Spitronics ECU - Air Temperature Sensor - Guide

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The Air Temperature Sensor measures the temperature of the air entering the engine.

Air temperature affects:

- Air density.
- Oxygen mass entering the engine.
- Fuel requirement.
- Knock sensitivity.
- Combustion temperature.

Cold air is denser and contains more oxygen. Hot air is less dense and contains less oxygen.

The ECU can use the Air Temperature signal to correct fuel and ignition timing so that the engine Tune remains more consistent as operating conditions change.

Software Setup

Enable the Air Temperature Sensor under:

Inputs → Air

When enabled, the Air Temperature input becomes available for calibration, Realtime monitoring and Air Temperature Compensation.

The exact options displayed depend on the Device and firmware generation.

Real-Time Verification

Before calibrating or tuning Air Temperature Compensation, first verify that the displayed temperature is believable.

With a completely cold engine, the Air Temperature should normally be reasonably close to the surrounding ambient temperature.

Small differences may occur because of:

- Sensor position.
- Engine-bay temperature.
- Heat retained in the intake system.
- Direct sunlight.
- Airflow around the sensor.

If the reading is obviously incorrect, diagnose the sensor, wiring and calibration before changing the Tune.

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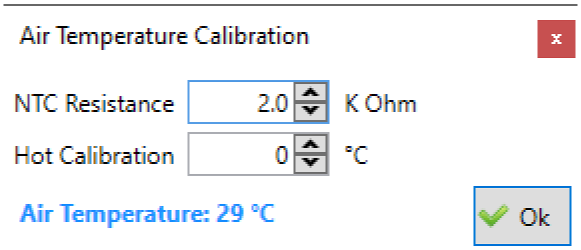
Sensor Calibration

Select **Sensor Calibration** to open the Air Temperature Calibration window.



The calibration includes:

- NTC Resistance.
- Hot Calibration.
- Current Air Temperature.

The exact available calibration options depend on the Device and firmware generation.

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NTC Resistance

The **NTC Resistance** setting selects the temperature-sensor curve used by the ECU.

Current software may provide selections such as:

- 1.0 kΩ.
- 2.0 kΩ.
- 2.5 kΩ.
- 10 kΩ.

The selected value represents the approximate nominal resistance of the NTC sensor at its reference temperature.

For example:

2.0 kΩ is used for a sensor of approximately 2 kΩ at 25°C.

For new installations, use the sensor specification recommended for the applicable Device.

Newer Spitronics systems are standardising on:

2 kΩ NTC Air Temperature Sensor

with a:

1 kΩ pull-up resistor

The older 10 kΩ option is being phased out on newer systems.

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Older and Newer Systems

Spitronics products have used different Air Temperature input arrangements over different generations.

Older Systems

Older hardware may use:

- Approximately 7.5 kΩ internal pull-up.
- Existing 10 kΩ sensor applications.
- Different supported NTC selections.

These systems should remain configured according to their original hardware and firmware requirements.

Newer Systems

Newer hardware is moving toward:

- 1 kΩ internal pull-up.
- 2 kΩ NTC sensor as the preferred standard.

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Pull-Up Resistor

An NTC temperature sensor does not generate a voltage by itself.

The sensor and the ECU internal pull-up resistor form a voltage divider.

The ECU measures the resulting voltage and converts it into a temperature value.

The pull-up value is a hardware characteristic and is not normally adjusted by the tuner.

The software sensor selection must therefore be compatible with both:

- The fitted NTC sensor.
- The hardware pull-up arrangement.

Changing the software sensor curve cannot always compensate correctly for an incompatible hardware pull-up.

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Hot Calibration

Hot Calibration applies a temperature offset to the selected sensor curve.

Start with:

Hot Calibration = 0°C

Then:

1. Allow the sensor to reach a known temperature.
2. Compare the ECU Air Temperature reading with an independent temperature reference.
3. Adjust Hot Calibration if a small correction is required.
4. Save the calibration.

Hot Calibration should be used only for small calibration corrections.

If a large offset is required, first check:

- Correct NTC Resistance selection.
- Correct sensor type.
- Wiring.
- Pull-up compatibility.

Do not use Hot Calibration to make an incompatible sensor curve appear correct.

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Quick Sensor Check

A resistance test can be used to confirm whether the sensor is approximately the correct type.

For the preferred 2 kΩ NTC sensor:

At approximately **25°C**, resistance should normally be around:

1.8-2.2 kΩ

Typical procedure:

1. Disconnect the sensor.
2. Set the multimeter to a suitable resistance range.
3. Measure across the sensor terminals.
4. Compare the resistance with the expected value.

The same basic resistance principle is used for the standard Spitronics Coolant Sensor.

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Open and Short-Circuit Check

The Air Temperature input follows the same basic NTC principle as the Coolant Temperature input.

With normal calibration:

Open circuit → cold extreme

Short to Sensor Ground → hot extreme

The exact displayed end temperatures may vary according to Device and firmware generation.

For this reason, use the direction of the response as the main diagnostic principle rather than relying on one universal numerical value.

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How the Sensor Works

The Air Temperature Sensor is normally an NTC resistor.

NTC means:

Negative Temperature Coefficient

Its resistance decreases as temperature increases.

As temperature rises:

Sensor resistance decreases → input voltage decreases → ECU temperature reading increases

As temperature falls:

Sensor resistance increases → input voltage increases → ECU temperature reading decreases

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Air Temperature Compensation

The Air Temperature Compensation Graph adjusts fuel and ignition timing according to intake-air temperature.

The graph normally contains two compensation functions.

Fuel Compensation

Fuel compensation is expressed as a percentage.

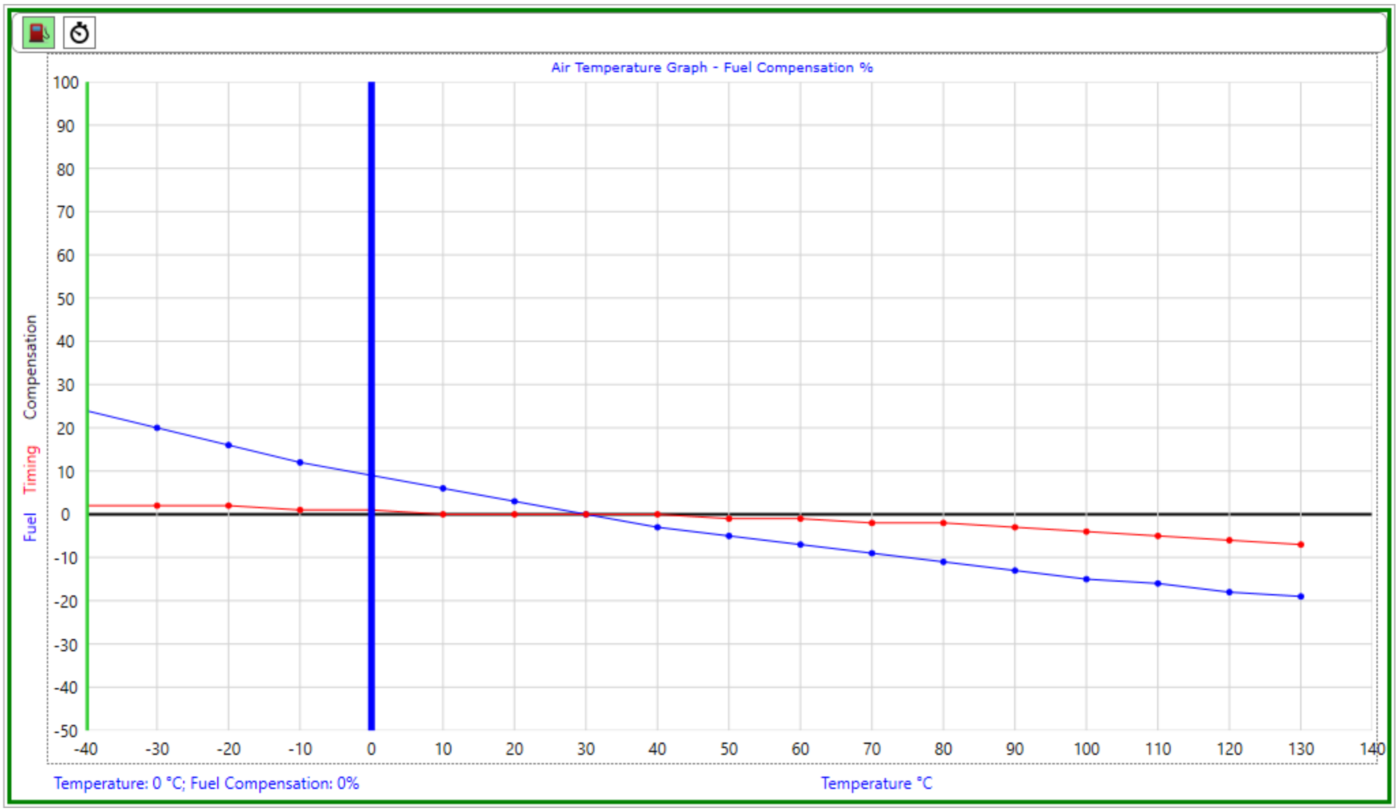
- Positive values add fuel.
- Negative values remove fuel.

Ignition Timing Compensation

Timing compensation is expressed in degrees.

- Positive values advance ignition timing.
- Negative values retard ignition timing.

Both corrections are added to the normal fuel and ignition calculations.



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Tuning Principle

The engine should first be tuned at a stable and known intake-air temperature.

This temperature becomes the neutral reference point.

Example:

Reference Air Temperature = 30°C

At this reference point:

Fuel Compensation = 0%

Timing Compensation = 0°

The Air Temperature Compensation Graph then corrects the Tune as intake temperature moves away from the reference temperature.

Do not use Air Temperature Compensation to hide an incorrect base fuel or ignition Tune.

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Why Air Temperature Compensation Is Required

A MAP sensor measures manifold absolute pressure.

It does not measure air temperature.

At the same MAP pressure, colder air is denser than hotter air.

For the same MAP value:

Cold air → greater air density → more oxygen

Hot air → lower air density → less oxygen

The Air Temperature signal allows the ECU to correct for this temperature-related difference.

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Basic Air-Density Principle

Air density changes approximately according to absolute temperature.

A useful theoretical relationship is:

Fuel Correction Ratio = Reference Absolute Temperature ÷ Current Absolute Temperature

Temperature must be converted to Kelvin.

Example:

Reference temperature:

30°C = 303 K

At 0°C:

303 ÷ 273 ≈ 1.11

This represents approximately 11% greater theoretical air density.

At 80°C:

303 ÷ 353 ≈ 0.86

This represents approximately 14% lower theoretical density compared with the 30°C reference.

These values explain the principle.

They should not automatically be copied directly into the Tune.

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Practical Compensation

The Air Temperature Sensor does not always measure the exact temperature of the air charge entering the cylinder.

The required practical correction can be influenced by:

- Sensor position.
- Manifold heat soak.
- Intake-runner temperature.
- Fuel evaporation.
- Charge cooling.
- Intercooler efficiency.
- Air movement around the sensor.
- Engine-bay temperature.
- Fuel type.

For this reason, the Spitronics Engineering Templates use a moderated practical curve rather than applying the complete theoretical density calculation.

The final compensation must always be verified on the actual engine.

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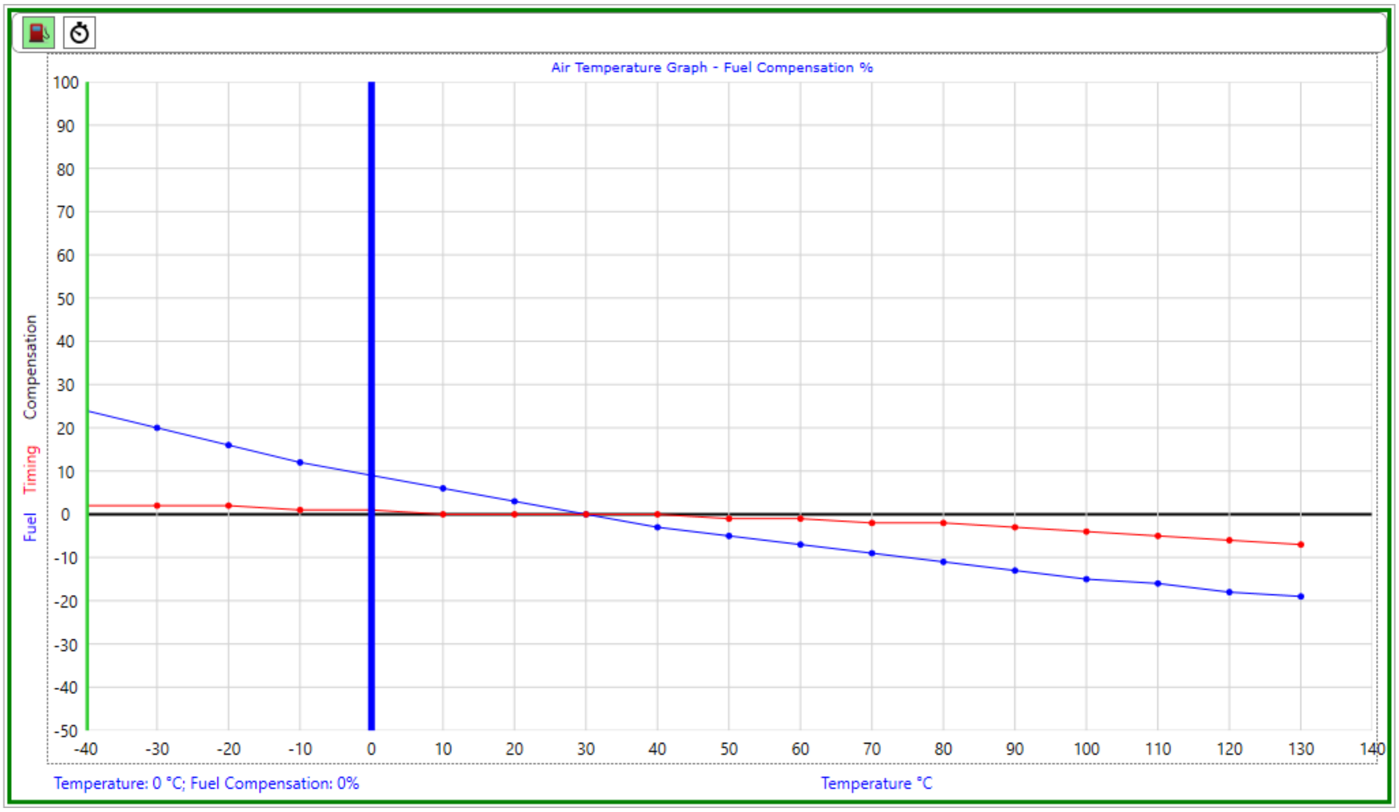
Naturally Aspirated Engineering Template

The Naturally Aspirated Engineering Template provides a practical starting point for a typical naturally aspirated petrol engine.

It includes:

- Air-density fuel compensation.
- Mild cold-air timing advance.
- Progressive hot-air timing retard.



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Naturally Aspirated Fuel Compensation

Typical starting values:

Air Temperature	Fuel Compensation
-40°C	+24%
-30°C	+20%
-20°C	+16%
-10°C	+12%
0°C	+9%
10°C	+6%
20°C	+3%
30°C	0%
40°C	-3%
50°C	-5%
60°C	-7%
70°C	-9%
80°C	-11%
90°C	-13%
100°C	-15%
110°C	-16%
120°C	-18%

Air Temperature	Fuel Compensation
130°C	-19%

The Engineering Template uses approximately 30°C as the neutral reference temperature.

These values are starting guidelines only.

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Naturally Aspirated Timing Compensation

Typical starting values:

Air Temperature	Timing Compensation
-40°C	+2°
-30°C	+2°
-20°C	+2°
-10°C	+1°
0°C	+1°
10°C	0°
20°C	0°
30°C	0°
40°C	0°
50°C	-1°
60°C	-1°
70°C	-2°
80°C	-2°
90°C	-3°
100°C	-4°
110°C	-5°
120°C	-6°
130°C	-7°

Cold-air advance is deliberately small.

Its purpose is mainly to support combustion stability rather than create additional power.

Hot-air timing retard can increase knock margin as intake temperature rises.
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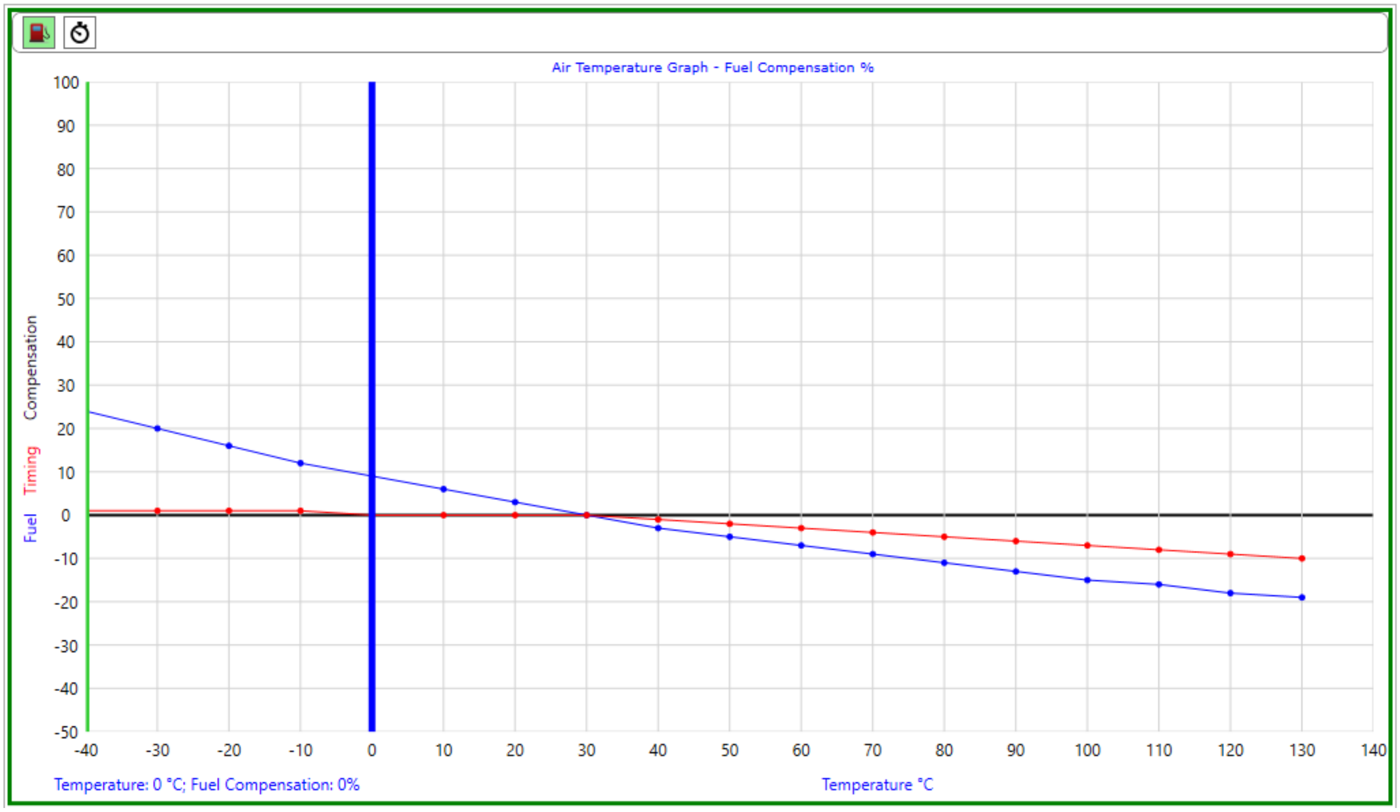
Turbocharged Engineering Template

Turbocharged engines are generally more sensitive to high intake temperature because boost increases:

- Cylinder pressure.
- Charge temperature.
- Knock tendency.
- Exhaust temperature.

The Turbocharged Engineering Template therefore uses a similar basic fuel-density correction but applies stronger high-temperature ignition retard.



Turbocharged Fuel Compensation

The same basic fuel-density curve can be used as the naturally aspirated starting template.

Air Temperature Compensation should primarily correct for temperature-related air-density changes.

Do not use the one-dimensional Air Temperature Graph as the main method of adding boost protection fuel.

Any correction on this Graph affects:

- Idle.
- Cruise.
- Part load.
- Boost.

Additional boost-related fuel should normally be handled by the appropriate load-dependent tuning or protection functions.

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Turbocharged Timing Compensation

A conservative turbocharged starting template is:

Air Temperature	Timing Compensation
-40°C	+1°
-30°C	+1°
-20°C	+1°
-10°C	+1°
0°C	0°
10°C	0°
20°C	0°
30°C	0°
40°C	-1°
50°C	-2°
60°C	-3°
70°C	-4°
80°C	-5°
90°C	-6°
100°C	-7°
110°C	-8°
120°C	-9°
130°C	-10°

Final timing protection depends on factors such as:

- Compression ratio.
- Boost pressure.
- Fuel octane.
- Intercooler efficiency.
- Combustion chamber design.
- Sensor position.
- Knock margin.

The template is a starting point only.
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Timing Retard and Turbocharger Behaviour

Retarding ignition timing causes more combustion energy to remain in the exhaust.

This can increase:

- Exhaust gas temperature.
- Exhaust energy.

- Turbine energy.

The turbocharger may therefore maintain or build boost more easily when timing is retarded.

This should be considered when using high-temperature timing protection on a turbocharged engine.

Timing retard should not be the only protection method.

A complete protection strategy may also include:

High Intake Temperature

↓

Retard Timing

↓

Reduce Boost or Engine Load where available

↓

Verify Safe AFR

↓

Apply further Engine Protection if required

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MAP-Based Tuning

With MAP-based tuning:

- MAP measures manifold pressure.
- Air Temperature provides information about the temperature-related density change.

A typical final fuel calculation may therefore contain several components:

Base MAP Fuel Tune

-

Air Temperature Compensation

-

Coolant Compensation

-

Injector and Voltage Compensation

=

Final Fuel Requirement

The Air Temperature correction should complement the base Tune rather than replace it.

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TPS-Based Tuning

TPS does not directly measure:

- Manifold pressure.
- Atmospheric pressure.
- Air density.

Air Temperature Compensation is therefore also important with TPS-based load tuning.

Barometric compensation may also be required because throttle position alone does not account for atmospheric-pressure changes.

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Sensor Position

The Air Temperature Sensor should measure the temperature of the air entering the engine as accurately as practical.

Naturally Aspirated Engine

Suitable locations may include:

- Intake manifold.
- Plenum chamber.
- Intake pipe near the throttle body.

Turbocharged Engine

Suitable locations may include:

- After the intercooler.
- Before the throttle body.
- Intake manifold where heat soak can be controlled.

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Avoid Heat-Affected Locations

Avoid sensor positions excessively affected by:

- Cylinder-head heat.
- Exhaust heat.
- Direct engine-bay heat.
- Stationary heat soak.
- Poor airflow.

A badly positioned sensor may indicate a temperature significantly higher than the actual moving intake charge.

The ECU may then:

- Remove too much fuel.
- Retard too much ignition timing.

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Heat Soak

Heat soak normally occurs when the vehicle is stationary or moving slowly and the Air Temperature Sensor absorbs heat from the manifold or engine bay.

The sensor may then indicate a temperature higher than the actual moving air entering the cylinders.

Typical symptoms include:

- Lean hot restart.
- Excessive timing retard.
- Poor throttle response.
- AFR changing as airflow cools the sensor after driving away.

Possible improvements include:

- Better sensor position.
- Faster-response sensor.
- Improved airflow around the sensor.
- Appropriate compensation adjustment.

Do not tune around a poor sensor installation where the installation itself can be corrected.

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Sensor Installation

Use a sensor suited to the application and position it where it receives representative intake airflow.

The sensor should:

- Be mechanically secure.
- Be protected from vibration.
- Not be excessively heated by surrounding metal.
- Receive airflow representative of the charge entering the engine.

Product-specific connector pins, jumper positions and hardware details are shown under the applicable Product information.

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Tuning Procedure

Establish the Reference Temperature

Tune the base fuel and ignition calibration at a stable intake-air temperature.

Record this temperature.

Example:

Reference Temperature = 30°C

Set fuel and timing compensation close to zero around this point.

Verify Sensor Accuracy

With the engine completely cold, compare the displayed Air Temperature with ambient temperature.

They should be reasonably close.

If not, investigate:

- Sensor.
- Wiring.
- Calibration.
- Heat affecting the sensor.

Start With the Correct Engineering Template

Select the template closest to the application:

- Naturally Aspirated Petrol.
- Turbocharged Petrol.

The template provides the starting shape.

It is not the final Tune.

Test Different Conditions

Where practical, compare operation under:

- Cold ambient temperature.
- Normal operating conditions.
- Hot weather.
- High engine load.
- Heat-soak restart.

Data Logging and AFR feedback are useful when comparing these conditions.

Adjust Fuel Compensation

If the engine becomes lean as intake temperature decreases:

Increase cold-air fuel compensation.

If the engine becomes rich as intake temperature decreases:

Reduce cold-air fuel compensation.

If the engine becomes rich as intake temperature rises:

Remove more fuel at high temperature.

If the engine becomes lean as intake temperature rises:

Remove less fuel at high temperature.

Adjust Timing Compensation

Start conservatively.

For naturally aspirated engines:

- Use only mild cold-air advance.
- Apply gradual hot-air retard where required.

For turbocharged engines:

- Apply stronger hot-air retard where required.
- Verify boost behaviour.
- Monitor for knock.
- Monitor exhaust temperature where practical.

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Typical Problems

Symptom	Likely Cause	Action
Air Temperature obviously wrong when cold	Incorrect sensor, calibration or wiring	Check sensor resistance and calibration
Temperature does not change	Open circuit or wiring fault	Check supply, signal and Ground
Temperature reads hot extreme	Input shorted to Ground	Check wiring
Temperature reads cold extreme	Open sensor circuit	Check sensor and connector
Lean AFR in cold weather	Too little low-temperature fuel compensation	Increase cold-air compensation
Rich AFR in cold weather	Too much low-temperature fuel compensation	Reduce cold-air compensation
Lean after heat soak	Excessive fuel removal or poor sensor position	Check sensor position and high-temperature correction
Rich in hot conditions	Too little high-temperature fuel removal	Increase fuel removal
Engine sluggish when hot	Excessive timing retard	Reduce retard where safe
Reduced knock margin when hot	Insufficient timing protection	Increase suitable retard or reduce load/boost

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Sensor Failure Strategy

Do not use the first and last points of the Air Temperature Compensation Graph as the primary method of sensor-failure protection.

Extreme temperatures may be genuine operating conditions.

Where supported, sensor failure should preferably be detected by firmware using suitable diagnostics such as:

- Open-circuit detection.
- Short-circuit detection.
- Implausible temperature detection.
- Safe substitute temperature.
- Engine-load or boost protection where required.

The exact diagnostic strategy depends on Device and firmware generation.

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Engineering Templates

The Air Temperature Engineering Templates are intended as starting calibrations.

Naturally Aspirated Petrol

Suitable starting point for:

- Typical naturally aspirated petrol engines.
- MAP-based tuning.
- TPS-based tuning with the required additional compensation.

Turbocharged Petrol

Suitable starting point for:

- Turbocharged engines.
- Supercharged engines.
- Applications requiring stronger high-temperature timing protection.

The templates must be verified on the actual engine.

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Setup Check

Before relying on Air Temperature information and compensation, verify:

[ ] Air Temperature Sensor is enabled.

[ ] Correct NTC Resistance selection is used.

[ ] Sensor is compatible with the Device hardware.

[ ] Hot Calibration is reasonable.

[ ] Cold-engine Air Temperature is reasonably close to ambient temperature.

[ ] Realtime temperature changes smoothly.

[ ] Sensor is positioned in representative airflow.

[ ] Sensor is not excessively affected by engine or exhaust heat.

[ ] Base fuel and ignition Tune is correct at the reference temperature.

[ ] Fuel compensation is approximately zero at the chosen reference temperature.

[ ] Timing compensation is approximately zero at the chosen reference temperature.

[ ] Naturally aspirated or turbocharged Engineering Template is suitable.

[ ] Compensation has been verified under different operating temperatures.

[ ] Heat soak is not being mistaken for true intake-air temperature.

[ ] Turbocharged applications have appropriate high-temperature protection.

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