Aloha Airlines Flight 243
Boeing 737-200
April 28,1988
Honolulu, HI

Aloha 243 was a watershed accident :

- There were very clear precursors that were not acted upon
- It reflected a basic lack of airplane level awareness
- It pointed out errors in basic design and certification philosophies
- There were catastrophic unintended effects

April 28, 1988, Flight 243 was scheduled for several “Island-hopping” flights:

- First Officer conducted preflight inspection in darkness and noted nothing unusual
- Airplane initially flew 3 round trip flights from Honolulu to Hilo, Maui, and Kauai. All flights were uneventful
- No requirement for visual inspection between flights, and none were conducted
- Accident flight departed Hilo at 1:25 pm with flight crew and 89 passengers on board

While leveling at inter-island cruise altitude of 24000 feet, a portion of the forward fuselage separated from the airplane:

- Resulted in immediate depressurization
- Captain assumed control, noting that airplane was rolling left and right, and flight controls were “loose”
- Captain noticed that the cockpit door was missing, and he could see blue sky where the first class ceiling had been
- Left engine failed, restart attempts unsuccessful
- Captain and first First Officer donned oxygen masks and initiated emergency descent

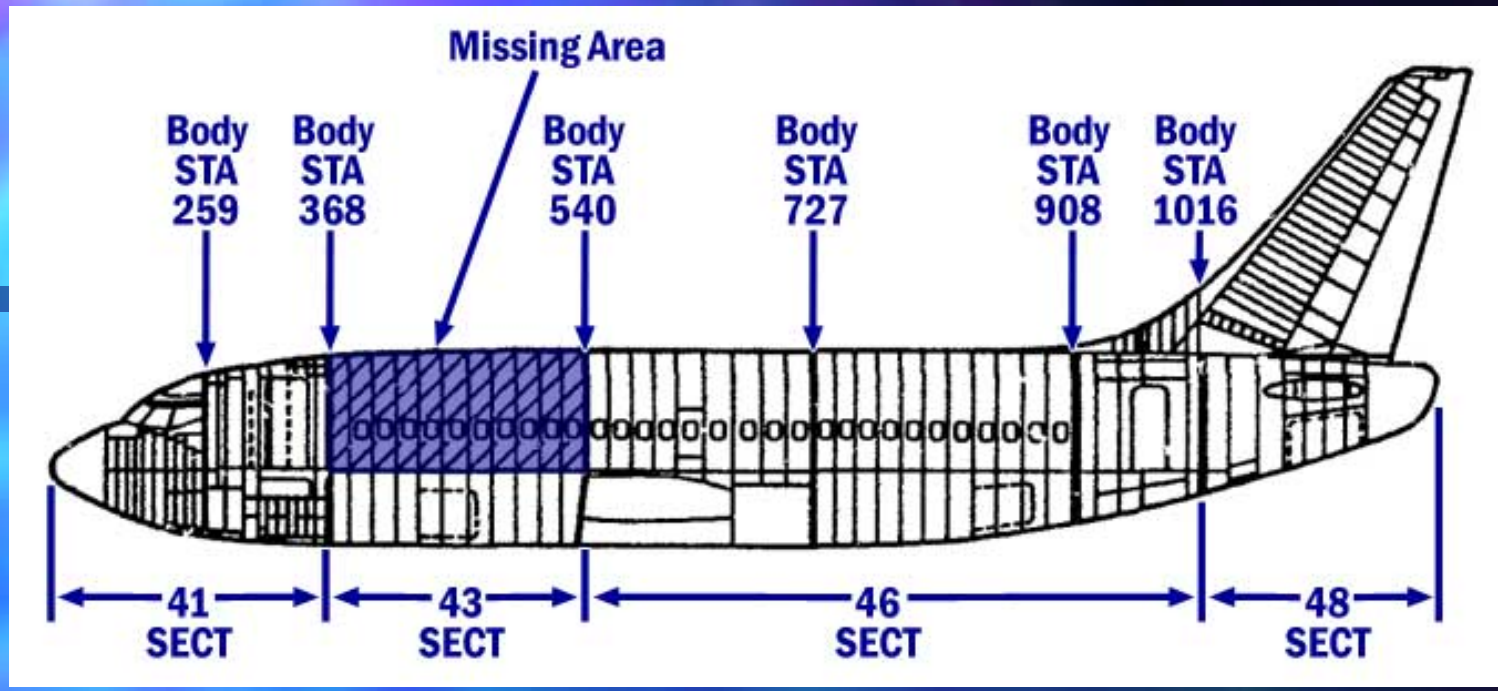
Successful landing in Honolulu:

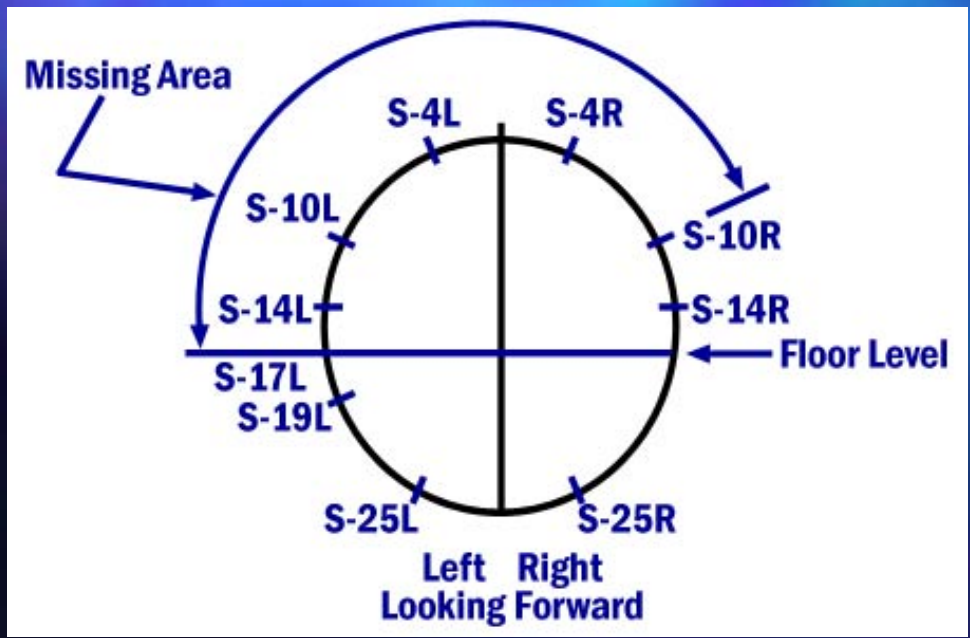
- Separated section extended from cabin floor, equivalent to ~1/4 of fuselage length
- One fatality, seven serious injuries
- The fatality was a flight attendant who had been standing at row 5, and was swept out of the cabin
- A flight attendant at row 15 was thrown to the floor and slightly injured. Flight attendant at row 2 sustained serious injuries from flying debris
- When depressurization occurred, all passengers were in their seats, and seat belt sign was already illuminated


Aloha

Damage Summary:

- At the time of the accident, the airplane had 89,680 flight cycles, and 35,496 flight hours
- After the accident, a passenger reported that as she boarded, she noticed a large vertical fuselage crack, but didn't mention it to anyone
- Final damage consisted of the total loss of a major portion of the upper crown, and damage to other structure in section 43
- Damage extended from the main entrance door, aft about 18 feet. Airplane was determined to be damaged beyond repair, and was dismantled on site


Missing Area
Body STA 259
Body STA 368
Body STA 540
Body STA 727
Body STA 908
Body STA 1016
41 SECT
43 SECT
46 SECT
48 SECT


Missing Area
S-4L
S-4R
S-10L
S-10R
S-14L
S-14R
Floor Level
S-17L
S-19L
S-25L
S-25R
Left
Right
Looking Forward

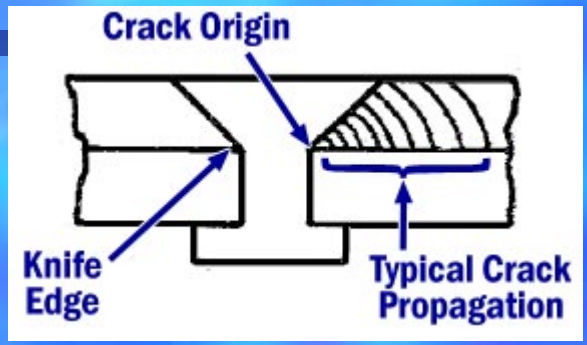
Accident was caused by pressurization related cyclic fatigue of fuselage lap joint:

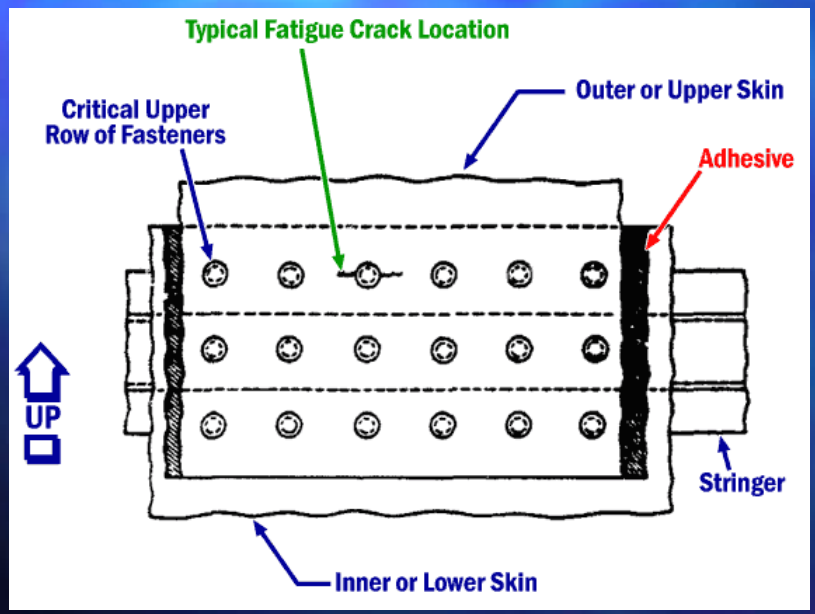
- Disbonding of joint led to improper load distribution, and fatigue cracking
- Joint disbonding also led to corrosion, which contributed to joint failure
- Lap joints in other locations had been the subject of AD's, but none in the area(s) of failure

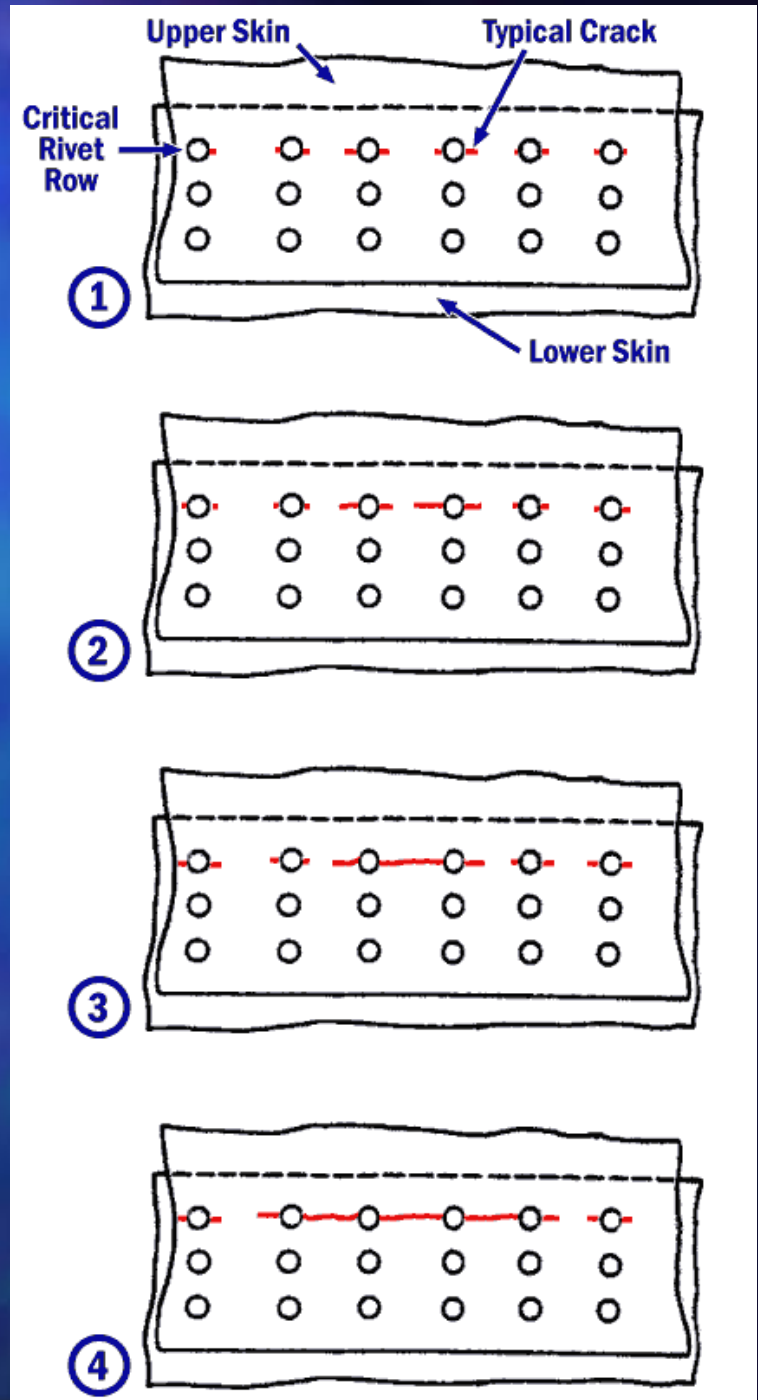
Crack growth

- When cracks form at the “knife” edges of holes, cracks propagate from hole edges.
  - As cracks grow, they may link up
  - Over time, this linking up of cracks can lead to catastrophic failure

Crack growth (Cont'd)







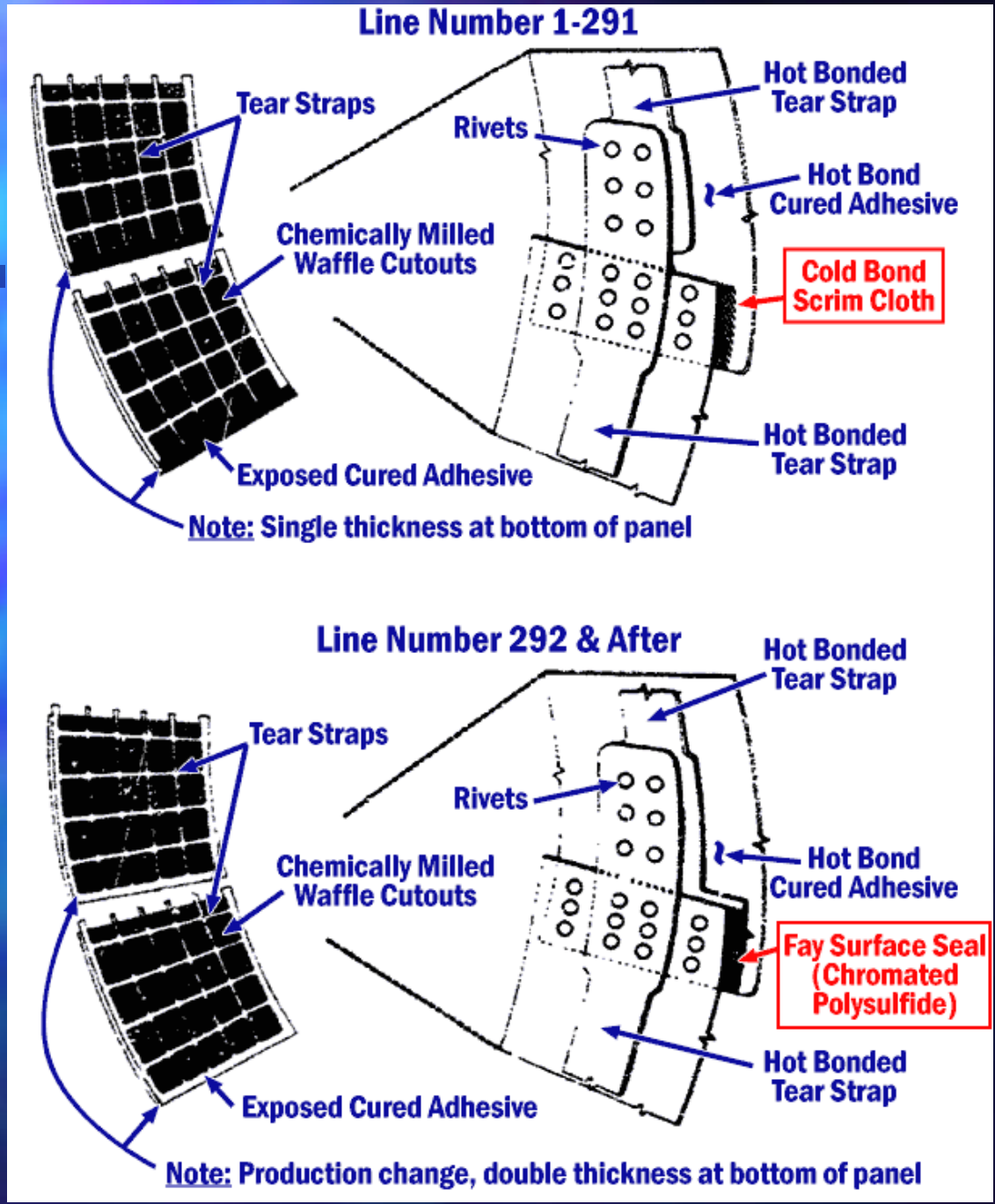
At airplane line number 292, Boeing changed production lap joint process:

- “Old” process utilized cold bonding, with fasteners used to maintain surface contact in joint, allowing bonding adhesive to carry/transfer load between skin panels
- Adhesive was breaking down, causing fasteners to carry load for which they were not intended
- Repeated pressurization cycles led to formation of cracks at the “knife” edges of fastener holes

Fuselage Lap Joint Process (Cont'd):

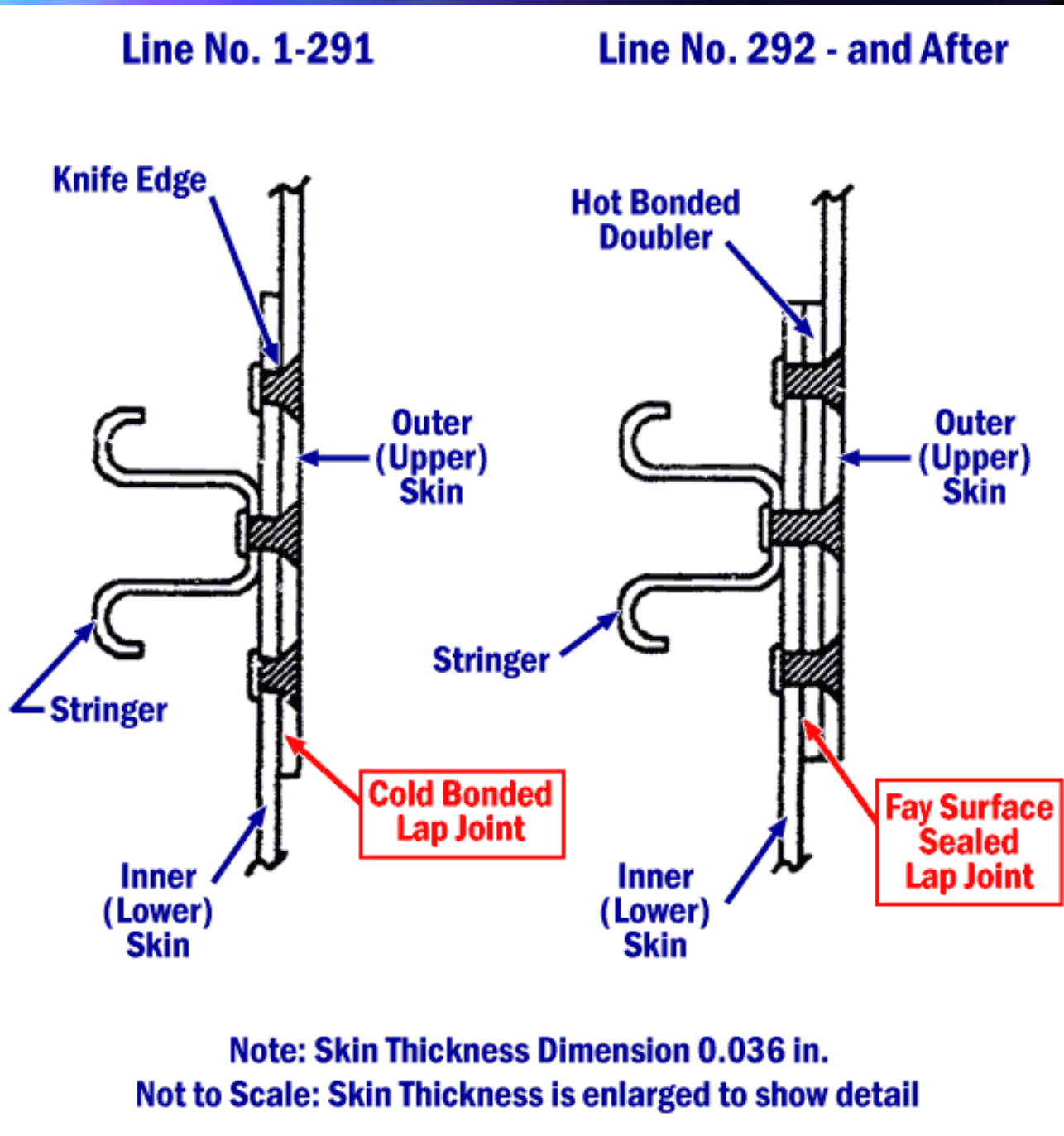
- The cold bonding process (scrim cloth) was replaced by a joint assembled with faying surface sealant (Chromated Polysulfide)
- The over-lapping upper skin at the lap joint was changed from a single 0.036" skin to a configuration with an 0.036" skin plus 0.036" doubler hot bonded together
- This construction improved the known problems with the joint by:
  - Eliminating the knife-edge fatigue detail, which resulted from the countersunk rivets in a disbonded upper skin
  - Eliminating the corrosion concern associated with the scrim cloth, which could wick moisture into the lap joint

Fuselage Lap Joint Construction:



Fuselage Lap Joint Construction:

Accident airplane was constructed using "old" method



Unsafe Conditions:

- Disbonding of lap splice(s) due to breakdown of joint adhesive
- Corrosion in the joints as a result of the disbonding
- Existing undetected cracks in fuselage skin, accelerated by the presence of corrosion in the joints
- Inefficient/ineffective airline maintenance program

Design and Safety Assumptions:

- In the event of a single crack, due to the presence of fasteners, crack growth would stop at stiffener, resulting in skin flapping, and safe decompression, eliminating the need for directed inspections
- Possibility of simultaneous presence of multiple cracks (multiple site damage – MSD) was considered unlikely, and assumed that local MSD would link up and propagate into a large crack that would be detected, and repaired
- Increased inspection program could detect tear strap disbonding on the older fleet of Boeing airplanes
- Design service life of airplane (20,000 hours) was such that fatigue analysis of joint fasteners, or effects of corrosion did not need to be considered

Precursors:

- Multiple ADs had directed inspections and repairs targeting specific sections of the airplane, but had not looked at the airplane as a whole
  - FAA AD 87-21-08 mandated inspection of lap splices at fuselage stringer 4. This AD did not recognize the risk of failing to mandate inspections of all lap splices, and only mandated inspections of the known unsafe condition
  - Boeing Alert Service Bulletin 737-53A1039 proposed inspection of all 737 lap joints – Service Bulletin NOT mandated by AD

Resulting Regulatory and Guidance Changes:

- **Mandatory corrosion control programs** - require that all operators have prevention and inspection systems sufficient to ensure that hazardous corrosion never occurs (11 ADs mandating inspections and modifications)
- **AD 2002-07-08 and 2002-07-11** mandate removal and replacement of certain areas of the skin lap splice
- **14 CFR 25.571 Amendment 96** was issued to require special consideration for WFD in the structure, and requires full-scale fatigue tests
- Repair Assessment for Pressurized Fuselages Rule (**14 CFR 91.410, 121.370, 125.248, and 129.32**)
- Widespread fatigue damage NPRM

Lessons Learned:

- Basic Design and Safety Assumptions need to be validated
  - Routine maintenance and inspection may not assure detection of cracks/corrosion which may lead to catastrophic failures
  - safety assumptions had been based on the ability of these inspections to detect damage

Lessons Learned: (cont'd)

- Mandatory repair/modification/replacement of Principal Structural Elements
  - Requirement to develop directed corrosion inspection and prevention programs and mandate them.
  - Review the adequacy of structural supplemental inspection programs, enhancing and mandating them, as necessary.
- Requirement to develop a limit of validity for WFD, and application in airlines maintenance programs.
  - Assess the quality of structural repairs with respect to long-term operation; Develop regulations and guidelines for this assessment. (Revisions to 14 CFR 91.410, 121.370, 125.248, and 129.32)

Aloha's Aircraft Maintenance Human Factors Lessons Learned.

- Inspectors working under pressure
- Inspections done at night –circadian rhythm upset
- Inspectors suspended by safety harnesses
- Required to inspect 1,300 rivets
- Documentation complicated & subject to interpretation
- Engineering Dept was outsourced
- Hanger lighting designed for DC-3's
- Lack of adequate manpower – Fatigue / 2 Jobs
- Lack of knowledge- just two hours of NDT training.