Advanced Automotive Fault Diagnosis

Third Edition

Tom Denton

Automotive Technology: Vehicle Maintenance and Repair

ROUTLEDGE

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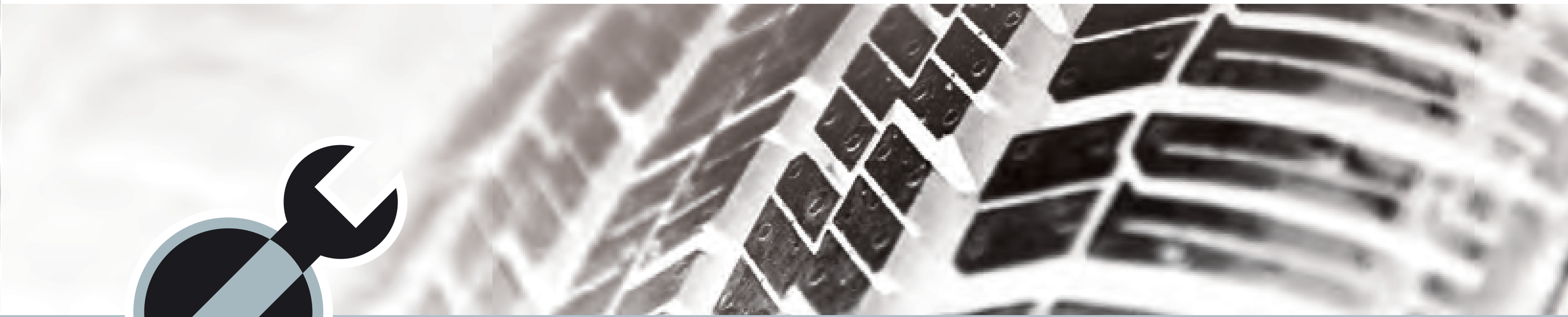

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Contents

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 f rst 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 qualif cation (if any) you are working towards.

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

The f nal 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 f nd automotive technology as interesting as I still do.

Acknowledgements

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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 rectif ed as soon as possible.

CHAPTER

Introduction

1.1 Diagnosis

1.1.1 Introduction

What is needed to f nd 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 def nitions:

- 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 f nd 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 faultf nding charts are also included. In the main text, references will be made to generic systems rather than to specif c vehicles or marques. For specif c 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 def nitely the case. As discussed earlier, there is a need for knowledge of the particular system, but diagnostic skills are transferable (Figure 1.1).

Def nition

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 f rst

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

1.2.1 Risk assessment and reduction

Table 1.1 lists some identif ed 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

Identified 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 25 000 V 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 C 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 and/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 jac 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. Disconnec the battery (earth lead off first and back on last) if any danger of a short exists. A very 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. Wash skin and clothes regularly

1.3.2 Diagnostic terminology

Table 1.2 Diagnostic terminology

Symptom	The effect of a fault noticed by the driver, user 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
Eff ciency	This is a simple measure of any system. It can be scientific, for example, if the power out of a system is less than the power put in, its percentage efficiency can be determined (P-out/P-in × 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 part or service. A quotation may often be considered to be legally binding
Estimate	A statement of the expected cost of a certain job (e.g. service or 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 'qualif ed' person should be able to extract enough information to be able to repeat the test – and check your f ndings. 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 f ve pages, a list of contents with page numbers will help the reader f nd his or her way through it.

Introduction

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

Test criteria

Def ne 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 f gures 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 f gures could be presented as an appendix. You should also note the accuracy of any f gures presented ($\pm$0.5% for example).

Key fact

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

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 leaf ets relating to the test equipment.

1.4.3 Example report

An example report is presented here relating to a simple alternator test where its actual output is to be compared to the rated output. Minimal details are included so as just to illustrate the main points.

Introduction

A 'Rotato' 12 V alternator was tested under different temperature conditions to check its maximum output. The manufacturer's specif cations stated that the alternator, when hot, should produce 95 A at 6000 rpm.

Test criteria

Start at room temperature.

Run alternator at 3000 rpm, 30 A output for 10 minutes.

Run alternator at 6000 rpm, maximum output. Check reading every 30 seconds for 10 minutes.

Run alternator at 6000 rpm, maximum output for a further 20 minutes to ensure output reading is stable.

Facilities/Resources

A 'Krypton' test bench model R2D2 was used to drive the alternator. The test bench revcounter was used and a 'Flake' digital meter f tted with a 200 A shunt was used to measure the output. A variable resistance load was employed.

Test procedures

The alternator was run for 10 minutes at 3000 rpm and the load adjusted to cause an output of 30 A. This was to ensure it was at a nominal operating temperature. The normal fan was kept in place during the test.

Speed was then increased to 6000 rpm and the load adjusted to achieve the maximum possible output. The load was further adjusted as required to keep the maximum possible output in case the load resistance changed due to temperature. Measurements were taken every 30 seconds for a period of 10 minutes.

Measured results

Speed held constant at 6000 (±200) rpm

Room temperature (18 °C)

See Table 1.4.

To ensure the alternator output had stabilised it was kept running for a further 20 minutes at full output. It continued to hold at 96 A.

Analysis of results

Figure 1.2 shows the results in graphical format.

Table 1.4 Results

Time (±1 s)	0	30	60	90	120	150	180	210	240	270	300	330	360	390	420	450	480	510	540	570	600
Output (±0.2 A)	101	100	99	99	98	98	98	98	98	98	97	97	96	96	96	96	96	96	96	96	96

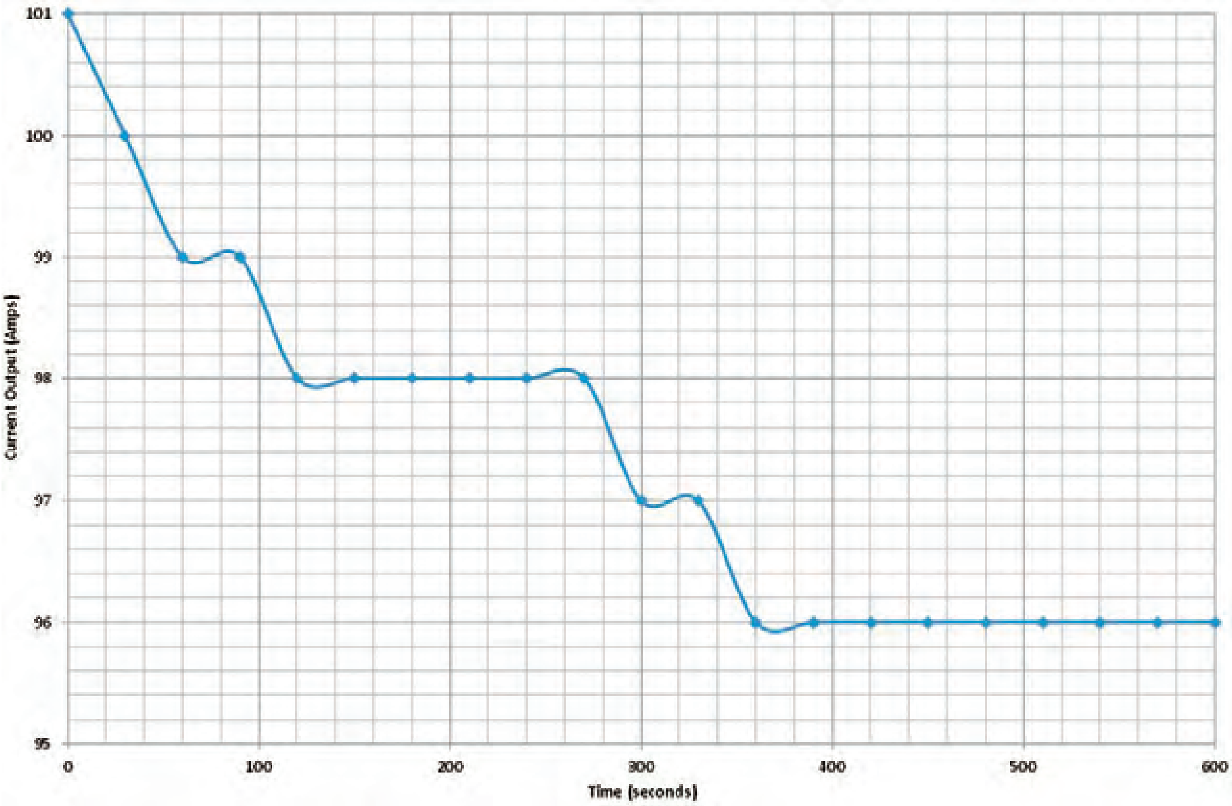

Figure 1.2 Alternator output current over time

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