



**QUEST AERONAUTICS**  
Advanced Solutions for General Aviation

STRUCTURED PROCEDURES  
FOR AIRCRAFT OWNERS

# IN-FLIGHT ENGINE DIAGNOSTIC SUITE



## Clarity Before Commitment

Most aircraft owners operate without structured engine diagnostic procedures. As a result, maintenance decisions are often reactive, expensive, and based on incomplete data.

This suite was created to help pilot-owners systematically evaluate engine health, identify abnormalities earlier, and make more confident technical decisions.

### How The System Works

PROCEDURE	PURPOSE
Mixture Distribution Test	Fuel/Air balance
Ignition Stress Test	Ignition system integrity
Induction Leak Test	Intake system leak detection

### List of Symbols and Abbreviations

CHT... Cylinder Head Temperature

EGT... Exhaust Gas Temperature

GPH... Gallons per Hour

LOP... Lean of Peak

MAP... Manifold Pressure

PPH... Pounds per Hour

ROP... Rich of Peak

TIT... Turbine Inlet Temperature

WOT... Wide Open Throttle



# Introduction

In-flight test procedures are an excellent way to verify if your aircraft engine is functioning optimally. The best test results are typically achieved when you use an engine monitor unit set to the highest sample rate possible. While it's possible to perform these in-flight test procedures without an engine monitor unit, it can be more challenging and you may not obtain the highfidelity data that you're seeking. We recommend upgrading to a reliable engine monitor unit early in your aircraft ownership journey if your plane isn't equipped with one yet.

## Rotax Engines

In-flight test procedures shall not be performed on Rotax engines, with the exception of the induction lean test. This is because Rotax engines are modern internal combustion engines that don't require manual leaning and are equipped with state-of-the-art ignition systems.

## Safety Pilot and Pre-Flight Brief

Though not particularly difficult, in-flight test procedures may be unfamiliar to many pilots, so it's important to take your time. Consider bringing along a second pilot to assist with the procedures. Always ensure a comprehensive pre-flight briefing covering all the procedures is conducted on the ground. Also, clearly designate the pilot-in-command to prevent any misunderstandings.



## Mixture Distribution Test

It's advisable to carry out the mixture distribution test every twelve months or after every 100 hours of flight time, and anytime you suspect any irregularities with the engine. The purpose of this in-flight test procedure is to examine the mixture distribution and detect issues like dirty or (partially) clogged fuel nozzles, improperly-sized fuel nozzles, intake valve problems, induction leaks, and other engine anomalies that can cause uneven mixtures among cylinders. It also checks the requirements for **GAMIjector®** fuel injectors.

### General Aviation Modifications, Inc.

Our partner, General Aviation Modifications, Inc. (GAMI), has long promoted the mixture distribution test, which is why it's often referred to as the GAMI lean test. This test quantifies the balance of the fuel/air ratio in the engine, a value known as the GAMI Spread and measured in gallons-per-hour (GPH). The GAMI Spread is calculated by determining the total engine fuel flow at which each cylinder reaches peak exhaust gas temperature (EGT), then subtracting the lowest flow rate from the highest.

## GAMI Lean Test

While performing these in-flight test procedures, GAMI strongly recommends the presence of a safety pilot. GAMI also suggests keeping the cowl flaps open, if so equipped, and conducting the test at 65% power. It may be necessary to use a lower power setting to keep the cylinder head temperatures (CHTs) below 400°F and/or the turbine inlet temperature (TIT) beneath your max continuous redline (Note: All turbochargers permit short-term exceedance of the TIT limit for leaning purposes – usually one minute or less).



## GAMI Lean Test – Methods

There are three effective methods for performing the GAMI lean test. The following methods assume you have some means to measure the EGT on each cylinder and the total engine fuel flow (this can be digital or analogue). We recommend the download method with the shorthand method as an alternative.

- Download Method
- Shorthand Method
- Longhand Method

Perform the GAMI lean test procedure by setting up the airplane in normal cruise – utilise your autopilot if available. For **normally aspirated engines**, you should climb to a height that lets you achieve no more than 65% power, even at wide-open throttle (WOT). If you're operating **turbo engines**, firstly choose a manifold pressure (MAP) and RPM that equate to 65% power or less. Next, climb to an altitude where the ambient air pressure is almost the same as your selected MAP. A rule of thumb to remember is that ambient sea level pressure, usually around 29.92, drops by 1" for every increase of 1000 ft in altitude.

**IMPORTANT:** Cruise power setting for this test should be 65% or less at wide open throttle to avoid excessive CHTs and stress on the cylinder assemblies.

**IMPORTANT:** There's no added value in leaning beyond the onset of roughness to the point of engine stumble or flame-out



## **GAMI Lean Test – Download Method**

Perform the following procedure (JPI users – we obtain better data if you're not in Lean Find mode):

- Begin with a rich mixture of at least 100°F rich of peak (ROP).
- Retard the mixture control as slowly and steadily as possible until the onset of roughness. Try to do this slowly enough that it takes no less than 3-4 minutes to transition from the rich mixture to the lean one. The slower and smoother you move the mixture control, the better. Note the fuel flow in GPH or PPH. For turbos that do not have automatic waste gates, strive to maintain your target MAP as you lean the mixture by adjusting MAP as necessary.
- Reverse the process, enriching very slowly until you get back to about 100°F ROP. Then reverse again and lean to your previously noted GPH or PPH lean point. Again, attempt to do this slowly enough that it takes 3-4 minutes to perform the sweep while maintaining your target MAP.
- Repeat this rich-to-lean-to-rich mixture sweep procedure, preferably three times. (This allows us to obtain an average of several sweeps, providing more accurate information than one sweep alone and enabling us to discard sweeps with poor data e.g., moving too quickly through peak.)
- On your last rich-to-lean sweep, while still on the lean side, don't simply return to a cruise ROP or lean of peak (LOP) cruise setting, but instead transition to the in-flight lean of peak magnetos check before making any changes. (The reason for this is we want to precisely determine how LOP the engine is when the in-flight lean of peak magnetos check is performed.)



## **GAMI Lean Test – Shorthand Method**

Most engine monitors allow you to view all your EGTs simultaneously in a graphical format as individual columns. As you gradually adjust the mixture from rich to lean, those columns will rise as each individual EGT approaches its peak. The columns will then fall as each cylinder reaches its peak EGT and becomes lean of peak. Some monitors simplify determining peak EGT by inverting the EGT columns, making them flash, or changing the bar colour when a particular cylinder peaks. Perform the following procedure:

- Begin with a full-rich mixture and record the exact total engine fuel flow (to the nearest 0.1 GPH or 1 PPH) and EGT for each cylinder.
- Lean very slowly until the first cylinder reaches peak EGT. Note which cylinder has peaked, the exact total engine fuel flow, and peak EGT for that cylinder.
- Continue in this manner until you've recorded the total engine fuel flow and peak EGT of each cylinder in the order they reached peak.
- Reverse the process, enriching the mixture very slowly and note which cylinder has peaked, the exact total engine fuel flow, and peak EGT for that cylinder.
- Repeat this rich-to-lean-to-rich mixture sweep procedure multiple times to ensure reliable results.

## **GAMI Lean Test – Longhand Method**

This method is more comprehensive but more time-consuming than the shorthand method. With this method, you record each EGT (and optionally each CHT) at small increments of fuel flow adjustment from around 2 GPH rich of the first peak EGT to a point lean of the last peak EGT.



Aim for these lines of data to be in the smallest practical fuel flow increments – 0.2 to 0.3 GPH works well. Also, try to use the smallest EGT resolution possible. For many monitors, this means 1°F, though for some monitors 5°F or 10°F is the smallest. An 1°C resolution works fine, too.

The monitor's "lean find" or "lean assist" function may be necessary to find the 2 GPH rich of peak starting point. The reason for starting 2 GPH rich of peak is to avoid either collecting more data than necessary or starting the data collection too late to capture sufficient information.

Do not lean each cylinder individually. Start at a fuel flow where all EGTs are ROP, and lean in small increments until all EGTs are LOP, recording the EGT of all cylinders at each increment.

## **GAMI Lean Test – Results**

You can calculate the GAMI Spread and Lean Range once you have completed the in-flight test procedures.

- GAMI Spread: Total Engine Fuel Flow (Last cylinder to reach peak EGT) – Total Engine Fuel Flow (First cylinder to reach peak EGT) in GPH
- Lean Range: Full-rich EGT – peak EGT in °F (for each cylinder)

Typically, the GAMI Spread must be under 1 GPH for the engine to operate smoothly when lean-of-peak (LOP). Most engines are considered to have a good fuel/air ratio balance if the GAMI Spread is less than 0.5 GPH.

We recommend installing GAMIjector® or TurboGAMIjector® when the GAMI Spread is more than 1 GPH and other issues like dirty or (partially) clogged fuel nozzles, improperly sized fuel nozzles, intake valve problems, or induction leaks have been ruled out.





We can fine-tune your GAMIjector® or TurboGAMIjector® when the GAMI Spread is more than 0.5 GPH (0.7 GPH for Continental engines) and other issues like dirty or (partially) clogged fuel nozzles, improperly-sized fuel nozzles, intake valve problems, or induction leaks have been ruled out.

The lean range of each cylinder should typically be around 250 to 300°F. If any cylinder has a substantially lower lean range than the others, it could indicate a clogged fuel nozzle or induction leak. This in turn could result in excessively lean operation at take-off and potentially lead to overheating or detonation.

## **ANNEXES**

Annex 1:

In-Flight Test Procedures - Test Cards - Cover Page

Annex 2:

In-Flight Test Procedures - Test Cards - GAMI - NA - Download Method

Annex 3:

In-Flight Test Procedures - Test Cards - GAMI - Turbo - Download Method

Annex 4:

In-Flight Test Procedures - Test Cards - GAMI - NA - Shorthand Method

Annex 5:

In-Flight Test Procedures - Test Cards - GAMI - Turbo - Shorthand Method



# Ignition Stress Test

Regularly performing the ignition stress test (preferably every second or third flight) and any time you suspect anomalies with the engine is advisable. The purpose of this in-flight test procedure is to evaluate your ignition system under demanding conditions, in contrast to the pre-take-off magnetos check done on the ground. As a lean mixture is more challenging to ignite than a rich one, an in-flight lean of peak magnetos check truly evaluates your ignition system's performance.

## In-Flight Lean of Peak Magnetos Check

The in-flight lean of peak magnetos check is a diagnostic tool for your ignition system, used to identify potential issues with magnetos, ignition harnesses, spark plugs, or ignition timing. A lean mixture can reveal a weak plug that might be concealed in a richer mixture. Our objective is to select a mixture that will uncover weak sparks without causing them.

To perform the in-flight lean of peak magnetos check, set up the airplane in normal cruise mode – using autopilot if available. Follow the steps below:

- Start by conducting at least one GAMI Lean sweep as outlined above from rich of peak (ROP) to lean of peak (LOP). Alternatively, at the end of your multiple GAMI Lean sweeps from ROP to LOP, continue to lean to 50° LOP if possible, or to the onset of roughness. If you have leaned to the point of initial roughness, slowly enrich just enough to revert to a smoothly running engine. (We do not recommend exceeding 50° LOP as this is the maximum LOP you should ever need to run, and there's no value in maintaining an unnecessarily lean operation.)
- Activate the "normalise mode" on your engine monitor. This sets all the exhaust gas temperature (EGT) bars to mid-scale and heightens the sensitivity of the bar-graph display.



- If your aircraft has a key or rotary style magneto switch (found in most singles), cycle through BOTH-LEFT-BOTH-RIGHT-BOTH, letting the mag switch remain in each of these positions for at least 10 engine monitor sample times or a minimum of 30 seconds, including in the BOTH position. (If your sample interval is 6 seconds, that will be a full minute; if your sample interval is 1 second, then adhere to the minimum of 30 seconds.)
- If your aircraft has individual magneto toggle switches (common in most twins), follow the same procedure but with individual magneto switches.

## Notes

- It's normal for engines to run slightly rougher on one magneto than on two, but the roughness should not be excessively uncomfortable. Please report the level of perceived roughness during each phase of the test. (e.g. smooth, moderate, severe).
- If the engine stalls while switching to single mag operation, reduce the mixture to idle cut off, switch to the other mag, then slowly increase the mixture until the engine restarts.
- For turbocharged engines, TIT may rise to or exceed the red-line during single-magneto operation. This is typical and not harmful for the short duration of the flight test.
- RAM engines or Experimental engines with uneven or split timed magneto timing and unconventional spark plug wiring may respond differently. If your engine is a RAM engine or has uneven mag timing, please provide relevant details.
- For engines with Electronic Ignition, follow the same LEFT-BOTH-RIGHT order, but remember to inform us which magneto is conventional and which one is electronic, the type of electronic mag, and any unconventional wiring details.



## In-Flight Lean of Peak Magnetos Check – Results

A healthy ignition system should cause all EGT bars to rise by 50 to 100°F when you switch to single-magneto operation.

The rise may not be uniform; it's perfectly normal for even-numbered cylinders to rise more than odd-numbered cylinders, and vice versa. What's important is that all EGT bars rise and remain stable at their elevated levels.

During single-magneto operation, you may notice a slight loss of power and an increase in roughness. However, this roughness should not be alarming.

### ANNEXES

Annex 1:

In-Flight Test Procedures - Test Cards - Cover Page

Annex 2:

In-Flight Test Procedures - Test Cards - Ignition Stress Test - Download Method

Annex 3:

In-Flight Test Procedures - Test Cards - Ignition Stress Test - Shorthand Method



# Induction Leak Test

You should perform the induction leak test whenever you suspect a manifold pressure (MAP) or mixture distribution anomaly. The purpose of the induction leak test is to examine your induction system for leaks. The most suitable scenario for this test is level cruise flight at approximately 5000 feet MSL.

## Induction Leak Test

This test comprises two parts: a high-MAP test and a low-MAP test.

- For the high-MAP test, begin with relatively high-power settings – wide-open throttle (WOT) for normally aspirated engines, or MAP equal to outside ambient pressure for turbocharged engines – and a full-rich mixture. (Assume that the ambient sea level pressure of approximately 29.92 drops 1" with every 1000 MSL of altitude.) Record the exhaust gas temperature (EGT) for each cylinder.
- For the low-MAP test, decrease MAP by about 10 inches and once again record the EGT for each cylinder.

Ignore the absolute EGT values. Instead, calculate the change in EGT ("delta") for each cylinder between the high-MAP and low-MAP tests. Ideally, the amount of EGT change should be roughly the same for all cylinders. If one cylinder (or two adjacent cylinders) shows significantly less change than the others, this may indicate an induction system leak affecting that cylinder (or those adjacent cylinders).



## Induction Leak Test – Results

Here's the principle behind this test: During the high-MAP test, the induction manifold pressure is very close to outside ambient pressure, meaning any induction leak will have minimal or no impact on engine operation. However, during the low-MAP test, the manifold pressure is considerably lower than the outside ambient (by about 10 inches), so any induction leak will cause the affected cylinder(s) to run significantly leaner than the others, resulting in a smaller drop in EGT than the others.

### ANNEXES

Annex 1:

In-Flight Test Procedures - Test Cards - Cover Page

Annex 2:

In-Flight Test Procedures - Test Cards - Induction Leak Test - NA

Annex 3:

In-Flight Test Procedures - Test Cards - Induction Leak Test - Turbo



QUEST AERONAUTICS  
Advanced Solutions for General Aviation

# Independent Support for Aircraft Owners

We believe aircraft ownership should feel structured, understandable, and controllable.

Quest Aeronautics helps pilot-owners make more confident ownership and maintenance decisions through independent consulting, operational thinking, maintenance strategy, and data-driven decision frameworks.

Our goal is to help owners move from reactive aircraft ownership to confident, structured operation.

Every two weeks, we host **professional workshops** for pilot-owners covering topics such as:

- aircraft ownership strategy
- maintenance oversight
- engine reliability
- operating costs
- acquisition decisions
- long-term ownership planning

For owners seeking more individualized support, we also offer **professional diagnostic sessions** focused on ownership strategy, maintenance concerns, and operational decision-making.

[EXPLORE UPCOMING WORKSHOPS](#)

[BOOK A DIAGNOSTIC SESSION](#)