Improving the Service Life of FLIGHT DECK WINDSHIELDS

Airlines can improve the service life of the flight deck windshields in their fleets by adopting a few basic practices. Actions include identifying the age and design of the windshields, predicting their service life, performing scheduled maintenance and repairs, and replacing unserviceable windshields with those of improved design. The result will be fewer system interruptions caused by unexpected windshield damage.

MAINTENANCE

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Unscheduled replacement of flight deck windshields (often referred to as cockpit windows or windscreens) can result in a significant cost to airlines and can cause delays in flight schedules. To improve the service life of the windshields in their fleets, airlines should consider the following steps:

1. Determine windshield age and design.
2. Predict windshield service life.
3. Properly maintain and repair windshields.
4. Replace unserviceable windshields with those of improved design.

1 DETERMINE WINDSHIELD AGE AND DESIGN

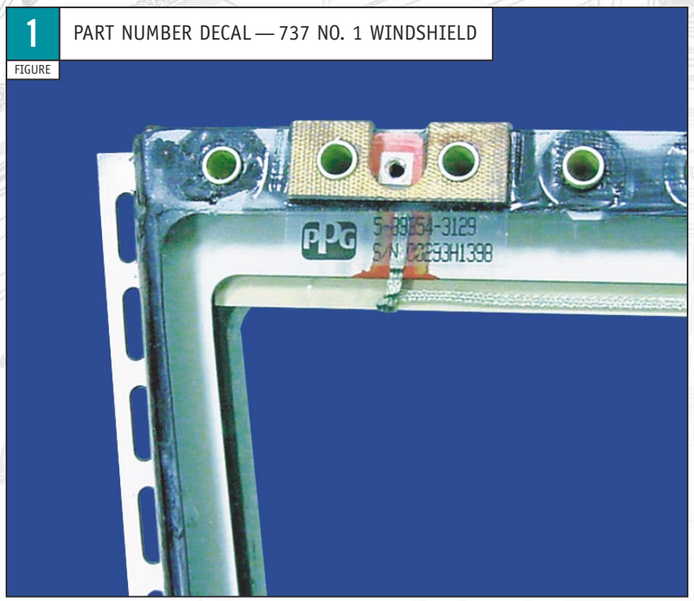
To determine the age and design configuration of a flight deck windshield, an airline must know the windshield part number, supplier name, and date of manufacture. Most windshield assemblies for Boeing-designed airplanes have a part number decal, or tag, located on the inboard side along the perimeter near the top of the windshield assembly (fig. 1).

The decal has two numbers: the Boeing part number and the manufacturing serial number of the windshield supplier. For example, a decal on a 737 no. 1 windshield manufactured by PPG Aerospace, Pittsburgh, Pennsylvania, displays the numbers P/N 5-89354-3129 and S/N 00293H1398. Airlines can identify the windshield design configuration and flight deck location by looking up the Boeing part number in one of several Boeing information sources — the Airplane Illustrated Parts Catalog (AIPC), engineering data, or the Boeing Part Analysis and Requirements Tracking (PART) Page. (All these sources are available on the World Wide Web at MyBoeingFleet.com.) In this example, the window is the pilot's no. 1 left-hand windshield (fig. 2).

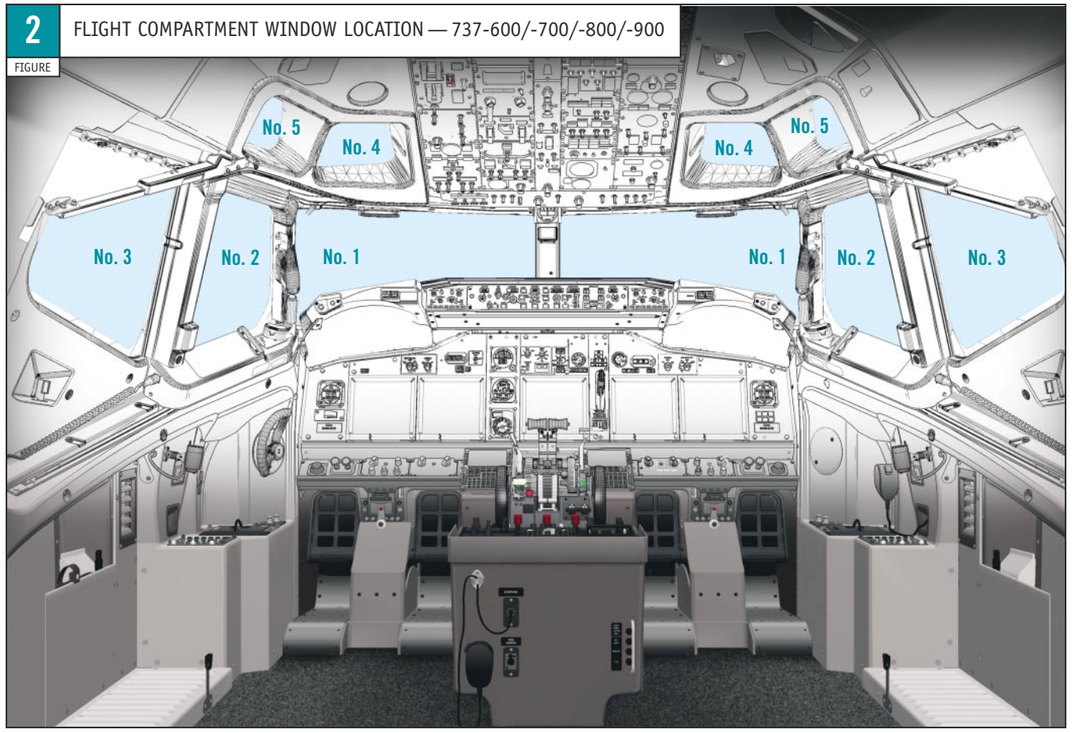
The supplier manufacturing serial number provides information about when and where the windshield was manufactured. For the number given in the example, S/N 00293H1398, "00" identifies the year of manufacture (2000); "293" is the manufacturing day of the year; "H" indicates where the windshield was manufactured (Huntsville, Alabama); and "1398" is the supplier serial number of the windshield. (*Note:* Some windshield suppliers provide the date of manufacture in a separate field on the decal rather than including it in the serial number.)

Typical supplier codes stamped on the part number decal are "F" or "PPG" for PPG Aerospace; "S" for Swedlow, Pilkington Aerospace, Garden Grove, California; "SS" for Sierracin/Sylmar, Sylmar, California; and "XXX" or "PA" for Triplex, Pilkington Aerospace.

1 FIGURE — PART NUMBER DECAL — 737 NO. 1 WINDSHIELD



2 FIGURE — FLIGHT COMPARTMENT WINDOW LOCATION — 737-600/-700/-800/-900



Markings on Douglas-designed airplanes, located along the top of the windshield, include the manufacturer's name or trade name, Douglas part number, drawing change letter, and serial number.

(*Note:* Acrylic windows on Boeing- and Douglas-designed airplanes do not necessarily have decals. The transparent material often is marked directly by pin-stamping, grit-blasting, or laser-etching.)

In addition to measuring the age of a flight deck windshield in years, the age also can be measured in flight-hours. If the windshield is original equipment, the total flight-hours on the airplane — a value commonly tracked by operators — can be used to determine the age of the windshield in flight-hours. For a replacement windshield, operators should separately track the number of flight-hours on the airplane since the new windshield was installed.

2 PREDICT WINDSHIELD SERVICE LIFE

By establishing the age of the flight deck windshields in its fleet (in both years and flight-hours), an airline can compare its windshield fleet performance with Boeing data from reporting operators and make changes to improve service life and reduce unscheduled system interruptions.

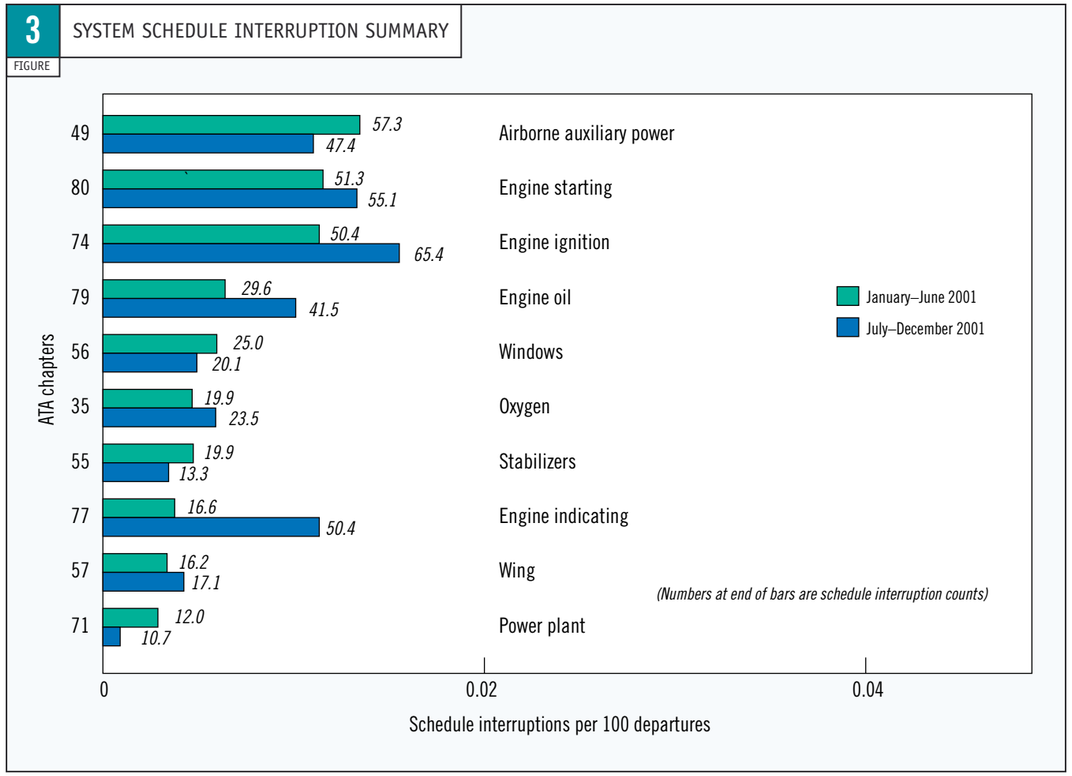
Figure 3 summarizes the causes of system schedule interruptions for 737-300/-400/-500 airplanes for two 6-month periods ending December 2001. Of the 30 items tracked by the Air Transport Association (ATA), windows (i.e., Chapter 56) were the 18th most significant cause of delay. Although ATA Chapter 56 covers all window-related delays, including those involving passenger cabin windows, it does provide an overall guideline for 737 flight deck windshields. (Data on system schedule interruptions for all Boeing- and Douglas-designed airplanes are available on the MyBoeingFleet.com web site under Fleet Reliability Statistics.)

Boeing analysis of the 737 ATA Chapter 56 data revealed the following:

- Flight deck windshields no. 1 (left and right) and no. 2 (left and right) significantly affected system schedule reliability.
- Flight deck windshields manufactured before November 1992 lasted approximately 6,000 flight-hours (4 years) of in-service use before replacement, compared with 20,000 to 30,000 flight-hours (8–11 years) for those manufactured after November 1992. (The 737 analysis did not measure airplane utilization, which was not a meaningful factor because it was taken into account in the usage [flight-hours] measurement.)

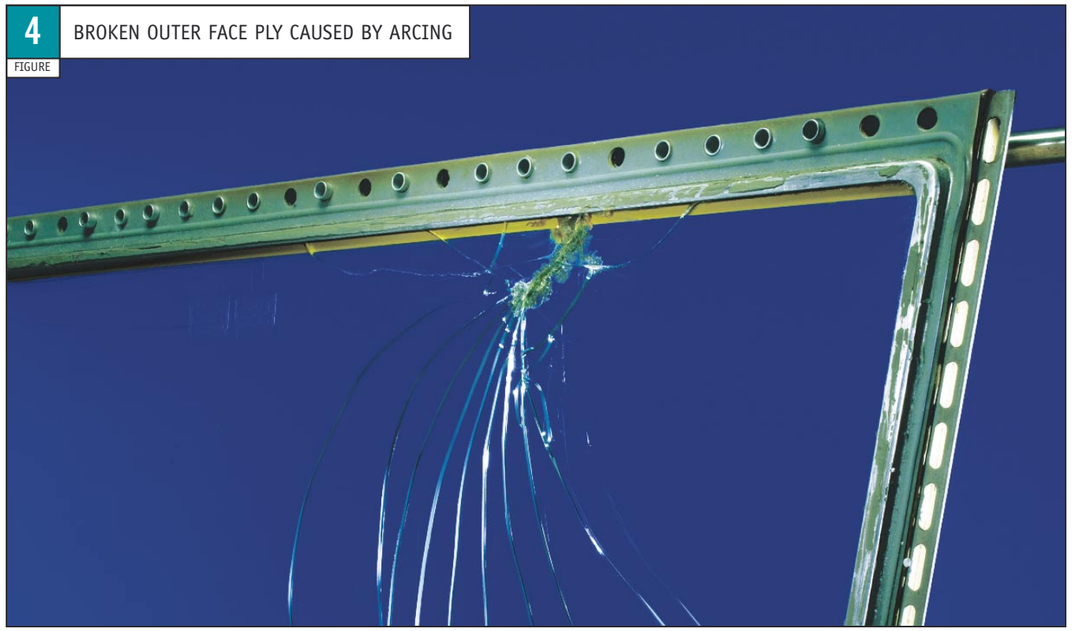
3 SYSTEM SCHEDULE INTERRUPTION SUMMARY

FIGURE



4 BROKEN OUTER FACE PLY CAUSED BY ARCING

FIGURE



- The most common problem with flight deck windshields is in-flight cracking of the outer ply (fig. 4).
- Scheduled inspection of windows is the most effective means to reduce system interruptions caused by unscheduled windshield removals.

3 PROPERLY MAINTAIN AND REPAIR WINDSHIELDS

Proper maintenance and repair of flight deck windshields entail identifying damage, performing maintenance and repairs, and replacing windshields during scheduled maintenance. Recommended maintenance intervals are defined in the maintenance planning data for each airplane model.

Airlines can identify windshield damage using data in the appropriate aircraft maintenance manual (AMM) for Boeing-designed airplanes or, in some cases, the structural repair manual (SRM) for Douglas-designed airplanes. The maintenance data in the AMM or SRM will help airlines determine whether a windshield should remain in service, be maintained or repaired in situ, or be removed from service. When windshield removal is warranted, an airline must determine whether the windshield can be repaired using the overhaul manual (OHM) or component maintenance manual (CMM). In some cases, airlines may contract with Boeing, windshield suppliers, or repair stations to return windshields to serviceable condition.

Given the Boeing analysis of 737 data and reports from fleet operators, airlines should focus on seven maintenance and repair issues: in-flight cracking, scheduled visual inspections, power connectors, service bulletins and letters, window removal and repair, repair stations, and training.

In-flight cracking.

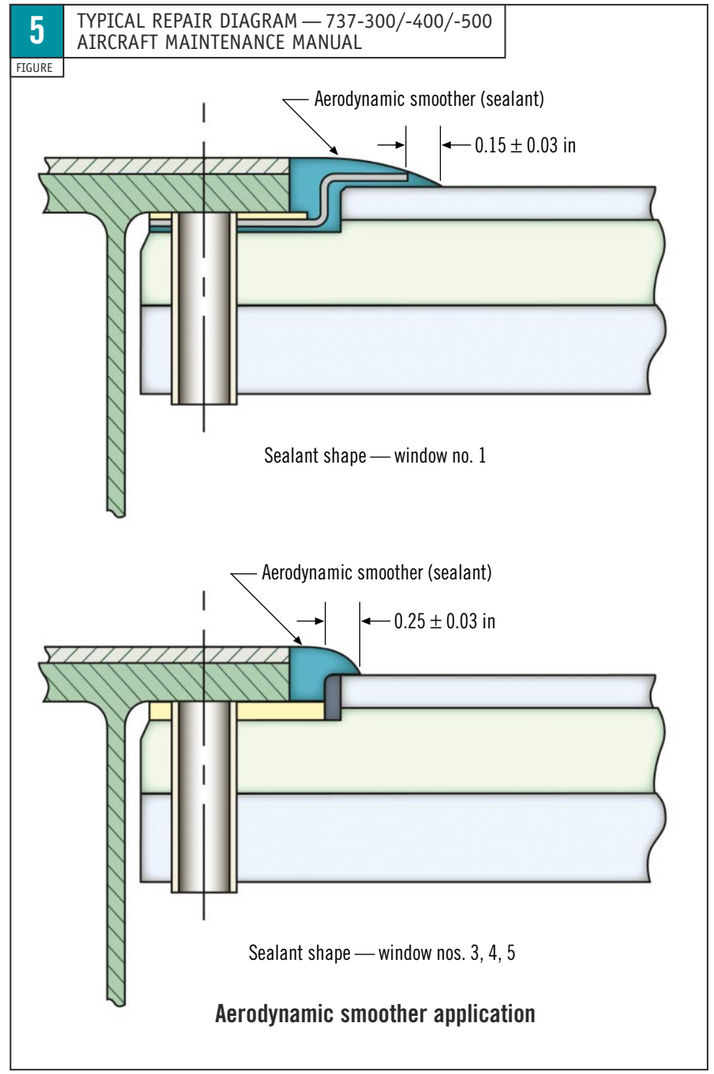
The most common problem that airlines have with flight deck windows is in-flight cracking of the outer ply (fig. 4). Conditions that lead to cracking begin with moisture around the aerodynamic seal (also referred to as the aero seal, moisture seal, or hump seal). Moisture ingress eventually causes delamination, heat-coating problems, and arcing, which — if not corrected — lead to cracking of the outer ply. The aerodynamic seal around the perimeter of a window is subject to erosion by wind and rain. Maintaining the aerodynamic seal in good condition is critical in preventing erosion and moisture ingress and improving the windshield service life. The recommended visual inspection of the aerodynamic seal for erosion, cuts, nicks, and overall condition and repair is discussed in the applicable sections of the AMM or SRM for each airplane model. Figure 5 shows a typical repair diagram of the aerodynamic seal.

Scheduled visual inspections.

Scheduled visual inspections are the best way to check for window conditions that may require window removal. Cloudy areas at the upper aft corner of a window or window periphery in the interlayer indicate moisture

5 TYPICAL REPAIR DIAGRAM — 737-300/-400/-500 AIRCRAFT MAINTENANCE MANUAL

FIGURE



Aerodynamic smoother application

ingress. Burn marks, bubbles, and moisture stains also indicate that the window may reach an unserviceable condition in the future. Window conditions and damage are described in the appropriate sections of the AMM or SRM for applicable Boeing- and Douglas-designed airplanes.

Power connectors.

Airlines should ensure that the power connections are tight and sealed properly to help prevent arcing. Typical information on maintenance procedures can be found in the AMM or SRM.

Service bulletins and letters.

Each airline should review all applicable Boeing-, Douglas-, and supplier-issued service bulletins, service letters, and similar advisories to evaluate the potential effects of windshield-related issues on its fleet. For example, Boeing service bulletin 737-56-1010 (Sept. 2, 1999) recommends replacement of windshields on certain models if they do not pass a dielectric leak check. Replacement helps prevent electrical arcing and reduces system schedule interruptions.

Window removal and repair.

Once an airline has removed a windshield from service, the windshield can be scrapped; repaired as directed in the applicable OHM or CMM; or returned to Boeing, the supplier, or the repair station for repair. Boeing-recommended overhaul procedures are published in the OHM or CMM for the appropriate windows. In general, these procedures describe disassembly of the window frame and any attached mechanism but do not address disassembly of the window transparency itself.

In most cases, the 707, 727, and 737 windshields are structurally and functionally interchangeable. This is important when an airline is managing a fleet with various airplane models. Other Boeing- and Douglas-designed airplane windshields also are interchangeable within models and sometimes across families. The AIPC can be consulted to help determine interchangeability for each applicable model.

Repair stations.

Repair stations are approved by the U.S. Federal Aviation Administration or other appropriate regulatory agency. Stations include Boeing, Boeing-approved suppliers, and original window manufacturers.

Training.

Airlines are encouraged to use supplier-provided training aids, which include color illustrations that help in the identification of damage requiring window removal. Airlines also should consider training select maintenance personnel in flight deck windshield repair and sending them to industry-related conferences to promote better understanding of windshields.

4 REPLACE UNSERVICEABLE WINDSHIELDS WITH THOSE OF IMPROVED DESIGN

Replacing damaged, unserviceable windshields with windshields of improved design helps airlines take advantage of the best design practices available for specific windshield positions. This helps ensure that airlines realize the longest windshield service life possible and thereby minimize unscheduled system interruptions.

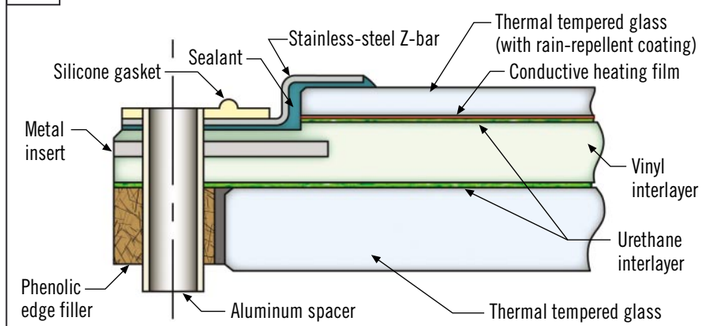
Boeing Spares typically stocks windows to the most recent design configuration and sends them to airlines as a kit of parts that includes the attaching hardware. Airlines can check the Boeing Spares inventory for windshield availability on the Boeing PART Page of MyBoeingFleet.com or contact their Boeing Field Service representatives. Windshield configurations for a particular airplane model are described in the AMM or SRM.

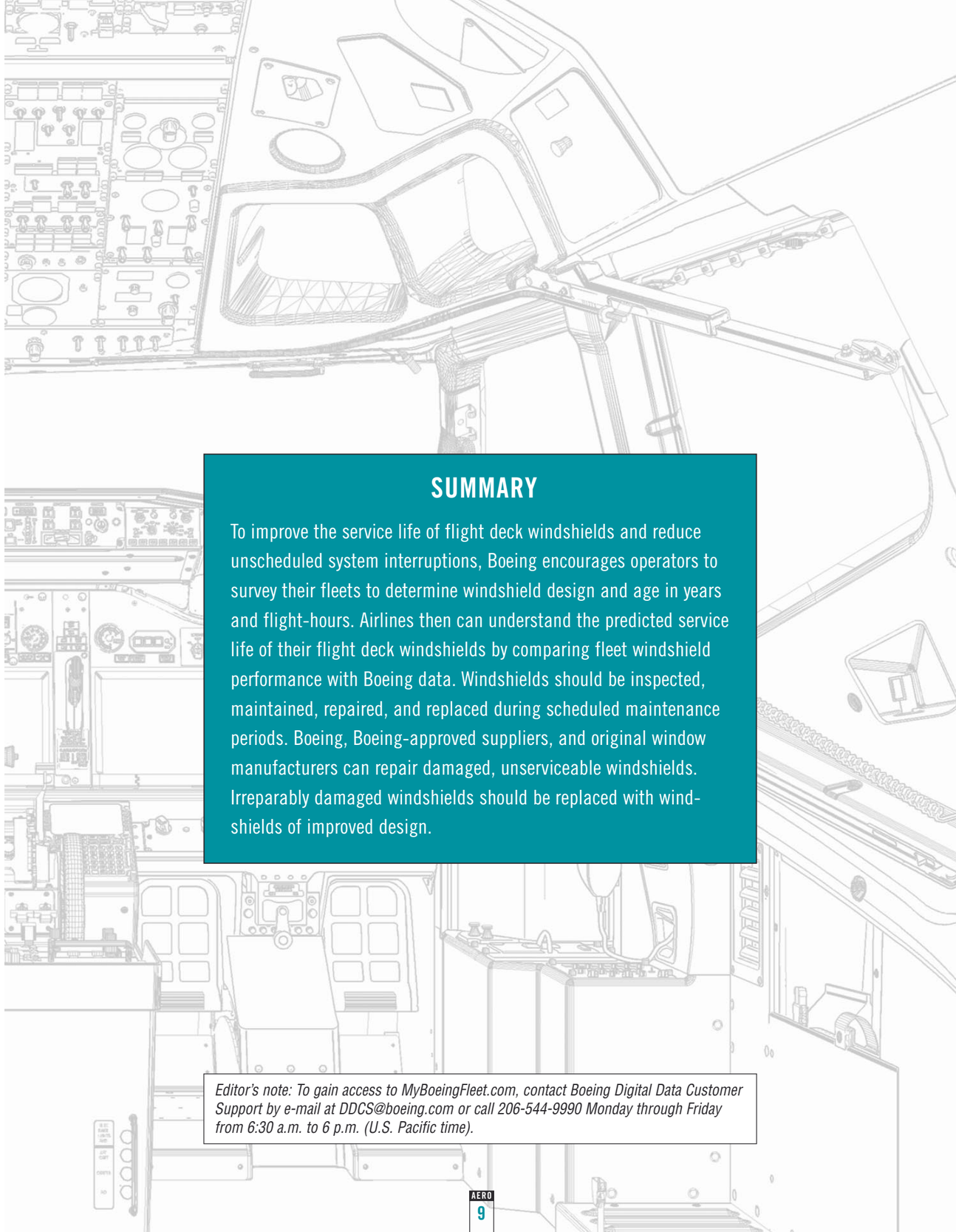
Changes to the 737 no. 1 windshield illustrate how design improvements can significantly improve service life (fig. 6). As mentioned earlier, Boeing data collected from reporting operators show a significant improvement in service life for 737 no. 1 windshields manufactured after November 1992. This corresponds with several important design changes implemented by Boeing that eliminated cracking of the vinyl interlayer and slowed moisture ingress into the windshield, thereby reducing the incidence of delamination, electrical arcing, and outerpane breakage. The design changes included the following:

- Adding no-slip planes in the vinyl interlayer to help prevent vinyl cracks.
- Adding a urethane interlayer between the vinyl and glass to act as a buffer for mechanical and thermal stresses.
- Adding a stainless-steel Z-bar to form a barrier against moisture.
- Improving the sealant used under the Z-bar to perform better when exposed to ultraviolet light, low temperatures, and moisture.

6 CROSS SECTION OF THE 737 NO. 1 WINDSHIELD

FIGURE





SUMMARY

To improve the service life of flight deck windshields and reduce unscheduled system interruptions, Boeing encourages operators to survey their fleets to determine windshield design and age in years and flight-hours. Airlines then can understand the predicted service life of their flight deck windshields by comparing fleet windshield performance with Boeing data. Windshields should be inspected, maintained, repaired, and replaced during scheduled maintenance periods. Boeing, Boeing-approved suppliers, and original window manufacturers can repair damaged, unserviceable windshields. Irreparably damaged windshields should be replaced with windshields of improved design.

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