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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, DC

FACTUAL REPORT ON SPLATTER DEPOSITS

JULY 20, 2000

(18 pages)

NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Washington. D.C. 20594

July 20, 2000

FACTUAL REPORT ON SPLATTER DEPOSITS

A. ACCIDENT: DCA96MA070

Location: East Moriches, New York
Date: July 17, 1996
Time: 2031 Eastern Daylight Time
Airplane: Boeing 747-100, N93119

B. SPLATTER GROUP PARTICIPATING

Chairman	Merritt Birky, NTSB
Co-Chairman	Michael Marx, NTSB
Member	Jim Wildey, NTSB
Member	Rocky Miller, IAM/FA
Member	Stephen F. Klapach, FAA
Member	Tony Cable, AAIB, United Kingdom
Member	Mike Huhn, ALPA
Member	Dan Rephlo, TWA
Member	Fred Liddell, IAM

C. BACKGROUND

Parts of the wing center section (WCS) and portions of the cabin interior above and forward of the WCS were found to have deposits of a dark brown rubbery (spongy) material whose presence and characteristics were not initially readily understood or explained. The features of the deposits were recorded in detail and their composition and physical characteristics were assessed by chemical analysis. The group met at the Calverton hanger on November 5 to November 7, 1997.

Components in area of splatter

A large conditioned air plenum chamber located on top of the WCS aft of spanwise beam #2 (SWB2) is fed from the three environmental conditioning system (ECS) packs beneath the WCS. A large outlet duct at the forward left corner of the plenum has a small branch off at SWB2 between Floor Beams 1-2 for the flight deck conditioned air supply. The branch incorporates a "Y" inlet between stringers[1] 21-22 for trim air. The trim air is higher temperature bleed air diverted from the pack inlets and is added on demand to the conditioned air to increase the conditioned air temperature. The trim air pipe, an insulated metal pipe, is routed under the WCS, up behind the rear spar and forward over the WCS top skin. It attaches to the conditioned air duct inlet via an elastomeric sleeve/jubilee clip connector.

The forward end of the flight deck branch (located between stringers 22-23) is connected with adhesive tape to a long duct passing over the WCS between Floor Beams[2] 1-2 to the front spar (FS) and then forward to the flight deck. The long duct over the WCS is of rectangular section, mounted to the WCS top skin at stringers 23 and 30. It is covered with an approximate ½-inch-thick insulation blanket of flexible plastic foam. The duct occupies approximately the left 30-40% of the approximately 22-inch width of the bay between Floor Beams 1 and 2. The duct cross section varies over its length, with the bottom of the duct roughly following the curvature of the WCS top skin. There are gaps between the duct and both the top skin and Floor Beam 1. These gaps vary between one to two inches. The ducts are made of GRP (glass reinforced plastic).

D. DEPOSITS - GENERAL

The deposits were generally found around the left, forward upper region of the WCS (Figure 1), on the following surfaces:

Deposit 1	Top surface of the upper WCS skin (WCS exterior), including floor beams attached to the WCS skin (CW 114).
Deposit 2	Aft surface of the WCS Front Spar (WCS interior, CW 504) .
Deposit 3	Area of left fuselage frames and floor beams just forward of the WCS.
Deposit 4	Passenger seats, particularly the left side of the left armrest of Seat 23-4.
Deposit 5	Left side ECS duct from above and forward of the WCS.
Deposit 6	Floor board and floor board support at station 960.

Parts of Deposit 1 had a somewhat different nature from the other deposits, but superficially all appeared to be of the same material. This was a generally amorphous, dark-brown, elastomeric material that adhered tightly to the various surfaces, similar in

[1] Stringers in this report refer to lateral stiffening members on the lower (interior) surface of the upper skin of the WCS. The stringers are numbered from the rear of the WCS in the forward direction.
[2] Floor beams are oriented longitudinally above the WCS and are numbered from left to right.

appearance and consistency to the WCS fuel tank sealant. Much of the deposit was present as specks of typically around 0.05-0.10 inch diameter, with varying separation between specks. In quite a number of cases the deposit was in the form of narrow streaks, typically around 0.1-1.0 inch long.

Parts of the Deposit 1 were in the form of blobs, with a typical diameter of around 0.3 inch, that were somewhat darker in color and less flexible than the other deposits and had a slightly sticky feel. These appeared to have dripped or splattered onto the surface but most of the material seemed to have sprayed on. The material generally appeared to have been deposited in molten or semi-molten form and to have solidified on the surfaces (perhaps due to a phase change on cooling, solvent evaporation, or chemical curing). Small parts of the front spar deposit appeared to have been smeared onto the surface, rather than having been deposited in molten form. Deposit 2 also included small fragments of a light brown material with a cellular structure adhering to the surface.

All surfaces of all the identified parts of the WCS and the surrounding fuselage were examined closely, together with the available identified floor panels and carpet in the general area. Surrounding passenger seats (approximately Rows 15-30) were also inspected closely. Except as described below, no other signs of splatter deposit were found on any of these components.

The characteristics of the splatter deposits in the above five areas were as follows.

E. DEPOSIT DETAILS

Deposit 1 - Top Surface of WCS Upper Skin

Figure 2 shows a schematic of the location, density and nature of Deposit 1. The main deck longitudinal floor beams over the WCS and the bays between them are numbered left to right (see also figures 5 and 6).

Longitudinal Extent: The deposit extended from just aft of SWB2 to the FS, a distance of approximately 100 inches.

Lateral Extent: The deposit was between main deck longitudinal Floor Beams 1-2 (left buttock line LBL 98.6-LBL 75.9), plus a few spots between Floor Beams 2-3 near the intersection of Floor Beam 2 and the Front Spar (within around 3 inches of both).

Vertical Extent: The deposit was present on the left side of Floor Beam 2 forward of approximately Stringer 27, commonly over its full remaining height (approximately 85% of the original height), particularly near the FS (stations 1052-998). The longitudinal floor beam forward of 998 is not present. A few

spots were present on the right side of Floor Beam 1. The tension fitting of SWB3 at LBL 98 has splatter deposits on the aft side.

Concentration: The area of the deposit on the WCS top skin between Floor Beams 1-2 was generally biased somewhat left of center over its aft portion (between stringers 20 and 26) and right of center between Stringer 26 and the FS (approximately between LBL 76-87). The left side of the top surface between SWB3-FS where the flight deck conditioned air duct runs (LBL 89-97) had some deposit between stringers 23-26 but generally only isolated spots further forwards. In the forward region the left edge of the deposit area was fairly sharply, albeit incompletely, demarcated at approximately the position of the right side of the duct.

Direction: Deposits had accumulated on the aft face of the vertical stiffeners attached to the left side of Floor Beam 2; on the aft side of the dome heads of top skin rivets immediately aft of the FS; on the aft facing side of scallops in the top skin just behind the FS; on the aft facing side of scallops in the right side of Floor Beam 1. Directional features were not evident in parts of the deposit, particularly much of that on the WCS top surface between stringers 25-29.

Continuity: The deposit was generally continuous across fractures in the WCS top skin. In most cases parts of individual streaks could be found on either side of the fracture. There were some signs of possible discontinuity across a small length of the fracture between CW114 and CW164, at Stringer 30. LBL 90-92, but the evidence was inconclusive and could be the result of recovery, reconstruction, etc.

Nature: The deposit was generally of moderate density, medium sized streaks between stringers 20-25; of high density, large blobs (lacking direction) between stringers 25-29; and of moderate density, smaller sized streaks between Stringer 29-FS.

Deposit 2 - WCS Forward Spar

Longitudinal Extent: The deposit was found on the aft face of part of the FS formed by CW504 and CW515, on both the spar web and on the vertical stiffeners (Figure 3). The top edge of the FS (CW504) has splatter material between LBL100 to 104.

Lateral Extent: The deposit was found on the whole width of the upper part of CW504 and on the left one half of CW515. The total width was approximately 32 inch at the top of the FS (LBL 83-114).

Vertical Extent: The deposit area extended from the top of the FS down to a depth of approximately 36 inch on the left side and 14 inch on the right side.

Concentration: The deposit was most dense over the upper few inches of CW504, particularly in the top left corner of CW504 (estimated coverage in the order of 10%), becoming progressively sparser with distance from this point to fade out at the extremities of the area. FS stiffeners had been deformed in a number of places in the area; in some cases the deformation appeared to have resulted in blanking (an absence of the deposit) of the forward facing part of the deformed stiffener and of the part of the FS web aft surface covered by it, but not in others. No pattern was discerned in these features.

Direction: No pattern was strongly evident, but some signs suggested a predominance of deposit streaking in a radial pattern, down and to the right from an area around the top left corner of CW504.

Continuity: The deposit was totally discontinuous across the fractures between the left side of CW504 and the adjoining FS fragments CW518, CW504A and CW516. No deposit was found on the latter three fragments. The deposit was continuous across the fracture between CW504 and CW515. There was splatter on the left top of the 504 web where the web is normally masked by the pickle fork fitting.

Nature: The deposit was generally of moderate density, small sized spots and streaks near the top left, progressing to sparse very small spots at the extremities of the deposit area. Small parts of the deposit in the upper central part of CW504 (LBL 98-107) appeared to have been smeared. In some areas of the deposit, particularly towards the top of the FS, small fragments of a light-brown material with a cellular structure were found adhering to the surface. A gouge in the vertical stiffener at LBL98.48 has splatter material in it.

Deposit 3 - Fuselage and Floor Beams Forward of WCS

Location: The deposit was present on localized areas of three fuselage frames and adjacent main deck lateral floor beams between stations 1000-940 and left fuselage stringers 26-27 (just below the main deck floor).

Concentration: The deposits were sparse, with maximum density towards the region where the left side of the floor beam met the respective frame, and were more marked towards the rear of the area. There is more splatter at station 980 than on 960.

Direction: The deposits were exclusively on the aft face of the fuselage frame webs and on the aft face of the floor beams.

Continuity: No evidence was available as the deposits were localized and did not cross fractures where the fragments on each side had been identified.

Nature: The deposit was generally of sparse, very small specks.

Deposit 4, Passenger Seats

Seat 23-4 Armrest

Location: Deposit on left side of the left armrest of Passenger Seat 23-4, located approximately relative to the WCS (see figure 7):

Longitudinal	-	WCS stringers 22-24
Vertical	-	34 inch above the WCS top surface

Features: The deposit consisted of a series of fairly sparsely spread, generally horizontal streaks of moderate size, apparently similar to the WCS deposit material. A similar effect was not present on any other identified seats in the center or forward cabin.

Seats 21-2 and 21-3

Location: Possibly similar deposit on the under surface beneath the seat pan webbing of Seats 21-2 and 21-3, located approximately relative to the WCS:

Longitudinal	-	WCS Stringer 31-FS.
Lateral	-	Between Floor Beams 1-3.
Vertical	-	21 inch above the WCS top surface

Features: The deposit consisted of a very few spots of dark rubbery material, superficially similar to the material of Deposits 1, 2 & 3.

Seats 19-1 and 19-2

Location: Deposit on the two trays hinged from the back of Seats 19-1 and 19-2, on the aft face of the tray, as stowed, located approximately relative to the WCS:

Longitudinal	-	Station 954 (46 inch forward of FS).
Lateral	-	LBL 87 and LBL 104.

Features: The deposit consisted of one or two small spots of material on each tray, superficially similar to the material of Deposits 1, 2 & 3.

Deposit 5 - Ducts

Three pieces of the air conditioning long duct were identified (P/N 69B42220) which were located between the cabin floor and the WCS top surface. The three pieces had an aggregate length of about 67 inches of a total of length of about 85 inches (figure 5). The aft section of the "S" duct was located. This section curves down and outboard and attaches to the long duct. This "S" duct piece had mechanical damage to the

polyurethane insulation but contained no fire damage. According to the date written on the piece it was recovered during trawling operations. The insulation on the "S" duct appears to have been scraped off and the "S" duct is split longitudinally on the forward end. The inside surface was relatively clean but did contain some evidence of splatter in two locations. The first location was on the inside outboard top corner. In this location the piece fractured with 3 distinct plies separated with splatter material between the plies. The second inside surface splatter location extended from the forward separation where the piece contained a partial split intersecting the fracture. The duct was permanently deformed which resulted in the split surfaces overlapping each other along the length of the split. Movement of the split surfaces apart showed some evidence of blanking (lack of splatter) under the overlap on the inside surface of the duct. Both spatter areas on the inside of the duct indicated the duct was separated in part when the splatter was deposited on these surfaces. An FTIR chemical analysis of a sample of the splatter like material taken from the inside of the "S" duct showed the same characteristic peaks of a sample taken of polyurethane foam insulation (Artech Testing report dated November 18, 1997, attached).

Three pieces of the long duct were located and re-assembled to the top of the WCS skin in their approximate correct positions by mating fracture features and fastening positions.

The first piece of long duct identified was about a 14-inch length of the forward portion that extends from the FS to about WCS upper stringer 32. This portion assembles to the aft end of the "S" duct. Most of the insulation was missing from this piece and there was little evidence of fire or heat damage. There was evidence of splatter like material in various locations on the outboard surface as well as on the bottom surface directly on the fiberglass duct material. Splatter like material was also noted on the inside aft bottom 3 inches that continued across the aft fracture surface. Also some splatter material was found on the inside surface of the duct on the outboard side in the same location.

The second piece of straight long duct identified (intermediate section) was about 28 inches long, had essentially no insulation left on it, and was darkened from fire (figure 5). There was a color discontinuity across the fracture line between this duct piece and the forward duct piece. The forward fractured end corresponded in location to about a position 2 inches forward of Stringer 32 (fuselage station 1015) with the aft end at about SWB3. This piece had part of the duct inboard mounting bracket attached to it for exact positioning relative to the WCS top skin. Splatter like material extended about 1 foot into the duct along the inside bottom surface on the forward end. On the inside inboard surface the splatter material starts at the forward end and goes back about 6 inches. On the inside outboard surface the splatter material starts at the forward end and goes back about 16 inches, although it is intermittent (figure 5).

The third long duct piece, about 25 inches long, mated to the aft end of the above intermediate duct piece. This piece was darkened more than the mating intermediate piece. Splatter like material was found on the inside surfaces starting at the forward end. On the inner surface outboard side the splatter material goes back about 4 inches. No splatter material was noted on the inner surface inboard side. There was also some splatter noted on the inside bottom at the aft end and there was a couple of spots on the aft top inside surface that extends forward about 8 to 10 inches.

Deposits, Floor Panel and Floor Panel Support at Station 960

The floorboard labeled 125 was examined. This board extends from station 980 to 1100 and goes from floor beams 2 to 4 on figure 7. No thermal damage was detected and the white insulation on the underside was largely intact except for areas aft of station 1075. No splatter material was found on this floorboard.

A piece of horizontal support of a floor panel at station 960 between LBL 75 and LBL 98 was located (aft piece of floor panel 108). There was material that was similar to splatter on the inboard aft face extending about 4 inches. This material was also on the inboard fracture surface of this piece and on the underside of the corresponding floorboard (aft piece of 108) near the area of the horizontal support. A sample of the material was taken and analyzed by Artech Testing at the request of the Safety Board. Chemical comparisons by FTIR of the sample to a sample of polyurethane foam insulation showed it was not polyurethane. Artech indicated the substance was probably an oxidized polyolefin or hydrocarbon oil.

F. DEPOSIT ANALYSES

Samples of Deposits 1, 2 & 4 were taken on January 17, 1997 and sent to a NASA analytical laboratory for analysis. Sample 1 was scraped from part number CW114 (reference figure 2) and sample 2 was collected from the surface of CW 504 (reference figure 3). Sample 4 was scraped from the left armrest of seat 4 row 23. Samples 1 and 2 contained chloride, nitrate, and sulfate ions. Sample 4 was too small for an ion analysis. The NASA laboratory identified the dark part of the samples 1, 2 and 4 as a polyurethane and also noted the presence of Nylon and Azlon fibers (see attached NASA reports).

The samples collected on 20 January were analyzed by the Analytical Chemistry Department of the Structural Materials Center, DERA (Defense Evaluation and Research Agency) at Farnborough, UK. Deposits 4 were not analyzed because of the small quantities present. Two of the samples were from the WCS top skin, two from the FS and one from the fuselage frame at station 960. They were compared with samples of materials considered to be possible source candidates from typical components similar to those that would normally be close to the splatter deposit region. These components included fuel tank sealant, composite floor panel, carpet, and 1inch thick plastic foam bonded to the underside of some main deck floor panels. Details of the samples and the sampling procedure are in figure 4.

The DERA analysis (DERA Report No DRA/SMC/WP972038 of 25 February 1997) and discussions with DERA showed that Deposits 1, 2 & 3:

1. Were of the same material.
2. Originated from a flexible polyurethane elastomer.
3. Were of the toluene diisocyanate/polypropylene glycol type, a common source of elastomeric polyurethanes.
4. Were not the same material as either the WCS sealant, the carpet, the floor panel or the floor panel foam samples.
5. Appeared to be molten when deposited.
6. Had initially melted, and solidified on the surfaces due to a phase change when the material had cooled.
7. Had been at a temperature in excess of 493° F (256° C), as determined by the softening temperature and may have been at higher temperatures resulting in a scorched appearance and/or hardening (a portion of deposit 1 around SWB3).

It was also reported that:

1. NASA analysis of the foam insulation and an independent analysis conducted by the FBI at Brookhaven National Laboratory on the foam insulation on the ECS duct and a sample of the splatter from the top of the tank showed that the foam insulation and the splatter were both polyurethane. The dark part of deposit 4 taken from the left armrest of seat 4 row 23 was identified as a polyurethane material (see attached NASA Report dated April 30, 1997).

2. The cellular structure of some of the deposits on the FS of CW 504 was reported by NTSB to contain a cellular structure similar to a sample of the foam insulation from a duct.

G. ANALYSIS OF MATERIAL FROM ANOTHER B-747 AIRCRAFT

An S shaped duct taken from a B-747-131 airplane with serial number 19675 and hull number 43 built in 1970, was examined. The purpose of this examination was to determine the uniqueness and source of the fibers that were observed to be imbedded in the urethane splatter material on the accident airplane. Similar fibers were found on the outside surface of this second duct. These fibers had the same physical and chemical characteristics as the fibers found in the splatter material. Fibers from the seats and the carpeting material were analyzed from this airplane and found to be consistent with the fibers found on the duct. Further details of this analysis are found at the end of this report.

H. "Y" INLET BETWEEN STRINGERS 21-22 FOR TRIM AIR

The group explored possible airplane sources of higher than normal heat incoming to the area of the splatter. The only airplane source identified by the group was possible overheated trim air entering the duct between stringers 21-22. Splatter on the top of the WCS appeared to extend to the "Y" inlet area for the trim air. The insulated metal trim air pipe attaches to the conditioned air duct inlet via an elastomeric sleeve/jubilee clip connector. This trim air pipe was located within the recovered wreckage and examined. As recovered it contained a separated portion of the elastomeric sleeve still connected to the end that attaches to the "Y" inlet. Examination of the sleeve piece disclosed no evidence of an overheated condition.

I. FINDINGS

1. In all WCS, fuselage frame, and passenger seat locations the splatter deposits were consistent in chemical composition with the polyurethane foam insulation attached to the outside surfaces of the long and "S" ducts above and forward of the WCS. The softening temperature of this material is approximately 493°F or above.
2. The discontinuity of the splatter pattern across CW504 and CW515 compared to adjacent pieces of the front spar show that these two pieces had displaced forward prior to splatter accumulation on them. Motion of CW504 forward would cause the top edge of this piece to strike the "S" duct at the position where cellular deposits were found. The splattered piece, CW504, was located in the early debris field indicating that it had displaced and separated from the aircraft very early in the break-up sequence.
3. The presence and location of splatter inside the long and "S" duct showed that the duct pieces had fractured prior to deposition of this portion of the splatter.
4. There had been a generally forward airflow through the region for at least part of the time during which Deposits 1, 2 & 3 had accumulated. This was clearly evident from the location of the deposits on aft facing surfaces in all three areas (Fig 6).
5. The fibers noted in the deposits are consistent with fibers from the seats and carpeting materials that apparently accumulate on the outside surface of the conditioning ducting.
6. Floor beam 2 was still intact and the cabin floor panels above the bay between floor beams 1 and 2 were probably still in place when the accumulation of Deposit 1 had finished, since the deposit is almost entirely confined to bay 2. However, the floor panels above Deposit 1 were not identified and the presence or lack of splatter on these panels could not be verified.
7. The WCS top skin splatter material had finished accumulating before most or all of the fractures in the affected area of the top skin had occurred. This was shown by the general continuity of deposit streaks across the fractures.
8. The air conditioning long duct remained in bay 2 approximately in its proper position throughout the period when Deposit 1 was accumulated. This was shown

by the deposit distribution pattern. The standoff of the duct from the top of the tank allowed some splatter under the duct.

Merritt M. Birky
Chief Technical Advisor
Fire & Explosions and Chemical Analysis
Chairman, Splatter Group

Figure 1

CENTRE WING BOX

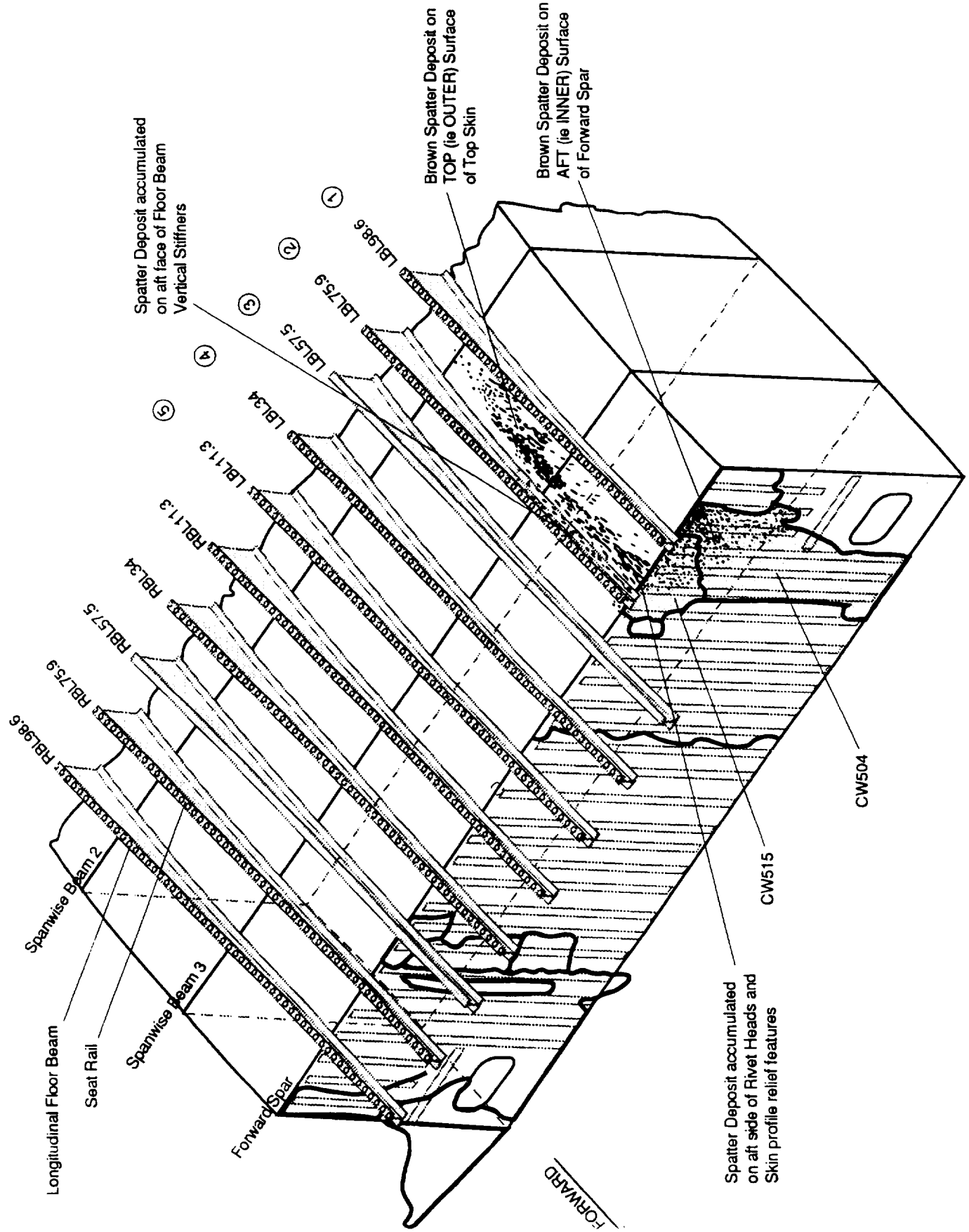


Figure 2

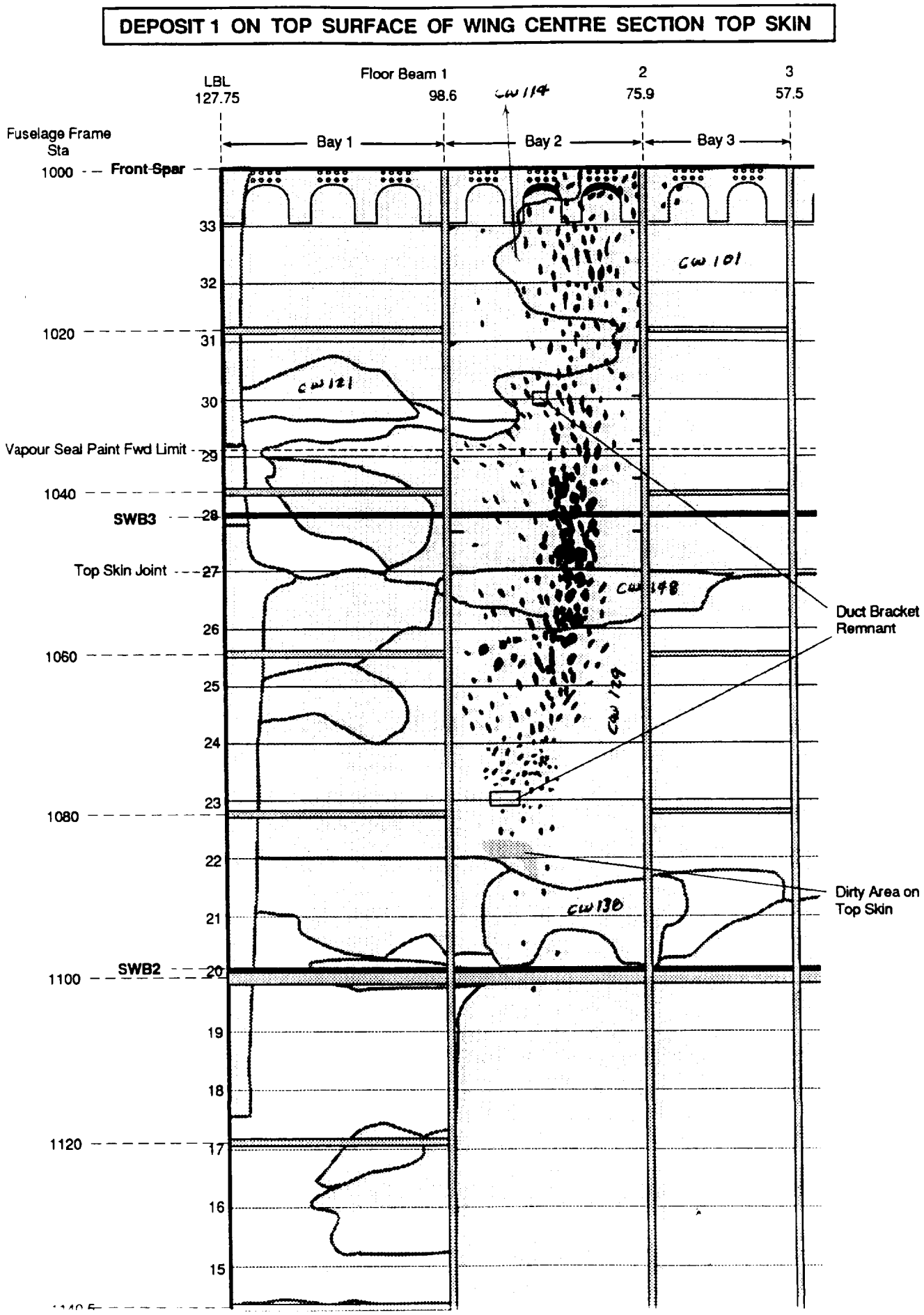
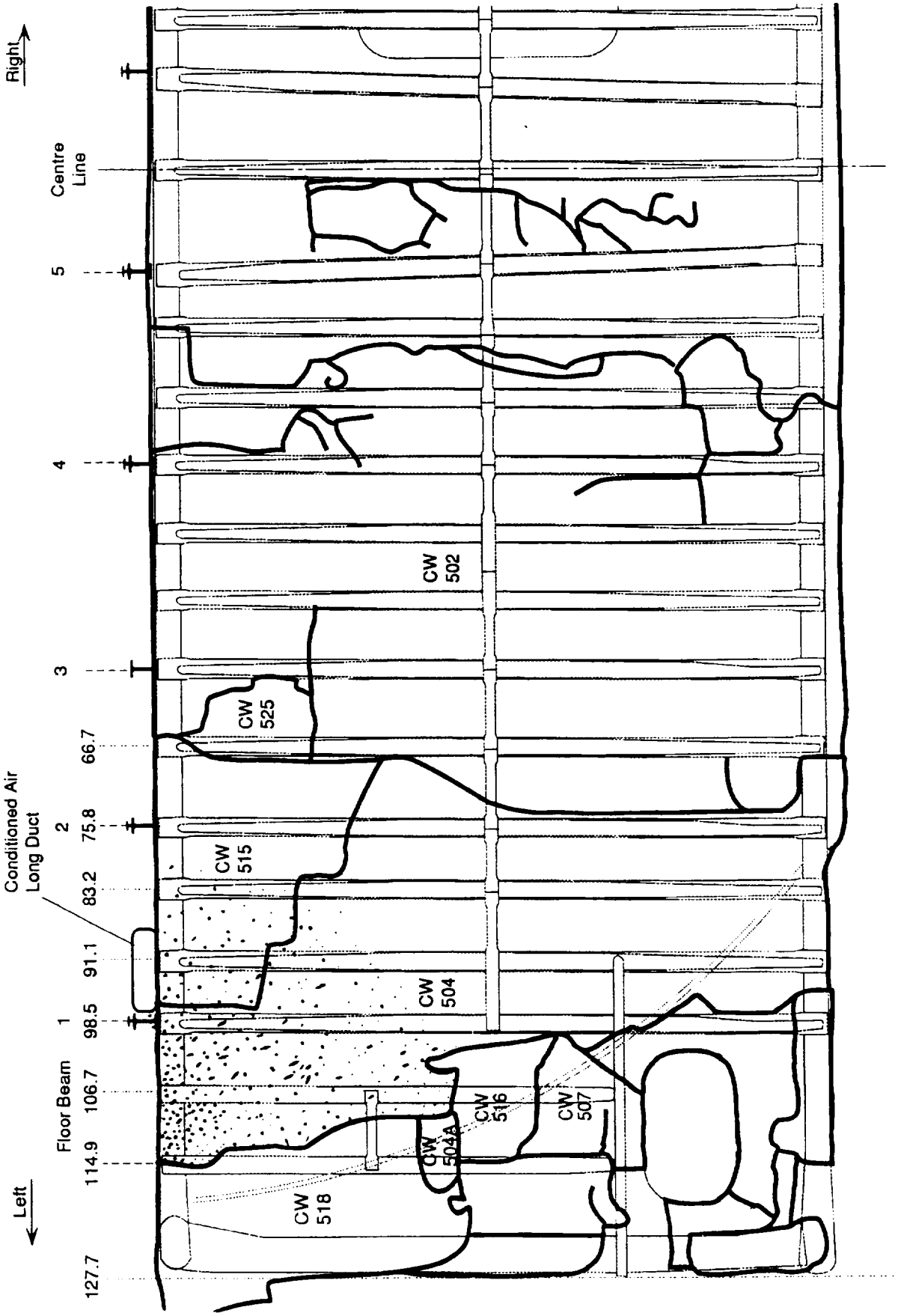

DEPOSIT 1 ON TOP SURFACE OF WING CENTRE SECTION TOP SKIN
LBL
127.75
Floor Beam 1
98.6
2
75.9
3
57.5
Bay 1
Bay 2
Bay 3
Fuselage Frame Sta
1000
Front Spar
1020
Vapour Seal Paint Fwd Limit
1040
SWB3
Top Skin Joint
1060
1080
1100
SWB2
1120
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
CW 114
CW 101
CW 121
CW 148
CW 129
CW 130
Duct Bracket Remnant
Dirty Area on Top Skin

Figure 3

DEPOSIT 2 ON CENTRE WING BOX FRONT SPAR



MPLE ENT 3119-	COMPONENT	GENERAL AREA	LOCATION	POSITION	METHOD
C1	Centre Wing Box	Forward Spar Aft Surface	Top left of Spar Web, Piece CW504	Sta 1000, LBL 109, 12 inch below CWB Top Skin	1
C2	Centre Wing Box	Forward Spar Aft Surface	Right surface of Vertical Stiffner Web, Piece CW504	Sta 1000, LBL 106.72, 12 inch below CWB Top Skin	1
C3	Centre Wing Box	Top Skin Upper Surface	12 inch aft of FS, between longitudinal members under left Seat Rail pair, Piece CW114	Sta 1012, LBL 83	1
C4	Centre Wing Box	Top Skin Upper Surface	5 inch fwd of SWB2, between longitudinal members under left Seat Rail pair, Piece CW130	Sta 1093, LBL 86	2
C5	Fuselage Frame	Left side fwd of CWB FS	Aft face of Frame Web between Stringers 26-27 (ie just below Main Deck Floor)	Sta 960	1
C6	Centre Wing Box	Forward Spar Fwd Surface	Typical Sealant Sample from near Forward Spar top left corner	Sta 1000, LBL 107, 3 inch below CWB Top Skin	2
C7	Carpet	Main Deck	Typical Main Deck Floor Panel Sample		3
C8	Floor Panel	Main Deck	Typical Main Deck Carpet Sample		3
C9	Floor Foam	Main Deck	Typical Sample of 1 inch thick plastic Foam bonded to underside of Main Deck Floor Panel		3

MPLING METHODS:	1 Blob of material sliced off the painted aluminium surface with a cleaned knife blade. 2 Blob of material peeled off surface with cleaned tweezers. 3 Material cut with cleaned knife blade.
ANING:	Tools cleaned with 70% Isopropyl Alcohol before each use.
ECKAGE:	No appreciable fire or sooting in the relevant areas, wreckage submerged in salt water for a number of weeks.

N93119 - DEFINITION OF 20 JAN 97 SPATTER SAMPLES

Figure 4

Figure 5

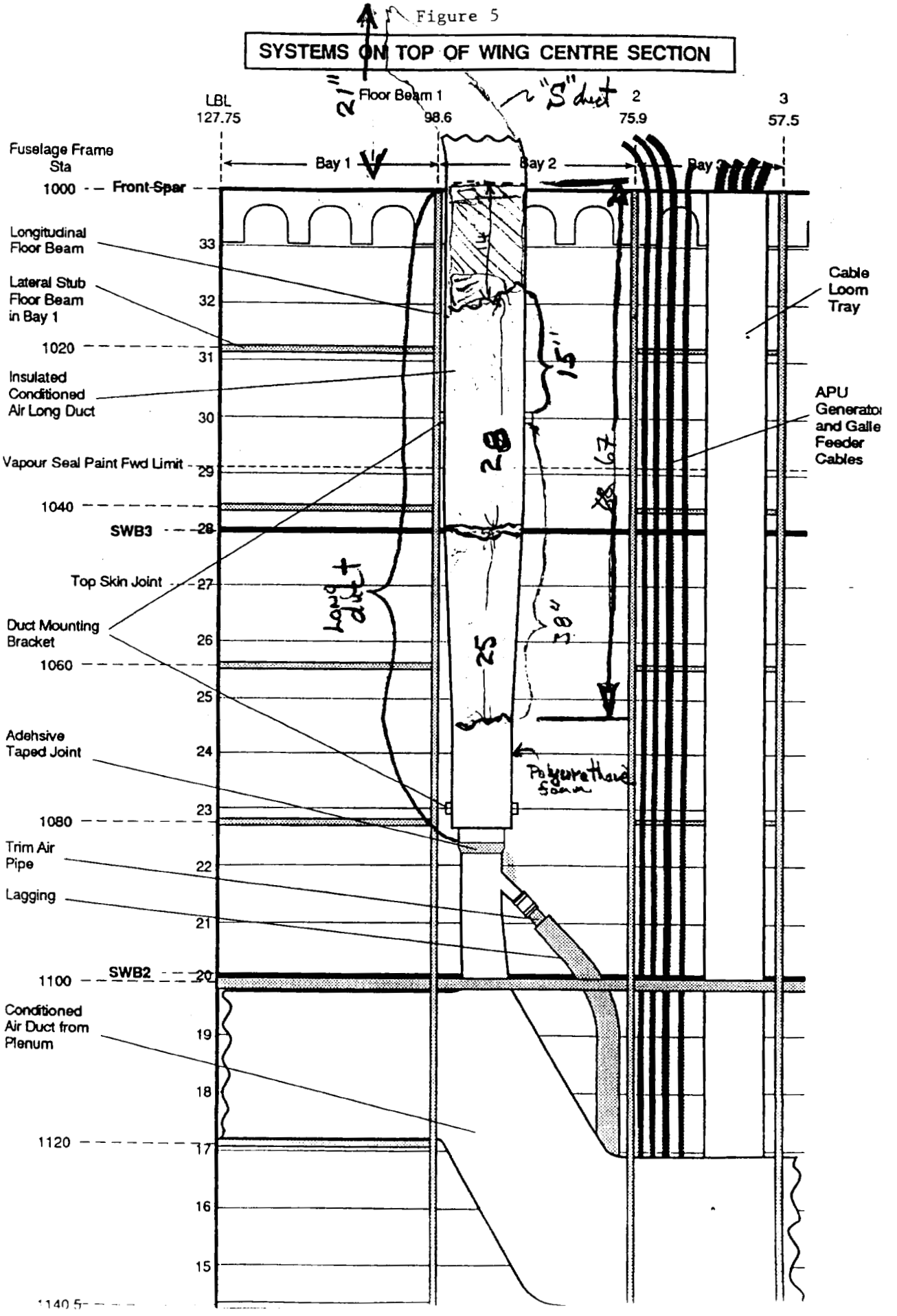

SYSTEMS ON TOP OF WING CENTRE SECTION
LBL
127.75
Floor Beam 1
98.6
"S" duct
2
75.9
3
57.5
Fuselage Frame Sta
Bay 1
Bay 2
Bay 3
1000
Front Spar
Longitudinal Floor Beam
Lateral Stub Floor Beam in Bay 1
1020
Insulated Conditioned Air Long Duct
Vapour Seal Paint Fwd Limit
1040
SWB3
Top Skin Joint
Duct Mounting Bracket
1060
Adehsive Taped Joint
1080
Trim Air Pipe
Lagging
SWB2
1100
Conditioned Air Duct from Plenum
1120
1140.5
Cable Loom Tray
APU Generator and Galle Feeder Cables
Polyurethane foam
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15

Figure 6

DEPOSIT 1 AND SYSTEMS ON TOP OF WING CENTRE SECTION

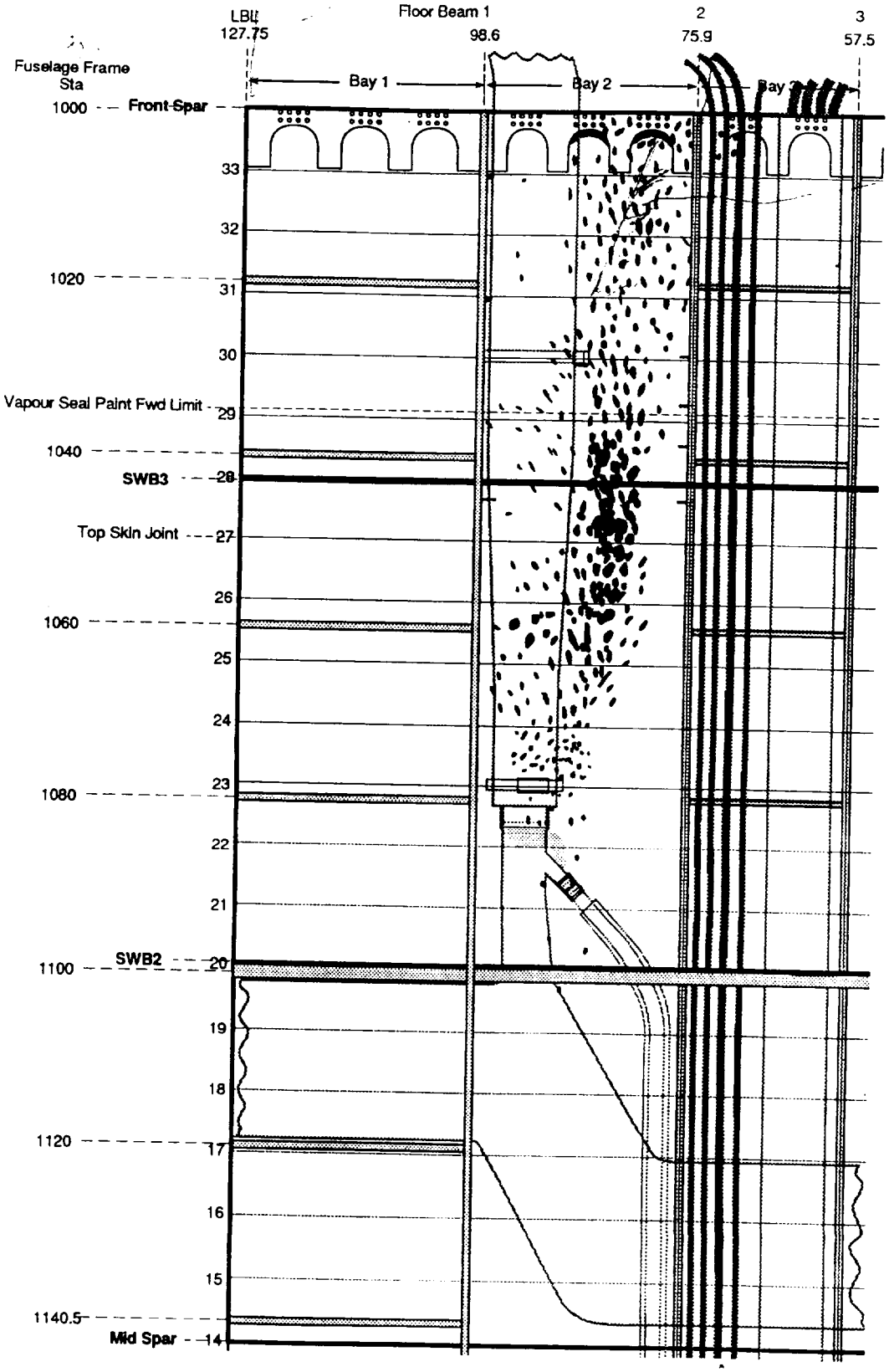


Fig 6

Figure 7

DEPOSITS AROUND WING CENTRE SECTION, SYSTEMS AND SEATS