C Diagnostic Equipment

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General Information

This section covers the use of engine analyzers made by Bear and Sun and their measurement capabilities. The desired measurement results are explained in the appropriate sections, and malfunctions are illustrated by examples.

These engine analyzer allows more in-depth testing when solving engine running problems. As a result, the troubleshooting sequence or procedures are different. The Engine testing, adjusting (job no. 07-1100) procedure remains valid for these engine analyzers.

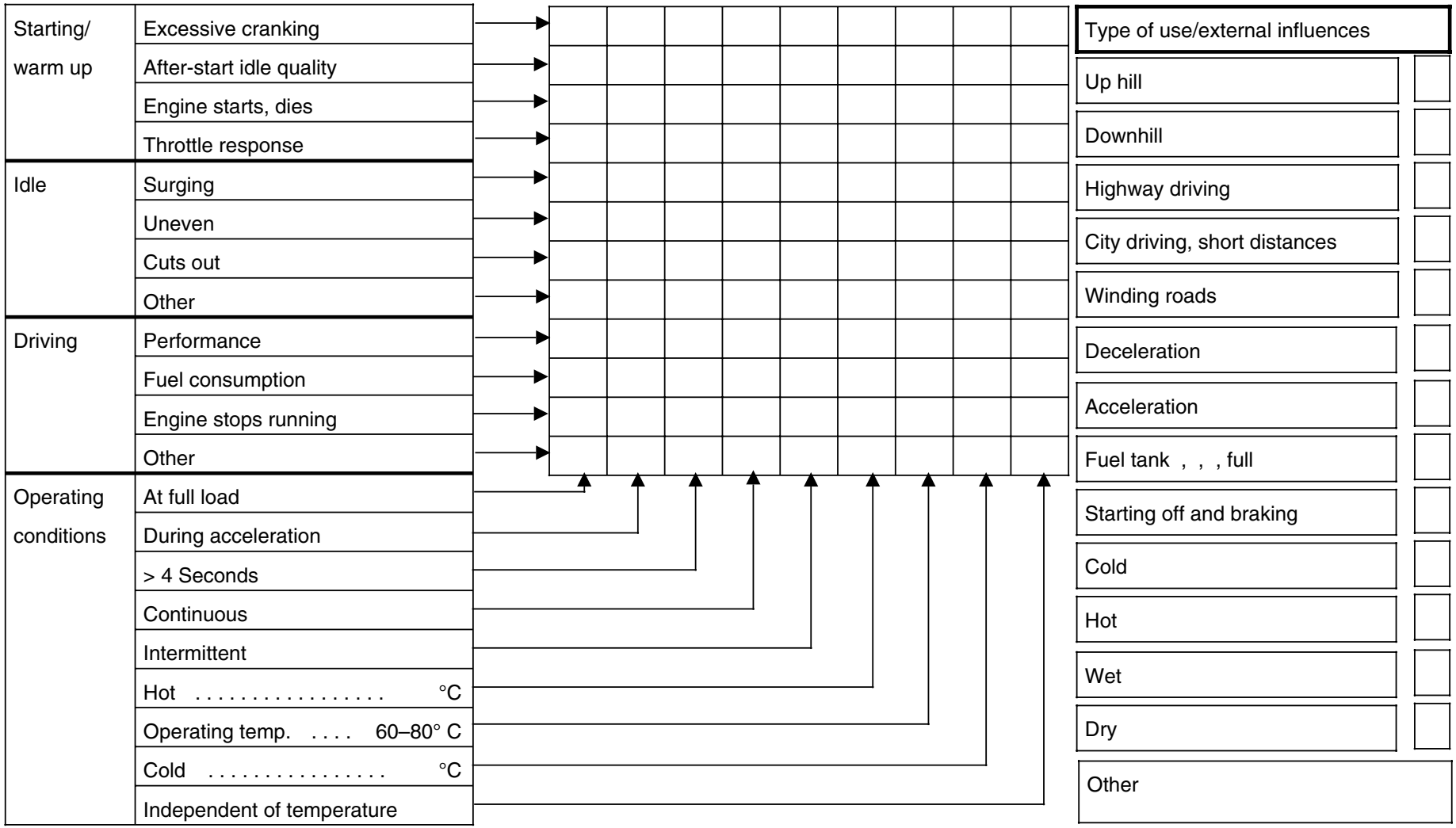
To simplify the start of the test procedures, a complaint analysis form, see page 12/1, can be used to record customer complaints. In this way, a broader information base is available when performing the necessary test procedures, which are intended to result in a faster diagnosis. Block diagrams (flowcharts) labeled **Engine does not run** or **Engine runs,** shown on pages 13/1 and 14/1, respectively, show a general approach to starting the test sequence.

The engine analyzer is equipped with an automatic data storage feature, automatic program start and cycle sequence. Individual data can be displayed on the screen and printed via an attached printer. Thus, the test data are available at all times in print.

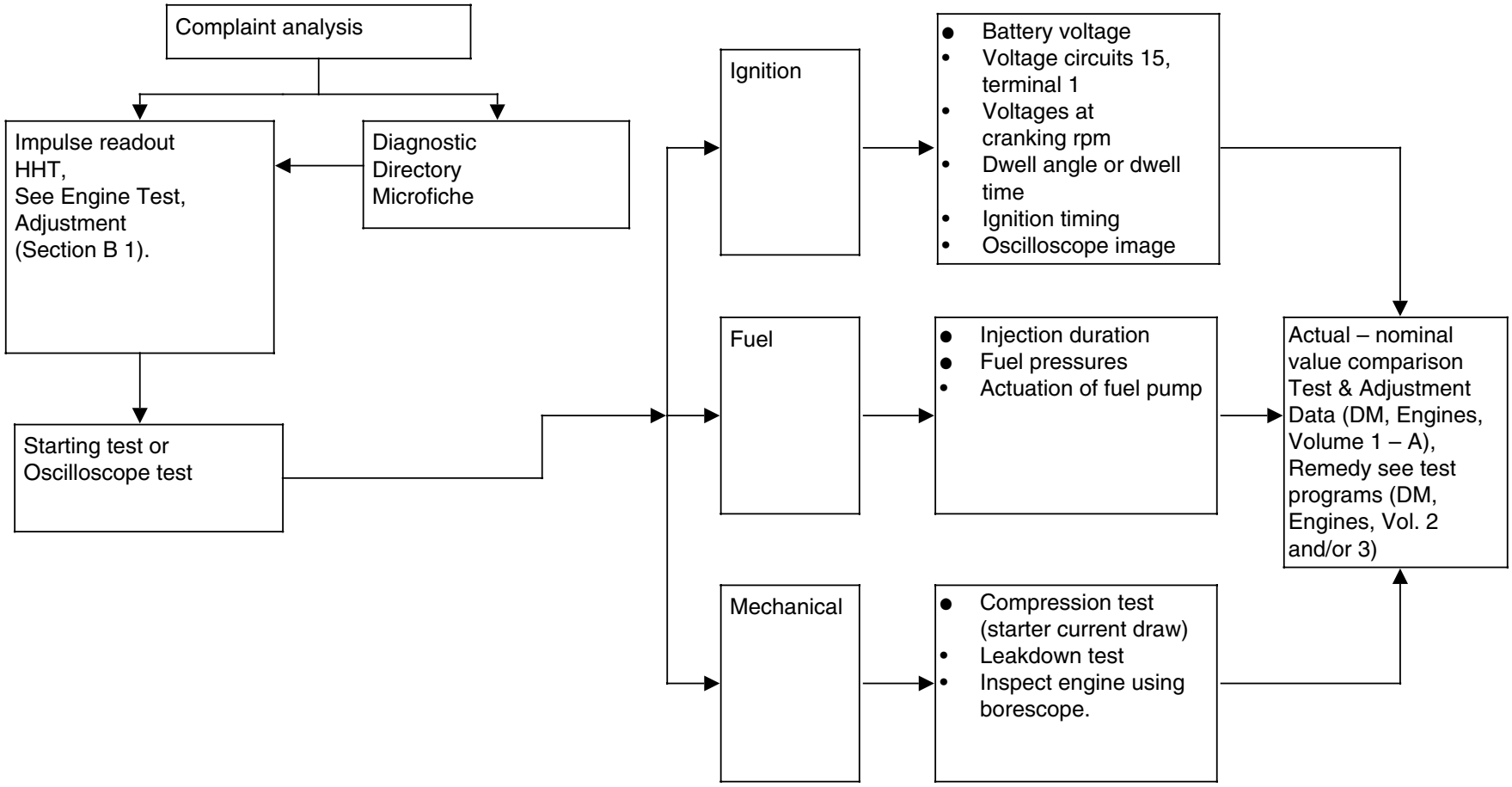
Wrong entries, due to operator error, are automatically recognized and displayed or not executed. The exact operating description is stored in the engine analyzer and can be recalled at any time. If necessary, the individual page can be printed.

Complaint Analysis

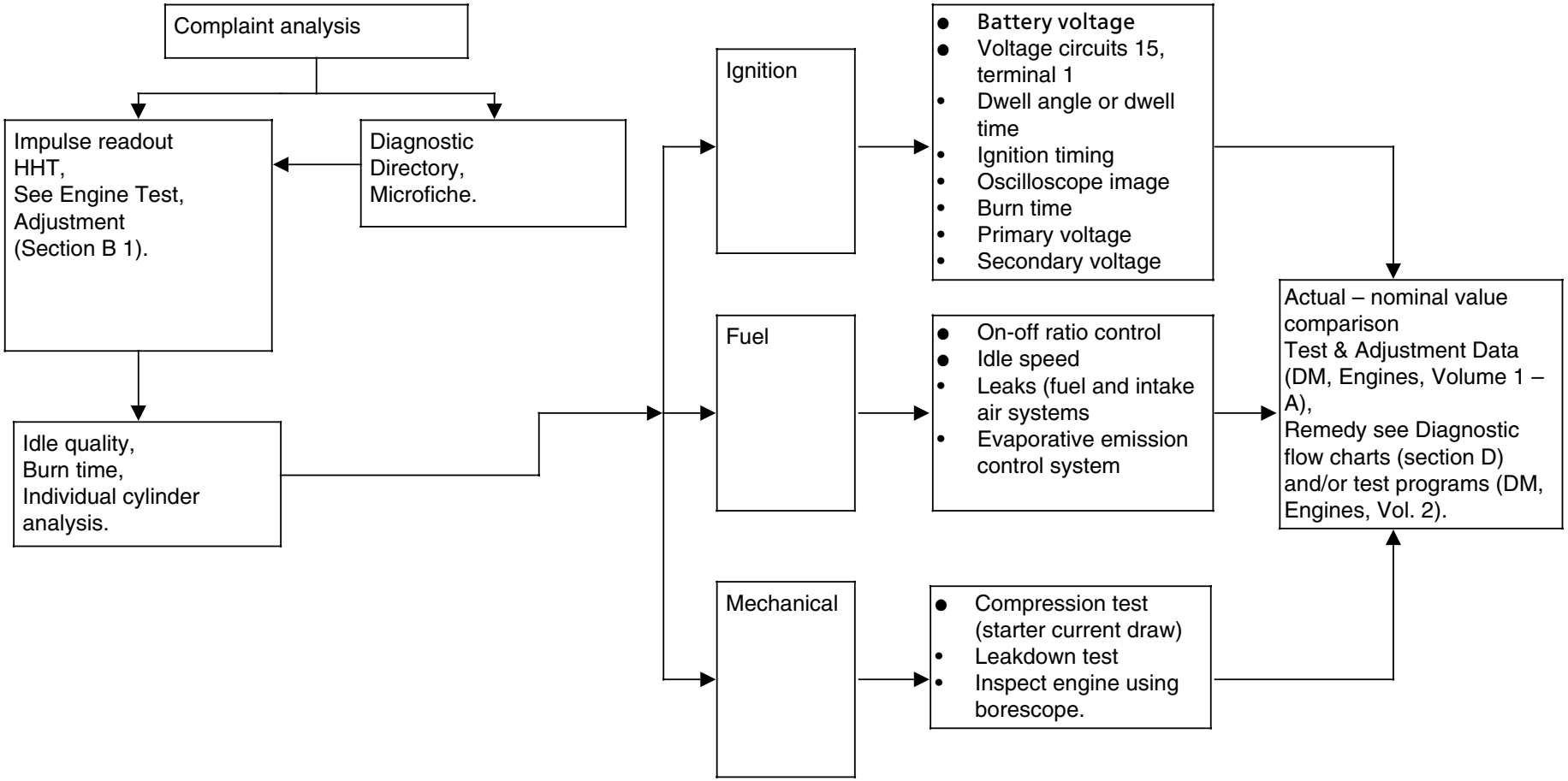
(Make copies of this master form, which should be filled in according to customer complaint, noting the problem and under what conditions it occurs.)



Test Sequence: Engine does not run



Test Sequence: Engine runs



Connection Diagrams – Test Conditions, General Information

Test conditions

- Inspect external condition of engine, check for leaks and noises.
- Most recent oil change should not be more than 1 year or 7,500 miles (12,000 km) ago. Otherwise, oil and filter **must** be changed under separate repair order.

⚠

- Engine oil temperature approximately 80 °C.

⚠

When diagnosing starting or warm up complaints, do not check engine at operating temperature, instead proceed according to specific complaint.

- Climate control system switched off.
- Engine coolant level correct.
- Engine oil level correct.
- Automatic transmission fluid level correct.
- Air injection must be off.
- Additional consumers must be turned off.

Safety notes:

⚠

All disconnecting/connecting of electrical components, as well as test meters and other test equipment, in the engine compartment and on the ignition system, must always be performed with the engine and the ignition turned off.

No voltage carrying components on the ignition system are to be touched when the ignition is turned on or the engine is running. Dangerously high voltage is present on the secondary as well as the primary side.

The safety cautions in the SMS repair instructions, group 15 are to be strictly followed.

Connection Diagrams – Single Ignition System

Engines 102/103/116/117 CFI, 104 CFI/LH-SFI

⚠

When diagnosing starting or warm up complaints, do not check engine at operating temperature, instead proceed according to specific complaint.

Diagnostic plug (060) to diagnostic socket (X11)	connect, disconnect
Trigger clamp (061) on ignition cable “1”	connect, disconnect
Kilovolt clamp (062) on ignition cable “4” of ignition coil T1	connect, disconnect
Oil thermometer (064) in engine oil dipstick tube	insert, remove
DC inductive clamp [1] (065) to battery G1 ground	connect, disconnect
Exhaust vent hose (014) to exhaust pipe	connect, disconnect
Vacuum connection with Y-adapter (068) to DI control module (N1/3)	connect, disconnect
Vehicle data	enter.

⚠

Engine oil temperature approximately 80 °C	warm engine up.

1) On model 129, connect to ground strap between engine, transmission and body (vehicle right side), or for inductive clamp connection to positive battery lead, remove passenger side floor mat and connect to positive cable.
On model 140, connect to ground strap between engine, transmission and body (vehicle lower left side), (on engine 104 connect to starter positive cable).

Connection Diagrams – Single Ignition System

Engines 102/103/104 CFI

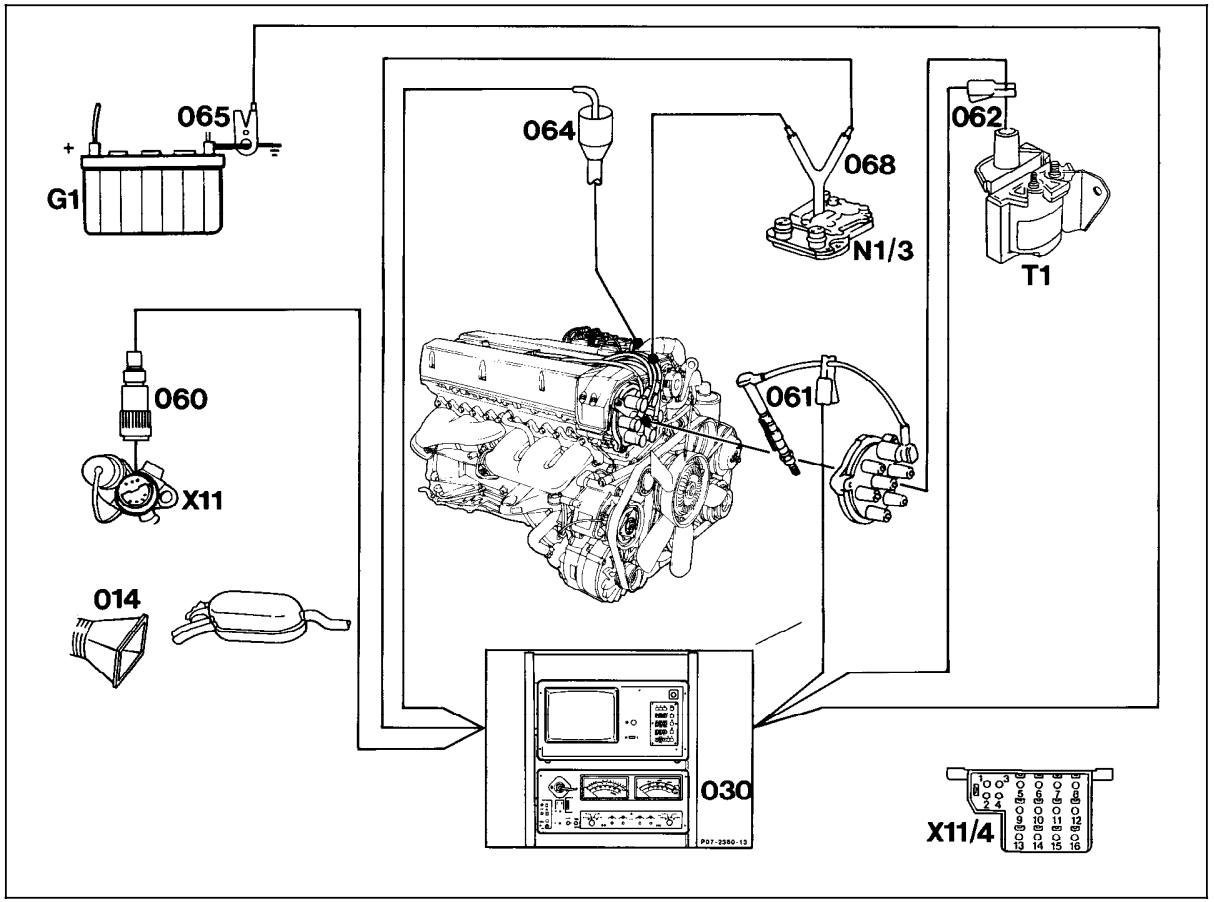


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Figure 1

G1	Battery
N1/3	DI control module
T1	Ignition coil
X11	Diagnostic socket (9-pole)
X11/4	Data link connector (DTC readout)
014	Exhaust vent hose
030	Engine analyzer
060	Diagnostic plug
061	Trigger clamp (cylinder 1)
062	Kilovolt clamp (on ignition coil)
064	Oil thermometer
065	DC inductive clamp
068	Y-adapter (vacuum)

Connection Diagrams – Single Ignition System

Engine 104 LH-SFI

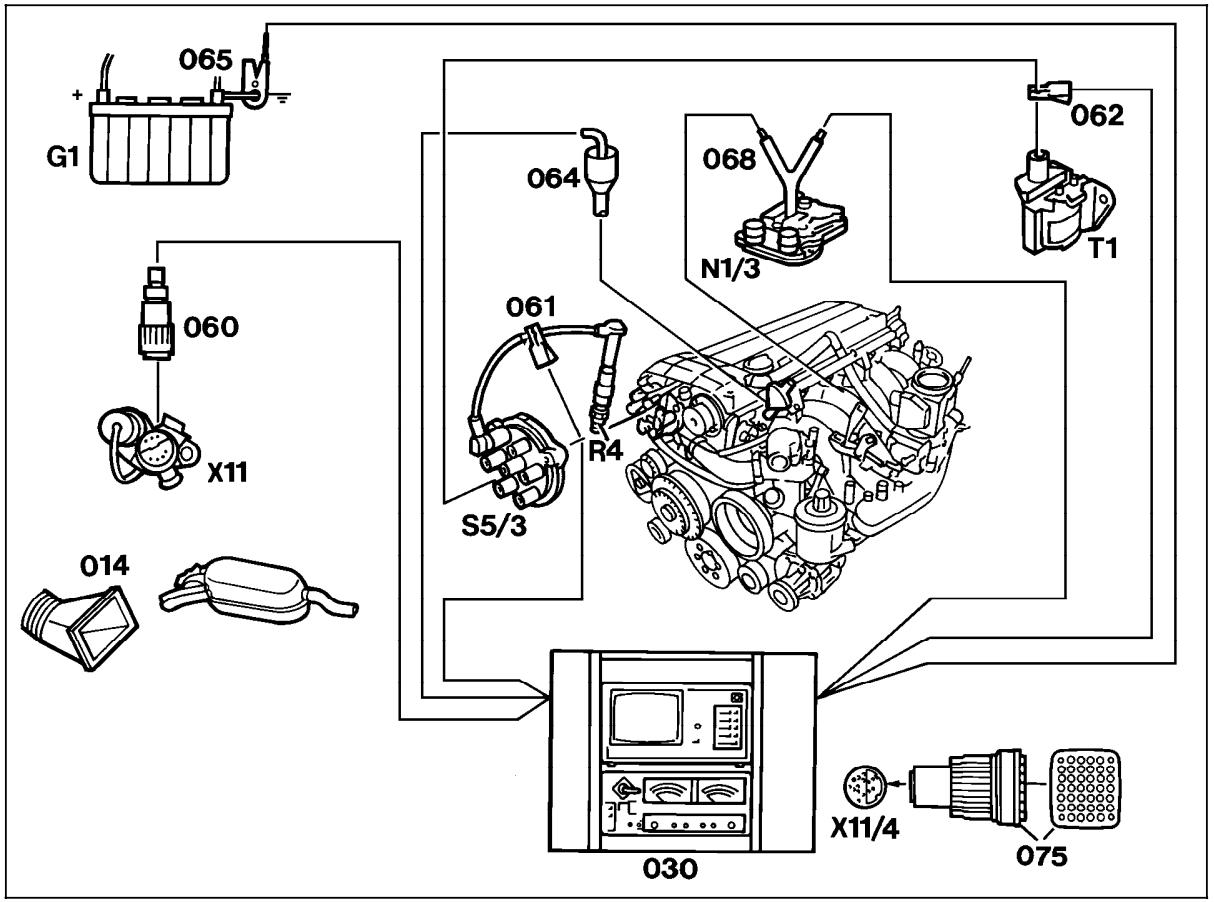

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Figure 2

G1	Battery
N1/3	DI control module
R4	Spark plug
T1	Ignition coil
X11	Diagnostic socket (9-pole)
X11/4	Data link connector (DTC readout)
014	Exhaust vent hose
030	Engine analyzer
060	Diagnostic plug
061	Trigger clamp (cylinder 1)
062	Kilovolt clamp (on ignition coil)
064	Oil thermometer
065	DC inductive clamp
068	Y-adapter (vacuum)
075	Impulse counter scan tool adaptor

Connection Diagrams – Single Ignition System

Engines 116/117 CFI

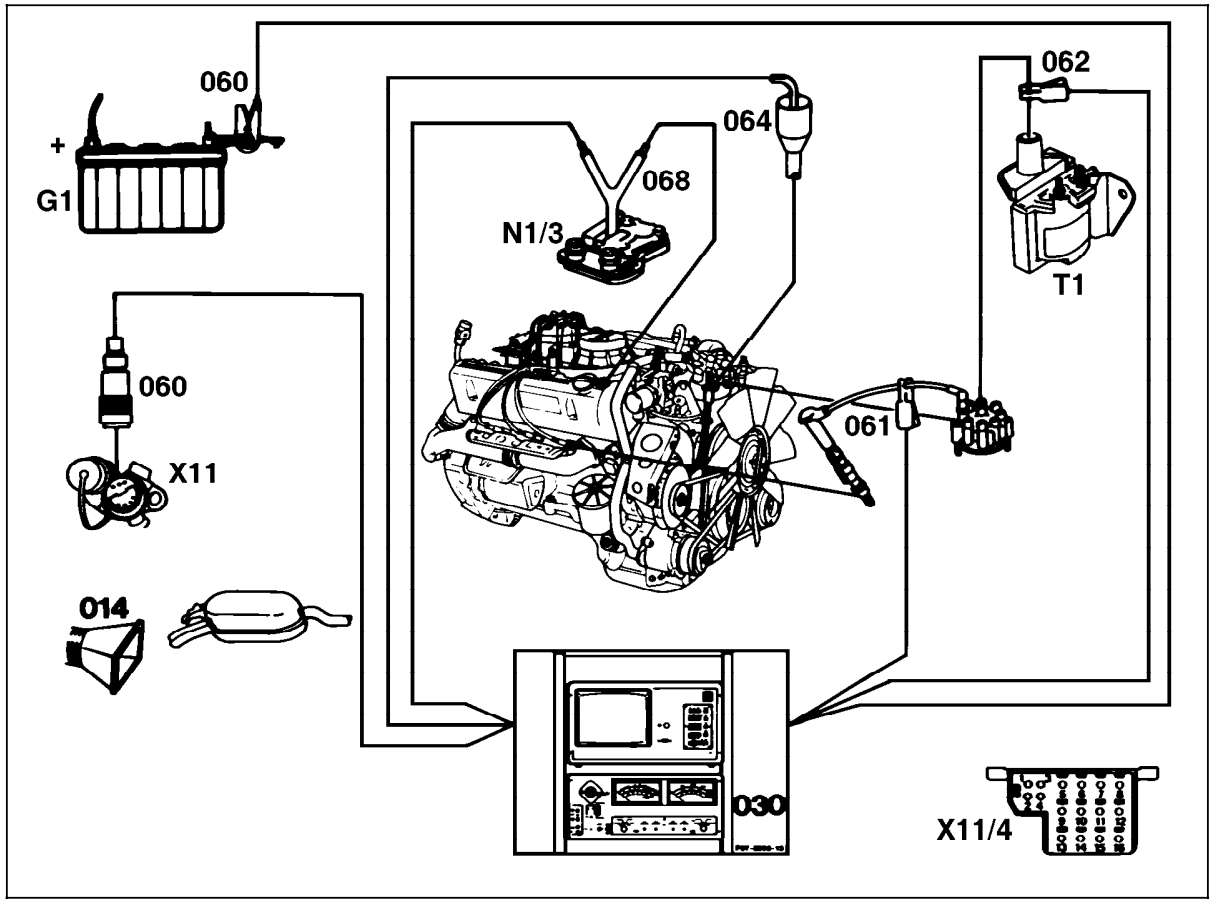

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Figure 3

G1	Battery
N1/3	DI control module
T1	Ignition coil
X11	Diagnostic socket (9-pole)
X11/4	Data link connector (DTC readout)
014	Exhaust vent hose
030	Engine analyzer
060	Diagnostic plug
061	Trigger clamp (cylinder 1)
062	Kilovolt clamp (on ignition coil)
064	Oil thermometer
065	DC inductive clamp
068	Y-adapter (vacuum)

Connection Diagrams – Dual Ignition System

Engines 119 CFI/LH-SFI

⚠

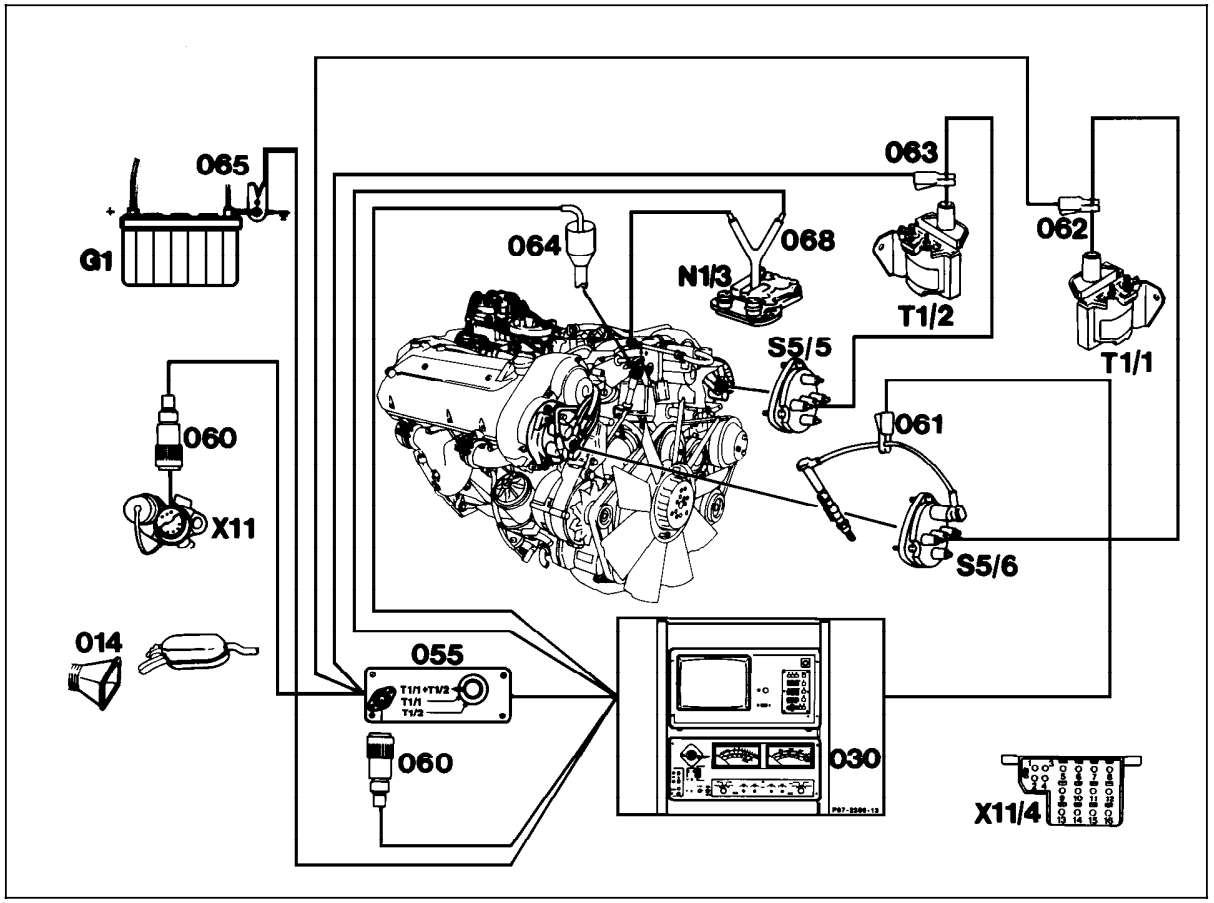
When diagnosing starting or warm up complaints, do not check engine at operating temperature, instead proceed according to specific complaint.

Diagnostic plug (060) to diagnostic socket (X11)	connect, disconnect
Diagnostic plug (060) to dual ignition adaptor	connect, disconnect
Knob to position “T1/1 & T1/2”	turn
Plug of dual ignition adaptor (055) to diagnostic socket (X11) [2]	connect, disconnect
TN signal/on-off ratio signal connector [3]	connect, disconnect
Trigger clamp (061) on ignition cable “1”	connect, disconnect
Kilovolt clamp (062) and (063) on ignition cable “4” of ignition coil T1/1 and T1/2	connect, disconnect
Oil thermometer (064) in engine oil dipstick tube	insert, remove
DC inductive clamp [1] (065) to battery G1 ground	connect, disconnect
Exhaust vent hose (014) to exhaust pipe	connect, disconnect
Vacuum connection with Y-adapter (068) to DI control module (N1/3)	connect, disconnect
Vehicle data	enter.
⚠ Engine oil temperature approximately 80 °C	warm engine up.

1) On model 129, connect to ground strap between engine, transmission and body (vehicle right side), or for inductive clamp connection to positive battery lead, remove passenger side floor mat and connect to positive cable.
On model 140, connect to ground strap between engine, transmission and body (vehicle lower left side).
2) Up to 06/93.
3) Starting 07/93.

Connection Diagrams – Dual Ignition System

Engine 119 CFI



U07-0312-57

Figure 1

G1	Battery
N1/3	DI control module
S5/5	Left high-voltage distributor
S5/6	Right high-voltage distributor
T1/1	Ignition coil 1 (right cylinder bank)
T1/2	Ignition coil 2 (left cylinder bank)
X11	Diagnostic socket (9-pole)
X11/4	Data link connector (DTC readout)
014	Exhaust vent hose
030	Engine analyzer
055	Dual ignition adaptor
060	Diagnostic plug
061	Trigger clamp (cylinder 1)
062	Kilovolt clamp, right (on ignition coil)
063	Kilovolt clamp, left (on ignition coil)
064	Oil thermometer
065	DC inductive clamp
068	Y-adapter (vacuum)

Connection Diagrams – Dual Ignition System

Engine 119 LH-SFI up to 06/93 with Diagnostic Socket X11

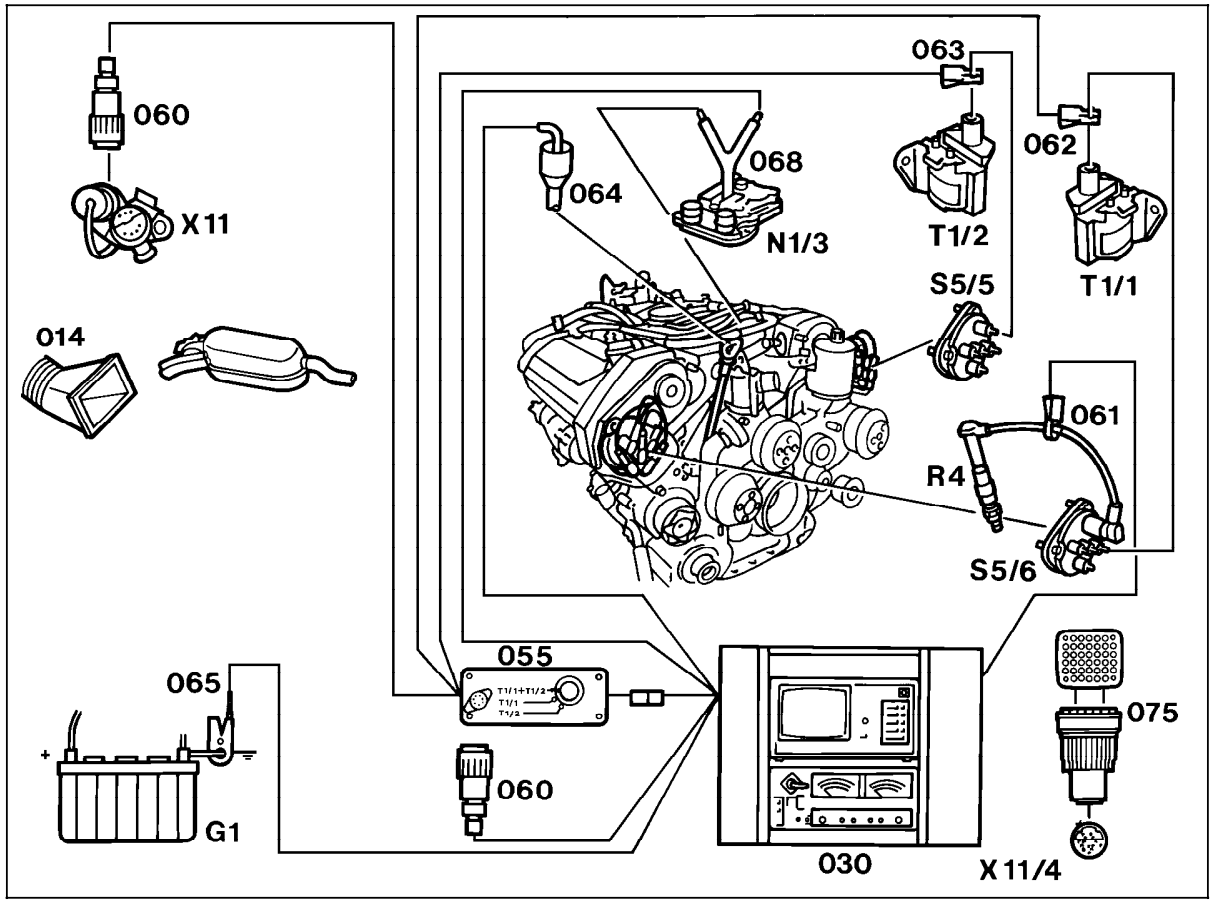


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Figure 2

G1	Battery
N1/3	DI control module
R4	Spark plug
S5/5	Left high-voltage distributor
S5/6	Right high-voltage distributor
T1/1	Ignition coil 1 (right cylinder bank)
T1/2	Ignition coil 2 (left cylinder bank)
X11	Diagnostic socket (9-pole)
X11/4	Data link connector (DTC readout)
014	Exhaust vent hose
030	Engine analyzer
055	Dual ignition adaptor
060	Diagnostic plug
061	Trigger clamp (cylinder 1)
062	Kilovolt clamp, right (on ignition coil)
063	Kilovolt clamp, left (on ignition coil)
064	Oil thermometer
065	DC inductive clamp
068	Y-adapter (vacuum)
075	Impulse counter scan tool adaptor

Connection Diagrams – Dual Ignition System

Engine 119 LH-SFI starting 07/93 without Diagnostic Socket X11

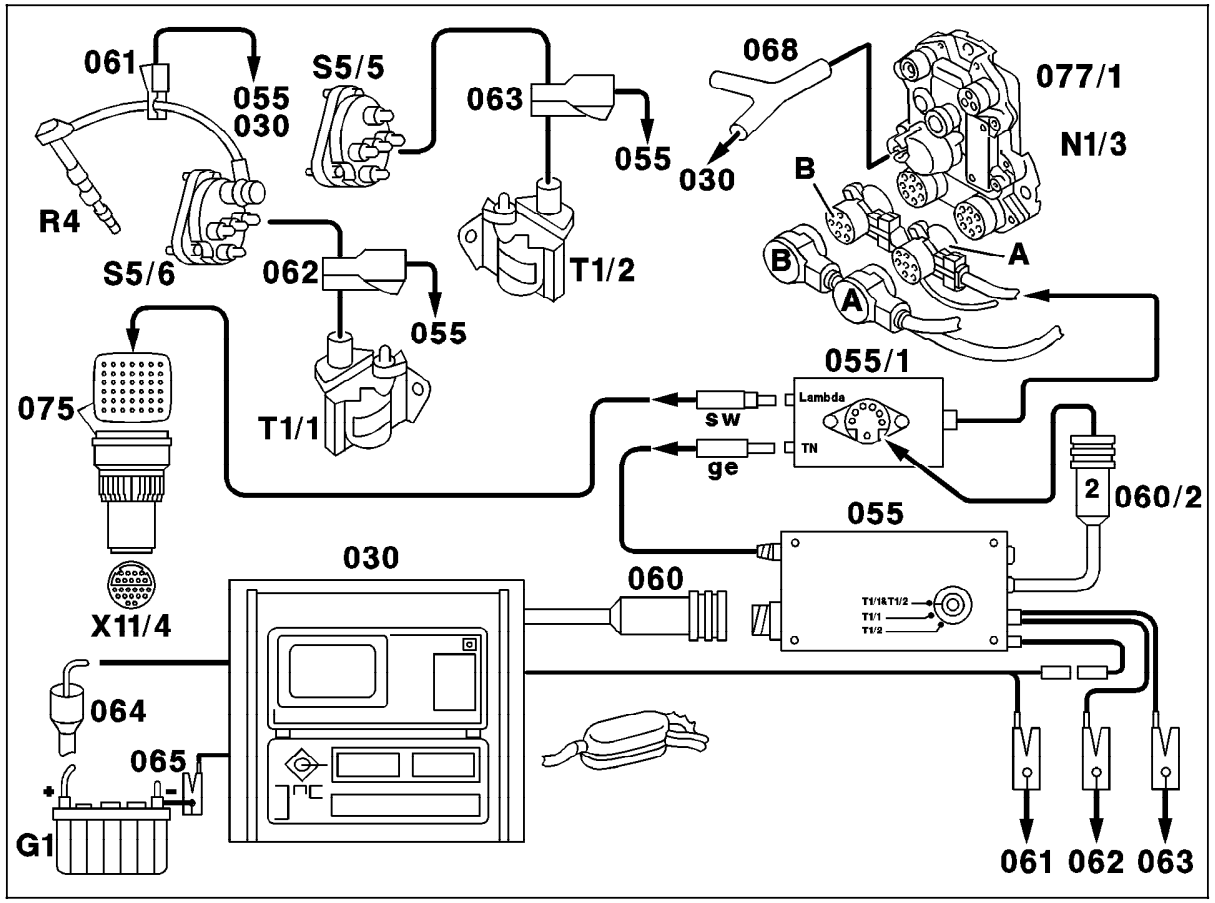

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Figure 3

G1	Battery
N1/3	DI control module
R4	Spark plug
S5/5	Left high-voltage distributor
S5/6	Right high-voltage distributor
T1/1	Ignition coil 1 (right cylinder bank)
T1/2	Ignition coil 2 (left cylinder bank)
X11/4	Data link connector (DTC readout)
030	Engine analyzer
055	Dual ignition adaptor
055/1	TN signal/on-off ratio signal adaptor
060	Diagnostic plug
060/2	Dual ignition adaptor diagnostic plug
061	Trigger clamp (cylinder 1)
062	Kilovolt clamp, right (on ignition coil)
063	Kilovolt clamp, left (on ignition coil)
064	Oil thermometer
065	DC inductive clamp
068	Y-adapter (vacuum)
075	Impulse counter scan tool adaptor
077/1	TN signal plug (in wiring diagram connector “A”, “B”)

Connection Diagrams – Dual Ignition System

Testing with dual ignition adaptor (055)

The dual ignition adaptor provides engine diagnosis on engines with dual ignition systems (engine 119) when using the Bear DACE (Model 40-960) engine analyzer.

With the dual ignition adaptor (055), the single ignition circuits T1/1 and T1/2 are combined to an 8-cylinder ignition circuit. This enables the display of the single circuits and the complete ignition circuit on the oscilloscope. Next to the standard measurements, the diagnostic measuring methods for dynamic compression test, idle quality test and ignition system analysis can be performed. The switch on the dual ignition adaptor allows the selection of measurements on a single ignition circuit, for example: dwell angle, ignition timing, on-off ratio and voltage values of the primary/secondary ignition circuit.

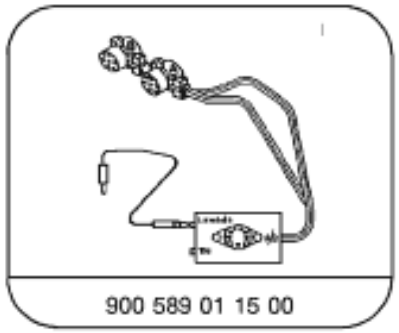
In the total display (switch position T1/1 & T1/2) with the osilloscope in the parade setting, the ignition impulse of ignition circuit T1/1 is shown first. At the end of the fade-out process, switch over to ignition circuit T1/2 occurs and according to firing order the next cylinder, including dwell and current draw are displayed.

Connection Diagrams – Dual Ignition System

	Engine analyzer		Switch position Dual ignition adaptor (055)
	Cyl. number	Trigger clamp	
Dwell angle	4 cylinder	Cylinder 1	T1/1 or T1/2
Ignition timing	4 cylinder	Cylinder 1 Cylinder 2	T1/1 T1/2 ⚠ Measured angle minus 90° CKA
On-off ratio	8 cylinder	Cylinder 1	T1/1 or T1/1 & T1/2
Ignition oscilloscope	8 cylinder	Cylinder 1 Cylinder 5	T1/1 & T1/2 T1/1 firing order 1 – 4 – 6 – 7 T1/2 firing order 5 – 8 – 3 – 2
Compression	8 cylinder	Cylinder 1	T1/1 & T1/2
Idle quality	8 cylinder	Cylinder 1	Idle quality test. Set engine analyzer to TN signal

Connection Diagrams – Dual Ignition System

Special Tools



On-off ratio signal adapter

Equipment

Engine analyzer [1)]	Bear DACE (Model 40-960) Sun MEA-1500 MB
Dual ignition system adaptor	Bear 43-322

1) Available through the MBUSA Standard Equipment Program.

Connection diagrams – Dual Ignition System

Engine 120 LH-SFI

⚠

When diagnosing starting or warm up complaints, do not check engine at operating temperature, instead proceed according to specific complaint.

Diagnostic plug (060) to diagnostic socket (X11), disconnect connector “A” from DI control module and connect plug (077) in between	connect, disconnect
Diagnostic plug (060) to dual ignition adaptor (055)	connect, disconnect
Knob to position “T1/1 & T1/2”	turn
Plug of dual ignition adaptor (055) to diagnostic socket (X11) [2]	connect, disconnect
TN signal/on-off ratio signal connector [3]	connect, disconnect
Trigger clamp (061) on ignition cable “1”	connect, disconnect
Kilovolt clamp (062) and (063) on ignition cable “4” of ignition coil T1/1 and T1/2	connect, disconnect
Oil thermometer (064) in engine oil dipstick tube	insert, remove
DC inductive clamp [1] (065) to battery G1 ground	connect, disconnect
Exhaust vent hose (014) to exhaust pipe	connect, disconnect
Vacuum connection with Y-adapter (068) to DI control module (N1/3)	connect, disconnect
Vehicle data	enter.

⚠

Engine oil temperature approximately 80 °C	warm engine up.

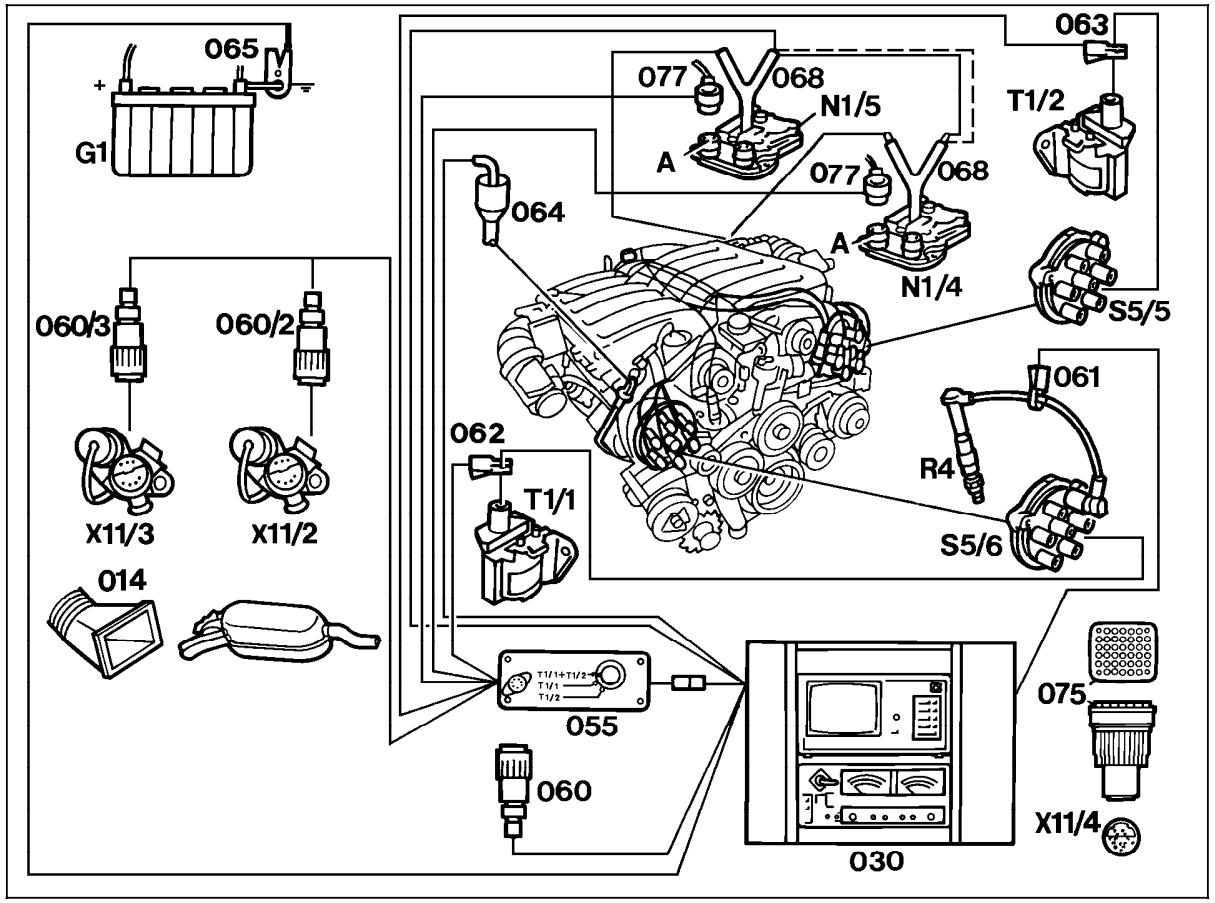
1) On model 129, connect to ground strap between engine, transmission and body (vehicle right side), or for inductive clamp connection to positive battery lead, remove passenger side floor mat and connect to positive cable.
On model 140, connect to ground strap between engine, transmission and body (vehicle lower left side).
2) Up to 06/93.
3) Starting 07/93.

Connection Diagrams – Dual Ignition System

Engine 120 LH-SFI up to 06/93 with Diagnostic Socket (X11)

Figure 1

G1	Battery
N1/4	Left DI control module
N1/5	Right DI control module
R4	Spark plug
S5/5	Left high-voltage distributor
S5/6	Right high-voltage distributor
T1/1	Ignition coil 1 (right cylinder bank)
T1/2	Ignition coil 2 (left cylinder bank)
X11/2	Left diagnostic socket (9-pole)
X11/3	Right diagnostic socket (9-pole)
X11/4	Data link connector (DTC readout)
014	Exhaust vent hose
030	Engine analyzer
055	Dual ignition adaptor
060	Diagnostic plug
060/2	Diagnostic plug – left diagnostic socket
060/3	Diagnostic plug – right diagnostic socket
061	Trigger clamp (cylinder 1)
062	Kilovolt clamp, right (on ignition coil)
063	Kilovolt clamp, left (on ignition coil)
064	Oil thermometer
065	DC inductive clamp
068	Y-adapter (vacuum)
075	Impulse counter scan tool adaptor
077	TN signal plug (in wiring diagram connector “A”)



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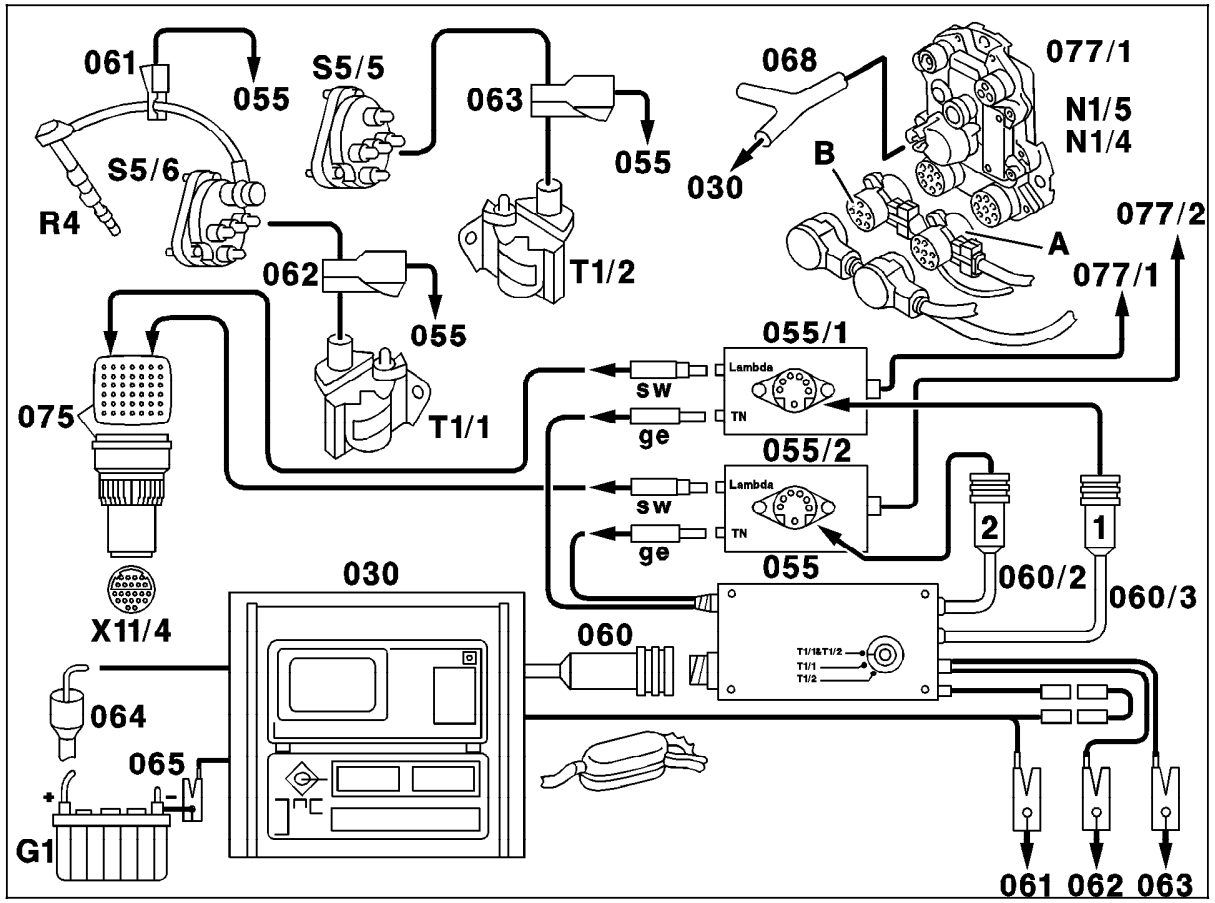
Connection Diagrams – Dual Ignition System

Engine 120 LH-SFI starting 07/93 without Diagnostic Socket X11

Figure 2

G1	Battery
N1/4	Left DI control module
N1/5	Right DI control module
R4	Spark plug (cylinder 1)
S5/5	Left high-voltage distributor
S5/6	Right high-voltage distributor
T1/1	Ignition coil 1 (right cylinder bank)
T1/2	Ignition coil 2 (left cylinder bank)
X11/4	Data link connector (DTC readout)
030	Engine analyzer
055	Dual ignition adaptor
055/1	TN signal/on-off ratio signal adaptor
055/2	TN signal/on-off ratio signal adaptor
060	Diagnostic plug
060/2	Diagnostic plug 2 – right diagnostic socket
060/3	Diagnostic plug 1 – left diagnostic socket
061	Trigger clamp (cylinder 1)
062	Kilovolt clamp, right (on ignition coil)
063	Kilovolt clamp, left (on ignition coil)
064	Oil thermometer
065	DC inductive clamp
068	Y-adapter (vacuum)
075	Impulse counter scan tool adaptor
077/1	TN signal plug to right N1/5 (in wiring diagram connector “A”)
077/2	TN signal plug to left N1/4 (in wiring diagram connector “B”)



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Connection diagrams – Dual Ignition System

The DI control modules on model 129.076 are located in the engine compartment on the left wheelhousing. The 9-pole diagnostic sockets (X11/2, X11/3) are above the DI control modules (N1/4, N1/5).
The assignment of the components to the respective ignition circuit is as follows:

- The DI control module (N1/4) and the diagnostic socket (X11/2) for ignition circuit T1/2 (cylinders 7 – 12) are in the front, as viewed in the driving direction. The connectors “A” and “B” are easily accessible (Figure 6 and 8).
- The DI control module (N1/5) and the diagnostic socket (X11/3) for ignition circuit T1/1 (cylinders 1 – 6) are in the rear, as viewed in the driving direction. The connectors “A” and “B” are not accessible.
  The hot wire MAF sensor must be removed by opening 2 clamps on front of the air filter housing to make the test connections.
  The MAF sensor together with the formed hose (leading to the throttle valve) can then be pushed aside.
- The connectors “A” and “B” of the DI control module (N1/5) are now accessible and the necessary connections to the TN signal/on-off ratio signal adaptor can now be performed.

  ⚠
  The MAF sensor must be installed again for the engine diagnosis, since otherwise it can lead to interferences in the engine performance.

The location of the ignition coils is similar to that of model 129 with engine 119. The outer ignition coil belongs to ignition circuit T1/2 (cylinders 7 – 12), the ignition coil towards the engine belongs to ignition circuit T1/1 (cylinders 1 – 6).

Connection Diagrams – Dual Ignition System

Component Locations

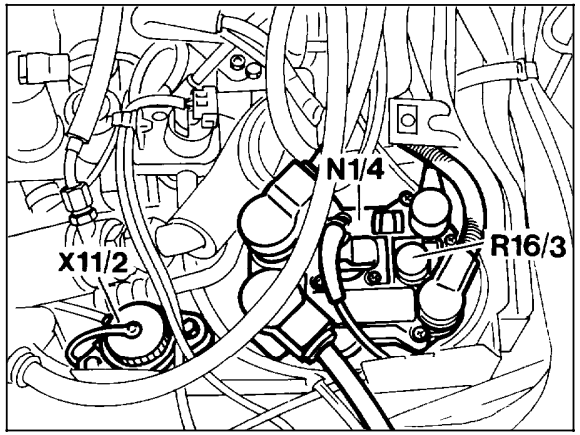

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Figure 3
Model 140

N1/4	Left DI control module
R16/3	Left reference resistor (DI)
X11/2	Left diagnostic socket (9-pole)

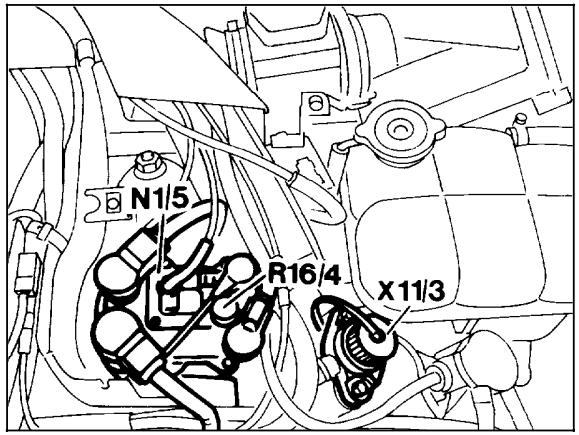

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Figure 4
Model 140

N1/5	Right DI control module
R16/4	Right reference resistor (DI)
X11/3	Right diagnostic socket (9-pole)

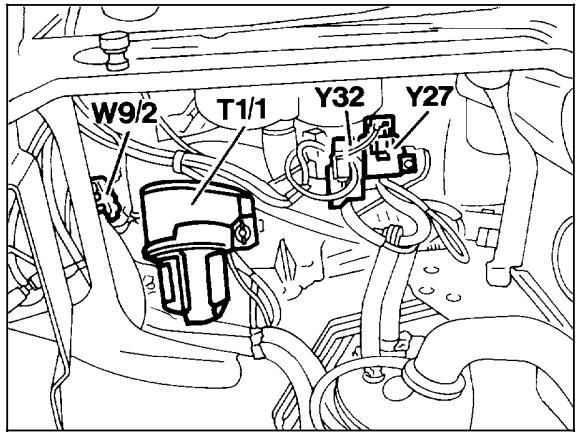

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Figure 5
Model 140

T1/1	Ignition coil 1 (right cylinder bank)

Connection Diagrams – Dual Ignition System

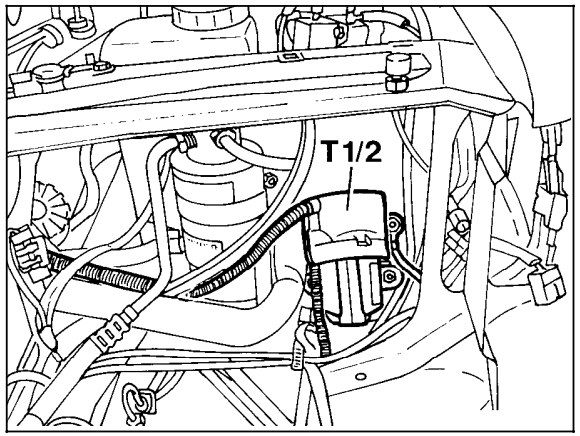

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Figure 6

Model 140

T1/2 Ignition coil 2 (left cylinder bank)

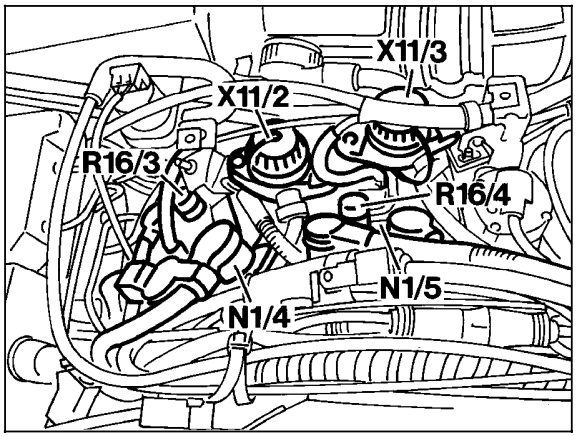

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Figure 7

Model 129

N1/4 Left DI control module
N1/5 Right DI control module
R16/3 Left reference resistor (DI)
R16/4 Right reference resistor (DI)
X11/2 Left diagnostic socket (9-pole)
X11/3 Right diagnostic socket (9-pole)

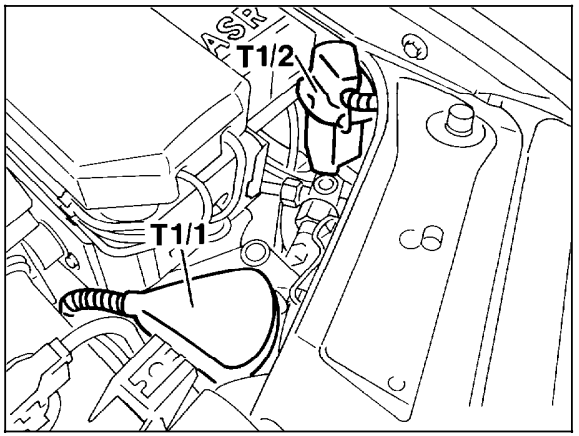

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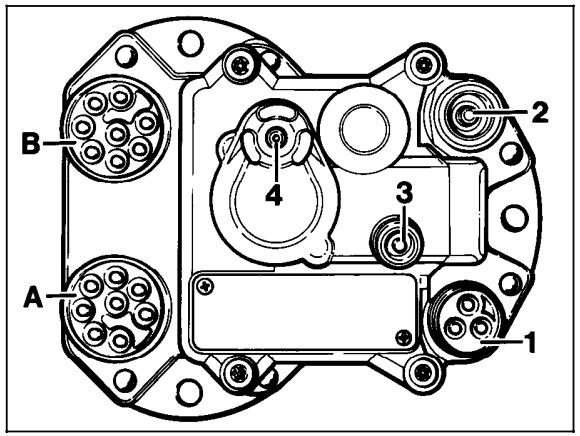
Figure 8

Model 129

T1/1 Ignition coil 1 (right cylinder bank)
T1/2 Ignition coil 2 (left cylinder bank)

Connection Diagrams – Dual Ignition System



P15-2030-13A

Figure 9

Model 129, 140

1	Connector for knock sensor (A16)
2	Connector for CKP sensor (L5)
3	Connector for reference resistor (R16/3, R16/4)
4	Vacuum connector
A	8-pole connector
B	8-pole connector

Connection Diagrams – Dual Ignition System

Testing with dual ignition adaptor (055)

The dual ignition adaptor provides engine diagnosis on engines with dual ignition systems (engine 120) when using the Bear DACE (Model 40-960) engine analyzer.

With the dual ignition adaptor (055), the single ignition circuits T1/1 and T1/2 are combined to a 12-cylinder ignition circuit. This enables the display of the single circuits and the complete ignition circuit on the oscilloscope. Next to the standard measurements, the diagnostic measuring methods for dynamic compression test, idle quality test and ignition system analysis can be performed. The switch on the dual ignition adaptor allows the selection of measurements on a single ignition circuit, for example: dwell angle, ignition timing, on-off ratio and voltage values of the primary/secondary ignition circuit.

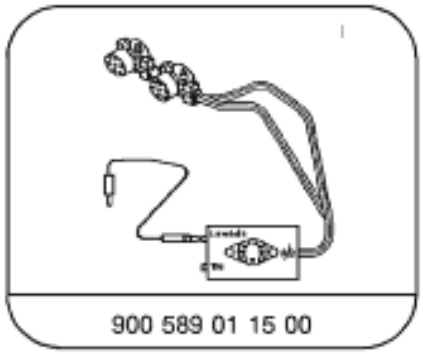
In the total display (switch position T1/1 & T1/2) with the osilloscope in the parade setting, the ignition impulse of ignition circuit T1/1 is shown first. At the end of the fade-out process, switch over to ignition circuit T1/2 occurs and according to firing order the next cylinder, including dwell and current draw are displayed.

Connection Diagrams – Dual Ignition System

	Engine analyzer		Switch position Dual ignition adaptor (055)
	Cyl. number	Trigger clamp	
Dwell angle	6 cylinder	Cylinder 1	T1/1 or T1/2
Ignition timing	6 cylinder	Cylinder 1 Cylinder 12	T1/1 T1/2
On-off ratio	12 cylinder	Cylinder 1	T1/1 or T1/2
Ignition oscilloscope	12 cylinder	Cylinder 1 Cylinder 1 Cylinder 12	T1/1 & T1/2 (possible only up to 4400 rpm) T1/1 firing order 1 – 5 – 3 – 6 – 2 – 4 T1/2 firing order 12 – 8 – 10 – 7 – 11 – 9
Compression	12 cylinder	Cylinder 1	T1/1 & T1/2
Idle quality	12 cylinder	Cylinder 1	Idle quality test. Set engine analyzer to TN signal

Connection diagrams – Dual Ignition System

Special Tools



On-off ratio signal adapter

Equipment

Engine analyzer [1]	Bear DACE (Model 40-960) Sun MEA-1500 MB
Dual ignition system adaptor	Bear 43-322

[1] Available through the MBUSA Standard Equipment Program.

Connection diagrams – Electronic Ignition (EI) System (distributor-less)

Ignition coil description

Engine	Model	Fuel Injection/ Ignition System		Ignition Coil Design		
		HFM-SFI	ME-SFI	Dual Firing Ignition Coil without kV Pickup Mounting [1]	Dual Firing Ignition Coil with kV Pickup Mounting [1]	Single Firing Ignition Coil with kV Pickup Mounting [1]
104	129 up to 05/96	X		X		
104	129 as of 06/96		X		X	
104	140 up to 05/96	X		X		
104	140 as of 06/96		X		X	
104	202 up to 07/96	X		X		
104	202 as of 08/96		X		X	
104	210 up to 05/96	X		X		
104	210 as of 06/96		X		X	
111	170.447		X		X	
111	202.022 up to 07/96	X		X		
111	202.023 as of 08/96		X		X	

[1] Ignition coils with KV pickup mountings are designed to allow for mounting of KV inductive pickup adapters (from an engine analyzer) on the ignition coil. Refer to specific connection diagrams in the following sections and to engine analyzer operation instructions for proper procedure and applications.

Connection diagrams – Electronic Ignition (EI) System (Distributor-less)

Ignition coil description

Engine	Model	Fuel Injection/ Ignition System		Ignition Coil Design		
		HFM	ME	Dual Firing Ignition Coil without kV Pickup Mounting [1)]	Dual Firing Ignition Coil with kV Pickup Mounting [1)]	Single Firing Ignition Coil with kV Pickup Mounting [1)]
119	129		X			X
119	140		X			X
119	210		X			X
120	129		X			X
120	140		X			X

1) Ignition coils with KV pickup mountings are designed to allow for mounting of KV inductive pickup adapters (from an engine analyzer) on the ignition coil. Refer to specific connection diagrams in the following sections and to engine analyzer operation instructions for proper procedure and applications.

Connection diagrams – Electronic Ignition (EI) system (distributor-less)

Note:

- **The following section applies to Hermann engine analyzers, tests and connections for Bear DACE engine analyzers are similar, please refer to**
  instruction manual supplied with EI (distributor-less) test adapters.
- When diagnosing starting or warm up complaints, do not check engine at operating temperature, instead proceed according to specific complaint.

Air intake hose at intake air temperature sensor (IAT)	Remove, reinstall
Ignition coil cover (on top of valve cover)	Remove, reinstall
Primary ignition side connections: (HFM/ME)	
3 cables from primary side adapter (055/1) **to** ignition coils (T1, T2, T3)	Connect, disconnect (between primary connections at coil)
Remaining cable from 055/1 **to** connector T1/X on the EI adapter (055)	Connect, disconnect
Impulse counter scan tool adapter (075) (excluding model 124) **to** data link connector (X11/4)	Connect, disconnect
Cable from TN connector on EI adapter (055) **to** X11/4 (socket 10 for model 124, socket 17 for model 202, socket 13 for models 129/140/210)	Connect, disconnect (for TN signal)
Secondary ignition side connections: (HFM)	
Red trigger clamp **from** engine analyzer **to** metal handle on adapter (CD1222) and and conector for kV trigger (061/1)	Connect, disconnect
Red trigger clamp **from** adapter (CD1222) **to** no. 1 ignition wire	Connect, disconnect
Harnesses with kV clamps (nos. 1, 3, 5) **to** adapter (CD1222)	Connect, disconnect
kV clamps (063/1, 063/3, 063/5) **to** secondary ignition wires for cyls. 1, 3, 5	Connect, disconnect
Harnesses with kV clamps (nos. 2, 4, 6) **to** adapter (CD1222)	Install, remove
kV (coil) pickups (063/2, 063/4, 063/6) **on** top of coils for cyls. 2, 4, 6	Connect, disconnect
Power supply for EI (distributor-less) adapter (055)	
Black lead (sw) **to** vehicle ground, red lead **to** terminal 15 (red) of X11/4	Connect, disconnect

Note:

- Ensure that the kV (coil) pickup is properly seated on the ignition coil. Improper readings will be displayed if a large air gap exists between the KV pickup and ignition coil.
- Ensure that the arrow on the inductive kV (coil) pickup points in the direction of the coil output (for May and Christie coils).

Connection diagrams – Electronic Ignition (EI) System (distributor-less) HFM-SFI

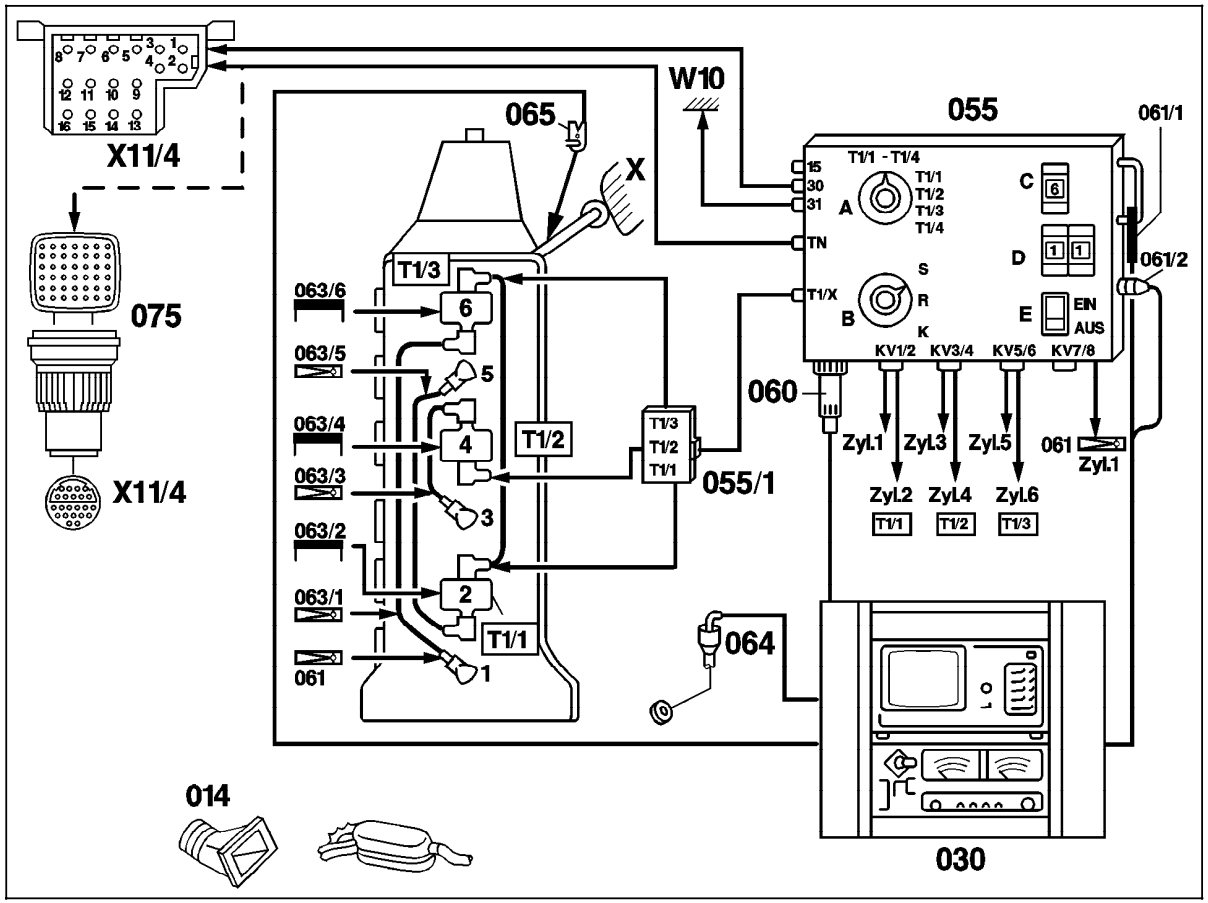
Note:
Due to the differences in the designs of the Bosch and May and Christie ignition coils; different secondary pickups are required.

Diagnostic connector (060) from engine analyzer (030) to 9 pin diagnostic socket on EI (distributor-less) adapter (055)	Connect, disconnect
Vehicle information	Input
Engine analyzer (030) and EI adapter (055)	Set to 6 cyl. (refer to following pages)
EI (distributor-less) adapter (055)	Set according to table (refer to following pages)

Note:
If the the oscilloscope pattern is upside-down (displays 2 ignition voltage lines at the bottom of the screen) or shows no pattern (with engine running), select a different firing order selection at switch D on the EI (distributor-less) adapter 055 (the base setting is 11; select 12, 13, etc. until correct pattern is displayed).

Connect D.C. inductive (pickup) clamp (065) to battery ground cable (model 124) or to ground strap between the transmission and chassis on left side of vehicle (models 129/140/202/210)	Connect, disconnect
Exhaust vent hose (014)	Insert, remove
Engine coolant temperature approx. (80 °C)	Engine at operating temperature

Figure 1



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T1/1 Ignition coil 1 (cylinder no. 2 and 5)
T1/2 Ignition coil 2 (cylinder no. 3 and 4)
T1/3 Ignition coil 3 (cylinder no. 1 and 6)
W10 Battery ground
X11/4 Data link connector (DTC readout) 16 or 38 pole
X Ground wire between transmission and chassis
014 Exhaust vent hose
030 Engine analyzer with oscilloscope
055 EI (distributor-less) adapter (CD1222)
055/1 Primary ignition adapter
060 Diagnostic connector from engine analyzer
061 Trigger clamp for no. 1 cylinder
061/1 Trigger clamp (from engine analyzer)
061/2 Kilovolt clamp connector plug (with kV clamp removed)
063/1 Kilovolt clamp no. 1 cylinder
063/2 Kilovolt (coil) pickup no. 2 cylinder
063/3 Kilovolt clamp no. 3 cylinder
063/4 Kilovolt (coil) pickup no. 4 cylinder
063/5 Kilovolt clamp no. 5 cylinder
063/6 Kilovolt (coil) pickup no. 6 cylinder
064 Oil temperature sensor
065 D.C. inductive clamp
075 Impulse counter scan tool adapter

Designations on EI (distributor-less) adapter (CD 1222)

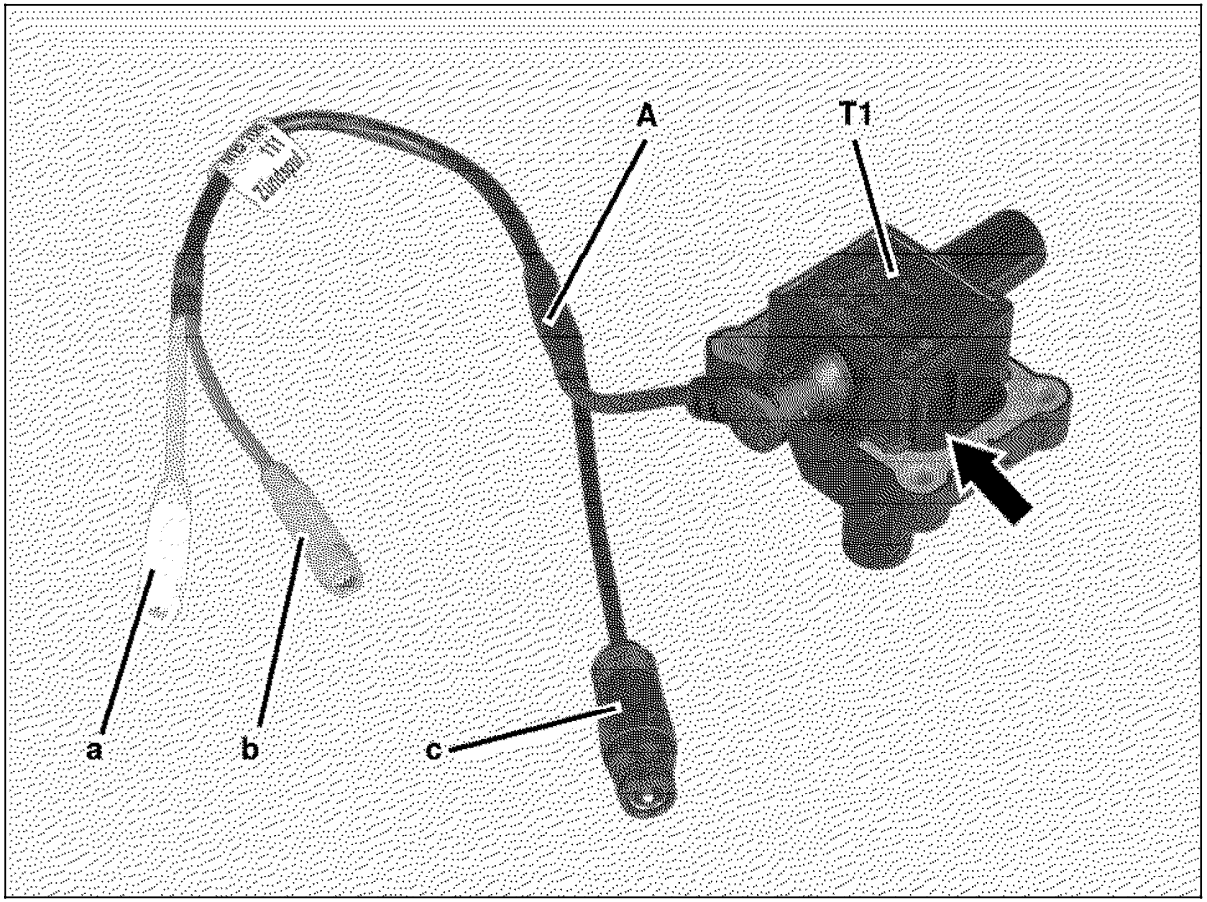
A Ignition circuit selection switches
B Diagnostic test selection switches:
- S Scope pattern
- R Idle quality
- K Compression

C Cylinder selection
D Firing order selection
E Scope pattern compensation (EIN = ON, AUS=OFF)

Figure 2

Primary ignition adapter cable

Note:
The ability to measure secondary ignition voltage is not possible on this coil. Only the primary ignition voltage can be mesured using the primary ignition adapter cable A.



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A	Primary adapter cable
T1	Ignition coil:
a	Yellow (female) lead = terminal 15
b	Green (female) lead = terminal 1
c	to ignition harness

Component Locations

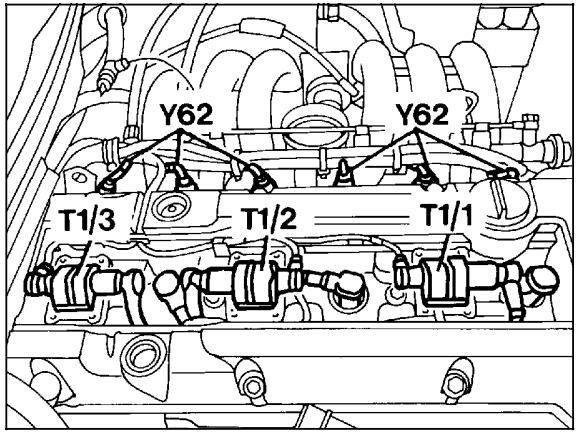

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Figure 3

Model 202

T1/1 Ignition coil for no. 2 and 5 cylinders
T1/2 Ignition coil for no. 3 and 4 cylinders
T1/3 Ignition coil for no. 1 and 6 cylinders

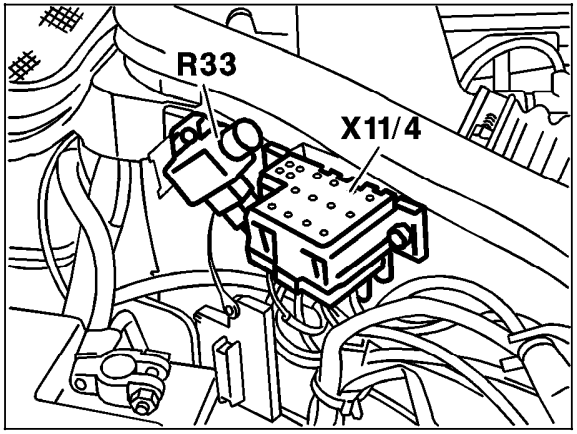

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Figure 4

Model 124

X11/4 Data link connector (DTC readout)

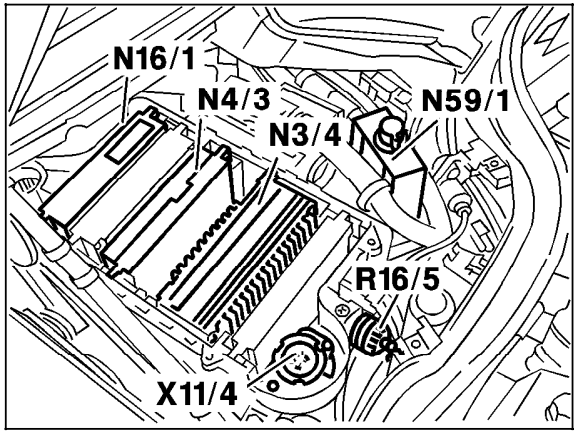

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Figure 5

Model 129 with HFM

X11/4 Data link connector (DTC readout)

Component Locations

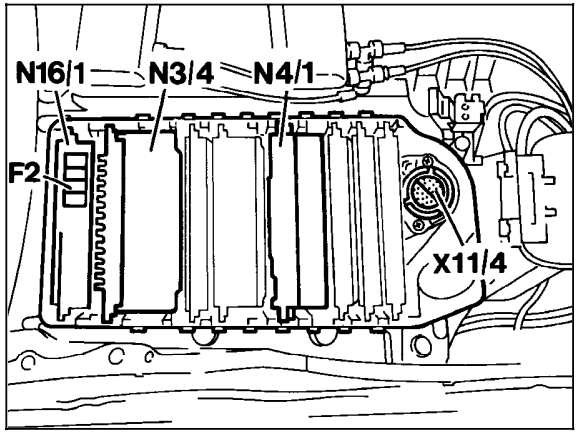

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Figure 6
Model 140 With HFM
X11/4 Data link connector (DTC readout)

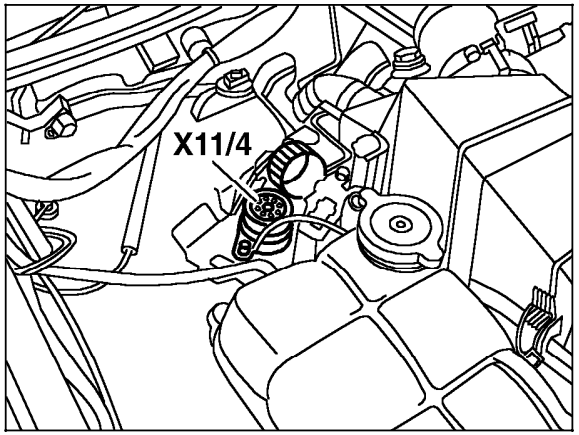

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Figure 7
Model 140 With ME
X11/4 Data link connector (DTC readout)

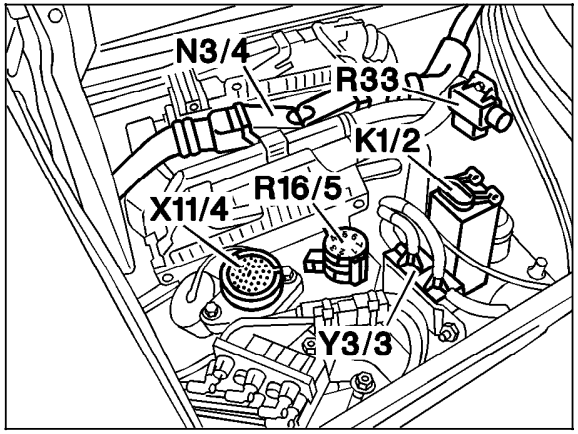

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Figure 8
Model 202
X11/4 Data link connector (DTC readout)

Component Locations

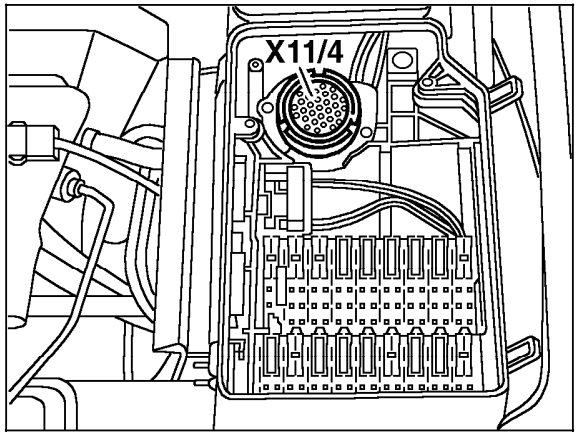

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Figure 9
Model 210
X11/4 Data link connector (DTC readout)

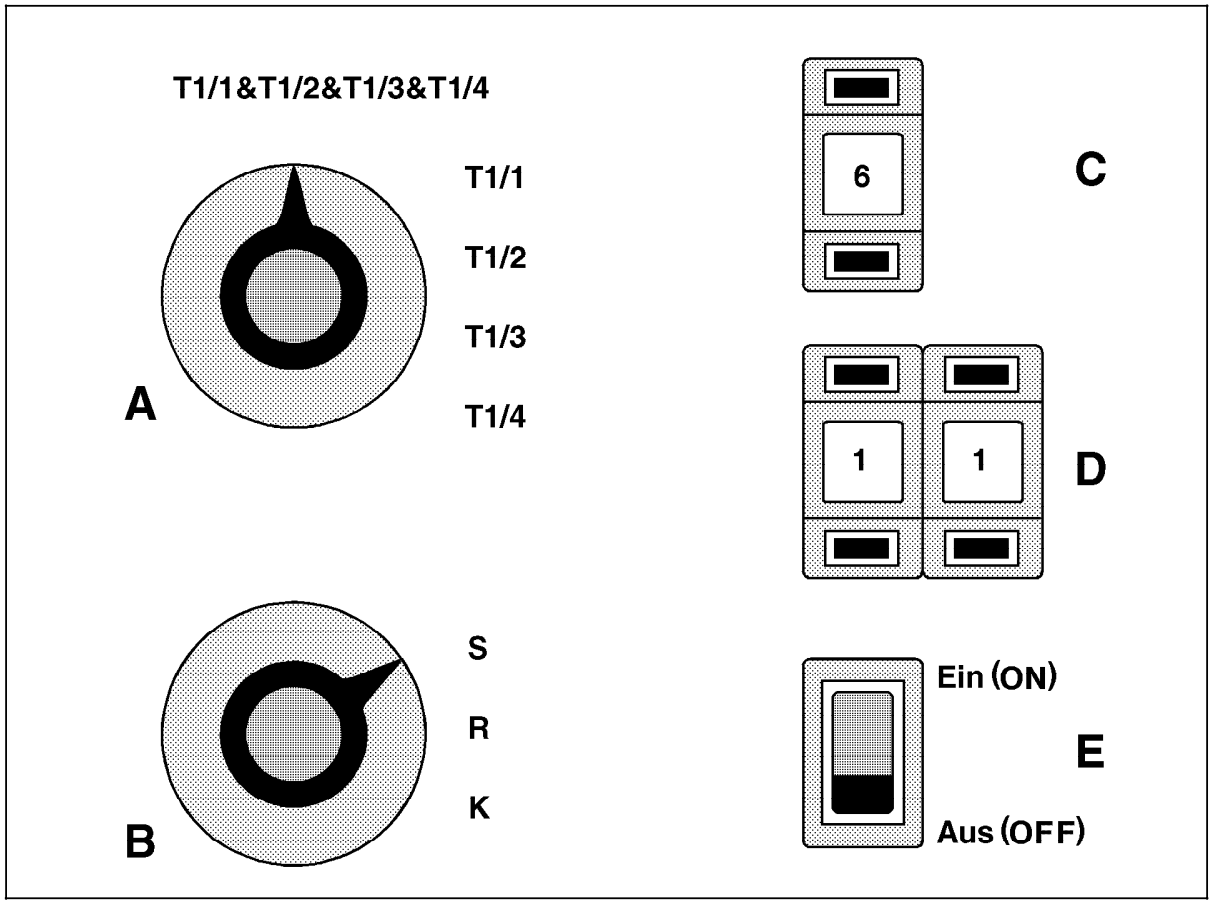
Overview of the Electronic Ignition (EI) System (distributor-less) Adapter (CD 1222)

A: IGNITION CIRCUIT SELECTION SWITCH

T1/1, T1/2, T1/3, T1/4: Primary and secondary
Superimposed pattern of the individual circuits
Primary Circuit:
T1/1: Single circuit display of ignition circuit T1/1, cyl. 2 and 5.
T1/2: Single circuit display of ignition circuit T1/2, cyl. 3 and 4.
T1/3: Single circuit display of ignition circuit T1/3, cyl. 1 and 6.
T1/4: Not used for engine 104

B. DIAGNOSTIC TEST SELECTION SWITCH

S- Scope pattern: For scope pattern display of the primary/secondary and single circuit testing.
R- Idle quality: For idle quality tests
K- Compression: For dynamic compression test
C- Number of cylinders: Set for number of cylinders in engine being tested.
D- Firing order: For engine 104 set to no. 11.
E- Scope pattern compensation: Compensation is used for better evaluation of the scope pattern by stabilizing the firing-voltage curve. Without compensation the firing-voltage curve is very unstable jumping above and below the oscilloscope zero line.



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Test Settings - Engine Analyzer and Electronic Ignition (EI) System (distributor-less) Adapter

Switch A	Engine Analyzer Settings	Test
T1/1&T1/2& T1/3&T1/4	6 Cyl	**Superimposed display** **Cyl. 1-5-3-6-2-4:** Primary/seconary oscilloscope patterns Idle quality Dymanic compression
T1/1	2 Cyl **primary**	**Single circuit display T1/1** **Cyl. 2+5** **Primary** oscilloscope pattern only Transistor on (dwell) Transistor off (circuit off) Voltage drop at terminal 1 [1)]
T1/2	2 Cyl **primary**	**Single circuit display T1/2** **Cyl. 3+4** **Primary** oscilloscope pattern only Transistor on (dwell) Transistor off (circuit off) Voltage drop at terminal 1 [1)]
T1/3	2 Cyl **primary**	**Single circuit display T1/3** **Cyl. 1+6** **Primary** oscilloscope pattern only Transistor on (dwell) Transistor off (circuit off) Voltage drop at terminal 1 [1)]
T1/4	–	Not used at this time

[1)] Primary ignition switching circuit

Switch B	Engine Analyzer Settings	Test
S – Scope pattern	6 Cyl	**Oscilloscope Display – Ignition** Switch ”A” select: • T1/1&T1/2&T1/3&T1/4
	2 Cyl **primary**	**Oscilloscope Display – Ignition** Switch ”A” select: • T1/1 • T1/2 • T1/3
R – Idle quality	6 Cyl	**Idle Quality** Switch ”A” select: • T1/1&T1/2&T1/3&T1/4
K – Compression	6 Cyl	**Dynamic Compression Test** Switch ”A” select: • T1/1&T1/2&T1/3&T1/4

Equipment

Hermann Electronics [1]	Datascope D950 or D960 S
Automotive Diagnostic [1]	Bear DACE 40-960A
Electronic ignition (EI) System (distributor-less) adapter [1] Includes: Kilovolt clamp and kilovolt pickup harness with trigger clamp for no. 1 cylinder, TN-adapter harness, primary ignition adapter harness and operating instructions.	Hermann CD 1222 [2] Bear 43-320 (ref: DACE CD 1222 BA) [2]
Adatper set ME-SFI 1.0 Includes: Primary adapter cable for one cylinder, primary adapter cable (for DACE) secondary adapter cable, kilovolt (coil) pickup	Hermann CD 1230 [2] Bear 43-324 [2]

1) Refer to the MBUSA Standard Equipment Program.

2) Equipment supplied with EI (distributor-less) adapter may vary from equipment listed above, refer to MBUSA Standard Equipment Catalog for complete listing.

Connection diagrams – Electronic Ignition (EI) system (distributor-less)

Note:

- **The following section applies to Hermann engine analyzers, tests and connections for Bear DACE engine analyzers are similar, please refer to instruction manual supplied with the EI (distributor-less) test adapters.**
- When diagnosing starting or warm up complaints, do not check engine at operating temperature, instead proceed according to specific complaint.

Air intake hose at intake air temperature sensor (IAT)	Remove, reinstall
Spark plug covering (on top of valve cover)	Remove, reinstall
Primary ignition side connections:	
Unplug connector X26/24 **from** engine harness and install 2 - pole"piggyback" connector **from** primary adapter cable (055/2) **in between** connector X26/24 and engine harness	Connect, disconnect
Primary adapter cable (055/2) **to** EI adapter (055) connector T1X	Connect, disconnect
Impulse counter scan tool adapter (075) **to** data link connector (X11/4)	Connect, disconnect
Cable from TN connector on EI adapter (055) to X11/4 socket 17	Connect, disconnect (for TN signal)
Secondary ignition side connections: (HFM)	
Trigger clamp (061/1) **from** engine analyzer **to** metal handle on EI (distributor-less) adapter (055)	Connect, disconnect
Kilovolt clamp connector (061/2) **from** engine analyzer **to** EI adapter (055) for kV recognition (**Note:** kV clamp must first be removed from connector 061/2)	Connect, disconnect
Trigger clamp (061) **from** EI adapter (055) **to** no. 1 ignition wire	Connect, disconnect
Harness connector **from** kV clamps (no. 1 and 2) **to** EI adapter (055) connector (KV 1/2)	Connect, disconnect
KV clamps (063/1, 063/2) **to** secondary ignition wires for cylinders 1, 2	Connect, disconnect
Harness connector **from** kV clamps (no. 3 and 4) **to** EI adapter (055) connector (KV 3/4)	Connect, disconnect
KV clamps (063/3, 063/4) **to** secondary ignition wires for cylinders 3, 4	Connect, disconnect
Power supply for distributorless ignition adapter (055)	
Black lead to vehicle ground, red lead to terminal 30 at connector X12/3, yellow lead to terminal 15 at connector X12/3	Connect, disconnect

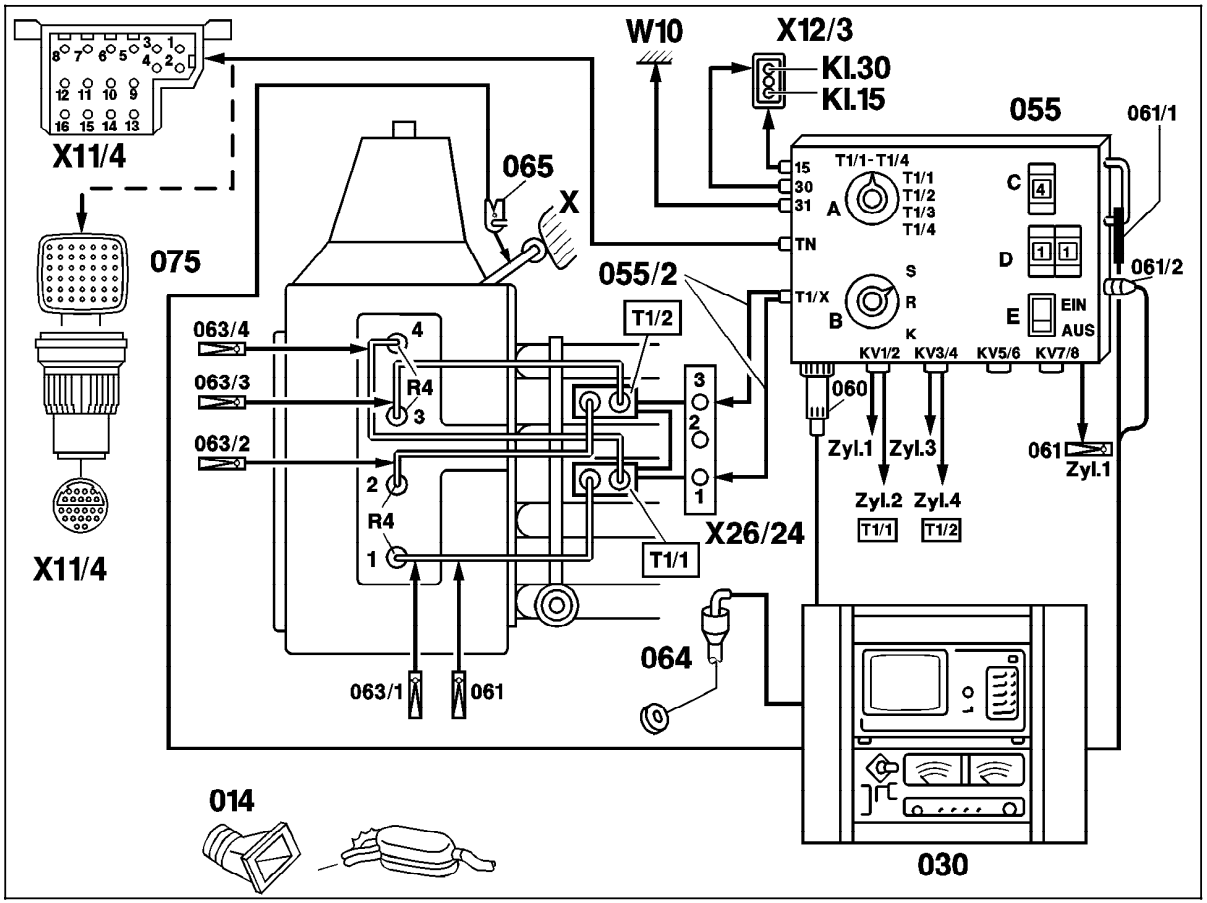
Connection diagrams – Electronic Ignition (EI) system (HFM - SFI)

Diagnostic connector (060) from engine analyzer (030) to 9 pin diagnostic socket on EI (distributor-less) adapter (055)	Connect, disconnect
Vehicle information	Input
Engine analyzer (030)	Set to 4 cyl. (refer to following pages)
EI (distributor-less) adapter (055)	Set according to table (refer to following pages)

Note:
If the the oscilloscope pattern is upside-down (displays 2 ignition voltage lines at the bottom of the screen) or shows no pattern (with engine running), select a different firing order selection at switch D on the EI (distributor-less) adapter 055 (the base setting is 11; select 12, 13, etc. until correct pattern is displayed)

Connect D.C. inductive (pickup) clamp (065) to battery ground cable (model 170) or to ground strap between the transmission and chassis on left side of vehicle (models 202/210)	Connect, disconnect
Exhaust vent hose (014)	Insert, remove
Engine coolant temperature approx. (80 °C)	Engine at operating temperature

Figure 1
Ignition coils located on intake manifold

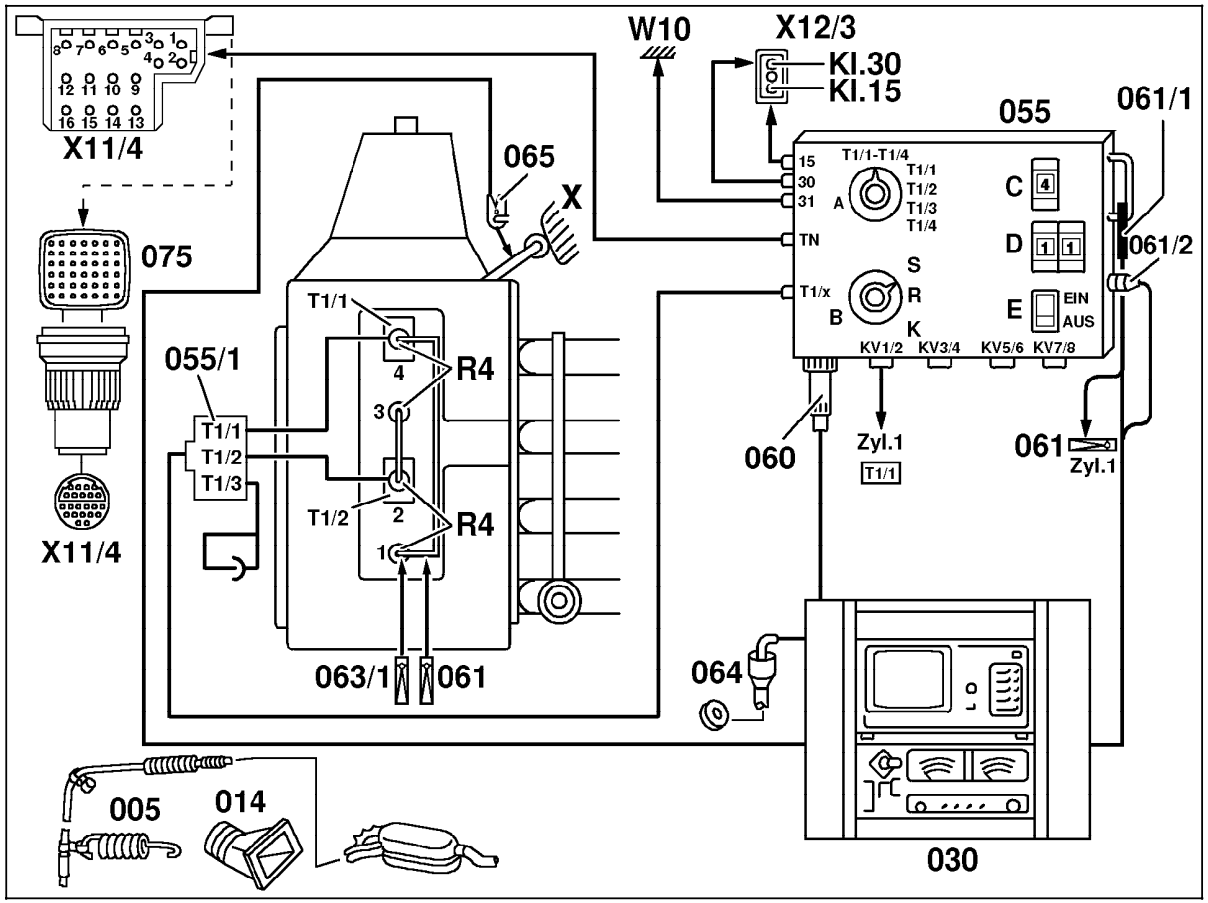


R4	Spark plugs (cylinder nos. 1 through 4)
T1/1	Ignition coil 1 (cylinder nos. 1 and 4)
T1/2	Ignition coil 2 (cylinder nos. 2 and 3)
W10	Battery ground
X11/4	Data link connector (DTC readout) 16 or 38 pole
X12/3	Terminal block (circuit 30, 15, 61, 3-pole)
X26/24	Engine/ignition coil connector (3-pole)
X	Ground wire between transmission and chassis
014	Exhaust vent hose
030	Engine analyzer with oscilloscope
055	EI (distributor-less) adapter (CD1222)
055/2	Primary adapter lead (coil terminal 1)
060	Diagnostic connector from engine analyzer
061	Trigger clamp no. 1 cylinder
061/1	Trigger clamp (from engine analyzer)
061/2	Kilovolt clamp connector plug (with kV clamp removed)
063/1	Kilovolt clamp no. 1 cylinder
063/2	Kilovolt clamp no. 2 cylinder
063/3	Kilovolt clamp no. 3 cylinder
063/4	Kilovolt clamp no. 4 cylinder
064	Oil temperature sensor
065	D.C. inductive clamp
075	Impulse counter scan tool adpater

Designations on EI (distributor-less) adapter (CD 1222)

A	Ignition circuit selection switches
B	Diagnostic test selection switches:
	S Scope pattern
	R Idle quality
	K Compression
C	Cylinder selection
D	Firing order selection
E	Scope pattern compensation (EIN = ON, AUS = OFF)

Figure2
Ignition coils located on cylinder head



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R4 Spark plugs (cylinder nos. 1 through 4)
T1/1 Ignition coil 1 (cylinder nos. 1 and 4)
T1/2 Ignition coil 2 (cylinder nos. 2 and 3)
W10 Battery ground
X11/4 Data link connector (DTC readout) 16 or 38 pole
X12/3 Terminal block (circuit 30, 15, 61, 3-pole)
X26/24 Engine/ignition coil connector (3-pole)
X Ground wire between transmission and chassis
014 Exhaust vent hose
005 Exhaust gas analyzer (not required)
030 Engine analyzer with oscilloscope
055 EI (distributor-less) adapter (CD1222)
055/1 Primary adapter lead (circuits T1/3 combined)
060 Diagnostic connector from engine analyzer
061 Trigger clamp no. 1 cylinder
061/1 Trigger clamp (from engine analyzer)
061/2 Kilovolt clamp connector plug
(with kV clamp removed)
063/1 Kilovolt clamp no. 1 cylinder
064 Oil temperature sensor
065 D.C. inductive clamp
075 Impulse counter scan tool adpater

Designations on EI (distributor-less) adapter (CD 1222)

A Ignition circuit selection switches
B Diagnostic test selection switches:
S Scope pattern
R Idle quality
K Compression
C Cylinder selection
D Firing order selection
E Scope pattern compensation
(EIN = ON, AUS = OFF)

Component Locations

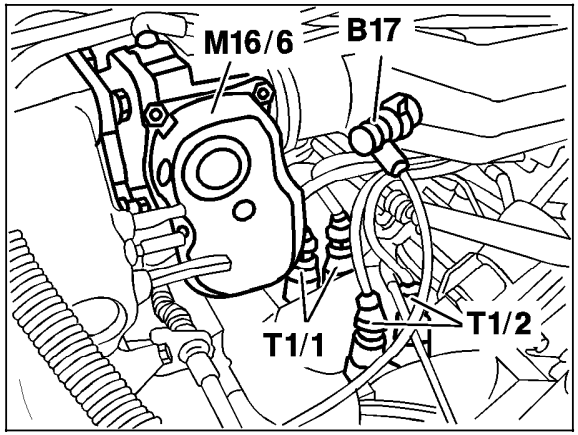

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Figure 3

Model 202

T1/1 Ignition coil 1, cylinders 1 and 4
T1/2 Ignition coil 2, cylinders 2 and 3

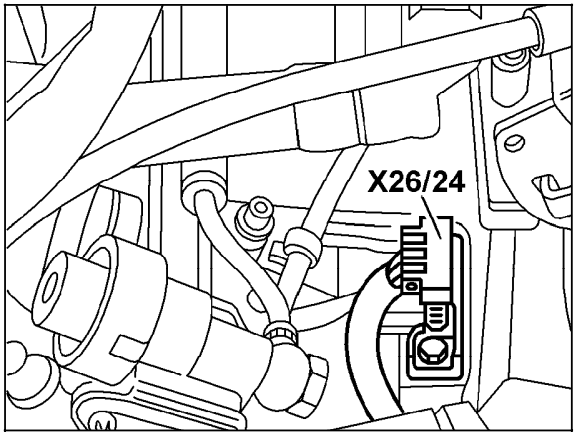

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Figure 4

Engine 111 HFM-SFI

X26/24 Engine /ignition coils connectors (3-pole)

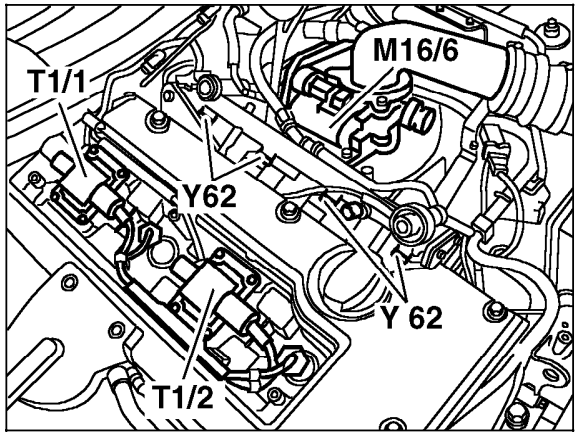

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Figure 5

Engine 111 ME

T1/1 Ignition coil 1, cylinders 1 and 4
T1/2 Ignition coil 2, cylinders 2 and 3

Component Locations

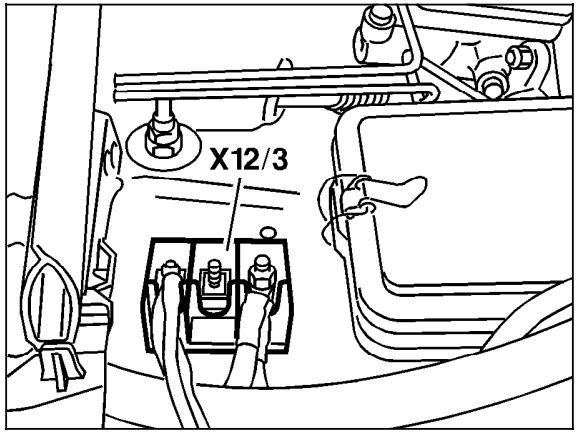

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Figure 6
Model 202
X12/3 Terminal block (circuit 30/15 unfused) (3-pole)

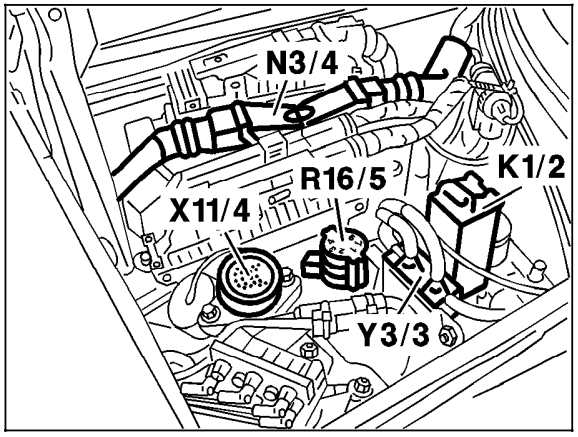

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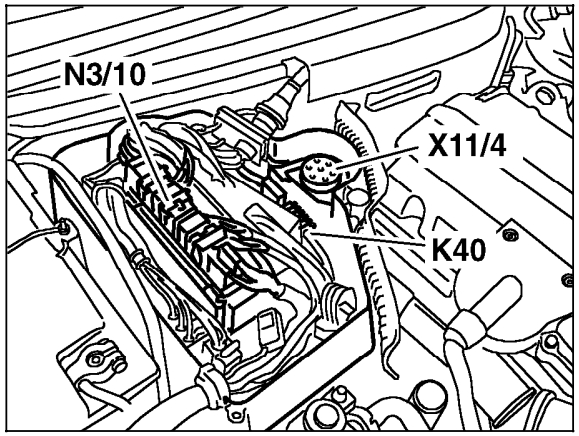
Figure 7
Model 202
X11/4 Data link connector (DTC readout)



P07.61-0319-13

Figure 8
Model 170
X11/4 Data link connector (DTC readout)

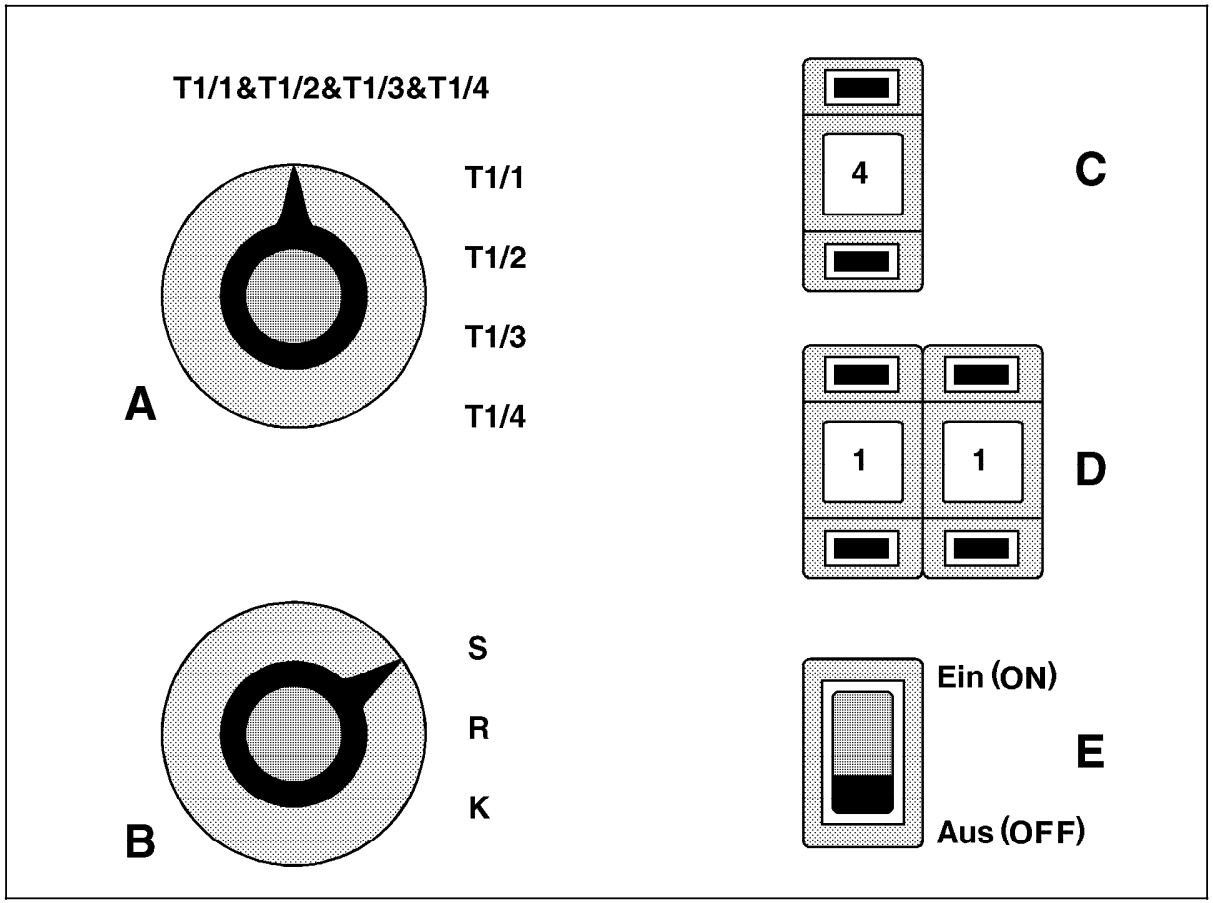
Overview of the Electronic Ignition (EI) system adapter (CD 1222)

A: IGNITION CIRCUIT SELECTION SWITCH

T1/1, T1/2, T1/3, T1/4: Primary and secondary
Superimposed pattern of the individual circuits
Primary Circuit:
T1/1: Single circuit display of igntion circuit T1/1, cyl. 1 and 4.
T1/2: Single circuit display of igntion circuit T1/2, cyl. 2 and 3.
T1/3/4: Not used for engine 111

B. DIAGNOSTIC TEST SELECTION SWITCH

S- Scope pattern: For scope pattern display of the primary/secondary and single circuit testing.
R- Idle quality: For idle quality tests
K- Compression: For dynamic compression test
C- Number of cylinders: Set to number of cylinders in engine being tested.
D- Firing order: In the event of an upside down scope pattern (due to one of the two secondary ignition wires being switched at one of the coils) a different firing order must be selected. To select a different firing order, press the button until all of the spark lines are pointing up.
E- Scope pattern compersation: Compensation is used for better evaluation of the scope pattern by stabilizing the firing-voltage curve. Without compensation the firing-voltage curve is very unstable jumping above and below the oscilloscope zero line.



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Operation Settings - Engine Analyzer and EI System (distributor-less) Adatpter

Switch A	Engine Analyzer Input Information	Test
T1/1&T1/2& T1/3&T1/4	4 Cyl	**Superimposed display** **Cyl. 1-3-4-2-:** Primary/seconary oscilloscope patterns Idle quality Dymanic compression
T1/1	2 Cyl **primary**	**Single circuit display T1/1** **Cyl. 1+4** **Primary** oscilloscope pattern only Transistor on (dwell) Transistor off (circuit off) Voltage drop at coil terminal 1 [1)]
T1/2	2 Cyl **primary**	**Single circuit display T1/2** **Cyl. 2+3** **Primary** oscilloscope pattern only Transistor on (dwell) Transistor off (circuit off) Voltage drop at coil terminal 1 [1)]
T1/3	–	–
T1/4	–	Not used at this time

1) Primary ignition switching circuit

Switch B	Engine Analyzer Input Information	Test
S – Scope pattern	4 Cyl	**Oscilloscope Display – Ignition** Switch ”A” select: • T1/1&T1/2&T1/3&T1/4
	2 Cyl **primary**	**Oscilloscope Display – Ignition** Switch ”A” select: • T1/1 • T1/2
R – Idle quality	4 Cyl	**Idle Quality** Switch ”A” select: • T1/1&T1/2&T1/3&T1/4
K – Compression	4 Cyl	**Dynamic Compression Test** Switch ”A” select: • T1/1&T1/2&T1/3&T1/4

Equipment

Hermann Electronics [1]	Datascope D950 or D960 S
Automotive Diagnostic [1]	Bear DACE 40-960A
Electronic ignition (EI) System (distributor-less) adapter [1] Includes: Kilovolt clamp and kilovolt pickup harness with trigger clamp for no. 1 cylinder, TN-adapter harness, primary ignition adapter harness and operating instructions.	Hermann CD 1222 [2] Bear 43-320 (ref: DACE CD 1222 BA) [2]
Adatper set ME-SFI 1.0 Includes: Primary adapter cable for one cylinder, primary adapter cable (for DACE) secondary adapter cable, kilovolt (coil) pickup.	Hermann CD 1230 [2] Bear 43-324 [2]

1) Refer to the MBUSA Standard Equipment Program.

2) Equipment supplied with EI (distributor-less) adapter may vary from equipment listed above, refer to MBUSA Standard Equipment Catalog for complete listing.

Connection diagrams – Electronic Ignition (EI) system (distributor-less)

Note:

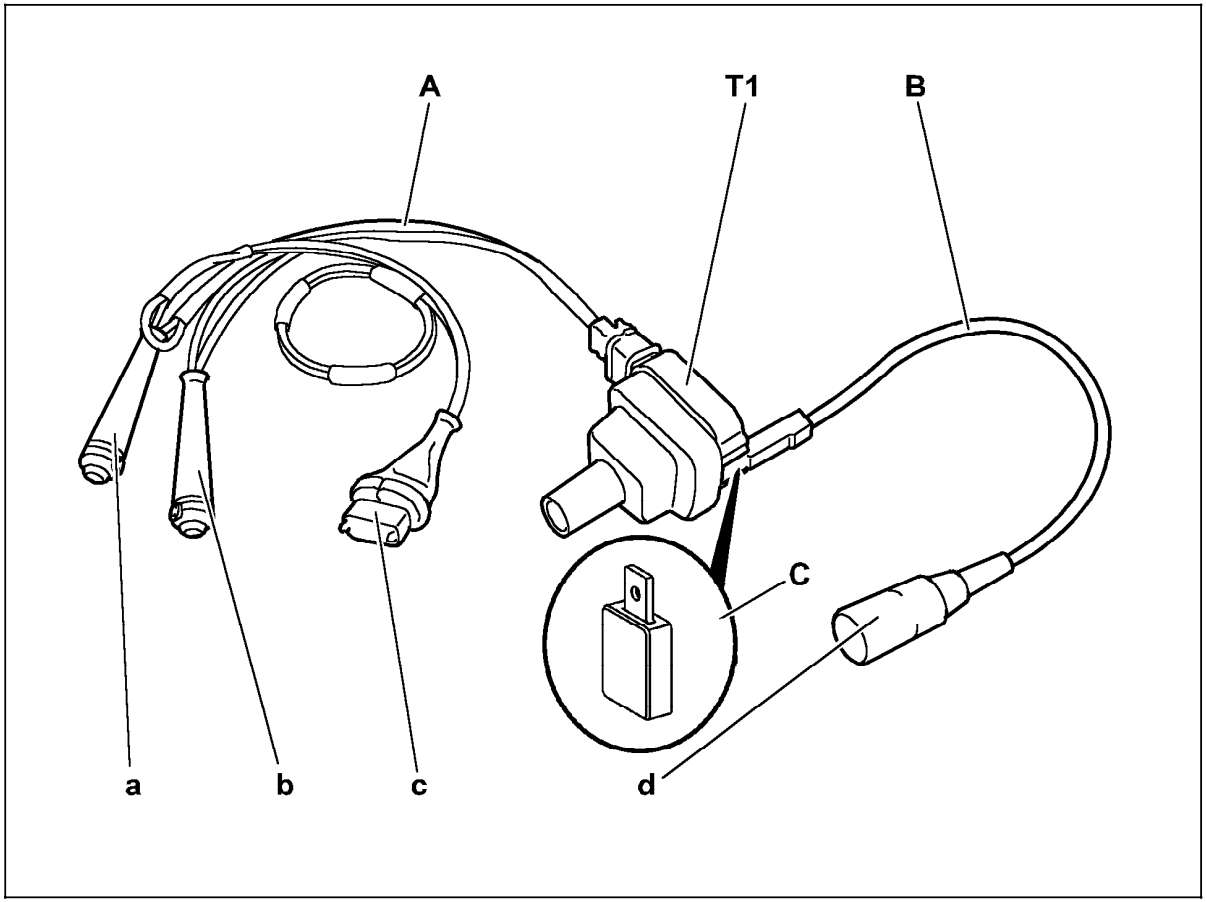
- **The following section applies to Hermann engine analyzers, tests and connections for Bear DACE engine analyzers are similar, please refer to instruction manual supplied with the EI (distributor-less) test adapters.**
- When diagnosing starting or warm up complaints, do not check engine at operating temperature, instead proceed according to specific complaint.

Connection method:
Set engine analyzer to cylinder 1, select primary or secondary and test each ignition circuit

The primary and secondary ignition systems can be tested. The ignition coils are equipped with a mounting slot (Figure 2) for the kV (pickup) sensor. The primary pattern can be picked up using the primary adapter lead (Figure 3), or through a connection from the socket box to the ME-SFI engine control module.

Air filter	Remove, install
Ignition coil covers on top of valve covers	Remove, install
Primary side connections:	
Disconnect engine harness from selected ignition coil (T1/1 - T1/8 or T1/1 - T1/12) and install primary adapter cable (A) **in between** selected ignition coil (T1) and engine harness	Connect, disconnect
Primary leads with yellow (a) and green (b) connectors (from primary adapter cable) **to** primary leads on engine analyzer	Connect, disconnect
Secondary side connections:	
Kilovolt (pickup) sensor (C) **to** selected ignition coil (T1) mounting slot	Connect, disconnect
Kilovolt clamp connector **from** engine analyzer (**Note:** kV clamp must first be removed) **to** secondary adapter cable connector (d [3 pole]) . .	Connect, disconnect
Secondary adapter cable connector (1- pole) **to** kV (pickup) sensor connector	Connect, disconnect

Figure 1
Connection diagram for Electronic Ignition System



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A	Primary adapter cable
B	Secondary adapter cable
C	kV (pickup) sensor
T1	Ignition coil
a	Yellow (female) lead = terminal 15
b	Green (female) lead = terminal 1
c	to ignition harness
d	to kV clamp conector (kV clamp must first be removed

Equipment

Hermann Electronics [1]	Datascope D950 or D960 S
Automotive Diagnostic [1]	Bear DACE 40-960A
Electronic ignition (EI) System (distributor-less) adapter [1] Includes: Kilovolt clamp and kilovolt pickup harness with trigger clamp for no. 1 cylinder, TN-adapter harness, primary ignition adapter harness and operating instructions.	Hermann CD 1222 [2] Bear 43-324 (ref: DACE CD 1222 BA) [2]
Adapter set ME-SFI 1.0 Includes: Primary adapter cable for one cylinder, primary adapter cable (for DACE) secondary adapter cable, kilovolt (coil) pickup	Hermann CD 1230 [2] Bear 43-324 [2]

1) Refer to the MBUSA Standard Equipment Program.

2) Equipment supplied with EI (distributor-less) adapter may vary from equipment listed above, refer to MBNA Standard Equipment Catalog for complete listing.

Connection diagrams – Electronic Ignition (EI) system (distributor-less)

Note:

- **The following section applies to Hermann engine analyzers, tests and connections for Bear DACE engine analyzers are similar, please refer to instruction manual supplied with the EI (distributor-less) test adapters.**
- When diagnosing starting or warm up complaints, do not check engine at operating temperature, instead proceed according to specific complaint.

Connection method:
Set engine analyzer to cylinder 1, select primary or secondary and test each ignition circuit

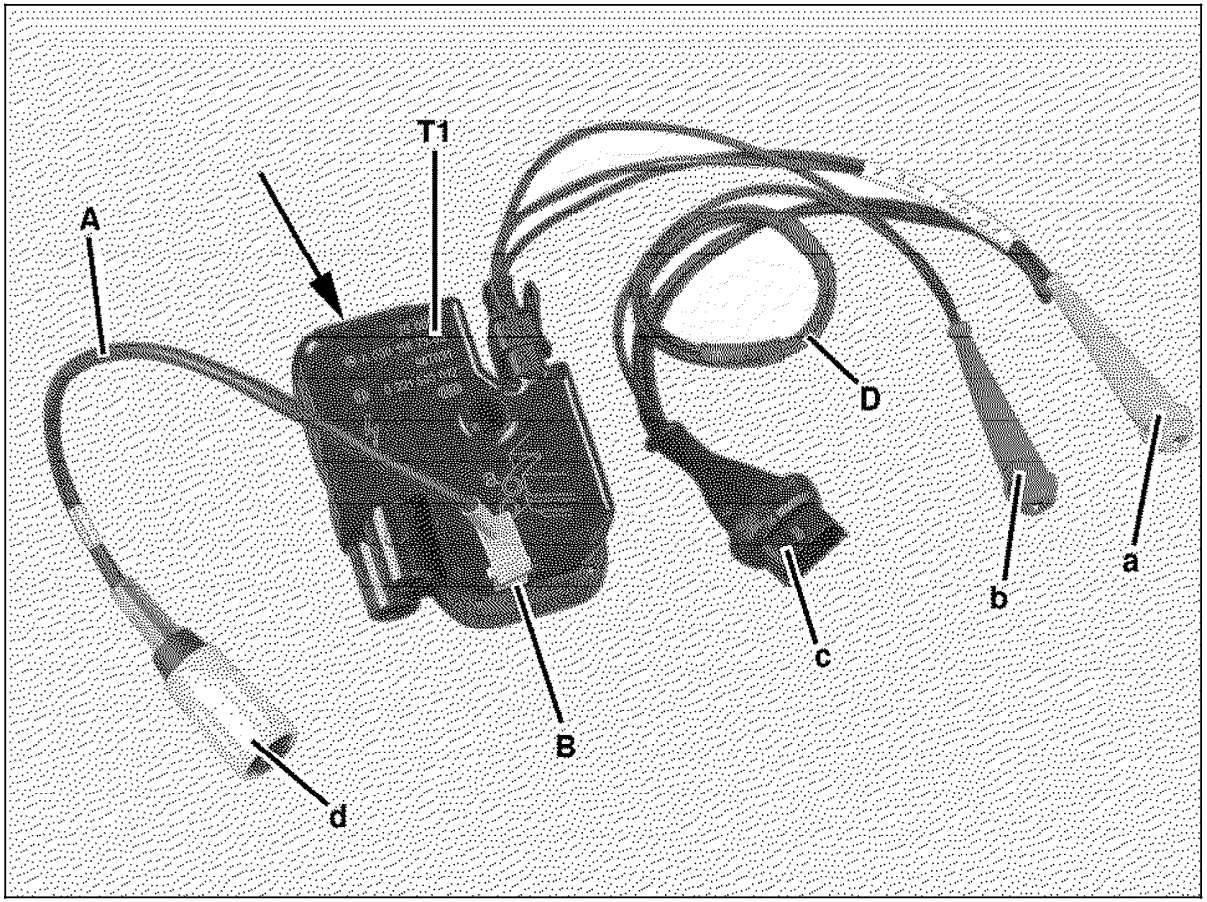
The primary and secondary ignition systems can be tested. The individual ignition circuits on each coil must be tested one after the other (ignition circuit a then ignition circuit b). The ignition coils are equipped with a mounting slot for the kV (pickup C) sensor. The primary pattern can be picked up using the primary adapter lead (D), or through a connection from the socket box to the ME-SFI engine control module.

Air filter	Remove, install
Ignition coil covers on top of valve covers	Remove, install
Primary side connections:	
Disconnect engine harness from selected ignition coil (T1/1 - T1/6 or T1/1 - T1/8) and install primary adapter cable (A) **in between** selected ignition coil (T1) and engine harness	Connect, disconnect
Primary leads with yellow (a) and green (b) connectors (from primary adapter cable) **to** primary leads on engine analyzer	Connect, disconnect
Secondary side connections:	
Kilovolt (pickup) sensor (C) **to** selected ignition coil (T1) mounting slot	Connect, disconnect
Kilovolt clamp connector **from** engine analyzer (**Note:** kV clamp must first be removed) **to** secondary adapter cable connector (d [3 pole]) . .	Connect, disconnect
Secondary adapter cable connector (1- pole) **to** kV (pickup) sensor connector	Connect, disconnect

Figure 1
Connection diagram for Electronic Ignition System

The individual ignition circuits on each coil must be tested one after the other (ignition circuit a then ignition circuit b).

Connect green connector of the motor tester to either the yellow or green socket on the adapter cable (dependant on which ignition circuit is to be tested).
Connect yellow connector (Term. 15) of the motor tester to battery positive (Terminal 30/15).



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A	Primary adapter cable
B	Secondary adapter cable
C	kV (pickup) sensor
T1	Ignition coil
a	Yellow (female) lead = terminal 15
b	Green (female) lead = terminal 1
c	to ignition harness
d	to kV clamp conector (kV clamp must first be removed

Equipment

Hermann Electronics [1]	Datascope D950 or D960 S
Automotive Diagnostic [1]	Bear DACE 40-960A
Electronic ignition (EI) System (distributor-less) adapter [1] Includes: Kilovolt clamp and kilovolt pickup harness with trigger clamp for no. 1 cylinder, TN-adapter harness, primary ignition adapter harness and operating instructions.	Hermann CD 1222 [2] Bear 43-324 (ref: DACE CD 1222 BA) [2]
Adapter set ME-SFI 1.0 Includes: Primary adapter cable for one cylinder, primary adapter cable (for DACE) secondary adapter cable, kilovolt (coil) pickup	Hermann CD 1230 [2] Bear 43-324 [2]

1) Refer to the MBUSA Standard Equipment Program.

2) Equipment supplied with EI (distributor-less) adapter may vary from equipment listed above, refer to MBUSA Standard Equipment Catalog for complete listing.

Diagnosis – Diagnostic Test Overview

The following is an overview of the contents of the various tests possible with the engine analyzer. Detailed information regarding test scope and evaluation is given in the individual test sequences. Engine specific test and adjustment data are covered in section A. Repair procedures are available in the appropriate service literature.

System test
- Diagnostic trouble code (DTC) readout
- On-off ratio readout

Engine adjustments/universal program
- Battery voltage
- RPM, dwell
- Ignition timing
- On-off ratio control
- Ignition voltage
- Charging current
- Vacuum
- Engine oil temperature

Engine electrical
- Battery test
- Starting test
- Ignition coil test (primary)
- Generator test
- RPM
- Engine oil temperature
- Graphic displays

Idle quality/per cylinder
- Idle quality/Starting test
- Burn time per cylinder
- Engine oil temperature
- Graphic displays
- Table displays

Individual cylinder analysis
- Compression/starter current draw
- RPM
- Balance
- Ignition system (secondary)
- Battery voltage
- Engine oil temperature
- Table displays

Oscilloscope
- Parade pattern
- Individual pattern
- Raster pattern
- Additional signals
  (i.e. TN/on-off ratio, position sensor)

Diagnosis – Starting Test

Ignition: ON

- Starting test should only be performed if engine does not run.
- Test and adjustment data section A.

a) Engine 102, 103, 116, 117 CFI, 104 CFI/LH-SFI

Test sequence:

- Connect engine analyzer.
- Ignition: **ON**.
- Observe measured values and store or print out.
- Specifications appearing on the following page must appear on the engine analyzer screen.

Note:
The starting test on engines 104, 111 HFM-SFI is only possible with the oscilloscope.

b) Engine 119, 120 CFI/LH-SFI

- Set engine analyzer to:
  4 cylinder position for engine 119;
  6 cylinder position for engine 120.
- Set dual ignition adaptor to **T1/1** [1].
- Ignition: **ON**.
- Observe and store measured values.
- Set dual ignition adaptor to **T1/2** [1].
- Observe and store measured values, then
- Print out measured values and compared with specifications.
- Specifications appearing on the following pages must appear on the engine analyzer screen.

⚠

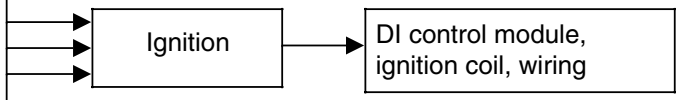
On engine 120, the diagnostic socket adapter must in addition be set for the appropriate ignition circuit.
Example: Dual ignition adaptor **T1/1**
When checking ignition timing on circuit **T1/2** the trigger clamp must be attached to the ignition cable for the no. 12 cylinder.

[1] The measurements between T1/1 and T1/2 must be carried out separately.

Diagnosis – Starting Test

Ignition: ON

Engine rpm		– rpm
Engine oil temperature		20 °C
Battery voltage		13.8 V
Ignition coil voltage, circuit 15		13.8 V
Ignition coil voltage, circuit 1		13.5 V
Current draw measured with inductive clamp		5 A
Dwell		– °
Ignition timing		– °
Ignition voltage		– KV
On-off ratio control	Control range	– %



Note:
The specifications shown are examples for a 4 cylinder engine and can not be compared directly.

Diagnosis – Starting Test

At Cranking RPM

- Starting test – Ignition: **ON**.
- Starting test should only be performed if engine does not run.
- Test and adjustment data section A.

a) Engine 102, 103, 116, 117 CFI, 104 CFI/LH-SFI

Test sequence:

- Connect engine analyzer.
- Actuate starter.
- Observe measured values and store or print out during the starting process.
- Specifications appearing on the following page must appear on the engine analyzer screen.

Note:

The starting test on engines 104, 111 HFM-SFI is only possible with the oscilloscope.

b) Engine 119, 120 CFI/LH-SFI

- Set Engine analyzer to:
  4 cylinder position for engine 119;
  6 cylinder position for engine 120.
- Set dual ignition adaptor to **T1/1** [1].
- Actuate starter.
- Observe and store measured values .
- Set dual ignition adaptor to **T1/2** [1].
- Actuate starter.
- Observe and store measured values, then
- Print out measured values and compare with specifications.
- Specifications appearing on the following page must appear on the engine analyzer screen.

⚠

On engine 120, the diagnostic socket adapter must in addition be set for the appropriate ignition circuit.

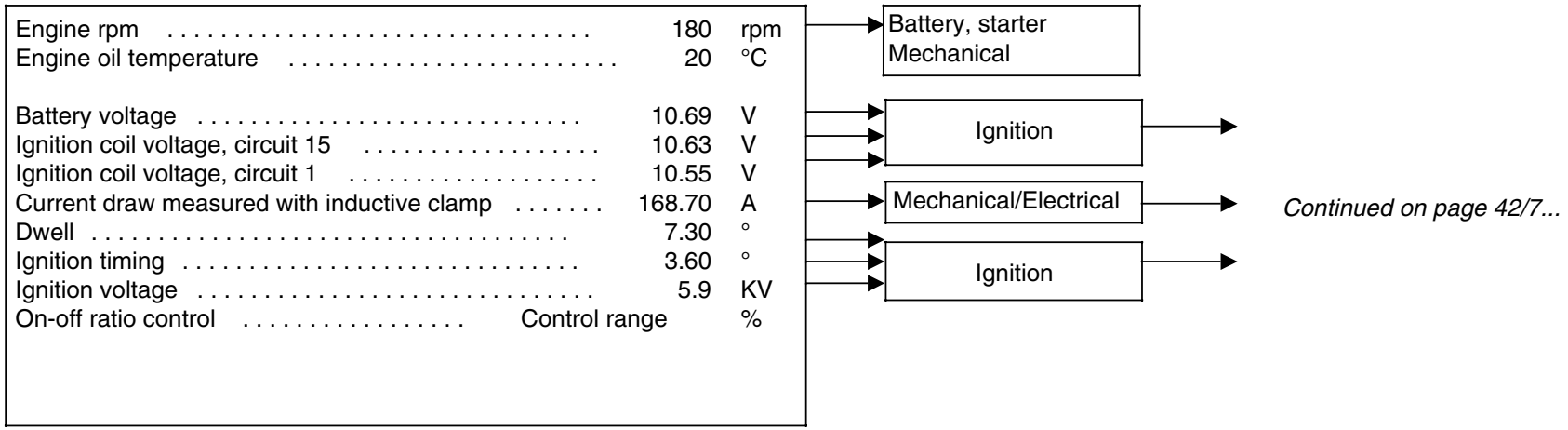
Example: Dual ignition adaptor **T1/1**

When checking ignition timing on circuit **T1/2** the trigger clamp must be attached to the ignition cable for the no. 12 cylinder.

[1] The measurements between **T1/1** and **T1/2** must be carried out separately.

Diagnosis – Starting Test

At Cranking Rpm



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Note:
The specifications shown are examples for a 4 cylinder engine and can not be compared directly.

Diagnosis – Starting Test

At Idle Rpm

a) Engine 102, 103, 104, 116, 117 CFI/LH-SFI

Test sequence:
- Connect engine analyzer.
- Start engine.
- Observe measured values and store or print out.
- Specifications appearing on the following pages must appear on the engine analyzer screen.

Note:
The starting test on engines 104, 111 HFM-SFI is only possible with the oscilloscope.

b) Engine 119, 120
- Set engine analyzer to:
  4 cylinder position for engine 119;
  6 cylinder position for engine 120.
- Set dual ignition adaptor to **T1/1** [1].
- Start engine.
- Observe and store measured values.
- Set dual ignition adaptor to **T1/2** [1].
- Observe and store measured values, then print out measured values and compare with specifications.
- Specifications appearing on the following pages must appear on the engine analyzer screen.
- Test and adjustment data section A.

⚠

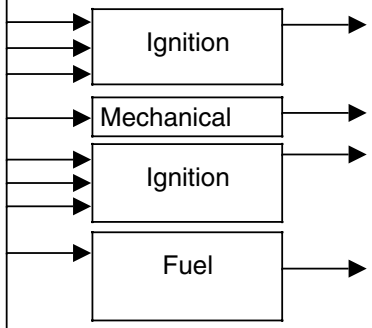
On engine 120, the diagnostic socket adapter must in addition be set for the appropriate ignition circuit.
Examples: Dual ignition adaptor **T1/1**
When checking ignition timing on circuit **T1/2** the trigger clamp must be attached to the ignition cable for the no. 12 cylinder.

[1] The measurements between **T1/1** and **T1/2** must be carried out separately.

Diagnosis – Starting Test

At Idle Rpm

Engine rpm	650	rpm
Engine oil temperature	20	°C
Battery voltage	13.5	V
Ignition coil voltage, circuit 15	13.5	V
Ignition coil voltage, circuit 1	13.5	V
Current draw measured with inductive clamp	7.5	A
Dwell	8.9	°
Ignition timing	16.1	°
Ignition voltage	8.3	KV
On-off ratio control . . . . . Control range	50	%

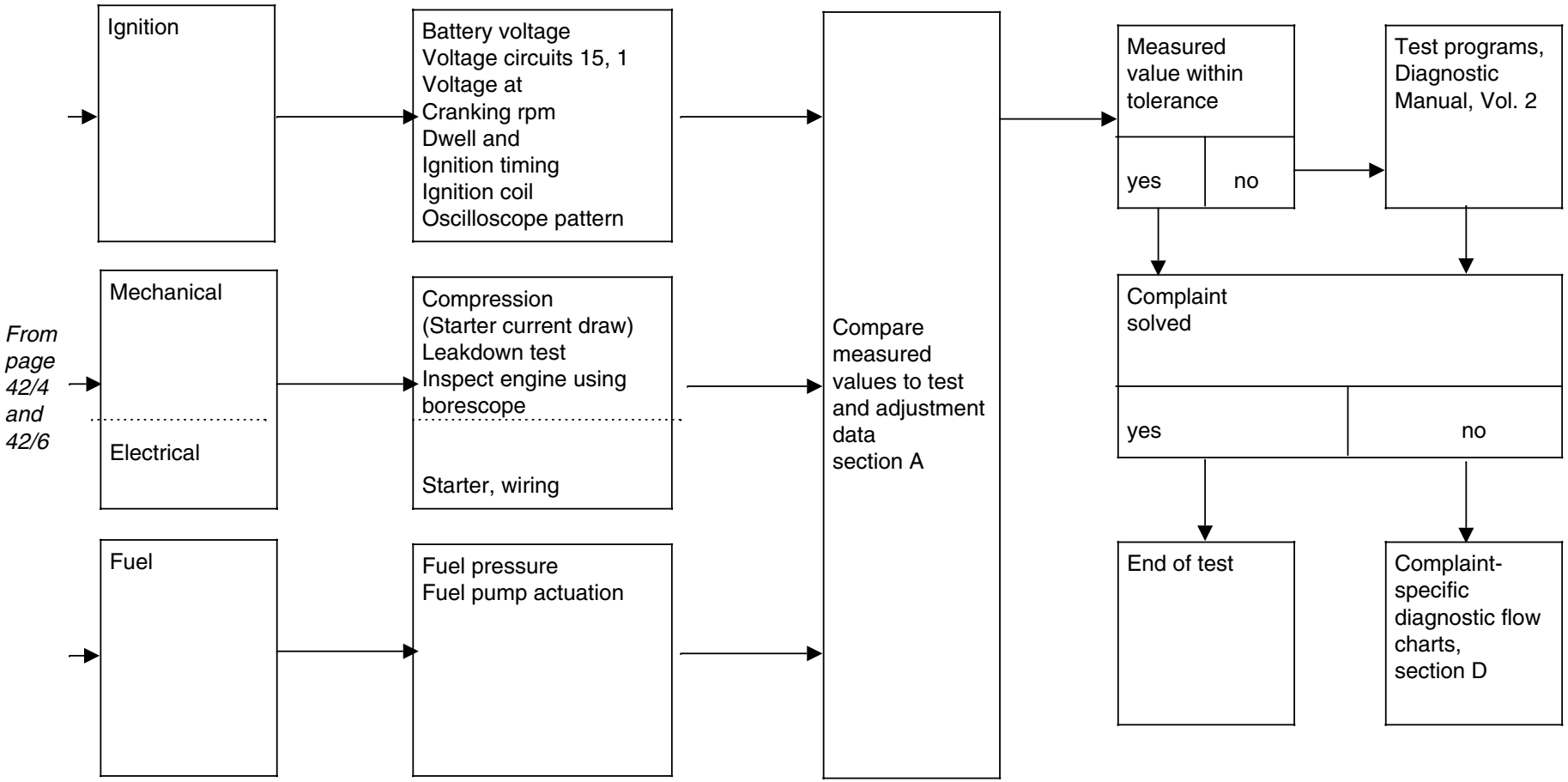


Continued on page 42/7...

Note:
The specifications shown are examples for an 8 cylinder engine and can not be compared directly.

Diagnosis – Starting Test

At Cranking and at Idle Rpm



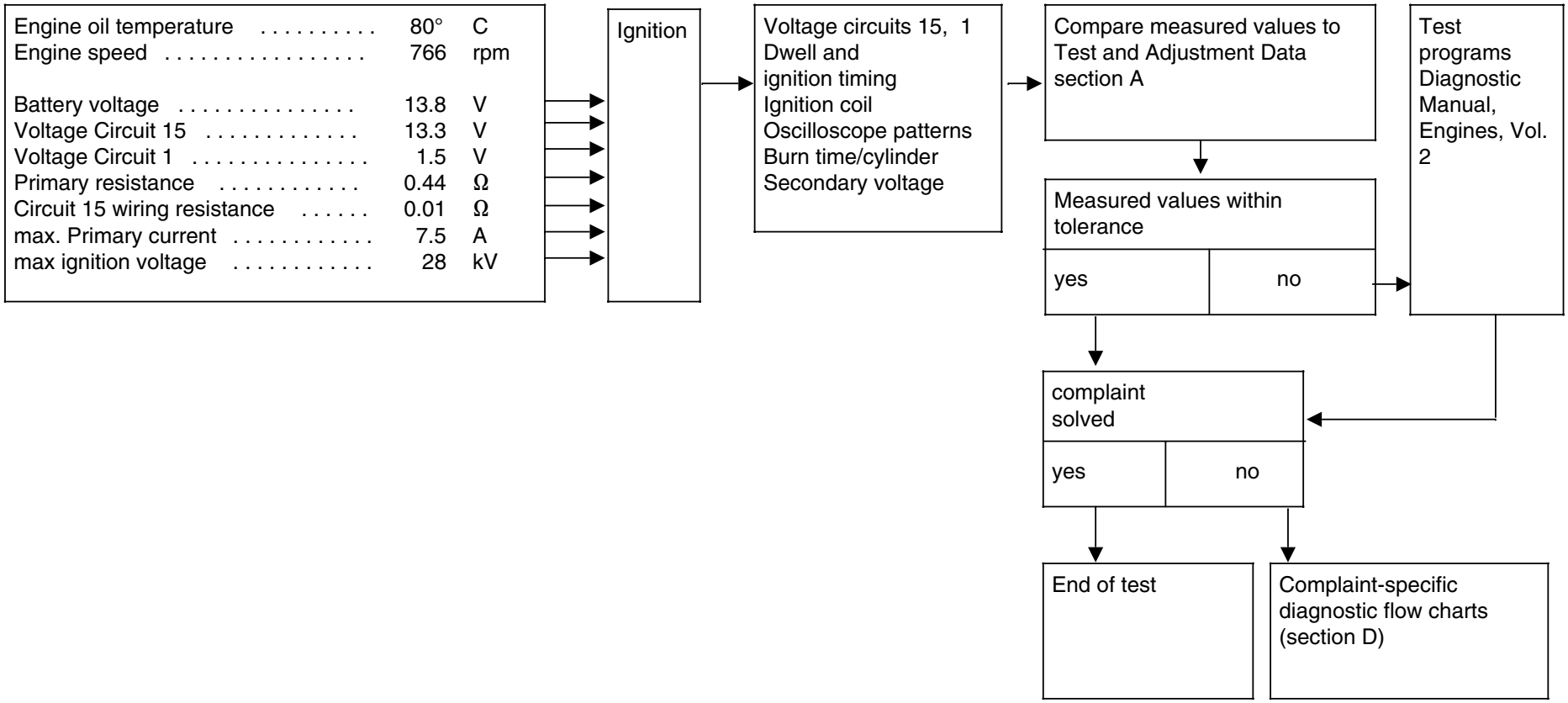
Diagnosis – Ignition Coil Test

Bear engine analyzer only!
Single/dual ignition systems

- Perform ignition coil test only at idle rpm.
- In addition, the ignition coil must be checked against the oscilloscope pattern in the single display mode, see pages 48/7 and 48/8.
- Program selection “engine electrical ignition coil test.”
- Test and adjustment data see section A.

Diagnosis – Ignition Coil Test

Bear engine analyzer only!
Single/dual ignition systems



Note:
The specifications shown are for a 4 cylinder engine and can not be compared directly.

Diagnosis – Generator Test

Good display

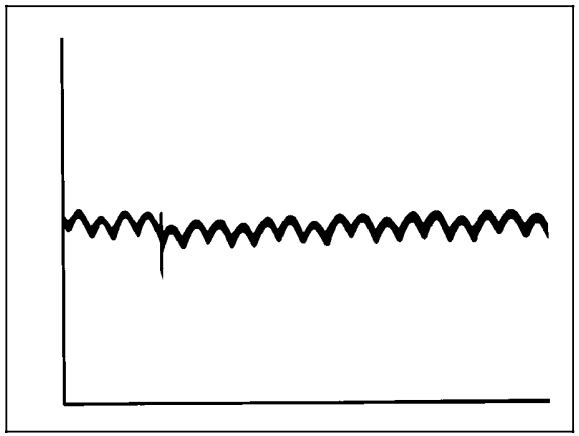
Prerequisite:

Check battery condition by checking specific gravity.

- Test and adjustment data, see Generator in groups 15 or 54 in the technical data book or the appropriate repair instructions.

Test sequence:

- Connect engine analyzer.
- Inductive DC clamp connected to cable immediately behind generator.
- Check output at the prescribed rpm (repair instruction group 15 or 54 and technical data books).



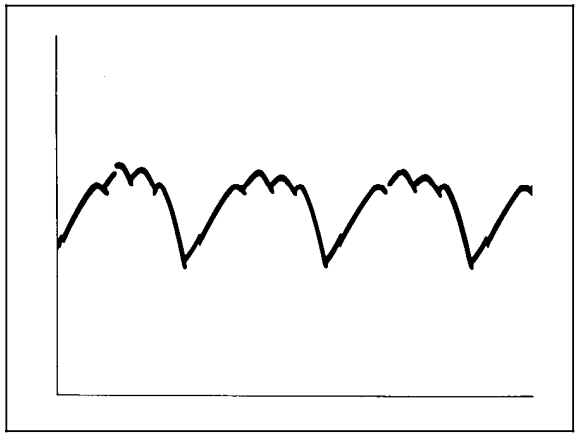
Good scope pattern
(Diodes OK)

P15-0174-13

Engine speed 666 rpm	13.60 V
Current output	7.10 A
Harmonic	0 %

Note:

The specifications shown are examples for a 4 cylinder engine and can not be compared directly.



Bad scope pattern
(Diodes defective)

P15-0175-13

Diagnosis – Engine Adjustment

Single/dual ignition systems

⚠ Static high-voltage distribution only possible with HHT.

The test is comprised of the following:

a) Dwell
b) Ignition timing
c) On-off ratio control

Note:

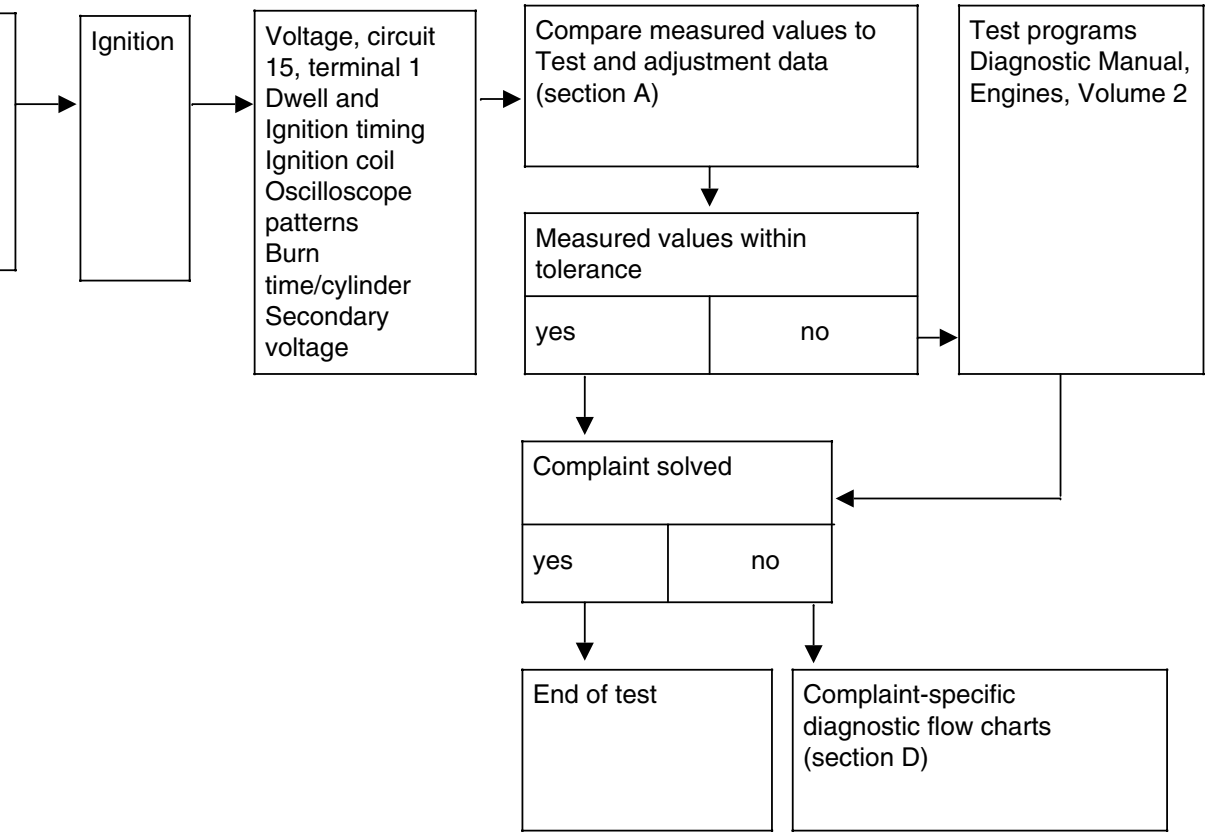
The following should be noted on engines with dual ignition systems (engine 119 CFI, engine 119 LH-SFI and 120 LH-SFI):

- Engine analyzer should be set to 4 cylinder position (engine 119) or to 6 cylinder position (engine 120).
- Connect dual ignition adaptor and set to **T1/1** position.
- Engine at idle.
- Compare dwell value of **T1/1** with test data.
- Set dual ignition adaptor to **T1/2**.
- Engine at idle.
- Compare dwell **T1/2** with test values.

Diagnosis – Engine Adjustment

a) Dwell

Engine speed.	751 rpm
Engine oil temperature	79.00 °C
Dwell	12.80 °
Dwell	21.40 %
Dwell offset	1.40 °
Voltage drop terminal 1 (static)	1.40 V



Note:
The specifications shown are examples for a 4 cylinder engine and can not be compared directly.

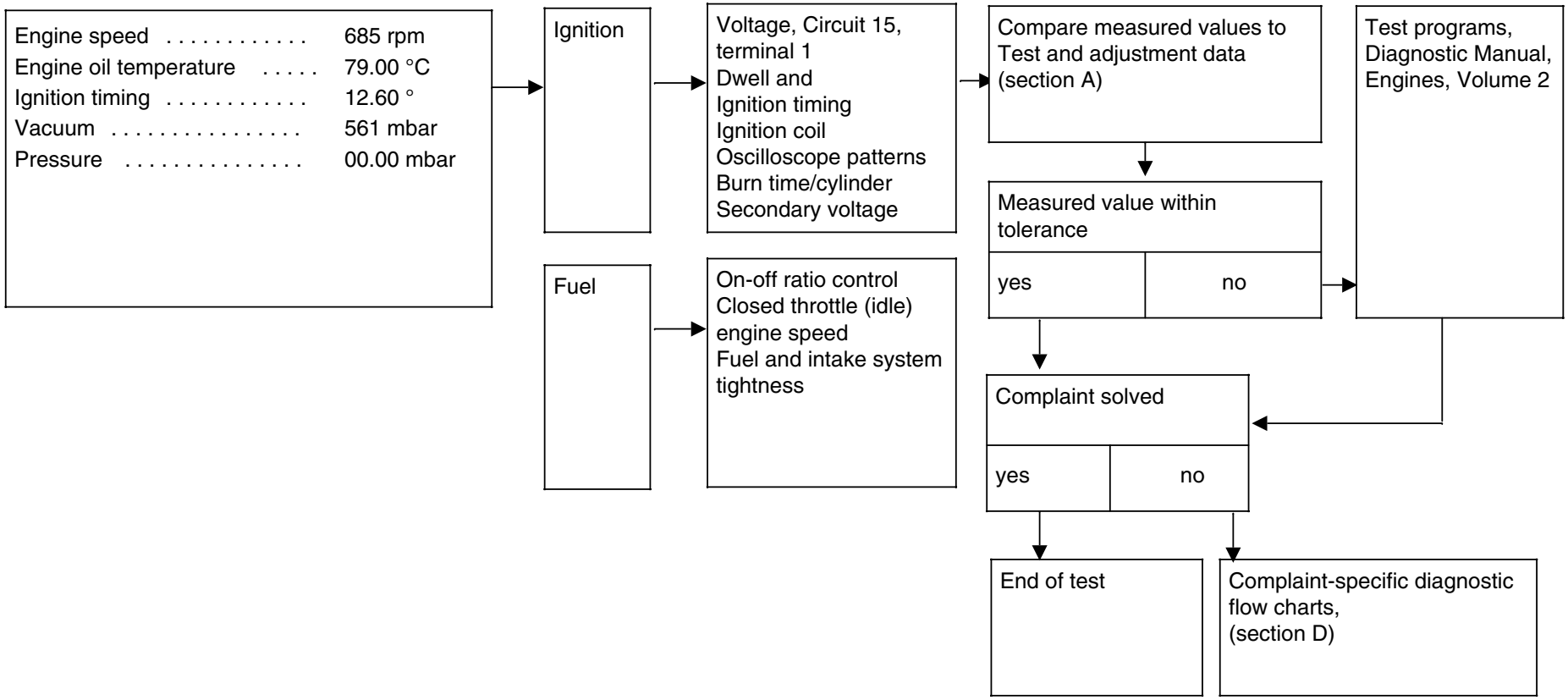
Diagnosis – Engine Adjustment

- The idle speed control can be checked with the dwell test program on engines 102 and 103. In this case, the dwell % measurement is used as an on-off ratio measurement. For the measurement use test cable 102 589 14 63 00 or 103 589 00 63 00.
- Test and adjustment data see section A.

b) Ignition timing

By switching the trigger clamp from cylinder 1 to cylinder 2 on Engine 119, an ignition timing comparison measurement can be made. Subtract 90° from the indicated measurement value to determine the correct specification. This will show any defects in the segments on the starter ring gear.

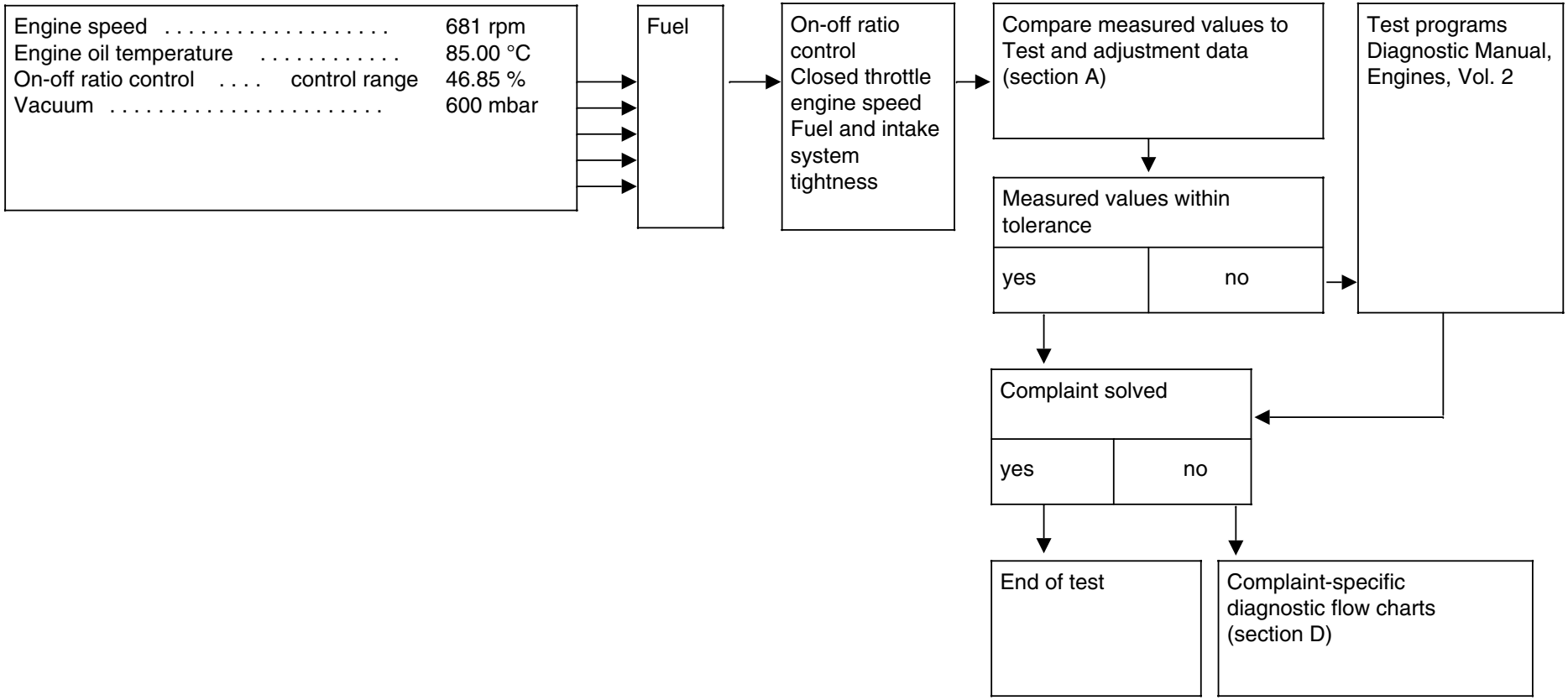
Diagnosis – Engine Adjustment



Note:
The specifications shown are for a 4 cylinder engine and cannot be compared directly.

Diagnosis – Engine Adjustment

c) On-off ratio



Diagnosis – Idle Quality

General Information

The idle quality test allows more in-depth diagnosis of such engine complaints such as rough idle, missing when idling, or delayed starting time. The test scope is divided into:

- Idle quality, engine speed per cylinder,
- Idle quality, burn time per cylinder,
- Idle quality, while starting.

The methods for using each test sequence are explained on the following pages.

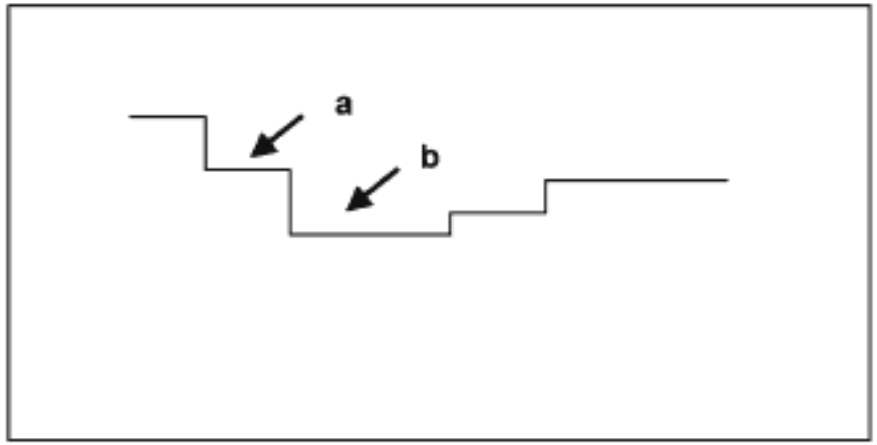
It is necessary in all three test sequences to evaluate the tabular examples and/or the graphic examples. The two should be compared and checked for agreement.

⚠

When evaluating the idle quality measurement, the following should be noted according to the number of cylinders the engine has:

- **4-Cylinder engine**

On 4-cylinder engines, the 2nd engine speed drop, or the following drop in the case of multiple failures, should be evaluated.
With multiple failures, the oscilloscope pattern should be read from the bottom up.



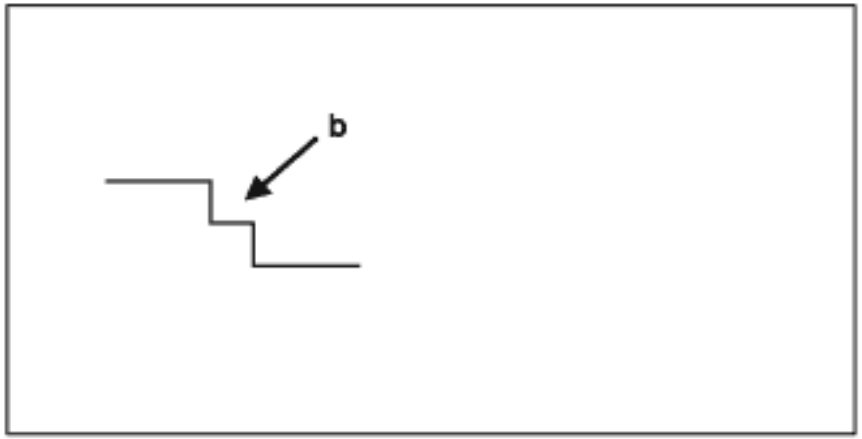
P07-C46.1

Figure 1
a Speed drop from previously firing cylinder
b Defective cylinder

Diagnosis – Idle Quality

- **6-Cylinder engine**

The first engine speed drop should be noted.

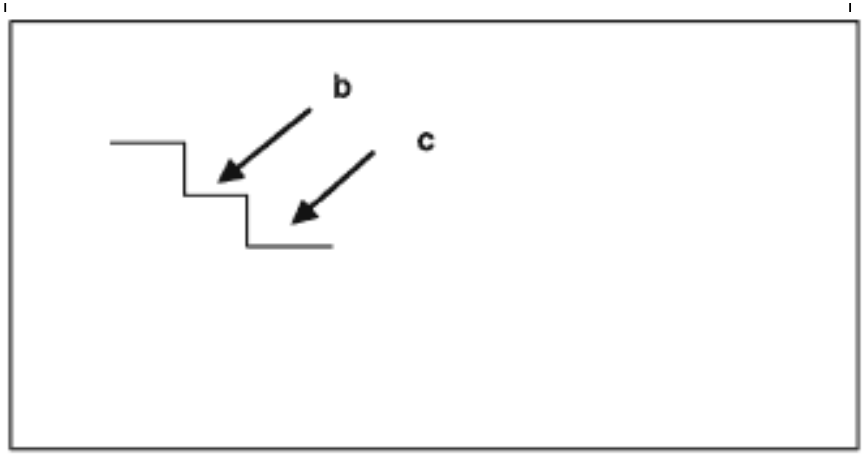


P07-C46.2

Figure 2
b Defective cylinder

- **8-Cylinder engine**

The first engine speed drop should be noted. The engine speed drop occurring after the defective cylinder can be ignored.



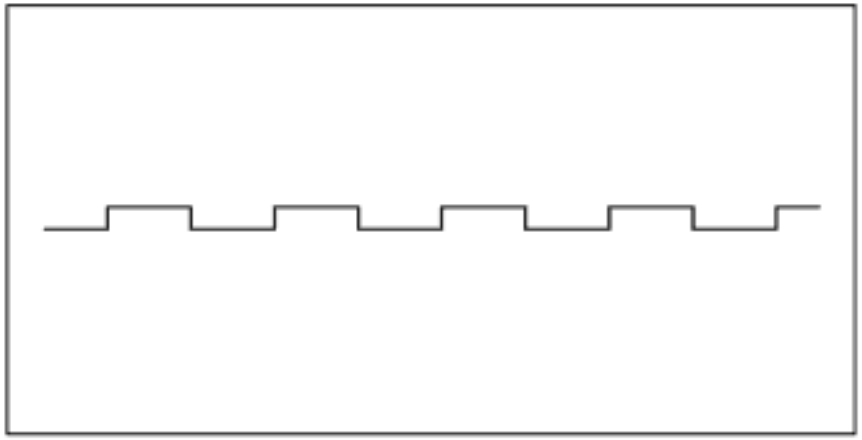
P07-C46.3

Figure 3
b Defective cylinder
c Effect on following cylinder

Diagnosis – Idle Quality

- **12-Cylinder engine**

Retrieving the idle measurement value is difficult due to the large number of cylinders and the simultaneous firing of both ignition circuits. During a smooth engine idle, a small engine speed difference may occur between the cylinder banks in the engine speed table and engine speed graphic. As can be seen in the table, the average engine speed change value of one cylinder bank may exhibit an engine speed decrease when compared to the previously ignited cylinder of the other bank (Figure 5). For this reason, idle quality interpretation via the table (arrows) and the engine speed graphic is more difficult.



P07-C46.4

Figure 4
Correct engine idle

Medium engine speed: 459 rpm

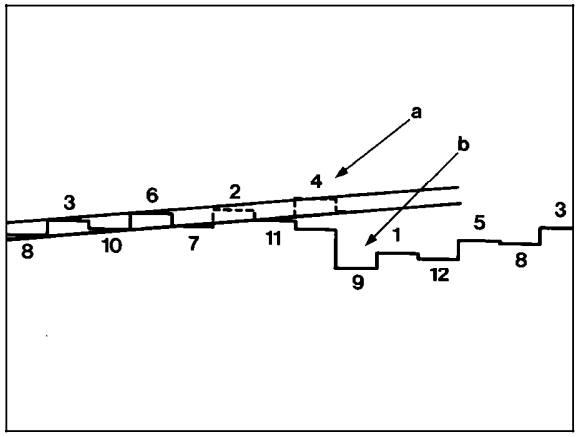
Cylinder	Average engine speed rpm	Average engine speed change rpm
1	664	6
12	658	–6 ◄
5	663	5
8	659	–4 ◄
3	665	6
10	660	–5 ◄
6	665	5
7	658	–7 ◄
2	664	6
11	658	–6 ◄
4	663	5
9	658	–5 ◄
MAX	665	
MIN	658	
DIFF	7	

Figure 5
Correct engine idle

Diagnosis – Idle Quality

- **12-Cylinder engine**

In certain cases, the problem may present itself differently from engine to engine. Therefore, it is almost impossible to determine fault assignment from the engine speed table.



P07-5976-13

Figure 6

a Defective cylinder
b Effect on following cylinder
----- Normal course

By tracking the engine speed of the individual cylinders (starting from the left column), it is shown in the examples given that cylinder 4 (Figure 7) and/or cylinder 10 (Figure 9) is the defective cylinder resulting in a engine speed decrease and engine running complaint.
One method to identify the correct cylinder is to print out the engine speed graphic and draw in two lines. The lines should intersect the trailing edge of individual engine speed segment for each cylinder bank (Figures 6 and 8).

Cylinder	Average engine speed rpm	Average engine speed change rpm
1	716	11
12	712	–4
5	723	11
8	721	–2
3	732	11
10	730	–2
6	740	10
7	734	–6
2	743	9
11	737	–6
4	730	–7 ← a
9	705	–25 ← b
MAX	743	
MIN	705	
DIFF	38	

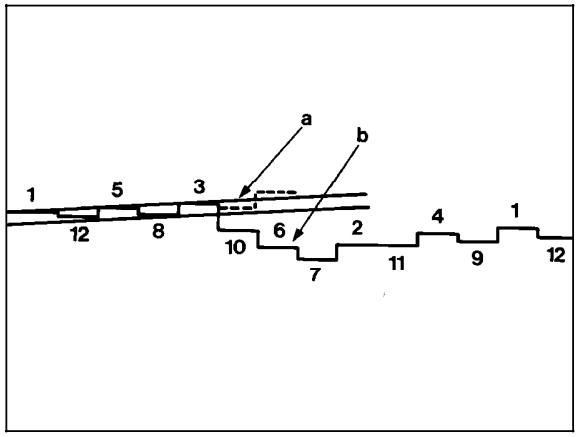
Figure 7

Cylinder 4 defective (right bank)

Diagnosis – Idle Quality

- **12-Cylinder engine**

The subsequent, and somewhat larger engine speed decline should not be observed for evaluation. In order simplify evaluation, the dotted course in the given example represents the engine speed sequence without a running complaint (Figure 4).



P07-5977-13

Figure 8

a Defective cylinder
b Effect on following cylinder
----- Normal course

Cylinder	Average engine speed rpm	Average engine speed change rpm
1	743	11
12	739	–4
5	748	9
8	744	–4
3	752	8
10	734	–10 ← a
6	722	–12 ← b
7	717	–5
2	727	10
11	724	–3
4	735	11
9	732	–3
MAX	752	
MIN	717	
DIFF	35	

Figure 9

Cylinder 10 defective (left bank)

Diagnosis – Idle Quality

Engine Speed per Cylinder

The “Engine Speed per Cylinder” table clearly shows that the cylinder with the lowest engine speed is the weakest.
As a result, the measured value is well suited as a confirmation in cases of frequent missing which can not be identified with certainty by use of the engine speed graphic example.
Since these values represent an average of individual values, intermittent missing can not be identified.
Intermittent misses can only be identified and evaluated by means of the sample graphic illustration.
Before starting repair work based on test results, the vehicle should be evaluated from the driver’s seat and compared to typical production vehicles.
(Vehicles with automatic transmissions should be evaluated with the transmission in a drive range.)
In such a case, test results can not replace individual judgment and the experience of a specialist.

a) 4-cylinder engine, example 1

In principle, the **average engine speed change or average engine speed difference** measurements should **not** be used to diagnose 4-cylinder engines for reasons of measuring technique.

The reason is:

The average speed change value of a properly functioning cylinder can indicate a high speed drop of the following cylinder, thereby leading to a false diagnosis.
In case of a failure, the average speed change value on 4-cylinder engines can not clearly indicate the defective cylinder.

Diagnosis – Idle Quality

Engine Speed per Cylinder

Idle quality table – Engine 102/111, Example 1

Cylinder	Average engine speed	Average engine speed change
1	785	1
3	776	– 9
4	784	8
2	784	0
Max	785	
Min	776	
Difference	9	

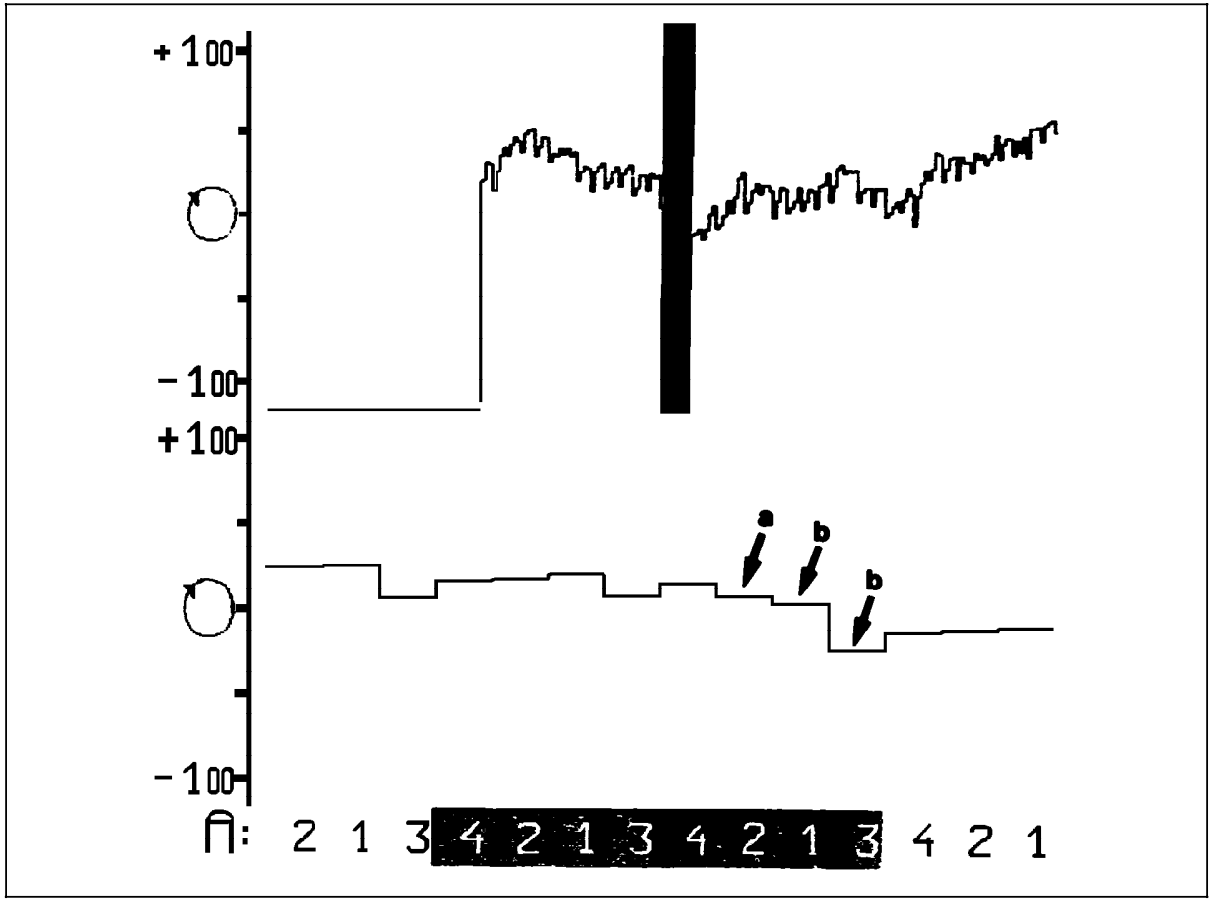
Note:
Brief or intermittent misfires can not be recognized from the table, for this purpose, the **scope pattern** must be used to identify the defective cylinder. The column “Average engine speed change” **must not be used** for the evaluation. A clear statement is only possible via the **Average engine speed**.

Diagnosis – Idle Quality

Engine Speed per Cylinder

Idle Quality Scope Pattern
Example 1 – Engine 102/111
On 4-cylinder engines the 2nd engine speed drop, or the following drop in the case of multiple failures, should be evaluated. The scope pattern must be read from **bottom to top**. In the example, cylinder 3 (arrow) is defective. **3rd engine speed drop**.

Average engine speed	768 rpm
Engine oil temperature	75 °C



P15-0408-57

Figure 10
a Engine speed drop from previously firing cylinder
b Defective cylinder

Diagnosis – Idle Quality

Engine Speed per Cylinder

Table Idle quality – Engine 102/111, Example 2

Cylinder	Average engine speed	Average engine speed change
1	999	5
3	994	– 5 Incorrect reading
4	**976**	**– 18 Defective cylinder**
2	994	18
Max	999	
Min	**976**	
Difference	23	

Note:
Brief or intermittent misfires can not be recognized from the table, for this purpose, the **scope pattern** must be used to identify the defective cylinder. The column “Average engine speed change” **must not be used** for the evaluation. A clear statement is only possible via the **Average engine speed**.

Diagnosis – Idle Quality

Engine Speed per Cylinder

Table Idle quality – Engine 102 with Tandem Mass Flywheel, Example 3

Cylinder	Average engine speed	Average engine speed change
1	753	– 1
3	750	– 3
4	**739**	**– 11 Defective cylinder**
2	754	15
Max	754	
Min	739	
Difference	15	

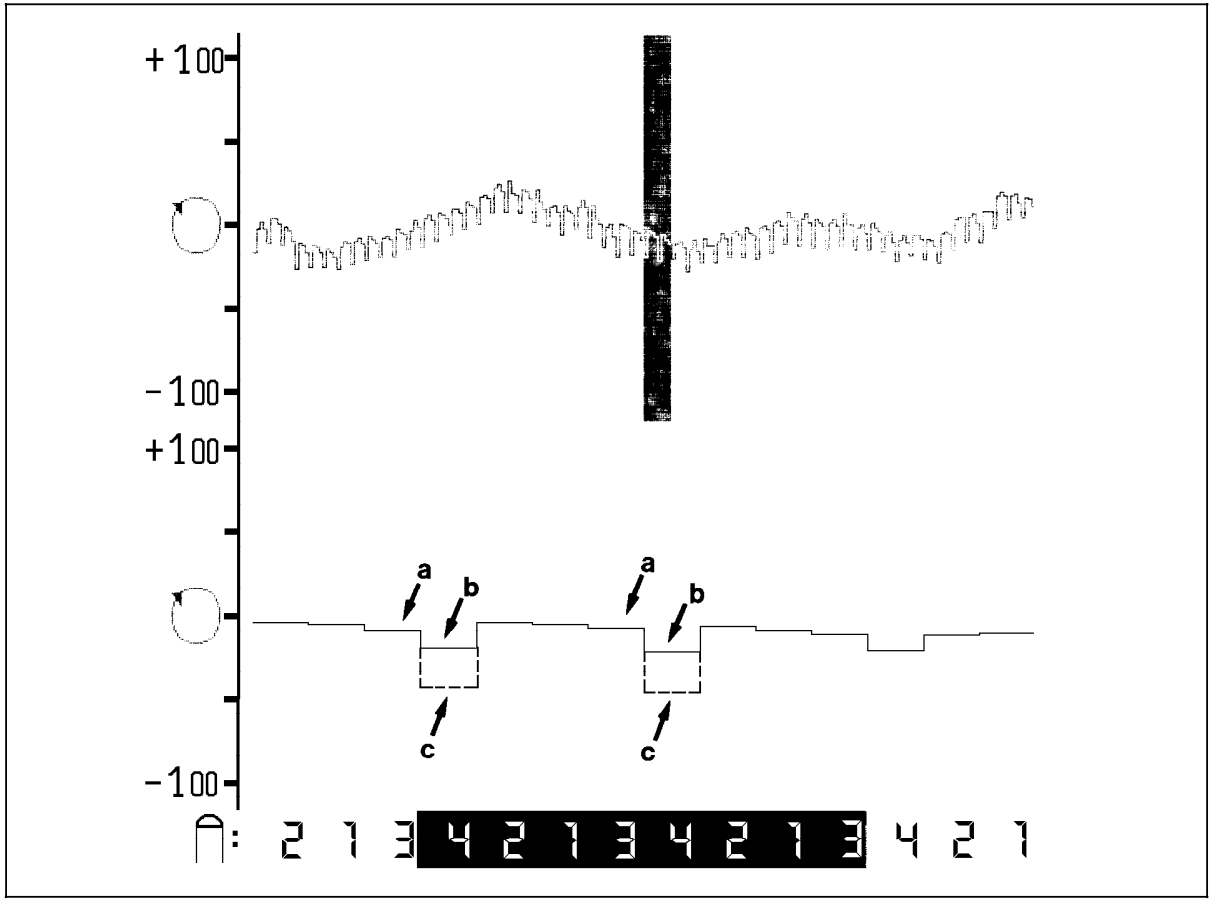
Diagnosis – Idle Quality

Engine Speed per Cylinder

Idle Quality Scope Pattern
Engine 102 with Tandem Mass Flywheel
In the example, cylinder 4 is defective (arrow b), 2nd engine speed drop. On engines with tandem mass flywheel, the engine speed drop of a non-working cylinder is not shown as noticeably.

Average engine speed	735 rpm
Engine oil temperature	90 °C

The dotted area “c” shows the engine speed drop of an engine without tandem mass flywheel.



P07-5155-57

Figure 11

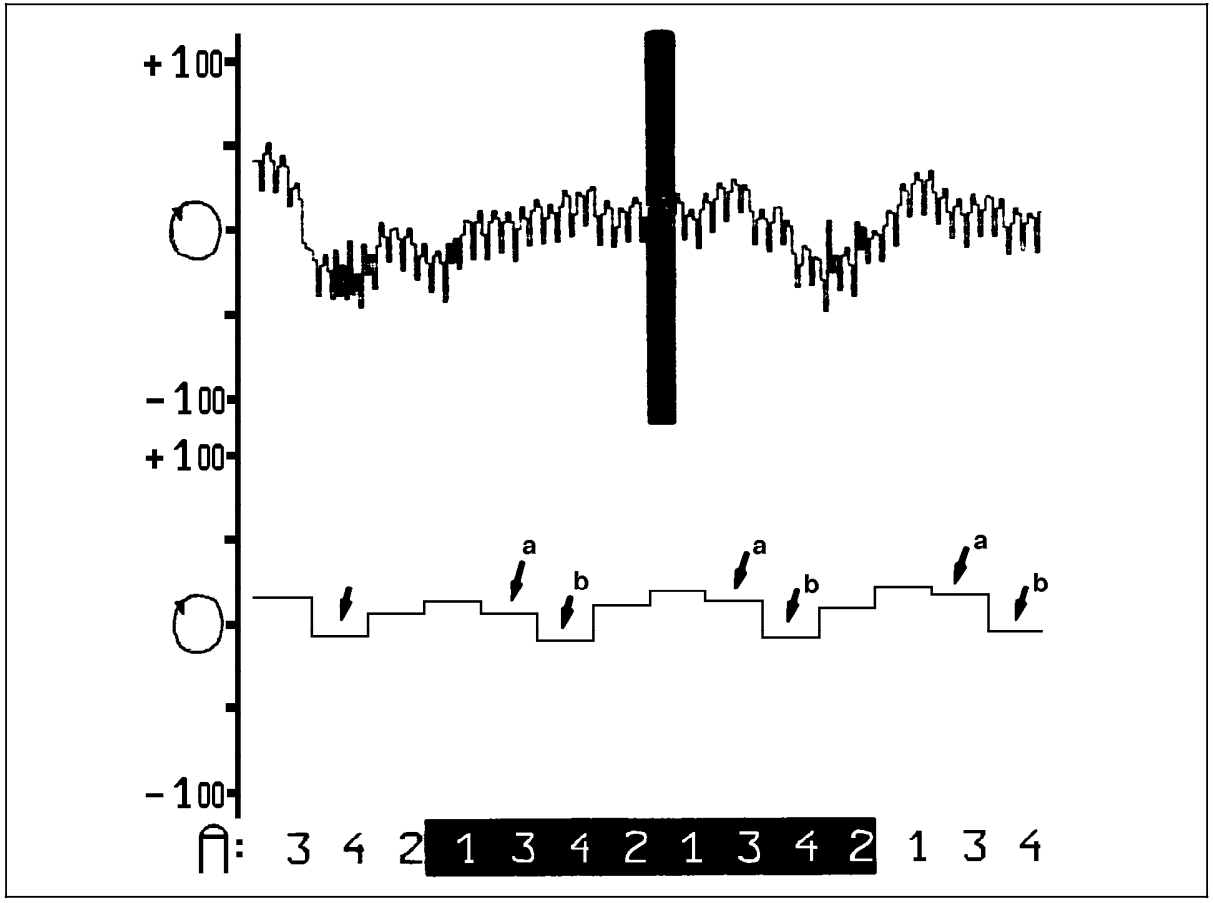
a Engine speed drop from previously firing cylinder (only one failure)
b Defective cylinder
c Engine speed drop of engine **without** tandem mass flywheel

Diagnosis – Idle Quality

Engine Speed per Cylinder

Idle Quality Scope Pattern
Engine 102 with Tandem Mass Flywheel
In the example, cylinder 4 is defective (arrow b), 2nd engine speed drop. The previous cylinder is also influenced. The scope pattern must be read **from bottom to top**.

Average engine speed	997 rpm
Engine oil temperature	75 °C



P15-0355-57

Figure 12

a Engine speed drop from previously firing cylinder (only one failure)
b Defective cylinder

Diagnosis – Idle Quality

Engine speed per cylinder

c) 6-Cylinder engine, Engine 103

In the example shown in the table below, the average engine speed for cylinder 6 is the lowest. The average engine speed change at cylinder 6 is clearly the greatest and can be used for the evaluation.
The engine speed drop is also clearly visible in the scope pattern.

Table Idle quality

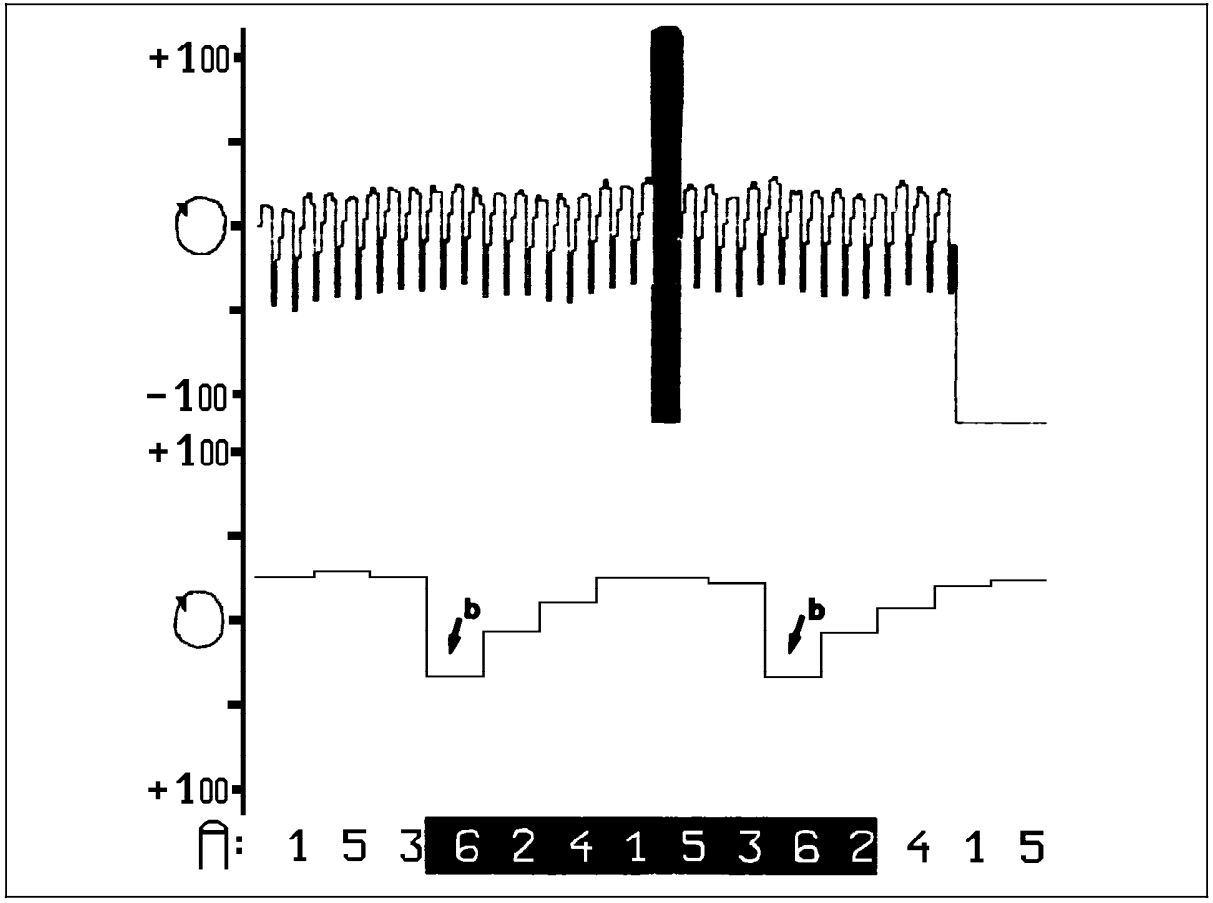
Cylinder	Average engine speed	Average engine speed change
1	727	14
5	728	1
3	**726**	– 2
6	**670**	**– 56 Defective cylinder**
2	698	28
4	713	15
Max	728	
Min	670	
Difference	58	

Diagnosis – Idle Quality

Engine Speed per Cylinder

Idle quality scope pattern, Engine 103
In this example it is clear that cylinder 6 (Arrow) is defective.

Closed throttle engine speed	712 rpm
Engine oil temperature	70 °C



P15-0357-57

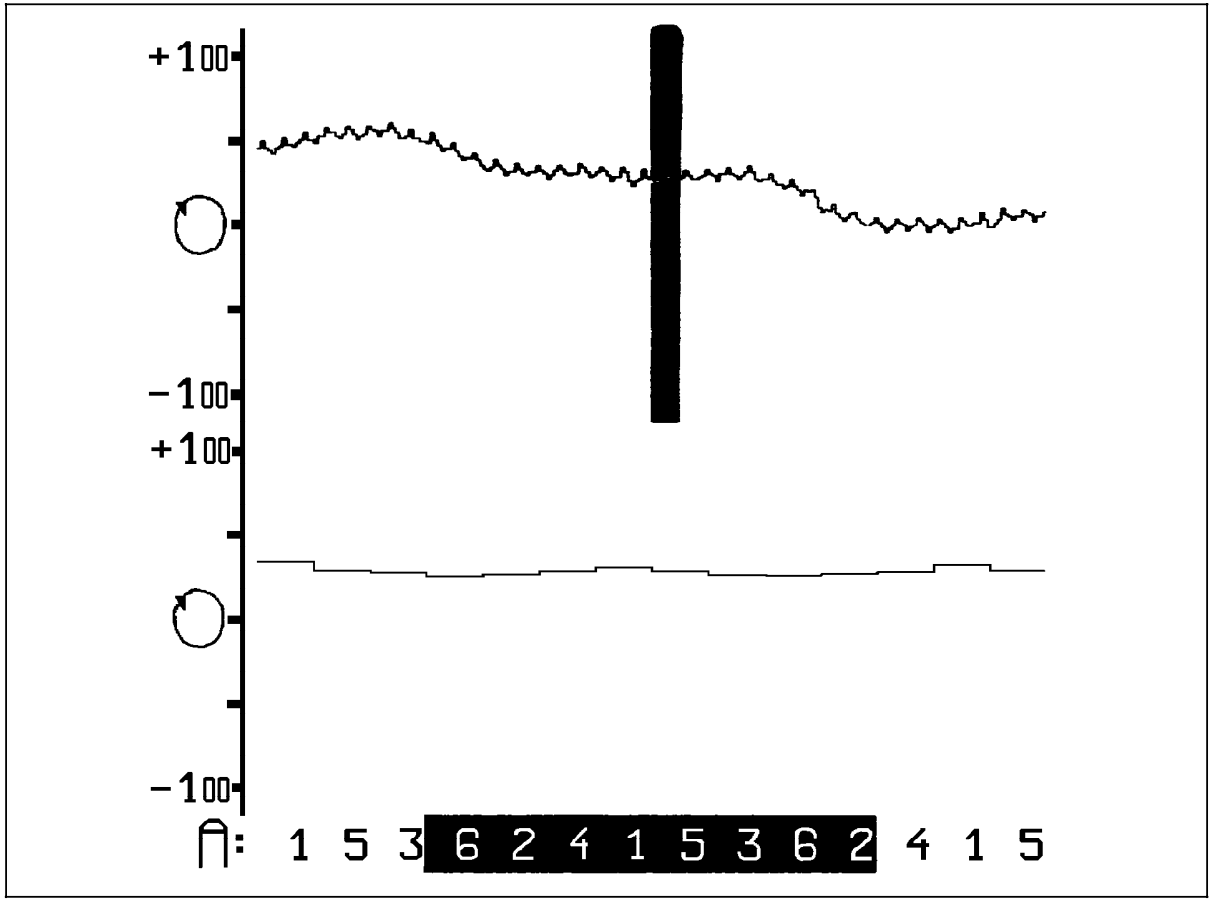
Figure 13
b Defective cylinder

Diagnosis – Idle Quality

Engine Speed per Cylinder

Idle quality scope pattern, Engine 104
In this example the engine operation is correct.

Closed throttle engine speed	712 rpm
Engine oil temperature	70 °C



P15-0356-57

Figure 14

Diagnosis – Idle Quality

Engine Speed per Cylinder

d) 8-Cylinder engine, Engine 116/117

In principle, the average engine speed change or average engine speed difference value measured should **not** be used for diagnosis of 8 cylinder engines.

Cause:

The engine speed difference value can indicate an excessive engine speed drop on the cylinder following a strong cylinder, thus leading to a faulty diagnosis.

The engine speed difference value can not be traced **with certainty** to the **defective cylinder**.

In the example shown in the table, the average engine speed for cylinder 6 is the lowest. However, the average engine speed change for cylinder 8 is the greatest.
Since the greatest engine speed drop occurs at cylinder 8, cylinder 8 is the defective cylinder. Cylinder 6, which follows, is affected by cylinder 8 and should be ignored.

Table Idle quality

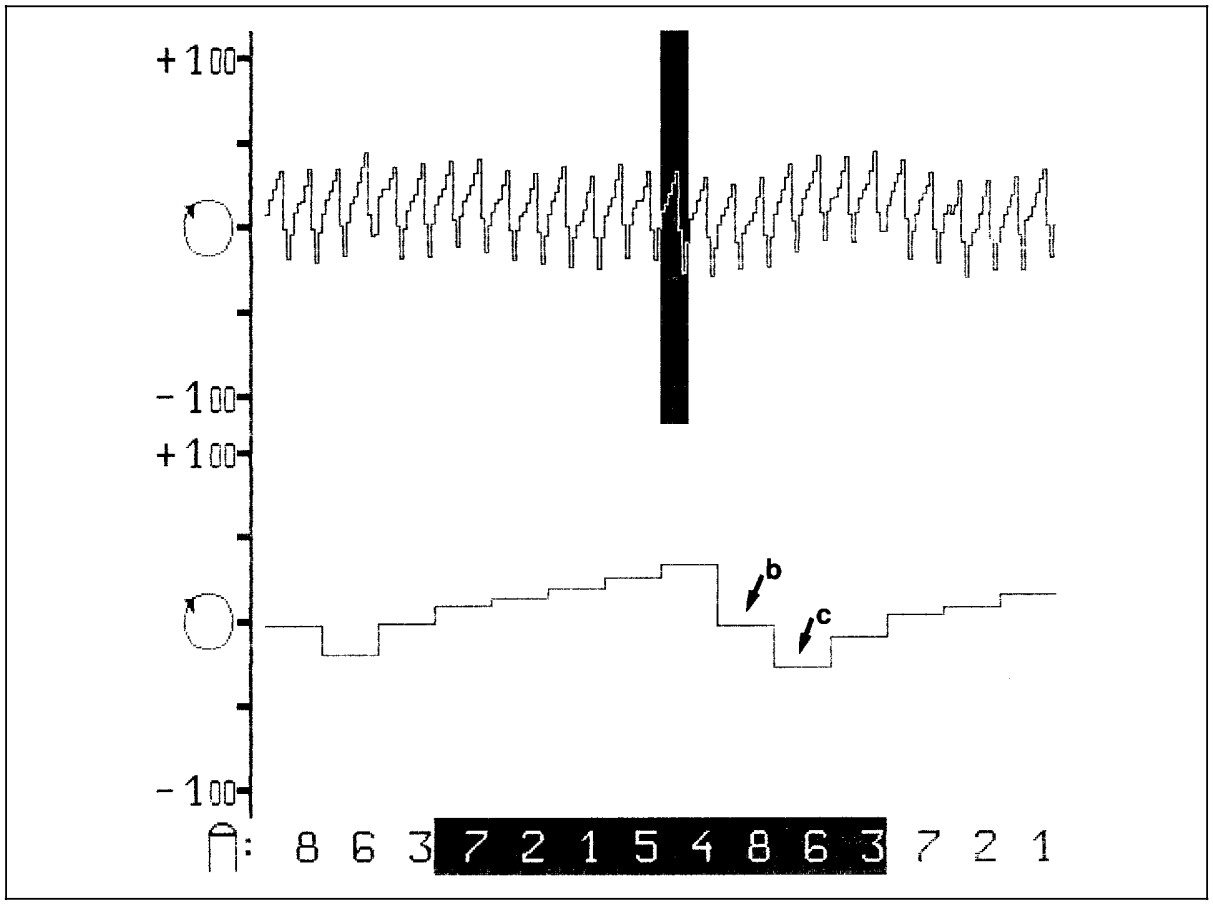
Cylinder	Average engine speed	Average engine speed change
1	704	4
5	712	8
4	720	8
8	**686**	**– 34 Defective cylinder**
6	**668**	– 18 Effect from cylinder 8
3	684	16
7	695	11
2	700	5
Max	720	
Min	668	
Difference	52	

Diagnosis – Idle Quality

Engine Speed per Cylinder

Idle quality scope pattern, Engine 116/117
During diagnosis, evaluate the largest engine speed drop (long edge, arrow) on the display and confirm with the table, if necessary.
An intermittent miss can only be determined from the graphic since the table can not indicate intermittent misses. This is dependent on the frequency of the miss.

Closed throttle engine speed	690 rpm
Engine oil temperature	85 °C



P15-0358-57

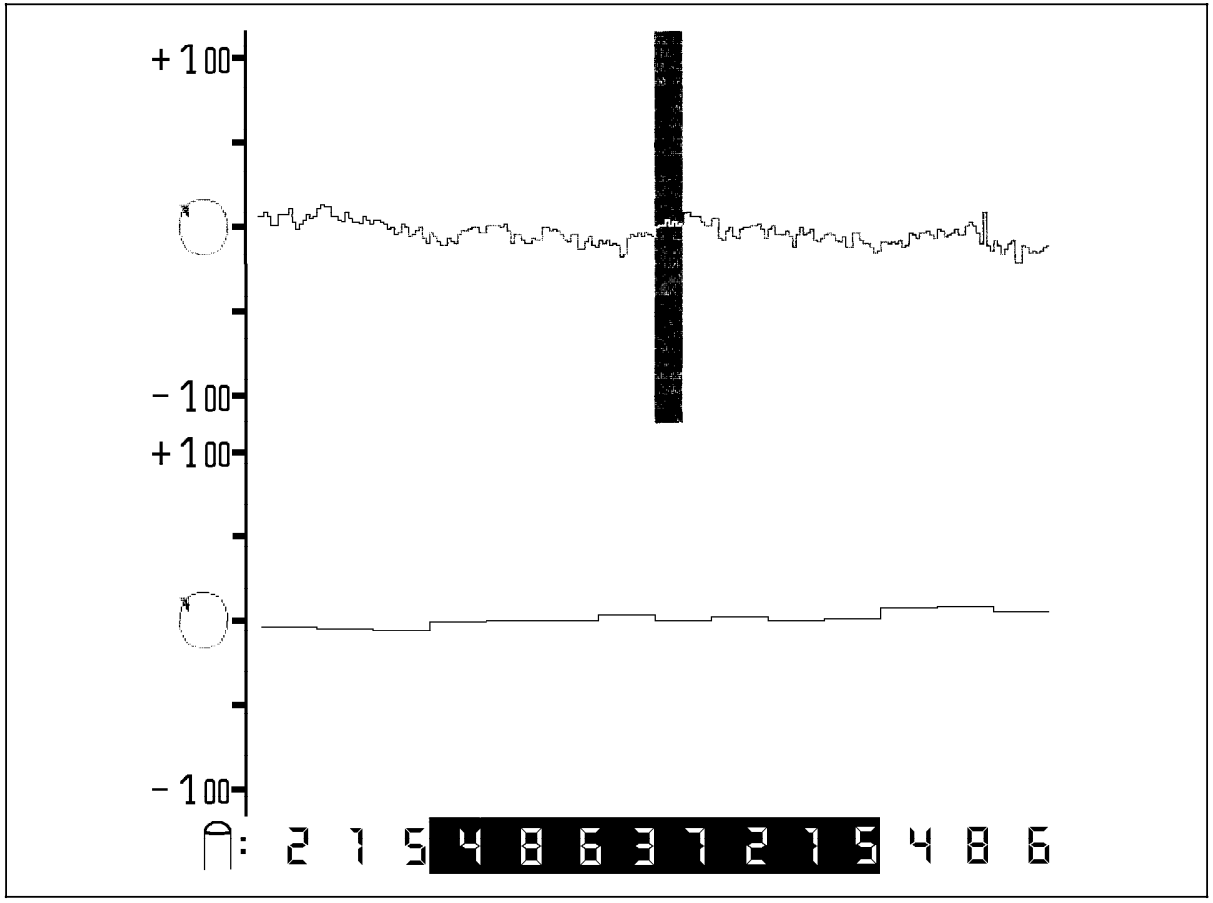
Figure 15
b Defective cylinder
c Effect on following cylinder

Diagnosis – Idle Quality

Engine Speed per Cylinder

Idle quality scope pattern, Engine 116/117
In this example the engine operation is correct.

Closed throttle engine speed	665 rpm
Engine oil temperature	85 °C



P15-0359-57

Figure 16

Diagnosis – Idle Quality

Engine Speed per Cylinder

e) 8-Cylinder Engine, Engine 119

Table Idle quality

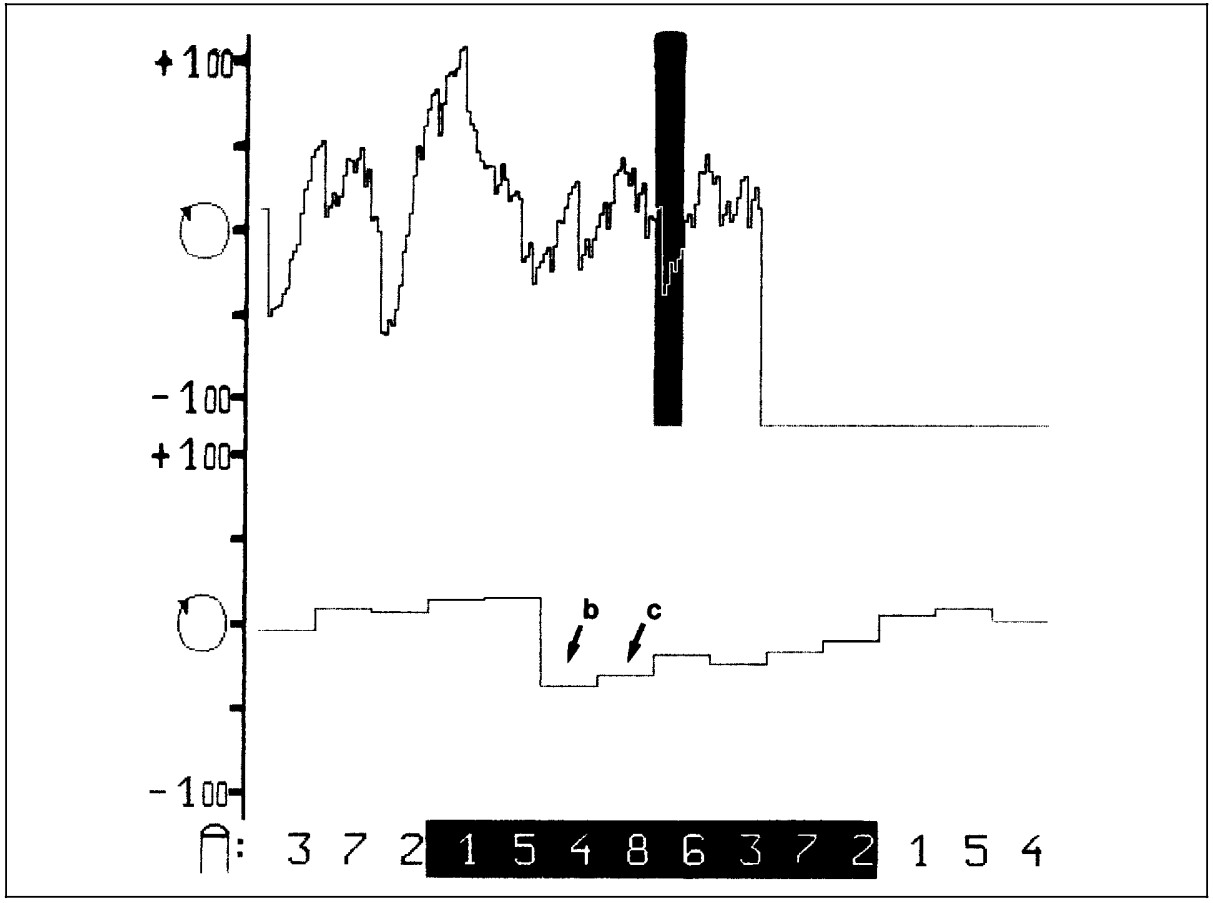
Cylinder	Average engine speed	Average engine speed change
1	658	3
5	656	– 2
4	660	4
8	658	– 2
6	659	1
3	656	– 3
7	660	4
2	655	– 5
Max	660	
Min	655	
Difference	5	

Diagnosis – Idle Quality

Engine Speed per Cylinder

Idle quality scope pattern, Engine 119

Closed throttle engine speed	690 rpm
Engine oil temperature	85 °C



P15-0365-57

Figure 17

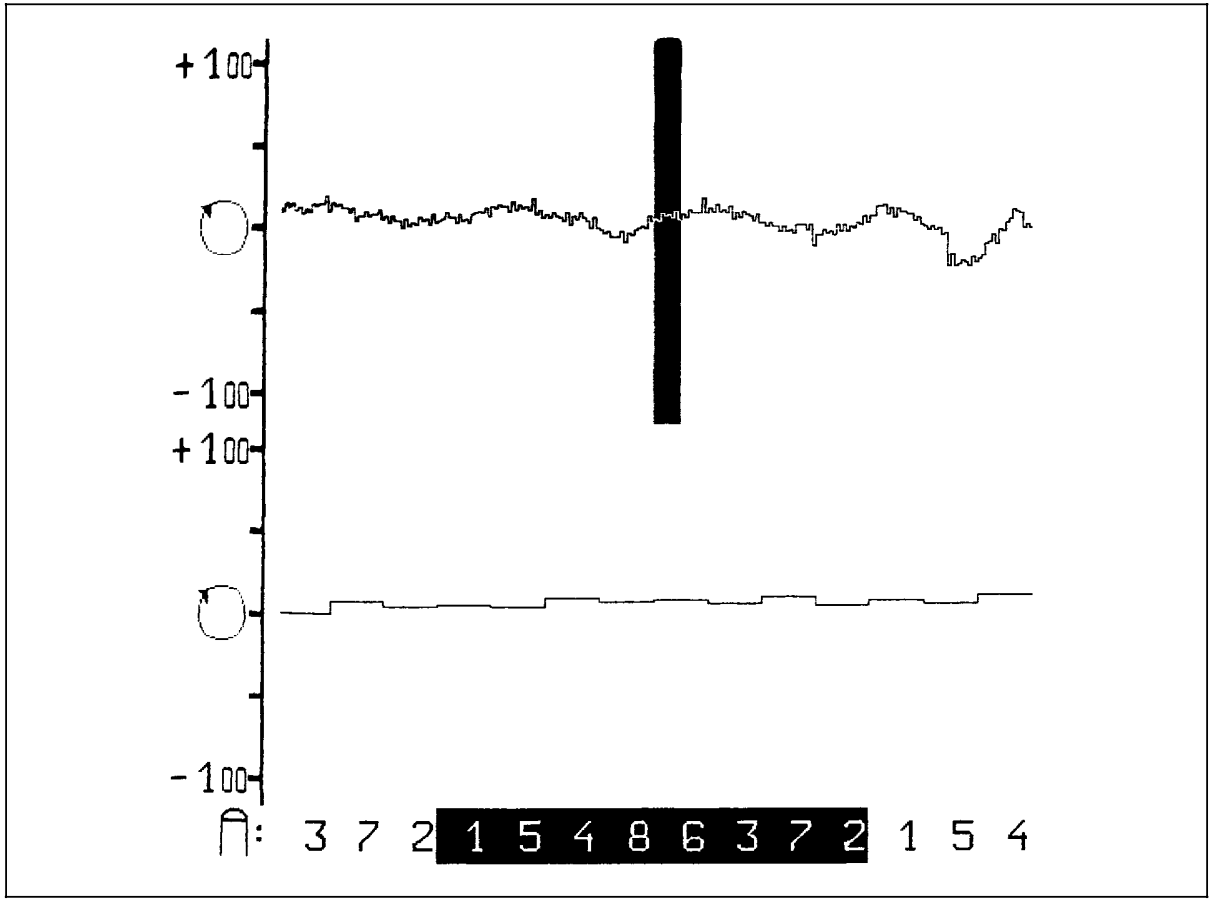
b Defective cylinder
c Effect on following cylinder

Diagnosis – Idle Quality

Engine Speed per Cylinder

Idle quality scope pattern, Engine 119
In this example the engine operation is correct.

Closed throttle engine speed	654 rpm
Engine oil temperature	85 °C



P15-0386-57

Figure 18

Diagnosis – Idle Quality

Engine Speed per Cylinder

f) 12-Cylinder Engine, Engine 120

Table Idle quality

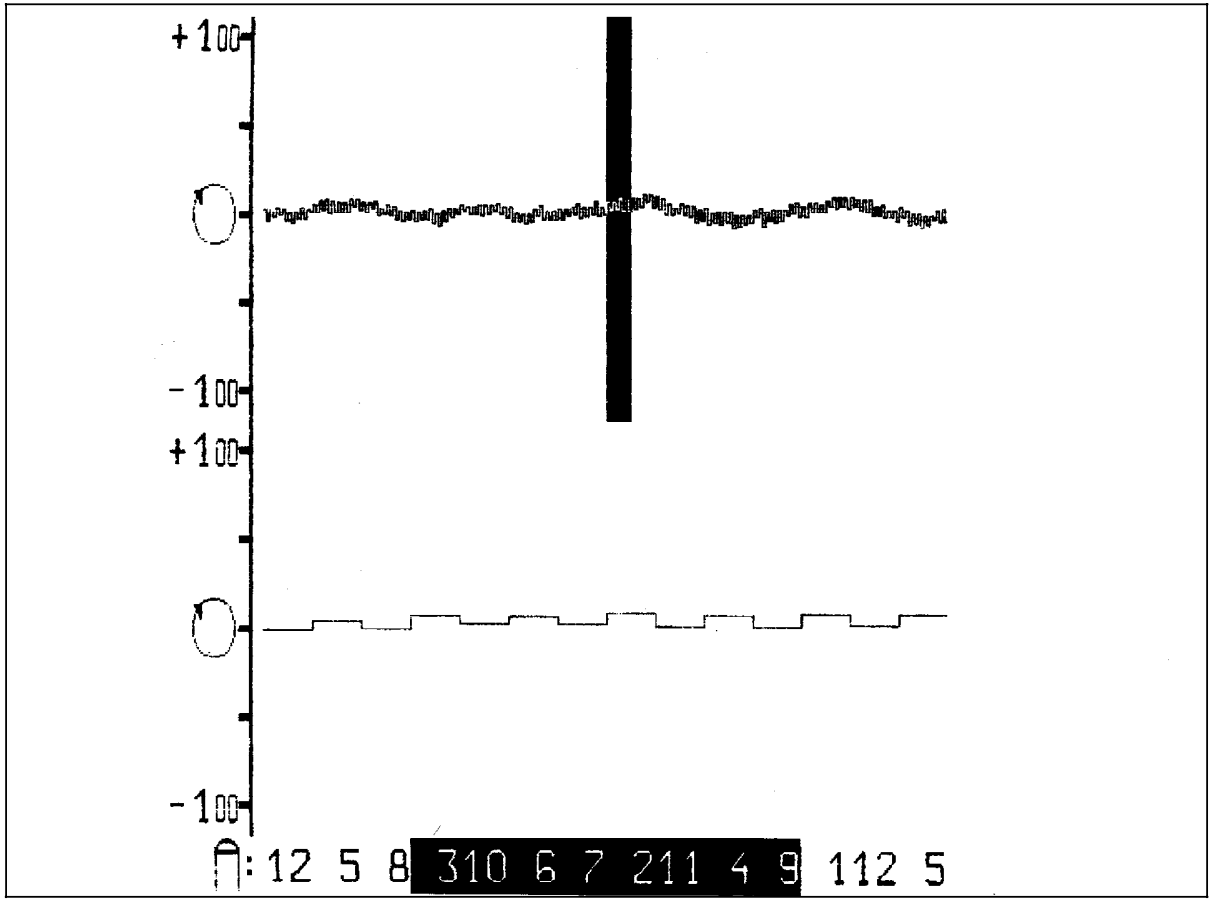
Cylinder	Average engine speed	Average engine speed change
1	664	6
12	658	– 6
5	663	5
8	659	– 4
3	665	6
10	660	– 5
6	665	5
7	658	– 7
2	664	6
11	658	– 6
4	663	5
9	658	– 5
Max	665	
Min	658	
Difference	7	

Diagnosis – Idle Quality

Engine Speed per Cylinder

Idle quality scope pattern, Engine 120
In this example the engine operation is correct.

Closed throttle engine speed	659 rpm
Engine oil temperature	85 °C



P07-5978-57

Figure 19

Diagnosis – Idle Quality

Engine Speed per Cylinder

f) 12-Cylinder Engine (Engine 120)

Table Idle quality

Cylinder 4 defective (right bank)

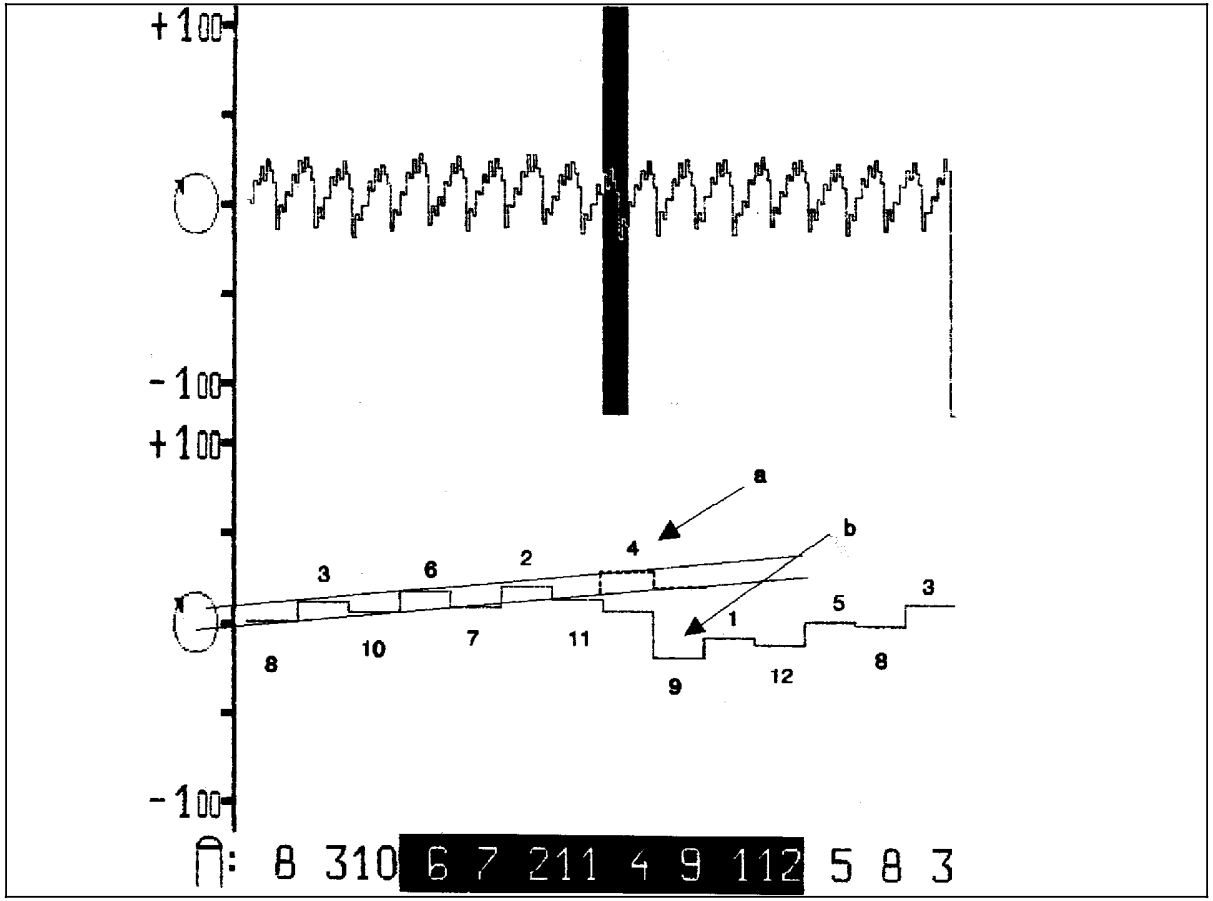
Cylinder	Average engine speed	Average engine speed change
1	716	11
12	712	– 4
5	723	11
8	721	– 2
3	732	11
10	730	– 2
6	740	10
7	734	– 6
2	743	9
11	737	– 6
4	730	– 7 Defective cylinder
9	705	– 25 Effect on following cylinder
Max	743	
Min	705	
Difference	38	

Diagnosis – Idle Quality

Engine Speed per Cylinder

Idle quality scope pattern, Engine 120

Closed throttle engine speed	723 rpm
Engine oil temperature	approx. 75 °C



P07-5975-57

Figure 20
Cylinder 4 defective (right bank)

a	Defective cylinder
b	Effect on following cylinder
------	Normal course (w/o defective cylinder)

Diagnosis – Idle Quality

Engine Speed per Cylinder

f) 12-Cylinder Engine, Engine 120
Table Idle quality

Cylinder 10 defective (left bank)

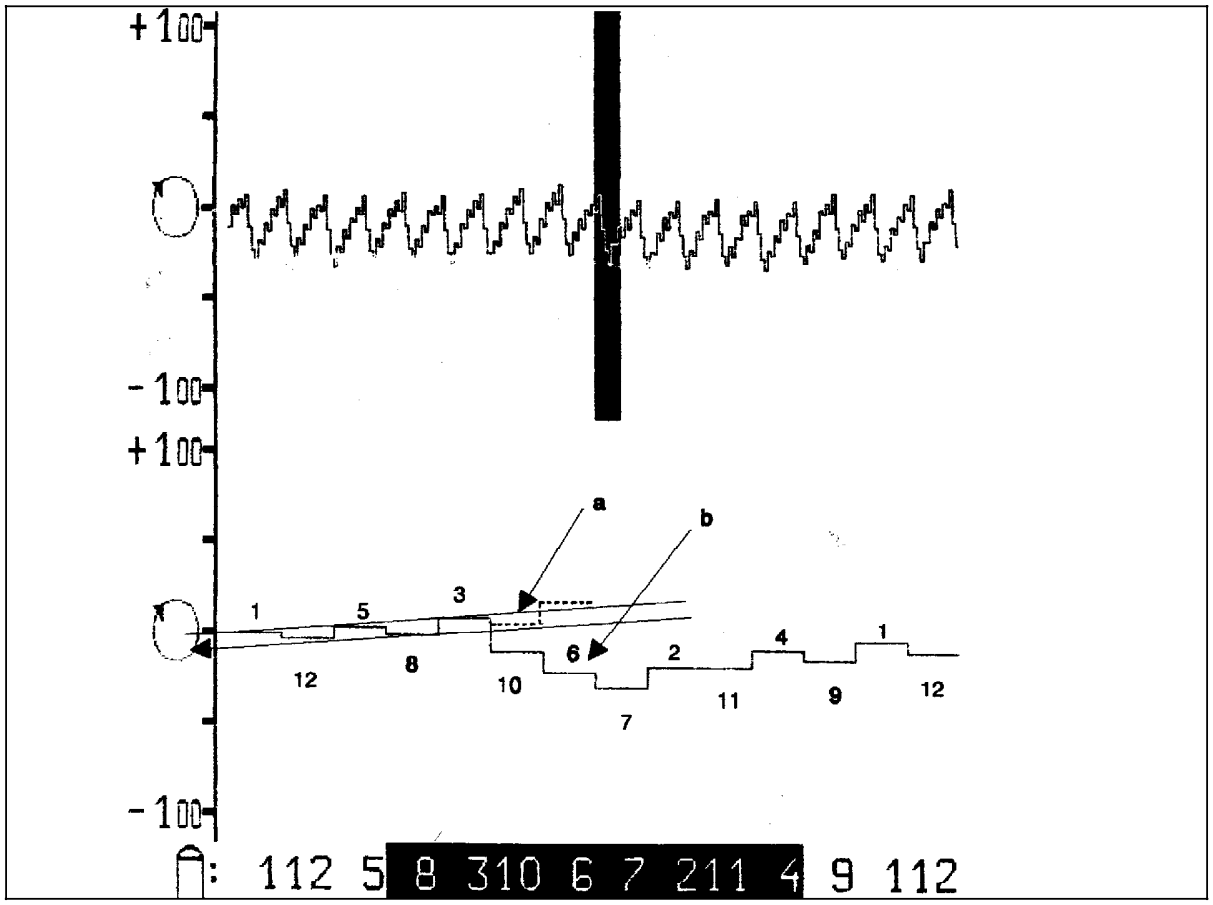
Cylinder	Average engine speed	Average engine speed change	
1	743	11	
12	739	– 4	
5	748	9	
8	744	– 4	
3	752	8	
10	734	– 18	Defective cylinder
6	722	–12	Effect on following cylinder
7	717	– 5	
2	727	10	
11	724	– 3	
4	735	11	
9	732	– 3	
Max	752		
Min	717		
Difference	35		

Diagnosis – Idle Quality

Engine Speed per Cylinder

Idle quality scope pattern, Engine 120

Closed throttle engine speed	723 rpm
Engine oil temperature	approx. 75 °C



P07-5974-57

Figure 21
Cylinder 10 defective (left bank)
a Defective cylinder
b Effect on following cylinder
---- Normal course (w/o defective cylinder)

Diagnosis – Idle Quality

Burn Time per Cylinder
(only with Bear engine analyzer)

This test is intended as an initial measurement similar to the idle quality test. Positive or negative variations, which always occur at the same cylinder, indicate a problem in the ignition system which will not always necessarily result in an engine speed drop. However, engine missing may occur at higher mileage.

⚠

Burn time per cylinder, Engine 104/111 HFM-SFI can be tested with HHT starting 01/94.

Major positive or negative variations may be caused by carbon fouled spark plugs (e. g. short-distance driving).
The vehicle should be driven for a longer distance to obtain a more exact diagnosis.
The variations shown in the table do not result in an unacceptable engine speed drop.

Table Idle quality, Engine 102

Cylinder	Average engine speed	Average engine speed change
1	683	– 4
3	684	1
4	686	2
2	687	1
Max	687	
Min	683	
Difference	4 – Difference value still acceptable	

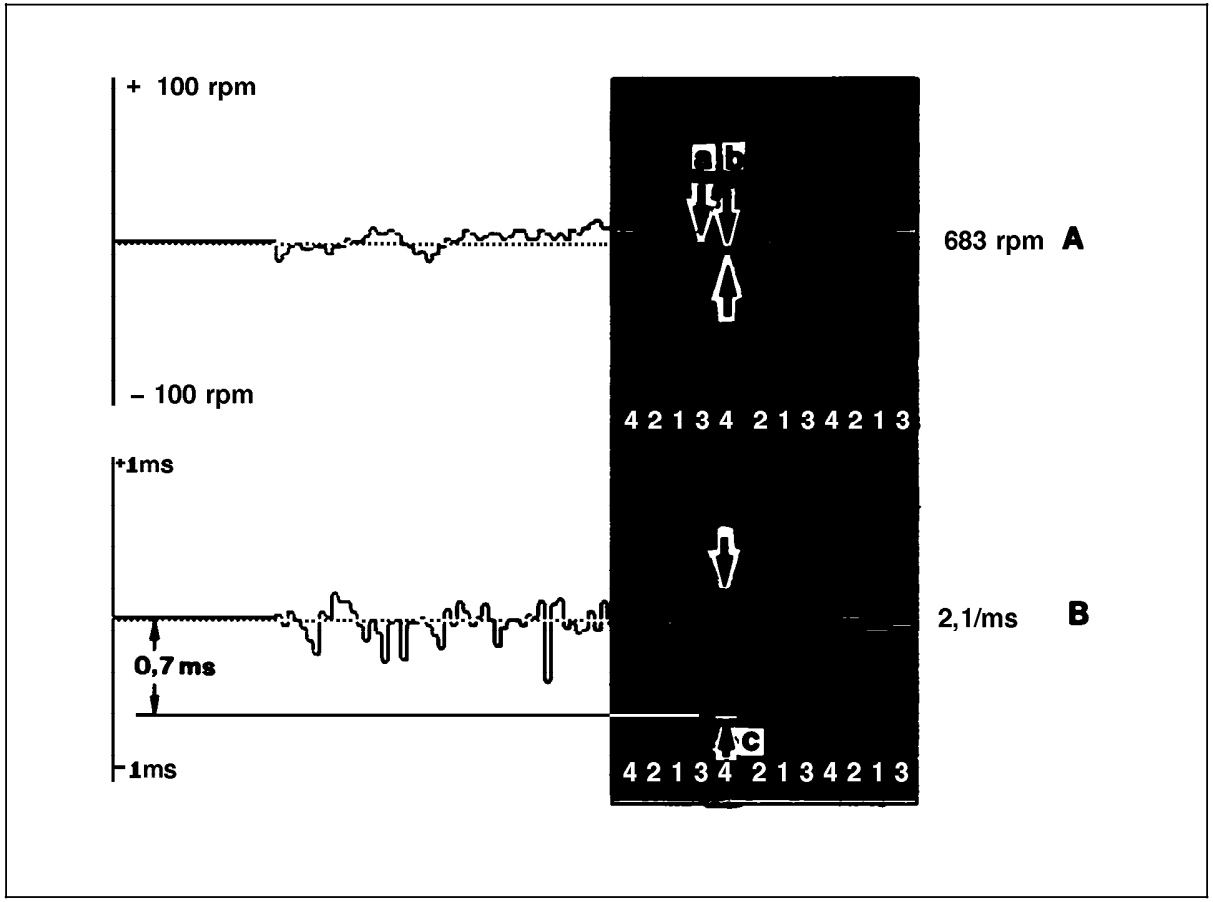
Diagnosis – Idle Quality

Burn Time per Cylinder

Variations >± 0.5 ms per cylinder should be confirmed by additional measurements such as **oscilloscope and secondary ignition system table.**

Scope pattern, Engine 102

A –	Average engine speed	683 rpm
	Engine oil temperature	75 °C
B –	Average burn time/cylinder	2.1 ms



U15-0413-57

Figure 22

a Engine speed drop caused by preceding cylinder
b Defective cylinder
c Ignition malfunction caused by carbon or oil fouled spark plug. Possible defective insulation on secondary side.

Diagnosis – Idle Quality

While Starting

The program "**Idle Quality**" can be used as a "**Starting Test**" to quickly isolate leaking injection valves.

Preconditions:

- Warm up engine to at least 80 °C engine oil temperature.
- Shut off engine for at least 15 minutes. Observe "Complaint related notes."
- Select idle quality program, the program "Idle quality".
- Starting test appears only when engine is turned off.
- Start engine and follow instructions displayed on engine analyzer.

⚠

The idle quality table must not be used for analysis.
The fault indications can only be determined from the scope pattern (see example 4-, 6- and 8-Cylinder engine).

The example shows a 4 cylinder engine
Idle quality table, Engine 102

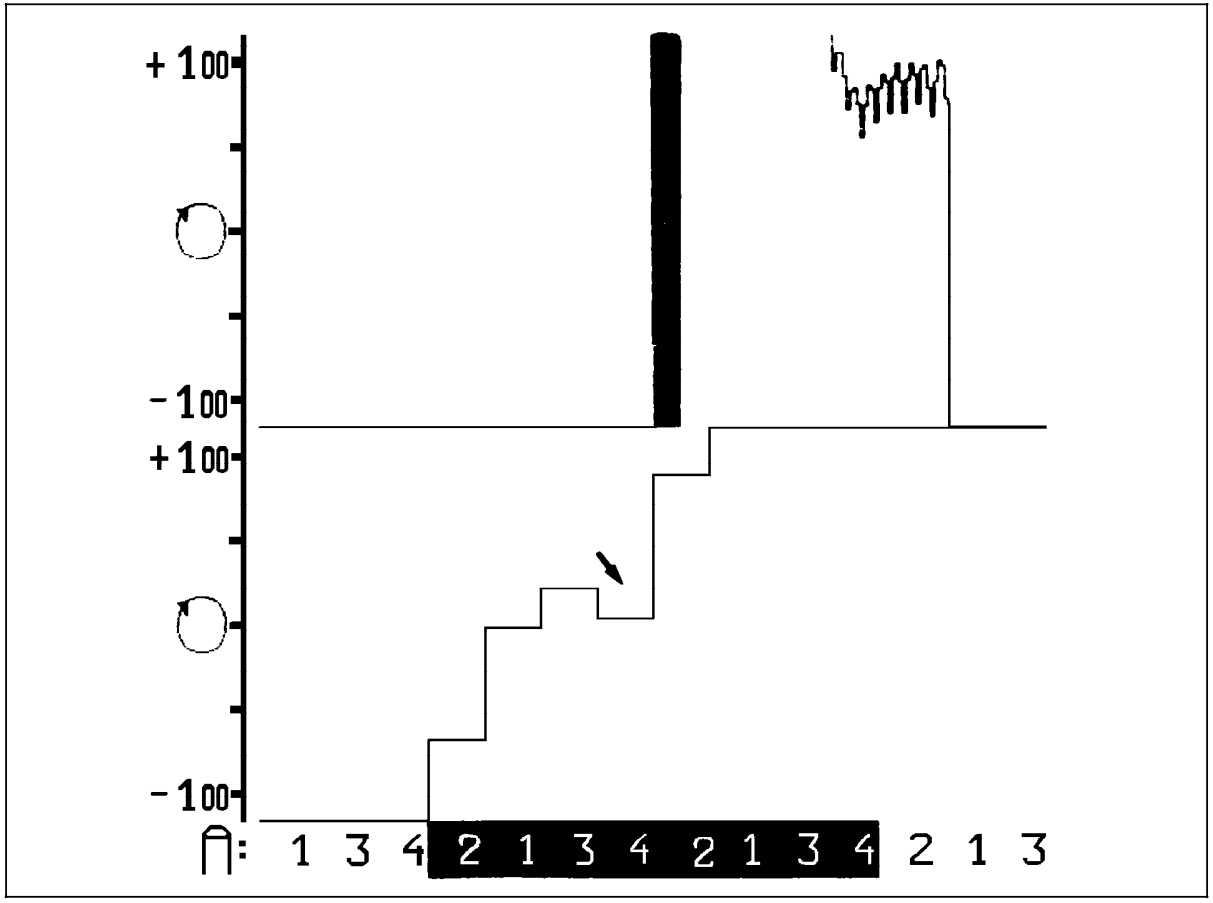
Cylinder	Average engine speed	Average engine speed change
1	1056	17
3	1051	– 5
4	1047	– 4
2	1039	– 8
Max	1056	
Min	1039	
Difference	17	

Diagnosis – Idle Quality

While Starting

a) 4-Cylinder engine, Engine 102
Malfunction at cylinder 4, arrow.
Cause: leaking injection valve.
Engine shut off for approximately 15 minutes after previous start.

Closed throttle engine speed
after starting . . . . . 938 rpm
Engine oil temperature . . . . . 80 °C



P15-0362-57

Figure 23

Diagnosis – Idle Quality

While Starting

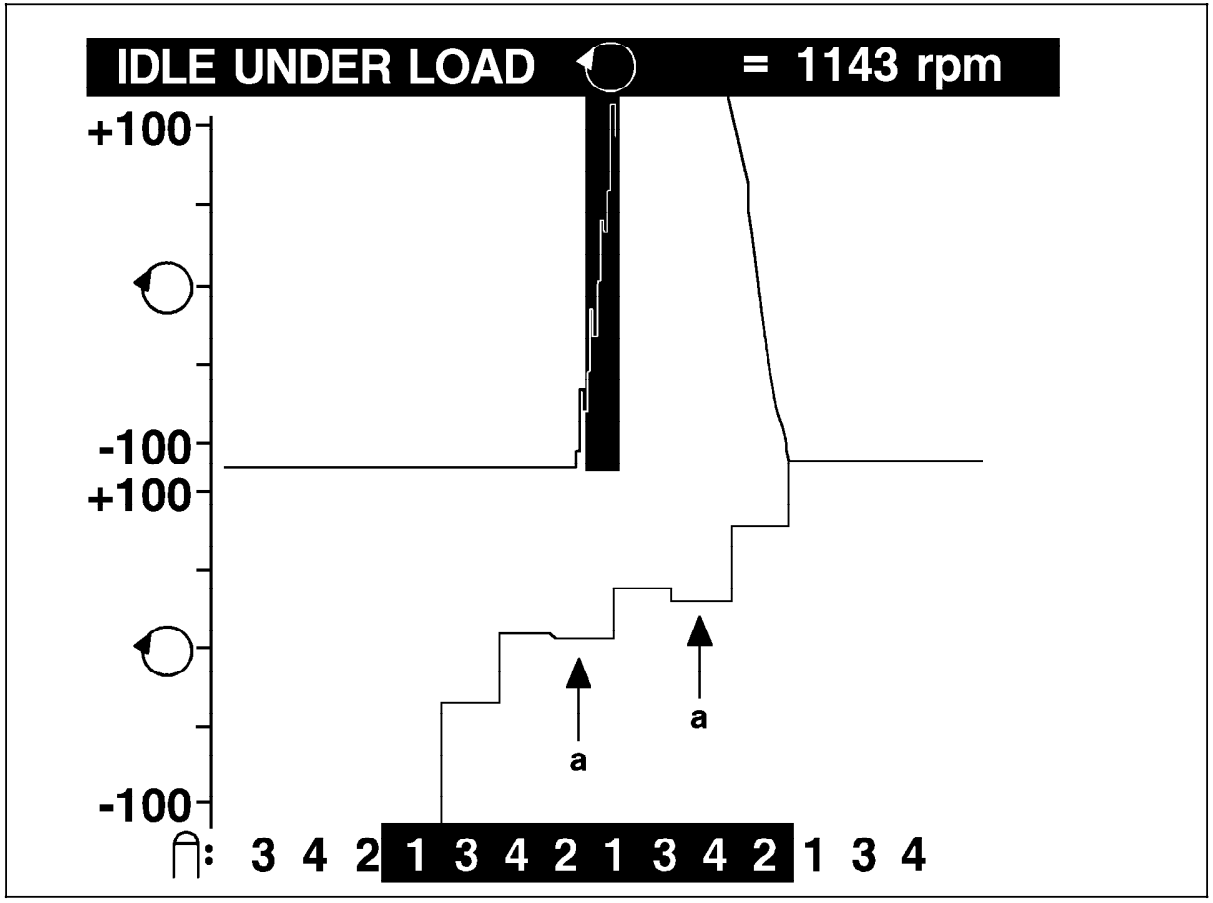
b) 4-Cylinder engine, Engine 111 HFM-SFI

Cylinders 2 and 3 do not work correctly.

Cause: for example, ignition coil.

- Turn off engine.
- Select illustration “Idle Quality During Starting Process”.
- Engine: at Idle.
- Accelerate briefly one or several times.
- Stop display.

Closed throttle engine speed
after starting . . . . . 1143 rpm
Engine oil temperature . . . . . 80 °C



U07-6579-57

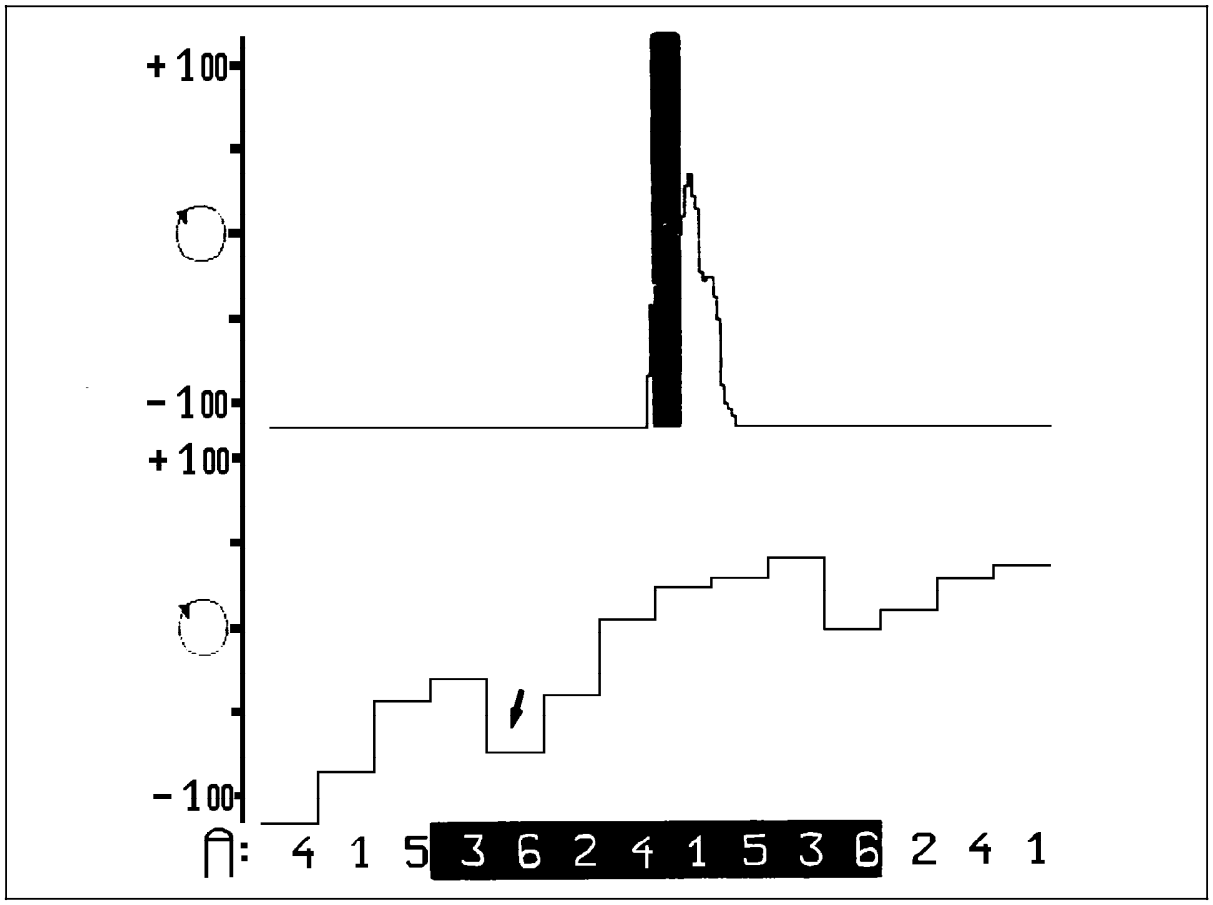
Figure 24
a Defective cylinder

Diagnosis – Idle Quality

While Starting

c) 6-Cylinder engine, Engine 103, 104 CFI/LH-SFI
Malfunction at cylinder 6, arrow.
Cause: leaking injector.
Engine shut off for approximately 15 minutes after previous start.

Closed throttle engine speed
after starting . . . . . 1251 rpm
Engine oil temperature . . . . . 80 °C



P15-0361-57

Figure 25

Diagnosis – Idle Quality

While Starting

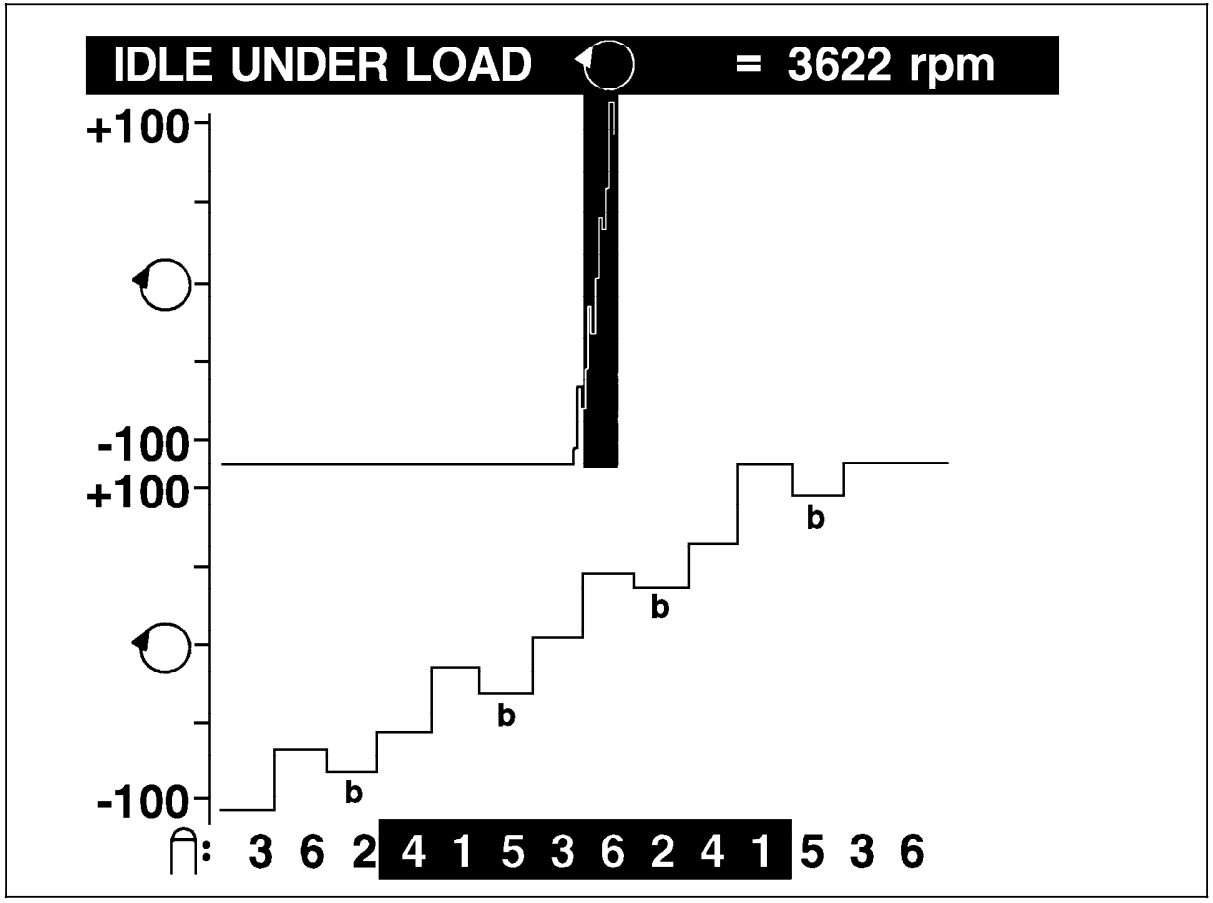
d) 6-Cylinder engine, Engine 104 HFM-SFI

Cylinders 2 and 5 do not work correctly.

Cause: failure in ignition circuit T1/1, cyl. 2 and 5.

- Turn off engine.
- Select illustration “Idle Quality During Starting Process”.
- Engine: at Idle.
- Accelerate briefly one or several times.
- Stop display.

Closed throttle engine speed
after starting . . . . . 3622 rpm
Engine oil temperature . . . . . 80 °C



U07-6580-57

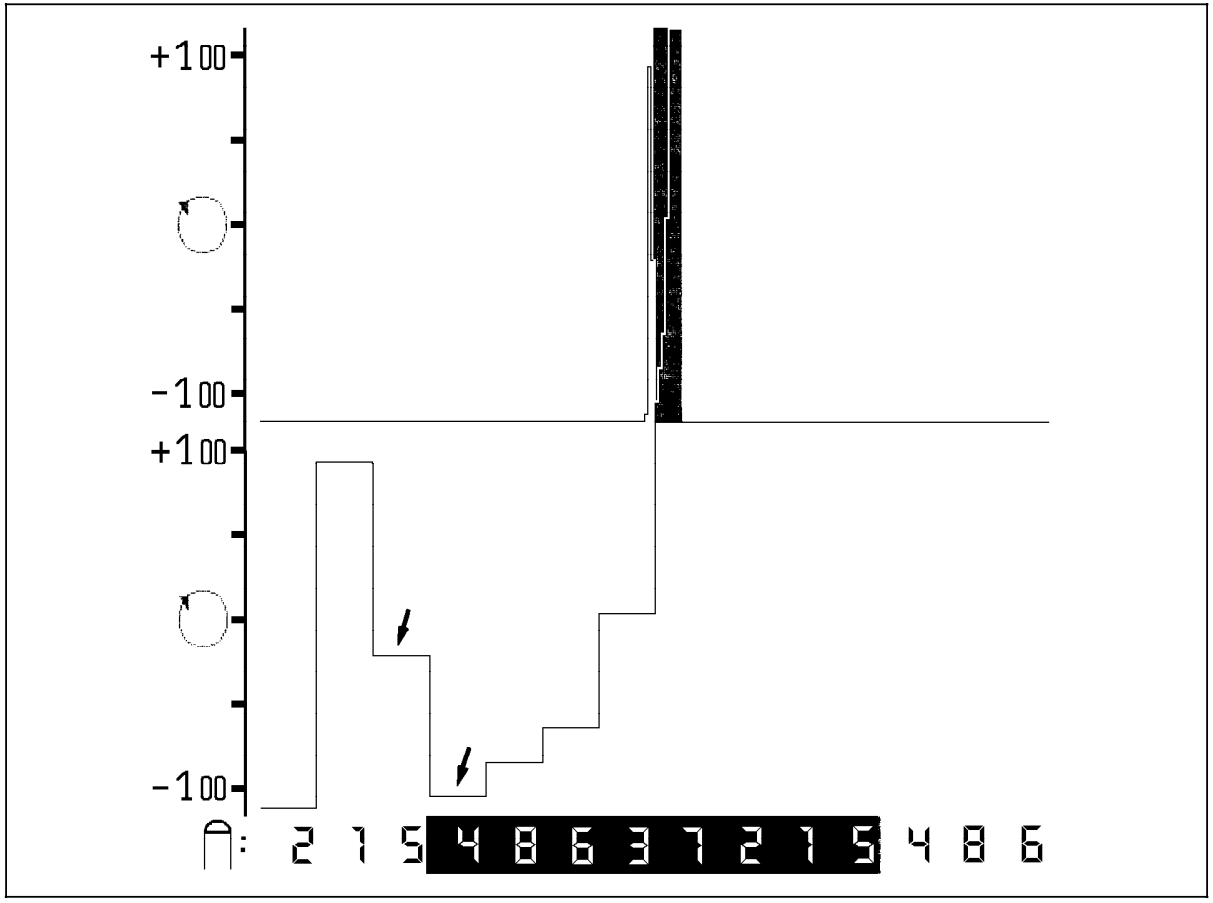
Figure 26
b Defective cylinder

Diagnosis – Idle Quality

While Starting

e) 8-Cylinder engine, Engine 116, 117 CFI
Malfunctions at cylinders 4 and 5, arrows.
Cause: leaking injectors.
Engine shut off for approximately 15 minutes after previous start.

Closed throttle engine speed
after starting . . . . . 878 rpm
Engine oil temperature . . . . . 80 °C



P15-0360-57

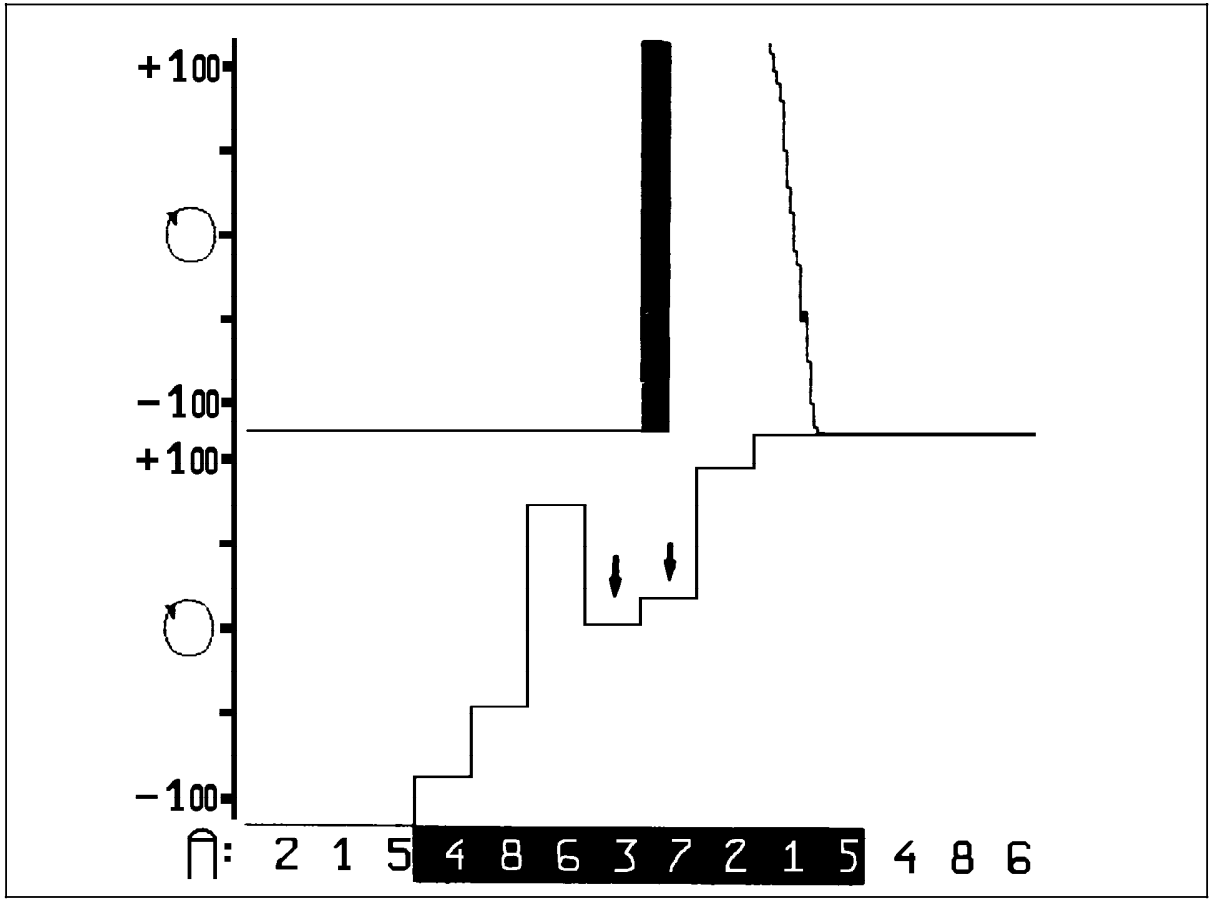
Figure 27

Diagnosis – Idle Quality

While Starting

f) 8-Cylinder engine, Engine 119
Malfunction at cylinders 3 and 7, arrows.
Cause: leaking injection valve.

Closed throttle engine speed after starting	878 rpm
Engine oil temperature	80 °C



P15-0364-57

Figure 28

Diagnosis – Cylinder Analysis

Cylinder Analysis

This test is comprised of the following:

- Compression (dynamic)
- Ignition system

⚠ Due to the complexity of the fuel injection system on HFM-SFI engines, only the compression test is meaningful.

Compression (dynamic)

General Information

The compression test is performed over the starter current draw. The decompression cycle is measured to indicate the mechanical condition of the engine. This data will provide indirect information about engine timing, frictional horsepower and compression via data tables and scope patterns.

Prerequisite:

- Engine: **OFF**
- Attach current clamps to battery negative (B–) terminal (on model 129, ground connection between transmission and chassis [accessible from underneath only] on right hand side; on model 140/202, left hand side).
- Wait for additional instructions to appear.
- Start engine.
- Engine at idle until further instructions.
- Display: *Print display or diagram*

Diagnosis – Cylinder Analysis

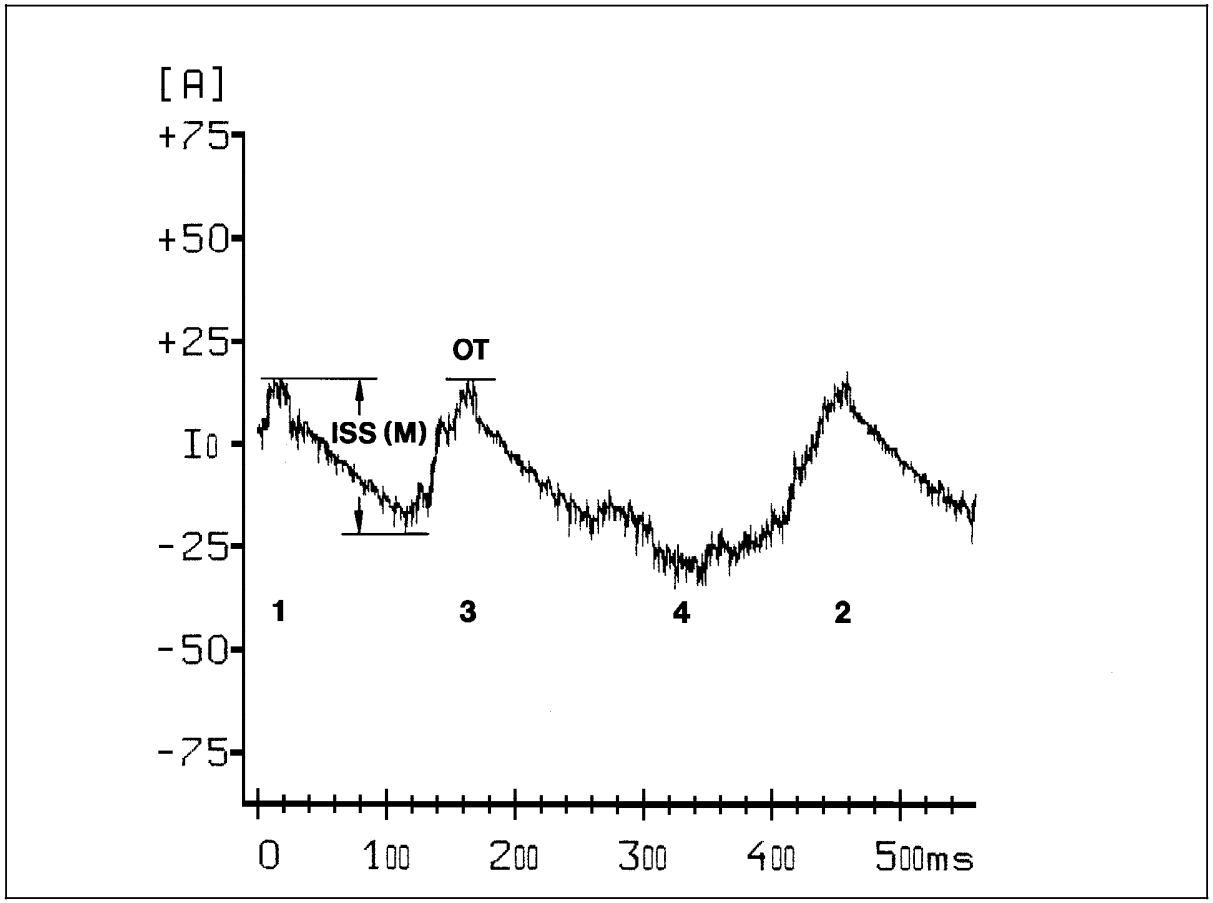
Compression (dynamic)

General information

Bad scope pattern

Starter speed	250 rpm
Current	31 A
Engine oil temperature	80 °C

OT	Top dead center (TDC)
Cylinder 4	Cylinder with low starter current (bad compression)
ISS	Starter current in Ampere
M	Measurement value
ms	Time in milliseconds



P15-0378-57

Figure 1

Diagnosis – Cylinder Analysis

Compression (dynamic)

a) 4–cylinder engine, Engine 102/111

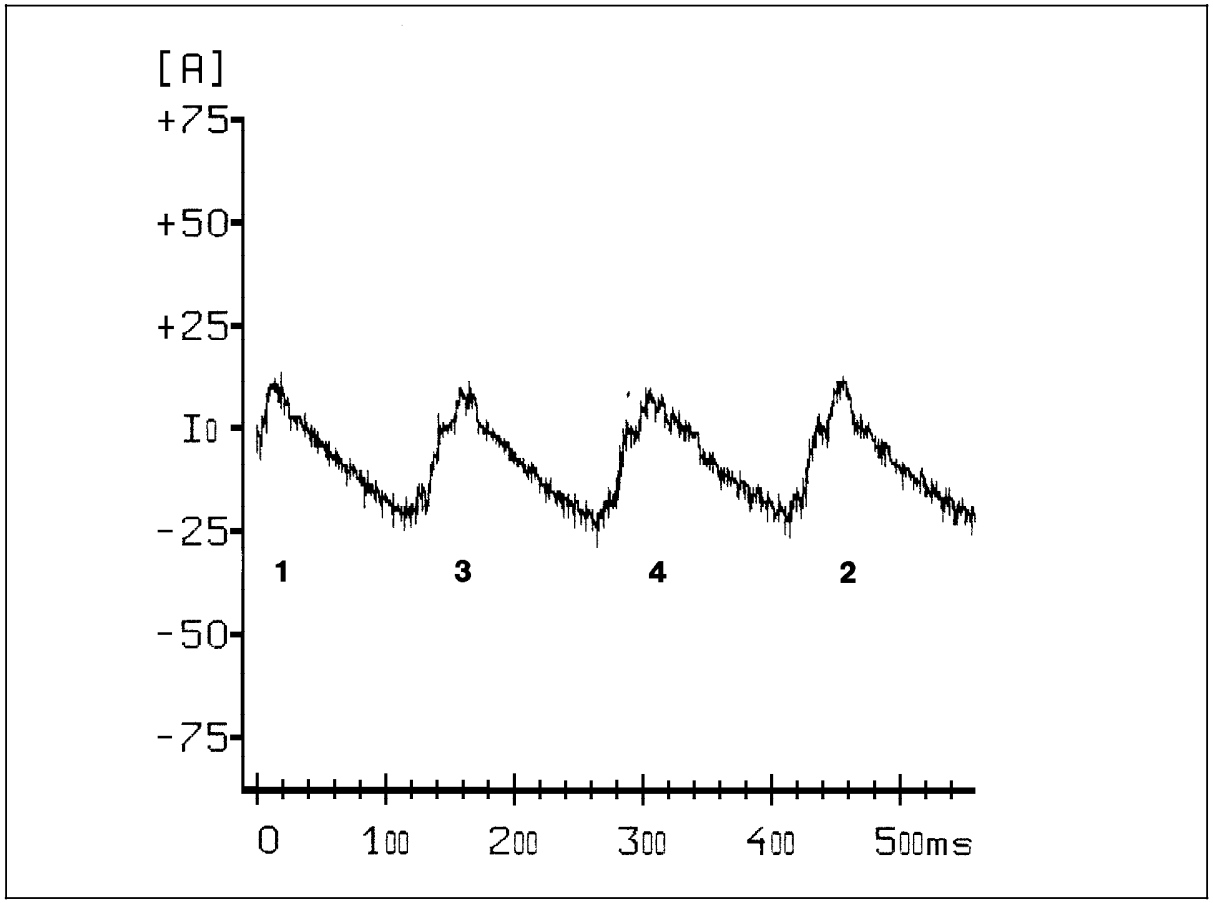
Cylinder	Engine speed/cylinder rpm	ISS (A)	Engine speed rpm	Temperature °C
Ref.			221	35
1	193	57		
3	244	65		
4	196	55		
2	251	63		
Minimum	193	55		
Maximum	251	65		
Difference	58	10		

The largest and smallest cylinder values, as well as the difference of these values, are given when printing the current table.
This will make the evaluation of the magnitude of the failure easier.
The value listed under difference can be used to determine if a mechanical failure is present, for example: difference of ISS > 4A on 4-cylinder engines means that there is possibly a mechanical failure present.
See section A for Test and adjustment data.

Diagnosis – Cylinder Analysis

Compression (dynamic)

Compression scope pattern, Engine 102/111
Good scope pattern.
The relation of the curve to the cylinders is determined by the entered firing sequence 1 – 3 – 4 – 2, starting with cylinder 1.



P15-0363-57

Figure 2

Diagnosis – Cylinder Analysis

Compression (dynamic)

b) 6–cylinder engine, Engine 103, 104

The relation of the curve to the cylinders is determined by the entered firing sequence 1 – 5 – 3 – 6 – 2 – 4, starting with cylinder 1.

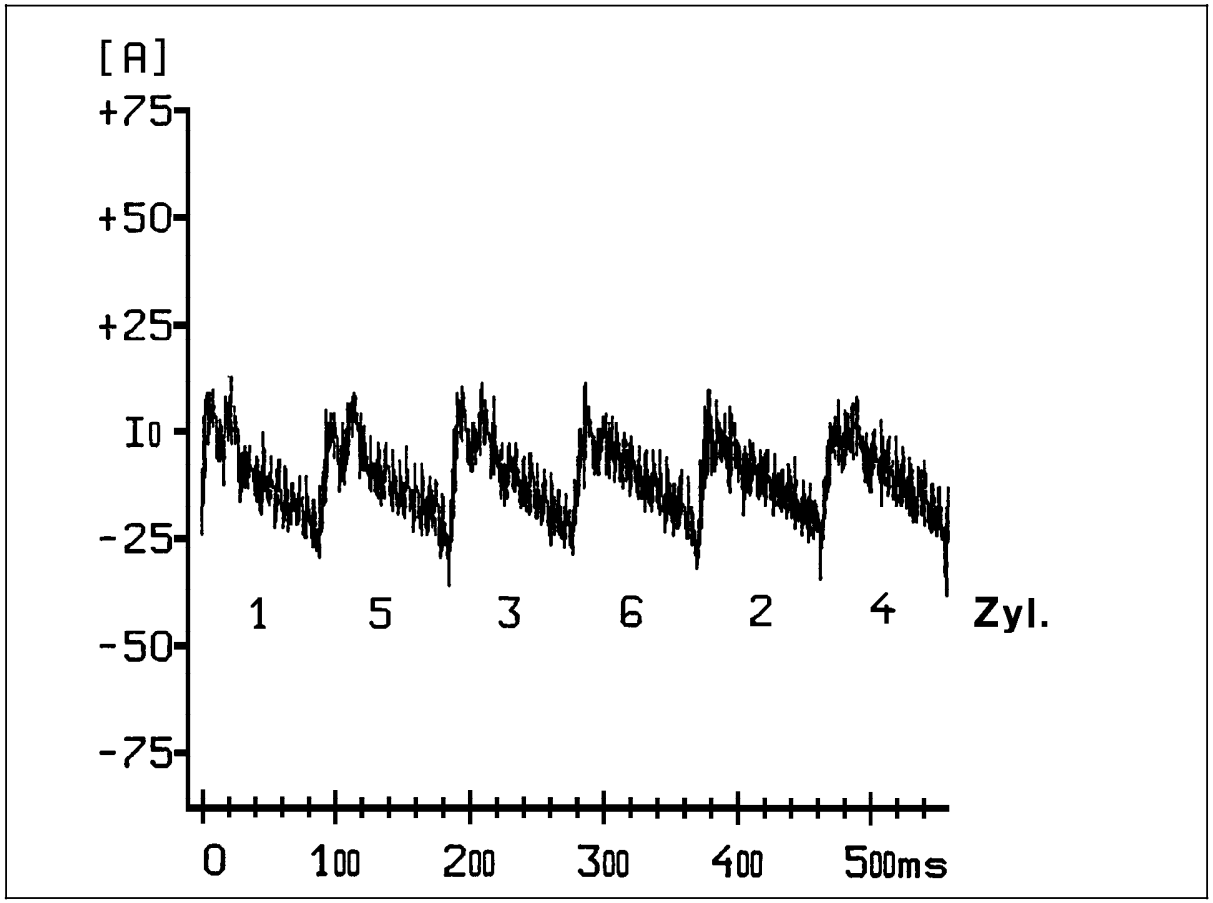
Cylinder	Engine speed/cylinder rpm	Iss (A)	Engine speed rpm	Temperature °C
Ref.			250	35
1	249	27		
5	248	29		
3	249	31		
6	250	30		
2	250	30		
4	250	30		
Minimum	248	27		
Maximum	250	31		
Difference	2	4		

See section A for Test and adjustment data.

Diagnosis – Cylinder Analysis

Compression (dynamic)

Compression scope pattern, Engine 103,104
Good scope pattern.



P15-0093-57A

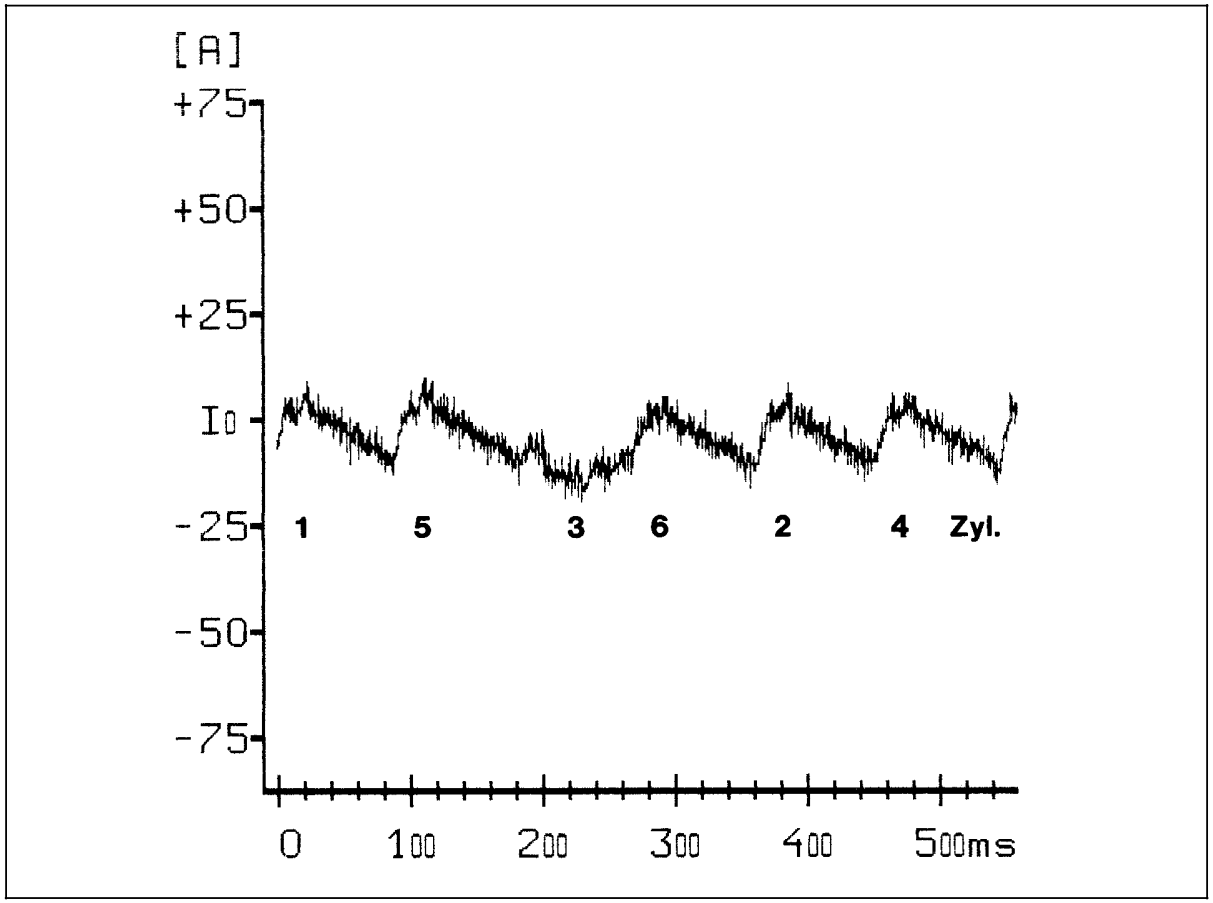
Figure 3

Diagnosis – Cylinder Analysis

Compression (dynamic)

6–cylinder engine scope pattern, Engine 103, 104
Bad scope pattern.
Low starter current on cylinder 3, bad compression.

Starter speed	250 rpm
Current	31 A
Engine oil temperature	80 °C



P07-0409-57

Figure 4

Diagnosis – Cylinder Analysis

Compression (dynamic)

e) 8–cylinder engine, Engine 116, 117

Cylinder	Engine speed/cylinder rpm	Iss (A)	Engine speed rpm	Temperature °C
Ref.			190	35
1	190	60		
5	191	59		
4	189	60		
8	189	61		
6	189	59		
3	191	62		
7	191	59		
2	189	60		
Minimum	189	59		
Maximum	191	62		
Difference	2	3		

See section A for Test and adjustment data.

Diagnosis – Cylinder Analysis

Compression (dynamic)

On 8–cylinder engines, the average current value between the cylinder banks is compared and the difference shown. This allows identification of engine timing failures.

	left cylinder bank	Iss (A)	right cylinder bank	Iss (A)
	5	59	1	60
	8	61	4	60
	6	59	3	62
	7	59	2	60
Total		238		242
Minimum		59		60
Difference				

See section A for Test and adjustment data.

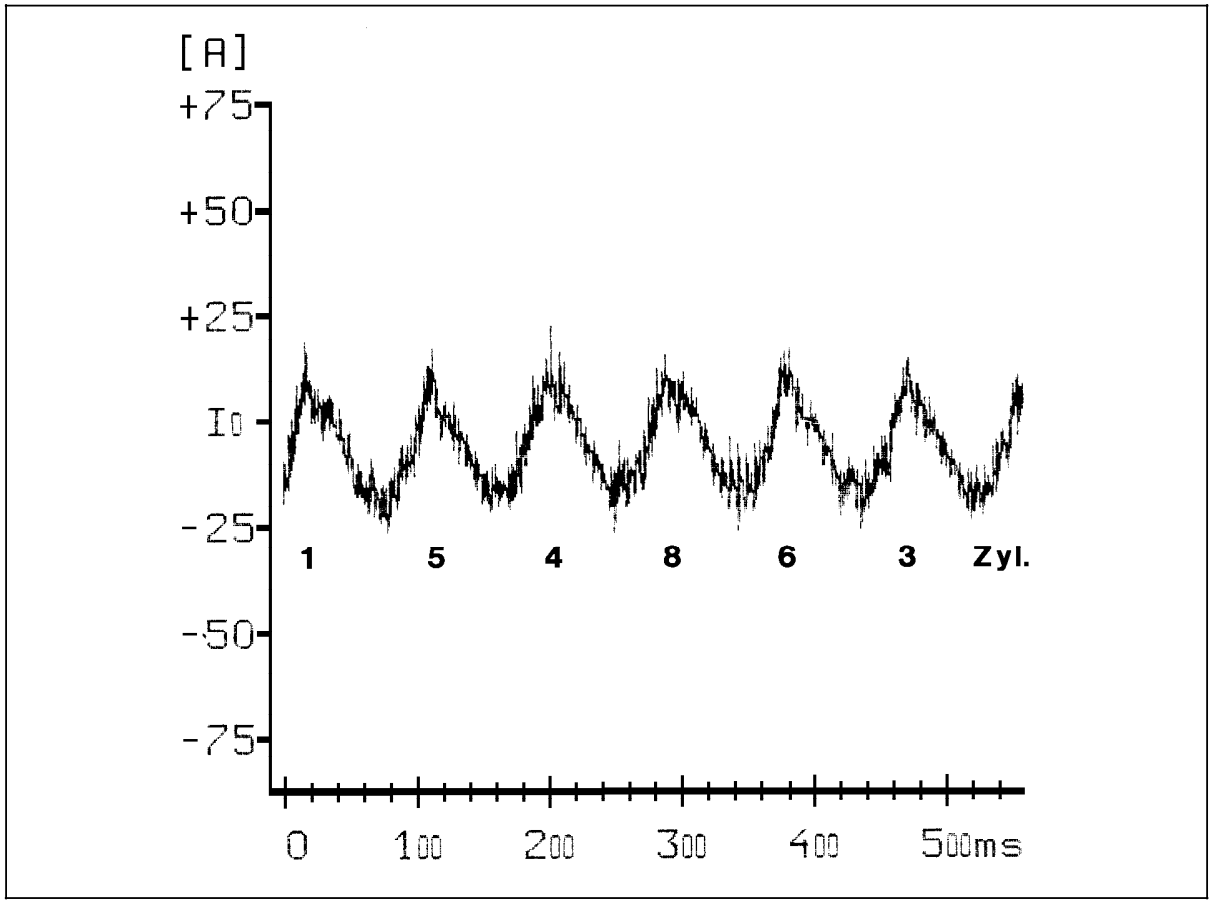
Diagnosis – Cylinder Analysis

Compression (dynamic)

8–cylinder engine scope pattern, Engine 116, 117
Good scope pattern.
The relation of the curve to the cylinders is determined by the entered firing sequence 1–5–4–8–6–3–7–2, starting with cylinder 1.

Starter speed	191 rpm
Current	62 A
Engine oil temperature	80 °C

On 8–cylinder engines, the scope pattern is continued on the following page of the engine analyzer with cylinders 7 and 2.



P07-0408-57

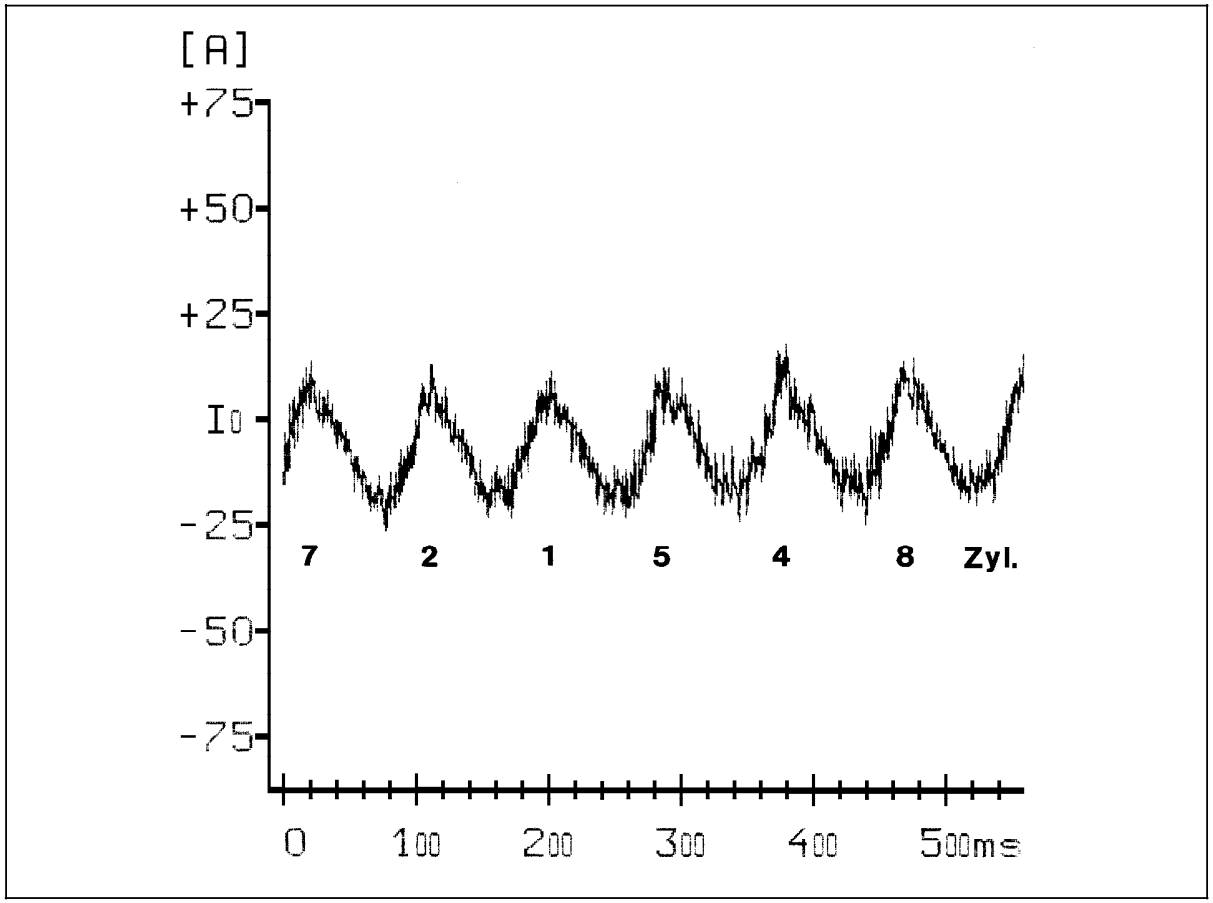
Figure 5

Diagnosis – Cylinder Analysis

Compression (dynamic)

8–cylinder engine scope pattern, Engine 116, 117
Good scope pattern.
Continuation of scope pattern on second page.

Starter speed	191 rpm
Current	62 A
Engine oil temperature	80 °C



P07-0407-57

Figure 6

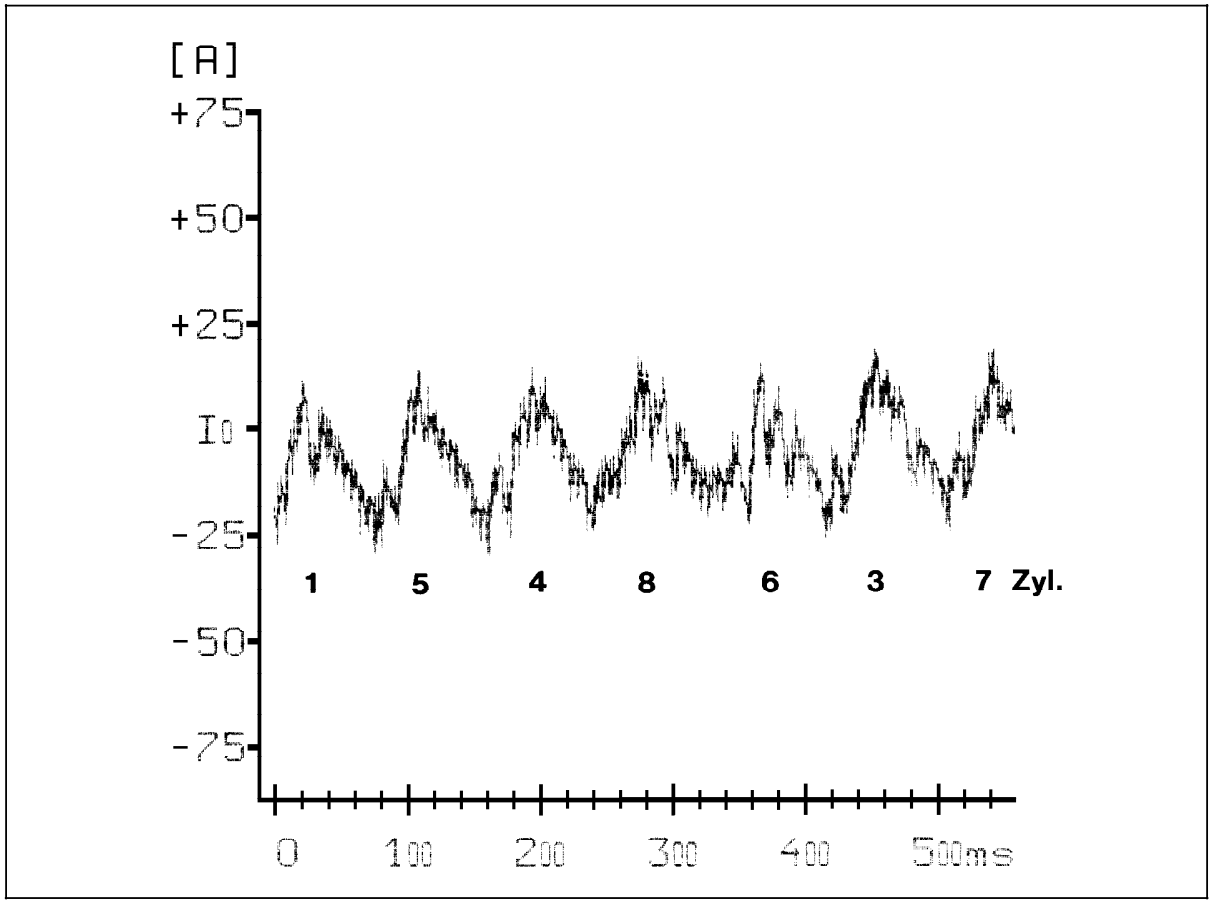
Diagnosis – Cylinder Analysis

Compression (dynamic)

8–cylinder engine scope pattern, Engine 116, 117
Bad scope pattern.
Low starter current on cylinder 2, bad compression.

Starter speed	191 rpm
Current	62 A
Engine oil temperature	80 °C

On 8–cylinder engines, the scope pattern is continued on the following page of the engine analyzer.



P15-0248-57

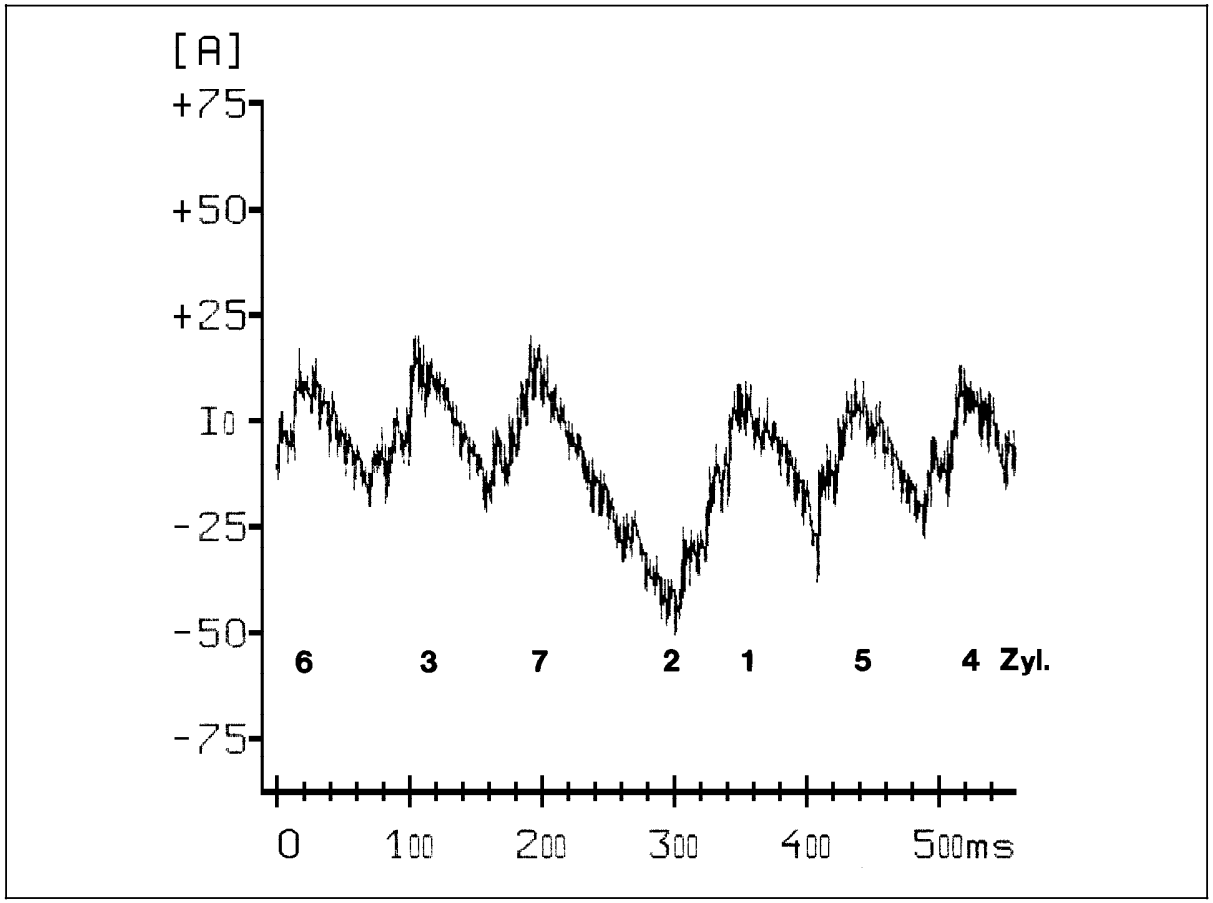
Figure 7

Diagnosis – Cylinder Analysis

Compression (dynamic)

8–cylinder engine scope pattern, Engine 116, 117
Bad scope pattern.
Continuation of scope pattern on second page.

Starter speed	191 rpm
Current	62 A
Engine oil temperature	80 °C



P15-0249-57

Figure 8

Diagnosis – Cylinder Analysis

Compression (dynamic)

On 12–cylinder engines, the average current value between the cylinder banks is compared and the difference shown. This allows identification of engine timing failures.

	left cylinder bank	Iss (A)	right cylinder bank	Iss (A)
	12	26	1	28
	8	23	5	29
	10	27	3	22
	6	26	7	27
	2	25	11	26
	4	26	9	26
Total		153		158
Minimum		25		26
Difference				

See section A for Test and adjustment data.

Diagnosis – Cylinder Analysis

Compression (dynamic)

e) 12–cylinder engine, Engine 120

Cylinder	Engine speed/cylinder rpm	Iss (A)	Engine speed Ref.187	Temperature °C Ref. 82
1	187	28		
12	188	26		
5	189	29		
8	189	23		
3	188	22		
10	188	27		
6	188	26		
7	187	27		
2	187	25		
11	187	26		
4	187	26		
9	186	26		
Minimum	186	22		
Maximum	189	29		
Difference	3	7		

See section A for Test and adjustment data.

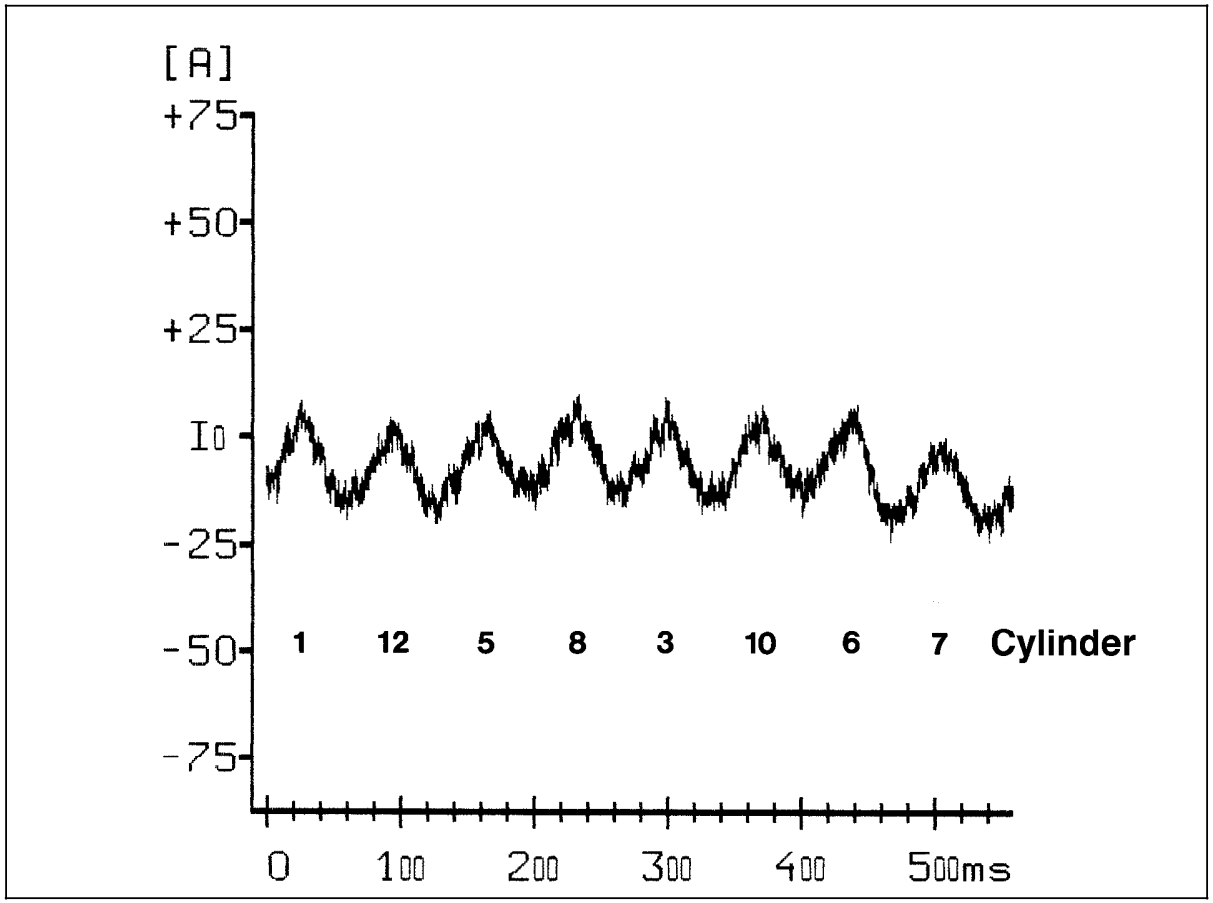
Diagnosis – Cylinder Analysis

Compression (dynamic)

12–cylinder engine scope pattern, Engine 120
Good scope pattern.
The relation of the curve to the cylinders is determined by the entered firing sequence 1–12–5–8–3–10–6–7–2–11–4–9, starting with cylinder 1.

Starter speed	187 rpm
Current	311 A
Engine oil temperature	82 °C

On 12-cylinder engines, the scope pattern is continued on the following page with cylinder 7 and 2.



P07-5118-57

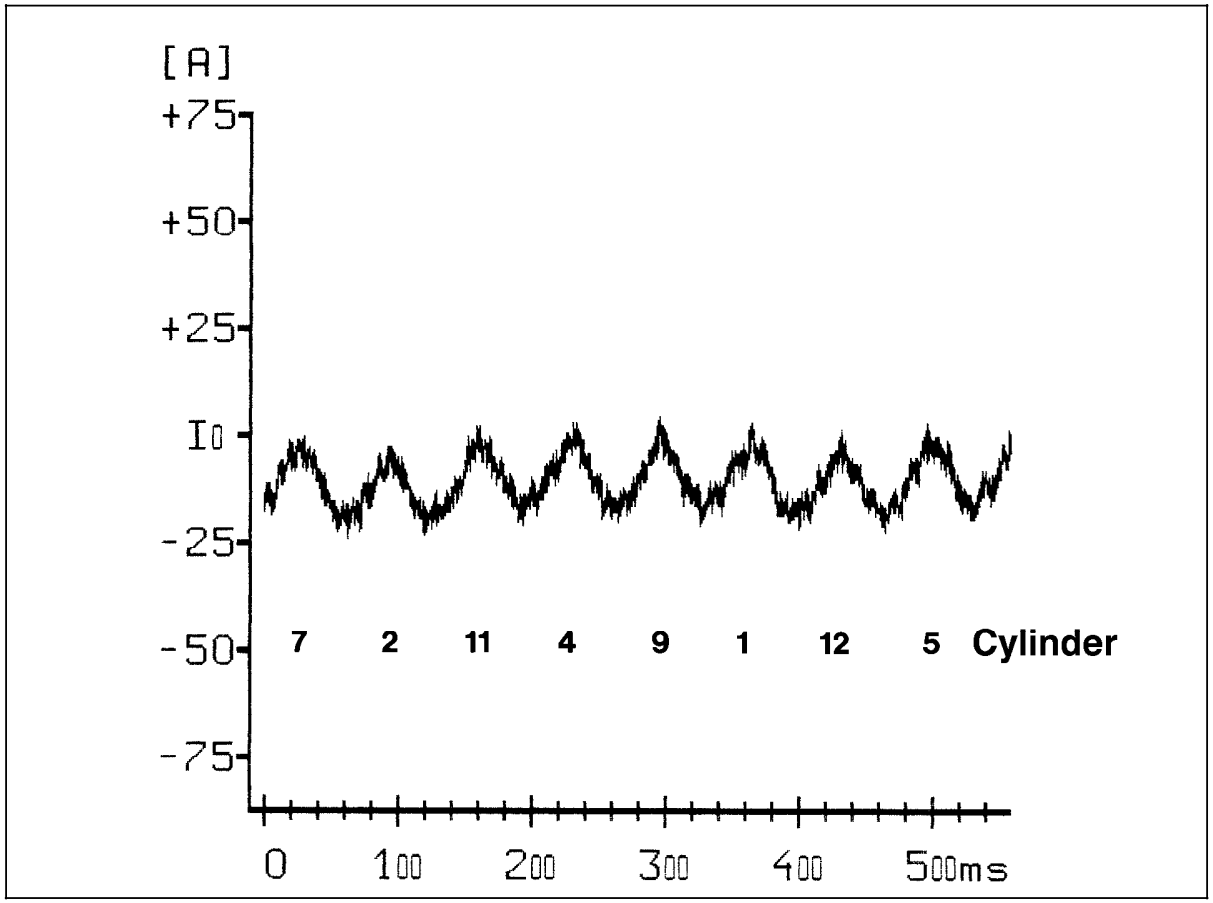
Figure 9

Diagnosis – Cylinder Analysis

Compression (dynamic)

12–cylinder engine scope pattern, Engine 120
Good scope pattern.
Continuation of scope pattern on second page.

Starter speed	187 rpm
Current	311 A
Engine oil temperature	82 °C



U07-5119-57

Figure 10

Diagnosis – Cylinder Analysis

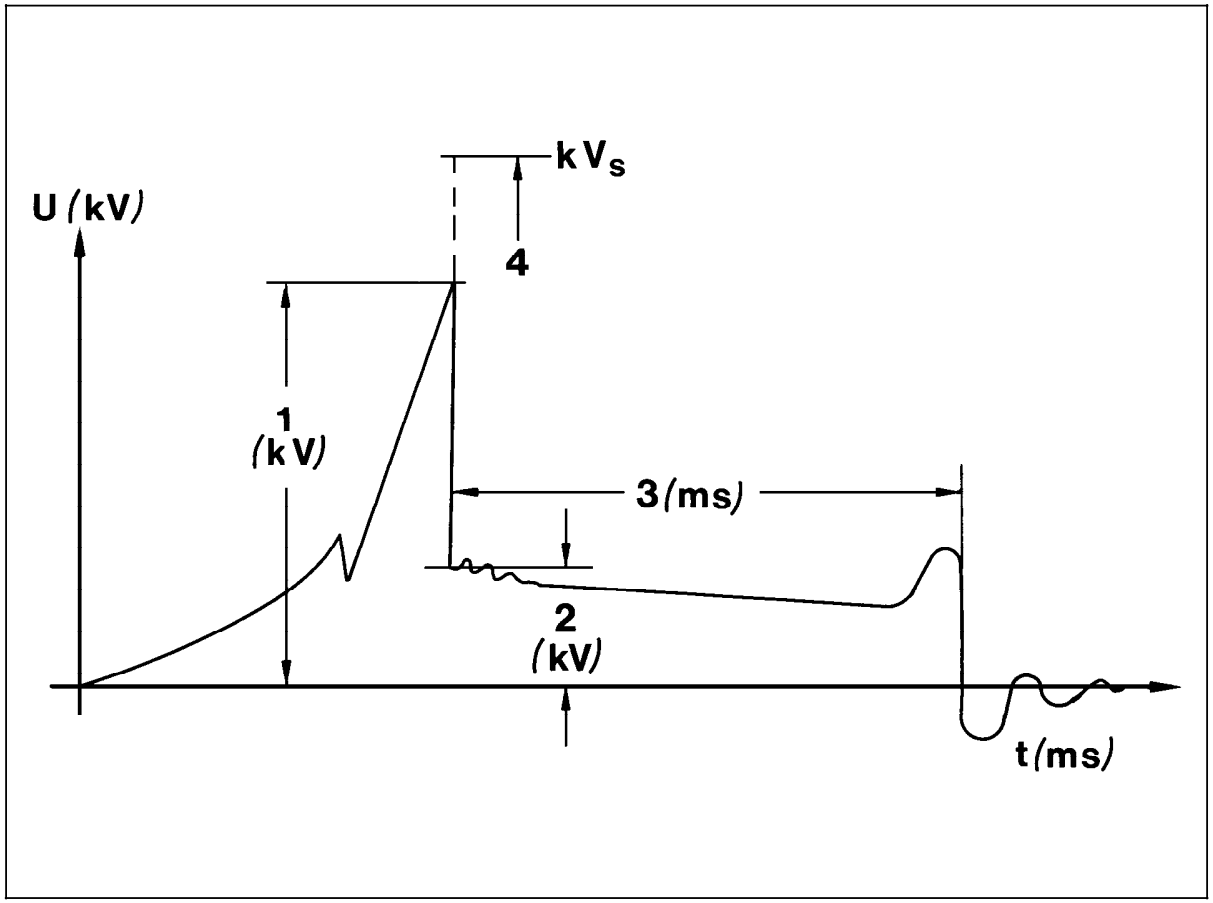
Ignition System

⚠

This test program is not suitable for HFM-SFI engines, due to the complexity of the fuel injection system on.

General information

With this test program, all existing constant (non-intermittent) ignition system faults can be recognized by their numerical value.
For details see Figure 11.
For intermittent faults, the oscilloscope should be used (see 48/2). The numerical values can be read from the oscilloscope.
See section “A” for Test and adjustment data.



P15-0196-57

Figure 11

1 Ignition voltage U (kV)
2 Projection point, burn voltage (kV)
3 Burn time, burn voltage line t (ms)
4 Ignition voltage, peak value (kV max)

Diagnosis – Cylinder Analysis

Ignition System

a) 4–cylinder engine, Engine 102

During the **Ignition system** program the following data must appear on the engine analyzer:

Cylinder	Engine speed rpm	Engine oil temperature °C	Ignition voltage		Projection point, burn voltage	
			kV max [1]	kV	kV	ms
Ref.	855	69				
1			15	13.0	1.0	2.6
3			14	10.0	1.4	1.8
4			12	10.5	1.0	2.6
2		**Defective cylinder**	**11**	7.8	**0.9**	**1.9**
Minimum				7.8	0.9	1.8
Maximum				13.0	1.4	2.6
Difference				5.2	0.5	0.9

[1] The “kV max values” are stored peak values.
They are used to evaluate the spark plugs after brief acceleration.
The kilovolt clamp must be positioned as close as possible to the ignition coil.

Note:

The data shown is a representative example of a 4–cylinder engine. The data in actual tests will vary.

Diagnosis – Cylinder Analysis

Ignition System

b) 6–cylinder engine, Engine 103

During the **Ignition system** program the following data must appear on the engine analyzer:

Cylinder	Engine speed rpm	Engine oil temperature °C	Ignition voltage		Projection point, burn voltage	
			kV max [1]	kV	kV	ms
Ref.	855	69				
1			15	13.0	1.0	2.6
5			14	10.0	1.4	1.8
3			12	10.5	1.0	2.6
6			13	11.3	1.0	2.7
2		**Defective cylinder**	**10**	**7.3**	**0.8**	**1.5**
4			12	12.2	1.2	1.7
Minimum				7.3	0.8	1.5
Maximum				13.0	1.4	2.6
Difference				5.7	0.6	0.9

[1] The “kV max values” are stored peak values.
They are used to evaluate the spark plugs after brief acceleration.
The kilovolt clamp must be positioned as close as possible to the ignition coil.

Note:

The data shown is a representative example of a 6–cylinder engine. The data in actual tests will vary.

Diagnosis – Cylinder Analysis

Ignition System

c) 8–cylinder engine, Engine 116/117

During the **Ignition system** program the following data must appear on the engine analyzer:

Cylinder	Engine speed rpm	Engine oil temperature °C	Ignition voltage		Projection point, burn voltage	
			kV max [1]	kV	kV	ms
Ref.	673	88				
1			15	12.3	1.2	1.7
5			12	10.3	1.0	1.6
4			14	11.5	1.2	1.8
8			12	9.5	1.0	1.7
6			14	12.3	1.1	1.8
3		**Defective cylinder**	**11**	**7.8**	**0.9**	**1.9**
7			14	12.0	1.2	1.8
2			11	9.5	1.0	1.7
Minimum				7.3	0.9	1.6
Maximum				13.0	1.2	1.9
Difference				5.7	0.3	0.3

[1] The “kV max values” are stored peak values.
They are used to evaluate the spark plugs after brief acceleration.
The kilovolt clamp must be positioned as close as possible to the ignition coil.

Diagnosis – Oscilloscope

General information

Sample digital oscilloscope patterns are shown on the following pages. The Bear and Sun engine analyzers feature a memory with a manual display freeze. The sample oscilloscope display patterns should be compared to those of the test and adjustment equipment. However, the same test depth is not available since analog instruments can not store data.

The **ignition oscilloscope** can perform the following functions:

- Parade display,
- Raster display,
- Single display,
- Switching from time and voltage ranges.

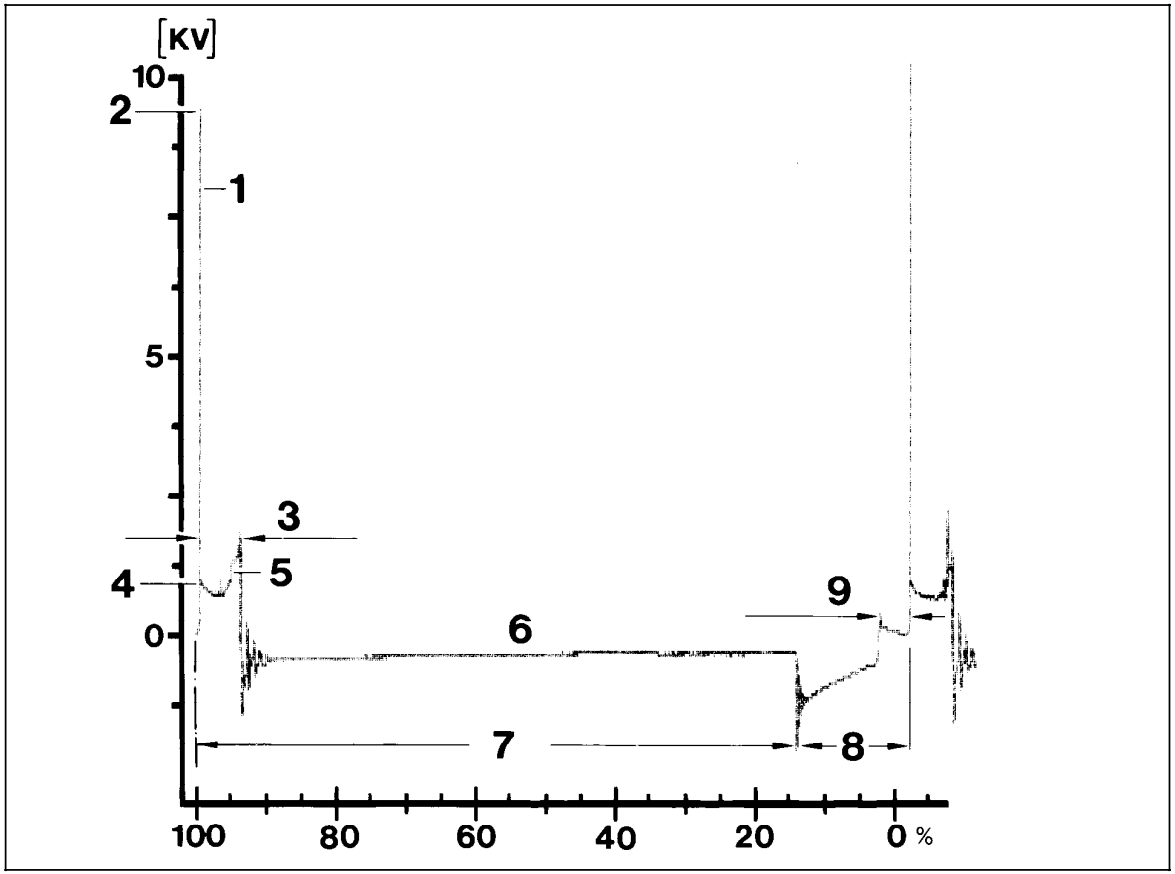
The displays listed can be stored, stopped and printed out individually.
In addition to the high voltage displays in the kV range, it is also possible to record signal displays in the low voltage range, for example, signals from sensors with 100 % or millisecond time basis.
Refer to page 50/1 for additional signal checks.

Diagnosis – Oscilloscope

Oscilloscope

Good scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side.

Time range	100 %
Measurement range	10 kV



P15-5068-57A

Figure 1

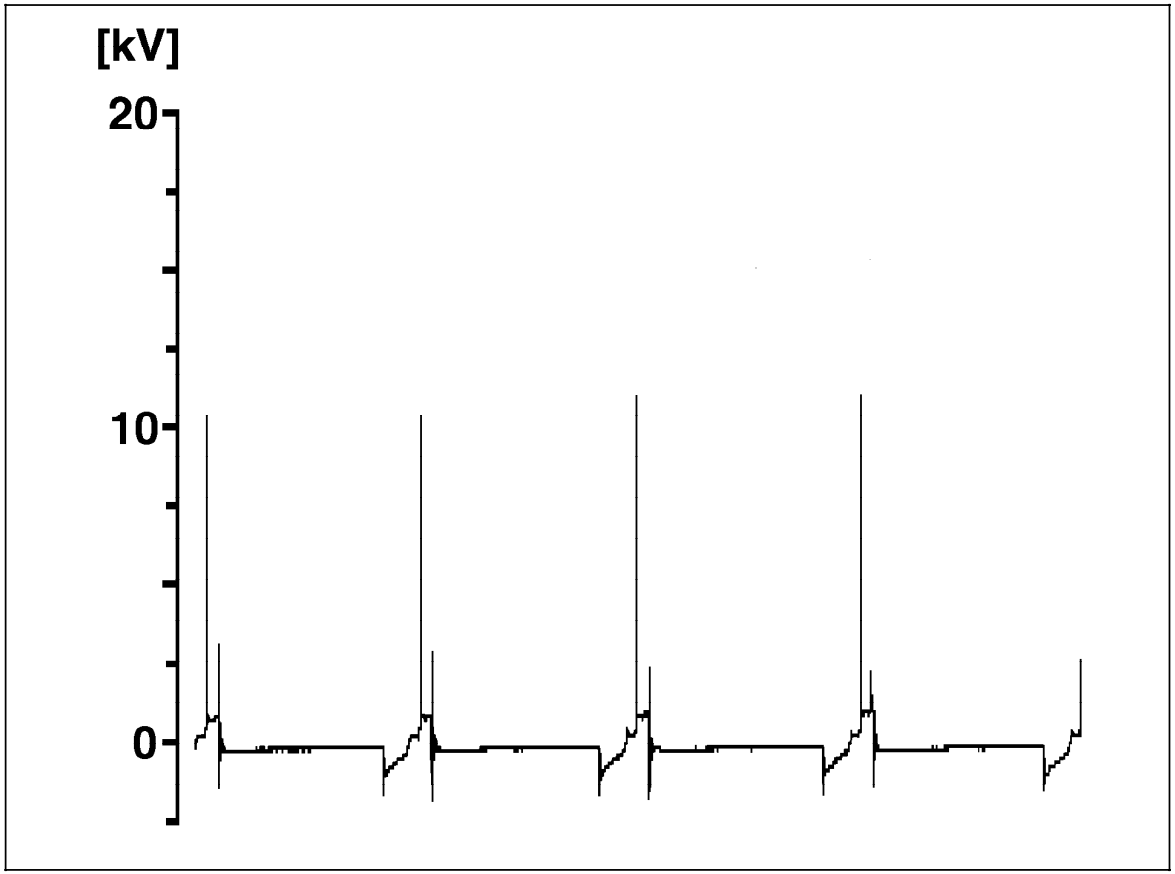
1	Ignition voltage line
2	Ignition voltage height
3	Burn time
4	Burn voltage height
5	Burn voltage line
6	Decay process
7	Opening section
8	Closing section
9	Primary current limiting (active only up to 2000 rpm)

Diagnosis – Oscilloscope

Oscilloscope

Good scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (parade).
Engine at idle.
Example: 4 cylinder engine 102.
Display follows firing order 1 3 4 2.

Measurement range . . . . . 20 kV



P15-0005-57

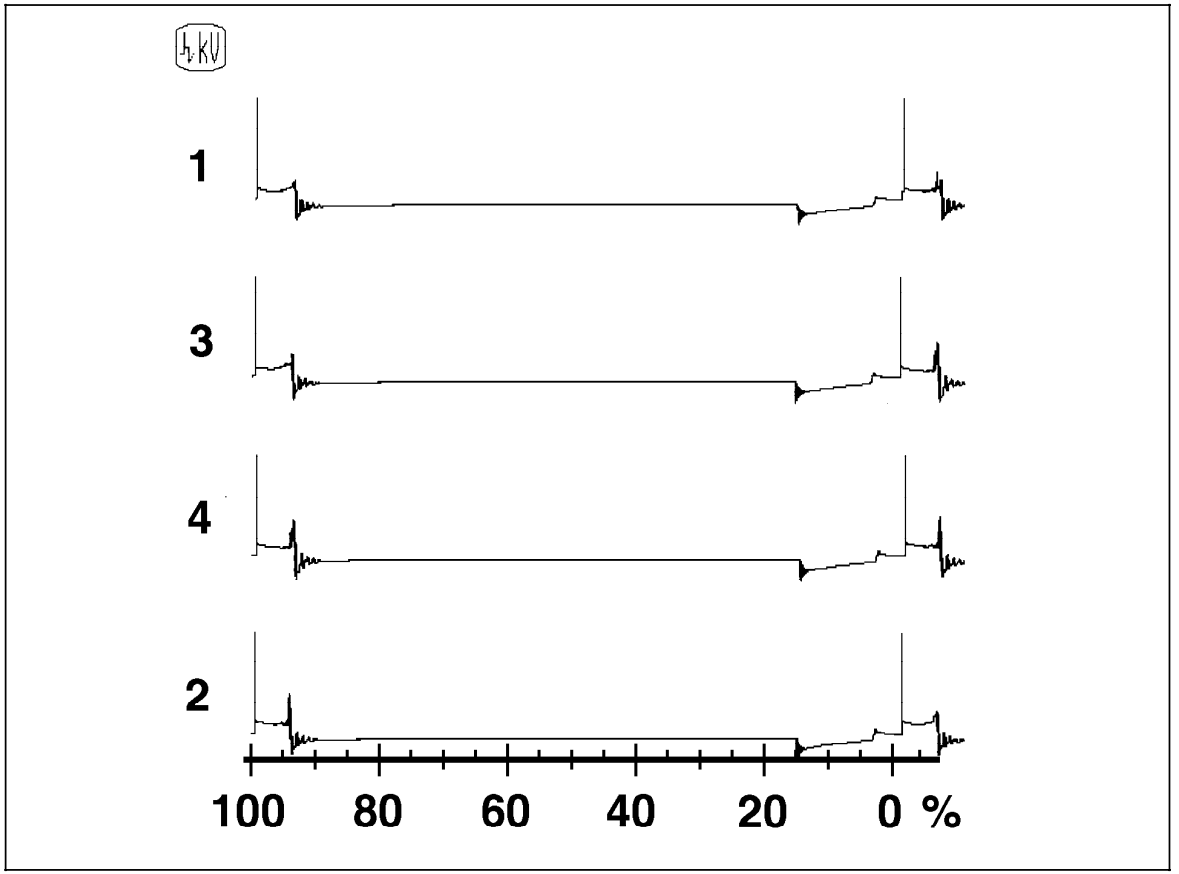
Figure 2

Diagnosis – Oscilloscope

Oscilloscope

Good scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (Raster).
Engine at idle.
Example: 4-cylinder engine.

Measurement range	20 kV
Time range	100 %



P15-0006-57

Figure 3

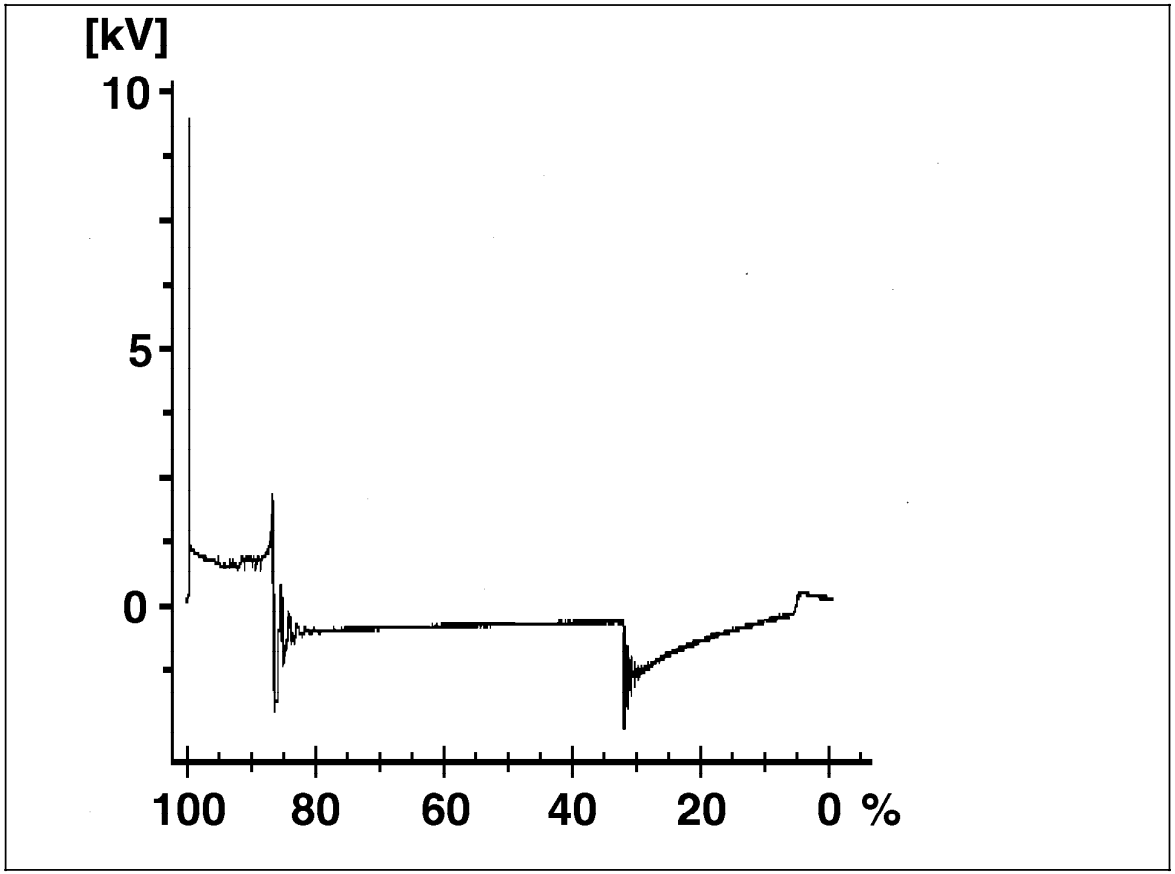
Diagnosis – Oscilloscope

Oscilloscope

Good scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (single display).
Engine at idle.

Measurement range	10 kV
Time range	100 %

Note:
The next cylinder is displayed according to firing order.



P15-0007-57

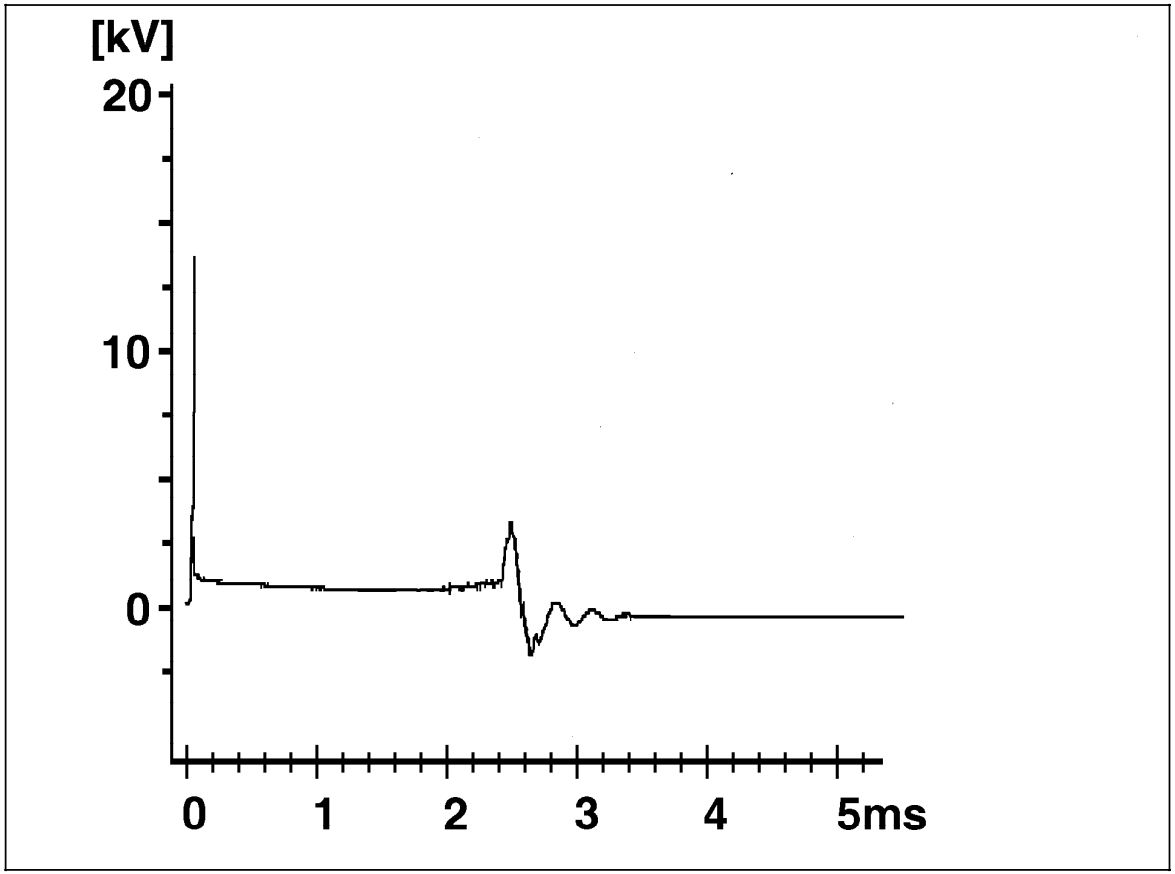
Figure 4

Diagnosis – Oscilloscope

Oscilloscope

Good scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (single display).
Engine at idle.

Measurement range	20 kV
Time range	5 ms



P15-0008-57

Figure 5

Diagnosis – Oscilloscope

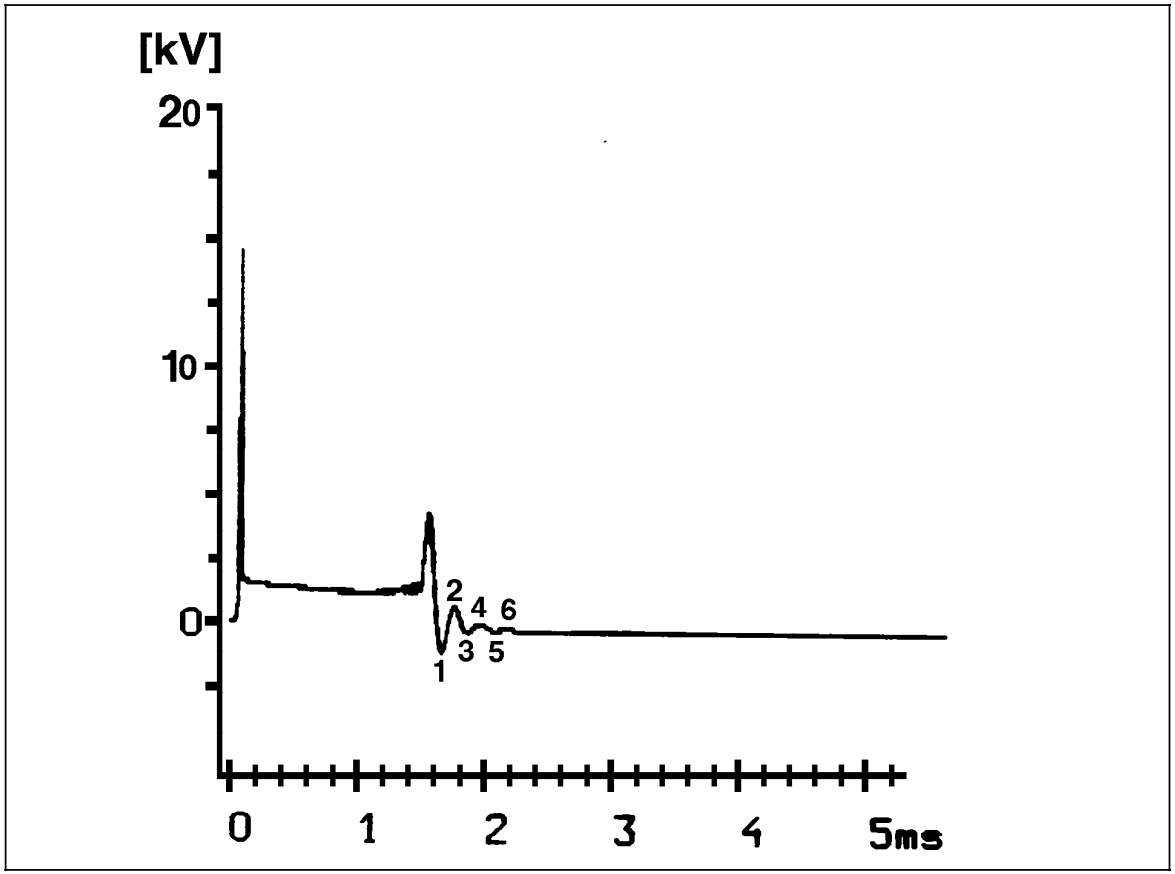
Oscilloscope

Good scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (single display).
Engine at idle.

Measurement range	20 kV
Time range	5 ms

Note:
Bosch ignition coil 11 A.

Identification:
Green sticker at least 5 oscillations.



P15-0384-57

Figure 6
1 Oscillation
2 Oscillation
3 Oscillation
4 Oscillation
5 Oscillation

Diagnosis – Oscilloscope

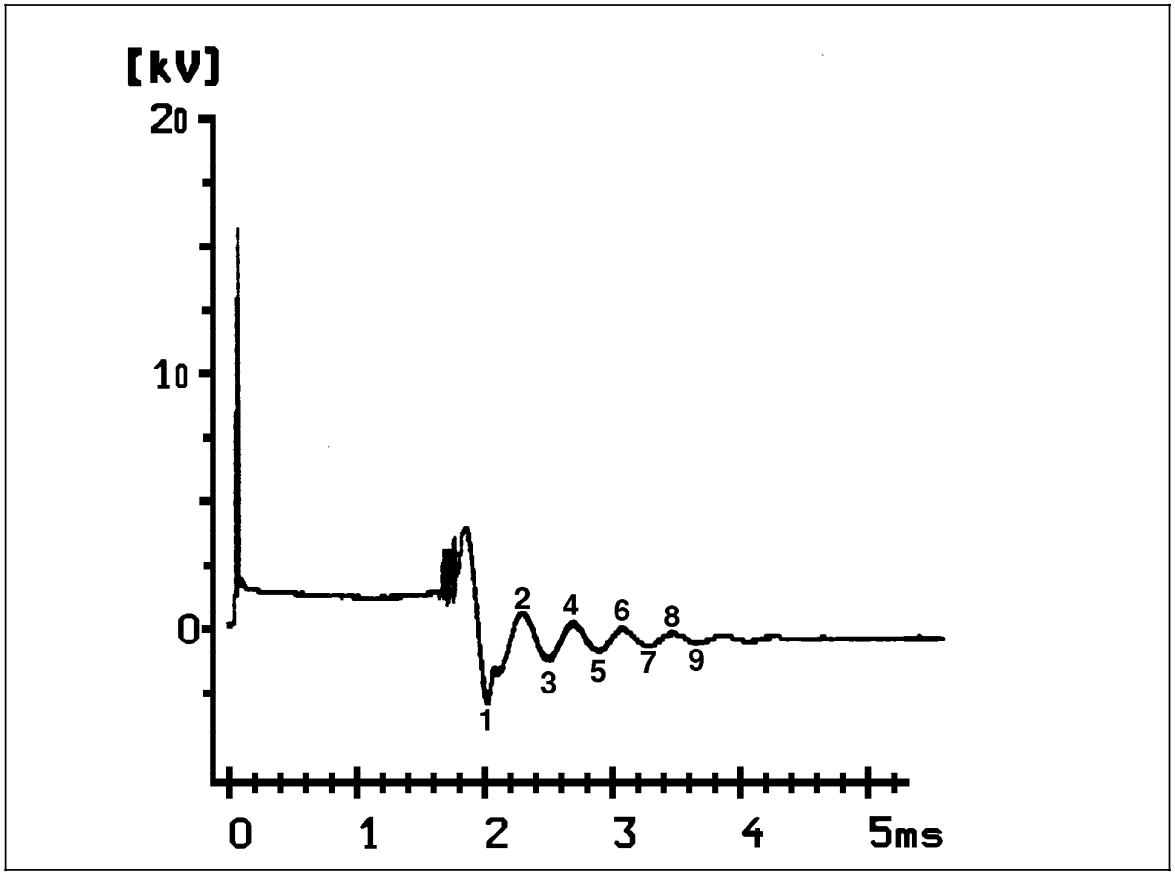
Oscilloscope

Good scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (single display).
Engine at idle.

Measurement range	20 kV
Time range	5 ms

Note:
May Christi ignition coil 8 and 11 A.
Bosch ignition coil 8A.

Coil Identification:
8 A yellow sticker.
11 A green sticker.
at least 8 oscillations.



P15-0385-57

Figure 7

1 Oscillation
2 Oscillation
3 Oscillation
4 Oscillation
5 Oscillation
6 Oscillation
7 Oscillation
8 Oscillation
9 Oscillation

Diagnosis – Oscilloscope

Oscilloscope

Good scope pattern, single and dual ignition system (CFI/LH-SFI)

Secondary side (parade).

Measurement range . . . . . 20 kV
Acceleration to . . . . . 3000 rpm

Test condition: accelerate engine repeatedly to 3000 rpm.

Note

- As a result of the acceleration process, several cylinders are displayed in succession according to firing order, see display example (1–3–4–2–1–3–4–2 etc.).
- The ignition voltage shows a uniform increase at all cylinders during the acceleration phase. The ignition voltage increase must not exceed 6 kV.

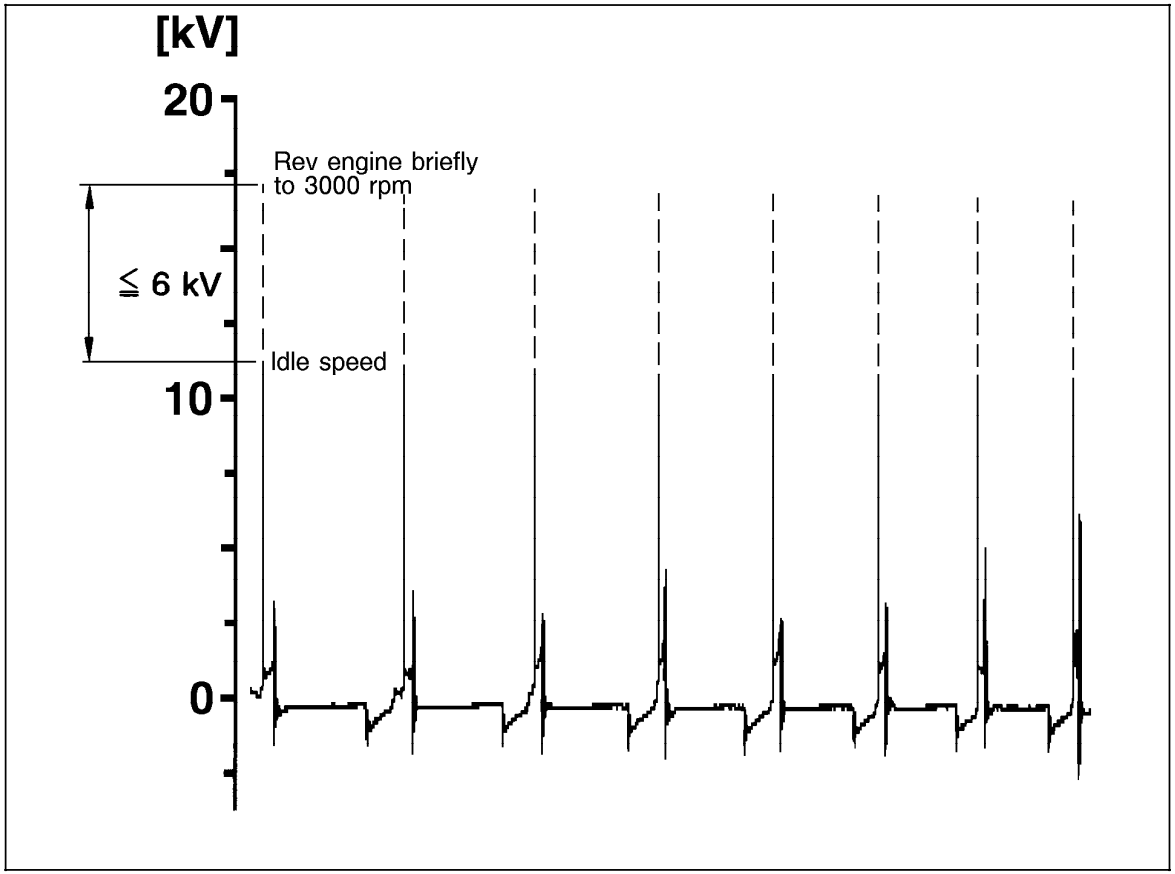


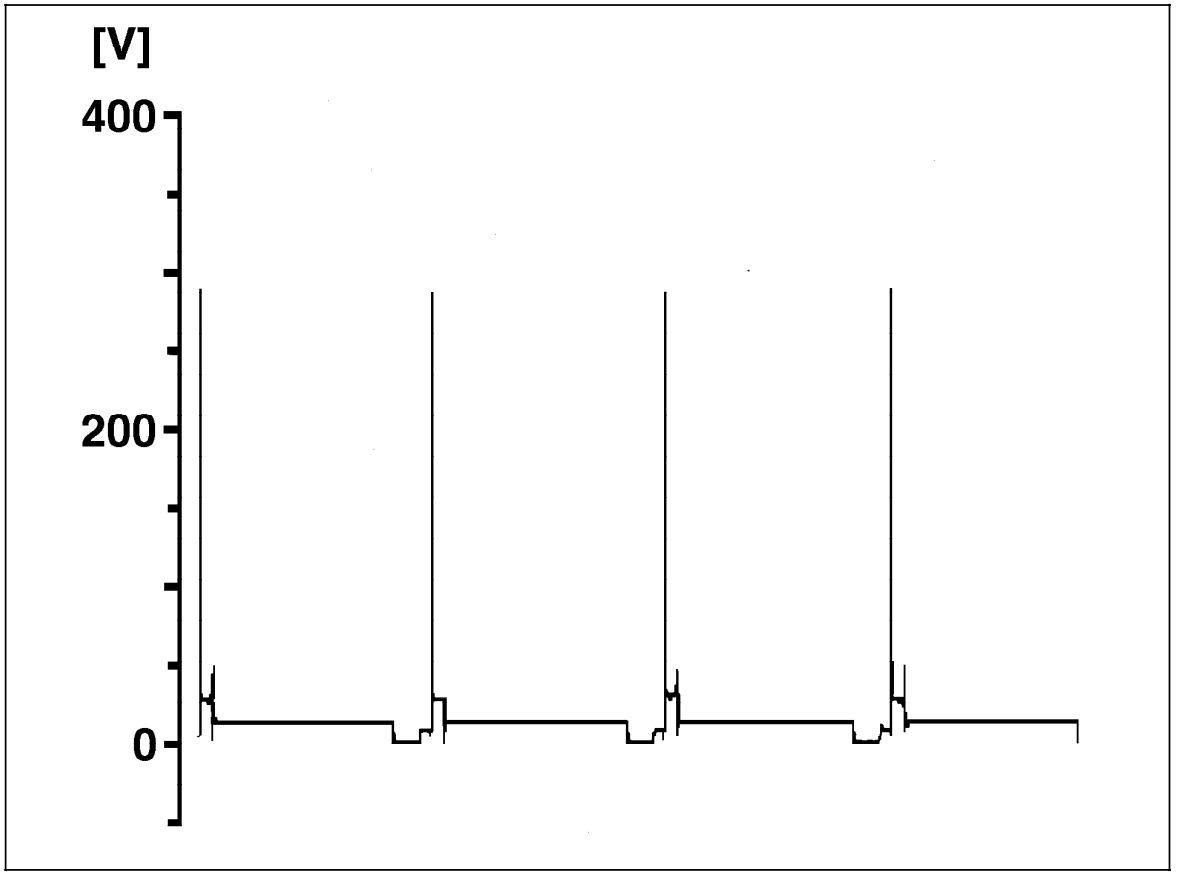
Figure 8

Diagnosis – Oscilloscope

Oscilloscope

Good scope pattern, single and dual ignition system (CFI/LH-SFI)
Primary side (parade).
Engine at idle.

Measurement range . . . . . 400 V



P15-0009-57

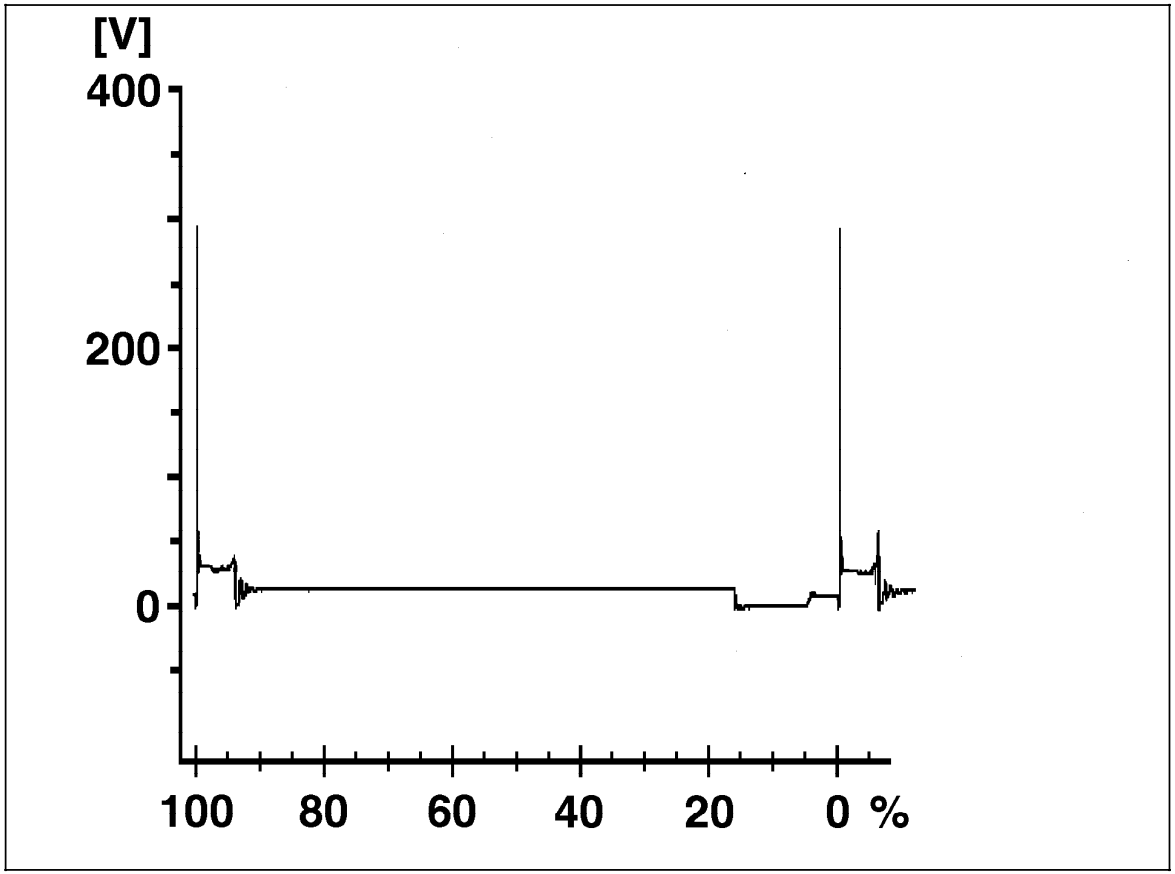
Figure 9

Diagnosis – Oscilloscope

Oscilloscope

Good scope pattern, single and dual ignition system (CFI/LH-SFI)
Primary side (single display).
Engine at idle.

Measurement range	400 V
Time range	100 %



P15-0010-57

Figure 10

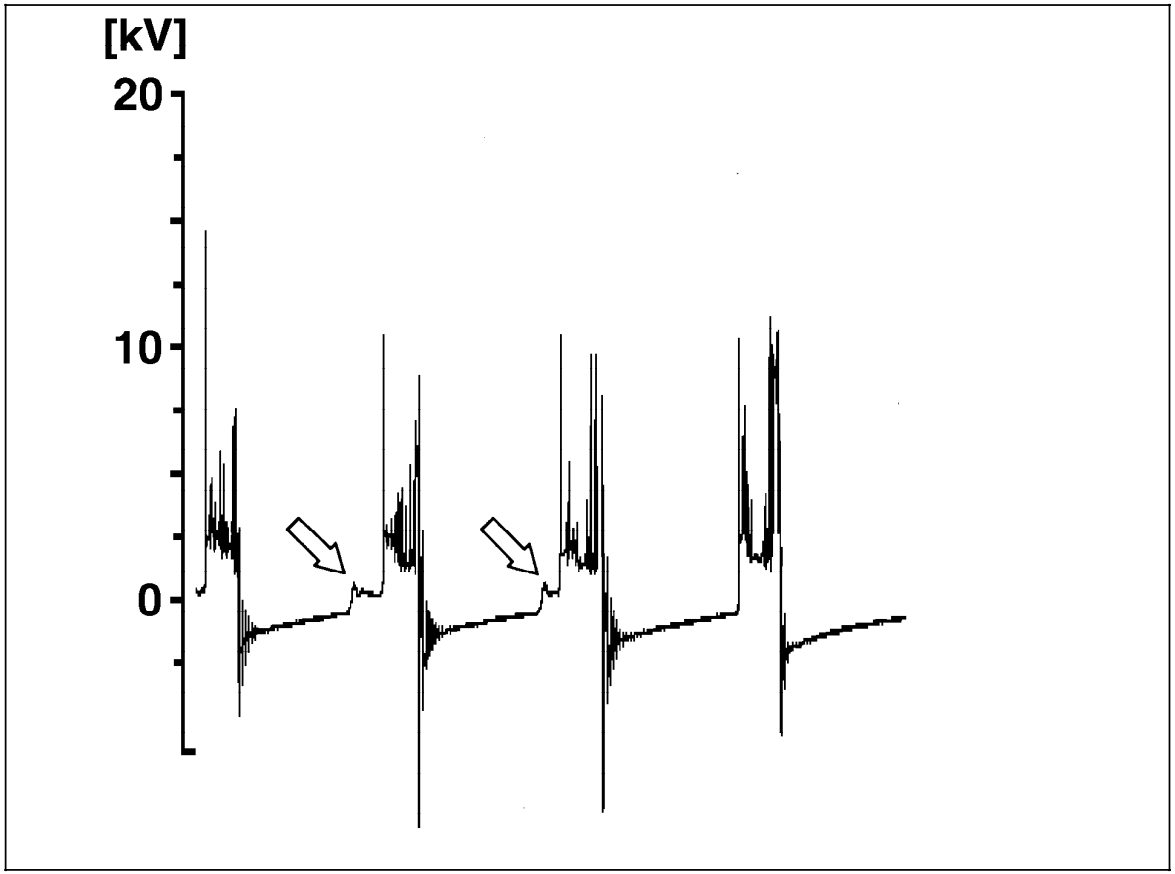
Diagnosis – Oscilloscope

Oscilloscope

Good scope pattern, single and dual ignition system (CFI/LH-SFI)
Primary side (Primary current limit).

Measurement range . . . . . 20 kV
Acceleration to . . . . . 3000 rpm

Note:
Limiting of the primary current can occur intermittently, at one or all cylinders, at engine speeds above 2000 rpm with and without load (arrows).



P15-0012-57

Figure 11

Diagnosis – Oscilloscope

Oscilloscope

Bad scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (parade).

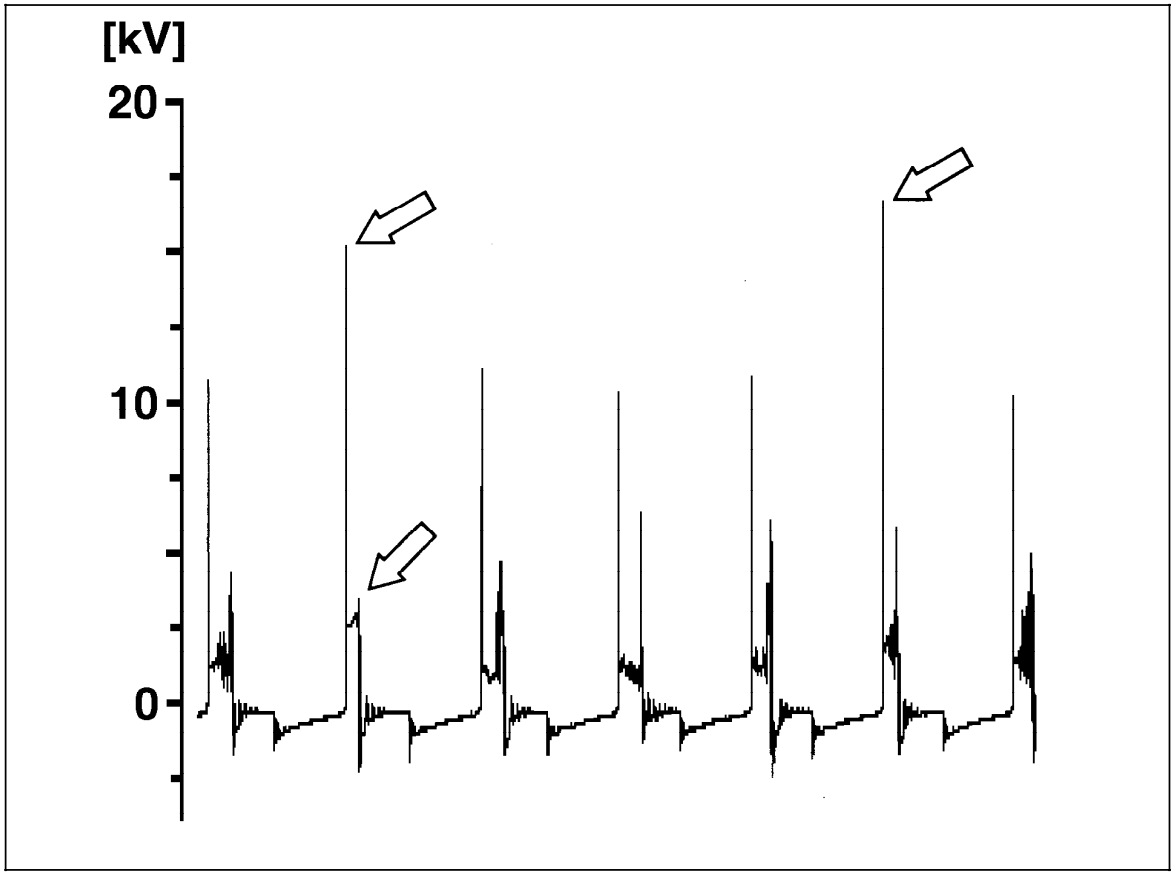
Measurement range . . . . . 20 kV

Ignition voltage too high/burn time shorter (arrows).

Test condition: can occur at **any engine RPM with** or **without load.**

Cause

- Spark plug electrode gap too large,
- Additional spark paths on secondary side,
- Fuel/air mixture too lean.



P15-0013-57

Figure 12

Diagnosis – Oscilloscope

Oscilloscope

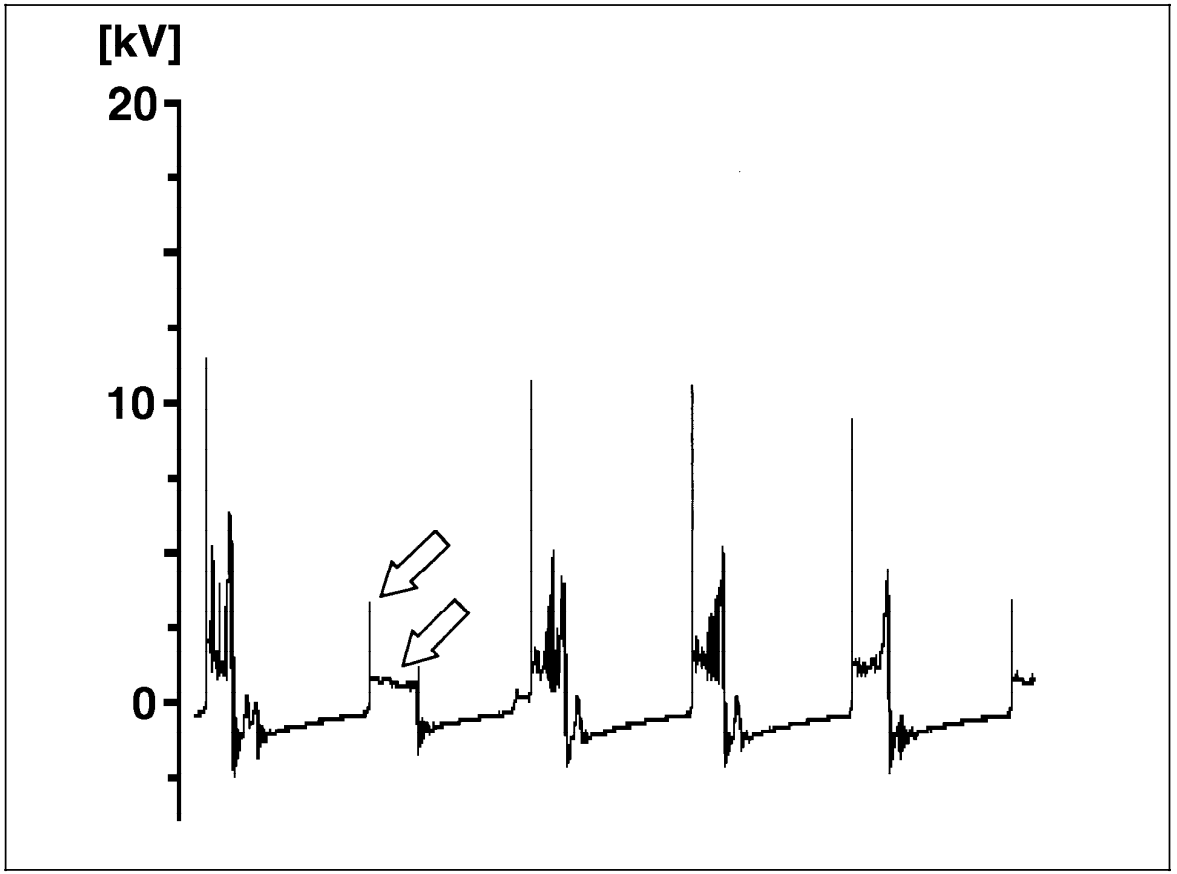
Bad scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (parade).

Measurement range	20 kV

Ignition voltage too low/combustion time longer.

Test condition: can occur at **any engine RPM with** or **without load.**

Cause:
- Spark plug gap too small,
- Fuel/air mixture too rich,
- Loss of compression.



P15-0014-57

Figure 13

Diagnosis – Oscilloscope

Oscilloscope

Bad scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (parade).

Measurement range . . . . . 20 kV

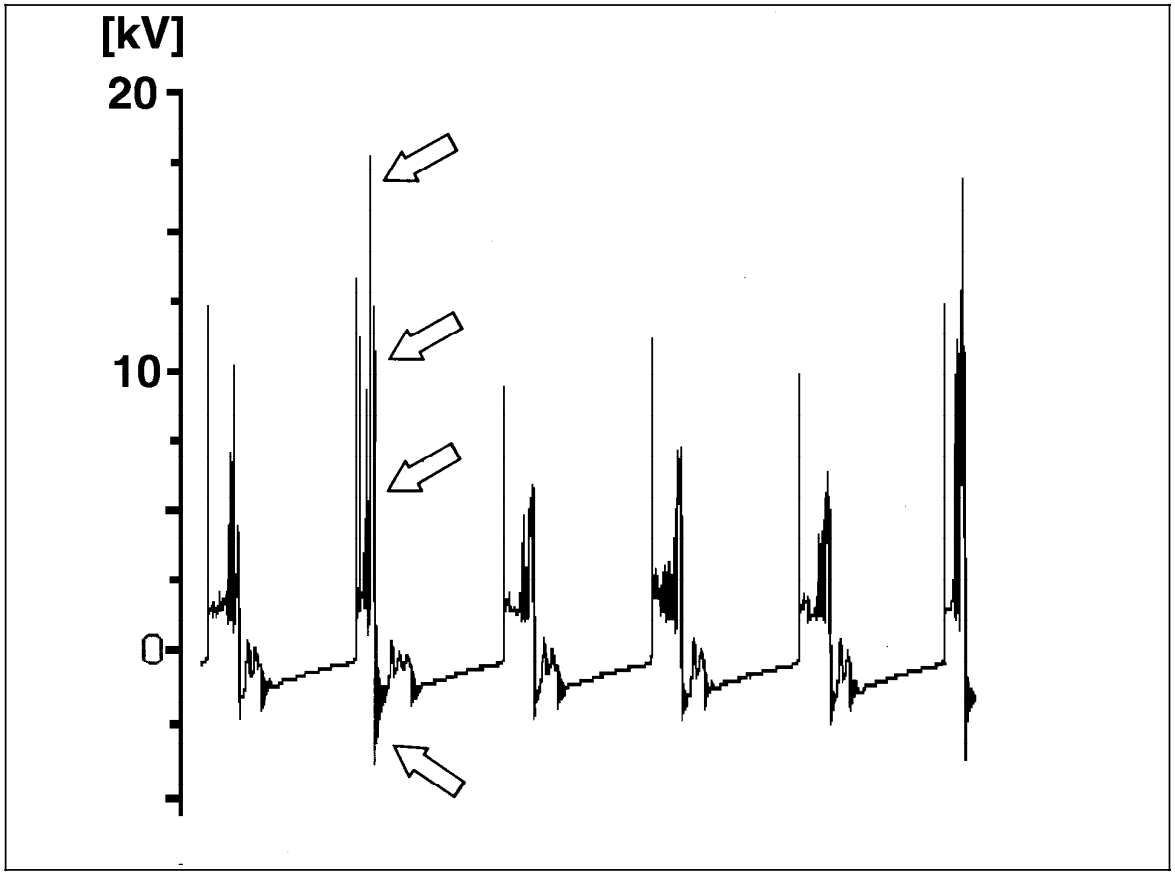
Decay process too high.

Test condition: **Accelerate engine repeatedly up to approx. 3000 rpm or operate engine under load on dynamometer.**

Cause
Fuel/air mixture too lean at one cylinder (arrows).

Note
If engine is not running smoothly (not running on all cylinders) after start up, the engine should be turned off at normal operating temperature and started again after a cool off period (approx. 15 min.) to allow a better diagnosis.
When re-starting, note test condition.

⚠
Malfunction may only occur momentarily.



P15-0015-57

Figure 14

Diagnosis – Oscilloscope

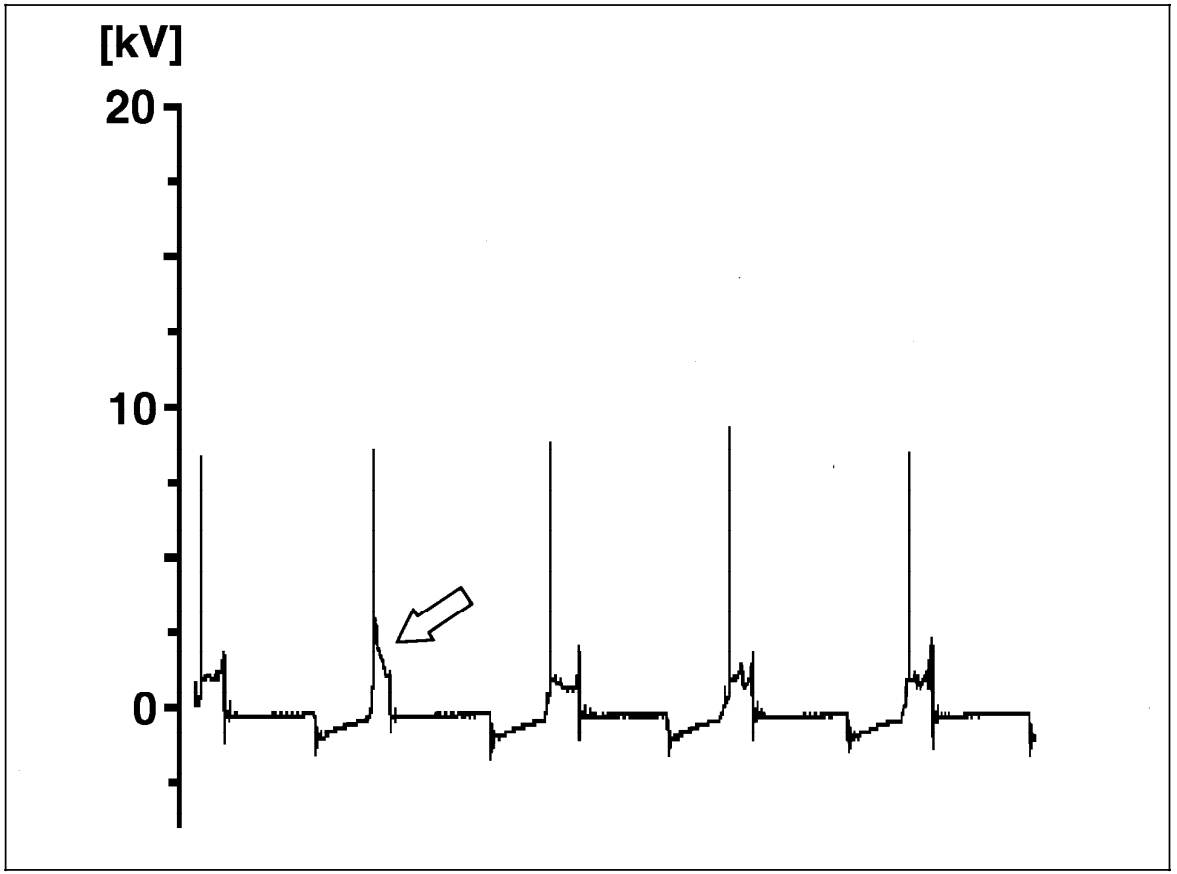
Oscilloscope

Bad scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (parade).

Measurement range . . . . . 20 kV
Higher voltage >1.5 kV at single cylinder

Test condition: can occur at **any engine RPM with** or **without load.**

Cause:
Spark plug fouled by carbon, oil, (arrow).
Excessive resistance at secondary side.



P15-0017-57

Figure 15

Diagnosis – Oscilloscope

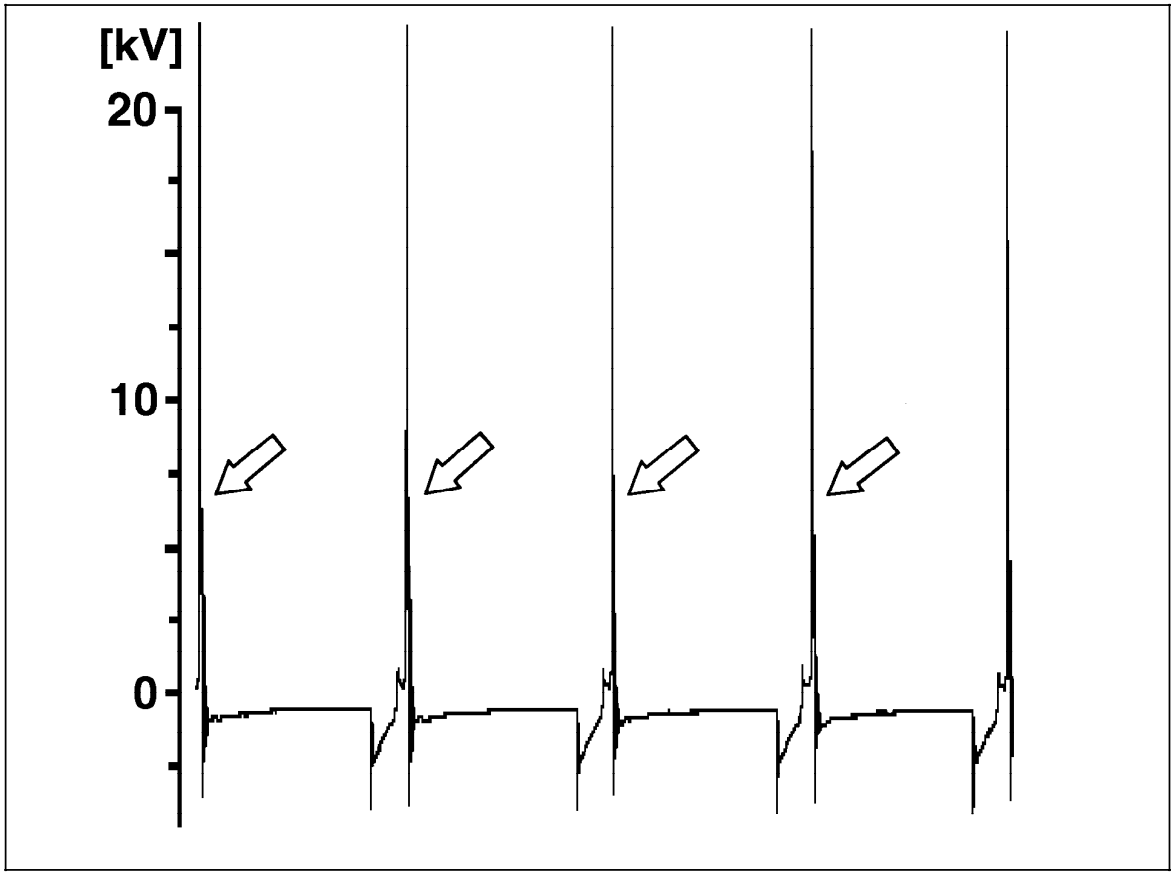
Oscilloscope

Bad scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (parade).

Measurement range . . . . . 20 kV
Voltage too high >1.5 kV at one cylinder (arrow).

Test condition: can occur at **any engine RPM with** or **without load.**

Cause:
Excessive resistance at secondary side
(ignition cable 4, distributor rotor, ignition coil, or high voltage output).



P15-0018-57

Figure 16

Diagnosis – Oscilloscope

Oscilloscope

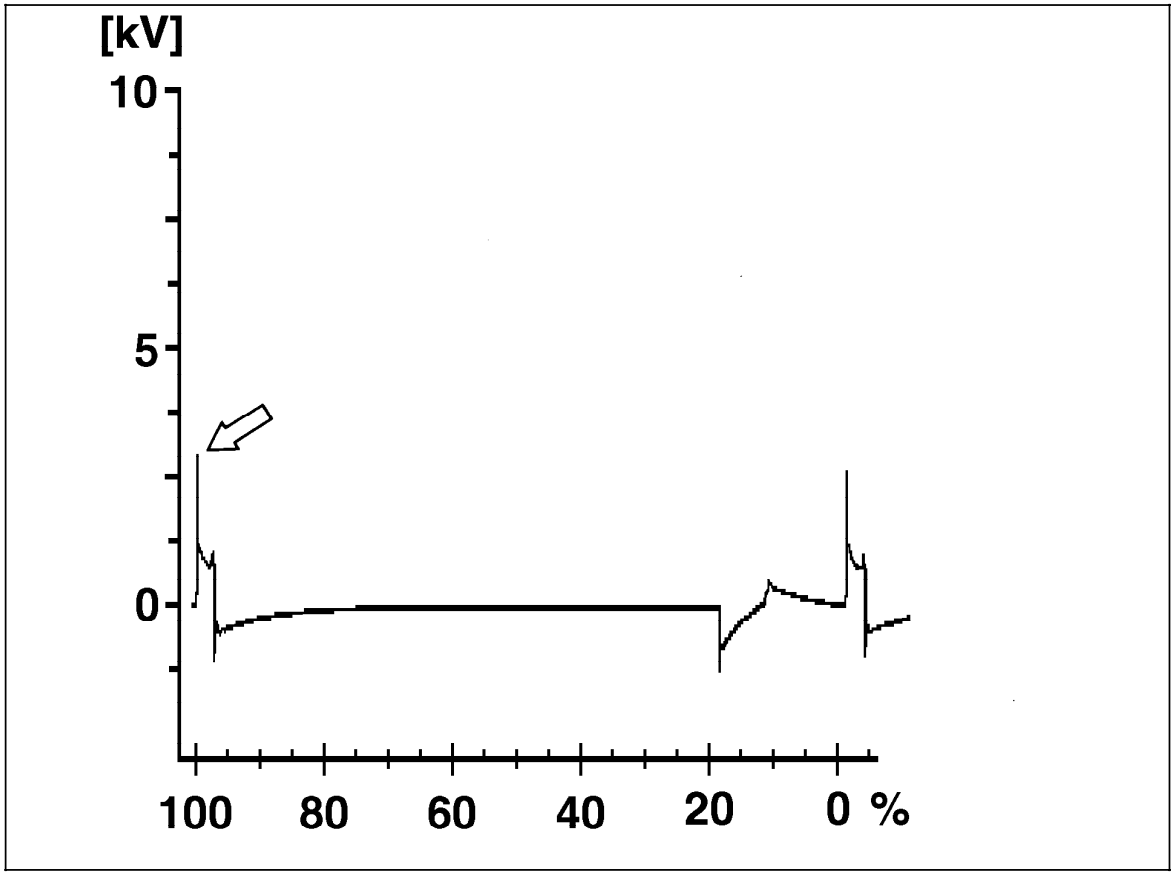
Bad scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (single display).

Measurement range . . . . . 10 kV
Time range . . . . . 100 %
Ignition voltage . . . . . <8 kV at terminal 4

Test condition: **Starting RPM**.

Cause:
Ignition coil, voltage terminal 15, terminal 1.

Note
Engine does not start (engine not running).



P15-0019-57

Figure 17

Diagnosis – Oscilloscope

Oscilloscope

Bad scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (single display).

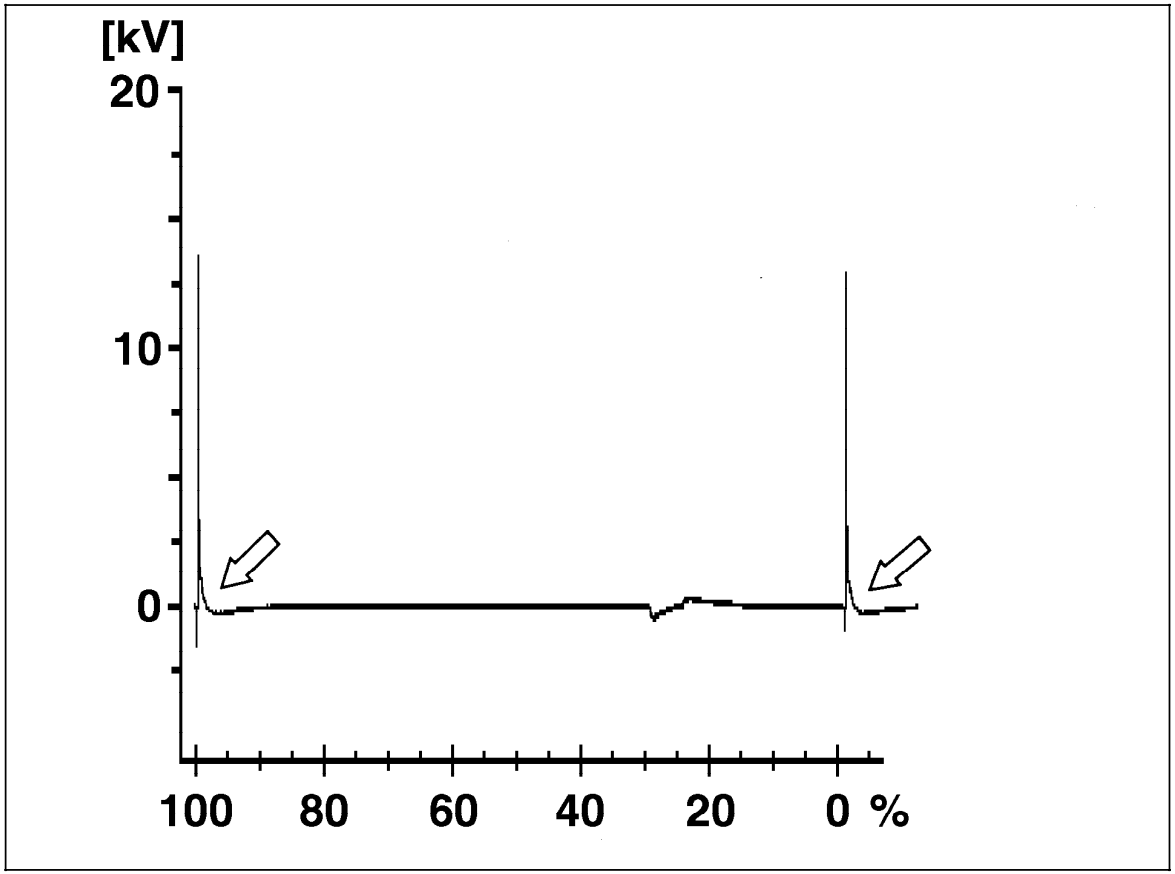
Measurement range . . . . . 20 kV
Time range . . . . . 100 %

No decay process.

Test condition: **cranking rpm**.

Cause:
Ignition coil or DI control module.

Note:
Engine does not start (engine not running).



P15-0021-57

Figure 18

Diagnosis – Oscilloscope

Oscilloscope

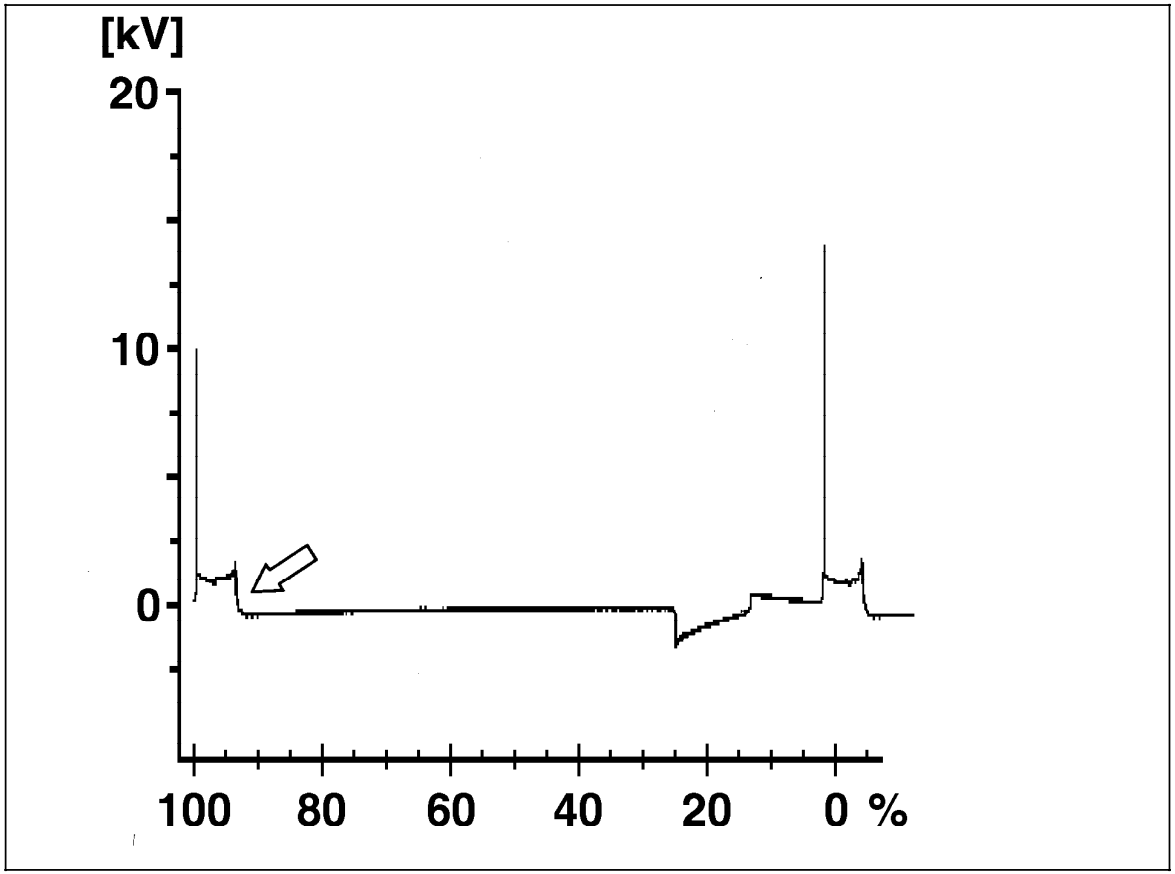
Bad scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (single display).

Measurement range . . . . . 20 kV
Time range . . . . . 100 %
too few oscillations

Test condition: can occur at **any engine rpm with** or **without load**.

Engine running

Cause:
Ignition coil or DI control module.



P15-0023-57

Figure 19

Diagnosis – Oscilloscope

Oscilloscope

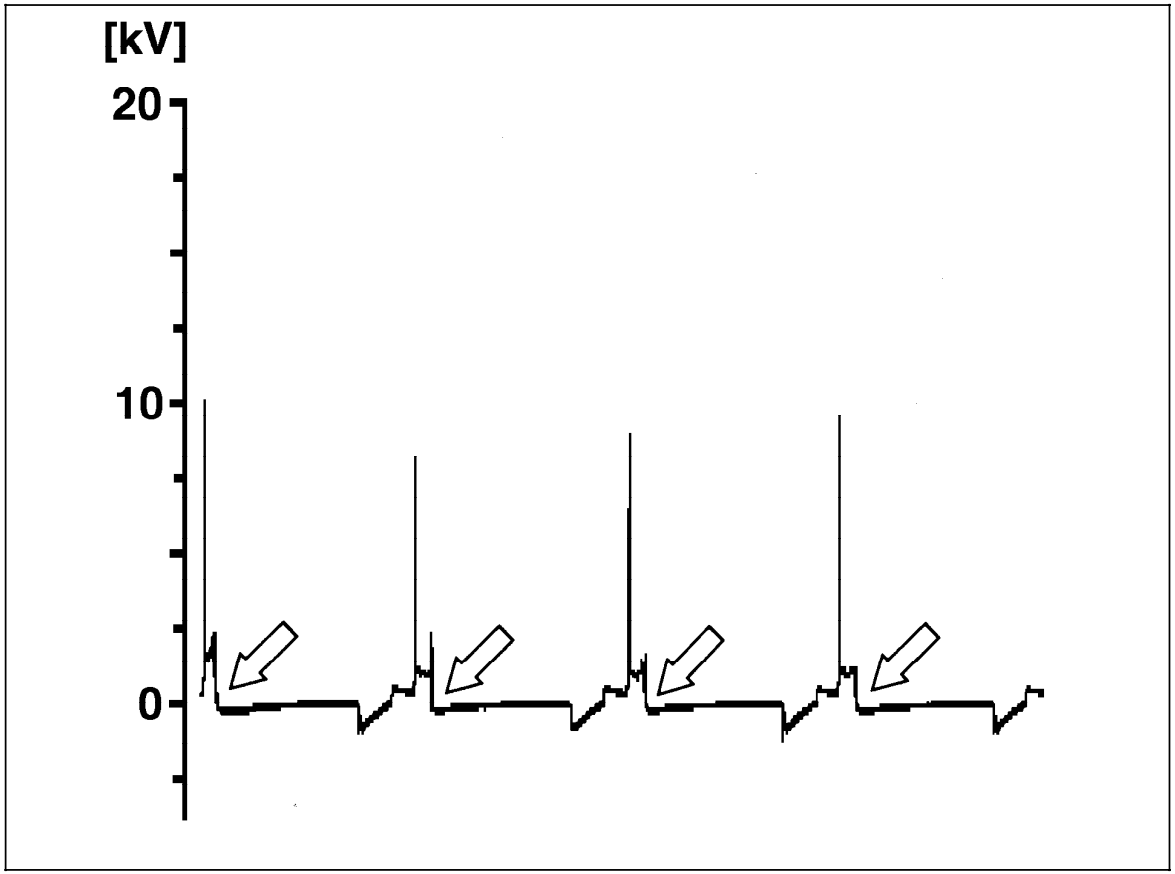
Bad scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (parade).

Measurement range . . . . . 20 kV

Too few oscillations.

Test condition: can occur at **any engine rpm with** or **without load**.

Cause:
Ignition coil or DI control module.



P15-0022-57

Figure 20

Diagnosis – Oscilloscope

Oscilloscope

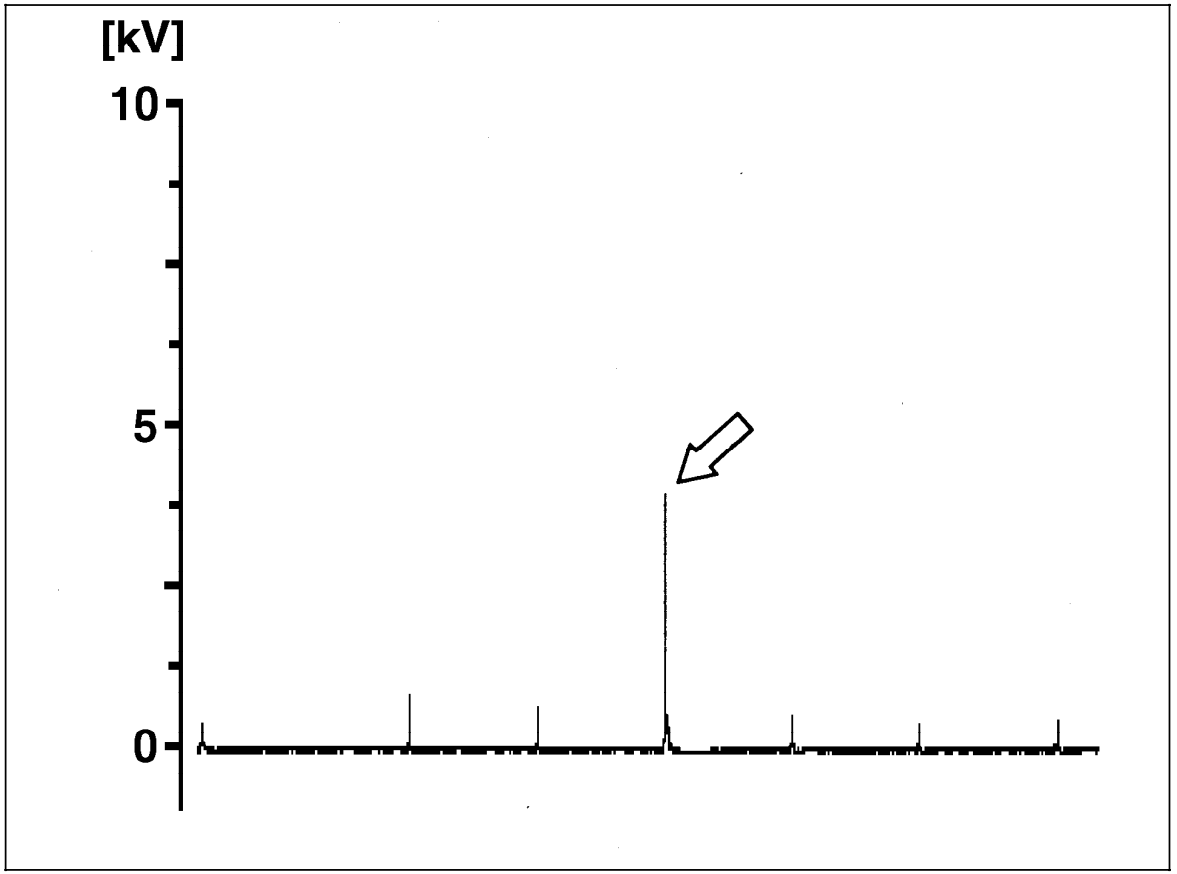
Bad scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (parade).

Measurement range . . . . . 10 kV
Ignition voltage . . . . . <6 kV at one cylinder

Test condition: **cranking rpm**.

Cause:
Ignition coil.

Note:
Engine does not start (engine not running).



P15-0020-57

Figure 21

Diagnosis – Oscilloscope

Oscilloscope

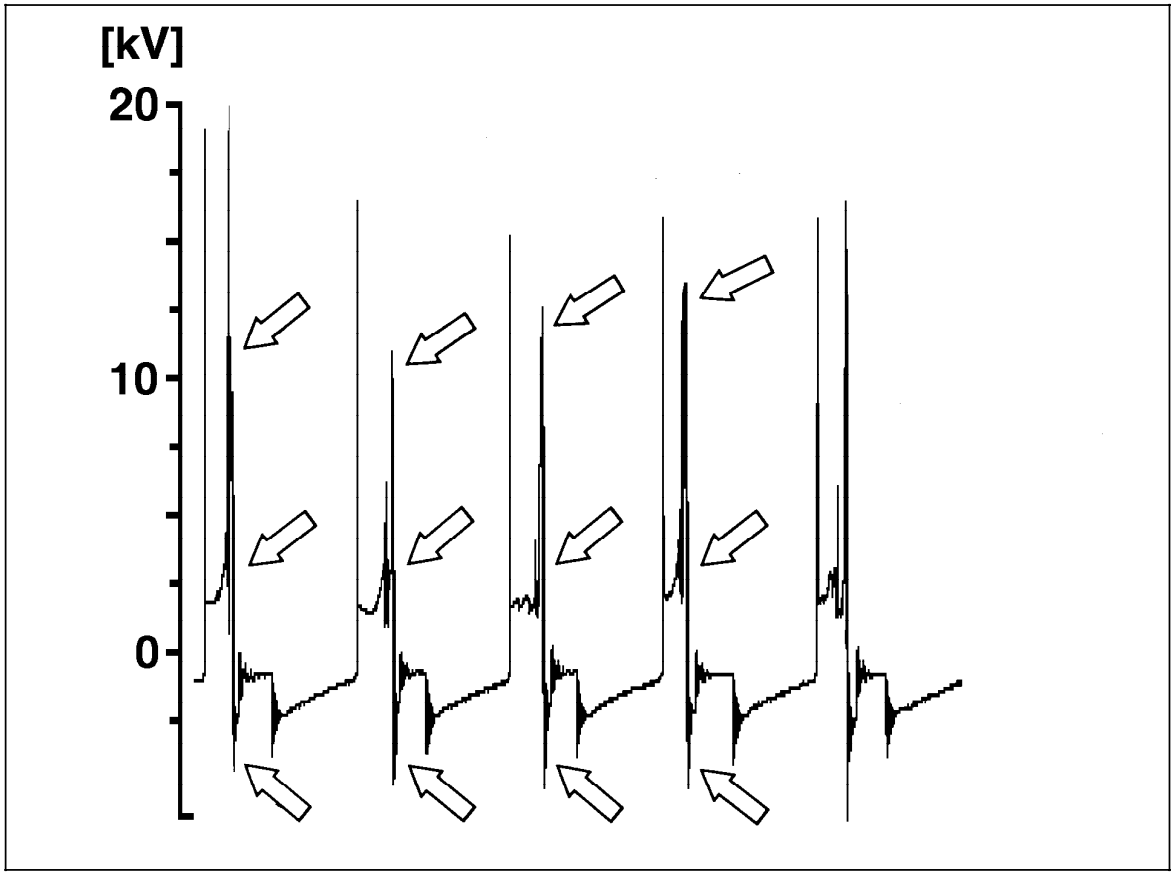
Bad scope pattern, single and dual ignition system (CFI/LH-SFI)
Secondary side (parade).

Measurement range . . . . . 20 kV

Decay processes too high.

Test condition: **Accelerate engine repeatedly up to approx. 3000 rpm or operate engine under load on dynamometer.**

Cause:
Fuel/air mixture too lean at all cylinders.



P15-0016-57

Figure 22

Diagnosis – Oscilloscope

Oscilloscope

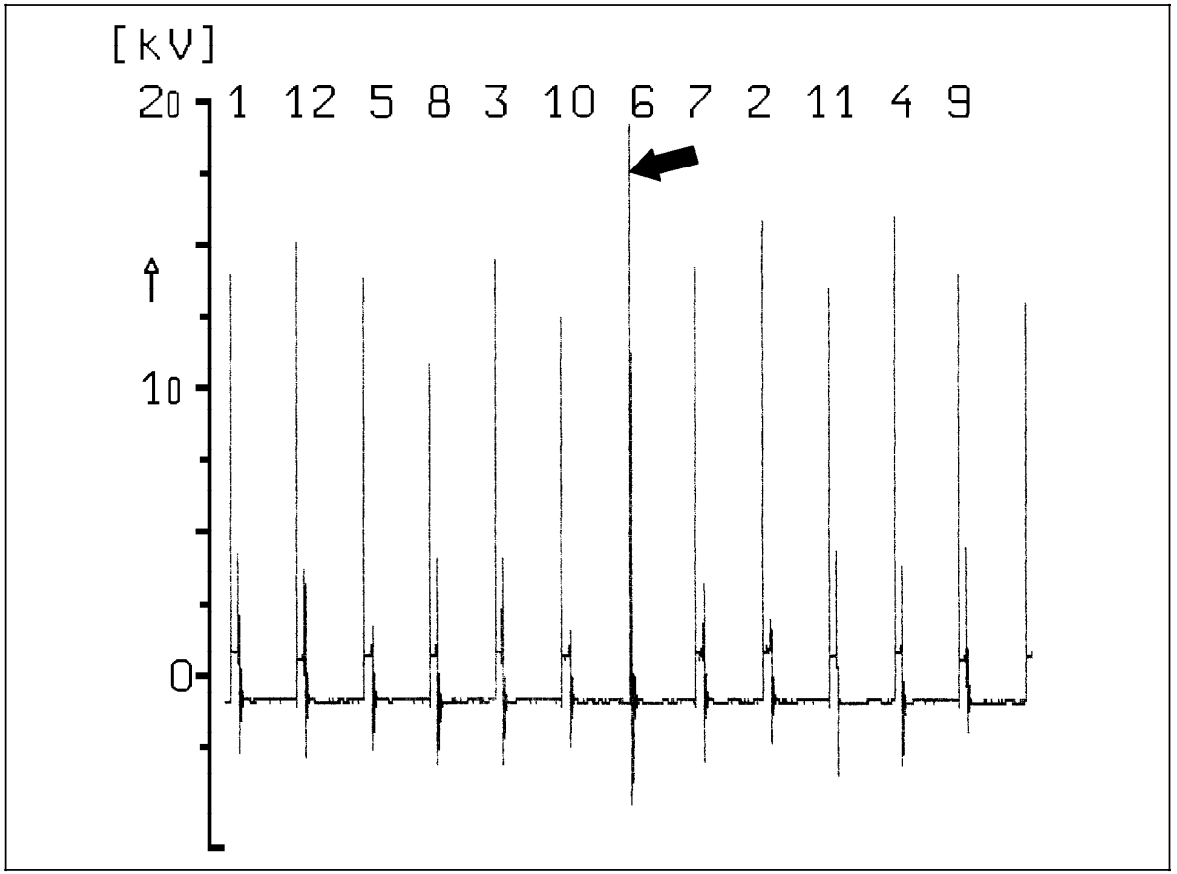
Bad scope pattern, dual ignition system (LH-SFI)
Secondary side (parade) 12-cylinder engine 120.

Measurement range . . . . . 20 kV
Ignition voltage . . . . . > 20 kV

Test condition: can occur at **any engine rpm**.

Cause:
Spark plug connector, ignition wire defective.

Note:
Engine does not run smoothly.



P07-5125-57

Figure 23

Diagnosis – Oscilloscope

Oscilloscope

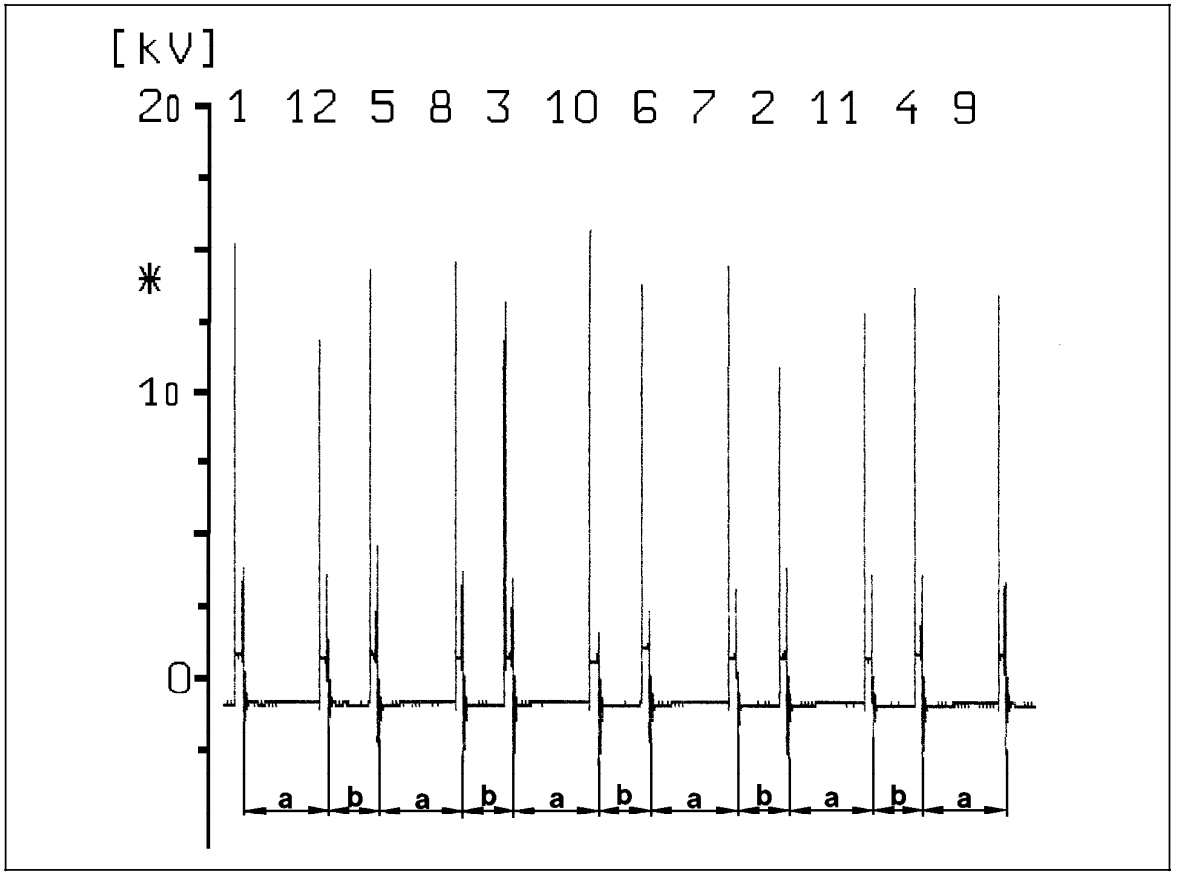
Bad scope pattern, dual ignition system (LH-SFI)
Secondary side (parade) 12-cylinder engine 120.

Measurement range . . . . . 20 kV

Retarded ignition angle of cylinders 1–6.

Test condition: can occur at **any engine RPM**.

Cause:
Vacuum line on DI control module for cylinders 1–6 defective or not connected.
DI control module defective.



P07-5126-57

Figure 24
a Retarded ignition timing, cylinder bank 1–6
b Cylinder bank 7–12

Diagnosis – Oscilloscope

Oscilloscope

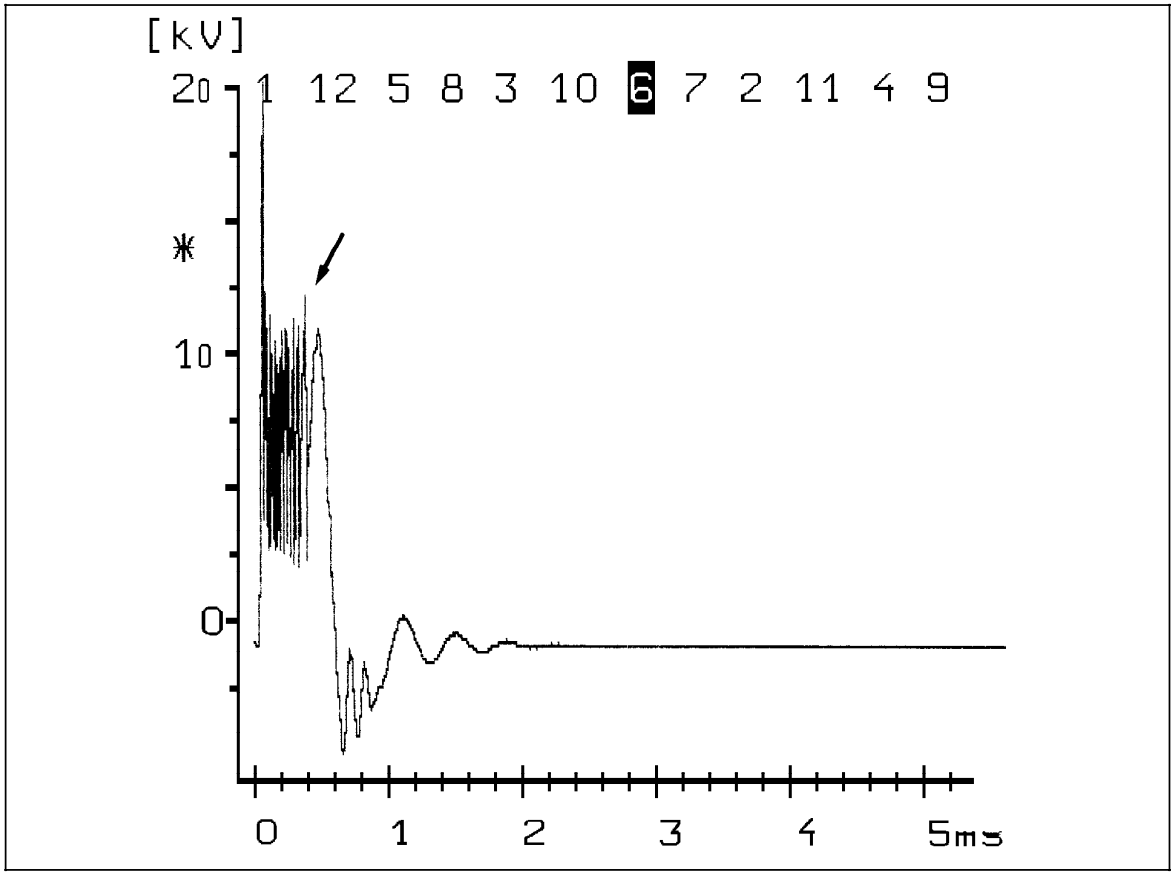
Bad scope pattern, dual ignition system (LH-SFI)
Secondary side (single display) 12-cylinder engine 120.

Measurement range	20 kV
Time range	5 ms

Test condition: can occur at **any engine RPM**.

Engine runs rough at idle.

Cause:
Spark plug connector, ignition wire defective.



P07-5127-57

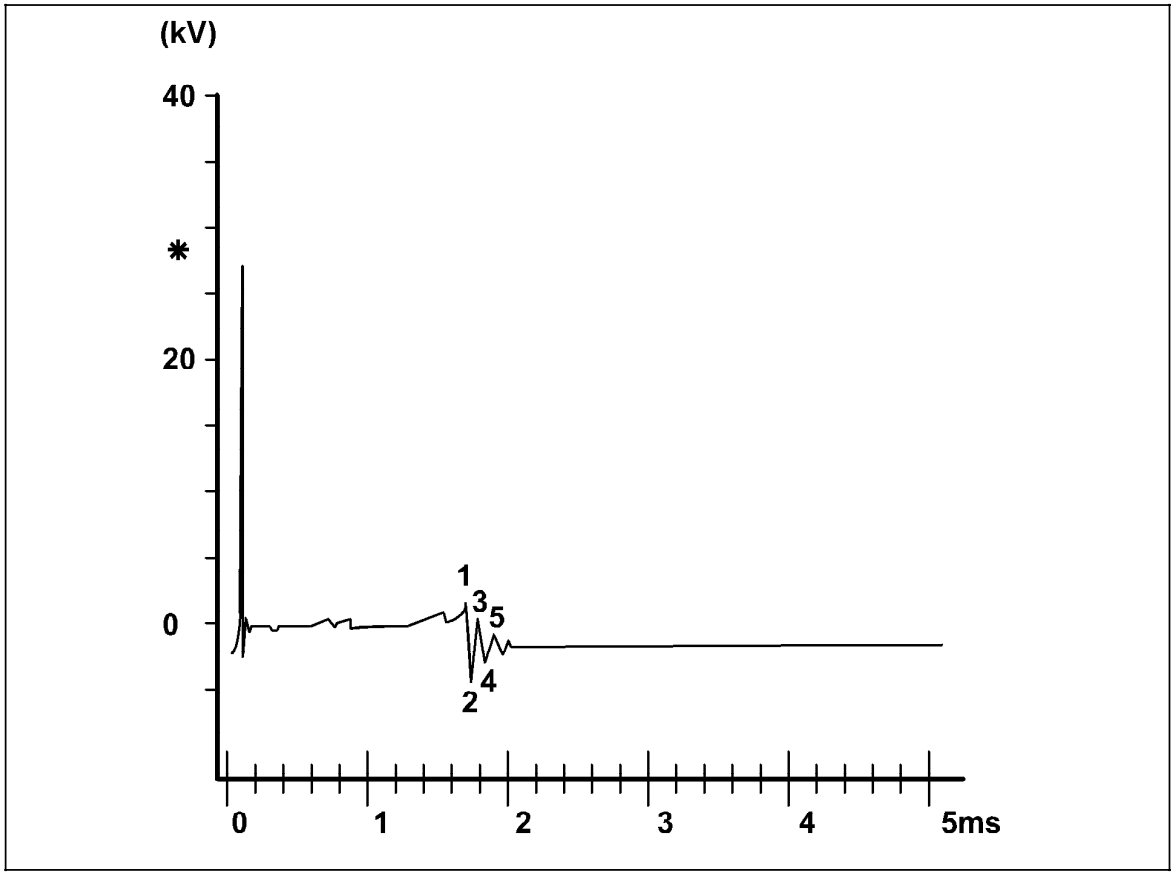
Figure 25

Diagnosis – Oscilloscope

Oscilloscope

Good scope pattern, Electronic Ignition (EI) System (distributor-less) (ME-SFI)
Secondary side (single display)
Engine: Idle
e.g. 8-cylinder, engine 119
No.1 cylinder displayed

Measurement range	40 kV
Time range	5 ms



P07.61-0434-57

Figure 26
Bosch ignition coil

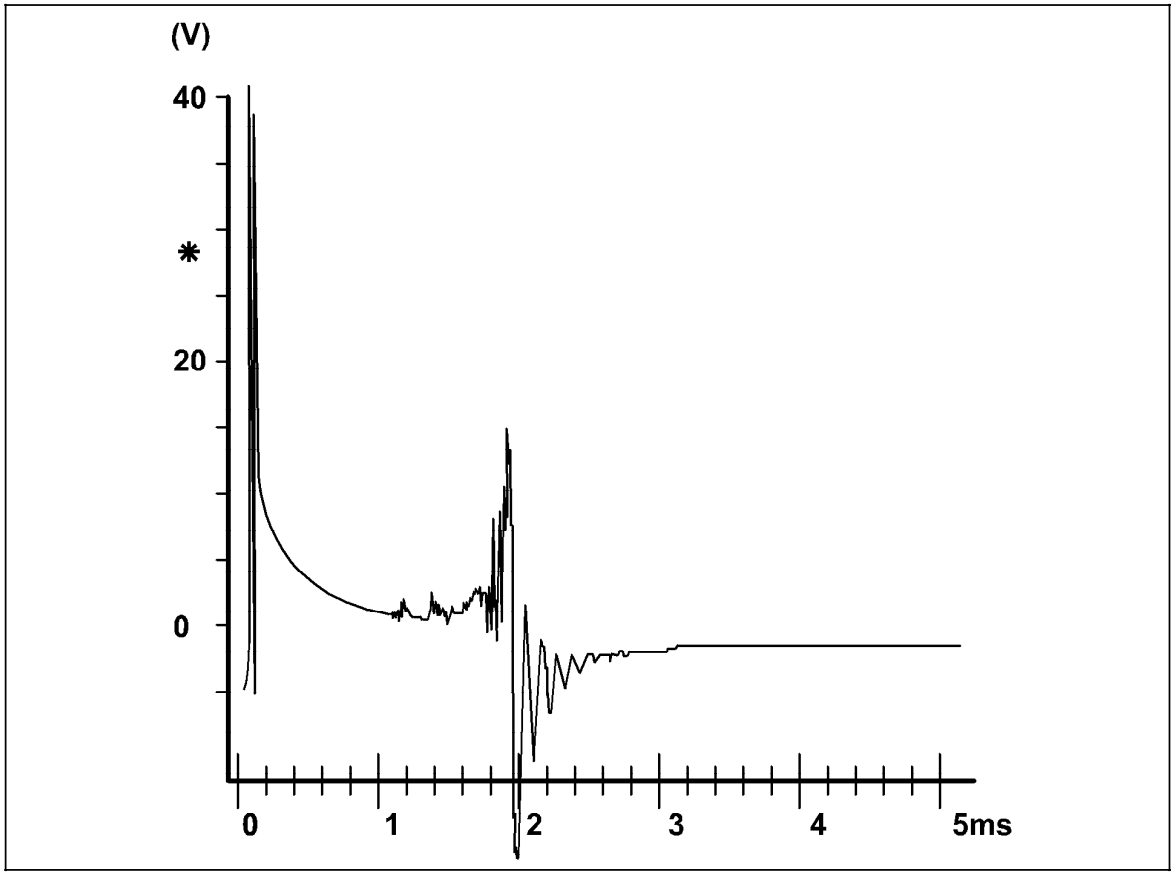
1 Oscillation
2 Oscillation
3 Oscillation
4 Oscillation
5 Oscillation

Diagnosis – Oscilloscope

Oscilloscope

Good scope pattern, Electronic Ignition (EI) System (distributor-less) ME-SFI
Primary side (single display)
Engine: Idle
e.g. 8-cylinder, engine 119
No.1 cylinder displayed

Measurement range	40 kV
Time range	5 ms



P07.61-0435-57

Figure 27

Diagnosis

Diagnosis using the HHT

Activation applications

Activation using HHT	Possible symptoms, no DTC's stored	Examples of possible causes in system (refer to corresponding DM)
Camshaft	Rough idle, poor performance	Adustable camshaft control
Secondary air injection pump	Excessive emissions	Secondary air injection piping, oxygen sensor, secondary air injection pump
Injection valve	Rough idle, poor performance	Injection valve, engine control module
Throttle valve	Idle speed too high, rough idle, motor hunts	Poor idle control, position sensor
Electric fuel pump	Repairs to fuel system (relieve fuel pressure)	Repairs to fuel system
Evaporative emission control system	Fuel odor	Purge valve, leak in EVAP system
Purge control valve Carbon canister	Test EVAP system, check for system integrity	
Exhaust gas recirulation	Rough idle, high fuel consumption	EGR valve, (binding)
Air/fuel mixture control	Off-idle or warm-up faults	Ignition coil, air leak, injection valve

Diagnosis

Diagnosis using the HHT

Activation applications

Activation using HHT	Possible symptoms, no DTC's stored	Examples of possible causes in system (refer to corresponding DM)
Electric cooling fan	Motor temperature too high	Cooling fan defective, engine control module, wiring
Ignition control	Rough idle, poor performance	Ignition coil, spark plugs, wiring
Switchable intake manifold	Poor performance	Switchover valve, vacuum lines, vacuum tank
Compression test	Rough idle, poor starting, poor performance	Check for mechanical faults
Supercharger	Poor performance	Supercharger, air flap/air filter motor, engine control module
Supercharger clutch	Poor performance	Supercharger, wiring, engine control module
Air intake	Poor performance	Air intake switchover valve/motor, engine control module

Activation functions

Activation using HHT	Function	
Camshaft	ON	Motor idles poorly (uneven)
Secondary air injection pump	ON	Oxygen sensor voltage goes to < 40 mV in max 60 s.
Injection valve	OFF	Idle speed drops briefly when an injector is switched off. Idle quality deteriorates.
	ON	Idle quality improves when the injector is switched on again.
Throttle valve	OPEN	Idle speed increases as throttle angle increases.
	CLOSED	Idle speed decreases as throttle angle decreases.
Electric fuel pump	OFF	OFF: Fuel pressure drops and the motor stalls.
EVAP system	ON	Purge valve ON: Purge valve cycles
Purge control valve Carbon canister	ON	Test EVAP system, for leaks, engine off.
Exhaust gas recirulation	ON	Motor runs poorly, stalls.
Air/fuel mixture control	RICH\LEAN	LEAN: Idle quality deteriorates

Activation functions

Activation using HHT	Function	
Electric cooling fan	PLUS/MINUS	Cooling fan can be regulated between 20 and 90%.
Ignition control	ON	Motor runs somewhat poorly recognizable by poor idle quality. If no change in idle quality, check ignition circuit for faults.
Switchable intake manifold	ON	ON: Operation of switchover valve is visible under motor cover.
Compression test		Test for internal cylinder damage.
Supercharger clutch	ON	Supercharger clutch engages
Air flap/air filter actuator	ON	Air flap can be heard switching.

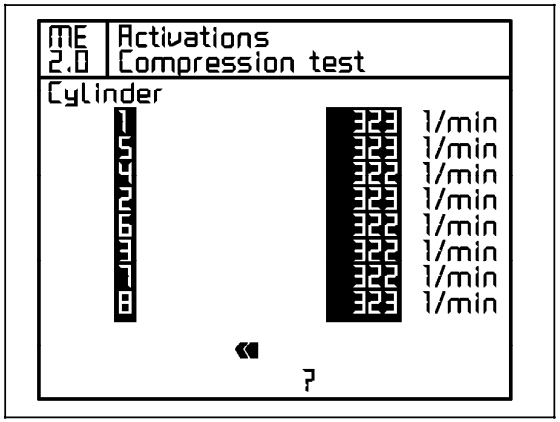
Additional information to the actual value screens

HHT actual value screen	Possible symptoms, no DTC's stored	Possible faults in system
Testing engine at idle, emissions testing	Complaints of poor performance	Refer to corresponding DM volume
Testing engine	Test of motor functions Check idle speed control system	Refer to corresponding DM volume
Engine, cold start	Engine won't start or starts with difficulty	Refer to corresponding DM volume
Engine, warm-up	Complaints during warm-up	Refer to corresponding DM volume
Engine performance	Testing on a chassis dynamometer Poor acceleration Poor performance High fuel consumption	Refer to corresponding DM volume
Cruise control	Complaints with cruise control operation	Refer to corresponding DM volume
Drive authorization system	Engine will not start	Refer to corresponding DM volume
Cylinder balance test (smooth running function)	Engine complaints (mechanical, engine management)	Refer to corresponding DM volume
Compression testing	Engine shakes Engine starts with difficulty Blue exhaust smoke after start up Poor performance	Refer to corresponding DM volume
Tests completed	After repaired faults	Refer to corresponding DM volume

Compression Testing

Compression can be tested as an input using the HHT.
A mechanical problem may be present if the difference in engine speed is > 8 rpm for engines 104/112/113, and > 5 rpm for engine 111.
Any engine speed difference will not present itself in the same manner in all engines, so no conclusions can be drawn concerning the affected cylinder.

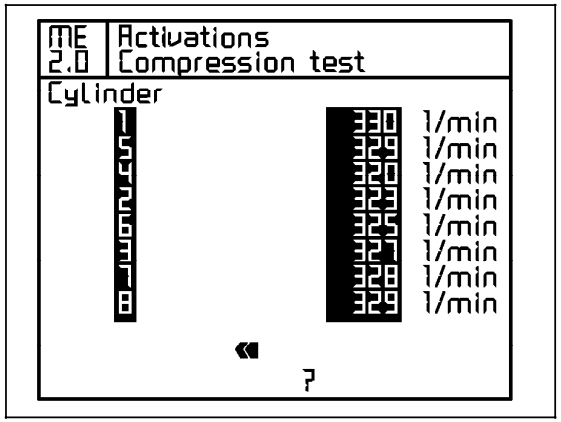
If the engine speed difference is greater than the set value, perform a compression/cylinder leakage test to determine the affected cylinder.



P07.61-2279-13

Figure 1

Good compression test
Engine 113



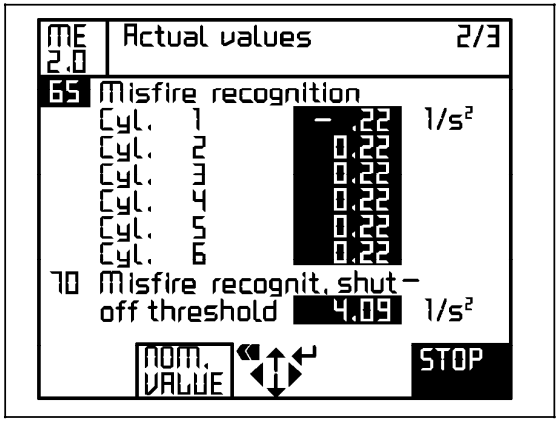
P07.61-2280-13

Figure 2

Failed compression test
Engine 113
Example:
Cylinder 1 330 rpm (max. value)
Cylinder 4 320 rpm (mni. value)
Difference 10 rpm

Cylinder balance test

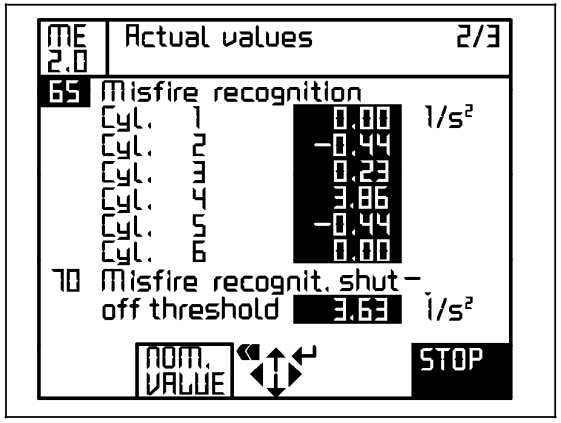
The cylinder balance test must be performed at idle. If the misfire recognition shutoff threshold is exceeded, a fault will be stored and at the same time the fault count will increases. After repairs, clear the diagnostic memory.



P07.61-2281-13

Figure 3

Good cylinder balance test
Engine 112
1/s²=Engine speed difference between cylinders



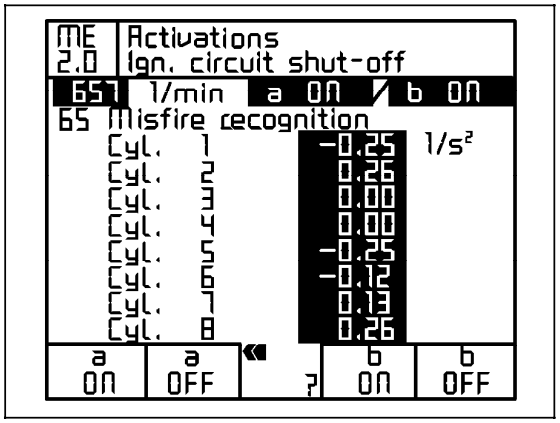
P07.61-2282-13

Figure 4

Failed cylinder balance test
Engine 112
Fault in cylinder 4

Ignition circuit shutoff

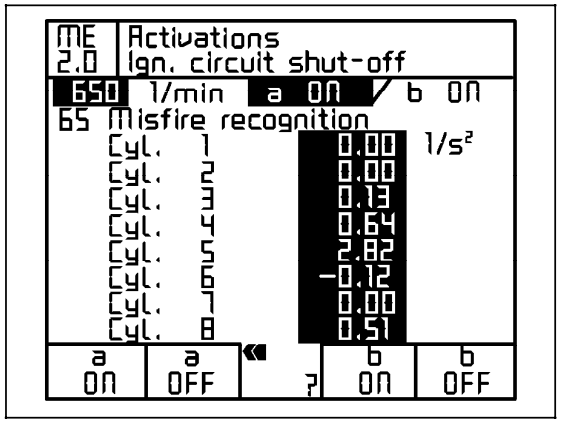
Ignition circuit shutoff can only be performed on Motor 113.



P07.61-2283-13

Figure 5

Good ignition shutoff test
Engine 113



P07.61-2284-13

Figure 6

Failed ignition shutoff test
Engine 113
Ignition circuit b switched off
Fault in cylinder 5, ignition circuit a