APPENDIX A

Note: The following extracts are from documents current at the time of the accident.

1. Definition of the symbol ‘CHK’ used in the Dan-Air 707 Maintenance Schedule (and other 707 Schedules of UK origin).

The following extract defines the meaning of ‘CHK’ as it applies to the structural and mechanical areas relevant to this investigation.

"1. Throughout the schedule the abbreviation ‘CHK’ has been used to signify the inspection requirements. This is to be interpreted to mean:-

1.1 That the item has been inspected 'in situ' (unless otherwise stated) to a degree at least sufficient to ensure it remains serviceable until the next higher period for inspection of the item becomes due.

1.2 That the item was free at the time of inspection from any defects likely to affect airworthiness.

1.3 The inspections made to ensure the above must comply with the minimum standards set out hereunder having regard to the material from which the item is made and applying these standards wherever physically possible.

1.4 Metal parts - eg all structural members, bodies or casing of units in systems and in instrument, electrical and radio installations, metal pipes, ducting, tubes, rods, levers etc.

Inspect for:-

(a) Cleanliness. External evidence of damage, leaks, overheating or discharge. Bulging. Obstruction of drainage or vent holes or of overflow pipe orifices. Correct lie of fairings and serviceability of fasteners.

(b) Security of attachments, fasteners, connections, locking and bonding.

(c) Freedom from - cracks (visual), distortion, dents, scores, chafing, evidence of wear, pulled or missing fasteners - eg rivets, bolts, screws, separation of bonds, failure of welds and spot welds. Deterioration of protective treatment and corrosion. Correct sealing of fairings. Fluid ingress.

(d) Discolouration and flecking of dial markings.

1.5 Rubber, Fabric, Fibreglass and Plastic Parts - eg ducting, flexible pipes, flexible mountings, seals, insulation of electrical cables, windows, etc.


(b) Security of attachment (supports, packing and electrical bonding correctly positioned, serviceable and secure) connections and locking.
1.6 Control System Components


2. Definition of the term CHECK used in the Boeing Maintenance and Planning Data document (BMPD).

The following is extracted from the relevant BMPD.

"EXPLANATION OF TERMS

(a) CHECK: A check is construed to mean a thorough examination of an item, component and/or system for general condition, as applicable, with special emphasis in the following areas:

Proper attachment, safety wiring, cotter pins, fasteners, clamps, latches, tubing, plumbing, electrical wiring and connections, linkages, cables, broken strands, bearings, alignment, clearances, lubrication, obvious damage, cracks, delamination, fraying, operating pressures, fluid leakage, excessive wear or play, corrosion, evidence of overheating, rubbing, aging, preservative coating or finish, cleanliness and general appearance."

3. The following extracts from the Dan-Air Boeing 707 Approved Maintenance Schedule were those regular inspection items which were intended to cover the rear spars and related structure of the horizontal stabilizers outboard of the root attachment fittings:
**HORIZONTAL STABILIZERS, ELEVATORS AND TAB INSPECTION**

**NOTE:**
1) Includes ME112 items (27-13 and 27-14)
2) Move control surfaces to both extremes to facilitate inspection of area. Shake check surfaces for play and wear.

<table>
<thead>
<tr>
<th>1</th>
<th>Inspect for condition, security and fluid leaks, all visible structure, balance panels and cables, actuating mechanism linkages, hinges, bonding straps, system components including snubbers. Include fuselage structure above stabilizer area. Inspect fairings, plates and Vortex generators.</th>
</tr>
</thead>
</table>
| (a) | AD 62-8-4. Required 321 A/C ONLY
Inspect horizontal stabilizers balance panel covers per Fig 1. |
| (b) | Check the condition, security and number of static discharges installed. (A total of 12). |

**INCLUDE KEYPOINTS:-**

1. Cracks, elevator closure ribs.
2. Elevator hinge cracks.
3. Tap check honeycomb tabs and trailing edges for delamination and for unbonding at bonded seams.
4. Skin doubler cracks at fin attach fittings.
5. Balance panel cover cracks.

**FIGURE 1**

**HORIZONTAL STABILIZER BALANCE PANEL COVERS INSPECTION**

Perform a visual inspection of all balance covers and elevator tab control covers (located inboard of No 1 balance bay) on upper and lower surface of horizontal stabilizers.

(a) Inspect all panel attachments and all small insp. door attachments for cracks.

(b) All cracked panels must be repaired or replaced before further flight (Ref Repair Manual 51-9-1 & 2)

(c) If track grips are defective, remove and check balance panels for cracks.
<table>
<thead>
<tr>
<th>Item</th>
<th>QTY</th>
<th>Requirement</th>
<th>General</th>
<th>Location Access Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>55.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STABILIZERS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HORIZONTAL STABILIZER</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal stabilizer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External skin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-flight</td>
<td>Walk around inspection</td>
<td>PA Card 55-3280</td>
<td>91,92</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(lower surfaces)</td>
<td>52-3080</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>CHK - close visual inspection, check all exterior plates closed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal stabilizer</td>
<td>2C</td>
<td>CHK</td>
<td>1630-1635</td>
<td>1667</td>
</tr>
<tr>
<td>Internal structure</td>
<td></td>
<td></td>
<td>1609-1612</td>
<td></td>
</tr>
<tr>
<td>3C</td>
<td>CHK</td>
<td></td>
<td>1669 L/R</td>
<td></td>
</tr>
<tr>
<td>6C</td>
<td>CHK</td>
<td></td>
<td>1614, 1615</td>
<td>1624-1628</td>
</tr>
<tr>
<td>2D</td>
<td>CHK</td>
<td></td>
<td>1649-1653</td>
<td>1668</td>
</tr>
<tr>
<td>Elevator balance panel bays</td>
<td></td>
<td>CHK</td>
<td>93,94,1615</td>
<td>1624-1628</td>
</tr>
<tr>
<td>Elevator hinge assy on elevator and tail-plane</td>
<td></td>
<td>CHK</td>
<td></td>
<td>93, 94</td>
</tr>
</tbody>
</table>
4. Extract of relevant 'C' check items listed in Manufacturers BMPD document, i.e. corresponding to the Dan-Air inspection items listed previously:

**'C' CHECK TYPE ITEMS**

<table>
<thead>
<tr>
<th>MODEL 707–320B/C</th>
<th>DESCRIPTION</th>
<th>CHECK</th>
<th>ACCESS DOOR NUMBER</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>STABILIZERS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>04-55-01</td>
<td>Horizontal stabilizers</td>
<td>X</td>
<td></td>
<td>HOURS &amp; TENTHS</td>
</tr>
<tr>
<td>A. Exterior surfaces</td>
<td></td>
<td>X</td>
<td></td>
<td>0.4</td>
</tr>
<tr>
<td>B. Brush and seal</td>
<td></td>
<td>X</td>
<td></td>
<td>0.8</td>
</tr>
<tr>
<td>C. Rear spar and hinge fittings</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Drain holes</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>04-55-04</td>
<td>Vertical and horizontal stabilizers. Check for aerodynamic cleanliness including skin damage, rough paint, large gaps or dents, rough patches, surface mismatch at access panels and condition of aerodynamic sealant at skin butt joints.</td>
<td>2</td>
<td>NONE</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.6</td>
</tr>
</tbody>
</table>
The text of the Structural Inspection contained in the Dan-Air Schedule was identical to that in the Manufacturers BMPD document, and the relevant item is listed below:

"Horizontal stabilizer internal structure.

A. Inspect spar and rib chords, webs and stiffeners for cracks or loose fasteners.

B. Inspect center section spar chords, fittings and lower skin.

C. Inspect adjacent structure."
Figure 1 WRECKAGE PLOT

KEY

0  Nose undercarriage complete
1  Nose impact point
2  No. 3 engine
3  No. 4 engine-fan and LP compressor section
4  No. 4 engine-diffuser case
5  Section of right mainplane lower skin containing No. 3 and 4 engine pod drag strut attachments with struts
6  No. 2 engine—complete
7  No. 1 engine—complete
8  Main undercarriage complete (right)
9  Section of left mainplane lower skin containing No. 1 and 2 engine pod strut attachments with one strut attached
10  Main undercarriage (left) almost complete
11  No. 4 engine-turbine section
12  Flap section (left inner)
13  Outer right mainplane, aileron, spoiler (parts) and tip-stbd
14  No. 4 engine—thrust reverser (rear)
15  Section of fuselage left undercarriage
16  Flaps section (left outer)
17  Section of flap with screw jack (ext 50° approx.)
18  Section of fuselage and STN 990 exit door
19  Air cycle unit
20  Intercooler
21  Rear fuselage section split in half (from rear press.bulkhead fwd approx 8m)
22  Section of fuselage around stn990 area, fwd end rear freight compartment
23  Left horizontal stabilizer, elevator and centre section complete with stabilizer screw jack
24  Section of wing skin (upper) with stringer from outboard section
25  Section of wing skin (upper) with stringer from outboard section
26  Pair of wheels on axle with brake units
27  Section of wing (w360)
28  Fin complete (less rudder and HF aerial)
29  Thrust reverser
30  Left outer wing sections and flap with aileron
31  Section of left wing tip with aileron
32  Right fillet flap and structure complete with screw jack extended approx. 50°
33  Intercooler
34  Air cycle unit
35  Mid section of rudder with pfcu
36  Rudder—badly damaged top section
37  Flap screw jack (extended)
38  Rudder-bottom section (badly damaged)
39  Rudder—lower front spar section
40  Trim drum and cable—horizontal stabilizer
41  Thrust reverser (rear)
42  Honda generator—stored in rear of cargo hold during flight
43  Right horizontal stabilizer complete
44  Piece of closure rib from right horizontal stabilizer
45  Piece of rear fuselage skin and structure from left side adjacent to stabilizer rear spar (with stabilizer position witness marks)
Figure 2  G-BEBP ESTIMATED TRAJECTORY FOLLOWING STABILIZER SEPARATION
Figure 4  G-BEBP HORIZONTAL STABILIZER STRUCTURAL FAILURE DETAILS – rear spar outboard fracture surfaces and closure rib fracture.
Figure 5  G-BEBP HORIZONTAL STABILIZER TOP CHORD FATIGUE FRACTURE – showing bruising on fracture surface and fretting on top skin.
Over-lay to Figure 6 - Fatigue Fracture details

**KEY**
- CRACK PROGRESSION IN FATIGUE MODE
- CRACK PROGRESSION AS "SINGLE" STATIC TENSILE JUMP
- FINAL STATIC TENSILE FAILURE

**Figure 6**
FATIGUE FRACTURE DETAILS - G-BEBP HORIZONTAL STABILIZER REAR SPAR TOP CHORD
Figure 7  G-BEBP HORIZONTAL STABILIZER TOP CHORD FATIGUE FRACTURE DETAILS – origin regions in forward flange.
Figure 8  Boeing 707 300 SERIES. EMPENNAGE AND REAR FUSELAGE – showing area of fuselage structure which on G-BEBP was found to contain witness marks of stabilizer incidence (see figure 9)

NOTE: AIRCRAFT SHOWN DIFFERS FROM G-BEBP IN HAVING AN UNDERFIN
Figure 9  G-BEBP SECTION OF REAR FUSLAGE FROM REGION DETAILED IN FIGURE 8—Containing witness marks of stabilizer incidence setting made by edge of left stabilizer bottom skin
Figure 10    POST ACCIDENT STRUCTURAL TEST RIG
Figure 11a  G-BEBP REAR SPAR FRACTURE

Figure 11b  TEST SPECIMEN REAR SPAR FRACTURE

COMPARISON OF HORIZONTAL STABILIZER REAR SPAR FRACTURE LINES - G-BEBP AND POST ACCIDENT STRUCTURAL TEST SPECIMEN
Figure 12  TYPICAL FLIGHT STRESS PROFILE - 707 300 SERIES HORIZONTAL STABILIZER STRESS IN REAR SPAR TOP CHORD
Figure 13a
BOEING 707-100 SERIES/720 SERIES.
HORIZONTAL STABILIZER STRUCTURE

Figure 13b
BOEING 707 300 SERIES/400 SERIES.
HORIZONTAL STABILIZER STRUCTURE

COMPARISON OF THE TWO TYPES OF HORIZONTAL STABILIZER STRUCTURE ON THE BOEING 707.
Figure 14  BOEING 707 300/400 SERIES. DETAILS OF TORSION BOX SKINS AND REAR SPAR FORWARD FLANGE | FASTENERS

TOP SKIN: 060" THICK STAINLESS STEEL (AISI 301 1/2 HARD)
BOTTOM SKIN: DOUBLE SKIN EACH 063" LIGHT ALLOY (2024-T3)

045" THICK LIGHT ALLOY (2024-T3) INTERNAL DOUBLER

REAR SPAR

STEEL FASTENERS

LIGHT ALLOY FASTENERS (EXCEPT AT RIB ATTACHMENTS)

ELEVATOR LINE

TOP AND BOTTOM SKINS:
071" THICK LIGHT ALLOY (2024-T3)

TOP AND BOTTOM SKIN
045" THICK LIGHT ALLOY
(1) Failafe spar chord fractures and right stabilizer separates from aircraft. Departing stabilizer pulls elevator push/pull tube from elevator quadrant (located in rear fuselage) forcing elevator control circuit to full-up elevator condition. Witness mark produced on push/pull tube by contact between tube and side of tube aperture in rear fuselage skin whilst at the full-up elevator position.

(2) Sudden loss of stabilizer download on right side combined with simultaneous increase in download on left side (caused by full up elevator) produces excessive asymmetric load on stabilizer centre section to rear fuselage mountings. Left stabilizer wrenches tip downwards twisting centre section in rear fuselage and producing fuselage fracture at 'A', bulging at 'B' and 'S' shaped distortion of right hand pivot housing structure.

(3) Stabilizer pitch trim screwjack bends at base to accommodate distortion.

(4) Witness mark (corresponding to stabilizer trim setting of 6/0 units aircraft nose up) produced at 'C' by contact between inner edge of stabilizer bottom skin and fuselage side skin.

(5) Left stabilizer tip downwards movement continues. Right hand pivot mountings torn from fuselage structure and whole left stabilizer moves outboard and downwards, pivoting about lower end of screw jack which bends further to accommodate movement. Left side lower fuselage skin remains attached.

(6) Screwjack fractures at base allowing whole stabilizer to rotate nose up about left pivot under influence of the full up elevator. Second witness mark produced at 'C' recording new stabilizer position.

(7) Reduction in download caused by change in stabilizer incidence acts to reduce the downwards velocity of the stabilizer, but momentum prevents immediate arrest of movement.

(8) Stabilizer tip downwards motion continues to the point where the section of rear fuselage containing witness marks is broken out of aircraft by downwards movement of stabilizer rear spar.

(9) Stabilizer tip downwards motion eventually ceases and stabilizer pitch attitude stabilizes in a high aircraft nose down condition.

Complete breakup sequence occurs in less than 0.5 second.
Figure 16  EFFECT OF CLOSURE RIB STIFFNESS (IN BENDING) ON TOP AND BOTTOM SKIN STRESS DISTRIBUTION IN A TYPICAL WING BOX CONSTRUCTION
Figure 17  POST-ACCIDENT STRUCTURAL TEST DATA: SKIN STRESS DISTRIBUTION
Figure 18  G-BEBP HORIZONTAL STABILIZER TORSION BOX TOP SKIN DOUBLERS FROM REGION ADJACENT TO INNER END OF REAR SPAR—Comparison fastener hole distortion patterns and fretting damage to inner face of skins from left (undamaged) and right (separated) stabilizers
Figure 19  POST-ACCIDENT STRUCTURAL TEST DATA, SPANWISE STRESS COMPONENT IN TOP SKIN ADJACENT TO REAR SPAR
1 STRUCTURE INTACT – centre chord carries no load

2 TOP CHORD AND WEB FRACTURED – load path assumed during initial analysis

3 TOP CHORD AND WEB FRACTURED – actual load path

NOTE: CHORD FLANGE OMITTED FOR CLARITY

Figure 20 IDEALIZED LOAD PATHS IN REAR SPAR (shear loads omitted)
Figure 21  POST ACCIDENT TEST DATA – stress distribution in rear spar adjacent to web fracture
Figure 22  BOEING 707-300/400 SERIES ACCESS PANELS USED TO INSPECT INTERNAL STRUCTURE OF HORIZONTAL STABILIZERS

<table>
<thead>
<tr>
<th>PANEL DESCRIPTION</th>
<th>PANEL REF. Nos.</th>
<th>BOEING RECOMMENDED PERIOD</th>
<th>DAN AIR SCHEDULE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRAILING EDGE CAVITIES: BOTTOM SURFACE SMALL PANELS</td>
<td>1667, 1630, 1635</td>
<td>NONE</td>
<td>ALTERNATE 'D' CHECKS (2000 HRS.)</td>
</tr>
<tr>
<td>TRAILING EDGE CAVITIES: TOP SURFACE SMALL PANELS</td>
<td>1668, 1669, 1650, 1651, 1652, 1653</td>
<td>NONE</td>
<td>ALTERNATE 'D' CHECKS (14,000 HRS.)</td>
</tr>
<tr>
<td>TRAILING EDGE CAVITIES: BALANCE PANEL COVERS (LARGE PANELS) EXCLUDING INNERMOST PANEL OVER BELL CRANK BAY</td>
<td>1615, 1624, 1625, 1626, 1627, 1628</td>
<td>'C' CHECKS</td>
<td>ALTERNATE 'D' CHECKS (14,000 HRS.)</td>
</tr>
<tr>
<td>TRAILING EDGE CAVITIES: BOTTOM SURFACE BELL CRANK BAY COVER</td>
<td>1614</td>
<td>NONE</td>
<td>ALTERNATE 'D' CHECKS (14,000 HRS.)</td>
</tr>
<tr>
<td>LEADING EDGE SECTIONS</td>
<td>1608, 1607</td>
<td>SAMPLE INSPECTION</td>
<td>SAMPLE INSPECTION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FLEET EVERY 21,000 HRS. (84,000 HRS. MAX.)</td>
<td>FLEET EVERY 14,000 HRS. (56,000 HRS. MAX.)</td>
</tr>
</tbody>
</table>