Lockheed

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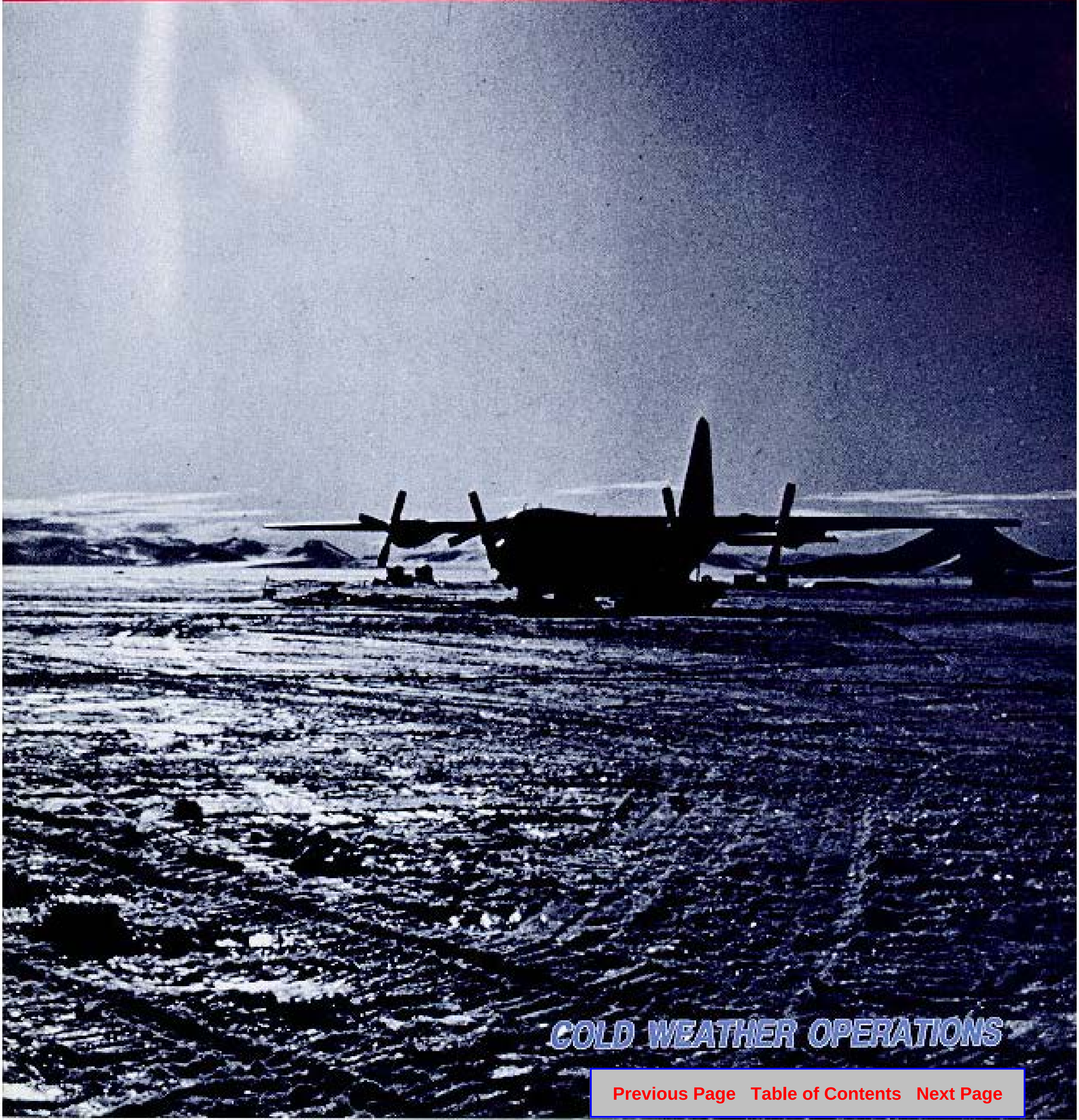
service news

A Service Publication of Lockheed Aeronautical Systems Company



COLD WEATHER OPERATIONS

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A SERVICE PUBLICATION OF
LOCKHEED AERONAUTICAL
SYSTEMS COMPANY

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Vol.17, No.4, October-December 1990

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Photographic Support: John Rossino

Cover: Ski-equipped Hercules aircraft have revolutionized the logistics of polar exploration and research. What were once among the most forbidding and remote regions on the planet are now accessible to year-round scientific study.

Focal Point

J. L. Bailey

LASC Supply Support: the Reliability Key

The Hercules aircraft is arguably the most reliable and durable flying machine ever assembled. This bold statement is supported by the fact that of the more than 1900 Hercules manufactured over the last 36 years, almost 1700 are still flying today. But even the most reliable aircraft occasionally "breaks down," or needs periodic maintenance to achieve maximum performance.

We in the LASC Supply Support Division like to think we are partly responsible for the excellent performance and reputation of the Hercules. Our organization provides spare parts, ground support equipment, special kits, overhaul and repair services, and technical data to our Hercules customers worldwide whenever the need arises.

The Supply Support organization provides support to our Hercules customer from "cradle to grave;" that is, from the time a prospective customer expresses an interest in purchasing a Here until the time the aircraft is retired from service. We feel that the more we know about our customers' facilities and maintenance capabilities, the better we will be able to supply the spare parts and support equipment required for a smooth-running operation. With this in mind, each prospective customer is assigned a support specialist who is well versed in all aspects of support for Lockheed's products. These professionals visit each prospective customer to acquire firsthand knowledge of their operation and assist the customer in selecting spare parts and support equipment tailored to their specific needs. After the aircraft is delivered, the specialists maintain contact with the customer to ensure that their Hercules are performing to their fullest capabilities.

In addition to the support specialists, each customer is assigned a supply administrator who provides personal service and rapid response to his requirements, using the latest computer technology. With the press of a button on a terminal keyboard, your administrator can provide you with the up-to-the-minute status of your request for quotation, order, or warranty claim.

But all of this personal service is wasted if we are not able to get the right part to you when you need it. Toward that end, we maintain a multimillion-dollar spares inventory, and provide service 24 hours *a* day, seven days and week, to handle emergency orders from our customers. Available parts are shipped to you within hours anytime of the day or night, any day of the week.

The entire Supply Support team, from the supply specialists to your personal supply administrator, and including the hundreds of people in technical support, overhaul and repair, shipping, and other areas, is totally committed to providing the best possible support to keep your aircraft flying. We are constantly seeking ways to improve quality and efficiency by automating many of the tasks involved in processing your requests for quotations and orders, while not compromising the personal attention you deserve.

(Please turn to page 15)

PRODUCT SUPPORT LOCKHEED AERONAUTICAL SYSTEMS COMPANY

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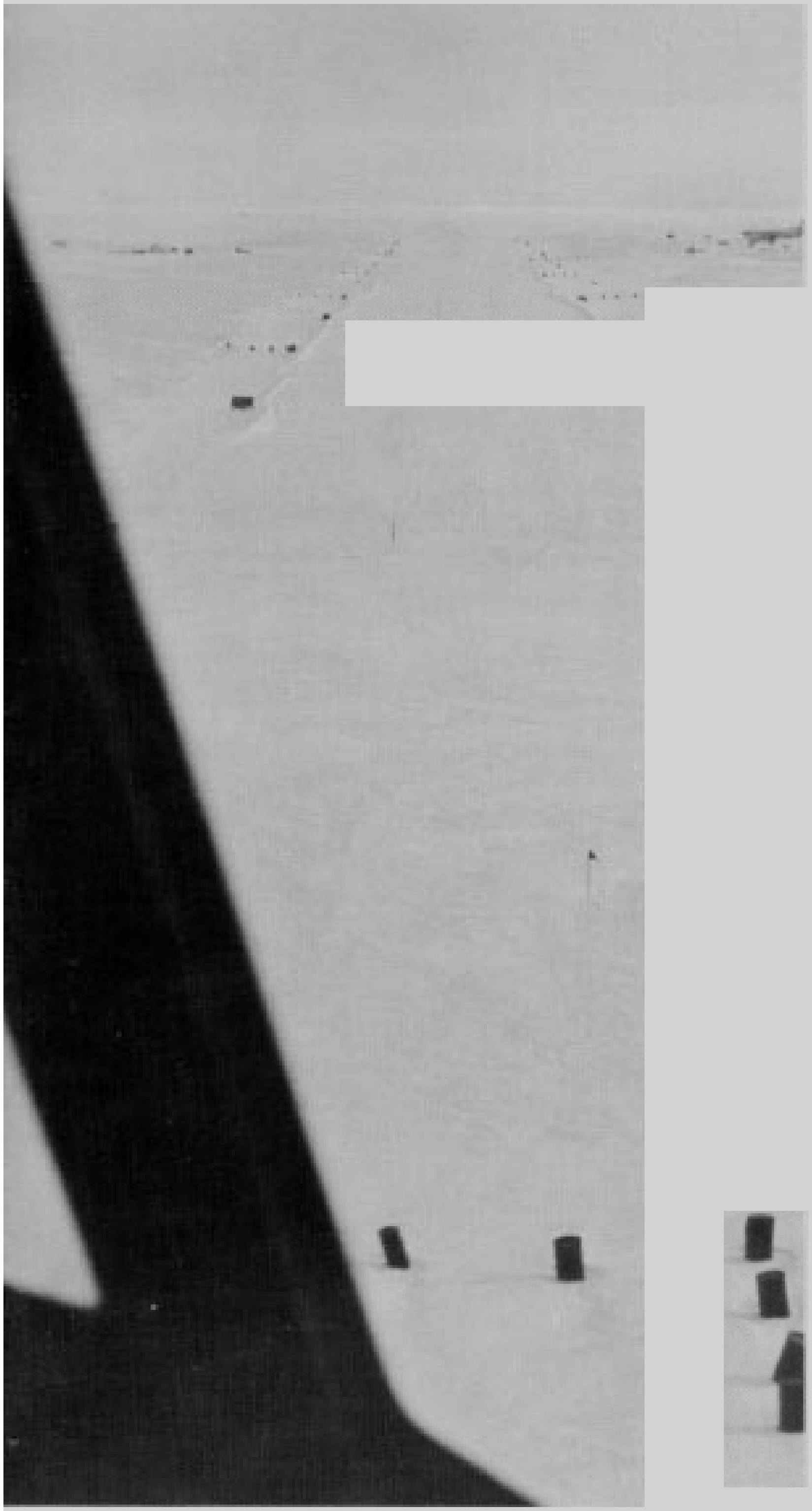
Cold Weather Operations

by **H. E. Greathouse,** *Training Coordinator*
Customer Training System Department

J. Torres, *Training Specialist*
Customer Training Systems Department



Compared with the conditions that exist elsewhere in the universe, our home planet is a very temperate place. The most extreme Antarctic low yet recorded, -89.2'C (-128.6” F), would be a mild evening on Mars, and the high end of the terrestrial temperature scale is equally moderate. Venus, our nearest planetary neighbor, has surface temperatures approaching a thousand degrees Celsius, but no place on earth has to endure temperatures higher than about 55°C (131 'F) for very long, or very often.

The temperate nature of the earth’s climate is due not only to the placement of our planet in orbit at a comfortable distance from a suitably luminous and stable star, but also to the protective and moderating influence of the earth’s atmosphere, its oceans, and its biosphere. Taken together, these effects ensure that the entire temperature range experienced on earth spans less than 150°C. By cosmological standards, this is scarcely a range at all.

Unfortunately, cosmological considerations offer little comfort to the power plant specialist struggling to change a fuel control in a broiling desert, or the hydraulics technician replacing a booster pack assembly on a snowy, subzero day. Even within the relatively moderate temperature range that prevails on earth, weather extremes have dramatic effects on every kind of human activity. Nowhere is this more apparent than in the case of aircraft, which by the nature of their mission and operating environment are regularly exposed to a greater variety of climatic extremes than any other device made by man.

Trouble, Hot and Cold

Almost any kind of extreme weather conditions pose potential problems for aviation, both from an operational and a maintenance standpoint. Too much heat can cause a number of adverse effects. Air is less dense when it is hot, which reduces both lift and engine efficiency. Even worse, high temperatures are often found in combination with dry conditions, which means blowing sand and dust: bad news for anything mechanical, and especially bad for a modern aircraft (see “Desert Operations,” *Service News,* Vol. 7, No. 4, Oct-Dec 1980).

The addition of moisture to heat, as in rainy, tropical climates, helps reduce airborne particulate matter, but introduces its own problems. Prolonged exposure to a

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hot, humid climate increases airframe corrosion. It also tends to encourage the deterioration of seals, fabrics, and electrical parts.

As far as the aircraft itself is concerned, a cold environment is far more benign than a hot one. Airplanes stored in extremely cold and dry conditions remain in excellent condition over long periods of time. Probably the best practical examples of this are the ski-equipped C-130 aircraft that have been left on the Antarctic icecap from time to time because of operational mishaps. Most of these aircraft were later repaired and recovered, sometimes after more than 15 years in involuntary cold storage. All were found to be in as good condition as the day they were stranded, and could be flown out under their own power as soon as the necessary repairs were made.

Although low temperatures are more likely to preserve an aircraft than harm it, the point of flying a large, versatile airlifter like the Hercules to some cold and remote corner of the world is to use it, not store it, and operating an aircraft in cold weather can be a challenging undertaking indeed. Extreme cold not only makes all human activities associated with aircraft operation and maintenance much more difficult, but it also affects the materials of which aircraft are built and the other substances upon which their operation depends.

The Effects of Cold

The materials used in all-weather airplanes such as the Hercules must meet rigid specifications which ensure that the aircraft can be operated at extremely low temperatures. It is therefore unlikely that cold will cause any damage if the temperature is lowered gradually, even if it reaches a value well below the -60°C (-76°F) extreme called for by specification. Sudden changes in temperature can be more problematical. Thermal shock resulting from a too-rapid increase or decrease in temperature exposes airframe components to severe stresses that can lead to damage or reduced service life.

If, for example, an airplane is parked in a warm hangar, and then moved outside into a cold, windy environment, the exposed surfaces will change temperature very rapidly. The sudden change induces stresses in the metal alloys and other materials of which the airplane is constructed. The temperatures at various points within the thickness of the materials will differ significantly for a period of time before thermal equilibrium is reached. These differentials produce uneven expansion or contraction, generating high internal stresses. Over a period of time, such stresses can result in cracks or delamination in structural materials.

The problems induced by cold weather are not limited to just the airframe materials. Cold also lowers the pressure in tires, landing gear struts, accumulators, and fire extinguisher bottles, and affects seals by reducing the flexibility of the materials from which they are made. This makes them less effective in preventing leaks and, in **some** applications, exposes them to damage unless appropriate precautions are observed.

Extreme cold also affects the viscosity of lubricating and hydraulic oils. Increased resistance to flow at low temperatures interferes with the lubrication of vital parts and slows the operation of hydraulic systems. New products have sometimes been substituted for those normally used in servicing the Hercules in the hope of finding better materials for use in frigid conditions. Unfortunately, not many of these substitutes have turned out to work as well as the lubricants and fluids originally specified. No changes should therefore be made in the oils specified for the engines, gearboxes, propellers, or hydraulic systems without appropriate authorization.

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Out of Antarctica: this C-130 was recovered in good condition more than 15 years after being stranded.

Operations and Climate

It is convenient to divide the challenges posed by cold conditions into two principal categories: operational and climatic. The operational problems are those which the aircraft is exposed to specifically during flight. In this regard, flying operations in cold weather are not fundamentally different from operations under normal conditions. Modern aircraft routinely operate at such high altitudes that every flight is an excursion into an area of Arctic conditions where potential cold-weather challenges abound. Climatic hazards, on the other hand, affect the airplane primarily where it is stored and serviced on the ground. In many locations, these problems are seasonal in nature, but wherever they occur, they impose a severe burden upon aircraft maintenance organizations.

By far the most serious problems affecting cold-weather operations are a direct result of the interaction of cold and moisture. The most commonplace of these is icing. Icing can be encountered by aircraft flying at high altitudes any season of the year, but it usually occurs when the aircraft is passing through cloud formations and weather fronts. These are situations which tend to arise more frequently, but certainly not exclusively, during the colder seasons.

Ice, snow, or frost accumulations on an aircraft reduce its aerodynamic efficiency and have specific and detrimental effects on takeoff, cruise, landing, and stall speeds, and other operational parameters. The formation of ice on wing and empennage surfaces adds weight to the aircraft, and changes the airflow over the wing. This reduces lift and alters other flight characteristics. Ice can also interfere with the movement of the flight controls by obstructing the hinge areas between control surfaces and supporting structure.

Anti-Icing and Deicing

Modern aircraft such as the Hercules are equipped with anti-icing and deicing systems designed to prevent these dangerous conditions from developing during flight. The design purpose of an anti-icing system is to raise the temperature of critical portions of the aircraft structure high enough to prevent ice from forming on them. This allows the moving air around the aircraft to evaporate away any moisture that reaches the heated surfaces.

Anti-icing is generally used on fixed portions of the aircraft structure which cannot readily fling off ice accumulations. A deicing system has a somewhat different mode of operation. It allows moisture to freeze and ice to build up briefly, but applies heat to the surfaces at regular intervals. This loosens the ice so that it can be mechanically dislodged. Deicing is therefore most effective on moving parts that can provide enough centrifugal force to remove the loosened accumulations, such as the propeller blades and spinners.

Anti-Icing **System** Operation

The Hercules aircraft uses a hot air evaporative anti-icing system in which hot bleed air supplied by the engines is directed to exposed areas such as the wings, empennage, engine inlets, and radome. The wing and empennage surfaces are divided into six sections for anti-icing purposes: left outboard wing, left inboard wing, right outboard wing, right inboard wing, left horizontal stabilizer and vertical stabilizer fin tip, and right horizontal stabilizer and vertical stabilizer base. An individual anti-icing control valve is provided in each section to control the flow of hot air. Two of these valves are located in each wing, and two more in the empennage.

The operation of the system is the same in all of these sections. The leading edges of the wings and empennage are double-walled. When anti-icing is selected for a particular section, bleed air drawn from the engines is routed through the anti-icing valve and an ejector assembly and into the space between the walls. Ambient air within the leading edge is mixed with the hot

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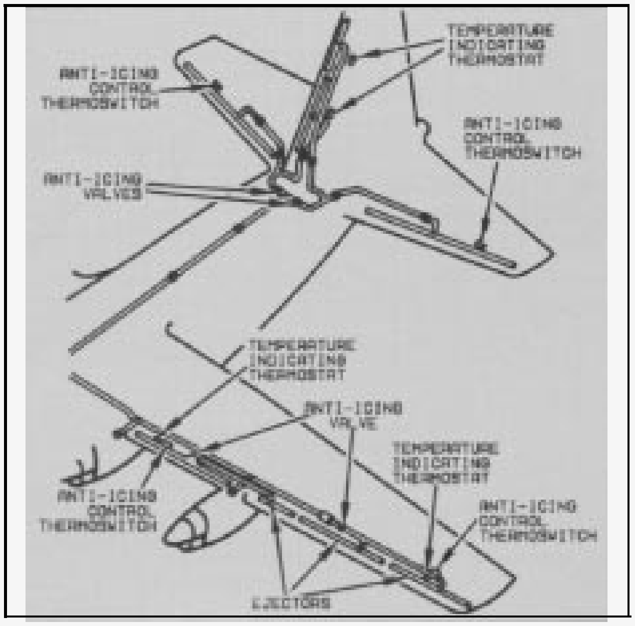
air, reducing its temperature to a safe level. The air mixture then circulates through the passages between the inner and outer skins, heating the leading edge and keeping it warm enough to prevent ice from forming.

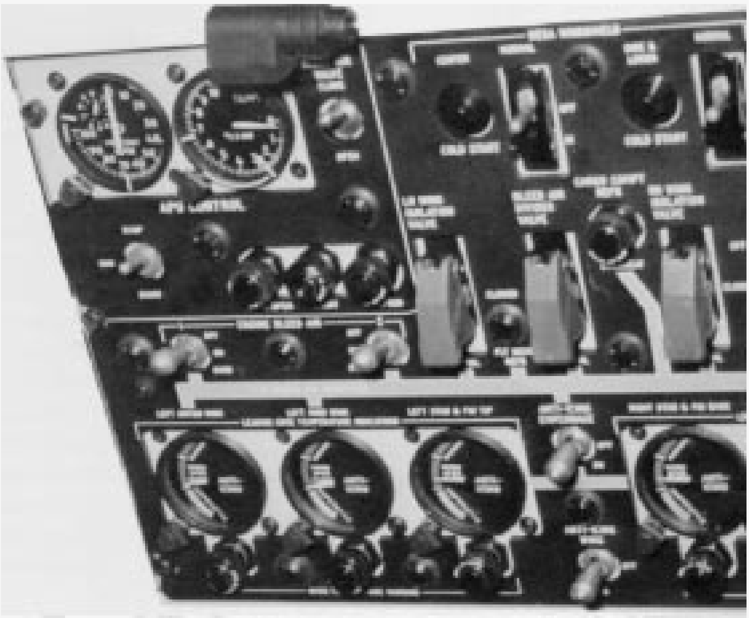
With the exception of radome anti-icing, the Hercules anti-icing system is operated and monitored from the overhead anti-icing control panel. The system is controlled by two switches, one for the wing and the other for the empennage. A third switch allows selection of automatic or manual operation of the engine and propeller anti-icing and deicing systems. If automatic operation is selected, the system will be activated whenever the icing detectors located in the No. 2 and No. 3 engine air inlets detect icing conditions.

Once the system is turned on, the operation of the control valve in each section is automatically regulated by its own thermostat, which maintains the temperature to between 70°C (158°F) and 82°C (180°F) in its portion of the leading edge. Temperature gages mounted in the anti-icing panel allow the aircrew to monitor the system's operation in each section. Each gage has a green area which indicates temperatures in the safe range of 24°C (75°F) to 88°C (190°F).

The radome is also equipped with an anti-icing system; however, this system is normally used only when ice accumulations on the surface of the radome interfere with the display presentation. In most Hercules aircraft, the operation of radome anti-icing is quite similar to that of the main system. Radome anti-icing is controlled by a three-position switch, typically located on the navigator's panel. System operation is either manual or automatic. When the switch is set to the AUTO position, radome anti-icing is coupled to the ice detection system. It will therefore be activated automatically whenever an icing condition is detected and the prop and engine anti-icing master switch is set in the automatic mode.

The Hercules anti-icing system is controlled by anti-icing valves located in the wings and empennage.





Most components of the anti-icing system are operated and

It is important to bear in mind that the wing, empennage, and radome anti-icing systems of the airplane are designed for use in flight; they should *not* be used for ice and snow removal while the aircraft is on the ground. These systems apply heat only to the airfoil leading edges, not to the rest of the wing and empennage structure. If they are used to melt ice and snow that have accumulated while the aircraft is on the ground, the water runoff will not be safely evaporated away, as would be the case in flight. Instead, the water is likely to flow to unheated areas of the aircraft structure and refreeze, perhaps in an even more critical area. Note also that extended ground operation of wing and empennage anti-icing systems can produce temperatures high enough to reduce the structural strength of the leading edge skin.

Deicing System Operation

The deicing system on the Hercules airlifter is also operated from the overhead anti-icing panel. As in the case of the anti-icing system, deicing can be activated automatically by the ice detection system. Deicing is used to control icing of the middle and rear sections of the propeller spinners and the blades themselves. Anti-icing is used for the spinner front sections and the propeller spinner afterbodies.

Heating for the spinners is accomplished by electric heater elements made of crimped wire and stranded braid that are molded into the fiberglass spinners. The propeller blades are warmed by heating blankets consisting of electrical elements embedded in synthetic rubber which are bonded to the leading edges of the blade fairings near the blade roots.

monitored from the anti-icing panel in the flight station.

The deicing action is accomplished cyclically. All four blades and spinner are deiced, but the deicing is accomplished one propeller at a time. Electrical current for deicing is applied to each propeller for a period of 15 seconds by the deicer timer. The power is then removed, and directed to the next propeller. The cycling action continues until the deicing system is turned off or the ice detection system is reset.

Climatic Hazards

The Hercules aircraft is unusually well equipped to deal with the routine operational hazards imposed by cold weather conditions. It was designed from the start as ‘an all-weather airplane, built of components and materials manufactured to all-weather specifications, and intended to be serviced with all-weather products.

Subsequent development and enhancements of the airplane’s capabilities have produced an extremely versatile airplane, able to operate in zones representing all temperatures found on earth. However, controlling the usual operational hazards involved in flying at high altitudes and in poor weather conditions is one thing; dealing with the problems imposed by extremely cold climatic conditions at the location where an aircraft is based is another.

Here again, moisture is at the root of many of the problems that are commonly experienced. Water is rather peculiar stuff in some ways. Most substances expand when heated and contract when cooled. Water is an important exception to this rule. The fact that water expands instead of contracting when it is cooled below the freezing point is the main reason why the oceans of the world are not underlaid by permanent sheets of solid ice. This is fortunate for the terrestrial climate, but the same property can also cause a great deal of trouble. This is especially true when the water in question happens to be trapped within the narrow confines of precision aircraft parts.

The adhesive nature of frozen moisture poses additional problems. Moisture from condensation or melted ice has an unfortunate tendency to freeze in critical areas during cold weather and remain there. The result can be binding of flight control surfaces, jammed valves, and obstructed drains. All of these are potentially serious, but not inevitable, complications of cold weather operations. Let’s look at some of the ways in which these challenges can be met.

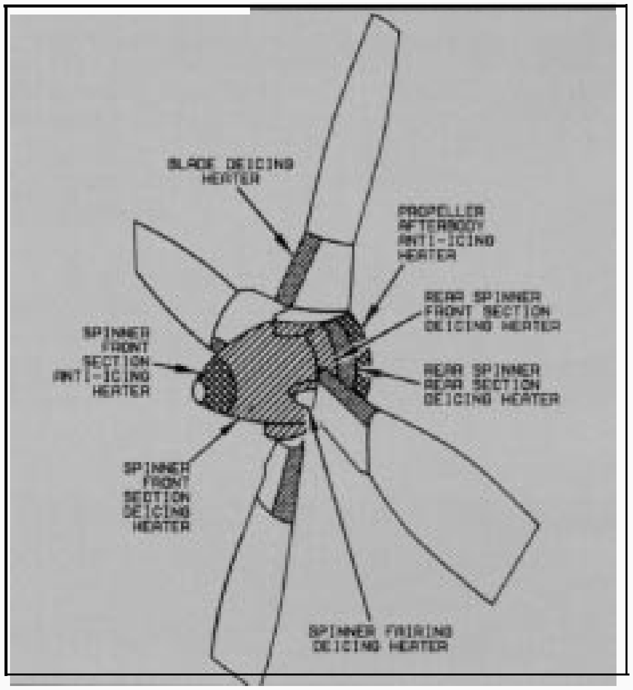
Cold Weather Savvy

The authorized aircraft manuals contain much useful information that addresses cold-weather problems, and these documents should always be reviewed first when questions about operations under frigid conditions arise. The military and commercial flight manuals contain special sections on cold weather operations that deserve attention, in particular the paragraphs that discuss taxi techniques, engine runup, takeoff, and landing.

For example, the U.S. Air Force manual T. 0.42C-1-2 covers anti-icing, deicing, and defrosting parked aircraft, and T.O. lC-130A-2-lCL-1 provides a handy maintenance checklist of cold weather procedures. Further information dealing specifically with the effect of cold conditions on the airframe, and the electrical, fuel, and hydraulic systems may be found in the applicable handbooks for your aircraft.

In many ways, meeting the challenges of cold weather operations is an exercise in applied common sense. Observing a relatively few basic precautions will

The propeller contains both anti-icing and deicing elements.



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go a long way toward helping to solve the kind of problems most often posed by aircraft operations under cold conditions.

First of all, an airplane that is covered with ice and snow cannot be flown. The ground crew needs to know how to remove such frozen accumulations safely and efficiently. As always, safety considerations must be paramount. The upper surfaces of large aircraft are far from the ground and slippery enough under the best of circumstances. The presence of frost or ice and snow on these surfaces can make them downright treacherous. Always ensure that appropriate safety belts or harnesses are used by personnel engaged in removing snow and ice from aircraft.

Cold metal surfaces can turn out to be dangerous even when maintenance personnel are standing on the ground. Bare metal must never be allowed to come in contact with the skin in very cold weather; always wear gloves and appropriate protective clothing. Unprotected skin can freeze to a cold metal surface on contact, and painful injuries can result from attempts to pull away. Liquids with low freezing points can also be dangerous when cold. Hands soaked in fuel that has been chilled to -40°C (-40°F) will probably suffer frostbite.

Ice and Snow Removal

The best way to deal with ice or snow accumulations on the aircraft is to avoid them in the first place. For this, nothing beats a heated hangar. Since hangars are luxuries not often available in remote regions, having a working knowledge of snow removal techniques is the most practical alternative. Loose accumulations of soft snow can usually be removed from an airplane by simply brushing it off with hand brooms. If ice and snow adhere to the structure, other approaches will be required. It is important not to strike the aircraft skin with broom handles or mallets in an effort to break up ice and snow accumulations. Never scrape or chip ice from the flight surfaces or the fuselage with sharp tools.

Heated deicing fluid is effective in removing ice and snow accumulations that adhere to aircraft surfaces.

The regular use of covers will help keep snow and ice out of intakes, ports, and other openings.

Frozen accumulations that cannot be brushed off should be removed by using a heated deicing fluid that conforms to MIL-A-8243. This material is available in Type 1 and Type 2 formulations. Both are essentially glycol-water mixtures. The two types are just about equal in deicing capabilities, but Type 1 is preferable because it uses a less toxic, propylene glycol base. Ice and snow can be removed more rapidly and efficiently if cold, undiluted deicing fluid is sprayed on aircraft surfaces before frozen precipitation begins to fall. The accumulations can then be cleaned by brushing the surfaces with a stiff broom.

Use hot air alone for ice and snow removal if approved deicing fluid is not available. Hot air is an excellent all-purpose weapon against frozen moisture. It. melts ice accumulations cleanly, helps the resulting water evaporate, and preheats the aircraft structure, all at the same time. Be careful, however, when using hot air on and around windows, either inside or out. Windows will crack if a heat source is held close to the surface long enough for a hot spot to develop. Note that hot water must never be used for deicing purposes.

Since moisture frozen and otherwise-is so often a source of trouble in cold weather operations, it is important to keep snow and ice outside the airplane and as far away from its intakes, ports, and other openings as possible. Regular use of protective covers will help keep unwelcome moisture out of exposed components, but wind-driven snow at Arctic temperatures is dry and

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powdery, so some will probably get in anyway. Make sure that any such accumulations are brushed away or scooped off before they penetrate too deeply.

Inspect the drain holes in the trailing edge of each control surface to ensure that they are clear. Ice and debris trapped within control surfaces may cause imbalance, which could result in flutter.

It is very important that all ice, snow, and frost accumulations be removed before an aircraft is released for flight. Even minor accumulations can significantly affect aerodynamic efficiency.

The Inside Story

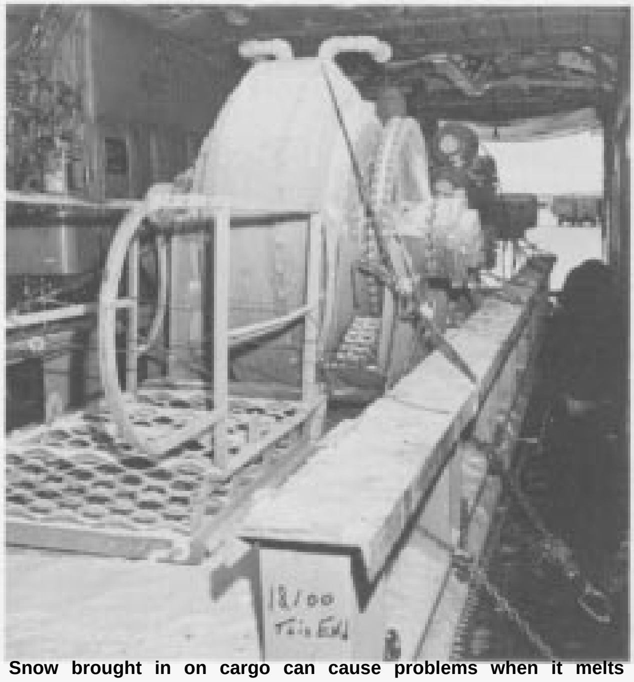
The inside of the aircraft needs special care in frigid weather. Once an aircraft has become “cold soaked,” even routine activities involve observing a few precautions. Many materials become weak and brittle when cold, and this includes electrical wiring. Wires and cables should not be flexed unnecessarily when they are very cold. For this reason, avoid opening the circuit breaker panels until the flight station has been preheated. Preheating is also important for the flight station instruments, which may be adversely affected by the cold. In frigid weather, the instruments should always be checked closely during taxi for proper operation.

Sudden, large temperature increases inside the aircraft should also be avoided. Do not heat the cabin too much or too quickly. A large volume of hot air introduced too rapidly inside a cold airplane can lead to an excessive amount of condensation, which causes electrical problems and encourages corrosion.

A surprising amount of moisture can collect in a Hercules fuselage in subfreezing weather. Much of it stows away as snow and ice brought in on cargo; it then melts in the warm compartment during the flight and runs down into the underfloor area. The aircraft is pressurized in flight, and therefore retains this water. Since the aircraft is flying in a cold environment, the accumulated water will probably freeze and may block the drain flapper valves.

Normally, this is not a serious problem since the water would be discharged as soon as the airplane lands. The pressurization system would by then be turned off, and the exposed areas of the fuselage structure would eventually warm up to the ambient temperature. But under extremely cold surface conditions, the frozen accumulations in the underfloor area do not get a chance to melt and permit the flapper valves to open. If this situation is allowed to continue, the buildup of ice in the underfloor area could be significant, and even present a gross weight or a weight and balance problem,

Probably the easiest way to correct this condition is to apply underfloor and external heat to the affected area. This will release the flapper valves and allow the melted ice to drain out.



Snow brought in on cargo can cause problems when it melts and water collects in the underfloor area.

Tanks and Fuel

Cold conditions require that an extra effort be made to ensure that all fuel vents are clear of ice and snow, and that the fuel drains are inspected for ice accumulation. Draining the condensate from Hercules fuel tanks in cold weather is no less important than it is at warmer temperatures, but it is a good deal more difficult to do. Sump draining should not be attempted unless the fuel temperature is above 0°C (32'F), and all pogo drains should be preheated prior to draining.

The anti-icing compounds now added to most jet fuels during manufacture will help prevent condensate freeze-up, but the overall quality of the fuel is especially important in cold conditions. The less water entrained in the fuel to begin with, the less likelihood there is of ice formation later.

The icing inhibitor used in military and commercial fuels performs two functions. It prevents water in the fuel from freezing, and it also helps control the microbial growth which results in aircraft tank corrosion problems. Note that anti-icing inhibitors cannot be added directly to aircraft fuel tanks. If they are added undiluted to fuel tanks, they can cause corrosion and damage to tank sealant and fuel system seals. These fuel additives must be blended in by the petroleum supplier or added to the base fuel storage tanks with appropriate special equipment.

JP-4 fuel, which contains anti-icing additives and has a freezing point of -58°C (-72'F), is the fuel of choice

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for cold weather operations. Although the freezing point of JP-4 is quite low, the ambient temperatures in some areas and at certain altitudes can drop even lower. To avoid fuel freeze-up, temperatures should be monitored to ensure that they are not lower than about 3°C (6°F) above the fuel's freezing point. Since the fuel tanks and most components of the fuel system are located in unheated areas, the fuel temperature should be considered equal to the outside air temperature as shown on the OAT gage.

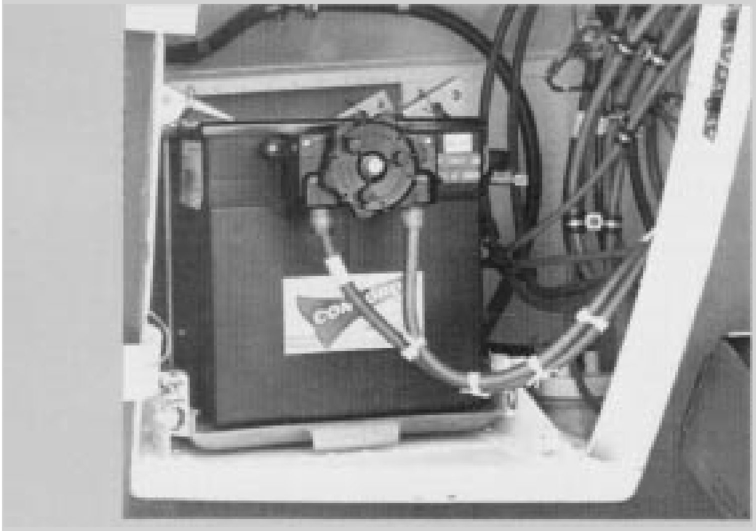
A word of caution concerning fueling the airplane through the wing filler ports: make sure that snow, ice, and water from the wing do not go in with the fuel. The ice that results from this kind of fuel contamination could remain undetected in the tank until it is melted by a general warm-up of the wing.

One aspect of ground handling that needs special attention during operations on snow is electrical grounding. It is very important to provide proper electrical ground connections in polar regions, especially for such operations as fuel transfer. Cold air is much drier than warm air, and it will allow a higher electrical potential to build up on the airplane. Unfortunately, even though it is made of water, snow does not make a good ground because it contains so much air. Thus an extra-long electrical grounding rod must be used to penetrate through the loose surface snow to a more compacted and conductive medium.

Batteries

The lead-acid battery installed in the Hercules aircraft battery compartment can provide the power necessary to start the GTC or APU if it is fully charged and warm enough (above 0°C; 32°F). It is essential to give these batteries the maintenance priority they deserve so that they will be ready to do their job when independent starting is necessary.

In very **cold weather, remove the battery and warm it up before attempting to start the GTC or APU.**



On occasions when the aircraft will be inactive for more than four hours in very cold weather (temperatures below about -29 “C; -20°F), it is a good idea to remove the battery from the airplane to warm it up and charge it before attempting to use it to start the GTC or APU. The electrical power that a lead-acid battery is capable of producing is significantly affected by low temperatures. Only about half the current produced at normal room temperatures will be available when the battery is cooled to -9°C (16°F). By the time the battery's temperature drops to -40°C (-4O'F), its output will be virtually zero.

When the temperature is extremely cold, the battery needs to be warmed to at least 5°C (41°F) before charging. It can take a long time to get a cold battery to accept a full charge. If it is necessary to add distilled water to the battery in a sub-freezing environment, ensure that the water is thoroughly mixed with the electrolyte by charging the battery for a while afterwards. Make certain that no electrical loads are applied to the battery before disconnecting the cables, and keep moisture in any form off of the electric connections.

Remember that other batteries, such as the emergency exit batteries and emergency radio batteries, also must be checked often when exposed to very cold weather. The contents of these batteries may freeze and expand, which can rupture the casing material. This will cause the batteries to fail and leak corrosive chemicals.

Engine Preheating

Operators who regularly encounter surface temperatures of -40°C or below in their cold-season operations will find it beneficial to install the functional components necessary to activate the nacelle preheating system. In aircraft so equipped, all the resources necessary for completing all preflight activities under cold conditions are available when the GTC or APU is in operation. This includes preheating as well as starting the four engines.

The same ducts used for engine bleed air are also available to distribute hot air from the GTC or APU to the engine nacelle for preheating. The outlet diffusers that deliver the warm air to the interior of the nacelles are located just forward of the engine oil tanks. A nacelle preheat switch for each engine is located on the anti-icing system control panel, overhead in the flight station. These switches are effective only when the engine condition levers are at the GROUND STOP or FEATHER positions.

The engine preheat system may only be used when ambient temperature has dropped below about -18°C (0°F). Preheat operations should be limited to about five minutes before engine starting, and the preheating must be turned off before an actual start is attempted. Note that the air supplied to the nacelle preheating system by

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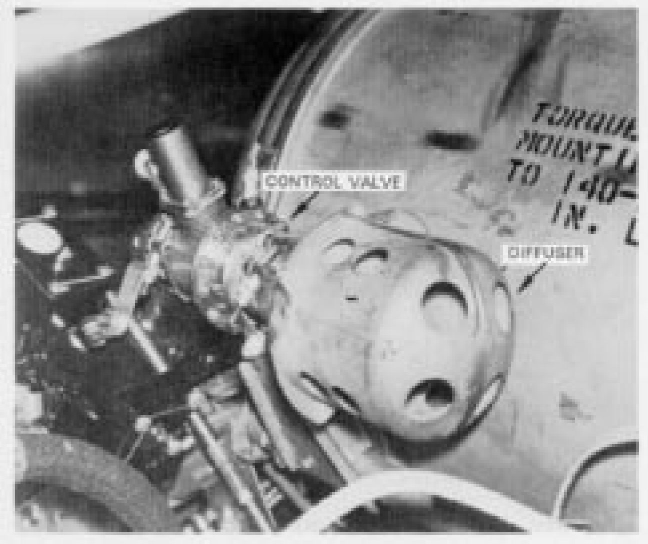


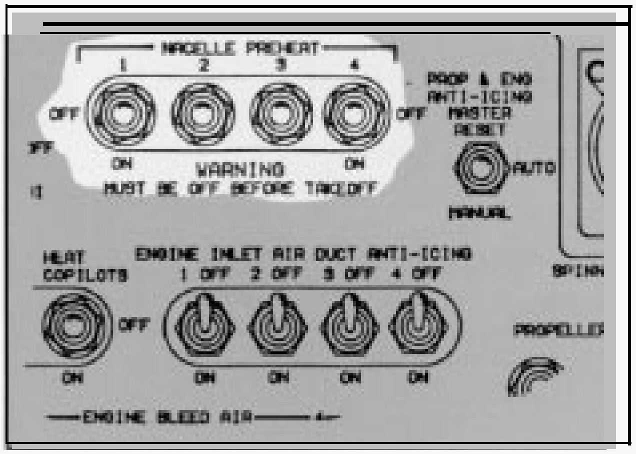
The outlet diffusers of the preheating system deliver warm air to the nacelle interiors just forward of the oil tanks.

the GTC or APU is at a temperature of about 177°C (350'F), while the hot bleed air from the engine is approximately 316°C (600°F) at the same point. After one engine is started, the bleed air it supplies can be used for more rapid preheating of the other engines. Caution must be exercised, however, to prevent possible damage from overheating, particularly to electronic components.

Ground heaters are employed to warm the APU or GTC; they must also be used for the engines in cases where the aircraft is not equipped with nacelle preheating. Such heaters are less efficient at warming the engines than the nacelle preheat system, so a longer preheating period of 15-30 minutes should be allowed.

Note that the expression “engine preheating” is actually somewhat misleading. It is primarily the engine oil within the tank and circulation lines, as well as the engine accessories in thenacelle, that require preheating. For this reason, it is ineffective to direct air from a ground heater into the engine air inlet or oil cooler inlet. Introduce the hot air into the nacelle by opening a lower panel and directing the flow upward toward the oil tank. After warming the oil tank, the air will circulate through the top of the nacelle and exit through the louvers in the upper panels.

Nacelle preheating is controlled from the anti-icing system control panel, overhead in the flight station.



Appropriate care must be used to prevent damage to heat-sensitive components. The hot air should not be allowed to blow directly on electronic components, wiring harnesses, flexible hoses, or other rubber or fabric materials. **All** ground heater ducts must be removed before starting the engines.

Engine Starting

The design of the Hercules aircraft makes engine starting possible without ground support equipment, but in very cold weather it is a good practice to use ground equipment for starting if it is available. Starting in cold weather normally poses no extraordinary problems, but remember that engine oils meeting MIL-L-23699 specifications are only certified for use down to -40°C. Whenever the temperatures fall below -37°C (-35'F), the engines and the GTC/APU should be preheated before starting. MIL-L-7808 oils are serviceable down to **-54°C (-65'F),** but appropriate authorization must be obtained before using oils of this type in the engines of the Hercules aircraft.

Ensure that ice, snow, frost and any remaining moisture are removed from the engines and propellers before starting. De-icing fluid must not be sprayed into static ports or engine intakes; this could cause corrosion damage in these areas. Normal starting procedures can be used, but patience is required and careful attention must be paid to start limitations.

The steps for starting the engines in cold weather are in general routine, but low temperatures do occasionally cause starting problems. If the propeller rotates but the engine fails to start, check for ice in the low and high pressure fuel filters or fuel heater. Clearing the filters and applying heat should help. If the starter fails to rotate the engine during a start attempt, the starter control valve may be frozen or the power section locked by frozen moisture. Here again, hot air will solve the problem.

Starts may be accomplished with or without fuel enrichment, and differing start characteristics will result depending on which mode is selected. Some flight manuals have encouraged the use of fuel enrichment for cold weather starting in the past, but the engine manufacturer discourages it. Be sure to refer to the authorized flight manual for your aircraft before making a determination concerning the use of fuel enrichment.

Note that operation of the controls for the propeller and components of the hydraulic systems should be delayed until the seals and packings have had a chance to regain at least some of their normal flexibility, and are

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also warm enough to melt any moisture that might have frozen around them.

The engine power levers should be left in GROUND IDLE/GROUND START position until the engine oil temperature reaches 0°C. The use of low speed ground idle will help control gearbox oil pressure, which may be high when the engine is very cold. Note that the gearbox oil pressure limitation (250 psi) may be exceeded during start and warmup in cold weather. When the oil temperature rises to between 0°C and 4O'C, the power levers may be set to a maximum of 4500 inch-pounds of torque. As soon as the oil temperature reaches or exceeds 40°C and the gearbox oil pressure indication shows no fluctuations, maximum power may be applied.

Operators who are experienced in dealing with very cold conditions often complete ground operations of relatively short duration without shutting down the engines. In other cases, one or both outboard engines are left running and used to start the stopped engines for the next leg of the flight. For longer stays (one to four hours) at extremely cold, unequipped landing fields, it is advisable to start the GTC or APU before engine shutdown. Hot air from this source should then be used to prevent chilling of the flight station and supply electrical power requirements.

Propellers

The aircraft propellers are in particularly exposed locations, and their hubs benefit little if at all from the engine preheating system. Prior to starting, the propellers should be pulled through manually and checked to ensure that the blades and cuffs are free of ice and snow. Severe engine vibration may occur on start if the blades are not thoroughly cleaned of accumulations. During the actual start, ground personnel should stand well clear of the plane of propeller rotation. This is a good practice under all circumstances, but especially so when there is any possibility of being hit by flying ice.

At temperatures below 0°C (32'F), avoid any unnecessary static or dynamic cycling of the propeller blades until the engines have been started and the engine oil temperature indications have started to climb above 0°C. External hydraulic leakage may occur if the propellers are cycled at ambient temperatures below the freezing point because the blade seals have taken a “cold set.” The pitch of the blades should not be changed until the shaft seals have had an opportunity to warm up. Pitch changes should then be made a few degrees at a time, increasing and decreasing the blade angle to free the seals gradually.

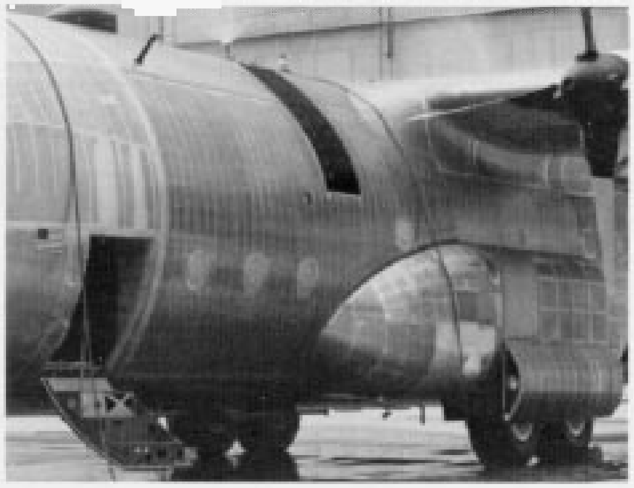
Sometimes a propeller low oil light will illuminate during engine start because the prop oil is slightly low and the oil supply has congealed in the forward part of the propeller housing. Shut the engine down by placing the condition lever in GROUND STOP-feathering the prop could cause seal damage-and check the oil level. Try to bring the propeller to normal temperatures before adding oil to prevent over-tilling. The propeller oil temperature can be considered in the normal range if the engine oil temperature is 40°C.

Hydraulic fluid may leak from the propeller blade seals during the engine start at extremely low temperatures. This leakage should cease when normal operating oil temperature has been reached. If such leakage has been observed, operate the engine until the engine oil temperature is above 70°C; then shut down the engine. Check the propeller oil quantity and replenish as necessary. Restart the engine, allow time for the propeller to warm up, and then check the propeller blade seals for further oil leakage.

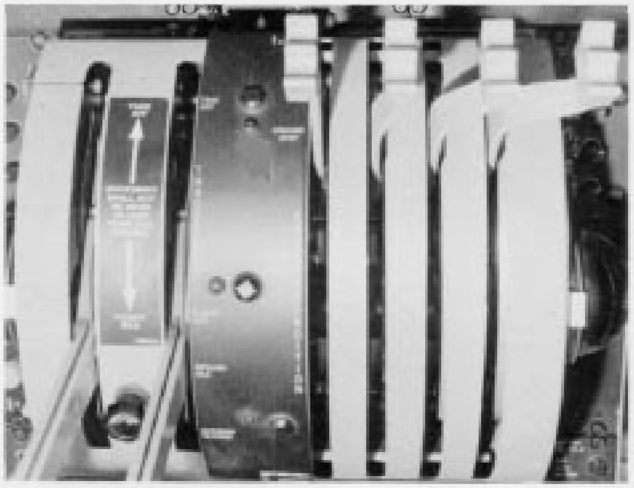
Hydraulic Systems

Check the hydraulic systems for leaks. Minor hydraulic leaks may occur after an aircraft has been exposed to low temperatures for prolonged periods, and they can be difficult to eliminate without replacement of

Watch for flying ice during engine startup. The fuselage is protected by an ice shield; ground personnel usually are not.



Use GROUND STOP to shut engines down in cold weather. This will help prevent seal damage at the next startup.



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lines and fittings. However, the leaks often disappear after the hydraulic system is warmed up sufficiently. Seeps and minor leaks caused by cold-soaked O-rings can sometimes be stopped by direct application of heat from a ground heater.

Keep in mind that the boost assemblies for the flight controls and the hydraulic system reservoirs are located inside the cargo compartment. Preheating the cargo compartment will also warm up the aircraft's hydraulic systems. This will help ensure normal operation and reduce the possibility of a boost unit "rolling" an O-ring. But warming up cold hydraulic fluid takes time. Delay the initial movements of the flight controls as long as possible to permit the boost units to absorb the maximum amount of heat from the cargo compartment.

Avoid using excessive force when actuating the flight controls initially. They may be difficult to move at first because the effects of low temperatures on the viscosity of hydraulic fluid. MIL-H-83282 hydraulic fluid is used for temperatures down to -29°C (-20°F). When the temperature drops below this point, MIL-H-5606 is the hydraulic fluid of choice.

Landing Gear

Frigid conditions require that some special precautions relating to the landing gear and wheels be observed before every flight. First of all, be sure to remove all snow, ice, slush, and foreign material from the wheel wells and the struts. Wipe the strut extensions using a clean rag soaked in hydraulic fluid to remove ice and dirt.

Inspect the main landing gear downlock friction washer for cleanliness. Current new production Hercules aircraft are equipped with a splash guard that protects the friction washer assembly from water and debris and prevents icing of the friction washer. The splash guard assembly can also be retrofit to older aircraft.

Check the landing gear shock struts for proper pressure and extension. If pressure is low, use dry nitrogen to bring the struts up to the proper level. Warm the strut before servicing it with hydraulic fluid. Strut warmers (blankets) can be used to warm up the struts in extreme cold. Remember that while low struts are often caused by low temperatures, a flat strut can also be evidence of a hydraulic leak.

Tlle use of the salt compounds that are sometimes used to melt ice and snow from runways must be scrupulously avoided anywhere on or around the aircraft. These can be very harmful to the landing gear and the metal structure of the underside of the airplane.

In very cold weather, grease and debris in the main landing gear tracks will tend to solidify and may prevent proper gear retraction. Cleaning and lubricating the tracks more frequently than normal may help alleviate this problem.

Cold weather can significantly reduce MLG strut pressure. Always use dry nitrogen to restore to normal values.

A run through an area of slush on takeoff means that the wheel wells will probably get loaded with it. If this adhesive mixture of ice and water is allowed to freeze with the landing gear in the retracted position, there may be a problem when it comes to getting the gear back down. Retracting and extending the main landing gear several times after takeoff will displace the slush into the slipstream before it can solidify. Sometimes extreme cold will retard centering of the nose gear. Make certain it is directed straight ahead (towards the 12 o'clock position) before retracting it.

Ensure that the wheel chocks and tires are not frozen to the ground before attempting to start out on a mission. This is a common problem. Tires that are frozen to the ground may be freed by the following methods:

1. Overinflation - Tire pressure may be raised up to 50 percent above normal to free the tire from a frozen surface. Overinflated tires must have their pressures returned to normal before the aircraft is taxied.
2. Ground Heat Application - Apply hot air to the tires and the frozen surface. However, ground heat should be used with caution because it can raise tire pressures beyond safe limits.
3. De-icing - A liberal application of de-icing fluid around the tires will often break them loose.

Skis

The Air Force's C-130Ds and LC-130Hs, and the Navy's LC-130F and LC-13OR models are equipped with skis so they can land on snow where landing on wheels would not be feasible. The skis are fitted to the

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conventional tandem main wheels and to the dual nose wheels. Wheels and skis may be used independently or together, depending on runway surface conditions. For normal landings on the wheels, the skis retract.

The C-130's nose ski, unlike those on earlier ski-equipped aircraft, is directionally controllable and the airplane steers easily for taxiing and parking under normal wind conditions. In soft snow, raising the skis lets the wheels help anchor the aircraft.

If it becomes necessary to unstick a frozen-in gear when leaving a parking area, try alternately lowering and raising the skis. If this doesn't work, apply heat. Be ready to move the airplane the moment the gear becomes free; if it freezes again it will get increasingly harder to unstick.

NESA Windshields

A good rule of thumb for the Hercules aircraft in extreme cold is to avoid rapid temperature changes whenever possible. As we have already noted, when an airplane is moved from a sheltered area into a cold, windy environment, the exposed metal, glass, etc., components will change temperature rapidly. This causes stresses in the materials, and has been known to result in delaminated or cracked windshields.

The windshield panels must be kept clear at all times. The primary windshield panels are kept free of ice by the NESA windshield anti-icing system. This system electrically heats the seven center windshield panels and, on C-130 models, the two lower panels on the pilot's side. Hot air defogging is provided for the other panels.

The thermistors that control the temperature of the NESA windows will not allow normal system function when they are very cold. Special provision has therefore been made to initiate system operation when the ambient surface temperatures are below about -43 "C (-45°F). Manually pressing the cold start switches on the anti-icing control panel permits DC power to bypass the normal control system. This allows AC power to heat the windows enough for automatic operation to begin.

In practice, these switches must be operated on for 5 seconds and off for 10 seconds for several cycles to allow the windshield temperature to rise slowly. Windshield heat should be applied with particular caution if the airplane has been allowed to cold soak for a long period of time. Under such conditions, it can be useful to preheat the windshield with warm air heaters or operate the flight station air conditioning with the window defog turned on before selecting normal windshield heat. This will help reduce the possibility of the windshield panels cracking because of thermal shock.

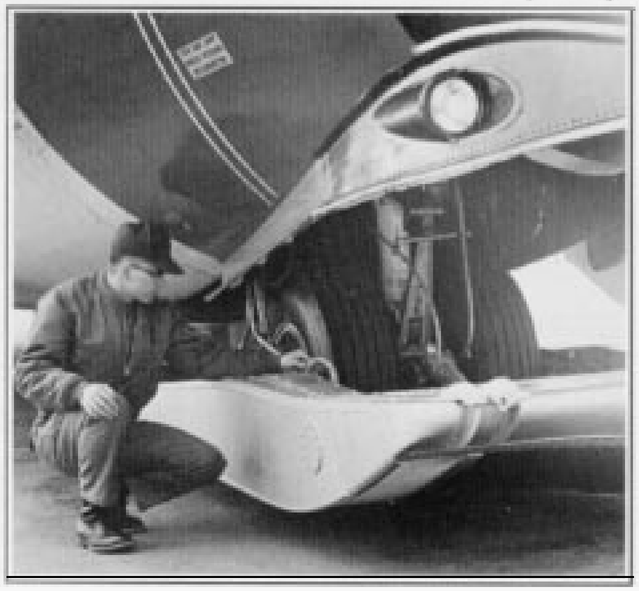
Cargo Handling

Cargo loading and hauling in remote, very cold regions often calls for improvised methods because of the severity of the weather, the need to transport bulky payloads such as fuel, and the frequent lack of adequate terminal facilities.

It is not uncommon to unload non-fragilecargo such as lumber by "driving" the airplane out from under the load. Remember that because of their weight, heavy items stored on ice or snow will slowly melt their way down; they must therefore be moved around frequently.

Airplanes will also gradually settle into snow or ice after a long time parked in one spot. They should be moved from time to time. If the airplane is parked on its tires, rather than skis, frequent repositioning is also desirable to prevent flat spots from developing.

Ski-equipped C-130s provide ideal support in polar regions. The nose ski is steerable; all skis retract for runway landings.



Rugged cargo can sometimes be unloaded by "driving" the airplane out from under the load.

Plywood shoring can protect the cargo floor from damage caused by heavy equipment.

The cargo that is transported into frigid, remote areas often involves unusually heavy, bulky, and cumbersome items, and these sometimes must be loaded individually. Repeated loading and unloading of cargo of this type leaves its mark (or marks) on the aircraft floor. Plywood panels can be used and secured to the cargo floor to give a smooth loading surface and to protect the existing floor. These wear out after a while, of course, but they are worth many times their cost in view of the protection they offer against direct contact between heavy metal objects and the metal cargo floor (see "Cargo Floor Shoring," Service News, Vol. 6, No. 2, Apr-Jun 1979).

Adequate plywood decking needs to be at least three-quarters of an inch thick. Cutouts should be made in the plywood to permit opening the landing gear inspection door. The use of anti-skid paint on top of the plywood may be considered since it is a good safety measure and helps protect the plywood from moisture. Making cut-outs for tie-down fittings is easy, since the tie downs are arranged in a uniform grid pattern. The plywood can also be fastened to the floor, using improvised methods at the tie-down fitting cutouts.

Fuel, one of the most necessary items at extremely cold forward areas, can be transported in the Hercules in a variety of ways. A 3600-gallon auxiliary fuselage tank, like those used on the KC-130F/R/T, can be used for this purpose. And of course surplus fuel from the fuel tanks of the airplane can be off-loaded through the single point refueling system.

Canadian Forces C-130s have had considerable success hauling diesel fuel in collapsible rubber tanks or bags. Five of these 1 ,OOO-gallon rubber tanks fit into the cargo compartment. They can be filled and emptied individually or collectively through a manifold. As in other systems, frozen moisture in fueling and defueling valves has proven to be a prime troublemaker in connection with this operation. Oversize plumbing, a minimum of restrictions, and careful attention to the condition of pumps and valves are the primary preventive measures used to combat moisture.

It is important to remember that an airplane and its components are designed and tested with certain operational and environmental parameters in mind. Whenever an aircraft-r for that matter any piece of mechanical equipment-isoperatedextensivelyunderenvironmental conditions which are significantly harsher than those for which it was designed, appropriate special operating and maintenance procedures are required to ensure normal service life.

(Continued from page 21

We are proud to have been a part of the distinguished history of the Hercules aircraft and, with new production anticipated well into the 21st century, we look forward to supporting the Here for many years to coma. At the right, I have identified some of the key members of the Hercules Supply Support management for your information and use. If we can assist you in any way, please do not hesitate to give us a call.

Sincerely,

J L Bailey

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Supply Support Division
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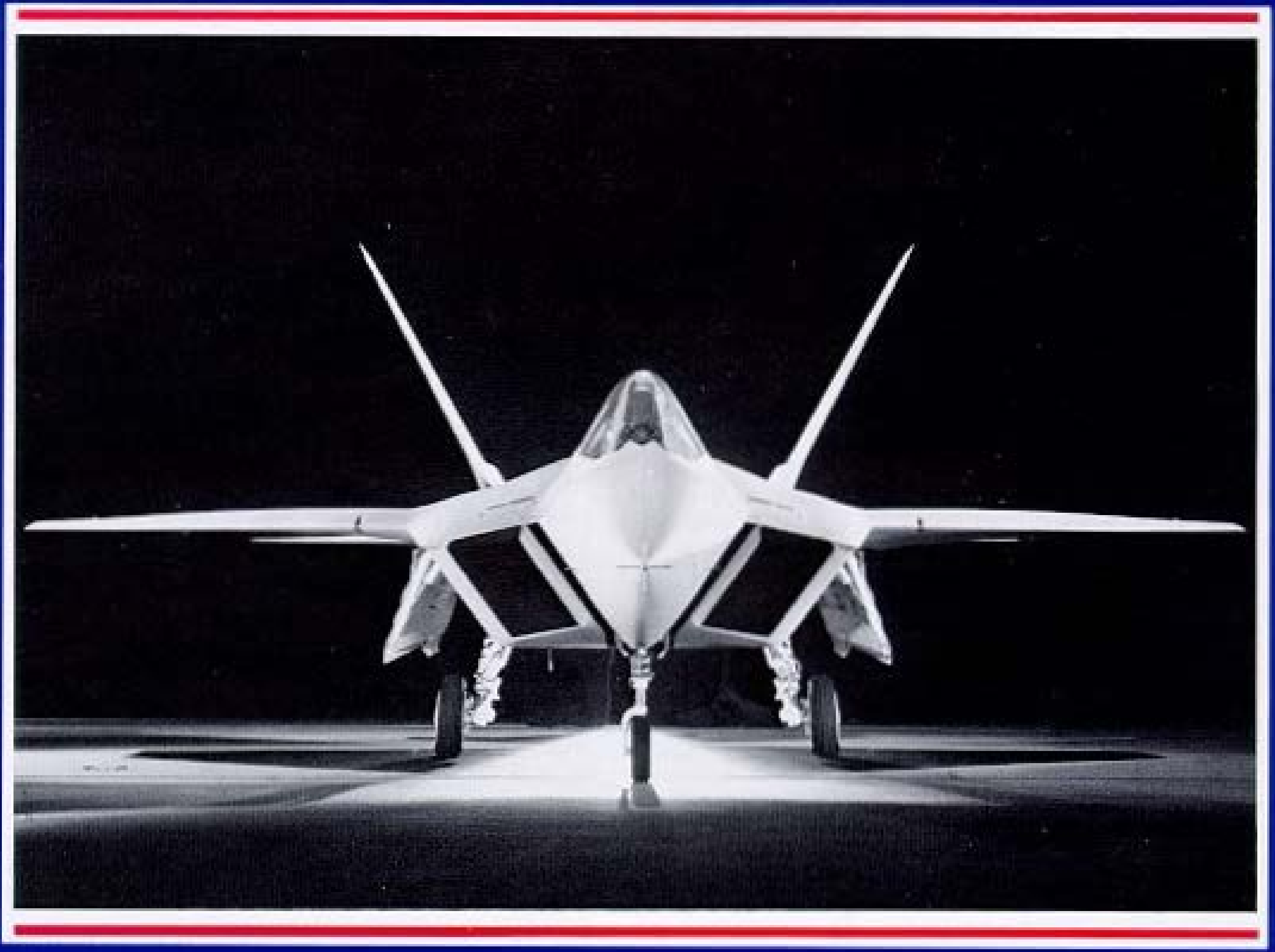

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