WELCOME TO TECHNICAL ORDER 00-105E-9, 1 FEBRUARY 2006, REVISION 11.

THIS IS SEGMENT 1 COVERING TITLE PAGE, A, B & C PAGES, FOREWORD, LIST OF ILLUSTRATIONS, FAA/ICAO DESIGNATORS, AND CHAPTERS 1, 2, & 3.

TO NAVIGATE

CLICK ON THE BOOKMARKS AND CLICK ON THE (+) SYMBOLS, THEN CLICK ON SUBJECT LINKS TO GO TO SPECIFIC VIEWS IN THIS SEGMENT.

CONTINUE

NOTICE

CONTACT

TO GO DIRECTLY TO THE TECHNICAL ORDER, CLICK ON THE CONTINUE BUTTON.

TO SEE THE SEGMENT INFORMATION CHANGE NOTICE, CLICK ON THE NOTICE BUTTON.

TO CONTACT THE TECHNICAL CONTENT MANAGER , CLICK ON THE CONTACT BUTTON.

TECHNICAL ORDER 00-105E-9 TECHNICAL CONTENT MANAGER

WRITTEN CORRESPONDENCE:

HQ AFCESA/CEXF
ATTN: Fire and Emergency Services Egress Manager
139 Barnes Drive Suite 1
Tyndall AFB, Florida 32403-5319

E-MAIL: HQAFCESA.CEXF@tyndall.af.mil

INTERNET: HQ AFCESA Fire and Emergency Services PUBLIC WEB PAGE:
http://www.afcesa.af.mil/CEX/cexf/index.asp
Safety Supplements: http://www.afcesa.af.mil/CEX/cexf/_firemgt.asp

PHONE: (850) 283-6150
DSN 523-6150

FAX: (850) 283-6383
DSN 523-6383

For technical order improvements, correcting procedures, and other inquiries, please use the above media most convenient.

SEGMENT 1 INFORMATION CHANGE NOTICE

This page is provided to notifiy the user of any informational changes made to Technical Order 00-105E-9 in this Segment and the current Revision. Informational changes will be referenced in the Adobe Reader's Bookmark tool as a designator symbol illustrated as a <[C]> for quick reference to the right of the affected aircraft. The user shall insure the most current information contained in this TO is used for his operation. Retaining out of date rescue information can negatively affect the user's operability and outcome of emergencies. If the user prints out pages his unit requires, the user shall print the affected page(s), remove and destroy the existing page(s), and insert the newly printed page(s) in the binder provided for that purpose. A Master of this TO shall be retained in the unit's library for reference, future printing requirements and inspections.

CHAPTER	AIRCRAFT	PAGE	EXPLANATION OF CHANGE
N/A	N/A	Title	Supercedes Revision #10 of 1 May 2005. Safety Supplement statement added. All active Safety Supplements incorporated. Revision 11 reflects date of 1 February 2006.
N/A	N/A	A, B & C	Updated to reflect pages affected by all Revisions.
N/A	N/A	i -ix	List of Illustrations updated.
N/A	N/A	x	Page address three topics, not to be considered an LOI page.
3	N/A	ALL	Chapter 3 completely updated and reorganized, most notably the composite materials information.

Technical Order 00-105E-9 and STANAG 3896

Aerospace Emergency Rescue and Mishap Response Information (Emergency Services)

Segment List for Revision 11 - 1 February 2006

TO 00-105E-9

TECHNICAL MANUAL

AEROSPACE

EMERGENCY RESCUE AND MISHAP RESPONSE INFORMATION

(EMERGENCY SERVICES)

THIS PUBLICATION SUPERCEDES TO 00-105E-9, REVISION 10, DATED 1 MAY 2005 AND SAFETY SUPPLEMENTS 1, 2, 3, 4, 5, 6, 7, 8 AND 9.

DISCLOSURE STATEMENT: This Technical Order (TO) is a Security Assistance Technical Order Data System (SATODS) used for the management of TOs. It is used by foreign governments or international organizations and is cleared to share this information with the general global public. This TO is designated as the NATO Crash Fire Rescue (CFR) Standardization Agreement (STANAG) 3896.

DISTRIBUTION STATEMENT: Approved for public release; distribution is unlimited. Questions concerning technical content and distribution should be directed to HQ AFCESA/CEXF Attention: Air Force Fire and Emergency Services - Egress Manager, 139 Barnes Drive Suite 1, Tyndall AFB, FL 32403-5319.

PUBLISHED UNDER AUTHORITY OF THE SECRETARY OF THE AIR FORCE

REVISION 11
1 February 2006

LATEST REVISION. DESTROY SUPERCEDED REVISIONS.

LIST OF EFFECTIVE PAGES

Important Notice: This publication is published in digital media format. All previous paper and CD-ROM editions are not valid and shall not be circulated for official use. Each revision of this publication will be treated as a new basic with incorporated changes and supplements, therefore each superceded revision should not be used in order to prevent using outdated information.

Dates of issue for original and changed pages are:

Issue	Date	Media
Original	1 July 1970	Paper Media
Revision 1	1 July 1972	Paper Media
Change 1	1 April 1973	Paper Media
Change 2	12 December 1973	Paper Media
Change 3	2 March 1976	Paper Media
Change 4	2 May 1977	Paper Media
Revision 2	15 October 1978	Paper Media
Change 1	6 March 1979	Paper Media
Change 2	11 June 1979	Paper Media
Change 3	29 August 1980	Paper Media
Change 4	3 August 1981	Paper Media
Change 5	19 November 1981	Paper Media
Change 6	21 August 1983	Paper Media
Change 7	4 February 1985	Paper Media
Change 8	1 September 1986	Paper Media
Change 9	15 June 1988	Paper Media
Change 10	1 December 1988	Paper Media
Revision 3	25 July 1990	Paper Media
Change 1	30 October 1991	Paper Media
Revision 4	12 May 1994	Paper Media
Change 1	10 February 1995	Paper Media
Change 2	15 May 1995	Paper Media
Revision 5	21 January 1999	CD-ROM
Revision 6	8 October 1999	Web Media
Revision 7	15 January 2001	Web Media
Revision 8	30 September 2002	Web Media
Revision 9	1 July 2004	Web Media
Revision 10	1 May 2005	Web Media
Revision 11	1 February 2006	Web Media

NOTE:

According to official WR-ALC records, this is the numerical and chronological order for all revisions and changes to this technical order. When the TO was converted to electronic media, the revision was temporarily considered an original, but TO management dictates that the historical order be restored to keep the TO records accurate. The A, B and C pages will reflect this order as applicable. This TO has been offered electronically on the authorized web site since November 1999 and is the **only mode of distribution.** Paper media terminated officially with Revision 5. CD-ROM media officially terminated with Revision 6. This TO is limited to 10 MB segments to facilitate downloading through network system firewalls.

--TO Content Manager and Editor.

THIS PUBLICATION CONSISTS OF THE FOLLOWING:

Page No.	*Revision No.	Page No.	*Revision No.	Page No.	*Revision No.
Title	11	A-37.1	9	C-17A.1	11
A - C	11	A-10.1	8	C-27.1	8
i - xi	11	A-37.1	9	C-32A.1	10
FAA/ICAO Appendix A & B	9	Chapter 5 Cover	8	C-37A.1 - C-38A.1	8
1-1	10	5-1	8	C-40.1	10
2-1 - 2-16	8	B-1.1 - B-52.1	8	C-130.1	11
2-17 - 2-21	9	Chapter 6 Cover	8	C-130J.1 - WC-135W.1	10
3-1 - 3-105	11	6-1	8	KC-10.1	9
Chapter 4 Cover	8	C-5.1	11	Chapter 7 Cover	8
4-1	8	C-7.1 - (V)C-9A/C.1	8	7-1	8
A-10.1	8			E-3 30/35.1 - VC-25A.1	8

* Zero in this column indicates an original page.

LIST OF EFFECTIVE PAGES - Continued

Page No.	*Revision No.
Chapter 8 Cover	8
8-1	8
QF-4.1	11
F-5E/F.1	8
F-15.1 - F-16.1	11
F/A-22.1	10
F-117A..1	11
Chapter 9 Cover	8
9-1	8
UH-1N.1 - MH-60G.1	0
V-22.1	8
Chapter 10 Cover	8
10-1	8
OV-10.1	8
MQ-1/RQ-1.1	10
RQ-4A.1 - SR-71.1	8
U-2.1	10
Chapter 11 Cover	8
11-1	8
DA 20-C1.1	9
T-1A.1	11
T-3A.1	0
T-6A.1	11
T-37.1 - OT-47B.1	0
Chapter 12 Cover	8
12-1	8
U-3.1 - U-26A.1	0
Chapter 13 Cover	8
13-1	8
AH-1S.1 - UH-60A/L.1	0
Chapter 14 Cover	8
14-1	8
T-41.1 - T-42.1	0
Chapter 15 Cover	8
15-1	8
U-8F.1 - U/RU-21.1	0
Chapter 16 Cover	8
16-1	8
OV-1.1 - DASH 7.1	0
Chapter 17 Cover	8
17-1	8
ISS.1	9
Orbiter.1	9
DDMS Procedures	11
Orbiter Carrier.1.	8
T-38N.1	10
Chapter 18 Cover	9
18-1	9
DC-3.1 - 77	9
Chapter 19 Cover	9
19-1	9
USCG	9
USFS	11
Chapter 20 Cover	9
20-1	9
AV-8B.1	9
Chapter 21 Cover	9
21-1	9
F-5E/F.1 - F-14.1	8
F/A-8.1	9
Chapter 22 Cover	9
22-1	9
E-2.1 - S-3.1	6
Chapter 23 Cover	9
23-1	9
C-2.1 - C-20.1	6
UC-26.1	9
C-130	8
Chapter 24 Cover	9
24-1	9
T-2.1 - T-45A.1	6
Chapter 25 Cover	9
25-1	9
AH-1W.1	9
H-2.1-H-53.1	6
UH/SH-3.1-HH-60H/SH-60.1	9
TH-57.1-UH-1N.1	6
Chapter 26 Cover	9
26-1	9
Alpha Jet.1 - Harrier T10.1*	7
Sea Harrier FA2	10
Jaguar.1 - Tornado GR4.1	7
Chapter 27 Cover	9
27-1	9
Atlantic BR 1150.1 - Canberra TT18.1	7
Fallon 50 Marine.1	10
MB 326.1 - P3/CP-140/CP-140A.1	7
Chapter 28 Cover	9
28-1	9
Airbus A310-300/CC-150-CC/CE/CP-144.1	7
CN-235.1	10
DO 28.1 - YS-11A.1	7
Chapter 29 Cover	9
29-1	9
CM-170.1	7
EF-2000.1	10
E-25 CASA 101 - RAFALE	7
RAFALE MARINE	10
SU-22.1 - T-45/CT-155/Hawk TI &TIA.1/CT-55	7
Eurofighter.1	10
Chapter 30 Cover	9
30-1	9
A 109.1- AB 204.1	7
AB 206.1	9
AB 212.1-AH-64.1	7
AS 532.1-AS 550.1	9
BO 105CB.1- CH-146.1*	7
BO 105CB.1- CH-146.1*	7
Ecureuil alstar as 355.1	10
Ecureuil 2.1*	7
Fennec AS 555AN.1	10
Gazelle AH-1.1 - Gazelle HT2.1	7
Gazzelle HT3.1	10
HH-3F.1* - Lynx LBH MK 9	7
Lynx MK3.1 - Lynx MK90B.1	10
Lynx MK95.1 - Lynx WG13	7
Merlin.1	10
OH-13S.1 - Sea King HAS/ASW/6.1	7
Sea King MK4.1 - Sea King MK7.1	10
Sea King HC4/MK-41/S-61/Westland SAR.1 - Wessex HC2/HC5C.1	7
Chapter 31 Cover	9
31-1	9
Cessna Skymaster 337.1- CP-121.1	7
E-3A.1	10
E-3F.1 - O-1.1	7
MRT.1	10
PD 808.1	9
S-2E.1 - Sentry AEW Mk1	7
Chapter 32 Cover	9
32-1	9
CR-100.1 - SM 1019.1	7
TCA.1	10
T-33/CT-133.1 - Tucano T-1.1	7
Chapter 33 Cover	9
33-1	9
KDC-10.1	7
MRT.1	10
TriStar K1/kc1.1 - VC-10/K4.1	7
Chapter 34 Cover	9
34-1	9
U-17.1	7
Chapter 35 Cover	9
35-1	9
Caravan II F406.1-Cessna/EC-2.	8
Cessna 421.1	9
Falcon 900.1 - Xingu.1	7

* Zero in this column indicates an original page.

LIST OF EFFECTIVE PAGES - Continued

Page No.	*Revision No.	Page No.	*Revision No.	Page No.	*Revision No.
Chapter 36 Cover	9				
36-1	9				
A380	10				
707-307C.1 - DC-8F.1	7				

* Zero in this column indicates an original page.

FOREWORD

This Technical Order (TO) and NATO STANAG 3896 has been designed to provide information and establish procedures that may be encountered during various types of emergencies on US Air Force, US Army, selected commercial for the Civil Reserve Airfleet, US Navy/Marines, USCG, NOAA, other US Government, NASA, NATO and Partners for Peace aircraft. These aircraft could land or have an incident at your location on any given day, making inclusion in this manual very necessary. Each emergency presents a different problem, but with a thorough knowledge of the TO, you as a Fire and Emergency Services Technician can make knowledgeable decisions in performing a critical aircraft rescue or incident mishap response. Aircraft accident personnel, from post fire to clean-up should also be familiar with this information to aid in a successful conclusion to a aircraft incident.

Firefighting and emergency response is a highly technical profession in and around grounded or crashed aircraft and the **rescue of aircraft occupants will take precedence over all other operations until it is established that there is no further life hazard involved.** The secondary responsibility is to **extinguish and limit the damage to the aircraft by fire or explosion.** During the rescue of entrapped personnel, the sequence of events listed in this TO should be followed. **Due to the variations injected in every situation, the senior firefighting officer-in-charge has the prerogative to change or alter the sequencing of events as he/she deems necessary.** In addition, the senior firefighting officer-in-charge may use all equipment and resources available to accomplish the rescue regardless of prescribed instructions contained within this TO. Preplanning for various emergencies is another extremely important function of the Fire and Emergency Services or Emergency Response Technician. Each technician must know his/her duties as they are outlined in the pre-planning for aircraft emergencies. This knowledge cannot be acquired solely from the study of the diagrams published in this TO and should not be construed to replace or substitute frequent "hands-on" training with crew members and aircraft.

Constant attention must be given to the aircraft construction, position and location of crew members and passengers, aircraft skin penetration points, normal and emergency entry points (internal and external), ejection seat safety and canopy jettison removal with associated impact areas for ejected seats and canopies, armament, fuel amount, oxygen systems, batteries, overheated brakes and exploded wheel shrapnel areas, engine intake and exhaust danger areas, radar emitting areas, composite material areas, various hazardous chemicals, gases, fluids, possible radioactive materials and all other points of interest that would lead to early rescue of aircraft personnel safely. Therefore, it is essential that all material contained herein be studied and assimilated by all Fire and Emergency Services and aircraft accident personnel.

The TO information contained herein is based on Source Data that is provided by System Program Offices for specific weapon systems or aircraft manufacturers or systems safety engineers or a verification review by the technical content manager. Modifications to a weapons system where fire fighting procedures are affected or changed are also provided to HQ AFCESA/CEXF. Source Data is provided in accordance with Data Identification Description DI-TMSS 81532 dated 24 January 1997.

All information, once edited and formatted for publishing, is returned to the originator of the information and reviewed for accuracy in all statements and technical procedures. The information is then sent and published to the authorized web site. Any new information in the form of Safety Supplements, Changes, or Revisions is revealed through a formal notification to all USAF major air commands who in-turn notify all their field units under their command. The TO 00 Series manager at Robins AFB, GA will update the 01 Index in the JCALS TO System. NATO customers will be informed through the official web site of the Crash Fire Rescue Working Panel. All other customers outside of this process will find it necessary to monitor the authorized web site of any change to this publication.

At no time will there be any outdated information posted at the authorized web site of this TO. All customers/users of this TO are reminded not to use outdated information in their possession. Any copies of this TO, used for training or actual operations, that is outdated and superceded by a more current version should be destroyed.

Any technical content questions about TO 00-105E-9, contact:

HQ AFCESA/CEXF
139 Barnes Drive Suite 1
Tyndall AFB, FL 32403-5319
Attention: US Air Force Fire and Emergency Services Egress Manager

DSN 523-6150 FAX 523-6390
Comm: (850) 283-6150
Comm FAX: (850) 283-6383
HQAFCESA.CEXF@tyndall.af.mil

LIST OF ILLUSTRATIONS

* A Boeing 707 airframe redesignated as the 717 military version. This is not the current Boeing 717 designation from the original McDonnell Douglas MD-95 design.

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS

* INFORMATION PENDING

LIST OF ILLUSTRATIONS

* INFORMATION PENDING

LIST OF ILLUSTRATIONS

* INFORMATION PENDING

LIST OF ILLUSTRATIONS

* INFORMATION PENDING

LIST OF ILLUSTRATIONS

* INFORMATION PENDING

MILITARY AIRCRAFT PREFIX IDENTIFICATION/FUNCTION FOR THIS MANUAL			
PREFIX ID	**MILITARY FUNCTION**	**PREFIX ID**	**MILITARY FUNCTION**
A	ATTACK	N	TEST BED
B	BOMBER	O	OBSERVATION
C	CARGO/TRANSPORT	Q	SPECIAL TEST
E	ELECTRONIC	R	RECONNAISSANCE
F	FIGHTER	S	STRATEGIC
H	HELICOPTER	T	TRAINER
K	TANKER	U	UTILITY
M	SPECIAL OPERATIONS	V	VIP CARRIER

NOTE: COMBINATION OF PREFIXES DENOTES MULTI-ROLE MISSION. DOES NOT APPLY TO NATO AIRCRAFT.

NATO NATION DESIGNATIONS-THREE LETTER ISO CODES (REF: STANAG 1059 ED8)

BEL: BELGIUM
BGR: BULGARIA
CAN: CANADA
CZE: CZECH REPUBLIC
DNK: DENMARK
EST: ESTONIA
FRA: FRANCE
GEU: GERMANY
GRC: GREECE
HUN: HUNGARY
ISL: ICELAND
ITA: ITALY
LVA: LATVIA
LTU: LITHUANIA
LUX:LUXEMBOURG
NLD: NETHERLANDS
NOR: NORWAY
POL: POLAND
PRT: PORTUGAL
ROU: ROMANIA
SVK: SLOVAKIA
SVN: SLOVENIA
ESP: SPAIN
TUR: TURKEY
GBR: UNITED KINGDOM
USA: UNITED STATES

PARTNERS FOR PEACE (PFP) *

ALB: ALBANIA
ARM: ARMENIA
AUT: AUSTRIA
AZE: AZERBAIJAN
BLR: BELARUS
HRV: CROATIA
FIN: FINLAND
GEO: GEORGIA
IRL: IRELAND
KAZ: KAZAKHSTAN
KGZ: KYRGYZSTAN
MDA: REPUBLIC OF MOLDOVA
RUS: RUSSIAN FEDERATION
SWE: SWEDEN
CHE: SWITZERLAND
TJK: TAJIKISTAN
TKM: TURKMENISTAN
UKR: UKRAINE
UZB: UZBEKISTAN
FYR: FORMER REPULIC OF MACEDONIA

***** Nations cooperating with NATO. Membership pending.

FAA/ICAO DESIGNATORS

Different aircraft designations between the military and Federal Aviation Adminstration (FAA) / International Civil Aviation Organization (ICAO) have been known for sometime. However, air traffic control (ATC) have adopted the official source for FAA/ICAO aircraft designations IAW FAA Order 7110.65, *Air Traffic Control* and ICAO standards. ATC is required to use the official designators in all written and verbal communications. This action has been adopted by the military and has led to confusion in correctly identifying aircraft by military emergency responders. To solve this problem and eliminate emergency response delays, the FAA AT publication Appendices A and B have been added to this publication to help in the identification process.

FAA/ICAO Aircraft Designators/Information for Control Towers (Appendix A)

TYPE ENGINE ABBREVIATIONS

P	piston
T	jet/turboprop
J	jet

CLIMB AND DESCENT RATES

Climb and descent rates based on average en route climb/descent profiles at median weight between maximum gross takeoff and landing weights.

SRS

SRS means "same runway separation;" categorization criteria is specified in para 3-9-6, Same Runway Separation.

MANUFACTURERS

Listed under the primary manufacturer are other aircraft manufacturers who also make versions of some of the aircraft in that group.

AIRCRAFT WEIGHT CLASSES

a. Heavy. Aircraft capable of takeoff weights of more than 255,000 pounds whether or not they are operating at this weight during a particular phase of flight.

b. Large. Aircraft of more than 41,000 pounds, maximum certificated takeoff weight, up to 255,000 pounds.

c. Small. Aircraft of 41,000 pounds or less maximum certificated takeoff weight.

STAGE 3 AIRCRAFT DESIGNATORS

Stage 3 aircraft designators such as B72Q, B73Q, DC8Q, DC9Q are only for use within the U.S. These designators will not be recognized in Canadian airspace or any other airspace outside the U.S.

NOTE-
** Denotes single-piloted military turbojet aircraft or aircraft to receive the same procedural handling as a single-piloted military turbojet aircraft.*

**** Denotes amphibian aircraft.*

+ Denotes aircraft weighing between 12,500 lbs. and 41,000 lbs. For Class B Airspace rules, these aircraft are "large, turbine-engined powered aircraft."

FIXED-WING AIRCRAFT

AERONCA (USA- see Bellanca)

AERO SPACELINES (USA)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Super Guppy, Super Turbine Guppy	SGUP	4T/L	1,500	1,500	III

AEROSPATIALE (France) *(Also MORANE-SAULNIER, PZL-OKECIE, SOCATA, SUD, SUD-EST, TBM)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Rallye, Rallye Club, Super Rallye, Rallye Commodore, Minerva (MS-880 to 894)	RALL	1P/S	750	750	I
Caravelle SE 210	S210	2J/L	2,300	2,000	III
Corvette SN601	S601	2J/S+	2,500	2,000	III
Tampico TB-9	TAMP	1P/S	600	700	1
TBM TB-700	TBM7	1T/S	1,700	1,500	1
Tabago TB10C/200	TOBA	1P/S	700	700	1
Trinidad TB-20/21	TRIN	1P/S	850	700	1

AEROSPATIALE/AERITALIA (France/Italy) *(Also ATR, ALENIA)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
ATR-42-200/300/320	AT43	2T/L	2,000	2,000	III
ATR-42-400	AT44	2T/L	2,000	2,000	III
ATR-42-500	AT45	2T/L	2,000	2,000	III
ATR-72	AT72	2T/L	2,000	2,000	III

AEROSPATIALE/BRITISH AEROSPACE (France/UK) *(Also BAC, SUD, SUD-BAC)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Concorde	CONC	4J/H	5,000	5,000	III

AIRBUS INDUSTRIES (International)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
A300B2	A30B	2J/H	3,500	3,500	III
A300B4 - 600	A306	2J/H	3,500	3,500	III
A310	A310	2J/H	3,500	3,500	III
A319	A319	2J/L	3,500	3,500	III
A320	A320	2J/L	3,500	3,500	III
A321	A321	2J/L	3,500	3,500	III
A330	A330	2J/H	3,500	3,500	III
A340	A340	4J/H	3,500	3,500	III

AIR TRACTOR , INC. (USA)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Air Tractor 401/301	AT3P	1P/S	1,000	-	I

ALON, INC. (USA) *(Also AIR PRODUCTS, ERCO, FORNAIRE, FORNEY, MOONEY)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Aircoupe A2/F-1	ERCO	1P/S	630	630	I

ASTRA JET (USA- see Israel Aircraft Industries)

AVIONS MUDRY ET CIE (France) (Now called MUDRY) *(Also CAARP)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Cap 10	CP10	1P/S	1,500	2,000	I
Cap 20	CP20	1P/S	1,500	2,000	I

BEAGLE AIRCRAFT (UK) *(Also BEAGLE-AUSTER)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
B.206 Basset Series	BASS	2P/S	1,200	1,300	II
B.121 Pup Series	PUP	1P/S	575	750	I

BEECH AIRCRAFT COMPANY (USA) *(Also CCF, COLEMILL, DINFIA, EXCALIBUR, FUJI, HAMILTON, JETCRAFTERS, RAYTHEON, SWEARINGEN, VOLPAR)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Beech 1900/C-12J	B190	2T/S+	2,400	2,400	III
Super King Air 350	B350	2T/S+	3,000	3,000	III
King Air 100 A/B (U-21F Ute)	BE10	2T/S	2,250	2,250	II
Stagger Wing 17 (UC-43 Traveler)	BE17	1P/S	1,375	1,375	I
Twin Beech 18/Super H18	BE18	2P/S	1,400	1,000	II
Sport 19, Musketeer Sport	BE19	1P/S	680	680	I
Super King Air 200, 1300	BE20	2T/S+	2,450	2,500	II
Sundowner 23, Musketeer 23	BE23	1P/S	740	800	I
Sierra 24, Musketeer Super	BE24	1P/S	1,000	1,000	I
Super King Air 300/300LW	BE30	2T/S+	3,000	3,000	III
Bonanza 33, Debonair (E-24)	BE33	1P/S	1,000	1,000	I
Bonanza 35	BE35	1P/S	1,200	1,200	I
Bonanza 36	BE36	1P/S	1,100	1,100	I
Beechjet 400/T-1 Jayhawk	BE40	2J/S+	3,300	2,200	III
Twin Bonanza 50	BE50	2P/S	1,600	1,600	II
Baron 55/Chochise	BE55	2P/S	1,700	1,700	II
Baron 58, Foxstar	BE58	2P/S	1,730	1,730	II
Duke 60	BE60	2P/S	1,600	1,600	II
Queen Air 65 (U-8F Seminole)	BE65	2P/S	1,300	1,300	II
Duchess 76	BE76	2P/S	1,500	1,500	II
Skipper 77	BE77	1P/S	750	750	I
Queen Air 80	BE80	2P/S	1,275	1,275	II
Travelair 95	BE95	2P/S	1,250	1,250	II
Airliner 99	BE99	2T/S	1,750	1,750	II
King Air 90, A90 to E90 (T-44, V-C6), Taurus 90	BE9L	2T/S	2,000	2,000	II
Beech F90 King Air	BE9T	2T/S	2,600	2,600	II

BEECH AIRCRAFT COMPANY (USA) (Also CCF, COLEMILL, DINFIA, EXCALIBUR, FUJI, HAMILTON, JETCRAFTERS, RAYTHEON, SWEARINGEN, VOLPAR) **(CONTINUED)**

Starship 2000	STAR	2T/S+	2,650	2,650	III
Mentor T34A/B, E-17	T34P	1P/S	1,150	1,150	I
Turbo Mentor T-34C	T34T	1T/S	1,100	1,000	I
Ute	U21	2T/S	2,000	2,000	II

BELLANCA AIRCRAFT (USA) *(Also AERONCA, CHAMPION, DOWNER, HINDUSTAN, NORTHERN)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Aeronca Chief/Super Chief, Pushpak	AR11	1P/S	500	500	I
Aeronca Sedan	AR15	1P/S	500	500	I
Cruisair, Cruismaster 14-19	B14A	1P/S	1,030	1,030	I
Super Viking,Turbo Viking	BL17	1P/S	1,100	1,100	I
Decathlon, Super Decathlon, Scout 8	BL8	1P/S	1,000	1,000	I
Champion Lancer 402	CH40	2P/S	650	1,000	II
7 Champion Citabria, Traveler, Tri-Con, Tri-Traveler, Champ 7AC/7ACA/7BCM/ 7CC/7CCM/7DC/ 7EC/7ECA/7FC/7JC	CH7A	1P/S	750	750	I
7 Champion Challenger, Citabria, DX'er, Olympia, SkyTrac 7GC/7GCA/ 7GCAA/7GCB/ 7GCBA/7GCBC/ 7HC/7KC/7KCAB	CH7B	1P/S	1,100	1,100	I

BOEING COMPANY (USA) *(Also GRUMMAN, NORTHROP-GRUMMAN, IAI)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Stratofortress	B52	8J/H	3,000	3,000	III
707-100, VC-137707-100, VC-137	B701	4J/H	3,500	3,500	III
707-300, E-8 J-Stars, EC-137	B703	4J/H	3,500	3,500	III
717-200	B712	2J/L	-	-	III
720	B720	4J/L	3,000	3,000	III
727-100 (C-22)	B721	3J/L	4,500	4,500	III

BOEING COMPANY (USA) *(Also GRUMMAN, NORTHROP-GRUMMAN, IAI)* **(CONTINUED)**

727-200	B722	3J/L	4,500	4,500	III
727 Stage 3 (-100 or -200)	B72Q	3J/L	4,500	4,500	III
737-100	B731	2J/L	3,000	3,000	III
737-200 (Surveiller, CT-43, VC-96)	B732	2J/L	3,000	3,000	III
B737 Stage 3	B73Q	2J/L	3,000	3,000	III
737-300	B733	2J/L	5,500	3,500	III
737-400	B734	2J/L	6,500	3,500	III
737-500	B735	2J/L	5,500	3,500	III
737-600	B736	2J/L	4,000	4,000	III
737-700	B737	2J/L	4,000	4,000	III
737-800	B738	2J/L	4,000	4,000	III
747-100	B741	4J/H	3,000	3,000	III
747-200	B742	4J/H	3,000	3,000	III
747-300	B743	4J/H	3,000	3,000	III
747-400	B744	4J/H	3,000	3,000	III
747SR	B74R	4J/H	3,000	3,000	III
747SP/SUD	B74S	4J/H	3,000	3,000	III
757-200	B752	2J/L	3,500	2,500	III
757-300	B753	2J/L	3,500	2,500	III
767-200	B762	2J/H	3,500	3,500	III
767-300	B763	2J/H	3,500	3,500	III
767 AWACS (E-767)	E767	2J/H	2,500	2,500	III
777-200	B772	2J/H	2,500	2,500	III
777-300	B773	2J/H	2,500	2,500	III
C-135 Stratolifter (EC-135, NKC-135, OC-135, TC-135, WC-135)	C135	4J/H	2,000	2,000	III
Stratotanker KC-135A (J57)	K35A	4J/H	2,500	3,000	III
Stratotanker KC-135D/E (TF33)	K35E	4J/H	5,000	3,000	III
Stratotanker KC-135R/T (CFM56)	K35R	4J/H	5,000	3,000	III
RC-135	R135	4J/H	3,000	3,000	III
Stratofreighter	C97	4P/L	2,500	3,000	III
E-3A (TF33)/B/C Sentry	E3TF	4J/H	3,500	4,000	III
E6 Mercury	E6	4J/	3,500	3,500	III
KE-3	KE3	4J/	3,500	3,500	III
Stearman	ST75	1P/S	840	840	I

BRITISH AEROSPACE (BAe) (UK) *(Also AIL, AVRO, BAC, BUCURESTI, DE HAVILLAND, HANDLEY-PAGE, HAWKER-SIDDELEY, JETSTREAM, KANPUR, MCDONNELL-DOUGLAS, RAYTHEON, SCOTTISH-AVIATION, VOLPAR)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
BAe HS 748 (Andover, C-91)	A748	2T/L	2,500	2,000	III
Jetstream 61, Advance Turboprop (ATP)	ATP	2T/L	3,000	3,000	III
BAC One-Eleven	BA11	2J/L	2,400	2,400	III
BAe 146, RJ, Quiet Trader, Avroliner	BA46	4J/L	3,500	3,500	III
BAe HS 125 Series 1/2/3/400/600	H25A	2J/S+	2,500	2,000	III
BAe HS 125 Series 700/800	H25B	2J/S+	3,000	4,000	III
BAe HS 125 Series 1000	H25C	2J/S+	3,000	4,000	III
BAe Harrier	HAR*	1J/L	5,000	8,000	III
Jetstream 1	JS1	2T/S+	2,200	2,200	III
Jetstream 200	JS20	2T/S+	2,200	2,200	III
Jetstream 3	JS3	2T/S+	2,200	2,300	III
BAe-3100 Jetstream 31	JS31	2T/S+	2,200	2,200	III
BAe-3200 Jetstream Super 31	JS32	2T/S+	2,600	2,600	III
BAe-4100 Jetstream 41	JS41	2T/L	2,200	-	III

BRITTEN NORMAN LTD. (a subsidiary of Pilatus Aircraft LTD.) (UK) *Also AVIONS FAIREY, BAC, BUCURESTI, DE HAVILLAND, HAWKER-SIDDELEY, IRMA, PADC, ROMAERO, VICKERS)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
BN-2A/B Islander, Defender	BN2P	2P/S	1,250	1,250	II
BN-2T Turbine Islander, Turbine Defender	BN2T	2T/S	1,500	1,500	II
Trident	TRID	3J/L	3,000	3,000	III
BN-2A Mark III Trislander	TRIS	3P/S	1,200	1,000	III
VC-10	VC10	4J/H	1,900	2,000	III
Viscount	VISC	4T/L	1,200	1,500	III

BUSHMASTER AIRCRAFT CORP. (USA) (Now AIRCRAFT HYDRO-FORMING)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Bushmaster 2000	BU20	3P/S+	2,000	2,000	III

CAMAIR AIRCRAFT CORP. (USA) *(Also RILEY, TEMCO)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Twin Navion 480, 55, D-16	TNAV	2P/S	1,800	2,000	II

CANADAIR BOMBARDIER LTD. (Canada)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Regional Jet	CARJ	2J/L	3,000	-	III
CL600/610 Challenger	CL60	2J/L	2,250	3,000	III

CESSNA AIRCRAFT COMPANY (USA) *(Also AVIONES-COLOMBIA, COLEMILL, DINFIA, ECTOR, FMA, FUJI, REIMS, RILEY, SUMMIT, WREN)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Dragonfly 318E	A37*	2J/S	3,370	3,000	III
Cessna 120	C120	1P/S	640	640	I
Cessna 140	C140	1P/S	640	640	I
Cessna 150	C150	1P/S	670	1,000	I
Cessna 152	C152	1P/S	750	1,000	I
Cessna 170	C170	1P/S	690	1,000	I
Skyhawk 172/Cutlass/ Mescalero	C172	1P/S	650	1,000	I
Cutlass RG, 172RG	C72R	1P/S	650	1,000	I
Skylark 175	C175	1P/S	850	1,000	I
Cardinal 177	C177	1P/S	850	1,000	I
Cardinal RG, 177RG	C77R	1P/S	850	1,000	I
Skywagon 180 (U-17C)	C180	1P/S	1,130	1,130	I
Skylane 182	C182	1P/S	890	1,000	I

CESSNA AIRCRAFT COMPANY (USA) *(Also AVIONES-COLOMBIA, COLEMILL, DINFIA, ECTOR, FMA, FUJI, REIMS, RILEY, SUMMIT, WREN)* **(CONTINUED)**

Skylane RG, Turbo Skylane RG, R182, TR182	C82R	1P/S	890	1,000	I
Skywagon 185 (U-17A/B)	C185	1P/S	1,000	1,000	I
AGWagon/AGTruck/ AGHusky 188	C188	1P/S	1,000	1,000	I
Cessna 190	C190	1P/S	1,090	1,090	I
Cessna 195	C195	1P/S	1,200	1,200	I
Super Skywagon/ Super Skylane	C205	1P/S	965	1,000	I
Stationair 6, Turbo Stationair 6	C206	1P/S	975	1,000	I
Stationair/Turbo Stationair 7/8	C207	1P/S	810	1,000	I
Caravan 1- 208, (Super) Cargomaster, Grand Caravan (U27)	C208	1T/S	1,400	1,400	I
Centurion 210, Turbo Centurion	C210	1P/S	900	1,000	I
Pressurized Centurion	P210	1P/S	1,000	1,000	I
Crusader 303	C303	2P/S	3,500	3,000	II
Cessna 310/Riley 65, Rocket	C310	2P/S	2,800	2,000	II
Skyknight 320	C320	2P/S	2,900	2,000	II
Cessna 335	C335	2P/S	2,200	2,000	II
Skymaster 336	C336	2P/S	1,340	1,340	II
Super Skymaster 337	C337	2P/S	1,250	1,500	II
Pressurized Skymaster T337G, P337	P337	2P/S	1,250	1,500	II
Cessna 340	C340	2P/S	2,900	2,000	II
Cessna 401, 402, Utiliner, Businessliner	C402	2P/S	2,500	2,000	II
Titan 404	C404	2P/S	2,600	2,000	II
Caravan 2 - F406	F406	2T/S	1,850	-	II
Cessna 411	C411	2P/S	2,800	2,000	II
Chancellor 414, Rocket Power	C414	2P/S	2,300	2,000	II
Golden Eagle 421	C421	2P/S	3,200	2,000	II
Corsair/Conquest I-425	C425	2T/S	3,500	2,500	II
Conquest/Conquest 2 - 441	C441	2T/S	4,200	3,000	II
Citation 1	C500	2J/S	3,100	3,500	III
Citation 1-SP	C501	2J/S	4,300	3,000	III
Citationjet C525	C525	2J/S	3,000	-	III

CESSNA AIRCRAFT COMPANY (USA) (Also AVIONES-COLOMBIA, COLEMILL, DINFIA, ECTOR, FMA, FUJI, REIMS, RILEY, SUMMIT, WREN) **(CONTINUED)**

Citationjet C526	C526	2J/S	3,000	-	III
Citation 2/-S2	C550	2J/S+	5,300	3,000	III
Citation 2-SP	C551	2J/S	5,300	3,000	III
Citation 5	C560	2J/S+	6,000	3,500	III
Citation 3/6/7	C650	2J/S+	3,900	4,000	III
Citation 10	C750	2J/S+	3,500	3,500	III
Bird Dog 305/321	O1	1P/S	1,150	1,150	I
Cessna 318	T37*	2J/S	3,000	3,000	III

CHAMPION (USA-see Bellanca Aircraft)

CONSTRUCCIONES AERONAUTICAS (CASA) (Spain) *(Also NURTANIO, NUSANTARA)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
C-212 Aviocar	C212	2T/S+	900	900	III

CHRISTEN INDUSTRIES, INC. (USA) *(Also AVIAT)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
A-1 Huskey	HUSK	1P/S	1,500	1,500	I

COLEMILL (USA) *(See BEECH, PIPER, CESSNA)*

CURTIS-WRIGHT CORP. (USA)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Commando C-46 (CW-20)	C46	2P/L	600	700	III

DASSAULT-BREGUET (France)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Falcon 10, Mystere 10	FA10	2J/S+	2,300	1,600	III
Falcon 20, Mystere 20 (T-11)	FA20	2J/S+	2,000	2,200	III
Falcon 50, Mystere 50 (T-16)	FA50	3J/S+	1,800	1,600	III
Falcon 900, Mystere 900 (T-18)	F900	3J/L	2,000	1,700	III
Falcon2000	F2TH	2J/S+	2,500	1,500	III

DEHAVILLAND (Canada/UK) *(Also AIRTECH, HAWKER-SIDDELEY, OGMA, RILEY, SCENIC)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Comet DH-106	COMT	4J/L	2,900	2,000	III
Chipmunk DHC-1	DHC1	1P/S	900	1,000	I
Beaver DHC-2	DHC2	1P/S	840	1,000	I
Turbo Beaver DHC-2T	DH2T	1T/S	1,220	1,000	I
Otter DHC-3	DHC3	1P/S	750	1,000	I
Caribou DHC-4	DHC4	2P/S+	1,350	1,000	III
Buffalo DHC-5D/E	DHC5	2T/L	2,000	1,500	III
Twin Otter DHC-6 (all series)	DHC6	2T/S	1,600	1,800	II
Dash 7 DHC-7	DHC7	4T/L	4,000	4,000	III
Dash 8, DHC8 - 100	DH8A	2T/L	1,500	1,500	III
Dash 8, DHC8 - 200	DH8B	2T/L	1,500	1,500	III
Dash 8, DHC8 - 300	DH8C	2T/L	1,500	1,500	III
Dash 8, DHC8 - 400	DH8D	2T/L	2,500	2,500	III
Dove DH-104	DOVE	2P/S	1,420	1,420	II
Heron DH-114	HERN	4P/S+	1,075	1,075	III

DIAMOND (Canada) *(Also HOAC)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
DV-20 Katana, DA-22 Speed Katana	DV20	1P/S	730	-	I

DORNIER GmbH (FRG) *(Also CASA, HINDUSTAN)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Do 228-100/200 Series	D228	2T/S+	2,000	2,000	III
Do 328 Series	D328	2T/S+	2,000	2,000	III
Do 27	DO27	1P/S	700	800	I
Do 28 A/B (Agur)	DO28	2P/S	1,500	1,500	II
Do 28D/D-1/D-2, 128-2 Skyservant	D28D	2P/S	1,000	-	II
Do-28D-6, 128-6 Turbo Skyservant	D28T	2T/S	1,500	-	II

EMBRAER (Brazil)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Bandeirante EMB-110/111	E110	2T/S+	1,500	1,500	II
Brasilia EMB-120	E120	2T/S+	2,300	2,300	III
EMB-145	E145	2J/L	2,350	-	III

EXTRA (Germany)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Extra 200	E200	1P/S	1,000	1,000	I
Extra 230	E230	1P/S	1,500	1,500	I
Extra 300, 350	E300	1P/S	2,500	1,500	I
Extra 400	E400	1P/S	1,500	1,500	I

FAIRCHILD INDUSTRIES (USA-includes Swearingen Aviation) *(Also CONAIR, FAIRCHILD-HILLER, FLEET, FOKKER, KAISER, PILATUS, SWEARINGEN)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Thunderbolt II	A10*	2J/L	6,000	5,000	III
Flying Box Car	C119	2P/L	750	750	III
Provider	C123	2P/L	890	1,000	III
Friendship F27, F227, Troopship, Maritime, Firefighter	F27	2T/L	3,000	3,000	III
Cornell	FA62	1P/S	650	650	I
Pilatus/Peacemaker/ Porter	PC6P	1P/S	580	600	I
Turbo Porter	PC6T	1T/S	580	600	I
Merlin 2	SW2	2T/S	2,350	2,500	II
Merlin 3	SW3	2T/S+	2,350	2,500	III
Metro, Merlin 4	SW4	2T/S+	2,400	2,500	III

FOKKER BV (Netherlands) *(Also FAIRCHILD, FAIRCHILD-HILLER)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Friendship F27, Troopship, Maritime, Firefighter	F27	2T/L	3,000	3,000	III
Fellowship F28	F28	2J/L	4,650	2,000	III
Fokker 50, Maritime Enforcer	F50	2T/L	3,500	3,500	III
Fokker 60	F60	2T/L	3,500	3,500	III
Fokker 70	F70	2J/L	4,500	3,000	III
Fokker 100	F100	2J/L	3,500	3,500	III

GATES LEARJET CORP. (USA) *(Also LEAR JET, LEARJET, SHIN MEIWA)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Learjet 23	LJ23	2J/S	4,500	4,000	III
Learjet 24	LJ24	2J/S+	4,500	4,000	III
Learjet 25	LJ25	2J/S+	4,500	4,000	III
Learjet 28, 29	LJ28	2J/S+	4,500	4,000	III
Learjet 31	LJ31	2J/S+	4,500	4,000	III
Learjet 35, 36	LJ35	2J/S+	4,500	4,000	III
Learjet 55	LJ55	2J/S+	5,000	4,000	III
Learjet 60	LJ60	2J/S+	5,000	4,000	III

GENERAL DYNAMICS CORP. (USA) *(Also BOEING CANADA, CANADAIR, CANADIAN VICKERS, CONSOLIDATED, CONVAIR, FOKKER, KELOWNA, LOCKHEED, LOCKHEED MARTIN, MITSUBISHI, SABCA, SAMSUNG, TUSAS)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Canso/Catalina***	CAT	2P/S+	600	600	III
Convair 990	CV99	4J/L	2,500	2,500	III
Convair 240/340/440, Liner, Samaritan	CVLP	2P/L	1,000	800	III
Convair 540/580/600/640	CVLT	2T/L	1,500	1,500	III
F-111/FB-111	F111*	2J/L	5,000	5,000	III
Fighting Falcon	F16*	1J/L	8,000	5,000	III
Valiant	VALI	1P/S	600	750	I

GOVERNMENT AIRCRAFT FACTORIES (Australia) (Now GAF)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
N2/22/24 Nomad	NOMA	2T/S	1,300	1,100	II

GREAT LAKES (USA)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Sport Trainer, Sport, 2T-1	G2T1	1P/S	1,000	800	I

GROB (Germany)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
G109 Ranger (Vigilant)	G109	1P/S	600	600	I
G115 A/B/C/D, Bavarian (Heron)	G115	1P/S	1,200	1,100	I

GRUMMAN AEROSPACE CORP. (USA) *(Also AERO MOD, AMERICAN GENERAL, GRUMMAN AMERICAN, GULF- STREAM AMERICAN, MID-CONTINENT, NORTHROP GRUMMAN, SERV-AERO)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Intruder, Prowler	A6*	2J/L	7,500	5,000	III
AA1 Trainer, Yankee, TR/TS-2, T-Cat, Lynx	AA1	1P/S	850	1,250	I
Cheetah AA-5, Traveller, Tiger	AA5	1P/S	660	1,000	I
Greyhound	C2	2T/L	1,000	2,200	III
Hawkeye, Daya	E2	2T/L	2,690	3,000	III
Tomcat	F14*	2J/L	6,000	4,000	III
Model G-164 Ag-Cat, Super Ag-Cat, King Cat	G164	1P/S	1,500	1,500	I
Model G164 Turbo Ag-Cat	G64T	1T/S	1,500	1,500	I
Goose/Super Goose	G21	2P/S+	1,000	1,000	III
Widgeon/Super Widgeon	G44	2P/S+	1,000	1,500	III
Mallard***	G73	2P/S+	1,600	1,600	III
Cougar GA-7	GA7	2P/S	1,600	1,500	II
Albatross***	U16	2P/S+	1,500	1,500	III
Mohawk	V1	2T/S+	2,100	1,300	I

GULFSTREAM AEROSPACE CORP. (USA) *(Also GRUMMA N, GRUMMAN AMERICAN, GULFSTREAM, GULFSTREAM AMERICAN)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
GAC 159-C, Gulfstream 1	G159	2T/S+	2,000	2,000	III
Gulfstream 2	GLF2	2J/L	5,000	4,000	III
Gulfstream 3	GLF3	2J/L	5,000	4,000	III
Gulfstream 4	GLF4	2J/L	5,000	4,000	III
Gulfstream 5	GLF5	2J/L	5,000	4,000	III

HAMBURGER FLUGZEUBAU (FRG) (Now HFB) *(Also MBB)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
HFB-320 Hansajet	HF20	2J/S+	4,500	4,500	III

HANDLEY PAGE (UK) *(Also BRITISH AEROSPACE, JETSTREAM, SCOTTISH AVIATION, VOLPAR)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
HP-137 Jetstream 1	JS1	2T/S+	2,200	2,200	III
HP-137Jetstream 200	JS20	2T/S+	2,200	2,200	III

HAMILTON AVIATION (USA) *(Also VOLPAR)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Westwind 2/3, Turbo 18, Turboliner	B18T	2T/S	2,000	2,000	II

HELIO AIRCRAFT COMPANY (USA)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Courier, Strato-Courier, Super Courier (H-391/392/395/ 250/295/700/800)	COUR	1P/S	850	1,000	I
H-550/A Stallion	STLN	1T/S	2,200	2,200	I
H-580 Twin Courier	TCOU	2P/S	1,250	1,500	II

HOWARD (USA)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
DG-15P, -15W, -15J	DG15	1P/S	1,000	1,000	I

ILYUSHIN (USSR)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
IL-62	IL62	4J/H	3,500	2,500	III
IL-76/78	IL76	4J/H	3,000	2,500	III

ISRAEL AIRCRAFT INDUSTRIES (Israel)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
101 Avara, 102, 201, 202	ARVA	2T/S+	1,300	1,000	III
1123 Westwind	WW23	2J/S+	4,000	3,500	III
1124 Westwind	WW24	2J/S+	4,000	3,500	III

ISRAEL AIRCRAFT INDUSTRIES & ASTRA JET (Israel/USA)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Astra 1125	ASTR	2J/S+	4,000	3,500	III

JETSTREAM (UK - see British Aerospace)

LAKE AIRCRAFT (USA)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
LA-250/270 (Turbo) Renegade/(Turbo) SeaFury***, Seawolf	LA25	1P/S	700	700	I
LA-4/200, Buccaneer***	LA4	1P/S	1,100	1,000	I

LOCKHEED CORP. (USA) *(Also AERITALIA, CANADAIR, FIAT, FOKKER, HOWARD, LEAR, LOCKHEED-MARTIN, MBB, MESSERSCHMITT, MITSUBISHI, PACAERO, ROCKWELL, SABCA)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Hercules, Spectre	C130	4T/L	1,500	1,500	III
C-141 Starlifter	C141	4J/H	3,500	3,000	III
C-5 Galaxy	C5	4J/H	2,500	2,000	III
Constellation, Super Constellation, Starliner (L-049/749/1049/ 1649)	CONI	4P/L	1,700	1,700	III
F-104 Starfighter	F104*	1J/L	5,000	4,000	III
L-1011 Tri-Star (all series)	L101	3J/H	3,500	3,000	III
Lodestar	L18	2P/L	1,800	2,000	III
Electra 188	L188	4T/L	1,850	2,000	III
1329 Jetstar 6/8	L29A	4J/L	4,000	3,500	III
1329-5 Jetstar 2/731	L29B	4J/L	4,000	3,000	III
Orion, Aurora (L-185/285/685/785)	P3	4T/L	1,850	2,000	III
Viking S-3	S3	2J/L	2,000	2,000	III
T-33, T-Bird, F-80 Shooting Star	T33*	2J/L	2,000	2,000	III
TR-1 Trigull	TR1*	1J/L	6,000	6,000	III
U-2	U2*	1J/S+	6,000	6,000	III

MARTIN COMPANY (Division of Martin Marietta) (USA)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Martin 404	M404	2P/L	1,600	1,500	III

MAULE AIRCRAFT CORP. (USA) *(Also SAASA)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
M-4 Strata-Rocket, Astro Rocket, Bee-Dee, Jetasen, Super Rocket	M4	1P/S	1,000	1,000	I
M-5 180C/200/235C Lunar-Rocket, 210TC Strata-Rocket, Patroller	M5	1P/S	1,000	1,000	I
M-6 Super-Rocket	M6	1P/S	1,500	1,000	I
M-7-235, MT-7, MX-7-160/180/235, MXT-7-160/ 180 Super Rocket, Star Rocket	M7	1P/S	825	-	I
M-7-420, MX-7-420, MXT-7-420 Star Craft	M7T	1T/S	4,500	-	I

MCDONNELL-DOUGLAS CORP. (USA) *(Also ASTA, DOUGLAS, GAF, LISUNOV, MITSUBISHI, ON MARK, SHANGHAI, VALMET)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Skywarrior	A3*	2J/L	5,000	6,000	III
Skyhawk	A4*	1J/L	5,000	5,000	III
Invader	B26	2P/L	1,000	1,000	III
Globemaster 3	C17	4J/H	-	-	III
DC-10 (all series)	DC10	3J/H	2,400	2,000	III
Skytrain (C-47, C-53, C-117 A/B/C, R4D 1 to 7)	DC3	2P/S+	1,200	1,200	III
Super DC-3 (C117D, R4D 8)	DC3S	2P/S+	1,330	1,330	III
Skymaster	DC4	4P/L	2,300	2,300	III
DC-6/B Liftmaster	DC6	4P/L	1,000	1,000	III
DC-7/B/CSevenSeas	DC7	4P/L	1,250	1,250	III
DC-8-50, Jet Trader	DC85	4J/H	4,000	4,000	III
DC-8-60	DC86	4J/H	4,000	4,000	III
DC-8-70	DC87	4J/H	5,000	4,000	III
DC-8 Stage 3	DC8Q	4J/H	4,000	4,000	III
DC-9, Skytrain 2, Nightingale	DC9	2J/L	3,000	3,000	III

MCDONNELL-DOUGLAS CORP. (USA) *(Also ASTA, DOUGLAS, GAF, LISUNOV, MITSUBISHI, ON MARK, SHANGHAI, VALMET)* **(CONTINUED)**

DC-9 Stage 3	DC9Q	2J/L	3,000	3,000	III
F-15 Eagle	F15*	2J/L	8,000	5,000	III
F/A-18 Hornet	F18	2J/L	8,000	6,000	III
Phantom 2	F4*	2J/L	8,000	6,000	III
MD-11	MD11	3J/H	-	-	III
MD-80 Series	MD80	2J/L	3,500	3,000	III
MD-90	MD90	2JL	-	-	III

MESSERSCHMITT-BOLKOW-BLOHM (MBB) (FRG) *(Also BOLKOW, HFB, NORD)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
BO 209 Monsun	B209	1P/S	1,100	1,100	I
HFB 320 Hansa Jet	HF20	2J/S+	3,500	3,000	III
ME 108 Taifun	ME08	1P/S	400	500	III

MITSUBISHI AIRCRAFT INTERNATIONAL INC. (USA/Japan) *(Also BEECH, RAYTHEON)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Mitsubishi MU-2, Marquise, Solitaire	MU2	2T/S	3,500	3,000	II
Mitsubishi Diamond I/MU-300	MU30	2J/S+	3,500	4,000	III

MOONEY AIRCRAFT CORP. (USA) *(Also AEROSTAR)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
M-18 Mooney Mite, Wee Scotsman	MITE	1P/S	750	750	I
Mark 10 Cadet	M10	1P/S	800	800	I
M20/A/B/C/D/E/F/ G/J/L/R, Mark 21, Ranger, Master, Super 21, Chaparral, Executive, Statesman, Ovation, 201, 205, ATS, MSE, PFM	M20P	1P/S	1,000	1,000	I
Turbo Mooney M20K/M20M, Encore, 231, 252, TLS, TSE	M20T	1P/S	1,500	1,200	I
Mark 22, Mustang	M22	1P/S	1,300	1,300	I

MUDRY (See AVIONS MUDRY ET CIE)

NAMC (Japan) *(Also MITSUBISHI)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
YS-11	YS11	2T/L	1,500	1,500	III

NAVION RANGEMASTER AIRCRAFT CORP. (USA) *(Also CAMAIR, RILEY, TEMCO)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Rangemaster	RANG	1P/S	1,250	1,500	I
Twin Navion 480, 55	TNAV	2P/S	1,800	1,500	II

NOORDYUN AVIATION LTD. (Canada) *(Also CCF)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Norseman Mk 4/5/6	NORS	1P/S	700	1,000	I

NORD AVIATION (Affiliate of Aerospatiale) (France) *(Also HOLSTE, NORDFLUG, TRANSALL)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Transall C-160	C160	2T/L	2,000	2,000	III
Super Broussard 260	N260	2T/S+	2,500	2,000	III
Mohawk 298, Fregate	N262	2T/S+	2,500	2,000	III
Nortatlas 2501 to 2508	NORA	2P/L	1,500	1,500	III

NORTHERN AVIATION (USA-see Bellanca)

NORTHROP CORP. (USA) *(Also CANADAIR, CASA, AIDC, F+W EMMEN, KOREAN AIR)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Freedom Fighter Tiger II	F5*	2J/S+	8,000	5,000	III
T-38 Talon	T38*	2J/S+	8,000	5,000	III

PARTENAVIA CONSTRUZIONI AERONAUTICHE SpA (Italy)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
P66/64 Charlie, Oscar	OSCR	1P/S	800	1,000	I
P68/B/C/-TC, Victor, Observer/P68R	P68	2P/S	1,200	1,000	I

PARTENAVIA & AERITALIA (Italy)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
AP68TP-300 Spartacus	P68T	2T/S	1,500	1,500	II
AP68TP-600, Viator	VTOR	2T/S	1,500	1,500	II

PIAGGIO (Industrie Aeronautiche E Meccaniche Rinaldo Piaggio SpA) (Italy) *(Also PIAGGIO-DOUGLAS, TRECKER)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
P136 Gull***	P136	2P/S	1,250	1,500	II
P166 Portofino***, Albatross	P66P	2P/S	1,350	1,500	II
Vespa Jet PD808	P808	2J/S+	4,000	3,500	III

PILATUS FLUGZEUGWERKE AG (Switzerland) *(Also FAIRCHILD, FAIRCHILD-HILLER)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
PC-6 Porter	PC6P	1P/S	600	600	I
PC-6A/B/C Turbo Porter	PC6T	1T/S	1,250	1,500	I
PC-7 Turbo Trainer	PC7	1T/S	2,800	-	I
PC-12	PC12	1T/S	1,900	-	I

PIPER AIRCRAFT CORP. (USA) *(Also AEROSTAR, AICSA, CHINCUL, COLEMILL, EMBRAER, INDAER CHILE, JOHNSTON, MACHEN, MILLER, NIEVA, SCHAFER, SEGUIN, PZL-MIELEC, TED SMITH, WAGAERO)*

Model	**Type Designator**	**Description**	**Performance Information**		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Aero Star 600/700	AEST	2P/S	1,500	1,500	II
J-2 Cub	J2	1P/S	500	500	I
J-3 Cub	J3	1P/S	500	500	I
J-4 Cub Coupe	J4	1P/S	500	500	I
J-5 Cub Cruiser	J5	1P/S	500	500	I
Cub Special	PA11	1P/S	500	500	I
Super Cruiser	PA12	1P/S	600	600	I
Family Cruiser	PA14	1P/S	600	600	I
Vagabond Trainer	PA15	1P/S	500	500	I
Clipper	PA16	1P/S	500	500	I
Vagabond	PA17	1P/S	500	500	I
Super Cub	PA18	1P/S	1,000	1,000	I
Pacer	PA20	1P/S	850	1,000	I
Tri-Pacer, Colt, Caribbean	PA22	1P/S	1,000	1,000	I
Apache 150/160	PA23	2P/S	1,050	1,000	II
Comanche	PA24	1P/S	900	1,000	I
Pawnee	PA25	1P/S	650	650	I
Aztec, Turbo Aztec	PA27	2P/S	1,500	1,500	II
Cherokee, Archer, Warrior, Cadet, Cruiser (PA-28 140/150/151/160/161/ 180/181)	P28A	1P/S	750	1,000	I
Dakota, Turbo Dakota, Charger, Pathfinder (PA-28-201,T-235/236)	P28B	1P/S	900	1,000	I
Cherokee Arrrow 2/3, Turbo Arrow 3	P28R	1P/S	750	1,000	I
Cherokee Arrow 4, Turbo Arrow 4	P28T	1P/S	900	1,000	I
Twin Comanche, Turbo Twin Comanche	PA30	2P/S	1,500	1,500	II
Chieftan, Mohave, Navajo, T-1020	PA31	2P/S	1,500	1,500	II
Cherokee Six, Lance, (Turbo) Saratoga	PA32	1P/S	850	1,000	I
Cherokee Lance PA-32R, Saratoga SP, Turbo Saratoga SP	P32R	1P/S	850	1,000	I

PIPER AIRCRAFT CORP. (USA) *(Also AEROSTAR, AICSA, CHINCUL, COLEMILL, EMBRAER, INDAER CHILE, JOHNSTON, MACHEN, MILLER, NIEVA, SCHAFER, SEGUIN, PZL-MIELEC, TED SMITH, WAGAERO)* **(CONTINUED)**

Lance 2, Turbo Lance 2	P32T	1P/S	850	1,000	I
Seneca 2/3	PA34	2P/S	1,300	1,300	II
Brave, Pawnee Brave, Super Brave	PA36	1P/S	800	1,000	I
Tomahawk	PA38	1P/S	750	750	I
Seminole, Turbo Seminole	PA44	2P/S	1,100	1,000	II
Malibu, Malibu Mirage	PA46	1P/S	1,000	1,000	I
Malibu Meridian	P46T	1T/S	1,500	1,500	I
T-1040	PAT4	1P/S	1,300	1,200	I
Cheyenne 1	PAY1	2T/S	2,200	2,000	II
Cheyenne 2	PAY2	2T/S	2,400	2,000	II
Cheyenne 3	PAY3	2T/S	2,400	2,000	II
Cheyenne 400	PAY4	2T/S	2,500	2,000	II
Pillan PA-28R-300	PILL	1P/S	750	1,000	I
Voyager, Station Wagon 108	S108	1P/S	800	800	I

PITTS AEROBATICS (Manufactured by Christen Industries, Inc.)(USA) *(Also AEROTEK, AVIAT, CHRISTEN)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
S-1 Special	PTS1	1P/S	1,500	1,500	I
S-2 Special	PTS2	1P/S	1,500	1,500	I

RAYTHEON (See BEECH)

RILEY AIRCRAFT CORP. (USA) *(Also AVIONES, COLOMBIA, CESSNA, COLEMILL)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
M65 Rocket, Turbo Rocket, Super 310	C310	2P/S	1,500	1,500	II

ROCKWELL INTERNATIONAL CORP. (USA) *(Also AERO COMMANDER, CANADAIR, CCF, COMMANDER, OMMONWEALTH, GULFSTREAM, HAMILTON, MITSUBISHI, NOORDUYN, NORTH AMERICAN PACAERO, PACIFIC AIRMOTIVE, ROCKWELL, RYAN, SUD, TUSCO)*

Model	**Type Designator**	**Description**	**Performance Information**		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Commander 112/114	AC11	1P/S	1,000	1,200	I
Commander 500	AC50	2P/S	1,340	1,500	II
Commander 520	AC52	2P/S	1,340	1,500	II
Commander 560	AC56	2P/S	1,400	1,500	II
Super Commander 680S/E/F/FP	AC68	2P/S	1,375	1,375	II
Grand Commander 685/680FL	AC6L	2P/S	1,250	1,250	II
Alti-Cruiser	AC72	2P/S	1,300	1,300	II
Turbo Commander 680/681 Hawk Commander	AC80	2T/S	2,000	1,500	II
Turbo Commander 690, Commander Jetprop 840/900	AC90	2T/S	2,500	2,500	II
Turbo Commander 695, Commander Jetprop 980/1000	AC95	2P/S	2,500	2,500	II
Lancer	B1*	4J/H	3,000	5,000	III
Mitchell	B25	2P/L	980	980	III
Sabre	F86*	1J/L	4,000	4,000	III
Jet Commander 1121	JCOM	2J/S+	5,000	4,500	III
Lark 100 Commander	LARK	1P/S	700	1,000	I
Commander 200	M200	1P/S	1,400	1,000	I
Navion NA 145/154	NAVI	1P/S	750	600	I
Mustang	P51	1P/S	2,500	2,500	III
Sabreliner 65/40/50/60	SBR1	2J/S+	4,000	3,500	III
Super Sabre F-100	SSAB	1J/L	4,000	4,000	III
Buckeye	T2*	2J/L	5,700	6,000	III
Trojan, Nomair, Nomad	T28	1P/S	2,500	2,500	III
Texan, Harvard	T6	1P/S	800	800	I
Bronco	V10*	2T/S	2,000	2,500	II
Darter 100	VO10	1P/S	850	850	I

RUSHCMEYER (Germany)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
R90R-90-230FG	R90F	1P/S	1,000	1,000	I
R90R-90-230RG, MF-85	R90R	1P/S	1,000	1,000	I

SAAB & FAIRCHILD INDUSTRIES (Sweden/USA)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
SF-340	SF34	2T/L	2,000	2,000	III

SHORT BROTHERS LTD. (UK)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Shorts SC7 Skyvan, Skyliner	SC7	2T/S	1,500	1,500	II
Shorts 330, Sherpa	SH33	2T/S+	1,380	1,380	III
Shorts 360	SH36	2T/S+	1,400	1,400	III

SIAI MARCHETTI SpA (Italy) *(Also AGUSTA)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
SF260TP	F26T	1T/S	1,800	1,100	I
F600, SF-600TP Canguero	F600	2T/S	2,100	-	II

SILVAIRE (USA) *(Also LUCSOME, TEMCO)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Luscombe Silvaire	L8	1P/S	900	1,000	I

SOCATA (See AEROSPATIALE)

STINSON (USA) *(Also PIPER)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Sentinel V-76, L-5, U-19, OY	L5	1P/S	750	750	I
Reliant (Vultee) V-77	RELI	1P/S	700	700	I
Voyager 10/105	S10	1P/S	750	1,000	I
Voyager/Station Wagon 108	S108	1P/S	750	1,000	I

SUD AVIATION (See Aerospatiale)

SWEARINGEN AVIATION (USA-see Fairchild Industries)

TAYLORCRAFT AVIATION CORP. (USA) *(Also TAYLOR KITS)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
F-15 Tourist, Foursome	TA15	1P/S	800	1,000	I
F-19 Sportsman	TF19	1P/S	800	1,000	I
F-20A Topper, Ranchwagon, Seabird, Zephyr	TA20	1P/S	1,000	1,000	I
F-21, T-Kraft	TF21	1P/S	1,100	1,100	I

TED SMITH AEROSTAR CORP. (USA) *(Also AEROSTAR, AICSA, MACHEN, PIPER)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Aero Star	AEST	2P/S	1,800	1,500	II

VFW-FOKKER (Zentralgesellschaft VFW-Fokker mbH (FRG/Netherlands))

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
VFW 614	VF14	2J/L	3,100	3,000	III

VOUGHT CORP. (USA) *(Also GLOBE, LTV, TEMCO)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Corsair A-7, TA-7, EA-7	A7*	1J/L	8,000	6,000	III
Swift	GC1	1P/S	1,000	1,000	I

ZENAIR (Canada) *(Also ZENITH)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
CH-2000 Zenith	CH2T	1P/S	780	-	I

TYPE ENGINE ABBREVIATIONS

P	piston
T	jet/turboprop
J	jet

CLIMB AND DESCENT RATES

Climb and descent rates based on average en route climb/descent profiles at median weight between maximum gross takeoff and landing weights.

SRS

SRS means "same runway separation;" categorization criteria is specified in para 3-9-6, Same Runway Separation.

MANUFACTURERS

Listed under the primary manufacturer are other aircraft manufacturers who also make versions of some of the aircraft in that group.

HELICOPTERS/ROTORCRAFTS

AEROSPATIALE (France)*(Also ATLAS, CASA, CHANGHE, EUROCOPTER, HELIBRAS, HINDUSTAN, IAR, ICA, NURTANIO, NUSANTARA, REPUBLIC, SINGAPORE, SUD, WESTLAND)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Lama SA-315	LAMA	1T/S	1,000	1,000	I
Alouette 2	ALO2	1T/S	1,280	1,280	I
Alouette 3	ALO3	1T/S	1,500	1,500	I
Dauphine SA-360/361	S360	1T/S	1,400	1,500	I
Dauphine 2 SA-365C	S65C	2T/S	1,800	1,000	I
Ecurevil/AStar AS-350/550	AS50	1T/S	1,000	1,000	I
Gazelle SA-341/342	GAZL	1T/S	1,620	1,620	I
Puma SA-330 (CH-33, HT-19)	PUMA	2T/L	1,250	1,500	I
Super Puma AS 332/532, SA-330)	AS32	2T/L	1,250	1,500	I
Super Frelon SA-321/Z-8	FREL	3T/L	1,200	1,500	I
Twin Star AS-355/555	AS55	2T/S	1,350	1,300	I

AUGUSTA (Constuzioni Aeronautiche Giovanni Agusta SpA) (Italy) *(Also BELL, NUSANTARA, SABCA)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Model 147J-3B-1, Ranger	B47J	1P/S	500	500	I
Model A 109/A/A-II	A109	2T/S	1,620	1,500	I
Model 212 ASW, Griffon	B12	2T/S	1,420	1,420	I

BELL/BOEING

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Osprey	V22	2P/L	-	-	II

BELL HELICOPTER TEXTRON (USA) *(Also AGUSTA, AIDC, COMMONWEALTH, DORNIER, FUJI, GLOBAL, KAWASAKI, NUSANTARA, TROOPER, UNC, WESTLAND)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Biglifter, Bell 204, 205, 214A/B,AB-204	UH1	1T/S	1,500	1,500	I
Cobra	HUCO	1T/S	1,375	1,375	I
Jet Ranger/ Long Ranger/ Sea Ranger/ Kiowa/ Model 206, Combat Scout	B06	1T/S	1,200	1,000	I
Huey/Iroquois/ Model 205 A-1	UH1	1T/S	1,500	1,500	I
Ranger Model 47J	B47J	1P/S	1,000	1,000	I
Sioux/Model 47**G**, OH-13	B47G	1P/S	1,000	1,000	I
Twin Huey, Model 212, Model 214B/ B-1, Model 412, Griffon	B12	2T/S	1,420	1,420	I
Model 214ST, Super Transport	BSTP	2T/S	1,420	1,420	I
Model 222, 230, 430	B222	2T/S	1,500	1,000	I

BOEING VERTOL COMPANY (USA) *(Also BOEING HELICOPTERS, KAWASAKI, MERIDIONALI, VERTOL)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Chinook, Model 234	H47	2T/L	1,500	1,500	I
Sea Knight 107, CH-113, Labrador	H46	2T/S+	2,130	2,130	I

BOLKOW (Germany) *(Also CASA, EUROCOPTER, MBB, MESSERSCHMITT-BOLKOW, NURTANIO, NUSANTARA, PADC)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Model 105, BO-105	B105	2T/S	1,500	1,500	I

BRANTLEY-HYNES HELICOPTER, INC. (USA) *(Also BRANTLEY, HYNES)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Model B-2/A/B, H-2	BRB2	1P/S	1,400	1,400	I
Model 305	B305	1P/S	1,300	1,300	I

ENSTROM CORP. (USA) *(Also WUHAN)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Falcon/Model F-28/A/C/F, Sentinel/ Model F-28-FP, Model 280, Shark	EN28	1P/S	800	800	I
Shark/Model 280FX, 28, Falcon, Sentinel	EN28	1P/S	1,200	1,200	I
Turbo Shark 480, TH-28	EN48	1P/S	1,500	1,500	I

FAIRCHILD/REPUBLIC (includes Hiller) (USA) *(Also FAIRCHILD HILLER, ROGERSON HILLER)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Hiller UH-12/ Raven, HTE	UH12	1P/S	1,500	1,500	I

HILLER (See FAIRCHILD/REPUBLIC (USA))

HUGHES HELICOPTERS (See MCDONNELL-DOUGLAS HELICOPTERS (USA))

KAMAN AEROSPACE CORPORATION (USA)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
H-2 Seasprite, Super Seasprite	H2	2T/L	2,400	2,400	I
Huskie 600-3/5	H43B	1T/L	2,000	2,000	I

KAWASAKI HEAVY INDUSTRIES LTD. (Japan) *(Also BOEING VERTOL, VERTOL)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
KV-107/II, Sea Knight, Labrador, Voyaguer, CH-113	H46	2T/S+	1,500	1,500	I

MCDONNELL-DOUGLAS HELICOPTERS (includes Hughes Helicopters) (USA) *(Also AGUSTA, BREDANARDI, KAWASAKI, KOREAN AIR, NARDI, RACA, SCHWEIZER)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Model 77/ Apache, Pethen, Longbow Apache	H64	2T/S+	1,500	1,500	I
Model 269, 200, 280, 300, Skynight, TH-55 Osage	H269	1P/S	1,000	1,000	I
Model 300/C	H269	1P/S	1,200	1,200	I
Model 500C, 369, 530F, Defender, Black Tiger, Night Fox, Lifter	H500	1P/S	1,500	1,500	I
Osage	H269	1P/S	1,000	1,000	I
Pawnee, Model 369, Model 500D/MD/MG	H500	1T/S	1,500	1,500	I

MESSERSCHMIDTT-BOLKOW-BLOHM (MBB) (FRG) *(Also BOLKOW, CASA, EUROCOPTER, MBB, NURTANIO, NUSANTARA, PADC)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Model BO 105	B105	2T/S	1,200	1,200	I

MBB/KAWASAKI (FRG/Japan)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Model BK 117	BK17	2T/S	1,500	1,500	I

ROBINSON HELICOPTER COMPANY INC. (USA)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Model R22	R22	1P/S	800	800	I

SCHWEIZER AIRCRAFT CORP. (USA) *(Also BREDANARDI, HUGHES, KAWASAKI, NARDI)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Model 269C, 200, 280, 300, Skynight	H269	1P/S	1,000	1,000	I

SIKORSKY AIRCRAFT (USA)*(Also AGUSTA, ASTA, HAWKER DE HAVILLAND, HELIPRO, KOREAN AIR, MITSUBISHI, TUSAS, UNITED CANADA, VAT, WESTLAND)*

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
Blackhawk, S-70, WS-70, Seahawk, Pavehawk, Rescuehawk, Thunderhawk, Jayhawk, Oceanhawk, Deserthawk, Yanshuf, LAMPS MK3, Blackhawk	H60	2T/S+	2,000	2,000	I
Chickasaw, S-55, H-19, HO4S, HRS	S55P	1P/S	800	1,000	I
Choctaw/Seashore/ Seaboat S-58, CH-34	S58P	1P/L	1,120	1,120	I
Model S-51	S51	1P/L	1,000	1,000	I
Model S-52, Hummingbird	S52	1P/L	950	1,000	I
Model S-62	S62	1T/S	1,020	1,000	I
Model S-76, Spirit, Eagle	S76	2T/S	1,300	1,300	I
S-61R (CH-3, HH-3, Pelican)	S61R	2T/L	1,500	1,500	I
S-61A/B/D/L/N Sea King, Commando, CH-124	S61	2T/L	1,500	1,500	I
Sea Stallion S-65, Yasur	H53	2T/L	1,500	1,500	I
Skycrane, S-64E/F, Tarhe S-64	S64	2T/L	1,300	1,300	I

WESTLAND HELICOPTERS LTD. (UK)

Model	Type Designator	Description	Performance Information		
		Number & Type Engines/Weight Class	Climb Rate (fpm)	Descent Rate (fpm)	SRS Cat.
WG 30	WG30	2T/S	1,200	1,200	I

NOTE from the Editor:
The FAA/ICAO information for this Technical Order was taken from the FAA web site and makes the same claim. Please read their statement below.

Restriction of Liability & Disclaimer
The FAA makes no promises or guarantees as to the accuracy, completeness, or adequacy of the contents of this web site (http://www.faa.gov/ATPubs/ATC/Chp3/3-9-6) and expressly disclaims liability for errors and omissions in the contents of this web site. Reference in this web site to any specific commercial products, processes, or services, or the use of any trade, firm or corporation name, is for the information and convenience of the public, and in no manner constitutes endorsement or recommendation by the FAA.

CHAPTER 1
INTRODUCTION

1-1. PURPOSE, SCOPE, ARRANGEMENT.

a. The Purpose of this manual is: to provide fire protection, support organizations, either military or civilian, whose duties are related directly or indirectly to the performance of aerospace emergency rescue and mishap response with uniform and chronologically assembled information.

b. The Scope and Arrangement of this manual is: basically two-fold; first to provide general information in Chapter 2, Hazardous Materials and Mishap Hazards in Chapter 3, and secondly specific information for DoD, Civil Reserve Air Fleet, various US Government agencies including NASA and finally NATO aircraft. Each Revision alters the size and content of the information. With this in mind, chapters may change in order to allow the logical flow to continue. Chapter 2 includes general aircraft characteristics with regard to entry and exit facilities; prevention of suffocation; removal of personnel from seats; types, safetying and hazards of ejection seats; and forcible entry. Chapter 3 has been expanded to include valuable informtion for primary and secondary responders. Chapters 4 through the remainder of the publication include, as applicable to any of the given 330+ aircraft, the following information:

c. General Arrangement Information:

(1) Overall Description.

(2) Color Code Legend.

(a) Blue - Fuel (tanks/cells/lines), quantity in US gallons/litres, and location.

(b) Red - Skin penetration, armament, flare and chaff dispensers, controls, switches, door/hatch cut-in areas and portable fire extinguishers.

(c) Yellow - Oxygen/OBIGGS bottles/systems and converters and window cut-in areas.

(d) Black - Batteries.

(e) Purple - Hydrazine.

(f) Orange - N2O4 Nitrogen Tetroxide.

(g) Green - Ammonia.

(h) Brown - Hydraulic and oil fluid systems.

(i) Miscellaneous Colors - Airframe structure, composite materials, chemicals, and radioactive materials. A key will be provided to determine these items corresponding to an accompanying graphic. Other support information may be provided to inform the user of these unstable substances in a mishap response incident.

d. Normal/Manual/Emergency Entry:

(1) Normal/Manual - location and operational details for doors, hatches, and handles for manual aircraft entry.

(2) Emergency - location and operational details for doors, hatches, handles and canopy/hatch jettison controls.

(3) Skin Penetration and Cut-In - location and identifying markings of areas.

e. Engine/Auxiliary Power Unit (APU)/Emergency Power Unit (EPU) and Battery Shutdown:

(1) Engine - location and position of engine throttle/control levers, engine fire shutdown switches, and T-handles for fire retardant agent release.

(2) APU/EPU - Location (internal and external) and position of APU/EPU master control switches, and fire retardant agent release switches.

(3) Battery - Location and operational switches for shutdown from flight deck or manual disconnect at battery terminals.

f. Ejection/Escape System Details:

(1) Location of ejection seat/s, canopy/ies, hatch/es and door/s jettison systems and associated control handles.

(2) Location and method for safetying and/or cutting initiator hoses, shield mild detonating cord (SMDC), or flexible linear shaped charge (FLSC) to disarm the system.

(3) Identification and location of initiating (triggering) devices (e.g. face curtain, D-ring, armrest/ejection control handle) and dangerous mechanical linkages that can initiate the system if pulled, hit or damaged.

(4) Location of initiators, rocket catapults/packs/motors, drogue guns for forced parachute deployment, canopy/hatch removers, and any other possible danger areas related to the system.

g. Aircrew/Passenger Extraction:

(1) Location of handles/controls, quick-disconnects, releases for safety belts, harnesses, straps, restraints, hoses and any other personnel connections that prevents entanglement during the extraction process.

(2) Location and release of survival kits and personal parachutes.

(3) Location of seat positioning controls (tilt, vertical, horizontal, pivotal), associated switches and their operation.

h. Information Presentation: To facilitate maximum presentation of information in Chapter 4 and onward for each type and model aircraft, all general arrangement contents will list special tools/equipment on top left corner of page, including aircraft type on right side with a view of the color code identifying location of fuel, armament, control switches, oxygen, cut-in and skin penetration areas, and batteries. Respectively, the four basic steps in detail will be listed on left side of the page: step by step method of aircraft entry, engine/APU/battery shutdown, ejection system safety, aircrew extraction. Other pages maybe added to expand the methodology of the four basic areas including modifications and hazards affecting the rescue of personnel.

1-2. HOW TO OBTAIN COPIES.

a. Military Organizations: Download this TO from the designated web site at Robins AFB, GA to a PC hard drive or writeable CD-ROM. The official web address for the main TO site is located at Robins AFB, GA. and the associated Safety Supplements are located at HQ AFCESA Fire and Emergency Services web page. Web addresses can change for any given reason and will no longer be stated here. This manual uses the Adobe Reader software for downloading and reading the portable document format (PDF) files. This manual will be maintained in each user customer's master TO file. The downloaded PDF file have print capability for user copies for the fire chief's vehicle, alarm communication center, training section and mishap responder teams. A color printer is recommended to take advantage of the color coding. This publication will be maintained in current status by the using organization. The National Guard and Reserve units may obtain this publication by following the above procedures. Any installation desiring information on Navy aircraft may requisition NAVAIR 00-80R-14, 00-80R-14-1, and 00-80R-20 in accordance TO 00-5-2. NAVAIR now has an assigned web site for their publications and customers will have to set up an account before receipt. US Navy/Marine aircraft information has been incorporated and information is extracted from the above NAVAIR publications.

b. Non-availability of Paper Copies. Paper and CD-ROM copies are no longer funded, warehoused and distributed by the USAF. The only distribution is an electronic download from the authorized web site.

c. Non-Military Organizations: The web site is a public web site and the information can be downloaded without restrictions. Foreign government access has also been authorized.

d. Customer Accounts. Customer accounts do not have be established and the techncial content manager does not have be contacted for authorization to use the manual.

e. Printing Copies. Printing the whole TO is not necessary for operations use and is very expensive. For this reason it is recommended by HQ AFCESA/CEXF that users only print those desired pages affecting assigned, transient, special occassion, static display, etc. aircraft only. This partial printing of information is for those units desiring to store printed information in rescue and other emergency response vehicles in book form. The rationale behind this recommendation is that no one unit will have assigned every weapons system at its location, however it must be sensitive to those aircraft that frequent their location on the ground and fly in their vicinity.

f. How to make a CD-ROM copy of the TO. It is recommended to obtain the latest Adobe Reader. Set up a designation for your downloaded files. Open the Reader and then type in the required web address. Go to the address. Download the information with the Reader open to a PC hard drive. This speeds up the download process and may avoid 'timing out'. After all information is downloaded, copy all information or files to a CD. Properly label and date.

g. Use of TO CDs. Use only the latest version of the TO. Never use outdated TO CDs for your operations. This could cause problems with rescue and successfully extracting aircrew and passengers from aircraft. Equipment where CD-ROMs can be carried and played on rescue vehicles is now available. This equipment is able to carry all TOs and other information to locations where they are most needed, thus eliminating the desire to carry volumes of paper books.

1-3. RECOMMENDING CHANGES.

a. MAJCOM Fire and Emergency Services and Emergency Response Functions: These functions are responsible for notifying HQ AFCESA/CEXF of any desired/required changes to this TO for their assigned aircraft. AFTO Form 22s will be used for recommending changes or correcting errors IAW AFR 60-9 and TO 00-5-1. The forms will be forwarded through the MAJCOM to HQ AFCESA/CEXF which is designated as the Office of Primary Responsibility (OPR) and functional manager for the technical content and management of this TO. Go to the contact page for further information if contacting the technical content manager is required. (Page two of each Segment.)

1-4. AIRCRAFT PRE-FIRE PLAN.

a. AFTO Form 88 or Computer Generated Equivalent: will be used to supplement lesson plans for aircraft familiarization and egress training. The prepared or computer generated form for an aircraft will be inserted, preceding the first page, into the appropriate aircraft section of this Technical Order.

b. Optional Computer Generated AFTO Form 88: An optional computer generated form, allows for greater flexibility for information, over the 20 year old printed form.

c. AFTO Form 88 Use: Information may be expanded to include areas as follows: the Incident Command System/ assignments, manpower utilization, agent requirements and availability, vehicle position at the aircraft, duties of the rescue crew, fire suppression team and other optional information peculiar to local operations. Extended hazard and safety information, not included in Chapter 3 of this Technical Order, may be included, but HQ AFCESA/CEXF should be informed to see if these areas have wider applicability.

c. AFTO Form 88 Misuse: This form is not to be used to change official/approved procedures stated in the TO. This violation may cause far reaching implications leading to a failed rescue and loss of an aircraft. AFTO Form 88 information should never contradict procedural information that has been fully researched through multiple channels such as the aircraft manufacturer's engineers, the aircraft SPO, and approved source data submitted by these channels to assemble the aircraft file specifically used for successful emergency responses, aircrew and passenger extraction, and saving the aircraft/resource. Authorities responsible for writing the AFTO Form 88's information should ensure these precautions are taken before operational implementation.

CHAPTER 2
GENERAL AEROSPACE RESCUE AND MISHAP INFORMATION

2-1. PURPOSE AND SCOPE.

2-2. The introduction of high performance aircraft and aerospace vehicles into military and commercial use has resulted in aircraft/aerospace design changes that affect the rescue of personnel and mishap response under emergency and post-emergency conditions. The continuing search to improve personnel escape and survival has resulted in many changes and modifications to equipment. Fire protection and mishap response personnel must keep abreast of these changes and modifications as they occur, so they may safely and quickly perform their duty of rescuing personnel under emergency conditions and post incident environments. Lack of knowledge may result in fatal or serious injury to the fire protection and mishap response personnel as well as to those they are attempting to rescue. Of necessity this chapter is general in nature and does not include equipment, procedures or modification for each type aircraft. Familiarization with the type aircraft fire protection and mishap response personnel may encounter, must be scheduled by the fire chief and/or an incident commander. This should be accomplished in coordination with local Egress technicians, Life Support technicians, aircrew and response team members.

ORGANIZATION, PROCEDURES, TACTICS, FIREFIGHTING EQUIPMENT, AND TRAINING ARE DEVOTED TO ONE CAUSE: THE RESCUE OF PERSONNEL INVOLVED IN AIRCRAFT EMERGENCIES.

THE SECOND CAUSE IS TO SAVE THE AIRCRAFT OR AEROSPACE VEHICLE FROM FURTHER DAMAGE WHILE KEEPING THEMSELVES SAFE INSIDE THE INCIDENT OR MISHAP AREA.

2-3. RESCUE AND MISHAP PERSONNEL RESPONSIBILITIES.

2-4. Rescue and mishap response personnel will be proficient in:

a. Aircraft entry, normal and emergency methods including crew, passenger locations for type aircraft involved. If conditions permit, enter the aircraft through normal access provisions, i.e., doors, canopies, and hatches, as this provides the most effective and expeditious entrance into the aircraft. At times, entry through a confined space may be necessary. Paragraph 2.59 defines confined space for USAF aircraft according to AFOSH Standard 91-25.

b. Engine(s) and APU/EPU shutdown, emergency engine and APU/EPU shutdown procedures. Personnel will be knowledgeable of other engine and APU/EPU shutdown procedures, i.e., normal. If aircraft type alllows, engine(s) and APU/EPU shutdown will be accomplished immediately after gaining access to the cockpit or flightdeck. If the aircraft intake location presents a hazard, use an alternate engine(s) and APU/EPU shutdown procedures if applicable, to preclude the danger and possibility of personnel ingestion, and/or engine disintegration/exhaust burns/turbulence.

NOTE

Emergency seat or escape system safetying procedures may be accomplished prior to engine shutdown on those aircraft equipped with ACES II ejection seat(s); if, in the professional opinion of the rescue crew, engine shutdown will not be delayed.

c. Ejection system safetying procedures and precautions for the type seats used on various aircraft.

d. Aircrew extraction and methods of releasing crewmembers from seat restraints and survival equipment. Personnel shall also be knowledgeable of safety precautions required during the removal of aircrew member's life support equipment and high pressure flight suits.

2-5. ENTRY AND EXIT FACILITIES.

2-6. DOORS.

2-7. Depending upon type of aircraft, doors may be located on either side of the fuselage, or in the rear of the fuselage. Doors may open to the side, up or down, and from the interior or exterior of the aircraft. In many cases an emergency release is provided in the interior at the hinge side of the door. The release location is normally indicated and the pull handle is painted red. Pulling the handle will withdraw the pins from the hinges. This arrangement, if the latch or frame is jammed, will allow the door assembly to be pushed out of position from the hinged side.

WARNING

Some aircraft doors, when opened from the inside the aircraft, escape slide or chutes manufactured with flammable materials, are deployed. These escape slides or chutes, if deployed during the rescue process, may endanger the rescue crew who are attempting to enter the aircraft. The intended use these doors should be known.

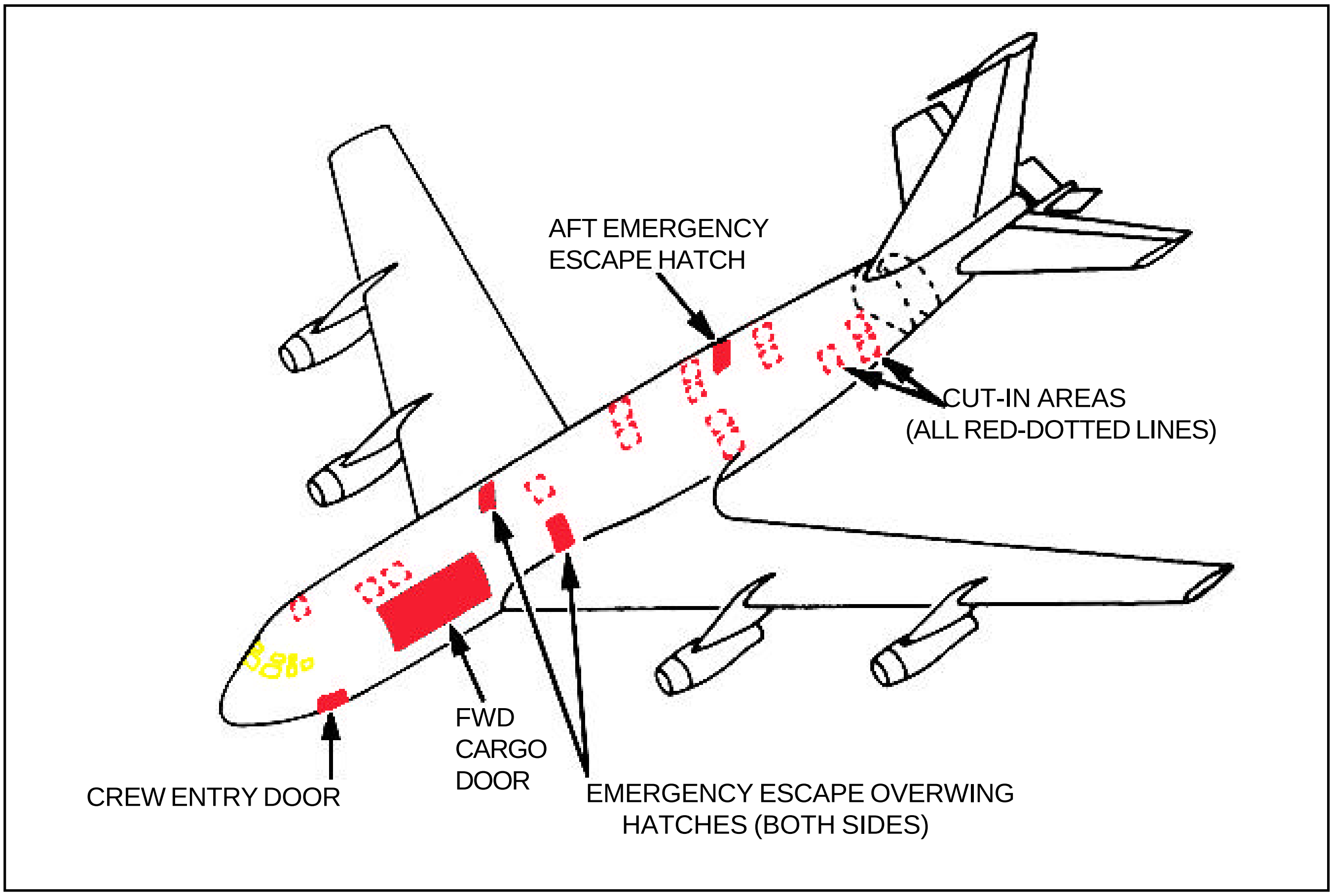


Figure 2-1. Hatch Location for One Type of Aircraft

2-8. HATCHES

2-9. Hatch locations vary according to type of aircraft and may be located on the sides, bottom or top of the fuselage. Hatches designed for normal personnel access are hinged and may be opened internally or externally. Hatches designed for emergency escape from the interior of the aircraft are generally secured internally with quick-opening compression devices around the circumference and when released from the inside or outside of the aircraft the complete hatch is removed. Figure 2-1 shows different locations of hatches on one type aircraft. The study of hatch locations and the means of opening for specific aircraft are included in Chapter 4 throughout the remainder of the publication.

2-10. CANOPIES.

2-11. The canopy, a metal framework with a transparent material covering, is provided to enclose the cockpit and afford protection and visibility to the pilot and/or crewmen. The canopy system includes the canopy itself, plus all the components used in opening and closing for normal entrance and exit, as well as those used in jettisoning the canopy during an emergency. Three types of canopies, the clamshell, sliding, and hinged are commonly used on military aircraft (see Figure 2-2). The clamshell is hinged aft and opens upward at the forward end. The sliding type rests on tracks on the fuselage and opens and closes by a sliding action. The hinged type is hinged at the side or top and opens from the side. The sliding type canopy offers the greatest ease in rescue of crewmember(s) since no overhead restrictions exist. Special emphasis must be placed on drills for removal of crewmember(s) from aircraft utilizing clamshell canopies to assure that fire protection personnel are thoroughly familiar with restrictions imposed.

2-12. CANOPY OPENING.

2-13. The method employed to open a canopy varies with the type of aircraft. They may employ one, two, or three methods of opening. Fire Protection personnel must become familiar with each method in order to gain access in the most expedient manner. Normal opening procedures are the primary means of gaining access to the cockpit, followed by manual jettison and finally cut-in method. If conditions warrant, canopy will be jettisoned.

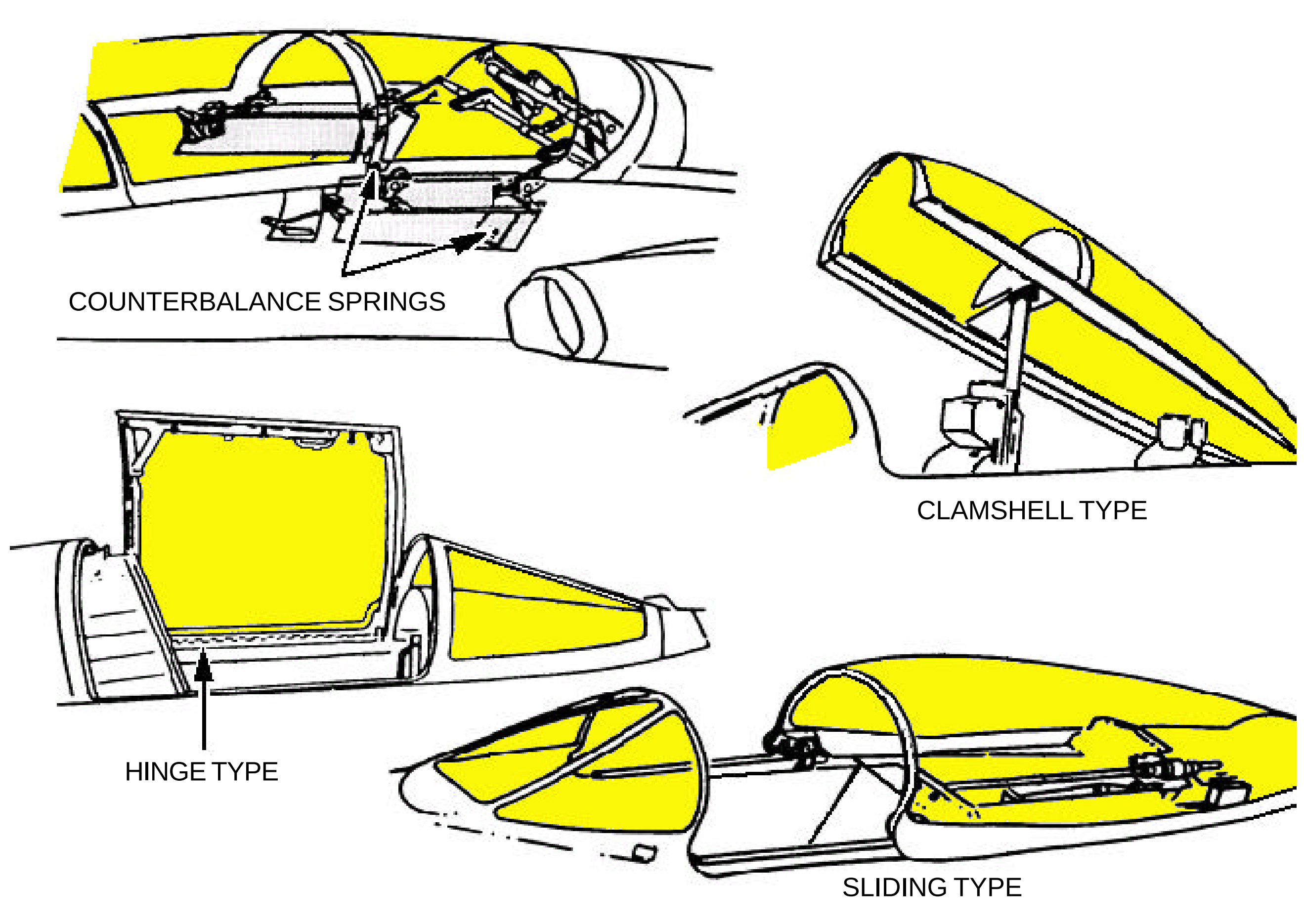


Figure 2-2. Types of Canopies

2-14. NORMAL. Normal opening and closing may be accomplished either pneumatically, electrically, hydraulically and mechanically with counterbalance springs. In the event of malfunction or mechanical damage to the canopy system, it may be opened manually. When the clamshell and pneumatic canopy is opened manually, it must be physically held, propped, or locked open with a canopy lock depending on type of aircraft.

2-15. JETTISON. Jettisoning is another method of opening the canopy. A handle for this purpose is located on the exterior of the aircraft, either left or right under the canopy sill and so identified. The handle is normally concealed behind a hinged access door and is normally red or yellow and black in color. The trajectory of the canopy is normally up and aft under conditions with no wind. Personnel selecting canopy jettison need to stand forward of this trajectory while making sure that the impact area is vacated by all personnel. During adverse conditions, the canopy can impact the aircraft, causing possible damage to fuel cells thus increasing the fire hazard as fuel is exposed to fire. Under these conditions, all considerations for canopy jettison can not be overlooked.

WARNING

The ejection seat is armed at all times during flight and should be considered armed until safetied. Be sure to clear impact area when jettisoning canopies - DEATH or INJURY can occur from falling jettisoned devices. Keep in mind when jettisoning a canopy, the jettisoned canopy may impact and damage other aircraft that are parked in the vicinity. Never jettison a canopy in a covered area such as a hanger, radar or inspection dock.

2-16. PREVENTION OF SUFFOCATION.

2-17. To eliminate the possibility of crew member suffocation from lack of oxygen due to a damaged system or other obstruction to the air passage, fire protection personnel must act expeditiously during aircraft ground emergency conditions. As soon as crew members are reached, immediately disconnect their oxygen face masks and hoses. IF A PRESSURE SUIT IS BEING WORN, DEPRESSURIZE THE SUIT BEFORE OPENING THE FACEPLATE. These procedures will be followed except when an oxygen mask or faceplate would provide additional fire, fumes, or heat exposure to the crew member. Refer to Figure 2-3 for depressurization of pressure suits and faceplates; Figure 2-4 for disconnecting oxygen masks; and Figure 2-5 for disconnecting oxygen hoses.

2-18. REMOVAL OF PERSONNEL FROM SEAT.

2-19. In order to accomplish rescue of personnel involved in an aircraft incident, they must be removed from their seats. Seat restraints may range from a simple lap belt in transport aircraft, to shoulder harness, lap belt systems and leg and arm restraints. More sophisticated systems are employed in high performance aircraft.

2-20. SEAT RESTRAINT EQUIPMENT.

2-21. To restrain personnel in their seats, four systems are employed as follows:

a. Lap belt.

b. Lap belt and shoulder harness combination.

c. Integrated torso harness, including a crotch strap.

d. Leg and arm restraints.

2-22. The lap belt is a belt provided across the lap, which when secured, restrains personnel in the seat. The safety belt in an automobile operates on the same principle.

2-23. The lap belt and shoulder harness combination provides a lap belt and two shoulder harness straps,one over each shoulder. The shoulder harness straps fit into the lap securing fitting. Addition of the shoulder harness straps prevents the upper part of the body from being thrown forward in event of a crash. To release lap belt and shoulder harness straps from the locked position after a G force lock, pull harness release handle or inertia reel release handle upward. The lap belt and shoulder harness straps tension will be released. A lapbelt fitting and shoulder straps fittings are provided for quick manual release from the crew member.

2-24. The standard military parachute harness can be removed by releasing three ejector release fittings. One fitting snaps across the chest of the wearer, and one snaps across each leg at the thigh. When leg and chest straps are unhooked, the harness and all attached gear can be slipped off the shoulder of the wearer. See Figure 2-7.

2-25. TORSO HARNESS SUIT AND TORSO HARNESS.

2-26. The integrated torso harness suit and torso harness, see Figure 2-8 and 2-9, are designed for use in military aircraft with integrated parachute/restraint harness systems. In comparison with the standard restraint (lap belt and shoulder harness) and the parachute harness system, the integrated system improves comfort, mobility, and retention; provides better donning and doffing features; and reduces the number of fittings used to release the parachute and accomplish seat separation. See Figure 2-8.

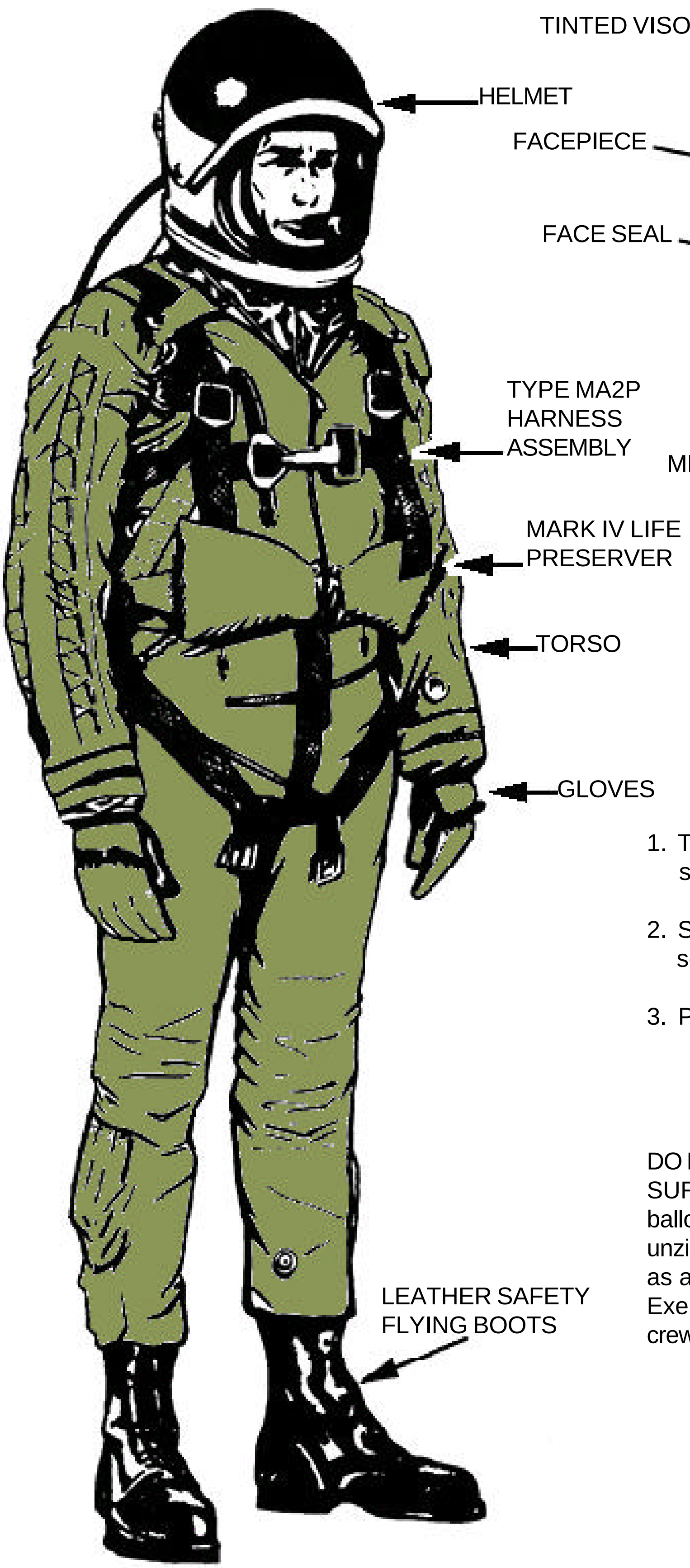
2-27. Three different type release fittings are used on the integrated system; these are the Rocket Jet, Koch, and Frost fitting. Figure 2-9 shows the releasing procedure for Rocket Jet and Koch. Frost fitting is shown in the F-16 Fighter Chapter 8.

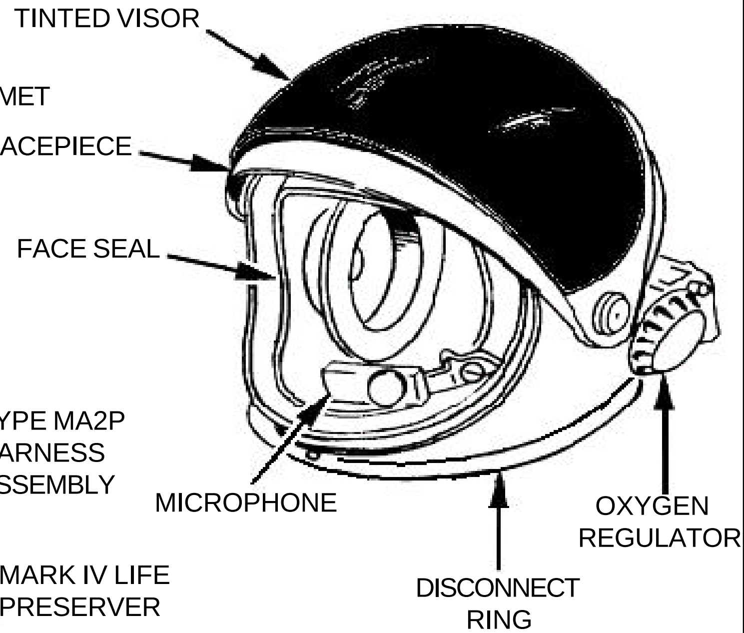
2-28. PERSONAL SERVICES CONNECTIONS.

2-29. According to manufacturer of the aircraft, the personal services connections in aircraft will vary in type, method of disconnect, and locations of connections. In aircraft familiarization training, these conditions must be included, as they must be disconnected prior to removing personnel from their seats. These connections include the oxygen supply hose, anti-G pressurization, vent air, and on full pressure suits, an exhaust vent hose and communication leads.

2-30. LEG AND ARM RETENTION DEVICES.

2-31. On some types of ejection seats, leg and arm retention devices are incorporated. See Figure 2-10 for leg type.These devices will prevent removal of personnel in rescue operations unless the retention devices are released, as those devices are attached to the seat .The leg restraint devices may be released by manually actuating the leg restraint release lever, by manually releasing the fittings on the straps. Arm restraints employ a web that spreads over the arms with a wand spring, lanyards are attached to floor.





1. To raise tinted sun visor, depress button on right side hinge point.
2. Slide oxygen switch (regulator) aft to off. Face seal will deflate when oxygen is shut off.
3. Push facepiece up.

WARNING

DO NOT OPEN FACEPIECE WHEN SUIT IS PRESSURIZED. Pressurization will be identified by the ballooning appearance of the suit. Vent pressure by unzipping and removal of a glove, opening zippers or as a last resort by cutting an opening into the suit. Exercise caution when cutting to prevent injury to crewman.

Figure 2-3. Full Pressure Suit and Helmet

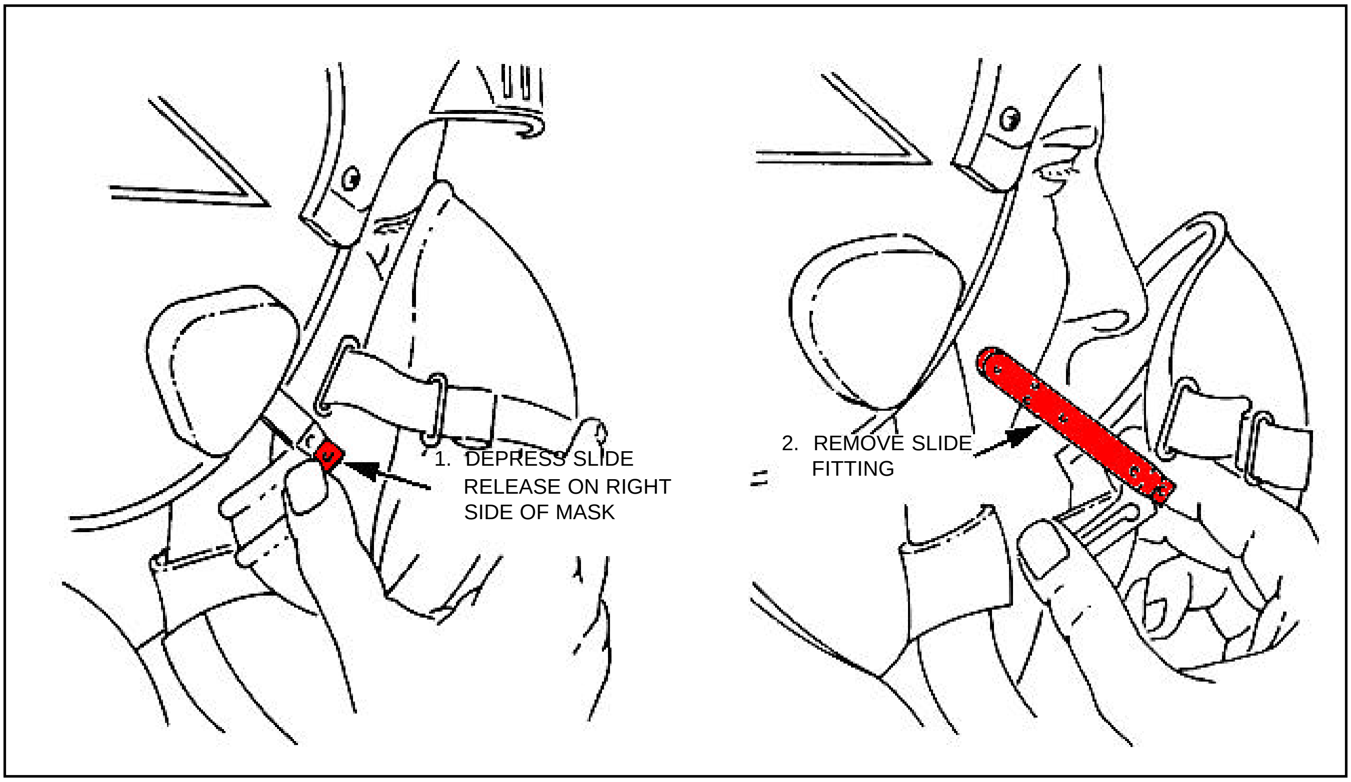


Figure 2-4. Removal of Oxygen Face Mask With Sierra Slide Fittings

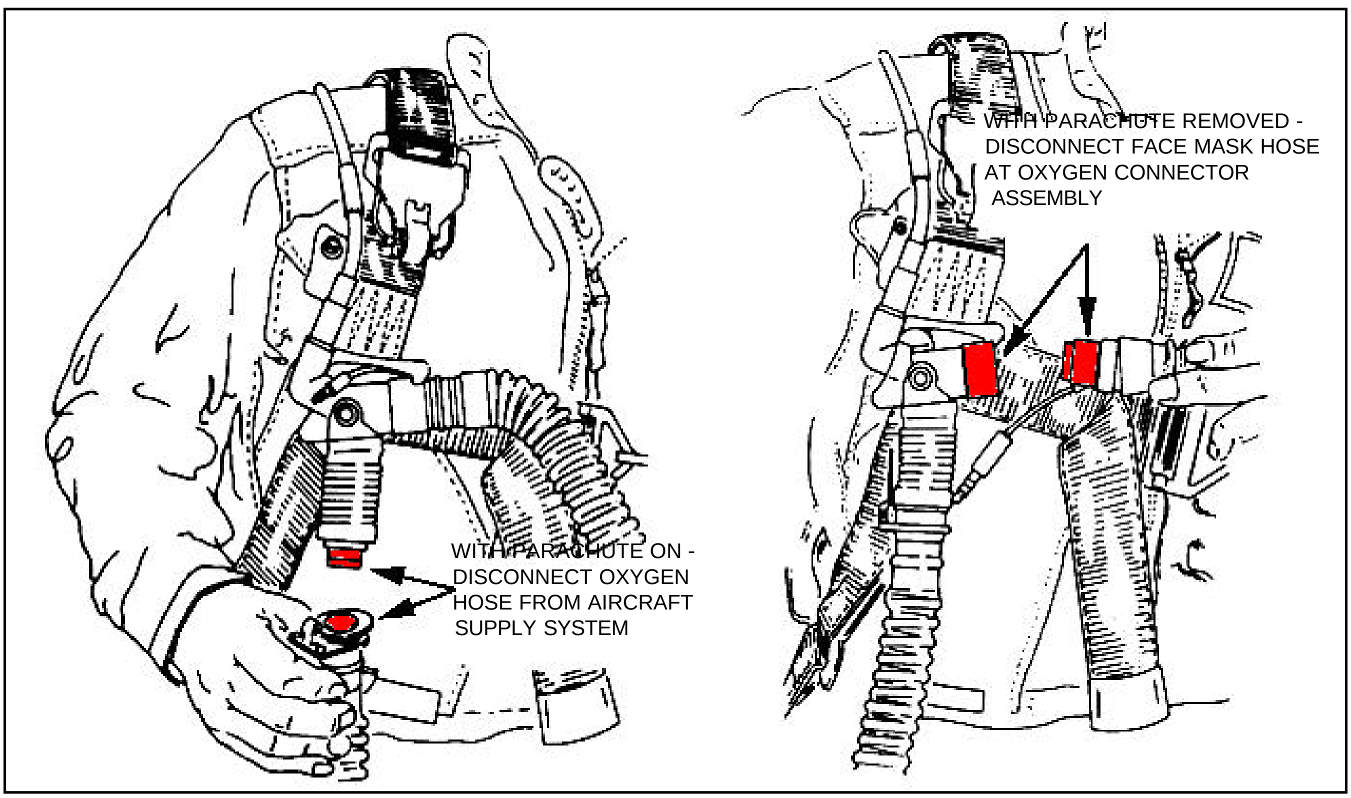


Figure 2-5. Disconnecting Oxygen Hoses With Crewmember Wearing Parachute and Parachute Removed

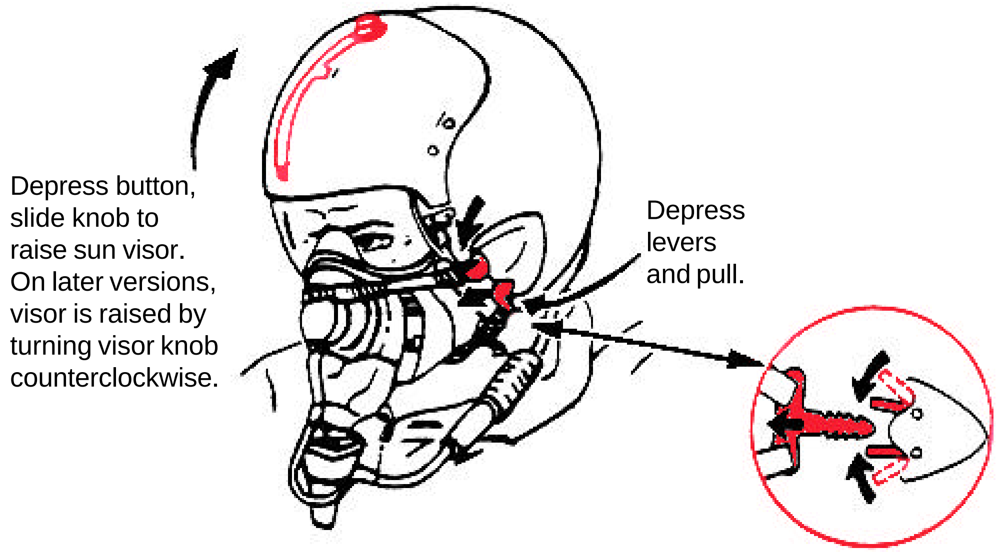


Figure 2-6. Removal of Oxygen Face Mask With Hardman Fittings

2-32. EMERGENCY HARNESS RELEASE.

2-33. On aircraft utilizing certain types of ejection seats, an emergency harness release system is incorporated on the seat to release the crewmember from his seat. Aircraft employing the ACES II seat have changed the function of this handle and it no longer releases the restraint system. Restraints will have to be manually separated in this case. By pulling this handle, most devices employed to restrain the crewmember in the seat are released. In some cases, the parachute and survival kit are still attached to the crewmember and must be manually separated as well. The parachute and survival kit weight is between thirty and sixty five pounds, which adds to the difficulty of personnel rescue. Some seats employ an explosive cartridge in the emergency release system. When the handle is actuated, the cartridge is expended and forcibily releases and cuts through the restraints and parachute chords to release the crewmember saving precious time during the rescue.

Release procedures for the parachute and survival kit:

a. Pull up on emergency release handle to release survival kit.

b. Release parachute harness fittings. See Figure 2-9.

c. Disconnect vent air hose and anti-G suit hose from left console by pulling hoses sharply apart.

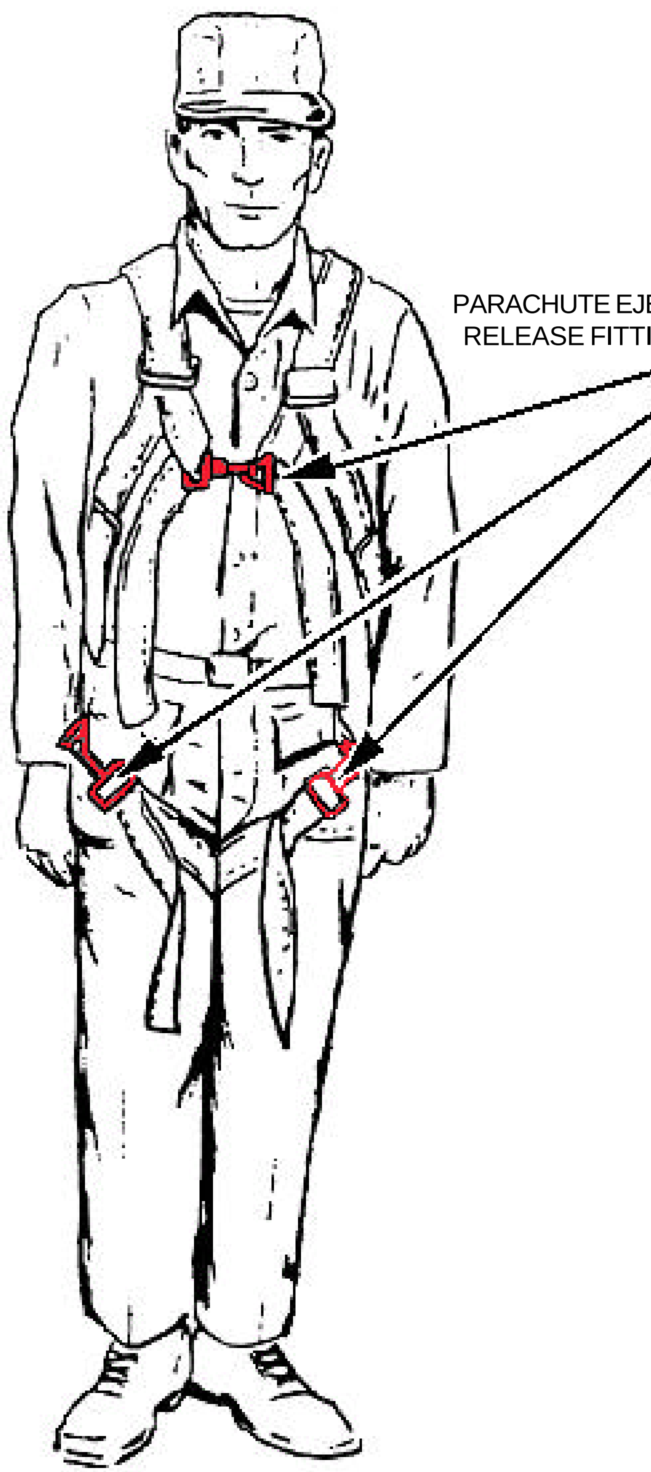
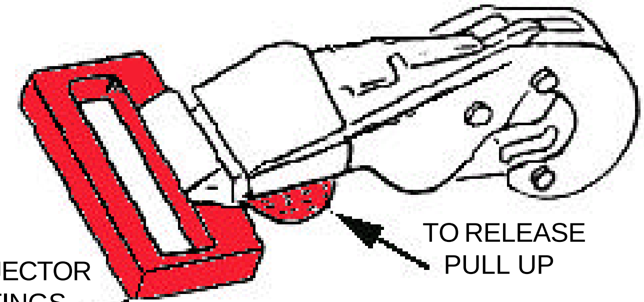
WARNING

Fire protection personnel must be thoroughly familiar with aircraft incorporating the emergency harness release system. Some Air Force aircraft utilize a handle similar in appearance to the emergency harness release handle on the seat armrest, which will fire the canopy and eject the seat. Death or severe injury will occur in this case.

2-34. EJECTION SEATS.

2-35. EJECTION SEAT FIRING MECHANISMS.

2-36. Of primary concern to fire protection personnel is the prevention of inadvertent firing of an ejection seat or canopy or hatch during rescue operations. Firing of the escape system devices, especially the ejection seat, during rescue operations would in all probability be fatal for the crewmember and very likely for fire protection personnel as well. As previously stated, ejection seats vary in design, operation and firing procedures, and as research continues, additional seats or modifications to present seats require keeping abreast of all changes that affect rescue of personnel. This is accomplished by aircraft familiarization classes and the reviewing of aircraft Maintenance Instruction Technical Orders for all current inventory aircraft.

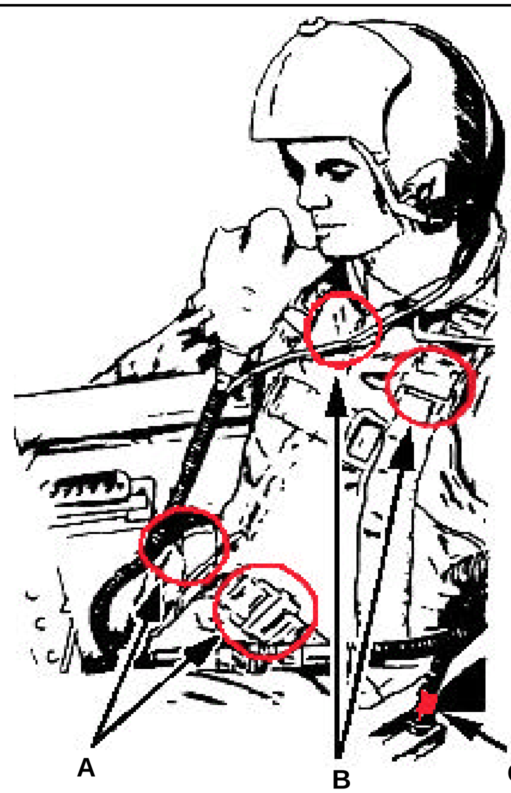
TO REMOVE PARACHUTE

1. Unfasten the leg straps by releasing the ejector fittings.

2. Release the chest strap by releasing the ejector fitting.

3. Slip shoulder straps over the shoulders.

Figure 2-7. Standard Military Parchute Harness



A. Releases crewmember from the seat and survival equipment.

B. Releases crewmember from the parachute.

C. Personal services connection.

NOTE:
If incorporated in the seat, leg restraint lines and/or arm restraint cables will require disconnecting.

Figure 2-8. Integrated Torso Harness Suite

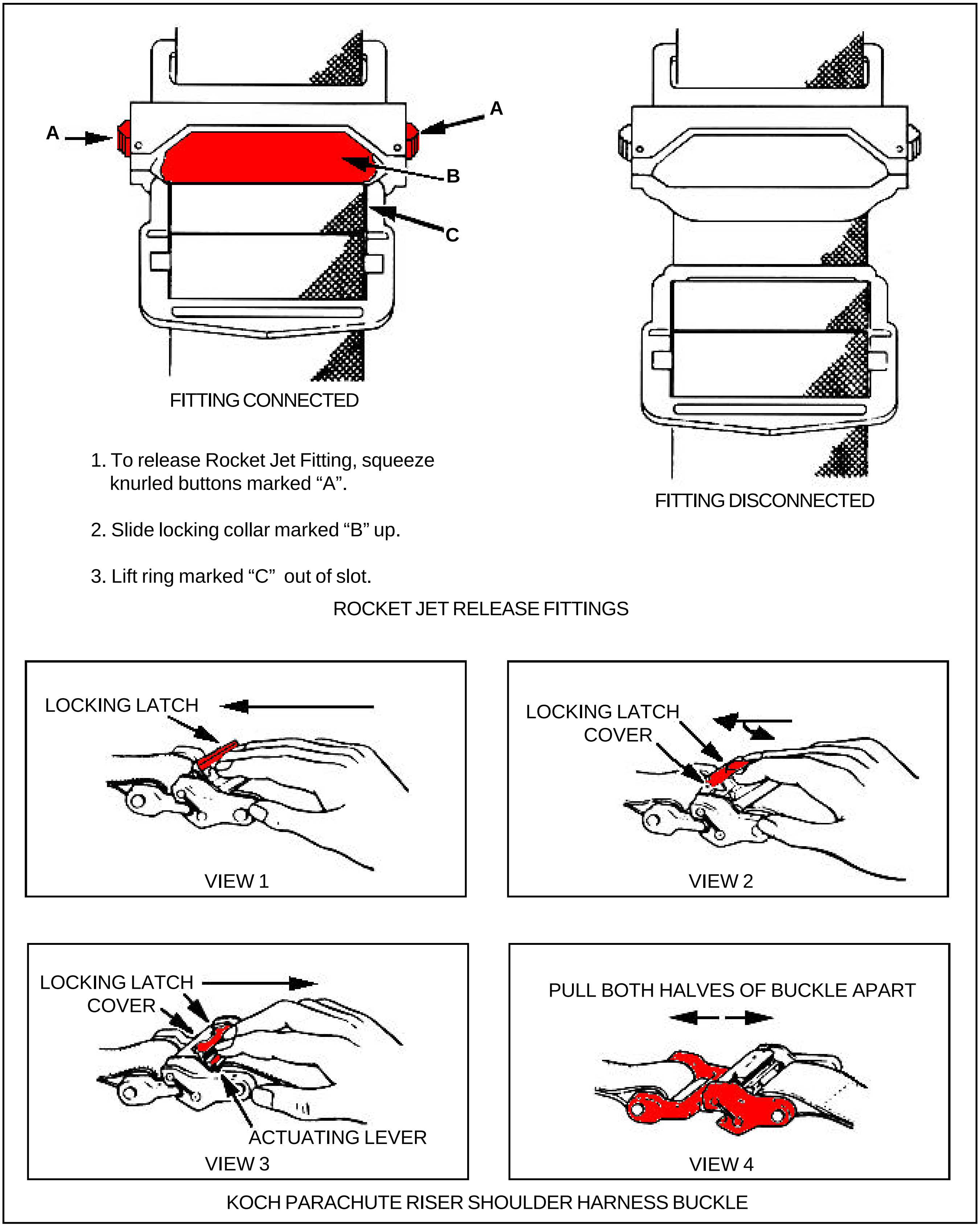


Figure 2-9. Release of Rocket Jet and Koch Harness Release Fittings

2-37. Fire protection personnel are concerned with the various ways an ejection seat and/or drogue gun, if incorporated, may be inadvertently fired. We know the results if an ejection seat is fired, but if the drogue gun is fired with personnel in its trajectory, the results could be fatal.

2-38. Many ejection seats are fired from the aircraft by pulling down a face curtain handle. The lower firing handle, or “D” ring, is normally located on the forward portion of the seat between the legs of the occupant; however, the lower firing handle may be located else where on the seat. On most Air Force aircraft, the seat firing mechanism is located on the forward portion of the armrest. A rule of thumb to be observed is, “If the seat does not have a face curtain, beware of the armrests.” In attempting to get into the cockpit to effect rescue, it is a natural tendency to reach for a handhold The face curtain is ideally located as a handhold, which if used as such, most likely will cause the seat to fire. Unless the necessary safety precautions are exercised prior to removing the crewmember, his flight clothing or feet can become entangled in the lower firing handle or armrest firing mechanism and cause the seat to fire, see Figure 2-12.

2-39. DROGUE GUN.

2-40. Certain drogue parachutes are deployed by means of a drogue gun. The drogue gun on the Martin -Baker seat is normally located on the upper portion of the left side of the seat frame-work. The gun consistsof a barrel, which requires the drogue gun cartridge, and a weighted piston. When the seat is ejected or the drogue gun mechanism is inadvertently tripped, a sear is withdrawn from the firing mechanism of the gun. This causes the piston to be fired from the barrel, thereby extracting the drogue parachute from its container. See Figure 2-13 for a view of drogue gun used on one type of seat. The drogue gun may be fired by an accidental tripping of the trip rod or gun actuator. When safetying the drogue gun, it is adviseable not to place yourself over the barrel and in the trajectory area of the weighted piston.

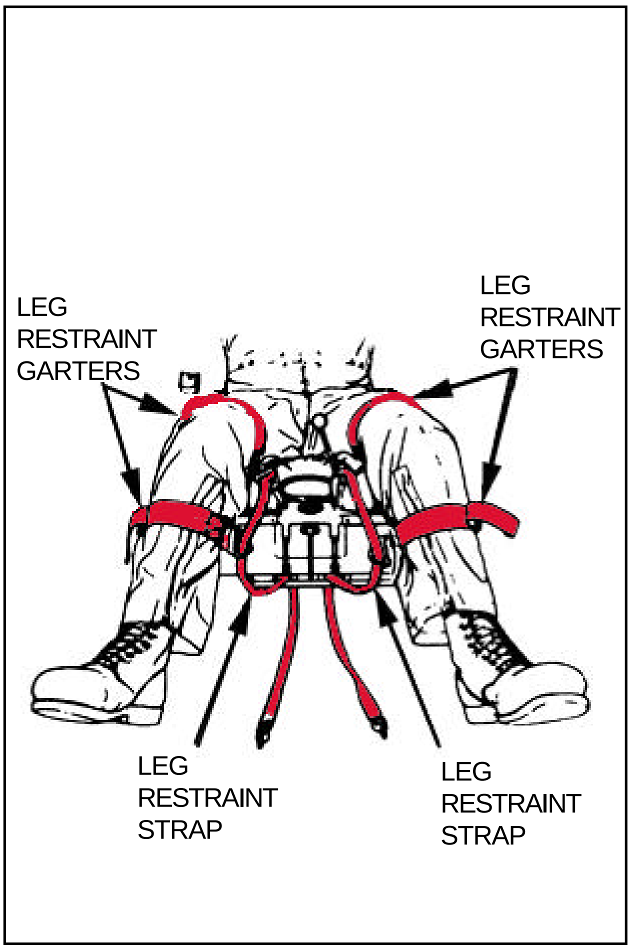
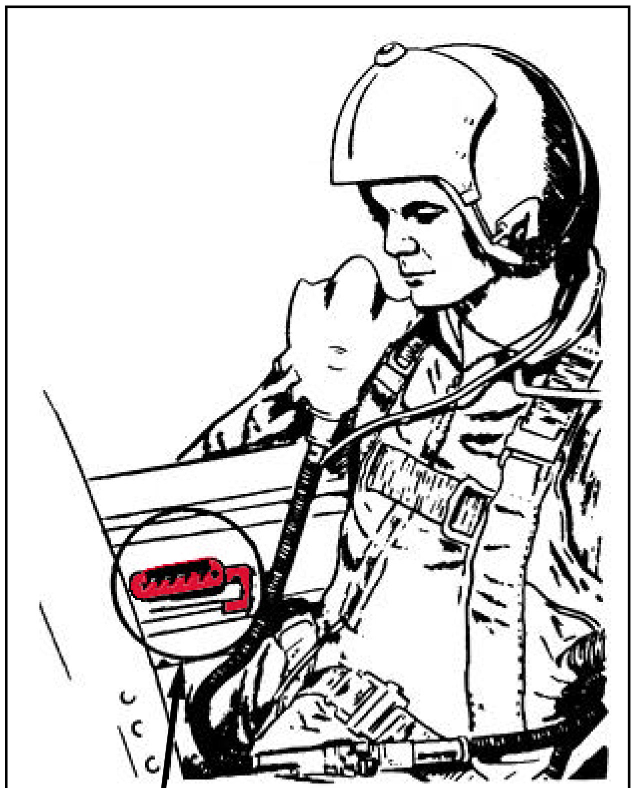


Figure 2-10. Leg Retention Devices



If the seat incorporates the emergency harness release system, the method of operation and location will vary, depending upon the ejection seat manufacturer.

Figure 2-11. Emergency Harness Release

2-41. SAFETYING THE EJECTION SEAT.

2-42. The method of safetying the ejection seat varies with the manufacturer's different models and modification to the seat. The firing mechanism which causes the seat to eject is mechanically or gas activated. All seats have ground safety features which will render the seat safe for removal of personnel. See Figure 2-14. Safetying of ejection seats is a simple task for those familiar with the safetying features. Of prime concern to the fire protection personnel is:

SAFETYING CATAPULT FIRING MECHANISM
SAFETYING OF EJECTION HANDGRIPS

Safetying of the seat or seats may be accomplished by:

a. Insertion of safety pins in the catapult firing mechanism and the drogue gun.

b. Insertion of safety pins in the ejection seat firing handles, triggers, or face curtain.

c. By rotating the seat ejection ground control safety lever up and forward, if incorporated OR by rotating a "red flag" up to safe the lower ejection control "D" ring.

d. Mechanically actuated firing mechanisms may be disarmed by (1) insertion of safety pins in the catapult firing initiator, (2) disconnecting the gas line between the firing initiator and a catapult by means of the quick disconnects or (3) cut the initiator hose between the firing mechanism and the catapult.

2-43. If time does not permit normal safetying of the seat, cut the initiator hose. Figures 2-15 and 2-16 showmethods by which some ejection seat catapult firing mechanism are safetied.

2-44. FORCIBLE ENTRY.

2-45. TRANSPARENT PLASTIC COVERED AREAS.

2-46. In gaining entry into the canopy by forcible means, the desire is to obtain the largest opening in the shortest period of time. Using a power rescue saw, this is accomplished by cutting the plastic along the edges of the frame. In cutting, commence operations at the front of the frame. After three sides have been cut, carefully cut the fourth side and prevent the glass from falling on the crewmember during removal. Older aircraft canopies can be cut on three sides, lifted, and broken off. See Figures 2-16, 2-17, and 2-18.

WARNING

Extreme caution must be exercised when cutting the top rear of the canopy, to avoid hitting crewmember(s) and firing the ejection seat firing mechanisms in this area.

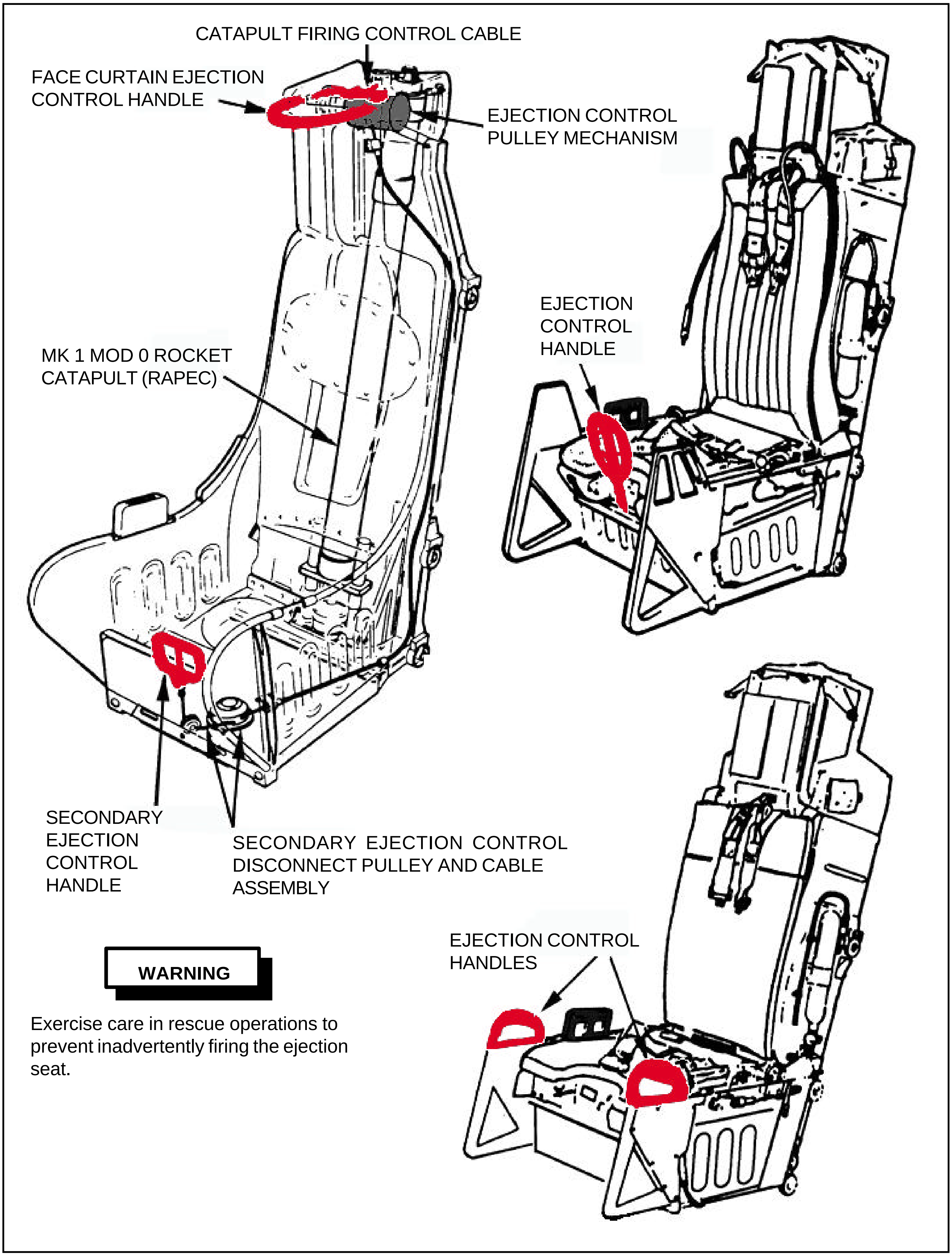
NOTE

For new generation transparencies use a thick Carbide tipped blade in the power rescue saw.

2-47. FORCIBLE ENTRY INTO FUSELAGE AREAS.

2-48. Gaining entry into aircraft through the fuselage presents the most difficult problem in making forcible entry. The increase in performance of aircraft has placed a demand on increasing the thickness and strength of the aircraft skin. Fire protection personnel, when cutting through the fuselage, must have a knowledge of the aircraft interior. He/she must know the locations of bulkheads, equipment inside the aircraft that would prevent entry, location of fuel tanks, fuel, flammable liquids, oxygen lines and cylinders, and where forcible entry presents the least obstacles to cut and gain entry. On large aircraft, an outline of cutting areas is stenciled on the aircraft exterior, as an aid to fire protection in making forcible entry. These marked areas offer the least obstacle in gaining entry. Markings are red dashed lines in a rectangular or square shape.

2-49. Fire Protection personnel must not be dependent upon these markings, as they may be obliterated during an incident. However, during aircraft familiarization, fire protection personnel must study these areas and become familiar with their location on all types of aircraft. When making forcible entry, the desire is to gain the largest opening as quickly as possible. The power rescue saw, equipped with metal cutting blades, is the most satisfactory tool for forcible entry. If the aircraft is relatively thin skinned, three cuts may bemade and then the area cut may be bent down and outward from the aircraft. If the aircraft fuselage is of thicker material, four sides must be cut. When cutting through an aircraft, particularly when utilizing the power rescue saw, a danger exists of ignition of fuel, or any other flammable liquid, that may be present by sparks produced by the cutting operations. Adequate fire prevention measures must be taken and standby protection should always be at hand.



WARNING

Exercise care in rescue operations to prevent inadvertently firing the ejection seat.

Figure 2-12. Examples of Ejection Seat Firing Mechansim

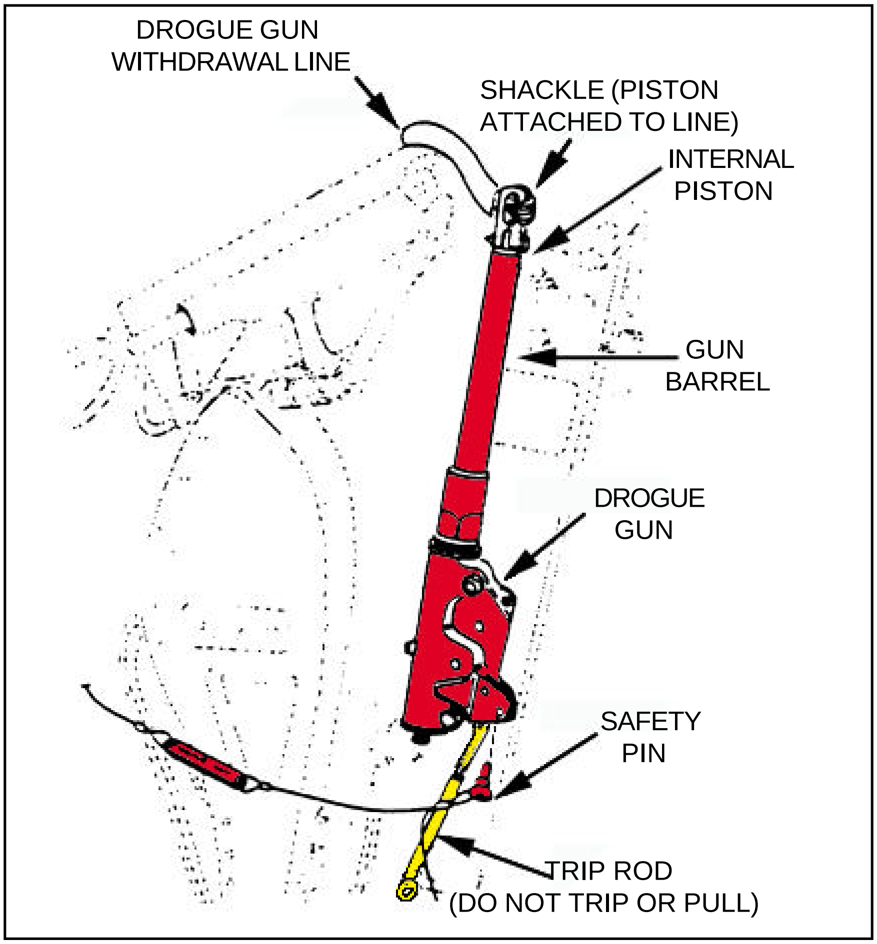


Figure 2-13. Martin-Baker Ejection Seat Drogue Gun

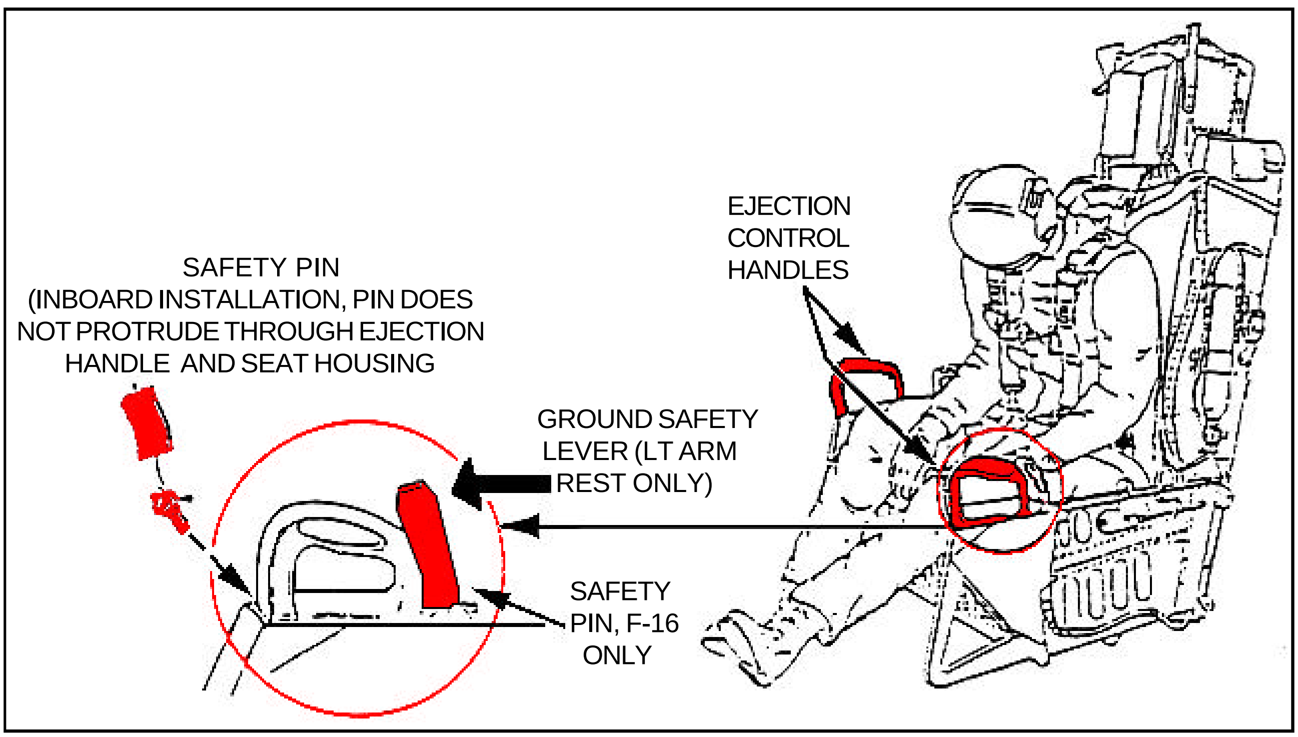


Figure 2-14. ACES II Escape Ejection Seat Showing Methods of Safetying for the A-10, B-1, B-2, F-15, F-22A and F-117. F-16 safety pin is installed at aft bottom of Ground Safety Lever. (See Chapter 8)

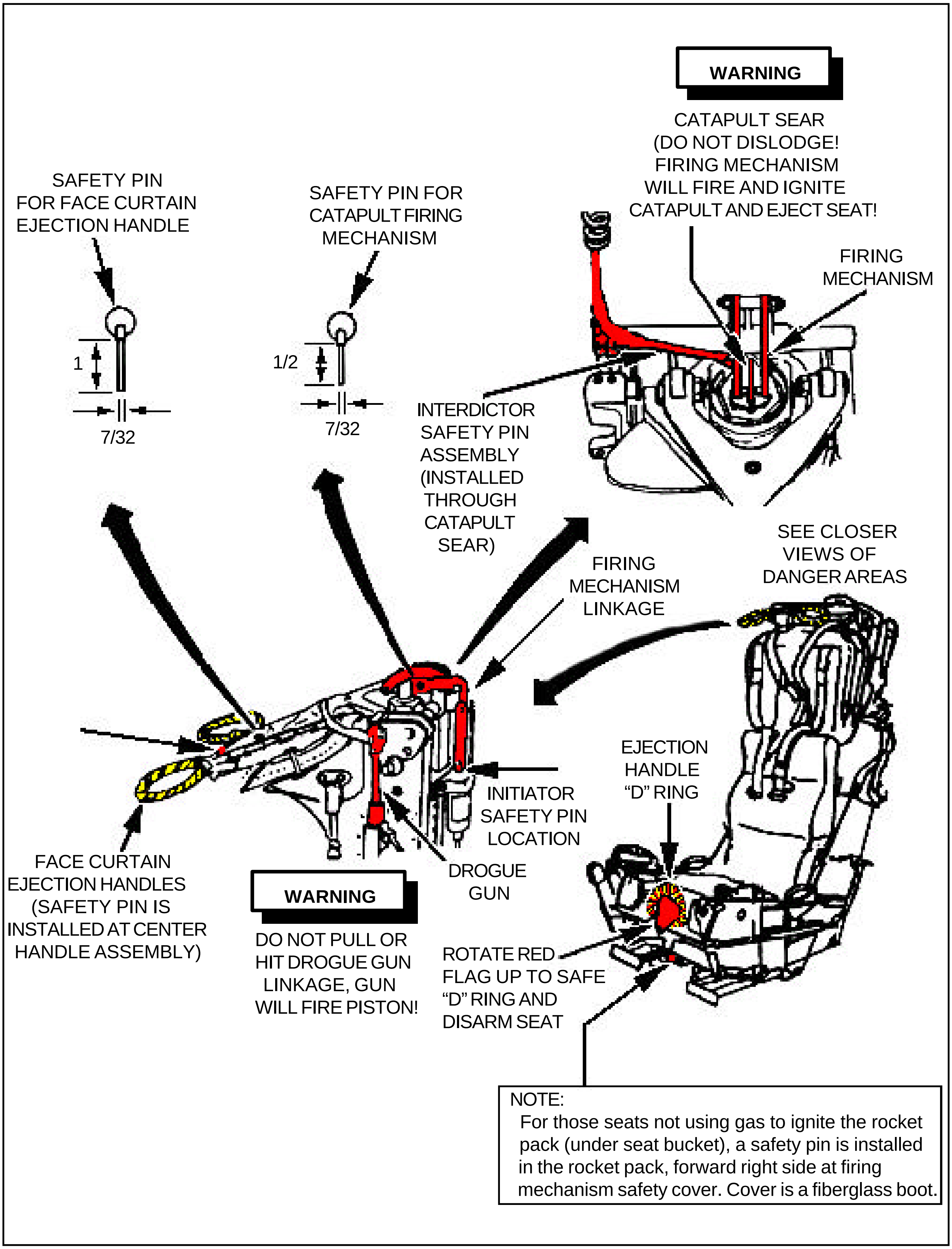
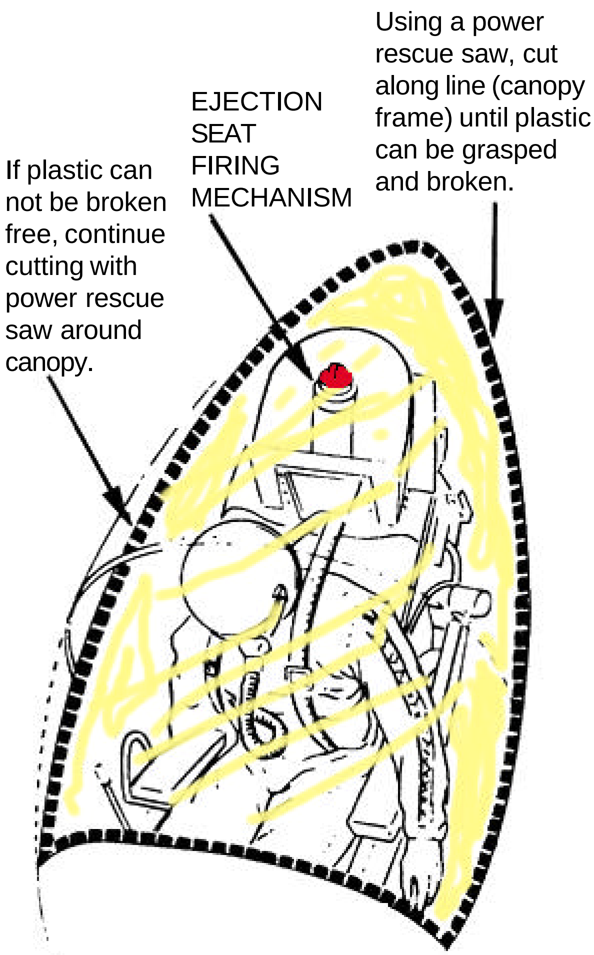


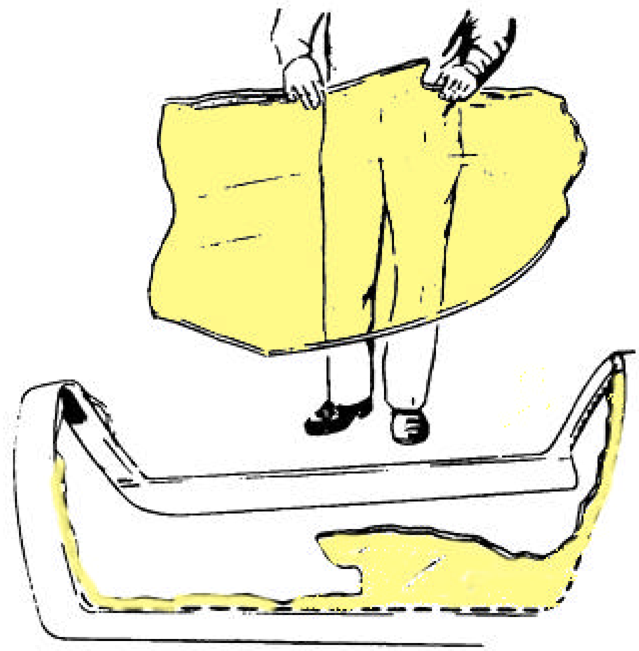
Figure 2-15. Martin-Baker Ejection Seat Showing Disarming Safety Pins and Red Flag



WARNING

Watch for fragmentation and jagged edges. Edges are very sharp. Fragmentation characteristics differ in type and construction of acrylic plastic.

Figure 2-16. Forcible Entry into Plastic Canopies



NOTE:
Lines denote area cut and the plastic was then grasped and broken free. Note the large section removed and the absence of shattering.

Figure 2-17. Forcible Entry into a Plastic Canopy

NOTE:
Lines denote area cut and the plastic was then grasped and broken free. Note large section removed.

Figure 2-18. Forcible Entry into a Plastic Canopy Exposed to Fire Conditions

2-50. AIRCRAFT HOT WHEEL AND BRAKES.

2-51. Aircraft hot wheel and brakes pose serious considerations for Fire Protection personnel. These considerations are: (1) Danger Zones are areas where exploding wheel, brake and tire assemblies can injure personnel, (2) Safe Zones are areas of approach to the wheels, brakes and tires if a fire is present and requires immediate suppression, and (3) Heat Dissipation times before the wheel and brake assemblies can be safely approached if there has been no fire or damage. (Aircraft tires use fuse plugs designed to melt at a given temperature and relieve tire air pressure.)

The following is general information that is common to most aircraft:

2-52. Danger Zones. Avoid inflated main landing gear tire side area within 300 feet. (See Figure 2-19.)

2-53. Safe Zones. Approach wheel/brake and tire assemblies from the front or rear of assemblies at a 45 degree angle. Munitions loaded on the aircraft must also be taken into consideration when determining the proper approach.

2-54. Heat Dissipation. After aircraft has stopped, wait 30 minutes for the heat in wheel and brake assemblies to dissipate before relocating the aircraft. In a parked condition, and when air circulation is at a minimum, it takes 12 to 15 minutes for brake heat to transfer to the wheel and tire bead. Braking conditions may increase heat and therefore the approach time requirement from 45 to 60 minutes, assuming there is no fire.

2-55. HEATED BRAKE DON'TS.

2-56. There are certain actions the fire department must be aware of and ensure the proper procedures are followed if brakes are in a heated condition. The following DON'TS references TO 4B-1-1:

A. Do NOT Set parking brakes while overheated conditions exist.

B. Do NOT approach landing gear from either side--approach only from the front or rear.

C. After excessive use of brakes, do NOT taxi aircraft after clearing the active runway.

D. Do NOT tow aircraft into a crowded parking area.

E. Do NOT move the aircraft until the brakes have cooled.

WARNING

F. Do NOT attempt to physically determine wheel or brake temperature by mechanical means. (Explanation: extensive research has been shown that there is NO SAFE OR FEASIBLE WAY to mechanically DETERMINE wheel or brake temperature. WHEN A DANGEROUS OVERHEAT CONDITION EXISTS, as a result, the risk to personnel is not warranted.)

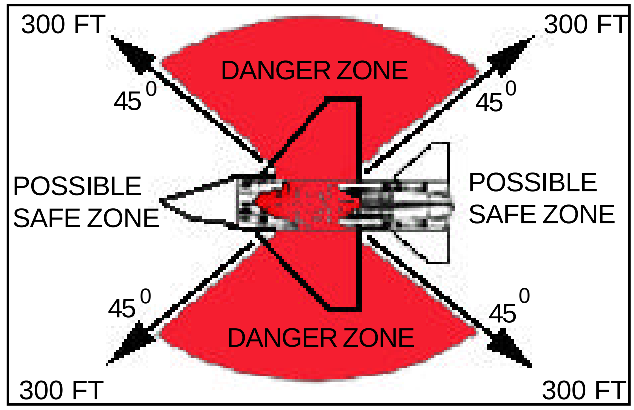


Figure 2-19. F-16 Example

2-57. ENGINE INGESTION OF FIREFIGHTING AGENTS.

2-58. Engine Ingestion of Firefighting Agents: Fire fighters must use **"CAUTION"** to prevent the inadvertent discharge of firefighting agents into aircraft engines and cockpits. Only when it is absolutely necessary for the purposes of preservation of life or the aircraft, should any **firefighting agent** be discharged into the aircraft engine or cockpit area. The chemical composition of firefighting agents can result in a corrosive chemical reaction when in contact with these components. Unnecessary or inadvertent discharge of firefighting agents into these areas can decrease the probability of critical component salvage. Aircraft maintenance personnel must be notified anytime there was a possibility of firefighting agent being discharged into any of these critical components.

2-59. CONFINED SPACES.

2-60. An aircraft confined space is a location on an aircraft or aerospace vehicle where a person can either fully or partially access an internal space. These spaces can also be associated with dangerous equipment or may be a space where breathable air is compromised. AFOSH Standard 91-25 lists the aircraft and areas that meet the definition of a confined space. Requirements of this standard will be applied as appropriate. This list is not all-inclusive and indicates only the minimum aircraft confined spaces.

The following information has been paraphrased from the original article to match this manual's language.

2-61. ROCKET-DEPLOYED PARACHUTES ON CIVILIAN AIRCRAFT MAY EXPOSE UNKNOWN HAZARDS TO EMERGENCY PERSONNEL

2-62. An emergency call takes you to the scene of an aircraft accident. Victims inside may be injured. You want to act quickly but people at the scene warn you about a rocket-deployed parachute installed on this aircraft. The pilot did not activate the safety device and now you may find yourself working on or near the aircraft with its ballistic device stillarmed and capable of firing.

What do you do? You want to help the victims, but you don't want to hurt yourself or others around you. Perhaps the occupants escaped without serious injury. They may have left the aircraft. But a damaged aircraft with a ballistically-deployed parachute can be lethal. What do you do!?

Those who arrive first at the scene of an accident (rescue workers, investigating officers, fire fighters, and other safety personnel) may not recognize the parts of the aircraft particularly well.

One device rescue workers may encounter is a rocket-deployed emergency parachute system (sometimes called a ballistic parachute). While these devices are intended to save lives, they have the potential to cause injuries or even death to rescue workers.

To prevent such tragic results, this information provides vital information and awareness to emergency personnel. The following summary provides the minimum steps to disarm a BRS rocket motor:

(1) Locate the BRS parachute system by finding the parachute (see photo of container types).

NOTE

Keep in mind that a badly broken apart aircraft may have already put the activating housing into a stretched state that may be close to detonation.

(2) Identify the rocket motor launch tube (photo below). Note where the activating housing screws onto the base of the launch tube.

(3) Using a Felco-brand cutter (identified below), cut the activating housing at the base of the launch tube where the activating housing screws onto the launch tube.

(4) Remove the still-live rocket motor to a secure place and contact BRS for further directions about permanently disabling the rocket motor.

2-63. The term ballistic in this reference has nothing to do with guns or ammunition. Instead it refers to a means of extracting a parachute. For Ballistic Recovery Systems (BRS) today, this means a rocket-deployed emergency parachute system. The term recovery has nothing to do with recycling ammunition, but instead means bringing a payload to the ground via parachute canopy.

[**National Transportation Safety Board states**: "*CAPS uses a solid-fuel rocket (stored in a compartment in the aft fuselage of Cirrus airplanes) to deploy a 55-pound parachute that allows the airplane to descend in a level attitude at about 26 feet per second. To activate the system, a pilot pulls an overhead handle in the cockpit (after removing a metal pin that secures the handle in a stowed position). The aluminum CAPS rocket, which weighs 1 pound 6 ounces, contains 1 pound of propellant, fires for 1.2 seconds, and accelerates to over 100 miles per hour in the first tenth of a second. It produces peak thrust of about 300 pounds. Under normal conditions, CAPS is well secured and is not prone to accidental firing. The rocket will only fire if the activation handle in the cockpit is pulled with sufficient force (about 35 pounds for Cirrus airplanes [6]). However, the system can be less predictable if an airplane has been in an accident.*"]

Used as intended, these BRS-brand emergency parachute systems have saved over 150 lives. However, the pilot must elect to deploy the system, completely different than, say, an airbag which deploys automatically when certain conditions develop. Because the pilot (or his passenger) must pull the activating handle, sometimes the units are not used.

The pilot may have felt he could rescue the aircraft from its predicament. Or he may have been unable to deploy for physical or other reasons. Regardless of why a ballistic parachute was not used, the fact remains for safety personnel that when handling an accident where a BRS unit was not deployed, a potentially dangerous device now confronts them.

2-64. Consider the rockets extremely dangerous. While the total firing period is only one second, someone in the path of an escaping rocket could be seriously injured or killed. These are powerful little rockets (about one and a half inches diameter and 10 inches long) that work very efficiently.

The rocket motors are activated by pulling a firing handle in the cockpit. Both parachute container and handle should be permanently fastened to the aircraft. However, in an accident, things come apart. Should the sections of an airplane be broken apart, the activating housing may become stretched tight. If the parts separate enough, the unit could be detonated even with the blast handle still secured by its safety pin.

The danger to safety personnel may now be more obvious. A rescue worker who disregards the position of the ballistic parachute system, or who moves the aircraft without determining the existence of a ballistic parachute system may put him or herself in considerable jeopardy.

BRS staff members have worked with several NTSB people as well as rescue personnel at airshows in Florida and Wisconsin. BRS company employees have assembled some information for safety personnel to disarm these systems.

When an accident happens, emergency personnel may need to call for assistance.

Fortunately, those of you reading this article have the luxury of time to respond. The accident has not yet occurred. Given enough time, BRS has a simple solution to offer. First, we need to provide a little background information.

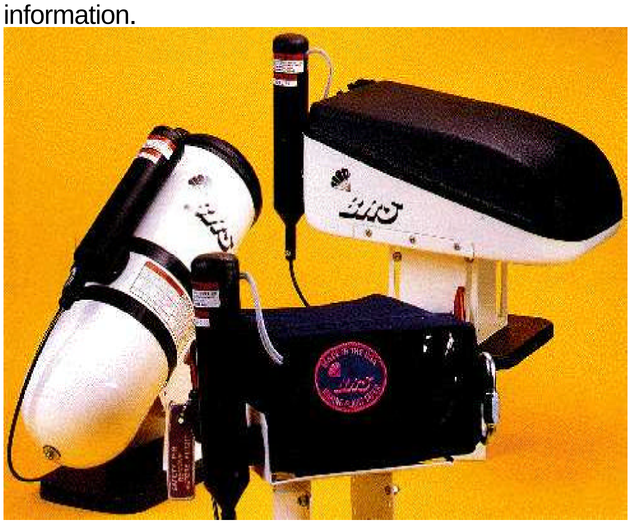


Figure 2-20. BRS Unit

2-65. A BRS unit is comprised of four major elements. The first thing emergency people will see may be a red

Figure 2-21. BRS Firing Handles

firing handle. This will usually be located near the victims as it should be close to the pilot so it can be operated. The red firing handle will connect to an activating housing, an armored yet flexible shaft that links the firing handle to the parachute.

Figure 2-22. BRS Flexible Shafts

The second part is the parachute container itself. This is probably a white-painted aluminum canister about 6-8 inches wide and 15-25 inches long (depending on the size parachute packed inside the container). The parachute may also be housed in a fabric covering called a softpack, or in a fiberglass box. The location of this parachute and container varies by the aircraft but will always be at the opposite end of the activating housing from the firing handle.

Figure 2-23. BRS Parachute Container With Rocket Motor

The third component is the potentially dangerous part: The rocket motor (or other ballistic device). The rocket motor has been used since 1987, so it is increasingly unlikely that emergency personnel will examine the older systems. However, like the rocket motor, all ballistic devices which are used to extract the parachute with great speed will be located very near the parachute. For engineering reasons, the parachute and ballistic device should be near one another.

On some aircraft the parachute and its ballistic device will be mounted on top of the aircraft; in other cases, they are toward the lower side of the fuselage. In most cases, they will be near the surface of an enclosed aircraft.

It is important to observe at this time that the elements described above may no longer be in the same relation to one another after the aircraft has crashed.

The fourth element and final items that make up a BRS are mounting hardware and attachment bridles which connect parachute to aircraft. Since these are not in the least hazardous, we'll ignore them.

Connecting the firing handle to the rocket motor is a housing, the purpose of which is to protect an internal stainless steel cable against binding or jamming. The activating housing itself does nothing but protect; it is the cable inside this housing that detonates the rocket motor.

The housing on BRS units has changed over the years. The material used to be a flexible, strip-wound, bright silver metal tube of about a half inch diameter. Later this became a braided material similar in appearance and size, except that the exterior is made of many small wires braided together. The newest models use a black plastic exterior that resembles a bicycle brake housing except that it has a slightly larger diameter.

The housing joins the firing handle on one end to the rocket motor on the other. Pulling either end away from one another can detonate the unit (see diagram of the rocket motor operation). Normally the handle and the parachute unit will be mounted securely, but as stated above, in an accident positions may change. Rescue workers, police officers, and fire fighters should exercise extreme care when working around these devices, especially if the airplane is broken into parts.

The rocket motor should* always be aimed away from the aircraft, commonly toward the rear, upwards or downwards, and sometimes toward the side of the aircraft. Every one tends to be different as most aircraft are designed differently. (* the aiming of the motor may be affected by the accident and it may no longer be aimed as advised by BRS).

Rescue personnel should first determine the existence of a BRS-brand unit. You can scan for a company logo, often placed on the outside of the aircraft. Or you can look for the unit itself. These containers, which hold the parachute canopy, will always have a company logo on them. A few other brands exist but overwhelmingly, these units will be the BRS brand name.

Alongside the parachute container will be a 2-inch black or white tube about 12 inches in length. This is called the launch tube and it contains the rocket motor. A rocket motor consists of two principle parts: The launch body, which will leave the launch tube when fired; and the igniter or trigger, which remains in the launch tube after detonation. The launch tube on newer units is covered with a plastic cap while on older models it remained open so you could see the business end of the rocket motor.

The open end or the cap-covered end of this black or white launch tube is the exit point of the rocket motor and therefore this is the dangerous end. Under no circumstances should rescue personnel place any part of their person in front of the departure end of the launch tube.

Figure 2-24. BRS Rocket Launch Tube

2-66. The solution to the problem is to cut the housing. The rocket motor is NOT an armed, hair-trigger device. It requires a deliberate pull of about 30-40 pounds to cock and fire the system. Both cocking and firing are accomplished by one pull of the handle. While customers are told to pull about one foot, in fact the system needs only about one-half inch of movement at the trigger to detonate. Some extra slack is built into the system to allow for easier mounting but once the wire inside the housing is drawn tight, only an additional half inch of movement is needed to fire the rocket.

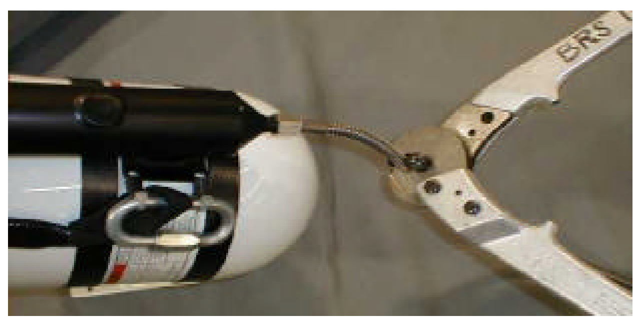


Figure 2-25. Disarming Rocket

The housing attaches on the launch tube at the opposite end of the rocket's exit. This is a tapered end with a screw thread onto which the housing is fitted. After you locate this part of the rocket motor, you are ready to act.

BRS **STRONGLY RECOMMENDS** using a Felco-brand C.16 cutter (part number 39601-63-00). This can be obtained from various sources and BRS will soon be able to sell these directly to law enforcement, rescue organizations, fire departments, or other emergency personnel. It is also available from Sanlo Manufacturing Co. (219-879-0241).

Figure 2-26. Felco-brand C.16 Cutter

NOTE

DO NOT ATTEMPT TO CUT THE HOUSING WITH AN ORDINARLY BOLT CUTTER!

A bolt cutter is NOT effective at cutting the housing as it tends to squeeze the housing out of its grip. The Felco-brand cutter gathers the housing and cuts rather thick cables with surprising ease. The tool sells for about $225 plus shipping and would make a worthy addition to any rescue organization's standard tool box. It has proven useful for cutting fences, steel cables, and other obstacles which may prevent workers from reaching the scene of an accident. The cutting edge can be replaced if worn.

With the Felco-brand tool and after finding the launch tube base, workers can simply cut the housing, including the activating cable inside, near the base of the rocket launch tube where the housing screws on the launch tube.

Although the Felco-brand cutter can slice through the housing and cable with ease, care must be taken not to twist the housing while cutting it, as this may have the effect of pinching the cable inside and possibly pulling it enough to fire the rocket motor.

Once the housing is cut, the system is relatively harmless and rescue workers should have no further danger handling the accident victims or aircraft wreckage.

After removing victims to safety, workers are advised to remove the rocket motor and to completely disarm it by removing the rocket fuel, and firing the igniter. BRS is also able to provide assistance to this purpose, but this is not time critical once the activating housing has been removed. Advice on this subject can be obtained by calling BRS during regular business hours.

2-67. The following summary provides the minimum steps to disarm a BRS rocket motor.

(1) Locate the BRS parachute system by finding the parachute (see photo of container types).

NOTE

Keep in mind that a badly broken apart airplane may have already put the activating housing into a stretched state that may be close to detonation.

(2) Identify the rocket motor launch tube. Note where the activating housing screws onto the base of the launch tube.

(3) Using a Felco-brand cutter, cut the activating housing at the base of the launch tube where the activating housing screws onto the launch tube.

(4) Remove the still-live rocket motor to a secure place and contact BRS for further directions about permanently disabling the rocket motor.

2-68. For a second method, it is also possible to disconnect the activation housing on many BRS units using BRS Drawing 600 or Drawing 610 under the Technical Information section, if available.

2-69. A disclaimer is necessary. While the advice above should prevent problems for safety personnel in most situations, the instructions given apply to BRS brand products only. BRS dominates the U.S. market with 80% or more of all so-equipped aircraft. However other brands called Pioneer, Second Chantz, Advanced Ballistic Systems, Galaxy, or GQ Security have been sold in the past. While these systems are similar, they are not identical. BRS cannot provide positive information on how to disarm these systems.

END OF ARTICLE.

Editor's Note: We appreciate the information that BRS has provided to help fire fighters, rescue squads, and mishap responders. This greatly enhances the understanding of these systems and will help train these personnel in the preparedness of these dangerous systems and their associated components.

2-70. NTSB SAFETY COMMENTS ON WARNING LABELS

2-71. The following information and illustrations are from the National Transportation Safety Board (NTSB) Safety Recommendations, dated 29 April 2004. They are provided due to their findings with the warning labels affixed to aircraft with ballistically loaded parachute systems.

The full report is located here:
http://www.ntsb.gov/recs/letters/2004/A04_36_41.pdf.

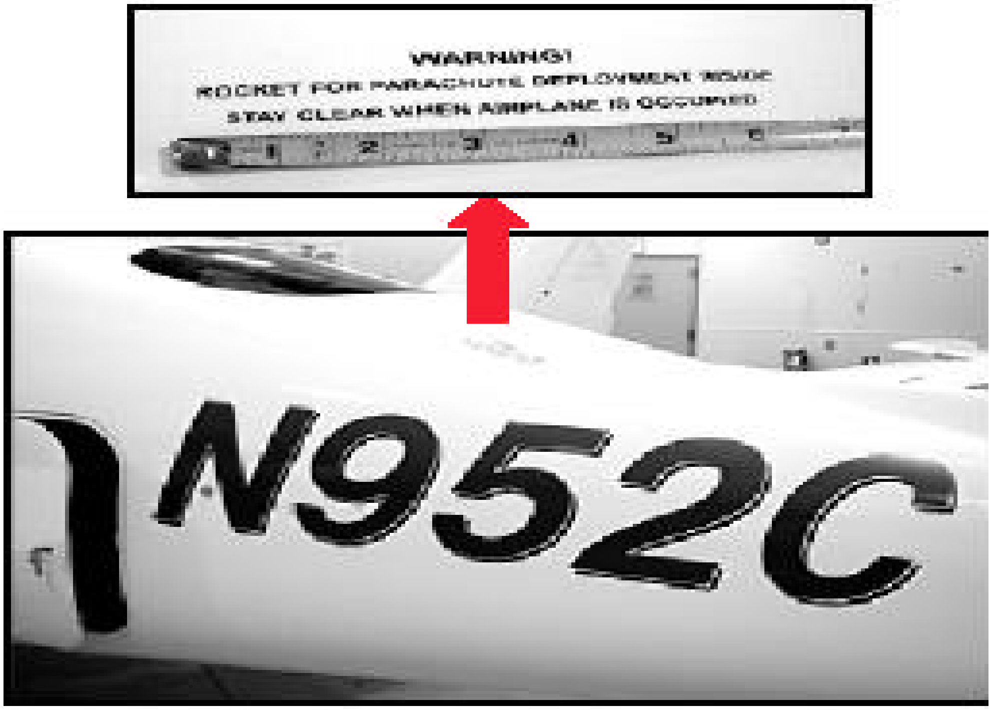


Figure 2-27. CAPS Warning Label For Cirrus SR20 and SR22 Aircraft

Figure 2-28. Label Affixed To Aircraft Rear Window

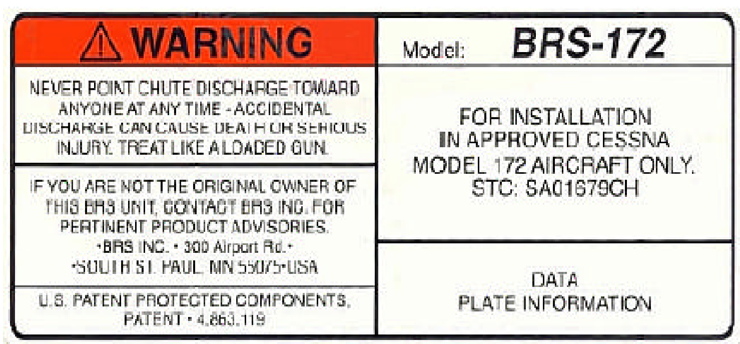


Figure 2-29. Label Affixed To Parachute Cannister

2-72. The problem with the existing labels are apparent. As shown above, the Cirrus warning label does not use the recommended NTSB panel format. Although it contains an appropriate signal word (in this case, "warning"), it does not contain a safety alert symbol, nor does it use the recommended orange background. The label also lacks a message panel that provides information regarding steps that emergency responder can take to avoid the hazard and that explains the potential consequences of failing to avoid the hazard (in this case, that a person struck by the rocket or flying debris or exposed to the blast during an accidental firing could be killed or seriously injured).

CHAPTER 3
HAZARDOUS MATERIALS AND MISHAP HAZARDS

TOPIC **PAGE**

TOPIC	PAGE

3.1 INTRODUCTION AND USE. There are chemical and materials found within an aircraft that are known to be hazardous if an exposure occurs. There are non-hazardous materials and situations that can become a hazard during an aircraft mishap response if not handled properly. The presence of hazards may be obvious, as in the case of a fuel spill. In other situations, the hazardous nature of the chemical may not be immediately apparent such as radioactive material. To ensure the safety of the responder, this chapter is dedicated to providing information for the anticipated hazards for an aerospace mishap response. Information needed to quickly identify hazards of chemical and flammable liquids and hazardous aerospace materials are found in paragraphs 3.3 and 3.4. Situations that could become mishap-hazards are discussed in paragraph 3.5. Specific mishap response procedures are contained in paragraph 3.6. Since most mishap responders will not have had any previous composite materials training, see paragraph 3.7 for mishap-composite awareness. Paragraph 3.8 provides checklists for Team Briefings and Safety and Health. Paragraph 3.9 are Flowcharts depicting Safety and Health and Composite Handling Logic. Paragraph 3.10 concludes with a List of Mishap Documents to Respond With. Colored coded diagrams depicting hazardous materials and chemicals for each aircraft are provided, starting with Chapter 4.

3.2 ACRONYMS AND DEFINITIONS.
Emergency response terms vary within the DoD. Terms are defined in this chapter according to USAF instructions.

a. BLOODBORNE PATHOGEN (BBP). Pathogenic micro-organisms that may be present in human blood and can cause disease in humans. Infections such as Hepatitis B, Hepatitis C and human immuodeficiency virus (HIV, the virus that causes AIDS) are some examples of BBP.

b. COMPOSITE AND ADVANCED COMPOSITE. A composite "system of materials", made up of two unlike materials, acting as a homogenous solid in its finished form. Two common materials used in aerospace design are a man-made fiber embedded within a matrix. The matrix is a polymeric material or resin consisting of long-chained organic molecules. The fiber provides the strength and the matrix provides toughness and durability while protecting the fibers. Glass fiber dispersed within an epoxy matrix is an example of a conventional composite. Advanced composites use fibers that possess greater strengths than fibers used within a conventional composite system. Examples of an advanced composite are carbon, boron or Kevlar®(aramid) dispersed within an epoxy resin.

c. DISASTER CONTROL GROUP (DCG). The response element that deploys to the scene of a major accident to command, control and recover (not aircraft recovery) the site in preparation for the arrival of the investigation board. The DCG is comprised of two subgroups, the initial re-sponse group and the follow-on element.

d. FIRST RESPONSE. The firefighting response is sometimes called the first response because they reach the mishap scene first. The fire chief will serve as the on-scene-commander until the site is declared safe and casualties are under medical care.

e. FOLLOW-ON RESPONSE. This disaster control subgroup responds to a pre-planned assembly point and deploys when the on-scene-commander (fire chief) determines a safe route to enter the scene. The element may include readiness, bioenvironmental engineering, civil engineering, EOD, aircraft maintenance, ground/flight safety, mortuary affairs, transportation, public affairs, accident investigators and others deemed necessary.

f. HAZARDOUS AEROSPACE MATERIALS. Materials and systems integrated into aerospace vehicles that can present a potential safety and health hazard to personnel responding to mishaps. This includes composites, radar absorbing material (RAM), radioactive material and protective coatings.

g. INITIAL RESPONSE ELEMENT. This disaster control subgroup responds immediately to on or near-base mishap scenes. The element consists of medical, security, fire protection and possibly munitions or ordinance.

h. RADAR ABSORBING MATERIAL (RAM). There are a number of design parameters used to achieve a low observable (LO) or "stealth" characteristic. One is to use a coating material that is radar absorbing. One type of RAM coating is a polymeric based material loaded with a metal or ceramic particles/powder. The older RAM coatings used ferrite as the particle.

i. SECONDARY RESPONSE. When the investigation process releases the site, activity occurs to recover the aircraft and to return the property/real estate to its normal state. The secondary response are the elements that prepare the pieces for shipment, off site aircraft storage, environmental assessment and finally disposal. Even though the emergency response has ceased, potential hazards can still exist for the secondary response elements.

3.3 KNOWN SOLID, LIQUID AND GAS HAZARDS. This paragraph contains information on known hazardous chemicals and flammable liquids associated with aircraft or aerospace vehicles. A list of vehicles and locations of materials is provided where possible. A summary of hazards for specific vehicles are found in Table 3.3-1.

a. ANHYDROUS AMMONIA. Anhydrous ammonia is 99.5% (by weight) basic ammonia (NH_3) and is normally a pungent, color-less vapor.

(1) HEALTH HAZARD. A hazardous toxic fluid. Liquid form produces severe burns on contact. Gaseous form is a strong irritant and can damage the eyes and the entire respiratory tract.

(2) FIRST AID. Remove victim from contaminated atmosphere. If skin is contacted, flush the area of contact with large amounts of water, and seek the care of a physician.

(3) RESPIRATORY PROTECTION. Entry into an ammonia atmosphere is extremely hazardous. Approved respiratory protection equipment shall be worn at all times in this atmosphere.

(4) AIRCRAFT AND LOCATION. Orbiter Vehicle has two tanks in the aft fuselage.

b. ANTI-ICING FLUID. Anti-icing fluids are usually a mixture of about 85% alcohol and 15% glycerin. While not as great as other aircraft hazards, it should be remembered that the alcohol used in aircraft anti-icing systems burns with an almost invisible flame. The best method of control is by dilution with water.

c. AQUEOUS FILM FORMING FOAM (AFFF). AFFF, a clear, amber colored liquid. Concentrates consist primarily of synthetic fluorocarbon surfactant materials that are noncorrosive until it is mixed with water and have an unlimited shelf life when stored in a protected area where temperatures may range from 32°F (0°C) to 120°F (48°C).

NOTE

Failure to follow manufacturer storage procedures may cause AFFF to break down and separate, degrading its ability to form a vapor seal.

(1) CONCENTRATIONS. These concentrates must meet current military specification standards (M&F-24385), three % and six% AFFF concentrate is approved for naval use. Optimum performance for a 3% concentrate is realized when proportioned at 3 parts concentrate to 97 parts water. For a 6% concentrate, optimum performance is achieved when proportioned at 6 parts concentrateto 94 parts water. Current shipboard equipment requires 6% con-centrate. When AFFF is mixed with water, corrosive effects occur because of the corrosive properties of water (particularly saltwater) and the AFFF-induced low-surface tension of the mixture promoting seepage through small cracks, etc. Either fresh water or sea water may be used for proportioning systems. For premixing, only fresh water should be used to reduce corrosion activity. The OPNAVINST 4790.2 series outlines the mandatory procedures that must be followed whenever an aircraft is sprayed with AFFF solution.

(2) FIREFIGHTING EFFICIENCY. The unique extinguishing and securing action of AFFF on flammable liquid fires results from a combination of rapid foam blanketing and vapor sealing when applied properly. During fire extinguishment, the AFFF foam blanket rapidly yields a very thin layer of AFFF solution that also extinguishes the fire and forms a vapor seal, restricting further emission of flammable vapors.

(3) AIRCRAFT CLEAN UP. After AFFF has been used on a aircraft and if moveable, aircraft maintenance will tow the aircraft to a wash rack and rinse thoroughly and wash the aircraft IAW the specific aircraft T.O. If not moveable, rinse in place and transport as soon as possible to a wash rack with the above procedures. Engine washing will be done IAW specific engine T.O.s.

(4) HEALTH HAZARD. Toxic by-products, including small amounts of HF, may be formed. Thermal decomposition may produce toxic materials including HF. If introduced under skin through cuts or punctures, slow-healing ulcers may develop. For eyes, may cause moderate irratation. For skin, may cause irritation on prolonged contact. For inhalation, mist or vapors may cause irritation of the respiratory system, resulting in vomiting, nausea, diarrhea, abdominal pain and stupor. Very high concentrations may cause pulmonary edema. Possible injury of the blood. For ingestion, not an expected route of industrial exposure. May cause unconsciousness, flushing of face with dizziness, nausea, headache, cough, sore throat, shortness of breath, confusion, convulsions and lethargy.

NOTE

There may be storage concerns relating to contaminated mishap materials/debris in the form of off-gasing.

(5) FIRST AID. Immediately flush with plenty of water. Continue for 15 minutes. Call a physician or poison control center. Wash affected area with soap and water. For inhalation, remove victim to fresh air. For ingestion, give two glasses of water.

NOTE

Application of AFFF fire extinguishing efficiency is not critically dependent on foam expansion as is the case with protein-type foam concentrates. AFFF can be applied witheither approved nonair-aspirating nozzles or air-aspiratingfoam nozzles. However, the variable stream fog nozzle type is preferred because of the rapid stream adjustability afforded the firefighter. Additionally, these nozzles produce a more fluid foam, resulting in faster control and extinguishment. AFFF is compatible with Halon 1211 and PKP dry chemical firefighting agents.

WARNING

Periodic reapplication of AFFF is essential to avoid reflash when working in and around crashed aircraft.

d. BERYLLIUM. Beryllium as a dust or powder form is a silvery looking material resembling aluminum powder. Hard as a solid is a brittle gray-white metal.

(1) HEALTH HAZARD. Toxic respiratory and eye irritant. If introduced under skin through cuts or punctures, slow-healing ulcers may develop. Dust is highly toxic.

(2) FIRST AID. After exposure to beryllium fire, personnel should bathe carefully and all equipment and clothing should be laundered separately from other non-contaminated material and clothing.

(3) FIRE HAZARD. Dust forms explosive mixtures in air. Hazard is greater as particle fineness increases. Reacts readily with some strong acids, producing hydrogen.

(4) AIRCRAFT AND LOCATION. C-5 brake pads, F-100 wing tip area and around cockpit; and the A-7D landing gear bushings. (Older aircraft may still be in use.)

e. ETHYLENE GLYCOL. Ethylene glycol is clear viscous liquid with a slight odor and sweet taste. Used for liquid controls, calibrators, coolant, and a deicing fluid ingredient.

(1) HEALTH HAZARD. Can be inhaled and may cause irritation of mucous membranes and respiratory passages. Can be ingested and may cause intoxication and coma. Skin contact may cause irritation.

(2) FIRST AID. For skin, was affected areas thoroughly. For ingestion, eyes, or contact with open wound, obtain medical attention in all cases.

(3) PERSONAL PROTECTION. Skin and respiratory protection from mists.

(4) FIRE HAZARDS. Stable, but heat should be avoided. Materials to avoid: strong oxidizers.

(5) DISPOSAL RELEASE PROCEDURES. Dispose as necessary IAW applicable laws and regulations.

f. FC-77. Non-reactive, non-corrosive, non-flammable, and an inert liquid. When heated above 572° F or when electricity is passed through the solution some forms of nerve gas may evolve.

(1) HEALTH HAZARD. Contacting skin or eyes with liquid is no problem except for prolonged exposures which causes dermatitis.

(2) RESPIRATORY PROTECTION. Approved respiratory equipment will be worn in a FC-77 atmosphere.

(3) AIRCRAFT AND LOCATION. E-3, used to cool radar system.

g. FREON - 502 REFRIGERANT. Freon is a clear, colorless liquified gas with a slight ether odor. Used for cooling and refrigeration systems. A mixture of Freon 115 and 22.

(1) HEALTH HAZARD. Overexposure by inhalation may include discomfort, nausea, headache, weakness, temporary nervous system depression with anesthetic effects like dizziness, confusion, incoordination, loss of consciousness. Gross overexposure (>20%), possible temporary alternation of the heart's electrical activity with irregular pulse, palpitations, inadequate circulation. Misuse can result in death.

(2) FIRST AID. Inhalation, get fresh air. Keep calm. If breathing stops, give artificial respiration. If difficult, give oxygen. Call a physician. For skin, clean skin after use. For eyes, immediately flush with water. Inform physician due to possible disturbances of cardiac rhythm, catecholamine drugs, such as epinephrine, should be used with special caution only in situations of emergency life support. Eyes and skin contact: flush with water for 15 minutes.

(3) PERSONAL PROTECTION. SCBA is required if cylinders rupture or release under fire conditions.

(4) FIRE HAZARDS. Will not burn. Cylinders are equipped with temperature and pressure relief devices, but still may rupture under fire conditions. Decomposition may occur. Avoid open flames and high temperatures. Materials to avoid: alkali or alkaline earth metals - powered A1, An, Be, etc. Conditions to avoid: hydrofluoric acids and possibly carbonyl halides. Decomposition is HF, HC1 and carbonyl halides.

(5) AIRCRAFT AND LOCATION. Multiple types.

(6) SPILL RELEASE PROCEDURES. Use neoprene rubber gloves. Eye protection, use chemical splash goggles. SCBA for spill or release. Avoid open flame and high temperatures.

(7) WASTE DISPOSAL METHODS. Comply with applicable laws and regulations. Remove to a permitted waste disposal facility or reclamation by distillation.

h. HYDRAULIC FLUID. Hydrocarbon based fluid with the addition of oxidation resistant and performance-enhancing addatives. See SKYDROL.

i. HYDRAZINE. Hydrazine is highly alkaline. Hydrazine at room temperature is a clear, oily, fuming, liquid with an odor similar to ammonia. It is hazardous to health in both the liquid and vapor form; combustible and explosive. Hydrazine fuel (H-70) is a blend of 70% hydrazine and 30% water and is used to power the EPU on F-l 6 series aircraft.EPU operation results in noise similar to the rapid firing of a rifle. Exhaust gases exiting from the EPU turbine are approximately 1600°F (871°C) and basically consist of 40% ammonia, 17% nitrogen, 15% hydrogen, and 28% water. See page F-16.4 for hydrazine bottle view.

(1) HEALTH HAZARD. Hydrazine is highly alkaline and can cause severe local damage or burns if it comes in contact with the eyes or skin. It can penetrate skin to cause systemic effects similar to those produced when swallowed or inhaled. If inhaled, the vapor causes local irritation of eye and respiratory tract and systemic effects. On short exposure, systemic effects involve the central nervous system with symptoms including tremors. On exposure to high concentrations, convulsions and possible death follow. Repeated or prolonged exposures may cause damage to the liver and kidneys, as well as anemia.

(2) FIRST AID. Remove the victim from the contaminated environment, remove all contaminated clothing and wash propellant from the skin with water. If eyes have been exposed, flush with water for at least 15 minutes and get immediate medical attention. Emergency limits for exposure to hydrazine vapors are in concentrations of 30 parts per million for 10 minutes, 20 PPM for 30 minutes, and 10 PPM for 60 minutes. Irreversible health effects occur at 80 PPM for 30 minutes. Such high concentrations are only attainable in enclosed areas like a hangar and cannot be achieved in open air.

(3) RESPIRATORY PROTECTION. Entry into a hydrazine atmosphere is extremely hazardous and only warranted in dire emergency. Approved respiratory protection shall be worn at all times when working in atmospheres where there is a potential for exposure to hazardous vapors.

(4) FIRE HAZARD. Hydrazine is a strong reducingagent. It is hypergolic with oxidizers such as nitrogen tetroxide and metal oxides of iron, copper, lead, etc. Spontaneous ignition may occur if it is absorbed in rags, cotton waste, etc. Hydrazine will ignite when exposed to heat, flame or oxidizing agents. The flashpoint is 126°F (52°C). As opposed to liquid form, hydrazine vapors as much more sensitive to electrical sparks, embers, flame, etc. Move container to area from fire area if possible without risk. Ignited vapor will continue to burn exothermically without air or other oxidants. Decomposition starts exothermically at 320°F. Spray cooling water on containers exposed to flame or smoldering debris until well after fire is out.

(5) AIRCRAFT AND AMOUNT. The F-16 has 6.8 and the Orbiter Vehicle has 1676 US gallons.

(6) CLEAN UP. Specific hydrazine cleanup and firefight-ing instructions are contained in USAF Technical Orders T.O. 42Bl-1-18, General Procedures Handling of H-70, Hydrazine-Water and T.O. IF-16C-2-49GS-OO-1, H-70 Fuel Spill Management and Neutralization.

j. HYDROGEN-LIQUID. A non-toxic, non-corrosive, transparent, colorless, and odorless liquid of low viscosity.

(1) HEALTH HAZARD. In gaseous form, hydrogen acts as a simple asphyxiant. If in very high concentration, atmospheric oxygen content may be reduced and oxygen deprivation will result Contact with skin can cause serious burns.

(2) FIRST AID. If contact with skin occurs, flush affected area with water. Extensive burns will require prompt medical attention.

(3) RESPIRATORY PROTECTION. Approved respiratory protection shall be worn. Self-contained breathing equipment that uses oxygen should be of the re breathing type to minimize release of oxygen to the atmosphere. Ifdemand-type equipment is used, compressed air must be used.

(4) FIRE HAZARD. Hydrogen gas is highly combustible with air over a wide range of mixtures and will explode when heated. When no impurities are present, hydrogen burns in air with an invisible flame. Liquid hydrogen evaporates rapidly, consequently fires are of short duration. Vapors are heavier than air and spreads on and around th e affected area and low spots. May travel back to source of ignition and flash back.

(5) AIRCRAFT AND LOCATION. Orbiter Vehicle has two tanks in the middle of the fuselage.

k. HYPERGOLIC MIXTURES. Hypergolic mixtures are used as propellants for rockets and missiles. Hypergolic fuels ignite on contact with certain chemical oxidizers anddo not require an ignition source. Examples of hypergolic combinations used missile/rocket propulsion systems are:

(1) MIXTURE NO.1. Fuels: ammonia, hydrazine, hydrogen. **Oxidizers:** fluorine or chlorine trifluoride.

(2) MIXTURE NO.2. Fuels: hydrazine, analine, furfmyl alcohol, deta hydrazine. **Oxidizers:** nitric acid.

(3) MIXTURE NO.3. Fuels: hydrazine, unsymmetrical dimethyl-hydrazine. **Oxidizers:** hydrogen peroxide.

(4) MIXTURE NO.4. Fuels: aniline, hydrazine, furfuryl alcohol. **Oxidizers:** nitrogen tetroxide.

(5) HEALTH HAZARDS. The health hazards include chemical burns, poisoning, and frostbite.

(6) PROTECTION. In accidents involving these materials, personnel shall use full respiratory protection and protective clothing.

(7) FIRE HAZARD. Fires involving these materials can best be handled by diluting the fuel and oxidizer with large quantities of water.

l. JET FUELS. Jet Propulsion/aviation turbine fuels. Amber in color.

(1) AVGAS. The flashpoint (by closed cup method at sea level) of AVGAS is -50°F (-46°C). The rate of flame spread has been calculated to be between 700 and 800 feet per minute.

(2) JP-4. JP-4 jet fuel is a blend of gasoline and kerosene and has a flashpoint from -10°F (-23°C). The rate of flame spread has also been calculated to be between 700 to 800 feet per minute.

(3) JP-5. JP-5 fuel is a kerosene grade with a flashpoint of 150°F (66°C). The rate of flame spread has been calculated to be in the order of 100 feet per minute.

(4) JP-8. JP-8 is a kerosene grade with a flashpoint of 115°F (approximately 46°C). The rate of flame spread is in the order of IOO feet per minute.

The lowest flashpoint considered safe for use aboard naval vessels is 140°F (60°C).

WARNING

As little as a 2.5 % mixture of JP-4, JP-8, or commercial equivalents in JP-5 greatly reduce the flashpoint below 140° F. Aircraft that have refueled in flight or ashore from Air Force, civilian, or Army facilities may contain unsafe fuel mixtures.

NOTE

As little as a 2.5 % mixture of JP-4 in JP-5 will reduce the flashpoint by 40°F (5°C). 10% JP-4 reduces the flashpoint of the mixture by 90°F (32°C).

(5) FIRE HAZARD. Although there are differences in the properties, it must be emphasized that under aircraft crash impact conditions where fuel mists (fuel-air mixture) are created, all of the fuels are easily and readily ignitable. There is so little difference in the heat of combustion be-tween the various aircraft hydrocarbon fuels that the severity after ignition would be of no significance from the fire safety point of view. The firefighting and control measures are the same for the entire group of aviation hydrocarbon fuels. Structural firefighters will only provide limited protection.

(6) HEALTH HAZARD. Irritates or burns skin and eyes.Fire will produce irritating, corrosive and/or toxic gases. Vapor may cause dizziness or suffocation. Run off from fire control may cause pollution.

(7) FIRST AID. Remove victim from area and then get immediate medical attention. Removed contaminated clothing and wash exposed areas.

(8) RESPIRATORY PROTECTION. Approved SCBA respiratory protection shall be worn.

(9) AIRCRAFT AND LOCATION. All aircraft throughout this publication.

m. KAPTON® (POLYIMIDE FILM). A polyimide film coated with a polyfluorocarbon is an electrical insulation material. Some uses are wire and cable insulator, radiation shield and insulation blanket.

(1) HEALTH HAZARD. Heating Kapton polyimide film above 527° F or from smoking cigarettes contaminated with fluorocarbon coatings may cause polymer fume fever, a temporary, flu-like illness of approximately 24 hours duration with fever, chills and sometimes cough. Exposure to temperature above 662° F produces trace amounts of carbonyl fluoride, perfluorisobutylene causing severe eye, skin and respiratory tract irritation. Inhalation can cause shortness of breath and other respiratory effects and symptom may be delayed. Handling Kapton polyimide films produces static charge.

(2) FIRST AID. Move to fresh air. Wash with soap and water when skin contact is made with burnt debris. If skin irritation develops or symptons persit contact or consult a physician.

(3) FIRE. The polyimide film is self-extinguishing. Kapton chars, but does not burn in air. Extinguish with foam.

(4) PERSONAL PROTECTION. Wear SCBA and clothing to protect from hydrogen fluoride which reacts with water to form hydrofluoric acid. Wear neoprene gloves when handling refuse from a fire involving fluorocarbon resins.

n. LITHIUM THIONYL CHLORIDE. A soft, silvery, highly reactive metallic element, used as a heat transfer medium, in thermonuclear weapons and in alloys.

(1) HEALTH HAZARD. Serious injury to personnel can occur if incorrect fire suppression procedures are ignored such as using Halon.

(2) FIRST AID. Remove victim from area and then remove all contaminated clothing with protective gloves. Get immediate medical attention.

(3) RESPIRATORY PROTECTION. Approved respiratory protection shall be worn. SCBA for firefighters.

(4) AIRCRAFT AND LOCATION. Various aircraft onboard mission computer batteries.

(5) FIRE SUPPRESSION PROCEDURES. Lithium metal and thionyl chloride reacts violently with water. Use only a graphite powder such as Lith-X. Never use water, wet sand, carbon tetrachloride, carbon dioxide, or any other liquid or powder to extinguish a lithium fire.

o. LUBRICATING OIL. Hydrocarbon based oil with the addition of corrosion and oxidation inhibitors. See Skydrol.

p. MAGNESIUM. Magnesium is a silvery-white metal that looks like aluminum, but is lighter in weight.

(1) HEALTH HAZARD. Magnesium dust is a slight irritant. In fire conditions, protect eyes and skin against flying particles. Avoid direct viewing of magnesium fires as eye injury may result. Fire produces toxic gas.

(2) FIRST AID. If burns are received, contact a physician. Corrosive solution in contact with water. Treat skin contact for corrosive burns.

(3) FIRE HAZARD. Do not use water or foam. Corrosive solution in contact with H_2O. Fine powder, thin sheets, chips and trimmings, are easily ignited and burn with intense heat and brilliant white flame. Pieces having thickness over 1/8 inch are difficult to ignite or to maintain flame as heat is conducted away so rapidly. However, thick pieces can be ignited when enough heat is applied. In finely divided form, will react with water and acids to release hydrogen; also hazardous in such form with chlorine, bromine, iodine, oxidizing agents, and acids. Produces flammable gases in contact with water.

(4) AIRCRAFT AND LOCATION. Magnesium parts arelocated on most aircraft in different locations. One major use is in wheel assemblies.

q. NITROGEN TETROXIDE. Fumes vary in color from light orange to reddish brown to blue or green at low temperature. Is a strong oxidizer.

(1) HEALTH HAZARD. Skin contact with liquid form will cause burns similar to nitric acid. Eye contact may cause blindness. If swallowed, may result in death from sever internal burns. Prolonged inhalation will result in irritation of respiratory tract and may cause pulmonary edema. Toxic, may be fatal if absorbed through skin or inhaled.

(2) FIRST AID. Remove victim from contaminated area and then carefully remove all contaminated clothing. Wash victim with liberal amounts of water. Get immediate medical attention.

(3) FIRE HAZARD. Contain fire and let burn. If fire has to be fought, use water only.

(4) PERSONAL PROTECTION. Fully encapsulate for vapor protection entry into a nitrogen tetroxide atmosphere which is extremely hazardous. Approved respiratory protection shall be worn for spills.

(5) AIRCRAFT AND LOCATION. Orbiter Vehicle has one tank in nose and four in aft section.

r. OXYGEN - GASEOUS AND LIQUID. Oxygen is a powerful oxidizer in the liquid and gaseous states. It is colorless, odorless, and slightly heavier than air. In theliquid state, it is pale blue in color and slightly more dense than water.

(1) HEALTH HAZARD. The oxygen rich atmosphere can be ignited by an ignition source. Oxygen in the liquid state is generally less dangerous than oxygen stored as a high pressure gas. Liquid oxygen boils (vaporizes) at minus 297°F, and will freeze any object that comes in contact with it.

(2) FIRST AID. If liquid oxygen contacts the skin, flush the affected area with water; contact a physician.

(3) FIRE HAZARD. Non-flammable in normal concentrations; however, it reacts vigorously with both flammable and many non-flammable materials.

(4) LOCATION AND AMOUNT. Oxygen is located in different places aboard the aircraft and of various amounts. See aircraft diagrams for location starting with Chapter 4.

s. POLYCRYLIC ACID (PPA). PPA is a hydrotreated light distillate petroleum with a white semi-solid appearance with a slight odor. Common name: Easy Glaze. Used as a fixant on broken up aircraft materials that are prone to being airborne, such as composite fibers.

(1) HEALTH HAZARD. Inhalation, dizziness, abdominal discomfort, central nervous system depression, headache, nausea and mucous membrane irritation. For eyes, conjuctivitis. For skin/ingestion, irritation.

(2) FIRST AID. Wash skin and hands after use. If ingested, do not induce vomiting. Give water. Obtain medical attention in all cases.

(3) FIRE HAZARD. Flashpoint 200°F. Extinguishing media: CO2, foam, dry chemical, or water. Wear SCBA in positive pressure mode and full protective gear. Conditions to avoid: heat sources, sparks, flames, freezing. Materials to avoid: oxidizing agents and acids. Store between 40° and 120°F and use in properly ventilated areas.

(4) ENVIRONMENTAL HAZARD. The fixant is an environmental hazard. The concentrated fixant may have a PH characteristic of a hazardous waste. CAUTION: Do not overspray objects, fixant contaminates the ground and dirt and becomes a hazardous waste for disposal considerations.

t. POLYALPHAOLEFIN. PAO listed as MIL-PRF-87252, is a synthetic hydrocarbon lubricating base oil used as a dielectric coolant. Appearance is clear and has no odor. Manufactured under trade name of Royco 602.

(1) HEALTH HAZARD. Mildly irratating to the skin, prolonged or repeated liquid contact can result in defatting and drying of the skin which may result in skin irritation and dermatits. Release during high pressure usage may result in injection of oil into the skin causing local necrosis. Mildly toxic to internal organs is inhaled. Inhalation of vapors (at high temperatures only) or oil mist may cause mild irritation of the mucous membrane upper respiratory tract. May be harmful or fatal if swallowed. Ingestion may result in vomiting. Signs and symptoms of exposure are irritation/aspiration pneumonitis may be evidenced by coughing, labored breathing and cyanosis (bluish skin). In sever cases, death may occur. Local nacrosis is evidenced by delayed onset of pain and tissue damage a few hours following injection.

(2) FIRST AID. For eye contact, flush eyes with water. For skin contact, remove contaminated clothing/ shoes and wipe excess from skin. Flush skin with water. Follow by washing with soap and water. Do not reuse clothing until cleaned. If material is injected under the skin, get medical attention promptly to prevent serious injury. For inhalation, remove victim to fresh air and provide oxygen if breathing is difficult. For ingestion, do not induce vomiting. If vomiting occurs spontaneously, keep head below hips to prevent aspiration of liquid into the lung. Get medical at- tention for all above exposures.

(3) FIRE HAZARD. Flash point is 350°F. Product will float and can be reignited on surface of water. Release on hot surfaces will cause a fire. Use water fog, foam, dry chemical or CO_2. Do not use a direct stream of water. Material will not burn unless preheated. Do not enter confined fire space without full PPE. Cool fire exposed containers with water. Thermal decompostition products are highly dependent on the combustion conditions. A complex mixture of airborne solid, liquid, particulates and gases will evolve when this material undergoes pyrolysis or combustion. Carbon monoxide and other unidentified organic compounds may be formed upon combustion. Keep away from open flames and high temperatures.

(4) AIRCRAFT AND LOCATION. Used in all military aircraft as a coolant for avionics, radar, and radar countermeasure systems since the 1970s. Replaced former coolants for this purpose.

u. QUARTZ.

(1) HEALTH HAZARD. Long term exposure to inhaled cyrstalline silica (silicon dioxide, SiO) in the form of quartz has shown to be carcinogenic in humans. Skin, eye and respiratory irritations can occur from exposure to dust containing silica. Dust can be generated when crushing, grinding, cutting or handling severely damaged and shattered parts containing quartz. Pure quartz is chemically and biologically inert when ingested in any of its physical forms.

(2) FIRST AID. Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, brochitis, or pneumonitis. Irrigate exposed eyes with copious amounts of tepid water for 15 minutes. Irritation, pain, swelling persists, seek medical attention. Wash exposed dermal area with soap and water. If irritation persists, seek medical attention.

(3) PERSONAL PROTECTION. Contact lenses should not be worn. Protective suits must be worn in situations where dust cannot be controlled. Respirator and gloves to protect from dust.

(4) FIRE HAZARDS. Rescuers do not enter areas with potential high airborne particulate concentrations without SCBA.

(5) AIRCRAFT AND LOCATIONS. High purity silica or quartz can be found in plastic and resin materials as a filler in a particulate form. Fibrous quartz material can be used to make antenna windows, radomes, ablative and ablative and thermal barriers. B-1, B-2, F-15, F-117, F-22 radome. Replacement radome material for F-16.

v. SKYDROL LD-4. Used as a hydraulic fluid and is fire resistant under normal conditions and not fire resistant in a mishap. Appearance is clear, purple oily liquid and ordorless. Considered environmentally friendly and non cancer causing, precautions should be maintained.

(1) HEALTH HAZARD. Target organs: eyes, skin, respiratory and gastrointestinal tracts. Acute-eye: may cause severe pain. Skin: prolonged/repeated con-tact may cause drying and cracking. Inhale: vapors or mists may cause respiratory irritation. Oral: may be harmful if ingested. Chronic-may cause urinary bladder damage based on animal studies. Signs and symptoms of overexposure: irritation, redness, nausea, vomiting, blurred vision, tearing, defatting of skin, headache, cracking.

(2) FIRST AID. Get medical help if symptoms persist. Inhaled: move to fresh air. Provide CPR/oxygen if needed. Eyes: flush with water for 15 minutes. Hold eyelids open. Skin: wipe off excess and wash skin with mild soap and water or waterless cleaner. Oral: get medical attention.

(3) PERSONNEL PROTECTION. Wear protective clothing appropriate for the job. Always wear gloves and chemical resistant clothing such as rubber apron, face shield, respirator. Launder or destroy contaminated clothing. Use of barrier creams is not recommended. Always use safety glasses. Use chemical goggles or face shield if potential for splashing or spraying exists. Have eye flushing equipment available. Maintain proper ventilation in the workplace. Use NIOSH/MSHA approved respirator if necessary. Prevent exposure to inhalation by maintaining good industrial hygiene, wash after handling, and clean contaminated clothing. Do not wear contact lenses.

(4) FIRE HAZARDS. Flash point: 320°F, 160°C. Autoignition: 750°F, 398.9°C. Use water fog, carbon dioxide, sand, foam/dry chemical. Water spray may be used to keep fire exposed containers cool. Gases are toxic.

(5) AIRCRAFT AND LOCATION. Various aircraft now have Skydrol installed in systems and reservoirs.

w. SKYDROL 5. Used as a hydraulic fluid and is fire resistant under normal conditions, but not fire resistant in a mishap. Appearance is clear, purple oily liquid and ordorless. Considered environmentally friendly and non-cancer causing, precautions should be maintained.

(1) HEALTH HAZARD. Eye contact produces severe pain with eye damage. Skin contact removes oils causing drying and cracking after repeated/prolonged use. Exposure to aerosolized fluid or vaors may cause nose and throat irritation, nausea, headache. Inhalation of tributyl phosphate, a component, may cause nausea and headache. Signs and symptoms of overexposure are eye pain, skin irritation, skin drying/cracking, respiratory tract irritation, nose irritation, throat irritation, coughing, wheezing, nausea, and headache.

(2) FIRST AID. If in eyes, immediately flush with plenty of water for at least 15 minutes. Get medi-cal attention. If on skin, immediately flush with plenty of water. Remove contaminated clothing. Get medical attention. Wash clothing before reuse. If Inhaled movemove to fresh air. If not breathing give artificial respiration. If breathing is difficult, give oxygen. Get medical attention. If swallowed, imme-diate first aid is not likely to be required. A physician or poison control center can be contacted for advice. Wash contaminated clothing before reuse.

(3) PERSONNEL PROTECTION. Wear protective clothing appropriate for the job. Always wear gloves and chemical resistant clothing such as rubber apron, face shield, respirator. Launder or destroy contaminated clothing. Use of barrier creams is not recommended. Always use safety glasses. Use chemical goggles or face shield if potential for splashing or spraying exists. Have eye flushing equipment available. Maintain proper ventilation in the workplace. Use NIOSH/MSHA approved respirator if necessary. Prevent exposure to inhalation by maintaining good industrial hygiene, wash after handling, and clean contaminated clothing. Do not wear contact lenses.

(4) FIRE HAZARDS.

WARNING

Flash point: 320°F, 160°C. Autoignition: 750°F, 398.9°C. Use water spray (fog), foam, dry chemical and carbon dioxide. Do not enter any enclosed or confined area without proper protective equipment and NIOSH-approved self-contained breathing apparatus. Products of combustion include hazardous carbon monoxide, carbon dioxide and oxides of phosphorus. Exposure to strong oxidizing agents may result in generation of heat and combustion products. Oxides of phosphorus may form during decomposition. No other uniquely hazardous decomposition products are expected. Product is stable under of use up to approximately 250 - 275°F.

(5) AIRCRAFT AND LOCATION. Various air craft now have Skydrol installed in systems and reservoirs. This product is not considered hazardous under the applicable DOT, ICAO/IATA, OR IMDG regulations.

(6) SPILL RELEASE PROCEDURES. Contain large spills with dikes and transfer the material to appropriate containers for reclamation or disposal. Absorb remaining material and then place in a chemical waste container.

(7) WASTE DISPOSAL METHODS. Prevent waste from contaminating surrounding environment. Discard any product, residue, disposal container or liner in accordancewith all Federal, State, and local regulations.

x. <u>SULFURHEXAFLOURIDE GAS (SF-6).</u> Colorless, tasteless, and non-toxic. Heavier than air and is nonflammable and non-corrosive. This gas reacts with water to form hydroflouric acid.

(1) HEALTH HAZARD. SF-6 is a simple asphyxiant that displaces oxygen in the lungs and causes suffocation.

(2) RESPIRATORY PROTECTION. Entry into a SF-6 atmosphere is extremely hazardous. Approved respiratory protection equipment shall be worn at all times.

(3) AIRCRAFT LOCATION. E-3A, aft lower lobe.

y. <u>TRIETHYLBORANE (TEB).</u> Used as a fuel additive to provide rapid ignition of non-hyperbolic fuel or propellant. Extremely toxic and volatile liquid. with a sweet pungent odor.

(1) HEALTH HAZARD. Inhalation of vapors are unlikelysince spontaneous ignition occurs at lower concentrations than those required to cause toxic reac-tions. TEB contact with the skin or eyes will cause deep thermal burns.

(2) PERSONNEL PROTECTION. Full protective equipment must be worn during periods of exposure to TEB.

(3) FIRE HAZARDS.

WARNING

Detonations or violent reactions may occur when TEB comes in contact with strong oxidizing agents or halogenated hydrocarbons. Do not use Halon to extinguish TEB fires. TEB ignites immediately when exposed to air. Mechanical foam or chemical foam are the most effective extinguishing agents to use on TEB fires by establishing a stable foam blanket over the fire. When the foam blanket is broken, re-ignition usually occurs. Water, dry chemical, carbon dioxide and inert gas can also be used to combat TEB fires.

(4) AIRCRAFT AND LOCATION. TEB is used on the SR-71 during high altitude operations. A 700cc TEB tank is mounted on the upper left side of each engine.

z. <u>TRICRESYL PHOSPHATE.</u> TCP listed as MIL-L-23699E, is a synthetic hydrocarbon and additive lubricating oil. Appearance is liquid, brown in color with a mild ordor. Manufactured under the trade name of Mobil Jet Oil 254.

(1) HEALTH HAZARD. This product is determined to be hazardous, but is not expected to produce neurotoxic effects under normal conditions of use and with appropriate personal hygiene practices. Avoid inhalation of mists. Overexposure to TCP by swallowing, prolonged or repeated breathing of oil mist, or prolonged or repeated skin contact may produce nervous system disorders including gastrointestinal disturbances, numbness, muscular cramps, weakness and paralysis. Paralysis may be delayed. Wash thoroughly before eating or smoking. Keep away from feed or food products. Do not use on food processing machinery. Store in a cool, dry, well ventilated area away from heat.

(2) FIRST AID. For eye contact, flush eyes with water. For skin contact, wash contact area with soap and water. Do not wear ordinary clothing wet with this product. Remove contaminated clothing. Do not reuse clothing until cleaned. For inhalation, remove victim from further exposure. If respiratory irritation, dizziness, nausea, or unconsciousness occurs, seek immediate medical assistance.If breathing has stopped, assist ventilation with bag-valve-mask device or use mouth-to-mouth resuscitation. For ingestion, seek immediate medical attention. If medical attention will be delayed, contact a Region Poison Center oremergency medical professional regarding the induction of vomiting or use of activated charcoal. Do not induce vomiting or give anything by mouth to a groggy or unconscious person. Get medical attention for all above exposures.

(3) FIRE HAZARD. Flash point is 475°F. Unusual fire or explosion hazard: none. Extinguishing media: carbon dioxide, foam, dry chemical and water fog. Water or foam may cause frothing. Use water to keep fire exposed container cool. Water spray may be used to flush spills away from exposure. Prevent runoff from fire control or dilution from entering streams, sewers, or drinking water supply. For fires in enclosed areas, use full PPE. Hazardous decomposition: carbon monoxide.

(4) AIRCRAFT AND LOCATION. Used on military and commercial aircraft gas turbine engines of the turbo-jet fan, turbo-prop, and turbo-shaft (helicopter) types.

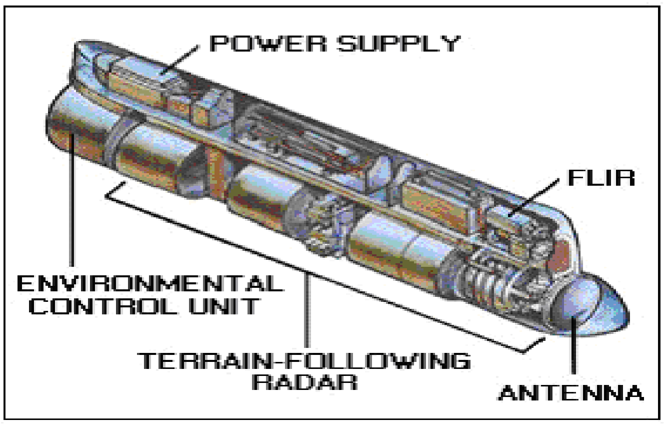
Table 3.3-1 Chemical Hazards

CHEMICAL	AIRCRAFT	LOCATION [1]
Anhydrous Ammonia	Orbiter Vehicle	Aft fuselage - 2 tanks
Anti-icing Fluid	Various	Various
Aqueous Film Forming Foam (AFFF)	N/A	N/A
Beryllium	A-7D, C-5, F-100, F-22	Landing gear bushings, brakes, wing tips. Avionics line replacement units and line replaceable modules located in the forward avionics bay, wing root and wing tip.
Ethylene Glycol	Various	Liquid controls and calibrators
FC-77	E-3	Radar system coolant
Freon - 502 Refrigerant	Various	Various
Hydraulic Fluid	Most	Various
Hydrazine	F-16, Orbiter Vehicle	Top of the EPU
Hydrogen – Liquid	Orbiter Vehicle	Middle of fuselage - 2 tanks
Hypergolic Mixtures	Various	Various
Jet Fuels	All	Assorted tanks and cells
Kapton Polyimide Film	Selected	Wire and cable insulator, radiation shield and insulation blanket.
Lithium Thionyl Chloride	C-17	On-board mission computer batteries
Lubricating Oil	All	Various
Magnesium	Most	Various, wheel assemblies
Nitrogen Tetroxide	Orbiter Vehicle	Nose - 1 tank, Aft - 4 tanks
Oxygen – Gaseous and Liquid	All	Various
Quartz	B-1, B-2, F-15, F-117, F-22	Radome, replacement radome for F-16
Polyacrylic Acid (PAA)	Fixant	N/A
Polyalphaolefin (Royco 602)	Various	Avionics, radar, radar countermeasure systems
Skydrol LD-4	Various	Hydraulic fuel line and reservoirs
Skydrol 5	Various	Hydraulic fuel line and reservoirs
Sulfurhexaflouride Gas (SF-6)	E-3A	Lower lobe
Triethylborane (TEB)	SR-71	TEB bank mounted upper left side of engines
Tricresyl Phosphate (Mobil Jet Fluid 254)	Various	Gas turbine engines of the turbo-jet fan, turbo-prop, and turbo-shaft (helicopter) types

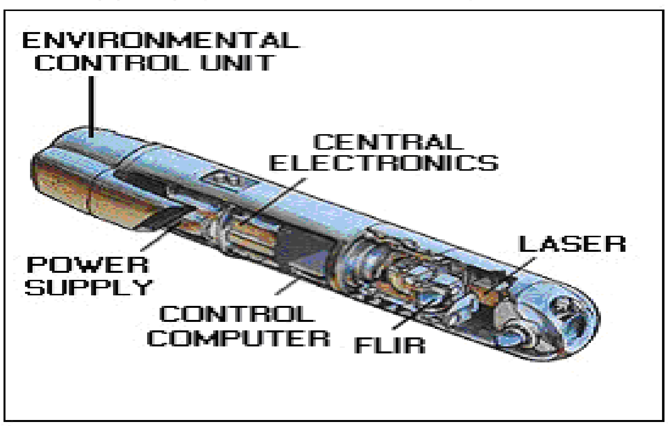
[1] Refer to Paragraph 3.3 for detailed discussion.

3-4. RADIOACTIVE MATERIALS HAZARDS. This paragraph provides information on what to expect from the material during initial and follow-on response phases of an incident. The most significant potential hazards of the material are identified and guidance given on the initial action to be taken. The information includes potential health hazards, fire hazards and emergency actions to take in the event of fire with appropriate first aid measures. At the end of the paragraph are hazards for specific vehicles in Table 3.4-1 and Depleted Uranium (DU) is explained.

a. AMERICIUM- 241. A synthetic radioactive metallic element. Metallic americium is silver-white with a melting point of 210°F. AM-241 is found within the LANTIRN (Low Altitude Navigation and Targeting Infrared for Night) system in the F-18 A/B/C/D. The material is located in the forward-looking infrared pod (FLIR).



AN / AAQ-13 NAVIGATION POD



AN / AAQ-14 TARGETING POD

(1) HEALTH HAZARDS. Americium is a gamma and an alpha emitter, radioactive poison. AM-241 emittance is approximately 5 MeV; Gamma emittance is approximately 60KeV.

(2) HANDLING PROCEDURE. Destruction of the FLIR unit is needed for an AM-241 exposure. The pod may become damaged during impact and expose the AM-241 coated contents of the FLIR. Handling of the optical module includes wearing gloves and a properly fitted protective mask while double sealing it in plastic bags or containerizing it. Keep unnecessary people out of incident area until area is declared safe by the radiological response team.

(3) FIRE HAZARD. If the material is on fire keep upwind, avoid breathing dust and fumes.

(4) FIRST AID. Wash away any material which may have contacted the body with copious amounts of water or soap and water.

b. DEPLETED URANIUM (DU). Used as ballast or counterweights in aircraft gyroscopes, flight controls, helicopter blades, elevator balances, aileron balances, aircraft rockets, projectiles and missiles. DU is natural uranium having most of the U-234 and U-235 removed; it is principally U-238. It is a heavy metal that oxidizes taking on a yellow color and then a black color. To avoid oxidation, the DU is cadmium plated. Some DU is conversion coated and has a gold or brass color. A problem arising from damaged plating is flaking from formed uranium oxidation.

(1) POTENTIAL HEALTH HAZARDS. DU presents a two fold hazard, chemical and radiation.

(a) The chemcial properties of DU present a health hazard only after entry into the body by inhalation, ingestion, or through an open wound. Inhalation is the most significant mode of entry. If involved in fire, DU will give off very toxic fumes. Once oxidized DU is deposited in the respiratory tract, it can be taken into the blood stream and deposited in internal organs where damage may result. Most dusts from DU, in the body, are relatively insoluble and not as hazardous as the soluble forms.

(b) DU provides both an internal and external radiation hazard. When taken into the body, intense ionization produced by the alpha particles may cause severe localized damage to cells. Externally, the beta radiation is classified as a skin exposure. Given these limits, DU does not constitute a serious external radiation hazard. The beta radiation exposure to the extremities can be reduced up to 50% by wearing leather gloves. A few feet away, there is little radiation exposure for beta and or gamma.

(2) RADIATION MEASUREMENT. Radiation surveys to detect the presence of DU in disassembled aircraft can be accomplished by using a Ludlum model 3 or 18 meter in conjunction with an Eberline model HP260 GM probe or a XETEX model 308 radiation detector. Pancake type probes provide excellent results for aircraft surveys.

(3) HANDLING INSTRUCTIONS.

(a) No drilling, filing, machining, sanding, or other abrasive procedure is permitted.

(b) Where prolonged body contact is possible or where abrasive operations are likely to affect the DU, it will be removed and stored in a secure area.

(c) Skin contact should be avoided. Thick gloves should be worn if handling is required. DU with damaged plating will be wrapped and sealed in plastic bags or wrapping material.

(d) Industrial eye protection and approved respirators will be worn when removing and handling damaged or cor-roded DU.

(e) Materials used in handling corroded or damaged DU (such as gloves or plastic wrap) will be bagged in plastic and placed in radioactive waste containers for disposal IAW applicable technical orders.

(f) Personnel handling DU will wash hands thoroughly with soap and water immediately after removal of gloves, before eating, drinking, smoking or at the end of the shift.

(g) The Radiation Safety Officer should survey areas where corroded DU has been handled or stored. Periodic surveys should be accomplished for all DU storage or work areas.

(h) DU waste will be disposed of IAW TO 00-110N-3 and shipped IAW applicable federal regulations (10 and 49 CFR).

(4) FIRE HAZARDS. Fire or explosion: Some of these materials may burn, but most do not ignite readily. Uranium and thorium granules may ignite spontaneously if exposed to air. Nitrates are oxidizers and may ignite other combustibles.

(5) RESPIRATORY PROTECTION. When entering an area where DU is burning, approved respiratory protection shall be worn.

(6) AIRCRAFT AND LOCATION. (See on pg 3-16.)

c. <u>KRYPTON - 85.</u> A colorless and odorless inert gas. This gas is used as part of an oil level indicating system in aircraft. The gas is contained in a metal tube which is partitioned, therefore, a break may not allow all of the gas to escape.

(1) HEALTH HAZARDS. Krypton is beta and gamma producing material. The need to enclose Krypton gas in a metallic container for aircraft use significantly reduces the beta hazards. However, due to the nature of gamma radiation, this is a primary hazard. The safety procedures for gamma radiation are distance and limiting physical contact.

(2) FIRE HAZARDS. Non conbustible.

(3) HANDLING PROCEDURES.

(a) Maintain minimum of three (3) feet distance from the source, when possible.

(b) When transporting the source, use an approved container (do not keep container with source in the passenger section of vehicle).

(c) Use mechanical fingers when physically handling the source, when possible. Personal contact should be kept to the minimum.

(d) If a tube source should break: clear the area (upwind, if outside) and notify the following:

<u>1</u> Maintenance Control.

<u>2</u> Your supervisor.

<u>3</u> Safety Officer.

<u>4</u> Base Bio-environmental Officer.

(4) TAGGING PROCEDURES. Indicators removed from engines will be tagged with an AFTO Form 350 and tracked with an AMARC Form 83. The AFTO Form 350 will be filled out IAW applicable regulations and will also have the oil level indicator serial number, engine serial number, and aircraft serial number listed.

(5) CONTAINMENT. Removed indicators will be placed in an approved container and SE notified for pickup.

(6) MARKING. Jet engines shipped with the source installed will be marked for radioactive material and shipped IAW applicable technical orders and federal regulations (10 and 49 CFR).

d. <u>RADIUM</u>. Is used to mark signs, warning placards, circuit breakers, and instruments for emergency use in case of electrical failure. Radium impregnated lacquers and paints may be found on a variety of aircraft and support equipment components. Radium provides a luminescent characteristic mixed with paints. It is a radioactive metal which emits alpha particles and energetic gamma radiation and causes the radium to be visible in darkness. While the radium particles are held together with paint, there is no health hazard. The health problems arise when the paint begins to chip and spill off which releases radium dust into the environment.

(1) POTENTIAL HEALTH HAZARDS. Radium presents a twofold hazard, chemical and radiation.

(a) The chemical properties of radium present a health hazard only after entry into.the body; by inhalation, ingestion, or through an open wound. Inhalation is the most significant mode of entry. Radium deposits in bone as much as calcium.

(b) Radium provides both an internal and external ra- diation hazard. When taken into the body, the intense ionization produced by the alpha particles may cause se-vere localized damage to cells. Externally, the beta radia-tion causes skin exposure, the gamma radiation causes deep exposure. Given the limits, radium can constitute a serious external radiation hazard. The beta radiation exposure to the extremities can be reduced up 50% by wearing leather gloves. A few feet away, there is little radiation exposure.

(2) FIRE HAZARDS. If material is on fire or involved infire: contact the local, state, or department of energy radiological response team. Extinguish fire using agent suitable for type of surrounding fire. The material itself does not burn or burns with difficulty. Fizzles as radioactive material.

(3) HANDLING PROCEDURES.

(a) Skin contact should be avoided. Heavy gloves should be worn if handling is required. Radium components which are deteriorated should be wrapped and sealed in plastic bags or wrapping material. Bags should be marked for contents and radiation status. Lead can also be used to shield against the gamma radiation.

(b) Industrial eye protection and approved respirators should be worn when removing or handling damaged or corroded radium components.

(c) Materials used in handling deteriorated radium components (such as gloves or plastic wrap) will be placed in radioactive waste container for subsequent disposal IAW applicable guidance.

(d) Personnel handling deteriorated radium should wash hands thoroughly with soap and water immediately after removal of gloves, before eating, drinking, smoking and at the end of the shift.

(e) At no time will an attempt be made to removethe radium from a component with out specific approval from the USAF Radioisotope Committee, USAF OMS/ SGPR, Brooks AFB, TX.

e. <u>STRONTIUM-90.</u> A radioactive material used in aircraft construction. Typically used in anti-ice detectors and blade integrity indicators for helicopters.

(1) POTENTIAL HEALTH HAZARDS. Strontium-90 is a a high energy beta material. Highly toxic radioactive poison. Therefore, the hazard is both an internal and external radiation hazard. When taken into the body, the ionization produced by the beta particles may cause severe localized damage to cells. Attacks bone marrow with possibly fatal results. Externally, the beta radiation is classified as a skin exposure hazard only. Beta radiation exposure to the extremities can be reduced up to 10% by wearing leather gloves. At a distance of 30 feet, there is little radiation exposure.

(2) FIRE HAZARDS. Fire or explosion: Flammable/ combustible material. May ignite on contact with air or moist air. May burn rapidly with flare-burning effect. Some react vigorously or explosively on contact with water. Some may decompose explosively when heated or involved in a fire. May re-ignite after fire is extinguished. Runoff may create fire or explosion hazard.

(3) HANDLING INSTRUCTIONS.

(a) No drilling, filing, machining, sanding, or other abrasive procedures are permitted.

(b) Where prolonged body contact is possible or where abrasive operations are likely to affect the strontium alloy,the component should be removed and stored in a secure area.

(c) Skin contact should be avoided. Heavy gloves should be worn if handling is required. Stronium-90 alloy metals with damaged plating will be wrapped and sealed in plastic bags or wrapping material. The plexiglas cap or suitable substitute will be installed on IBIS indications dur-ing all handling operations. Plastic goggles or glasses should also be worn when handling the IBIS indicators.

(d) Industrial eye protection and approved respirator will be worn removing or handling damaged or corroded stronium alloys.

(e) Materials used in handling corroded stronium-90 alloys (such as gloves or plastic wrap) will be placed in a radioactive waste container for subsequent disposal IAW applicable technical orders.

(f) Personnel handling stronium alloys will wash hands thoroughly with soap and water immediately after removal of gloves, before eating, drinking, smoking, or at the end of the shift.

(g) The AMARC Radiation Safety Officer will survey areas where corroded stronium alloyed material has been handled or stored. Periodic surveys will be accomplished of all stronium storage or work areas.

(h) Stronium waste will be disposed of IAW TO 00-

110N-2 and shipped IAW applicable federal regulations (10 and 49 CFR).

(i) Personnel handling or removing items containing stronium 90 from aircraft will wear a plastic face shield or goggles to protect the eyes from bremsstrahlung and or beta radiation.

f. THORIUM. A metallic element often alloyed with various metals to produce a strong lightweight aircraft component. Thorium is also found in the form of an optical coating on optical systems. These parts present no handling problems if appropriate precautions are followed.

(1) POTENTIAL HAZARD. Will occur when damaged or deformed parts are handled and fine dust fills the working environment. (The F-15 LANTIRN Pod is coated with a Thorium Dust.) The F-16 FLIR lens and mirror are coated with thorium fluoride 232. The sources are contained within two bolts within the unit, therefore, if the unit is destroyed personnel should avoid handling the bolts unless they are checked fro radioactivity. Special handling is required for the lens and mirror.

(2) POTENTIAL HEALTH HAZARD. Thorium presents an internal and external radiation hazard. When taken into the body, the intense ionization produced by the alpha particles may cause severe localized damage to cells. Externally, the beta radiation is classified as a skinexposure hazard only. Beta radiation exposure to the extremities can be reduced up to 50% by wearing leather gloves. At adistance of a few feet, there is little radiation exposure.

(3) FIRE HAZARD. Fire or explosion: Some of these materials may burn, but most do not ignite readily. Uranium and thorium granules may ignite spontaneously if exposed to air. Nitrates are oxidizers and may ignite other combustibles.

(4) HANDLING INSTRUCTIONS.

(a) No drilling, filing, machining, sanding or other abrasive procedures are permitted.

(b) Where prolonged body contact is possible or where abrasive operations are likely to affect the thorium alloy, it should be removed and stored in a secure area.

(c) Skin contact should be avoided. Heavy gloves should be worn if handling is required. Thorium alloy com-ponents with damaged surfaces should be wrapped and sealed in plastic bags or other wrapping material. Damaged components should be treated with caution and turned in as radiological waste.

(d) Industrial eye protection and respiratory protection should be worn when removing or handling damaged or corroded thorium alloys.

(e) Materials used in handling corroded thorium alloys (such as gloves or plastic wrap) should be placed in a radioactive waste container for subsequent disposal IAW applicable technical orders.

(f) Personnel handling thorium alloys should wash hands thoroughly with soap and water immediately after removal of gloves, before eating, smoking, drinking and at the end of the work task.

(g) The Radiation Safety Officer should survey areas where corroded thorium components have been handled or stored. Periodic surveys should be accomplished of all thorium component storage or work areas.

(h) Thorium waste must be disposed of IAW TO 00-110N-2 and shipped IAW applicable federal regulations (10 and 49 CFR).

g. TRITIUM. A radioactive isotope of hydrogen gas. Used as a luminescent material and can be found as a gas or impregnated paint compound.

(1) POTENTIAL HEALTH HAZARD. Tritium is a low energy beta producing material. Therefore, the primary health hazard is ingestion into the body. The low energy significantly decreases the external radiation hazard. Tritium converted to the oxided tritiated water is approximately 1,000 times more hazardous than the gas.

(2) FIRE HAZARD. Severe, when exposed to heat or flame.

(3) HANDLING PROCEDURES.

(a) Wear gloves when handling items containing tritium.

(b) If an item containing tritium should break while handling (such as an aircraft exit sign):

1 Wash hands immediately.

2 Clear and control access to the area.

3 Notify:

a Maintenance Control (MOC).

b Safety Officer.

c Base and AMARC Radiation Safety Officer.

d Your supervisor.

4 Provide positive ventilation into the area.

(c) Wrap all components containing tritium in plastic prior to storage, supply turn-in or turn-in as radioactive waste.

Table 3.4-1 Radioactive Hazards

RADIOACTIVE MATERIAL	AIRCRAFT	LOCATION [1]
Americium-241	Various	FLIRS
Depleted Uranium (DU)	A-10 C-5 C-130 C-140 C-141 F-16 (certain models) H-3 DC/KC-10, L-1011, 747	30 mm Ammo Ailerons, elevator Ailerons, elevator, rudder Rudder Ailersons, elevator Gun pods Control stick Ailerons, elevator, rudder
Krypton	Most	Oil level indicating system
Radium	Various	In paints to mark warning signs
Strontium-90	Helicopters	Anti-ice detectors and blade integrity
Thorium	Various	Metal alloy, optical coating
Tritium	Various	Luminescent material as a gas or in paint

[1] Refer to Paragraph 3.4 for detailed discussion.

DEPLETED URANIUM (DU). (Article)

a. WHAT IS RADIATION? Radiation is defined as the process of emitting radiant energy in the form of waves or particles; alpha particles, beta particles, gamma rays, and x-rays are all examples. Radiation can be emitted by radiation producing devices (i.e. medical x-ray machines) or from radioactive materials. Many radioactive materials exist naturally in the environment; uranium is an example of one of these.

b. WHAT IS DEPLETED URANIUM? DU is a byproduct of the uranium enrichment process and is natural uranium depleted in the isotopes U-234 and U-235. Natural uranium ore contains three isotopes in the following weight percentages: approximately 99.3% U-238, 0.7% U-235, and trace quantities of U-234. After enrichment, the DU byproduct material contains a lower percentage of U-234 and U-235, and thus a higher percentage of U-238 (typically 99.7%). This “depletion” of U-234 and U-235 leaves the DU in a less radioactive state, than naturally occurring uranium. Due to the high abundance and low fabrication costs of DU, industry and the military have made extensive use of DU. The military is using DU in munitions, shielding, and counterweights.

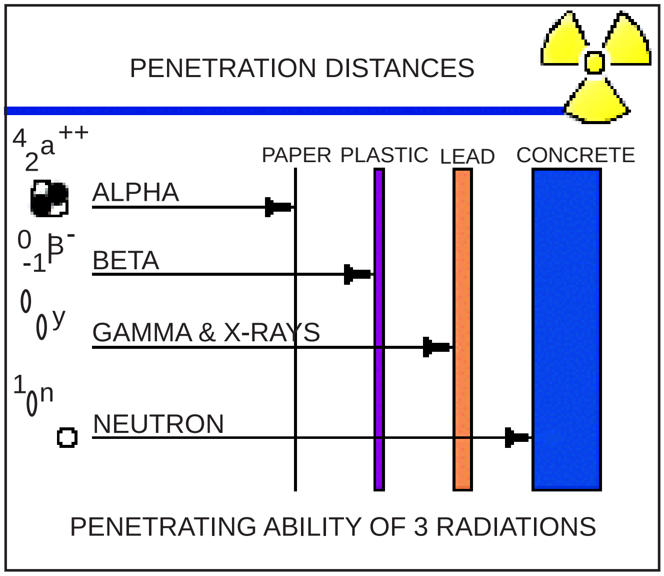
c. WHY USE DU AS A COUNTERWEIGHT? DU is used as counterweights due to its high density (over 1.5 times that of lead), favorable material properties, low cost, high density making it ideal for aircraft counterweights where space is often limited. Counterweights may be found in aircraft gyroscopes, flight controls, helicopter blades, elevator balances, and aileron balances.

d. WHAT ARE THE HAZARDS FOUND IN DU? When handled properly, DU produces very little hazard to the worker or associated personnel. However, there are some hazards associated with DU that must be understood by personnel prior to working with the material.

e. RADIATION HAZARDS FROM DU. DU is a low level radioactive material. DU emits alpha and beta particles, and gamma rays. Alpha radiation exposure is most hazardous when DU is ingested, inhaled, or otherwise internalized into the body. Beta radiation is primarily a skin exposure hazard when DU is in close proximity to the body. Gamma radiation exposure is normally not a significant hazard from DU, since a significant fraction of the gamma rays emitted are self-absorbed by the DU.

(1) ALPHA PARTICLES. Are easily shielded and cannot even penetrate the dead layer of skin. They present no external radiation hazard but are an internal radiation hazard under certain conditions. If DU is inhaled or ingested, the emission of alpha particles can cause localized cell damage. The most significant adverse health hazard from this low level exposure is the risk for cancer induction.

(2) BETA PARTICLES. Possesses a greater ability to penetrate materials than alpha particles. Like alpha particles, beta particle emissions present internal radiation hazards if internally deposited. Externally radiation hazards are only significant for close proximity/prolonged exposures.



(3) GAMMA RAYS. Are the most penetrating of the radiations emitted by DU. The exposure rate at 1 inch from a typical source is 7 mrem/hr, but drops to undetectable levels at a distance of about one to two feet from most DU counterweights.

f. CHEMICAL HAZARDS FROM DU. Ingestion or inhalation of DU may pose a chemical toxicity hazard. Once DU enters the lungs much of it is dissolved in the blood. It is then dispersed throughout the body and concentrates primarily in the kidneys, bones, and liver, remaining there for years. The metabolism of DU by the body can damage tissues. These chemical effects include kidney damage, and can be more serious than those caused by the radiation if the exposure is acute.

g. PHYSICAL HAZARDS FROM DU. DU can be an internal exposure problem when inhaled or incorporated into the body through ingestion or open wounds. The degree of risk from inhaled DU is directly related to the particle size and exposure duration. A burning piece of DU can emitted highly respirable particles (1-10 um AMAD), and thus a DU fire (exhibited by white smoke) should always be considered an internal exposure hazard. Ingestion or incorporation of DU into open wounds can also be a hazard. However, due to the relatively insoluble nature of DU, inhalation exposure is considered the greater risk. Appropriate emergency response actions should always be taken during and after a DU fire. These actions include crash site entry upwind, use of respiratory protection (SCBA or HEPA filtered mask) if available, and radiation surveys and decontamination of all personnel and equipment exposed to fires involving DU. Treatment of life threatening injuries always takes precedence over radiation surveys or decontamination. DU exposure, whether external or internal, is always accompanied by some health risk, however during most aircraft accidents, the risk from other hazards (UXOs, jet fuel, composite materials, and various organic compounds emiited during a aircraft fire heavily outweighs the risk from DU exposure. This is due primarily to the relatively low specific activity of DU and its low solubility when exposed to high temperatures (i.e. UO^2 form).

h. HOW DO I PROTECT MYSELF FROM DU HAZARDS?
External doses from DU are easily controlled by standard health physics practices of reducing time, increasing the distance, and using shielding around counterweights. Wearing gloves will prevent skin contact and reduce beta exposure when handling DU. Protective respiratory masks are needed if DU dust exists. Dust from DU is common when the material undergoes oxidation (the material turns from silvery-white to a black or brownish color). When in this state, the dust should be suppressed by atomized water spray. As an internal radiation hazard, thermoluminescent dosimeters and other monitoring devices do not provide any reduction in exposure.

i. HOW MUCH RADIATION AM I BEING EXPOSED TO? We are exposed every day to radiation that occurs naturally in the environment. This background radiation comes from cosmic and terrestrial sources that exist in food, water, and the air. On average, Americans receive 350 mrem per year from background radiation sources. Through safe handling practices, radiation from DU will be significantly less than these background sources. By Federal law, dose limits to members of the general public are 100 mrem per year. As well, the Air Force applies this limit to non-radiation workers including most aircraft maintenance personnel.

j. SAFE HANDLING INSTRUCTIONS FOR DU.

(1) No drilling, filing, machining, sanding, or other abra-sive procedures are permitted.

(2) Where prolonged body contact is possible or where abrasive operations are likely to affect the DU. DU parts will be removed and stored in secure areas.

(3) Materials used in handling corroded or damaged DU (such as gloves or plastic wrap) will be bagged in plastic and placed in radioactive waste containers for disposal IAW applicable technical orders.

(4) Personnel handling DU will wash hands thoroughly with soap and water immediately after removal of gloves, before eating, drinking, and smoking or at the end of work shifts.

(5) The Radiation Safety Officer should survey areas where corroded DU has been handled or stored.

(6) DU waste will be disposed of IAW AFI 40-201 and shipped IAW applicable Federal regulations (10 CFR & 49 CFR).

For further information or, in the event of a potential DU overexposure, contact your local Bioenvironmental Engineering (BEE) office or Medical Treatment Facility for urgent care.

For more information on DU safety contact the AFIERA Radiation Surveillance Division through the ESOH Service Center 1-888-232-ESOH or DSN 240-5454.

Depleted Uranium (DU) Counterweight Safety

3.5 COMPOSITE MATERIAL HAZARDS. The mishap responder's primary duties do not provide an opportunity to learn about composite system or materials associated with aerospace vehicles. This paragraph contains introductory information that will aid with a familiarization of composite systems pertinent to a mishap scenario. Information in subparagraph a and b can be used to identify composite debris among the wreckage and provides a common language that will help with communication consistency for all response types.

a. BASICS OF COMPOSITES. Knowing how a composite part is made will help explain what happens to it when it becomes damaged. A Photo Gallery located in 3.5d has been provided in this section to enhance understanding.

(1) SYSTEM OF MATERIALS. Composites are a SYSTEM of two or more *different* materials. Most common for aircraft manufacturing are man made fibers surrounded by a matrix. The matrix is a resin or plastic material. During the manufacturing process the resin chemically bonds to the fiber and each adjacent layer of material. The resin seals and holds thousands of fibers in place. Without the fiber the resin would be a solid chunk of plastic material. Without the resin the fiber behaves similar to thread used for making clothes or hair found in a hairbrush. (Photo 1)

(2) INTERMEDIATE MATERIAL.

(a) "PREPREG". Different manufacturing processes are used to make or repair aircraft parts and different material forms are used for each process. One common material form is the "prepreg". "Prepreg" is a fibrous material that has been coated or pre-impregnated with a tacky or viscous resin. It is received from the materials manufacturer in a ready-to-use state.

(b) "PREGREG" TYPES. "Prepreg" is identified by the fiber direction. Fibers are oriented in a parallel fashion for the unidirectional "prepreg" and are weaved into various interlacing patterns for the woven "prepreg". The roving "prepreg" is a collection of fiber bundles and is delivered just like a spool of thread. The unidirectional and the woven "prepreg" is received as a sheet of material wound around a cardboard spool for storage and handling purposes. Because the spool resembles a roll of tape, the material is sometimes referred to as a "prepreg" tape. (Photos 2 thru 8)

(3) BUILDING THE COMPOSITE PART. To obtain a specific shape, one way of building a composite is by *stacking multiple layers* of "prepreg" (resin-coated fibers) material around a tool that has the desired shape. The layers of "prepreg" material is produced by cutting the desired size from the spool much like cutting textile fabric used to make clothing. The layers are stacked until the desired thickness is reached. (Photos 9 and 10)

To become a solid part the matrix solidifies during a cure cycle. During the cure, the resin chemically attached to each fiber within a layer and between the layers. After cure, the tool is removed and the "prepreg" material now has a permanent shape. The layers are not distinguishable from one another and the part appears to be homogenous. The bulk solid part is considered to be chemically and biologically inert to the touch.

(4) FINISHED FORM TYPES. There are several different types of parts made by layering of materials that can be found at a mishap scene. The solid laminate, the sandwich laminate and the filament wound laminate will be identifiable among the damage debris.

(a) SOLID LAMINATE. The cured part is called a laminate. The laminate can have various forms but the solid laminate is usually referenced to a flat or slightly curved form. This type of laminate is used to make aircraft skins, panels, and doors. Ribs, stiffeners, and spars are other composite applications made by layering of materials. (Photos 11 and 12)

(b) SANDWICH LAMINATE. To reduce the weight of the part a sandwiched laminate was developed. A light weight core material is sandwiched between two thin layers of a flat laminate. The core may be foam or a honeycomb shaped material. Common honeycomb materials are aluminum foil, and a paper-like organic material called Nomex®. Sandwiched panels are easy to recognize because of the core. Flight control panels and various other panels are common applications for the sandwiched panel. Nose radomes have also been made using core material. (Photos 13 thru 15)

(c) FILAMENT WOUND LAMINATE. Cylindrical, round or shell shaped parts are made by winding resin-wet fiber from a roving of fiber over a mandrel to get the desired shape. Each pass is called a layer. The process has the flexibility to tightly wind the fibers in various patterns. Different winding patterns have different strengths. The more tightly wound, the greater the strength the part will have. Storage tanks, tubes, gas cylinders (liquid oxygen bottles, LOX), rocket motors and nose radomes are filament wound.

Filament wound parts are easy to recognize because of the winding pattern. It may still be in one piece after the damage has occurred. Under severe impact damage the winding pattern will unravel and the layers will begin to separate. Complex winding patterns will reduce the release of fibers. (Photo 16)

(d) HYBRID LAMINATES. It was most common to build aircraft components from unidirectional tape with a surface layer of woven fabric. Advanced materials and manufacturing techniques now include hybrid composite systems (stacking with varying types of material) with complex shapes. The design may include a metal-coated fiber, the resin may contain metal particulate or a metal mesh layer may be incorporated between the layers to protect against lightening strikes. New aircraft and redesigns for existing aircraft are being manufactured using advanced applications. Except to see more composites at the mishap site because of this.(Photo 17)

(5) FIBER - RESIN DETAILS. The strength of the composite system is in the fiber direction. The amount depends on the number of very small diameter size fibers (micron range) within the tape. Prepreg material contains thousands of long continuous length fibers. Laminate thickness can vary. The number of prepreg layers can range from less than 10 to more than 50. A quarter inch thick, four-inch square composite made from a four-inch tape prepreg[1] could have over 4 million fibers.

Prepreg tapes are manufactured with a very specific amount of fiber to resin weight. The system will contain more fiber weight than resin weight. A typical weight ratio is 65% fiber to 35% resin. For example, the F-16C/D contains approximately 200lbs of composite. If the composites were made from **just** prepreg tape, 130lb of the composite would be fiber weight.

(6) SUMMARY. A composite is a system of materials – fibers and a polymeric resin or plastic. Without the interaction of each material within the system, the system would not be able to perform.

a Psuedo-homogenous solid. The solid laminate looks like a homogenous solid in the cured state.

b One way of building a composite is to stack multiple layers of material.

c Ready-to-build materials are unidirectional, woven fabric, and roving "prepreg" and metallic or organic paper-like core material.

d Each tape layer has thousands of long continuous length fibers and the finished part contains millions of individual fibers.

e The system is made with a specific amount of fiber to resin weight.

f Various types of parts can be made from layering of materials: solid laminate, sandwich laminate filament wound laminate or the hybrid laminate.

g Re-designs may have used composite materials. Except to see more composites parts at a mishap site than what may be found in the documentation.

h Terms used to describe the material at various stages of manufacturing or repair.

- prepreg tape
- layers or plies
- stack
- filament wound
- solid laminate
- sandwich laminate
- hybrid laminate

[1] 6K tow

b. MISHAP- COMPOSITE DAMAGE. An undamaged composite looks and behaves like a homogenous solid. It is almost impossible to determine if the material is a composite under the coatings unless the design includes a textured surface layer like a woven fabric. When the composite is damaged it becomes obvious it is a "SYSTEM"[1] of materials. When damaged, the materials within the system begin to separate.

(1) DESCRIPTION OF MISHAP PIECES. Paragraph 3.5a gave general information for the types of material in a composite system and the various finished forms a part may have. This will help with the identification of the undamaged pieces. However, information is needed to determine what damaged debris looks like. Damaged debris is categorized in the following way (largest to smallest in size):

(a) FRAGMENTS. Whole laminate pieces, bulk composite debris is termed fragments. Impact fragments can be found within the emergency response cordon, in the impact crater or in the debris field some distance from the crater. Because of their weight, fragments will not travel far from their initial contact with the ground. (PHOTOS 18 and 19)

(b) STRIPS. Single laminate layers are called strips. Damage can cause the layers to separate. Strips produced from physical damage will have resin attached to the fibers except at the fractured ends and will be found close to the originating composite part. If a separation was caused by fire damage, some resin or char material will be holding the fibers together. Fire generated strips will be found both within and right outside the combustion zone. (PHOTO 20)

(c) FIBER BUNDLES. Bundles are broken fiber/matrix pieces created only by physical damage. When a composite breaks, the fiber and matrix cracks creating broken fiber/matrix sections. It could crack within a layer or between layers. The fibers are held together by the matrix creating a bundle of fibers. Fiber bundles are found on

[1] Composites are a "system" of two or more unlike materials, paragraph 3.7a.

and near the fracture surfaces (on the debris surface and within the laminate layers). If the fracture damage was severe, bundles will be dispersed all around the immediate area. (PHOTOS 21 and 22)

(d) CLUSTER. A cluster contains hundreds or thousands of long continuous length fibers generated from a fire exposed unidirectional tape or filament wound layer. Clusters differ from the strip by the amount of time spent in the fire. Clusters will have very little resin or resin char holding the fibers together. The fibers will be free to move. Carbon fiber clusters are dark wooly-looking mass that resembles a clump of hair. If produced, clusters can be found dispersed around the site and outside of the combustion zone or attached to strips. Clusters will not remain airborne. (PHOTO 23)

(e) DUST. Damage creates composite dust. The dust is shattered or crushed resin and fiber fragments. Fire damage creates resin char, degraded fiber dust and fuel soot. Microscopic dimensions will vary. Resin char and soot particles will be spherical in size. The dust generated from crushed resin or fiber and burnt fibers will have irregular shapes. The more severe the damage the greater the dust generation will be. Dust will be found on and near the damaged surfaces.

(f) SINGLE FIBER. Physical damage causes fiber sections to pull out of the matrix. Single fibers are fibers that are small enough to become airborne. Depending on the size, airborne fibers may not be visible. Single fibers produced from physical damage are not a source of free-floating fibers at a mishap site. A carbon fiber unidirectional tape laminate when engulfed in a JP-8 fire is the major source for free-floating fibers that can linger right at the burnt debris for a period of time. (PHOTO 24)

(2) PHYSICAL DAMAGE. Composites do not break like metal when stressed. At failure the system will develop matrix and fiber fracture lines. How and where a composite material will fracture depends on the direction of the load, fiber orientation in each layer, and the type of material within the system. Damage can occur either primarily within the matrix or can affect both the fiber and matrix. Aircraft mishaps will affect both. The severity of the damage (the amount and length of fracture or crack lines) will determine what type of debris and how much is generated. Severe impact damage crushes and shatters the material into pieces of varying sizes.

(a) SOLID LAMINATE. When damaged the matrix forms crack lines between the layers and between the fibers within a layer (PHOTO 25). A severe matrix fracture between layers will cause a complete separation of layers known as delamination. Delamination exposes individual layers within the laminate stack. Identification of the comsite system can be attempted because the type of prepreg tape, fiber direction and core material is exposed. Under severe load the fiber bends, kinks, buckles, or begins to shear apart causing the fiber to finally crack. Fracture lines can advance through layers breaking fibers into shorter sections creating fiber bundles (PHOTOS 25 and 26). Most of the synthetic fibers will shear, buckle or bend creating irregular fiber fracture surfaces at the break. The original fiber diameter will be retained (PHOTOS 27 and 28). Kevlar® is one fiber that responds differently. A fracture produces a surface layer of fibrils instead of cracking. The parent fiber divides into smaller size fibers called fibrils. The original diameter of the parent fiber has been changed by the creation of fibrils and the fibrils have smaller size diameters than the original parent fiber diameter.

(b) SANDWICHED LAMINATE. In addition to the damage described for the solid laminate, a sandwiched panel can develop separations between the surface layers and the core. The core can be crushed and torn. (PHOTO 30)

(c) FILAMENT WOUND LAMINATE. Matrix and fiber cracking occurs as explained for the solid laminate. Layers separate creating fiber/matrix strips. The winding pattern unravels revealing each individual winding layer. (PHOTO 31)

(d) DEBRIS TYPES. Using the terms described in paragraph 3.7.b.1, the type of physically-damaged debris that can be produced are fragments, strips, and dust. The dust includes fiber bundles, minute amount of single fibers, resin and fiber particulate. The particulate does not linger in the air (excluding detached Kevlar® fibrils). Fibers are exposed on the surfaces and at the ends of the broken pieces. Small fiber bundles and dust will be laying on the surfaces of the damaged pieces and in the immediate area. There may not be any surface indications that reveal internal damage. Material failure due to excessive load doesn't shatter the material that is common for impact damage.

(e) FIBER PATTERN EFFECTS. The finished form of the material affects the way the composite releases broken and separated debris. Fibers are held tightly together in a fabric or filament wound part. The fabric weave and complex winding patterns inhibits movement of the fracture surfaces and fiber layers. In comparison to the unidirectional tape layer, less fraying and fiber separation is observed and the weave sustains for the most part.

(f) HEALTH CONCERNS. Generally, released particulate concentrations remain close to their point of origin. In the case of localized damage, the particulate concentration will be right at the fracture surface. Extensive damage will produce particulate that will be dispersed in close vicinity of the shattered piece. Wind and site conditions will influence the dispersion while handling the broken pieces. The exposure concerns are: sensitization response from dermal contact with the dust, puncture wounds from fiber bundles, eye and throat irritation from internal and surface particulate.

(3) FIRE DAMAGE

(a) EFFECTS OF HEAT AND FIRE. There are physical and chemical changes that occur to the materials within the composite system. Fuel fires such as JP-8 fires create extremely high temperatures that can exceed 2000°F. As the heat penetrates the layers, the coatings are burned off and the resin layers are thermally and oxidatively attacked. Heat causes the cured resin or plastic to break apart into smaller and smaller size molecules creating char material and volatiles (an analogy would be the refining of crude oil to obtain lighter grades of fuel oil). When volatile concentrations reach combustion levels, flaming combustion occurs.

When the resin no longer seals and supports the fiber, the composite layers become unattached. Without the solid matrix, air can move between the fibers within and between the layers. A fiber layer without resin is very light and the thermal column within the flame can release surface layers outside of the burn area. Fibers decompose or melt. Fibers that melt are Spectra® and glass. Kevlar® and carbon fiber are oxidatively attacked and decomposes. Boron fiber surfaces oxidize causing a change in color.

A heat source is needed to ignite a composite. Ignition temperature depends on the resin type and will vary. When the composite does ignite some resin systems become a source of fuel and add heat to the JP-8 flame. Some resins give off more dense black smoke than others but liquid fuels like JP-8 will be the major contributor to smoke density in a composite fire. Char formation will also depend on the resin type.

Most epoxy formulations will start to burn around 440-500°F. As the JP-8 flame temperature penetrates the composite, the epoxy decomposes in a matter of seconds. If the composite laminate is not very thin, epoxy will begin to smolder after the flame ceases at much lower temperature than the flame temperature. The smoldering is described as a slow, flameless form of combustion emitting toxic compounds. It is difficult to detect epoxy smoldering because little or no visible smoke is produced (smoke is being produced, it is just not detectable in the visible range). Smoldering epoxy is not sensitive to wind and does not spread to areas that didn't previously experience an increase in temperature. Smoldering composites are dangerous because the condition can go undetected and can easily transition to flaming combustion.

Carbon fiber combustion starts to occur when most or all resin has burned off and the external heat is around 1000°F (fiber type dependent). This is the stage when carbon fiber oxidizes and decomposes creating fibrils. Adequate airflow is needed to supply sufficient oxygen to self-sustain. A red glow is visible at higher temperatures (~1400°F). Smoldering epoxy doesn't generate enough heat to cause carbon fiber combustion.

(b) COMBUSTION PRODUCTS. The final combustion product for all organic material is carbon, carbon dioxide (CO_2) and water. Complete combustion is never reached. Carbon monoxide (CO) and many other products of incomplete combustion will be produced. See Table 3.5-2 for a list of possibilities.

1 JP-8 FUEL. JP-8 fuel consists of aliphatic and aromatic hydrocarbons with small amounts of proprietary additives. The plume at an aircraft mishap is a dense black sooty smoke, majority of it coming from the burning of JP-8. The smoke contribution from the composite materials is minimal in comparison to the quantity of fuel burning. Soot is carbon particles and products of incomplete combustion. The soot has a very small particle size, therefore will rise in the thermal column, become diluted and disperse downwind.

2 MISCELLANEOUS AIRCRAFT MATERIALS. In addition to carbon and hydrogen resins, adhesives, plastics, core material and coatings contain other chemical elements. Elements like oxygen, nitrogen, chlorine, bromine, fluorine, and metal compounds. These elements contribute to the increase in the amount or number of toxic gases and irritants generated. Toxic products released from the combustion of coatings and the composite are carried with the JP-8 smoke.

3 FIBERS. Melting glass fibers can fuse, which destroys the fiber shape. If melting glass is released during a flaming combustion stage, glass beads will form and do not remain airborne.

Burning Kevlar® fiber decomposes releasing toxic combustion products similar to burning resin, plastic or wool. When the ignition source is removed Kevlar® tape and fabrics are not expected to continue to burn. Kevlar® pulp in core material may smolder.

Carbon fiber is ~ 92-98% carbon, the remaining is nitrogen and trace processing contaminates. Burning carbon fiber releases nitrogen. Oxidation erodes the fiber causing a change in the original diameter and length of the fiber. Smaller size fibers can become airborne and remain airborne during a flaming combustion condition (PHOTO 32 and 33). Unidirectional carbon fiber tape engulfed in the flame for a period of time forms clusters, decomposed carbon fibers, and fiber ash. Clusters form first, then the decomposing fiber and finally the ash forms.

Fiber clusters are lightweight but will not remain suspended in air. If created, clusters will be found all around the site. Clusters do not cause puncture wounds. The matrix is needed to support the fiber to provide the stiffness necessary to cause a puncture. Small size fibers will travel with the plume but starts to settle out while the plume continues downwind. Due to surface winds, plumes are almost always tilted. Higher wind velocities increase the plumes angle of tilt that will result in a limited plume rise and the potential for an increased ground level concentration. Single carbon fibers are hard to see floating in the air. They may linger around the burnt debris after the fire is out but will settle out. Re-suspension potential is greatest right after the initial deposit (24 to 48 hours). With weathering the fibers become incorporated in the environment (into the soil) and the chance of re-suspension drops quickly. Dry areas with little vegetation will increase the potential of re-suspension.

(c) RADAR ABSORBING MATERIAL (RAM) AND CONVENTIONAL COATINGS. Due to the lack of burn data for specific RAM coatings, combustion products are not assessed as greater health hazard than those of the existing composite materials or conventional coatings. Conventional coatings for corrosion and electrostatic discharge concerns are based on organic polymers with the addition of metallic compounds. The majority of RAM is also polymeric based, with the addition of metallic compounds. Polymeric coatings will burn as described for the resin releasing similar combustion products. Depending on the type of RAM additive, the burn characteristic RAM coatings may differ from those of conventional coatings. The mishap concern for coatings are the same as those of the resin, such as emission of toxic combustion products into the plume any unexpected burn conditions caused by the addition of additives.

(d) FIBER PATTERN EFFECTS. The fiber form of the composite layer influences the release of fire-damaged particulate in the same way it influences a release for physically damaged composites [3.5(b)(2)e)]. Patterns in the filament wound part and the cross weave of the woven fabric holds fibers in place not allowing for the free movement of the individual fibers. The inability of the fibers to move freely decreases the amount of particulate released during flaming combustion. Unidirectional tape does allow for an easier release and contributes to most of the carbon fiber particulate release during a fire and when handling fire damaged carbon fiber debris.

(4) FIRE SCENARIOS.

(a) FIREBALL. Upon impact fuel and vapor is suddenly dispersed over a large area of the site. A mist of fuel vapor ignites, creating the fireball that very rapidly follows the spread of fuel. Extent of composite damage caused by fireballs varies depending on where the debris lands after impact. The fireballs path may miss the pieces com-pletely, cause slight surface-scorch or entirely engulfed the debris. Even though fireballs can create very, very hot flame temperatures (2400°F) extent of fire damage depends on the time within the fireballs path. (PHOTOS 34 and 35)

(b) POOL FIRE. Pool fire is the scenario that can create the greatest amount of fire damage. Quantities of fuel have collected in a relatively small area creating a pool. The flaming combustion stage of a pool fire can be much longer than for a fireball (the fuel is not used up as rapidly as within a fireball scenario). More time spent at high temperatures allows the flame and heat to penetrate many more composite layers causing more damage and also produces the conditions for a smoldering combustion stage. (PHOTO 36)

(c) LOW TEMPERATURE HEATING OVER TIME. The ignition source may determine whether a composite material burns in the smoldering or flaming mode. A slow but low temperature heating, such as a heated wire may lead to smoldering combustion. A restricted air supply, as in a closed compartment will promote smoldering combustion that may go undetected for a long time. A transition to flaming combustion after smoldering for a long time can produce a very rapid growing fire due to the preheating of the fuels, and the accumulation of combustible gases during the smoldering phase.

(d) IN-FLIGHT FIRES. The generation of smoke and toxic gases provides the first evidence that a fire is developing. The distinct odor produced by burning composites is noticeable right away. While visibility is immediately impaired by the smoke, the rapid generation of acutely toxic compounds presents an even greater danger. The confined space of aircraft cockpits increase toxicity because limited ventilation contributes to the increase of toxic gas concentrations. If a rapid generation of toxic gases in confined spaces ignites, a very rapid destructive fire can result.

(5) HEALTH.

(a) SMOKE PLUME. Smoke contains airborne solid and liquid particulates, and gases which can be toxic if concentrations are high enough. Foremost among the hazards are impaired vision from eye irritation, narcosis from inhalation of asphyxiants and irritation of the upper/or lower respiratory tracts. The emergency phase of the mishap is concerned with the most dangerous or lethal hazards of the smoke, which are the asphyxiants and irritants. Carbon monoxide and hydrogen cyanide are the primary toxic or lethal gases in smoke. The predominant irritants are the acid gases (hydrochloric acid, hydrogen bromide, and hydrogen fluoride HCl, HBr, HF), nitrogen oxide compounds, and organic irritants like acrolein, formaldehyde, and isocyanates. When a material burns carbon monoxide, carbon dioxide and water is formed along with products of incomplete combustion. The chemical composition of the material is used to predict possible incomplete combustion products. If the material contains nitrogen, hydrogen cyanide (HCN) and nitrogen dioxide are likely to be generated. Nylon, polyurethane are two resins containing nitrogen. Halogenated or flame retardant materials produce the acid gases (HCl, HBr, HF). Aerospace resins and adhesives are likely to contain halogenated compounds. If oxygen is part of the chemical composition of the material, acrolein and formaldehyde may form. Polyesters, acrylics, epoxies and phenolic resins contain oxygen. Isocyanates form from burning polyurethane resins but the major fuel at an aircraft mishap is JP-8. JP-8 will be the major contributor of toxic gases in the smoke plume during a flaming composition state, see Table 3.7-3.

(b) SMOLDERING. A smoldering condition for any material produces harmful smoke. Carbon monoxide and dioxide is formed along with products of incomplete combustion. Many of the products produced are different from a flaming combustion state because of the lower temperature at which smoldering occurs. Harmful effects occur if concentrations are high enough. Compared with flaming combustion, smoldering is a slow process. Harmful concentrations can occur if smoldering were allowed to continue in a work environment, especially in an enclosed space or environment.

(c) AIRBORNE CARBON FIBER. A significant fiber release during a flaming combustion state will not occur for a fire-damaged-only composite or for a composite made entirely from a fabric or by filament winding. The potential of a significant fiber release during a flaming combustion state comes from a composite that was made with many layers of carbon fiber unidirectional tape that experience both physical then fire damage.

(d) HANDLING. Fire damaged composites are very fragile, more fragile than just physically damaged composites. Decomposed fibers will continue to break down when handled; producing particulates. Handling burnt (decomposed) carbon fiber may produce particulates from the inhalable to the respirable size.

(e) STORAGE. Burnt composite may continue to offgas for a period of time. Offgasing is a slow release of volatiles at ambient temperatures. Due to buildup of concentrations in a storage container, ventilation may be necessary when the storage container is initially opened.

(6) SAFETY.

(a) SMOKE. The formation of acidic gases from resin and plastic materials can create an acidic smoke plume. Entering a plume may cause skin burns from acidic gas penetration through the zipper or seam of the firefighter suit.

(b) SMOLDERING. Smoldering composites are difficult to extinguish with water. If the material is not entirely cooled to ambient temperature, deep-seated smoldering may continue to exist. A smoldering state can easily transition to a flaming combustion condition. If smoldering goes undetected, an unexpected fire can occur in the work environment.

(c) CONFINED SPACE. Specific outdoor conditions may present a “confined-space” scenario at a mishap site. These conditions include thick vegetation, foliage cover, deep impact crater, pool fire as well as lack of rain and wind. Confined space increase the likelihood of hazard exposures.

(7)MISHAP SITE MATERIAL COMPATIBILITY. A bulk cured composite material is non-reactive, chemically and biologically to the touch. A mishap may contaminate the debris with aircraft fluids, melting metals, battery acid or hydrazine. The compatibility of composite material with other materials at the site is found in Table 3.7-3.

(8) MISHAP DAMAGED COMPOSITES SUMMARY.

- Coatings make it difficult to determine whether the underlying part is a composite or metal.

- When damaged, the material within the “system” begins to separate. It becomes apparent that the composite part is not a homogenous material.

- Terms used to describe “mishap” composite:
  - o Single fiber
  - o Cluster
  - o Strip
  - o Dust, particulate
  - o Impact damage
  - o Fire damage
  - o Fiber bundle

- Impact damage:
  - o All fiber types break into shorter sections.
  - o Kevlar fibers create fibrils on the fractured surface.
  - o The solid matrix cracks and starts to pull away from the fiber and the adjoining layers.
  - o Core material crushes and tears.
  - o Fiber bundles and impact-fragment ends cause punc ture wounds.
  - o Composite dust cause allergic reactions.

- Fire damage:
  - o Resin combustion immediately releasing toxic prod ucts into the plume.
  - o Fibers either melt, oxidize and/or decompose.

- o Fibers that melt do not remain airborne.
- o Severely impact and fire damaged carbon fiber will release fibers that linger.
- o Filament wound, woven fabrics inhibit release of particulate into the air.
- o Advanced composites can smolder without any visible sign.

c. DISPOSAL OF COMPOSITES Routine decisions made for industrial waste is not routine when determining how to dispose of mishap-composites. Characterizing mishap-composite debris for regulatory compliance requires knowledge of the materials within the system and mishap conditions. The knowledge is needed to adapt sampling plans for composite material. The knowledge is needed when reviewing regulatory lists and when interpreting analytical results. This paragraph reviews the material specific aspects for environmental concerns of mishap-composites.

(1) WASTE CHARACTERIZATION. Waste characterization begins with an understanding of what the materials are within the system. A composite part is made by layering-of-material[1]. A basic system will use the same material for each layer, a polymeric resin and a synthetic fiber. A hybrid system contains different material layers. For instance, the design may incorporate a metal-coated fiber layer, a metal mesh layer or the resin may contain metal particulate. If the debris was not involved in a fire, the composite will have coatings. Waste characterization also considers what could have contaminated the composite during the mishap.

(a) Physical Damage. The chemical and physical properties of the composite used for environmental assessment has not changed when a composite fractures. The solid matrix surrounds the fiber protecting it from environmental exposure and is still considered chemically non-reactive in the bulk form.

(b) Fire Damage. Chemical and physical changes do occur when a composite is thermally damaged. Fibers melt, oxidize or decompose. The resin melts, decomposes, volatilizes and forms a char[2] layer. Post-fire material is in a solid form. The decomposition products of the materials will vary widely and may be a potential environmental hazard if present in detectable concentrations. The decomposition products for JP8 fuel will also be present.

(c) Mishap-Site Contamination. Was the debris JP8 soaked, AFFF soaked or hydraulic fuel soaked? Is the hold-down solution environmentally friendly?

(2) SAMPLING.

(a) Amount. Most of the composites in an aircraft will take the form of a solid laminate or sandwich laminate. Each form will be considerably less dense than soil or sludge of the same volume. The four-ounce soil jar used for organic sampling may not hold the minimum amount of sample required for TLCP[1] analysis.

(b) Collection and handling method. Zero headspace will be hard to achieve because the form may not allow for compaction within the sampling jar. Cutting composites out in the field to fit into a sampling jar will require special tools and personal protection equipment. Avoid cutting in the field if at all possible.

(c) Selection of sampling location. Because composites are made with layers sample selection could mistakenly leave out the layer that could be of concern. Composite[1] sampling should be used. However, results obtained from composite sampling of a mishap-composite is considered representative of only one specific site and sample type.

(d) To minimize worker exposure when sampling and handling burnt carbon fiber composites, glass bottle is preferred over plastic.

(3) SAMPLE PREPARATION. The sample preparation step for a volatile analysis is performed with or without heat depending on the sample type. If a fire-damaged sample is going to be analyzed (and not it's leachrate), handle it just like it was a soil. The carbonaceous nature of the char and soot material will require heat to desorb any combustion products.

(4) ANALYSIS. To determine what constituents to test for, and what concentrations to expect a better understanding of the material in relationship to the analytical methods is needed. The three major components of the system to consider for environmental disposal are the fiber/matrix and core layer, the coatings layer and the hybrid layer. Generally speaking, an organic constituent may originate in the fiber/matrix, core or coating layer. The inorganic constituents may be found in the coatings or the hybrid layer.

(a) Results. There are several reasons why a non-detect might be expected. Reason one is the regulatory limits are too high. Reason two is the list doesn't reflect the type of material that is being testing.

1 Regulatory limits. The regulatory limits for the F and D listed organic compounds are ppm levels. The lack of analytical sensitivity when reporting ppm levels may have eliminated trace or low-level compounds.

---

[1] Paragraph 3.7a, Basics of Composites

[2] Char

[3] TCLP = toxicity characteristic leaching procedure

[4] Composite sampling = Sample is a nondiscrete sample composed of more than one specific sample collected at various location on site or within a bulk piece.

2 Regulatory lists. The lists are generated for chemicals used in industrial processes. That is the raw products used to make the composite. Once the composite material is formed to a specific shape (becomes a solid), the raw products in their original form no longer exist (or exists only in undetectable amounts). The lists may not reflect the chemistry of the solid material or it's combustion or decomposition products.

(5) WASTE CATAGORIES[1]. Of the six different ways a mishap-composite could be defined as a hazardous waste, the most likely would be the "characteristic" waste or the contaminated media. Discussion for each follows.

- Listed waste (F, K, P, U)
- "Characteristic" waste (D)
- Mixture of solid and listed waste
- Contaminated debris
- Derived from hazardous waste
- Contaminated media

(a) "Characteristic" waste. Characteristics of waste that are separate from listed wastes are ignitibility, corrosivity, reactivity, and toxicity. Elimination of a characteristic is based on the chemical a physical condition of the material, the reasoning follows.

Ignitability Corrosivity Reactivity Toxicity

1 Ignitibility. A waste is an ignitable waste if it meets any of the following.

- Liquid - Flash Point <140°F

Not applicable to mishap-composites

- Solid - Spontaneous combustion through friction.

May be applicable to mishap-composites if saturated with fuel

- Solid - Spontaneous combustion through absorption or loss of moisture.

Not applicable to mishap-composites.

- Compressed gas or oxidizer defined by DOT

Not applicable to mishap-composite

2 Corrosivity. A waste is corrosive if it meets the following conditions:

- pH $\leq$ 2 or $\geq$ 12.5

Not applicable to mishap-composites unless site contamination occurred (spilt battery acid or hazardous cargo).

NOTE

Burning resins can produce an acidic plume. The resin char and fuel soot can be slightly acidic. Plume exposure or a surface layer of resin char is not expected to cause a 5-gram composite sample to have corrosive pH conditions as defined.

3 Reactivity. A waste is reactive if it meets any of the following conditions:

- Readily undergo chemical change
- React violently or forms explosive mixture when mixed with water
- Capable of detonation or explosion when exposed to pressure and heat
- Capable of detonation or explosion at standard temperature and pressure
- Defined as a forbidden explosive or Class A or Class B explosive by DOT

Not applicable to mishap-composites

- Toxic gas generation. Cyanide and sulfide bearing waste when exposed to mild acidic or basic conditions generates toxic gases.

250mg of free cyanide per kilogram of waste
500mg of free sulfide is generated per kilogram of waste

Hydrogen cyanide and sulfide are possible combustion products for various resin types. Liberation occurs at very high flame temperatures. When liberated, the compounds could condense out on nearby surfaces, react with other chemical species in the thermal column or rise with the plume. Probability of detection on a mishap-composite at the levels of concern is considered low.

4 Toxicity. A land-disposed waste is considered toxic if it contains a toxic constituent. The constituent categories are metals, volatile and semi-volatile organics, pesticide, and herbicide.

[1] 40CFR 261

- Metals:
  - Arsenic
  - Barium
  - Cadmium
  - Chromium
  - Lead
  - Mercury
  - Selenium
  - Silver

Several of the metals could be present in reportable concentrations.

- Volatile Organics:
  - Benzene
  - Carbon tetrachloride
  - Chlorobenzene
  - Chloroform
  - 1,2-dichloroethane
  - Hexachloroethane
  - Methyl ethyl ketone
  - Tetrachloroethylene
  - Trichlorethylene
  - Trichlorethylene
  - Vinyl chloride

An undamaged or physically damaged composite is not expected to contain any residual solvents that were introduced during the production of the raw material or in the manufacturing process of the composite part. Benzene is the most likely compound from the list to be detected in a fire-damaged sample. Benzene is an expected combustion product of the fuel and resin. The char and soot may contain traces of benzene.

- Semi-volatile organics:
  - o,m,or p-Cresol(s)
  - 1,4-dichlorobenzene
  - 2,4-dinitrotoluene
  - Hexachlorobenzen
  - Hexachlorobutadiene
  - Nitrobenzene
  - Pentachlorophenol
  - Pyridine
  - 2,4,5-trichlorethylene
  - 2,4,6-trichlorethylene

Chemical knowledge of a specific resin system is needed to determine if any semi-volatiles are a possibility. If a compound is found to be part of the resin formulation it is not expected to be detected once the composite has been shaped to its final form. An undamaged or physically damaged mishap-composite is not expected to contain any detectable amounts of resin. Detection is highly unlikely when using the TCLP preparation method for organic constituents in a fire or physically damaged composite.

- Pesticide and Herbicides:

Not applicable to mishap-composites.

(b) Contaminated Media. Contamination can be caused by many sources within the mishap environment. Blood-borne pathogen exposure will make the composite debris a medical waste. Radiation exposure will cause the debris to become a radioactive waste. Exposure to hazardous liquids will cause the composite debris to become hazardous waste. Fire suppressant soaked composites may be a disposal issue. Information must be gathered at and about the mishap needed to determine if site contamination is a potential disposal problem for the mishap-composite.

(5) Landfill. Landfills do not operate under the same permit. One permit may require the D-listed compounds and another may require the F and D-listed compounds. One may require only a TCLP sample preparation while the other may require a total preparation method.

Table 3.5-1 Recommended Analysis for Possible Major Contaminants of a Fire-Damaged Composite.

Expected contamination° of a fire damaged composite: PNA, hydrocarbons, resin monomers, oxidized resin and fiber compounds, petroleum fuel, aviation gas, jet propulsion fuel, halogenated products from the fire suppressant.			
Recommended Analysis	Sample Type	Possible Contamination Levels	Comments
TPH	Composite debris	ppb or ppm	VOA and semi-volatile molecular weight range.
PAH	Composite debris	ppb or ppt	Soxhlet extraction more efficient than sonication preparation.
Semi-volatile organics	Composite debris	ppb or ppt	Soxhlet extraction more efficient than sonication preparation.
Volatile organics	Composite debris	ppb or ppt	Headspace or heated purge is a efficient preparation method.
Metals	Composite debris	ppb, ppm	
TCLP metals	Leachate	ppm	

° Recommendation doesn't consider cross-contamination possibilities.

- **WHAT ARE THE COMPOSITE MATERIAL LAYERS?**
- **HAS IT BEEN CONTAMINATED AT THE MISHAP SITE?**
- **WHAT STATE?**
- **WHAT LANDFILL WILL BE USED?**
- **ARE ANY OF THE LISTED CONSTITUENTS WITHIN THE MATERIAL LAYERS.**
- **IS IT A SOLID WASTE OR A HAZARDOUS WASTE??**

d. <u>PHOTO GALERY OF COMPOSITES.</u> The following photos are examples of composite materials in normal, unburnt, burnt and damaged configurations.

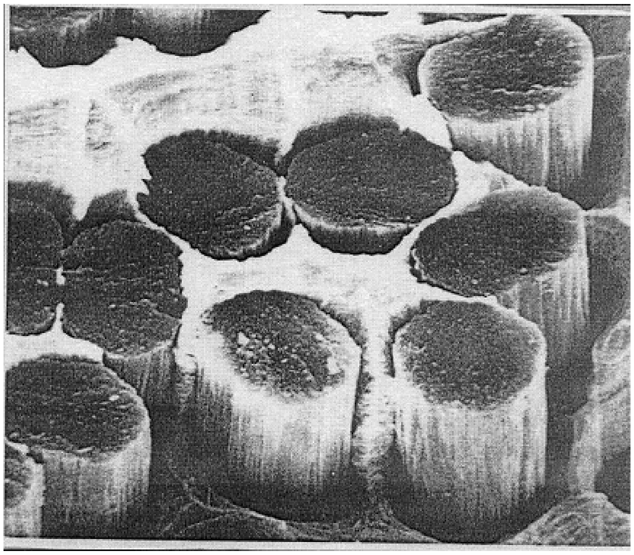


Photo 1. Micrscopic View - Fiber/Matrix

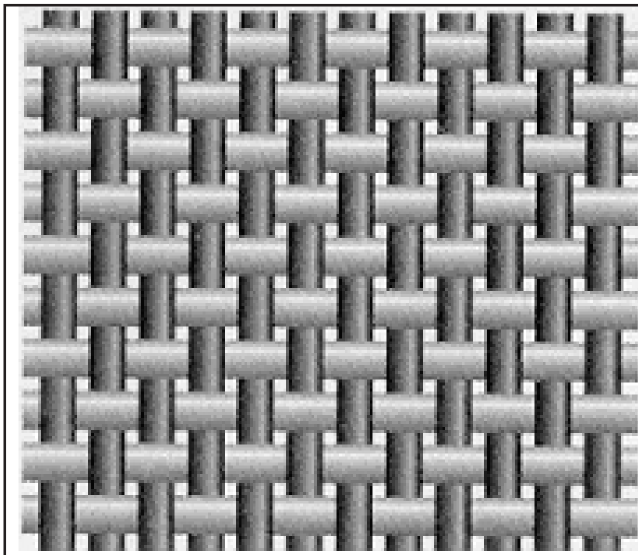


Photo 3. Plain Weave Fabric

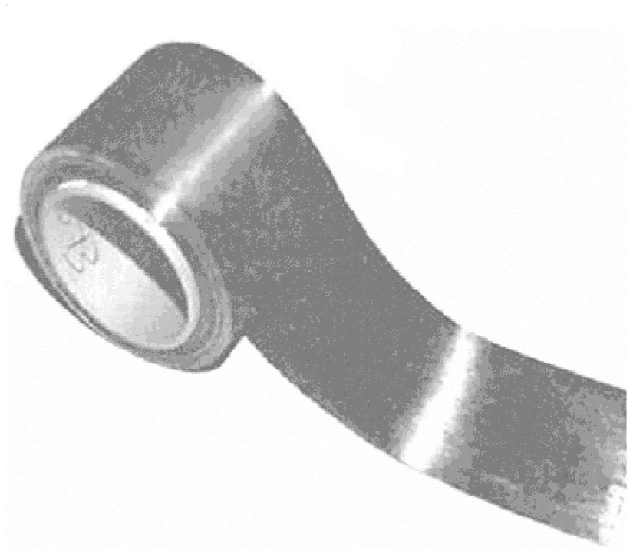


Photo 2. Unidirectional prepreg.

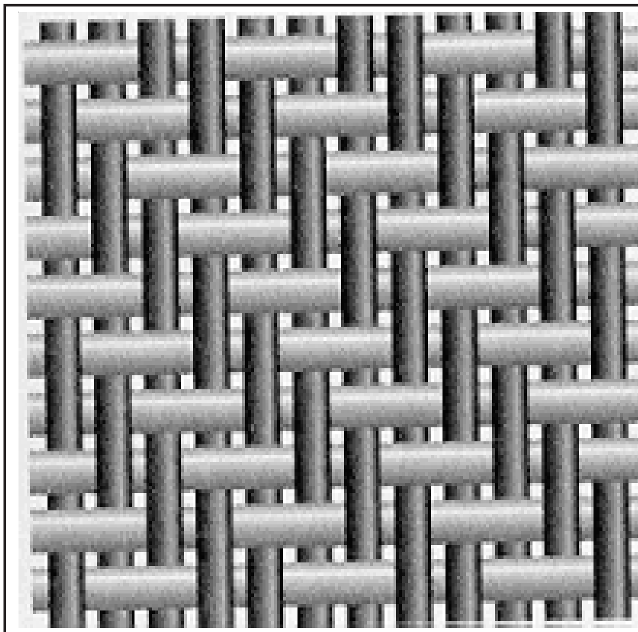


Photo 4. Twill Weave Fabric

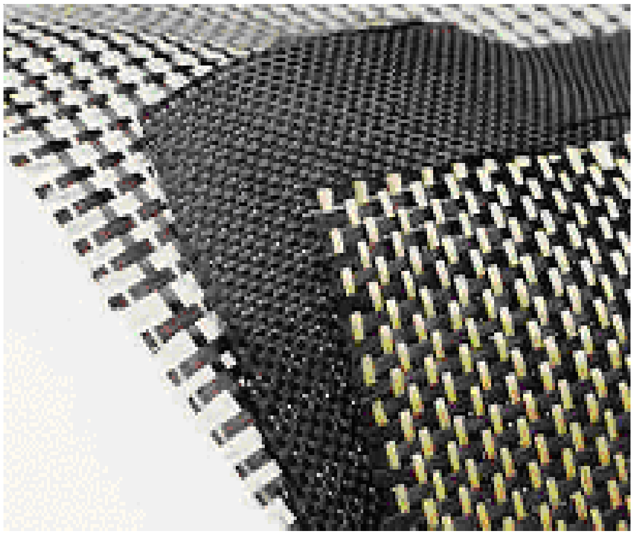


Photo 5. Assorted Fabric Types

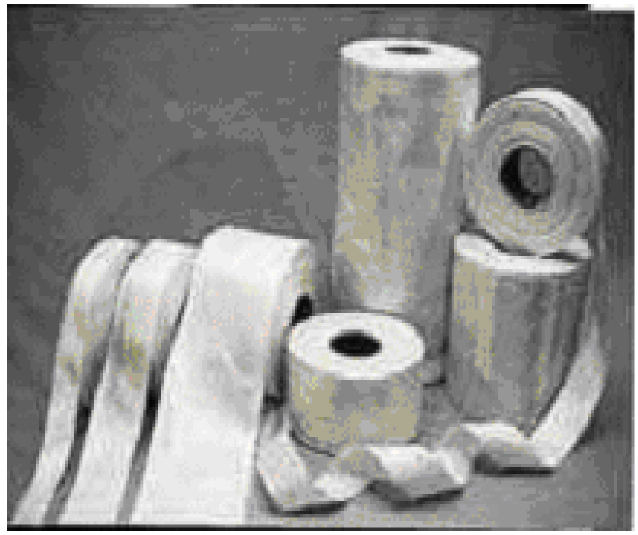


Photo 7. Glass Fiber “prepreg” Tape

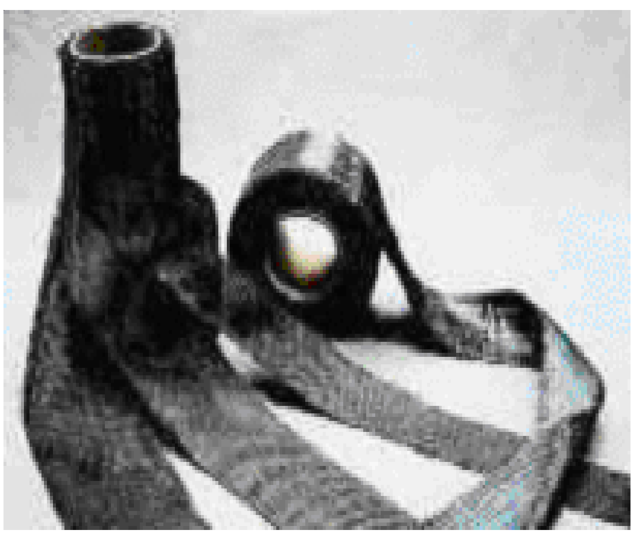


Photo 6. Carbon Fiber “prepreg” Tape

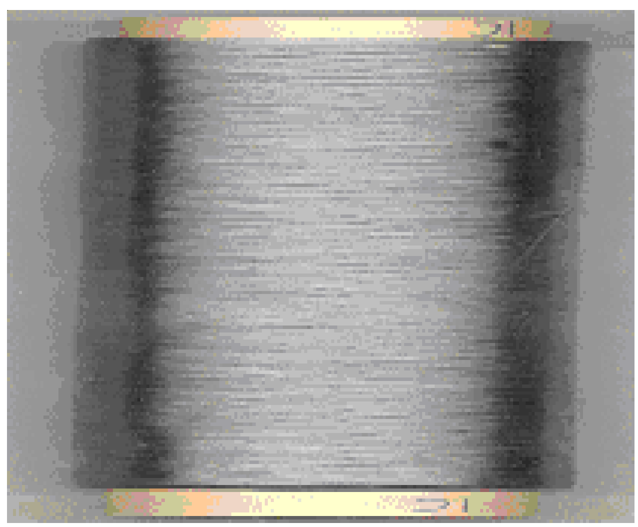


Photo 8. Roving carbon fiber “prepreg”

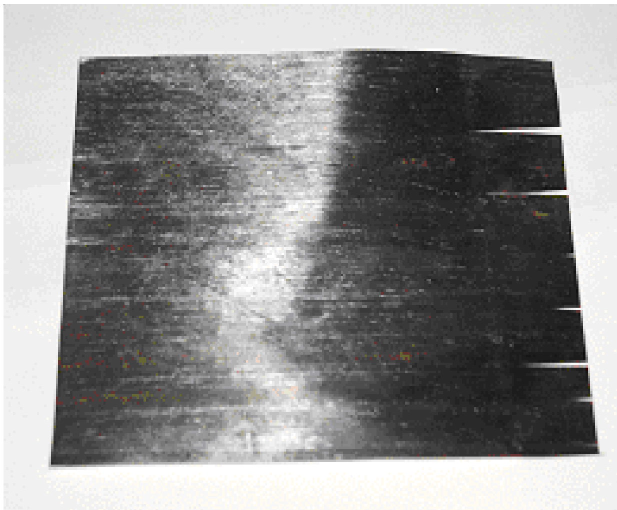


Photo 9. Preparing to build the part by stacking layers.Carbon fiber “uni” tape cut from a spool.

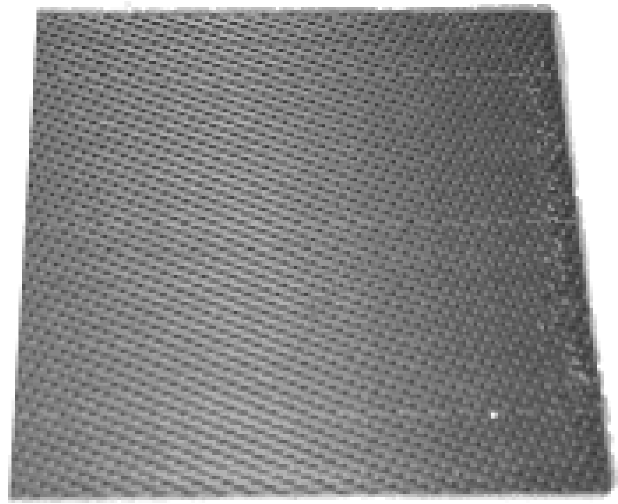


Photo 11. Flat Carbon Fiber Laminate

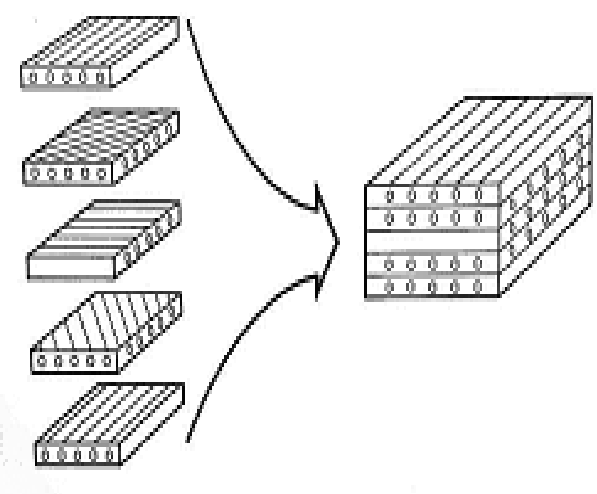


Photo 10. Stacking of Layers

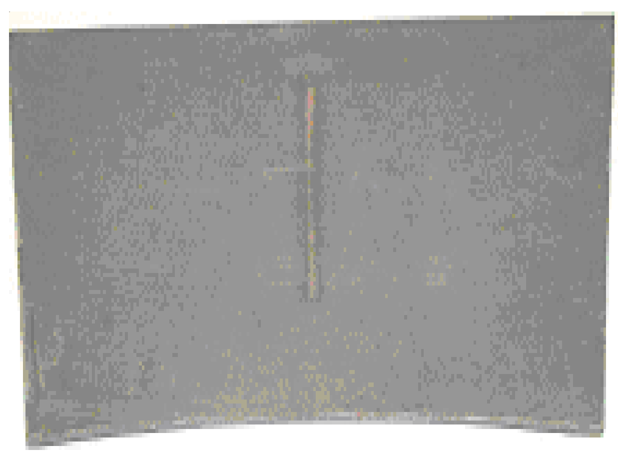


Photo 12. Slightly Curved Carbon Fiber Laminate

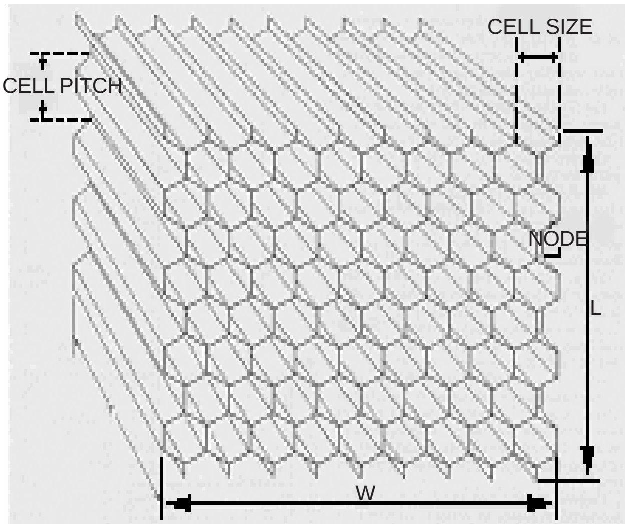


Photo 13. Honeycomb Layer

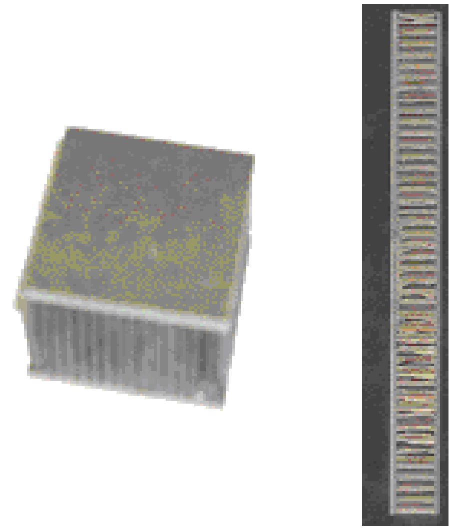


Photo 15. Cured Sandwich Laminate

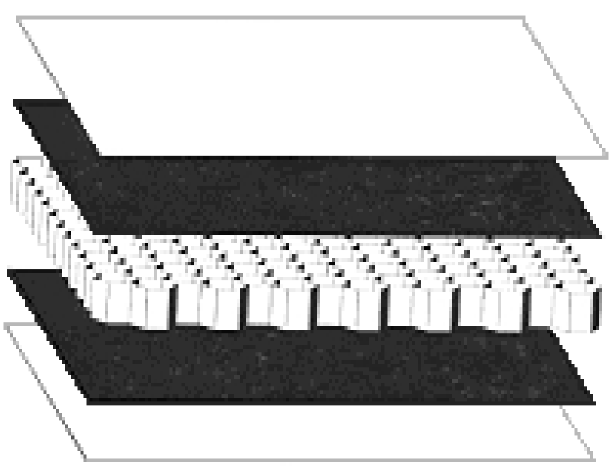


Photo 14. Sandwich Laminate Layer Sequence

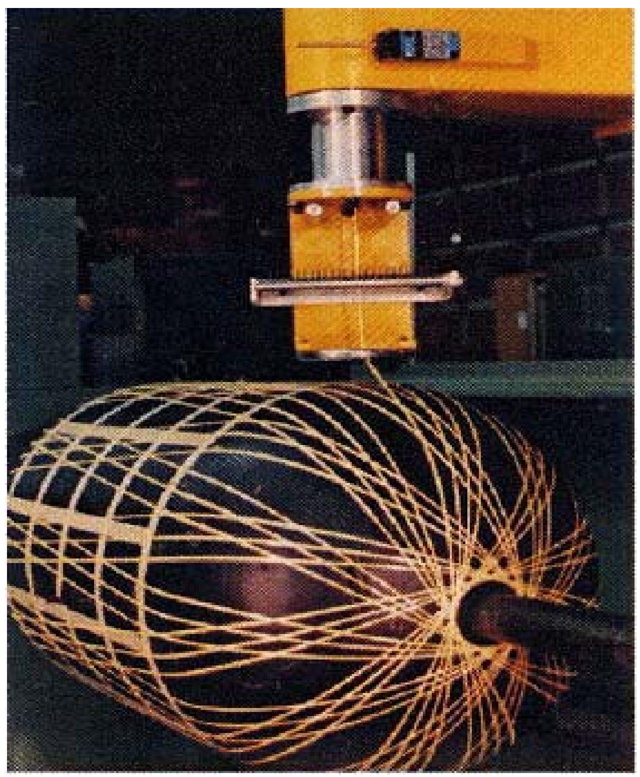


Photo 16. Filament Winding Process

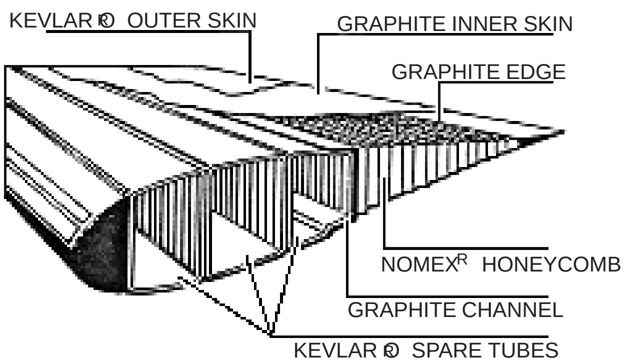


Photo 17. Hybrid Composite Parts

Photo 19. Fragment

Photo 18. Fragment

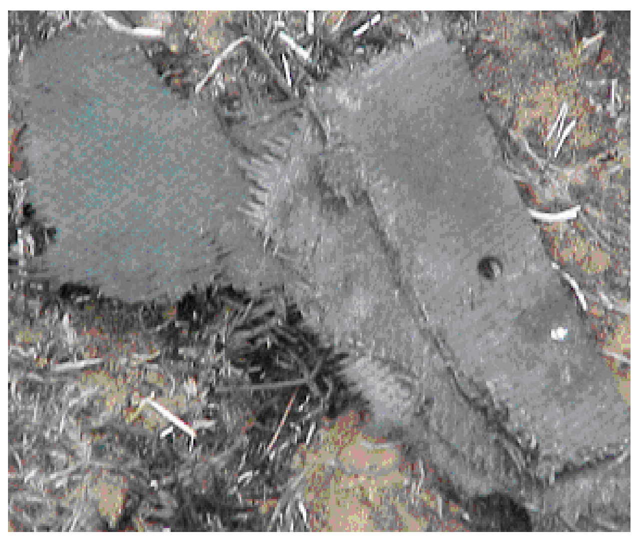


Photo 20. Strips - Single Layers or Plies

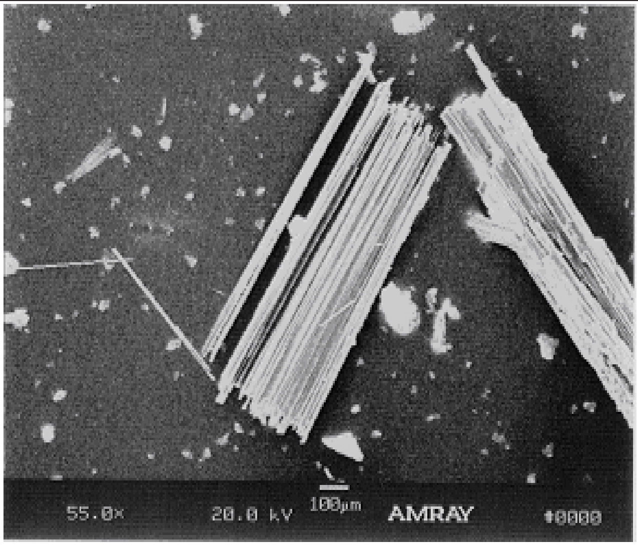


Photo 21. Microscopic View of Fiber Bundles

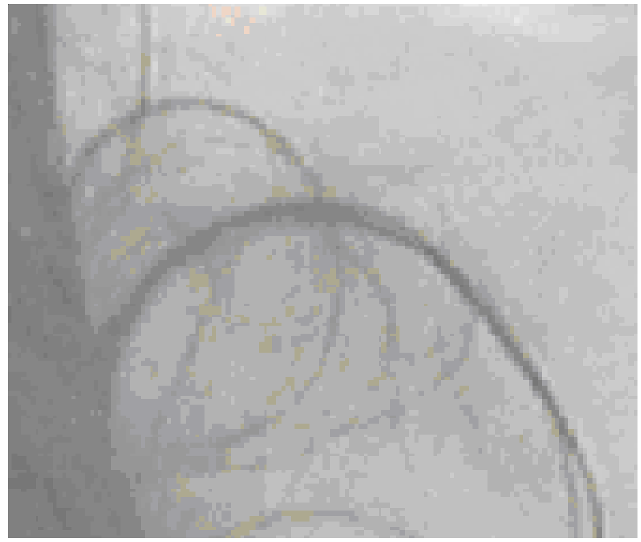


Photo 23. Carbon Fiber Cluster

Photo 22. Large Fiber Bundles

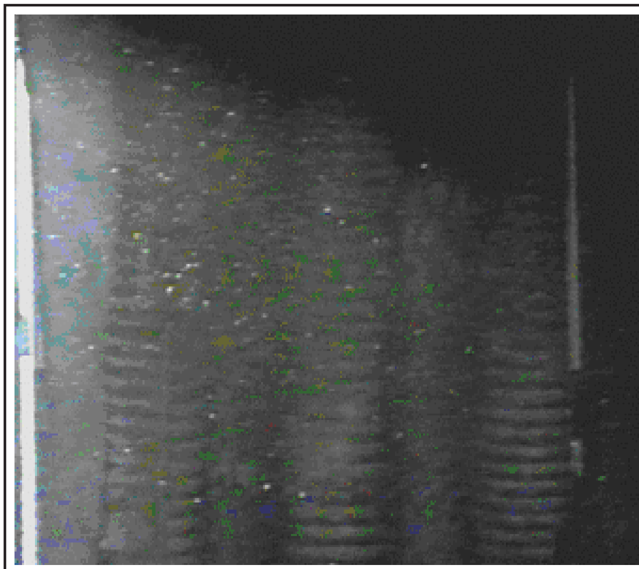


Photo 24. Slightly Curved Carbon Fiber Laminate

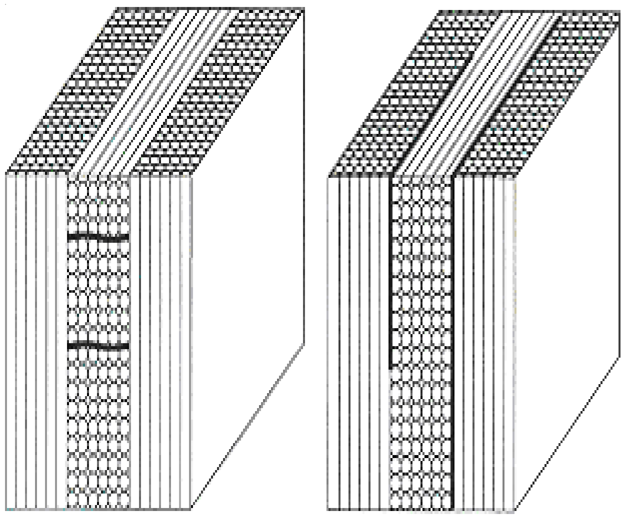


Photo 25. Crack Lines Within a Solid Laminate

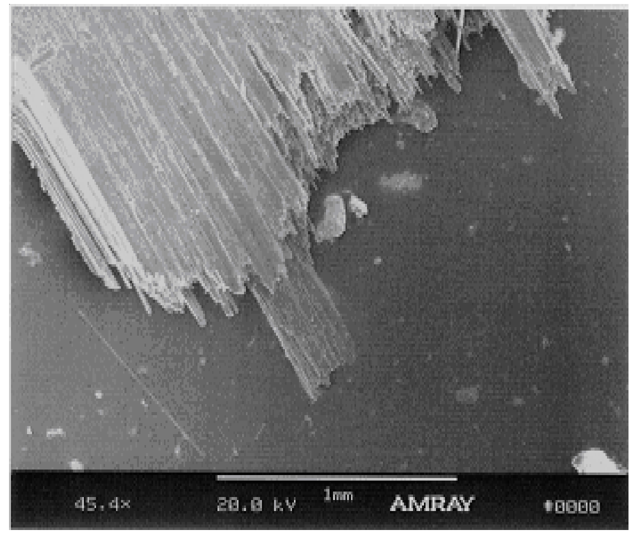


Photo 27. Microscopic View of Broken Fibers, Single Fibers and Dust Is Generated

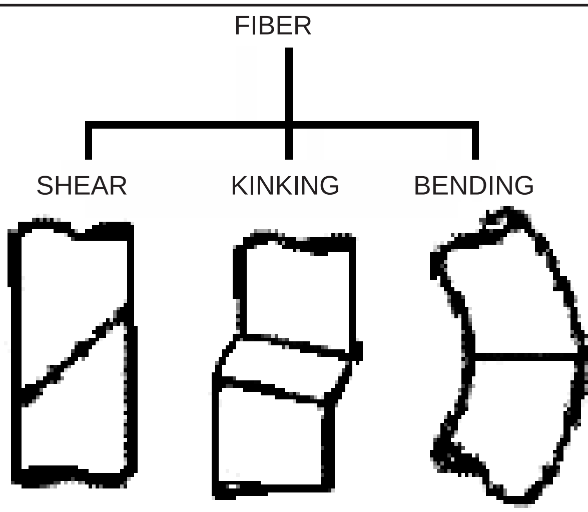


Photo 26. Fiber Cracking

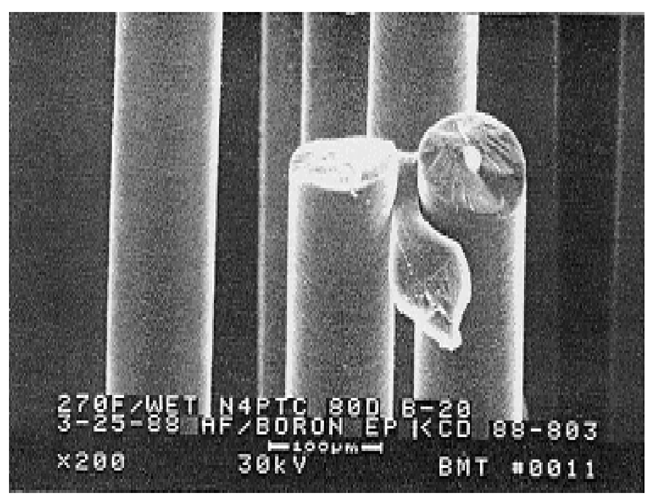


Photo 28. Microscopic View of Fractured Boron Coated Tungsten Wire, a Minute Amount of Resin Is Found Between Two Fibers

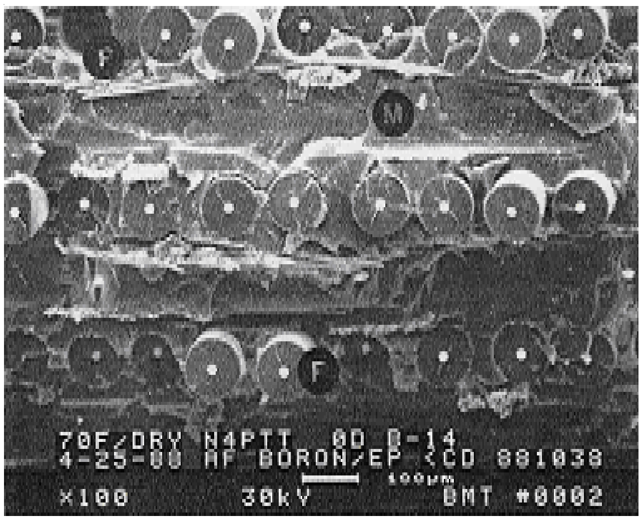


Photo 29. Side View, Damaged Boron Fiber Epoxy Laminate.View shows Fiber/Resin Cracking, Delamination and Fiber pull-out.

Photo 31. Impact and Burnt Glass Fiber Filament Wound Radome.

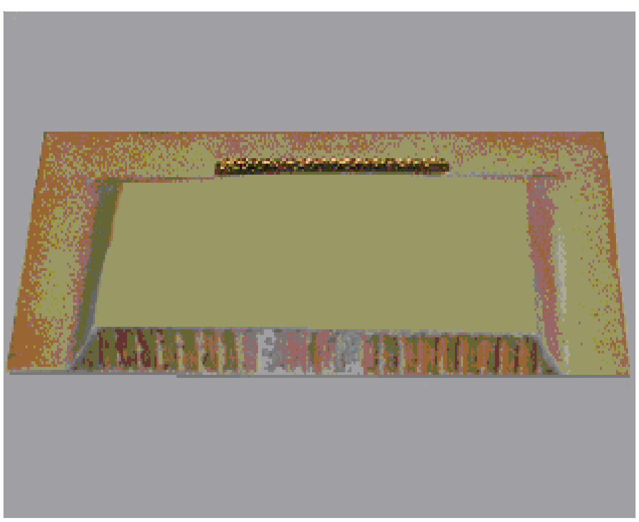


Photo 30. Top View – Fibrillated Kevlar Fiber End. Bottom View – Severely Fibrillated Kevlar Fiber.

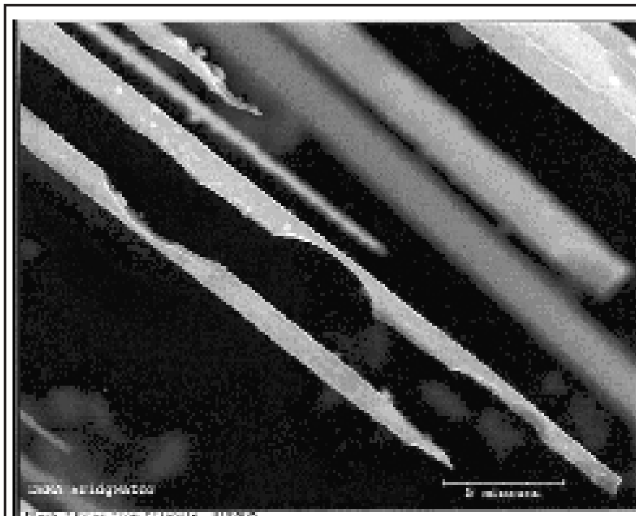


Photo 32. Burnt Carbon Fiber

Photo 33. Burnt Carbon Fiber

Photo 35. Surface Scorching From A Fireball

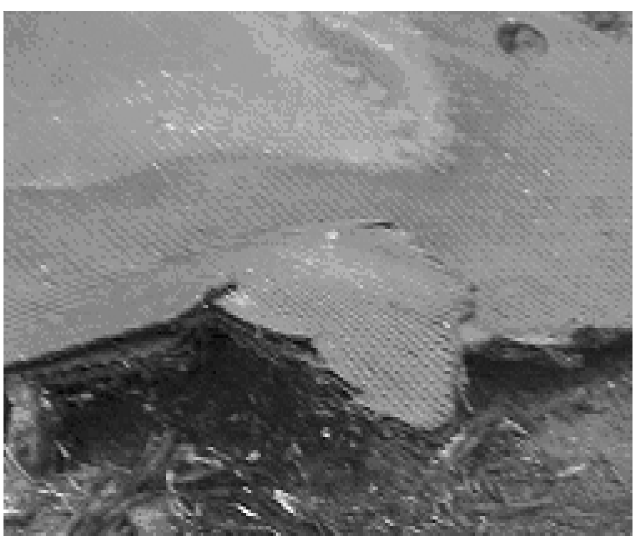


Photo 34. Effects Of A Fireball

Photo 36. Pool Fire Damage

Table 3.5-2 Possible Combustion Products

MATERIAL	PRODUCTS (in addition to C, CO, CO_2, H_2O)
FIBER	
Carbon (PAN based)	nitrogen, oxides of carbon
Kevlar ®	C2H4, CH4, NOx1, HCN, NH3, aldehydes, aliphatic hydrocarbons
Boron/tungsten	boron oxides
Glass	Non-flammable. Products of combustion are from the combustion of the sizing material.
SPECTRA (HD polyethylene)	Short chain aldehydes, long chain hydrocarbon, acrolein
RESIN	
Epoxide- amine cured (more flammable than most thermoset resins)	CH4, CH2CH2, CH3CH3 propane, propylene, aniline, dimethylaniline, toluidine acrolein, phenols, amines, aldehydes, aomatic amines, hydrofluoric /fluoroboric acid
Nylon	amines, ammonia, cyclic ketones, esters, hydrogen cyanide, benzene
Phenolics	acetone, formaldehyde, methane, phenol
Polyamide	ammonia, cyanides, NOx
Polycarbonate	Short-chain aldehydes and ketones
Polyimide	Hydrogen, aniline, phenol, benzene
Polypropylene	Short chain aldehydes, long chain hydrocarbon, acrolein formaldehyde
Polystryene	benzene, styrene, toluene, acrolein
FOAMS	
Phenolic	See Resin above
Polypropylene	See Resin above
Polyvinyl chloride (Tradename: Divinycell, Legecell, Airex)	HCl, HCN, NOx
Polystryene (Styrofoam)	ethyl benzene, aldehydes, aromatics, HFl, HBr, (depends on manufacturer)
Polyurethane foams	toluene, HCN, isocyantes, TDI
CORE	
Kevlar®, fiberglass, or carbon fiber substrate coated with one of the following: Phenolic (NOMEX) Polyimide Epoxy	 See Resin information above See Resin information above See Resin information above
FUEL	
JP-8	sulfur oxides, sulfur particulate, short chain aldehydes , intermediate hydrocarbons - aromatic and aliphatic, polynuclear aromatic, residual JP-8 fuel

Table 3.5-3 Mishap Composite Materials Compatibility

	REACTIVITY [1]
Carbon	Can react with strong oxidizing agents
Glass	NR
Boron	Reacts exothermally with metals above 1652 ° F. Exothemic with molten aluminum.
Kevlar	NR

	Carbon	Glass	Boron	Kevlar	Epoxide	PEEK	BMI
		E,S					
Hydrazine	Core material; foam, paper-like honeycomb.						
A/C Fuels	NR	NR	NR	NR	NR	NR	NR
Hydraulic Fluid	NR	NR	NR	NR	NR	NR	NR
Hypergolic Mixtures	NR	NR	NR	NR	NR	NR	NR
Liquid Oxygen	May react with the matrix, Kevlar® fiber, organic core material, carbon fiber.						
Battery Acid	NR	NR	NR	NR	NR	NR	NR
Bloodborne Pathogen Decontamination Soln.	NR	NR	NR	NR	NR	NR	NR

NR = Non Reactive [1] The ability to release energy.

	CHEMICAL RESISTANCE TO MATERIAL DEGRADATION							
	Carbon	Glass E	Glass S	Boron	Kevlar	Epoxide	PEEK	BMI
Strong Acid	R	SA	R	A	A	SA (sulfuric acid)	SA	A
Weak Acid	R	SA	R	R	R	SA (acetic acid)	R	R
Strong Alkalis	R	SA	SA	R	A	R	SA	A
Weak Alkalis	R	R	SA	R	R	R	R	R
Hydraulic Fluids	R	R	R	R	A	R	SA	R
Organic Solvents	A	R	R	R	R	R	R	R
Bloodborne Pathogen Decontamination Solution	R	R	R	R	R	NI	R	R
Hydrazine	NI	A	A	NI	NI	NI	NI	A

NI=No Information A =Attack SA =Slight Attack R=Resistant to Attack P=Poor

Table 3.5-4 Composite Identification Information

FIBER	COLOR UNDAMAGED	COLOR FIRE DAMAGED	ORIGINAL DIAMETER SIZE (μm)	THERMAL DAMAGE	APPLICATION
Carbon	Black	Black	5-10	Oxidation: varies with fiber type 660 -1000° F Melting Point 6600° F	Primary and secondary structures
Glass (E and S)	White or transparent	Char color on surface	4-13	Melting Point 1550° F for E glass 1778° F for S glass noncombustible	Radome, sacrificial surface layer and corrosion protection layer between carbon and metal, secondary structures.
Kevlar ®	Yellow	Brown	12	Decomposes ~ 800 - 900° F Total ash occurs at 1292° F	Where impact is a concern.
Boron	Black	Black	100 and 140 (tungsten boride core 7.5)	Melting points: Boron 4172° F Tungsten Boride 5252° F	Where high strength and stiffness is needed. Very limited application. F-15, F-14, B-1 and repair patch for metallic structures (C-130, C-141).
Quartz	White to Reddish	Surface char	4-10	Melting point 3121° F noncombustible	Radome
Spectra®	Opaque	Char	4-12	Melting point: 297° F ignites: ~ 660° F	Radome

The systems color could be attributed to the resin or fiber. A general rule of thumb follows:

System color will be from the resin for systems using one if the lighter colored fibers. A black or dark appearance is from carbon fiber unless the fiber diameter size is as large as human hair then it would be boron.

Table 3.5-5 Fire Damage Evidence

MATERIAL (° F)		OBSERVATION
Aircraft Expoxy Paint		
	400	softens
	600	discolors
	800 - 850	blisters
	900 - 950	burns off
Zinc Chromate Primer		
	900 - 950	burns off
	800 - 850	blisters
	700	black
	600	dark brown
	500	brown
	540	tan
Stainless Steel		
	800 - 900	tan to light blue
		to bright blue
		to black
	2700	melts
Titanium		
	1100	blue, scale form
	1300	oxide scale
	1200 - 1500	grey or yellow
	1620	allotropic transportation
	3100	melts
	5600	TiO_2 boils, burn
Aluminum		
	1000 - 1200	melts
Carbon Fiber		
	1000 or above	individual fibers or very small fiber bundles are turning ash
	1400	in color . glowing red
Boron		
	?	gray
Glass		
	1550	beads form
Kevlar ®		
	800 - 900	brown
Epoxy		
	above 500	shiny surface

Table 3.5-6 DoD Aircraft Composite Systems (Sheet 1 of 3)

US ARMY	K/e	K/p	B/e	C/BMI	G/BMI	G/e	G/pami	G/pe	G/pimi	C/BMI	C/e	C/pimi	C/thpls	C/pbc	Q/bmi	Q/e	Q/pimi
AH-1	X					X					X					X	
AH-60	X					X					X						
AH-64	X					X					X						
CH-46						X					X						
CH-47	X					X					X						
CH-48																	
CH-53	X					X					X						
MH-53	X					X					X						
MH-60	X					X					X						
OH-58						X											
RAH-66	X										X						
RC-12	X					X					X						
UH-1						X											
UH-60	X					X					X						

Key for 3.7-12: (fiber / matrix)

K/e = Kevlar / epoxy
K/p = Kevlar / phenolic
B/e = Boron / epoxy
C/bmi = carbon / bismaleimide
G/bmi = glass / bismaleimide

G/e = glass / epoxy
G/pami = glass / polyamide
G/pe = glass / polyester
G/pimi = glass / polyimide
C/bmi = carbon / bismaleimide

C/e = carbon / epoxy
C/pimi = carbon / polyimide
C/thpis = carbon / thermoplastic
C/pbc = carbon / phenolic based carbon
Q/bmi = quartz / bismaleimide

Q/e = quartz / epoxy
Q/pimi = quartz / polyimide

Table 3.5-6 DoD Aircraft Composite Systems (Sheet 2 of 3)

USAF	K/e	K/p	B/e	C/BMI	G/BMI	G/e	G/pami	G/pe	G/pimi	C/BMI	C/e	C/pimi	C/thpls	C/pbc	Q/bmi	Q/e	Q/pimi
A-10						X					X						
B-1		X	X			X					X			X	X	X	
B-2	X					X				X	X	X			X	X	
B-52						X											
C-5	X					X											
C-17	X					X					X	X					
C-32A	X										X						
C-37A	X					X					X						
C-38A	X										X						
C-130						X											
F-117	X				X	X	X		X	X			X	X			X
F-15			X			X		X						X	X		
F-16						X								X			
F/A-22				X	X					X		X	X	X	X		
OV			X								X						
SR-71																	X
T-1A	X																
T-4A						X											

Table 3.5-6 DoD Aircraft Composite Systems (Sheet 3 of 3)

US NAVY	K/e	K/p	B/e	C/BMI	G/BMI	G/e	G/pami	G/pe	G/pimi	C/BMI	C/e	C/pimi	C/thpls	C/pbc	Q/bmi	Q/e	Q/pimi
A-6						X					X						
AV-8B	X				X	X		X		X	X						
C-2						X											
E-2																	
E-2C						X										X	
E-6B																	
EA-6B					X						X				X		
F-14			X			X		X			X						
F/A-18	X					X		X			X						
H-53D,E						X											
P-3						X											
SH-60	X					X					X						
T-2						X											
T-34						X											
T-39						X											
T-44	X					X					X						X
T-45						X					X						
TH-57						X											
UC-12						X											
UH-1N						X											
V-22					X	X				X	X						

Table 3.5-7 How to read the Master List of European Aircraft Hazards

Cell 1: Code number of hazard.
Cell 2: Known hazard.
Cell 3: Function.
Cell 4: Toxicity to lungs. Hazardous materials to human life by inhalation.
- A. Not considered toxic.
- B. Low. Judged harmful only after massive exposure.
- C. Moderate. May cause illness or injury but not considered fatal except for unusual circumstances.
- D. High. May cause death or permanent injury.

Cell 5: Toxicity to skin. Hazardous materials to human life by destruction of skin tissue or absorption through the skin into the system.
- A. Not considered toxic.
- B. Low. Judged harmful only after massive exposure.
- C. Moderate. May cause illness or injury but not considered fatal except for unusual circumstances.
- D. High. May cause death or permanent injury.

Cell 6: Toxicity to atmosphere. Combustion released products.
- A. Not considered toxic.
- B. Low. Judged harmful only after massive exposure.
- C. Moderate. May cause illness or injury but not considered fatal except for unusual circumstances.
- D. High. May cause death or permanent injury.

Cell 7: Danger rating from fire of a material.
- A. No hazard.
- B. Slight.
- C. Moderate.
- D. Readily detonates when exposed to fire or shock.

Cell 8: Substance or material.
- S1. Flammable or oxidizing substances.
- S2. Explosive substances.
- M1. Moderately or highly toxic materials.
- M2. Radioactive materials.
- M3. Water-reactive materials.
- M4. Cryogenic materials.

Cell 9: Evacuation distance in all directions. Monitor wind conditions. Be prepared to relocate. Check points should be established up wind. Beware of smoke and/or vapor clouds.
- E1. 500 feet/1,640.45 meters/200 paces
- E2. 1,000 feet/3,280.9 meters/400 paces
- E3. 1,500 feet/4,921.35 meters/600 paces
- E4. 2,500 feet/8,202.25 meters/1,000 paces
- E5. 5,000 feet/16,404.5 meters/2,000 paces

Note from the Editor:
HQ AFCESA/CEXF would like to thank Charles J. Baker and acknowledge his excellent effort in the HAZMAT arena. Permission was granted to use information from his book *The Firefighter's Handbook of Hazardous Materials,* 5th Ed, 1990.

Table 3.5-8 Master List For European Aircraft Hazards (Sheet 1 of 4)

CODE	KNOWN HAZARD	FUNCTION	TOXICITY - INHALE	TOXICITY - SKIN	TOXICITY - AIR	DANGER	SUB/-MAT	EVAC
1	ACIDS - SULFURIC	Batteries	C	D			S1	E2
2	ACFT ASSISTED ESCAPE SYSTEM	Various Acft Types				D	S2	E1
3	ALKALINES (general)		C	D				E2
3	ALKALINES (general)		C	D				E2
4	ARCTON 12							
5	ARCTON 112	Phosgen Gas When Heated						
6	ASBESTOS (dust/particles)	Insulation	C	A	B	A		E1
7	BERYLLIUM + BERYLLIUM OXIDES		C		D		M1	E1
8	BROMOCHLORODIFLUOROMETHANE	BCF Fire Extinguishant	B		C	A		E1
9	BROMOTRIFLUOROMETHANE	BTM Fire Extinguishant	B	A	C	A		E1
10	CADIUM (general)	Batteries/Bolt & Steel Protection	C		D	C	S1	E2
11	CARTRIDGE OPERATED EQUIPMENT	Non-Armament/PAD/CAD			A	D	S1	E1
12	CHLOROBROMOETHANE	Fire Extinguishant	C		C	A	M1	E1
13	COMPOSITE MATERIALS	Man-made Mineral Fibers (various acft)				D	S2	E2
14	COOLANOL							
15	CHAFF DISPENSER	Defensive Systems (various acft types)				D	S2	E2
16	DEPLETED URANIUM		D	C	D	D	M2	E2
17	DIMETHYLFORMAMIDE	Strobe Power Pack	B	C	C	C	M1	E1

Table 3.5-8 Master List For European Aircraft Hazards (Sheet 2 of 4)

CODE	KNOWN HAZARD	FUNCTION	TOXICITY - INHALE	TOXICITY - SKIN	TOXICITY - AIR	DANGER	SUB/-MAT	EVAC
18	EJECTOR RELEASE UNITS (ERU'S)	Various Acft Types					S2	E2
19	ETHYLENE GLYCOL		C	B	B	A	M1	E1
20	FLARE DISPENSER	Various Acft Types				E	S2	E2
21	FLUOROLASTOMERS	Burnt Seals						
22	FREON * (all types)	Air Conditioning/ Environmental Units	B	B	D	A		E2
23	GROUND ILLUMINATING FLARE DISPENSER	Various Acft Types				D	S1	E2
24	ISOPROPYL NITRATE	"AVPIN"	C		C	E	S1	E2
25	LEAD (all types)		D	C	D	E	M1	E2
26	LITHIUM	Batteries					M3	E2
27	MERCURY(general)	Temperature Bulbs	D	D	D		M1	E1
28	METHYL BROMIDE	Fire Extinguishant	D	D	D	A	M1	E2
29	MINIATURE DETONATING CORD	Escape Systems/ Hatches/Canopies				E	S2	E2
30	NIEMONIC STEEL	Heat Shields	A	B	B	C		E1
31	NITESUN LIGHT SYSTEM							
32	POLYCHLORINATED BIPHENYLS	PCBs	C	C	D	A	M1	E1
33	POLYTETRAFLUOROETHYLENE	PTFE						

Table 3.5-8 Master List For European Aircraft Hazards (Sheet 3 of 4)

CODE	KNOWN HAZARD	FUNCTION	TOXICITY - INHALE	TOXICITY - SKIN	TOXICITY - AIR	DANGER	SUB/-MAT	EVAC
34	POTASSIUM HYDROXIDE		C	D	C	A	M1	E1
35	RADIOACTIVE SOURCES	DU, Thorium	C	D	D	A	M2	E1
36	SKYDROL HYDRAULIC OIL OX-20		A	B	A	A	S1	E2
37	SONAR LOCATOR BEACON(S)	Lithium Battery					M3	E2
38	STRONTIUM CHROMATES		B	B	C	A		E1
39	SULPHUR HEXEFLUORIDE SF-6		B	B	D	A		E1
40	THALLIUM (compounds)		C	C	D	A	S1	E1
41	THORIUM FLUORIDE		C	C	D	A	S1	E1
42	TRITIUM LIGHT SOURCES	Beta Lights	C		C	D	M2	E3
43	VERY FLARE							
44	WATER METHANOL		B		B	D	S1	E2
45	WEAPON LOAD	If fitted, various acft types						
46	WINDSCREEN WASH FLUID AL-36							
47	ZINC SELENIDE	FLIR	C		C	A	M1	E1
48	HYDRAZINE H70	F-16, Orbiter, various acft types	D	D	D	C	M1	E2
49	HALON (gas and liquid)	Fire Extinguishant, Refrigerant	D	C	*	E	M4	E5

Table 3.5-8 Master List For European Aircraft Hazards (Sheet 4 of 4)

CODE	KNOWN HAZARD	FUNCTION	TOXICITY - INHALE	TOXICITY - SKIN	TOXICITY - AIR	DANGER	SUB/-MAT	EVAC
50	ISOPROPYL ALCOHOL		B	B	B	D	S1	E2
51	METHYLETHYLKETONE (MEK)	Cleaning Solvent	B	B	B	D	S1	E2
52	INSTRUMENT MIL 17808							
53	MOLYKOTE D32-1/R	Anti-icing Fluid						
54	AL-5	Windscreen Wash Fluid						
55	MERCURY CADIUM TELLURIDE (HgCdTe)	FLIR						

NOTE:
Cargo cabin insulation blanket produces phosgene gas on burning.

*Ozone depleting.

e. <u>F-22A COMPOSITE MATERIALS BURN TEST 2004-2005.</u> The following information is summarized test results completed by AFRL/MLQ (Fire Research), Tyndall AFB, FL, in coordination with AFRL/MLS-OL (Advanced Composites Office), Hill AFB, UT.

(1) BOTTOM LINE.

As standard grades of aluminum typically found on an F-15 aircraft approach the temperature melting point, the aluminum deforms and begins to drip. Comparative tests were performed and this behavior occurred at 89 and 86 seconds respectively, producing a hole in the sample and allowing the flame to penetrate or burn through.

The effects of fire on composite materials were much more dramatic. Samples of the F-22A composite materials burn through, accounting for the type of composite, its thickness and location, had a range of 9 to 120 seconds. This occurred with a JP-8 fuel fire within 6 feet of a simulated aircraft. Therefore response to a fire on or near an aircraft is much more critical than for metal skinned aircraft.

The normal level of personal protection (proximity clothing and SCBA) is adequate for these emergencies, incidents, and encounters with advanced composite materials under burning, off gasing, smoldering, and fiber release conditions. These factors are explained here.

(2) SCOPE OF TESTS.

Three test phases were performed under controlled laboratory conditions and scales. Authentic F-22A materials in various sizes, thicknesses (1/8” to 3/8”) and selected aircraft locations were used, including some with Low Observable Coatings (LOCs). The tests were performed to determine fire properties, burn through and transient heat flux.

(3) RESULTS.

(a) Functionality of a composite material **degrades as the material looses mass or weight**. If the maximum temperature an aircraft has been exposed to in a fire is known, (charts in the main report) can be used to determine which components may have been damaged.

(b) A **higher ash** content is the principle observed difference in results when composite materials have been coated with LOC. The firefighter will be able to readily identify this. Results indicate principal constituents of the LOCs are inorganic in nature, and do not contribute significantly to combustion load. Regardless of aircraft sample, in all cases, when present, the **LOC cracked and flaked away becoming severely damaged.** The presence of a LOC did not influence ignition times or heat release rates. The LOCs used on the F-22A start to degrade much faster than the composite materials and **offer no protection** against thermal damage to the underlying materials.

(c) Two passive detection methods were used in an attempt to identify the individual decomposition gases using JP-8. The most common result was carbon monoxide from the polymers and resins. After the resins are consumed, fibers continue to burn producing carbon dioxide. Plume models were not explored.

(d) **NDI evaluation revealed that damage to the composite material occurred in 20 seconds.** Cone calorimeter results confirmed that composite materials ignited in **under a minute** for both the horizontal and vertical positions, regardless of the presence of coatings. Ignition time on average was 43 seconds using samples from various aircraft locations.

(4) RECOMMENDATIONS AND CONSIDERATIONS.

(a) In addition to the current fire fighting procedures set forth in TO 00-105E-9, firefighters need to treat aircraft composite material pieces and its associated resins as a fuel source.

(b) Fire fighting objectives include cooling of the entire surface of the aircraft exposed to heat to prevent thermal damage. Tactically, more cooling time and water are required to bring composite components and debris to ambient temperatures before the area can be proclaimed fire safe.

(c) Improved fire response time or additional fire protection equipment co-located with high risk aircraft should be considered.

(5) SUMMARY.

Aircraft constructed with large quantites of composite fibers constitute a significant change in firefighting tactics. Rapid response, aircraft skin cooling, and resupply of ARFF vehicles are key considerations since an exterior fire can become an interior fire rapidly. Composite aircraft present extra considerations, but with proper fire tactics, are manageable. Firefighting PPE is suitable for use in secondary operations until composite fibers are sealed.

f. **Postcrash Health Hazards from Burning Aircraft Composites**

NOTE

This Abstract is edited in its original format and moved into this section with associated information.

Postcrash Health Hazards from Burning Aircraft Composites

Sanjeev Gandhi
Galaxy Scientific Corporation
Fire Safety Section, AAR-422
Federal Aviation Administration
William J. Hughes Technical Center
Atlantic City International Airport, NJ 08405

AN ABSTRACT

The release of toxic combustion products from advanced composite materials in aircraft fires presents an unusual health risk to the various emergency response personnel. There is concern among the aviation fire fighting, rescue, and recovery and investigation groups that a health hazard is posed by the combination of various combustion products. This paper provides a review of the current scientific literature on the potential hazards from inhalation exposure to airborne carbon fibers and the combusted resin residues which are released when there is a crash impact, fire, and explosion involving advanced composites materials. Data collected from fire tests and crash-site investigations suggested that a small fraction of the fibers released in fires and during recovery operations were of respirable size and can be inhaled deep into the lung. However, most of the carbon fibers were 2-10 times larger than the critical fiber size generally associated with asbestos toxicity. The concentration of carbon fibers was well below the OSHA recommended levels for chronic exposure. Based on current published studies, no direct and conclusive linkage can be made between human exposure to the airborne carbon fibers alone with any long-term diseases. At issue, however, are the toxicological effects of the adsorbed combustion products generated in composite fires. Chemical extraction analyses have shown that a large number of toxic organic compounds are adsorbed on the fibers, several of which are known carcinogens in animals. Detailed toxicological studies are needed to assess the long-term health effects from exposure to single high dose of fibrous particulates and any synergistic interactions with the organic chemicals.

INTRODUCTION

Aircraft mishaps involving advanced composite materials present unique safety, environmental, and potential health hazards due to the disintegration of materials in postcrash fire, explosion, and high energy impact. There is growing concern regarding the potential health risks encountered by the civilian and Airport Rescue and Fire Fighting (ARFF) personnel when there is a postcrash fire associated with an advanced composite aircraft. The health concerns center around exposure to the fragmented composites and fibers which, are liberated as the resins burns off, and may splinter in to particles that are small enough to be inhaled and retained in the lungs. Such health risks from a single, acute exposures to combustion products of advanced composite materials are largely unknown. In recent years, a number of incidents have been reported on the toxic effects of fibrous matter and aerosols on personnel responding to the crash site [1]. Incident reports vary concerning the nature and severity of short- and long-term adverse effects on the responding crews, ranging from eye and skin irritation to severe respiratory problems with chronic post-exposure symptoms including forced breathing and reduced exercise capability. In certain instances, response teams equipped with enhanced protective clothing have suffered from penetration by strands of needle-sharp carbon fibers resulting in infected wounds [2-4]. The burning of polymeric materials generates heat and combustion products that consist of a complex mixture of gaseous and solid particulates from incomplete combustion, collectively referred to as smoke. Combustion involves complex chemical/physical processes in which the nature of products formed varies greatly with the composition of the material(s) and the burning conditions. The composition and the concentration of combustion products are dependant upon ventilation i.e., the amount of available oxygen and the resulting fire growth rate. At any stage of the fire development, the smoke stream contains a mixture of evolved gases, vapors, and solid particles. Aerosols constitute the visible component of smoke and are comprised of aggregates of solid particles mixed with combustion vapors and gases. Airborne particles vary widely in size from submicron to many microns. Smaller particles stay suspended in air longer and are more likely to adsorb chemical vapors from the smoke. The physiological effects of human exposure to fire effluent depend upon the size distribution, solubility characteristics, and chemical composition of the aerosols, which determine the depth of penetration in the lungs and the degree of absorption inside the body [5]. Firefighters are routinely exposed to harsh and uncontrolled conditions, with partial products of combustion constituting the major source of chemical exposure. They are frequently exposed to extremely high concentrations of a wide array of chemical and particulate matter. There have been various studies on the health hazards posed to firefighters from various individual chemicals in typical fire scenarios such as residential fires, industrial fires, and wildland forest fires. In a recent review, Lees [6] has described the various chemical species, particulate matter, and their concentrations frequently encountered by firefighters. However, little has been published describing the combustion products that are generated from burning composites and the health hazards they might pose to the firefighting and rescue personnel. In view of the current and projected use of composites in commercial aircraft, an extensive literature survey was undertaken to determine what has been done by researchers to address the hazards related to composite materials. The primary objective was to compile information on health effects caused by single acute exposure to various pollutants including micron-sized fibers that become airborne during the burning and explosion in fiber composites on impact. This study presents results of the literature review. The paper describes the general nature of hazards due to fiber inhalation, and the potential hazards specific to particulate matter with associated chemicals released during aircraft composite fires. Characteristics of fibers released from burning composites and their size distribution are described. This review also examines some of the toxicological data available to assess the potential inhalation hazard of carbon fibers.

POLYMER MATRIX COMPOSITES

Composites are generally classified according to their matrix phase. There are polymer matrix composites, ceramic matrix composites, and metal matrix composites. These materials are commonly referred to as advanced composites because they combine the properties of high strength and high stiffness, low weight, corrosion resistance, and in some cases special electrical properties. The combination of such properties makes advanced composites very attractive functional substitutes for metallic structural parts. The original impetus for development of advanced composites was the performance improvement and weight savings for aerospace systems and military aircraft and subsequently in the field of commercial aviation. Polymer matrix composites are very lightweight with a superior strength-to-weight ratio and offer high fuel efficiency over the lifetime of the aircraft. There has been a steady increase in the use of composites in both military and commercial transport aircraft. Until recently, the use of composite materials in commercial transports was limited to non-load or low-low carrying structural parts. However, with the modern technology, composites are increasingly used for primary, load-carrying structural parts. There has been a three-fold increase in the structural weight of composite parts used in Boeing 777 aircraft compared to the previous generation airplanes. In Boeing 777, the vertical and horizontal tail sections as well as major wing sections were made with toughened carbon fiber-reinforced epoxy composite [7]. Given the lightweight, low cost, and performance advantages of advanced composite materials, their use in future aircraft will continue to grow. Boeing estimates that the average structural weight fraction of polymer composites in their commercial airplanes will increase from about 7 percent currently to about 20 percent over the next 15 years [7-8]. Already, smaller business aircraft and helicopters are now being produced with entire aircraft structure made from composite materials [9].

Polymer matrix composites are engineered materials comprised of continuous, high-strength fibers impregnated with a polymer matrix to form a reinforced layer (ply), which is subsequently bonded together with other layers under heat and pressure to form an laminate. The resin acts to hold the fibers together and protect them and to transfer the load to the fibers in the fabricated composite part. The strength and stiffness of the laminate are determined by the orientation of the fibers with respect to the loading direction and their volume fraction in the composite. For a typical polymer matrix composite, fibers comprise about 55-60 volume percent of the laminate with the polymer resin being the remainder.

Resins

There are two main classes of polymer matrix composites depending upon the type of resin used, thermosets and thermoplastics. Thermoset resins are the predominant type in use today with epoxies and phenolics by far being the most dominant resins in commercial aircraft applications because they are relatively tough, easy to process, and require moderate forming temperature. Composite panel materials used in aircraft cabin interiors are required to comply with strict heat release rate regulations. Epoxies are highly flammable and thus cannot be used in composites for large surface area, interior panels such as partitions, stowage bins, galley walls, and ceilings. Phenolics are currently the thermoset resin of choice for aircraft interiors because of their low heat release rate. Thermoplastic resins have found limited use as matrix resins in aircraft interior and structural composites because they require high forming temperatures in manufacturing. Unlike the thermosets, the thermoplastics can usually be reheated and reformed into another shape, if required. Thermally stable engineering thermoplastics, such as polyetheretherketone and polysulfone, are used as resin tougheners in commercial and military applications [8]. The development of high-performance thermoplastic resin systems is an area of evolving research that holds great promise for future applications of polymer matrix composites.

Carbon/Graphite Fibers

Continuous carbon fibers are the most commonly used reinforcement materials because of their high strength-to-weight ratio. Fibers are used alone or in combination with other fibers (hybrids) in the form of continuous fiber fabrics, tapes, and tows or as discontinuous chopped strands. Common raw materials, also known as precursors, for carbon and graphite fibers are polyacrylonitrile (PAN), rayon, and petroleum pitch. The synthesis process involves controlled pyrolysis at 1000-2000 C for carbon fibers while graphite fibers require pyrolysis temperatures of 2000-3000 C and contain 93-95 and 99 percent carbon atoms, respectively [8]. Typical carbon fibers used as reinforcement material in composites are 6-8 µm in diameter.

HAZARDS FROM INHALATION EXPOSURE

The assessment of fiber toxicity is complex process that generally requires substantial epidemiological data along with long-term exposure studies for the health effects on humans. This is because it a long time for the biological processes to manifest following the exposure. The gestation period for physiological changes in humans may be as long as 20-30 years depending upon the severity and duration of the exposure.

There are two major routes to exposure from fibers - dermal and inhalation. Dermatitis results from mechanical or chemical irritation or sensitization of the skin. This condition is a typical response to surface abrasion and puncture by sharp, needle-like fibers of diameter greater than 4-5 µm. The breakage of stiff carbon fibers into smaller fragments and rubbing against exposed skin may increase severity of the exposure and infection of the affected area. Such irritation effects are generally not permanent. However, the inhalation exposure from fibers poses the greatest potential for adverse health effects.

Asbestos is the most widely studied fiber for its health impact on humans. Extensive epidemiological data combined with animal studies have been done to study the pathological impact of this silica-based fiber [10-14]. Inhalation of asbestos fibers in the lungs initiates an inflammatory response in that region [11]. The lung's efforts to repair this damage manifests as progressive scarring in the lung walls. This interstitial scarring effect caused by the deposition of fibers is called pulmonary fibrosis, a condition in which scar tissue forms in the connective tissues that support the alveoli in the lungs. Scarring can be a reaction to a large number of diseases and conditions. The induction of fibrosis retards the process of fiber clearance resulting in longer fiber retention. Extended chronic exposure to asbestos is known to result in bronchogenic carcinoma or lung cancer, and may also lead to mesothelioma - a cancer of the pleural cells lining the lungs. The causal relationship between asbestos exposure and onset of lung cancer has been demonstrated in numerous epidemiological studies [12-14].

The framework of information on asbestos and fiberglass has been applied for the study of health effects from new, organic fibers such as kevlar and carbon and to delineate the contributing factors in fiber toxicity. Using the animal models in studies with asbestos, researchers have identified the important characteristics that describe a given material's fiber toxicity. By definition, a particle is considered a fiber if it has a length-to-diameter ratio (L/D) of greater than 3:1.

It appears that fiber size and geometry and its durability are the most important factors in fiber toxicity. Fiber dimension determines whether the fiber can be inhaled deep into the lungs that lie below the larynx, tracheal conducting airways which constitute the upper respiratory tract. Only those fibers with dimensions smaller than the bronchial airways' size can penetrate the deep lung (alveolar) region. Generally, fibers larger than 10 microns (μm) in diameter can not penetrate deep enough into the alveoli to cause disease [12].

However, the respirability of fibers is not entirely governed by their physical dimensions. The respirability or the extent fibers are deposited in the deep pulmonary region and the alveoli is primarily determined by their aerodynamic equivalent diameter (D). The parameter D reflects the way a particle behaves when airborne. For a fiber, D refers to the diameter of an equivalent spherical particle having the same terminal velocity as the fiber. The number of deposited fibers increase significantly when D lies between 2-3 μm and falls off to 0 when the D is between 7and 10 μm. Long and thin, aerodynamic fibers line up straight in an airstream and are more likely to penetrate deeper into the lungs. Studies on size analysis of fibers in human lungs exposed to asbestos fibers have shown that the upper limits of respirable fibers are either 3.5 μm in diameter or 200 μm in length [10].

The aerodynamic character of the fibers (D) also determines the manner in which the fibers are deposited in the lung tissue. There are five different modes of fiber deposition in the respiratory airways. In the human lung, the airways region consists of a series of branching airways called bronchi and bronchioles that become progressively smaller. The multiple division of the bronchi greatly increases the total cross-sectional area of the airways available for fiber deposition. Fibers aligned vertical to the airway flow stream are primarily deposited by interception at each successive bifurcation. The probability of interception increases when the fiber length is greater than 10 μm. The larger airway bifurcations are the primary sites of fiber deposition and lung cancer in humans from mineral fibers [14]. In smaller airways where the airflow velocity becomes very small, sedimentation is the primary mode of fiber deposition. Three other mechanisms of fiber loading in lungs are interception, diffusion, and electrostatic deposition. The durability of fibers inside the body depends on the response of the local cell tissues in the lungs. Warheit [13] has shown that fibers can be cleared from the pulmonary region via dissolution in lung fluids or through an internal, pulmonary self-defense mechanism. Cells known as alveolar macrophages that are present on the outer walls of the lungs facilitate removal of these fibers. The primary function of these cells is to remove bacteria, dead cells, and foreign particles and fibers by ingestion [13]. Hesterberg [15] has given a detailed description of the biological mechanism in the clearance of fibers by the macrophage cells.

Carbon Fiber Toxicity

Compared to asbestos and other mineral fibers, very little work has been done on the inhalation toxicology of carbon fibers. Few studies have been published on the health effects related to chronic exposure from carbon fibers and dusts in the manufacturing environment. Two conferences [16-17] brought together experts from the aerospace and composites industries and government agencies to address the health implications of exposure to carbon fiber-reinforced composites. These proceedings primarily focussed on the hazards related to exposure from carbon fibers and dusts during the machining and handling of fiber composites. In a review of the to date toxicology research on carbon fibers, Thomson [18] concluded that there are no long-term health risks associated with exposure to PAN-based carbon fibers alone under occupational conditions. The health effects are limited to temporary irritations of the skin and upper respiratory tract since given that exposure under occupational conditions is limited to relatively large-diameter, nonrespirable fibers (nominal diameter ~ 6-8 μm). In a separate review of studies that included some consideration of the health effects of exposure to composites duringvarious stages of manufacturing, Luchtel [19] concluded that, "carbon fibers and composite dusts should be regarded as more hazardous than the so-called nuisance dusts, and present a low health risk." The author noted that the pulmonary effects of the composite materials are not in the same class as asbestos in terms of toxicity, however adequate respirable protection should be used to minimize the occupational exposure. One consistent shortcoming of the previous studies is the lack of complete information about the characteristics of the material being studied, i.e., the size distribution of fibers, their Dea, multiple dosages, if used, and the type of resin matrix. In addition, these studies used unequal time periods for the animal exposure and post-exposure recovery. Today, standard design requirements for the toxicological evaluation in a lifetime inhalation study with rats call for an exposure time of at least 2 years and a post-exposure evaluation period of 2-3 years [20]. A post-exposure recovery period allows evaluation of reversibility of effects. In the studies reviewed by Luchtel, the exposure times used by all the researchers were very short compared to the required 2 years. Similarly, post-exposure times for recovery were too short compared to the current standard guidelines.

Further studies are needed to assess the carbon fiber toxicity in the presence of surface contaminants from the combustion environment. Fibers and other small particles, with high surface-to-volume ratio, generated in fires can carry with them a diverse package of chemical species with potentially harmful effects. It has been suggested that adsorbed chemicals may enhance the pathology of inhaled particles similar to the example of diesel soot [6, 21]. In the case of inert fibers such as carbon, the presence of fire-caused surface contaminants might affect fiber retention in the lung.

COMBUSTION PRODUCTS FROM COMPOSITE FIRES

Fiber Size Characterization

Characterization of fiber dimensions is an important requirement in any toxicology study in order to determine their respirability. Bell [22] described an extensive series of tests conducted by the National Aeronautics and Space Administration (NASA) to ascertain the extent of carbon fiber release during an aircraft crash. In one series of tests conducted at the Naval Weapon Center (NWC), China Lake, CA, full composite sections of a Boeing 737 spoiler and an F-16 fuselage were subjected to flames for 4-6 minutes in 15.2 m pool of JP-5 jet fuel to simulate aircraft fires. Fibers released during the fire were collected through adhesive coated papers 20x25 cm located on an elevated platform 0.3 m above the ground. However, this sampling procedure yielded very low amounts of single fibers. The massive smoke plume that reached a height of ~1000 m carried the majority of the single fibers away from the test location to distances beyond the instrumentation limit of 2000 m. Sampling size was also reduced due to difficulties in separating the fibers from the paper, thus limiting the number of fibers analyzed for size distribution [23]. A second series of large-scale fire tests were conducted at the U.S. Army's Dugway Proving Ground, UT to measure the concentration of single carbon fibers. Carbon-epoxy composite parts weighing about 45 kg were burned in 10.7 m diameter JP-4 jet fuel pool fires for 20 minutes. The fire-released fibers were collected using an array of filters suspended inside the smoke plume at a height of 40 m. The filters consisted of stainless steel canisters with stainless steel mesh to trap the fibers carried in the smoke plume. Collected fiber samples from these tests were analyzed for fiber count and size distribution by optical and electron microscopy.

The results showed that fibers were released in several forms ranging from single fibers to large fiber clumps and fragmented pieces of composite laminate [23]. Single fibers constituted less than 1 percent of the carbon fiber mass initially present in the composite. Under certain conditions involving thin composites with turbulence (e.g., air blast or explosion) the total number of single fibers released from burning composite parts increased significantly. There was a threefold increase in the total mass of collected single fibers under the turbulent fire conditions [22-23]. Microscopic fiber analysis revealed that fiber diameter was significantly reduced in the fire due to fiber oxidation and fibrillation.

Overall, the collected fibers had a mean diameter in the range of 4.2 μm versus 7μm for the virgin fibers. At extreme flame temperatures (> 900 C) and under oxygen-rich test conditions, large amounts of fibers were completely consumed through oxidation. The fiber diameters were reduced drastically inside the flame after the fibers were released from the composite. Sussholz [24] determined that reduction in the fiber diameter in fires occurred due to partial surface oxidation and fibrillation effects–splitting of fibers into smaller, finer fibrils due to surface pitting and or surface flaws. The main reasons for fibrillation of carbon fibers were found to be the presence of sodium impurities and morphological flaws such as voids in the fiber structure. Elemental analysis of the carbon fibers confirmed the presence of sodium impurities. The surface oxidation effects were significantly more pronounced in the regions of low crystalline density.

Considering the potential health implications from inhalation of micron-sized fibers, NASA conducted a scanning elec-tron microscopy (SEM) study for physical characterization of the fibers. Seibert [25] summarized the results of the SEM analysis for respirable fibers (diameter <3 µm, length <80 µm) which constituted less than 24 percent of the total fibers released from burning composites. The respirable fibers had an average diameter of 1.5 µm and were 30 µm long. Overall, the fiber sizes spectrum ranged from ≈ 0.5 to 5 µm in diameter. To quantify the concen-tration of respirable fibers and determine the potential exposure levels, Sussholz [35] estimated that an aircraft fire involving fiber composites would release 5x10 respirable fibers per kilogram of carbon fibers released (or five percent by weight). This quantity corresponds to an estimated peak exposure of 5 fibers/cm within the smoke plume. This exposure is only half the permissible OSHA limit [26] for time-weighted average (TWA) over an 8-hour period for asbestos fibers.

The fiber concentration was also measured directly via sampling of fibers from the smoke plume in large-scale tests conducted at Dugway Proving Grounds [22]. All fibers with an L/D ratio greater than 3 were counted and fiber concentrations were determined for the 20-minute burn time. The results indicated an average fiber concentration of less than 0.14 fibers/cm . This is ten times lower than the OSHA mandated permissible exposure limit (PEL) of 1.0 f/cm for short term exposure, averaged over a sampling period of 30 minutes [26]. Lacking evidence of any known pathological effects, the authors concluded that carbon fiber exposure should be treated in the same manner recom-mended by NIOSH for fibrous glass [27].

The U.S. Coast Guard (USCG) conducted a series of tests to characterize the graphite fibers emitted from burning graphite/epoxy composites [28]. The study primarily focused of on the size distribution of fibers released during small- and large-scale burn tests with advanced composites. The laboratory-scale tests were conducted using the Cone calorimeter at 50 and 75 kW/m^2 on composite parts from an HH-65A helicopter. A modified sampling system was used in the cone calorimeter to maximize the collection of fibers after the epoxy resin was completely burned. The fiber size distribution was determined through SEM analysis. The study revealed that 23 percent (by weight) of the fibers generated were in the respirable range. Overall, the fiber diameter ranged between 0.5-9 µm and the length was between 3-210 µm. The mean fiber diameter and lengths were 2.5 and 52 µm, respectively.

In a separate test series, USCG burned 48x48 cm^2 sections of graphite/epoxy composite in heptane pool fires [28]. The fiber sampling system consisted of a cascade impactor placed inside the exhaust duct. Analysis of the fiber size distribution indicated that the diameters ranged between 0.5-5.0 µm with a mean diameter of 2.4 µm. The scatter in the fiber lengths was much greater in pool fire data, and ranged between 5-900 µm with a mean fiber length of 77 µm. Results from both the Cone calorimeter and large scale tests indicate that fibers are significantly oxidized during the burning process, with fiber diameters reduced from 7 µm originally to an average value of less than 3 µm. The US Coast Guard studies did not include toxicological evaluation of combustion products.

Additional data on the characteristics of the airborne carbon fibers have come from recent aircraft postcrash inves-tigations. Mahar [29] measured fiber concentration (fibers/cm) and aerodynamic diameter of the fibers collected at a military jet crash site. Fiber samples were collected from the personal respirator filters worn by the investigators fitted with 25-mm cassettes containing 0.8-µm mixed cellulose ester filters. Mahar reported that there is a significant increase in the particulate levels during cleanup operations with the disturbance of the aircraft wreckage. Less than 20 percent of the collected fibers were found respirable with aerodynamic diameter smaller than 10 µm. Microscopic analysis revealed that respirable fibers were approximately 2 µm in diameter and 7-8 µm long. The total concentra-tions of the fibers collected from breathing air zones ranged from 0.02-0.06 fibers/cm. The Navy guidelines limit exposure to a time-weighted average of 3.5 fibers/cm of air and a maximum of 10 fibers/cm over a 40-hour work-week [29].

Recent Studies

The Civil Aviation Authority [30] in the United Kingdom investigated the toxic nature of combustion products of composite materials used in structural components of a public transport aircraft and a helicopter. Samples were subjected to a flaming heat source at a temperature of 1150 C+/- 50 C in a combustion chamber. The chemical analysis of the combustion products via gas chromatography and mass spectroscopy revealed several organic chemicals, the exact composition of which was not reported. Although no fibers were found in the soot filters, visual inspection of the burnt samples indicated evidence of surface pitting and fiber fibrillation. In further investigations of various air crashes in England in past 10 years, the Defense Evaluation and Research Agency (DERA) [30-31] found that typically 35-50 % of the free fibers still attached to the wreckage pieces and which could be released during handling were smaller than 1 mm in length. These fibers could cause significant skin and eye irritation, and irritation of upper respiratory tract, they are unlikely to be inhaled deep into the lungs. There were however a small fraction of airborne carbon fibers and some still attached to composite parts with signs of intense fire, which showed tapering and surface pitting. These results areconsistent with the previous NASA test results showing reduction in fiber size to smaller diameters and could pose a risk of deep lung penetration depending on their lengths.

The US Air Force Toxicology Division conducted a series of tests [32] for evaluating combustion toxicity of advanced composite materials used in military aircraft. Preliminary studies focused on the morphology and chemical composition of organic compounds associated with particulates carried in the smoke from burning composites. The test materials consisted of carbon fiber impregnated in a modified bismaleimide resin [32]. The SEM analysis did not reveal the presence of any fiber-shaped particles i.e., L/D >3. Forty percent of the particles were of respirable dimension with aerodynamic diameter $\leq 5\ \mu$m. These particles are small enough to penetrate deep below the tracheobronchial airways. Approximately 15 percent of particles had an aerodynamic diameter $\leq 1\ \mu$m, which can be deposited in the alveoli. The study did not report the fiber length measurements. The study did however identify a large number of organic species that were adsorbed on the particulate matter. Lipscomb [33] confirmed 90 different chemicals which can be broadly classified as polycyclic aromatic hydrocarbons, nitrogen-containing aromatics such as aniline, and phenol-based organic compounds. Several of these chemicals, e.g., aniline, quinoline, and toluidine, are known to induce carcinogenic and mutagenic effects in animals [33].

RISK MITIGATION

It is apparent from the above discussion that the health risks associated with carbon fibers are not clearly understood. There is a lack of scientific studies which conclusively link exposure to airborne carbon fibers and combusted resin residues to severe health impact on personnel, or that risks of inhalation are similar to other known pathogenic and carcinogenic fibers such as asbestos. However, it is prudent for safety personnel engaged in various stages of an aircraft mishap response to take precautionary measures. The US Air Force Advanced Composites Program [34] has developed guidelines establishing minimum safety and health protection requirements for firefighters, investigators, and cleanup crews in accidents involving aircraft with advanced composite materials. These guidelines were established to prevent acute inhalation and dermal exposure to various pollutants including respirable fibers. All personnel working in close proximity to a crash-site are required to wear self-contained breathing apparatus, chemical protective clothing, leather gloves, and neoprene coveralls to minimize exposure to all airborne species. Once the fire is extinguished, the scattered debris is sprayed with a fixing agent such as polyacrylic acid or liquid floor was mixed with water to agglomerate the loose fibers and frayed edges of composite parts. Personnel working in close proximity to crash location and engaged in recovery and removal of fragmented composite parts should wear NIOSH approved half-mask respirators with cartridges for organic vapors and fumes, and carbon fibers and dusts. All personnel also wear leather gloves and impermeable Tyvek or equivalent coveralls.

CONCLUSIONS

Aircraft fires involving advanced composite materials present hazardous conditions during the fire fighting, rescue, and investigation and recovery operations in a postcrash situation. Release of a mixture of gaseous, particulate, and other combustion products of unknown composition poses unique protection problems. A small fraction of carbon fibers released from burning composites are of respirable size and contaminated with a diverse range of chemicals including polycyclic aromatic hydrocarbons, nitrogenous aromatics, and phenolics. There have been both anecdotal and a few cited reports [1-4] indicating that firefighters and rescue people responding to such aircraft fires have suffered adverse health effects ranging from skin irritation, puncture, and sensitization to severe respiratory problems from inhalation of fiber particulates. Data available from research on exposures during manufacturing of carbon fibers and during machining, milling, and sawing of composite materials, indicate that no adverse health effects occur from inhalation of carbon fibers. However, the previous studies were focused on the short-term, chronic workplace exposure to airborne carbon fibers and composite dusts, not on the long-term health effects from a single high exposure to airborne fibers which is expected in aircraft crash and rescue situations. The long-term health outcomes due to inhalation of micron-sized carbon fibers contaminated with an array of organic chemicals generated in aircraft fires are largely unknown. No epidemiological data are available on the extent of personnel exposure to such combustion products from burning composites. Similarly, no animal studies have been conducted with the required post-exposure duration to assess the toxicology of the carbon fibers generated in a fire scenario. Synergistic interactions between the solid, vapor, and gaseous combustion products remain to be identified. Detailed toxicological studies are needed to assess the toxicity implications of combustion products from advanced composites. Efforts to fill these gaps in our knowledge of these recently recognized hazards, both in the United States and England, are still at a preliminary stage. Until adequate assessments are made, use of personal protective equipment (PPE) can mitigate the dangers encountered by crash rescue personnel. In the absence of complete PPE ensemble, particle filtration masks may provide some measure of protection. Guidelines, developed by the USAF for adequate protection of the various response personnel during handling and disposal of composite wreckage, should also be made available to civilian and airport fire fighting and rescue personnel that are often the first to respond to a postcrash fire. It is equally important to document the on-site exposure among the personnel responding to the crash site to establish specific protective-gear requirements and adequate requirements for fire fighting effectiveness.

REFERENCES

1. Bickers, C. 1991. “Danger: Toxic Aircraft,” in Jane’s Defense Weekly, p. 711.
2. Tannen, K. 1993. “Advanced Composite Materials,” Fire and Arson Investigator, 1:50-51.
3. Gaines, M. 1991. “Composites Menace Crash Teams,” Flight International, p. 17.
4. Anon. 1995. “Danger: Fibers on Fire,” Professional Engineering, 8(11):10-12.
5. Henderson, R. F. 1995. Toxicity of Particulate Matter Associated with Combustion Processes, in Fire and Polymers, Gordon L. Nelson ed., American Chemical Society Symposium Series, pp. 28-66.
6. Lees P. S. J. 1995. “Combustion Products and Other Firefighter Exposures,” Occupational Medicine: State of the Art Reviews, 10(4):691-706.
7. National Research Council. 1996. New Materials for Next-Generation Commercial Transports, Committee on New Materials for Advanced Civil Aircraft, National Materials Advisory Board, NMAB-476, National Academy Press, Washington, D.C.
8. FAA. 1997. Handbook: Manufacturing Advanced Composite Components for Airframes, DOT/FAA/AR-96/75, Federal Aviation Administration, Department of Transportation.
9. Stover, D., 1991. “Composites Use Increases on New Commercial Transports,” Advanced Composites, Sept./Oct., pp. 30-38.
10. Warheit, D. B. 1993. Fiber Toxicology, in Academic Press, New York.
11. Lippman, M. 1993. Biophysical Factors Affecting Fiber Toxicity, in Fiber Toxicology, D. B. Warheit ed., Academic Press, New York, pp. 259-303.
12. International Agency for Research on Cancer (IARC). 1988. “IARC Monograph on the Evaluation of Carcinogenic Risks to Humans From Man-Made Mineral Fibers,” Lyon, France.
13. Warheit, D. B. 1995. “Contemporary Issues in Fiber Toxicology,” Fundamental Applied Toxicology, 25(2):171-183.
14. Kennedy, G. L. and D. P. Kelly. 1993. “Introduction to Fiber Toxicology,” in Fiber Toxicology, D. B. Warheit ed., Academic Press, New York, pp. 15-40.
15. Hesterberg, T. W., G. A. Hart, and W. B. Bunn. 1993. “In Vitro Toxicology of Fibers: Mechanistic Studies and Possible Use for Screening Assays,” in Fiber Toxicology, D. B.Warheit ed., Academic Press, New York, pp.139-149.
16. Bishop, E.C. and H.S. Clewell, eds. 1991. Conference on Advanced Composites, March 5-7, San Diego, CA.
17. Kutzman, R. S. and H. J. Clewell, Eds. 1989. Conference on Occupational Health Aspects of Advanced Composite Technology in the Aerospace Industry, Applied Industrial Hygiene, Special Issue, December, pp. 1-85.
18. Thomson, S. A. 1989. “Toxicology of Carbon Fibers,” Proceedings Occupational Health Aspects of Advanced Composite Technology in the Aerospace Industry, Health Effects and Exposure Considerations, pp. 164-176.
19. Luchtel, D. L. 1993. “Carbon/Graphite Toxicology,” in Fiber Toxicology, D. B. Warheit ed., Academic Press, New York, pp. 493-516.
20. Warheit, D. B. and M. A. Hartsky, 1997. “Initiating the Risk Assessment Process for Inhaled Particulate Materials: Development of Short-Term Inhalation Bioassays,” J. of Exposure Analysis and Environmental Epidemiology, 7 (3), pp. 313-325.

21. Hill, I. R. 1996. “Reactions to Particles in Smoke,” Toxicology, 115, pp.119-122.
22. Bell, V. L. 1980. “Potential Release of Fibers from Burning Carbon Composites,” NASA N80-29431.
23. Office of Science and Technology Policy. 1980. “Carbon/Graphite Composite Materials Study,” Third Annual Report, Washington, DC.
24. Sussholz, B. 1980. “Evaluation of Micron Size Carbon Fibers Released From Burning Graphite Composites,” NASA CR-159217.
25. Seibert, J. F. 1990. Composite Fiber Hazard, Air Force Occupational and Environmental Health Laboratory, Brooks AFB, TX, AFOEHL Report 90-EI00178MGA.
26. OSHA, 1977 and 1995. General Industry Safety and Health Standard, U.S. Department of Labor, OSHA 3095.
27. NIOSH, 1977. Criteria for a Recommended Standard: Occupational Exposure to Fibrous Glass, Publication No. 77-152.
28. Clougherty, E., J. Gerren, J. Greene, D. Haagensen, and R. G. Zalosh. 1997. “Graphite Fiber Emissions From Burning Composite Helicopter Components,” Draft Report, United Sates Coast Guard, Department of Trans portation.
29. Mahar, S. 1990. “Particulate Exposures From the Investigation and Remediation of a Crash Site of an Aircraft Containing Carbon Composites,” J. American Industrial Hygiene Association” 51:459-65.
30. Greene, G. 1997. “Post-Crash Fire Hazards Research,” Proceedings Aircraft Fire Safety, Advisory Group for Aerospace Research and Development, AGARD-CP-587, Germany.
31. Morrey, E. 1998. “Investigation into the Behavior of Composite Materials Involved in Aircraft Accidents,” DERA/MSS/CR980346/1.0, England.
32. Courson, D. L., C. D. Flemming, K. J. Kuhlmann, J. W. Lane, J. H. Grabau, J. M. Cline, C. R. Miller, B. J. Larcom, and J. C. Lipscomb. 1996. “Smoke Production and Thermal Decomposition Products From Advanced Composite Materials,” US Air Force Armstrong Laboratory, Technical Report AL/OE-TR-1996-0124.
33. Lipscomb, J. C., and D. L. Courson. 1998. “Chemical, Physical, and Toxicological Assessment of the Atmosphere Generated from the Combustion of Advanced Composite Materials,” Conference on Issues and Applications in Toxicology and Risk Assessment, Tri-Service Toxicology, Air Force Research Laboratory, Wright-Patterson AFB, Ohio.
34. Olson, J. M. 1994. “Mishap Risk Control for Advanced Aerospace/Composite Materials,” Air Force Systems Command, Advanced Composites Program Office, McClellan AFB, CA, AJ554083.

3.6 RADAR ABSORBING MATERIAL AND CONVENTIONAL COATINGS. Coatings are applied to the majority of aircraft surfaces. The thickness of the coatings will vary depending on the aircraft type and location on the aircraft. RAM and conventional coatings are a polymeric based material. The RAM coatings differ from conventional coatings by the addition of a radar absorbing material. The primary hazards associated with both coatings are the same. Because they are a polymeric based material the health hazard concern of coatings are not different than the composite matrix or resin, although the addition of the RAM may change the burning characteristics of the coating. Once the coatings are burned off, the surface resin is affected. Information about coatings and Low Observable Coatings (LOCs) concerns and their burn behavior are also found in 3.5e.

a. <u>HAZARDS.</u>

(1) FIRE AND EXPLOSION. Coatings are a combustible material. Ignition occurs by flame or heat. Some may burn more rapidly with flare burning effects. See 3.4i(1)(a) Composite Materials.

(2) HEALTH. Fire will produce toxic and irritating gases. Contact with fire debris may cause burns to skin and eyes. Runoff from fire control may cause pollution.

b. <u>PUBLIC SAFETY.</u>

(1) See 3.7d(2) Composite Materials.

c. <u>EMERGENCY RESPONSE.</u>

(1) See 3.7d(3) Composite Materials.

3.7 MATERIALS AND SITUATIONS THAT MAY BECOME HAZARDS. The mishap site can be a dirty workplace. Sharp objects, such as metal shards, glass and precariously positioned debris is not uncommon. Holes or ditches, steep grades, uneven terrain, unstable surfaces can make it difficult to move about the workplace. To help assist site personnel to be on the look out for potential safety hazards, this section contains information for potentially lethal debris, hazardous materials that were generated under mishap conditions and hazardous situations to be aware of while working at the mishap scene. A description of the situation or debris is given along with instructions that can be used to minimize environmental, safety and health hazards. Helpful Tables are found at the end of this section and provide information to assist in the documentation of the mishap site conditions and activities.

a. <u>BATTERIES.</u> Alkaline or nickel-cadmium and lithium thionyl-chloride battery. Damaged battery detection can be a pungent odor due to venting. An overheat problem is detected by presence a short circuit and hot to the touch.

(1) HAZARD. Overheated batteries resulting from internal shorting or thermal runaway or mishap damage or abuse can cause rupturing or venting. It presents a hazard to personnel and aircraft through explosion and/or fire. Gases released can be noxious or lethal. If the battery is damage or ejected into the mishap area, electrolyte solution can be spilled and fumes may be emitted. Ni-Cad solution in potassium hydroxide (KOH). Lead based electrolyte solution is sulfuric acid.

(2) FIRE. Open battery compartment and check for flame. For alkaline or nickel-cadmium battert fire, use Halon or CO_2. A lithium battery fire should be extinguished by a Class D fire extinguisher. Overheated batteries should be removed to the outdoors. Use water fog to reduce battery temperature.

(3) PERSONNEL PROTECTION. During fire use positive-pressure SCBA and eye protection. For a mishap or overheated cells wear rubber gloves, faceshields or goggles.

(4) FIRST AID. The electrolite used in Ni-Cad battery is a strong alkaline solution. It is caustic and corrosive. Serious burns from contact with any part of the body. Treat burns as applicable.

b. <u>BLOODBORNE INFECTIONS.</u> Compliance with 29 CFR 1910.1030 is required for an aircraft mishap involving a potential exposure to bloodborne pathogens. Exposure can occur when rescuing victims, recovering deceased, handling human remains, handling investigative evidence, or during site cleanup. Contact with surfaces contaminated with blood and body fluids or a puncture from contaminated composite fibers are a threat. To reduce the emergency response risks the subsequent information was derived from, *Occupational Exposure to Bloodborne Patho-gens Precautions for Emergency Responders, OHSA 3130.*

(1) HEALTH HAZARDS. Blood, bloody fluids, body fluids, and tissues are potential sources of bloodborne infections. Blood and body parts can easily contaminate equipment, and the immediate area of the mishap scene. Exposure can occur for any personnel who assist in the search and rescue response, the recovery of aircraft parts or components, safety investigation laboratory analysis, the site clean up and disposal of contaminated aircraft parts.

(2) ROUTE OF EXPOSURE. Through the skin via a cut or puncture wound; through mucous membranes (eye, nose, mouth); through broken skin, cut or abraded (dermatitis/rashes, injuries, abrasions).

(3) PRECAUTION. If a mishap fatality has occurred or if there is any other reason to suspect an exposure possibility, team briefings should include information for safeguarding against the exposure. Contact the mishap medical or health representative. Treat all human blood and certain fluids as if they are infectious.

(4) FIRST AID. Report any exposure to blood, body fluids or tissue to the mishap medical or health representative. Wash wounds and skin sites that have been in contact with blood or body fluids with soap and water; mucous membranes should be flushed with water; eyes should be rinsed. Wash exposed area with soap and water.

- Flush splashes to nose, mouth, or skin with water·
- Irrigate eyes with water or saline

(5) PERSONNEL PROTECTION. An evaluation is made at the scene to determine how much protection is needed. The type and characteristics of the PPE will depend upon the task and degree of exposure anticipated. General safety measures are given below.

NOTE

Depending on the process that is occurring with and around the composite debris, required protection for mishap composites may provide adequate protection against bloodborne pathogens.

NOTE

The minimum protection required for blood-borne pathogens will not provide adequate protection for a composite exposure. Surgical gloves will not protect against all puncture wounds. A surgical mask will not provide complete protection from airborne particulate or fibers.

(a) When infectious materials are present in the work area, a hazards warning sign with the biohazard symbol shall be posted at the access point.

(b) Wear powder free latex or nitrile gloves to protect the hands. Preferably long sleeve gloves. If other mishap hazards warrant leather gloves then wear the plastic glove underneath if soak-through is likely. Have extra pair of clothes available so torn gloves can be replaced immediately. Disposable clothes will not be washed or decontami-nated for re-use if the integrity of the glove is not compromised. Decontaminate the leather gloves according to the clothing manufacture's instructions or use decontamination solution if it doesn't degrade the leather.

(c) Use eye protection (goggles, glasses with solid side shield or chin-length face shields) and mask to cover the nose and mouth to protect the skin of the face and the mucous membranes from splashes, sprays, spatters or droplets of infectious materials. Use protection in accordance with level of exposure encountered. An extra change of clothing should be available.

(d) Use disposal suits that are impervious to BBP to protect exposed skin.

NOTE

Tyvek suits will not completely protect against BBP and gross contamination. Tyvek suit protects against a light liquid splash only. Tychem will protect against BBP. If conditions warrant sealed seams it must be specifically requested from the manufacturer.

(e) Hood and shoe covers or boots is needed when gross contamination is anticipated.

(f) Immediately after removing gloves or other protective clothing, wash hands with soap and water. If hand washing is not feasible, use antiseptic towelettes and wash as soon as possible.

(g) Protective clothing must be removed and containerized at the location where used before leaving the area or upon contamination.

(h) Protective clothing must be placed in closeable, leak-proof container built to contain all contents during handling, storing, transporting or shipping and be appropriately labeled or color-coded.

(6) HANDLING CONTAMINATED COMPOSITES. If it is evident or suspected the debris is contaminated, protection is mandatory.

Handle is such a way as to not cross contaminate other surfaces. Minimize splattering and generation of droplets. Place contaminated pieces in an impervious plastic bag before placing in the appropriate transportation or shipping container. Double bagging is required if there are exposed fibers that could puncture the bag. These bags can also be referred to as barrier paper.

NOTE

Regulated waste found at a mishap site would be contaminated aircraft debris that would release blood or infectious materials in a liquid or semi-liquid state if compressed; items that are caked with dried blood or other potentially infectious materials are capable of releasing these materials during handling and the personal protective clothing.

(7) LABELING PROCEDURE. Contaminated pieces will be bagged or wrapped in plastic and labeled as biological waste before the pieces are removed from the mishap site. Red bags or a red container may be substituted for a label. Labels shall state which portions are contaminated. Containers used to store, transport or ship infectious materials will have warning labels affixed to the container. If the storage or shipping container is labeled then the individual waste containers that are placed in the storage container does not have to be labeled.

(8) DECONTAMINATION OF EQUIPMENT OR WORK SURFACES. A solution of 5.25% sodium hypochlorite (household bleach) diluted between 1:10 to 1:100 with water is acceptable for cleaning. If decontamination of equipment is not done at the work site, the equipment is properly labeled before leaving the work site.

NOTE

Do not decontaminate laboratory samples. Make sure the laboratory sample has been properly identified for BBP.

c. <u>CONFINED SPACES</u>. Limited openings, restricted work areas and unfavorable natural ventilation can be caused by terrain, environmental conditions and crash conditions.

(1) HEALTH HAZARDS. Trapped air and an increase of toxic air contaminants.

(2) FIRST AID. Provide fresh air.

(3) PRECAUTIONS. Monitor the space for hazards conditions. Light the area as much as possible. Use appropriate PPE—such as an air purify respirator if airborne particulate is present or is going to be generated.

NOTE

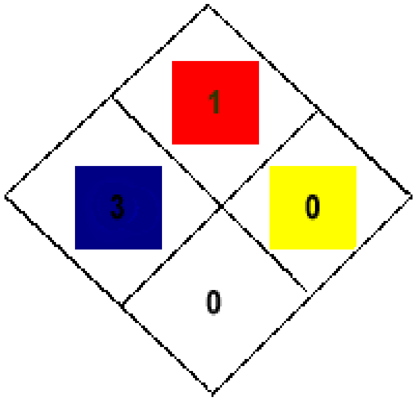
Respirator cartridge life will decrease for labor intensive work (increases the breathing rate) and for increased localized airborne particulate concentrations.

d. <u>COMPOSITE MATERIALS.</u> To make a rapid assessment, the information is provided in a similar format found in Emergency Response Guidebook (ERG). Always use the current version to avoid misinformation.

(1) HAZARDS. Mishap scenarios present different types of damage. Typical damages are structural or explosion with or without a fire or just fire damage. Two fire situationsoccur that present different exposure concerns. Situation one is the early stage of a fuel-fed fire. With or without composite material a burning aircraft generates a large amount of soot, lethal and toxic gases. The addition of composite materials adds to the amount of lethal and toxic gases. Composite materials do contribute to the soot content of the plume but most of the soot will be due to the JP8 fuel during a flaming combustion condition. Situation two is when the fire is largely out and only a small amount of fume and smoke is being generated and large amount of debris is present. Rapid generation of lethal gases will drop rapidly with the decrease in flame temperature. Deep-seated composite smoldering may be occurring without producing visable smoke, light or intense heat. Smoldering smoke is toxic.

(a) HEALTH. Health concerns associated with burning plastics apply to burning composite material. Avoid skin contact with dust/particulate. Avoid inhaling airborne fibrous particulate. Effects of smoldering inhalation may be delayed. Fire produces irritating, corrosive, and /or toxic gases. Structural and explosion damaged composites will cause puncture wounds and the particulate will cause skin irritations.

(b) FIRE. Using NFPA 704 M placard system, the following placard describes a generic composite part for a fire-fighting response. **Health** describes the combustion or decomposition products generated in a large fire. **Flammability** rating can change from 1 to 2 depending on the type of coating. The **reactivity** rating of zero was given because the material is stable under normal fire conditions although it chemically changes, and will decompose under high temperatures. Reactivity reassessment is needed for hybrid composite systems and for the addition of the coating materials.



A composite system is a combustible solid because the matrix will ignite by heat or flame. As the matrix burns volatile gases and smoke are released and char material forms. Some resin types may melt and flow and others just decompose. Depending on the fiber type, the fiber may or may not be combustible. Some composite systems may continue to burn when the fuel source has been removed. Resin smoldering can occur and could re-ignite. The burning material may produce a popping noise. Imbedded metallic material may be found within the surface layers of the composite aircraft part and could change the fire characteristics of the composite. Lightweight fibrous material can be thrown from the seat of the fire. Boron coated fibers reacts exothermically with molten aluminum and other metals at high temperatures. Fires from a physically damaged carbon fiber composite can produce airborne carbon fibers, if released during a flaming combustion condition. Carbon fibers may linger for a time after the flame is out right at the burnt pieces. Avoid inhaling debris and dust when handling the wreckage. Enclosed areas increase exposures for smoldering gases and lingering fibers immediately following the fire. Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution.

(c) EQUIPMENT. Single carbon fibers and soot is electrostatic. Because of this property, they have the potential to cause electronic interference in unprotected circuits, and electrical connections. Single carbon fibers tend to settle in high voltage areas, which could cause equipment malfunction or failure if a large concentration develops. Carbon fiber fines (particulate) have abrasive qualities. If they contaminate lubrication or hydraulic systems, those systems can be at risk. Tests have shown that widespread equipment failure is highly unlikely, but the risk of equipment failure is always present if fibers and soot are not contained and reasonable precautions aren't taken to minimize the likelihood of contamination.

(2) PUBLIC SAFETY. Make upwind direction known and stay upwind with or without a fire condition. If a mishap occurred during a fire in a populated area, advise to remain in doors, shut doors and windows, turn off forced air intake and wait for the plume to travel downwind.

There is a materials and particulate dispersion concern from damaged composites. There can be a spread of damaged materials around the site depending on the mishap scenario. Keep unauthorized personnel away from the pieces. If there are severely shattered and burnt carbon fiber composites isolate a close-in area (30 - 80 feet*) in all directions immediately following the extinguishments of flaming and smoldering conditions until a thorough assessment is made. Downwind fiber fallout area is dependent on wind speed and direction. Use mishap cordon size established for other immediate hazards like munitions (4000ft) or smoke plume (2000ft).

Once the fibers fallout they will become integrated within the environment. Re-suspension of fibers is highest immediately after combustion conditions have ceased. Minimize movement of debris and soil.

(a) PROTECTIVE CLOTHING. Wear self-contained breathing apparatus when fighting composite fires and smoldering conditions. Full personnel protective equipment will be worn for a flaming and smoldering combustion state.Structural gear provides only limited protection. If the fire fighter has to move in close to fight the fire, the protective clothing should be decontaminated of soot, combustion products and fiber as soon as possible. (See paragraph 3.6c.)

(b) EVACUATION. Consider initial downwind evacuation for 2000 feet during plume generation. Keep everyone out of immediate area, if not, in SCBA for smoldering conditions.

(3) EMERGENCY RESPONSE.

(a) FIRE. Composites can be a Class A or B fire depending on the matrix type. Large quantities of water will be required to extinguish large piles of smoldering epoxy composites. AFFF is better suited for extinguishing all conditions of composite fires. A pool fire should be contained first, then concentrate on the burning composite. A fast response will reduce the chances that smoldering combustion can establish itself. Continuous and direct application of foam is needed for extinguishments of smoldering combustion with AFFF foam for at least three minutes. A thorough overhaul inspection must be conducted to determine if deep-seated smoldering is occurring. Check for hot spots with infrared detections. Expect a smoldering condition within a pile of severely shattered and burnt composite debris produced from a pool fire. Expect to spend more time at the fire scene and to use more extinguishments than for liquid fuel fires.

(b) MATERIAL DISPERSION. Dispersal pattern from the plume will depend on the wind. The plume will rise, become diluted and dissipate. Under certain mishap scenarios, carbon fiber could be dispersed. About half of the carbon fibers released will be lifted with the plume. Explosions will release more particulate at ground level than a fire release. Most plumes will have a tilt and greater wind speed will reduce the plume raise that could add to the ground level concentrations of carbon fiber. Collect shattered debris and place in closable container for disposal.

(c) FIRST AID. Move victim to fresh air. Effects of inhalation exposure, or skin contact may be delayed. Ensure that medical personnel are aware of the materials involved and take precautions to protect them. Wash particulate from skin with soap and water.

(d) SITE ASSESSMENT. A description of the composite debris is needed to determine the appropriate response level before transfer of command is made. After fire and smoldering conditions have ceased and the material is at ambient temperature walk around the debris and categorize the type of debris. Presence of carbon fiber clusters around the site is a sign that carbon fiber was released. Communicate this information at transfer of command.

(e) TRANSFER OF COMMAND. Provide the following information so a safety and health sketch can be drafted: type of composite debris, downwind direction, wind speed, plume condition, and if overhaul was needed to determine if smoldering conditions exist.

(4) SMOLDERING COMPOSITES, PLASTICS AND RUBBER.

a HAZARD. Some resin within a composite system can smolder. Some plastic and rubber material can smolder. Smoldering composite material is a safety hazard because it can advance to a flaming combustion state relatively easy. Smoldering composites produce toxic gases. Smoke is barely visible and does not radiate high temperatures.

b PUBLIC SAFETY. Isolate the immediate area and keep unauthorized personnel away. Stay upwind. If smoldering is noticed, alert the firefighting response.

c PROTECTIVE CLOTHING. Wear full protection with SCBA.

d FIRE. Extinguish with AFFF.

e FIRST AID. Move victim to fresh air immediately.

(5) FUEL CONTAMINATED COMPOSITE MATERIAL.

a HAZARD. Cutting through composites with a rescue saw that contains residual fuels will cause sparking and possible ignition of the fuel. Cool the blade with a fine water mist from a hose line while cutting. Use full protection. Spray area with AFFF for high potential of ignition.

b PUBLIC SAFETY. Isolate the immediate area and keep unauthorized personnel away. Stay upwind.

c PROTECTIVE CLOTHING. Full protection with SCBA for firefighting. When cutting composite debris without a fire potential, use tyvek suit, eye protection,

*** Based on Department of Transportation recommendation when first setting up a cardoned area.**

hand protection, air purifying respirator for organic vapor and particulate within in the respirable range. If cutting through metal, metal vapor cartridge may be required.

d FIRE. Extinguish with AFFF.

e FIRST AID. Move victim to fresh air. In case of contact with burning substance, flush skin and eyes with water.

e. HEAT STRESS. Heat stress can occur from wearing protective equipment and/or performing heavy work in hot, humid climate. Additional guidance for work vs. rest cycles can be found in AFMAN 32-4005.

(1) HEALTH HAZARD. Heat stroke, heat exhaustion, heat cramps, transient heat fatigue and heat rash are the hazards of working in a hot environment.

(a) Heat stroke occurs when the body's temperature reatory system fails. Symptoms for heat stroke are skin is hot, usually dry, red or spotted and body temperature is high, 104°F or higher. When body temperature increases the victim becomes mentally confused, delirious, and convulsions or unconsciousness could incur.

(b) Heat exhaustion is caused by the loss of large amounts of fluid or electrolytes. The worker suffering from heat exhaustion experiences extreme weakness or fatigue, giddiness, nausea, or headache. The victim may vomit or lose consciousness. The skin is clammy and moist, the complexion is pale or flushed and the body temperature is normal or only slightly elevated.

(c) Heat cramps are painful muscle spasms that occur among those who seat profusely, drink large amounts of water and do not adequately replace the body's electrolyte loss. The cramps can occur during or after work.

(d) Heat rash or prickly heat can occur in hot, humid environments where sweat is not easily evaporated so the skin remains wet most of the time.

(2) FIRST AID.

(a) Immediate attention is needed to stop the effects of heat stroke. The efforts for heat stroke would concentrate on lowering the body temperature by loosening tight clothing and soaking the clothing with water, removing the victim to a cool and shady area and fanning the head and upper body vigorously.

(b) Resting in a cool place and drinking plenty of water or liquids containing electrolytes is usually all that is needed for a heat exhaustion recovery.

(c) Lightly salted liquids or an electrolyte solution can relieve heat cramps or muscle spasms.

(d) Loose garments and good personal hygiene is the best prevention against heat rash.

(3) PRECAUTIONS. Work, using the buddy system. Watch out for each other. Be conscious of those around you. Pace yourself and take frequent breaks. The key to adapting to high temperatures is fluid intake—an 8 ounce glassful every quarter-hour, a quart an hour, two gallons during an 8 hour shift. There is know need to remove personnel protective clothing to rest just step out of the immediate work area and stop working. Monitor body temperature. Don't hesitate to tell others how you feel.

f. HIGH PRESSURE SYSTEMS. The hydraulic system consists of a reservoir, pumps, accumulators and tubing that interconnects the system. The fluid is circulated and stored under pressure in the accumulator. Hydraulic fluid under pressure operates the landing gear, nose gear steering, brakes and wing flaps.

(1) HAZARD. Cutting into pressurized hydraulic line will release the fluid in a fine mist that is toxic and flammable. If sprayed on hot surfaces the fluid may ignite. A hydraulic fire produces a torch effect, or if confined, the fuel vapors may explode. Broken composite debris will wick spilled hydraulic fluid.

(2) FIRST AID. See Skydrol.

(3) PERSONAL PROTECTION. See Skydrol.

g. LIQUID OXYGEN OR LIQUID OXYGEN CONVERTER BOTTLES (LOX).

(1) HAZARDS. Liquid oxygen bottles may leak or vent because of overheating, crash impact, or ruptured seals. Liquid oxygen forms combustible and explosive mixtures when in contact with flammable or combustible material like wood, cloth, paper, oil, kerosene. Contact will cause frostbite. Gas is heavier than air and will collect and stay in low areas. Containers may explode when exposed to fire (BLEVE).

(2) PUBLIC SAFETY. Stay upwind. Determine extent of problem. Isolate the area of release or fire and deny entry. Remove all ignition sources. Evacuate the area in all directions when LOX bottle is exposed to fire.

(3) PROTECTIVE CLOTHING. Fight fire with full protection and SCBA.

(4) FIRE. Cut off the flow of liquid oxygen or fuel. Blanketing or smothering agents are ineffective. If flammable or combustibles are present, use large amounts of water at the seat of the fire, continue through to the

source of the LOX leak and apply water until the ice forms and seals the leak. If water is not available, allow natural venting to occur with fire fighters at a safe distance with AFFF hoses in ready positions during the venting process.

(5) FIRST AID. Provide basis life support as needed. Warm frostbite area in very warm water.

h. <u>VITON.</u> Viton is a trademark for a series of fluoroelastomers found in small quantities throughout the aircraft. In small quantities it poses as no threat to firefighting or for the initial response. Some aircraft does contain large quantities. Runoff from fire control may cause pollution.

(1) HAZARD. Produces highly toxic combustion products like hydrogen fluoride, carbonyl fluoride, carbon monoxide and low molecular weight fluorocarbon fragments. Creates corrosive residue like hydrogen fluoride.

(2) PUBLIC SAFETY. Stay upwind. Ventilate closed spaces before entering.

(3) PROTECTIVE CLOTHING. Full protective wear with SCBA. Neoprene clothes are needed to handle burnt pieces or residue.

(4) FIRE. Extinguish with AFFF. Do not rinse burnt pieces with water or AFFF. It only contributes to the residues corrosiveness.

(5) FIRST AID. Remove victim exposed to fumes to fresh air at once and call a physician.

(6) AIRCRAFT LOCATION. F/A-18, F-14D applied to engine exterior and other locations of the aircraft. Aircraft use gaskets and seals in small quantities.

i. <u>TIRES.</u>

(1) HAZARD. Tires present an explosion hazard when heated. An increase of air pressure occurs and can explode the tire. Rubber tires may ignite at about 500°F to 600°F and can develop extremely hot fires. Re-ignition may occur if the rubber sustains autoignition temperature or the rubber is abraded and the fire is deep seated.

(2) PUBLIC SAFETY. Stay upwind. Keep all unauthorized personnel out.

(3) PROTECTIVE CLOTHING. Full protection with SCBA.

(4) FIRE. Use Halon 1211, AFFF or water fog as early as possible.

(5) FIRST AID. Remove to fresh air immediately. Seek medical attention.

Table 3.7-1 Cordons (Sheet 1 of 2)

SCENARIO	INITIAL ISOLATION ZONE [1]	RESOURCE
Initial approach for a small JP8- spill	80-160 feet in all directions	Emergency Response Guidebook for a kerosene response.
Initial approach for a large JP-8 spill	1000 feet downwind	Emergency Response Guidebook for a kerosene response. [2]
JP-8 fire	½ mile in all directions	Emergency Response Guidebook for a kerosene response. [2]
Any fires burning in wreckage where HAZMAT is present	2000 feet upwind	AFPAM 91-211
Unknown substances	1/2 mile in all directions	Emergency Response Guidebook for a large spill. [2]
B-2 mishap	5000 feet	Whiteman Oplan 32-1
Helicopter approach for conditions:a. Hazardous material spills. Smoldering composite debris b. Piles of burnt and/or shattered composite debris .	500feet above ground level 1000 feet horizontally	AFI 32 Series
Burnt composite debris immediately following the extinguishment of flaming combustion or smoldering.	30-80 feet in all directions	Emergency Response Guidebook for an initial approach for an asbestos spill. [2]
Burnt or broken composite debris piles - work zone	Not more than 25 feet	Composite Aircraft Mishap Safety and Health Guidelines. [3]

[1] The on-scene-commander will determine necessary cordon distances.
[2] U.S. Department of Transportation. 2000 North American Emergency Response Guidebook. A guidebook for First Responders During the Initial Phase of a Hazardous Materials/Dangerous Goods Incident.
[3] Air Standardization Coordinating Committee, Advisory Publication 25/41

Table 3.7-1 Cordons (Sheet 2 of 2)

Minimum Withdrawl Distances for Explosives Involved in Fires 1, 4 and 5 (Ref. T.O. 11A-1-46)

CLASS/DIVISION			DISTANCE (FEET)					
			300	600	2500	4000	5000	K105
1.4	Minimum Distance		X					
1.3	Minimum Distance (See NOTE 2)			X				
1.2/1.6	Minimum Distance				X			
1.1 and 1.5	Unknown Quantity	Aircraft, Truck, Facility				X		
		Railcar					X	
	Transportation	500 pounds or less, all modes			X			
		More than 500					X	
		More than 500 pounds, all other modes including aircraft				X		
		All quantities bombs and explosive greater than 5 -inch caliber				X		
	Facilities	15,000 pounds or less			X			
		More than 15,000 pounds, less than 50,000 pounds				X		
		More than 50,000 pounds						X

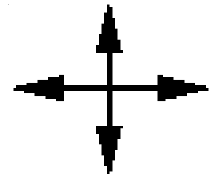
ESSENTIAL PERSONNEL (SEE NOTE 3).
ACCIDENTS INVOLVING EXPLOSIVES WITHOUT FIRE (SEE NOTE 6).

NOTES:

1. For Class/Division 1.1 and 1.2 munitions, use maximum debris and fragment throw ranges, if known, in lieu of distances in this table.
2. For quantities of 1.3 over 100,000 pounds, withdrawal distance is equal to K16.
3. On-scene authorities will determine minimum withdrawal distances for essential personnel.
4. K105 distance is determined by: $D=105W^{1/3}$ or $D=KxW^{1/3}$
5. The withdrawal distances in this table apply to nonessential personnel only.
6. When accidents occur and there is no fire, the on-scene commander will determine whether to implement withdrawal criteria.

Table 3.7-2 Hazards Analysis Sketch (Sheet 1of 2)

MISHAP SITE HAZARDS ANALYSIS SKETCH



Direction

Plume Direction

Mishap/Date: **Aircraft:**

Site Location: **Model:**

1. Identify site and plume direction.
2. Sight along the centerline of the wreckage path.
3. Locate 4 corners of debris.
4. Site entry control point (ECP).
5. Sketch crater or scar marks.
6. Identify major aircraft parts.
7. Identify composite parts.
8. Locate Hazards: see Table 3.7-7
9. Sketch bloodborne pathogen area

ACCURACY IS NOT NECESSARY!!!

Table 3.7-2 Hazards Analysis Sketch (Sheet 2 of 2)

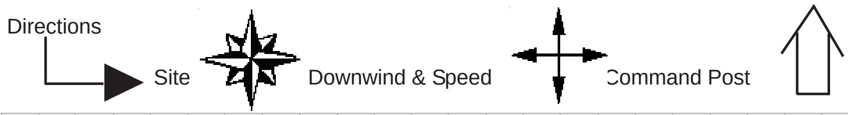
Mishap/Date: ________________________________

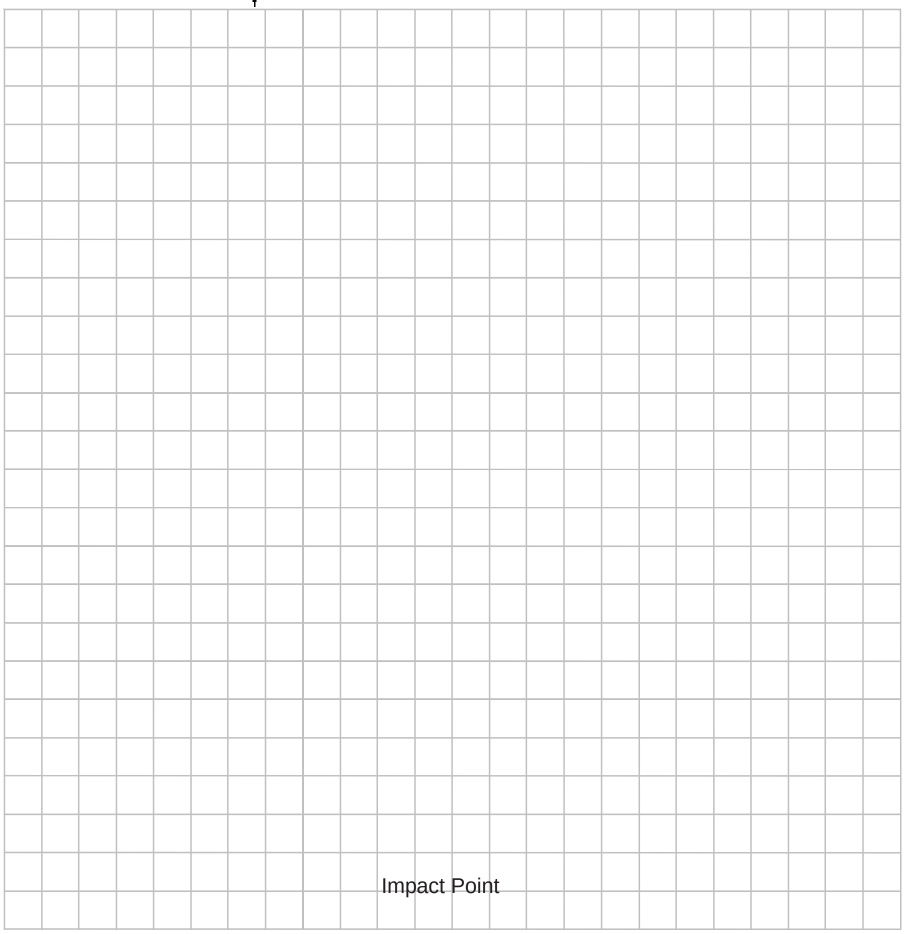
Aircraft MDS: ________________________________

Site Location: ________________________________

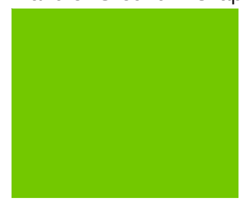
Weather during incident ___
____

Terrain Description________
____
____

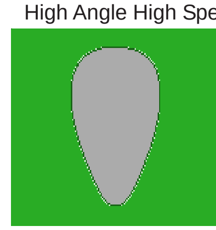




Land or Ground Mishap

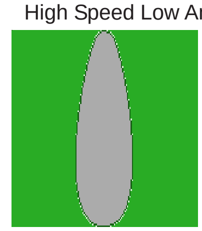


High Angle High Speed Impact:



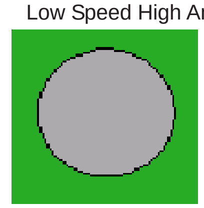
Deep Crater. Wreckage spread is short and wide.

High Speed Low Angle Impact



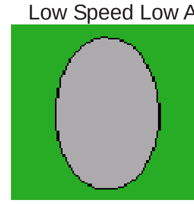
Shallow Crater. Wreckage is long and narrow. Heavy parts are furthest away.

Low Speed High Angle Impact



Wreckage is centralized.

Low Speed Low Angle Impact



Ground scars leading to wreckage Fracture along primary structure.

AIRCRAFT DEBRIS MAY TUMBLE SEVERAL TIMES BEFORE REACHING ITS FINAL LOCATION AT THE SITE.

1. Identify site and plume direction.
2. Sight along the centerline of the wreckage path.
3. Locate 4 corners of debris.
4. Site entry control point (ECP).
5. Sketch crater or scar marks.
6. Identify major aircraft parts.
7. Identify composite parts.
8. Locate Hazards: see Table 3.7-7
9. Sketch bloodborne pathogen area

ACCURACY IS NOT NECESSARY!!!

SYMBOLS

Highest concentrations 

ECP 

Bloodborne pathogen++++

COMPOSITE TERMINOLOGY

Form:	tape	Damage:	fragments
	fabric		strips
	layer, ply		clusters
	stack		fiber bundles
	filament wound		dust
	solid laminate		single fibers
	sandwiched laminate		delaminated
	core material		scorched

Table 3.7-3 Major Aircraft Terminology Used at Crash Sites

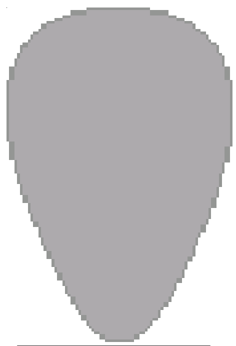
Radome	Engine	Missile
Forward fuselage	Engine Air Inlet	Gun
Center fuselage	Power train	External stores
Aft fuselage	Powerplant	BDU
Horizontal tail or stabilizer	Landing gear	Ammunition Drum
Vertical fin	Wheels/Brakes	Nitrogen Bottle
Vertical Stabilizer	Speedbreak	Hydrazine Bottle
Stablator	ThrottleFlight control equipment	Liquid Oxygen Bottle (LOX)
Tail/Cone*	Actuators	LATRIN
Rudder	Accumulators	POD
Wing Box	Hydraulic reservoir, gauges, or filter	Chaff/Flare Dispensers
Flaperon Leading Edge	Fuel pump	Escape System pyrotechnics
FlapTrailing Edge Flap	EPU	- Shield Mild Detonating Cord
Control surfaces	AOA	- Initiators (on seat and in cockpit)
Canopy(s)*	Tail hook	- Explosive transfer sequencers
Doors*	Warning System	-- Mounted on panel or bulkhead
Hatches*	Electrical System	- Rocket catapult (behind seat)
Emergency Exits*	Fuel System	- Rocket pack (under seat)
Emergency Windows*	Pneumatic System	
Panels*	Avionic	
Pylon*	Fuel tank/cell	
*** These items may be explosively loaded, use extreme caution.**		

Table 3.7-4 Composite Assessment Questions

Composite Assessment Questions - Approximations are adequate			
Location	indoor outdoor		
Terrain	description		
Weather conditions at the time of occurrence	wind direction, velocity, temperature, description		
Cause of damage	Fire, physical, explosion		
Fire conditions: Where started TypeAircraft location SizeDuration Ignition source Major fuel source Other burning materials Fire extinguishment Overhaul	 In-flight, impact, other Fireball, pool, smoldering		
Material Damage(if hazards sketch isn't available)	Description Site distribution or spread		
Work Process	Type		
Weather conditions at the time of work process	wind direction , velocity temperature, description		
Air disturbances at the time of work process	Other than weather		
Weather Description Hail Sleet Fog Drizzle Rain Snow Thunderstorm Gusty wind Freezing rain Sunny	Composite form Terminology Tape Fabric Layer Stack Filament wound Solid laminate Sandwich laminate Corematerial Fibers Resin/matrix	Damaged Composite Terminology Fragment Strips Clusters Fiber bundles Dust Single fibers Scorched Delaminated	Work Process Overhaul Visual Inspection Cut, pry, saw, pound Search & rescue Cleanup Sorting Disposal Other

Table 3.7-5 Mishap Impact Crater Signatures

HIGH SPEED - HIGH ANGLE

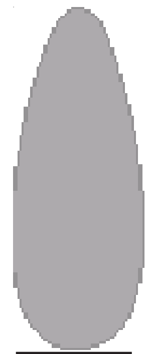


IMPACT POINT

Crater: Deep

Wreckage: Random parts within crater and short wide distribution. Some parts may be short of crater.

HIGH SPEED - LOW ANGLE



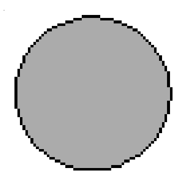
IMPACT POINT

Aircraft skips

Crater: elongated and shallow.

Wreckage: Long narrow path.
Breakup from bottom to top. Heavy parts furthest down range.

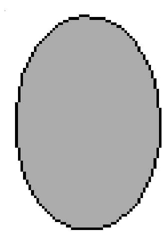
LOW SPEED - HIGH ANGLE



IMPACT POINT

Centralized Wreckage.
Inertial Breakup.

LOW SPEED - LOW ANGLE



IMPACT POINT

Ground scars leading to wreckage.
Aircraft breakup along primary structure - wing, tail, engine.
Impact forces may be survivable.

Table 3.7-6 Work Progress Survey

ACTIVITY	DEBRIS INFORMATION [1]	WORK CONDITIONS [2]	PPE
Physical Damage			
Fire			
Smoldering			
Overhaul			
Explosion			
Walking to the Site			
Visual inspection with hand movement			
Cutting, prying, sawing, pounding			
Search and Rescue			
Site Clean-up Picking pieces from topsoil Dissembling pieces Sorting Preparing for Transport Off site Excavating Digging Sweeping			
Preparing for Transportation			
Transportation			
Storage			
Disposal Open storage boxes Sorting Cutting			

[1] Debris Information = type and amount of debris, condition of debris, location of debris.
[2] Work Conditions = Site hazards, weather conditions, terrain, type of work process and duration

Table 3.7-7 Mishap Hazards Summary

POTENTIAL MISHAP HAZARDS	POST CRASH MISHAP SITE HAZARDS
Fire	Fuel and fuel tanks Hydraulic fluid Gaseous or liquid oxygen Cutting tools and other heat generating equipment Smoking on site Batteries Smoldering materials
Explosive	Hydraulic accumulators Aircraft engine fire bottles Emergency nitrogen blowdown bottles Parachute severance cartridges Ejection seat (s) unexploded CAD/PAD items Ejection seat (s) emergency oxygen bottles Canopy removers and thrusters Liquid oxygen bottles Chaff and flare dispensers
Electrical	Power lines Live wires
Electronic radiation	Avionics equipment
Toxic	Hypergolic mixture in propellants Hydrazine Cargo may contain hazardous chemicals
Composite	AFFF soaked composite material Damaged composites bundles and airborne particulate Fuel contaminated composites Cutting operations
Miscellaneous	Battery acid Accumulators Shocks Struts Tires Pneumatic systems Fire bottles Shattered metal
A/C Lifting	Unequal distribution of weight Pitch and roll attitudes outside of maximum limits Work zone distances

3.8 MISHAP RESPONSE PROCEDURES. This section explains terms, mishap phases, initial, follow-on and secondary response procedures. Since mishap conditions vary, each response will vary. The initial response will be general in nature until the mishap/incident is sized up. At this point of the initial response, other responders will be called upon to perform duties followed by others that will perform follow-on and secondary response duties. These responses will have phases until the mishap site is returned to its former state prior to the mishap. Returning a site to its former state will depend on how well the phases are executed. Other organizations may model their response methods after the USAF method of response. Supplemental information is provided in Tables 3.8-4 thru 3.8-13 found at the end of this section.

a. DEFINITIONS

(1) DISASTER RESPONSE FORCE (DRF). The local organization used for disaster response, command and control and recovery (site).

(2) CRISIS ACTION TEAM (CAT). Operations develop a team and procedure that include reaction to downed and missing aircraft.

b. MISHAP RESPONSE Six flight mishap scenarios[1] have been categorized to illustrate the number of possibilities. The list can be used to determine what scenario is most likely to occur for a particular installation. There are seven types of mishap classes[2] within the USAF with a different type of response for each mishap class. The mishap can occur on the ground or in-flight causing the aircraft to crash, see Table 3.7-5 for aircraft impact signatures. Many organizations participate behind the scene (base involvement) and at the mishap site (see Tables 3.8-9 and 3.8-10). Mishap response doesn't happen frequently and when it does the response force will be different from mishap to mishap. A mishap response is conducted by USAF instructions 32 and 91 Series.

The rest of the paragraph summarizes the USAF response phases in the order in which they are executed. The sequence of events and responsibilities are explained within. In a real-world situation some phases of the response will overlap or may not be executed depending on the mishap class. For example, a flight line mishap will speed up the cleanup phase and a Class C mishap may not require an environmental assessment.

(1) EMERGENCY RESPONSE. The purpose of an emergency response is to control the immediate hazards through USAF 32 Series instructions, manuals, and pamphlets. The emergency response is conducted in four phases: notification, response, withdrawal, and the recovery phase. The base has been notified that a flight mishap has occurr- ed, the DRF and CAT activates and Phase 1 begins.

PHASE I. Involves gathering of information for an immediate response.

PHASE II. The initial response deploys followed by the disaster control group when a safe route has been determined.

PHASE III. Instructs the initial response to order a withdrawal when mishap site conditions are unsafe.

PHASE IV. When the initial response has controlled the fire conditions, completed rescue and first aid activities and has declared the site safe, the site can be turned over to the DCG for the execution of Phase IV - site recovery (not aircraft recovery). The on-scene-commander (OSC) will set up control points, establish communications and direct activities of support services in preparation for the arrival of the interim safety investigation board.

(2) SAFETY INVESTIGATION RESPONSE. The purpose is to prepare for and conduct a flight safety investigation through USAF 91 Series instructions and pamphlets by day 30. This response is explained in six phases: preparation, notification, interim Board, SIB arrival, investigation, analysis and reporting. Phase I occurs before a mishap has taken place. Each installation establishes a disaster response force and a crisis action team. Wing safety develops a Disaster Preparedness Operations Plan (O-Plan 32-1) and identifies potential interim board and possible MAJCOM permanent board members. Phase II begins when a mishap has actually occurred. Interim board assembles, MAJCOM owning aircraft notifies individual to serve on SIB and the HQ AFSC appoints officers to serve on the permanent board for Class A mishap. Phase III begins when the DCG, OSC turns over the site to the interim safety board. the interim board controls the site, preserves the evidence and prepares for hand-off to the permanent board. The permanent board assembles within 3 days of the event, receives formal briefing from the interim board and then reviews their roles during Phase IV of the mishap.

---

[1] A/C from X AF Base crashes at X AF Base
A/C from X AF Base crashes at Y AF Base
A/C from X AF Base crashes at a civilian facility
A/C from X AF Base crashes in isolated area in the Continental United States (CONUS)
A/C from X AF Base crashes near a sister service installation
A/C from X AF Base crashes away from AF facilities outside CONUS

[2] A,B,C,D, L,X

PHASE V is the investigation and analysis phase. Investigation, sorting and analysis of the evidence is done to answer the what, how and who questions. Base support is critical.

PHASE VI is the reporting phase that actually begins the moment a mishap has occurred. The final report is assembled according to AF instructions by day 30.

(3) HAZARDS AND SAFETY INFORMATION. During the emergency response bioenvironmental engineering (BEE), explosive ordnance disposal (EOD), to the OSC and the fire department provide guidance on specific hazards. There is a requirement for each transfer of command to include safety and health information which is usually given as a verbal form of communication.

(4) SECONDARY ROLE RESPONSE. There are supporting roles needed for a major accident. These roles may or may not follow specific USAF instructions. The roles are: reclaim wreckage, transport off site, site cleanup, short-term storage, environmental assessment, long-term storage (years) and demilitarization storage. Note that some of the activities may occur simultaneously with an emergency or safety investigation response. Functional performing role will be dependent on local base resources.

(5) ACTIVITIES. From the time the mishap debris is created to disposal there are many processes that take place around and with the debris. To avoid injury while responding, safety and health assessment would include knowledge of the mishap processes. Following are some of the activities that could be anticipated (see Table 3.7-6).

(a) firefighting response including overhaul

(b) walking to and around the site

(c) debris inspection with hand movement

(d) mortuary affair land search involving movement of soil and debris

(e) cutting, prying, sawing, pounding, manual dissembling of debris

(f) lifting with equipment (CDDAR), backhoe

(g) site cleanup

1 picking pieces from topsoil

2 sorting

3 packaging and/or crating for transport off site

4 excavating the site – racking, backhoe, digging

5 sweeping

(h) transport to short term storage (usually inside)

(i) transport to long term storage (usually outside)

(j) disposal

1 opening crates

2 sorting

3 cutting with a saw

c. BEST PRACTICES

(1) EN ROUTE. The initial and follow-on response must be alert to hazards when responding to a call.

(a) Determine the nature of the incident so the possibility of specific hazards can be determined. Ask the dispatcher if there were any unusual signs or symptoms, for example, pungent odors or eye irritations, the extent of fire, wind direction and velocity, location of the fire, color of the smoke, color of the flame.

(b) Pay attention to the sensory signals such as smell, color and nasal or eye irritations.

(c) Look for clues that suggest the possibility of hazardous materials like smoke or cloud of vapor.

(d) Pay attention to the wind direction and topography when approaching the site. Advance upwind and upgrade of suspected emissions.

(2) ARRIVAL.

(a) Avoid unnecessary contamination of equipment by giving exact information on safe routes of arrival and vehicle staging locations and by reporting anything suspicious.

(b) Do not drive through spilled or released material, including smoke, vapors and puddles.

(c) Unless otherwise directed, responders should park at a safe distance upwind, upgrade and pointing away from any incident where hazards are suspected. The firefighting response will determine the safest path to enter.

(d) Pay attention to low-lying areas such as streambeds and gulleys, or in urban areas places such as courtyards or tall buildings. They may contain vapor clouds or the plume protected from dispersal by the wind.

(e) Anticipate a rush of people when in a populated area.

Keep unauthorized people out. Use a PA system to give instructions if need be.

(f) Remember there are risks to entering a contaminated area to rescue an injured victim.

(g) Do not approach anyone coming from a contaminated area.

(h) Do not attempt to recover shipping papers or manifests unless adequately protected.

(i) Exclusion zones (see Table 3.7-1) should be immediately established and enforced around the hazards taking care not to become exposed during the process.

(j) Essential to minimizing secondary contamination, a deliberate decontamination process should exist for any amount of exposure and should occur at the site if possible.

(k) A safety and health sketch of the scene (see Table 3.7-2) should be drafted and be made available at each site transfer of command.

(l) Team briefs which includes the safety and health information are given during site orientation and before any processes are conducted at the site.

(3) DURING A FIRE.

(a) Observe conditions that will help with the determination of the extent of damage. Abnormal fire behavior of burning composite material like heat intensity, rate of flame spread, unusual behavior when suppressant is applied. Information will be useful in understanding the behavior of the material. Communicate unusual behavior to the composite materials technical representative.

(4) POSTFIRE.

(a) If a pressurized container (and possibility buried munitions) is being heated by a deep-seated smoldering composite it can explode hours after the initial response has left the site. Move all pressurized bottles (LOX) and hydrazine containers away from burning and burnt debris piles if possible.

(b) Perform overhaul to search for hidden fire. Check for smoldering debris and extinguish it---tires, plastics and composite materials. Self-contained breathing apparatus should always be worn when fighting a smoldering composite fire or performing an overhaul operation on composite debris.

(c) Do not allow post-incident thoughts to interfere with the overhaul operation.

(d) Overhaul is necessary if the mishap conditions produced confined spaces or closed-in working areas for the follow-on response.

(e) Overhaul should only move what is absolutely necessary to complete fire extinguishment.

(f) Portable infrared heat detectors can be used to locate hot spots in composite materials inside the aircraft.

(g) Pool fire. After flame suppression expect the underside of the composite debris to still be in a combustion state. The combustion state could be smoldering of the resin and core material or fiber combustion. Resin smoldering can last for hours or days if not extinguished emitting faint smoke or heat that is only noticeable with a touch of the hand. Carbon fiber combust with a red glow and can last up to 1 hour after flaming combustion conditions has ceased (the pool fire is out). Temperature associated with the red glow is about 1400°F.

(h) For investigation purposes, debris should not be moved more than what is necessary. If drastic movement of large debris was necessary declare original locations at transfer of command.

(5) SITE ASSESSMENT.

(a) Do not allow entry to any unauthorized personnel until the site has been adequately surveyed.

(b) Include a gross assessment of composite debris to determine if there could be airborne particulate at the damaged debris and down wind.

(6) TRANSFER-OF COMMAND.

(a) Information is needed for the evaluation of composite damage and exposure concerns post incident. Document and disclose the following information.

1 Disclose fire conditions of composites – pool fire, fireball, surface scorched only.

2 Disclose the condition of damaged composites. Estimate the amount of debris.

3 Disclose if overhaul of composite materials was needed. Continue to apply extinguishment until debris and materials reach ambient temperature.

4 If overhaul was performed disclose what was discovered.

5 Disclose plume direction and tilt behavior.

(7) COMPOSITE WORK PRACTICE.

(a) Do not bend or flex fibers over a small radius. Do not run hands along the end of the laminate or fracture surfaces.

(8) BASICS FOR CUTTING MISHAP-COMPOSITE MATERIALS.

(a) Ordinary shears will not successfully cut most composite materials.

(b) A razor or utility knife is fine for cutting a small number of layers. Use a template to help guide the blade. To prevent injury, wear a leather or Dupont Kelvar® glove on the non-cutting hand.

(c) An abrasive cut-off wheel blade will work for most mishap-composites. The manufacturer for Kelvar® fibers recommends a carbide tipped blade with an alternating tooth angle.

(d) Cutting with a circular saw creates resin dust and particulate, single fibers and fiber bundles ranging in size. Cutting Kevlar® creates fibrils. Cutting composites with carbon, boron, glass or quartz will create single fibers ranging in length and some of the single fibers will be longitudinally split. Respiratory protection is required.

(e) A high-speed saw will heat the resin and produce nuisance-level organic vapor. The resin may become tacky and gum-up the edge of the blade.

(f) Backing the piece with aluminum, wood or cardboard before cutting will improve the cutting quality (quality may be necessary for an investigative piece).

(g) Composites are made of layers of material. Consider the presence of a metal layer within the laminate or on the backside when cutting completely through the piece.

(h) Consider tools used for the repair of composites to cut small sections of composite for investigation purposes.

(i) Damaged composite material can absorb liquids. Damaged composite may contain fuel residue or other combustible liquid residue. Cutting composites with a rescue saw creates a lot of airborne debris and noxious vapor. The cutting operation should be water cooled when possible. Foam should blanket the working area if there is a potentially high risk of sparking residual fuel.

d. <u>INITIAL RESPONSE PROCEDURES.</u>

(1) Military aircraft may contain munitions that are an explosion hazard. Military aircraft may contain large amounts of fuel that is a flammable liquid hazard. Military aircraft brake assemblies are a flammable solid hazard. Military aircraft contains small amounts of radioactive material. Until it can be determined what the conditions are during the initial phase of the response consider isolating the area at least 80-160 feet in all directions and allow no unauthorized personnel.

(2) Initial response will establish cordon size for fire conditions such that cordon lies outside the smoke plume. All non-authorized, non-essential personnel will remain outside of the cordon.

(3) Ensure no material is taken out of the area.

(4) Only firefighters wearing turnout (bunker) gear, aluminized proximity suits and SCBA will be allowed into the area where an aircraft is on fire. Do not wear rubber gloves. Burning fuel metal, plastics and composite materials are toxic.

(5) Activation of the Personal Alert Safety System (PASS) is necessary when entering a hazardous area.

(6) Class B foam is most effective.

(7) Restrict all unprotected personnel from assembling downwind of the site.

(8) Advise population in the immediate downwind plume area of protective measures.

(a) Shut external doors and windows.

(b) Turn off heating ventilation and air conditioning units.

(c) Remain indoors until the plume has traveled downwind and dispersed.

(9) Low flying aircraft will be restricted from flying within 500 feet above ground level (AGL) and 1000 feet horizontally.

(10) Do not attempt to handle cylindrical objects, ejection seats, and anything that does not hamper firefighting action.

(11) Radioactive materials are used in small quantities. Radiation is invisible and some types of rays easily penetrate firefighter's protective clothing. Breathing apparatus may protect against one kind but not another. Protection is managed by limiting time around the source and creating distance from the source.

(a) Radiation is measured by a survey meter or a Geiger counter. The dosage absorbed can be measured by a dosimeter. The Bioenvirnonmental Engineer will be equipped to detect and measure radiation.

(12) Attempt to control runoff without endangering personnel and equipment.

(13) Overhaul is to be performed to determine if deep-seated smoldering is occurring. A systematic approach is taken so the wreckage isn't disturbed beyond that which is necessary to conduct firefighting and rescue operations. Check for hotspots using infrared detection.

(14) Due to the possibility of deep-seated smoldering of plastics and composite materials, postfire does not begin until composite material is at ambient temperature.

(15) A combination of health and safety concerns can exist. The preliminary site evaluation will identify suspected conditions that are immediately dangerous to life or health or may cause serious harm. A summary of specific hazards is found in Table 3.5-6. Approximate locations should be noted. The immediate concerns include the following:

(a) smoldering

(b) explosives

(c) electrical

(d) radiological

(e) toxic

(16) Once the immediate threats are controlled the following is noted.

(a) Area affected by bloodborne pathogen contamination.

(b) Amount of environmental exposure from fire fighting agents.

(c) Type and amount of site damage.

(d) Local equipment damage.

(e) Exposed personnel.

(f) Type and amount of composite debris. Common terms are used to describe the debris:

1 fragments

2 delaminated layers

3 strips

4 clusters

5 fiber bundles

6 dust

7 charred

8 surface scorched

9 coatings

10 sandwich laminate

(17) Take note of conditions that are likely to produce airborne carbon fiber:

(a) dry or arid climate

(b) large amount of unidirectional tape carbon fiber laminate that experienced physical and fire damage.

(c) pool fire

(d) high prevailing winds

(e) carbon fiber clusters strewn around the burnt debris and outside of the burn area

(f) single fibers can collect on plastics around the area.

(g) airborne fibers collected on plastic face piece

(h) By reflection, fibers can be seen floating in the air surrounding the burnt debris directly following flaming combustion.

(18) Adequate protection from airborne particulate and smoke is needed if EOD needs to enter an area of the site where there is a high potential of smoldering composites.

(19) Recovery operations will not begin until all firefighting and rescue efforts are complete.

(20) Fixant can be applied once all site imminent hazards have been taken care of and the composite temperature is at ambient. Approval may be needed from the SIB before application begins.

(21) Composite spray team may need to be escorted if area is not clear of explosives hazards.

(22) A gross washdown pool can be used to avoid secondary exposure from soot and composite dust from firefighting gear but to minimize contaminated waste at the site a simple wipe down of the gear can serve to eliminate surface dust.

(a) Gently wipe the aluminized proximity suit, helmet, and boots, with soap and water or hand wipes for plume exposure.

(23) Decontamination for bloodborne pathogen will follow NFPA Standard 1500 protocol.

(24) Firefighting equipment should be decontaminated at the site by water washing (preferred) or vacuum.

(25) Soot and carbon fiber is electrostatic. If the aircraft was exposed to the plume, the following should be taken:

(a) Vacuum the air intakes.

(b) For internally ingested smoke, visually inspect all components for debris and vacuum thoroughly.

(c) Prior to flying perform electrical checks and engine run-up.

(d) For significantly affected equipment thoroughly clean antenna insulators, exposed transfer bushings, circuit breakers, etc. Inspect air intakes and outlets for signs of smoke or debris and decontaminate as necessary.

(26) Include all safety and health information in writing at the transfer of command (see Checklist 3.10-2).

Initial Response for Composite Operations	Protective Equipment
Fire, Smoldering and Cutting with a Rescue Saw	Bunker gear, SCBA and Aluminized proximity suit*

* OSC will make the call as to what will be worn depend- ing on the severity and type of fire.

e. <u>FOLLOW ON RESPONSE PROCEDURES.</u>

(1) Consider having adequate firefighting equipment and personnel retained at the scene to combat latent fires.

(2) Be equipped to detect and measure radiation exposures.

(3) If smoke or smoke haze is seen, tasted or smelled the area shall be evacuated.

(4) Conduct team brief before any work is done on site. See Checklist 3.10-1 for briefing topics.

(5) Bloodborne pathogen assessment is made at the scene to determine how much protection is needed before work processes begin. Personal protection guidance is given for the initial approach in Table 3.9-1.

(6) Initial assessment of composite debris is made to determine the type of personal protection equipment needed before work processes begin. Guidance is given for the initial approach (use protection in accordance with level of exposure encountered): in Table 3.9-2.

NOTE

Avoid excessive disturbance of immediate fallout area around the composite debris.

NOTE

For initial approach, leather or thick nitrile gloves are sufficient protection if direct contact is not made with the debris. Care should be taken when choosing a glove that is resistant to spilled aircraft fluids typical for a mishap (See Table 3.8-5).

(7) The DCG initial site assessment will verify safety information reported by the initial response element along with performing their individual assessment roles. A walk-through is conducted to identify sources of hazards to workers that will be conducting mishap processes at the site.

The information is communicated to the OSC:

<u>1</u> sources of high temperature or sparks
<u>2</u> types of chemical exposure
<u>3</u> sources of harmful dust
<u>4</u> sources for radiation
<u>5</u> sources of sharp objects
<u>6</u> sources of rolling/pinching objects can crush feet
<u>7</u> layout of workplace and location of workers
<u>8</u> electrical hazards
<u>9</u> obstructed vision sources

(8) Airborne debris will interfere with site work processes. To stop composite surface dust and fractured fiber ends from becoming airborne by wind or debris movement a temporary hold-down solution or fixant is applied to the damaged debris. Polyacrylic acid (PAA) such as floor wax or Carboset 525[1] has been used.

NOTE

Fixant is a surface application only. It does not provide fiber stiffness. It does not penetrate composite layers. It does not prevent re-suspension of particulate under or within the debris. It does not prevent the generation of new particulate from handling the damaged debris.

(9) Approval may be needed from the SIB before application begins.

(10) Fixant application can be performed when the material has reached ambient temperature and after all site imminent hazards have been taken care of.

[1] Carboset 525 requires mixing with warm water (140°F) and the addition of ammonium hydroxide until the pH is 8 or higher.

Table 3.8-1 Bloodborne Pathogens - Personal Protective Equipment For Specific Tasks

Task or Activity	Gloves	Eyewear	Mask	Gown/ Apron	Head Cover	Shoe Cover
Handling human remains	Yes	No[1]	No[1]	Yes	No[1,2]	No[1,2]
Extricating human remains from wreckage	Yes	No[1]	Yes	Yes	Yes[3]	Yes
Handling clothing and personal effects	Yes	No	No	No[2]	No	No
Extricating personal effects from wreckage	Yes	No	Yes	No[2]	Yes[3]	Yes
Opening bodies/ evisceration of organs	Yes	Yes	Yes	Yes	Yes	Yes
Collecting blood, body fluids, tissues	Yes	Yes	Yes	Yes	Yes	Yes
Closing body cavities	Yes	No[1]	No[1]	Yes	No[1,2]	No[1,2]
X-raying human remains	Yes	No[1]	No[1]	No[2]	No	No
Cleaning floors	Yes	No[1]	No	No[1]	No	No
Cleaning instruments/ equipment	Yes	Yes	Yes	Yes	No	No
Cleaning tables	Yes	Yes	Yes	Yes	No	No
Disposing of trash	Yes	No	No	No[2]	No	No
Cleaning	Yes	Yes	Yes	Yes	No	No

[1] Unless splasing is likely
[2] Unless soiling is likely
[3] Hardhats may be required for extrication from wreckage

Table 3.8-2 Bloodborne Pathogens - Situation and Protection

SITUATION	PROTECTION
Site is suspected to have bloodborne pathogen gloves..	Should approach contaminated area of the site with concern, but there is no evidence of blood or tissue contamination.
Site had minimal injuries and limited evidence of blood or tissue.	Should approach contaminated area of the site with glove and disposable shoe covers.
Site experienced gross contamination with blood and tissue.	Should approach contaminated area of the site with gloves, shoe protection, body cover and mask.

Table 3.8-3 No Direct Debris Contact Situation and Protection

SITUATION WITH NO DIRECT DEBRIS CONTACT	PROTECTION
Physical damage only	Approach contaminated area of the site with hard sole shoes, eye protection, long sleeves and pants, and longcuff gloves (no surgical gloves).
Explosion or high energy impact	Approach contaminated area of the site with hard sole shoes, eye protection, long sleeves and pants and long-cuff may be need for re-suspension of particulate in the immediate area.
Fire damage only	Approach burnt debris with long sleeve and pants, long-cuff gloves and filter for nuisance vapor if inspection has to be performed in close proximity to the burnt debris.
Physical damaged and burnt composites	Approach contaminated area of the site with hard soles shoes, hooded garment, long sleeve gloves, eye protection and air purifying respirator if inspection is performed in close proximity to the burnt debris.

(11) Ensure area is clear of explosives hazards from EOD. If not, the composite spray team may need to be escorted.

(12) PAA fixant application has been applied using various types of sprayers. Small sprayers are chosen based on fluid capacity and handling capability. The backpack style seems to be most efficient.

(13) **The fixant is diluted with a ratio of 2 parts water and 1 part fixant or 50% solution.** The amount of fixant varies. A recommendation for an F-16 mishap involving impact damage and fire is to take two five-gallon backpack sprayers for the initial spray and use the extra wax for subsequent treatments. As the wreckage is moved or recovered more application is required.

(14) Typically the composite spray team consists of 2 primary members with 2 backup members. Rotating teams may be necessary during high heat stress or cold exposure conditions.

(15) The team PPE consists of the following:

(a) hooded coverall (Tyvek or Kimberly-Clark) for particulate protection

(b) long cuffed gloves for members that will not come in contact with the debris.

(c) leather gloves with an inner dust and PAA resistant gloves.

(d) hard sole shoes

(e) eye protection

(f) air-purifying respirator for organic vapor and particulate

(g) duct tape seals the top of the coverall zipper

(h) duct tape can be used to seal torn coverall seams

(i) outer glove is pulled over the sleeve and taped

(16) An area not more than 25 feet around the debris will be marked with traffic cone or barrier tape to secure against unauthorized entry before spraying begins.

(17) PPE will be donned before entering the spray area.

(18) The composite spray team briefing will discuss downwind direction, spray approach and site hazards associated with the operation.

(19) All exposed surfaces, edges and particulate is sprayed.

(20) Fixant may have a pH that is a hazardous waste concern if it is excessively sprayed around the site contaminating the soil. Avoid over spraying the surrounding environment.

(21) Decontamination of the composite spray team necessitates a process applicable to all mishap scenarios including remote locations.

(a) Three zones are established around the composite debris:

- Hot - the composite debris area.
- Warm – PPE removal area.
- Cold – clean area

(b) The decontamination process will be conducted upwind of the hot zone.

(c) Place disposal containers for PPE and equipment drop in warm zone.

(d) To minimize creating wastewater the roll-back decontamination method is preferred.

1 Hood is rolled back from face and turned inside out.

2 The zipper on the front of the suit is lowered and the suit is pulled off so the arms are turned inside out (the gloves were taped over the garments sleeves).

3 The suit is lowered while the contaminated person remains standing until only the boots remain in the suit. Each leg is lifted and the suit is removed and placed in the dedicated disposal container.

4 If the respirator is visibly dirty, clean while on the face with wipes.

5 While wearing the inner gloves remove respirator.

6 Remove cartridge.

7 Wipe inside and outside of respirator with wipes.

8 Replace cartridge and hang to dry in clean area.

9 Remove the inner glove and proceed to the clean area.

(e) HEPA vacuum can be used to remove debris from respirator face piece but wiping with toilettes will suffice.

(f) Wipe any skin-exposed areas with toilettes.

(g) Wipe dust and particulate collected on equipment with toilettes.

(22) After the initial fixant application, minimize foot traffic around any composite debris.

(23) Drape or wrap composite with plastic or rubber coated canvas in wet weather

(24) The systematic search and rescue process for remains needs to consider bloodborne pathogen exposure along with all the other potential hazards, see Table 3.7-7-Mishap Hazards Summary. Buried munitions, composite pieces, sharp metal pieces, burnt pieces will have handling concerns.

(25) The use of helicopters to visually survey the terrain and assist in determining the overall search area for remains needs to consider the potential of composite dust re-suspension.

(26) The mishap site will be diagrammed for investigation purposes. Major components will be identified. Oil, fuel and hydraulic fluid will be collected. Constant situational awareness is required to limit any site exposures.

(27) Composite wreckage involved in a safety investigation will be transported to a “safe-area”, as directed by the safety investigation board. The area should be not subjected to weather.

(28) Proper containment prior to transportation is required before transporting the investigation debris to a “safe-area”.

(29) If possible, do not spray investigative debris with fixant.

(30) Composite wreckage will be wrapped in 0.006 inch thick plastic and taped. Cover plastic with canvas to pad sharp fibers when needed.

(31) Tag and label all debris at the crash site prior to transporting to “safe-area”.

(32) Plastic attracts loose carbon fibers. Unwrap plastic at the “safe area” wearing gloves and a long sleeve garment. Burnt pieces will require protection from organic vapor. Air purifying respirator for particulate and organic vapor will be required for direct handling of burnt carbon fiber composites.

f. SECONDARY RESPONSE PROCEDURES.

(1) Preparation. The site has to be prepared for aircraft rescue and cleanup. Safety measures are taken to ensure the response operations go without incident.

(a) Verify safety and health information received from OSC then conduct safety and health assessment (see Checklist 3.9-2 and Flowchart 3.10-1) based on operations that will be performed. Discuss assessment with OSC before operations begin.

(b) Factors that complicate operations at the site include (see expanded list in Table 3.8-10):

1 buried munitions

2 buried remains

3 composite fragments and fiber bundles buried around the bulk debris

4 splashing of fuels/oils

5 animals

6 sharp metal edge debris

7 environment and terrain conditions

8 deep-seated smoldering composites (evacuate immediately)

9 hot tires and brakes (evacuate immediately)

(c) Determine the need for work, support and security zones.

1 To eliminate the need to decontaminate equipment and tools.

(e) Cover equipment and tools with plastic sheets that can be removed during decontamination where appropriate.

(f) Include in the first aid kit an eye wash for composite dust and fibers, medication for localized burns from corrosive materials, tweezers for boron fiber puncture wounds (seek medical attention), hydrocortisone for minor skin rashes from composite dust exposure, antimicrobial skin wipes and heat stress monitor.

(g) Enforce the buddy system.

(2) Aircraft recovery.

(a) Hoisting an aircraft with a crane and sling, jacking and towing have specific safety hazards associated with each operation. Include a review of the hazards in the team brief.

(b) The ground crew involved with a helicopter aerial recovery operation is exposed to hazards of the noise, rotor downwash and electrical shock when contacting the helicopter cargo hook when it is positioned over a cargo hookup point. Include a review of the hazards in the team brief.

(c) Recovery operations will not begin until the OSC has released the aircraft to the Crash Damaged or Disabled Aircraft Recovery (CDDAR) team chief. Notify the OSC when the operation is commencing.

(d) Retain firefighting element if de-fueling is necessary.

(e) Prior to moving ensure the safety investigation board has all necessary cockpit switch and gage readings.

(f) All external stores and armament should be removed from the aircraft prior to performing any recovery operations. The removal of munitions may not always be possible due to the condition of the aircraft. A case-by-case evaluation is made.

(g) Verify components of canopy jettison and seat ejection system has been safed or disarmed prior to performing recovery operations.

(h) Verify all electrical systems are de-energized.

(i) Disconnect battery prior to recovery operations. Remove the battery from the aircraft if there was any spillage or damage.

(j) Obtain weather information prior to lifting. Conditions may interfere with cranes, tow vehicles, or helicopter use and crash trailer placement at the site.

(k) Use absorbent pads as soon as possible to soak up spilled fuels when performing the recovery operation. Avoid any operation that can cause a spark or ignite the spill.

(l) Identify downwind direction especially when working around spills and burnt composite debris.

(m) Contain damaged composites with fixant and canvas before aircraft recovery operations begin following instructions found in paragraph 3.8.e.

(n) Before removing aircraft wreckage perform a dry run with the equipment and technique.

(o) Team chief monitor operations and evaluate the effectiveness of the plan.

(p) Aerial recovery of aircraft will disperse loose dust or debris. A soil tackifier spray will help keep the dust from becoming airborne.

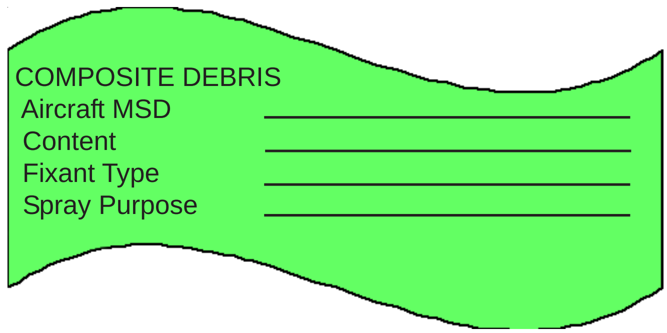
(3) Mishap debris containment.

(a) Debris that will be scrapped requires a sorting process and proper composite containment before transport-ing off-site. Systematically separate and box the debris. Composite material is separated from non-composite and containerized. Containers needed:

1 Large bulk pieces: wood box with a cover (cardboard will not provide containment throughout the lifecycle of the wreckage).

2 Small size pieces: five or ten-gallon plastic buckets with lids.

3 Labeled tags:



WARNING

Flammable solid. Use Class B fire extinguishant. Dust is an eye, skin and inhalation irritant. Fibers cause puncture wounds. Burnt debris has an unpleasant odor.

(b) Indoor storage. Burnt and/or damaged bulk composite pieces are sprayed with fixant and wrapped before containerizing.

1 Follow fixant spraying procedure in 3.8.d. and see Table 3.8-6 for Fiber Hold-Down Solution(s) Rationale.

2 Wrap with plastic and/or canvas and tape.

(c) Outdoor storage. Plastic wrap and tape is not suitable for outdoor storage. PAA fixant is not a permanent hold-down solution. Sharp edges tear the plastic exposing the debris and the tape degrades. Canvas wrapped plastic can provide additional protection but may not be waterproof. The following is required if the composite debris cannot be containerized.

1 Contain fibers with a permanent fixant solution. Corrosion preventative compound (CPC), MIL-C-16173 Grade 4 spray has been tested for environmental exposure.

2 If CPC is not available then use PAA fixant.

3 Wrap and tape with 0.006-inch plastic and canvas or with rubber coated canvas.

4 Tag and label, see 3.a.3 above.

(4) Site Cleanup.

(a) Work practice:

1 Do not dry sweep. It puts dust in the air.

2 Use water or a vacuum system with a HEPA filter for cleaning surfaces and equipment.

3 Compressed air is not for cleaning clothes or equipment.

4 Work upwind of dust clouds or dusty areas when possible.

5 Report any skin and breathing irritations, cuts or rashes.

NOTE

When in a protective suit under high heat conditions, heat stress or prickly heat can be misconstrued to be a rash developed from composite exposure.

6 No smoking, drinking or eating.

7 Shower as soon as possible after working with severely damaged composites, contact with burnt debris and liquid spills.

8 Use hand signals for line-of-sight communication.

(b) Composite handling at the site is a localized concern. Exposure issues are right at the damaged pieces. Identify work area when clearing site of composite debris piles. A work zone of not more than 25 feet is appropriate for handling quantities of damaged composites.

CAUTION

CONTAINS
COMPOSITE DUST AND FIBERS
Avoid creating dust
Do not enter work area without proper protection

(c) Moving composite debris around with a backhoe or forklift will generate loose composite dust and fibers. Avoid flying fragments and spread of debris when moving piles of debris. Spray fixant solution on bulk composite debris before movement begins.

(d) Direct contact when moving piles of loose composite debris requires full respiratory, eye and skin protection.

(e) If the conditions at the site are going to re-suspend airborne particulates during cleanup, a tackifer spray can be used to adhere loose particulates to the soil.

(f) Collect the debris and containerize in an organized fashion. The debris can be sorted by system and material type.

(g) Cleanup randomly scattered composite small fragments, strips, clusters, core material, and foam by placing into plastic labeled buckets.

(h) Large bulk pieces are placed into wood boxes.

(i) Bloodborne contaminated pieces will be boxed separately and properly labeled, see paragraph 3.8.b.

(j) Remove loose contaminate such as composite dust composite from hard surfaces like concrete by vacuuming or a water/detergent wash.

(k) Soot removal from solid surfaces will require washing with a high alkaline cleaner.

(l) Aircraft fuel and liquids, fire suppressant, and hydrazine contamination will cause an environmental site assessment. The final cleanup process will be determined by the environmental assessment.

(n) Equipment decontamination method will depend on type of contaminate:

1 loose contaminates like dust or particulate: HEPA vacuum or water/detergent wash.

2 aircraft liquids:chemical rinses or high pressure rinses with or without heat.

3 adhering contaminates like resin char or tacky plastic materials: scrapping and brushing with a chemical rinse.

4 electrostatic attached particles: spray or clean eqipment before use with antistatic solutions.

(o) Wastewater should be collected and disposed of properly. A number of methods have been used for collection: trench, pool or tarp. The means of disposal will be determined by the water contaminate and concentration.

(5) Transportation. All debris will be adequately contained as described before transporting off site.

(a) Buckets are sealed with a lid.

(b) Debris is in a wood box covered with a lid or contained within canvas.

(c) All containers are labeled.

(6) Personal protective equipment considerations are based on the operation, site conditions and debris (type, condition and amount). Use protection in accordance with level of exposure encountered. A large number of disposable gloves and disposable coveralls will be needed. See Table 3.8-4 for PPE Considerations.

Table 3.8-4 Personal Protective Equipment Considerations (1 of 3)

OPERATION	PROTECTION CONSIDERATION		EQUIPMENT
Clean up of randomly scattered small size composite debris: fragments, strips, clusters, pieces of sandwich structures, foam. Picking up small pieces scattered over a large area does not generate an appreciable amount of airborne particulate.	Eye and Face	Loose fibers protruding from the debris.	Goggles.
	Respiratory	-	-
	Head	-	-
	Foot	Puncture from sharp objects. Fluid spills. Harsh terrain.	Hard sole work shoes.
	Hand/ Forearm	Puncture wounds from protruding fibers. Residual dust, char material or spilled fluids.	Inner long-cuffed nitrile glove. Outer leather glove.
	Body	Dirty and/or harsh environment.	Long sleeve BDU or protective coverall.

NOTE

Other operations, occurring at the same time, site conditions and weather may require additional protection.

Table 3.8-4 Personal Protective Equipment Considerations (2 of 3)

OPERATION	PROTECTION CONSIDERATION		EQUIPMENT
Backhoe, forklift or shoveling of damaged/burnt composite debris. Handling piles of damaged composites can produce appreciable amounts of airborne particulate. WITH OR WITHOUT FIXANT. Requirement is for direct contact with the debris. Requirement is for anyone within the workzone when piles of composite debris are being moved.	Eye and Face	Airborne composite dust and fibers of various sizes.	Goggles with half-face respirator.
	Respiratory	Airborne composite dust, fibrous particulate.	Full-face respirator preferred: combination filter (organic vapor and particulate 99% efficiency) for burnt debris and particulate for physically damaged debris.
	Head	Flying debris.	Hard hat.
	Foot	Puncture wounds from sharp objects, impact from carrying objects that can fall on the feet.	Hard sole and toe working shoes.
	Hand/ Forearm	Puncture wounds, residual dust, char material or spilled fluids.	Inner-long-cuffed nitrile glove. Outer leather glove.
	Body	Generation of airborne composite dust, fibers, char material. Puncture wounds from fibers.	Protective coverall with hood, elastic wrist and ankles. Booties are optional.

Table 3.8-4 Personal Protective Equipment Considerations (3 of 3)

OPERATION	PROTECTION CONSIDERATION		EQUIPMENT
Cutting the composite with a saw, pounding, or drilling. Cutting with a saw will generate heat, airborne particulate and organic vapor, WITH OR WITHOUT FIXANT. Requirement is for the team in direct contact with the debris and anyone within close proximity.	Eye and Face	Airborne particulate	Goggles with half-face respirator.
	Respiratory	Airborne composite dust, fibrous particulater eaching the micron size range	Full-face respirator preferred: combination filter (organic vapor and particulate 99% efficiency) R series filter is needed when lubricates or cutting fluids are used.
	Head	Fibrous particulate	Protective coverall with hood
	Foot	Puncture from sharp objects	Hard sole and toe working shoes
	Hand/ Forearm	Puncture wounds, residual dust, char material or spilled fluids.	Inner long-cuffed nitrile glove. Outer leather glove.
	Body	Generation of airborne particulate, fibers, char material. Puncture wounds from fibers.	Protective coverall with hood, elastic wrist and ankles. Cutting with a saw may cause sparking. Sparks will destroy the protective coverall . An outer covering like rubber apron or leather chaps can be used to protect against sparks. Booties are optional.

Table 3.8-5 Glove Types

GLOVE TYPE	USE FOR
Neoprene	Freon Burnt Kapton ®
Leather, Kevlar ®	Boron fiber puncture Carbon fiber puncture Radioactive material
Nitrile [1] Thick nitrile	Composite dust JP-8 soot Bloodborne pathogens (BBP) Antifreeze Hydrazine Gasoline Keresene Hydraulic fluid Jet fuel BBP decontamination solution Carbon fiber
Latex	BBP
Butyl-rubber	Battery electrolyte Chemical warefare agents Antifreeze BBP decontamination solution

Lessons learned:

1. Never have enough.
2. Gloves too thin. Require frequent changes.
3. Use only powder-free gloves.
4. Get the right size. Mishap response involves manual labor. The wrong size will interfer with the job.
5. Close-fitting gloves should be used to avoid catching.
6. Short-cuffed gloves will not protect forearms from fiber puncture wounds.
7. Effectiveness of the plastic glove depends on the thickness.

(7) Mishap response requires more than one type of glove. Leather, cowhide or Kevlar is chosen for fiber puncture resistance and sharp or jagged metal and glass. Plastic gloves are chosen for chemical and particulate resistence and there are a number of plastic gloves to choose from. A glove selection guide has been tabulated, based on common mishap hazards, see above Table 3.8-5, Glove Types.

[1] The selection criteria was based on minimizing the number of gloves needed.

Table 3.8-6 Fiber Hold-Down Solution(s) Rationale

HOLD-DOWN SOLUTION TYPE	COMMON NAMES	PURPOSE
PAA fixant Polyacrylic Acid	Floor wax Carboset 525	Temporary surface coating to hold down loose debris that could become airborne when working around the debris at the mishap site.* PAA fixant can be removed if the sprayed piece needs to be analyzed for investigation reasons. PAA has environmental concerns. Try not to over-spray the ground.
Permanent fixant	Corrosion Prevention Compound (CPC), MIL-C-16173, Grade 4, Asbestos encapsulate	Permanent coating for long-term scrapped debris storage. It is not sprayed on debris that may need laboratory analysis.
Tackifier	Polychem, J-Tack, or Terra Tack TM	Soil preparation used to eliminate the potential of fiber and dust re-suspension for low vegeation, dry soils-- Tackifier is used to keep hay and straw mulch from becoming airborne. There should not be an environmental concern when using it to hold down dust.

*** Solution is 2:1 with water. Reapply when needed to retain effectiveness, such as after rainfall or overnight dampness or dew which will dilute the mixture allowing fibers to regain airborne ability.**

(8) To hold down composite dust fixant application can be performed following the control of the immediate safety hazards. Additional application will take place depending on the needs at the site. There are three different holddown solutions based on the performance requirement. Use the above Table 3.8-6 Fiber Hold-Down Solution(s) Rationale to determine which solution is most appropriate.

Table 3.8-7 Levels of Protection and Protective Gear

LEVELS OF PROTECTION	HAZARD
LEVEL A	Greatest level of skin, respiratory and eye protection is required.
LEVEL B	Highest level of respiratory protection but with a lesser level of skin protection.
LEVEL C	Concentration of types of airborne substances are known and criteria for using air-purifying respirator is met.
LEVEL D	A work uniform providing minimal protection for nuisance contamination only.
Ref: 29 CFR Part 1910.120	

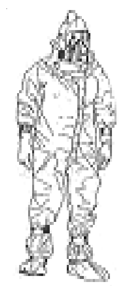
			
LEVEL A	**LEVEL B**	**LEVEL C**	**LEVEL D**

Table 3.8-8 Equipment Possibilities

Required + Optional

EQUIPMENT POSSIBILITIES	LEVEL A	LEVEL B	LEVEL C	LEVEL D
SCBA	#	#		
Full-face air purifying respirator			#	
Encapsulating gas-tight suit	#			
Chemical resistant clothing		#	#	
Coverall (not chemical resistant)				#
Chemical resistant inner/outer glove	#	#	#	
Chemical resistant boots with steel toe	#	#	#	
Two way radio	#	#	#	
Hard hat	+	+	+	+
Faceshield		+	+	+
Safety glasses or splash goggles				#
Disposable boot covers	+	+	+	+
Gloves (not chemical resistant)				+
Escape mask		+	+	+
Safety boot (not chemical resistant)				#

(9) Level of protection for aircraft mishap response can drastically change from initial response to the secondary role response. Selection can be complex. The levels of protection (A,B,C,D) designated by the EPA, is used as a selection guide, see Tables 3.8-7 and 3.8-8 above. Note that a secondary response operation would not take place if a situation developed warranting a level A or B ensemble.

Table 3.8-9 Emergency Response – Illustration of Behind-The-Scene Involvement. [1]

The emergency response mission is to preserve life, Air Force resources, property and evidence for the safety investigation that will follow. Local base operation plan 32-1 and safety plan 91-204 strive to provide rapid notification, correct and timely response, and containment of the mishap situation. The amount of behind-the-scene involvement can be immense.

Wing Operations Center	Operations Group	Logistic Group	Support Group	Communications Group	Medical Group	Interim Safety Board
Wing Commander Wing Staff Judge Advocate Wing Public Affairs Wing Command Post Wing Safety Wing Comptroller	Operations Group Commander Aeromedical Evacuation Squadron Commander Airlift Squadron Commander Operations Support Squadron Commander Airfield Operations Flight Weather	Logistic Group Commander Logistic Support Squadron Commander Maintenance Squadron Commander Supply Squadron Commander Transportation Squadron Commander	Support Group Commander Security Police Squadron Commander Civil Engineer Squadron Commander Mission Support Squadron Commander Information Management Flight Causality AssistanceMortuary Affairs Fire Protection Disaster Preparedness	Commander Communications Squadron Commander Visual Information	Medical Group Commander	President Investigation officer Pilot member Maintenance member Medical Recorder

[1] The exact notification chain is mishap type and base dependent.

Table 3.8-10 Emergency Response – Illustration of Possible Site Involvement. [2]

PHASE 1	PHASE 2	PHASE 3	PHASE 4
Initial Response Fire Department Flight Surgeon Security Police Follow-on Response DCG: OSC Safety Flight Surgeon BEE Crash Recovery EOD Maintenance Fuel Systems LANTRIN Photo	Security Police Medic Flight Surgeon Bioenvironmental Engineering Crash Recovery EOD Fuel Systems LANTRIN Photo	Security Police Medic BEE Crash Recovery EOD Fuel Systems ANTRIN Photo OG Environmental Civil Engineering Avionics EWS Services Transportation Flight Safety	Security Police Medic BEE OG Environmental Services Transportation Crash Recovery

[2] Not a complete list of all possible involvement.

Table 3.8-11 Summary of Garments [1,2,3]

EXPOSURE	GARMENT (not a comprehensive list)
Blood-borne pathogen	NexGen™ Tychem®
Chemical	
Liquid	Tychem® -several types, Pro/shield 2, NexGen™
Hydrazine	Tychem® F, SL and TK
JP-8	Tychem® TK (other Tychem® types were not tested)
harp object cut	No garment listed provides 100% protection. Tychem® types are more rugged than Tyvek®.
Fiber puncture	Tyvek® types will provide adequate fiber protection for most fiber. Boron fiber may puncture Tyvek®.
Dry particulate	Tyvek®, New Tyvek®, Tyvek® Type and 1431N and 1422 Tychem® SL, QC Pro/shield 2, NexGen™
Radioactive dust	Tyvek®, Type 1422 , Tychem® SL, New Tyvek®

(10) PPE choices should be realistic to the exposure because wearing PPE can introduce potential work problems (limited visibility, reduced dexterity, claustrophobia, restricted movement, suit breach, insufficient air supply, dehydration) and costs increase dramatically with an increase in the level of protection. The garment selection depends on the type(s) of exposure (biological, chemical, cut/puncture, dry particulate and radiation). The most common disposable garment used during the secondary role response is the Tyvek® or Kleenguard® suit. There is a selection of suits to choose from. In preparation for a response, a summary is provided in Table 3.8-12 for detailed descriptions.

[1] Proshield, NexGen™, are Dupont products

[2] Tyvek® style 1422 and 1431N is a Tyvek®-ProTech product

[3] Tyvek® and Tychem ®are Dupont products

Table 3.8-12 Detailed Description of PPE Possibilities (Sheet 1 of 2)

COVERALL	BARRIER	COMMENTS
Tyvek® Kimberly-Clark Kleenguard ® Select Olefin fabric	Dry particle and aerosol hazards. Resist light splash. Dry chemical, dirt and radioactive dust. Seams: stitched and bound Color: white	* Not flame resistant. Should not be used around spark or potentially flammable or explosive environments * Not liquid resistant * Not BBP resistant (ASTM F1670)
New Tyvek ® Kimberly-Clark Kleenguard® Ultra Tyvek® fabric that is softer, more comfortable prior to 2001.	Dry particle and aerosol hazards. Resist splash. Dry chemical, dirt and radioactive dust. Breathable BBP resistant (Passes ASTM F1670 & F1671 Seams: stitched and bound or sealed Color: white	* Not flame resistant. Should not be used around spark or potentially flammable or explosive environments * Not liquid resistant

NOTE: Below are garments primarily designed to protect against hazardous liquid and vapor exposure, handling quantities of hazardous waste.

COVERALL	BARRIER	COMMENTS
Tychem® QCTyvek® fabric coated with polyethylene	For minor chemical spills where there is a potential for mist or light splash Color: bright yellow Seams: stitched or taped	* EPA mid-level protection
Tychem® SL Tyvek® coated with Dow Saranex ® 23-P film	Protects against a broad spectrum of chemicals. Hazardous materials response, radioactive environments, environmental cleanup, some chemical warfare agents, biohazards. Strong fabric, rugged and durable. Color: white Seams: stitched or NSR®	* EPA mid-level protection * Available in different seam types * Biohazard protection
Tychem® BR Multi-layer film barrier	Protects against moderate to heavy chemical splash. 250 chemicals protection. Strong abrasive resistant fabric. Color: bright yellow Seams: taped	* EPA mid-level protection * Designed for industrial hazmat situations
Tychem® LV Multi-layer film barrier	Same chemical resistance as BR but in a color for military operations. Protects against moderate to heavy splash Color: military olive green Seams: taped	* Marketed for military use
Pro/shield® 1 Nonwoven fabric	Non-hazardous light liquid splash Breathable. Anti-static treated Color: white or blue Seams: stitched	* To avoid nuisance contamination * General maintenance work
Pro/shield® 2 Breathable film and nonwoven fabric	Particles and some toxic liquids Light weight, soft and strong. Breathable Color: white. Seams: stitched or NSR®	
NexGen ™ Breathable film and nonwoven fabric	Particles and some hazardous liquids. Blood-borne pathogen resistant Antistatic treated Color: white Seams: stitched or NSR®	

Table 3.8-12 Detailed Description of PPE Possibilities (Sheet 2 of 2)

ACCESSORIES	BARRIER	COMMENTS
Over the shoulder Tyvek ® or SARANEX® hood	Fiber puncture wounds Composite dust	* Protection when the garment does not include a hood
Tyvek® sleeve protector	Fiber puncture wounds Composite dust	* Good for composite inspection with slight hand movement when not wearing a garment
Tyvek® boot cover	Dust	* Not liquid resistant * Will tear walking around a crash site
Cool-Guard® jacket	Heat stress One-size fits all garment, cooling for several hours, more efficient than ice.	* Expensive
Chem-Tape®	Used to attach components of a protective ensemble and to reduce the possibility of gross liquid flow at interfaces: sleeve-to-glove, ankle-to-boot, hood-to-face and storm flap	* Duct tape can be used to protect againt dust
Kevlar sleeve with leather forearm	Cuts, abrasion and puncture resistant.	* Made for glass and sheet metal handling * Could be used for damaged composite handling for extraction protection
Leather riding chaps Welding leg protection	Sparks from rescue saw	* No garment listed will protect against sparks or fire
BOOTS	**BARRIER**	**COMMENTS**
Rubber Boots with steel midsole and toe	PVC boots Chemical resistance and puncture resistance	* Easy to pull on and off * Slip resistance * Easy to clean * Usually knee length
Non-rubber firefighting boot	Waterproof, flame and cut resistant. Resists oil, heat and slips. Puncture resistant bottom and steel toe.	* More comfortable than rubber boot and not as hot * More expensive than rubber boot
Military issue boots: Hot weather Combat field Jump “MACH” hot weather Steel toe tropical or hot weather	Fabric upper may not prevent puncture wounds or cuts. Spills may degrade fabric. No steel toe or shank. No steel toe. No steel toe or shank. Fabric may not prevent puncture wounds or cuts. Spill may degrade fabic. Fabric may not prevent puncture wounds or cuts. Spills may degrade fabric.	

Lessons Learned:

- Stitched seams will split during operation if the suit doesn’t fit properly. Common for broad shoulders individuals.
- Front zipper without flap will unzip during operations. It needs to be taped.
- Elastic hood closure, wrist and ankles recommended over open wrist, ankle and tied hood closure.
- Boot covers are cumbersome if they are too large. Can cause tripping or slipping.
- Boot covers were not designed for mishap sites. They will rip if there is a lot of movement around the site.

Table 3.8-13 Emergency Response Publications

INSTRUCTION	TITLE	INTENTION	RESPONDER	SECTION OF INTEREST
AFPD 32-4001	Disaster Preparedness Planning Operations	Outlines planning, responsibilities at each level of the AF and training equirements	Disaster Control Force Base Civil Engineering (CE)	App 1 list table of SRC composition and responsibilities. Att 2 list functional support. Att 3 provides Base O-Plan guidance
AFPD 32-4002	Hazardous Material Emergency Planning and Response Planning	Plan for HAZMAT, Emergency Response	Base Civil Engineering (CE)	Att 3 has a format for HAZMAT emergency response for OPlan 32-1, Annex A
AFMAN 32-4004	Emergency Response Operations	Specific response procedures for the 4 phases of emergency response	Disaster Control Force Base Civil Engineering (CE)	Attachments contain example checklist. Att 3 contains guidance for response involving composites
AFMAN 32-4013	Hazardous Material Emergency Planning and Response Guide	Establishing a HAZMAT program	Base Civil Engineering (CE)	Chapter 8, post emergency clean up and disposal but no composites information
AFH 32-4016V1 and V2	CE Readiness Flight Response and Recovery Handbook	Summarizes emergency response and recovery considerations.	Base Civil Engineering (CE)	Includes hazards considerations. Volume 2 has an overview of major accident mishap response.
AFI 91-202	USAF Mishap Prevention Program	Establishes program requirements and responsibilities	Safety Staff	Att 4, Mishap Response
AFPAM 91-211, 1996 draft	USAF Guide to Safety Investigation	Procedures for Investigating and Reporting AF Mishap	Interim and formal SIB	Chapter 2 - interim SIB and hand-off information Chapter 4, Mishap Hazards
T.O. 00-105E-9	Aerospace Emergency Rescue and Mishap Response Information (Emergency Services)	Location of hazards on DoD, various US Gov't, NASA and NATO aircraft	All responders, crash recovery, BEE, & accident investigators	Chapter 3, Hazardous Materials and Mishap Hazards and specific aircraft files
AFI 34-242	Mortuary Affairs Program		Mortuary Affairs	Chapter 6, Mishap Response

SRC = survival recovery center
MRP = mishap response plans

NOTE

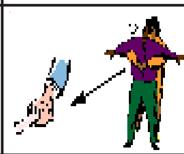
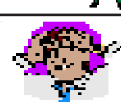
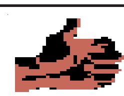
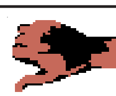
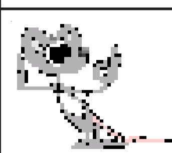
All publications are subject to change due to continous updating by the respective publication managers. Insure the unit publications library is using the most current edition, revision, changes and supplements.

Checklist 3.9-1 Team Briefing (Sheet 1 of 2)

TOPIC	DISCUSSION	NEED
Site Orientation	Accessibility Location, size of site, topography, confined spaces Environmental conditions	
Safety and Health	Types of exposures (hazard checklist) Hidden fire potential Unspent munitions Procedure for site evacuation Pre-exposure preparation training (CISM refresher) Pathway for hazard substance to be dispersed Composite Material Review	
Personal Protection Equipment (PPE)	Proper use Procedure for equipment failure	
First Aid	Location of first aid kit Emergency eye wash Emergency shower	
Work plan	Objective Work party Worker duties and time to complete work task Work practices Work zones Buddy system and hand signals	
Decontamination Process	Emergency Routine level	
Sanitation for temporary workplaces	Water Toliet	

Checklist 3.9-1 Team Briefing (Sheet 2 of 2)

Hand Signals in support of line-of-sight communications

HAND GRIPPING THROAT		OUT OF AIR OR CAN NOT BREATHE
GRIP PARTNER'S WRIST OR BOTH HANDS AROUND WAIST		LEAVE AREA IMMEDIATELY
HANDS ON TOP OF HEAD		NEED IMMEDIATE ASSISTANCE
THUMBS UP		OK OR I AM ALL RIGHT OR I UNDERSTAND
THUMBS DOWN		NO, NEGATIVE
THUMB AND INDEX FINGER TOUCHING TO FORM A CIRCLE		ARE YOU OKAY?

Checklist 3.9-2 Safety and Health (Sheet 1 of 2)

SAFETY AND HEALTH CHECKLIST

Mishap/Date: ______________________

Aircraft MDS: ______________________

Location: ______________________

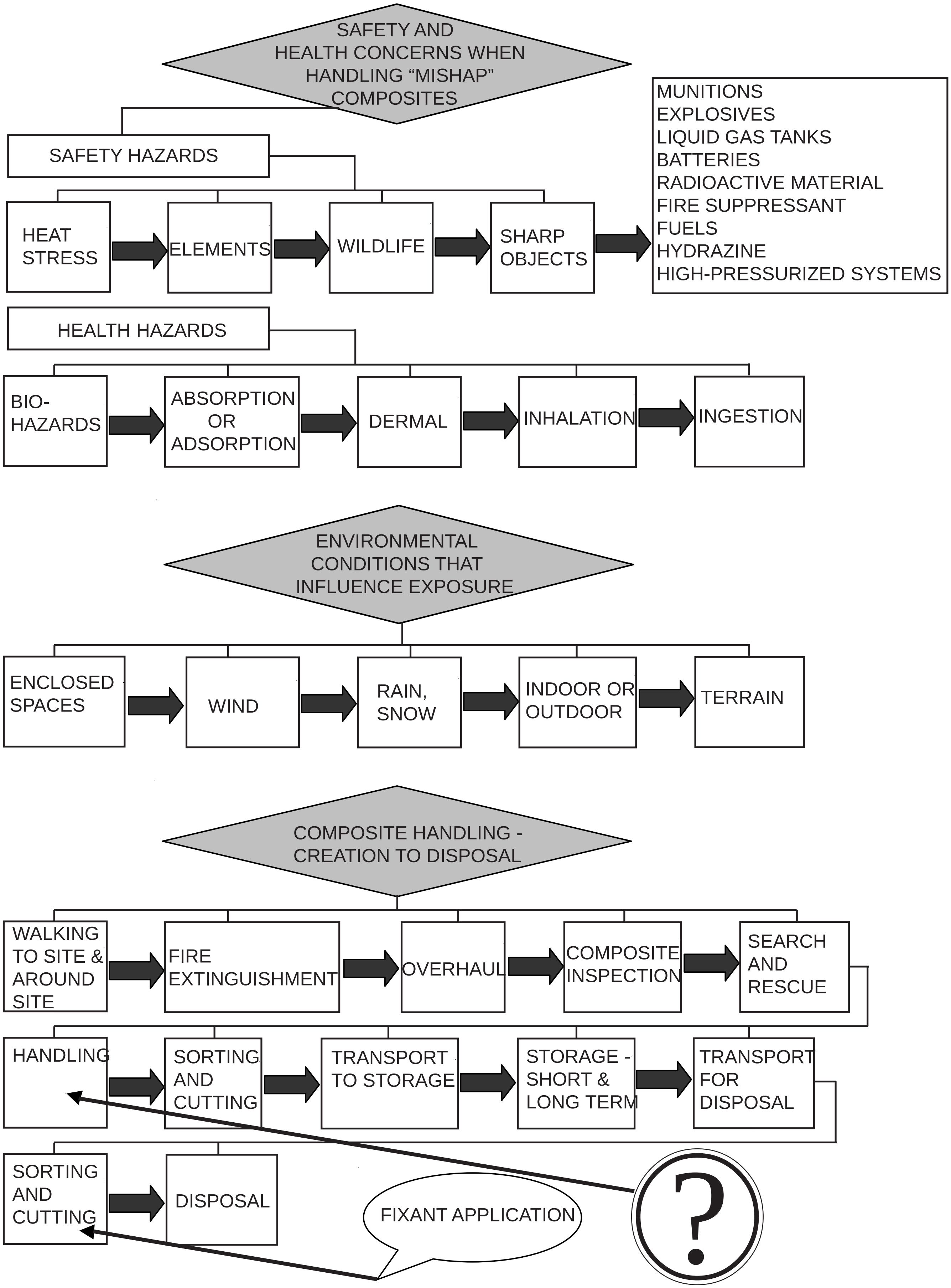
CATEGORY	HAZARD	CONDITION	LOCATION
FIRE	Fuel and fuel tank		
	Overheated battery		
	Hydraulic fluid		
	Leaking oxygen		
	Leaking or hot batteries		
	Smoldering materials		
	Smoking on site		
	Cutting tools and other heat		
	Cutting tools and other heat generating equipment		
	Signal flares		
	Anti-icing fluid		
HIGH PRESSURE SYSTEM	Hydraulic accumulators		
	Pneumatic systems		
	Shocks, struts		
EXPLOSIVE	Hot brakes and tire		
	Unspent munitions and warhead		
	Aircraft engine fire bottles (APU)		
	Nitrogen blowdown bottles		
	Ejection seat oxygen bottles		
	Liquid oxygen bottles		
	Pylon ejector cartridges		
	Canopy and ejection seat devices		
	External fuel tank ejector cartridge		
ELECTRICAL	Power lines		
	Live wires		
RADIOLOGICAL	POD		
	Nuclear weapens		

Checklist 3.9-2 Safety and Health (Sheet 2 of 2)

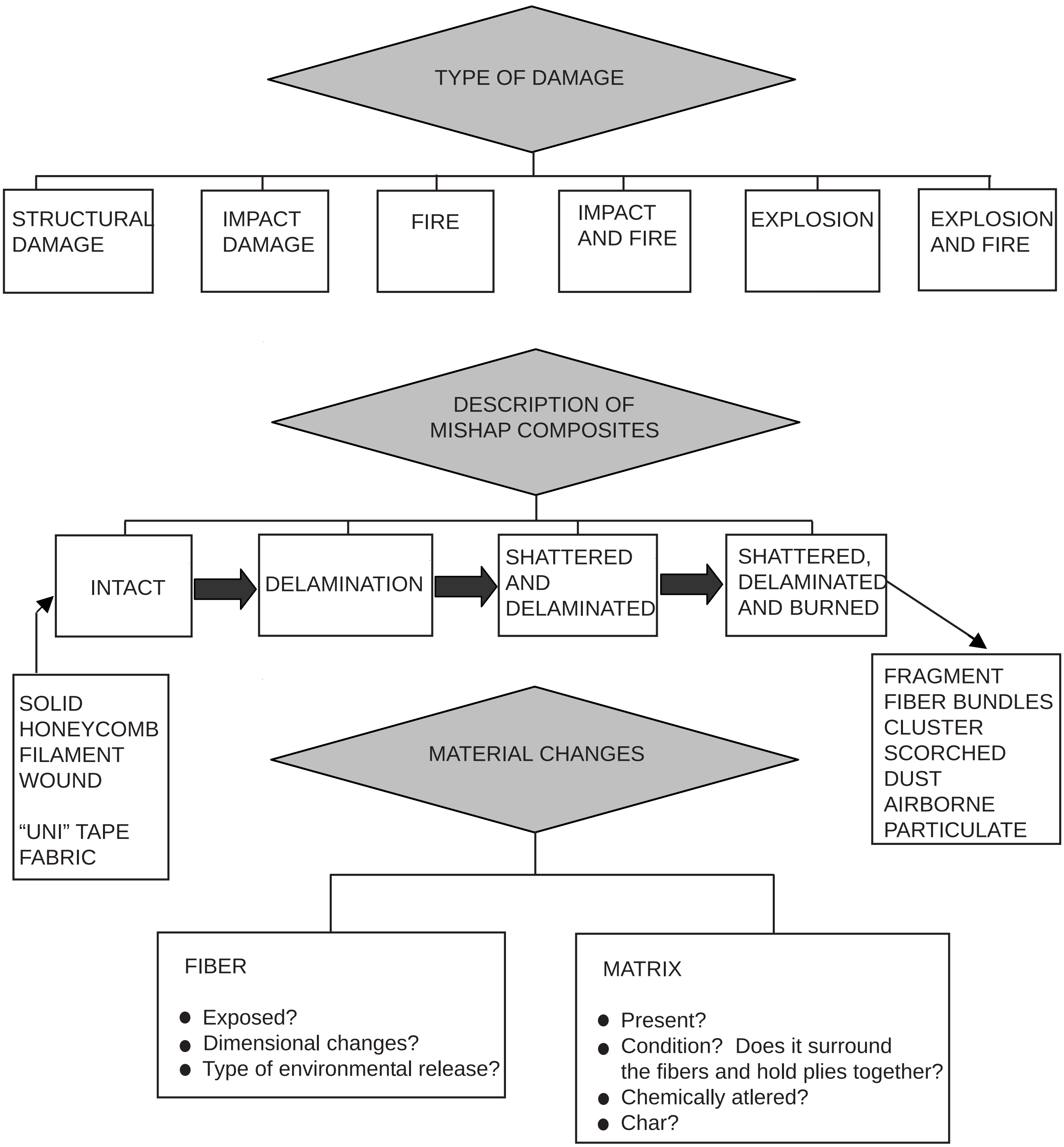
CATEGORY	HAZARD	CONDITION	LOCATION
A/C LIFTING	Unequal distribution of weight		
	Incorrect work zone distances		
BIOLOGICAL	Bloodborne pathogen		
	Bloodborne pathogen		
	Poisonous plants		
	Poisonous insects		
	Animals		
TOXIC	Hypergolic rocket and missile propellant		
	Hydrazine		
	Cargo may contain hazardous chemicals		
	Battery acid and gases		
	Smoke and smoldering material		
COMPOSITE MATERIAL	AFFF soaked composite material		
	Damaged composites: dust and fiber bundles		
	Fuel contaminated composites		
ELEMENTS	Heat stress		
	Cold exposure		
MISCELLANEOUS	Sharp objects		

NOTES:

Flowchart 3.10-1 Safety and Health



Flowchart 3.10-2 Composite Handling Logic



3.11 WHAT TO RESPOND WITH. The information in Table 3.11-1 illustrates what is needed to respond with to an aerospace mishap concerning equipment, apparel and supplies.

Table 3.11-1 Emergency Response Equipment, Apparel and Supplies

Communication Equipment	Hand-held radio
Protective Equipment	Air purifying respirator with dual cartridge (particulate and organic vapor) Disposal respirator N-100 particulate Safety goggles/glasses Mask shield defogger BDU Long sleeve and pant leg Hooded Tyvek Coveralls Hard sole work boots Hard sole and toe boots Hard hat Gloves (liquid chemical resistant, dust resistance, puncture resistant) Biohazard supplies Disposable garbage bags Antibacterial wipes Cleaners & towlettes (alcohol free) Cool vestCold pack Windbreaker Wet Weather Gear Cold Weather Wear
First Aid	First Aid Kit, general purpose Including: metal tweezers, hydrocortisone, burn gels Heat stress indicator Portable eyewash Portable wash unit Thrust quench
Field Equipment	GPS Compass Binocular Wind Speed Indicator Wind Direction Indicator Temperature Indicator Infrared Sensor HEPA Vacuum Floodlights and flashlight Canvas Duct Tape Batteries 6mil plastic sheeting Felt tip marker Shipping Labels Back Pack Sprayer Fixant 10 gallon water container Rescue tools and multi-pliers
Reference Material	T.O. 00-105E-9, Chapter 3 and aircraft specific chapter S/H sketch S/H summary