from which these fluctuation values were derived.

RECOMMENDATIONS

Avoid areas where severe CAT is forecast. On occasion, jet stream CAT will occur in or near cirrus clouds. Near the jet core the cirrus is in definite isolated bands, while a little distance away they are banded within a shield of cirrus clouds. Avoid flight through such areas. Be suspicious of approaching shear when changes occur in free air temperature, true airspeed and ground speed. Slow down when clues first become apparent. It may require two to three minutes to slow from 300 indicated to recommended turbulent air penetration speed clean configuration.

In regard to mountain wave flying, suggestions made several years ago still apply:

Fly around the area; if not possible, cross at an altitude at least 50 per cent higher than the height of the mountain range.

Do not fly high speed aircraft into the wave, particularly downwind.

Avoid the rotor (roll) cloud and the foehnwall (cap) cloud.

Avoid high lenticular clouds if edges are very ragged and irregular.

Turbulence Intensities

	DESCRIPTION
LIGHT	• Seat belts may be required • Objects remain at rest
MODERATE	• Seat belts required • Occasional tension on seat belt • Unsecured objects move about
SEVERE	• Aircraft momentarily out of control • Much tension on seat belt • Unsecured objects tossed about
EXTREME	• Aircraft tossed violently • Almost impossible to control • May cause structural damage

Inflight CAT Reports
(PIREPS)

1. Location	Over Columbus
2. Time, ZED	2005Z
3. Phenomenon encountered	Moderate turbulence
4. Altitude	31,000
5. Aircraft type	C-135
6. In or out of cloud	In cirrus clouds
7. Indicated airspeed fluctuation	IAS fluctuation 22
8. Other	Temperature increase 7 deg C in 50 miles

Do not place much confidence in pressure altimeter readings near mountain peaks.

Avoid penetrating a strong mountain wave on instruments.

If necessary, updraft areas, especially the one in front of the rotor cloud, may be used as an aid in gaining the altitude necessary to pass through the downdraft and cross the mountain range. ☆

Credit: Information in this article was adapted, primarily, from a presentation made last February by Dr. Robert D. Fletcher, *AWS*.

Hey, Sarge, you won't believe this, but there's a fella here reporting CAT over the Rockies.

An aero club pilot flew a T-34 aircraft solo to a field near his parents' home. After spending the weekend there, he took off VFR, telling the airport manager he would file a clearance in the air. The weather was 700 feet overcast with light rain. A short time after takeoff, he was observed doing low level acrobatics near a college and a high school. Witnesses state the aircraft completed a series of loops. During pullout on the fourth loop, the aircraft struck some trees and crashed. The pilot was killed. Because of repeated accidents of this type, the future of the program is jeopardized, and Hq USAF is taking . . .

A HARD LOOK AT AERO CLUBS

"Aero clubs continue to experience a serious number of accidents and fatalities which reflect a need for a more aggressive flying safety program."

So said the experts during a seminar on aero clubs at the Fourth USAF Safety Congress. Although there has been some improvement in their safety record during the past couple of years, the aero clubs still have enough accidents with attendant fatalities to cause serious concern.

What is the aero club safety record? What has been done to improve it? What can the members and Air Force personnel responsible for the clubs do to further improve their record? These are some of the questions this article will attempt to answer.

Within the Air Force is a smaller but nevertheless sizeable air force of 10,000 members in 146 aeroclubs who fly some 680 aircraft. Like its parent, this little air force is deployed around the world and operates in all climes and conditions. It has an Air Force, Command, and Base structure; each club has a complement of officers and a board of directors to control club activities and to handle club business. In addition, base commanders, by regulation, provide guidance and support at least to the extent of appointing a club advisor who acts as a liaison officer between the club and the commander.

With all of this it would seem that aero club flying would be an extremely safe operation with only a very few accidents and practically no fatalities. Unfortunately the contrary has been true and it's past the time when every club must take a good look at itself and perform any necessary housecleaning.

Some, those with a good safety record, may take offense at a general statement that the aero clubs have been less than desirable when it comes to safety. This article deals with the broad picture, however, so clubs with perfect safety records can relax—but not to the point of complacency.

In order to get a perspective, a look at the record is in order. Since the clubs were first organized in 1948 there have been 576 accidents with 111 fatalities. This year alone, through 15 August, there were 36 accidents with 10 deaths.

Air Force aero clubs began in 1948 as private organizations and the number grew rapidly in the ensuing years. Official recognition by the Secretary of the Air Force came in 1955. Growth continued and reached a peak from 1958 to 1961 when the high point was 175 clubs, 15,000 members and more than 800 aircraft. In 1961 there were also 139 accidents and 26 fatalities. Compare this with the approximately 75,000 general aviation aircraft (below 12,500 lbs), 4625 accidents and 761 fatalities. (The accident and fatality figures are actually less for aircraft comparable with those used by aero clubs, since they are for all types of aircraft and all kinds of flying activities.)

In 1960 a USAF Ad Hoc committee was appointed to evaluate the program and take necessary steps to improve things. As a result an eight point improvement program was developed. The eight points fell into the following three broad areas: Supervision and Management, Accident Prevention, and Financial Assistance. To provide information and guidance, AFM 34-14 was developed. It is an excellent manual and clubs patterning their operations on it have taken a big step toward a smooth operating club and a good safety record. Safety does not depend solely on manuals, however, good as they may be. Individuals, flesh and blood people, breathe life into pages of words and transform these ideas into efficient, workable, day-by-day operations. Nevertheless, AFM 34-14 is a good foundation and contains much of the guidance necessary to build a good aero club.

As a result of the emphasis placed on improving the aero club program some drastic things have happened. For one thing, there are not as many clubs as there used to be. This is the result of a more hard-nosed attitude toward the clubs and the lax way in which many of them were managed and operated. Clubs have been told, in effect, to shape up or close up. As a result some clubs have gone out of business. Others were in bad financial shape and were forced to dissolve. In general, poor management and lack of support have been the primary reasons for clubs folding, with insufficient potential membership following close behind.

Since 1961 the program has shown definite improvement. Air Force statistics reveal that eight commands had gone accident free this year, as of 15 August. Others had got by with one or two accidents.

Study of a summary of aero club accidents during 1961 and 1962, provided by the CAB, gives a pretty clear picture of the kinds of accidents aero clubs have been having and the reasons these accidents occur. As is the case with almost every other activity, nearly all of these accidents were not only preventable but easily preventable and the clubs had the means to prevent them.

Many of these mishaps resulted from bonehead thinking, some from outright negligence, others from poor maintenance practices, quite a few from poor supervision, and some from inexperience on the part of pilots.

In the bonehead category was the fellow who, while making a touch and go, pulled up the gear instead of the flaps. This is pretty hard to do on a T-34, the flap control being down beside the left side of the seat and the gear knob on the left side of the instrument panel some distance away. Besides the gear knob is round, like a wheel, while the flap handle is flat, like a flap.

There have been many gear up landings for various reasons, mainly because pilots simply forgot to lower the rollers. But in one case a persistent lad silenced the warning horn twice before sliding in sans gear.

"Loss of control during the landing roll." The cause has been repeated many times with results as expected: "the aircraft veered off the runway and nosed over;" "causing the aircraft to veer and groundloop;" "in a 14 knot crosswind the aircraft groundlooped and nosed over." Often wind was a factor, however not always a very strong wind. The indication given by these accidents is that aero clubs would do well to adhere to crosswind restrictions in AFR 34-14 and make sure each flyer understands and can cope with crosswind landings.

Poor maintenance has taken its toll. When a pilot attempted to correct a landing approach with additional power the engine failed to respond. The aircraft hit some wires and crashed. Investigation revealed that the lower spark plugs were wet with oil and compression was low on all cylinders. This was a case of dual, or possibly even triple, responsibility. Maintenance was the primary cause, but the pilot knew the engine would overload during a glide, and others undoubtedly had detected the condition of the engine.

Airplanes without fuel do not fly. Some pilots, however, refuse to believe this and have to learn the hard way. One pilot wiped out the nose gear during a forced landing caused by engine failure. The engine quit because there wasn't any gas left. This lad contended that he flew the aircraft, a Navion, two and one-half hours plus about 40 minutes ground time since refueling. The recording tachometer, however, showed 4.9 hours since refueling. The main and aux tanks were found empty, and when the main tank was fueled the engine operated normally.

A commercial pilot had the misfortune of having the right landing gear collapse under him while he was taxiing to takeoff position. The gear warning system had indicated unsafe during the previous flight and this fact had been noted on the flight scheduling board, the aircraft being posted as out of service. This pilot, a new member of the club, had checked the aircraft records and found no discrepancy but had not checked the scheduling board. Why the problem was not written up in the aircraft records is not known.

The real culprit in this case is one that has been repeated many times. It is simply poor management. Often new members—old ones too—fly aircraft, the condition of which they really know nothing about. It starts, it runs, it doesn't fall down, so it must be okay. Fate alone keeps them out of trouble—usually.

To prevent accidents from this cause clubs must make sure that pilots know the procedures and where to find, and record, information. There have been instances where members did not know where and how to schedule an airplane, where to get fuel, or even the status of the aircraft.

Some accidents and deaths have resulted from pilots flying beyond their own capabilities and that of the aircraft. Typical examples include flying into known weather conditions, buzzing and unauthorized acrobatics. If these types survive, their resignations should be demanded—not requested.

Aero club flyers quite naturally chafe at added regulations and restrictions. The way to prevent even more restrictions is through self discipline on the part of club members with both the backing and insistence of the base commander. Here are some tips from the Maxwell-Gunter AFB Aero Club program.

- Operate the club as a business.
- The financial aspect is a most important subject.
- With students the accent is always on safety before proficiency.
- The club cannot tolerate violations and drastic action is taken with repeat violators.
- Members must maintain proficiency and currency required by FAA, Air Force and club regulations.
- Flying safety presentations are included in the agenda of each quarterly membership meeting and in each monthly newsletter.
- Scheduling is well organized and fairly administered.
- Good maintenance is as important to flying safety as good pilot techniques.
- Member participation is extremely important.

These are some of the items Captain Eugene R. Mangham, president of the Maxwell-Gunter club, cites in an article titled "The Air Force Aero Club," in the October-November issue of the Flying Safety Officers Special Study Kit. Club officers should contact their base Flying Safety Officer to get a copy of the article.

At the safety congress participants agreed that improvement in the operation of the clubs is necessary for a safer flying program. The theme of the many recommendations coming out of the seminar was that commanders and safety officers should keep a closer eye on the clubs. Recommendations were that the clubs concentrate on safety and tighten up their requirements to ensure their members are proficient and current in the aircraft they fly, that there be more participation by Air Force safety officers in investigation of aero club accidents, and that copies of the accident reports be sent to the Directorate of Aerospace Safety at Norton AFB.

Increased attention on the part of safety officers armed with knowledge gained from thorough analysis of aero club accidents should be a big factor in preventing the kinds of accidents related in this article. The only result can be a better, safer aero club program that will do a better job of providing recreation and service to the members. ☆

CHECK THE MAN

Fred A. Munder, Directorate of Operations, Hq ACIC

There are many definitions of MAN—the dictionary lists a dozen or more—but how many of you have thought of MAN as being a small piece of paper which could save your life? That's right, a little red bordered piece generally about 4¾" x 10" and invariably associated with a USAF/USN FLIP En route product.

MAN—what a little word to represent a mouthful of aviation jargon — MILITARY AVIATION NOTICE. By definition in AFR 96-13, 8 Nov 58 (slightly obsolete, but being rewritten), Military Aviation Notices are lists of changes issued periodically and as required to correct Aeronautical Information Publications (AIP). In other words, a MAN is really a NOTAM that is sent through the mail rather than by teletype to correct FLIP En route charts and supplements between scheduled revisions.

MANs are no longer issued with any degree of regularity in the U.S. This is because the FLIP—U.S. is revised to coincide with FAA's Airway change schedule and because of the effectiveness of the CONUS NOTAM system. For these reasons, most of you throttle benders or thrust lever pushers in the U.S. have all but forgotten this important little jewel. However, in overseas areas, ACIC organizations receive aeronautical information changes on an irregular basis and USAF NOTAMs are not published for all areas covered by USAF/USN FLIPs. Thus, MANs are published frequently overseas. Actually, all USAF/USN FLIP areas of the world publish MANs on an "as required" basis.

MANs appear in a variety of shapes and forms, the 4¾" x 10" size being a general rule of thumb rather than an iron clad restriction. In fact, even the red border may be dispensed with as was the case last January when a MAN for the U.S. charts had to be produced on short notice to promulgate the new "Radar Beacon Procedures" for air traffic control purposes and in July when one was issued to cover Exercise SWIFT STRIKE III.

Corrections and changes that are readily adaptable to a textual format are stated as briefly, clearly and concisely as possible, using standard phraseology and stressing the actual change in information. On the other hand, drastic changes to an airway system are best handled through a graphic MAN—reprinting the changed portion of a chart, as was done in the Europe and North Africa area last March, or issuing a completely revised chart. In July, ACIC simply translated and reproduced two Venezuelan charts to depict the air traffic control structure changes within the Maiquetia FIR which became effective between regular issues of the C&SA FLIPs.

Now for a little riddle. When is a MAN not a MAN? Brace yourself! When it's a PCN. Here we have the classic example of a rose smelling just as sweet under a different name. PCN (Planning Change Notice) is just another name devised for a list of corrections or changes to Aeronautical Information Publications. (Recognize the phraseology?) This time the changes apply to the substitute route structures, Oil Burner routes, air traffic rules, regulations and other items contained within the various sections of FLIP Planning. PCNs are issued on a scheduled basis in some of the foreign areas for interim correction of sections, but primarily PCNs, like MANs, are issued on an *as required* basis for all FLIP areas of the world and for all sections of FLIP Planning.

Base Operations personnel (plus others who receive FLIPs): When you receive the 4 3/4" x 10" size MAN, the best policy is to fasten it inside the Supplement front cover for ready reference and so it won't get lost. Naturally, a chart type of notice is best kept with the chart package—even tape or glue it in place on the face of a chart if the MAN is so designed.

Last, but not least, PCNs with their pre-punched holes should be inserted in the front of the appropriate Planning Section. You tigers can locate and use this corrective information on the ground easier than when you are strapped to your office tiptoeing through the thunder bumpers or flat on your back at angels four zero. Save yourself some anxious moments up there in the blue by checking your Military Aviation Notices *before* you blast off. Make reviewing your MANs and PCNs a routine part of your preflight planning—like when you check the NOTAM Board in Base Ops, MAN. ☆

FAA ADVISORIES

Robert L. Terneuzen, FAA Liaison Officer, Directorate of Aerospace Safety

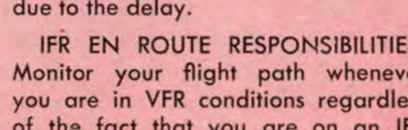
RADIO TECHNIQUE. Make your position reports clear and concise. Also, include your altitude in all initial airborne radio contacts.

Numerous pilots have poor microphone technique due mainly to poor planning. Decide what you want to say, then say it. Don't decide what it is you want to say as you transmit. Also, if a question arises relative to a clearance or request, ask the controller for clarification. Advise the controller of your predicament if his request will place your flight in jeopardy. Controllers may not understand the situation relative to your particular flight at the time of clearance change. Inform these people of your particular needs and every effort will be made to fulfill the request. Simple exchange of information would many times have eliminated the need for writing an Operational Hazard Report.

HIGH ALTITUDE CHANGE. Until recently civil jets were operating only as high as flight level 390 within jet advisory areas. A recent revision of the operations specifications however now permits civil jets within positive control areas up to and including flight level 410. The resulting dual ceiling for these aircraft complicates flight planning; however, few if any jet advisory areas will remain in effect upon completion of the area positive control program which is expected sometime next year.

GROUND DELAYS AND CLEARANCE CHANGES. Trouble or delays at the end of the runway prior to departure will many times cause consternation after takeoff. A difficult canopy latch, cockpit light, or faulty radio that delays your IFR departure may be the reason for the controller advising you that he has an amendment to your clearance, just as you are retracting the landing gear. If before takeoff delays are encountered, ask the tower controller if departure control is anticipating the delivery of a new or amended clearance due to the delay.

IFR EN ROUTE RESPONSIBILITIES. Monitor your flight path whenever you are in VFR conditions regardless of the fact that you are on an IFR clearance. ATC does not protect your flight from *all* traffic — both VFR and IFR. The controller attempts to advise the pilot of unidentified traffic when his workload permits; however, aside from this, there are many times when traffic will not appear on his radar scope. Keep a sharp lookout for other aircraft whenever you are in VFR conditions! ☆



WHY, SID?

AFR 55-106A, dated 3 May 1963, states: "Pilots may file an IFR flight plan without indicating a SID when there is no published SID for the intended route and use of existing SIDs would cause considerable deviation from intended route."

Now at first blush this addition to the regulation might indicate that things have finally taken a turn for the best and that there will be less ground and flight delay. Let it be known here and now that in most cases all Air Force bases considered the poor southbound pilot when they developed the northbound (with reverse) SID. The problem is not with the base or FAA but rather with the airway structure. It's not always possible to proceed in the departure direction planned, simply because it's the shortest way on the chart. Airways usually have en route aircraft moving to and fro which makes departure climbs rather difficult. This is why USAF/FAA developed SIDs that will provide a climb route for departing aircraft that will not interfere with en route traffic.

Now comes AFR 55-106A, which states that if there is no SID designed to allow departure in a planned direction, the heck with it, just file your DD-175 via airways. This is fine provided there is no other en route traffic already on the airway that could prevent you from climbing. If there is, then the ARTC controller will be obliged to delay your flight until the overhead traffic is no longer a factor, or provide an approved alternate departure procedure that will route the flight to avoid the traffic.

SIDs were specifically designed to avoid delays—get you in the air and on your way via a route that would be relatively easy to follow.

Seems to me that it would be a lot simpler to file a SID, even if it takes you off in the opposite direction from your en route course, and then indicate in the remarks section your desire to proceed on course via radar vector, if available. *All* FAA radar controllers will shortcut your SID flight path if at all possible.

Another point, if Base Operations people would sit down with local FAA controllers they might be able to simplify some of the present SIDs. Pilots can help too, when they discover a discrepancy, by reporting it on ACIC Form 0-150. These forms should be available in every Base Operations. ☆

IF YOU CAN WALK AWAY FROM IT... IT'S A GOOD ONE

Ralph Lesley, Republic Aviation Corporation

Not too long ago, when airplanes were fewer and emergency landings more frequent, a popular saying was: "If you can walk away from it, it's a good landing." After all, if you went up on your nose in the corn stubble and busted a prop, it was a lot better than washing out the airplane and getting hurt. All you needed to continue your pilot career was a new prop and a little indulgence on the part of the farmer whose field was so handy.

Today, things are different. Planes are too hot to put down in a convenient corn field or cow pasture and emergency situations don't always allow you a chance to bring the plane home. There comes a time when you gotta get out, and you'll need help because stepping over the side in a breeze of 300 knots plus, isn't easy. That's why we have ejection seats.

A lot of problems had to be licked before we got seats to get up and go, clear the tail and hold together long enough for the pilot to get out and ride the silk the rest of the way down. But those aren't the only problems. When the pilot gets kicked out of the protective form-fitting cockpit, he has to wrestle the breeze and that's a tough match. The higher the speed the tougher the fight. That breeze is built solid and it comes at you right now. It fights dirty. It wants to tear off your helmet, peel off your clothes, put your arms in a double hammer lock, apply toe holds to both feet and spread-eagle you—while applying blows to the head and body.

In that kind of fight a fellow can get hurt—even a Tiger! That's why slide-rule types had to burn a lot of midnight kilowatts to put devices on the ejection seat that will bring the Tiger back in one piece. The head rest will work okay if you remember to put your head back against it before you go. Armrests and hand grips are effective if you hold on tight. Your feet and legs present a problem. You can't hang on to anything with your feet. Curved toes won't help. We civilized types wear boots when we fly. You need something to protect your legs and feet so you can survive after ejection. The chopper may not get to you right away and in Arctic or desert regions a dislocated hip or wrenched knee won't add a thing to your chances for survival.

So it seems we have come full cycle, and now the old saying can be brought up to date: "If you can walk away from it, it's a good ejection." That brings us to the meat of the discussion of leg restraint—or limb restraint if you want to get fussy.

There are many forms of limb restraint devices. They may use hydraulic actuators, ballistic components, mechanical linkages, webbing, special boots or other equipment. The basic idea is the same in all: protect the pilot's limbs from flailing during ejection; keep them protected until he leaves the ejection seat; then release them when the danger is past.

Let's take a look at one of the best systems devised up to now for leg restraint. It's simple and rugged and requires no special training on the part of the pilot. That's the system installed in the Republic F-105D Thunderchief parked over there. You get into the cockpit and I'll stand on the ladder and explain it to you.

As you got into the cockpit you noticed that the survival kit installed in the seat pan has two nylon cords or lanyards suspended from it to the floor. The lanyards pass through two snubber blocks which are attached to the front of the kit. These snubbers allow the lanyards to pass through in one direction but lock up if there is any pull in the opposite direction. Now look at the ends of the lanyards. The lower end has a steel fitting with a shear pin inserted in it. The end coming up from the snubber has a rectangular steel ring which fits onto the swivel link of the automatic lap belt. If you lean forward you can see two brackets attached to the cockpit floor just in front of the seat. These receive the two lower ends of the leg restraint lanyards and are fastened to them by means of the shear pins when the kit is installed.

Now let's hook up. You're going to need a pair of garters. That's right, garters. A simple nylon strap that fits around your leg between the calf and the knee. Each garter has a D-ring on the inboard side. There's no discomfort. First you take the free end of the lanyard from the left snubber and pass it up through the D-ring of your right garter. You notice there is plenty of clearance for the ring to pass through. Then you pass the free end of the lanyard from the right snubber up through the D-ring of your left garter. That's all. A simple crossover. Now you're ready to buckle your safety belt.

In case you haven't used this type restraint before, here's the rundown on how to fasten it. First you put the right shoulder harness loop on the safety belt swivel link, then the steel ring of the leg restraint lanyard from the right garter, next the ring of the lanyard from your left garter followed by the loop from your left shoulder harness. Top it off with the anchor from your parachute lanyard. Now lock up your belt. Simple.

How does it work? Well, if you should ever have to eject, it goes like this: As the ejection seat rides up the rail the slack is pulled out of the leg restraint lanyards; your feet come off the rudder pedals and are pulled back toward the seat; as the lanyards tighten, your knees are brought together and are held in place by the snubbers acting on the lanyards. The seat has a perforated plate which is folded under when it is in the cockpit. When the seat rises, the plate snaps into position like an apron at the front. Your legs are supported from behind by this plate so they won't tuck under the seat when the breeze hits them. So now your legs are restrained fore and aft and laterally. As soon as the pull on the lanyards exceeds the shear strength of the pins, these pins fail and you are on your way out. The lanyards are proof loaded way above pin strength so you can rest assured the pins will let go.

When the automatic safety belt turns you loose, the shoulder harness loops and the rings from the leg restraint lanyards slide off the swivel link and you're as free as a bird. Sometime after the chute blossoms and well before you near the ground, you pull the release handle on the survival kit. The kit falls away, the lanyards slide easily through the D-rings of your garters and your legs are unrestrained.

Come what may, you are in full possession of your physical being and sound of limb. You are in the best possible shape to *Walk Away From It.*

Of all the recorded cases of the use of the F-105 ejection seat, all but two ejections were successful. In both cases, ejection was too close to the ground for the chute to open. In no case on record did the limb restraint fail to operate on an ejection.

If you should want to evacuate the aircraft while on the ground all you have to do is release the safety belt manually and flip the release handle on the survival kit. The kit will disconnect from your chute harness, the leg restraint lanyards will fall away and slide through the D-rings on your garters and you can *Walk Away From It.*

There are a few improvements on the boards that will add to the reliability of the system, like a quick disconnect for the leg restraint in case you elect to ditch in the pond and want to take the survival kit with you as you step out. In any event, engineers are still burning the midnight kilowatts to make it easier for you to *Walk Away From It.* ☆

Aerobits

F-105—NO CIN AFTER TAKEOFF? If you should find yourself closed in with a completely inoperative CIN (Communication identification navigation) and Doppler System approximately 60 seconds after takeoff, or if your CIN PWR/IFF TACAN ILS placard on the master caution panel starts illuminating periodically, there is a very good possibility that normal operation can be regained by reducing the airspeed to below 275 knots CAS and extending the landing gear.

This is not a common occurrence but it has happened occasionally as a result of a malfunctioning modular cooling system. Inoperative ram air valves may cause the CIN caution light to illuminate periodically, accompanied by time-out of the Doppler System. Failure of the CIN ground protection circuit can also interrupt power to the CIN System and cause Doppler System time-out.

Republic Service News

THE SNAKE PIT. Shortly before penetration at Luke in his F-100, the pilot experienced a hot cockpit condition. During his penetration, cockpit hot, he felt what he thought was a grasshopper lodged under his helmet between his ear and the earphone pad. While attempting to continue his instrument approach and dislodge the unknown intruder he saw a snake, variety undetermined, crawl across his legs and disappear from view under his right leg. Somehow, in the words of the report, "through superior skill and cunning while he tried to dislodge an insect, cool the cockpit and expect a snake bite at any moment the remainder of the approach and the landing were relatively normal."

The hot cockpit was caused by failure of the cooling turbine. The resultant heat evidently caused the unusual amount of movement by the uninvited inhabitants. The snake was apparently transported to the aircraft in the pilot's helmet bag which had been left for several hours in the squadron area at his Florida base of departure. What the pilot thought to be the grasshopper in his ear phone area could very well have been the snake whose length was estimated as 15 inches. Presence of the snake was confirmed by maintenance personnel who briefly saw it, but were unable to capture, kill or identify it. Insect and rodent control completely fumigated the aircraft and the canopy was left closed for two days. An entomologist from Arizona State University asserted that the snake could not have lived through two days of such intense heat as the closed canopy would cause. The seat was then removed for further search—negative results. The seat was replaced and the pilot finally agreed to complete his ferry mission.

It is recommended that pilots flying through or stationed at high insect, rodent or reptile infested areas be especially cautious as to disposition of personal equipment during times of delay or RON; above ground, always, helmet bags zipped.

PERSONAL LOCATOR BEACONS. In answer to many inquiries from the field, here is the latest info on personal locator beacons. The Air Force has purchased 500 off-the-shelf beacons for high priority projects. These are commercial items and are not to be confused with the new URT-21.

The URT-21 Personal Locator Beacon is to be purchased during 1964 in quantity for use throughout the Air Force. It is to be a fully automatic beacon that will start beeping when the parachute opens. It can be disconnected for combat operations or shut off manually to conserve battery life should the user desire. Transmission is on 243 megacycles to be compatible with the UHF homing devices currently in use in Air Force aircraft. The URT-21 will be the standard locator beacon for Air Force-wide use.

In order to extend signal output and battery life the URT-21 has no voice capability. If you're the talkative type, you will have to carry the URC-11 or the newer URC-10 for two-way communication. In safety, we are interested mainly in *finding* you, not in carrying on a conversation, at least until you're rescued!

Incidentally, PACAF, Alaskan Air Command and USAFE purchased the Search and Rescue, Automatic Homing (SARAH) Beacon and have been using it as a locator beacon for some time. The URT-21 is not to be confused with SARAH.

Maj William R. Detrick
Directorate of Aerospace Safety

T-BIRD ENGINE OPERATION—The seeming absurdity imposed by Safety of Flight Supplement TO 1T-33A-SF-1-16, limiting T-Bird engine operation, has been bombarded from many quarters. Therefore, it appears advisable to explain Aerospace Safety's position concerning this matter.

Maximum stresses on the T-Bird will happen during acceleration at high RPM and during operation at 100 per cent rpm. So-o, for this particular engine, the avoidance of these areas of maximum stress is a guarantee of longer engine life. Commercial airlines have consistently gotten longer life from engines which have been proven through AF service. They accomplish this by de-rating (running at less power) and operating in a more suitable environment. Therefore, longer trouble free operation of the J33-A-35 engine can be had for the sacrifice of performance. Note though that TO 1T-33A-SF-1-16 is permissive. Reference paragraph 3 which states: "If mission requirements permit, etc. . ."

It is significant that from 1 January 1962 through 15 August 1962, five major accidents occurred that were associated with turbine bucket failure. For the same time in 1963 there has been one major accident associated with turbine bucket failure.

The old S-816 turbine buckets are being scrapped as fast as the new Waspaloy buckets can be made, shipped and installed. The get well date is January 1964. Living with TO 1T-33A-SF-1-16 until that time is a small price to pay for a reduction in major accidents.

Lt Col K. I. Bass
Directorate of Aerospace Safety

PETTY MURDER. Let's suppose. A fighter pilot comes face to face with a right-now, unlivable, inflight emergency. He pulls the handles, squeezes and initiates the nylon descent sequence.

Now, let's suppose a little further. Everything works. The canopy blows. The rockets fire and the seat is ejected. The lap belt initiator fires the belt. The man-seat separator snaps the pilot free. The chute deploys. Got it made!

No! The chute inflates, holds momentarily, then the left riser breaks. Half the shroud lines whip free. The canopy streams. It's attached to the pilot's harness by one side only. Rate of fall rapidly increases; almost terminal velocity of 125 miles per hour when the pilot—conscious and uninjured after having done everything right in his ejection sequence—slams into the ground.

What happened? Investigation disclosed that the left riser had been cut almost all the way through sometime prior to the ejection. Just a minute, back in the beginning we said let's suppose. This accident hasn't happened yet. But it could.

At one Air Force base a person, or persons, has been pilfering from parachutes (approximately 75) for the purpose of obtaining the small minimum survival kit with which the chutes are equipped. In some instances parachute packs have been slit over the kit. What for? No one knows for sure. There is little of value, a survival knife being the most expensive item.

It would be petty theft on the police docket.

There's an associated problem. In some cases the timer covers were pried off (timers may have been damaged) apparently under the mistaken impression there may be something of value inside.

Of one thing we are sure, if it isn't stopped it won't be petty theft. It will be murder.

GROUNDED AIRCRAFT—In the Aerobits section of the October issue is an item about an aircraft that was flown even though Maintenance found six damaged turbine buckets and placed it on a red cross.

The Transient Maintenance Officer at Hq AFSWC has a plan to prevent pilots from flying (inadvertently, of course) an aircraft that has been grounded. He requires that a red bordered, 8 x 10" placard (pictured here) be attached to the control stick or control column of the grounded aircraft. It isn't easy to ignore such a colorful placard, therefore if prominently displayed it should eliminate the possibility of a pilot's flying an aircraft that has been grounded. ☆

Col Carmel M. Shook, DCS/Materiel, AFSWC

missilanea

COMPOUNDING PROCEDURAL ERRORS. Six major procedural errors made by Air Force and civilian technicians resulted in hardware damage and an extra week of down time on a missile.

The errors began during sustainer engine system checkout when the hydraulic control package failed to open the head suppression valve. The approved remove and replace procedure was not followed, resulting in an improper recharge of a hydraulic accumulator. (Since tech data procedures were not used it was impossible to reconstruct exactly who did what and when.)

The second error occurred when a leak was discovered in the accumulator during pressure check. The crew replaced the faulty accumulator with one from a hydraulic control package that previously had been rejected during inspection. Using components from a rejected assembly is inviting more trouble.

The third error was in breaking into two sealed components in a working environment which was not dust-free and humidity controlled.

The fourth error occurred when, during this installation, the wrong size and type of O-ring was used. Subsequently, it failed and leaked. This led to more trouble as, during efforts to correct this leak, it was discovered that a one-eighth inch piece of this O-ring was missing. When it could not be found it became necessary to reject the entire hydraulic control package.

The fifth error occurred when the hydraulic package from another missile was cannibalized. Logistics could not supply another package so soon after the initial request.

The sixth error stemmed from rotating sustainer turbopump gears three times in four days and failing to represerve for six days. Maximum delay should have been 72 hours.

Adapted from a ROCKETDYNE Report.

HYDRAULIC FLUID INJECTION. The hydraulic bleed valves installed in HGM-16F (Atlas) silo are hazardous in that personnel can fall against the valves, causing them to unseat. This can result in the injection of hydraulic fluid under 3000 psi into the flesh. It was found that three types of bleed valves are used interchangeably. Part No. P19-424 is the most hazardous as it requires only a push to unseat the valve. Compliance with Technical Order 21-SM65F-692 published 3 June 1963 should eliminate this hazardous condition.

Have you checked your TOC status lately?

Maj Curtis N. Mozley, Directorate of Aerospace Safety

GOOD HOUSEKEEPING. Visits to several HGM-16F (Atlas) complexes indicate that many housekeeping tasks that contribute greatly to accident prevention are being neglected. Readily apparent are spic 'n span, freshly painted areas within the complex. The neat appearance is commendable. Unfortunately, a closer look sometimes reveals corrosive and hydrocarbon residue partially covered by paint.

During their visits to missile complexes, commanders, supervisors, and inspectors should check for evidence of corrosion or hydrocarbon leaks and spills.

One effective method of determining the housekeeping status of a complex is the Finger Test. Feel in the out-of-the-way places where you can't see. The area should be dry.

CAUTION: *Do not use Finger Test near high-pressure gas lines.*

Check for trapped fluids in structural steel channels, floor gratings over structural members, under partitions, and the under side of tanks and lines which are near the floor. If the Finger Test reveals fluids and moist or greasy dirt, stop the leak, clean the area and make sure the LOX system hasn't been contaminated.

Experience indicates that missile complexes with the most eye appeal are not necessarily the safest. Many fail to pass the Finger Test. Cleanliness and eye appeal are not synonymous in this case. Both are desirable; however, if resources do not permit, priority must be given to the housekeeping tasks that help prevent accidents. ☆

Lt Col Medford E. Hollis, Directorate of Aerospace Safety

WELL DONE

Captain Joseph Chiodo,

438 Ftr Intcp Sq, Kincheloe AFB, Mich

On 28 February 1963, Captain Joseph Chiodo, flying a combat readiness flight check in an F-106A, completed thorough checks of all the aircraft systems during climb. Prior to reaching 30,000 feet, the automatic flight control system assist mode, coupled with heading hold, had been selected, tested, and allowed to remain in control of the aircraft. Just before he reached 38,000 feet, Capt Chiodo noted slight oscillations in pitch. When he depressed the momentary interrupt switch (a normal procedure under the circumstances), the aircraft pitched down violently to a diving attitude of approximately 50 degrees, exerting approximately two negative Gs on the aircraft and pilot. A linkage bolt had fallen out. This allowed fore and aft control stick movement without any movement of the elevator function of the elevons.

Captain Chiodo evaluated this control problem and at the same time noted that the aircraft was now supersonic. He immediately reduced power to idle and simultaneously extended the speed brakes in an attempt to decelerate and determine if complete pitch control had been lost. Captain Chiodo detected the nose starting to rise so he added power and at the same time tried using nose-high elevator trim. He found he had slow but positive reaction to the trim. The aircraft then entered a nose-high attitude and reached approximately 45 degrees nose up before Captain Chiodo was able to start it back toward a level flight attitude by use of trim.

Having gained time to analyze and determine the seriousness of his situation, Captain Chiodo found that the only pitch control remaining was by use of the electrical elevator trim. He also knew that an approach to the runway would have to be made close to the ground for several miles and at speeds well in excess of 200 miles an hour. He further realized that any small mistake on his part, or electrical problem with the pitch trim, could leave him in a position where both safe ejection and landing would be impossible. His dilemma was heightened when he discovered that unconscious slight fore and aft control stick movements at times caused sudden and erratic pitch changes that had to be corrected with trim.

Captain Chiodo found that with landing gear and speed brakes extended, at an airspeed of 200 knots, he received the best and most positive reaction to trim. After satisfying himself that he could control the pitch attitude of the aircraft with trim, and control his descent with power, Captain Chiodo decided to attempt a landing. His letdown, approach, and landing were accomplished in a precise manner. Captain Chiodo's superb airmanship in coping with this emergency saved the Air Force and the United States a $3,500,000 Air Defense weapon and he deserves a Well Done. ☆

☆ U.S. GOVERNMENT PRINTING OFFICE: 1963 - 701-211/4