Advisory Circular

Subject: Inspection and Care of General Aviation Aircraft Exhaust Systems

Date: 7/23/07

AC No: 91-59A

Initiated by: AFS-300

1. PURPOSE.

a. This advisory circular (AC) emphasizes the safety hazards of poorly maintained aircraft exhaust systems (reciprocating powerplants) and highlights points at which exhaust system failures occur. Further, it provides information on the kinds of problems to be expected and recommends pilots perform ongoing preventive maintenance and mechanics perform maintenance.

b. This AC provides an acceptable means of complying with the regulations; however, it is not the only means of compliance. This AC is not mandatory and does not constitute a regulation. When this AC uses mandatory language (e.g., "must" or "may not") it is paraphrasing a regulatory requirement or prohibition. When this AC uses permissive language (e.g., "should" or "may"), it describes an acceptable means, but not the only means, of complying with regulations. However, if you use the means described to comply with a regulatory requirement, you must follow it in all respects.

2. CANCELLATION. AC 91-59, Inspection and Care of General Aviation Aircraft Exhaust Systems, dated August 20, 1982, is canceled.

3. RELATED READING MATERIALS (current editions).

a. AC 20-32, Carbon Monoxide (CO) Contamination in Aircraft Detection and Prevention.

b. AC 20-106, Aircraft Inspection for the General Aviation Aircraft Owner.

c. AC 43-12, Preventive Maintenance.

d. AC 43.13-1, Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair.

e. AC 43-16, General Aviation Airworthiness Alerts.

f. AC 65-12, Airframe and Powerplant Mechanics Powerplant Handbook.

g. Aircraft manufacturers publish Service Letters, information letters, Service Bulletins, and maintenance manuals which inform the aviation public on recommended maintenance

(preventive or otherwise) and methods of correction for exhaust system problems. When conducting preventive maintenance and maintenance, always refer to information supplied by the manufacturer first.

4. BACKGROUND.

a. Review of accident and incident reports reveal numerous fatalities and injuries to pilots and passengers as a result of exhaust system component failures. The following conditions can contribute to these accidents and incidents:

- CO poisoning
- Partial or complete loss of engine power
- Fire

b. As an example, we received a safety recommendation concerning the internal failure of a muffler on a Cessna 207 airplane. The cone, which deflects or helps distribute exhaust gasses inside the muffler, came loose and blocked the exhaust gas outlet resulting in engine power loss during takeoff. This muffler configuration is common or similar to many other general aviation airplane mufflers.

5. DISCUSSION. We want to emphasize the safety hazards and potential dangers of inadequate and infrequent inspections, and a lack of routine preventive maintenance on exhaust system components between interval inspections. Regard any exhaust system component failure as a severe hazard.

a. Many light airplane cabins are warmed by air circulating around the engine exhaust pipes. Many of the most common exhaust system component failures are muffler or exhaust gas-to-air heat exchanger related.

b. Potential failures include:

(1) Escape of exhaust gas into the cabin, possibly through the cabin heat system, when there is muffler or heat exchanger leakage.

(2) Material failures in components of heat exchangers and mufflers that function as both, leading to leakage of the exhaust gas directly into the cabin or through the cabin heat system.

(3) Partial or full engine power loss caused by loose baffles, cones, or diffusers on mufflers and heat exchangers that partially or completely block the exhaust gas outlet flow. This condition may occur intermittently if internal components are loose within the muffler and move around during subsequent flights.

(4) Impingement heating or torching of the surrounding structure can occur in any area where exhaust system components exist or are breached and may lead to structural failure or fire

conditions. Torching is of particular concern on turbocharged engines, which operate at higher exhaust gas temperatures and pressures.

c. If the owner/operator of an aircraft has any questions on whether they can perform an inspection or repair, AC 43-12 should be reviewed or the local FAA District Office should be contacted for this information. Repair, replacement, and inspection must be recorded per Title 14 of the Code of Federal Regulations (14 CFR) part 43, § 43.9. Records must be retained in accordance with 14 CFR part 91, § 91.417.

6. EXHAUST SYSTEM INSPECTION AND CHECKING. All inspections, checks, and processes should be in accordance with the manufacturers' recommendations. The owner/operator of an aircraft is made primarily responsible by § 91.405 to see that between required inspections (e.g., annual, progressive, and 100-hour inspections), defects are repaired as prescribed in part 43. In the interest of safety, owners/operators should perform daily preflight inspections which include a thorough visual external inspection/check of the exhaust system.

a. Signs of Exhaust System Problems.

(1) Signs of exhaust system leakage on external surfaces include a flat gray, gray-white, or light gray powder or a sooty appearance. Signs of exhaust system and aircraft structural deterioration include warping, deformation, thinning, collapse, dents, cracking, tears, separation, scaling, weld separation, discoloration, corrosion, metal pitting, or burn-through.

(2) Signs of exhaust system leakage may appear on external joints, flex-joints, slip-joints, clamps, or couplings.

(3) Improper installation, including misalignment of exhaust stacks, ball joints, and/or connections can appear as abnormal wear or warped, broken, loose, or missing fasteners, clamps, gaskets, or seals.

(4) Airplanes that have had backfires or unburned fuel in the exhaust system may have damage such as weld failure to the baffles and cracks, particularly in areas where exhaust gasses could leak into cabin air heat exchangers.

b. Areas to Check.

(1) Because of the design of some aircraft cowlings, an engine exhaust system may not easily be inspected or checked as needed. The cowlings should be removed at frequent intervals (hours of operations) to perform a detailed inspection or check. Manufacturers' service bulletins, information letters, and maintenance manuals recommend when maintenance inspections and checks should be performed. Persons performing maintenance and preventive maintenance should have this information available to them. Using a high intensity light and telescoping, hinge handle mirror is recommended to facilitate an inspection or check.

(2) Examine the muffler's end plates (which adapt the connection for the inlet or the outlet) where it is inserted into the muffler shell to find muffler or heat corrosion before it breaks through the outer surface of the muffler. If corrosion is advancing in this area, swelling can occur

off the normal surface line of the muffler at either end. Protrusions such as dents in the exhaust gas flow can result in localized hot spots which can lead to burning, bulging, or rupture.

(3) Check to see if interior areas block, restrict, dent, or protrude into the exhaust flow path. Use a flashlight to look in the interior of the tailpipe for loose or displaced baffles, cones, or diffusers in the mufflers. On airplanes that have a bend in the tailpipe, remove the tailpipe at least as often as the annual inspection to check the interior of the muffler. Look for the accumulation of deposits from coking/carbonization which can form, grow, and create an ember or localized hot spot that could cause component malfunction or failure. Signs of abnormal wear or erosion appear where directional changes are made in the exhaust gas flow.

(4) Make sure the exhaust system is not contacting the engine mount or other parts of the airplane during start up and shut down. Typically this is visible with rub marks on the exhaust system or the structure that it is contacting. If contact is observed, a more thorough examination of the system is warranted. Prime areas of damage are usually welds, especially on the component in contact or areas that are stressed by the contact.

(5) Check the exhaust stack or riser-to-flange interface for cracks in welds or weld heat affected areas and blown out or missing gaskets. If leakage is suspected, remove the exhaust system to inspect the condition of the cylinder exhaust port. Any signs of pitting or erosion due to leakage must be addressed prior to replacing gasket and reinstalling the exhaust system. Torque all hardware to manufacturer’s specifications.

(6) Check all welds, and areas adjacent to the welds, for cracks or weld separation.

(7) Check tailpipes for erosion, thinning, bulging, or burn-through.

(8) Check contoured, shaped, or bend areas, and turns and interfaces (wyes) for erosion, thinning, bulging, or burn-through.

(9) Check fluid or moisture traps for scaling, corrosion, or cracks.

(10) Check bracing, supports, and support attach lugs on other structures for security, self-locking of safety hardware, and signs of overheat or burning.

(11) Check surrounding structures for discoloration, heat damage, or burning.

(12) Check bellows and support rods.

(13) Check for use of non-high temperature materials, or non-self-locking, or un-safetied hardware.

(14) Check seals on the belly fairings, windows, and door seals to ensure that exhaust gasses are not allowed to enter the cockpit.

(15) Checks areas such as firewalls, fuel system components, and other structures that may be hidden by insulation blankets or heat shields. Hidden damage such as corrosion and overheating must be addressed by repair or replacement in accordance with part 43. Some

aircraft utilize insulation blankets to protect the firewall. Insulation should be periodically removed to properly inspect the condition of the firewall for problems such as corrosion.

c. Inspection Procedures.

(1) We highly recommend thorough preflight inspections and subsequent repetitive inspection of the exhaust system components because failures can occur in a short period of time. All airplane owners and operators should acquaint themselves with the configuration, pieces, and parts that make up the exhaust system on their airplane. This will assist in any inspection to identify abnormal areas or areas that may have changed since the last review. Systems still made from carbon steel are more susceptible to corrosion than those made from stainless steel and therefore should be inspected more frequently.

(2) Perform daily inspections on aircraft. This consists of a visual inspection of the complete exhaust system installation, including exposed components in the vicinity of the exhaust system. Simple tools such as a flashlight, a mirror, an awl, a pick, a wooden dowel rod with a small diameter, or a solid core wire may assist in this process. Airplanes that do not operate on a more or less continual basis or those located in humid climates are more likely to have a higher rate of exhaust system component deterioration.

(3) When performing inspections, inspect exhaust system components thoroughly, noting at least the areas listed in paragraph 6b. The above inspections may be more practically implemented at the same interval that engine oil changes are, consistent with each aircraft's maintenance and inspection manuals or requirements.

(4) Pressure testing the aircraft's exhaust system, including turbocharger system components, if installed, will usually show leaks.

(a) Close the throttle and open the carburetor heat.

(b) Remove carburetor heat, cabin heat, and preheat shrouds.

(c) To pressurize the system sufficiently, attach a vacuum cleaner with a hose on the blowing side (with a filter installed) to the aircraft tailpipe and seal securely.

(d) Brush or spray a soap solution to the surface and contours of the exhaust system to show breaches (leakage) in the system from cracks and corrosion.

(e) If the aircraft's service manual does not specify this test at the aircraft annual inspection, accomplishing it is highly recommended.

(f) This test is recommended any time exhaust system components are removed or replaced.

(5) Partially removing exhaust system components may enhance inspections and checks. When conducting a pressurized leak test in a water tank, total removal of components may be required. We recommend completely inspecting the exhaust system when major work or overhaul of the aircraft engine is accomplished.

(a) Always use new gaskets or seals when replacing or reinstalling exhaust system components. Remember to use anti-seize compound on the slip-joints when recommended by the system manufacturer.

(b) Before checking the exhaust system for leaks, allow it to reach normal operating temperatures after shutdown.

(c) If necessary, realign the exhaust system components after run-up to preclude preloading the components.

(d) Re-torque all fasteners, taking care to not preload any of the components. If hardware cannot be re-torqued to proper settings, the hardware should be replaced because it may have stretched or deformed over time. Replace all corroded, worn, or otherwise defective hardware, including bolts, nuts, washers, springs, cotter pins, etc.

(e) Safety everything as required.

(6) Internal wear and damage is difficult to detect until failure has occurred. The use of a borescope is recommended for inspection of internal exhaust system components that cannot be visually inspected.

(7) Detailed inspection of turbocharger system components is critical. Removal of insulation blankets or heat shields is necessary to gain complete access to components. Inspect for leakage, corrosion, warping, bulging, and cracking of turbocharger components.

(a) Remove turbocharger ducting to access the internal turbocharger rotating components. Check for erosion, pitting, corrosion, and free movement. Ensure all ducting is replaced and properly aligned.

(b) Inspect all turbocharger oil plumbing for signs of leakage, chafing, or cracking. Ensure that all connections are properly torqued. Ensure any insulation or shielding for plumbing is properly installed and in serviceable condition.

(c) Inspect the turbocharger control components such as pressure controllers and waste gate actuators for their condition and security, as well as signs of leakage. Ensure all moving parts operate freely and are properly lubricated. Check the condition of all plumbing for signs of cracking or chafing.

(8) A complete inspection of the aircraft exhaust system is encouraged prior to cold weather operations. Most single engine general aviation aircraft, and some multi-engine aircraft, utilize the exhaust system heat for defrosting and heating the passenger compartment. Thoroughly inspect the exhaust system’s condition for integrity of the heating and defrost ducting. Check for signs of leakage, warping, cracking, bulging, missing or loose hardware, and any other signs of unserviceable conditions.

(9) Inspect installation of any exhaust system measuring components such as exhaust gas temperature probes for their condition and security, as well as signs of leakage. Inspect all

wiring for their condition and security, as well as chafing. Periodic calibration of these systems is encouraged.

(10) Using stainless steel to repair a carbon steel system can cause severe localized corrosion in the weld heat affected zone while the aircraft is in service and should be avoided.

d. Repairs and Overhaul.

(1) We recommended replacing any exhaust system component that either fails maintenance manual inspection procedures or is defective. This includes components that are burned, cracked, warped, or so worn that leakage occurs.

(2) Weld repairs to exhaust system components are complicated by contaminants and deposits that exist on any component after a short period of time, as well as problems with base materials, such as:

- constant deterioration
- proper identification
- general thinness
- changes in composition and grain structure,

(3) We encourage consultation with an appropriately rated FAA-certified repair station that has experience and demonstrated expertise in exhaust system inspection and repair prior to attempting the repair of any exhaust system component. We also recommend a pressure test after repairing a welded component of the exhaust system.

(4) Repairs of exhaust system components that are not in accordance with part 43 are a reason for rejection of approval for return to service.

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