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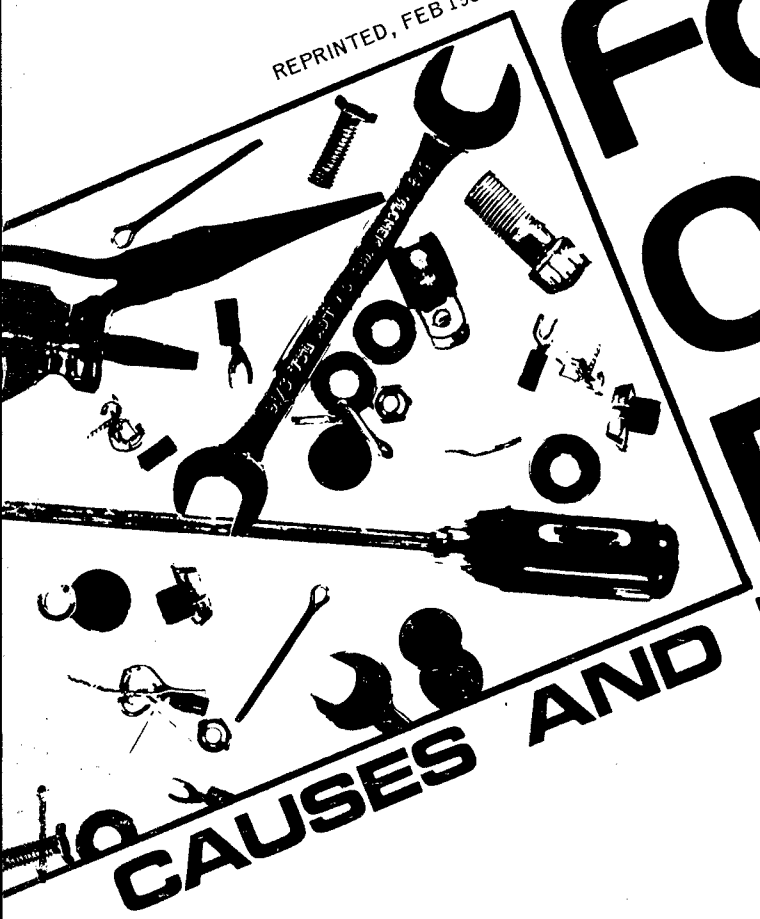


Foreign Object Damage

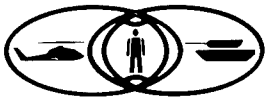
CAUSES AND PREVENTION

U.S. ARMY SAFETY CENTER

FOREIGN OBJECT DAMAGE: CAUSES AND PREVENTION

1 January 1970 through 31 December 1976

by
MSG Jerry E. Mills



PREFACE

This pamphlet was prepared to notify personnel of the damage that has been caused by foreign objects, to assist commanders, supervisors, and other individuals in preventing foreign object damage (FOD), and to provide suggested solutions to prevent FOD and subsequent aircraft mishaps.

The term "mishap" will be all inclusive in reference to all occurrences as classified in paragraphs 2-9b(1) through 2-9b(11), AR 385-40. Mishaps due to wire, tree, and stump strikes during nap-of-the-earth flights and bird strikes have not been included. Wood strikes, other than NOE, have been included when there was damage to the aircraft due to crew error or error on the part of ground guides.

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GENERAL

Certain information contained in this pamphlet was extracted from Army aircraft mishap data and from articles or reports of other military services. Also, information was used from U. S. Army/AVCO Lycoming T53 Reliability and Maintainability Evaluation Program Summary Report, November 1974. Due to variations in reporting procedures, all mishaps in which foreign objects were causes or contributing factors may not be included.

To define a foreign object or foreign object damage, a definition must be made that will include all possible combinations but not infringe on other aspects of analysis such as NOE mishaps and bird strikes.

Foreign object: Either a large or minute object that may or may not be common to a piece of equipment and when misplaced from its natural state or mismanaged by personnel could result in malfunction or damage to equipment and property or injury to personnel.

Contaminant: Minute particle(s) of foreign substance commonly associated with fuels, oils, hydraulic fluids, and their systems in both ground and aviation equipment which is considered a foreign object to the systems or fluids.

Foreign object damage: Any malfunction, damage, or destruction of equipment caused by contaminants or foreign objects.

FOD—a constant problem

Damage from foreign objects presents a problem, not only in dollars, but in unscheduled aircraft maintenance, premature removal and repair/overhaul of aircraft components, and possible injury to personnel.

During the period 1 January 1970 to 31 December 1976, foreign objects caused or contributed to 453 mishaps (table 1). Seventeen of these were ground, or

TABLE 1.—Number and Classification of FOD Mishaps

	Calendar Years							
Classification	70	71	72	73	74	75	76	Total
Total loss	8	3	1	0	0	0	0	12
Major accidents	9	7	0	0	0	0	2	18
Minor accidents	2	0	0	0	0	1	0	3
Incidents	22	17	18	17	14	31	46	165
Forced landings	11	1	9	1	3	11	7	43
Prec. landings	19	14	12	7	20	56	67	195
Subtotal	71	42	40	25	37	99	122	436
Other (ground)	1	1	1	4	3	1	6	17
Total	72	43	41	29	40	100	128	453

MOC, and are not included in the rate per flying hour totals.

The cost of FOD mishaps during the reporting period (table 2) was $5,384,587, 1.5 percent of the total cost of all mishaps in that period. This cost does not include components and/or man-hours required to replace,

TABLE 2.–Foreign Object Damage Mishap Rate per 100,000 Flight Hours*/Cost

Calendar Year	Rate	Cost (all FOD mishaps)
1970	1.11	$3,672,040
1971	.81	$810,942
1972	1.27	$185,386
1973	1.26	$270,799
1974	2.25	$26,593
1975	6.70	$101,986
1976	8.38	$316,841
	Total	$5,384,587

*Does not include "other" mishaps.

repair, or rebuild when the component failed or malfunctioned due to foreign objects and a successful forced landing was made.

There has been an upward trend in precautionary landings since 1973. The current percentage of precautionary landings is 54.9 percent of the total FOD mishaps (less "other") as opposed to 56.5 percent for 1975, and 26.7 percent for 1970. Incidents have increased the last 2 years. The incident rate for 1976 was 36.7 percent of the total mishaps.

Since 1973, there has been a steady increase in the FOD mishap rate, from 1.26 for 1973 to 8.38 for 1976. The lowest rate for this reporting period was 1971 with .81.

Foreign object damage to turbine engines has always been a major problem. Table 3 shows the type and

TABLE 3.–Engines With Foreign Object Damage Received at Overhaul Depots*

Type engine	Time frame	Number of engines received at depot	Number of engines with FOD	Percent with FOD
T53-L-11C/11D	1 Jan 68-31 Dec 69	227	69	30.4
T53-L-13/13A	1 Jan 68-31 Dec 70	11,086	2,934	26.4
T53-L-13B	1 Jan 73-30 Jan 74	1,193	253	21.2
T53-L-15	1 Jan 70-31 Jan 72	186	12	6.4
T53-L-11/11B	1 Jan 68-31 Dec 69	4,799	1,499	31.2
T53-L-701	1 Jan 71-31 Dec 73	69	6	8.7

*Time frames do not coincide with the 7-year period covered in this pamphlet.

number of engines received at depots during the indicated time frames. Of the total engines received for rebuild, 27.18 percent had FOD. From 1967 to 1972, 80 engines were involved in mishaps and sent in for teardown analysis. Any cost applied to engines for rebuild and return to the supply system would be an approximation, but based upon 1972 data, and the percent of rebuild needed, the cost to rebuild 4,773 engines was $33,755,610.

Types and areas of FOD

Just as the types of foreign objects vary, so do the areas of aircraft damage. No object or part of an aircraft is immune to misuse. Items were common to all Army geographical locations and all Army aircraft.

Hardware

In some cases, other contributing factors were present, but hardware initiated the emergency and any other action finalized the act. Sometimes the object was completely foreign to the piece of equipment that failed. In most cases, a thorough and complete inspection would have revealed the foreign object before the flight. FOD from hardware can be reduced, if not eliminated, if by-the-book maintenance and inspections are performed.

Selected briefs

• UH-1H total loss, 4 fatalities and $244,345 damage - Aircraft departed in known IMC. The crew had been in a hurry to get airborne. Aircraft crashed in a wooded area and burned. Numerous cause factors were present, but a major cause was the engine ingesting an AN525-10R machine screw at some time before impact.

• TH-55A MOC, $4,165 damage - Crewmember was running up aircraft for MOC after a PE. Clutch engagement was started, then stopped because blades started to move. Outside observer did not see anything wrong. Clutch switch activated and rotor went into quick engagement. Aircraft was shut down and excessive damage was noted to blades and dampers. Bolt had fallen into the "V" belt groove between the pulley and belt, reducing the amount of free play.

• UH-1C forced landing - Engine failed during flight. Caused by ingestion of Dzus fastener into compressor section. (figure 1)

FIGURE 1.–Damage to compressor blades caused by ingestion of Dzus fastener.

• UH-1H ground, $17,969 damage - After shutdown, crewmembers noticed smoke coming from transmission compartment. Burning material was found in lower aft avionics compartment. Pilot pulled the burning material out with his hands after two fire extinguishers failed to operate. A third extinguisher had to be used to

put the fire out. Fire was started by a piece of .032 safety wire which was lying across a terminal board at the ARC/102 radio mount. When power was applied, safety wire became hot and ignited aircraft technical manuals. In addition to the aircraft -20 and -34 TMs, an engine inlet cover, an engine exhaust cover, a length of nylon rope, and a rag (part of a sleeve) were found.

• UH-1H precautionary landing - Engine oil pressure dropped to zero and caution light came on. Oil pump shaft had been sheared by a small screw left in an oil line during installation.

• UH-1H incident, $438 damage - Aircraft was in stabilized hover during test flight when several loud bangs were heard and heavy feedback in controls and severe vibrations were felt. Hovering autorotation was executed, resulting in hard landing. Investigation revealed severe FOD. Imprints of the phillips head screw and threads and general imprint of Dzus fasteners left little doubt as to the type of foreign objects. (figures 2a and 2b)

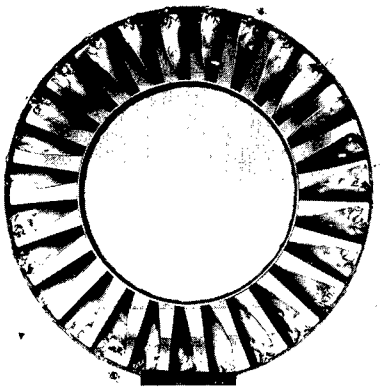


FIGURE 2a.–Damage to inlet guide vanes caused by Dzus fastener.

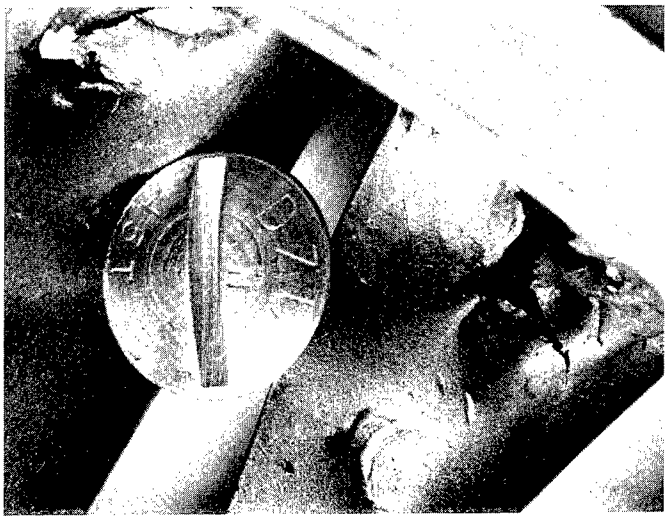
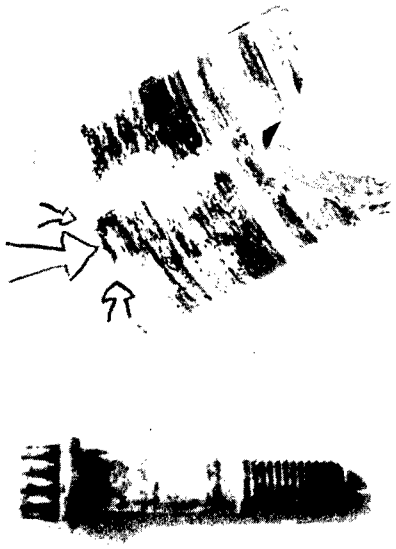


FIGURE 2b.–Closeup of damage.

FIGURE 3.–Compressor blades and rivet removed from engine.

• AH-1G total loss, 2 injuries and $471,630 damage - During final approach, high sink rate was encountered. There was no response to applied corrective action. Aircraft impacted twice and then became inverted in water. Investigation revealed engine malfunctioned due to FOD. The object could not be definitely identified, but it resembled a soft rivet. (figure 3)

• OH-6A major accident, $9,461 damage - Loud bang was heard, followed by partial loss of tail rotor control and severe high frequency vibrations. Pilot was advised his tail rotor had stopped. Running landing was made and skids hit some rocks hidden in the grass.



FIGURES 4a and 4b.–Bolt left in tail rotor drive shaft . . . caused drive shaft to shear.

Major damage resulted. Bolt left in tail rotor transition section caused tail rotor drive shaft to shear. (figures 4a and 4b)

• CH-47A total loss, 47 injuries and $990,717 damage - Aircraft was airlifting troops and had attained translational lift when rotor rpm began to deteriorate and continued to do so until aircraft settled into trees. Aft rotor blades separated from aircraft and flames erupted from right engine. Although there were other cause factors (aircraft was over max gross weight, for one), the right engine ingested an object similar to a cotter key in the air inlet, severely damaging inlet guide vanes and first stage compressor.

• OH-6A total loss, 3 injuries and $109,221 damage - Partial power loss occurred during takeoff. Autorotation was made and aircraft was checked. Another liftoff was made and power started to fail again. Emergency procedures were initiated, but the aircraft landed hard and rolled over four times. Engine malfunction was caused by ingestion of a screw of an unknown origin.

• UH-1H precautionary landing - Master caution light came on and engine oil pressure dropped to zero. Nut was lodged in oil inlet cavity. (figure 5)

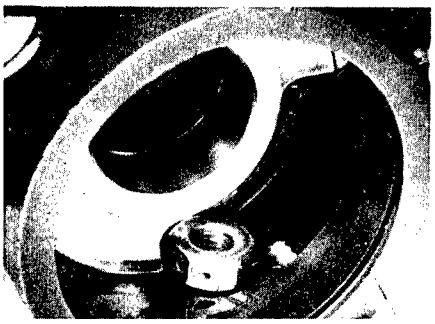


FIGURE 5.–Nut found in oil inlet cavity.

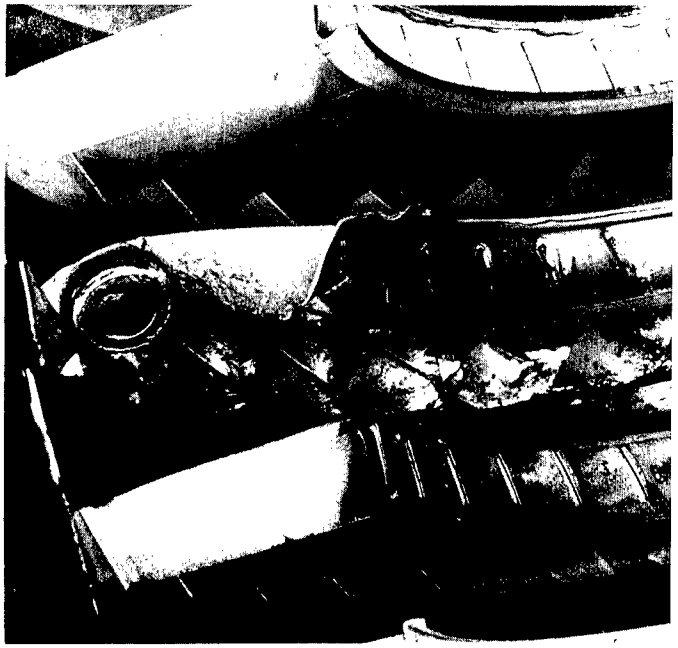


FIGURE 6a.–Washer ingested in stator vanes . . .

• CH-47A precautionary landing - Loud bang was heard and vibrations felt. Failed engine was secured and landing was made. Teardown analysis revealed a washer, used for drive shaft installation, was ingested. (figures 6a and 6b)

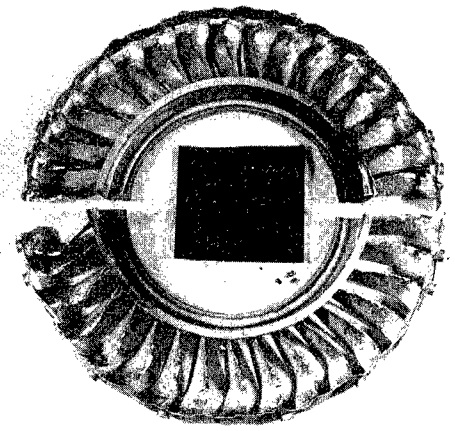


FIGURE 6b.—. . . caused damage to vane assembly.

• OV-1D incident, $2,000 damage - During night VFR landing, left entrance hatch blew open. Cotter pin had been jammed in gears of hatch locking mechanism, allowing gears to slip.

Runway/airfield

Policing of runways and airfields is just as important as positive tool control and maintenance/inspection procedures. Inspection and removal of loose objects on a routine basis would greatly reduce damage caused by items such as oil cans, engineer tape, and plastic sheeting. Figure 7 shows what was policed up during a safety survey of ramps and helipads where helicopters were in operation.

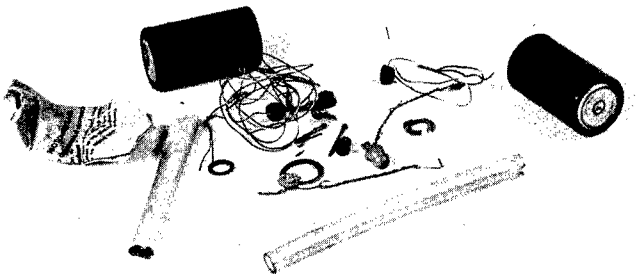


FIGURE 7.—During a safety survey of an airfield, these objects were policed up from the ramp and helipads where aircraft were in operation.

Selected briefs

• U-21A incident, $18,745 damage - During runup, propeller wash forced unknown foreign objects into propeller, damaging propeller.

• OV-1D incident, $18,745 damage - After takeoff roll, just after application of full power, rock struck one blade on No. 2 propeller. Aircraft speed was 50 knots. Fragments of rock entered right side of fuselage at seven points. One fragment entered through plexiglass

on right side, went through folded maps, and struck the TO. Pilot applied reverse thrust and stopped the aircraft without further mishap.

• U-21A incident, $3,080 damage - Aircraft was taxiing approximately 70 feet behind another aircraft on PSP taxiway when foreign objects from propeller blast struck No. 1 propeller blades.

• OH-58A incident, $182 damage - While OH-58 was at flight idle, another aircraft hovered onto adjacent pad for landing and blew 100-foot section of engineer tape into rotor system. Tape was in mast and around pitch change tubes. (figure 8)

FIGURE 8.–Hovering aircraft blew engineer tape into OH-58 rotor.

• CH-47A incident, $9,505 damage - While aircraft was landing on active runway, piece of plastic sheeting went through forward rotor blades, causing damage to one blade.

• UH-1H precautionary landing - During hover at airfield, piece of salvaged parachute canopy being used as equipment camouflage blew up into main rotor blades.

• YC-7A precautionary landing - During landing approach, right main gear dropped only about 10 inches. Emergency procedures were unsuccessful. During tower flyby, moderate turbulence was encountered and gear came down and locked. Striker pad on landing gear was bent by an object on the runway during takeoff, allowing door lock mechanism to jam.

• OH-58A minor accident, $3,454 damage - Pilot was practicing emergency procedures and making running landing when left skid struck broken fire hydrant. Skid was torn from aircraft.

Unsecured items

Unsecured items in cabins and ammo bays present serious problems. Raincoats and deflectors are among the major items causing the most severe damage, such as loss of tail rotor control. Compliance with published procedures would prevent mishaps of this type.

Selected briefs

- OH-58A incident, $192 damage - During flight, tactical map in plastic cover was blown out of the hands of the observer and out the left passenger door, ripping left FM homing antenna from aircraft.
- UH-1H incident, $783 damage - Crew heard noise during climbout and crew chief noted damage to vertical fin drive shaft cover. After shutdown, inspection revealed damage to tail rotor assembly and vertical fin drive shaft cover. Further investigation revealed that a piece of VIP carpeting was missing from aircraft.
- UH-1D incident, $72 damage - During maintenance test flight, aircraft started buffeting and nose fell into a 42-degree down attitude. Toolbox was left unsecured and when aircraft pitched forward, box was thrown, damaging honeycomb floor behind copilot's seat.
- AH-1G, OH-6A major accidents, $210,552 damage - During flight unsecured items blew out of ammo bay and passenger areas, hitting tail and causing tail rotor failure. (figures 9a, 9b, and 9c)

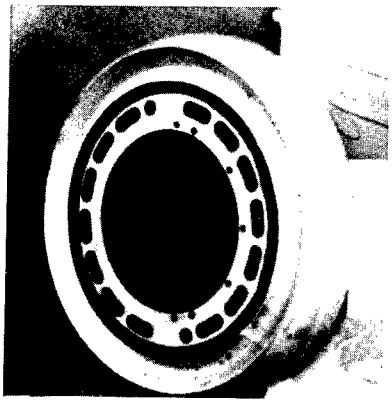


FIGURE 9a
Deflector assembly . . .

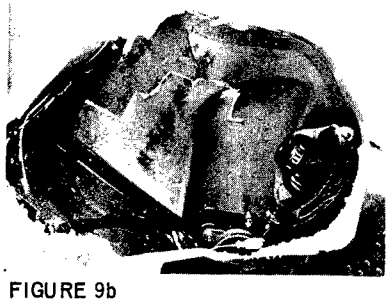


FIGURE 9b
caused tail rotor system to depart aircraft...

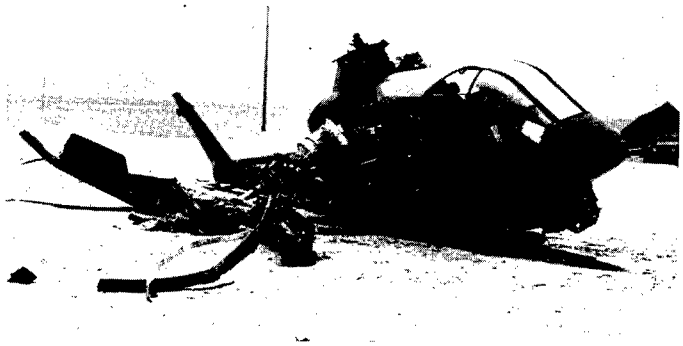


FIGURE 9c
and caused this.

Antennas

Both vehicle and individual backpack radio antennas have created problems with rotor blades. Ground personnel are walking into rotating blades with radio antennas in the upright position. Vehicle drivers are not securing antennas as they drive to the aircraft to deliver passengers or pick up items. It is not known whether the individuals involved had never had a briefing on procedures, or if they knew of the dangers involved and "just forgot."

Selected briefs

• UH-1H incident. $3,025 damage - Crew chief was cautioning passengers not to exit aircraft while blades were still turning. Passenger on opposite side of crew chief exited aircraft and raised an 8-foot Loran receiver antenna into the path of the main rotor blades, damaging one blade.

• OH-6A incident, $1,300 damage - Sedan with long antenna was driven too close to aircraft. One main rotor blade struck vehicle antenna.

• UH-1H incident, $3,697 damage - Ground guide approached aircraft just after it was landed. Before crew could stop the guide, a rotor blade struck PRC-77 antenna, puncturing blade.

• CH-47A incident, $14,500 damage - Truck was crossing under right front edge of rotor to recover a trailer. Antenna was jolted out of its securing clip, returned to upright position, and was struck by forward blade.

Contamination

Water and trash particles in fuel and fuel systems can cause accidents. Faulty refueling tankers and refueling personnel not complying with published procedures before refueling aircraft are main causes of water in fuel. Refueling vehicles are required to undergo daily and weekly inspections. From the amount of trash particles and water found in aircraft fuel systems, it appears these basic inspections are not being accomplished.

Some time ago, aircraft were brought to a maintenance facility to replace the existing fuel system with the crashworthy fuel system. As part of the routine induction, fuel samples were taken from each aircraft. Laboratory tests revealed particles of unknown substance. Since the fuel system modification was to be accomplished, the contaminated fuel was not a great concern. Defueling and purging of lines were routine. Since no contaminants were found in the lines, further investigation for the contaminant was in order. Inspection of the removed noncrashworthy fuel cells revealed numerous foreign objects. Figure 10 shows what was found in three separate fuel cells. It appears the rawhide mallet was left in the cell at initial installation. The 69 cents in change and the fuel nozzle cap (with the retainer cable) remain a mystery as to how they could have found their way into the cells. The money could have been lost upon installation or repair of the fuel cells and the nozzle cap during a refueling process. Numerous other items such as rivets, fuel nozzle strainer, etc., were also found.

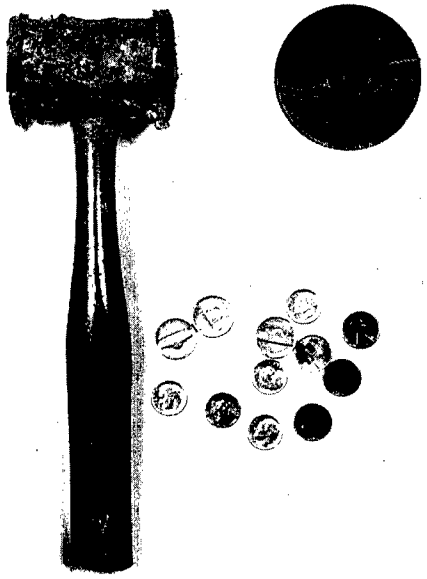


FIGURE 10.–Foreign objects found in fuel cells during modification process.

Figure 11 shows a metal shaving which was found in the inlet port of a fuel control, restricting fuel flow.

Selected briefs

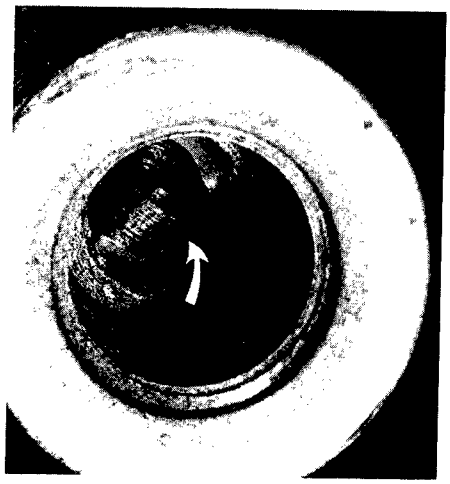


FIGURE 11.—Metal shaving found in inlet port of fuel control.

- UH-1H precautionary landing - Aircraft yawed to right during landing. Fuel analysis showed fuel contained 60 percent water. One fueling tanker was contaminated with water.
- OH-58A forced landing - Low rpm light and audio came on and N2 dropped to 60 percent. Landing was made in open field. Aircraft had been refueled after the first flight of the day from a recently serviced fuel truck. Fuel was contaminated with water and sediment.
- U-21A precautionary landing - During climbout, torque on No. 2 engine dropped to 300 pounds and aircraft yawed right. Landing was completed and No. 2 engine quit while aircraft was taxiing to ramp area. Fuel pump control had to be replaced due to water contamination.
- CH-47A forced landing - No. 1 engine flamed out, followed immediately by No. 2 engine. Successful night autorotation was made. Maintenance found water in fuel tanks and associated systems.
- OH-58A total loss, 2 injuries and $104,461 damage - Engine-out light and audio warning systems activated during low-level flight. Main rotor struck ground, then main fuselage impacted and began to roll right. Engine quit due to failure of fuel pump which was contaminated with foreign particles.
- UH-1H precautionary landing - During approach for landing, left fuel boost pump and master caution lights illuminated. Fuel pressure held at 13 psi through landing. Fuel mesh screen was clogged with particles of paint chips and rust.
- U-8F precautionary landing - During slow flight, No. 2 prop rpm decreased, oil pressure decreased to 30 psi, and cylinder head temperature rose. Engine was secured. Inspection revealed polyethylene substance in propeller governor oil screen, fuel oil screen, oil filter element, and engine oil pump adjustment spring and plunger.
- OH-58A precautionary landing - Fuel filter caution light came on during takeoff. Fuel filter was clogged by paint particles, dirt, and other black particles.
- OH-58A precautionary landing - Fuel filter caution light came on. Caused by fuel contamination from the unit's FARE system. Fuel nozzle had been allowed to accumulate dirt which was dispensed into aircraft during refueling.
- UH-1H incident, $4,000 damage - While climbing,

six to eight bangs were heard from engine area. Collective was reduced and N2 decreased with throttle. Flight was continued until suitable landing area was found. Maintenance inspection revealed compressor blade erosion and damage to both 42-degree and 90-degree gearboxes. There was also an accumulation of soap inside bleedband actuator.

Environmental factors

Dust and sand erosion, insects, and birds are some of the major environmental factor problems. Ice ingestion is not now the problem it was in past years. Dust and sand erosion is a continuing problem, especially in the desert environment. Continuous inspection and cleaning procedures as required by applicable technical manuals is the best insurance for needed power requirements. Proper daily inspections will reveal birds' nests or other foreign matter that would interfere with control movement.

Selected briefs

- AH-1G precautionary landing - Antitorque controls became excessively stiff during takeoff. After landing, bird's nest was found inside 90-degree gearbox cover. Other material, such as straw, grass, and short pieces of safety wire, was found wrapped around tail rotor drive shaft and around pitch change chain drive sprocket.
- CH-47A precautionary landing - No. 1 engine failed during short final to landing area. Caused by ice in fuel lines.
- OH-58A precautionary landing - During climbout from hover, transmission hot light came on. Grass accumulation was found on transmission oil cooler grill.
- AH-1G forced landing - During night approach, nose of aircraft swung right and was corrected with left pedal. Nose swung right again and left pedal would not correct condition. Power-off autorotation was completed. Birds had gained access to vertical fin interior and had deposited a 12-inch length of ¼-inch nylon rope and several pieces of straw. Rope had worked its way between silent chain assembly and had caused chain to slip off sprocket.
- AH-1G precautionary landing - During cruise flight, pilot noticed restriction in right pedal travel and initiated emergency procedures. Inspection revealed bird's nest in 90-degree gearbox area.

Thrown objects

Numerous rotor blades have been damaged by thrown objects. In some cases, personnel failed to consider how the downwash from the blades can affect the immediate area and in other cases items were deliberately thrown into or at aircraft.

Selected briefs

• OH-58A incident, $579 damage - After throttle was reduced to flight idle, during engine shutdown phase, observer started to exit aircraft. He was carrying a web belt canteen and gas mask in his hands. Since he wanted to secure the seatbelt, he decided to free his hands by tossing the equipment toward an area in front of the helicopter. Equipment entered the arc of the main rotor system and was hit by a blade.

• CH-47A incident, $34,000 damage - Fireguard was playing with rocks in front of aircraft. Crew saw a rock leave the fireguard's hand and go into forward blades, and saw a puff of dust when rock hit blade. One blade was damaged.

• OH-58A incident, $4,024 damage - During NOE flight, aircraft overflew an undetected opponent of a ground unit. Aircraft was struck by projectiles thrown by ground troops, damaging main rotor blade.

• UH-1B incident, $2,766 damage - Serviceman was standing by right cargo door while loading aircraft. He tossed a short piece of metal tubing to his rear. Tubing was carried upward, piercing one main rotor blade.

• CH-47A incident, $9,600 damage - While exiting the aircraft, infantry troop dropped an ammo pouch. Crew chief took it to the forward cabin to return it. No one was close enough to be called over to take it. Crew chief attempted to toss it out and away from the aircraft. It was picked up by rotorwash, damaging blade.

Items in landing zones

Ground personnel are not following accepted procedures during the installation of marker panels in landing zones. Failure to secure corners allows panels to be displaced by rotorwash. Damage by parachutes, sandbags, and other debris indicates that LZs are not properly policed.

Selected briefs

• OH-58A incident, $982 damage - Aircraft was hovering, moving slowly forward. It began to shudder and loud banging noises were heard. Pilot made hovering autorotation. Inspection revealed parachute had gone through both blade systems.

• OH-13E incident, $1,000 damage - Aircraft was positioning next to cloth marker panels which were not secured to the ground. Upon takeoff, marker panels were blown into tail rotor and then into main rotor blades. Panels wrapped around main rotor and struck FM antenna, breaking it off from the mount, then flew into tail rotor, damaging the blades.

• CH-47C/UH-1H incidents, $33,454 damage - As aircraft were setting down in LZ, empty and half-full

sandbags were drawn into rotor systems. (Composite of three CH-47Cs and one UH-1H)

- CH-47C incident, $34,354 damage - Aircraft was approaching LZ to pick up external load. Straw bag was picked up by rotorwash and driven through aft rotor system, damaging one blade.

Tools and items associated with toolboxes

During the reporting period, tools or items associated with toolboxes were identified as a cause factor in 50 of the mishaps. These included 4 major accidents, 1 minor accident, 23 incidents, 5 forced landings, 14 precautionary landings, and 3 ground incidents.

Damage exceeded a quarter of a million dollars, not including costs for more than 8,000 man-hours required to make needed repairs; or in those instances in which aircraft were successfully forced landed, for replacements of engines, transmissions, and other components damaged by tools and related items.

The toolbox FOD mishap rate was .24 per 100,000 flight hours which by itself does not appear significant, but it is 2.8 percent of the total FOD mishap rate.

Forty-eight percent of the rotary wing aircraft had tools left in tail rotor drive shaft tunnels which resulted in damage to tail boom areas.

There were cases where tools were found at accident sites but they were not considered causes or contributing causes of the accident. One such case was an AH-1G major accident. A pair of side-cutting pliers was found in the fuselage. The pliers were very rusty and unusable, and did not display any fresh markings. Other tools found in the wreckage included a screwdriver (figure 12) and a 7/16 open-end wrench (figure 13)

FIGURE 12.—Screwdriver found in wreckage of AH-1G.

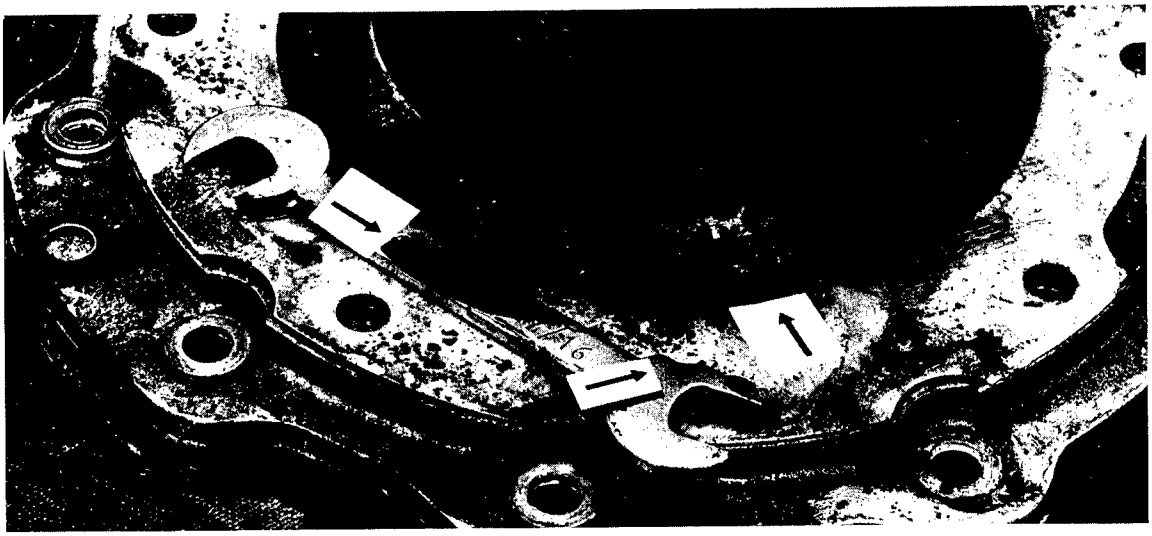


FIGURE 13.—Open-end wrench found in wreckage of AH-1G.

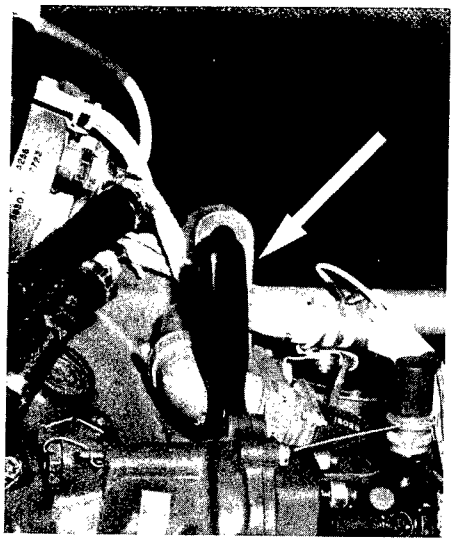


FIGURE 14.—Eighteen-inch screwdriver found on UH-1 engine.

Figure 14 depicts an 18-inch screwdriver found on a UH-1 engine. At least five different pilots had flown this aircraft and it had gone through two intermediate inspections before the screwdriver was found during the third inspection.

Figures 15 and 16 show damage to a UH-1H main transmission support case. A crew chief noticed something wedged between the transmission and side structural panel. Removal of the panel revealed the damage. It is suspected the cotter key removal extractor was dropped in the transmission well while work was being performed in the area of the main rotor hub assembly 25 to 30 hours before discovery. Damage resulted in replacement of the main transmission.

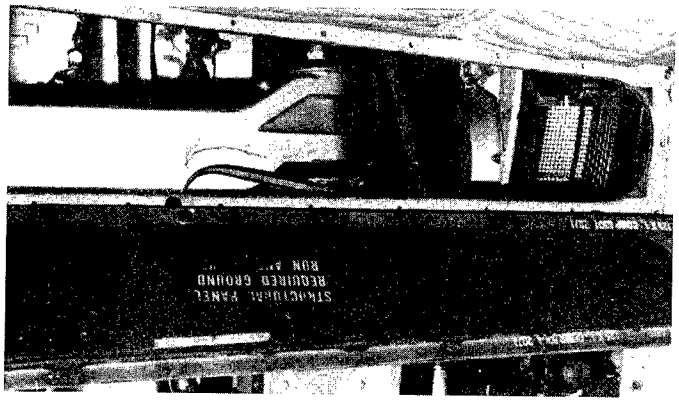


FIGURE 15.—Cotter key extractor found in transmission support case.

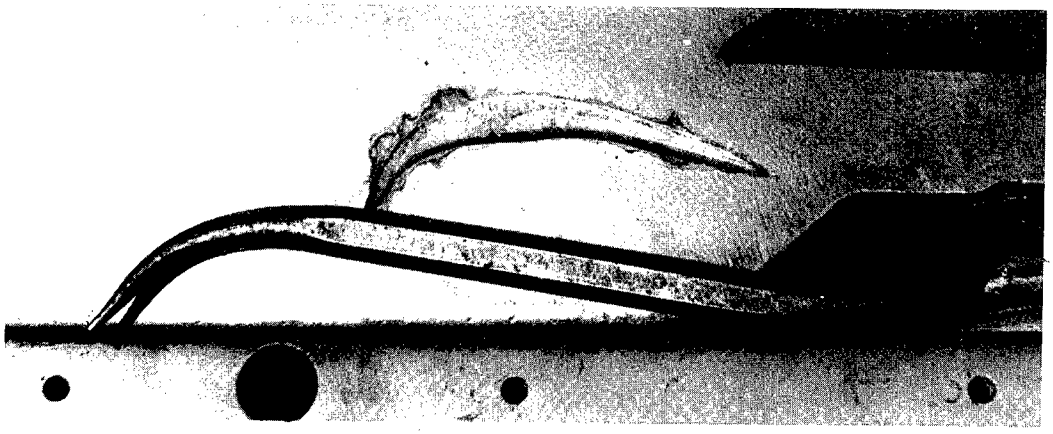


FIGURE 16

Selected briefs

• UH-1H incident, $1,390 damage - Loud noise was heard from transmission area. Pilot made hovering descent and short shaft failed. Pair of pliers was left inside engine housing.

• UH-1H forced landing - Aircraft shuddered and torque started to bleed off. Flames were seen in

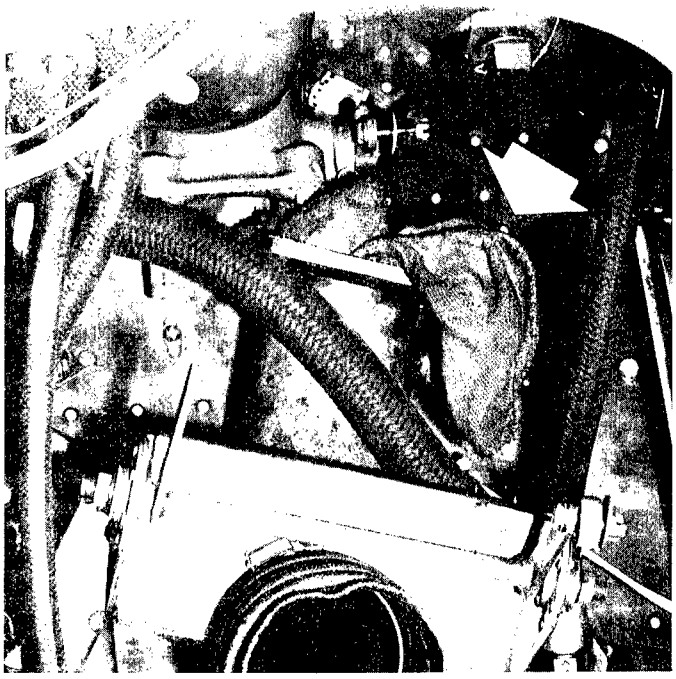


FIGURE 17.—Rag lodged in carburetor induction elbow assembly.

exhaust. Deep well socket was found between inlet guide vanes and first stage compressor.

• UH-1H major accident, $60,405 damage - Aircraft was flying at 2,800 feet and 80 knots when nose began to tuck under and to the right. Pilot suspected tail rotor failure, reduced collective pitch, and tried to streamline aircraft. At 50 feet, pilot initiated flare, and due to high operating rpm aircraft started a violent spin as airspeed was lost. Aircraft hit level, bounced back into the air, and on second landing left skid collapsed, causing aircraft to roll on its left side. Failure of tail rotor drive shaft forward of 42-degree gearbox was caused by 6-inch extension socket wrench.

• U-21A precautionary landing - During landing gear check, gear warning system indicated nose gear was not down and locked. Gear was recycled, then extended manually. Pair of wire cutters (mechanical dykes) was found in nose wheel well.

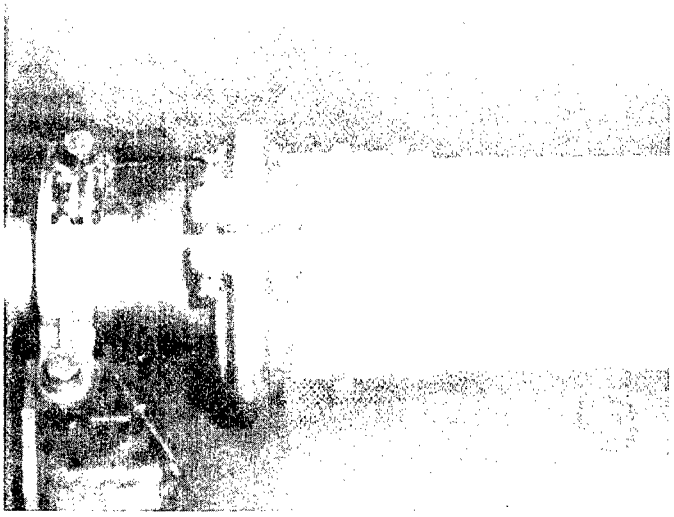
• AH-1G precautionary landing - Engine chip detector and master caution lights illuminated. Teardown analysis revealed that gearbox failure was a result of a large object trapped in the gear. A piece of screwdriver tip was found. However, a large foreign object had been lost or removed from the gearbox before receipt by the depot.

• UH-1D incident, $136 damage - Sheet metal maintenance had been performed to install new

fasteners on tail rotor drive shaft tunnel cowling. The same day a test flight was accomplished. A thorough preflight did not disclose the pliers. The next day a PMD was performed by crew chief and again the pliers were not found. The next day the pilot performed a preflight, including inspection of tail rotor tunnel area, and again pliers were not found. Postflight inspection revealed dents and a hole in tunnel cowling.

- AH-1G major accident, $16,175 damage - Tail rotor control was lost during ground taxi from revetment. Aircraft struck revetment wall, causing tail rotor and 90-degree gearbox to separate from aircraft and causing other damage to aircraft. Open end 7/8" x 15/16" socket was found in pylon.
- UH-1H incident, $235 damage - While refueling, crew chief noticed damage to tail rotor drive shaft tunnel cowling. Inspection revealed a pair of pliers under tail rotor drive shaft. One length of tail rotor drive shaft, two hanger bearing assemblies, and a section of the tunnel cowling were damaged. Aircraft had come out of periodic inspection the night before. Pliers were not noticed during several inspections that were conducted throughout the PE, nor during preflight or postflight inspections. Throughout these inspections, a minimum of 12 different people could have found the tool.
- AH-1G incident, $6,000 damage - Main rotor pitch change links were being adjusted for low autorotation rpm. Adjustment was made and crew chief left wrench on main rotor hub. Technical inspector and pilot failed to notice the tool on preflight. During runup, wrench fell into the main rotor blades, causing damage to both blades.
- CH-47A precautionary landing - Binding was felt in forward and aft cyclic on takeoff. The movement finally locked with no forward cyclic. Dykes were found in the area of the control tubes.
- UH-1H other (MOC), $30,000 damage - Aircraft was being run up following engine change. Engine started normally and ran for 10 minutes when loud bang was heard, followed by rpm loss. Engine was shut down and inspection revealed severe damage to IGV and compressor blades. Metal particles were found in tail pipe, on engine deck and in intake. Large pieces of compressor blades and pieces of duckbill pliers were found. Mechanic had broken the pliers while tightening a cannon plug. While looking for the pliers, he was summoned to act as a fireguard. Mechanic did not report the incident.
- UH-1H incident, $230 damage - Postflight inspection revealed hole in tail rotor drive shaft tunnel

cowling. Further inspection revealed a ratchet and mallet were left under No. 4 tail rotor drive shaft when drive shaft bearing was replaced the previous day. The maintenance was inspected and signed off by a technical inspector. The technical inspector and the crew chief, who performed the daily inspection, failed to find the tools. (figures 18a, 18b, and 18c)



Ratchet mechanism, gear to ratchet, and hammer found in UH-1 drive shaft tunnel cowling.

FIGURE 18a

FIGURE 18b

FIGURE 18c

FIGURE 19.—Ingestion of this cotton-type cloth caused a major OH-6A mishap.

• OH-6A major accident, $37,306 damage - After liftoff, engine lost power and rotor rpm. Extensive damage occurred on emergency landing. Engine had ingested a cotton-type cloth into compressor. (figure 19)

• UH-1H minor accident, $4,366 damage - Landing approach was made and terminated at hover. During hover, sound was heard and directional control was lost. After one complete clockwise rotation, aircraft touched down. The third section of the tail rotor drive shaft had failed due to FOD caused by paint brush. (figure 20)

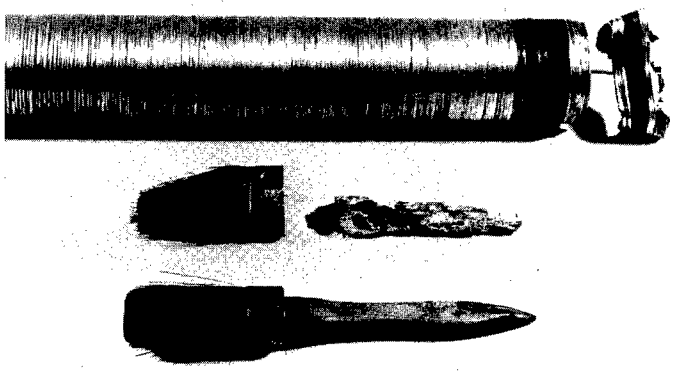


FIGURE 20.—Sheared tail rotor drive shaft caused by paint brush. New brush is shown with brush that caused damage.

• UH-1H major accident, $106,816 - During DER check, noise was heard coming from engine section. Engine chip detector and engine oil pressure lights illuminated. Engine and rotor tachometer needles split. On short final, obstructions were noted in path. Pitch was pulled to extend glide and rotor rpm dropped. Aircraft crashed. Rag was lodged against VIGV on lower right side of engine.

• AH-1G incident, $191 damage - While aircraft was being washed, maintenance personnel found bucking bar under tail rotor drive shaft. Drive shaft and clamp were scarred sufficiently to require replacement. (figure 21)

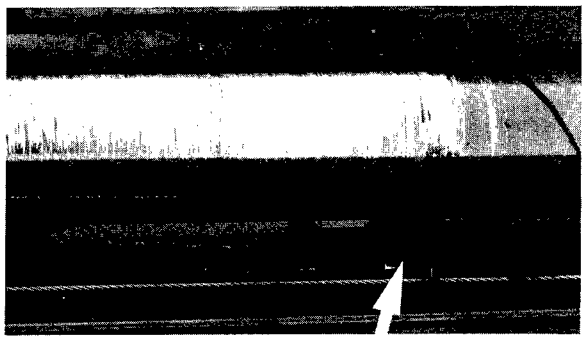


FIGURE 21.—Bucking bar left in AH-1 tail rotor tunnel.

Miscellaneous causes

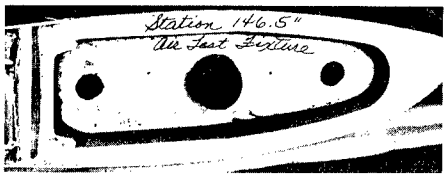


FIGURE 22.–Air test fixture left in blade of OH-58. Fixture was found because of balancing and rattling problems.

In many instances, personnel did not remove rotor blade tiedowns and engine inlet covers. Proper daily and preflight inspections would have prevented these mishaps, as well as most of the other miscellaneous cases. Figure 22 shows an air test fixture that was left inside the blade due to a manufacturing oversight. The blade was sent in when it could not be balanced properly and a rattling noise was heard.

Figure 23 shows safety wire residue found in the gearbox assembly of a T63A700 engine. The engine was undergoing analysis for a different reason, but the fact remains that the wire could have caused an emergency.

A new foreign object is being introduced--ladies' hair barrettes. As shown in figure 24, these hair restraining devices have been found on ramp areas and on aircraft. No damage has been reported, but the potential is there.

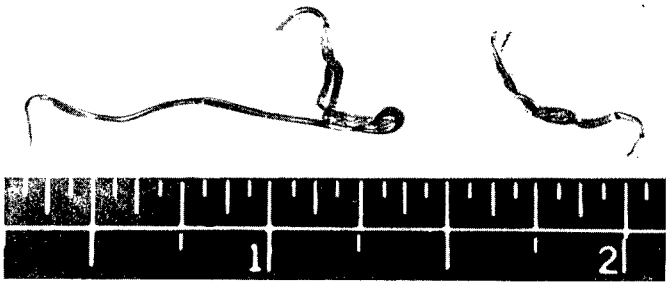


FIGURE 23.–Safety wire found in engine gearbox assembly.

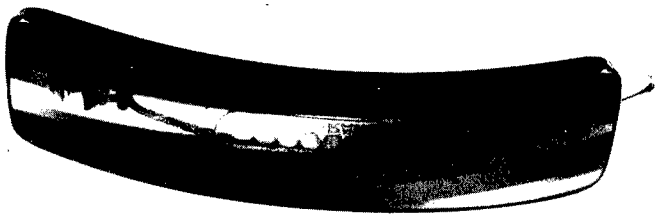


FIGURE 24.–Ladies' hair barrette found on aircraft during inspection.

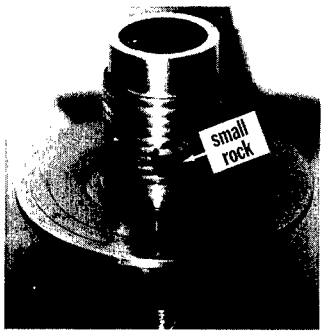


FIGURE 25.–Rock in fuel sump drain valve allowed it to be stuck in open position.

Many times foreign objects are found before they can cause trouble, such as when maintenance is being performed or modifications are being accomplished. Or a problem might be encountered, an item disassembled, and an object found.

Figure 25 shows what a small object can do. As a fuel sample was being taken from the forward fuel cell of an AH-1G, the sump drain valve stuck in the open position. The fire department was immediately notified, the battery was disconnected, and the aircraft was grounded. A POL truck was used for defueling. Had the aircraft been moved with ground handling

wheels and a tug, a skid could have dragged on the concrete, creating a spark and igniting the 262 gallons of JP4 pouring on the ramp. What caused all this? A small rock was found lodged in the spring mechanism of the push drain valve.

Particles of sand and other foreign matter can cause extra work due to inspections and time required for retaking oil samples. Figure 26 shows an enlarged internal thread area of a UH-1 tail rotor control quill. The threads were scored and gouged from the sand and other foreign particles during movement of the control quill. Particles of the soiled film lubricant and the base metal can work into the tail rotor gearbox. These minute particles, together with excess grease from the crosshead assembly, can damage the 90-degree gearbox.

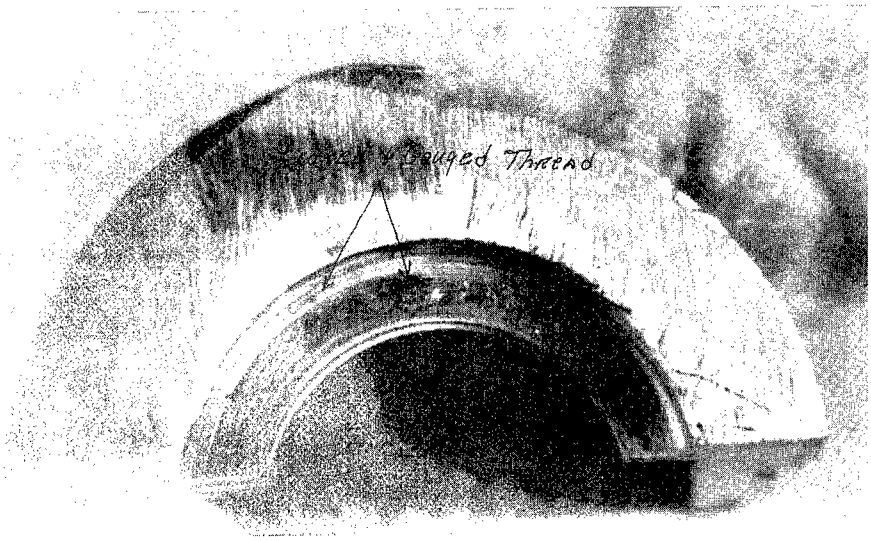


FIGURE 26.—Scored threads of UH-1 tail rotor control quill. Damage caused by sand and other foreign particles.

Selected briefs

- UH-1H incident, $5,740 damage - Aircraft was started with rotor blade tiedown hanging from blade. Tiedown wrapped around tail boom.
- CH-47C ground, $4,522 damage - During attempted motoring of engines, individual did not confirm that all necessary switches that would start engines were off. Engine ignited, causing rotors to turn. Blade tiedowns were untied but not removed and their whipping action damaged rainshield and aft pylon area.
- OH-58A incident, $958 damage - Aircraft was picked up to hover and moved to right to clear refueling area. After moving approximately 30 feet, loud bang was heard and aircraft made an immediate roll to the right, hitting right skid on ground. Refueling grounding wire was still attached to right skid.

• UH-1H precautionary landing - Just before aircraft was landed, engine oil pressure light came on and oil pressure gauge read 5 pounds. Loss of engine oil pressure was caused by two paper towels which were lodged in engine oil reservoir.

• UH-1H major accident, $73,000 damage - Aircraft was in level flight when loud bang was heard and tail rotor loss occurred. Aircraft hit hard and blades struck ground. Engine inlet cover had been left on roof of aircraft during preflight. Cover struck red tail rotor blade, and tail rotor, 90-degree gearbox, and a portion of the drive shafting separated from aircraft. (figures 27a, 27b, and 27c)

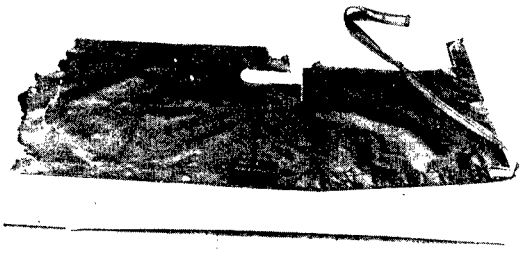
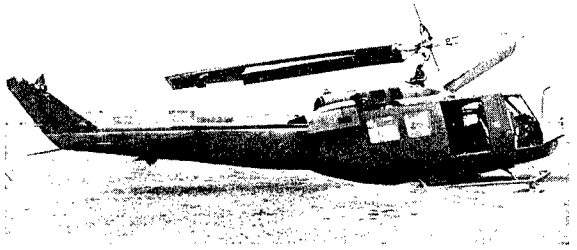


FIGURE 27a.– Unsecured engine inlet cover . . .

FIGURE 27b.–
. . . struck tail rotor . . .

FIGURE 27c.–
. . . and caused this.



Recognition of causes

Cause factors have been placed in categories under *cause* and *contributing cause.*

Cause

POL

• Improper fuel inspection techniques prior to dispensing, as evidenced by aircraft serviced from tankers contaminated with water.

• Refueler used improper procedures, such as leaving refueling nozzles uncovered and dragging them on the ground.

Supervisory

• Failure to insure that maintenance personnel

received adequate on-the-job training for functions being performed.

- Failure to insure that subordinates were performing their duties according to written procedures and/or instructions.
- Inadequate supervision of ground and ground support personnel.
- Failure to properly train subordinates in the correct methods of securing landing panel markers and clearing LZs of potential damaging debris, and failure to insure that subordinates followed instructions.

Crew

- Failure to perform a thorough daily inspection as outlined in the PMD technical manual.
- Failure to perform a proper preflight inspection as outlined in the CL technical manual.
- Inattention and complacency.
- Failure to follow unit SOP.

Maintenance

- Failure to remove tools or maintenance debris from work area upon completion of work.
- Improper use of tools.
- Failure to comply with written instructions/procedures in technical manuals or unit SOPs.
- Failure to record work being performed on appropriate DA forms.
- Performing maintenance not qualified or trained for.
- Improper procedures.

Inspection

- Failure to perform inspections properly.

Contributing cause

Requirements

- Lack of requirements in technical manuals to remove cowlings and inspect the opened area during preflight inspections.
- Inadequate SOPs.
- Lack of an Army-wide FOD prevention program and tool accountability program.

Crew

- Failure to properly brief passengers before flight.
- Failure to properly supervise the securing of loose items before flight.

Inspection

- Failure to inspect surrounding work area for debris.
- Failure to perform acceptance inspection in

accordance with technical bulletin.

Design

- Engine inlet areas located below main rotor system.
- "Work bench" configuration.
- Large number of tools required to perform maintenance.
- Toolboxes not designed for efficient use or accountability of tools.
- Inadequate cowling and cabin soundproofing fasteners.

Some of the design deficiencies probably will not be corrected until a new generation of aircraft and tools has been developed. The number of tools needed to perform maintenance functions is a problem because excess tools can be easily misplaced or lost. Also, the design of toolboxes now in use precludes the efficient inventory of tools upon completion of work.

Cause and contributing cause factors all are interrelated and create a "vicious cycle." An example is a case of a misplaced tool. *Design*: "Work bench" configuration, number of tools, and type of toolbox. *Maintenance*: Improper maintenance procedures. *Inspection*: Not inspecting surrounding work area for debris and tools. *Crew*: Crew chief not finding tool on PMD, when the tool was in the area of inspection. *Supervisory*: Throughout the maintenance and inspection system, various supervisors did not insure their personnel were qualified to perform the tasks and did not insure that procedures were being followed as per instructions. *Requirement*: No efficient FOD or tool control programs were in effect and there was no requirement to open certain cowlings due to *design* of fasteners.

Conclusions

1. Foreign objects have caused extensive damage and premature removal of aircraft components.
2. The actual cost of foreign object damage can not be accurately determined.
3. The elimination of foreign object damage requires an efficient and enforceable prevention program.
4. The basis for effective FOD prevention is proper maintenance and general housekeeping practices as outlined in aviation classes and various technical publications.
5. An equally important element in FOD prevention is supervision to insure that the basic principles of

FOD prevention are being followed by maintenance, inspection, and flight personnel.

6. With newer, more expensive, and more sophisticated aircraft programmed to join the inventory, and the emphasis accorded low level and nap-of-the-earth flying, positive action must be taken to eliminate FOD now!

Recommendations

1. That an FOD prevention program be initiated immediately in all Army units having organic aircraft and units supporting same.

2. That when failure or malfunction of a component is caused, or suspected to have been caused, by a foreign object, the part be examined closely for the type of damage. For example, FOD in turboshaft engines is compounded by high rotational speeds of the compressor. Tough objects of pliable construction will probably cause a bending/rolling distortion of the blades. Brittle objects can cause jagged cuts/tears and blade breakage. Often an imprint of the foreign object may be on a blade. Investigation as to the source of the foreign object should be made before removal of the component, as removal operations can obliterate the source. Missing hardware, worn or damaged cowling fasteners, missing cotter pins, Dzus fasteners and similar objects should all be looked for very carefully. After removal of the component, be especially careful during transport or placing on maintenance stand, as the foreign object could fall out.

3. That all maintenance be performed *by the book*. This includes making certain that excess grease is removed after components are lubricated and that adjacent areas are free from oily deposits that can cause dirt buildup. All oil and hydraulic containers should be cleaned before being opened. All disconnected oil, fuel, and hydraulic lines should be capped with approved materials, such as plastic caps or plugs, fuel- and oil-resistant paper or aluminum foil taped in place. NOTE: Tape should not be used alone, as the adhesive may dissolve and contaminate the system.

4. That engine inlet and exhaust covers are in place during maintenance of other systems not requiring access to the engine area.

5. That all work areas and engine inlet ducts on aircraft are cleared of litter, pebbles, and debris after maintenance has been completed. Should an item be dropped, it should be located. If the individual involved cannot find the dropped part, he should report the matter to his supervisor. The item should be

accounted for before releasing the aircraft.

6. That all tools are accounted for after completion of maintenance. Avoid relying solely on visual inspection of the work area. Sometimes a tool is difficult to spot as the color of the tool might blend in and be easily camouflaged by the background in which it is placed. Insure that a positive tool control program is in operation.

7. That all cargo and cargo doors are securely fastened before flight.

8. That all maintenance, ramp, and flight line areas be provided receptacles for the disposal of potential foreign objects. Insure that the receptacles are well identified, secure from unwanted movement, and emptied on a regular basis.

9. That any and all exterior covers that have been removed are securely stored before engine start.

10. That all rotor tiedown straps and/or grounding cables have been removed and stored before engine start/flight.

11. That commanders of aviation companies supporting ground personnel insure there is close coordination between the two units. Classes should be given to all concerned personnel on the proper procedures to use when securing ground marker panels, using portable radios with long antennas, and moving vehicles around aircraft.

12. That training and information programs for maintenance and refueling personnel be initiated. Subject matter should include:

- Correct methods to clean and maintain fuel filters.
- Correct procedures for refueling aircraft.
- Ways and means of disposing clipped pieces of safety wire and other small pieces of maintenance material.
- Jewelry and condition of uniform. Clothing with loose buttons or snaps should not be worn because objects within could fall out. Jewelry should not be worn while maintenance is being performed. As well as being an FOD source, it can also cause personnel injuries. Cases have been reported where watches and other metal objects completed an electrical circuit and the individual received an injury.
- A reminder that all dirt and mud should be cleaned from boots before maintenance or inspection on top of the aircraft.
- The importance of accountability of all hardware removed, or to be installed, on the aircraft.

13. That all daily and preflight inspections are performed in accordance with all published directives.

14. That you initiate your own FOD inspection. Figure 28 shows tools that were found inside a UH-1D tail boom during preflight inspection by a pilot placing his ear close to the tail boom, hitting the bottom side, and listening for rattling noises. Figure 29 shows what a good daily/preflight can accomplish. During an inspection, a ¼-inch wrench was found lodged underneath the base of the No. 4 hanger bearing. Rust had formed under the wrench. The aircraft had been out of a PE for 3 weeks and had been flown for 5 hours. Fortunately, the only damage was minor scratches to the drive shaft.

FIGURE 28.—Tools found in UH-1D tail boom during preflight inspection by placing ear close to tail boom, hitting bottom side, and listening for rattling noises.

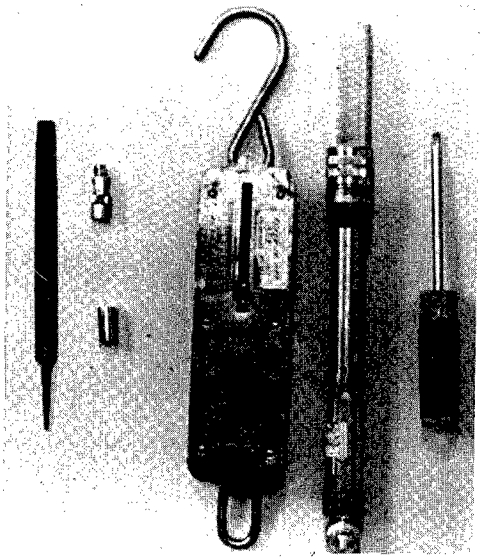
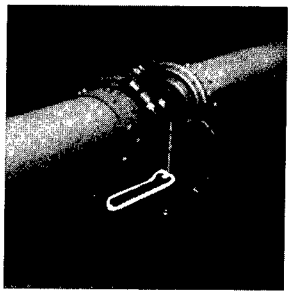


FIGURE 29.—This ¼-inch wrench was found during a proper daily inspection. Aircraft had been out of PE 3 weeks and had 5 hours' flight time.



Sample programs and poster material

A sample tool accountability/control program is included at appendix I, and a sample foreign object damage prevention program is at appendix II. These may be used separately or integrated as one program. These programs are in general form and should be supplemented as needed for a useful program/SOP.

Posters and toolbox FOD stickers can be ordered from USAAAVS, ATTN: IGAR-PG, Fort Rucker, AL 36362.

Appendix I

Sample
tool accountability/control program

Purpose

This program prescribes, as a minimum, procedures for safeguarding, accounting, and controlling individual hand tools, issued hand tools, special tools, tool sets, and other like equipment.

Scope

Applies to all personnel, DA civilians, USAR, NG, and Active Army, who use tools to perform maintenance on or near Army aircraft and other such equipment.

Definitions

- Individual hand tools -- hand tools supplied by the individual that are used to perform maintenance on Army equipment. These tools are used separately or in conjunction with Army-issue tools.
- Issue hand tools -- any tool that the U. S. Army, USAR, or NG issues as a part of a tool kit or on an individual basis.
- Tool kit, individual -- any tool kit that is issued to an individual for the successful accomplishment of a maintenance function on Army equipment.
- Tool set, shop -- any tool set issued to an activity/platoon for the successful accomplishment of its assigned mission.
- Special tools -- any tool authorized by TDA, TO&E, MTO&E, and applicable technical manuals to accomplish a maintenance function.

Responsibilities

Commanders will:

- Place maximum command emphasis on the security, accountability, and safe condition of all individual tools/tool sets in fixed and mobile situations.
- Insure that all individual hand tools, issued hand tools, tool sets, and special tools are accounted for.
- Insure that all saleable tools are marked with "US" or "USA."
- Insure that personnel know they are liable for lost tools and enforce individual pecuniary liability, where appropriate.

Property book officers will:

- Insure that all tools/tool sets on hand receipt are properly accounted for on current forms.
- Conduct a complete inventory of all hand tools, tool sets, and special tools quarterly, if practical, or at

least once semiannually.

- Take appropriate action to replace same in the event of shortages due to simple loss.
- Take appropriate action to have individuals replace lost tools or initiate a theft investigation, in the event of shortages due to loss through individual fault or theft.

Maintenance officers/NCOs/supervisors will:

- Have individual hand tools signed for by personnel who will use them in performing their duties and insure that the individuals are the only ones who have access to the assigned tools.
- Insure that all tools are properly secured and accounted for at all times.
- Make frequent spot checks of all assigned hand tools, tool kits/sets, and special tools to determine safe condition, accountability, and security of same.
- Insure accountability, safe condition, and security of personally owned hand tools is the same as for issued tools. Generally, the use of personally owned hand tools should be prohibited.
- Immediately report any tool shortage to the appropriate authority.
- Initiate action to replace any loss of tools through theft, simple loss, or negligence.
- Insure that only the tools needed to complete a specific maintenance function are used.
- Include FOD/tool control programs as subject matter in all safety classes.
- Continually use posters, signs, bulletin boards, and if available, photographs to emphasize the FOD/tool control programs.

Individuals will:

- Insure that tools are properly secured at all times.
- Insure that tools are kept in a safe condition at all times.
- Use only the tools required to complete a specific maintenance function.
- Restrict the use of "loan" tools.
- Inventory tools at beginning and ending of each work period to insure that tools are accounted for.
- Initiate action to replace tools that are damaged through use or simple loss.

All programs should include as a minimum, but not be limited to, the above.

References:

- AR 710-2
- AR 735-5
- AR 735-11
- OSHA Standard 1910.242(a)
- FORSCOM Reg 700-1

Appendix II

Sample
FOD prevention program

Purpose

The purpose of the program is to provide guidance so that an effective and meaningful foreign object damage prevention program can be initiated and maintained to meet a high degree of standards. The objective of the program is to increase the availability of aircraft and aircraft components and to decrease damage to aircraft and components and exposure of personnel to injury and overall cost.

Responsibilities

FOD prevention is a command responsibility. Commanders will insure that an aggressive and continuing prevention program is in effect. To assist the commanders, qualified officers and NCOs should be appointed and on written orders as the FOD control officers/NCOs.

FOD Control Officers/NCOs: Unit FOD control officers/NCOs have the overall responsibility for the foreign object damage prevention program. They are also responsible to the commander for, but are not limited to:

- Establishing and monitoring an FOD prevention program, considering the type unit and its mission.
- Inspecting and supervising FOD control procedures periodically.
- Investigating known or suspected FOD in coordination with the aviation safety officer, as appropriate.
- Monitoring to insure that equipment improvement recommendations (EIRs) and/or PRAMs, or both as the case may be, are sent to the appropriate addresses as stated in AR 385-40 and TM 38-750.
- Maintaining surveillance for unsatisfactory conditions and taking corrective actions as necessary.
- Insuring that incoming personnel are briefed concerning their responsibility in FOD control.
- Coordinating with appropriate supporting personnel to provide for foreign object inspection of proposed landing sites.
- Insuring that officers and enlisted safety meetings include FOD prevention topics.
- Coordinating with the maintenance officer/NCO and quality control officer/NCO to insure that proper procedures for tool control are maintained.

Aviation Safety Officer: The unit aviation safety

officer is responsible for maintaining communications between himself, FOD control officer, and unit commander. He will assist the FOD officer/NCO as necessary and accomplish specific duties which will include:

- Insuring that the appropriate supporting nonaviation units are briefed on the importance of FOD prevention in general and, specifically, the security of and proper placement of marker panels, proper policing of landing areas, and danger of operating vehicles with antennas in close proximity to approaching rotary wing aircraft.
- Insuring that aviation officer safety briefings include FOD prevention topics.

Operating procedures

Standing operating procedures (SOPs) written and maintained at all levels of units should include the following as a minimum:

- Conduct a visual inspection of all areas adjacent to the aircraft for objects removed that could cause FOD.
- Conduct a visual inspection of all areas of aircraft vulnerable to FOD on all daily and preflight inspections.
- Aircrew and maintenance personnel will insure that foreign objects have not been tracked up and deposited on the walkway or other areas during inspections or maintenance which require climbing up or around engine inlet areas, main rotor systems, or transmission decks.
- Insure that cargo is carried only in authorized areas and that it is properly secured.
- Inspect cockpit area of the aircraft before flight to insure that the area is free of debris or other type objects that could cause damage to or malfunctions of the control system.
- Inspect fuel tankers daily in accordance with published procedures to insure that water and other contaminants are not present.

Maintenance and maintenance areas

Inspection of air inlet and compressor inlet sections will be accomplished by supervisors and technical inspectors prior to installation of particle separators and screens after these items have been removed for maintenance.

Bolts, nuts, rivets, fasteners, screws, washers, safety wire, and other residue will be disposed of in receptacle appropriately marked for "foreign objects." These containers should be conspicuously placed in maintenance areas.

Items that may come loose from clothing such as

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Cynthia Gleisberg
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personnel identification badges, shop towels, and other loose personal objects (pens, pencils, etc.) will be removed when physically engaged in maintenance of aircraft or aircraft components susceptible to FOD. Also, items such as rings and watches should be removed, not only from an FOD prevention aspect, but as a safety measure to the individuals concerned.

All fuel, oil, and hydraulic lines will be capped when they are disconnected. Caps will be of the appropriate size and material as specified by the applicable or specific maintenance manuals. When installing the disconnected lines, an effort should be made to insure that the lines are not blocked by foreign objects.

All tools and supplies or equipment will be accounted for upon completion of maintenance and before performing a maintenance operational check or other such activities. Only tools necessary to perform the maintenance should be removed from the toolbox. Tool control shall be maintained and inventories should be accomplished at prescribed intervals and toolbox spot checks done as necessary.

Ramp and flight line areas

Aircraft parking and taxi areas shall be kept free of all objects that could cause damage to either rotary wing or fixed wing aircraft.

The areas shall be kept in a good state of repair at all times.

Receptacles appropriately marked will be placed in the ramp and flight line areas. There shall be enough receptacles so that personnel will not have to go a distance before one is available.

Parking and/or ramp areas shall be policed daily either by mechanical means or by use of personnel walking the line.

Ramps and flight lines also include rotary wing hover lanes. These lanes shall be kept free of all debris that could cause damage to the aircraft or rotor blade systems.

Training

Include FOD prevention and preventive measures in all aviator/maintenance safety meetings.

Post FOD-related educational material on unit/shop safety bulletin boards.