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OR

Approval tests for diesel engines of motive power units

Essai d'homologation des moteurs diesel d'engins moteurs
Zulassungsprüfung für Dieselmotoren der Triebfahrzeuge

UNION INTERNATIONALE DES CHEMINS DE FER
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The person responsible for this leaflet is named in the UIC Code

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Summary

This leaflet defines the procedure and conditions applicable to the approval testing of diesel engines for tractive units.

On completion of the test procedure, the engine shall be released by the UIC for use in railway tractive units without restrictions to the area of application. It shall be guaranteed, in particular, that the engine meets current exhaust requirements.

1 - Field of application

1.1 - The purpose of these international regulations is to define type approval tests for new types of diesel engines intended for installation in railway motive power units.

1.2 - These regulations apply to diesel traction engines for installation in railway vehicles with the exception of engines intended for special locomotives (e.g. refinery or mine locomotives) as well as traction engines with an effective output of less than 100 kW.

1.3 - These regulations may be applied by the railways for their own use if they wish to obtain a comprehensive guarantee of service reliability for any particular type of diesel traction engine.

2 - Definitions

2.1 - Choice of units

All units used in these international regulations must comply with the SI International System in accordance with *UIC Leaflet 800-00* (see Bibliography - page 48).

2.2 - Auxiliaries

The definitions of the dependent/independent, essential/non-essential auxiliaries comply with those in *ISO Standard 3046-1* (see Bibliography - page 48).

However, the input power of engine cooling fans is an exception to *ISO Standard 3046-1* since the power absorbed by these fans (depends on the structure of this equipment on the vehicle), hence they will be considered in railway applications to be essential independent auxiliaries, whether they are driven directly or indirectly by the diesel engine.

2.3 - Kinds of power output

Effective power output: power available at the drive shaft minus the power required for the essential dependent auxiliaries, if they are driven directly or indirectly by the engine.

UIC nominal power output (referred to as "nominal output" in the text): according to *ISO Standard 3046-1*, the UIC nominal power output is equal to:

- the **ISO standard power output** if the essential dependent auxiliaries are driven directly or indirectly by the engine;

- the **ISO continuous brake power** minus the power absorbed by the essential dependent auxiliaries if they are driven by an outside power source. In this case, the power used by each of these auxiliaries and measured in performance test conditions should be noted separately.

The cooling fans of water cooled engines are considered, according to point 2.2, as essential independent auxiliaries.

2.4 - Speed

The engine speed associated with the UIC nominal power output is the nominal speed.

3 - Presentation file from the manufacturer

3.1 - General

The attributes to be tested during the approval procedure of the engine submitted shall be specified in:

- a dimensional installation drawing,
- a technical data table,
- characteristic curves.

The numbering of the cylinders and the direction of rotation of the diesel engine shall conform with *international standard ISO 1204* (see Bibliography - page 48).

The engine shall be provided with a metal plate indicating the name and identification letters of the manufacturer, the engine type, the production number, and year of manufacture.

3.2 - Dimensional installation drawing

The dimensional installation drawing shall indicate the contour of the engine including the direct drive auxiliary machines. It shall also include the centre of gravity of the dry engine together with the length, width and height dimensions measured :

- overall and,
- with reference to the centre line of the crankshaft.

3.3 - Table of technical engine data

The table of technical engine data shall contain the following information, quoting tolerances where applicable:

1. Engine type.
2. Manufacturer.
3. UIC nominal output.
4. Nominal engine speed.
5. Normal idling speed.
6. Mode of operation: 2 or 4 strokes.
7. Characteristics of supercharging:
   - Method of supercharging.
   - Designation of type of turbo-compressor(s): with or without intercooling turbo-charger(s).
   - Method of cooling the supercharging air (water with or without pressure, air).

8. Injection characteristics:
   - Injection method (direct, pre-chamber or similar).
   - Type of injection pump.
   - Type and nature of injector.
   - Orifice pressure of injector.
9. Number, arrangement and angle of cylinders.
10. Cylinder bore.
11. Piston stroke.
12. Total piston displacement.
13. Compression ratio.
14. Firing order.
15. Timing diagram (to be appended to engine file).
16. Mean piston velocity at nominal speed.
17. Mean effective pressure at nominal output.
18. Maximum combustion pressure at nominal output.
19. Start of injection pump delivery at nominal output:
   - static (angle before upper dead centre),
   - dynamic (angle before upper dead centre).
20. Minimum idling speed
21. Maximum idling speed
22. Maximum permitted speed.
23. Speed ranges not permitted to be continuously operated in service.
24. Cylinder cooling method:
   - water, with or without pressure,
   - air.
25. Piston cooling method.
26. Temperature of the high temperature cooling water at engine outlet:
   - normal,
   - maximum permitted.
27. Temperature of the low temperature cooling water at the cooling air intake (if circuit exists):
   - normal,
   - maximum permitted.

28. Characteristic curves of the water pump(s) showing flow against overall pressure drop in the form of curves at constant speed and in particular for the nominal and minimum speed used.

29. Relationship between diesel engine speed and speed of the water pump.

30. Prescribed oil:

- Classification of viscosity (for example: SAE, ISO,...).
- Performance level (for example: API, CCMC, ...).

31. Lowest possible starting temperature with oil defined above (without additional aid).

32. Starting (peak) torque at this temperature.

33. Minimum ignition speed at this temperature.

34. Torque overcome at ignition speed at this temperature.

35. Temperature of lubricating oil at the engine outlet:

- normal,
- maximum permitted.

36. Lubrication oil consumption:

- at nominal output (kg/h),
- at idling speed (kg/h),
- oil change interval in normal service.

The measurements shall be carried out after the engine has run for 80 - 100 h.

37. Total delivery of the lubricating oil pump(s) at nominal speed.

38. Maximum oil volume effectively circulating in the engine.

39. Lubricating oil pressure at nominal speed at the engine intake after the regulator valve at normal working temperature.

40. Lubricating oil pressure at minimum operating speed at the engine intake after the regulator valve at normal working temperature.

41. Maximum permitted air intake pressure reduction.

42. Maximum permitted exhaust gas back-pressure.

43. Intake air volume (kg/s) at nominal output in the atmospheric reference conditions (according to point 4.2 - page 10).

44. Supercharging relative pressure at nominal output.

45. Supercharging rpm at nominal output:

- normal,
- maximum permitted.

46.1 Supercharged air temperature before and after charging air cooler (wherever present) at nominal output:

- normal,
- maximum permitted.

46.2 Air temperature at the cylinder head intake at nominal output:

- normal, (= T_{SCRef} in accordance with *ISO8178-1*)
- maximum permitted.

47. Exhaust gas temperature at nominal output, measured:

- at the cylinder head outlets:
  - normal,
  - maximum permitted;
- at the inlet to the turbine(s):
  - normal,
  - maximum permitted;
- at the outlet of the turbine(s):
  - normal,
  - maximum permitted.

48. The thermal balance of engine at nominal output (see Appendix D - page 29):

- Heat from fuel.
- Heat dissipated in:
  - high-temperature cooling water,
  - in low-temperature cooling water,
  - in cooling air,
  - fuel for cooling system,
  - lubricating oil,
  - exhaust gas and radiated heat.

49. Mass:

- of engine (with auxiliary equipment installed as per installation drawing), not including water and lubricating oil,
- of water contained in the engine,
- of oil contained in the engine.

3.4 - Characteristic curves of the diesel engine

The following characteristic curves are established under the prescribed conditions for the rig test as a function of the engine speed from the nominal speed to the minimum working speed. The specific fuel consumption will be corrected in a linear position in relation to the fuel with a minimum calorific reference value of 42 000 kJ/kg.

3.4.1 - Curves of torque, power and specific fuel consumption in g/kWh, as a function of engine speed indicating the tolerances for various injection pump settings, viz.:

- setting at which the engine develops the nominal output when running at nominal speed;
- setting at which the engine develops 3/4 of the nominal output when running at nominal speed;
- setting at which the engine develops 1/2 of the nominal output when running at nominal speed;
- setting at which the engine develops 1/4 of the nominal output when running at nominal speed.

3.4.2 - Constant specific fuel consumption curves of the engine.

3.4.3 - Torque curve which, based on the point corresponding to the nominal output at nominal speed, specifies the maximum torque for all rpm.

3.4.4 - Fuel consumption curve when idling from the minimum idling speed to the maximum speed and expressed in kg/h.

3.5 - The engine environment

3.5.1 - Exhaust gas emission

(see Appendix A - page 21).

The CO, NO_x and CH emissions are determined in the conditions of *ISO 8178* (see Bibliography - page 48). The following characteristic diagrams are to be drawn up for these emissions:

- the absolute emission in kg/h as a function of power and speed;
- the specific emission in g/kWh as a function of effective mean pressure and speed.

The characteristic diagrams of the NO_x emissions are contained in point A.3 - page 23 as an example.

The gaseous pollutants together with the particle emissions are assessed according to *ISO 8178-4, Cycle F*. In addition, exhaust opacity is determined using the respective measuring point (see point A.1 - page 21) until 31.12.2002.

From 1 January 2003, the measurement of the particulate's emission is compulsory.

3.5.2 - Noise emission

The manufacturer should furnish:

- the level of acoustic output per octave band and/or weighted (dBA);
- a reference to the standard specifying the method of determination.

4 - Approval test

4.1 - General

The general conditions for the type approval test are set out in *UIC Leaflet 623-1* (see Bibliography - page 48).

The test rig, on which the type approval test is carried out, must at least be equipped with the measuring instruments listed in the diagram of point B.1 - page 24. Point B.2 - page 25 contains an example of information to be provided in the report.

The measurement instruments should be regularly calibrated by a certification body which is recognized by the managing RU. It is recommended that the *ISO 9000 standards* be used. Their measuring accuracy must correspond to *ISO Standard 3046-3* (see Bibliography - page 48).

If the engine requires running-in, this must be carried out before presenting the engine for the test.

The engine shall be coupled to a brake, which will make it possible to carry out the programmes of the different test cycles and it is desirable that provision be made for a suitable automatic regulating system to perform these programmes insofar as torque and speed variations are concerned.

The accuracy of the torque measurements (if a brake type with direct reading of the torque is used) or power measurements (if a wattmeter with calibrated generator is used) shall be ± 2% of the full torque value.

4.2 - Rig test conditions

4.2.1 - Atmospheric conditions

The atmospheric conditions, barometric pressure, ambient temperature and relative air humidity shall be measured at a distance from the air intake of the engine where the flow is laminar and the temperature homogeneous.

The following atmospheric reference conditions shall apply:

- overall atmospheric pressure: 100 kPa,
- ambient temperature: 25°C,
- relative air humidity: 30%.

The test shall be performed with a power corresponding to the corrected nominal output in accordance with *ISO 3046-1*.

4.2.2 - Fuel

Determination of the pollutant diagrams as well as the control of the exhaust emissions against *ISO 8178-4, Cycle F* shall be performed with a reference fuel: *ISO 8178-5*.

The performance and the endurance test may be performed with commercial fuel. It has to be selected by the manufacturer from a list of commercial fuels prepared by the managing railway.

The fuel temperature on entry into the engine must be 20°C or above.

4.2.3 - Lubricating oil

No oil change is permitted during the endurance test. At most, an oil change is allowed between the performance test and the endurance test.

The lubricating oil shall be used in a closed circuit as in normal operation. No additional pump is permitted.

The approval test shall be performed with a lubricating oil to be selected by the manufacturer from a list of commercial grade oils prepared by the managing railway. This is to ensure that the test will be performed using an oil currently used by one of the railways. A request for a departure from this should be duly justified and discussed during the preparatory meeting. The choice of oil shall be recorded in the minutes of the preparatory meeting.

The lubricating oil temperature shall be maintained at the normal value contained in the table of technical engine data, but it must not be lower than + 65°C at the engine outlet.

The pressures shall be measured:

- behind the regulator valve of the lubricating oil pump,

- at the farthest accessible point from the pump.

4.2.4 - Cooling circuit

The normal operating temperature is equivalent to the temperature of the high temperature cooling water at the normal outlet. It should be equal to the normal value given in the table of technical engine data with a tolerance of ± 3°C. If a temperature range is specified for the normal value, the highest value should be taken.

4.2.5 - Air intake

The pressure loss at the inlet should be greater than or equal to 80% of that specified in the table of technical engine data.

The air temperature at the cylinder head inlet should be equal to the maximum permitted value specified in the table of technical engine data with a tolerance between of 0°C to -5°C

4.2.6 - Supercharging

The air pressure for supercharging at the cylinder head outlet should be equal to the normal value specified in the table of technical engine data with a tolerance of ± 5%.

4.2.7 - Exhaust circuit

The temperature of the exhaust gas at the cylinder head outlet should be equal to the normal value specified in the table of technical engine data with a tolerance of $^{+\ 80}_{-\ 0}$ °C.

The back-pressure at each turbine outlet should be greater than or equal to 80% of that specified in the table of technical engine data.

4.2.8 - Diesel engines with electronic engine control

The functions and the regulating characteristics of the electronic engine control system shall be identical within the nominal rating of the engine to those demonstrated by the standard control device used on the engine for which approval is requested. Type or list numbers can be used to document this for software and hardware.

In order to prevent software parameter modifications during the test run, the principal influencing variables shall be recorded and documented during the measurements (in accordance with Appendix C - page 26). For Common Rail Systems, this could be the start and duration of injector energisation. The respective parameters to be considered shall be established in the preparatory meeting.

4.2.9 - Notations

If an engine is not supercharged, the back-pressure at the exhaust immediately after leaving the engine shall be measured and recorded in the test report.

So as to avoid the need for the continuous presence of an inspector with the engine during the test, suitable calibrated and inviolable recording equipment shall be installed. which will make it possible to check whether the prescribed programme has been fully implemented and that the normal test conditions were maintained. All the measured results in column of Appendix C should be accessible at all times (except oil comsumption).

All information required to prepare the test report shall be kept in detail in a register.

This register shall indicate in particular:

- date and time,
- the operating times,
- the overall oil consumption,
- incidental stopping periods, interruptions for maintenance,
- maintenance operations and conditions found,
- irregularities and damage as well as the resulting disassembly and assessments.

4.2.10 - Removal of samples

The test engineer from the managing RU takes a one-litre sample of fuel. This is sealed and marked with the engine number, the date and the test engineer's name. The fuel tank is then sealed.

A one-litre sample of lubricating oil is also taken, following the same procedure.

The laboratory or laboratories entrusted with the analyses should be designated at the preparatory meeting.

4.3 - Performance testing

The test should be performed on a warm engine.

4.3.1 - Test cycles

The performance test consists of a continuous run of 100 hours carried out in the following order:

- 80 hours at nominal input,
- 1 hour under overload,
- 10 hours with partial power,
- 8 hours under alternating load,
- 1 hour at nominal input.

4.3.2 - Specific test cycles

4.3.2.1 - Overload test

The overload tests shall be carried out:

- for the first 45 minutes at nominal speed and with a torque corresponding to 110% of the torque at the nominal output;
- for the last 15 minutes with a torque corresponding to the nominal output and a speed of 110% of the nominal speed.

4.3.2.2 - Tests under partial load

The tests under partial load shall run with decreasing power.

The test shall consist of five equal periods of two hours at speeds between the nominal speed and the lowest operating speed with the maximum torque shown by the characteristic torque curve for each of the five speeds.

4.3.2.3 - Tests under alternating load

The tests under alternating load shall be carried out in an uninterrupted sequence alternating between 6 minutes of running at the nominal output and 4 minutes at lowest idling speed. These periods should include a maximum of 15 seconds for acceleration to nominal output and 15 seconds for deceleration.

4.4 - Endurance test

The endurance test is carried out immediately after the performance test. The endurance test shall be carried out with the engine used for the performance test.

Requests for exceptions shall be made with reasons to the managing RU.

The test consists of 15 periods of 24 hours each, arranged in five sections from I to V (see Appendices E - page 30 and F - page 31), characterised by suitable combinations of torque, rotational speed and cooling water temperatures.

In the table of Appendix E Section V, % of torque at any given speed indicates the percentage of maximum torque corresponding to the nominal output.

If certain torque values lie beyond the limiting curve permitted by the manufacturer, they must be reduced to values conforming with this curve.

To facilitate the preparation of the different test cycles the manufacturer should in advance determine and number those points on the torque/speed and power/speed curves which correspond to all planned working conditions. The numbering shall be transferred to the corresponding lines in the test cycle diagrams.

In some of these cycles the temperature of the cooling water shall be varied. The temperature gradients to be observed are indicated in the respective tables, in which the steady state temperature is that reached without action from the cooling unit.

The minimum speed of the engine indicated in the cycles of Figures 3 - page 31 to 19 - page 47 of Appendix F lies between 40 - 45% of the nominal speed and can be reduced to the normal idle speed of the engine.

Section I (5 periods - 120 hours)

Consists of two-hour cycles designated A, A', B, C, which are defined in Figures 3 to 6 - page 34 of Appendix F and combined for each 24 hour period.

Section II (5 periods - 120 hours)

Consists of two-hour cycles designated D, E, F, G, H, I, L, M, N, which are defined in Figures 7 - page 35 to 15 - page 43 of Appendix F and are combined for each 24 hour period.

Section III (3 periods - 72 hours)

In this section each period is divided into 2 half-periods of 12 hours each; altogether there are six half-periods designated K1, K2, K3, K4, K5, K6.

Each half-period consists of two-hour cycles L, M, N (Figures 13 - page 41 to 15 of Appendix F) as planned for section II.

Each half-period is also characterised by the operating conditions of the engine indicated in Appendix E - page 30.

The reduction of the water pump delivery is obtained by an easily accessible valve arranged at the engine outlet.

The temperature, pressure and delivery values indicated for half-periods K1 to K6 relate to the nominal output of the engine.

Section IV (1 period - 24 hours)

Consists of four cycles (O, P, Q, R) of 6 hours each as defined in Figures 16 - page 44 to 19 - page 47 of Appendix F.

Section V (1 period - 24 hours)

With 10 % overload obtained during the first 23 hours by increasing the torque only and in the last hour by increasing the speed only.

In this test, the water temperature at the outlet of the engine shall be equal to or higher than the normal operating temperature.

4.5 - Measurements

During the performance and endurance tests, periodic measurements are to be carried out for the purpose of establishing a complete test report.

The types of recording and their frequency are given in the table in Appendix C - page 26.

5 - Interruptions during the test

If force majeure is the reason for an interruption, that interruption is not counted and no measures are authorised.

Interruptions resulting from the normal running of the tests are not counted.

5.1 - Periods

The interruptions listed below are tolerated for each of the following periods:

- performance test (100 hours),
- section I of the endurance test (120 hours),
- section II of the endurance test (120 hours),
- sections III, IV, V of the endurance test (120 hours).

5.2 - Tolerated interruptions

The following interruptions are tolerated:

- two interruptions caused by irregularities of the engine or one of its dependent auxiliaries but neither may exceed 30 minutes between the point at which remedial action is initiated and restarting the engine. Only if staff safety so requires is it permitted to defer such remedial action (cooling of diesel engine for example);
- three interruptions from causes other than the diesel engine itself or one of its dependent auxiliaries (test rig for example). In this case the test engineers shall determine whether the test shall start anew or be extended by a length of time at least equal to the stopping time.

If the manufacturer makes use of an interruption not caused by the engine or one of its dependent auxiliaries to rectify irregularities and this action does not exceed 30 minutes, this is counted as two interruptions.

The duration of the test should be extended to cover the total stoppage time including the time it takes to restart the engine and return to the operating conditions prior to the stoppage.

5.3 - Role of the engineers

Particularly during the endurance test periods, any interruption, regardless of its cause, occurring in the absence of the test engineer should be reported to the test engineer as rapidly as possible. The test engineer should decide whether remedial action by the staff needs to be taken in his presence.

All interruptions should be recorded in a report produced by the participating test engineer. This report should be appended to the final report.

6 - Assessment

6.1 - Measurements on completion of the test

At the end of the test, the engine shall be dismantled to permit the assessment of the conditions and dimensions of the following individual components:

- frame and oil sump,
- cylinder heads and gaskets,
- cylinder liners* and packing,
- pistons*,
- piston rings,
- gudgeon pins,
- bolts,
- conrods,
- big end bearings,
- small end bearings,
- crankshaft,
- crankshaft bearings,
- valves*,
- valve stem guides*,
- camshaft(s),
- cam follower and tappet rollers,
- tappet push rods,
- rocker arms,
- rocker arm shaft,
- injectors,
- injection pump or pump injectors,
- gearing,
- oil pump,

- oil heat exchanger,
- water pumps,
- oil filters,
- turbo charger,
- intake air cooler,
- exhaust manifold,
- air intake manifold.

The components marked with an asterisk should also be given a dimensional check before and after the testing in the presence of a test engineer.

The measurement records should be attached to the test report.

The test report should include a succinct description of the general conditions of the engine. Any observations concerning its component parts should also be included.

The test enginners are entitled to repeat additional visual or dimensional checks.

6.2 - Final meeting with engine assessment

During the final meeting at the manufacturer's premises, the test engineers shall evaluate the general condition of the stripped-down engine.

Before the cylinder head is stripped down, the following valve leakage test shall be carried out in the presence of the test engineers. White spirit or gasoline shall be poured into the inlet and the exhaust port of the cylinder head where it shall remain for at least 15 minutes (per port).

If wet spots or traces appear on the fireside of the valves, this shall be considered a leak.

If there is considerable leakage from more than 10% of the valves, the engine may not be recommended for approval.

During the preparatory meeting, the manufacturer may put forward a procedure for checking the tightness of the valves that deviates from this method which, if endorsed by the test engineers, may be agreed as an alternative.

The occurrence of one or more of the following problems may result in the engine not being recommended for approval:

- liner polishing due to carbon build-up in the area around the top land of the pistons;
- abrasive wear in the piston top land or at the upper reversal point of the piston on the liner;
- carbon build-up in the piston ring grooves;
- poor general condition of the combustion chamber (e.g. excessive carbon build-up);

- turbochargers in very poor condition (scaling on the housing, rotor blades striking the housing due to plastic deformation);

- visible wear of the bearings of the crankshaft, camshaft or rocker-arm shaft;

- leaking water pump or oil cooler.

The following distinction shall be made in respect of liner polishing:

- light polishing (cross hatches of honing marks still fully visible);

- moderate polishing (some cross hatches of honing marks still visible);

- heavy polishing (honing marks no longer visible).

Light polishing will be accepted in a limited area of the surface between the top of the liner and the reversal point of the piston rings not exceeding 10% of this surface.

Moderate polishing will be accepted at a maximum of 2% of this surface.

Heavy polishing will not be accepted at all.

If during the assessment of the dismanbled engine, there are doubts over its suitability, additional tests agreed upon between the test engineers and manufacturers may be carried out to demonstrate suitability.

7 - Test report

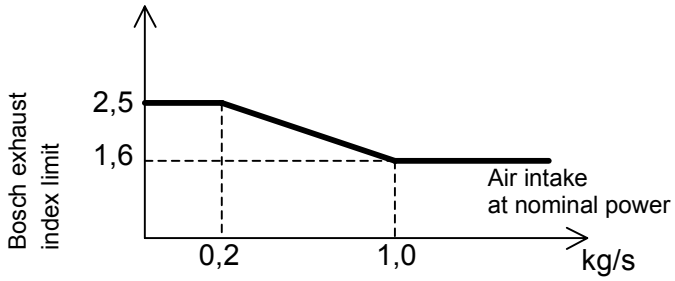
The test report to be supplied is specified in *UIC Leaflet 623-1, Appendix B* (see Bibliography - page 48).

Appendix A - Pollutant emission measurements: limits, findings, diagrams

A.1 - Permissible exhaust emissions

Pollutant	Permissible level up to 31.12.2002 (g/kWh) UIC I	Permissible level from 1.1.2003 (g/kWh) UIC II	
		P ≤ 560 kW	P > 560 kW
CO	3	2,5	3
NO_x	12	6	n > 1 000 rpm 9,5 n ≤ 1 000 rpm 9,9
HC	0,8	0,6	0,8
Bosch index[a]	1,6 (2,5)	-	-
Particulates	-	0,25	0,25

a. From an air throughput < 1 kg/s the value increases as shown in the curve below.



From 1.1.2003, both particulate and Bosch (as a reference value) index measurements shall be performed only at measuring points 1, 2 and 3.

A.2 - Record of pollutants measured in the exhaust gas

Table 1 : Record of pollutants

Record of Pollutants Measured in the Exhaust Gas

The Test Below was Conducted at the Following Test Conditions

Engine Manufacturer:		Atmospheric Pressure (kPa):	
Type of Engine:		Ambient Air Temperature (deg C):	
Serial Number of Engine:		Relative Humidity (%):	
Nominal Power (kW):		Water Content of the Air (g/g):	
Nominal Speed (RPM):		Height of Test Sight Above Sea Level (m):	
Min No-Load Speed (RPM):		Cooling Water Temperature (deg C):	
		MAT @ Nominal Power (deg C):	

(Note: MAT = Air Temperature at the Cylinder Head Inlet During Pollution Tests at Nominal Power)

Mode as per ISO 8178-4	Output Power (kW)	Speed (RPM)	Inlet Pressure (kPa)	Inlet Air Flow (kg/Hr)	Fuel Rate (kg/Hr)	CO		NOx			HC (Total)		PM (Total)
						PPM	(g/Hr)	PPM	(g/Hr)	ISO 8178 Corrected (g/Hr)	PPM	(g/Hr)	(g/Hr)
1													
2													
3													

Calculated Specific Emissions Values

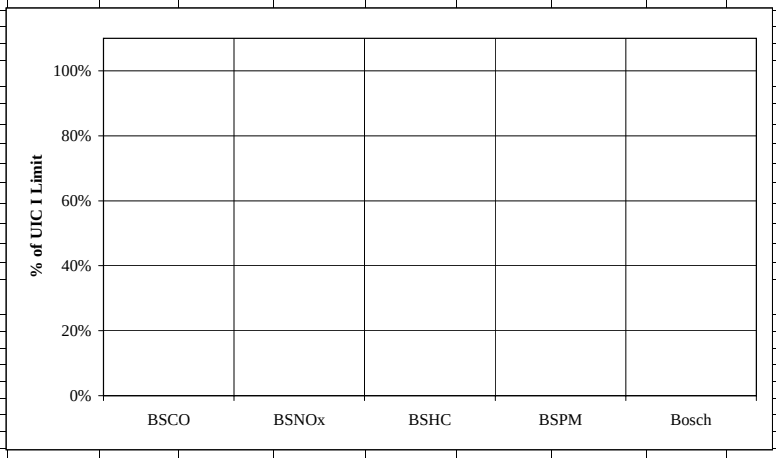
Mode as per ISO 8178-4	Output Power (kW)	Speed (RPM)	Air Flow (kg / Hr)	Fuel Rate (kg/Hr)	Weighting Factor (W.F.)	Weighted Power (kW)	Weighted Fuel Rate (kg/Hr)	Weighted CO Emissions (g/Hr)	Weighted NOx Emissions (g/Hr)	Weighted HC Emissions (g/Hr)	Weighted PM Emissions (g/Hr)
1					0.25						
2					0.15						
3					0.6						
				Summed Weighted Values	1.00						

Calculated Cycle Specific Values

	FC (kg/kW-Hr)	CO (g/kW-Hr)	NOx (g/kW-Hr)	HC (g/kW-Hr)	PM (g/kW-Hr)	Bosch (Smoke)
Calculated Cycle Values						
Limit Values for UIC I/II						
% of UIC I/II Limit Values						

Bosch Smoke Information

Air Flow (kg/Sec):	
Engine Speed (RPM):	
Engine Power (kW):	
Engine Torque (Nm):	
Bosch Smoke Number:	
Limit Values for UIC I:	
% of UIC I Limit Values:	



ERRI representative:

Signature:

Railway representative:

A.3 - Examples of characteristic diagrams for an exhaust gas component

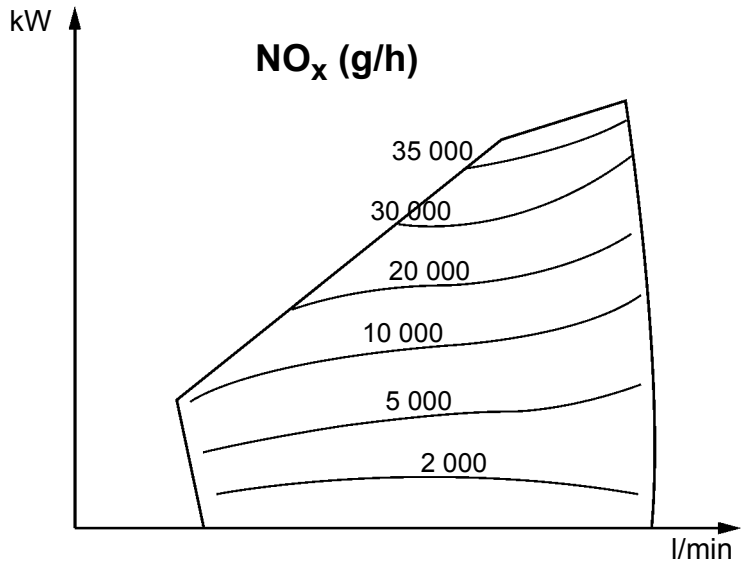


Fig. 1 -

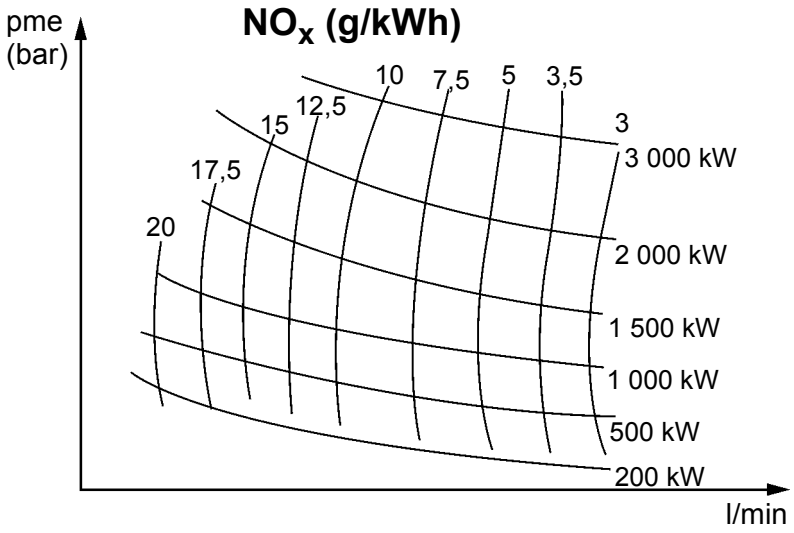
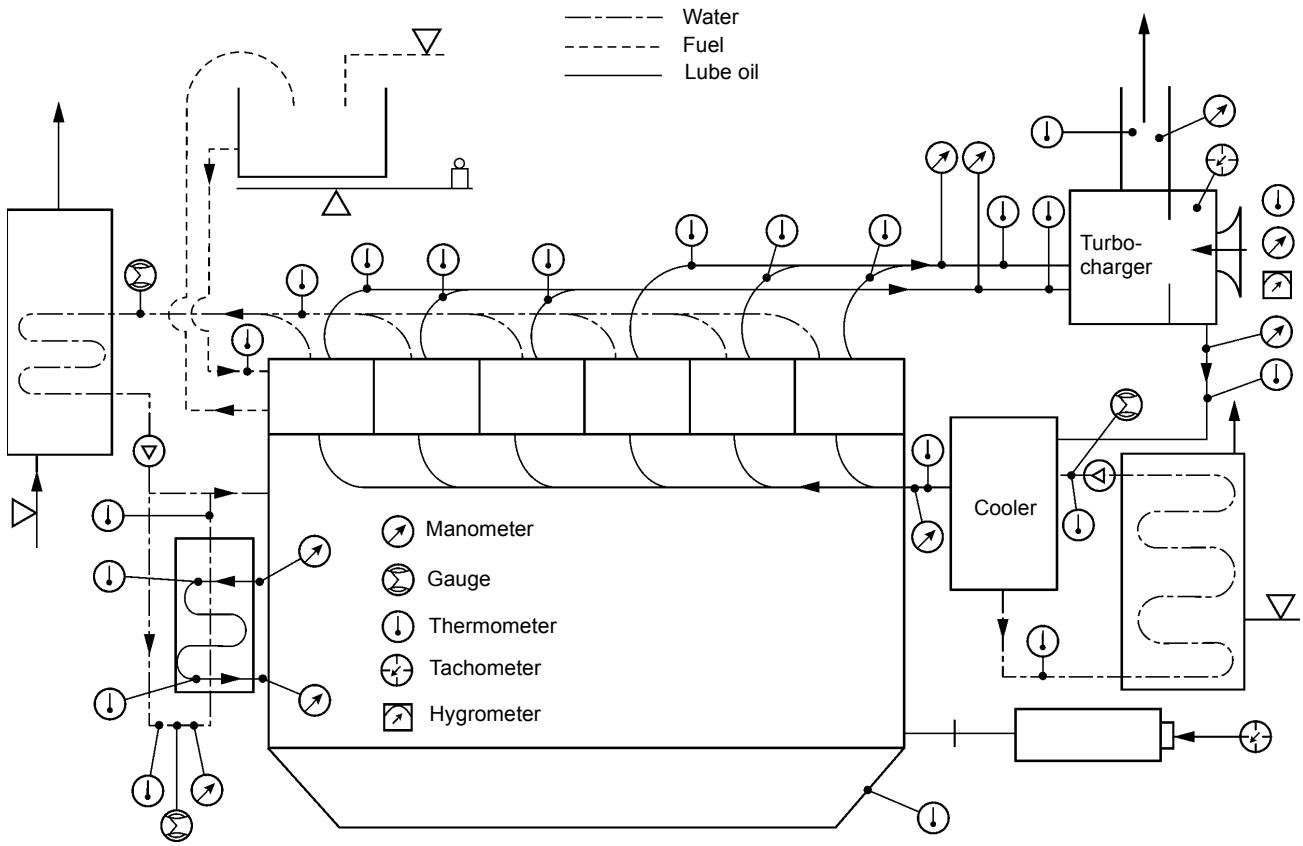


Fig. 2 -

Appendix B - Measured and calculated values: schema, measuring equipment, calculation

B.1 - Schema of measuring points



B.2 - Measured and calculated values

Table 2 : Measured and calculated values

Designation	No. of measuring point [a]	Sensors		Channels			Output		Observations [b]
		Type	Spec. [c]	N°	Characteristics	Freq. [d]	Screen [e]	Printer	
1) Water					(mV/°C)				
Temperature									
Throughput									
Pressure									
2) Oil									
Température									
Throughput									
Pressure									
3) Air									
Temperature									
Throughput Hygrometry									
Pressure									
4) Gas									
Temperature									
Throughput									
Pressure									
5) Fuel									Min. cal. value: [f]
Temperature Consumption per unit time									
6) Mechanical parameters									
rpm of engine turbo rpm engine torque									
7) Calculated values									
Mechanical engine power Mechanical engine output Specific consumption	Mathematical expression: Mathematical expression: Mathematical expression: [g]								

a. The numbers to be specified correspond to the manufacturer's referencing.
b. Indicate "manual data logging" against the values entered at the computer keyboard.
c. Spec: specification according to ISO 3046-3.
d. Freq indicates the scanning frequency of the different channels and the updating frequency of the calculated values when these appear on the screen.
e. Output shows whether a value is displayed on the screen and/or the printer.
f. Indicate the minimum calorific value actually employed.
g. Indicate the minimum calorific value according to point 3.4.

Appendix C - Table of measured data to be used for the final report

Table 3 : Measured data

		A	B	C	D	E	F	G	H	I	J	K	L	M
		Preliminary verification[a]	Thermal balance	Performance test					Endurance test					
				80 h nominal	1 h super-charge	10 h partial	8 h alternating	1 h nominal	Section 1	Section 2	Section 3	Section 4	Section 5	Nominal
N°	FREQUENCIES		After stabilisation	60 min	15 min	60 min	60 min	15 min	24 h	24 h	12 h	6 h	4 h	After stabilisation
	TEST CONDITIONS													
	Date	*	*	*	*	*	*	*	*	*	*	*	*	*
	Time	*	*	*	*	*	*	*	*	*	*	*	*	*
	Number of hours	*	*	*	*	*	*	*	*	*	*	*	*	*
	Ambient temperature	*	*	*	*	*	*	*	*	*	*	*	*	*
	Atmospheric pressure	*	*	*	*	*	*	*	*	*	*	*	*	*
	Hygrometry	*	*	*	*	*	*	*	*	*	*	*	*	*
1	**Engine rpm**	*	*	*	*	*	*	*	*	*	*	*	*	*
2	**Engine torque (braked weight)**	*	*	*	*	*	*	*	*	*	*	*	*	*
3	**Power**	*	*	* [b]	*	*	*	*	*	*	*	*	*	*
	WATER													
	Temperatures													
4	Engine intake		*	*	*	*	*	*						*
5	Engine outlet		*	*	*	*	*	*	*	*	*	*	*	*
6	Air coolant intake		*	*	*	*	*	*						*
7	Air coolant outlet		*	*	*	*	*	*						*
8	Oil exchanger intake		*	*	*	*	*	*						*
	Oil exchanger outlet		*	*	*	*	*	*						*
	Pressure													
9	Pump intake	*	*	*	*	*	*	*						*
10	Pump outlet	*	*	*	*	*	*	*						*
11	Coolant intake	*	*	*	*	*	*	*						*
	Throughput													
12	Engine outlet	*	*											
13	Air coolant intake		*											

Table 3 : Measured data

		A	B	C	D	E	F	G	H	I	J	K	L	M
		Preliminary verification[a]	Thermal balance	Performance test					Endurance test					
				80 h nominal	1 h super-charge	10 h partial	8 h alternating	1 h nominal	Section 1	Section 2	Section 3	Section 4	Section 5	Nominal
N°	FREQUENCIES		After stabilisation	60 min	15 min	60 min	60 min	15 min	24 h	24 h	12 h	6 h	4 h	After stabilisation
	OIL													
	Temperatures													
14	In front of oil exchanger			*	*	*	*	*	*	*	*	*	*	*
15	Behind oil exchanger			*	*	*	*	*						*
16	Sump			*	*	*	*	*						*
	Pressure													
17	Behind regulating valve			*	*	*	*	*						*
18	In front of most distant accessible point			*	*	*	*	*	*					*
	Analysis			* [c] + [d]	* [c] + [e]			* [c]	* [c]	* [c]		* [c]	* [c]	
	Consumption			* [c]										* [f]
19	**AIR**													
20	Temperature before coolant		*	*	*	*	*	*						*
21	Temperature after coolant		*	*	*	*	*	*						*
	Pressure													
22	After coolant			*	*	*	*	*						*
23	Before coolant			*	*	*	*	*						*
24	Pressure drop at intake			*	*	*	*	*	*	*	*	*	*	*
25	**Turbo rpm**	*												
	GAS													
	Temperatures													
26	Cylinder outlets			*	*	*	*	*						*
27	In front of turbo line A			*	*	*	*	*	*	*	*	*	*	*
28	In front of turbo line B			*	*	*	*	*	*	*	*	*	*	*
29	Behind turbo			*	*	*	*	*						*

Table 3 : Measured data

		A	B	C	D	E	F	G	H	I	J	K	L	M
				Performance test					Endurance test					
		Preliminary verification[a]	Thermal balance	80 h nominal	1 h super-charge	10 h partial	8 h alternating	1 h nominal	Section 1	Section 2	Section 3	Section 4	Section 5	Nominal
N°	FREQUENCIES		After stabilisation	60 min	15 min	60 min	60 min	15 min	24 h	24 h	12 h	6 h	4 h	After stabilisation
	Pressure													
30	Gas in front of turbo line A			*	*	*	*	*						*
31	In front of turbo line B			*	*	*	*	*						*
32	Back pressure from exhaust			*	*	*	*	*	*	*	*	*	*	*
33	**Exhaust index**	*		*	*	*	*	*						*
	FUEL													
	Consumption													
34	Time	*	*	*	*	*	*	*				* g		*
35	Mass	*	*	*	*	*	*	*				* g		*
36	Specific	*	*	*	*	*	*	*	*	*	*	* g		
	Temperature													
37	Injection pump intake		*	*	*	*	*	*						*
38	Injection parameters[h]	*	*	*	*	*	*	*	*	*	*	*	*	*

Continuous recording of engine rpm and torque is to be carried out.
In the absence of test engineer, all measurements given in column M (except oil consumption) are to be recorded at least every five minutes. The data storage system should allow consultation of the last three recordings at any time, particularly whenever a test is interrupted. This data is for monitoring the test procedure and should not figure in the final report.

a. Curve checks (torque, output, consumption).
b. Output should be corrected as specified in ISO 3046-1 depending on the atmospheric conditions.
c. At the end of a period.
d. At the beginning of a period.
e. Without stopping the engine.
f. Overall consumption during the endurance test.
g. Whilst slowing down.
h. For engines equipped with an electronic injection command.

Appendix D - Calculation of thermal balance

P	:	engine power	kW
C	:	specific consumption	g/kWh
CA	:	minimum calorific energy from fuel	kJ/kg
M1	:	engine cooling water throughput	kg/s
T1S	:	temperature of water leaving engine	°C
T1E	:	temperature of water entering engine	°C
M2	:	water throughput in supercharging air coolant	kg/s
T2S	:	temperature of water leaving air coolant	°C
T2E	:	temperature of water entering air coolant	°C
M3	:	water throughput in oil coolant	kg/s
T3S	:	temperature of water leaving oil coolant	°C
T3E	:	temperature of water entering oil coolant	°C

Power supplied by fuel:

- specified in the file presenting the engine kW
- calculated: $Q = \frac{P \cdot C}{1000 \cdot 3000} \cdot CA =$ kW

Energy dissipated in engine cooling water:

- specified kW
- calculated: Q1 = M1 (T1S - T1E) . 4,186 = kW

Energy dissipated in cooling water for supercharging air coolant:

- specified kW
- calculated: Q2 = M2 (T2S - T2E) . 4,186 = kW

Energy dissipated by lubricating oil:

- specified kW
- calculated: Q3 = M3 (T3S - T3E) . 4,186 = kW

The Q1 value may have to be reduced by the value of Q2 and/or Q3 depending on the arrangement of the circuits.

Appendix E - Chronology of endurance test

Table 4 : Chronology of endurance test

Engine operating conditions at nominal output:	
- Temperature of intake air	above 10°C
- Air intake pressure reduction	80% of p_1
- Exhaust gas back-pressure	80% of p_2

Section/ hours Cycles/ hours	Period	Hours	Half-periods	Succession of cycles	Conditions
I 120 h A A' B S 1-4	1	24 h		AAABA'ACAA'BAA	
	2	24 h		---------- ----------	
	3	24 h		---------- ----------	
	4	24 h		---------- ----------	
	5	24 h		---------- ----------	
II 120 h DEFGHILM 5-13	6	24 h		DEFGHILMMMMN	
	7	24 h		---------- ----------	
	8	24 h		---------- ----------	
	9	24 h		---------- ----------	
	10	24 h		---------- ----------	
III 72 h LMN 11-13	11	24 h	K1	LMMMMN	- air intake pressure reduction p_1
			K2	---------- ----------	- air intake pressure reduction p_1 - exhaust gas back-pressure p_2
	12	24 h	K3	---------- ----------	- engine water pump throughput reduced to 80%
			K4	---------- ----------	- exhaust gas back-pressure p_2 - engine water pump throughput reduced to 80%
	13	24 h	K5	---------- ----------	- air intake pressure reduction p_1 - exhaust gas back-pressure p_2 - engine water pump throughput reduced to 80%
IV 24 h OPQR 14-17	14	24 h		O 6 h P 6 h Q 6 h R 6 h	
V 24 h	15	24 h	with 10% super-charge	23 h 1 h	- 10% supercharge by increasing torque only - 10% supercharge by increasing speed only

p_1 : Maximum permitted air intake pressure reduction referred to in the table of technical engine data.

p_2 : Maximum permitted exhaust back pressure to in the table of technical engine data.

Appendix F - Test cycles

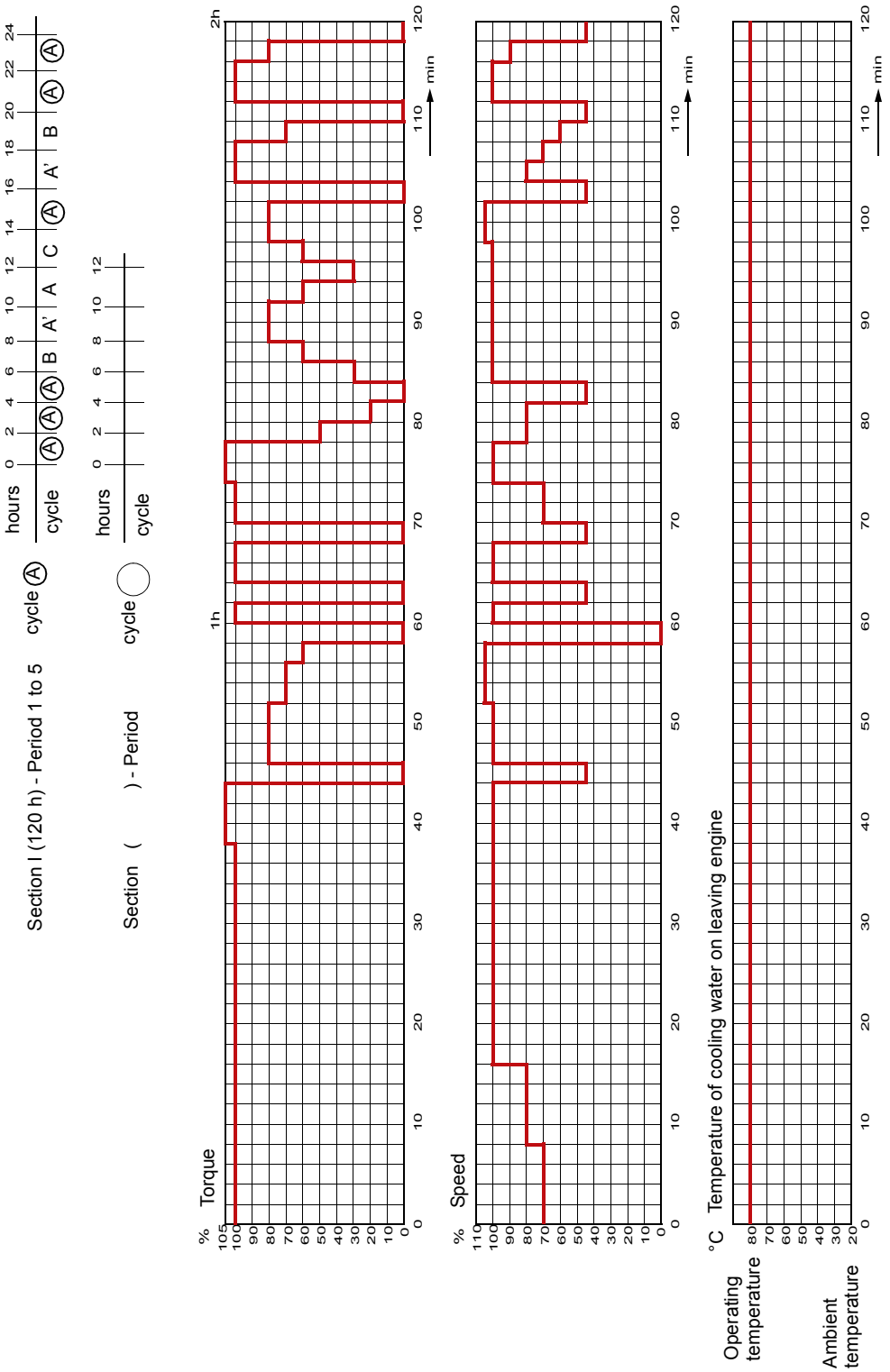


Fig. 3 - Test cycle A

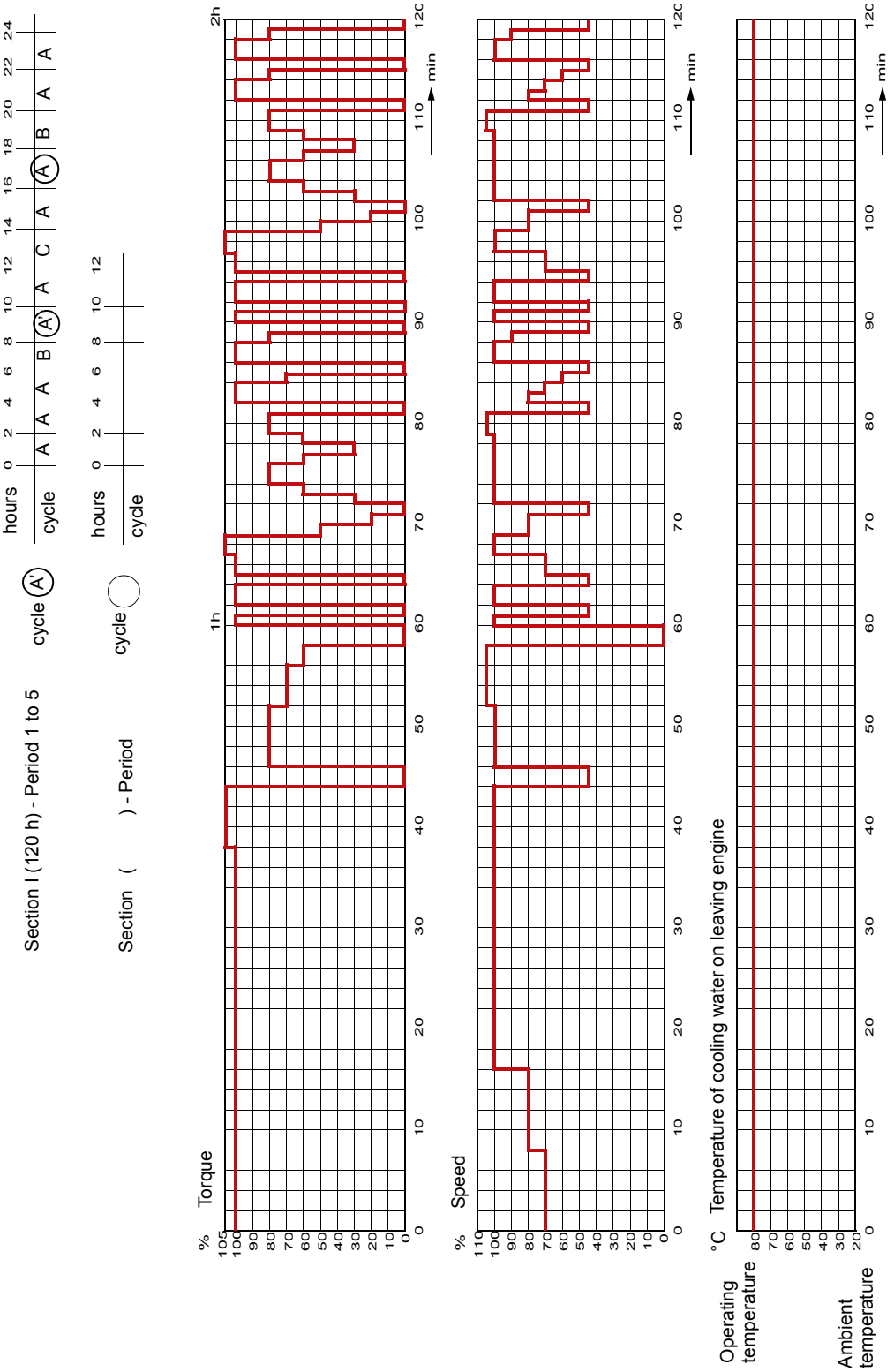


Fig. 4 - Test cycle A'

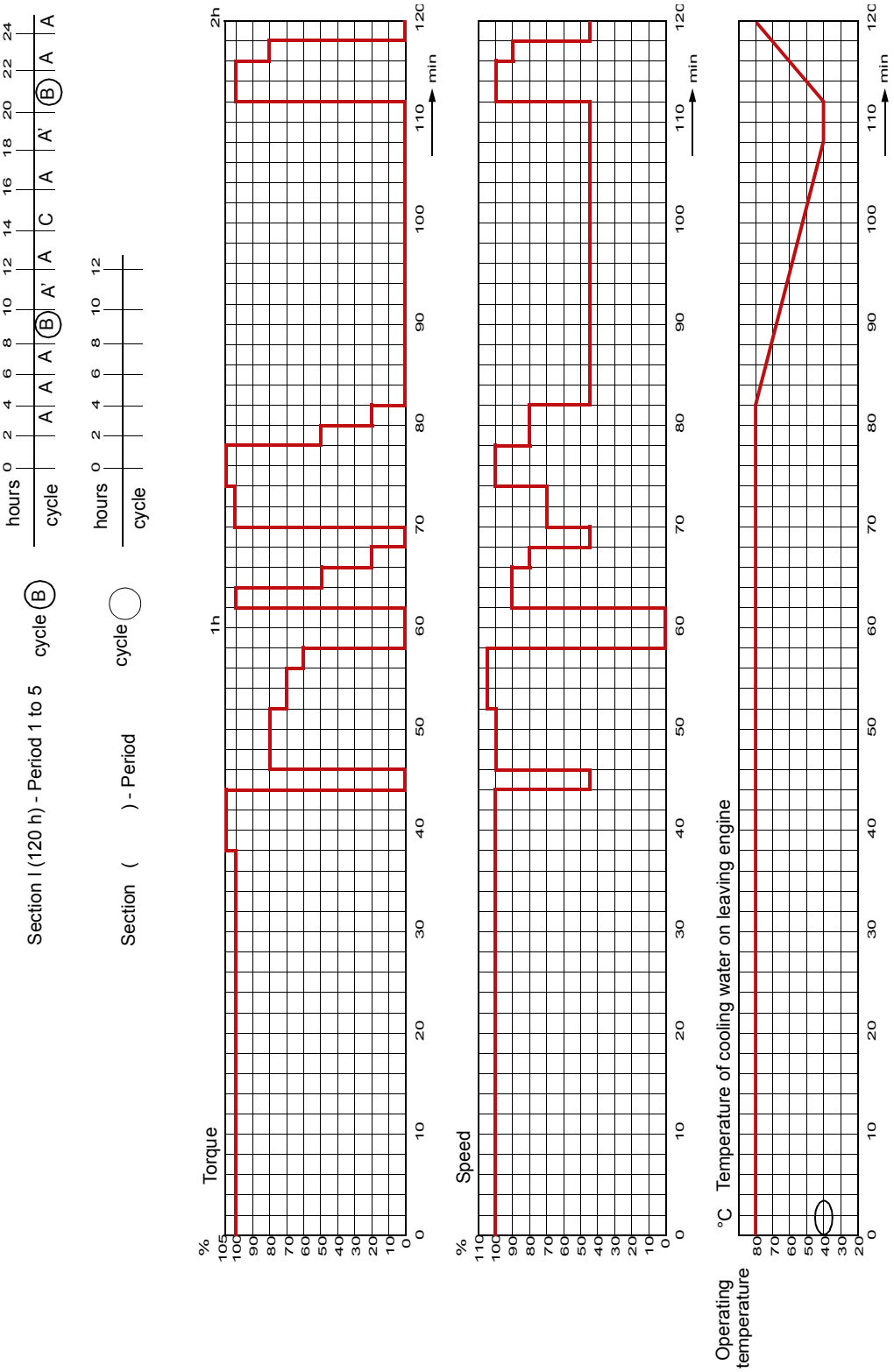


Fig. 5 - Test cycle B

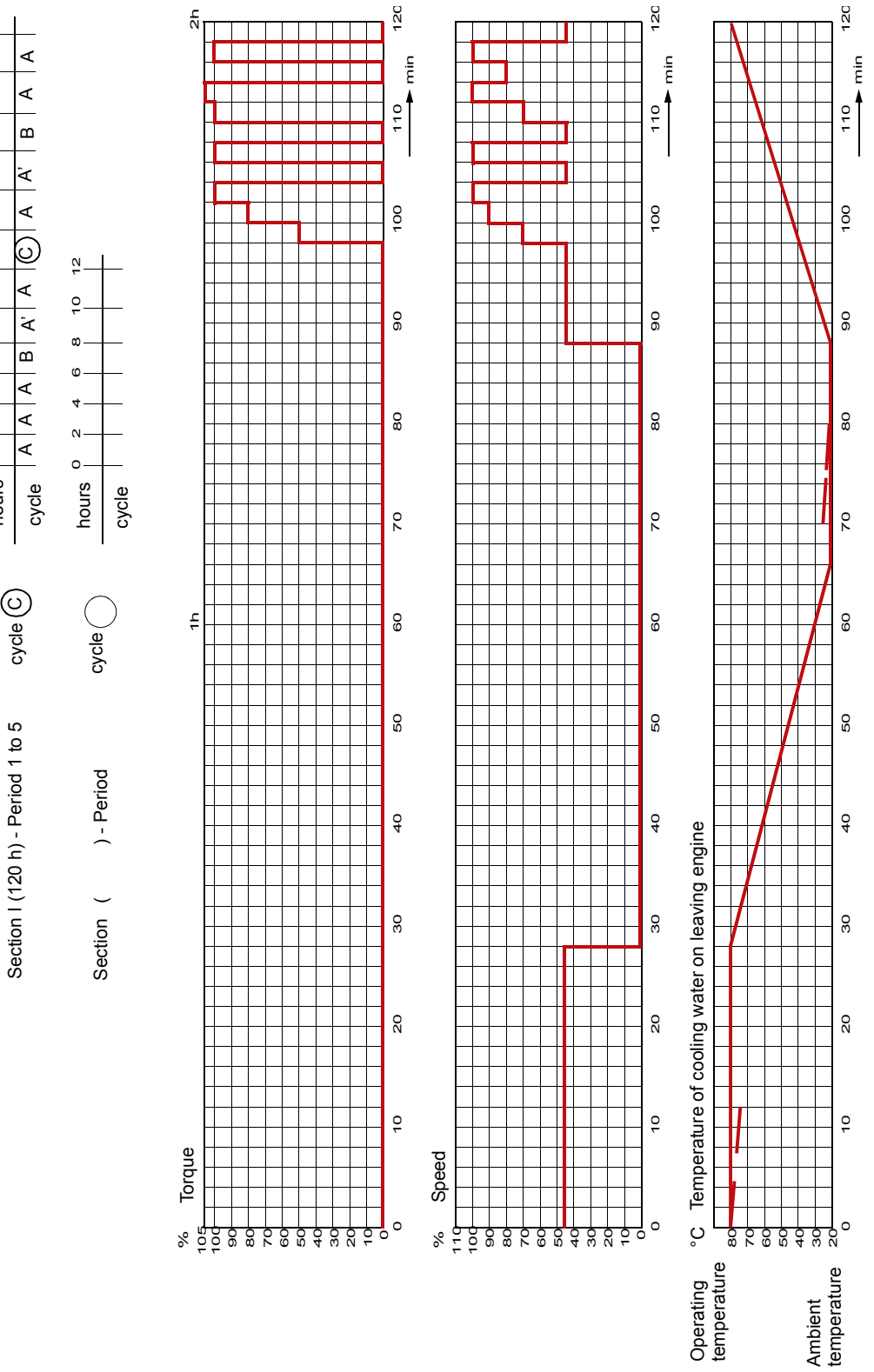


Fig. 6 - Test cycle C

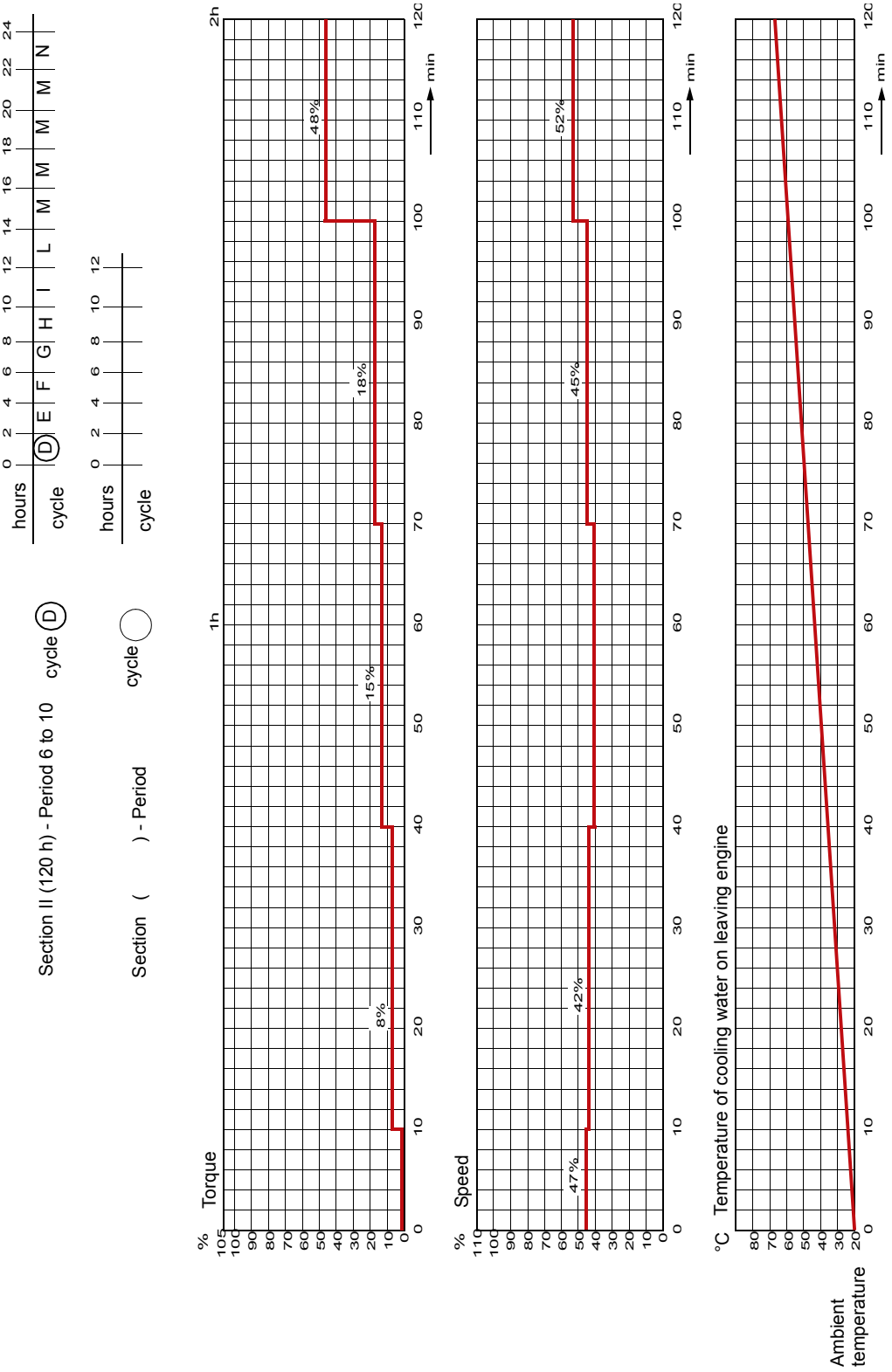


Fig. 7 - Test cycle D

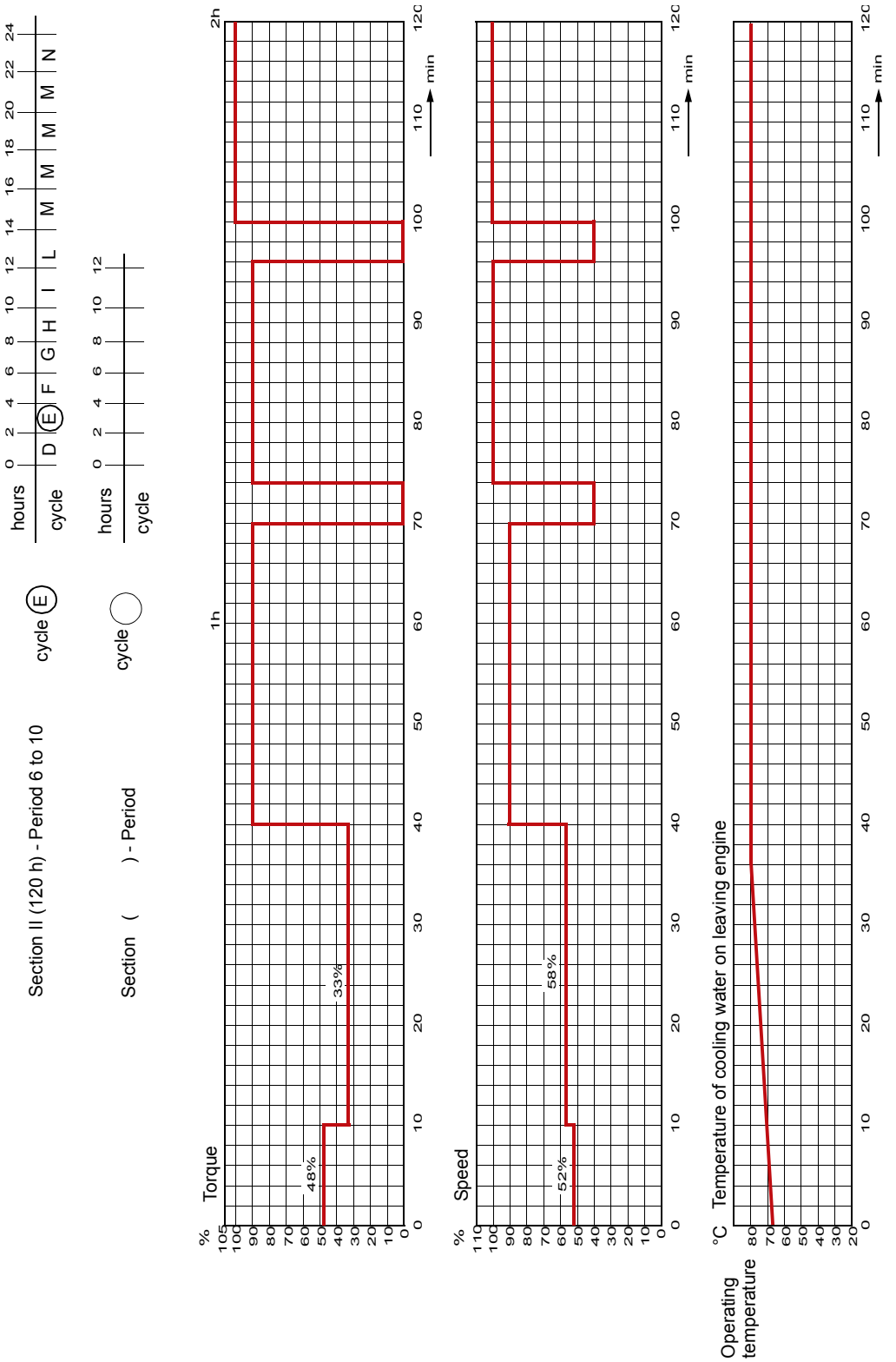


Fig. 8 - Test cycle E

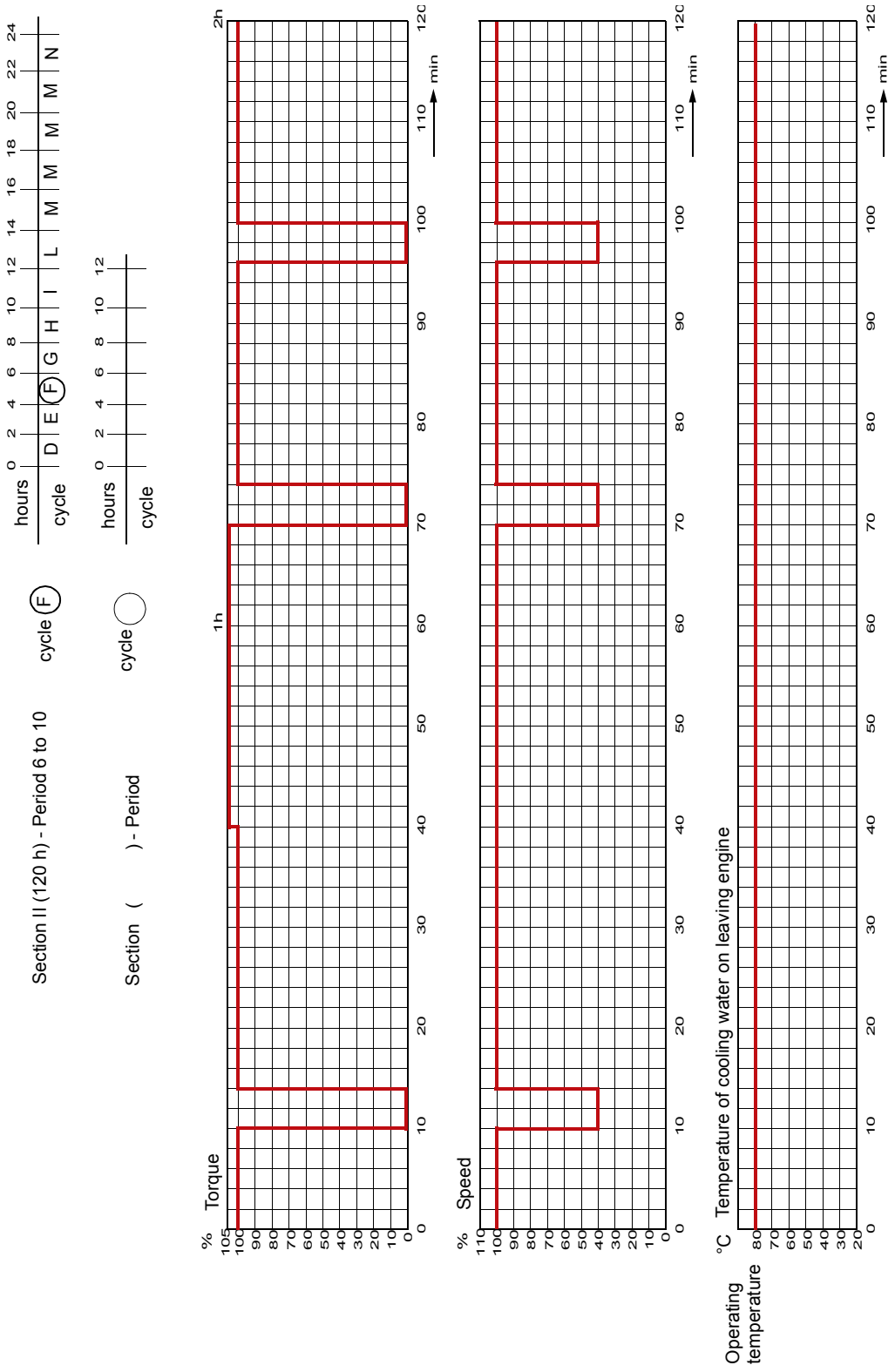


Fig. 9 - Test cycle F

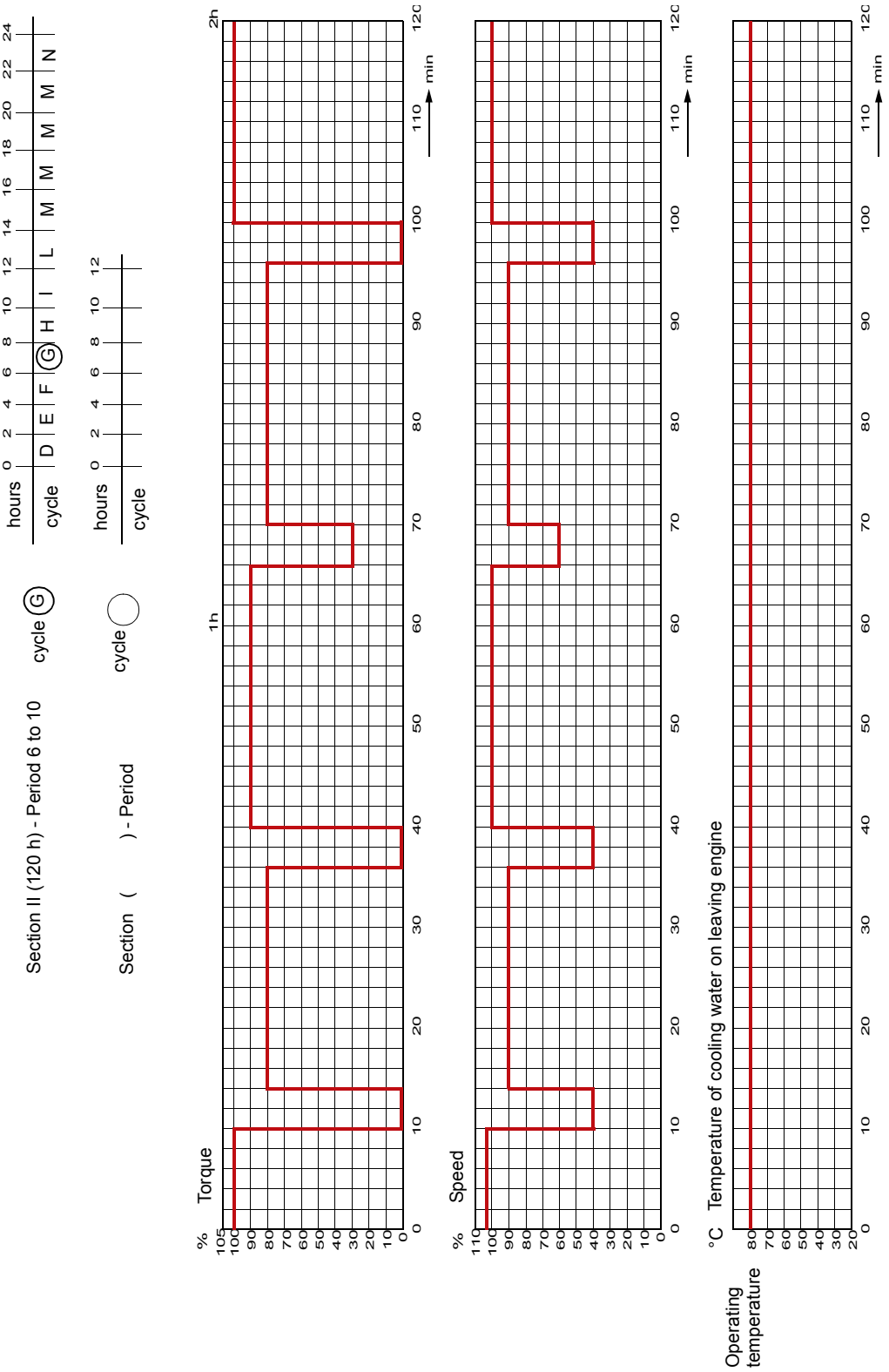


Fig. 10 - Test cycle G

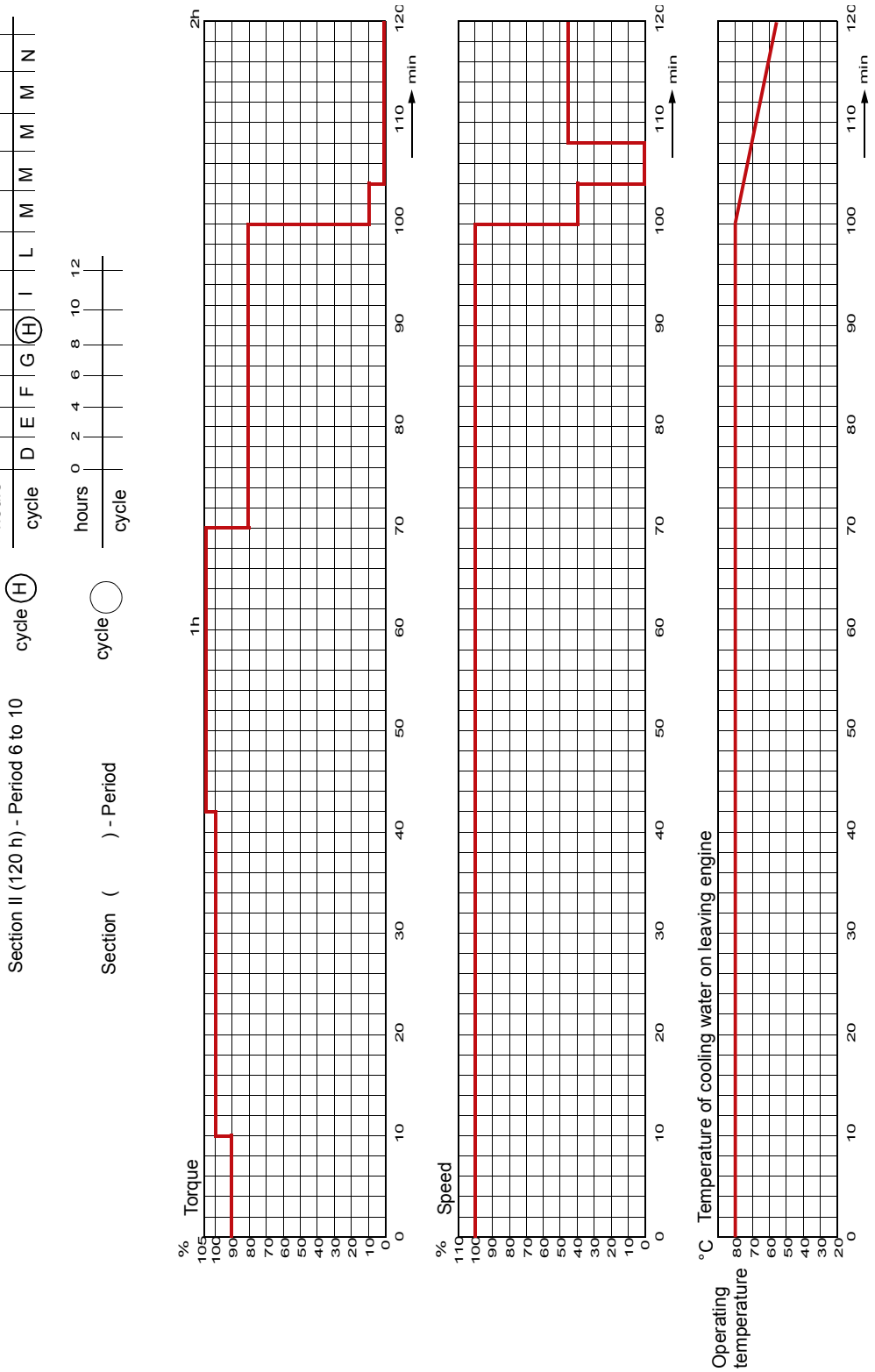


Fig. 11 - Test cycle H

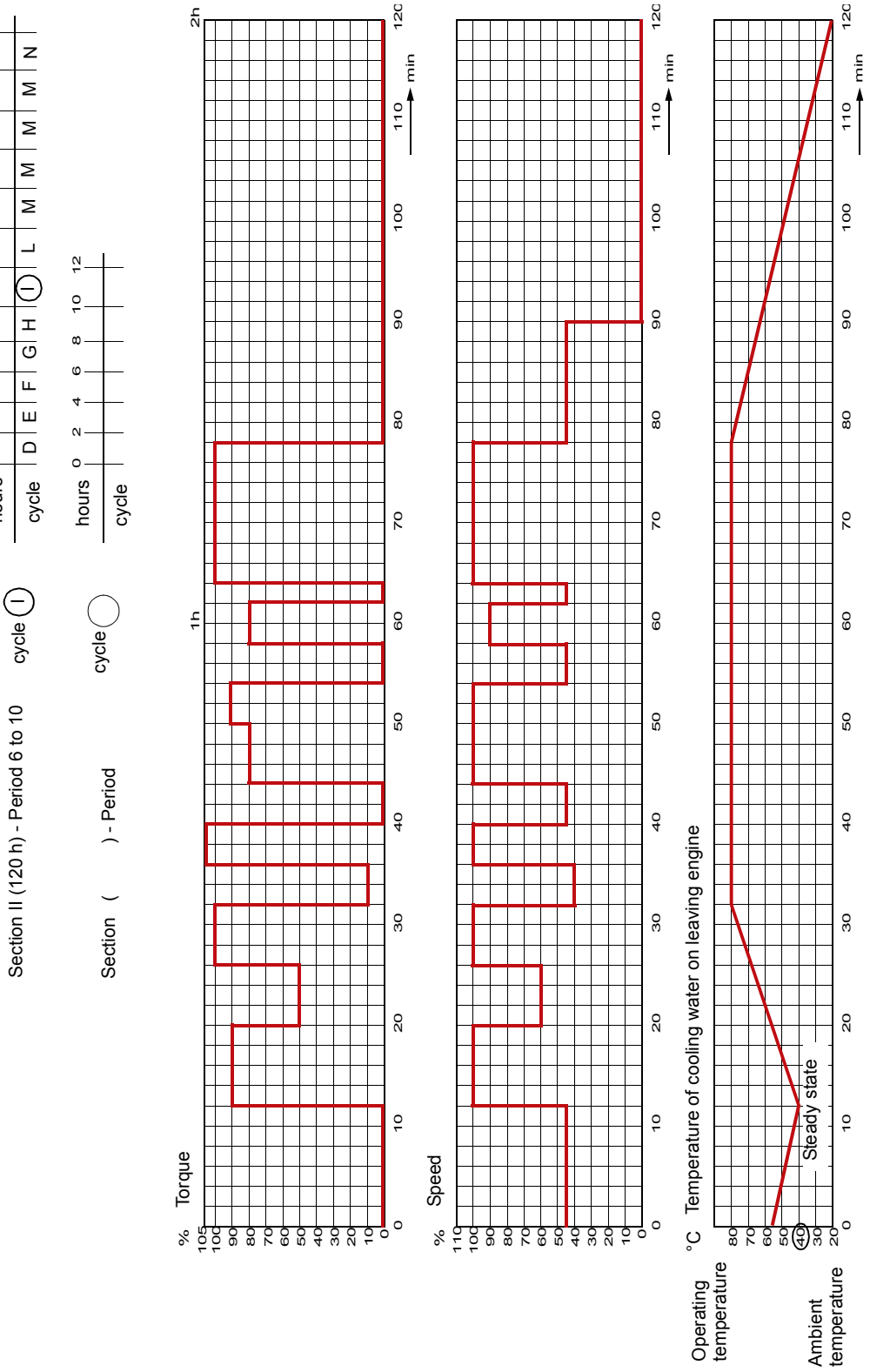


Fig. 12 - Test cycle I

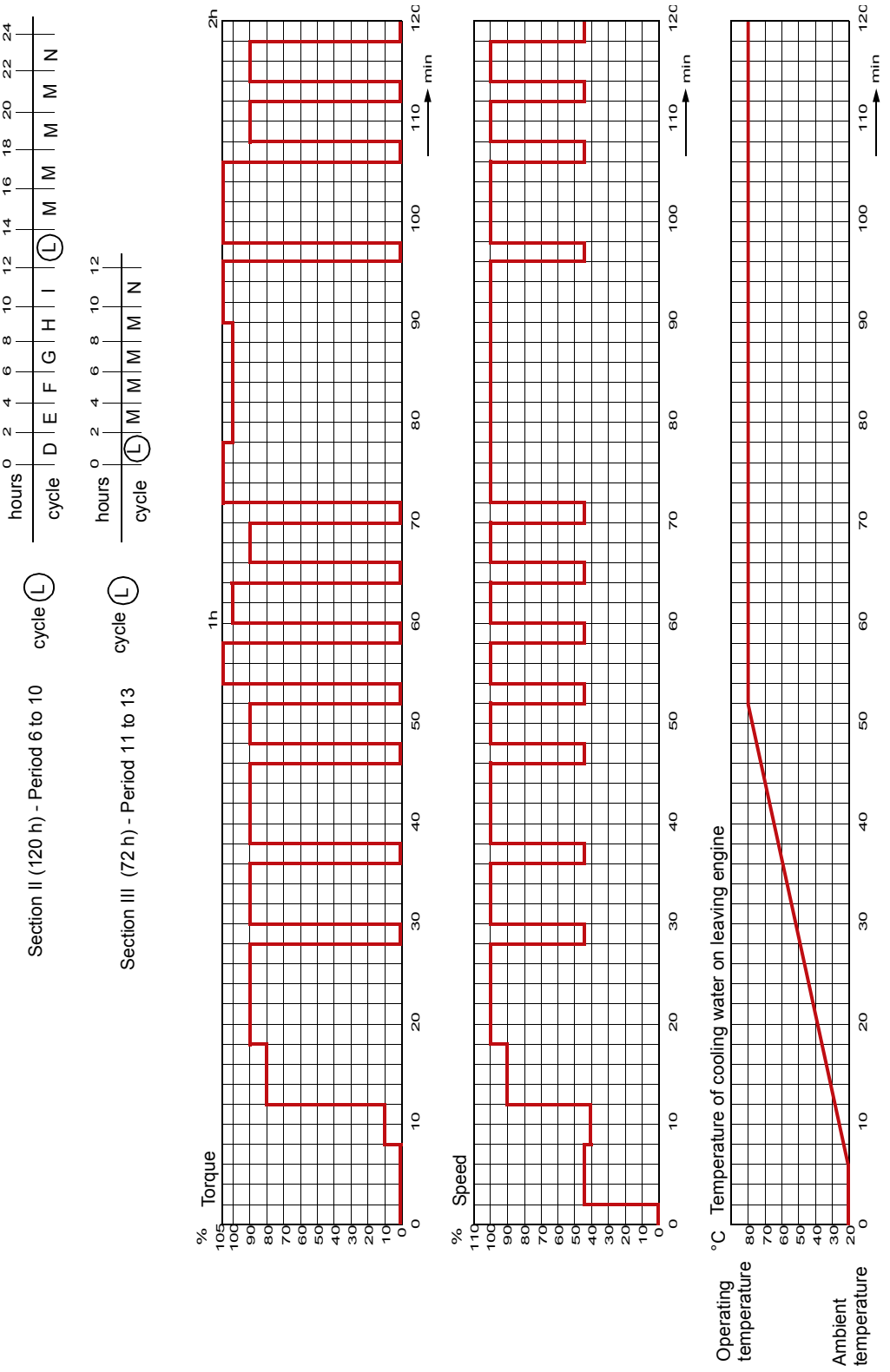


Fig. 13 - Test cycle L

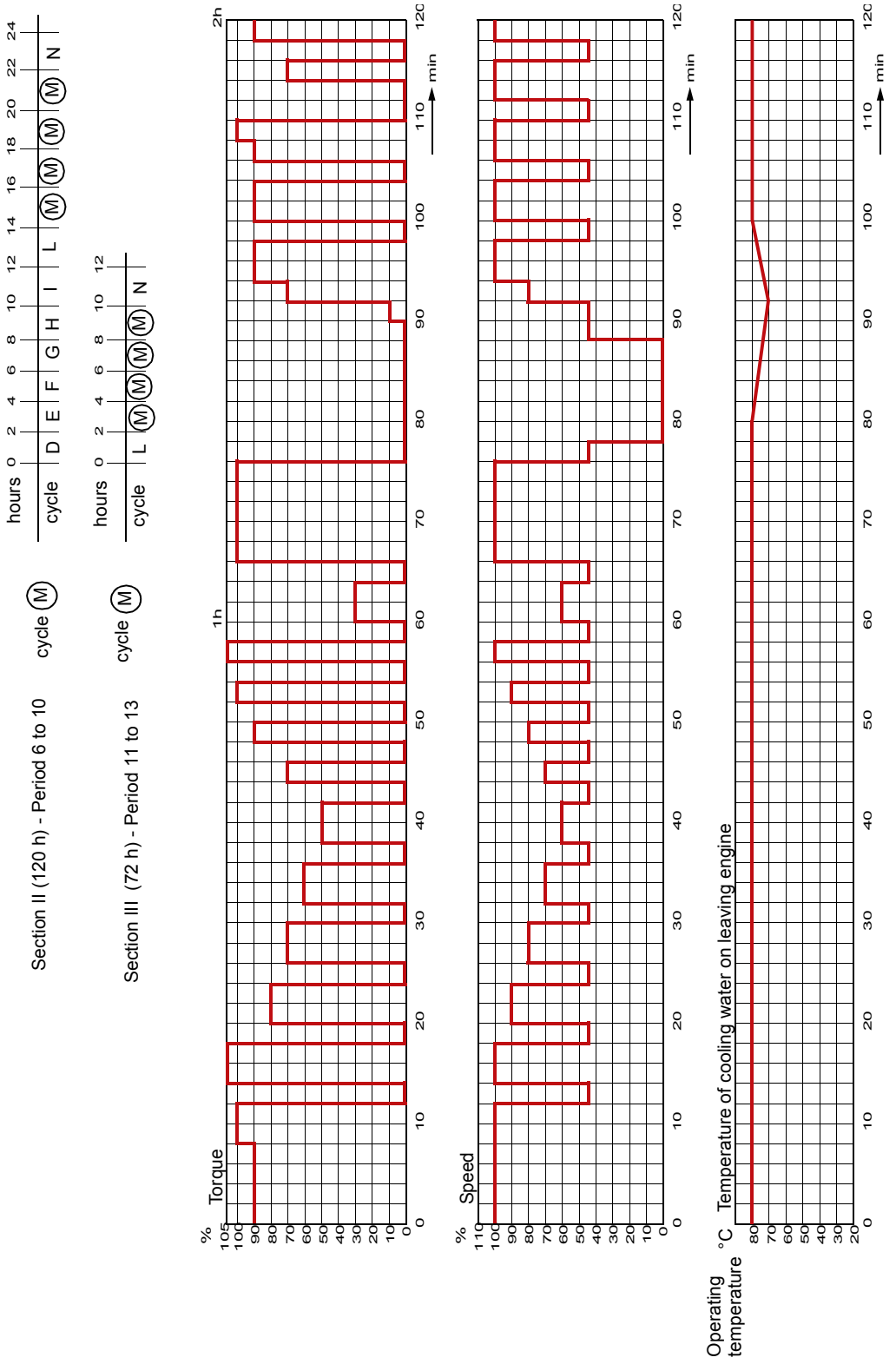


Fig. 14 - Test cycle M

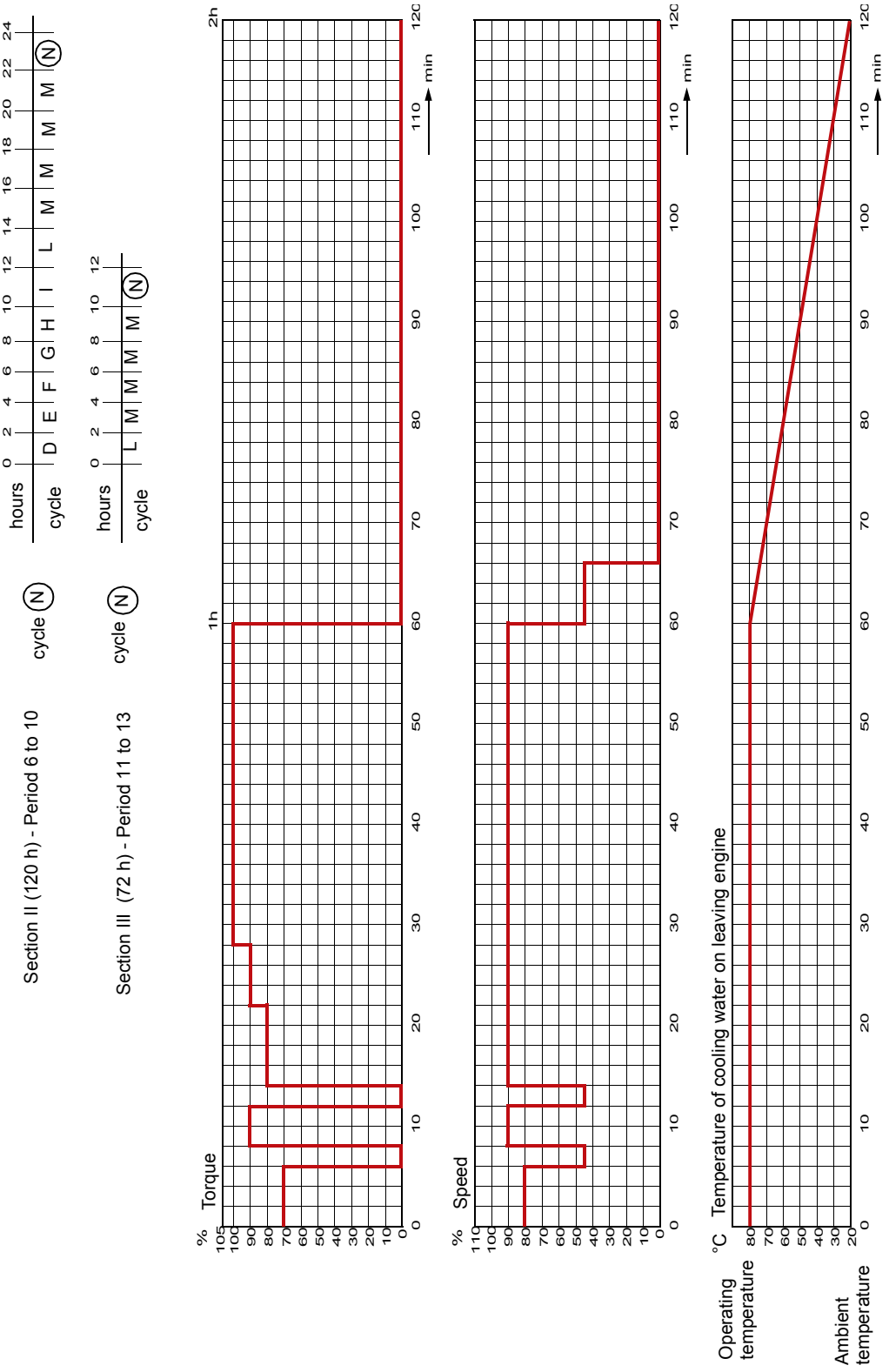


Fig. 15 - Test cycle N

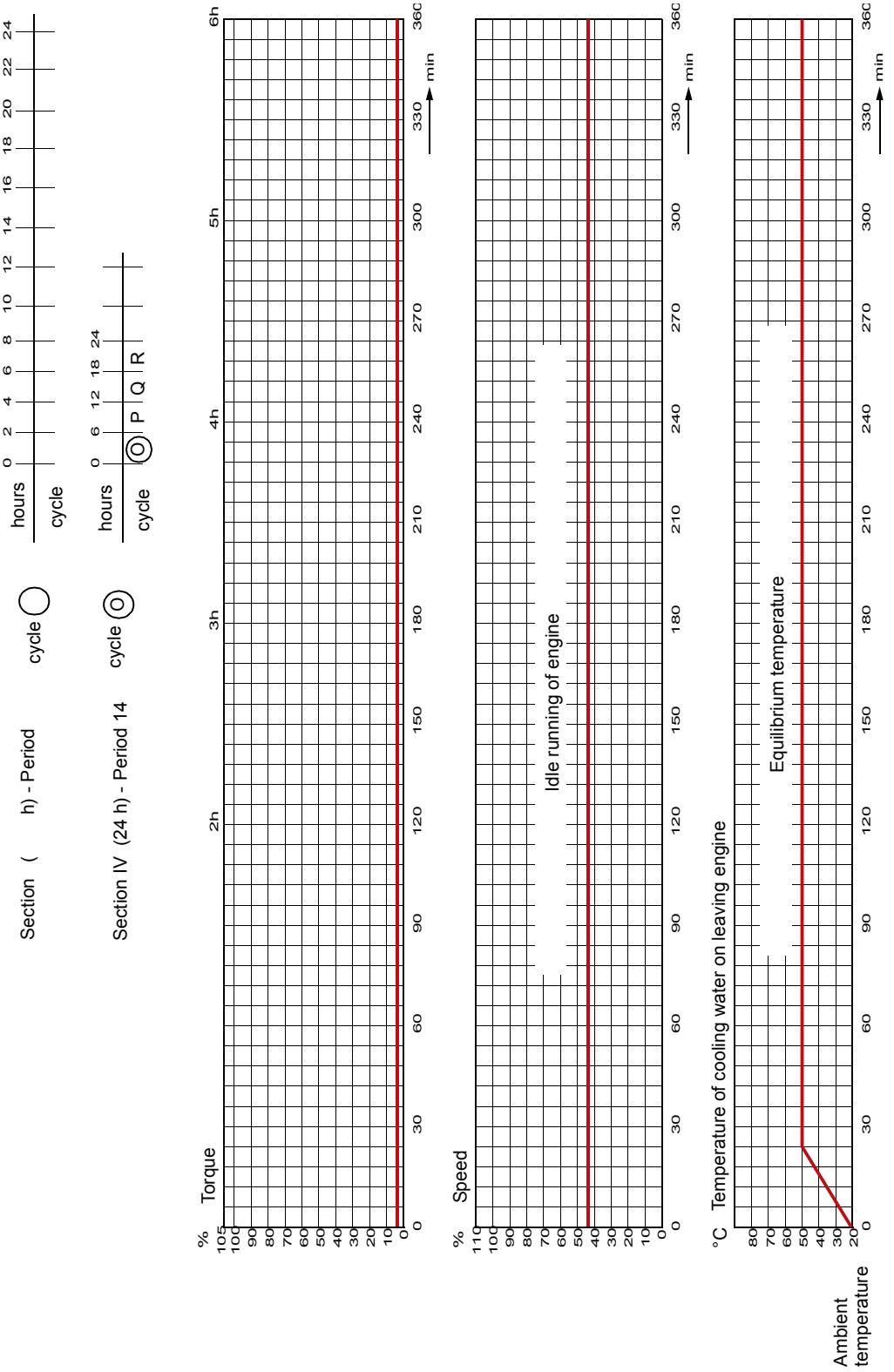


Fig. 16 - Test cycle O

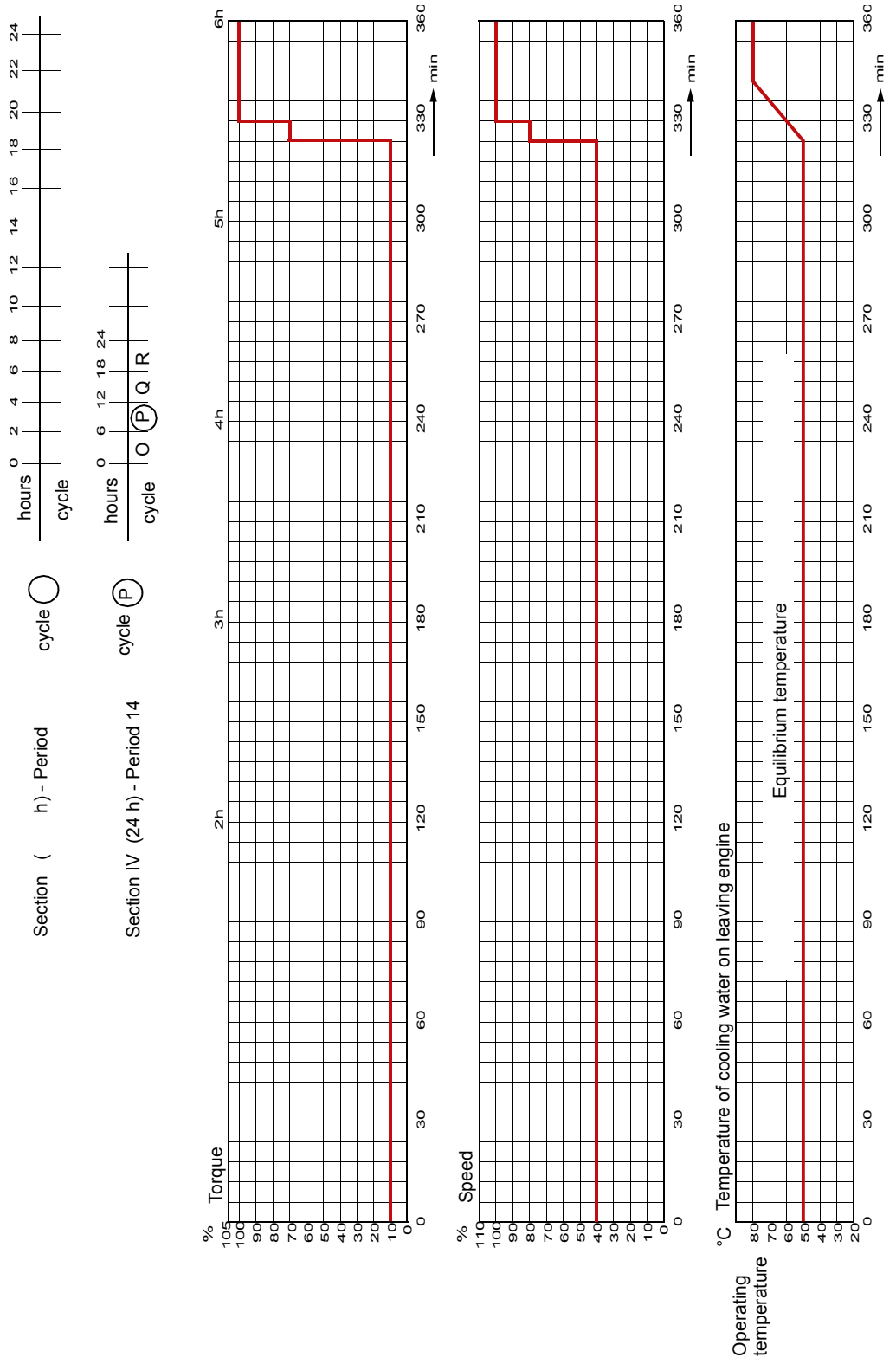


Fig. 17 - Test cycle P

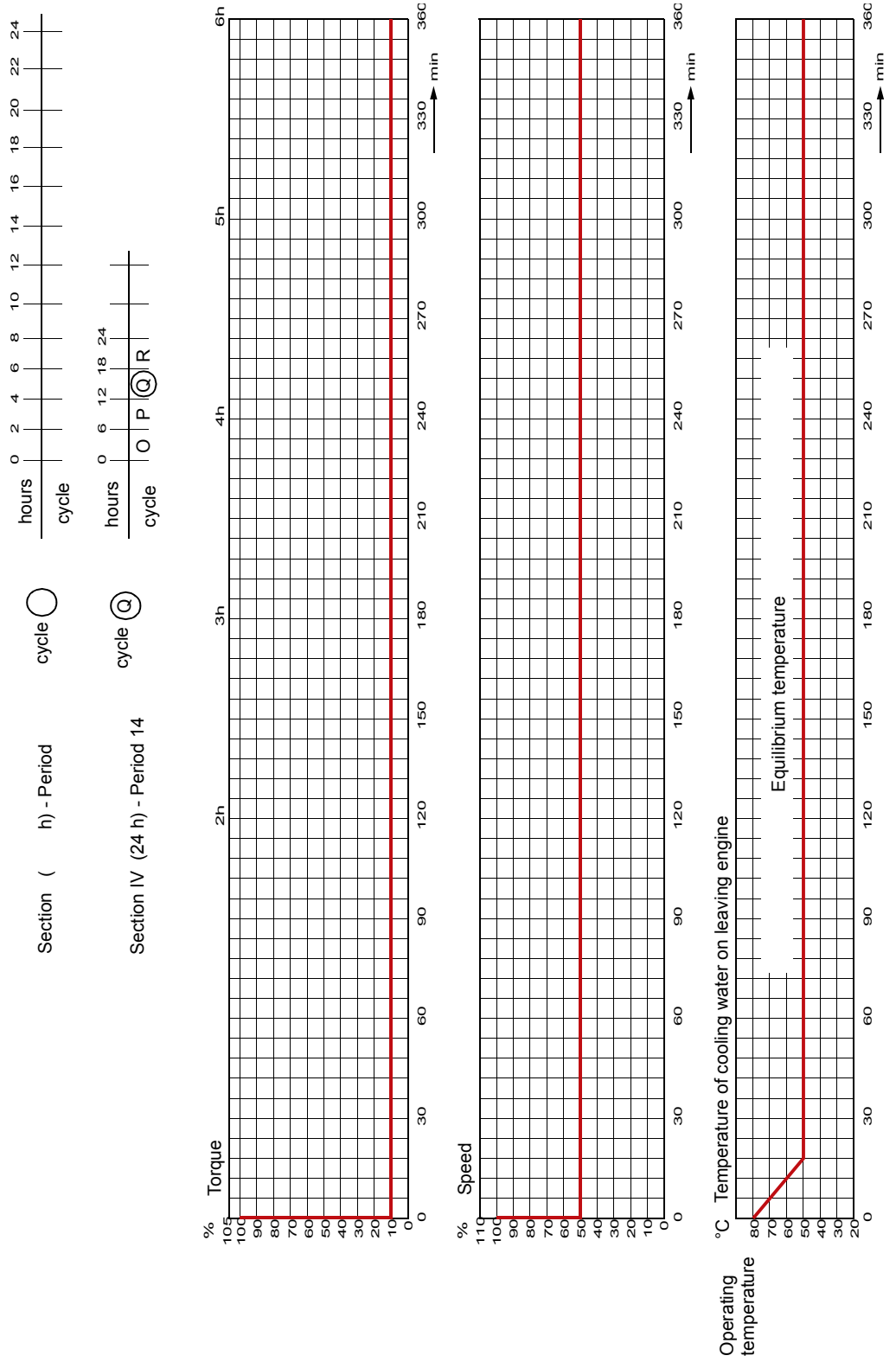


Fig. 18 - Test cycle Q

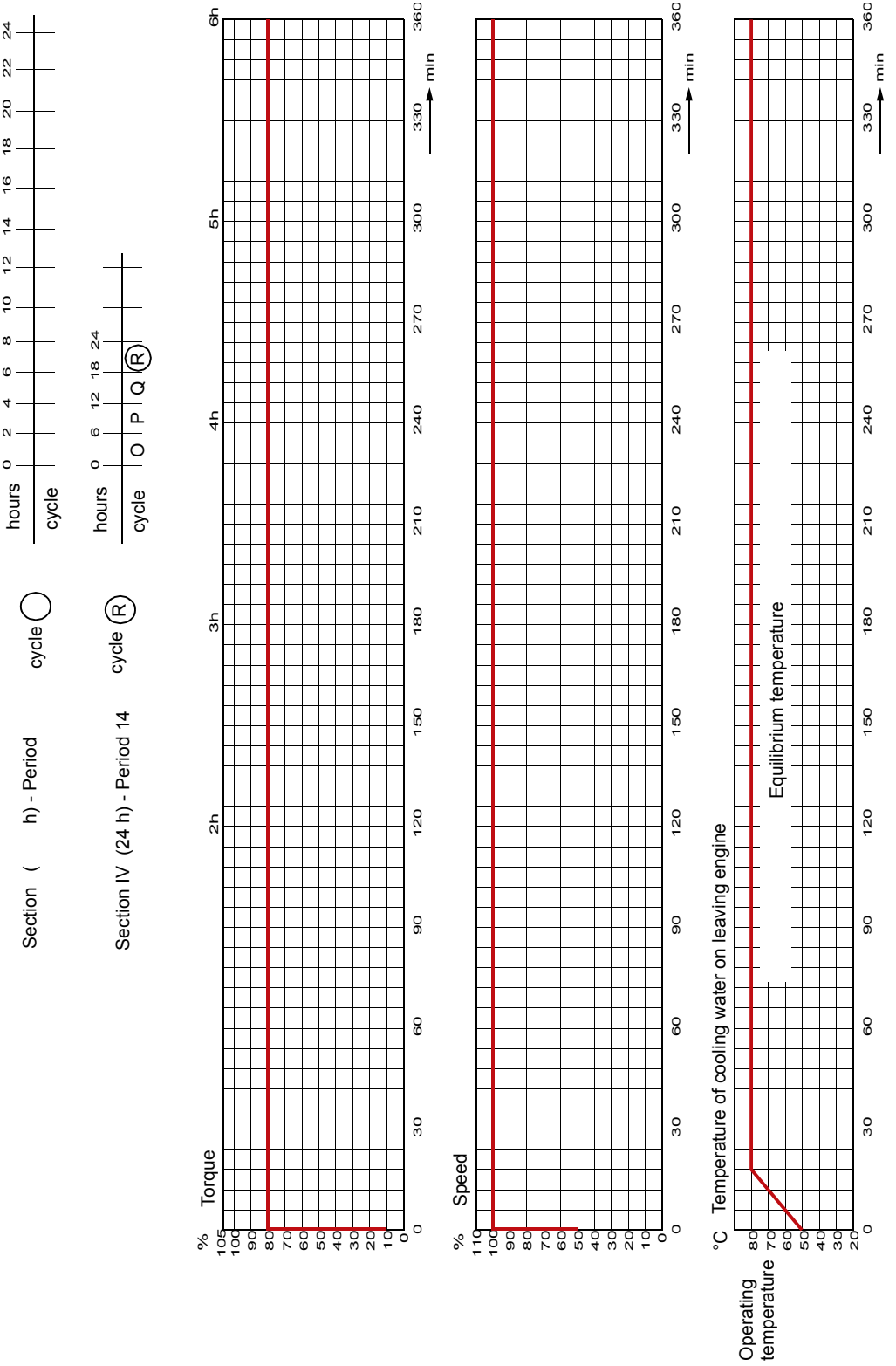


Fig. 19 - Test cycle R

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International Union of Railways (UIC)
UIC Leaflet 623-1: Approval procedures for the diesel engines of motive power units, 4th edition, June 2006

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ISO 9000:2000: Quality management systems - Fundamentals and vocabulary, 2000

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