



Advanced Automotive Fault Diagnosis

Third
Edition



Tom Denton

Automotive Technology:
Vehicle Maintenance and Repair

ROUTLEDGE



Advanced **Automotive Fault** **Diagnosis** **Third Edition**

Automotive Technology: Vehicle Maintenance and Repair



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Contents



Preface	xix
Acknowledgements	xxi
Chapter 1 Introduction	1
1.1 Diagnosis	1
1.1.1 Introduction	1
1.2 Safe working practices	2
1.2.1 Risk assessment and reduction	2
1.3 Terminology	2
1.3.1 Introduction	2
1.3.2 Diagnostic terminology	3
1.3.3 General terminology	4
1.4 Report writing	4
1.4.1 Introduction	4
1.4.2 Main headings of a report	5
1.4.3 Example report	6
Chapter 2 Diagnostic techniques	9
2.1 Introduction	9
2.1.1 Logic	9
2.1.2 Information	9
2.1.3 Where to stop?	9
2.2 Diagnostic process	10
2.2.1 Six-stage process	10
2.2.2 The art of diagnostics	11
2.2.3 Concern, cause, correction	12
2.2.4 Root cause analysis	13
2.2.5 Summary	15
2.3 Diagnostics on paper	16
2.3.1 Introduction	16
2.3.2 Examples	16
2.3.3 How long is a piece of string?	17
2.4 Mechanical diagnostic techniques	17
2.4.1 Check the obvious first	17
2.4.2 Noise, vibration and harshness	17
2.4.3 Noise conditions	18

2.4.4	Vibration conditions	19
2.4.5	Road test	19
2.4.6	Engine noises	20
2.4.7	Sources of engine noise	21
2.5	Electrical diagnostic techniques	22
2.5.1	Check the obvious first	22
2.5.2	Test lights and analogue meters – warning	22
2.5.3	Generic electrical testing procedure	23
2.5.4	Volt drop testing	24
2.5.5	Testing for short circuits to earth	24
2.5.6	On and off load tests	25
2.5.7	Black box technique	25
2.5.8	Sensor to ECU method	26
2.5.9	Flight recorder tests	26
2.5.10	Fault finding by luck – or is it logic?	27
2.5.11	Colour codes and terminal numbers	28
2.5.12	Back probing connectors	30
2.6	Fault codes	31
2.6.1	Fast and slow	31
2.6.2	Fault code examples	32
2.6.3	Clearing	33
2.7	Systems	34
2.7.1	What is a system?	34
2.7.2	Vehicle systems	34
2.7.3	Open-loop systems	35
2.7.4	Closed-loop systems	35
2.7.5	Block diagrams	36
2.8	Data sources	36
2.8.1	Introduction	36
2.8.2	Autodata	38
2.8.3	Bosch ESItronic	38
2.9	Summary	41

Chapter 3 Tools and equipment **43**

3.1	Basic equipment	43
3.1.1	Introduction	43
3.1.2	Basic hand tools	43
3.1.3	Accuracy of test equipment	43
3.1.4	Multimeters	45
3.1.5	Logic probe	47
3.2	Oscilloscopes	47

3.2.1	Introduction	47
3.2.2	Waveforms	49
3.3	Scanners/Fault code readers and analysers	50
3.3.1	On-board diagnostics introduction	50
3.3.2	Serial port communications	50
3.3.3	OBD2 signal protocols	51
3.3.4	AutoTap OBD scanner	52
3.3.5	Bosch KTS diagnostic equipment	53
3.3.6	Engine analysers	55
3.4	Emission testing	59
3.4.1	Introduction	59
3.4.2	Exhaust gas measurement	59
3.4.3	Exhaust analyser	60
3.4.4	Emission limits	60
3.5	Pressure testing	62
3.5.1	Introduction	62
3.5.2	Automotive pressure oscilloscope transducer	64
Chapter 4 Sensors, actuators and oscilloscope diagnostics		67
4.1	Introduction	67
4.2	Sensors	67
4.2.1	Introduction and sensor diagnostics	67
4.2.2	Inductive sensors	69
4.2.3	Variable resistance	74
4.2.4	Hot wire airflow sensor	77
4.2.5	Thermistors	78
4.2.6	Hall effect sensors	80
4.2.7	Piezo accelerometer	82
4.2.8	Oxygen sensors	84
4.2.9	Pressure sensors	87
4.2.10	Variable capacitance	89
4.2.11	Optical sensors	91
4.2.12	Dynamic position sensors	92
4.2.13	Rain sensor	93
4.3	Actuators	93
4.3.1	Introduction	93
4.3.2	Testing actuators	94
4.3.3	Motorised and solenoid actuators	94
4.3.4	Solenoid actuators	98
4.3.5	Thermal actuators	106
4.4	Engine waveforms	106

4.4.1	Ignition primary	106
4.4.2	Ignition secondary	108
4.4.3	Diesel glow plugs	110
4.4.4	Alternator waveform	111
4.4.5	Relative compression petrol	112
4.5	Communication networks	113
4.5.1	CAN	113
4.5.2	LIN	116
4.5.3	FlexRay	116
4.6	Summary	118

Chapter 5 On-board diagnostics 119

5.1	History	119
5.1.1	Introduction	119
5.1.2	Vehicle emissions and environmental health	119
5.1.3	History of the emissions control legislation	120
5.1.4	Introduction of vehicle emissions control strategies	122
5.2	What is on-board diagnostics?	123
5.2.1	OBD scenario example	123
5.2.2	Origins of OBD in the United States	124
5.2.3	P-code composition	125
5.2.4	European on-board diagnostics and global adoption	126
5.2.5	Summary	126
5.3	Petrol/Gasoline on-board diagnostic monitors	127
5.3.1	Introduction	127
5.3.2	Legislative drivers	127
5.3.3	Component monitoring	127
5.3.4	Rationality testing	128
5.3.5	Circuit testing	128
5.3.6	Catalyst monitor	128
5.3.7	Evaporative system monitor	129
5.3.8	Fuel system monitoring	130
5.3.9	Exhaust gas recirculation monitor	132
5.3.10	Secondary air monitor	133
5.3.11	Monitors and readiness dgs	134
5.4	Misfire redetection	135
5.4.1	Misfire monitor	135
5.4.2	Crank speed fluctuation	138
5.4.3	Ionising current monitoring	138

5.4.4	Cylinder pressure sensing	140
5.4.5	Exhaust pressure analysis	140
5.5	OBD summary	140
5.5.1	OBD2	141
5.5.2	EOBD	142
5.5.3	Features and technology of current systems	144
5.6	Driving cycles	145
5.6.1	Introduction	145
5.6.2	Europe	145
5.6.3	United States	146
5.7	Future developments in diagnostic systems	147
5.7.1	OBD3	147
5.7.2	Diesel engines	148
5.7.3	Rate-based monitoring	148
5.7.4	Model-based development	148
5.8	Summary	149
Chapter 6 Engine systems		151
6.1	Introduction	151
6.2	Engine operation	151
6.2.1	Four-stroke cycle	151
6.2.2	Cylinder layouts	153
6.2.3	Camshaft drives	153
6.2.4	Valve mechanisms	153
6.2.5	Valve and ignition timing	155
6.3	Diagnostics – engines	156
6.3.1	Systematic testing example	156
6.3.2	Test equipment	156
6.3.3	Test results	157
6.3.4	Engine fault diagnosis table 1	158
6.3.5	Engine fault diagnosis table 2	158
6.4	Fuel system	160
6.4.1	Introduction	160
6.4.2	Carburation	161
6.5	Diagnostics – fuel system	165
6.5.1	Systematic testing example	165
6.5.2	Test equipment	166
6.5.3	Test results	166
6.5.4	Fuel fault diagnosis table 1	167
6.5.5	Fuel fault diagnosis table 2	167
6.6	Introduction to engine management	168

6.7	Ignition	168
6.7.1	Basics	168
6.7.2	Advance angle (timing)	168
6.7.3	Electronic ignition	169
6.7.4	Hall effect distributor	170
6.7.5	Inductive distributor	171
6.7.6	Current-limiting and closed-loop dwell	171
6.7.7	Programmed ignition/electronic spark advance	172
6.7.8	Distributorless ignition	175
6.7.9	Direct ignition	176
6.7.10	Spark plugs	177
6.8	Diagnostics – ignition system	179
6.8.1	Testing procedure	179
6.8.2	Ignition fault diagnosis table	181
6.8.3	Ignition components and testing	181
6.8.4	DIS diagnostics	183
6.8.5	Spark plugs	183
6.9	Emissions	185
6.9.1	Introduction	185
6.9.2	Exhaust gas recirculation	186
6.9.3	Catalytic converters	186
6.10	Diagnostics – emissions	187
6.10.1	Testing procedure	187
6.10.2	Emissions fault diagnosis table	189
6.11	Fuel injection	189
6.11.1	Introduction	189
6.11.2	Injection systems	190
6.11.3	Fuel injection components	191
6.11.4	Fuel mixture calculation	193
6.12	Diagnostics – fuel injection systems	194
6.12.1	Testing procedure	194
6.12.2	Fuel injection fault diagnosis table	194
6.13	Diesel injection	195
6.13.1	Introduction	195
6.13.2	Electronic control of diesel injection	197
6.13.3	Common rail diesel systems	198
6.13.4	Diesel exhaust emissions	200
6.13.5	Catalytic converter diesel	200
6.13.6	Filters	201
6.14	Diagnostics – diesel injection systems	201
6.14.1	Test equipment	201

6.14.2 Diesel injection fault diagnosis table	202
6.14.3 Diesel engine smoke	202
6.14.4 Glow plug circuit	204
6.14.5 Diesel systems	204
6.15 Engine management	205
6.15.1 Introduction	205
6.15.2 Closed-loop lambda control	206
6.15.3 Engine management operation	206
6.15.4 Gasoline direct injection	212
6.16 Diagnostics – combined ignition and fuel systems	213
6.16.1 Testing procedure	213
6.16.2 Combined ignition and fuel control fault diagnosis table	215
6.16.3 Fuel pump testing	217
6.16.4 Injector testing	218
6.17 Engine management and faultfinding information	219
6.17.1 Diagnosis charts	219
6.17.2 Circuit diagrams	219
6.17.3 Component testing data	219
6.18 Air supply and exhaust systems	219
6.18.1 Exhaust system	219
6.18.2 Catalytic converters	222
6.18.3 Air supply system	224
6.19 Diagnostics – exhaust and air supply	225
6.19.1 Systematic testing	225
6.19.2 Test results	225
6.19.3 Exhaust and air supply fault diagnosis table	225
6.19.4 Exhaust fault diagnosis table 2	226
6.20 Cooling	226
6.20.1 Air-cooled system	226
6.20.2 Water-cooled system	226
6.20.3 Sealed and semi-sealed systems	227
6.21 Diagnostics – cooling	228
6.21.1 Systematic testing	228
6.21.2 Test equipment	229
6.21.3 Test results	229
6.21.4 Cooling fault diagnosis table 1	230
6.21.5 Cooling fault diagnosis table 2	230
6.22 Lubrication	230
6.22.1 Lubrication system	230
6.22.2 Oil filters	231

6.22.3	Oil pumps	232
6.22.4	Crankcase ventilation engine breather systems	233
6.23	Diagnostics – lubrication	233
6.23.1	Systematic testing	233
6.23.2	Test equipment	234
6.23.3	Test results	234
6.23.4	Lubrication fault diagnosis table 1	234
6.23.5	Lubrication fault diagnosis table 2	235
6.24	Batteries	235
6.24.1	Safety	235
6.24.2	Lead-acid batteries	235
6.24.3	Battery rating	236
6.25	Diagnostics – batteries	237
6.25.1	Servicing batteries	237
6.25.2	Maintenance-free	238
6.25.3	Charging	238
6.25.4	Battery faults	239
6.25.5	Testing batteries	240
6.26	Starting	243
6.26.1	Starter circuit	243
6.26.2	Inertia starters	243
6.26.3	Pre-engaged starters	244
6.26.4	Permanent magnet starters	245
6.26.5	Keyless starting system	247
6.27	Diagnostics – starting	248
6.27.1	Circuit testing procedure	248
6.27.2	Starting fault diagnosis table	248
6.28	Charging	249
6.28.1	Introduction	249
6.28.2	Basic principles	251
6.28.3	Rectification of AC to DC	251
6.28.4	Regulation of output voltage	253
6.28.5	Charging circuits	253
6.29	Diagnostics – charging	256
6.29.1	Testing procedure	256
6.29.2	Charging fault diagnosis table	256
Chapter 7 Chassis systems		257
7.1	Brakes	257
7.1.1	Introduction	257
7.1.2	Principle of hydraulic braking	258

7.1.3	Disc and drum brake systems	259
7.1.4	Brake adjustments	260
7.1.5	Servo-assisted braking	260
7.2	Diagnostics – brakes	261
7.2.1	Systematic testing	261
7.2.2	Test equipment	261
7.2.3	Dial gauge	262
7.2.4	Test results	262
7.2.5	Brakes fault diagnosis table 1	263
7.2.6	Brakes fault diagnosis table 2	263
7.2.7	Brake hydraulic faults	264
7.3	Antilock brakes	264
7.3.1	Introduction	264
7.3.2	General system description	266
7.3.3	ABS components	266
7.4	Diagnostics – antilock brakes	269
7.4.1	Systematic testing procedure	269
7.4.2	Antilock brakes fault diagnosis table	270
7.4.3	Bleeding antilock brakes	271
7.5	Traction control	271
7.5.1	Introduction	271
7.5.2	Control functions	272
7.5.3	System operation	272
7.6	Diagnostics – traction control	272
7.6.1	Systematic testing	272
7.6.2	Traction control fault diagnosis table	274
7.7	Steering and tyres	274
7.7.1	Construction of a tubeless radial tyre	274
7.7.2	Steering box and rack	274
7.7.3	Power-assisted steering	275
7.7.4	Steering characteristics	276
7.7.5	Camber	277
7.7.6	Castor	277
7.7.7	Swivel axis inclination	278
7.7.8	Tracking	279
7.7.9	Scrub radius	279
7.8	Diagnostics – steering and tyres	280
7.8.1	Systematic testing	280
7.8.2	Test equipment	280
7.8.3	Four-wheel alignment	281
7.8.4	Test results	283

7.8.5	Tyres fault diagnosis table	284
7.8.6	Tyre inflation pressures	284
7.8.7	Steering fault diagnosis table 1	285
7.8.8	Steering, wheels and tyres fault diagnosis	285
7.9	Suspension	286
7.9.1	Introduction	286
7.9.2	Suspension system layouts	286
7.9.3	Front axle suspensions	288
7.9.4	Rear axle suspensions	289
7.9.5	Anti-roll bar	289
7.9.6	Springs	290
7.9.7	Dampers	290
7.10	Diagnostics – Suspension	293
7.10.1	Systematic testing	293
7.10.2	Test equipment	293
7.10.3	Test results	293
7.10.4	Suspension fault diagnosis table 1	294
7.10.5	Suspension fault diagnosis table 2	294
7.11	Active Suspension	294
7.11.1	Active suspension operation	294
7.11.2	Delphi MagneRide case study	297
7.12	Diagnostics – active suspension	299
7.12.1	Systematic testing	299
7.12.2	Back to the black box	300

Chapter 8 Electrical systems 301

8.1	Electronic components and circuits	301
8.1.1	Introduction	301
8.1.2	Components	301
8.1.3	Integrated circuits	303
8.1.4	Digital circuits	304
8.1.5	Electronic component testing	305
8.2	Multiplexing	306
8.2.1	Overview	306
8.2.2	Controller area network	307
8.2.3	CAN data signal	310
8.2.4	Local interconnect network	311
8.2.5	FlexRay	312
8.3	Diagnostics – multiplexing	312
8.4	Lighting	316
8.4.1	External lights	316
8.4.2	Lighting circuits	317

8.4.3	Gas discharge lighting	318
8.4.4	LED lighting	319
8.5	Diagnostics – lighting	321
8.5.1	Testing procedure	321
8.5.2	Lighting fault diagnosis table	323
8.5.3	Headlight beam setting	324
8.6	Auxiliaries	325
8.6.1	Wiper motors and linkages	325
8.6.2	Wiper circuits	327
8.6.3	Two-motor wiper system	328
8.6.4	Headlight wipers and washers	328
8.6.5	Indicators and hazard lights	329
8.6.6	Brake lights	329
8.6.7	Electric horns	330
8.6.8	Engine cooling fan motors	331
8.7	Diagnostics – auxiliary	332
8.7.1	Testing procedure	332
8.7.2	Auxiliaries fault diagnosis table	334
8.7.3	Wiper motor and circuit testing	334
8.8	In-car entertainment security and communications	336
8.8.1	In-car entertainment	336
8.8.2	Security systems	338
8.8.3	Mobile communications	339
8.9	Diagnostics – ICE, security and communication	339
8.9.1	Testing procedure	339
8.9.2	ICE, security and communication system fault diagnosis table	341
8.9.3	Interference suppression	342
8.10	Body electrical systems	344
8.10.1	Electric seat adjustment	344
8.10.2	Electric mirrors	345
8.10.3	Electric sunroof operation	345
8.10.4	Door locking circuit	346
8.10.5	Electric window operation	347
8.11	Diagnostics – body electrical	348
8.11.1	Testing procedure	348
8.11.2	Body electrical systems fault diagnosis table	350
8.11.3	Circuit systematic testing	350
8.12	Instrumentation	351
8.12.1	Gauges	351
8.12.2	Digital instrumentation	352
8.12.3	Vehicle condition monitoring	353

8.12.4	Trip computer	355
8.12.5	Displays	355
8.13	Diagnostics – instruments	356
8.13.1	Testing procedure	356
8.13.2	Instrumentation fault diagnosis table	356
8.13.3	Black box technique for instrumentation	356
8.14	Heating, ventilation and air conditioning	359
8.14.1	Ventilation and heating	359
8.14.2	Heating system – watercooled engine	359
8.14.3	Heater blower motors	360
8.14.4	Electronic heating control	360
8.14.5	Air conditioning introduction	361
8.14.6	Air conditioning overview	363
8.14.7	Automatic temperature control	363
8.14.8	Seat heating	364
8.14.9	Screen heating	364
8.15	Diagnostics – HVAC	365
8.15.1	Testing procedure	365
8.15.2	Air conditioning fault diagnosis table	365
8.15.3	Heating and ventilation fault diagnosis table	367
8.15.4	Air conditioning receiver	367
8.16	Cruise control	367
8.16.1	Introduction	367
8.16.2	System description	368
8.16.3	Components	369
8.17	Diagnostics – cruise control	369
8.17.1	Systematic testing	369
8.17.2	Cruise control fault diagnosis table	371
8.18	Airbags and belt tensioners	371
8.18.1	Introduction	371
8.18.2	Components and circuit	372
8.18.3	Seat belt tensioners	374
8.19	Diagnostics – airbags and belt tensioners	375
8.19.1	Systematic testing	375
8.19.2	Airbags and belt tensioners fault diagnosis table	375
8.19.3	Deactivation and activation procedures	375

Chapter 9 Transmission systems 379

9.1	Manual transmission	379
9.1.1	Clutch	379
9.1.2	Manual gearbox	380

9.1.3	Driveshafts and wheel bearings	381
9.1.4	Final drive and differential	384
9.1.5	Four-wheel drive systems	384
9.2	Diagnostics – manual transmission	385
9.2.1	Systematic testing	385
9.2.2	Test equipment	385
9.2.3	Test results	385
9.2.4	Manual transmission fault diagnosis table 1	386
9.2.5	Manual gearbox fault diagnosis table 2	386
9.2.6	Clutch faults diagnosis table	387
9.2.7	Drive shafts fault diagnosis table	387
9.2.8	Final drive fault diagnosis table	387
9.3	Automatic transmission	388
9.3.1	Introduction	388
9.3.2	Torque converter operation	388
9.3.3	Epicyclic gearbox operation	389
9.3.4	Constantly variable transmission	390
9.3.5	Electronic control of transmission	391
9.3.6	Direct shift gearbox	393
9.4	Diagnostics – automatic transmission	395
9.4.1	Systematic testing	395
9.4.2	Test equipment	395
9.4.3	Test results	395
9.4.4	Automatic gearbox fault diagnosis table 1	396
9.4.5	Automatic gearbox fault diagnosis table 2	397
9.4.6	ECAT fault diagnosis table	397
9.4.7	Automatic transmission stall test	397
Chapter 10	Learning activities	399
10.1	Introduction	399
10.2	Knowledge check questions	399
10.2.1	Chapter 1 Introduction	399
10.2.2	Chapter 2 Diagnostic techniques	400
10.2.3	Chapter 3 Tools and equipment	400
10.2.4	Chapter 4 Sensors, actuators and oscilloscope diagnostics	400
10.2.5	Chapter 5 On-board diagnostics	400
10.2.6	Chapter 6 Engine systems	401
10.2.7	Chapter 7 Chassis systems	401
10.2.8	Chapter 8 Electrical systems	401
10.2.9	Chapter 9 Transmission systems	401

10.3 Assignments	402
10.4 Tips to help you learn	403
10.5 Practical work	404
10.6 Case studies	404
10.6.1 Introduction	404
10.6.2 1997 Land Rover Discover	405
10.6.3 1999 Audi A4 Quattro	406
10.6.4 2002 Ford Ranger	407
10.6.5 2005 Volkswagen Jetta	407
10.6.6 2004 Honda Accord	408
10.6.7 Summary	409
10.7 Software	409
10.8 Summary	409
Glossary of abbreviations and acronyms	411
Index	423

Preface



One of the things that I most enjoy about automotive work is being able to diagnose problems that others cannot. This skill takes a few years to develop, but it is really all about two things: knowledge of the vehicle system and an understanding of the importance of a logical diagnostic process. In this book, I have therefore included some basic technologies (as a reminder) and then examined appropriate diagnostic techniques.

This book is the third in the “Automotive Technology: Vehicle Maintenance and Repair” series:

- Automobile Mechanical and Electrical Systems
- Automobile Electrical and Electronic Systems
- Automobile Advanced Fault Diagnosis

Ideally, you will have studied the mechanical and electrical book, or have some experience, before starting on this one. This is the first book of its type to be published in full colour and concentrates on diagnostic principles. It will cover everything you need to advance your studies to a higher level, no matter what qualification (if any) you are working towards.

I hope you find the content useful and informative. Comments, suggestions and feedback are always welcome at my website: www.automotive-technology.co.uk. You will also find links to lots of free online resources to help with your studies.

The final chapter of this book contains lots of learning activities, questions, diagnostic case studies and more. You can look at this at any time or wait until you have studied the rest of the book.

Good luck and I hope you find automotive technology as interesting as I still do.

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If I have used any information, or mentioned a company name that is not listed here, please accept my apologies and let me know so it can be rectified as soon as possible.



1.1 Diagnosis

1.1.1 Introduction

What is needed to find faults?

Finding the problem when complex automotive systems go wrong is easy if you have the necessary knowledge. This knowledge consists of two parts:

- understanding of the system in which the problem exists;
- the ability to apply a logical diagnostic routine.

It is also important to be clear about these definitions:

- symptom(s) – what the user/operator/repairer of the system (vehicle or whatever) notices;
- fault(s) – the error(s) in the system that result in the symptom(s);
- root cause(s) – the cause(s) of the fault.

If a system is not operating to its optimum, then it should be repaired. This is where diagnostic and other skills come into play. It is necessary to recognise that something is not operating correctly by applying your knowledge of the system, and then by applying this knowledge further, and combining it with the skills of diagnostics, to be able to find out the reason.

The four main chapters of this book ('Engine systems', 'Chassis systems', 'Electrical systems' and 'Transmission systems') include a basic explanation of the vehicle systems followed by diagnostic techniques that are particularly appropriate for that area. Examples of faultfinding charts are also included. In the main text, references will be made to generic systems rather than to specific vehicles or marques. For specific details about a particular vehicle or system, the manufacturer's information is the main source.

Other chapters such as 'Sensors, actuators and oscilloscope diagnostics' and 'On-board diagnostics' are separated from the four previously mentioned chapters, because many operations are the same. For example, testing an inductive sensor is similar whether it is used on ABS or engine management.

An important note about diagnostics is that the general principles and techniques can be applied to any system, physical or otherwise. As far as passenger-carrying heavy or light vehicles are concerned, this is definitely the case. As discussed earlier, there is a need for knowledge of the particular system, but diagnostic skills are transferable (Figure 1.1).



Definition

Diagnosis: The word 'diagnosis' comes from the ancient Greek word *διάγνωσις*, which means discernment. It is the identification of the nature and cause of anything. Diagnosis is used in many different disciplines, but all use logic, analysis and experience to determine cause and effect relationships. In automotive engineering, diagnosis is typically used to determine the causes of symptoms and solutions to issues.



Key fact

General diagnostic principles and techniques can be applied to any system, physical or otherwise.



Figure 1.1 Diagnostics in action

1.2 Safe working practices

Safe working practices in relation to diagnostic procedures and indeed any work on a vehicle are essential – for your safety as well as that of others. You only have to follow two rules to be safe:

Use your common sense – do not fool about.

If in doubt – seek help.

Further, always wear appropriate personal protective equipment (PPE) when working on vehicles.

The following section lists some particular risks when working with vehicle systems, together with suggestions for reducing them. This is known as risk assessment.

Safety first



Always wear appropriate personal protective equipment (PPE) when working on vehicles.

1.2.1 Risk assessment and reduction

[Table 1.1](#) lists some identified risks involved with working on vehicles. The table is by no means exhaustive but serves as a good guide.

1.3 Terminology

1.3.1 Introduction

The terminology included in [Tables 1.2](#) and [1.3](#) is provided to ensure we are talking the same language. These tables are provided as a simple reference source.

Table 1.1 Identifying and reducing risk

Identify the risk	Reducing the risk
Battery acid	Sulphuric acid is corrosive, so always use good PPE – in this case overalls and if necessary rubber gloves. A rubber apron is ideal as are goggles if working with batteries a lot, particularly older types
Electric shock	Ignition HT is the most likely place to suffer a shock – up to 25kV is quite normal. Use insulated tools if it is necessary to work on HT circuits with the engine running. Note that high voltages are also present on circuits containing windings due to back emf as they are switched off – a few hundred volts is common. Mains supplied power tools and their leads should be in good condition, and using an earth leakage trip is highly recommended
Exhaust gases	Suitable extraction must be used if the engine is running indoors. Remember it is not just the CO that might make you ill or even kill you, other exhaust components could also cause asthma or even cancer
Fire	Do not smoke when working on a vehicle. Fuel leaks must be attended to immediately. Remember the triangle of fire – (heat/fuel/oxygen) – do not let the three sides come together
Moving loads	Only lift what is comfortable for you; ask for help if necessary or use lifting equipment. As a general guide, do not lift on your own if it feels too heavy
Raising or lifting vehicles	Apply brakes and/or chock the wheels when raising a vehicle on a jack or drive on lift. Only jack under substantial chassis and suspension structures. Use axle stands in case the jack fails
Running engines	Do not wear loose clothing – good overalls are ideal. Keep the keys in your possession when working on an engine to prevent others starting it. Take extra care if working near running drive belts
Short circuits	Use a jump lead with an in-line fuse to prevent damage due to a short when testing. Disconnect the battery (earth lead off first and back on last) if any danger of a short exists. A high current can flow from a vehicle battery – it will burn you as well as the vehicle
Skin problems	Use a good barrier cream and/or latex gloves on skin and clothes regularly

1.3.2 Diagnostic terminology

Table 1.2 Diagnostic terminology

Symptom	The effect of a fault noticed by the driver or technician
Fault	The cause of a symptom/problem
Root cause	This may be the same as the fault, but in some cases it can be the cause of it
Diagnostics	The process of tracing a fault by means of its symptoms, applying knowledge and analysing test results
Knowledge	The understanding of a system that is required to diagnose faults
Logical procedure	A step-by-step method used to ensure nothing is missed
Concern, cause, correction	A reminder of the process starting from what the driver reports, to the correction of the problem
Report	A standard format for the presentation of results

1.3.3 General terminology

Table 1.3 General terminology

System	A collection of components that carry out a function
Efficiency	This is a simple measure of any system. It can be defined as, for example, if the power out of a system is less than the power put in, its percentage efficiency can be determined ($P\text{-out}/P\text{-in} \times 100\%$). This could, for example, be given as say 80%. In a less scientific example, a vehicle using more fuel than normal is said to be inefficient
Noise	Emanations of a sound from a system that is either simply unwanted or is not the normal sound that should be produced
Active	Any system that is in operation all the time (steering for example)
Passive	A system that waits for an event before it is activated (an air bag is a good example)
Short circuit	An electrical conductor is touching something that it should not be touching (usually another conductor of the chassis)
Open circuit	A circuit that is broken (a switched off switch is an open circuit)
High resistance	In relation to electricity this is part of a circuit that has become more difficult for the electricity to get through. In a mechanical system, a partially blocked pipe would have a resistance to the flow of fluid
Worn	This word works better with further additions such as worn to excess, worn out of tolerance or even, worn, but still within tolerance
Quote	To make an estimate of or give exact information on the price of a particular service. A quotation may often be considered to be legally binding
Estimate	A statement of the expected cost of a certain job (e.g. vehicle repairs). An estimate is normally a best guess and is not legally binding
Bad	Not good – and also not descriptive enough really
Dodgy, knackered or @#%&*.	Words often used to describe a system or component, but they mean nothing. Get used to describing things so that misunderstandings are eliminated

1.4 Report writing

1.4.1 Introduction

As technicians you may be called on to produce a report for a customer. If you are involved in research of some kind, it is important to be able to present results in a professional way. The following sections describe the main headings that a report will often need to contain together with an example report based on the performance testing of a vehicle alternator.

Laying out results in a standard format is the best way to ensure all the important and required aspects of the test have been covered. Keep in mind that the report should convey clearly to another person what has been done. Further, a 'qualified' person should be able to extract enough information to be able to repeat the test – and check your findings. Use clear simple language remembering that in some cases the intended audience may not be as technically competent as you are.

Key fact

Setting out results of any test in a standard format is the best way to ensure all the important and required aspects of the test have been covered.

1.4.2 Main headings of a report

The following suggestions for the headings of a professional report will cover most requirements but can, of course, be added to or subtracted from if necessary. After each heading, I have included brief notes on what should be included.

Contents

If the report is more than about five pages, a list of contents with page numbers will help the reader find his or her way through it.

Introduction

Explain the purpose of what has been done and set the general scene.

Test criteria

Define the limits within which the test was carried out. For example, temperature range or speed settings.

Facilities/Resources

State or describe what equipment was used. For example: 'A "Revitup" engine dynamometer, model number C3PO was used for the consumption test'.

Test procedures

Explain here exactly what was done to gain the results. In this part of the report, it is very important not to leave out any details.

Measured results

Present the results in a way that is easy to interpret. A simple table of figures may be appropriate. If the trend of the results or a comparison is important, a graph may be better. Pictures of results or oscilloscope waveforms may be needed. If necessary a very complex table of results from which you draw out a few key figures could be presented as an appendix. You should also note the accuracy of any figures presented ($\pm 0.5\%$ for example).

Analysis of results

This is the part where you should make comment on the results obtained. For example, if, say, a fuel consumption test was carried out on two vehicles, a graph comparing one result to the other may be appropriate. Comments should be added if necessary, such as any anomaly that could have affected the results (change of wind direction for example).

Conclusions/Comments/Observations

Note here any further tests that may be necessary. Conclude that device X does perform better than device Y – if it did. If appropriate, add observations such as how device Y performed better under the set conditions, but under other circumstances the results could have been different. Comment on the method used if necessary.

Forecast

If necessary comment on how the 'item' tested will continue to perform based on the existing data.

Appendices

Detailed pages of results that would 'clog up' the main report or background material such as leaflets relating to the test equipment.



Key fact

Present test results in a way that is easy to interpret.

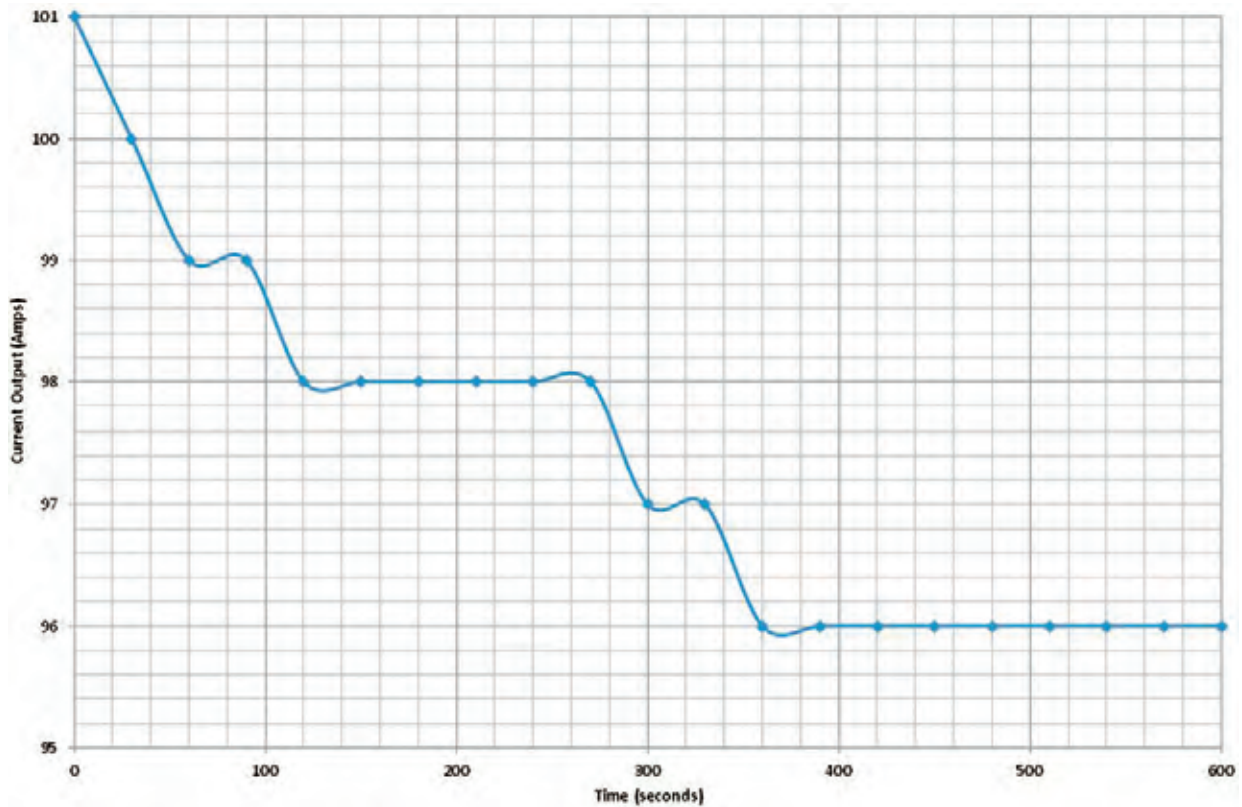


Figure 1.2 Alternator output current over time

Conclusions

The manufacturer's claims were validated. The device exceeded the rated output by 6% at the start of the test and under continuous operation at full load, continued to exceed the rated output by 1%.

The overall duration of this test was 40 minutes, it is possible, however, that the device would increase in temperature and the output may fall further after prolonged operation. Further tests are necessary to check this, for example, under more realistic vehicle operating conditions.

Overall the device performed in excess of its rated output in this test.

(Always sign and date the report)

Tom Denton, March 2012

