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Physiological problems caused by transportation of hazardous cargo in military aircraft

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This is the second of two articles describing reported incidents involving hazardous cargo on U.S. military aircraft over a 10 year period. In this article, we describe the various physiological responses reported on the incident reports. These physiological incidents may have involved either the aircrew, the passengers, or both. We also list the substances that caused the problems. Physiological responses ranged from nausea and lightheadedness to loss of consciousness. We discuss why flights involving a physiological incident may not have been aborted. The present military hazardous cargo incident reporting system is deficient in that there appears to be no requirement for reporting whether passengers were on board the incident aircraft, or whether passengers or aircrew suffered physiological responses to various toxic substances.

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TECHNICAL NOTE

Physiological Problems Caused by Transportation of Hazardous Cargo in Military Aircraft

94 8 18 190

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VOGE VM, TOLAN G. *Physiological problems caused by transportation of hazardous cargo in military aircraft*. Aviat. Space Environ. Med. 1993; 64:662–5.

This is the second of two articles describing reported incidents involving hazardous cargo on U.S. military aircraft over a 10-year period. In this article, we describe the various physiological responses reported on the incident reports. These physiological incidents may have involved either the aircrew, the passengers, or both. We also list the substances that caused the problems. Physiological responses ranged from nausea and lightheadedness to loss of consciousness. We discuss why flights involving a physiological incident may not have been aborted. The present military hazardous cargo incident reporting system is deficient in that there appears to be no requirement for reporting whether passengers were on board the incident aircraft, or whether passengers or aircrew suffered physiological responses to various toxic substances.

PHYSIOLOGICAL REACTIONS of aircrew and passengers to unexpected spills of hazardous cargo, or even supposedly non-hazardous cargo, can greatly endanger the safety of an aircraft mission. Strict guidelines for transportation of hazardous cargo on U.S. military aircraft are delineated in AFR 71-4 for the Air Force, and OPNAVINST 4660.3, Chap. 5, for the Navy. By regulation, passengers are not allowed to travel on military aircraft missions known to be transporting hazardous cargo. The military may transport such hazardous cargo, but only when specified conditions are met. However, in spite of rigorous guidelines, hazardous cargo is inappropriately found on military aircraft, even military aircraft carrying passengers.

This is the second of two articles examining reported hazardous cargo incidents as reported to the Naval and Air Force Safety Centers. The first article dealt with the types of problems experienced by the two services, types of aircraft involved, and types of hazards reported. This article will deal with the reported physiological incidents, experienced by both passengers and aircrew, during some of the hazardous cargo incidents.

METHODS

The method for this review is explained in the first article of this series (3).

RESULTS

The Air Force reported a total of 239 hazardous cargo incidents, and the Navy reported 88 incidents over the 10-year period examined. The incident reports occasionally lacked information as to whether a flight was aborted, or why it was or was not aborted; exactly what the hazard was; whether passengers were on board; how many passengers, if present, were on board; whether the passengers or aircrew experienced any physiological responses to the hazardous cargo (primarily when a toxic spill was present). No follow-up information was indicated on the incident reports when a physiological incident was reported. In this report, actual numbers are used where practical and available. Some of our results reveal descriptive information only. Almost all the reported hazardous cargo incidents were on flights where hazardous cargo was apparently not manifested and passengers could well have been on the flights.

Some of the actual abbreviated incident reports merit inclusion for illustrative purposes:

Example 1

". . . two hours into a scheduled transport flight . . . , crew chief smelled fumes emanating from cargo. . . . Fumes intensified throughout cabin, and crewmembers searching through cargo experienced headaches and a burning sensation of eyes and nasal passages. Aircraft commander considered donning oxygen masks if fumes intensified further . . . items discovered . . . glass fuel sample bottles with residual fuel . . . packed in rags, . . . oil servicing bowser with . . . 0.5 inch (1.3 cm) of residual oil, . . . can of glue . . . which had popped open inside cruise box . . . glue had toluene base . . . specifically prohibited from transport on passenger-carrying aircraft."

From Clinical Sciences, Armstrong Laboratory, Brooks AFB, TX.
This manuscript was received for review in September 1992. It was revised and accepted in December 1992.
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Example 2

". . . aircraft RTB [returned to base] . . . following incapacitation of flight attendant from fumes of leaking cargo. Ten minutes into flight, a liquid . . . was noticed leaking [and was] . . . determined . . . to be "coolanol" . . . the flight crew was informed the substance was non-hazardous. The fluid spread aft under the passenger seats, and attempts were made to contain the spill with rags. The liquid produced an odor that became very strong and irritating to the eyes. The cabin crew and passengers complained of nausea, headaches, light-headedness and weakness. A return to [base] . . . was initiated. Shortly thereafter, the flight attendant wiping up the spill became overcome by the fumes and passed out; additionally, a passenger passed out from the fumes. An emergency was declared, and emergency descent initiated, and oxygen masks deployed at FL 220."

Example 3

"During the climbout at 16,000-ft (4877 m) MSL, the loadmaster reported leakage of a chemical substance from . . . pallet. . . . The material . . . had a pinkish color and produced no detectable odor . . . aircraft leveled off at FL 180; aircrew donned O_2-masks, and smoke and fume elimination checklist initiated . . . the aircraft RTB. In flight, no crewmember experienced any signs of incapacitation . . . after landing, loadmaster and flight engineer contacted symptoms of dryness of throat, sinus irritation, gritty and watery eyes, and nausea."

Example 4

"Aircrew on joint airborne/air transportability training mission. . . . Crew uploaded 38 personnel with carry-on baggage. . . . Due to weather, the airdrop was cancelled. . . . Passengers were deplaned and baggage was offloaded into . . . pickup truck. . . . Security police noted smoke coming from bed of truck. Bottles of nitric and sulfuric acid had broken and leaked onto the bed of the truck . . . broken . . . containers were removed from truck onto the ground where the acid softened the asphalt . . . the acid was not certified, manifested or properly packaged. . . . Passengers knowingly brought eight 1-L bottles of acid (four each of nitric and sulfuric) aboard as carry-on baggage."

Example 5

". . . one hour after takeoff, at FL 200 . . . , four passengers were sprayed in the face and eyes with bromochloromethane (CB) agent as a hose on a 10-gallon (38 L) fire extinguisher ruptured. Fumes filled the cargo compartment. The crew immediately donned oxygen masks and passed out passenger oxygen kits." [Normal emergency procedures then carried out.] ". . . investigation . . . centered on why the extinguisher was charged in flight."

Example 6

"On descent, loadmasters noted . . . F-16 engine was leaking fuel, and there were toxic fumes. . . . The spill was contained . . . with buckets and absorbant material. . . . The pilots and flight engineer went on oxygen. The passengers and loadmasters did not go on oxygen for fear of creating a fire by mixing fuel fumes with oxygen . . . landing was uneventful. . . . The passengers and aircrew were feeling nauseous."

Example 7

". . . a power generator . . . [was] . . . delivered . . . for shipment without telling shipper's inspector the generator was serviced with JP-4 . . . the fuel was . . . assumed to be diesel. . . . In flight, JP-4 odors were identified. . . . Since the crew believed the generator was fueled with diesel fuel, passengers were permitted to smoke. Upon identifying the JP-4 fumes, all smoking was curtailed."

Neither the Air Force nor the Navy apparently requires information on the reactions of aircrew and passengers in their incident reports. The information we had for this study was gleaned from those reports that incidentally mentioned passenger information. We observed that 72% of Air Force and 66% of Navy reports had no passenger information (Table I). However, when reported and when numbers were given, the average number of passengers on the incident aircraft in the Air Force was 25. The Navy incident reports had no information in this area. The Air Force reported up to 65 passengers on its incident aircraft. When passenger information was available, the Air Force hazardous cargo incident command pilots seemed to abort a flight more frequently when hazardous cargo was discovered and when passengers were on board than did the Naval pilots. The Navy's low abort number with passengers on board may be artifactual. It may only reflect the high number of hazardous cargo incidents discovered while the aircraft was still on the ground, which would not be subject to abort procedures.

TABLE I. GENERAL PASSENGER INFORMATION: HAZARDOUS MATERIALS INCIDENTS, USAF VS. NAVY, 1980–1989.

	Air Force	Navy
Incidents stating passengers on board	65 (27%)	25 (28%)
Incidents stating passengers not on board	3 (01%)	5 (06%)
Incidents without passenger information	171 (72%)	58 (66%)
Average number of passengers on board, when reported	25	no information
Range of number of reported passengers	3–65	no information
In-flight incidents, with passengers, aborted	42 (65%)	7 (44%)
In-flight incidents, with passengers, not aborted	23 (35%)	9 (56%)
Ground incidents, with passengers	0 (00%)	9 (36%)

Most of the two services' hazardous cargo incident reports did not mention whether or not the aircrew or passengers experienced symptoms secondary to their exposure to the various fumes or chemicals. When pilot action was reported after discovering problems with hazardous cargo (fumes, spills), the command pilot, as per regulation, usually ordered all crew and passengers to go on oxygen, and normal smoke or fume elimination procedures were carried out. These routines frequently included aircraft depressurization and descent in altitude.

The symptoms that were reported were nausea, vomiting, headache, light-headedness, blurred vision, and loss of consciousness (Table II). Physiological incidents were reported in only 6% of all Naval hazardous cargo incident reports. The Air Force reported symptoms in 11% of its incident reports. When aircrew experienced symptoms in flight, 81% of Air Force and 40% of Navy

TABLE II. GENERAL INFORMATION ON PHYSIOLOGICAL INCIDENTS.*

	Air Force	Navy
Total incidents	26 (11%)	5 (06%)
Flight aborted on discovery of hazardous cargo	21 (81%)	2 (40%)
Incident flights with passengers on board	15 (62%)	2 (40%)
Incident flights with passengers on board, aborted	13 (81%)	1 (50%)

* i.e., nausea, vomiting, headache, light-headedness, blurred vision, loss of consciousness.

TABLE IIIa. AIR FORCE PHYSIOLOGICAL INCIDENTS* BY VARIOUS AIRCRAFT TYPES.

	Aircraft Type					
	C-141	C-130	C-5	C-9	KC-135	KC-10
Total incidents	15	9	1	1	0	0
Flight aborted	12 (80%)	9 (100%)	0	0	0	0
Passengers on board	9	6	0	1	0	0
Flight with passengers on board, aborted	7	6	0	0	0	0

* i.e., nausea, vomiting, headache, light-headedness.

TABLE IIIb. NAVY PHYSIOLOGICAL INCIDENTS* BY VARIOUS AIRCRAFT TYPES.

	Aircraft Type		
	C-9	C-130	P-3
Total incidents	4	1	0
Flight aborted	2 (50%)	0	0
Passengers on board	2	0	0
Flight with passengers on board, aborted	1	0	0

* i.e., nausea, vomiting, headache, light-headedness, blurred vision, loss of consciousness.

flights were aborted. When passengers were on board, 81% of Air Force and 50% of Navy flights were aborted.

Air Force physiological incidents were most frequently reported in the C-141 aircraft (15 incidents), followed by the C-130 aircraft (9 incidents) (Table IIIa). The Navy reported somewhat more serious symptoms, including blurred vision and loss of consciousness (Table IIIb). Most of the Navy's reported physiological incidents were in the C-9 aircraft (4 incidents).

The substances reported to cause actual physiological incidents or symptoms were varied both for the Air Force and the Navy (Table IV) and seem to cover all types of substances. Passengers were exposed to a wide variety of hazardous materials, although not all these instances resulted in reported symptoms (Table V).

DISCUSSION

Most flight surgeons do not think about hazardous cargo being carried by air transports on which they might be passengers, or as part of their premishap plan when they function as air station flight surgeons. However, such situations exist and can be quite dangerous. As can be seen from the physiological responses to the various substances, aircrew incapacitation is a very real possibility. Perhaps most frightening is when aircrew fail to protect the passengers, or even themselves, by inappropriately reacting to a toxic spill, as illustrated in Examples 1 and 6 above.

We suspect physiological reactions to the hazardous cargo spills and fumes reported in this evaluation are incomplete because of underreporting (see below). The Air Force reported three times more incidents and many more physiological problems than did the Navy. This may be because the Air Force transports much more cargo and passengers than does the Navy, or it could be artifactual (3).

The analysis of the actual incident reports also present problems because of different reporting formats (3). Important information such as: whether passengers were on board the incident aircraft and how many; whether the cargo was actually manifested as hazardous or not; how the abort flight decision was made; whether passengers or aircrew experienced physiological symptoms because of a toxic spill; whether the culpable party for the hazard was known, and what the corrective action would be; exactly how the hazardous problem was handled, etc., is apparently not required on the various incident reports.

We found no information on why a decision was made not to abort, even when passengers were reported to be on board and the aircrew or passengers were experiencing symptoms. Failure to abort could be poor judgement or a well-founded decision, such as when the aircraft is

TABLE IV. PHYSIOLOGICAL INCIDENTS, BY CAUSANT.*

Air Force	
Acetylene	Liquid cement
Battery acid**	Methylketone
Bromochloromethane**	? "Open cans in tool box"**
Calcium hypochlorate, hydrated**	Paint drier
Deicing fluid**	"Pink fluid"
Epoxy primer	Rocket motor fuel
Fuel (10 cases)**	? Substance/solvent**
Hydraulic fluid	Torpedo fuel (Otto II)
Navy	
Adhesive (glue) (2 cases)**	
Coolanol (2 cases)**	
"Corrosive material"	
Fuel**	

* One incident reported in all cases, except where otherwise noted.
** Passengers known to be on board.

TABLE V. PASSENGERS KNOWN TO BE EXPOSED VIA FUMES AND LEAKS TO HAZARDOUS MATERIALS.

Air Force	
Battery acid	Hydraulic fluid
Bromochloromethane	"Open cans in tool box"
Calcium hypochlorate, hydrated	Lithium
Corrosives and explosives	Paint
Creosote	Propane gas
Deicing fluid	Sulfuric acid and nitric acid
Fire extinguisher chemicals	Toluene
Fuel/diesel/MOGAS* (50 cases)	Unknown substance
Navy	
Coolanol	
Fuel	
Glue	

* Highly flammable fuel additive.

over water with the destination base closer than home base and no intermediate airfields available.

Of the recognized (named) substances reported to have caused physiological incidents in the aircrew or the passengers, various types of fuel were by far the most common. Many fuels contain benzene and other substances that are potential carcinogens. Besides this, fuels are strong skin, nose, and eye irritants, and can cause neurological alterations (headache, nausea, confusion, drowsiness, convulsions, loss of consciousness). Some of the other substances mentioned in the incident reports to have caused symptoms also can be quite dangerous: Otto fuel (torpedo fuel) is very volatile and can cause headache, methemoglobinemia, and circulatory problems leading to circulatory collapse. Deicing fluids can act similar to methanol (neurological symptoms). Methylethylketone (MEK) can cause narcosis and skin irritation. Chlorobromomethane (CBM) can cause pulmonary edema. Solvents are of many types, but most frequently cause incoordination, malaise, disorientation, euphoria, confusion, loss of consciousness and finally death (1,2). Obviously, the substances reported to have caused symptoms are not innocuous. Also, those incidents without reported symptoms involved substances with potential hazards, either immediate or delayed. Perhaps the aircrew where no symptoms were reported were just fortunate; perhaps the aircrews' adherence to the standard procedures for toxic spills or fumes served them well; or perhaps symptoms occurred but were not reported.

CONCLUSIONS

Physiological complications have occurred with manifested and unmanifested hazardous cargo on military transport aircraft. Many mishaps may have been prevented by current systems, but greater vigilance is needed to prevent loading hazardous cargo with passengers, and to protect aircrew. The potential seriousness of such incidents should not be understated.

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LETTERS TO THE EDITOR

Inflight Medical Aspects of a Massive Air Evacuation

Dear Sir:

On May 24–25, 1991, 14,400 Ethiopian Jews were transported from Addis Ababa, Ethiopia to Tel Aviv, Israel over a 33-hour period. The population consisted of a high proportion of women, children and elderly, gathered from refugee camps, where they suffered from malnutrition and a variety of infectious tropical diseases. This military operation employed 33 planes (civilian and military) performing 38 flights. Forty teams, consisting of a doctor and a paramedic, were enrolled to cope with medical emergencies during flight. The largest plane transported 1,200 people with 3 medical teams, and the smallest 200 people with 1 team. In addition to regular air medical transport equipment, a large amount of crystalloids, pediatric equipment, delivery sets and pulse oxymeters were taken. Duration of flight ranged from 3.5 to 5 hours.

Triage was performed by the medical team, assisted by translators, at the entrance to the plane or by walking among the sitting passengers. A separate area was then organized for isolation and treatment of the sick. There were 34 cases diagnosed and treated on the plane, including: 17 cases of acute gastro-intestinal disorders, requiring oral and parenteral rehydration, and a 3-year-old with an acute abdomen (later diagnosed as intestinal obstruction due to Ascaris infection); 7 obstetric emergencies, including two deliveries inflight and one woman with acute pre-eclamptic toxemia; 4 acute ophthalmic infections; 5 neurologic disorders, including a case of convulsions and coma; and 1 case of asthmatic crisis. The incidence of morbidity during the flights was 0.24%.

In conclusion, we recommend assigning a well equipped medical team (as defined above) for every 200 evacuees to cope with any acute medical emergency inflight. Those teams should include medical specialists according to the expected problems. Such a large and rapid air evacuation demands meticulous planning, organization, and the selfless cooperation of all teams and forces concerned.

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