Lockheed

VOL. 19, NO. 3, JULY-SEPTEMBER 1992

service news

THE HERCULES: SYMBOL OF HOPE

NESA WINDOWS UPDATE

A Service Publication of Lockheed Aeronautical Systems Company

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Vol. **19. No.** *3*, **July-September 1992**

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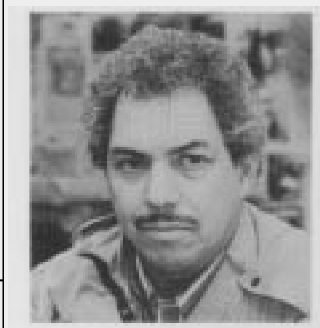
Photographic Support: John Rossino

Covers: Somali workers unload desperately needed relief supplies brought in by a Southern Air Transport L-l 00 Hercules. Note on the back cover the armed "technical" vehicle protecting the offloaded cargo from looters. Photos by Julius Alexander.

Focal Point

The Hercules: Symbol of Hope



Julius Alexander

The Hercules aircraft reinforced its military reputation in 1991 during the Gulf War. At that time, it was used in a variety of crucial combat roles: tactical airlift, aerial refueling, front-line resupply, and medical evacuation, to mention just a few.

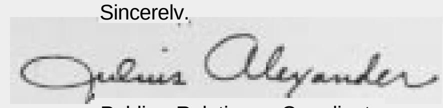
This year, the Hercules is enhancing its reputation in the humanitarian sector. Thousands of tons of emergency relief supplies have been airlifted into crude landing strips in Somalia on the wings of military C-130 and commercial L-l 00 transports. Considered by the USAF Air Mobility Command the most ambitious humanitarian airlift ever undertaken to a single country, the relief effort in Somalia has a strong civilian component as well. Southern Air Transport, the largest commercial operator of the Lockheed L-100, under contract to several humanitarian organizations. has been delivering relief cargo to war-torn Somalia for over a Year.

In the summer of 1992, I flew aboard several Southern Air L-100 Hercules airlifters into Somalia. There I watched the highly skilled crew members as they flew heavy loads of food, medicine, and other relief supplies into some of the most challenging landing strips imaginable. An example is Bardera, which has a 3,900.foot dirt runway. It would be difficult to exaggerate the dedication and professionalism with which these crews carried out their duties. I also observed and photographed the Somalis who unloaded the relief supplies and equipment. Their appreciation for this massive commitment of assistance was very obvious. Though there are many factions in this strife-torn country, and all are heavily armed, not one Southern Air Hercules was threatened or harmed. It was as if the Hercules is recognized by one and all as an airborne ambassador of help and goodwill.

The International Committee of the Red Cross, the Lutheran World Federation and the United Nations are the humanitarian organizations that engaged Southern Air to fly into Somalia. Southern Air's L-l 00s flew relief missions into Bardera, Baidoa, Beletweyene, Mandera, Mogadishu, Hargeisa Oddur, and Kismaayo. Each aircraft was launched on two or three flights a day, carrying approximately 35,000 pounds of food, medicine, fuel, and other desperately needed relief to the Somalis.

It is easy to take for granted an airplane that has been delivering the goods in both military and civilian airlift for nearly 40 years. But as Bob Koepp of the Lutheran World Federation told us, the beneficiaries of humanitarian airlift around the world never take the Hercules for granted. In third-world countries, especially Somalia, the Hercules has become a symbol of hope. It means someone cares; it means survival.

Sincerely,



Public Relations Coordinator
LASC Communications

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NESA WINDOWS: An Update on Electrically Heated Glass

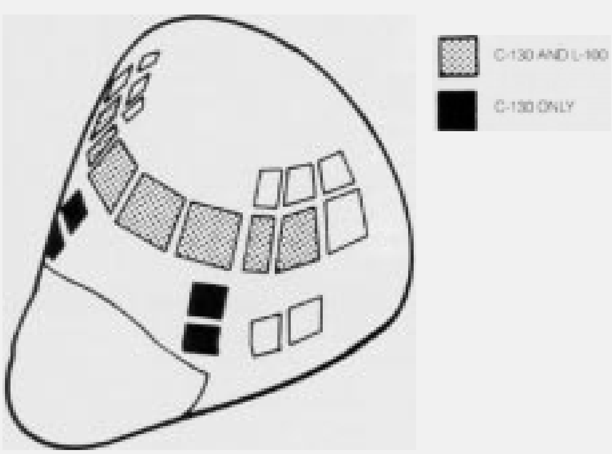
The mostrecent comprehensive discussionof NESA windows to appear in ***Service News*** magazine was published in Vol. 15, No. 1 (January-March 1988). That issue became one of the most popular ever released. Even though an unusually large press run was ordered at the time of publication, all reserve stocks of Vol. 15, No. 1 have been exhausted. For some months, we have been unable to satisfy requests for additional copies from the field.

This update on NESA windows is intended to meet the continuing demand on the part of Hercules operators for the latest information on electrically heated windows. Many subject-matter specialists have participated in revising and updating the material, but ***Service News*** wishes to express special thanks to David Hale, Jr. and Lanier Gramling of Lockheed engineering for their valued assistance in making this new edition possible.

System Description

Nine windshields on the C-130 aircraft, and seven on the L-100 aircraft, are electrically heated (Figure 1). These windows are of a type generally referred to by trade names such as Electrapane or, more commonly, NESA. NESA is an acronym that evolved from the term Non-Electrostatic Formulation A. It is a trademark of PPG Industries.

Figure 1. Electrically heated windows--Hercules aircraft.



The NESA windows on Hercules aircraft are of either five-layer or three-layer construction (Figure 2). In the case of five-layer panels, a central structural glass layer is sandwiched between two vinyl layers, which in turn are enclosed between two layers of glass.

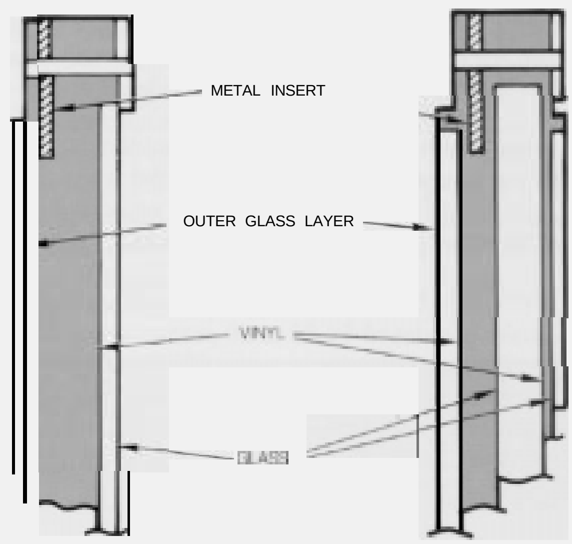


figure 2. NESA window cross sections. Left, three-layer panel; right, five-layer panel.

Three-layer panels consist of a single layer of vinyl between two glass panels. No adhesive is used between the vinyl and glass layers in either the three-layer or five-layer panels. The layers are bonded by heat and pressure during manufacture.

On L-100 models of the Hercules, five-layer NESA panels are used for the pilot's front, copilot's front, and center windshields, and in the pilot's and the copilot's hinged clear-vision windshields. Three-layer panels are used in the side windshields.

C-130 aircraft built to U.S. military specifications use three-layer NESA panels in all of the above locations. The pilot's forward upper and lower windows, which are not installed on commercial versions of the aircraft, also contain three-layer panels.

NESA FUNCTIONS

There are two reasons for providing electrical heating to aircraft windshield panels: one is to ensure that the panels remain clear and ice-free under all operating conditions. The other, also important, is the fact that heated windows offer more physical protection for the crew. NESA windows are significantly stronger and more resistant to shattering due to impact from hail, birds, and other solid objects when they are maintained at their design operating temperatures.

The required birdproof and fail-safe characteristics of a NESA windshield depend to a large degree on the plasticity of the vinyl interlayer of the panel. However, a modern aircraft's operating environment routinely exposes windows to a wide range of operating temperatures, and the physical characteristics of vinyl are markedly affected by temperature. This can produce significant changes in the contribution the vinyl makes to the strength of the windshield.

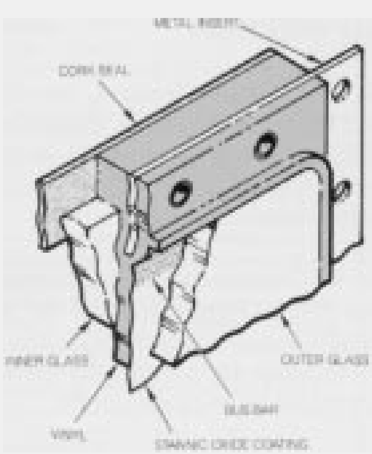
Vinyl tends to be brittle in the colder part of the operating range, and quite pliable in the warmer part. The ability of the windshield panels to withstand impact declines rapidly with lower temperatures.

For example, a panel's capacity to protect against a birdstrike is reduced by 30 to 50 percent when still at a relatively moderate temperature of 60 'F (15.5 ' C). The optimum temperature range for maximum energy absorptions by the vinyl is between 80°F (26.6 "C) and 120°F (48.8' C), This is the range in which the electrically heated panels are normally maintained.

Windshield Heating

The heating capability of NESA is provided by coating the inner surface of the outer glass on both types of NESA windows with a thin film of stannic oxide. This is a transparent, resistive material which heats up when an electric current is passed through it (Figure 3).

Figure **3. Detail of NESA window construction.**

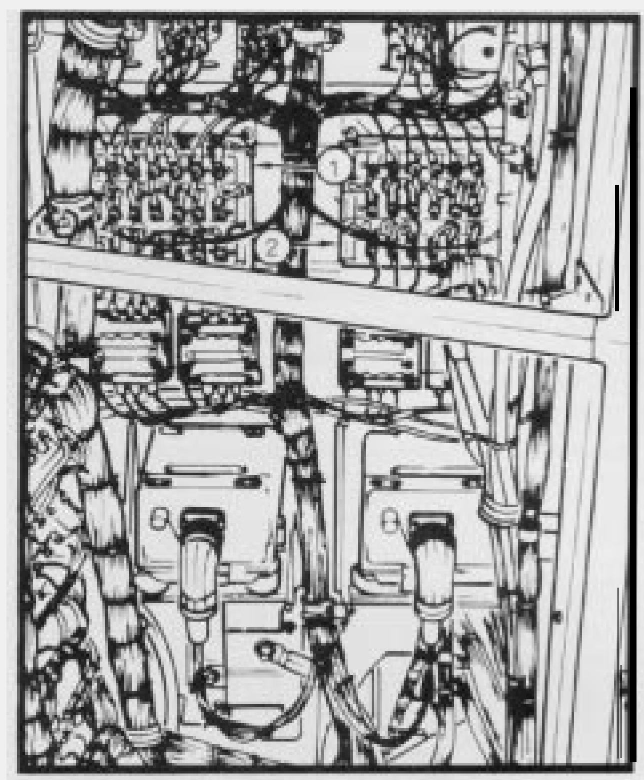


The electric power necessary to produce the required heat is supplied through metallic coatings across the top and bottom of each window that are connected to the stamric oxide and act as bus bars. Electrical connectors joined to these bars receive AC power from the NESA window system transformers when the applicable electrical control circuit is energized. This provides a current flow through the stannic oxide film, which heats the window.

Power Distribution

Provision for supplying the electric power required to heat the windows is divided between two electrical control systems located in the copilot's distribution panel (Figure 4). One 3-phase transformer supplies AC power to the three center windshield panels directly forward of the two pilots. A second 3-phase transformer provides power to the pilot's and the copilot's clear-vision windows and, on the C-130, to the pilot's two forward windows.

Figure 4. **NESA window power transformer locations.**



COPILOT'S DISTRIBUTION PANEL

1 MAIN NESA WINDSHIELD TRANSFORMER

2 SIDE AND LOWER NESA WINDSHIELD TRANSFORMER

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These systems are supplied with three-phase 115/200 VAC, 400-Hertz, AC power for heating from the left-hand AC bus through the NESA window circuit breakers on the pilot's upper circuit break panel. The transformers are used to step up the voltage, and provide two heating rates for the panels.

Approximately 290 VAC is supplied at the NORMAL, and 450 VAC at the HI setting of the center windshield panels circuit. The clear-vision, side, and pilot's forward window circuit provides about 205 VAC at the NORMAL, and 320 VAC at the HI positions.

Temperature Control – Conventional

Control of the NESA window heating system is automatic. Electrical resistance units commonly known as thermistors are embedded in the vinyl layers of several of the window panels (Figure 5). A typical installation in a NESA window is shown in Figure 6.

The thermistor resistances are part of a 28-VDC control circuit powered from the main DC bus through the NESA window circuit breakers on the copilot's lower circuit breaker panel. The control circuit serves to energize and deenergize the power relay shown in Figure 7, which applies power to the windows.

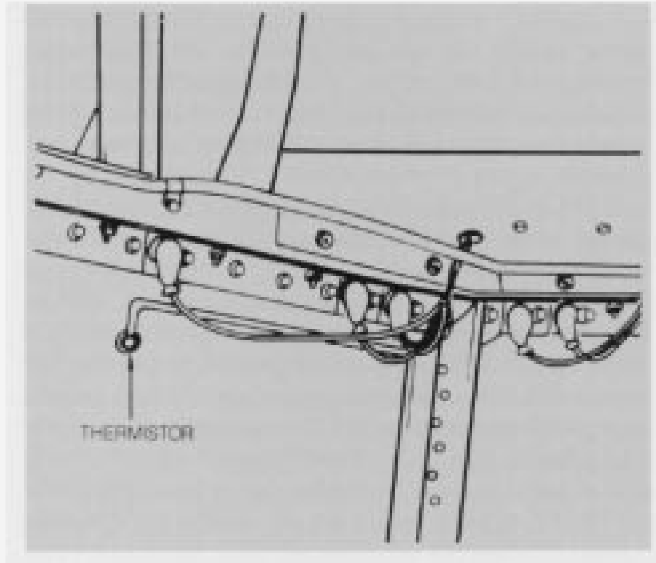


Figure 6. Typical thermistor installation.

The control circuit is designed to take advantage of the fact that the electrical characteristics of thermistors are affected by changes in temperature. The thermistors used in the NESA window control circuit have a negative temperature coefficient: their electrical resistance decreases when the temperature rises, and increases when the temperature falls.

Figure 5. **NESA windshield thermistor circuits (simplified).**

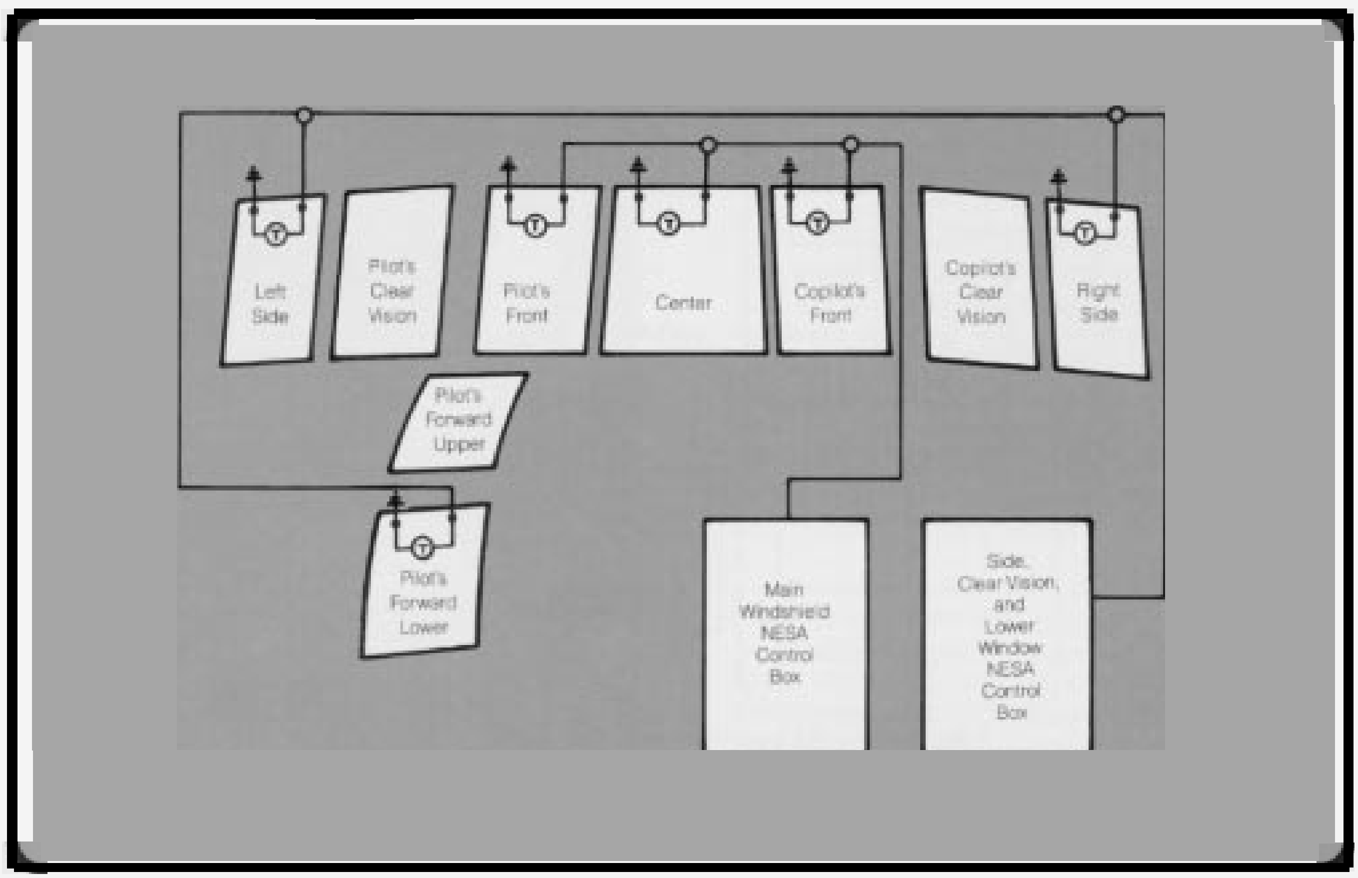


Figure 7 presents a simplified version of the resistance bridge circuit that provides the temperature sensing for conventional windshield heat controllers. For the sake of clarity, only one phase of the three-phase power circuit to the windshield heaters is shown.

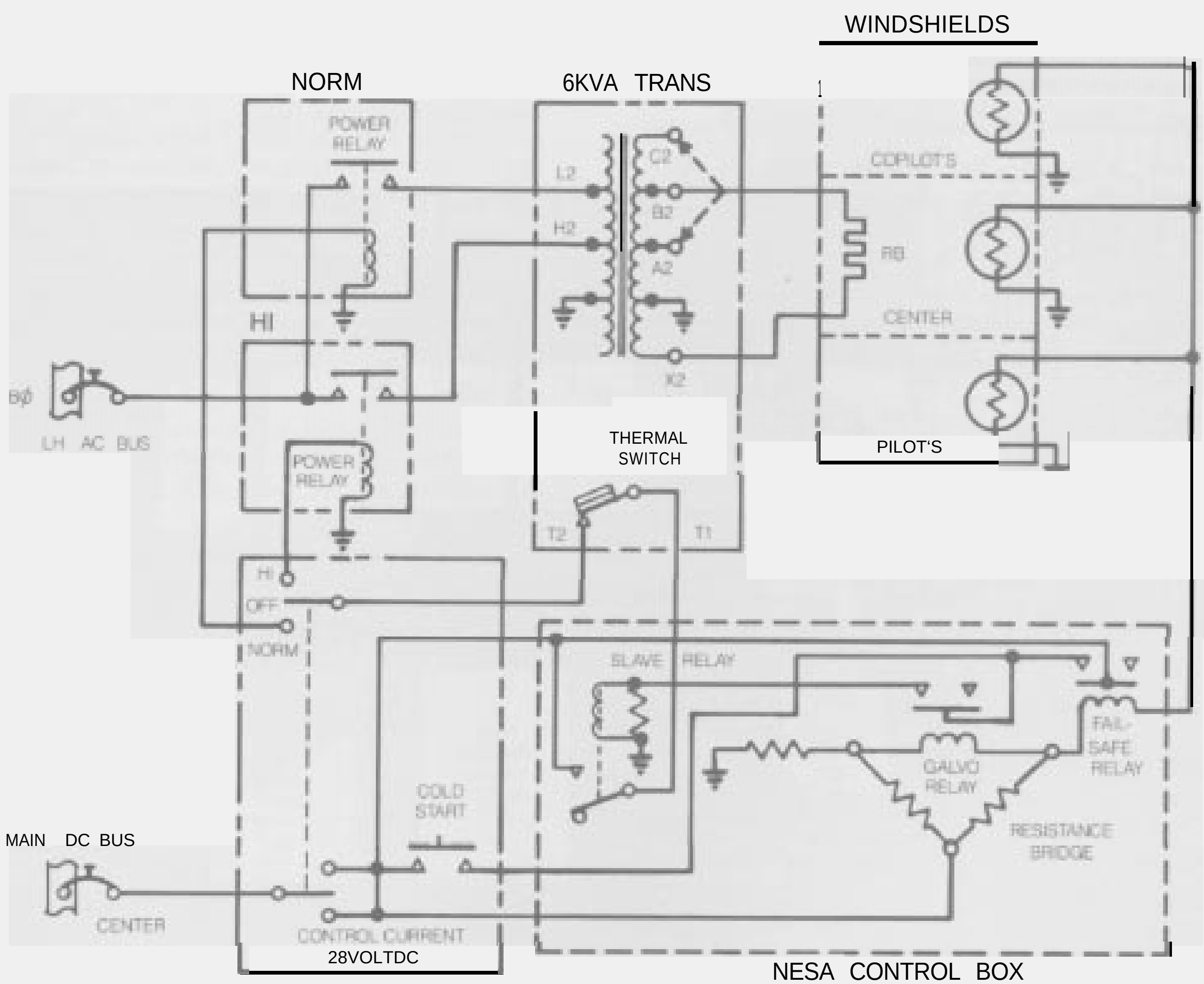
When the control switch is in NORMAL or HI, DC power is supplied from the main DC bus to the NESA control box. The resistance bridge divides the voltage between preset variable resistances to ground. One leg of the bridge connects through a fail-safe relay coil and three thermistors to ground. A galvanometer relay coil is connected across the bridge output. A slave relay is energized from the main DC bus through the contacts of the galvanometer and fail-safe relays.

Window temperature is controlled in the following manner. When the windows are cold, thermistor resistance is high and the fail-safe relay is energized. The bridge is unbalanced and the galvanometer relay contacts close, supplying DC power to the slave relay, which energizes the power relay to heat the windows. When the windows become warm, the thermistor resistance is low. The bridge then becomes balanced and the contacts open to deenergize the slave and power relays to shut off window heat.

With the heat off, window temperatures will decrease, causing the thermistor resistance to build gradually to a point at which the galvanometer relay closes and heat is again applied. This cycling will continue as long as the NESA control switches on the overhead anti-icing panel are in either the NORMAL or HI positions.

The NORMAL and HI selections provide different rates of heating for the various kinds of icing conditions which may be encountered. NORMAL is the appropriate choice in almost all circumstances where windshield

figure 7. NESA windshield conventional control system (simplified).



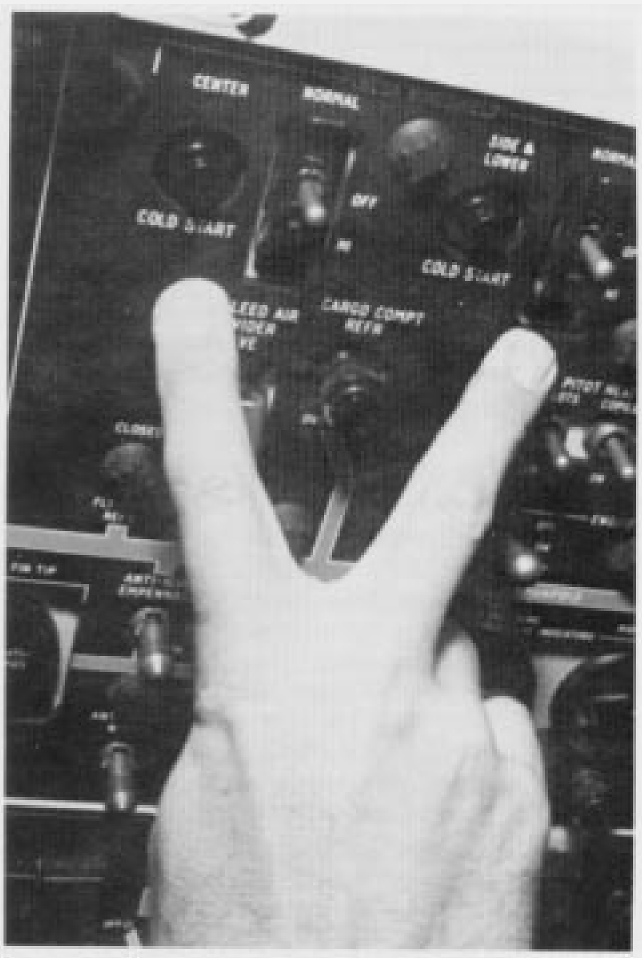
heating is required; HI heat should not be used except during extreme inflight icing conditions.

Cold Weather Operation – Conventional

When the windshield thermistors are extremely cold, not enough current will flow through them to energize the fail-safe relay. A special cold-start provision is therefore included in the system for initiating operation during ambient ground temperatures below approximately -45°F (-42.7'C). The cold-start feature can also be utilized to provide heating for the windshields in all temperature ranges if the automatic control system fails.

Manually pressing the cold start switches on the anti-icing control panel (Figure 8) permits DC power to bypass the normal control system and allows AC power to heat the windows sufficiently for automatic operation to begin. Inpractice, these push-type momentary switches are operated on for 5 seconds and off for 10 seconds for several cycles to allow the windshield temperature to rise slowly. Too-rapid heating could result in damage to the windshield panels.

Figure 8. **Cold start switch locations.**



Temperature Control – Solid-State

Hercules aircraft of recent manufacture are equipped with solid-state windshield heat controllers instead of the conventional type. The solid-state design eliminates the need for most mechanical relays and helps ensure greater reliability. Figure 9 presents a simplified schematic diagram which will be helpful in understanding the operation of these newer units.

The comparator bridge circuit shown in the diagram functions as a temperature detector. The temperature sensing input is applied to pin N from the thermistors embedded in the windows. The number of windows and thermistors used in parallel in the aircraft will determine which pins must be grounded to produce normal system operation.

If three thermistors are used for temperature sensing, as in C-130 applications, pin F is grounded externally and pin U is left open. If two thermistors are used, as in some of the circuitry for L- 100 windshield panels, pin U is grounded externally and pin F is left open.

Voltage comparators A, B, C, and Dare operational amplifier circuits contained on an integrated circuit chip. Voltage comparators A and B function as a temperature discriminator. These recognize the output signals from the comparator bridge as a more-heat signal or a less-heat signal. If the signal from the comparator bridge is for more heat, voltage comparators A and B will aid in producing an ON signal for the field-effect transistor (FET), which is used as a switch. A less-heat signal from the bridge will result in an OFF signal to the FET switch.

Whenever the FET switch is in the ON condition, it also allows the transistor switch to go to the ON condition. The transistor switch performs as a safety device in the event the final output from pin B is shorted to ground. If the output circuit is operational, voltage comparator D will be turned ON to allow the power amplifier to conduct. The output at pin B will then be capable ofproviding the required current to energize the power relays. When the power relays are energized, heat is applied to the windows.

Windshield temperature determines the automatic temperature control duty cycle of the controller. If the windshield temperature sensed by the thermistors is above -45°F (-42.7'(C), the controller causes the windshield temperature to increase to 108°F (42.2'C) and then turns the heating circuit off. As the windshield temperature decreases, controller circuits introduce a time lag, allowing the windshield to fall to 101°F (38.3'C) before the heating circuit is reapplied.

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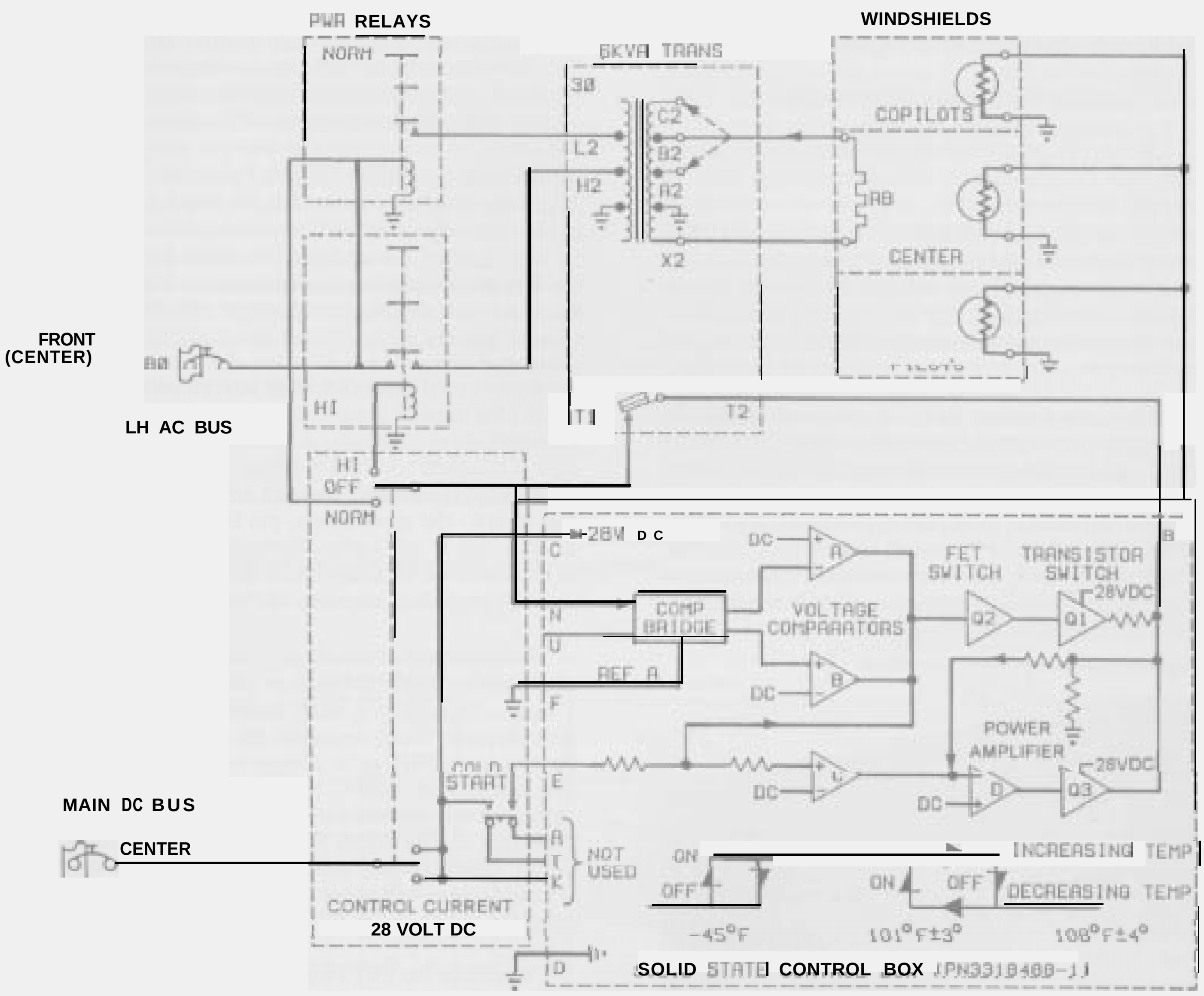

figure 9. NESA windshield solid-state control system (simplified).

Cold Weather Operation – Solid State

Windshield temperatures below -45°F (-42.7'C) will not activate the automatic temperature control. These low temperatures present high thermistor resistance input to the comparator bridge, which interprets the condition as an open thermistor circuit.

As in the case of the conventional controller, a cold-start feature is provided to deal with this situation. When the cold-start pushbutton is pressed, 28 VDC is supplied to pin E of the controller. This DC bypasses voltage comparators A and B to bias the FET switch ON to turn on the heat. The heat remains on until the pushbutton is released.

The cold-start capability also provides a way of manually heating the windshield in the event the automatic control components (the FET/Ql circuits) fail. The cold-start button can be used to power comparator C, which will then turn on comparator D. This energizes Q3, providing 28 VDC to the power relays.

WINDOW REPLACEMENT CRITERIA

Windshield panels mounted within the nose section of the aircraft are exposed to a great deal of physical punishment. They are deluged by rain, pounded by hail and ice, and bombarded by airborne solid particles of almost every conceivable size and kind.

In addition, the windows are exposed to repeated pressurization loads. The pressurization cycles cause the windows to flex in and out, and the rapidly changing temperatures during ascent and descent force the windows to expand and contract. It is not difficult to understand why some windows eventually fail under these conditions.

The decision to replace a window depends largely upon the nature of the failure and its severity. Let us look at some guidelines on the replacement criteria for various categories of windshield panel failure.

Superficial Defects

Light scratches, and minor chips, nicks, and spalls caused by contact with solid objects may be disregarded as long as visibility through the panel is not seriously affected. Such damage is significant mainly in that small defects may represent a starting point for more serious problems.

A deep chip, for example, may cause a local weakening in a panel and serve as a focus for crack development. Even superficial defects, such as those caused by the dry operation of the windshields wipers, can predispose a panel to premature failure.

That is why it is always a good idea to carry out periodic inspections of areas where minor damage is known to have occurred. It is important to be certain the minor damage does in fact remain minor.

Cracks

The appearance of a crack in a NESA panel means that a glass layer of the affected panel has been broken, even though both pieces are still being held in position by the contacting vinyl layer.

Windshield cracks do not usually present an immediate threat to safety of flight because the NESA windows used in Hercules aircraft are designed to be failsafe. They remain capable of withstanding the stresses imposed by pressurized flight even when some obvious defects are present.

The action that is required when a cracked windshield panel is discovered in flight depends mainly upon the type of panel involved (three-layer or five-layer) and which part of the laminate is damaged (inner, outer, etc.). The flight manual for the aircraft involved will contain the operational restrictions that apply in each situation. These may include such measures as reducing the cabin differential pressure to 10 inches of mercury or less, and limiting airspeed below 10,000 feet to ensure continued protection against bird strikes.

The maintenance manuals provide more detailed information on dealing with cracked windshield panels once the aircraft is back on the ground. Here again, there are differences in the documentation as it applies to various models of the Hercules aircraft. It is important to refer to the appropriate handbook for the affected airplane before repairs are undertaken.

In general, if a three-layer windshield develops a crack in the inner glass layer, a flight in progress may be completed in accordance with the precautions given in the applicable flight manual. But a three-panel windshield with a damaged inner glass panel should be replaced before subsequent flights of the aircraft are attempted. A NESA window with a cracked outer glass layer may be continued in service, although pressurization limits may apply. The panel must, however, continue to heat properly and visibility cannot be significantly impaired.

The guidelines are somewhat more uniform for the five-layer windshield panels used incommercial models. There should be no cracks, chips, or scratches in the center glass panel. If the center glass layer of a five-layer panel becomes damaged, the current flight may be completed, but the affected panel must be replaced before the aircraft is flown again.

Damaged NESA panels are more likely to require prompt replacement for reasons of reduced visibility or electrical malfunction than because of concern for their structural integrity. The strength of the vinyl layer may be counted upon to prevent the panel from blowing out, but a weakened window will flex excessively at normal pressurization levels, and this may lead to arcing or loss of electrical conductivity.

The above conditions will disturb the resistance values critical to the proper operation of the temperature control system and may cause the other windows in the circuit to overheat. It is important that the electrical operation of a cracked window be monitored carefully.

The heat may be left on if it is needed, but watch for electrical arcing and turn the heat off immediately if arcing is noted. In addition, check the heating of the other panels in the same circuit by placing your hand against the inside surface of each window. If any of these panels is too hot to touch with the bare hand, turn off the heat.

Crazing

Crazing is a condition characterized by microcracks that do not extend all the way through a glass panel. Sooner or later a window that shows crazing can be expected to develop true cracks, and become covered with an interlocking network of fine fractures that penetrate the entire thickness of the glass.

From the standpoint of both military and commercial replacement criteria, crazing is considered to be a form of cracking, and the same requirements apply. Note that crazing can progress to cracking quite suddenly, which sometimes results in an almost complete loss of visibility through the affected panel. If this occurs, the damaged window must be replaced immediately.

Arcing or loss of electrical heating are definite possibilities with crazed windows, just as in cases where simple, individual cracks are present. The situation with crazed windows is made more complicated by the fact that it is not easy to determine how deeply the crazing may penetrate. Monitor the electrical system closely, and turn the heat off if any indication of malfunction is apparent.

For the same reason, an extra note of caution is in order when checking the heating operation of a crazed outer glass panel. Such panels should not be checked with the bare hand when the NESA switches are on. The voltages exceed 400 VAC and electrical shock is a real possibility.

Bubbles and Delamination

Separation between the glass and vinyl layers is called delamination. Bubbles are small air pockets between the glass and vinyl layers. NESA windows are structurally acceptable with either of these faults.

A window that shows some evidence of delamination may be continued in service unless vision is seriously impaired or overheating is noted. Panels containing bubbles that are larger than 0.1 inch in diameter and closer than one inch to adjacent bubbles, or within one inch of the embedded metal frame that supports the vinyl interlayer, are not acceptable. A window in which delamination appears extensive enough to prevent a vinyl layer from properly supporting the associated glass layers during pressurization flexure should likewise be replaced.

Separation between the embedded metal insert frame and the vinyl layer may affect the electrical heating of the panel. When delamination occurs in the immediate vicinity of a thermistor, the thermistor may sense inaccurate temperatures and cause the other windows in the circuit to overheat. Check the other panels and turn off the system if these windows feel uncomfortably warm.

Vinyl Rupture

Vinyl rupture is a longitudinal separation or break which has formed within the vinyl layer itself. In early stages, vinyl rupture appears as a bright silver-colored line originating at and parallel to the metal insert. This can be detected by careful visual inspection using a strong, hand-held light source.

The silver line may show transverse streaks, which are comparable to craze marks in the plastic. The silver-colored line will appear somewhat wider than the edge of the insert and may extend inboard or outboard from the edge. Line extension both ways is an indication that the vinyl has completely separated from the insert.

NESA panels containing vinyl layers which show evidence of being ruptured or separated may no longer be able to provide adequate protection against an impact such as a birdstrike. It is unsafe to continue such windows in service. Panels with this condition must be replaced.

Corrosion

Occasionally, corrosion or evidence of moisture is discovered along the embedded metal insert frame. Milky, foggy, or cloudy areas around the border of a window are evidence of moisture and corrosion. Such panels must be replaced.

Arcing

Arcing in an electrically heated window is caused by the electrical current jumping a gap in the resistance coating. If a window is found to be arcing, the NESA system should be turned off. The intense local heating at the spot where the arcing occurs can cause the window to delaminate and crack. The longer arcing occurs, the more opportunity there is for damage to occur. The kind of damage that will result and how the arcing will affect the other windows in the circuit depends primarily on the location of the arcing.

Arcing in the area of the power studs, where the electrical harness lugs are connected to the window, will cause the stud and its wire or insulator to be damaged or burned. Inflight fires have occurred when corrosive delamination immediately around a power stud has allowed the stud to arc to the bus bar.

If arcing occurs in the vicinity of a thermistor, the thermistor or its wires will be damaged by the heat. This will unbalance the control circuit bridge, and may cause the windows in the circuit to overheat.

Arcing that occurs in areas of the window which are not at the edges or near the thermistor can still cause the windows in the circuit to overheat. This will not happen in every instance because a great deal depends upon the severity of the arc and the effect it has on thermistor sensing. There is nevertheless a good chance that the other windows will eventually begin to overheat.

When arcing occurs around the edges of a panel and along the bus bars, it may be due to the entrance of moisture. It is especially important to turn the system off immediately to prevent further damage in this situation because arcing of this type can often be corrected, as described in the next section.

It is always preferable to turn a NESA system off immediately when arcing occurs. The final decision on whether to leave a system on or turn it off must rest with the pilot. Under some flight conditions, such as when icing is occurring, it may be necessary to leave a system on to ensure adequate visibility for safe flight. If an arcing panel must be left on, it should be done with the knowledge that the arcing panel and the other windows in the same circuit may suffer further damage.

Preventing Window Arcing

In many cases where arcing is noted, it is found in the vicinity of the bus bars. The problem can often be traced to an area along the top of the window where the vinyl layer and the outer glass have begun to separate. Separation of the layers allows moisture to enter and cause arcing, which in turn can cause further delamination and deterioration of the window.

The remedy for arcing problems of this kind is to seal the mating line between outer glass and vinyl to keep out moisture. Although this area may have been sealed when the panel was first installed, pressurization loads cause the glass to be pushed outward repeatedly. This tends to open the parting line between the outer glass panel and the vinyl (Figure 10).

Another cause of glass and vinyl separation is hardening of the vinyl with age. The vinyl contains a compound called a plasticizer, which keeps it pliable. The plasticizer tends to evaporate out of the exposed edges of the panel, causing the vinyl to shrink and recede along the edges of the glass.

These potential sources of trouble mean that it is advisable to inspect the edges of the glass periodically for loose, cracked, or weathered sealant. New sealant should be applied as necessary to prevent moisture from entering, even when the windows are not being replaced.

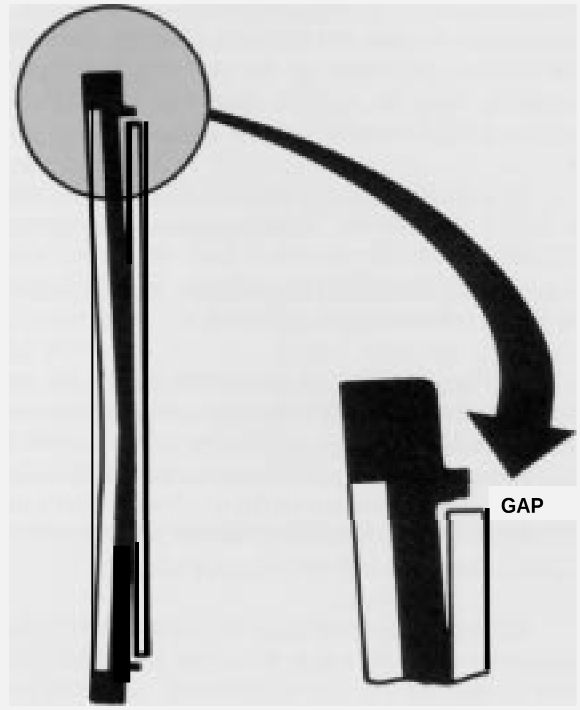

Figure 70. Gap development caused by pressurization cycles and vinyl shrinkage.

Improperly installed or overtorqued power studs can also be a potential source of arcing. There have been more than a few instances of NESA windows arcing or shorting out against the airplane frame where the electrical harness lug connects to the window power stud. Always make sure that power studs of the correct size and type are used, and torque them to 20 to 25 inch-pounds when they are initially installed.

Note also that an insulating sleeve is used to cover the harness lug. Arcing may occur if it slips or becomes damaged and insufficient clearance exists between the aircraft frame and the window terminal.

The power studs are exposed to moisture that condenses inside the aircraft skin and runs down the windows, and they should be checked periodically for corrosion. Corrosion is often found between the aircraft frame and the power stud. If present, the corrosion products should be wiped off with aliphatic naphtha. If the stud cannot be cleaned, it should be replaced. A corroded stud presents a potential inflight fire hazard.

NESA WINDOW REMOVAL AND INSTALLATION

Window damage and reduced service life can sometimes be traced to improper removal and installation techniques. It is therefore important that the technical

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personnel assigned to NESA window maintenance tasks be properly trained and certified. Only the materials and procedures described in the authorized maintenance manuals may be used in removing, installing, and sealing NESA panels.

Two technicians are required to remove and install a NESA windshield. During removal, one person is needed outside the aircraft to hold the screws securing the windshield panel to the airframe while someone else inside is loosening and removing the nuts.

During installation, the individual on the outside must insert the screws through the airframe to the interior of the airplane while the person on the inside positions windshield panels and retainers and holds them in place. The technician on the inside then places nuts on the screws and tightens the nuts while the person on the outside keeps the screws from turning.

Before starting to remove an old windshield, it is important to be sure that the areas immediately below and around the window are covered. This will prevent debris and loose objects from falling into cracks and crevices and damaging critical components. Particular attention should be given to protecting engine controls, flight controls, and propeller feather override buttons. Be sure that the protective covers are still securely in place when it comes time to install the new windshield.

The removal and installation procedures for NESA panels require the use of industrial solvents such as aliphatic naphtha, trichloroethane, and Federal Specification P-D-680 Type II, or their equivalents. Some of these substances are flammable, and all are toxic to the skin, eyes, and respiratory tract. Always wear skin and eye protection when handling industrial solvents, and use them only in a well-ventilated area away from open flames or other sources of combustion.

NESA window removal, installation, and sealing require the use of plastic, phenolic, and other nonmetallic materials in such tools as cutters, putty knives, wedges, blocks, scrapers, and spatulas. Metallic tools can damage both the windows and the airframe and must never be used.

Note that the best and safest techniques in the world will not ensure a successful window replacement if one common pitfall is overlooked: windows should never be replaced while the aircraft is on jacks. A windshield installed on a jacked aircraft may crack when the aircraft comes off the jacks.

With these preliminaries in mind, let us review techniques for removal and installation that will ensure maximum service life for your NESA windows.

Removal of NESA Windows-Fixed and Clear-Vision

To remove a NESA window, open the appropriate WINDSHIELD NESA CONTROL circuit breaker and install a warning tag. Then disconnect all of the panel's electrical connectors, remove all screws and clips from the retainers around the windshield panel, and remove the retainers and spacers. Save all windshield mounting hardware for possible reuse.

If the window is a clear-vision panel, remove the screws and nuts that fasten the hinge assembly to the fuselage. If the clear-vision panel is installed in a military aircraft, remove the cable assembly and safety pin.

Use a sharp cutter to slice through and pull away the old sealant from around both sides of the windshield panel, as well as from the edge of the adjacent panel if it shares the same frame post. On the exterior side, insert a putty knife or similar tool between the exterior edge of the windshield and the underside of the frame near one of the lower corners of the windshield.

Insert thin wedges spaced 2 to 3 inches apart into the crevice thus formed. Tap on the wedges with a plastic mallet to cause a peeling action of the windshield away from the frame. Continue to add wedges until the windshield breaks loose. After the windshield begins to come loose, take care that the panel does not suddenly pop out of the frame.

When a window is being removed, it is sometimes discovered that an incorrect sealant or parting agent (or no parting agent) was used to install it. If an improper sealant-such as regular fuel tank sealant-has been used instead of the authorized sealant, the removal task will be more difficult, but there are some techniques available that will make the job easier.

Work at normal room temperature, or apply heat if the airplane is out-of-doors in cold weather. After all the retainers have been removed, a thin spatula inserted between the aircraft frame and the damaged window will help loosen it. Apply steady pressure; avoid pounding on the panel with your hand or anything else. Pressure and patience will go a long way toward loosening glass panels. It is important to resist the temptation to use excessive force, which can damage the aircraft structure. A bent window frame may prove next to impossible to seal.

A number of maintenance organizations have reported good results from the use of a simple special tool during window removal. The tool consists of two 4-inch pieces of wooden dowel about the thickness of a broom handle, and a two-foot length of 0.032-inch safety wire (Figure 11).

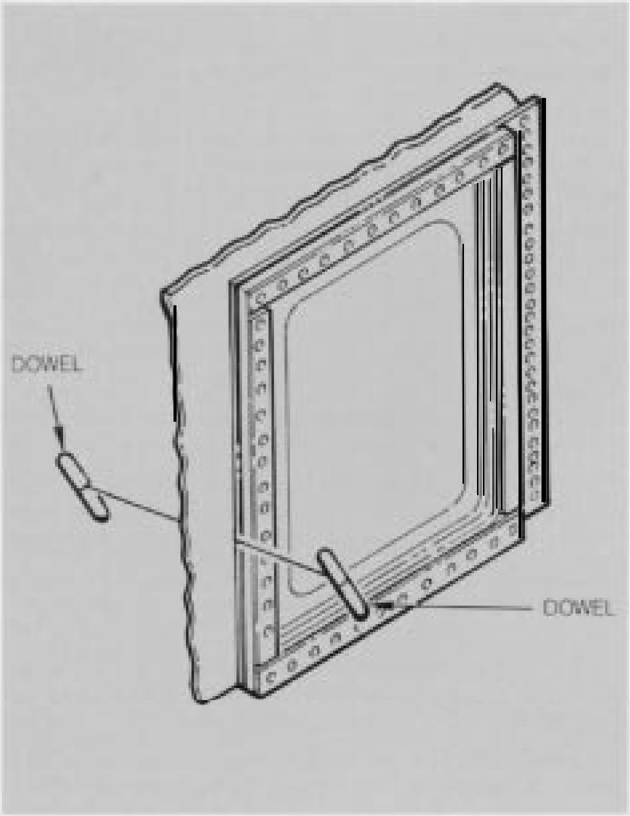


Figure 17. **Window removal tool (locally manufactured).**

To use it, first make a small opening in the sealant between the window and the frame with a putty knife and wedges, and then thread one end of the safety wire through. Secure both ends of the wire to the dowels; one inside the aircraft and one outside. Using a sawing motion, two technicians can then draw the wire all the way around the windshield frame, cutting the old sealant in the process. After the sealant has been cut, a little pressure on the glass will usually remove the panel.

Preparation of Windows and Mounting Surfaces, Fixed and Clear-Vision

Before a NESA window can be installed on the aircraft, the panel must be prepared. A padded work table is required for this. If the windshield is new, carefully peel back the protective paper approximately one inch from the edge on each side of the glass. Take care not to expose the glass surface to possible damage by removing more protective paper than necessary.

Fold the protective paper covering back and crease it. Insert a blunt-pointed knife or similar tool into the crease and carefully cut the paper along the crease line. Avoid scratching or marking the glass while cutting. Now apply 2-inch masking tape approximately I/8 inch inside the edge of the glass and parallel with the frame edge.

Moisten a clean, lint-free rag with aliphatic naphtha. Clean the mounting surfaces of the windshield, using a two-rag system. Apply the solvent with one rag, and then dry the surface immediately with a second clean, lint-free rag, refolding frequently to keep a clean section of rag on the surface being cleaned. After cleaning, be careful not to touch the area with your fingers or anything that could contaminate it.

Apply 1 -inch wide pressure-sensitive parting agent tape to the cleaned mounting surface of the fixed windshield that will come into contact with the windshield frame. It is acceptable to overlap the parting agent tape at the corners, but do not apply tape to the vinyl bumper strip (Figure 12). Trim the parting agent tape to conform to the shape of the windshield.

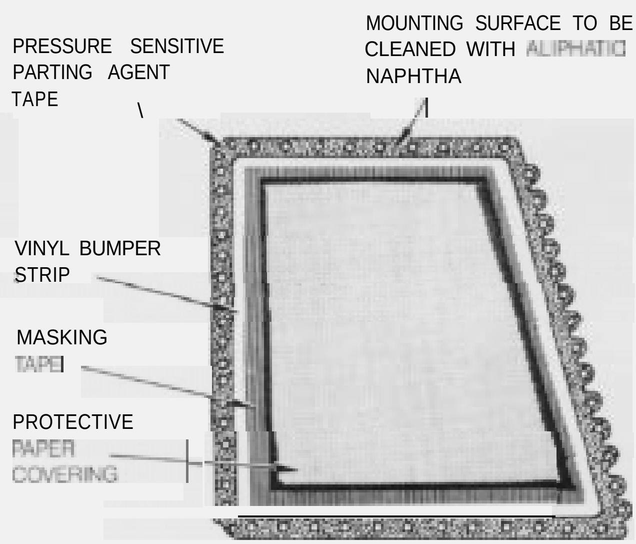


Figure 72. **Preparing a windshield panel for installation.**

Remove any old sealant, dirt, and grease from the area around the windshield opening on the aircraft back to a distance of about 2 inches. Clean the mounting surfaces of the airframe, again employing the two-rag system; but this time use trichloroethane or P-D-680 Type II cleaning solvent. Wipe the surface clean with a rag moistened with solvent. Dry immediately with a second clean rag, refolding frequently to keep a clean section of rag on the surface being cleaned.

Inspect the airframe mounting surfaces. Any evidence of corrosion or other damage that could interfere with the proper installation of the panel should be reported and appropriate action initiated.

Now apply a strip of 2-inch masking tape to the outside skin surfaces adjacent to the windshield opening to keep sealant off the structure and minimize cleanup. Use tape up to the edge of the windshield opening. Trim out each hole identified to receive a fastener so that when the fastener is installed, no part of the tape will be trapped between the fastener and the hole.

Retainer Preparation

Before proceeding to the actual installation of a replacement windshield panel, carefully check the screws, clips, retainers, spacers, etc. that were removed from the old window before reusing them in the new installation. Damaged or corroded items should be replaced.

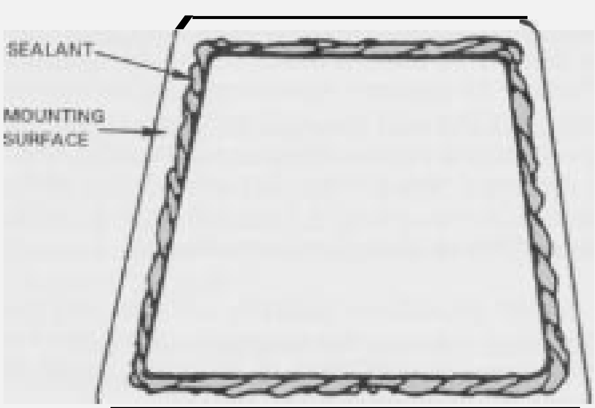
If a new retainer is to be installed, use the old retainer as a pattern to drill and prepare the new one. Check the new part against the airframe and the window to ensure that the holes are the proper size and correctly located. New retainers may need some filing and sanding to get a good fit. Make sure that any new retainers to be used are painted with Federal Specification TT-P-1757 zinc chromate primer or the equivalent prior to installation.

Installing NESA Windows – Fixed Panels

Note that the following is intended as a general description of typical NESA window installation procedures. Be sure to consult the authorized maintenance manuals for specific procedures that apply to your particular aircraft. For organizations operating under U.S. military technical orders, T.O. lC-130H-2-56JG-00-l deserves particular attention.

Apply a heavy fillet of MIL-S-8784 Class B low-adhesion sealant or equivalent to the clean airframe mounting surface (Figure 13). Use an air-driven sealant gun with a spatula tip to apply the sealant or spread it manually with a spatula. Use a sufficiently thick layer of the sealant to form a complete seal between the mounting surfaces of the windshield and the airframe.

Figure 73. Apply a thick enough layer of sealant to ensure a good seal between windshield and airframe.



Lift the windshield panel into the airframe opening from the inside, and position it on the mounting surface of the airframe. Press it carefully into place. Avoid floating the windshield panel higher than the outer skin surface. This might cause too much sealant to be extruded, leaving no cushion of sealant between the glass and the metal.

Install all screws, washers, spacers, and retainers around the windshield (Figure 14). Install glare shield clips in the proper positions. The nuts should initially be finger-tight only on all screws. Windshield screws that interfere with the screws which fasten the retainer to the windshield sill must be omitted. The affected holes in the airframe should be marked and filled with sealant after retainer installation is complete.

Note that if the windshield replacement involves the pilot's or copilot's panels, initially install only the screws, retainers, washers and nuts on the three sides of the panel opposite the center windshield. With these fasteners supporting the weight of the window, fill the void between the pilot's or copilot's window with sealant. Then install the remaining screws, spacers, retainer, washers, and nuts.

If the center panel itself is being replaced, initially install only the screws, retainers, washers, and nuts on the top and bottom of the window. These fasteners will hold the panel in place while the voids between the center panel and pilot's and copilot's panels are filled with sealant. Then install the remaining screws, spacers, retainers, washers, and nuts.

Now tighten several nuts in a criss-cross pattern to float the windshield to within 0.05inch of flush with the outer skin. Use enough screws to give an even pull to the windshield in order to prevent cracking the windshield. Make sure that there is a small amount of sealant squeeze-out all around the mounting surface.

Sealant Fill and Trim – Fixed Panels

Fill all depressions and voids between the airframe and windshield with sealant. Carefully examine the outer surface of the window along the edges of the frame where the vinyl and the outer glass layer meet. Apply sealant as necessary to ensure a smooth, continuous seal between the window frame and the glass insert (Figure 15). Remove any excess. Now remove the masking tape from the outside skin opening and allow the sealant to cure for the minimum cure time. Be sure to observe the sealant cure times described in the paragraphs below.

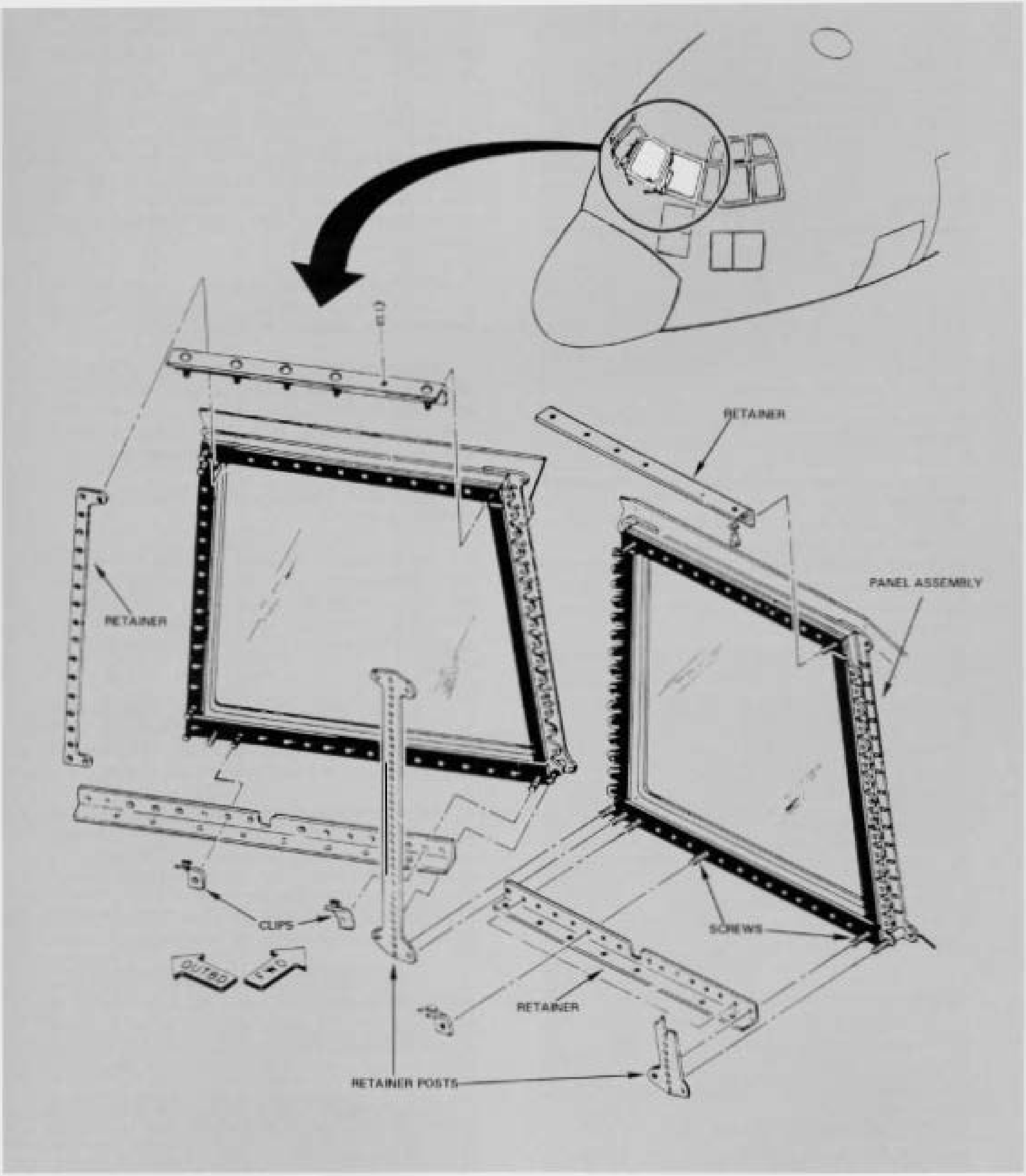


Figure 14. **Installing the pilot's or center windshield panels (typical).**

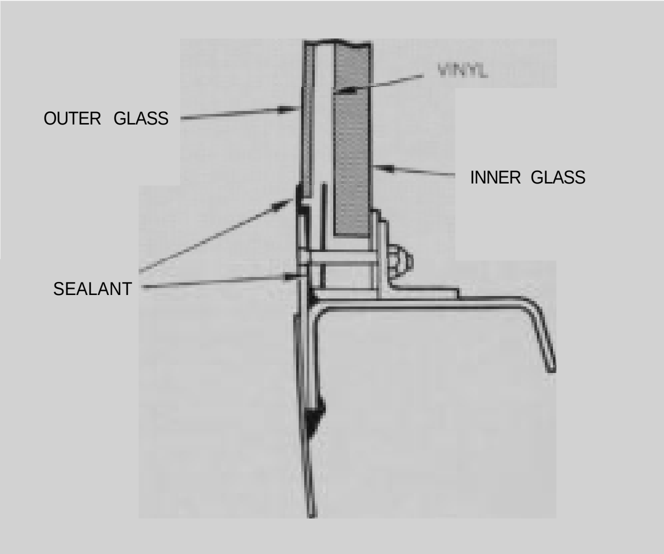


Figure 15 Exterior sealant trim.

Sealant Cure Times

Note that sealant cures times are based on standard conditions of 75 to 79°F (23.9 to 26.1 "C) at 45 to 55 % relative humidity. Sealant MIL-S-8784 Class B1/2 will be tack-free in 10 hours with a minimum cure time of 24 hours. MIL-S-8784 Class B2 can be expected to be tack-free in 24 hours, a with minimum cure time of 48 hours. MIL-S-8802 Class B1/2 will be tack-free in 10 hours with a minimum cure time of 48 hours. MIL-S-8802 Class B2 will be tack-free in 10 hours with minimum cure time of 72 hours.

Dow Corning 93-006-6 will be tack-free in 12 hours with a minimum cure time of 24 hours. Dow Corning 93-006-l will be tack-free in 24 hours with a minimum cure time of 48 hours.

Sealant curing requires both heat and moisture. For each 10°F (5.6'C) above the standard, curing time is reduced by one-half. For each 10°F (5.6'C) below standard, cure time is doubled. Do not attempt to cure sealant in very warm conditions above 100°F (37.7'C) or 95% humidity, nor in cool conditions below 40°F (4.4'C) and 15% relative humidity.

Final Installation of Fasteners – Fixed Panels

Remove all nuts, washers, and screws from the windshield perimeter. Dip-coat all screws in sealant and install wet. Install a washer and nut on each screw, but finger-tighten only.

Now torque the fasteners that pass through the windshield panels to 18 to 22 inch-pounds. Do not tighten the nuts in a criss-cross pattern in this case. Instead, start at the upper left-hand corner and go around the panel from left to right (clockwise), one time around only. Uneven torquing results in point loading and may eventually cause cracking.

Go around the windshield assembly and check to see that the washers are properly seated. If any washer is found loose, tighten the screw and nut just enough to seat the washer. Never retorque windshield fasteners once they have been tightened down. Loose nuts that may be discovered later on should be snugged down just enough to seat the fastener.

Now install the screws, washers, and nuts securing the retainers to the airframe. Torque the screws to between 25-30 inch-pounds.

Remove the protective paper from both inside and outside the glass panel. Thoroughly clean the windshield after the applied sealant has set. Connect the electrical wiring and perform an operational checkout in accordance with the applicable maintenance manual.

Installing **NESA Windows – Clear-Vision Panels (Military Aircraft)**

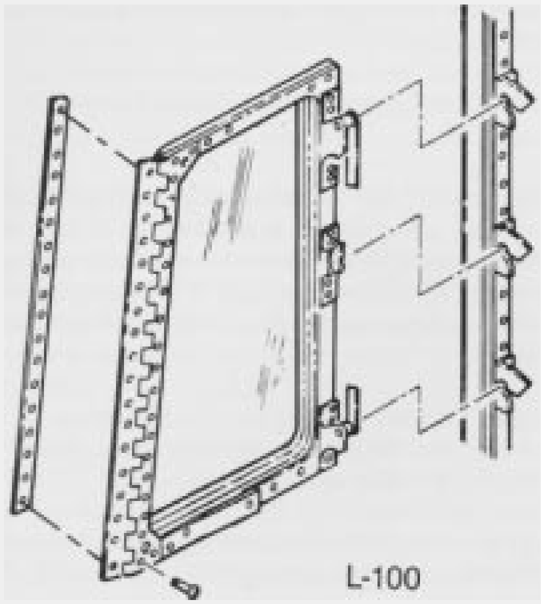
Lift the clear-vision panel assembly into the airframe opening and position it on the mounting surface of the airframe. It is helpful to install an awl into the top and bottom fastener holes to make it easier to adjust the clearances between the clear-vision panel and the airframe.

Temporary screws should then be installed from the outside into one of the top, middle, and bottom holes of the hinge assembly and fuselage frames. Place a nut on each temporary screw and tighten it finger-tight.

Adjust for proper clearance between the clear-vision panel and the airframe by pushing on the awls, tapping lightly, or prying so that the clearance is the same on all four sides. After installation, the gap on all sides around the clear-vision panel may vary from 0.03 to 0.12 inch. Now tighten the temporary screws sufficiently to hold the window in position while the latch is being adjusted.

Close and attempt to lock the clear-vision panel. Add shims (0.020-inch) under the latch bracket as required to adjust the height of the bracket until there is a mechanical interference between the latch locking pin on the window and the latch bracket on the airframe.

At this point the window will not lock. Remove two 0.020-inch shims from under the bracket in order to lower the bracket sufficiently so that the window will lock. The window is now ready for installation of the permanent fasteners, as described below.



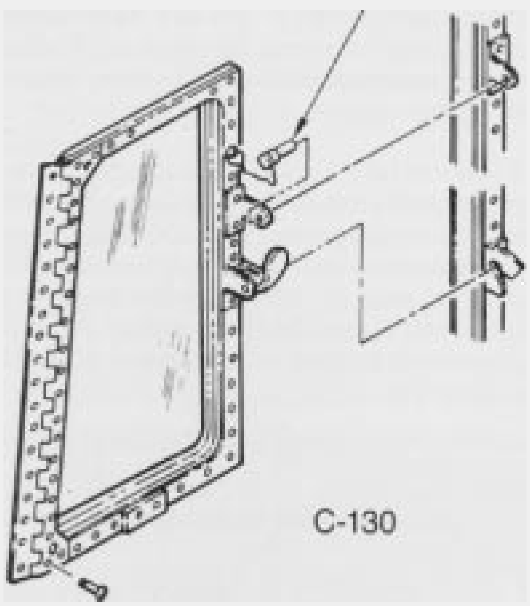


Figure 16 Commercial and military clear-vision windows.

Fastener Installation – Clear-Vision Panels (Military)

Dip-coat each permanent screw, including the threads, shaft, and underside of the screw head. Install screws through the aircraft skin and the aft hinge half while wet. Install a washer and nut on each screw and tighten down. Remove the awls and temporary fasteners used to position the window and install the rest of the permanent fasteners in the same manner. Torque 3/ 16-inch fasteners to 25-30 inch-pounds.

Sealant Fill and Trim – Clear-Vision Panels (Military)

The next step is to form the gasket that will serve as both weather and pressure seal when the clear-vision window is closed. Open the window and apply a light, uniform coating of Dow Corning DC-4 parting agent or equivalent to the contact surface of the clear-vision panel frame.

Now apply a film of MIL-S-8802 Class B sealant or equivalent about 0.03 to 0.06 inch in thickness, to the clean, contact surface of the airframe.

Close and latch the clear-vision panel. Remove all excess (squeeze-out) sealant and form a smooth seal. Remove the masking tape. Allow the sealant to cure for the minimum cure time. Observe the sealant cure times described on page 16.

Note that when the clear-vision panel is closed against the cured sealant, the surface of the glass should be flush with or up to 0.09 inch below the skin surface. The minimum sealant thickness should be 0.03 inch.

After the sealant has fully cured, open the clear-vision panel. Trim all excess sealant. The formed-in-place seal should have a smooth and continuous surface. Fill any voids in the sealant to a flush condition and allow to cure.

Rigging-Clear-Vision Panels (Military)

Add shims (0.020-inch thick) under the latch bracket as required to adjust the height of the bracket until there is mechanical interference between the latch locking pin on the window and the catch bracket on the airframe structure. At this point the window will not lock. Then remove one shim from under the bracket. Lock the window: there should be a positive, over-center snap. If not, remove one additional shim and lock the window again. When the latch is properly adjusted, you will have positive, over-center locking action. No other condition is acceptable.

Install the cable assembly and safety pin on the clear-vision panel. Shim the latch as required to line up the holes in the bracket and catch so the safety pin can be installed easily.

Torque the latch bracket and safety pin bracket to 25-30 inch-pounds. Remove protective paper and clean the window for use.

Installing NESA Windows – Clear-Vision Panels (Commercial)

Lift the clear-vision panel assembly into the airframe opening and position it on the mounting surface of the airframe. It is helpful to install an awl into the top and bottom fastener holes to make it easier to adjust the clearances between the clear-vision panel and the airframe.

Peel the filler under the hinge so that the exterior surface of the clear-vision panel and the exterior skin surface of the airframe are flush.

Temporary screws should then be installed from the outside into one of the top, middle, and bottom holes of the hinge assembly and fuselage frames. Place a nut on each temporary screw and tighten.

Close and lock the clear-vision panel. Add or remove shims (0.012- to 0.020~inch thick) under each of the three brackets as required until the exterior clear-vision panel surface is flush with the exterior surface of the airframe.

Loosen the temporary nuts holding the panel and adjust for proper clearance between the clear-vision panel and the airframe by pushing on the awls, tapping lightly, or prying so that the clearance is the same on all four sides.

After installation, the gap on all sides around the clear-vision panel may vary from 0.09 to 0.18 inch. Place a shim (0.012 to 0.020 inch) under the hinge and remove an equal thickness of shims from under each of the three brackets.

Sealant Fill and Trim – Clear-Vision Panels (Commercial)

The next step is to form the gasket that will serve as both weather and pressure seal when the clear-vision window is closed. Open the window and apply a light, uniform coating of Dow Corning DC-4 parting agent or equivalent to the contact surface of the airframe structure.

Apply masking tape to the inside portion of the airframe around the window opening to minimize the need for sealant clean-up.

Apply a thin, continuous coating (0.001 inch maximum thickness) of Dow Corning DC-1200 or G.E. SS-4004 adhesive silicone primer to the clear-vision panel mating surface. Allow the primer to dry at least 30 minutes.

Next apply about a l/4-inch thick continuous coating of Dow Corning 93-006-6 or 93-006-l or equivalent sealing compound to the clear-vision panel mating surface.

Close and latch the clear-vision panel. Remove all excess (squeeze-out) sealant and form a smooth seal. Remove the masking tape. Allow the sealant to cure for the minimum cure time. Observe the sealant cure times described on page 15. Note that when the clear-vision panel is closed against the cured sealant, the surface of the glass should be flush with or up to 0.12 inch below the skin surface.

After the sealant has fully cured, open the clear-vision panel. Trim all excess sealant. The formed-in-place seal should have a smooth and continuous surface.

Remove the 0.012- to 0.020-inch shim that was installed under the hinge and replace the 0.012- to 0.020-inch shims that were removed from under the brackets earlier in the installation. This helps ensure a good seal. The panel is now ready to be installed in the aircraft with permanent fasteners.

Fastener Installation – Clear-Vision Panels (Commercial)

The procedure for installing permanent fasteners in clear-vision windows is similar for both military and commercial aircraft. Dip-coat each permanent screw, including the threads, shaft, and underside of the screw head. Install screws through the skin and the aft hinge half while wet. Install a washer and nut on each screw and tighten down. Remove the awls and temporary fasteners used to position the window and install the rest of the permanent fasteners in the same manner. Torque 3/16-inch fasteners to 25-30 inch-pounds, and l/4-inch fasteners to 50-55 inch-pounds.

Matching Resistance Rating

The final step is to make the appropriate electrical connections, and it is important that this be done with care. Premature window failure may result from not properly matching the power source to the electrical resistance of the window.

The electrical resistance of a NESA panel is determined by the stannic oxide coating. Since it is not practical to coat windows with such uniformity that every window will have a standard resistance, there may be a variation of up to 10 percent between the resistance values of the individual panels.

NESA windows with lower resistance values will tend to warm up faster and become hotter. Those with higher resistance will tend to heat up more slowly and operate at a lower temperature. It is important that such differences be considered so that the temperature of all electrically heated windows remains within a safe operating range.

Windshield panels are tested after manufacture to establish into which of three resistance ranges each window falls. The panels are marked on the basis of the this check as RA, RB, or RC.

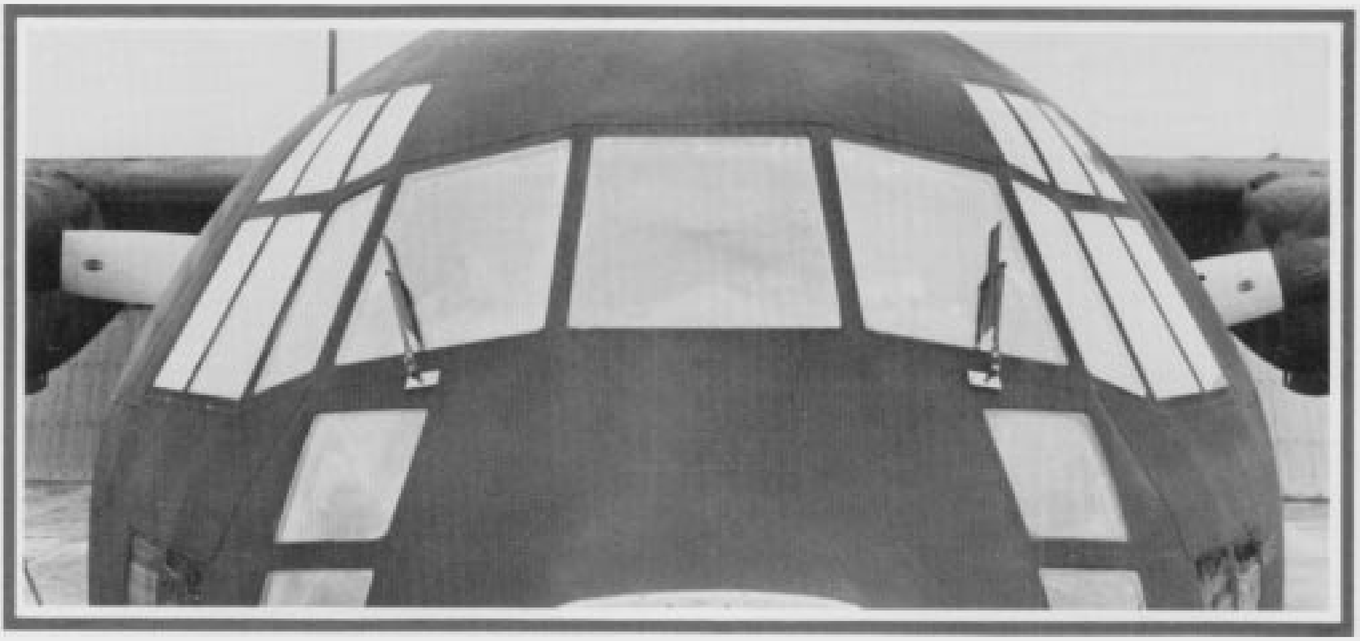
Since the approximate resistance range of a panel is known before installation, an effective way to control the heating of an individual NESA window is to select the voltage of the input power. The NESA windshield transformers are designed to accommodate these variations in window resistance. A choice of three transformer terminals is available for each power lead going to a window.

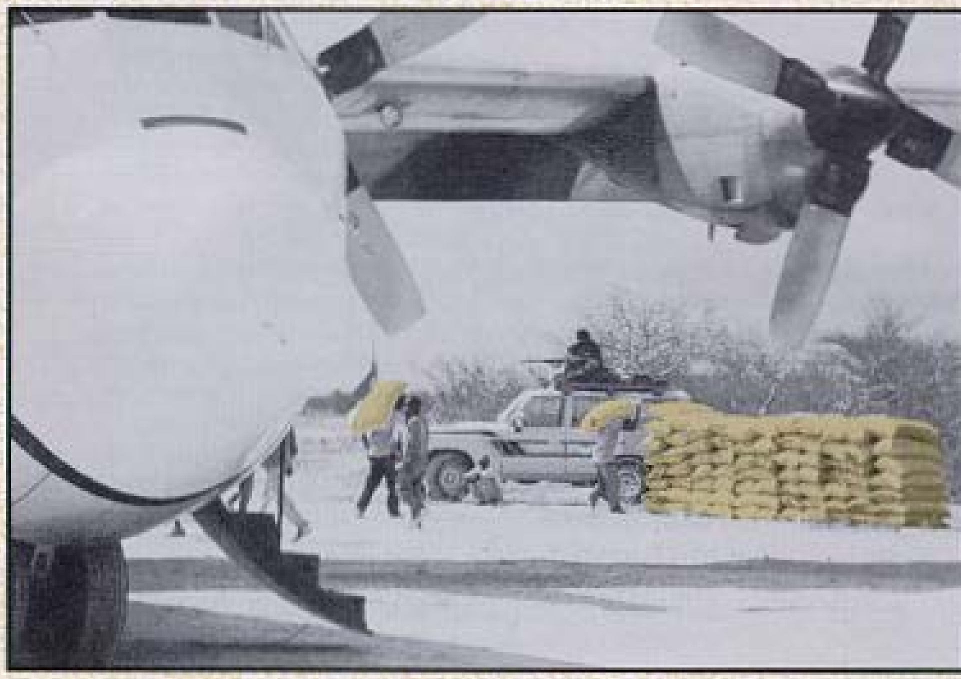
All that is necessary is to connect each window to the correct matching terminal in accordance with the callouts on the applicable aircraft wiring diagram. In the electrical schematics in Figures 7 and 9, for example, an RB panel mounted in the center windshield position is shown connected to the B2 terminal of the transformers.

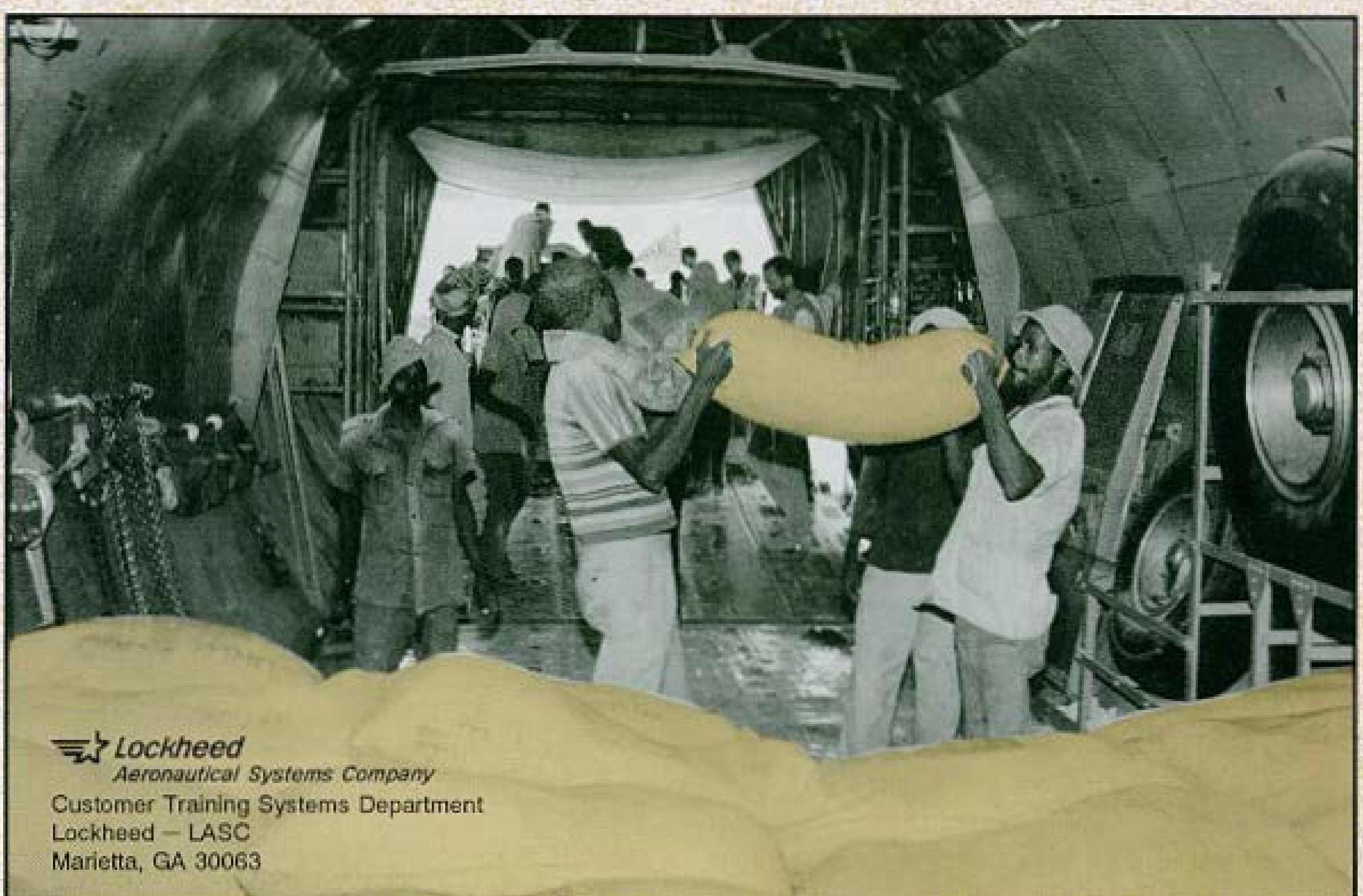
The windshield anti-icing wiring diagrams in the applicable handbooks show how to make the correct wiring connections. Note that if a side windshield, clear-vision window, or the pilot's forward window is being replaced, the resistance rating of the window connected in parallel to the new window must also be considered. Use the chart in the manual provided for this purpose to determine the correct transformer terminal.

After the correct terminal has been determined, make sure that power is not applied to the airplane, and open the copilot's distribution panel doors on the right side of the flight station. Locate the proper wire number and make the appropriate terminal connection.

The NESA panels on your Hercules aircraft are built for long, reliable service. With a reasonable amount of care, periodic inspection, and proper removal and installation techniques, NESA windows can offer thousands of hours of trouble-free performance.



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