the prototype, which was tested for the original certification, may have been made and may be available. Our experience indicates that there may be appreciable differences in the calibration for different individual airplanes of the same type.

04.5801 POWERPLANT INSTRUMENTS AND CONTROLS. (See §§ 04.650 and 04.651.)

04.5802 FUEL QUANTITY GAUGE. (See § 04.624.)

04.5803 MAGNETIC COMPASS. This instrument shall be properly damped and compensated and shall be located where it is least affected by electrical disturbances and magnetic influences.

04.5804 NAVIGATION INSTRUMENTS. Navigation instruments for use by the pilot shall be so installed as to be easily visible to him with the minimum practicable deviation from his normal position and line of vision when he is looking out and forward along the flight path and they shall also be visible to the second pilot.

04.5805 GYROSCOPIC INSTRUMENTS. All gyroscopic instruments shall derive their energy from engine-driven pumps or from auxiliary power units. Each source of energy supply and its attendant complete installation shall comply with the instrument manufacturer's recommendations for satisfactory instrument operation. On multiengine aircraft each instrument shall have two separate sources of energy, either one of which shall be capable of carrying the required load. Engine-driven pumps, when used, shall be on separate engines. The installation shall be such that failure of one source of energy or breakage of one line will not interfere with proper functioning of the instruments by means of the other source.

04.581 SAFETY EQUIPMENT INSTALLATION.

04.5810 SAFETY BELTS. Safety belts shall be so attached that no part of the attachment will fail at a load lower than that specified in § 04.2640.

04.5811 FIRE EXTINGUISHERS. The portable fire extinguisher specified in § 04.510 shall be so installed as to be accessible to the passengers. The two portable fire extinguishers specified in § 04.530 shall be so installed that one is readily available to the crew and the other is near the main external cabin door where it shall be readily available to passengers and ground personnel.

04.5812 SAFETY BELT SIGNAL. When a signal or sign is used to indicate to passengers the times that seat belts should be fastened, such signal or sign shall be located in a conspicuous place and so arranged that it can be operated from the seat of either pilot.

04.5813 LANDING FLARES. Landing flares shall be releasable from the pilot's compartment. Structural provision shall be made for the recoil loads.

04.5814 DE-ICERS. POSITIVE MEANS SHALL BE PROVIDED FOR THE DEFLATION OF ALL WING BOOTS.

During the official type inspection tests, the actual operation and effect upon performance and flight characteristics will be observed for any de-icing devices provided for wings, tail surfaces, propellers, etc. No hazardous effects on flight characteristics shall result during their operation.

04.582 ELECTRICAL EQUIPMENT INSTALLATION.

04.5820 GENERAL. ELECTRICAL EQUIPMENT SHALL BE INSTALLED IN ACCORDANCE WITH ACCEPTED PRACTICE AND SUITABLY PROTECTED FROM FUEL, OIL, WATER AND OTHER DETRIMENTAL SUBSTANCES. ADEQUATE CLEARANCE SHALL BE PROVIDED BETWEEN WIRING AND FUEL AND OIL TANKS, FUEL AND OIL LINES, CARBURETORS, EXHAUST PIPING AND MOVING PARTS.

04.5821 BATTERY. BATTERY SHALL BE EASILY ACCESSIBLE AND ADEQUATELY ISOLATED FROM FUEL, OIL AND IGNITION SYSTEMS. ADJACENT PARTS OF THE AIRCRAFT STRUCTURE SHALL BE PROTECTED WITH A SUITABLE ACID-PROOF PAINT IF THE BATTERY CONTAINS ACID OR OTHER CORROSIVE SUBSTANCE AND IS NOT COMPLETELY ENCLOSED. IF THE BATTERY IS COMPLETELY ENCLOSED, SUITABLE VENTILATION SHALL BE PROVIDED. ALL BATTERIES SHALL BE SO INSTALLED THAT SPILLED LIQUID WILL BE SUITABLY DRAINED OR ABSORBED WITHOUT COMING IN CONTACT WITH THE AIRPLANE STRUCTURE.

Regulations do not specify minimum permissible capacity for storage batteries. However, as a general rule, when no generator is installed, the battery should be capable of carrying the demand electrical load during a period equal to the cruising endurance of the aircraft without the battery voltage decreasing to less than 80% of normal while under the load which could be expected to exist at the end of the flight. When a generator capable of carrying the running load is installed, the above capacity may be reduced to 50% of the endurance.

The battery must be installed in an accessible location and adequately isolated from fuel, oil, and ignition systems. Adjacent structural parts of the aircraft must be protected with a suitable acid proof paint if the battery contains acid or other corrosive substances and is not completely enclosed. When the battery is completely enclosed, ventilation must be provided since gases from an active battery form an explosive mixture. A means must also be provided whereby spilled liquid is absorbed or drained without coming in contact with the aircraft structure.

Batteries should not be located in engine compartments unless

adequate measures are taken to guard against possible fire hazards and the injurious effects on a battery of excessively high temperatures. Battery manufacturers have determined that temperatures of 110°F. and higher cause wooden separators to deteriorate rapidly and temperatures of 125°F. and higher are injurious to batteries having composition separators. Therefore, the critical temperature specified by the battery manufacturers should not be exceeded. Forced ventilation of the battery container or compartment may be necessary to guard against excessive battery temperatures. This may be provided by means of a tube leading from the slip stream into the container or compartment with a suitable vent tube leading out of it.

Leakproof batteries listed in Product & Processes Specification No. 17 need not be enclosed nor will a drain be required. A suitable placard should be installed to prevent the installation of a standard battery in such cases.

04.5822 FUSES. FUSES SHALL BE SO LOCATED THAT THEY CAN READILY BE REPLACED IN FLIGHT. THEY SHALL BREAK THE CURRENT IN A GENERATING SYSTEM AT A SUFFICIENTLY SMALL CURRENT FLOW TO ADEQUATELY PROTECT THE LIGHTS, RADIO EQUIPMENT AND OTHER PARTS OF THE CIRCUIT.

A fuse should be provided in each circuit of the electrical system, except that no fuse is necessary in the starter main circuit. A complete set of spare fuses should be provided. All fuses and spares must be accessible to a member of the crew while in flight. The fuse block should be marked to show the required amperage and to identify the circuit.

04.5823 GENERATOR. WHEN A GENERATOR IS SPECIFIED IT SHALL HAVE SUFFICIENT CAPACITY TO CARRY THE ENTIRE RUNNING LOAD. SUCH GENERATOR SHALL BE ENGINE-DRIVEN UNLESS AN APPROVED EQUIVALENT SYSTEM IS PROVIDED. AUXILIARY POWER UNITS WILL BE APPROVED IN LIEU OF BATTERIES AND ENGINE-DRIVEN GENERATORS, PROVIDED THAT THEY ARE AT LEAST TWO IN NUMBER AND THAT THE SUPPLY SYSTEM IS CAPABLE OF CARRYING THE ENTIRE RUNNING LOAD WITH ANY ONE UNIT OUT OF ACTION.

Generators are not listed as certificated items of equipment. A generator of any capacity may be installed on aircraft except that where a generator is required for a specific operation, such as certain air carrier and instrument flying operations, it must be of sufficient capacity to carry the entire running load and should have sufficient additional capacity to recharge the batteries. (See CAR 04.58230.)

Wind-driven generators should be so located that the extended propeller swept disc does not intersect any portion of the pilot or passengers when they are in their respective seats, unless a protective strip of metal or other material is placed between the

propeller and the person intersected. In addition, if at all possible, the swept disc of the propeller should not intersect any fuel, oil or hydraulic lines.

It is recommended that a fuse or equivalent be installed in the circuit between generator and battery of all installations. Wiring must be protected against wear due to chafing and against deterioration due to oil or other substances.

04.58230 RUNNING LOAD. THE RUNNING LOAD SHALL BE DEFINED AS THE ELECTRIC CONSUMPTION OF ALL LIGHTS, RADIO EQUIPMENT AND OTHER ELECTRICAL DEVICES EXCEPT THOSE WHICH ARE DESIGNED ONLY FOR OCCASIONAL INTERMITTENT USE. EXAMPLES OF DEVICES REGARDED AS INTERMITTENT ARE RADIO BROADCASTING EQUIPMENT, LANDING LIGHTS AND ELECTRICALLY OPERATED LANDING GEARS AND WING FLAPS. RADIO RANGE SIGNAL RECEIVERS AND ALL OTHER LIGHTS ARE CONSIDERED A PART OF THE CONSTANT LOAD.

04.5824 ANCHOR LIGHTS. THE ANCHOR LIGHT SPECIFIED FOR SEAPLANES AND AMPHIBIANS SHALL BE SO MOUNTED AND INSTALLED THAT, WHEN THE AIRPLANE IS MOORED OR DRIFTING ON THE WATER, IT WILL SHOW A WHITE LIGHT VISIBLE FOR AT LEAST TWO MILES AT NIGHT UNDER CLEAR ATMOSPHERIC CONDITIONS.

04.5825 LANDING LIGHTS. ELECTRIC LANDING LIGHTS SHALL BE SO INSTALLED ON MULTI-ENGINE AIRCRAFT THAT AT LEAST ONE SHALL BE NOT LESS THAN 10 FEET TO THE RIGHT OR LEFT OF THE FIRST PILOT'S SEAT AND BEYOND THE SWEPT DISK OF THE OUTERMOST PROPELLER. ON SINGLE-ENGINE AIRCRAFT SUCH LIGHTS SHALL BE SO INSTALLED THAT NO VISIBLE PORTION OF THE SWEPT DISK OF THE PROPELLER, IF OF THE TRACTOR TYPE, IS ILLUMINATED THEREBY. INDIVIDUAL SWITCHES FOR EACH LIGHT SHALL BE PROVIDED IN THE PILOT'S COMPARTMENT.

04.5826 INSTRUMENT LIGHTS. INSTRUMENT LIGHTS SHALL BE SO INSTALLED AS TO PROVIDE SUFFICIENT ILLUMINATION TO MAKE ALL FLIGHT INSTRUMENTS EASILY READABLE AND SHALL BE EQUIPPED WITH RHEOSTAT CONTROL FOR DIMMING UNLESS IT CAN BE SHOWN THAT A NON-DIMMING LIGHT IS SATISFACTORY.

04.5827 POSITION LIGHTS SHALL BE INSTALLED SO THAT, WITH THE AIRPLANE IN NORMAL FLYING POSITION, THE FORWARD RED POSITION LIGHT IS DISPLAYED ON THE LEFT SIDE AND THE FORWARD GREEN POSITION LIGHT ON THE RIGHT SIDE, EACH SHOWING UNBROKEN LIGHT BETWEEN TWO VERTICAL PLANES WHOSE DIHEDRAL ANGLE IS 110 DEGREES WHEN MEASURED TO THE LEFT AND RIGHT, RESPECTIVELY, OF THE AIRPLANE FROM DEAD AHEAD. SUCH FORWARD POSITION LIGHTS SHALL BE SPACED LATERALLY AS FAR APART AS PRACTICABLE. ONE REAR POSITION LIGHT SHALL BE INSTALLED ON THE AIRPLANE AT THE REAR AND AS FAR AFT AS POSSIBLE AND SHALL SHOW A LIGHT VISIBLE AFT THROUGHOUT A DIHEDRAL ANGLE OF 140 DEGREES BISECTED BY A VERTICAL PLANE THROUGH THE LONGITUDINAL AXIS OF THE AIRPLANE. SUCH LIGHT SHALL EMIT (A) IN THE CASE OF A NON-AIR CARRIER AIRPLANE, EITHER A CONTINUOUS WHITE LIGHT AS SPECIFIED IN CAR 15.2014 OR ALTERNATE RED AND WHITE FLASHES AS SPECIFIED IN CAR 15.2015, AND (B) IN THE CASE OF AN AIR CARRIER AIRPLANE, ALTERNATE RED AND WHITE FLASHES AS SPECIFIED IN CAR 15.2015. IN LIEU OF SUCH A SINGLE FLASHING REAR POSITION LIGHT, AN AIRPLANE MAY CARRY TWO REAR POSITION LIGHTS, ONE RED AND ONE WHITE, SPACED AS CLOSELY AS POSSIBLE TO EACH OTHER WITH ONE UNIT ABOVE THE OTHER AND IN COMBINATION EMITTING THE RED AND WHITE FLASHES SPECIFIED IN CAR 15.2015.

"Position lights shall be installed so that, with the airplane in normal flying position, the forward red position light is displayed on the left side and the forward green position light on the right side, each showing unbroken light between two vertical planes whose dihedral angle is 110 degrees when measured to the left and right, respectively, of the airplane from dead ahead. Such forward position lights shall be spaced laterally as far apart as practicable. One rear position light shall be installed on the airplane at the rear and as far aft as possible and shall show a light visible aft throughout a dihedral angle of 140 degrees bisected by a vertical plane through the longitudinal axis of the airplane. Such light shall emit (a) in the case of a non-air carrier airplane, either a continuous white light as specified in 15.2014 or alternate red and white flashes as specified in 15.2015, and (b) in the case of an air carrier airplane, alternate red and white flashes as specified in 15.2015. In lieu of such a single flashing rear position light, an airplane may carry two rear position lights, one red and one white, spaced as closely as possible to each other and in combination emitting the red and white flashes specified in 15.2015."

All wiring must be firmly fixed to the aircraft structure and protected against chafing or rapid deterioration.

04.5828 MASTER SWITCH. ELECTRICAL INSTALLATIONS SHALL INCORPORATE A MASTER SWITCH EASILY ACCESSIBLE TO A MEMBER OF THE CREW.

All electrical installations must incorporate a master switch. A master switch is interpreted as being a switch by means of which all sources of electrical power may normally be disconnected from the electrical distribution system of the airplane and from each other at a point in the supply lines as near as practicable to the source of power. In installations which involve only one circuit, the circuit control switch may be considered as a master switch provided it is as near the ungrounded battery terminal as practicable.

04.589 MISCELLANEOUS EQUIPMENT INSTALLATION.

04.5890 SEATS. SEATS OR CHAIRS, EVEN THOUGH ADJUSTABLE, IN OPEN OR CLOSED AIRPLANES, SHALL BE SECURELY FASTENED IN PLACE WHETHER OR NOT THE SAFETY BELT LOAD IS TRANSMITTED THROUGH THE SEAT.

04.5891 ACCESSORIES. ENGINE-DRIVEN ACCESSORIES ON MULTIENGINE AIRCRAFT SHALL BE DISTRIBUTED AMONG TWO OR MORE ENGINES.

04.60 ENGINES.

ENGINES SHALL BE OF A TYPE AND DESIGN WHICH HAS BEEN TYPE CERTIFICATED, OR FOUND ELIGIBLE FOR USE IN CERTIFICATED AIRCRAFT, IN ACCORDANCE WITH THE REQUIREMENTS OF PART 13 OR SHALL HAVE BEEN APPROVED AS AIRWORTHY IN ACCORDANCE WITH PREVIOUS REGULATIONS.

The required information may be obtained by observing the engine behavior throughout the entire tests. The following suggestions are offered:

Engine vibration should feel normal at all operating speeds and should not result in harmful shaking or vibration of instruments or other component parts of the airplane.

Where installations include flexible mounting and engine movement is large, flexible joints, commensurate with engine movement will be required in all fuel and oil lines, controls, manifolds, and cowling to insure satisfactory service life.

Consideration must be given to the arrangement and operation of engine controls and instruments. All units must be easily operated from the pilot's seat and so arranged as to minimize the possibility of abrupt or inadvertent operation.

04.61 PROPELLERS.

PROPELLERS SHALL BE OF A TYPE AND DESIGN WHICH HAS BEEN CERTIFICATED AS AIRWORTHY IN ACCORDANCE WITH THE REQUIREMENTS OF PART 14 OR SHALL HAVE BEEN APPROVED AS AIRWORTHY IN ACCORDANCE WITH PREVIOUS REGULATIONS, EXCEPT THAT WOOD PROPELLERS OF A CONVENTIONAL TYPE FOR USE IN LIGHT AIRPLANES NEED NOT BE CERTIFICATED. IN CERTAIN CASES MAXIMUM ENGINE BORE LIMITATIONS ARE ALSO ASSIGNED TO PROPELLERS. PROPELLERS MAY BE USED ON ANY ENGINE PROVIDED THAT THE CERTIFIED POWER RATINGS, SPEED RATINGS, AND BORE OF THE ENGINE ARE NOT IN EXCESS OF THE LIMITATIONS OF THE PROPELLER AS CERTIFICATED, AND FURTHER PROVIDED THAT THE VIBRATION CHARACTERISTICS OF THE COMBINATION ARE SATISFACTORY TO THE ADMINISTRATOR.

The propeller as installed on the aircraft must permit the clearance provided in 04.611. The "Minimum Permissible Diameter" which will be listed for propellers on the aircraft specification is that of the smallest propeller tested, multiplied by .98. This 2 percent margin is arbitrarily chosen as being the maximum permissible reduction in diameter of a given propeller which will not noticeably reduce performance. It also provides a margin to allow dressing down of metal propellers in service.

Fixed or adjustable pitch propellers.--The Aircraft Specification for each newly certificated aircraft equipped with a fixed or adjustable pitch propeller will specify the following propeller limitations:

Static rpm at maximum permissible throttle setting. (Not more than _____ rpm
(Not less than _____ rpm

Diameter - - - - - - - - - - - - - - - - - - (Not more than ____ inches
(Not less than ____ inches

Normally propellers made from wood will require a different range of static rpm limits than metal propellers. The basis for the preceding limitations is summarized here for convenient reference.

Maximum static rpm.--The maximum permissible static rpm will be the lower of the two static rpm values determined by the methods shown below:

a. Using the propeller having both the smallest diameter and lowest static rpm with which compliance with the Steady Rate of Climb, Take-off Distance and First Minute Climb requirements can be met:

Maximum permissible static rpm = Rated engine rpm - (rpm at the best rate of Climb Speed - Lowest Static rpm).

b. Using a propeller having both the largest diameter and highest static rpm for which approval is desired, the power-off rpm at placard V_g speed must not exceed 110 percent of therated rpm of the engine at METO power.

Minimum static rpm.--The minimum static rpm will be established by the propeller having both the smallest diameter and lowest static rpm used in demonstrating compliance with the Steady Rate of Climb, Take-off Distance, and First Minute Climb requirements.

Maximum diameter.--The maximum diameter will be the smaller of the two values determined by the methods shown below:

a. Maximum diameter which will permit the clearances specified in 04.611. (Landplane 9 inches ground clearance, seaplane 18 inches water clearance. At least 1-inch clearance between propeller tips and structure.)

b. Maximum diameter used in placard V_g dive tests described in (b), "Maximum Static rpm".

Minimum diameter.--The minimum diameter will be the diameter of the smallest propeller used to demonstrate compliance with the Steady Rate of Climb, Take-off Distance and First Minute Climb requirements as described in "Minimum Static rpm" multiplied by a factor of 0.98.

To demonstrate that the vibration characteristics of the propelle are satisfactory in any given installation the blade vibration stress should be measured under flight conditions. Past experience has indicated that this procedure is necessary with all propellers, except wood types. In some cases it is possible to determine the effect of changes or slightly new combinations by ground tests or comparisons of previous data, but in most cases flight tests for this purpose are necessary. The propeller manufacturers have the

stress measuring equipment necessary to accomplish these tests and will furnish the results to the CAA together with their recommendations with respect to approval.

04.610 CONTROLLABLE PITCH. THE CONTROL MECHANISM SHALL BE DESIGNED AND EQUIPPED WITH A POSITIVE STOP WHICH SHALL LIMIT THE MINIMUM PITCH SO THAT THE TAKE-OFF CRANKSHAFT SPEED FOR WHICH THE AIRCRAFT IS CERTIFICATED IS NOT EXCEEDED DURING TAKE-OFF WITH TAKE-OFF POWER UNLESS IT IS NECESSARY TO SO LOCATE THE STOP THAT A HIGHER CRANKSHAFT SPEED MAY BE USED IN AN EMERGENCY. THE MEANS PROVIDED FOR CONTROLLING THE PITCH SHALL BE SO ARRANGED AS TO MINIMIZE THE ATTENTION REQUIRED FROM A PILOT TO PREVENT THE ENGINES FROM EXCEEDING THEIR CRANKSHAFT SPEED LIMITATIONS UNDER ANY FLIGHT CONDITION.

Controllable propellers.--The high pitch stop should be such that 110 percent of METO rpm will not be exceeded in power-off dives at placard "Never Exceed" speeds.

Constant speed propellers.--A control stop should be provided which will limit the low pitch range to the maximum permissible take-off rpm.

All stops should, when practicable, be located at the propeller governor or hub in order to reduce to a minimum the adjustments required in service.

Full feathering propellers.--Comments regarding requirements for control stops on constant speed propellers are also pertinent to full feathering propellers. The mechanism should be operated in flight to demonstrate satisfactory operation to full feathering position. These checks can usually be made during tests for one engine inoperative performance.

Add following to "Controllable propellers":--
The positive low pitch stop in the hub should be so located that the allowable take-off rpm is not exceeded during the take-off and initial climb at best rate of climb speed at the maximum permissible take-off manifold pressure.

Substitute for the first sentence after "Constant Speed Propellers":--
The positive low pitch stop in the hub should be so located that the maximum static rpm of the engine does not exceed the allowable take-off rpm with maximum permissible take-off manifold pressure and no wind.

04.611 PROPELLER CLEARANCE. PROPELLERS SHALL HAVE A MINIMUM GROUND CLEARANCE OF 9 INCHES WHEN THE AIRPLANE IS IN A HORIZONTAL POSITION WITH THE LANDING GEAR DEFLECTED AS IT WOULD BE UNDER THE MAXIMUM AUTHORIZED WEIGHT OF THE AIRPLANE. PROPELLERS ON SEAPLANES SHALL CLEAR THE WATER BY AT LEAST 18 INCHES WHEN THE SEAPLANE IS AT REST UNDER THE MAXIMUM AUTHORIZED LOAD CONDITION. A CLEARANCE OF AT LEAST 1 INCH SHALL BE PROVIDED BETWEEN THE TIPS OF PROPELLERS AND ANY PART OF THE STRUCTURE.

If the airplane is so designed that the normal ground attitude is more critical, from the standpoint of decreasing propeller clearance, than the horizontal attitude then the clearance should be measured in the normal ground attitude. The location of the center of gravity position should be such as to produce the most critical condition and shock struts and tires should be checked for recommended pressures before making measurements.

A minimum clearance of 1/4-inch between the blade or hub and the cowling is recommended, and if variable pitch propellers are used this clearance should exist under the feathered or highest pitch condition.

04.62 FUEL SYSTEMS.

04.620 CAPACITY AND FEED. THE FUEL CAPACITY SHALL BE AT LEAST 0.15 GALLON PER MAXIMUM (EXCEPT TAKE-OFF) HORSEPOWER FOR WHICH THE AIRPLANE IS CERTIFICATED. AIR-PRESSURE FUEL SYSTEMS SHALL NOT BE USED. ONLY STRAIGHT GRAVITY FEED OR MECHANICAL PUMPING OF FUEL IS PERMITTED. THE SYSTEM SHALL BE SO ARRANGED THAT THE ENTIRE FUEL SUPPLY MAY BE UTILIZED IN THE STEEPEST CLIMB AND AT THE BEST GLIDING ANGLE AND SO THAT THE FEED PORTS WILL NOT BE UNCOVERED DURING NORMAL MANEUVERS INVOLVING MODERATE ROLLING OR SIDE SLIPPING. THE SYSTEM SHALL ALSO FEED FUELS PROMPTLY AFTER ONE TANK HAS RUN DRY AND ANOTHER TANK IS TURNED ON. IF A MECHANICAL PUMP IS USED, AN EMERGENCY HAND PUMP OF EQUAL CAPACITY SHALL BE INSTALLED AND AVAILABLE FOR IMMEDIATE USE IN CASE OF A PUMP FAILURE DURING TAKE-OFF. HAND PUMPS OF SUITABLE CAPACITY MAY ALSO BE USED FOR PUMPING FUEL FROM AN AUXILIARY TANK TO A MAIN FUEL TANK.

The capacity of each tank is to be determined by placing the airplane in its normal ground attitude and filling the tank by means of a measuring pump or a container of known capacity. The tank quantity gauge is to be calibrated with the airplane in the level flight attitude. When required, the wobble pump must be so installed that its control is immediately available to the pilot should the engine pump fail. The emergency pump pressure relief valve should be adjusted to ensure satisfactory fuel pressure and preclude excessive flooding of the carburetor when the pump is operated. See CAM 04.725 re flight check of Fuel System Operation.

04.621 TANK INSTALLATION. NO FUEL TANK SHALL BE PLACED CLOSER TO AN ENGINE THAN THE REMOTE SIDE OF A FIREWALL. AT LEAST ONE-HALF INCH CLEAR AIR SPACE SHALL BE ALLOWED BETWEEN THE TANK AND FIREWALL. SPACES ADJACENT TO THE SURFACES OF THE TANK SHALL BE VENTILATED SO THAT FUMES CANNOT ACCUMULATE OR REACH THE CREW OR PASSENGERS IN CASE OF LEAKAGE. IF TWO OR MORE TANKS HAVE THEIR OUTLETS INTERCONNECTED THEY SHALL BE CONSIDERED AS ONE TANK AND THE AIR SPACE IN THE TANKS SHALL ALSO BE INTERCONNECTED TO PREVENT DIFFERENCES IN PRESSURE AT THE AIR VENTS OF EACH TANK OF SUFFICIENT MAGNITUDE TO CAUSE FUEL FLOW BETWEEN TANKS. MECHANICAL PUMP SYSTEMS SHALL NOT FEED FROM MORE THAN ONE TANK AT A TIME EXCEPT BY SPECIAL RULING FROM THE ADMINISTRATOR.

Tank supports should be padded to minimize vibration and preclude the possibility of chafing. Materials used for padding should be non-absorbent, or treated to prevent the absorption of liquids. The attachment to the supporting structure must be secure and sufficiently rigid to prevent movement or shifting.

All fuel tanks in passenger compartments should be enclosed by a well ventilated and drained enclosure to prevent fumes from accumulating or reaching passengers in the event of leakage. In small aircraft, however, tanks of 25 gallons or less, located in the forward position of the cabin, ahead of the instrument panel, need not be enclosed if an excess of ventilation is provided.

If special fuels (high octane for take-off) are to be carried in the airplane, the filler opening should be properly marked and a suitable placard installed at the cockpit fuel valve controls to insure that the proper tank will be used during take-off.

04.622 TANK CONSTRUCTION. EACH FUEL TANK SHALL BE PROVIDED WITH EITHER A SUMP AND DRAIN LOCATED AT THE POINT WHICH IS LOWEST WHEN THE AIRPLANE IS IN A NORMAL POSITION ON THE GROUND OR OUTLETS AT THE BOTTOM OF THE TANK PROVIDED WITH LARGE MESH FINGER STRAINERS. IF A SUMP IS PROVIDED, THE MAIN FUEL SUPPLY SHALL NOT BE DRAWN FROM THE BOTTOM OF THIS SUMP. IF NO SUMP IS PROVIDED THE SYSTEM DRAIN SHALL BE CONTROLLABLE FROM THE PILOT'S COMPARTMENT AND SHALL ACT AS A TANK DRAIN. EACH TANK SHALL BE SUITABLY VENTED FROM THE TOP PORTION OF THE AIR SPACE. SUCH AIR VENTS SHALL BE SO ARRANGED AS TO MINIMIZE THE POSSIBILITY OF STOPPAGE BY DIRT OR ICE FORMATION. WHEN LARGE FUEL TANKS ARE USED, THE SIZE OF THE VENT TUBES SHOULD BE PROPORTIONED SO AS TO PERMIT RAPID CHANGES IN INTERNAL AIR PRESSURE TO OCCUR AND THEREBY PREVENT COLLAPSE OF THE TANKS IN A STEEP GLIDE OR DIVE. TANKS OF 10 GALLONS OR MORE CAPACITY SHALL BE PROVIDED WITH INTERNAL BAFFLES UNLESS SUITABLE EXTERNAL SUPPORT IS PROVIDED TO RESIST SURGING.

Each fuel tank should be designed to incorporate an expansion space of at least 2% of the total tank volume. If possible, the filler neck should be so located that this expansion space cannot be inadvertently filled while the airplane is in the normal ground attitude. However, it will be acceptable to locate the "FULL" mark on the gauge or in the filler neck at a point which will provide a 2% expansion space when the fuel is at that level. A placard stating that the fuel level should not exceed a certain point (which will allow a 2% expansion space) is also considered sufficient. Each tank should be vented from the top portion of the air space in the tank to permit a sufficient flow of air to equalize internal and external pressures during rapid changes in altitude or the removal of fuel from the tank.

Vents and vent lines should be suitably arranged to avoid the collection of water and should be so designed and installed as to

Tank supports should be padded to minimize vibration and preclude the possibility of chafing. Materials used for padding should be non-absorbent, or treated to prevent the absorption of liquids. The attachment to the supporting structure must be secure and sufficiently rigid to prevent movement or shifting.

All fuel tanks in passenger compartments should be enclosed by a well ventilated and drained enclosure to prevent fumes from accumulating or reaching passengers in the event of leakage. In small aircraft, however, tanks of 25 gallons or less, located in the forward position of the cabin, ahead of the instrument panel, need not be enclosed if an excess of ventilation is provided.

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Vents and vent lines should be suitably arranged to avoid the collection of water and should be so designed and installed as to

preclude the possibility of their becoming clogged by ice or dirt in flight or servicing operations. In the small tanks usually installed in light airplanes where ventilation is accomplished by pin holes in the filler cap, two or more such holes should be provided in the cap for safe operation; where the float and rod type fuel quantity gauge is used, the clearance hole for the rod is considered adequate venting as this type of venting, due to the vibration of the rod, has proved satisfactory in service.

An airspace balancing line must be provided when tank outlets are interconnected, in order that such tanks will not "pump over" and overflow or feed unevenly due to air pressure differentials.

If a controllable system drain is used for a tank drain it should be so arranged as to also permit draining the strainer sump while in flight.

04.623 TANK STRENGTH. FUEL TANKS SHALL BE CAPABLE OF WITHSTANDING AN INTERNAL TEST PRESSURE OF 3-1/2 POUNDS PER SQUARE INCH WITHOUT FAILURE OR LEAKAGE. FUEL TANKS OF LARGE CAPACITY WHICH HAVE A MAXIMUM FUEL DEPTH GREATER THAN 2 FEET SHALL BE INVESTIGATED FOR THE PRESSURE DEVELOPED DURING THE MAXIMUM LIMIT ACCELERATION WITH FULL TANKS. TANKS SHALL BE SO DESIGNED, AND THE RIVETS OR WELDS SO LOCATED, AS TO RESIST VIBRATION FAILURES OR LEAKAGE.

04.624 GAUGE. A SATISFACTORY GAUGE SHALL BE SO INSTALLED ON ALL AIRPLANES AS TO INDICATE READILY TO A PILOT OR FLIGHT MECHANIC THE QUANTITY OF FUEL IN EACH TANK WHILE IN FLIGHT. WHEN TWO OR MORE TANKS ARE CLOSELY INTERCONNECTED AND VENTED, AND IT IS IMPOSSIBLE TO FEED FROM EACH ONE SEPARATELY, ONLY ONE FUEL-LEVEL GAUGE NEED BE INSTALLED. IF A GLASS GAUGE IS USED, IT SHALL BE SUITABLY PROTECTED AGAINST BREAKAGE.

The tank gauge accuracy must be checked by placing the airplane in its level attitude and filling each tank by adding successively quarters (or less) of the tank capacity as determined in 04.620.

04.625 LINES AND FITTINGS. ALL FUEL LINES AND FITTINGS SHALL BE OF SUFFICIENT SIZE SO THAT UNDER THE PRESSURE OF NORMAL OPERATION THE FLOW IS NOT LESS THAN DOUBLE THE NORMAL FLOW REQUIRED FOR TAKE-OFF ENGINE POWER. A TEST FOR PROOF OF COMPLIANCE WITH THIS REQUIREMENT SHALL BE MADE. ALL FUEL LINES SHALL BE SO SUPPORTED AS TO PREVENT EXCESSIVE VIBRATION AND SHOULD BE LOCATED SO NO STRUCTURAL LOADS CAN BE APPLIED. BENDS OF SMALL RADIUS AND VERTICAL HUMPS IN THE LINES SHALL BE AVOIDED. COPPER FUEL LINES WHICH HAVE BEEN BENT SHALL BE ANNEALED BEFORE INSTALLATION. PARTS OF THE FUEL SYSTEM ATTACHED TO THE ENGINE AND TO THE PRIMARY STRUCTURE OF THE AIRPLANE SHALL BE FLEXIBLY CONNECTED THERETO. FLEXIBLE HOSE CONNECTIONS AND FUEL LINES SHALL HAVE METAL LINERS OR THE EQUIVALENT. FITTINGS SHALL BE OF A TYPE SATISFACTORY TO THE ADMINISTRATOR.

Product and Process Specification No. 3 lists flexible hoses which have been approved for use in airplanes. (Note:--Metal liners are not now required in flexible hose connections.) The fuel lines should slope toward drains so as to form a downward angle of at least 3° with the airplane in the normal ground attitude. Vertical humps in lines tend to form airlocks and should be avoided. Low points in fuel lines should also be avoided as they often collect water which freezes at high altitudes or when cold air is encountered in flight, thus shutting off the fuel supply. Fuel lines should not be routed in close proximity to the exhaust unless suitable precautions are taken to preclude possibility of fire due to leakage or of vapor lock due to elevated temperatures.

The ends of all tubes having outside diameters greater than 3/8" used in flexible hose connections should be beaded. A fuel feed line size of less than 3/8 O.D. x .032 tubing with corresponding fittings should not be used unless properly substantiated. If the combined length of the feed lines and fittings from the tank to the carburetor is in excess of 10 feet, the size of the line should not be less than 1/2 x .035 O.D. tubing.

The fuel flow requirements of this part are interpreted in two ways depending upon whether the fuel system is gravity or pump operated.

Gravity Systems. The normal flow required for take-off power is interpreted to be .6 pounds per take-off brake horsepower per

hour. Using this figure, it is necessary in order to show compliance with the double flow requirement, that one gallon of fuel shall flow at the carburetor inlet or bowl in not more than:

$$\frac{18,000}{BHP} \text{ Seconds, where}$$

BHP is take-off brake horsepower for one engine. Compliance must be demonstrated by test for each tank and with the airplane, if a conventional tractor type, either at the normal ground attitude or the attitude of best angle of climb, whichever is critical. "Critical" in this case means producing the lower hydrostatic head at the carburetor.

Pump Systems. In the case of pump systems, double flow is interpreted to mean .9 pounds per take-off brake horsepower per hour or 110% of the take-off specific fuel consumption guaranteed by the engine manufacturer, whichever is greater. In order to show compliance with the requirement it is necessary that one gallon of fuel shall flow at the carburetor inlet or bowl in not more than:

$$\frac{24,000}{BHP} \text{ Seconds, or}$$

$$\frac{21,600}{\text{B.H.P. x 1.1 (T.O. Specific Fuel Consumption)}} \text{ seconds, where}$$

BHP is take-off brake horsepower of the engine or engines fed by the tank. Compliance must be demonstrated by tests such as are described above for gravity systems.

Fuel system flow characteristics should be obtained with the entire fuel system as installed in the airplane. The ability of the lines and fittings to provide sufficient flow is more readily determined by this method and separate investigations of each item are avoided. Gasoline of the physical properties and octane to be used in service should flow at the rate specified above at the pressure recommended by the carburetor or engine manufacturer for satisfactory operation of the installation involved. In the case of gravity systems, the hydrostatic head at the carburetor inlet, with the airplane in the critical attitude as regards fuel flow and with low fuel (see 04.725) in the tank, should be equal to or greater than the minimum pressure so recommended.

The flow will be measured at the float chamber drain or jet drain when possible with float type carburetor and at the inlet

with other types. When these drains are used they may be restricted so that the carburetor needle valve will furnish the required pressure.

All systems require official demonstration with flight operating conditions duplicated on the ground. This includes gravity, engine driven pump and wobble pump systems. For purposes of the ground tests, the engine driven pumps may be driven by electric motors duplicating the take-off speed of the pump. In some instances, however, it may be possible to determine that engine driven pumps are satisfactory based upon the manufacturer's data; e.g., when the pump rating is greatly in excess of the capacity required.

The following procedure is recommended in conducting the necessary tests:

Critical Airplane Attitude. For conventional tractor airplanes the fuel tanks are all ordinarily aft of the carburetor inlet. For this reason conditions grow less favorable for fuel flow the further the airplane is rotated in pitch, "nose-up". In order to determine the critical attitude in which the flow tests are to be conducted, information concerning the attitude of the airplane with respect to the ground while flying at best angle of climb is necessary. This information can be obtained, after the speed for best angle has been obtained from the results of the testing required under CAR 04.702, by mounting a protractor in a vertical plane in the airplane with its index line perpendicular to the airplane level datum, suspending a plumb line from the center of the protractor, flying the airplane steadily at best angle of climb and reading the angle at the intersection of the plumb line with the scale of the protractor. A similar reading may be made with the airplane in the normal ground attitude. The greater of the two readings should be used for the purpose of the tests.

Flow Tests. Prior to beginning tests the fuel system should be completely drained and the feed line to the carburetor disconnected at the carburetor inlet. If this connection is made by means of a reducing nipple, the nipple should remain attached to the line so that the flow will be measured through the nipple. For each tank tested, the system should be set to feed from this tank only. Measured quantities of fuel should be slowly added to the tank until steady flow is established at the carburetor end of the feed line. The total quantity of fuel which has been added to the tank should be noted and recorded. Systems requiring an excessive initial amount of fuel to produce steady flow are unsatisfactory since they tend to airlock.

Satisfactory flow should be obtained with low fuel as defined in CAM 04.725. One additional gallon of fuel should be added to the tank and the time, in seconds, required for this gallon to flow should be observed and recorded. In the case of pump fed systems, the hand pump is to be operated at not more than 120 strokes (or 60 cycles) per minute.

In the case of fuel systems which are symmetrical with respect to the plane of symmetry of the airplane, one tank only of each such pair of tanks symmetrically located need be tested provided it is obvious that the results of such test will be valid for both tanks.

Where flowmeters are installed, the system should either supply the required fuel flow at the carburetor with the flowmeters in operation or in the event the flowmeter imposes sufficient restriction in the system to prevent the attainment of this required flow, an adequate by-pass arrangement should be provided to permit the fuel to by-pass the flowmeter at take-off. The system should then be placarded to the effect that this by-pass must be opened for all take-offs.

04.626 STRAINERS. ONE OR MORE STRAINERS OF ADEQUATE SIZE AND DESIGN, INCORPORATING A SUITABLE SEDIMENT TRAP AND DRAIN, SHALL BE PROVIDED IN THE FUEL LINE BETWEEN THE TANK AND THE CARBURETOR AND SHALL BE INSTALLED IN AN ACCESSIBLE POSITION. THE SCREEN SHALL BE EASILY REMOVABLE FOR CLEANING.

04.627 VALVES. ONE OR MORE POSITIVE AND QUICK-ACTING VALVES THAT WILL SHUT OFF ALL FUEL TO EACH ENGINE SHALL BE WITHIN EASY REACH OF THE FIRST PILOT AND THE SECOND PILOT OR OF THE FLIGHT MECHANIC. IN THE CASE OF AIRPLANES EMPLOYING MORE THAN ONE SOURCE OF FUEL SUPPLY, SUITABLE PROVISION SHALL BE MADE FOR INDEPENDENT FEEDING FROM EACH SOURCE.

Valves which require more than one turn for complete operation are not considered satisfactory. A valve is not considered suitable or positive unless its on and off positions can be definitely indicated at all times. Notch stops should be such that they may be readily felt when operating the valve.

04.6270 DUMP VALVES. WHEN FUEL TANKS ARE EQUIPPED WITH DUMP VALVES, THE OPERATING MECHANISM FOR SUCH VALVES SHALL BE WITHIN CONVENIENT REACH OF THE FIRST PILOT AND THE SECOND PILOT, OR OF THE FLIGHT MECHANIC. DUMP VALVES SHALL BE SO INSTALLED AS TO PROVIDE FOR SAFE AND RAPID DISCHARGE OF FUEL.

04.628 DRAINS. ONE OR MORE ACCESSIBLE DRAINS SHALL BE PROVIDED AT THE LOWEST POINT ON THE FUEL SYSTEMS TO COMPLETELY DRAIN ALL PARTS OF EACH SYSTEM WHEN THE AIRPLANE IS IN ITS NORMAL POSITION ON LEVEL GROUND. SUCH DRAINS SHALL DISCHARGE CLEAR OF ALL PARTS OF THE AIRPLANE AND SHALL BE EQUIPPED WITH SUITABLE SAFETY LOCKS TO PREVENT ACCIDENTAL OPENING.

04.629 MISCELLANEOUS FUEL SYSTEM REQUIREMENTS.

04.6290 FILLER OPENINGS. ALL FILLER OPENINGS IN THE FUEL SYSTEM SHALL BE PLAINLY MARKED WITH THE CAPACITY AND WORD "FUEL." PROVISION SHALL BE MADE TO PREVENT ANY OVERFLOW FROM ENTERING THE WING OR FUSELAGE.

The minimum fuel octane number should also be marked at the filler opening.

04.6291 PREVENTION OF ICE FORMATION. AN ADEQUATE MEANS SHALL BE PROVIDED FOR PREVENTING THE FORMATION OF ICE IN THE ENGINE CARBURETORS. (SEE ALSO § 04.532 (i).)

1. General

The intake and carburetor passages should be arranged so as to avoid insofar as practical, the formation of ice. A hot air supply should be provided which is sufficient to permit safe operation under icing conditions, except in the case of diesel or fuel injection engines to which special rulings are applied. The use of any screen in the hot air system will only be permitted where over 100°F. heat rise is available for where a 40°F. heat rise is available together with a fluid deicing system is employed and so located that deicing provisions on the screen, etc., are effective. A screen may be used in the cold air intake provided it can be shown that no hazard exists if the screen should become clogged. A separate cockpit control is necessary for each engine to permit the pilot or flight mechanic to vary the carburetor air supply from full cold air to full hot air. This does not prevent the use of a two position heat control when the heat rise available is comparatively low and a fluid deicing system is employed.

The amount of heat available will be determined by measuring the temperature of the air before it enters the carburetor with the heat control in the fuel hot position. The heat rise is defined as the difference between this temperature and the outside air temperature. Care should be exercised that the method of measuring the temperature of the air as it enters the carburetor will give an indication of the average temperature of the airflow through the intake and not just a stratum of air. This can be accomplished by taking temperatures at several points in the cross-section of the air intake simultaneously and by being assured that the "full heat" condition has fully stabilized before recording the reading. Temperature measurements taken beyond the venturi are unsatisfactory. Any appreciable power loss due to heat or decreased ram should be determined.

All carburetor air heat rise requirements must be met at an

outside air temperature of 30°F. with the airplane in level flight at 75% maximum except take-off power.

Sea Level Engines With Conventional Venturi Carburetors. (Such as sea level engine with Stromberg or Marvel circular venturi carburetor.) A minimum temperature rise of 90°F. should be attainable unless the intake manifold has design features near the venturi which contribute appreciably to raising the mixture temperature or the temperature of intake passage. Where these features are present, a 60° rise may be considered satisfactory if based upon service experience under severe icing conditions.

Altitude Engines with Conventional Venturi Carburetors. A minimum temperature rise of 120°, unless service experience with the type of aircraft has indicated that 110° is satisfactory for the particular operation involved, should be attainable. In such cases, a suitable heat indicator shall be provided to guide the pilot in his use of intake heat.

Altitude Engines Incorporating a Cam Type Venturi or Injection System. One of the two following requirements shall be met:

a. A minimum temperature rise of 40° from a hot air source primarily dependent upon exhaust heat, and an auxiliary emergency deicing system controllable from the cockpit utilizing alcohol, or other suitable deicing fluid, which is suitably discharged in the intake system so as to remove carburetor and adapter ice. The emergency system need only be used under extreme conditions, since compliance with the 40°F. heat rise available and other design precautions is intended to prevent the formation of ice. Or,

b. A minimum temperature rise of 100° with a suitable intake heat indicator. The hot air source should be primarily dependent upon exhaust heat.

Method (a) above is considered preferable in view of adverse effects on engine reliability and power by the sole use of method (b). Method (a) further requires less attention upon the part of the crew.

2. Test Procedure

The installation should be checked in accordance with the interpretation above. The propeller used should be one which will not exceed 110% of the METO RPM in level flight at maximum permissible throttle setting on the particular airplane being tested.

The aircraft should be loaded to gross weight with normal c.g. position. It is not necessary to refuel during the test nor to keep account of fuel consumed.

For sea level engines with no manifold pressure gauge and with any except a constant speed propeller, it will be necessary to obtain readings at a minimum of three different altitudes in order to interpolate the heat rise at 75% power with an outside air temperature of 30°. One altitude should be approximately 500 feet above the ground, another at 8000 feet, and the third approximately the mean between these two. In any case, the maximum outside air temperature variation should be utilized and a minimum differential of 20° is preferred if prevailing air temperatures are 50° or higher. In the event an outside air temperature of 30°F. is present at an altitude where a suitable range of BHP can be attained for establishing the carburetor air heat rise at 75% METO power, the flight test need only be performed at this altitude. For altitude engines with any type propeller, including constant speed, the same procedure is applicable as is described for sea level engines above, except that the highest altitude should be that at which 75% of rated power can be attained with full throttle.

For sea level engines, the airplane should be flown in level flight on full cold air and maximum permissible throttle setting at the first of the chosen altitudes. After steady flight is attained, the following data should be recorded:

(1) Outside air temperature
(2) Pressure altitude
(3) Carburetor Air Temperature
(4) Indicated airspeed
(5) Engine RPM

When this is done, and while maintaining level flight, briskly move the carburetor heat control to the full hot position. (The control should operate in such a fashion that it will be unnecessary for the operator to hold it "full on".) When the carburetor inlet air temperature has stabilized, the following data should be recorded:

(1) Carburetor air temperature
(2) Indicated airspeed
(3) Engine RPM

Next reduce the IAS to 90% of the value obtained above at full throttle on full cold air while continuing in level flight at the same altitude.

The same procedure should be repeated in this condition as above at full throttle and the same data recorded.

The same procedure should be repeated at each altitude selected.

For altitude engines, the same procedure is applicable as for sea level engines above, except that manifold pressure is recorded in addition to the data specified above.

3. Corrections of Flight Data

The data obtained above may be completed by means of the sample Carburetor Heat Rise Work Sheet shown. A sample graph which illustrates the form the data takes when plotted is also shown.

Note: For supercharged engines equipped with manifold pressure gauges and any propeller, the work sheet should be completed as explained for sea-level engines, with the exception that indicated power, is read directly from the power curves for the engine.

FLIGHT DATA SHEET FOR CARBURETOR HEAT RISE

OBSERVED FLIGHT DATA

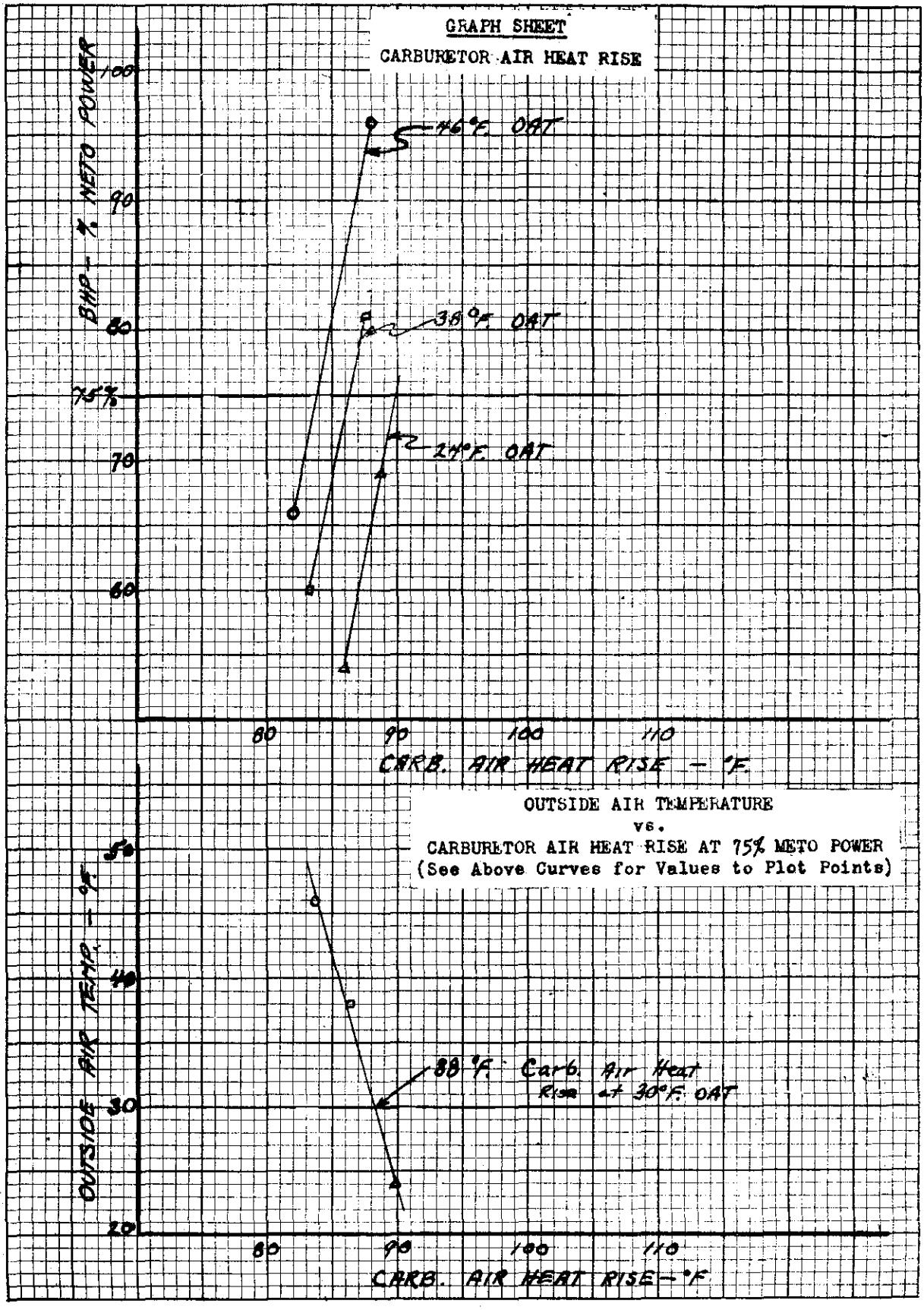
Press Altitude	OAT (°F)	Condition	Full Cold				Full Heat			
			Carb. Air	IAS	RPM	In. Hg.	Carb. Air	IAS	RPM	In. Hg.
			Full Throttle							
			90% FT IAS							
			90% FT							
			IAS							
			90% FT							
			IAS							

COMPUTED DATA

Press Altitude	OAT Full Cold	Std. OAT (°F)	Diff. + or −	Condition	Full Cold						Full Heat
					TIAS	I BHP	CF_P	CF_T	BHP	%BHP	Heat Rise
				FT							
				90%							
				FT							
				90%							
				FT							
				90%							
				FT							
				90%							
	(1)	(2)	(3)		(4)	(5)	(6)	(7)	(8)	(9)	(10)

(1) Obs. Flt data from above.
(2) From Fig. 46 (CAM 04).
(3) (1)−(2)= Degrees Std OAT is above (+) or below(−) Carb. Air Temp.
(4) From Airspeed Calibration.
(5) FT from Power Curve. 90% FT IBHP= $(RPM/RPM_{FT})^3 \times IBHP_{FT}$.
(6) Factor from SL vs Alt. Power (Fig. 47)
(7) 1.000 ± .001 each degree Std OAT is above/below Carb. Air Temp.
(8) BHP= (5) x (6) x (7).
(9) % HP = (8) ÷ METO HP.
(10) Heat Rise = Full Heat Carb. Air Temp. minus Out. Air Temp.

Graphs: (A) Plot (9) and (10).
(B) From (A), plot Heat Rise at 75% HP with corresponding Out. Air Temp.


GRAPH SHEET
CARBURETOR AIR HEAT RISE
BHP - % METO POWER
100
90
80
75%
70
60
46°F. OAT
36°F. OAT
24°F. OAT
80
90
100
110
CARB. AIR HEAT RISE - °F.
OUTSIDE AIR TEMPERATURE
vs.
CARBURETOR AIR HEAT RISE AT 75% METO POWER
(See Above Curves for Values to Plot Points)
50
40
30
20
OUTSIDE AIR TEMP. - °F.
38°F. Carb. Air Heat Rise at 30°F. OAT
80
90
100
110
CARB. AIR HEAT RISE - °F.

04.63 LUBRICATION SYSTEMS.

04.630 GENERAL. EACH ENGINE SHALL HAVE AN INDEPENDENT OIL SUPPLY. THE OIL CAPACITY OF THE SYSTEM SHALL BE AT LEAST 1 GALLON FOR EVERY 25 GALLONS OF FUEL BUT SHALL NOT BE LESS THAN 1 GALLON FOR EACH 75 MAXIMUM (EXCEPT TAKE-OFF) RATED HORSEPOWER OF THE ENGINE OR ENGINES. A SPECIAL RULING CONCERNING THE CAPACITY WILL BE MADE BY THE ADMINISTRATOR WHEN OIL MAY BE TRANSFERRED BETWEEN ENGINES IN FLIGHT OR WHEN A SUITABLE RESERVE IS PROVIDED. THE SUITABILITY OF THE LUBRICATION SYSTEM SHALL BE DEMONSTRATED IN FLIGHT TESTS IN WHICH ENGINE TEMPERATURE MEASUREMENTS ARE OBTAINED. THE SYSTEM SHALL PROVIDE THE ENGINE WITH AN AMPLE QUANTITY OF OIL AT A TEMPERATURE SUITABLE FOR SATISFACTORY ENGINE OPERATION.

The total capacity for each tank should be determined by placing the tank in such position that it can be completely filled. The expansion space is then the difference between this total capacity and the capacity determined with the tank installed in the airplane and the airplane in its normal ground attitude. CAR 04.631 requires that this difference be not less than 10% of the total capacity (volume) of the tank nor less than 1/2 gallon. One gallon is considered the minimum amount of oil satisfactory for engine operation with respect to cooling temperatures.

04.631 TANK INSTALLATION. OIL TANKS SHALL BE SUITABLY VENTED AND SHALL BE PROVIDED WITH AN EXPANSION SPACE WHICH CANNOT BE INADVERTENTLY FILLED WITH OIL. SUCH EXPANSION SPACE SHALL BE AT LEAST 10 PERCENT OF THE TOTAL TANK VOLUME, EXCEPT THAT IT SHALL IN NO CASE BE LESS THAN ONE-HALF GALLON.

04.632 TANK STRENGTH. OIL TANKS SHALL BE CAPABLE OF WITHSTANDING AN INTERNAL TEST PRESSURE OF 5 POUNDS PER SQUARE INCH WITHOUT FAILURE OR LEAKAGE. TANKS SHALL BE SO DESIGNED AND THE RIVETS OR WELDS SO LOCATED AS TO RESIST VIBRATION FAILURES AND LEAKAGE.

04.633 GAUGE. A SUITABLE MEANS SHALL BE PROVIDED TO DETERMINE THE AMOUNT OF OIL IN THE SYSTEM DURING THE FILLING OPERATION.

The calibration of the gauge should be made with the airplane in the normal ground attitude.

04.634 PIPING. OIL PIPING SHALL HAVE AN INSIDE DIAMETER NOT LESS THAN THE INSIDE DIAMETER OF THE ENGINE INLET OR OUTLET AND SHALL HAVE NO SPLICES BETWEEN CONNECTIONS. CONNECTIONS IN THE OIL SYSTEM SHALL BE OF A TYPE SATISFACTORY TO THE ADMINISTRATOR.

04.635 DRAINS. ONE OR MORE ACCESSIBLE DRAINS SHALL BE PROVIDED AT THE LOWEST POINT ON THE LUBRICATING SYSTEMS TO DRAIN COMPLETELY ALL PARTS OF EACH SYSTEM WHEN THE AIRPLANE IS IN ITS NORMAL POSITION ON LEVEL GROUND. SUCH DRAINS SHALL DISCHARGE CLEAR OF ALL PARTS OF THE AIRPLANE AND SHALL BE EQUIPPED WITH SUITABLE SAFETY LOCKS TO PREVENT ACCIDENTAL OPENING.

04.636 OIL TEMPERATURE. A SUITABLE MEANS SHALL BE PROVIDED FOR MEASURING THE OIL TEMPERATURE AT THE ENGINE INLET.

04.637 FILLER OPENINGS. ALL FILLER OPENINGS IN THE OIL SYSTEM SHALL BE PLAINLY MARKED WITH THE CAPACITY AND THE WORD "OIL."

04.64 COOLING SYSTEMS.

04.640 GENERAL. THE COOLING SYSTEM SHALL BE OF SUFFICIENT CAPACITY TO MAINTAIN ENGINE TEMPERATURES WITHIN SAFE OPERATING LIMITS UNDER ALL CONDITIONS OF FLIGHT DURING A PERIOD AT LEAST EQUAL TO THAT ESTABLISHED BY THE FUEL CAPACITY OF THE AIRCRAFT, ASSUMING NORMAL ENGINE POWER AND SPEEDS. COMPLIANCE WITH THIS REQUIREMENT SHALL BE DEMONSTRATED IN FLIGHT TESTS IN WHICH ENGINE TEMPERATURE MEASUREMENTS ARE OBTAINED UNDER CRITICAL FLIGHT CONDITIONS INCLUDING FLIGHT WITH ONE OR MORE ENGINES INOPERATIVE.

1. General

"____ safe operating limits ____" is interpreted to mean those maximum temperatures for which the engine has been certificated. They are listed on the APPROVED ENGINE SPECIFICATIONS. For all obsolete engines or those previously certificated for which temperature limits have not been established, the following are applicable:

Cylinder Head:	550°F.
Cylinder Barrel:	300°F.
Oil Inlet to Engine:	200°F.

"____ critical conditions ____" is interpreted to mean METO power on all engines or with one engine inoperative at the corresponding speed for best rate of climb and, in the case of flying boats only, taxiing on the water, all in air having the highest temperature likely to be encountered in the life of the airplane. This maximum expected outside air temperature has been arbitrarily defined as 100°F. at sea level and to decrease from this value at the rate of 3.6°F. per thousand feet of altitude above sea level.

2. Acceptable Method

The following procedure should be used in conducting cooling tests:

For single engine airplanes stabilize cylinder and oil inlet temperatures immediately prior to commencing the test. Take-off at full take-off power (reduce to METO power after one minute), climb

at best rate of climb speed, maintain METO power (or full throttle if above critical altitude) until at least five minutes after the first occurrence of the maximum cylinder head, cylinder barrel, or oil inlet temperature, whichever occurs last.

For multiengine airplanes stabilize cylinder and oil inlet temperatures in flight immediately prior to commencing the test. At an altitude approximately 1000 feet below the critical altitude of the first blower stage of the engines or 1000 feet below the altitude at which one engine inoperative best rate of climb is 50 feet per minute, whichever is lower, stop the coolest running engine by cutting off fuel supply and place dead engine propeller in most favorable pitch position (high or feathered), Climb at one-engine inoperative best rate of climb speed with operating engine(s) at METO power (or full throttle, if above the critical altitude) until at least five minutes after the first occurrence of the maximum cylinder head, cylinder barrel, or oil inlet temperature, whichever occurs last.

For long range flying boats, in addition to the climb test described above, the following taxiing test should also be conducted. Stabilize cylinder and oil inlet temperatures immediately prior to commencing the tests. First, head down wind, accelerate to a speed which is below the hump speed by not more than 5 knots and maintain that speed for at least 10 minutes. Second, head down wind, accelerate to a speed which is above the hump speed by not more than 5 knots and maintain that speed for at least 10 minutes.

During the above tests, record the following data at one minute intervals:

(1) Time
(2) Hottest Cyl. Head Temp.
(3) Hottest Cyl. Barrel Temp.
(4) Oil Inlet Temp.
(5) Outside Air Temp.
(6) Pressure Altitude
(7) Indicated Airspeed
(8) RPM
(9) Manifold Pressure
(10) Air. Temp. Engrg. Carb.
(11) Mixture Setting
(12) Throttle Setting

Consideration should be given to the following items for such tests:

a. The PROPELLER used during the cooling test must be that permitting the highest RPM for which approval is sought.

b. ALL INSTRUMENTS used during the cooling test must be calibrated

and all CALIBRATION curves submitted with the applicant's flight test report. Calibrations must be made of complete units as installed for the official tests and shall be witnessed or accepted by a CAA Inspector immediately prior to or following the official type tests.

c. No tests should be conducted under ATMOSPHERIC CONDITIONS in which moisture is visible in the air.

d. The gross WEIGHT at take-off should be the maximum permissible take-off weight.

e. The cylinder having the hottest spark plug gasket will be considered the HOTTEST CYLINDER. The determination of the hottest spark plug gasket will be verified by a CAA Inspector. The barrel temperatures of the cylinder having the hottest spark plug gasket will be used in determining the cylinder barrel temperatures. A description of the method of attaching the thermocouple and its location on the cylinder barrel shall also accompany the flight test report.

f. The manufacturer's recommended SETTINGS of the CARBURETOR should not be altered for official tests unless specifically approved.

g. If CHANGES have been made in the propeller, cowling, oil cooler or other features of the airplane subsequent to the original certification of the airplane such that the cooling characteristics may be adversely affected, such changes should be substantiated by submittal of data covering the changes and by flight tests, if considered necessary, to demonstrate adequate cooling.

h. The cooling characteristics of the powerplant installation will be RECOMMENDED for APPROVAL when the corrected calibrated temperatures are equal to or less than the "safe operating limits" as defined under "General" above. The characteristics will be RECOMMENDED for DISAPPROVAL if the corrected temperatures exceed these limits by any amount, however small.

3. Alternate Equivalent Method

If the cooling requirements outlined above under paragraph 2 cannot be met at the specified best rate of climb airspeed, but can be met at a higher speed, compliance with the following alternate procedures will be considered to provide equivalent satisfactory cooling:

a. Normal Category

(1) Single Engine Airplanes

(a) Airspeed Limitation for Cooling Test. (CAR 04.702) The airspeed chosen for cooling must result in the slope of the flight bath being equal to or greater than that which would result from the minimum required rate of climb specified in CAR 04.702 and the speed for best rate of climb. This is equivalent to increasing the minimum required rate of climb specified in CAR 04.702 by the ratio of the cooling airspeed to the best rate of climb speed and requiring that the rate of climb at the cooling speed meet the increased minimum rate of climb.

(b) Temperature Gauges.
A cylinder head and/or barrel temperature gauge will be installed as required equipment unless it has been demonstrated that cylinder temperatures meet cooling requirements at the best rate of climb speed. The necessary marking indicating the maximum permissible limit must be shown by a red radial line on the instrument(s).

(2) Multiengine Airplanes

(a) Airspeed Limitation for Cooling Test (CAR 04.702) The airspeed chosen for the cooling test shall not be greater than that which will provide compliance with item (1)(a) above with all engines operating at METO power. In all respects except airspeed, the cooling test must be conducted as described under acceptable method in paragraph 2 above.

(b) One-engine Inoperative Performance (CAR 04.723) The performance determined in accordance with CAR 04.723 will be that obtainable at the alternate airspeed so selected for the cooling test.

(c) Temperature Gauges
A cylinder head and/or barrel temperature gauge will be installed as required equipment unless

It has been demonstrated that cylinder temperatures meet the cooling requirements at the one-engine inoperative best rate of climb speed. The necessary marking(s) indicating the maximum permissible limit(s) must be shown by a red radial line on the instrument(s).

b. Transport Category

(1) Maximum One-engine-inoperative Altitude (CAR 04.7513-T) The airspeed chosen for the cooling test must provide the performance required by CAR 04.7513-T and 04.750-T(c).

(2) Temperature Gauges
Cylinder heads and/or barrel temperature gauge will be required as in item a(2)(c) above.

4. Corrections of Flight Test Data

The observed data should be reduced to a standard which is based on approved correction factors and maximum expected outside air temperatures. The correction factors and maximum expected outside air temperatures must correspond to the respective pressure altitudes at which the maximum cylinder head, cylinder barrel, and oil inlet temperatures first occur. The following corrections and correction methods may be used: (Other factors must be satisfactorily substantiated.) The approved correction factors for cooling air are as follows:

(1) Cylinder Head - - - - - - - - - - - - -1.0
(2) Cylinder Barrel - - - - - - - - - - - -0.7
(3) Oil inlet to engine - - - - - - - - - -1.0

For correction purposes the outside air temperatures observed at the time of the first occurrence of the respective maximum temperatures of the hottest cylinder head, the hottest cylinder barrel, and the oil inlet to the engine should be used.

Examples of applying the corrections are given below:

a. Cylinder Head Temperature Correction.
Corrected temperature
$$= \text{Obs. Max. Cyl. Head Temp.} + 100 - 3.6 \left(\frac{\text{Obs. Alt.}}{1000}\right) - \text{OAT}$$

Where O.A.T. = Outside Air Temperature.

b. Cylinder Barrel Temperature Correction.
Corrected Temperature
= Obs. Max. Barrel Temp. + .7 $\left[100 - 3.6 \left(\frac{\text{Obs. Alt.}}{1000}\right) - \text{OAT}\right]$

c. Oil Inlet Temperature Correction.
Corrected Temperature
= Obs. Max. Oil Temp. + 100 - 3.6 $\left(\frac{\text{Obs. Alt.}}{1000}\right)$ - OAT

04.641 RADIATORS. RADIATORS SHALL BE SO MOUNTED AS TO REDUCE VIBRATION AND ELIMINATE STRAINS CAUSING DISTORTION.

04.642 PIPING. PIPING AND CONNECTIONS SHALL CONFORM TO ACCEPTED STANDARDS AND SHALL NOT TRANSMIT VIBRATION TO THE RADIATOR OR THE STRUCTURE OF THE AIRCRAFT.

04.643 DRAINS. ONE OR MORE ACCESSIBLE DRAINS SHALL BE PROVIDED AT THE LOWEST POINTS ON THE COOLING SYSTEM TO DRAIN COMPLETELY ALL PARTS OF SUCH SYSTEM WHEN THE AIRPLANE IS IN ITS NORMAL POSITION ON LEVEL GROUND. SUCH DRAINS SHALL DISCHARGE CLEAR OF ALL PARTS OF THE AIRPLANE AND SHALL BE EQUIPPED WITH SUITABLE SAFETY LOCKS TO PREVENT ACCIDENTAL OPENING.

04.644 FILLER OPENINGS. ALL FILLER OPENINGS IN THE COOLING SYSTEM SHALL BE PLAINLY MARKED WITH THE CAPACITY OF THE SYSTEM AND THE NAME OF THE PROPER COOLING LIQUID.

04.65 POWERPLANT INSTRUMENTS, CONTROLS, AND ACCESSORIES.

04.650 INSTRUMENTS. THE ENGINE INSTRUMENTS REQUIRED ARE SPECIFIED IN § 04.5. THE INSTALLATION REQUIREMENTS FOR NAVIGATION INSTRUMENTS IN § 04.5804 SHALL APPLY TO TACHOMETERS AND MANIFOLD PRESSURE GAUGES. ALL OTHER INSTRUMENTS SHALL BE VISIBLE IN FLIGHT TO THE PILOT AND CO-PILOT OR TO THE FLIGHT MECHANIC. IF THE MANIFOLD PRESSURE GAUGES AND TACHOMETERS ARE NOT VISIBLE TO THE FLIGHT MECHANIC, HE SHALL BE PROVIDED WITH A DUPLICATE SET OF THESE INSTRUMENTS.

04.651 CONTROLS. ALL POWERPLANT CONTROLS, INCLUDING THOSE OF THE FUEL SYSTEM, SHALL BE PLAINLY MARKED TO SHOW THEIR FUNCTION AND METHOD OF OPERATION.

04.6510 THROTTLE CONTROLS. THROTTLE CONTROLS SHALL BE EASILY ACCESSIBLE TO BOTH PILOTS AND SHALL BE SO ARRANGED AS TO AFFORD A POSITIVE AND IMMEDIATELY RESPONSIVE MEANS OF CONTROLLING ALL ENGINES SEPARATELY OR SIMULTANEOUSLY. FLEXIBLE THROTTLE CONTROL SYSTEMS SHALL BE OF A CERTIFICATED TYPE. A FORWARD MOVEMENT SHALL OPEN THE THROTTLE.

All powerplant controls must be so designed as to resist wear and operate with a minimum of backlash. Where cable controls are used, provisions must be made for adjustment and suitable pulley guards installed. Stops should preferably be installed at the engine end of the control, with safety stops at the cockpit end if necessary, so as to minimize adjustment and attention required in service. The controls must be so designed that normal engine movement will not cause severe loads or "creeping" of the controls.

Carburetor air intake controls and controls for air shutters in the cooling and oil systems should be sufficiently strong to permit their operation under icing conditions.

Throttles should be arranged with a spring in the system at the carburetor so that in the event a breakage of the control system occurs the throttle will move into a predetermined open position.

04.6511 IGNITION SWITCHES. IGNITION SWITCHES SHALL BE EASILY ACCESSIBLE TO BOTH PILOTS. A POSITIVE MEANS FOR QUICKLY SHUTTING OFF ALL IGNITION OF MULTIENGINE AIRCRAFT, BY GROUPING OF SWITCHES OR OTHERWISE, SHALL BE PROVIDED.

04.6512 PROPELLER PITCH CONTROLS. SEPARATE PITCH CONTROLS SHALL BE PROVIDED FOR EACH PROPELLER.

04.652 ACCESSORIES (AIR CARRIER AIRPLANES). (See § 04.5891.)

04.66 MANIFOLDING, COWLING AND FIREWALL.

04.660 GENERAL. ALL MANIFOLDS, COWLING AND FIREWALLS SHALL BE SO DESIGNED AND INSTALLED AS TO REDUCE TO A MINIMUM THE POSSIBILITY OF FIRE EITHER DURING FLIGHT OR FOLLOWING AN ACCIDENT AND SHALL THEREFORE COMPLY WITH ACCEPTED PRACTICE IN ALL DETAILS OF INSTALLATION NOT HEREINAFTER SPECIFIED.

04.661 MANIFOLDS. EXHAUST MANIFOLDS SHALL BE CONSTRUCTED OF SUITABLE MATERIALS, SHALL PROVIDE FOR EXPANSION, AND SHALL BE ARRANGED AND COOLED SO THAT LOCAL HOT POINTS DO NOT FORM. GASES SHALL BE DISCHARGED CLEAR OF THE COWLING, AIRPLANE STRUCTURE AND FUEL SYSTEM PARTS OF DRAINS. THEY SHALL NOT BLOW BACK ON THE CARBURETOR AIR INTAKE OR THE PILOT OR PASSENGERS, NOR CAUSE A GLARE AHEAD OF THE PILOT AT NIGHT. NO EXHAUST MANIFOLDING SHALL BE LOCATED IMMEDIATELY ADJACENT TO OR UNDER THE CARBURETOR OR FUEL SYSTEM PARTS LIABLE TO LEAKAGE.

Exhaust manifolds should be constructed of stainless steel, nickel chromium steel, or equivalent when installed on engines of approximately 300 HP or over. Low carbon steel has been generally satisfactory for use on lower powered engines when wall thicknesses not less than .049" for installations above 125 HP and .035" for 125 HP and under are used and the manifold is well cooled.

Manifolds should not be located under the cowling unless isolated from the accessory compartment and well ventilated. Any portion of the manifold, within the accessory compartment must be shrouded except that for installations on low powered engines, (less than 100 HP) the upper portions need not be shrouded when such portions are far from parts of fuel and oil systems and it can be shown that a fire hazard does not exist. Shrouds or tunnels on engines of over 100 HP should be constructed of stainless steel or equivalent.

No portion of the manifold, whether located within or outside of cowling, should be routed directly below parts of the fuel or lubricating system which are likely to leak.

Exhaust outlets should be so located that gases will not enter pilot or passenger compartments. It should be borne in mind that

carbon monoxide, even when mixed with large quantities of fresh air as in open cockpit airplanes, is extremely dangerous as this gas will accumulate in the body until a dangerous quantity exists. The location of the outlets should also be such that there should be no glare ahead of the pilot at night. Where outlets are below the engine, the openings should be away from the center line of the cowl and pointed outward. A minimum distance of 10 inches laterally from the exhaust outlets to the carburetor intake or drain will be considered satisfactory. Outlets should not be directly in line with fuel system drains nor should the gases result in overheating of any part of the aircraft.

Sufficient cooling must be provided to eliminate local hot spots and to maintain temperatures well below the scaling point of the material used. When tunnels or shrouds are used to isolate portions of the exhaust manifold, positive ventilation must be provided by directing air between the shroud and manifold unless it can be shown by tests that the most severe operating conditions will not produce excessive temperatures. A temperature survey must be made whenever a doubt exists as to the adequacy of the ventilation provided.

Provisions must be made for expansion and movement between cylinders and between manifold and extensions.

(Also see CAM 04.665 re Heating Systems and absence of Carbon Monoxide.)

04.662 AIR INTAKES. CARBURETOR AIR INTAKES SHALL BE SUITABLY DRAINED AND SHALL OPEN COMPLETELY OUTSIDE THE COWLING UNLESS THE EMERGENCE OF BACK-FIRE FLAMES IS POSITIVELY PREVENTED. THE DRAIN SHALL NOT DISCHARGE FUEL IN THE PATH OF POSSIBLE EXHAUST FLAMES.

Intake screens, if used, should be of large mesh (1/2 inch or over) to minimize the possible accumulation of ice and snow.

If a carburetor intake air heater is installed to comply with CAR 04.6291, the cockpit control should be so designated as to "Pull for Heat" and otherwise be sufficiently rigid to eliminate tendency to "spring" when operated after ice has started to form. In cases where shrouds over the exhaust manifold are used for preheating the carburetor air, the quality and thickness of the manifold should be such as to minimize the tendency to burn through. Means must also be provided in such installations to ventilate the exhaust tubing, or intensifier tubes if used, when carburetor air preheat is not being used, unless the manufacturer can establish, through temperature survey, that critical temperatures are not obtained in most severe operating conditions. The assembly must be easily disassembled for inspection.

04.663 ENGINE COWLING. ALL COWLING AROUND THE POWERPLANT AND ON THE ENGINE SIDE OF THE FIREWALL SHALL BE MADE OF METAL AND SHALL BE SO ARRANGED THAT ANY ACCUMULATIONS OF DIRT, WASTE OR FUEL MAY BE OBSERVED WITHOUT COMPLETE REMOVAL OF THE COWLING. IT SHALL FIT TIGHTLY TO THE FIREWALL, BUT OPENINGS MAY BE PROVIDED IF THE AIRPLANE SURFACE WITHIN 15 INCHES THEREOF IS PROTECTED WITH METAL OR OTHER SUITABLE FIREPROOFING MATERIAL. THE COWLING SHALL BE COMPLETELY AND SUITABLY DRAINED IN ALL ATTITUDES OF FLIGHT AND ON THE GROUND, WITH SEPARATE DRAINS PROVIDED FOR THE PARTS OF THE FUEL SYSTEM LIABLE TO LEAKAGE. ALL SUCH DRAINS SHALL BE SO LOCATED AS TO PREVENT FUEL OR OIL FROM DRIPPING ONTO THE EXHAUST MANIFOLD OR ANY PARTS OF THE AIRCRAFT AND FROM PERMEATING ANY MATERIAL OF A CELLULAR NATURE.

04.664 FIREWALL. A FIREWALL SHALL BE PROVIDED UNLESS THE ENGINE IS MOUNTED IN AN ISOLATED NACELLE WITH NO FUEL TANKS. SUCH FIRE BULKHEAD SHALL BE CONSTRUCTED IN ONE OF THE FOLLOWING APPROVED MANNERS: (A) A SINGLE SHEET OF TERNE-PLATE NOT LESS THAN 0.028-INCH THICK. (B) A SINGLE SHEET OF STAINLESS STEEL NOT LESS THAN 0.015-INCH THICK. (C) TWO SHEETS OF ALUMINUM OR ALUMINUM ALLOY NOT LESS THAN 0.02-INCH THICK FASTENED TOGETHER AND HAVING BETWEEN THEM AN ASBESTOS PAPER OR ASBESTOS FABRIC SHEET AT LEAST 1/8-INCH THICK.

04.6640 THE FIREWALL SHALL COMPLETELY ISOLATE THE ENGINE COMPARTMENT AND SHALL HAVE ALL NECESSARY OPENINGS FITTED WITH CLOSE-FITTING GROMMETS OR BUSHINGS. ADJACENT INFLAMMABLE STRUCTURAL MEMBERS SHALL BE PROTECTED BY ASBESTOS OR AN EQUIVALENT INSULATING MATERIAL AND PROVISION SHALL BE MADE FOR PREVENTING FUEL AND OIL FROM PERMEATING IT.

04.665 HEATING SYSTEMS. HEATING SYSTEMS INVOLVING THE PASSAGE OF CABIN AIR OVER OR IN CLOSE PROXIMITY TO ENGINE EXHAUST MANIFOLDS SHALL NOT BE USED UNLESS ADEQUATE PRECAUTIONS ARE INCORPORATED IN THE DESIGN TO PREVENT THE INTRODUCTION OF CARBON MONOXIDE INTO THE CABIN OR PILOT'S COMPARTMENT. THEY SHALL BE CONSTRUCTED OF SUITABLE MATERIALS, BE ADEQUATELY COOLED AND BE SUSCEPTIBLE TO READY DISASSEMBLY FOR INSPECTION.

1. General

Heaters which utilize exhaust heat must be so designed as to reduce to a minimum the possibility of exhaust fumes entering the passenger or pilot's compartment. Intensifier tubes, when used, must be of stainless or equivalent heat resisting steel. Muff type heaters, passing cabin air directly over the exhaust manifold, may be used when the manifold is comparatively free from welds and expansion joints are well sealed.

Provision must be made for ventilating the muff or intensifier tube when cabin heater is turned "off." This can usually be best accomplished through the use of a bypass valve.

All parts of the heater unit must be capable of being readily disassembled for inspection.

Carbon monoxide content should not exceed 1 part in 20,000. This applies to all aircraft.

2. Test Procedure to Determine CO Content.

A carbon monoxide indicator should be used in determining compliance with the above requirement. The instrument manufactured by the Mines Safety Appliance Company or the Bulb Type Colorimetric Indicator may be used for this purpose, one of which is located at each Flight Engineering and Factory Inspection Branch Office. The following procedure should be used:

The aircraft should be flown in level flight at METO power or as nearly so as possible. Carburetor should be set Full Rich. With all windows closed, readings should be taken in at least the following locations:

a. Along the floor (approximately four inches above) in front of each occupant.

b. On each side of the cabin approximately a foot forward of each occupant.

c. A few inches in front of each occupant's face.

d. In front of the cabin heater opening(s) with heat on.

With windows partially open tending to produce a vacuum in the cabin, the same investigation should be made as windows closed, except for the heater location.

The aircraft should then be flown in a glide with power off (idling) and readings taken a few inches in front of each occupant's face with both windows open and closed as above.

The highest reading obtained at any of the above points shall not exceed .005.

04.69 MISCELLANEOUS POWERPLANT REQUIREMENTS.

04.690 MATERIALS. FUEL, OIL AND COOLING SYSTEMS SHALL BE MADE OF MATERIALS WHICH, INCLUDING THEIR NORMAL OR INHERENT IMPURITIES, WILL NOT REACT CHEMICALLY WITH ANY FUELS, OILS OR LIQUIDS THAT ARE LIKELY TO BE PLACED IN THEM.

04.708 GROUND AND WATER CHARACTERISTICS. LAND PLANES SHALL BE MANEUVERABLE ON THE GROUND AND SHALL BE FREE FROM DANGEROUS GROUND LOOPING TENDENCIES AND OBJECTIONABLE TAXIING CHARACTERISTICS. THE SEAWORTHINESS AND HANDLING CHARACTERISTICS OF SEAPLANES AND AMPHIBIANS SHALL BE DEMONSTRATED BY TESTS DEEMED APPROPRIATE BY THE ADMINISTRATOR. (SEE § 04.452 FOR WATER STABILITY REQUIREMENTS.)

1. Ground Characteristics

Taxiing tests should be conducted on smooth and rough ground as may likely be encountered under normal operating conditions. Speeds should be used which should vary up to approximately 70 percent of stalling speed. Particular attention should be paid to the following:

Taxiing over rough ground.--There is some evidence to indicate that critical loads can be built up in taxiing over rough ground, even when the shock-absorbing system is entirely satisfactory with respect to capacity for landing purposes.

Brakes.--Their adequacy in maneuvering on the ground and their tendency to cause nosing-over should be investigated. Any bad tendency will normally be exaggerated when taxiing in a strong side or tail wind.

2. Water Characteristics

In order to check water stability, taxiing tests should be made cross wind in a fairly strong breeze.

Sailing ability should be investigated by actually sailing the aircraft with appropriate use of the engine.

Porpoising tendencies should be investigated and reported upon for extreme loading combinations.

Ability to maneuver up to and while on the step should be investigated and reported on.

Effectiveness of the water rudders when provided should be checked.

3. Ski Handling--General

In the case of skis, the interpretation is that satisfactory landings and take-offs are required, as well as satisfactory ski trim in normal flight.

During landings, take-offs, taxiing, etc., particular attention should be paid to the following:

a. No undue directional instability.

b. Satisfactory ability to make normal speed taxiing turns without undue skidding tendency.

c. No undue tendency to have the nose of each ski digging in during landings or take-offs.

d. Trimming gear adequate with no danger of damage occurring during normal ground handling in taxiing or maneuvering over rough snow or drifts.

e. Ski trim in flight stable and satisfactory for all normal flight attitudes including slips and skids.

f. If braking devices are employed, attention should be given to adequacy, effectiveness, and protection during normal operation on the ground. Positive action should be required.

04.711 MODIFIED PERFORMANCE REQUIREMENTS FOR MULTIENGINE AIRPLANES NOT CERTIFICATED IN THE TRANSPORT CATEGORY.

THE WEIGHT OF ANY MULTIENGINE AIRPLANE MANUFACTURED PURSUANT TO A TYPE CERTIFICATE ISSUED PRIOR TO JANUARY 1, 1941, MAY BE INCREASED BEYOND THE VALUES CORRESPONDING TO THE LANDING SPEED SPECIFIED IN § 04.700 AND TAKE-OFF REQUIREMENTS OF § 04.701, SUBJECT TO THE FOLLOWING CONDITIONS:

(A) THE INCREASED WEIGHT SHALL BE KNOWN AS THE PROVISIONAL WEIGHT (§ 04.103). THE STANDARD WEIGHT (§ 04.102) SHALL BE THE MAXIMUM PERMISSIBLE WEIGHT FOR LANDING. THE PROVISIONAL WEIGHT SHALL BE THE MAXIMUM PERMISSIBLE WEIGHT FOR TAKE-OFF.

(B) COMPLIANCE WITH ALL THE AIRWORTHINESS REQUIREMENTS EXCEPT LANDING SPEED AND TAKE-OFF IS REQUIRED AT THE PROVISIONAL WEIGHT, EXCEPT THAT THE PROVISIONAL WEIGHT MAY EXCEED THE DESIGN WEIGHT ON WHICH THE STRUCTURAL LOADS FOR THE LANDING CONDITIONS ARE BASED BY AN AMOUNT NOT GREATER THAN 15 PERCENT, PROVIDED THAT THE AIRPLANE IS SHOWN TO BE CAPABLE OF SAFELY WITHSTANDING THE GROUND OR WATER SHOCK LOADS INCIDENT TO TAKING OFF AT THE PROVISIONAL WEIGHT.

(C) THE AIRPLANE SHALL BE PROVIDED WITH SUITABLE MEANS FOR THE RAPID AND SAFE DISCHARGE OF A QUANTITY OF FUEL SUFFICIENT TO REDUCE ITS WEIGHT FROM THE PROVISIONAL WEIGHT TO THE STANDARD WEIGHT.

(b) In no case shall the provisional weight exceed a value corresponding to a landing speed of 5 miles per hour in excess of that specified in § 04.700, a take-off distance of 1,500 feet in the case of landplanes, or a take-off time of 60 seconds in the case of seaplanes; nor shall any provisional weight authorized in respect to any type of airplane after January 1, 1945, exceed the value corresponding to a rate of climb of at least 180 feet per minute at an altitude of 5,000 feet with the critical engine inoperative, its propeller windmilling with the propeller control in a position which would allow the engine (if operating normally and within approved limits) to develop at least 50 percent of maximum-except-take-off engine speed, all other engines operating at the take-off power available at such altitude, the landing gear retracted, center of gravity in the most unfavorable position permitted for take-off, and the flaps in the take-off position.

Corrections.--In case it is considered necessary to use the weight or other correction in obtaining the true rate of climb in these check climbs, it will be acceptable to make these corrections as outlined in Flight Engineering Report No. 3.

2. One Engine Inoperative Performance Tests

The primary purpose of the requirements of 04.723 is to obtain the information necessary to inform the pilot of the one engine inoperative performance of the airplane under any condition likely to be encountered following an engine failure during the life of the airplane.

Unless some special reason is involved, "such weights as are necessary" is to be the maximum weight for which certification is sought. In order to accomplish this purpose it is necessary that sawtooth climbs be conducted. The nature and number of these sawtooth climbs should be the same as those described under 04.702 for the third purpose involved, except that the critical engine as determined immediately above is to be inoperative and the airplane is to be otherwise in the condition most favorable to climb, i.e., flaps retracted, inoperative propeller feathered or windmilling in high pitch. Cowl flaps, if present, are to be in the position that is used to demonstrate compliance with the cooling requirements as specified in 04.640.

In the past, the information which has been placed in the hands of the pilot concerning the one engine inoperative performance has been limited to a usable ceiling, i.e., the altitude in standard air at which the best rate of climb is 50 feet per minute. In order to accomplish the above purpose, however, it is obviously necessary to go beyond this and it is requested that the applicant furnish a chart showing the one engine inoperative best rate of climb and the corresponding true indicated airspeed against altitude at various weights covering the range of weight at which the airplane is likely to be operated. Provision should be made for keeping the chart, once it is approved, in the airplane at all times in a place conveniently accessible to the pilot.

Acceptable Method.--Same as described under 04.702 except additional data will need to be recorded.

Corrections.--The corrections necessary to determine the actual rate of climb are described in Flight Engineering Report No. 3.

04.724 AIRSPEED INDICATOR CALIBRATION. IN ACCORDANCE WITH § 04.5800, THE AIRSPEED INDICATOR OF THE TYPE AIRPLANE SHALL BE CALIBRATED IN FLIGHT. THE METHOD OF CALIBRATION USED SHALL BE SUBJECT TO THE APPROVAL OF THE ADMINISTRATOR.

04.725 CHECK OF FUEL SYSTEM. THE OPERATION OF THE FUEL SYSTEM SHALL BE CHECKED IN FLIGHT TO DETERMINE ITS EFFECTIVENESS UNDER LOW FUEL CONDITIONS AND AFTER CHANGING FROM ONE SUPPLY TANK TO ANOTHER. (SEE § 04.620.) FOR SUCH TESTS LOW FUEL IS DEFINED AS APPROXIMATELY 15 MINUTES' SUPPLY IN EACH TANK TESTED AT THE MAXIMUM (EXCEPT TAKE-OFF) POWER CERTIFIED.

1. General

a. The fuel system should be checked in flight to determine that it will feed satisfactorily in climbs at the best angle of climb speed and at the best gliding angle. Moderate rolls, slips and skids as might be made accidentally in the above climbs and glides with low fuel should not cause the engine(s) to cut out. The system should also feed promptly after one tank has run dry and the other tank is turned on.

b. Low fuel for the purpose of fuel system tests in flight is defined as approximately (METO HP + 40) gallons in the tank tested. Each tank will be tested unless the arrangement of the system indicates identical results would be obtained. Special rulings will apply in cases of fuel systems with several small tanks which would result in an unreasonably large amount of residual fuel. If the fuel system has only one tank, the engineering inspector may at his discretion during official tests request the installation of a temporary auxiliary fuel tank for low fuel flight tests in order to avoid the possibility of a forced landing due to lack of fuel.

c. Fuel systems of single engine aircraft shall not be considered satisfactory if more than 10 seconds elapse after changing over from a tank which has run dry in flight, before the engine resumes full power operation.

d. Systems with tank outlets and vents interconnected and so arranged that it is impossible to feed from each tank individually should be treated as single tank systems.

2. Acceptable Method

Single or individual tank tests.--(1) Flight tests should be conducted with fuel arranged in the tanks so that each tank can be tested separately with low fuel but always with a safe amount of

fuel in another tank. (2) If the aircraft has only one tank, the take-off will be made with a safe amount of fuel and the tests conducted with low fuel as defined above. (3) The tests should be conducted by changing over to the tank with low fuel after a safe altitude is reached. Each position or attitude should be maintained for a period sufficient to interrupt flow at the carburetor should the feed ports be uncovered. (4) Tests should include steady climbs with maximum permissible