PART 2 - X-RAY

WATER DETECTION IN HONEYCOMB STRUCTURE

1. **Purpose**

   A. To detect water in honeycombed structures using radiography.

   NOTE: This procedure will detect the presence of water in honeycombed structures fabricated with any combination of metallic and/or nonmetallic honeycomb cores and skins.

   B. Part 9, 51-00-01 and Part 9, 51-00-02 can be used as alternative procedure on non-metallic honeycomb parts. Before you use an alternative procedure, make sure there is sufficient sensitivity for the number of plies to be examined.

2. **Equipment**

   A. X-Ray Generator - Any X-ray generator capable of operating in the range from 30 to 100 kV may be used.

   B. Film - Any wide-range radiographic film is acceptable. ASTM Class II radiographic film was used to develop this procedure.

   C. Processor - Manual or automatic processor may be used.

3. **Prepare for the Inspection**

   A. Extend control surface or remove honeycombed panel if necessary to provide unobstructed access for radiographic exposure. See Figure 2.

4. **Inspection Procedure**

   A. Position X-ray generator perpendicular to the surface of the honeycombed panel at the area being inspected. Expose from lower side for control surfaces and flaps. See Figure 2 for typical orientation of X-ray tube head and inspection member.

   B. Place film on upper side of control surface, or side of part opposite X-ray tube head, covering area suspected of containing water. See Figure 2 flagnotes 3 and 4.

   NOTE: Approximately 70 inches (177 cm) can be inspected per exposure at a source-to-film distance (SFD) of 120 inches (305 cm).

   C. Set X-ray generator controls using Figure 1 as a guide. Expose film to obtain a cell density of 2.0 to 3.0.

   D. Repeat above procedure as required for all suspected water-contaminated honeycomb areas.

5. **Inspection Results**

   A. Interpretation of radiographs of water-contaminated honeycomb is dependent upon: the number of cells containing water; the volume of water per cell; the thickness of the honeycomb core; and the orientation of the X-ray beam to the honeycomb cell walls. Water is detectable when honeycomb core cell walls are aligned within 45 degrees of being parallel to the impinging radiation.

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B. Honeycombed structures may contain areas of uneven adhesive accumulation as a by-product of the manufacturing process. The appearance of adhesive accumulations on radiographs is not cause for rejection. Radiographic images of adhesive accumulations can be misinterpreted as water when the honeycomb cell wall orientation to the X-ray beam prevents individual cells from being recognized (Figure 3). Discrimination of water in honeycomb from adhesive accumulations is best accomplished when the cell walls are aligned parallel to the radiation beam. Water images usually have a constant film density in any particular cell when radiographed in this manner. Adhesive images can vary in film density within a cell and show indications of porosity. See Figure 4.

NOTE: Three to five times magnification will aid identification of adhesive porosity.

C. Water contamination usually involves several adjacent cells, whereas evidence of adhesive accumulations gives the appearance of significant amounts of water scattered randomly. Also, the appearance of adhesive images on radiographs does not vary significantly between radiographs with different X-ray beam-to-cell wall orientations. The presence of such accumulations is confirmed when no change in the appearance of the suspect images occurs on repeat inspections with different X-ray beam-to-cell wall orientations.

D. Small amounts of water can be difficult to detect. Baseline radiographs should be established for comparison when performing repeat inspections for small amounts of water in honeycomb.

E. Closely interpret radiograph for water at all areas with visible damage.

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X-RAY PARAMETERS						
EXPOSURE NUMBER	FILM			SFD	GENERATOR SETTINGS	
	POSITION	ASTM CLASS	SIZE		kV	MAS
1	2	II 3	14 X 17 (35 X 42.5)	120 (305)	30-100	4

NOTES

- ALL DIMENSIONS ARE IN INCHES (CENTIMETERS IN PARENTHESES)

1 USE AS MANY EXPOSURES AS NECESSARY TO INSPECT THE AREA OF INTEREST. SEE FIGURE 2 FOR TYPICAL X-RAY GENERATOR POSITION

2 AS MANY AS FIVE FILMS OF THE SIZE SPECIFIED MAY BE USED WHEN USING THE TYPICAL X-RAY SETUP SHOWN IN FIGURE 2

3 THIS FILM WAS USED TO DEVELOP THIS PROCEDURE. A WIDE RANGE OF FILM TYPES ARE ACCEPTABLE FOR RADIOGRAPHIC DETECTION OF WATER IN HONEYCOMB

4 MAS IS SELECTED TO OBTAIN A FILM DENSITY OF FROM 2.0 TO 3.0 AS MEASURED WITHIN A CELL

2159154 S0000470909_V2

X-Ray Generator and Film Parameters
Figure 1

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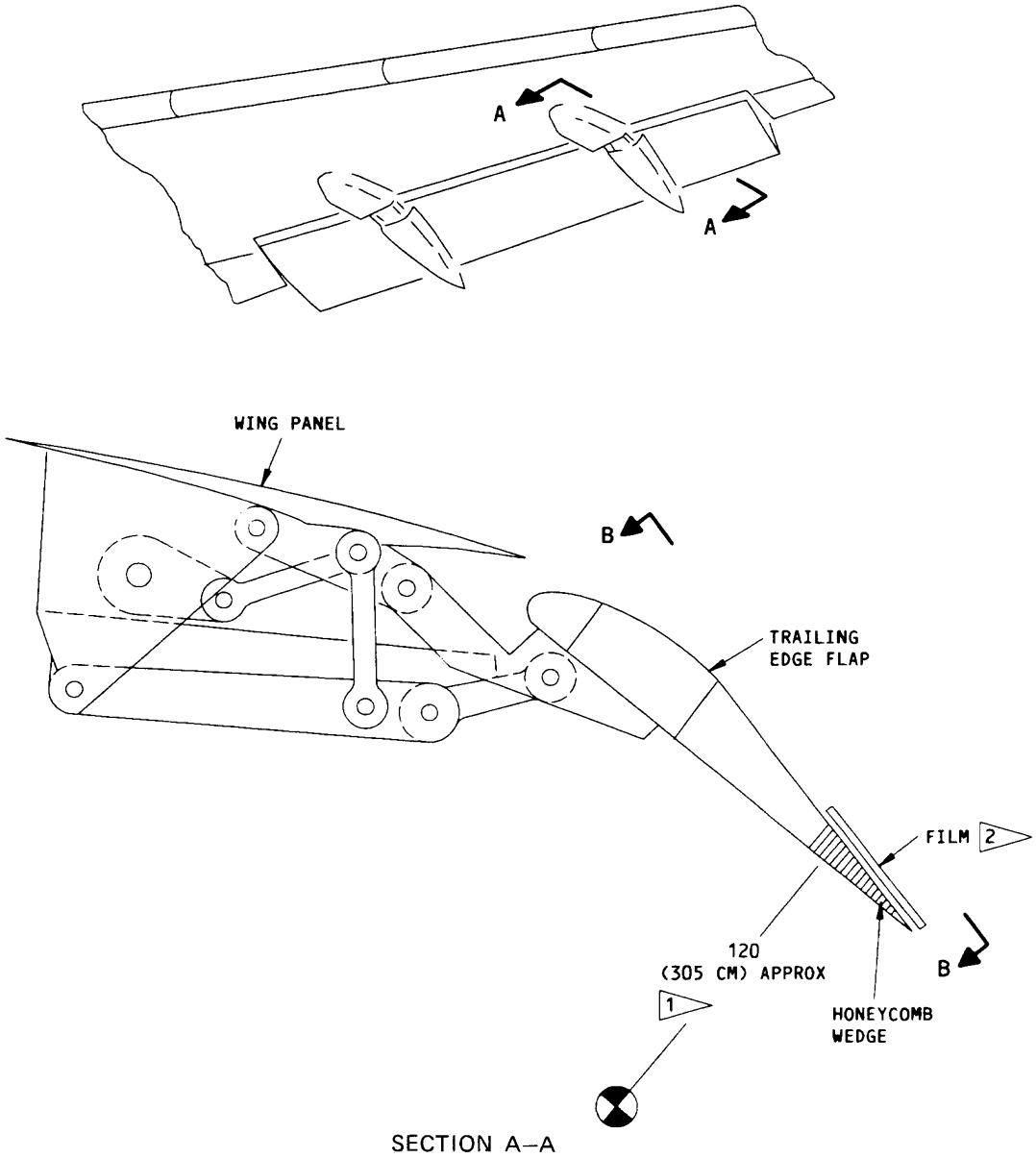

NOTES

- ALL DIMENSIONS ARE IN INCHES (CENTIMETERS IN PARENTHESES)

1. ALIGN X-RAY TUBE HEAD SO THAT RADIATION BEAM IS PERPENDICULAR TO FLAP LOWER SURFACE AT APPOX 120 (305 CM) SFD
2. PLACE FILM ON FLAP UPPER SURFACE COVERING FLAP TRAILING EDGE WEDGE HONEYCOMB STRUCTURE

2159167 S0000470910_V1

Typical X-Ray Setup to Detect Water in Honeycomb Structure
Figure 2 (Sheet 1 of 2)

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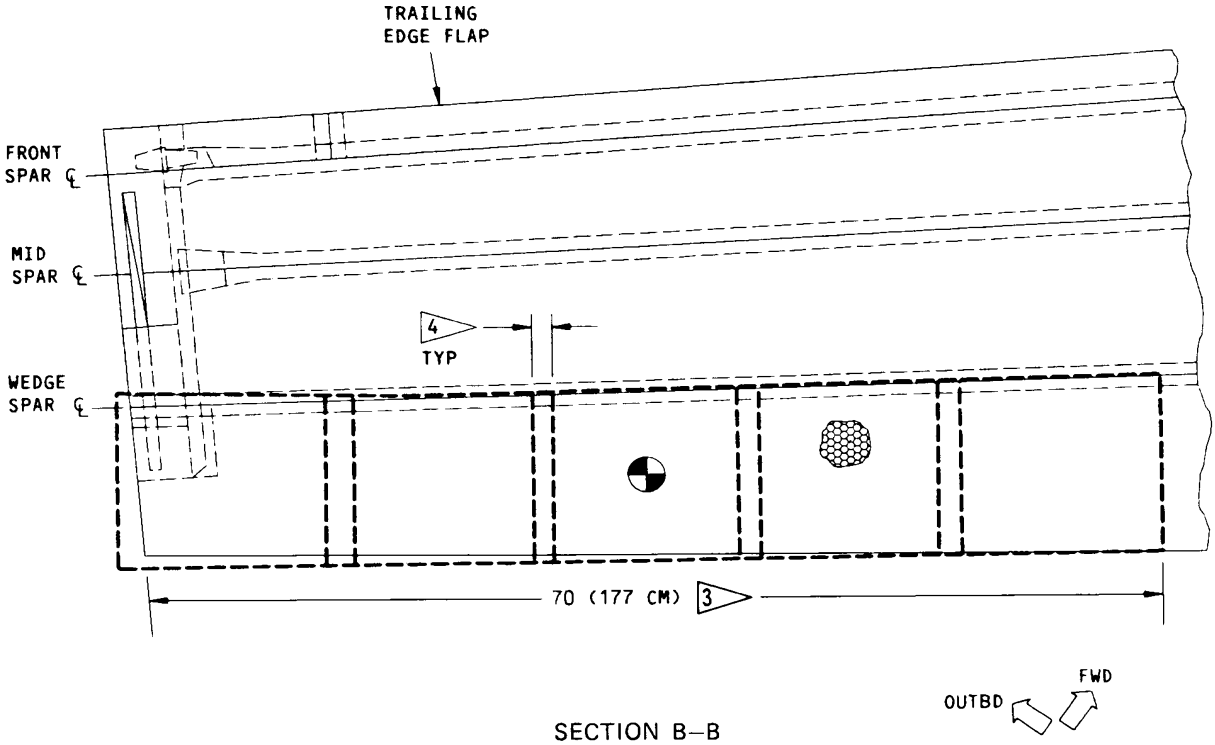

NOTES

- ALL DIMENSIONS ARE IN INCHES (CENTIMETERS IN PARENTHESES)
- AIM X-RAY GENERATOR AT CENTER OF FILM COVERAGE
- 3 APPROX 70 (177 CM) OF FLAP TRAILING EDGE WEDGE COVERAGE PER EXPOSURE
- 4 OVERLAP FILM 2.0 (5.0 CM) TO ENSURE COVERAGE IN EXPOSURE AREA

2159179 S0000470911_V1

Typical X-Ray Setup to Detect Water in Honeycomb Structure
Figure 2 (Sheet 2 of 2)

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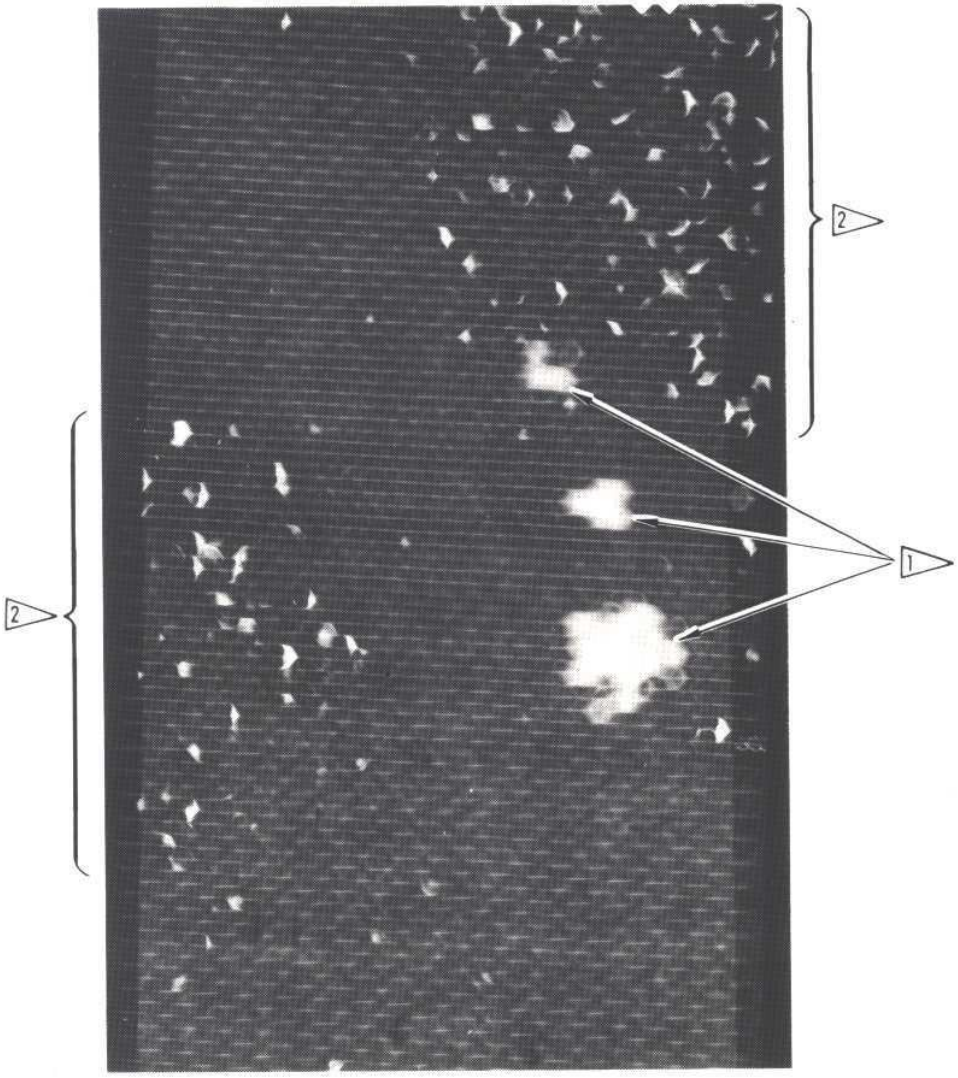

ACTUAL RADIOGRAPH

NOTES

- TYPICAL RADIOGRAPH INTERPRETATION FOR WATER CONTAMINATION WHEN RADIATION BEAM IS NOT PARALLEL TO HONEYCOMB CELL WALLS

1 HONEYCOMB CELLS CONTAINING VARIOUS AMOUNTS OF WATER

2 AREAS SHOWING UNEVEN ADHESIVE ACCUMULATION

2159207 S0000470912_V1

Radiographic Identification of Water and Adhesive in Honeycomb Structure
Figure 3

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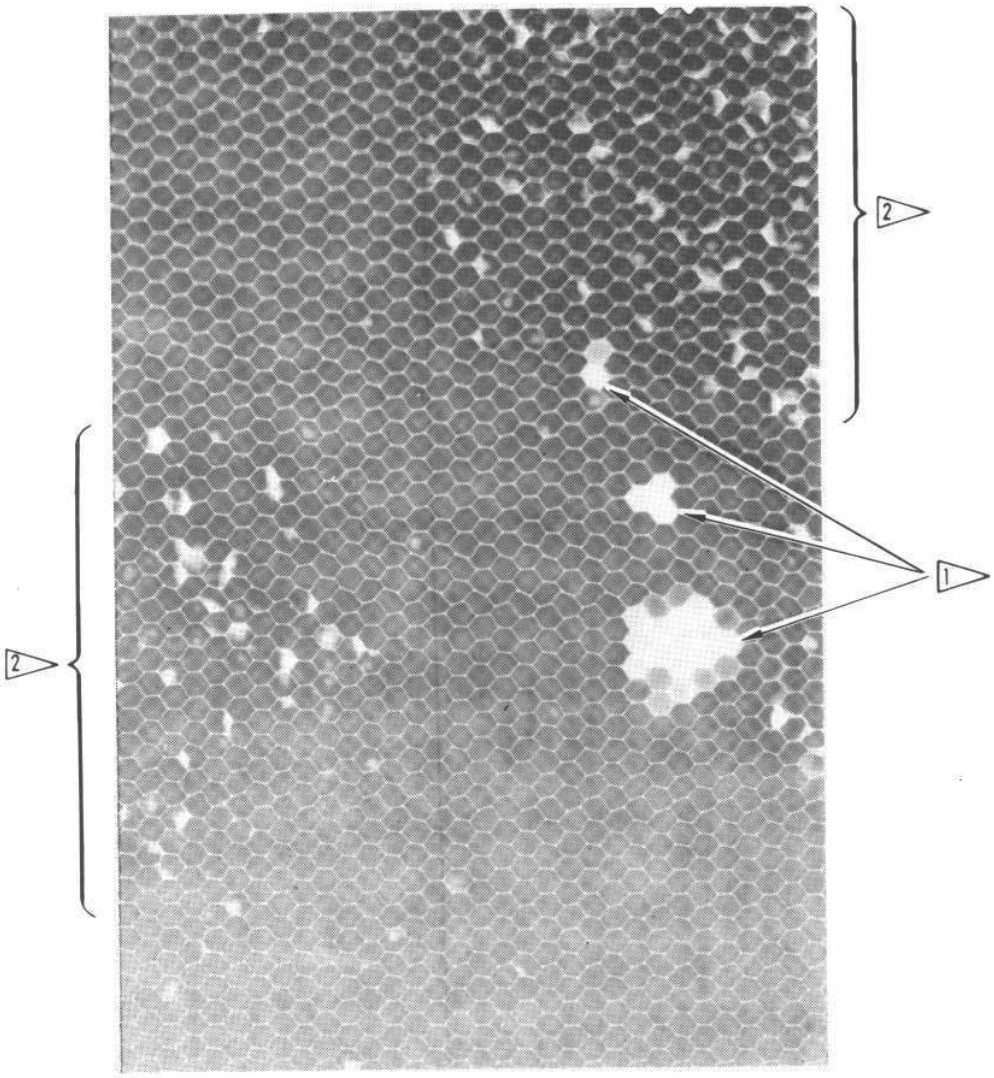

ACTUAL RADIOGRAPH

NOTES

- TYPICAL RADIOGRAPH INTERPRETATION FOR WATER CONTAMINATION WHEN RADIATION BEAM IS PARALLEL TO HONEYCOMB CELL WALLS

1 HONEYCOMB CELLS CONTAINING VARIOUS AMOUNTS OF WATER

2 AREAS SHOWING UNEVEN ADHESIVE ACCUMULATION

2159213 S0000470913_V1

Radiographic Identification of Water and Adhesive in Honeycomb Structure
Figure 4

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PART 2 - X-RAY

SUBSURFACE FRACTURE IN COMPOSITE STRUCTURE

1. **Purpose**

   A. Use this radiography procedure to do an inspection of graphite-epoxy composite structures for fractures or large subsurface fractures when there is a visible indication of subsurface damage.

   NOTE: It is possible that some subsurface fractures will not be identified if there are no visible defect indications on the surface of the part.

2. **Equipment**

   A. X-ray Generator - Use an X-ray generator that operates at a minimum of 20 kV and 3 mA.

   B. Film - Use ASTM Class I or II radiographic film.

   C. Processor - Use a manual or an automatic processor.

3. **Prepare for the Inspection**

   A. Get access to the inspection area.

   B. Remove loose paint, dirt and sealant from the surface of the inspection area.

4. **Inspection Procedure**

   A. Put the film on the side of the part that is on the opposite side of the X-ray generator. See Figure 1.

   B. Put the X-ray focal spot on the side of the part nearest the film and away from centerlines of the part thought to be fractured. See Figure 1.

   C. Set the X-ray generator controls and make an exposure to get a density of 1.8 to 2.5. Use a technique chart to help make the initial X-ray generator control adjustments.

   NOTE: A technique chart is necessary for each X-ray generator. Show the exposure time necessary for different thicknesses to get the maximum results in the least time.

5. **Inspection Results**

   A. Radiograph examples are shown in Figure 2 thru Figure 4. Analysis of radiographs for broken parts or large subsurface fractures in graphite-epoxy composite structure is equivalent to crack detection in metallic structures.

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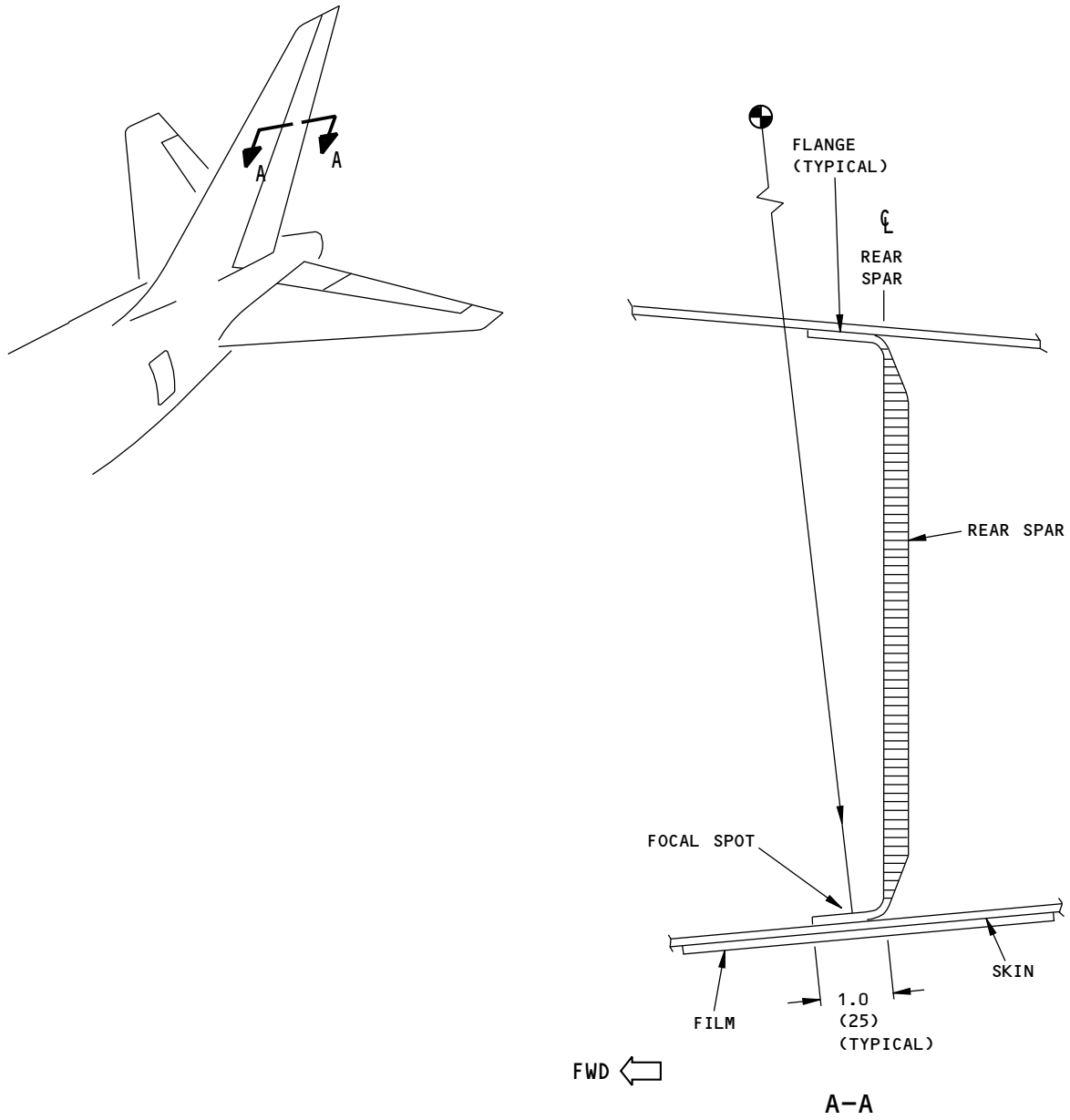

GRAPHITE/EPOXY RUDDER REAR SPAR

NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES).
- X-RAY GENERATOR POSITION TO EXAMINE THE REAR SPAR FLANGE - POSITION THE FOCAL SPOT AWAY FROM THE SPAR CENTERLINE TO PREVENT AN OVERLAP OF THE SPAR FLANGES ON THE RADIOGRAPH.

2125331 S0000458225_V1

Example Inspection of Internal Structure
Figure 1

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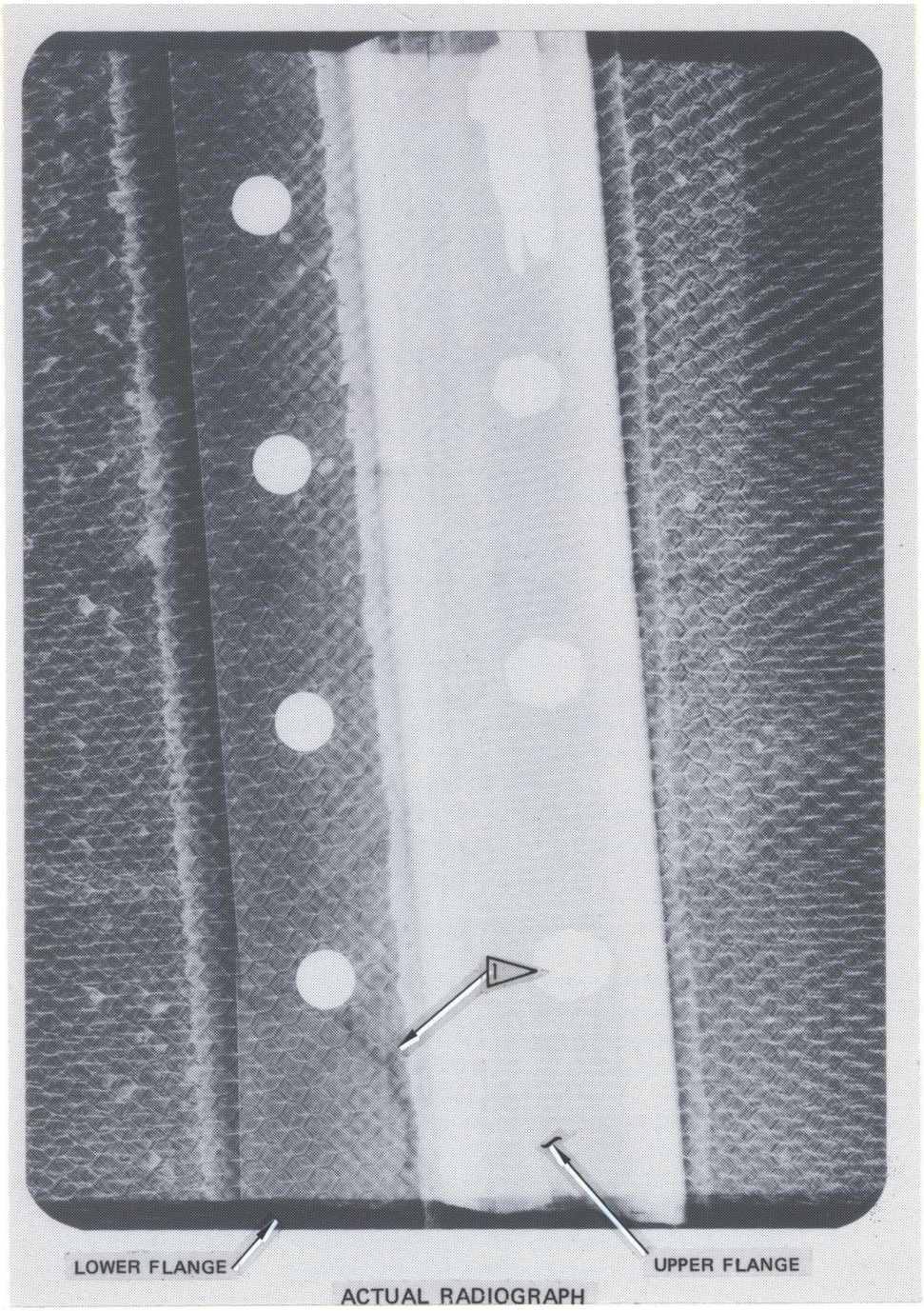

NOTES

1 EXAMPLE OF A RADIOGRAPH WHICH IDENTIFIES A LARGE SURFACE FRACTURE WITH SOME SEPARATION IN THE REAR SPAR FLANGE. THE REAR SPAR FLANGE IS AN INTERNAL PART OF THE RUDDER.

2125405 S0000458226_V1

Radiograph Analysis
Figure 2

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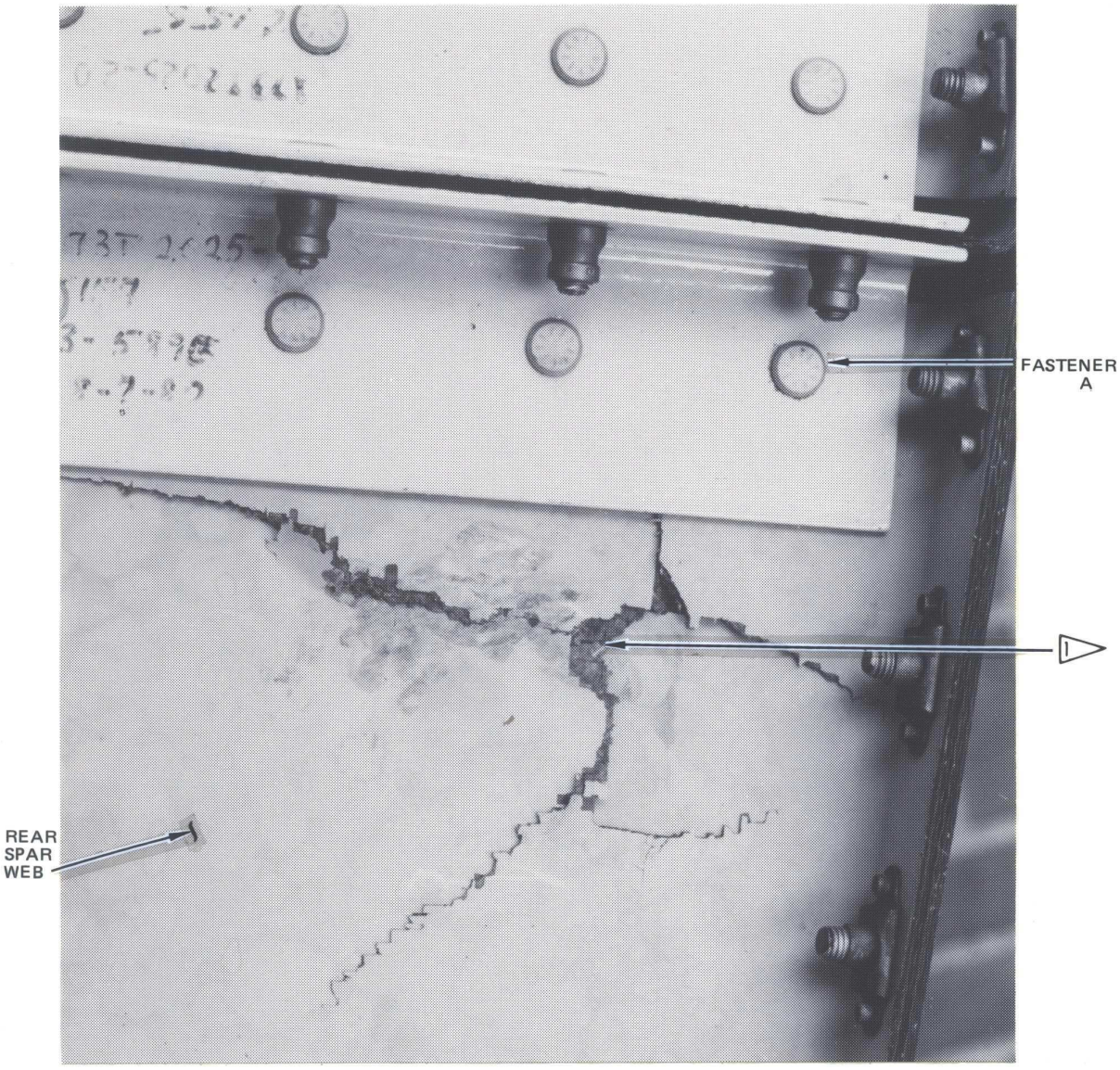

PHOTOGRAPH OF INTERNAL DAMAGE TO THE REAR SPAR OF THE RUDDER

NOTES

1 LARGE SKIN/CORE FRACTURE WITH PART SEPARATION.

2125416 S0000458227_V1

Radiographic Analysis
Figure 3 (Sheet 1 of 3)

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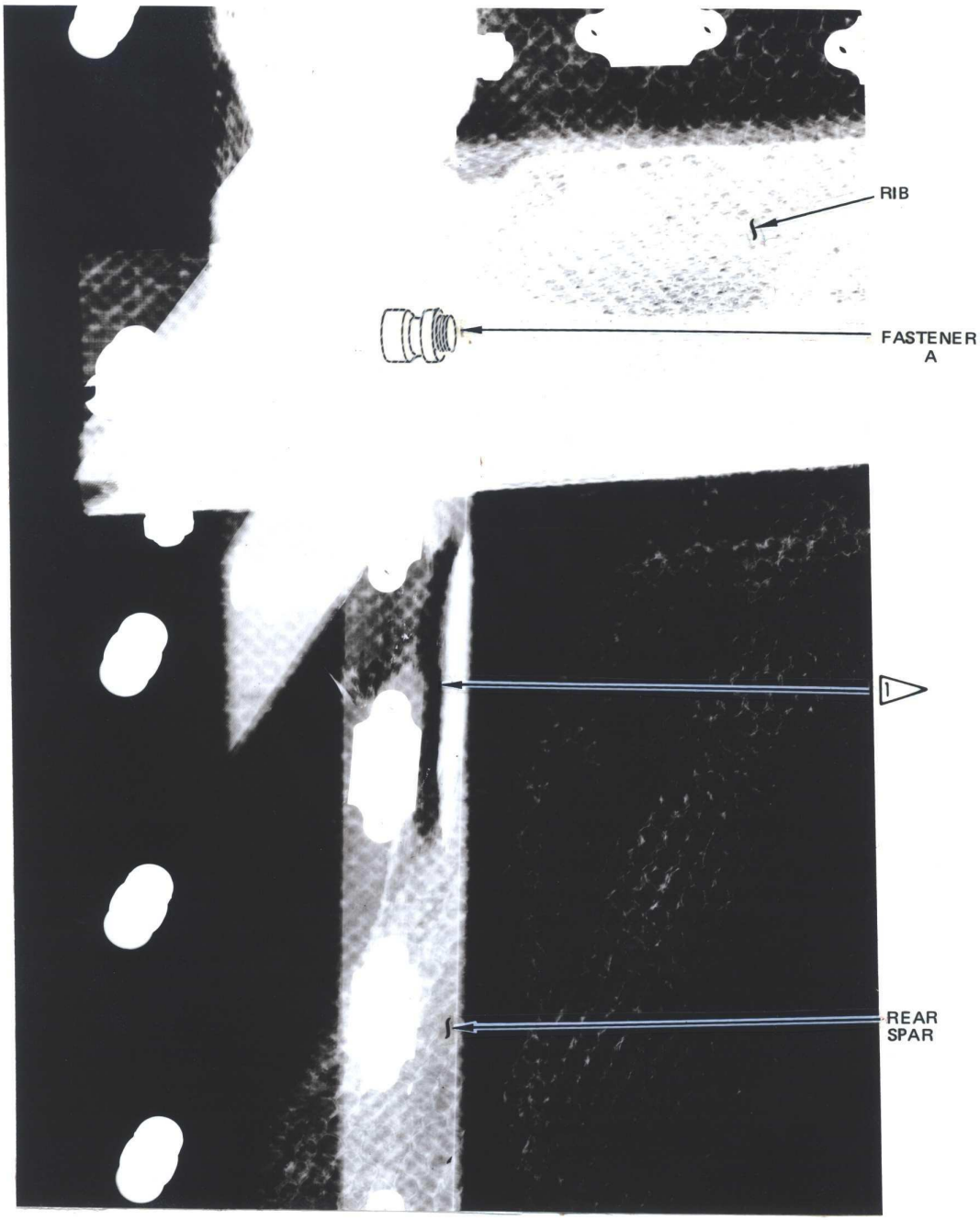

ACTUAL RADIOGRAPH

(EXAMPLE OF A RADIOGRAPH THAT IDENTIFIES FRACTURED PARTS
WHEN THE RADIATION BEAM IS NOT PARALLEL TO THE PART)

2125427 S0000458228_V1

Radiographic Analysis
Figure 3 (Sheet 2 of 3)

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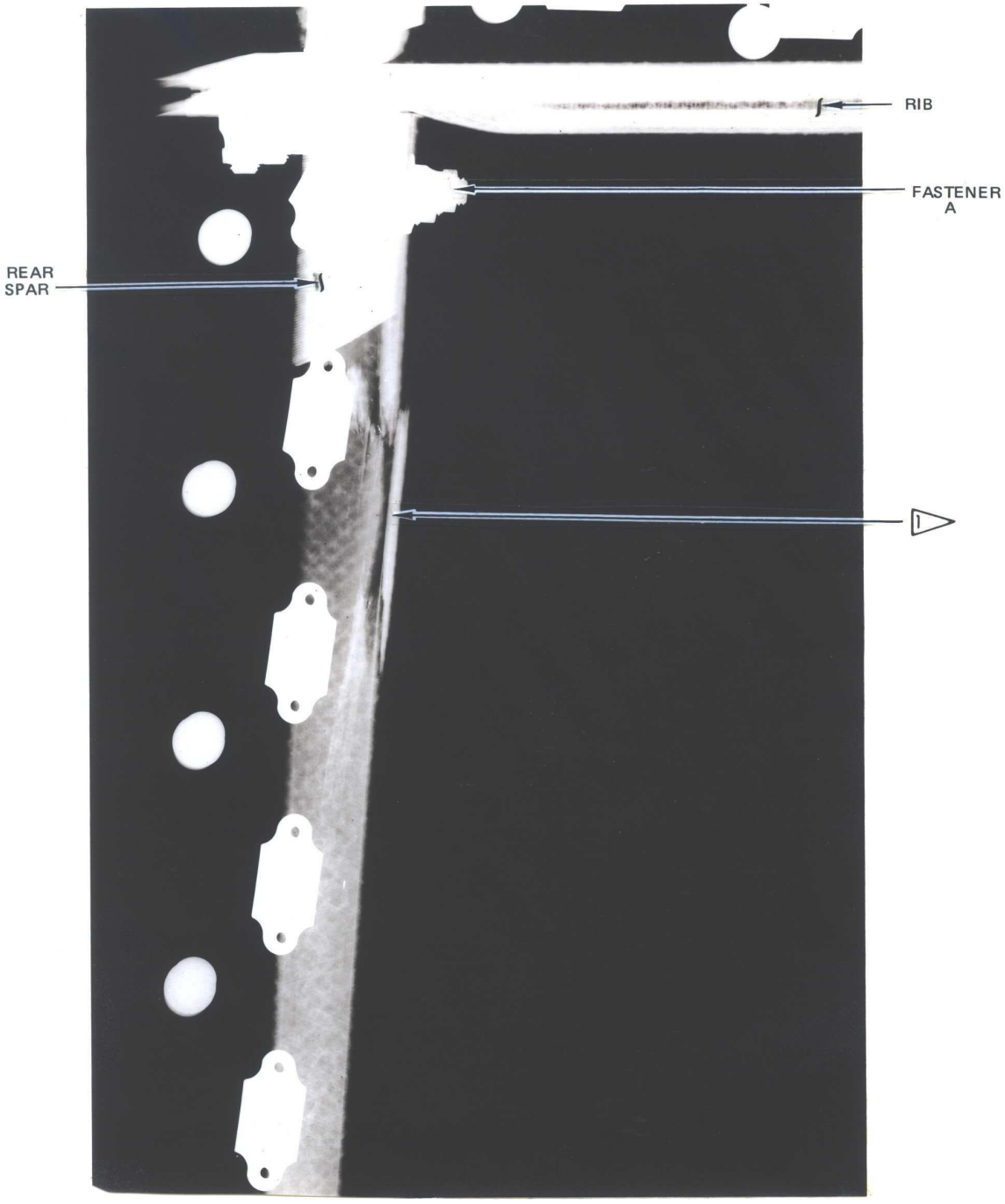

ACTUAL RADIOGRAPH

(EXAMPLE OF A RADIOGRAPH THAT IDENTIFIES FRACTURED PARTS WHEN THE RADIATION BEAM IS PARALLEL TO THE PART)

2125442 S0000458229_V1

Radiographic Analysis
Figure 3 (Sheet 3 of 3)

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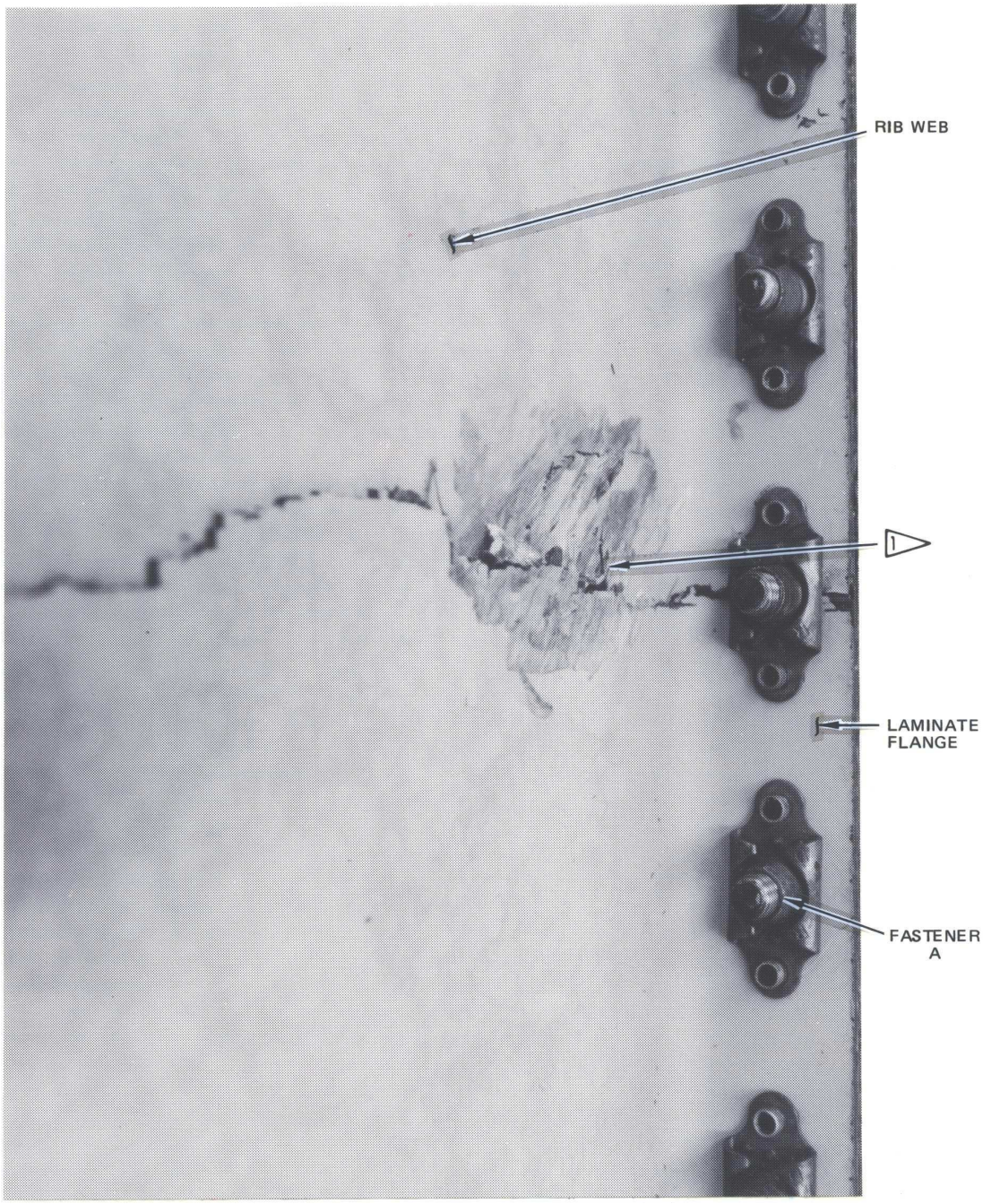

PHOTOGRAPH OF INTERNAL DAMAGE TO THE RUDDER RIB

NOTES

1 PART SEPARATION WITH A SKIN/CORE FRACTURE THAT EXTENDS THROUGH THE LAMINATE FLANGE.

2125443 S0000458230_V1

Radiographic Analysis
Figure 4 (Sheet 1 of 3)

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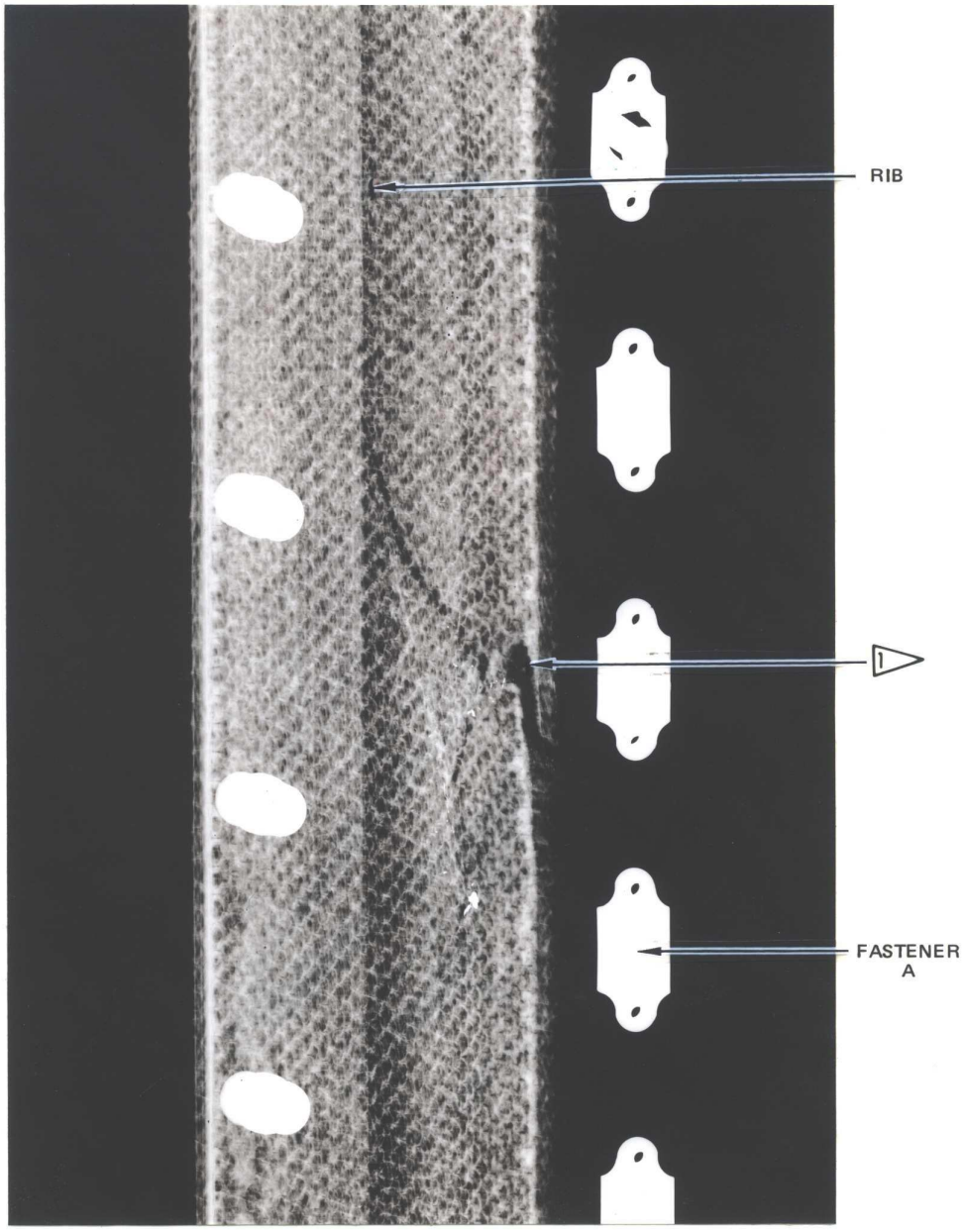

ACTUAL RADIOGRAPH

(EXAMPLE OF A RADIOGRAPH THAT IDENTIFIES FRACTURED PARTS WHEN THE RADIATION BEAM IS NOT PARALLEL TO THE PART)

2125467 S0000458231_V1

Radiographic Analysis
Figure 4 (Sheet 2 of 3)

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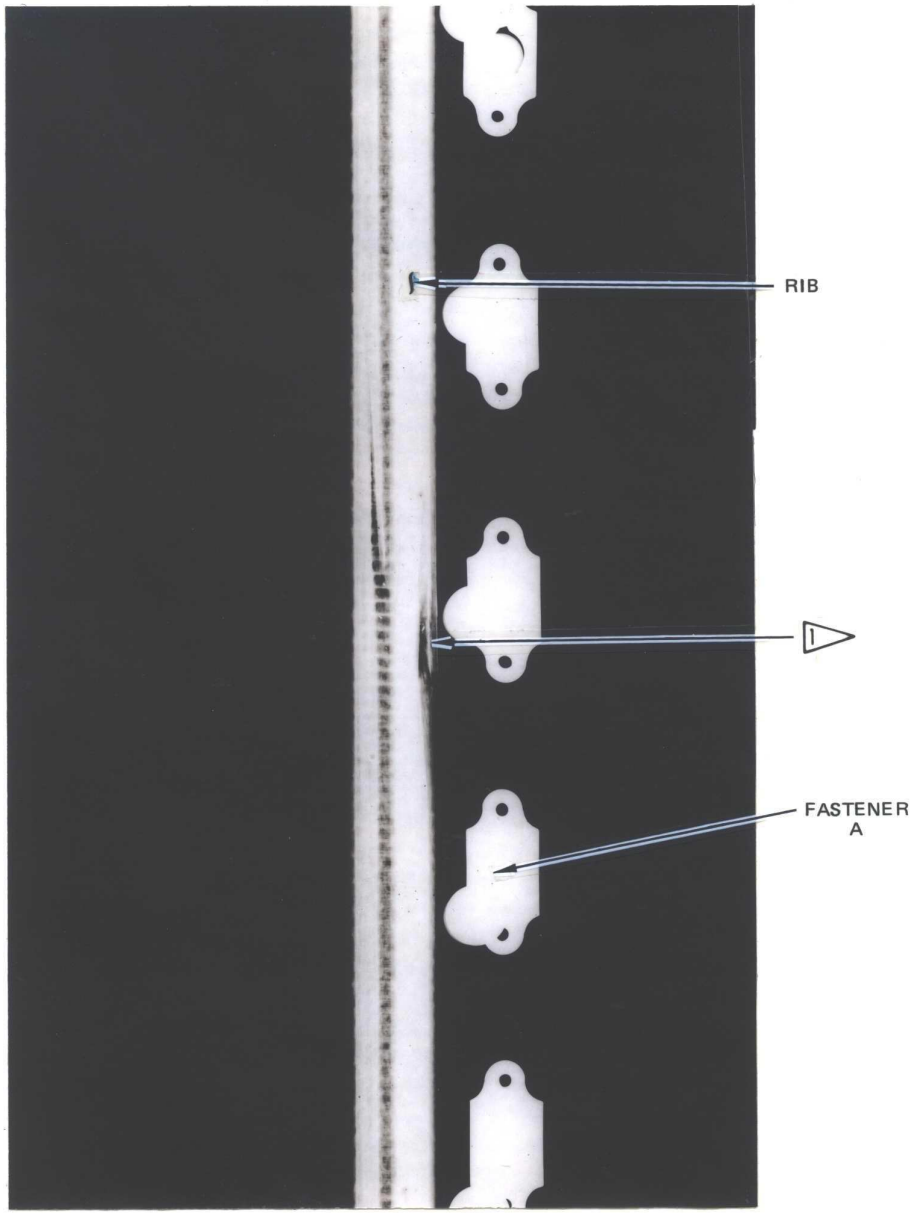

ACTUAL RADIOGRAPH

(EXAMPLE OF A RADIOGRAPH THAT IDENTIFIES FRACTURED PARTS WHEN THE RADIATION BEAM IS PARALLEL TO THE PART)

2125494 S0000458232_V1

Radiographic Analysis
Figure 4 (Sheet 3 of 3)

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PART 2 - X-RAY

INSPECTION OF HONEYCOMB STRUCTURE

1. **Purpose**
   A. Use this radiography procedure to examine nonmetallic honeycomb-sandwich structures for the defects identified below:
      (1) Damage caused by lightning strike.
      (2) Crushed or damaged honeycomb caused by a large impact.
   B. To examine honeycomb structures for water contamination, refer to Part 2, 51-00-01.
2. **Equipment**
   A. X-ray Generator - Use an X-ray generator that operates at a minimum of 20 kV and 3 mA.
   B. Film - ASTM Class I or II radiographic film.
   C. Processor - Use a manual or an automatic processor.
3. **Prepare for the Inspection**
   A. Get access to the inspection area.
   B. Remove the part to be examined from the airplane, if possible.
   C. Remove loose paint, dirt and sealant from the surface of the inspection area.
4. **Inspection Procedure**
   A. Position the X-ray generator to align the X-ray beam with the honeycomb cell walls in the inspection area.
      NOTE: Honeycomb cells are usually perpendicular to the aerodynamic surface. If there are two aerodynamic surfaces, the honeycomb cells are usually perpendicular to the surface with the largest radius.
   B. Put the film on the side of the part opposite the X-ray generator as shown in Figure 1.
   C. Set the X-ray generator controls and make an exposure to get a density of 1.8 to 2.5. Use a technique chart to help make the initial X-ray generator control adjustments.
      NOTE: A technique chart is necessary for each X-ray generator. Show the exposure time necessary for different thicknesses to get the maximum results in the least time.
5. **Inspection Results**
   A. Lightning Strike Damage
      (1) Compare the radiograph with the damaged area to find the full quantity of lightning strike damage. See Figure 2 for a radiograph example of an area damaged by lightning.
      (2) Make an inspection for crushed or damaged honeycomb core and signs of cracks in the inner skin plies.
   B. Large Impact Damage
      (1) Make an inspection for crushed or damaged honeycomb core and signs of cracks in the inner skin plies. See Figure 3.

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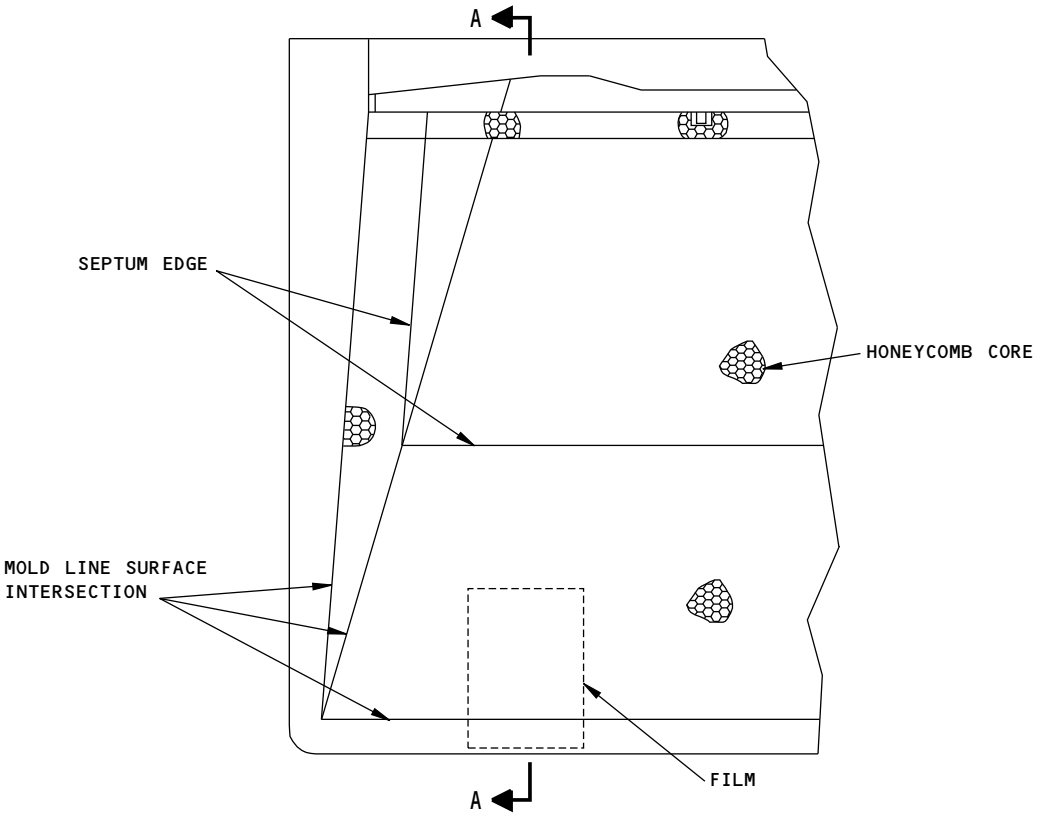
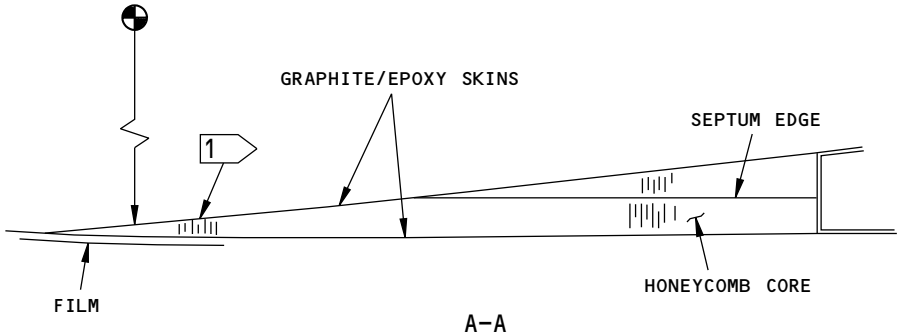


GRAPHITE/EPOXY COMPOSITE SPOILER



A-A
(TURNED 90°CW)

NOTES

X-RAY GENERATOR POSITION

1 ALIGN THE HONEYCOMB PART SO THAT THE CELL WALLS ARE PARALLEL TO THE RADIATION BEAM.

2125590 S0000458234_V1

Typical Inspection of a Honeycomb Structure
Figure 1

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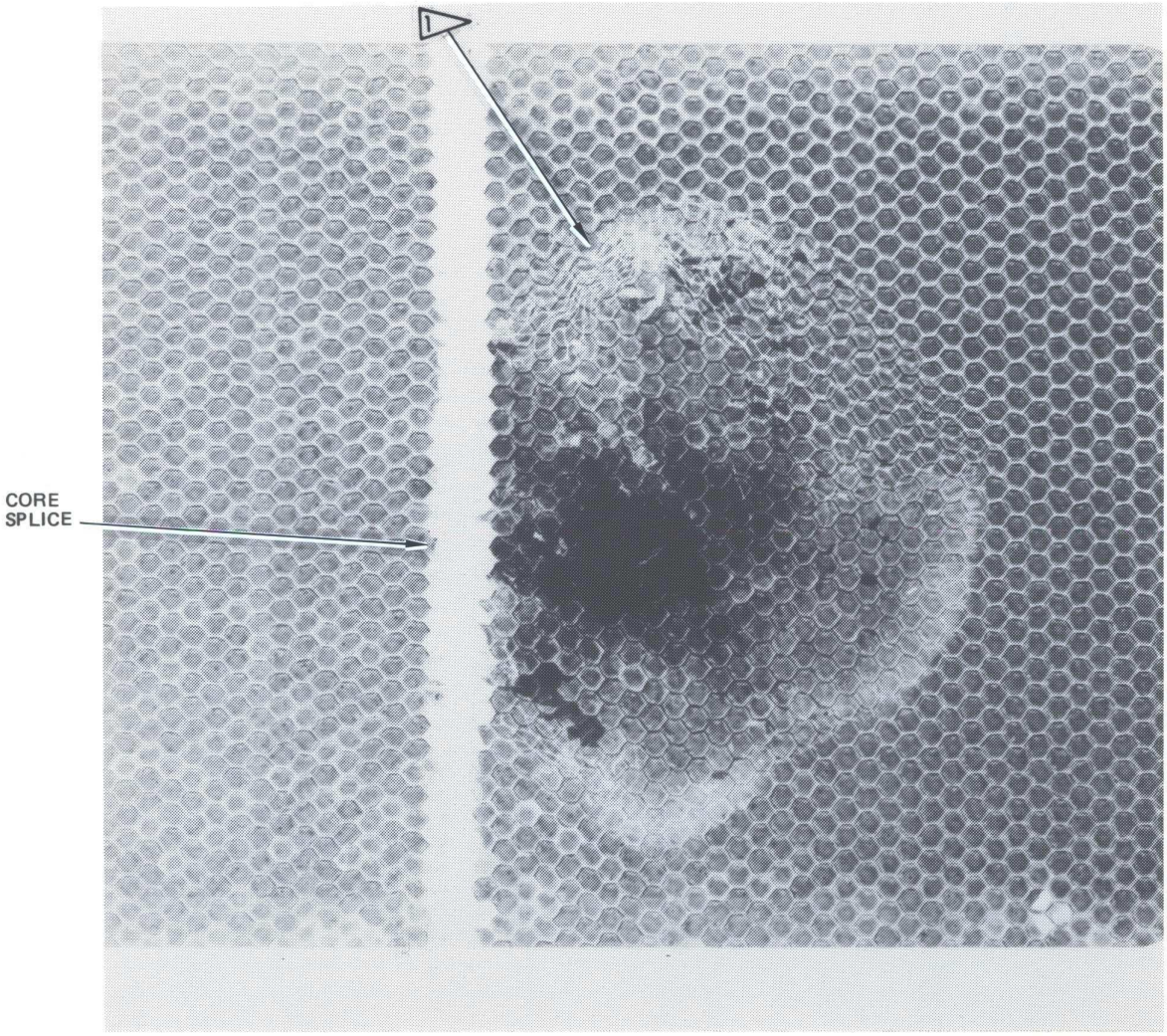

ACTUAL RADIOGRAPH

NOTES

- EXAMPLE RADIOGRAPH OF A HONEYCOMB PANEL WITH LIGHTNING DAMAGE.

1 DAMAGED HONEYCOMB CORE

2125594 S0000458235_V1

Lightning Strike Damage
Figure 2

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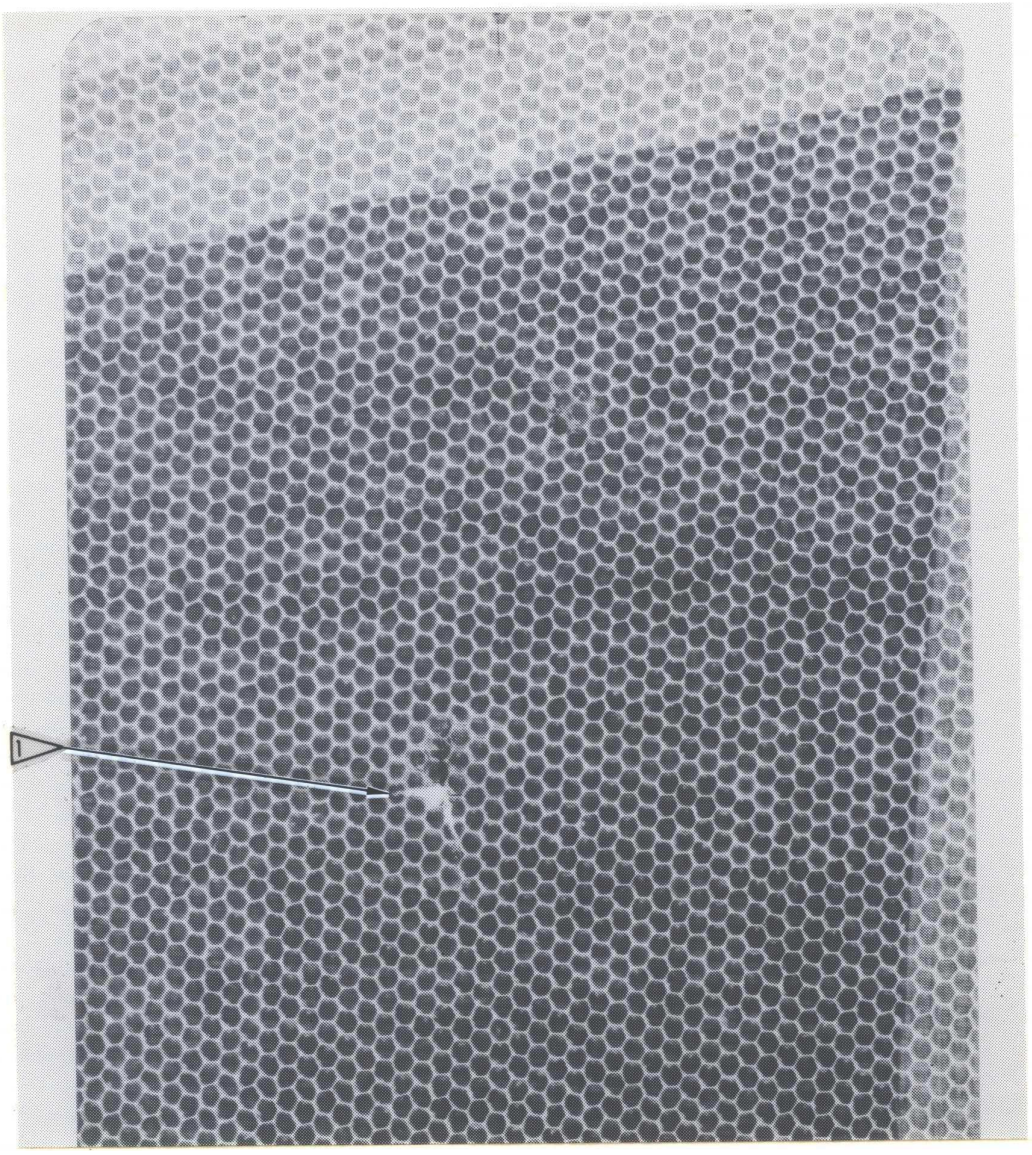

ACTUAL RADIOGRAPH

NOTES

- EXAMPLE RADIOGRAPH OF A HONEYCOMB PANEL WITH LARGE IMPACT DAMAGE.

1 IMPACT DAMAGE

2125605 S0000458236_V1

Impact Damage
Figure 3

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IDENTIFICATION OF MERCURY CONTAMINATION

1. Purpose

A. This procedure can be used to help find mercury.

B. This procedure is general and can be adapted as necessary for each location thought to have mercury contamination.

2. Equipment

A. X-ray source - Use an X-ray source that will satisfactorily send X-rays through the structure and help find mercury as specified in this procedure.

(1) An Eresco 42 MF2 200kV X-ray generator was used to help prepare this procedure.

B. Film - Use ASTM E 1815 Class II high speed, high contrast, fine grained film. This procedure was prepared with 14 x 17 inch (356 x 432 mm) Fuji IX80 film.

C. A device to identify the location of the central axis of the X-ray beam from the X-ray generator. This device can be a laser or a mechanical pointer.

D. A device to hold the X-ray tube is necessary to align the X-ray source relative to the area of inspection.

E. A tape measure.

F. Lead letters and numbers, for example, to identify the radiographic images.

G. Film Processor - A manual or an automatic processor can be used.

H. Refer to Part 1, 51-01-00, for data about the equipment manufacturers.

3. Prepare for the Inspection

WARNING: DO NOT GET MERCURY IN YOUR MOUTH, EYES, OR ON YOUR SKIN. DO NOT BREATHE THE FUMES FROM THE MERCURY. WEAR PROTECTIVE SPLASH GOGGLES AND GLOVES WHEN YOU CLEAN A MERCURY SPILL. MERCURY IS POISONOUS AND CAN CAUSE INJURY TO PERSONNEL.

A. Remove all mercury (see Figure 1) that is easy to see as specified in the mercury spill maintenance practices found in Aircraft Maintenance Manual (AMM) Section 05-51. Make sure the area has good airflow and you have and use the applicable personnel protection equipment. Take precautions to keep the mercury contained as you work in the airplane.

B. Get access to the mercury contamination area as necessary.

C. Identify the areas you think have mercury contamination. Make a plan for your X-ray sequence and how you will identify (number) the radiographs in relation to the X-ray locations.

D. Make a perimeter around the airplane to keep personnel out of the area to prevent accidental radiation exposure as specified by your radiation safety procedures.

E. Clean the airplane skin before you put the film in position.

F. If you have an area of known mercury, it can help to take an X-ray of that area so that you have an X-ray that shows mercury that can be compared with X-rays taken of other areas. Alternatively, you can put lead shot (Shot #12, approximately 0.05 inches (1.3 mm) in diameter is recommended) in a sealed X-ray translucent, plastic container (a ziplock bag for example), on the structure in the contamination area to cause a known shape to occur in the X-ray. See Figure 6.

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4. Inspection Procedure

WARNING: X-RAY RADIATION IS A POTENTIAL HEALTH HAZARD. DO THE STANDARD RADIATION SAFETY PROCEDURES.

A. See Figure 2 and Figure 3 for an example on how to prepare X-ray equipment for an X-ray, but you will have to adapt the positions and exposures for your configuration. Figure 3 shows the X-ray tube inside the fuselage, but it is permitted to put the X-ray tube outside the fuselage and the film inside.

B. Set identification markers so that you can identify the film location to the airplane location. A sealed plastic container of lead shot can be put in the X-ray area as a known object to simulate mercury drops and help make sure the X-ray intensity and exposure time is satisfactory.

C. Take the exposure and develop the X-ray film. The optical density of developed radiographs for the structure in the inspection area must range from 1.5 (minimum) to 3.5 (maximum) in the inspection area. Adjust the exposure to get the necessary film density. If used, the lead shot must be easily identified on the exposure (Figure 6).

D. Record the X-ray source and film locations, and the exposure adjustments so that you can do one or more X-rays again at that location after mercury clean up, if necessary.

5. Inspection Results

A. Examine the X-rays for signs of mercury.

(1) Drops of mercury will show on X-ray negatives as small, round, white spots as shown in Figure 4 and Figure 5. Mercury corrosion and embrittlement shows on the X-rays as tree shapes that go through the structural component.

(2) Be sure not to identify metal particles and other unwanted material as mercury.

B. If mercury drops are found, the area must be carefully cleaned to remove the mercury. All mercury that can be viewed on a radiograph without magnification must be removed. X-ray can be used again to make sure the area is clean.

C. If there are signs of structural damage, corrosion, cracks, embrittlement, or other damage, send a damage report to your engineering department for repair instructions before you do more.

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2202715 S0000490813_V1

Mercury (Silver in Color) shown on the Fuselage Skin in the Bilge of an Airplane
Figure 1

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EXPOSURE NUMBER	X-RAY DATA					
	FILM			SFD INCH (MM)	GENERATOR SETTINGS	
	POSITION	ASTM CLASS	DIMENSIONS		kV	MAS
1	1	II 2	3	60 4 (1524)	80 TO 150	5

NOTES

1 DO AS MANY X-RAY EXPOSURES AS NECESSARY TO EXAMINE A MERCURY SPILL AREA. SEE FIGURE 3 FOR TYPICAL X-RAY GENERATOR POSITIONS.

2 THIS FILM WAS USED TO HELP PREPARE THIS PROCEDURE. A WIDE RANGE OF FILM TYPES ARE PERMITTED FOR RADIOGRAPHIC IDENTIFICATION OF MERCURY.

3 USE STRIP FILM OR 14 X 17 INCH (356 X 432 MM) FILM AS NECESSARY FOR EACH EXPOSURE.

4 OTHER SOURCE-TO-FILM DISTANCES (SFD) ARE PERMITTED.

5 SET THE MAS (MILLIAMP SECONDS) TO GET A FILM DENSITY THAT IS FROM 1.5 TO 3.5 IN THE INSPECTION AREA.

2202814 S0000490814_V3

X-ray Generator and Film Data
Figure 2

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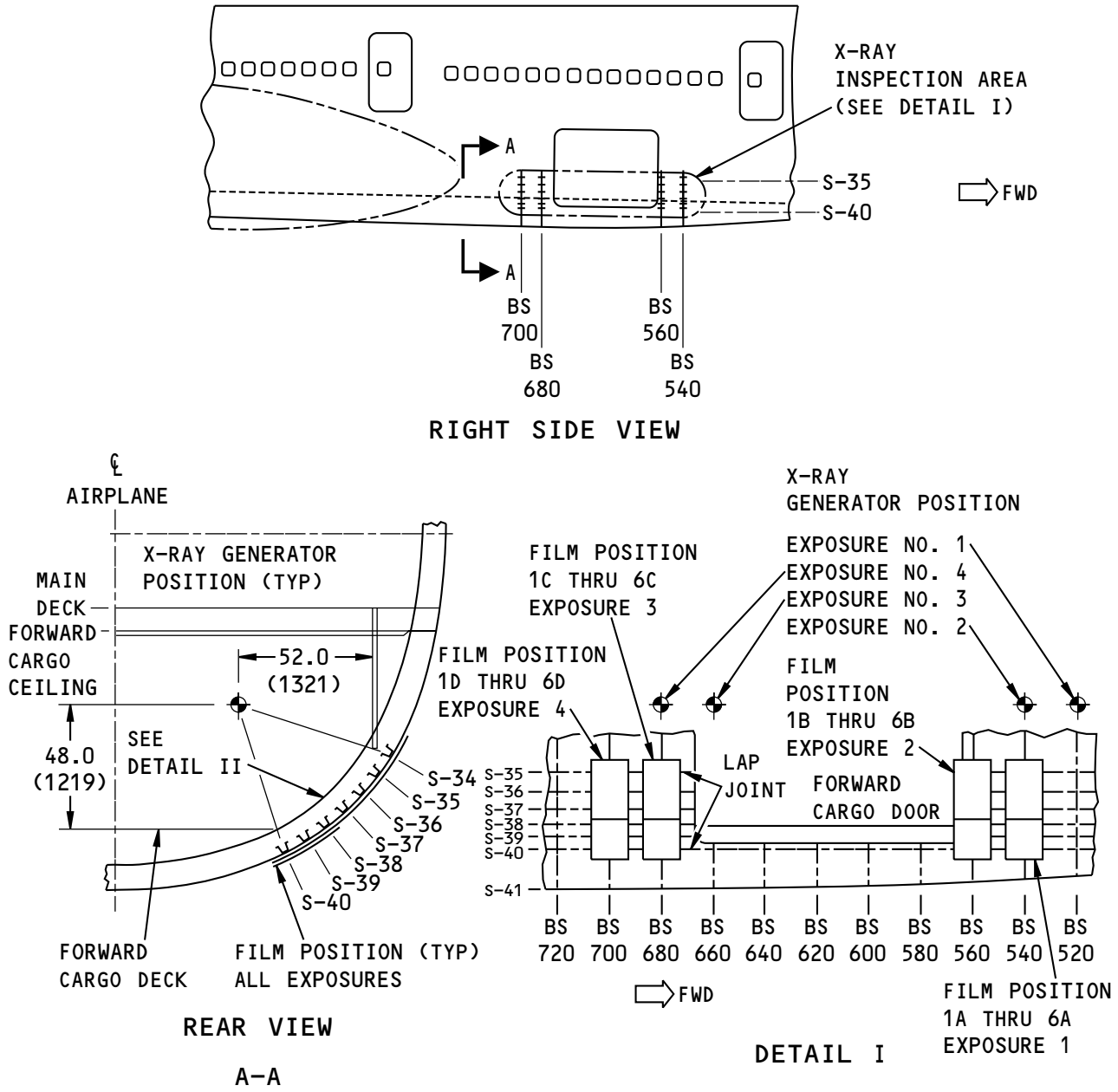

2202879 S0000490815_V2

Typical Example of the X-ray Generator and Film Positions for Identification of Mercury near the Cargo Door
Figure 3 (Sheet 1 of 2)

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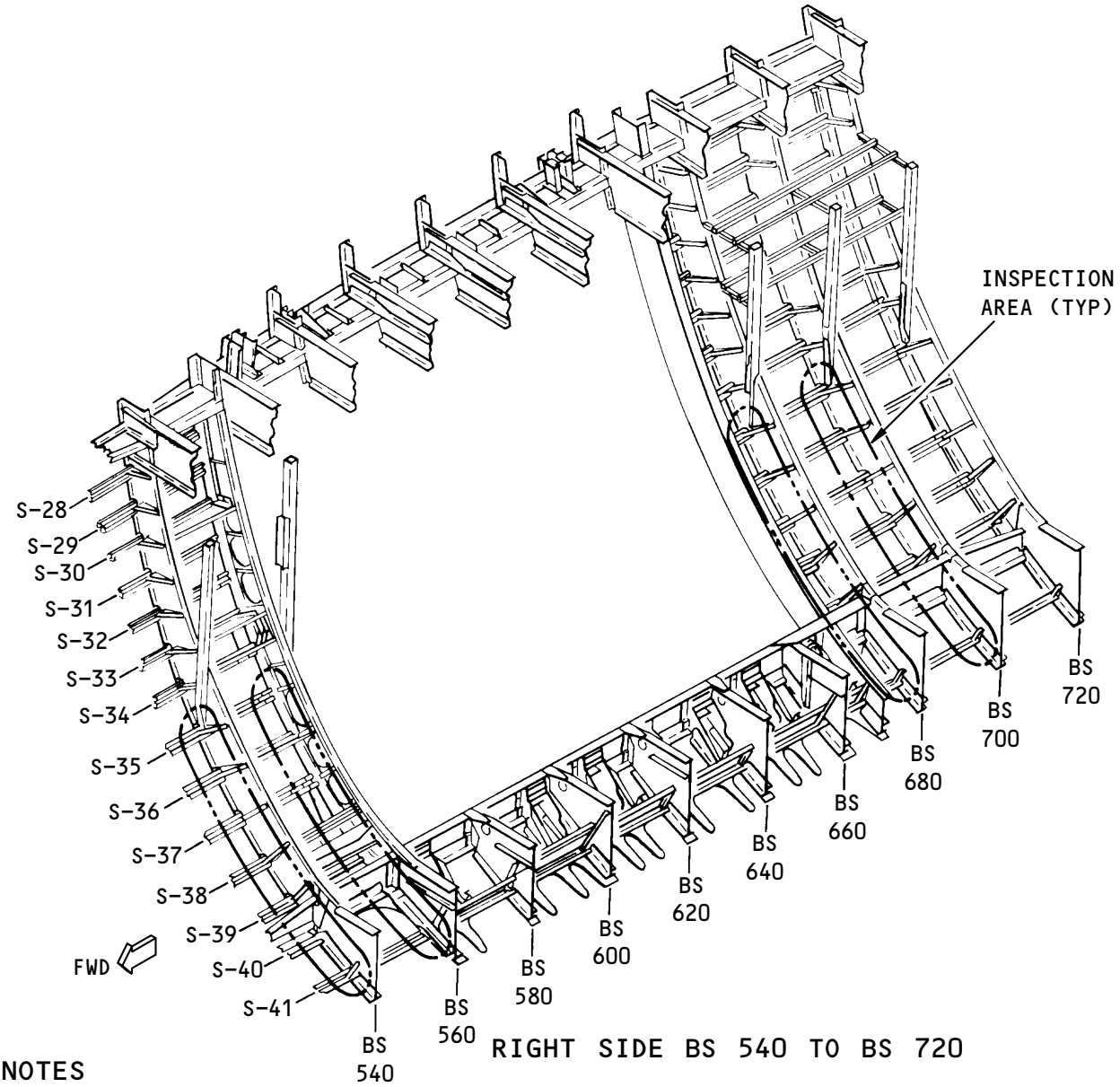

NOTES

- ALL DIMENSIONS ARE IN INCHES (MILLIMETERS ARE IN PARENTHESES)
- PUT THE X-RAY GENERATOR 20 INCHES (508 MM) FORWARD OF THE FRAME TO BE EXAMINED
- PUT THE FILM ON THE OUTER SURFACE OF THE SKIN SO THAT IT IS CENTERED ON THE FRAMES

DETAIL II

- DETAIL II IS ONLY AN EXAMPLE. STRINGER AND BODY STATIONS WILL BE DIFFERENT FOR OTHER INSPECTION AREAS.

2202886 S0000490816_V1

Typical Example of the X-ray Generator and Film Positions for Identification of Mercury near the Cargo Door
Figure 3 (Sheet 2 of 2)

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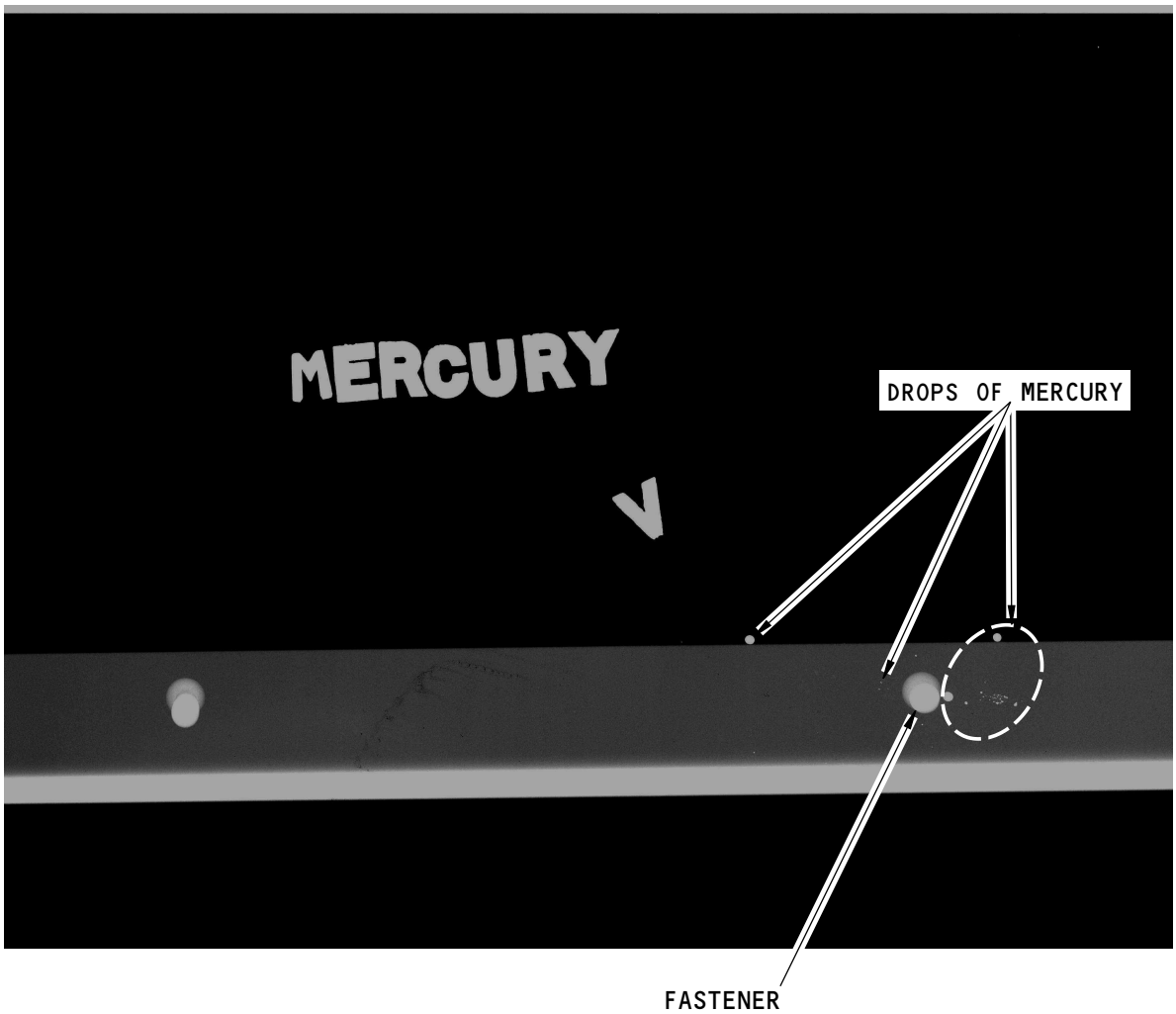

2202897 S0000490817_V1

Example Radiograph that Shows Mercury on a Structure
Figure 4

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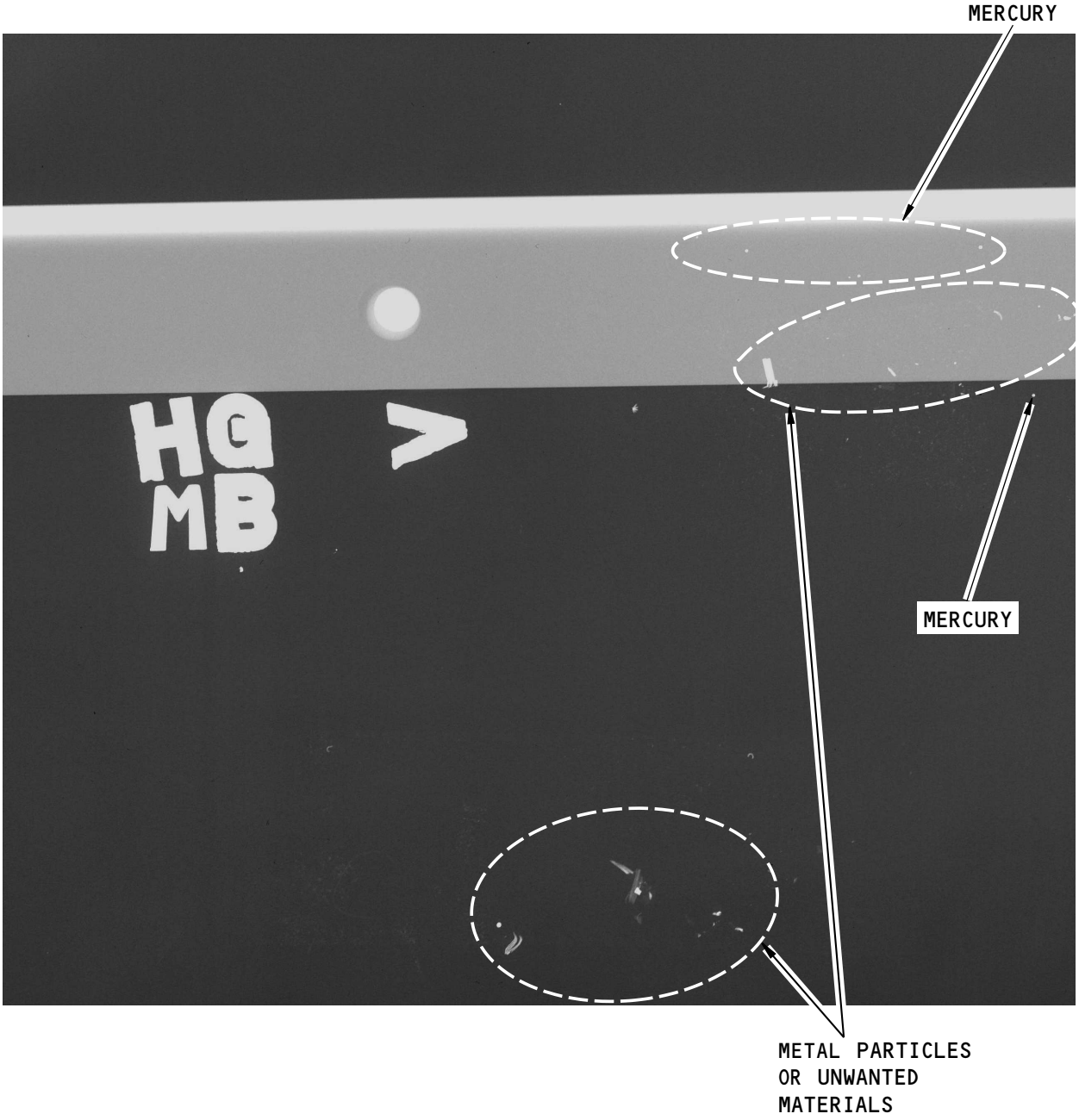

2202935 S0000490818_V2

Example Radiograph that Shows Mercury and Metal Particles on a Structure
Figure 5

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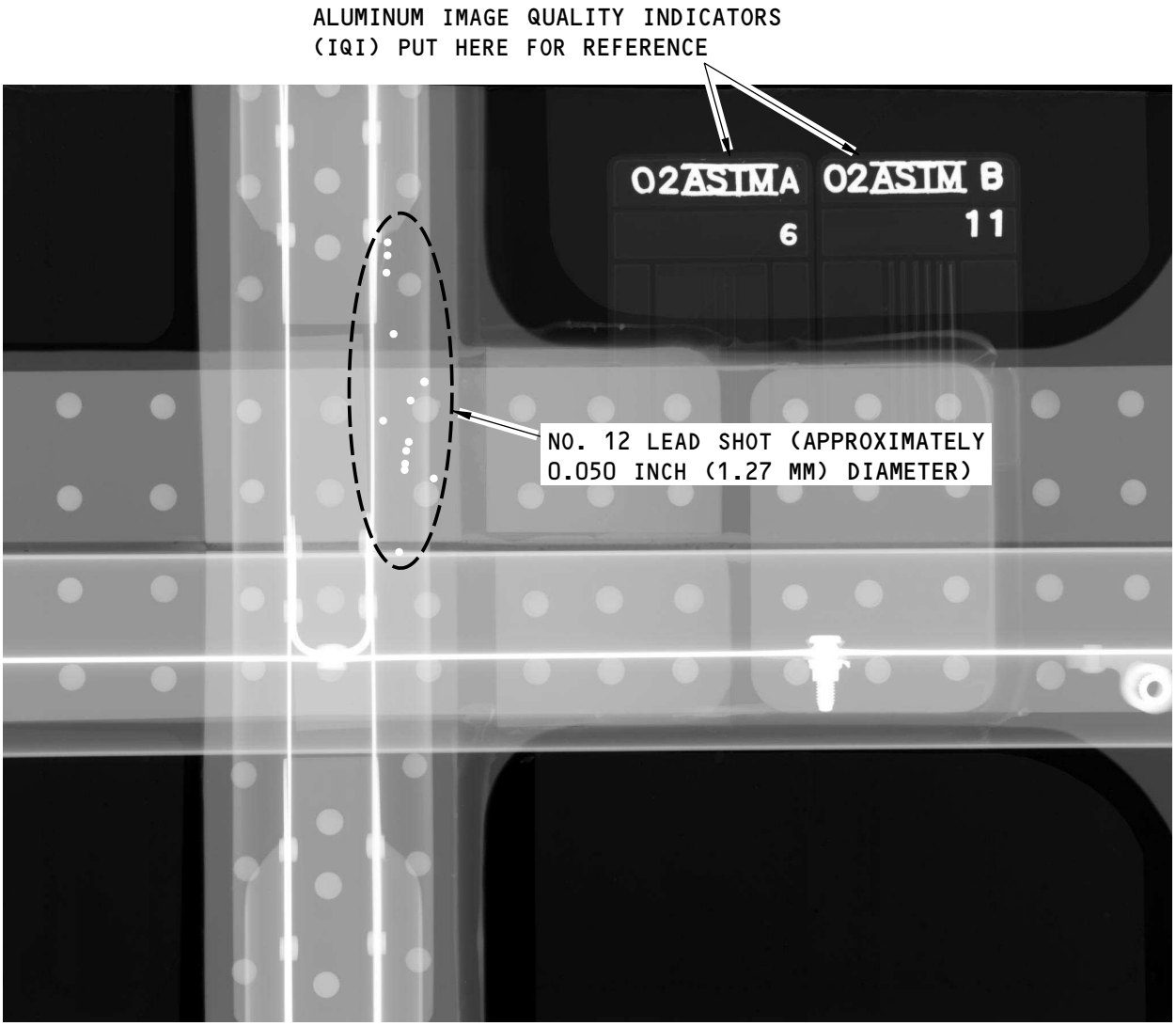

2231267 S0000497363_V1

Example Radiograph with Lead Shot Used to Simulate Mercury
Figure 6

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