firing angle is 0° ± 3° with the throttle switch at 0° (closed) the turbo control unit will switch from operating to start mode.
When the turbo control unit is switched to operating mode it works in conjunction with an operating ignition map stored in the ignition control unit. This combination of control unit data and ignition control unit data determines the optimum firing point for each operating condition based on engine load, engine speed, engine temperature, intake air temperature, 0° throttle switch and fuel selector switch position.
<u>Ignition delay:</u>
In order to ensure complete combustion of the fuel that may have been injected before the engine is turned off. The ignition will remain on for approximately 5 seconds after the engine is turned off.

Image courtesy of Steve Shanks

Other engine sensors and information sources

<u>Fuel selector switch:</u>
In certain countries fuel octane levels lower than the recommended RON 95 may be mandated for use in automobiles. In order to avoid random ignition taking place in the engine, the ignition may be retarded by 2.3° from a certain engine load via a 2-pin code plug using jumper part number 944 612 525 01.
<u>Manifold pressure sensor:</u>
When starting the engine, the manifold pressure sensor is checked for short-circuiting and open circuit, i.e. the firing angle corresponding to the full-load curve (1,800 mbar). If output pressure is below 750 mbar it will be short circuit or above 1250 mbar it will be open circuit.
<u>Electronic idle stabliser</u>
If the idle speed drops below a certain value a stabilising feature becomes effective by moving the firing angle in an "advance" direction.
<u>Signal sensor</u>
This sensor is identical to the flywheel speed/reference mark sensor used in the normally aspirated 964 series of engines. This sensor measures flywheel speed and supplies its signal to the ignition control unit.
<u>Engine temperature sensor</u>
A standard negative temperature co-efficient (NTC) sensor that measures the engine oil temperature (engine temperature). It is mounted into the crankcase. This sensor is used to adjust ignition timing in accordance with temperature. The condition of this

sensor is monitored and if it goes open circuit the engine temperature value from the sensor is ignored and a preset value is used.

Idle switch

The 0° throttle switch keeps the ignition control unit informed on the idle and overrun mode of the engine.

Engine speed governor:

To protect the engine from excessive speeds, the turbo control unit interrupts the ground pulse to the fuel pump relay at 6,800 rpm, causing the fuel pumps to be de-energised.

Fuel Delivery

Fuel pumps:

The turbo has two fuel pumps. One installed directly behind the fuel tank and the other, in the right hand side of the luggage compartment. Both pumps are controlled by the fuel pump relay R61.

Terminal 30 of the fuel pump relay is connected to the positive side of the battery. Voltage is present at terminal 86 when the ignition is switched on. When the engine is started, a rpm pulse (equivalent to approximately 30 rpm) is fed from the ignition control unit to the turbo control unit. This is in turn supplies a ground pulse to the relay coil of terminal 85 of the fuel pump relay. The relay contacts close, causing voltage to be present at the fuel pump fuses and the fuel pumps respectively across terminal 87. This wiring set up prevents the fuel pumps from operating when the ignition is turned on and the engine is not running.

Image courtesy of Steve Shanks

Note: *The turbo is fitted with 1 fuel filter and 1 fuel pressure reservoir. The single fuel filter is connected between the fuel pressure reservoir and the fuel distributor.*

Fuel injectors

CIS mechanical fuel injectors are precision nozzles. When the fuel system delivers fuel pressure within the normal pressure range, injector nozzles open and continuously deliver atomized fuel into the intake ports. Each fuel injector is mounted into an insert which is screwed into the intake runner. The injector is held in place by a thick sealing O-ring.

Carbon cannister fuel venting system:
(also known as the fuel tank breather system):

To protect the environment and to reduce specific fuel consumption, all 964s are fitted with a tank breather or carbon cannister system. Fuel vapour is collected in a carbon canister and fed back to the engine if specific requirements are met.

System operation:
The fuel vapours are routed from the fuel tank across the expansion tank and the rollover safety valve reservoir through the bleeder hose to the carbon canister. A purge air line ends in the left-hand rear wheel housing. The vent line of the carbon cannister is connected to the air filter assembly in the normally aspirated 964s and in the Turbo. In the Turbo 3.6 system the carbon cannister vent line is fed to the intake side of the turbocharger across three in-line vacuum controlled valves. These valves are;
Temperature valve which remains open when the engine oil temperature exceeds 40° C and provides a vacuum connection between the throttle body (2° bore) and the switch off valve.
Anti-run-on-valve which is triggered by the temperature valve and remains opens at engine oil temperatures above 40° C and with a minimum throttle deflection of 2° and the engine is not in the boost pressure range.
Control valve which is connected directly to the intake manifold below the throttle across a separate vacuum line. All three valves are connected in series and the carbon cannister contents can only be drawn off and the air-fuel mixture influenced under t he following conditions.
Engine oil temperature greater than 40° C.
Throttle is opened by at least 2° and
The engine is **not** in the boost pressure range

Ignition system

The 964 series of turbocharged engines, the M30/69 and M64/50 use a similar, but not identical, ignition system.
System components:
A single engine driven distributor assembly.

One ignition transformer with built in final driver stage. The ignition transformer is mounted above and to the right of the distributor assembly.
Six spark plugs.
Six spark plug lead set.
A Bosch EZ69 electronic ignition control unit which is mounted to the right of the engine bay electrical distribution panel.
The Ignition control unit relay (#1) is installed inside the engine bay electrical distribution panel.

Image courtesy of Michael Behrman

M30/69 engine:

The ignition system of this engine series is based upon the system installed on the 968/68 turbocharged engine. Most of the parts used are 930 part numbers except for the ignition transformer and the ignition control unit.
The changes introduced for the 964-770 turbo are:

The installation of an electronic ignition control unit with pressure sensor which provides pre-programmed dwell angle and timing maps mixed with air pressure or engine load from the throttle body to provide digital spark control. The ignition control unit part number is 965 602 706 01.

Ignition control unit, image courtesy of Steve Shanks

M64/50 engine:

Whilst similar to the earlier M30/69 engine ignition system some changes to the M64/50 were introduced the 964 Turbo 3.6 made its appearance in model year 1993. These differences are:

The installation of a new ignition control unit with modified ignition mapping pre-programmed into the control unit. The new part number is 965 602 706 02.

The pressure sensor line was relocated to the downstream section of the throttle body. This was done to reduce the impacts of full load pulsations on the pressure sensor installed in the control unit.

Distributor modifications:

Due to a modification to the cooling fan housing a new distributor assembly with a longer drive shaft was installed.

The centrifugal weights (as per the normally aspirated dual ignition system assembly) were installed to ensure overlap between the distributor rotor arm and the individual distributor cap contacts (each spark plug) at high distributor speeds (large ignition advance). These weights help adjust the rotor in the direction of rotation. Helps the rotor arm keep up and not lag behind the engine rpm.

The installation position of the distributor rotor in firing TDC of cylinder #1 was also modified. The notch in the distributor housing is now opposite the fastening nut. This modification also caused the spark plug lead positions to be changed.

The new distributor part number is 965 602 024 00.

The spark plugs used on the M64/50 are the Bosch FR 6 LDC. These are longer life and more efficient spark plugs with a replacement interval of 40,000 km (25,000 miles).

Note: *These new spark plugs were installed in all model year 1994 versions of the 964. They can be retro-fitted to all earlier models.*

Basic operation of the electronic ignition control unit
(Bosch EZ69).
(Applicable to all 964 Turbo versions).

The control unit receives inputs from;
Flywheel speed sensor (pulse generator in the parts catalogue).
Fuel octane code.
Boost air temperature.
0° throttle switch.
Power via the relay.
The control unit also has a pressure sensor installed. This pressure sensor is connected to the throttle body. The purpose of the pressure sensor is to provide engine load (amount and pressure of air entering the engine) data to the ignition control unit.
Note: *The pressure sensor in the ignition control unit has the same role as the air flow sensor in the normally aspirated engines.*
The control unit then calculates the correct dwell angle and when to fire each spark plug based in calculations from all the electronic inputs, the pressure input and the pre-programmed digital maps.
The outputs from the control unit are,
Signal at the ignition transformer
Engine speed (rpm) to the turbo boost control unit and to the tachometer (rev counter).

Turbo exhaust system

The exhaust system of the turbocharged engines (M30/69 and M64/50) serves two purposes;
To allow exhaust gases to leave the engine and enter the atmosphere and
To drive the turbocharger.
The turbocharged exhaust system is fitted with a metal three-way catalytic converter. The catalytic converter is mounted where the primary (or intermediate muffler) is mounted on normally aspirated 964 is installed.

<u>**Exhaust system operation:**</u>

The engine exhaust gases pass from the exhaust manifold into the heat exchangers. The exhaust gases are then routed to the turbine of the turbocharger. The exhaust gas then pass into the catalytic converter and into the muffler system (front and rear) and then exit the system from the right hand exhaust pipe.

Right hand side of the exhaust, image courtesy of Steve Shanks

The left exhaust pipe is connected to the boost control valve (waste gate) and used to dump the excess boost pressure to the atmosphere. There is a secondary catalytic converter connected between the waste gate and the left hand exhaust tip. This is required because there is a direct input connection between the boost control valve and the exhaust system.

Note: To meet very strict Swiss emission and noise requirements, turbocharged 964s sold in Switzerland are equipped with some different exhaust system components.

Left side exhaust, image courtesy of Steve Shanks.

Secondary Air injection:

Secondary air injection is provided by the secondary air injection pump. This pump is belt-driven off the left camshaft The purpose of this secondary air pump is to reduce emissions and to enable the catalytic converter and the oxygen sensor to heat up more rapidly to operating temperature. Fresh air is drawn in by the air injection pump and is supplied to the air diverter valve as long as the engine oil temperature is below 35° (95°F). The diverter valves control flow of secondary air to the exhaust ports. When the engine is cold, the valves are open to increase burning of excess fuel used for cold start and cold running. A check valve in the system keeps exhaust gases from flowing back through the system. If the engine is started with an engine oil temperature above 35° (95°F), the fresh air supplied by the secondary air pump is supplied to the catalytic converter, resulting in improved emission treatment.

Air pump and secondary injection components. Photo by Kevin Ross

Turbocharger

The reason for installing a turbocharger onto an engine is to obtain the maximum horsepower available from it. The basic principle of the turbocharger is to force-feed the engine with additional air and fuel. An increased volume of air and fuel in the combustion chamber of the engine provides more combustion power. Turbo-charging is a means to *dynamically* increase the engine compression ratio.

The turbocharger is powered by exhaust gases that are already on the way out of the engine, effectively making free additional power. Boost is the amount of pressure created by the turbocharger. Higher boost pressures translate into higher power output.

In the sports cars world, Porsche was a pioneer in turbo-charging. Porsche built the first series production run of turbocharged sports cars, releasing them in 1975 as the 930. On the road, nothing could touch them, and for many years, they remained the fastest sports cars avail-able.

This technology and expertise was integrated into the 964 series for the 1991 model year. The turbocharger used for the standard Turbo and Turbo 3.6 was the same as the one used on the 930/68 engine, part number 930 123 003 02. The 20 Turbo S2s were delivered to the USA with the same part number turbocharger but this was removed and replaced with a new larger assembly by Andial. The Turbo S and the Turbo 3.6S were fitted with new larger turbochargers at the factory.

<u>Boost pressure control valve (also known as the Waste gate)</u>

The boost pressure control valve has two ports. The lower port allows boost pressure to come in underneath the diaphragm and spring valve. As long as boost pressure from the turbocharger remains below the spring tension value which is equivalent to s specific boost pressure, the boosted air is permitted to continue on its way to the intercooler. Once the boost pressure has overcome the spring tension i.e. exceeded the allowable boost pressure value, a valve attached to the diaphragm and plates is pulled up. This then bypasses boost pressure through the control valve through a small catalytic converter and an exhaust pipe to atmosphere. The top port of the waste gate allows the air above the diaphragm to vent as pressure is built under it.

Image courtesy of Stephen Kaspar

Catalytic converter

The catalytic converter is a component of the emission control system. Once exhaust gasses enter the catalytic converter, chemical reactions occur within it that ensure that carbon monoxide (CO) and unburned hydrocarbons (HC) are converted to carbon dioxide (CO_2) and water vapor. A catalytic converter operates at 60 to 90% efficiency, depending upon age. This means that the amount of exhaust emissions that enter the catalytic converter are reduced approximately by this percentage. A catalytic converter has a limited life expectancy which depends upon use and external environmental conditions.

Image courtesy of Steve Shanks

Note: *Japanese versions of the 964 used a different catalytic converter from the rest of the world.*

Note: *Option M150 turbocharged engines do not have a catalytic converter installed.*

Caution: *The catalytic converters can be damaged by push- or tow-starting, misfiring of the engine, turning the ignition off whilst still in motion or by other unusual operating conditions.*

• Ensure that no unburned fuel enters the catalytic converter. If this occurs, overheating of the converter will result. In the worse case scenario, a fire could result.

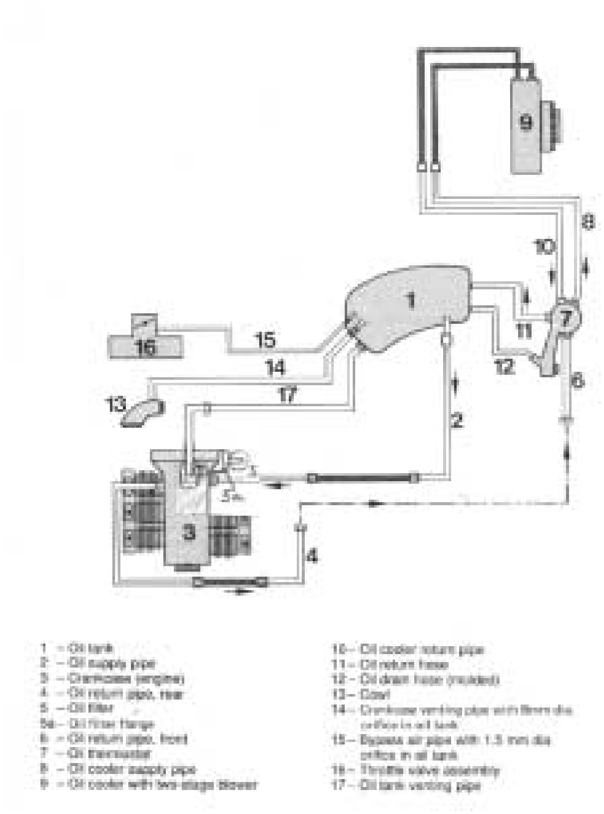
Turbo engine lubrication system

All the engines in the entire 964 series are dry-sumped. This means that the oil is stored externally to the engine in a remotely located oil tank. Oil is drawn out of this tank and through the engine only when it is running. When the engine is not running, most of the oil is returned to the oil tank. Approximately 2 litres remains in the engine and oil cooler system after the engine is turned off. This is important to remember at oil change time. Overfilling with oil can cause problems which are described elsewhere in this book.

Caution: *During a routine oil change service, filling the engine with more than 11 litres of oil will cause the system to be overfilled. Smoke out of the exhaust will result after each start.*

The components of the 3.3 litre turbocharged engine (M30/69) lubrication system are:

- Engine driven oil pump (inside crankcase)



- Oil filter
- Oil tank
- Oil thermostat and plumbing
- Oil cooler assembly and plumbing
- Oil temperature sensor
- Oil pressure switch

The components of the 3.6 litre turbocharged engine (M64/50) lubrication system are the same as the M30/69 engine except the left hand chain tensioner oil gallery has been adapted to supply oil to the turbocharger oil lubrication system.

Image courtesy of Dr. Ing. h. c. F. Porsche AG

Oil circuit description:

The turbocharger is lubricated via a steel pipe combined with a flexible hose. The oil enters the circuit across a union between the main engine oil-gallery and the turbocharger. The fitting at the crankcase features a ball valve which acts as a check valve.

Once the oil has passed through the turbocharger, the oil flows into an oil trap and then is returned to the oil tank via the camshaft driven oil pump. The crankcase breather line is fitted with a branch line to direct the return flow to the oil tank.

The Turbo 3.6 model uses the same lubrication system except for differences caused by the design of the M64 series engine. These are;

The connection to the turbo oil system is located on the oil supply galley at a connection in the left side chain tensioner. Previously unused (blocked off in the normally aspirated M64 engines) oil galleries are opened to provide the oil to the turbocharger.

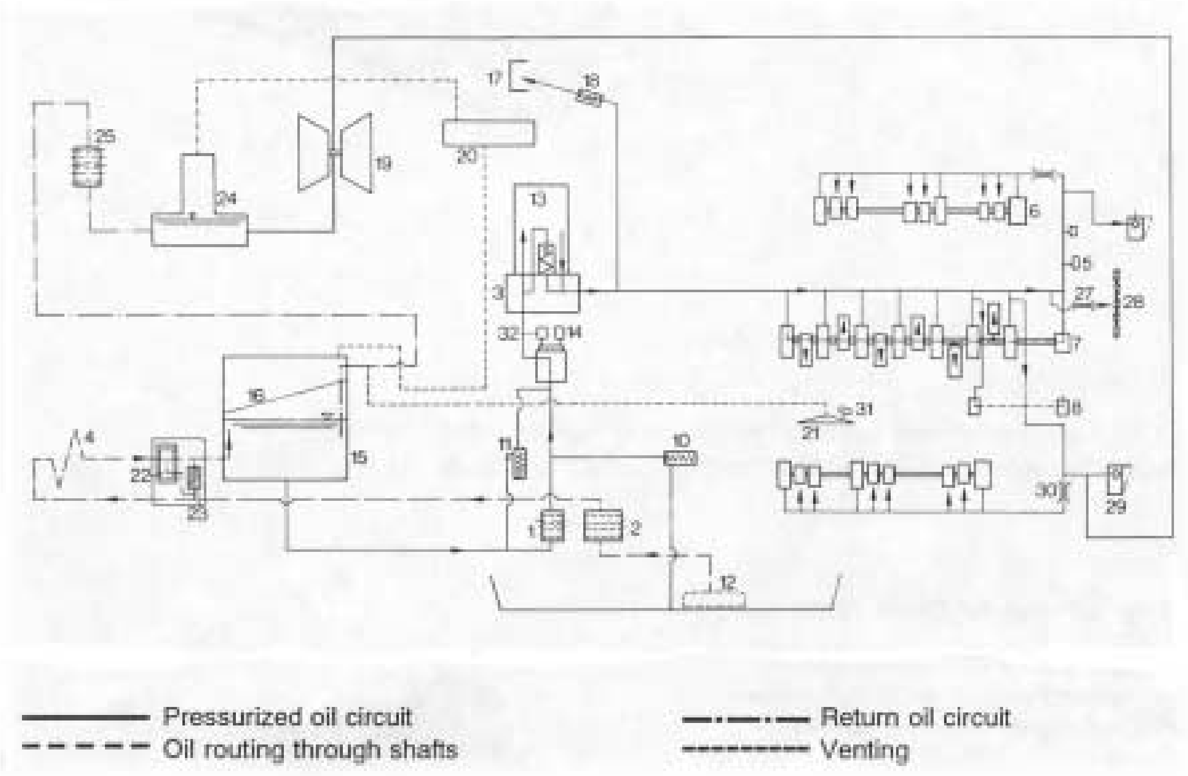


Image courtesy of Dr. Ing. h. c. F. Porsche AG

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