NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

September 24, 2014

MATERIALS LABORATORY FACTUAL REPORT Report No. 14-066

A. ACCIDENT

Place	:	Bagram Air Base, Afghanistan
Date	:	April 29, 2013
Vehicle	:	747-400 BCF
NTSB No.	:	DCA13RA081
Investigator	:	Brian K Murphy, AS-40

B. COMPONENTS EXAMINED

114 post accident tie-down strap segments

C. DOCUMENTS REVIEWED

J.W.S. Hearle, B. Lomas, and W.D. Cooke, *Atlas of Fiber Fracture and Damage to Textiles*, 2nd ed. (Cambridge, England: Woodhead Publishing Limited, 1998), Chapters 6 and 45.

C. DETAILS OF THE EXAMINATION

Prior to receiving the tie-down strap segments each strap segment was cut with shears on one end after the accident. The other end is in its post-accident as-recovered condition. There were 91 strap segments documented as-received at the Materials Laboratory Division. Of these 91 segments, 65 were positively identified. Many of the labelled markings on the strap segments had evanesced and became indistinguishable. In an attempt to identify as many of the segments as possible, comparisons were made with the as-received documented images. Figures 1 – 6 are images of the as-received tie down strap segments. The remaining 26 segments were labelled in a discriminating manner with segment type, for example, color, size, shape, and markings. These segments were labelled A – Z. Figures 7 – 12 are images of all the examined tie-down strap segments.

Table 1 is a list of all strap segments along with the type of segment. The third column lists examination observations on all as-received segments. All the strap segments were examined using a (5 – 200X) digital zoom microscope. The received strap segments appear to have all failed due to overstress (OS) pulling or tearing. In one case, the failed end of the strap segment exhibited 100 % melting of the filament ends. Segment number

10A is an example of this melting. In this case, the failure mode could not be determined. A portion of one of each different type of received strap segment was evaluated using Fourier Transform Infrared (FTIR) spectrometry. All received strap types exhibited some photodegradation. The strap identification and segment type is given as: 2A - 9M, 36A - CGU-1/B CL2 2Z947/C1287C240, 41A – Blue - 51A - GA-FFG09-1, 52A – White, 55A – Yellow, and 60A - TSO C172 S/N 077649. The following segment types were not received and therefore could not submitted for FTIR analysis: GA-NEU09-1, Red, and Tiger. FTIR spectrometry revealed that all submitted segment types were polyester-based strap material (table 2).

Approximately ½ inch of strap segment identified as 70A was observed to be shear-cut on one end. It was not known whether this cut was made before the accident occurred or during sample recovery. A close up view of the cut area is shown in figure 13 and compared to an exemplar shear cut from segment 1A in figure 14. After reexamining the cut end of the strap, it was observed that no melting or darkening of the strap filaments existed. Therefore it was determined that the cut was made in its post accident as-recovered condition.

Figure 1. Image 1 of as-received tie-down strap segments.

Figure 2. Image 2 of as-received tie-down strap segments.

Figure 3. Image 3 of as-received tie-down strap segments.

Figure 4. Image 4 of as-received tie-down strap segments.

Figure 5. Image 5 of as-received tie-down strap segments.

Figure 6. Image 6 of as-received tie-down strap segments.

Figure 7. Image 1 of examined tie-down strap segments.

Figure 8. Image 2 of examined tie-down strap segments.

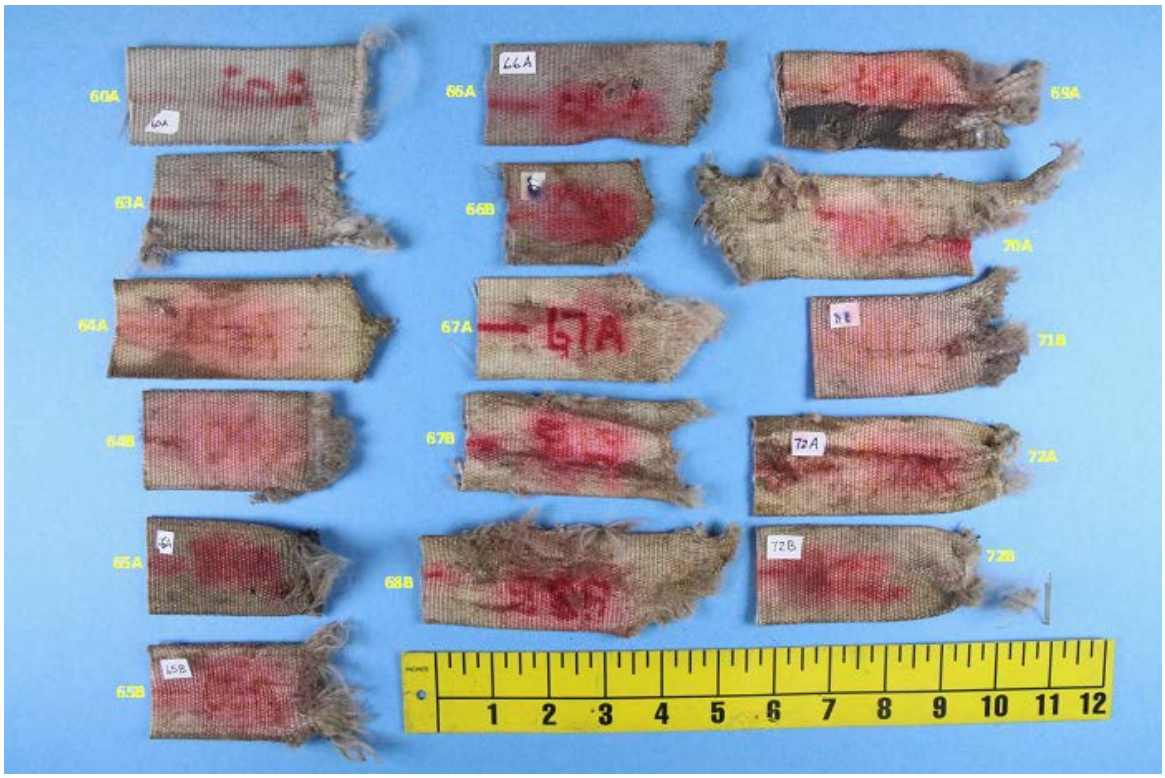

Figure 9. Image 3 of examined tie-down strap segments.

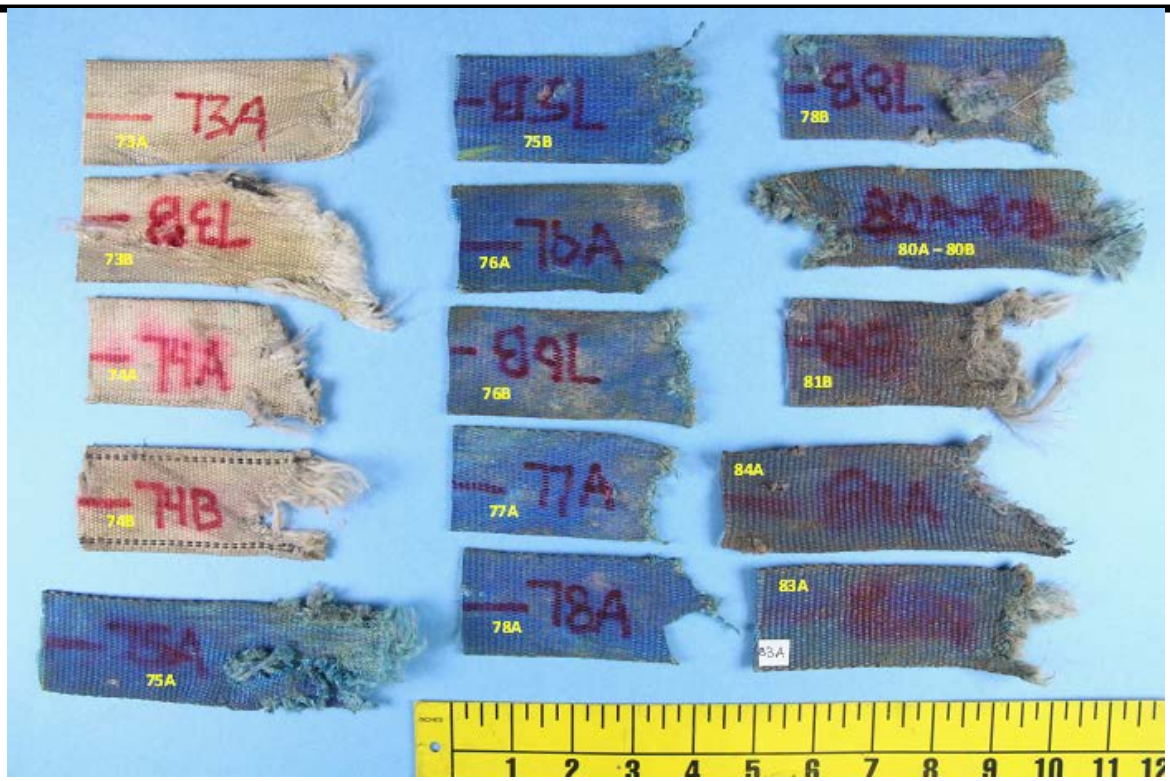

Figure 10. Image 4 of examined tie-down strap segments.

Figure 11. Image 5 of examined tie-down strap segments.

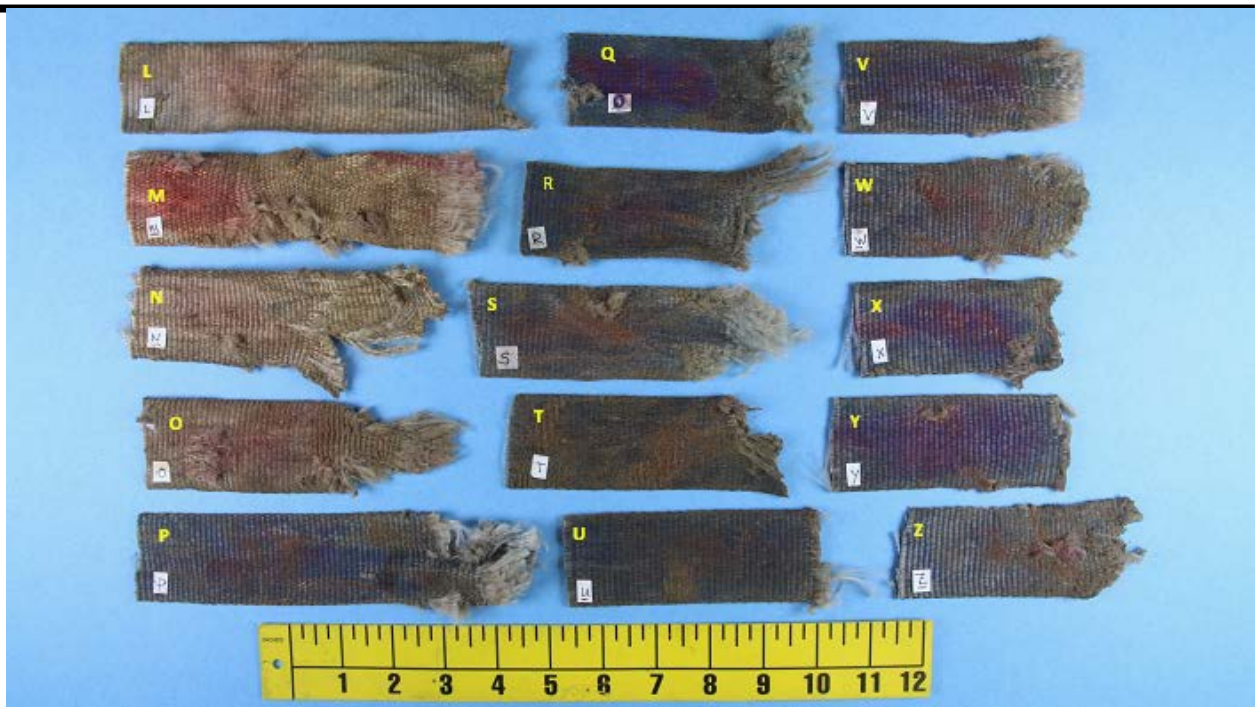

Figure 12. Image 5 of examined tie-down strap segments.

Table 1 (OS = overstress failure)

Strap End ID	Type	Observations
1A	9M	OS
2A	9M	OS
3A	9M	OS, angled tear consistent with contact with sharp object
4A	9M	OS
5A	9M	OS, necking
6A	9M	OS, angled tear consistent with contact with sharp object
6B (B)	9M	markings were not identifiable, arbitrarily assigned letter B to this segment, see B below
7A	9M	OS, necking (bottom), angled tear consistent with contact with sharp object
8A	9M	OS
9A	9M	OS
10A (D)	9M	markings were not identifiable, arbitrarily assigned letter D to this segment, see D below
10B	9M	extreme melting
11A	9M	OS

12A	9M	OS
13A	9M	OS, necking
14A (E)	9M	markings were not identifiable, arbitrarily assigned letter E to this segment, see E below
15A	9M	OS, slight necking
16A	9M	OS, darkening of filament ends, slight melting
17A	9M	OS
18A	9M	OS, slight necking
19A	9M	OS, considerable necking
20A (F)	9M	markings were not identifiable, arbitrarily assigned letter F to this segment, see F below
21A (G)	9M	markings were not identifiable, arbitrarily assigned letter G to this segment, see G below
22A (H)	9M	markings were not identifiable, arbitrarily assigned letter H to this segment, see H below
23A (I)	9M	markings were not identifiable, arbitrarily assigned letter I to this segment, see I below
24A (J)	9M	markings were not identifiable, arbitrarily assigned letter J to this segment, see J below
25A (K)	9M	markings were not identifiable, arbitrarily assigned letter K to this segment, see K below
26A	9M	strap segment missing
27A	9M	OS, slight necking
28A	Red	strap segment missing
29A	Red	strap segment missing
30A	GA-NEU09-1	strap segment missing
31A	Tiger	strap segment missing
32A	CGU-1/B CL2 2Z947/C12687C240	strap segment missing
33A	CGU-1/B CL2 2Z947/C12687C240	strap segment missing
34A	CGU-1/B CL2 2Z947/C12687C240	strap segment missing
35A	CGU-1/B CL2 2Z947/C12687C240	strap segment missing
36A	CGU-1/B CL2 2Z947/C12687C240	OS, consistent with contact with sharp object

37B	CGU-1/B CL2 2Z947/C12687C240	OS, darkened filament ends, consistent with contact with sharp object
38A	9M	strap segment missing
39A	9M	strap segment missing
40A (A)	Blue	markings were not identifiable, arbitrarily assigned letter A to this segment, see A below
40B (P)	Blue	markings were not identifiable, arbitrarily assigned letter P to this segment, see P below
41A	Blue	OS, melting
41B	Blue	OS
42A	Blue	OS, darkening of filament ends, consistant with contact with sharp object
43A (Q)	Blue	markings were not identifiable, arbitrarily assigned letter Q to this segment, see Q below
44A (R)	Blue	markings were not identifiable, arbitrarily assigned letter R to this segment, see R below
44B (S)	Blue	markings were not identifiable, arbitrarily assigned letter S to this segment, see S below
45A (T)	Blue	markings were not identifiable, arbitrarily assigned letter T to this segment, see T below
46A	Blue	OS, melting, consistent with contact with sharp object
47A	Blue	OS, consistent with contact with sharp object
47B	Blue	OS, darkening of filament ends, consistant with contact with sharp object
47C	Blue	OS, melted, consistent with contact with sharp object
48A (U)	Blue	markings were not identifiable, arbitrarily assigned letter U to this segment, see U below
49A (V)	Blue	markings were not identifiable, arbitrarily assigned letter V to this segment, see V below
50A (W)	Blue	markings were not identifiable, arbitrarily assigned letter W to this segment, see W below

51A	GA-FFG09-1	OS, significant melting
52A	White	OS
53A (L)	White	markings were not identifiable, arbitrarily assigned letter L to this segment, see L below
54A	White	OS, melting
55A	Yellow	strap segment missing
56A	Yellow	OS, melting
57A (M)	White	markings were not identifiable, arbitrarily assigned letter M to this segment, see M below
57B (N)	White	markings were not identifiable, arbitrarily assigned letter N to this segment, see N below
57C (O)	White	markings were not identifiable, arbitrarily assigned letter O to this segment, see O below
58A	White	strap segment missing
59A	Blue	strap segment missing
60A	TSO C172 S/N 077649	OS
61 A	White	strap segment missing
62A	White	strap segment missing
62B	White	strap segment missing
63A	White	OS, melting, consistent with contact with sharp object
63B	White	strap segment missing
64A	White	OS, melting, consistent with contact with sharp object
64B	White	OS, darkened filament ends
65A	White	OS, necking, considerable melting, consistent with contact with sharp object
65B	White	OS, significant melting
66A	White	OS, significant melting, consistent with contact with sharp object
66B	White	OS, significant melting
67A	White	OS, melting, consistent with contact with sharp object
67B	White	OS, significant melting (center of strap)
68A	White	strap segment missing
68B	White	OS, angled direction is consistent with contact with sharp object

69A	White	OS, significant melting observed
69B	White	strap segment missing
70A	White	LS + RS top OS,melting, RS botomt appears to be cut with knife or shear
70B	White	strap segment missing
71A	White	strap segment missing
71B	White	OS, curving to one side at failure
72A	White	OS, significant necking , significant melting
72B	White	OS, significant necking , melting
73A	White	OS, slight necking, slight melting
73B	White	OS, curving to one side at failure, necking
74A	White	OS, angled direction may be consistent with contact with sharp object, melting
74B	White	OS, melting
75A	Blue	OS, significant melting
75B	Blue	OS, significant melting
76A	Blue	OS, extreme melting, consistent with contact with sharp object
76B	Blue	OS, significant melting, consistent with contact with sharp object
77A	Blue	OS, melting, consistent with contact with sharp object
78A	Blue	OS, melting, consistent with contact with sharp object
78B	Blue	OS, melting, consistent with contact with sharp object
79A (X)	Blue	markings were not identifiable, arbitrarily assigned letter X to this segment, see X below
80A	Blue	OS, melting, necking, consistent with contact with sharp object
80B	Blue	OS, melting, consistent with contact with sharp object
81A (C)	Blue	markings were not identifiable, arbitrarily assigned letter C to this segment, see C below
81B	Blue	OS, darkened filament ends
82A (Y)	Blue	markings were not identifiable, arbitrarily assigned letter Y to this segment, see Y below

83A	Blue	OS, melting
83B (Z)	Blue	markings were not identifiable, arbitrarily assigned letter Z to this segment, see Z below
84A	Blue	OS, severe melting, consistent with contact with sharp object
84B	Blue	strap segment missing
A(40A)	Blue	OS, slight necking
B(6B)	9M	OS
C(81A)	Blue	OS, slight necking, melting, consistent with contact with sharp object
D(10A)	9M	OS
E(14A)	9M	OS, slight necking, darkened filament ends, possible slight melting
F(20A)	9M	OS, slight necking
G(21A)	9M	OS, necking, darkened filament ends
H(22A)	9M	OS, necking, pulling in bottom direction, some significant melting
I(23A)	9M	OS, angled tear and underside cut is consistent with contact with sharp object
J(24A)	9M	OS, darkened filament ends
K(25A)	9M	OS
L(53A)	White	OS, significant melting, consistent with contact with sharp object
M(57A)	White	OS, darkened filament ends
N(57B)	White	OS, significant melting, consistent with contact with sharp object
O(57C)	White	OS, darkened filament ends
P(40B)	Blue	OS, darkening of filament ends, portion of strap is consistent with contact with sharp object
Q(43A)	Blue	OS, slight necking, darkening for filament ends
R(44A)	Blue	OS, darkening for filament ends
S(44B)	Blue	OS
T(45A)	Blue	OS, melting

U(48A)	Blue	OS, significant melting, consistent with contact with sharp object
V(49A)	Blue	OS, darkening of filament ends
W(50A)	Blue	OS, significant melting
X(79A)	Blue	OS, extreme melting, consistent with contact with sharp obect
Y(82A)	Blue	OS, melting, consistent with contact with sharp object
Z(83B)	Blue	OS, extreme melting, consistent with contact with sharp obect

Table 2

Strap End ID	**Type**	**Results**
2A	9M	Polyester-based
36A	CGU-1/B CL2 2Z947/C1287C240	Polyester-based
41A	Blue	Polyester-based
51A	GA-FFG09-1	Polyester-based
52A	White	Polyester-based
55A	Yellow	Polyester-based
60A	TSO C172 S/N 077649	Polyester-based
30A	GA-NEU09-1	not received
28A, 29A	Red	not received
31A	Tiger	not received

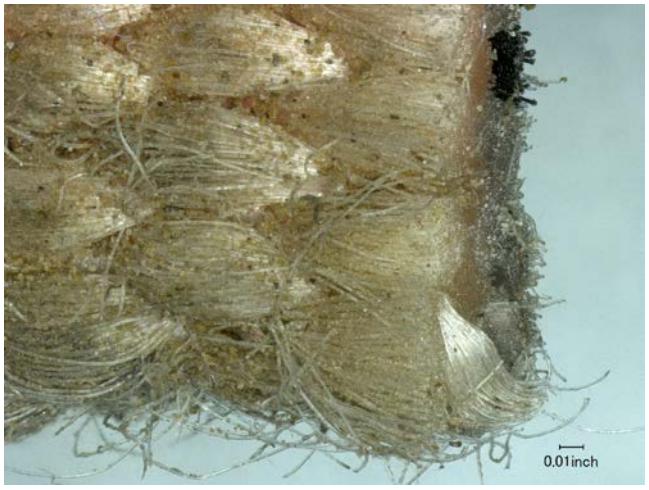

Figure 13. segment 70A

Figure 14. exemplar, segment 1A

Edward J. Komarnicki
Engineering Technician