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## 1 - SCOPE OF RULES

### 1 - Scope

These international rules for

- the definition of gas turbine output and
- the acceptance of gas turbines

are applicable to traction type gas turbines installed in motor rail vehicles, but not to gas turbines for locomotives in mines and traction type gas turbines for rail vehicles whose net output is less than 120 kW.

These regulations can also be applied to auxiliary gas turbines (e.g. for generation of electric current for lighting, cooking, heating, etc.), even when they are not used for rail traction purposes.

On the other hand, they shall not generally be applicable to gas turbines which constitute only one of the parts of a thermic unit for the production of mechanical energy (gas turbine playing the role of a generator of warm gases, for example).

## A - DEFINITION OF GAS TURBINE OUTPUT

### 2 - USEFUL SERVICE OUTPUT

#### 2 - Definition of the useful service output

The useful service output of the gas turbine is the mechanical output furnished for the propulsion of the vehicle and the driving of the auxiliary machines which are not essential to the operation of the gas turbine, whether the latter drives these machines directly or indirectly.

The output absorbed by all the auxiliary machines which are essential to the operation of the gas turbine is supplied by the gas turbine over and above the useful output, whether the gas turbine drives these machines directly or indirectly.

It is also necessary to indicate the output-shaft speed (in r.p.m.) at which the useful service output is developed.

### 3 - INTERNATIONAL RATING

#### 3 - Definition of international rating

The international rating is the useful output which, by agreement, the gas turbine is capable of developing under the conditions of acceptance defined in Part B of this leaflet. It corresponds to the functioning point A in Appendix 3.

The speed at which the gas turbine is capable of developing this international rating is the rated speed.

If, during the tests in accordance with Chapter 7, the output absorbed by the auxiliary machines essential to the operation of the gas turbine is provided by an independent power source, the international rating is, from the definition of useful service output given above in Article 2, equal to the useful output developed during the acceptance tests, diminished by the output absorbed by the auxiliary machines previously mentioned. It is necessary to list these machines and the output which they absorb.

4 - Performance conditions of the gas turbine at international rating

a) Atmospheric conditions

Enumerated below are the atmospheric conditions which should be used as a basis for determining the rated output ( $P_n$ ) of the gas turbine :

Atmospheric pressure	$p_n = 1\ 013\ \text{mbar}$
Ambient temperature	$t_n = \pm 15\ ^\circ\text{C}$
Relative air humidity	$\varphi_n = 60\ \%$

b) Intake and exhaust pressure loss

The rated output of the engine must be measured on the test bench without pressure loss on intake and exhaust, and without heterogeneity defect in distribution of the air entering the machine.

Consequently, the procedure for measuring the output is as follows :

- determining of the intake and exhaust pressure loss,
- in accordance with Article 10-3 b, application of the corresponding corrections for these pressure losses, to the output characteristic defined in Article 7.

These correction factors must be determined by separate tests or by calculations.

The intake and exhaust pressure losses must not exceed the values indicated in points 20 and 21 of Article 9.

The manufacturer must submit the formula for calculating pressure losses to the purchaser for approval.

c) Fuel and lubricating oil

If necessary, for the starting phase, the gas turbine can be supplied with a fuel with a pour point of  $- 25^\circ\ \text{C}$  or less.

In principle, after starting, the gas turbine must be supplied with diesel fuel.

Lubrication must be effected with a commercial oil approved by the manufacturer.

The diesel fuel and the oil must comply with the provisions of Article 18 a.

#### 5 - Reference fuel

Consumption shall be related to a reference diesel fuel with a calorific value of less than 41 870 kJ/kg (10 000 kcal/kg).

#### 6 - Measurement system

The metric system shall be used for all values, especially those concerned with the measurement of the ratio in corrected co-ordinates between the output and temperature at the input of the turbine ( $t_6$ ).

The unit of power is the kilowatt (kW).

All temperatures shall be expressed in °C.

If other measurement systems are used, attention must be specially drawn to this fact.

#### 4 - MAXIMUM SERVICE OUTPUT

##### 7 - Definition of the maximum service output

The maximum service output is the maximum useful output which the gas turbine can develop in service, on its vehicle, according to the particular conditions of utilisation (external temperature, atmospheric pressure, load cycles, etc.).

The values for the setting of the governors of the gas turbine when new shall be limited so that the temperature  $t_6$  at the input of the turbine is not greater than that corresponding to the international rating (point C of Appendix 3).

These settings for the utilisation output must ensure reliable operation of the turbine compatible with the guarantees required by the railway motive power department and permit reasonably long running periods between major overhauls.

For this purpose, the rating must be calculated on the output characteristic, so that the temperature  $t_6$  at the input of the turbine does not exceed the maximum value  $t_6$  (point E of Appendix 3), at the end of an overhaul period, taking account of the soiling of the gas generator.

In addition, the useful output at the end of an overhaul period must not be less than the minimum output P corresponding to Point D of Appendix 3.

#### 5 - GAS TURBINE DATA

Gas turbine data, to be checked during the type test, shall comprise:

- a dimensioned general arrangement drawing (see Article 8),
- a table of technical information (see Article 9),
- characteristic curves (see Article 10).

8 - Dimensioned general arrangement drawing

The dimensioned general arrangement drawing shall show the outline of the gas turbine and indicate the length, breadth and height measured respectively :

- overall and
- from the centre line of the output shaft.

It shall, futhemore, indicate the direction of rotation, in accordance with Article 13.

9. Table of technical information

The table of technical information shall include the following details :

- 1) exact description of the type of gas turbine (manufacturer and type)
- 2) whether it has a free turbine
- 3) international rating of the gas turbine  
(point A of Appendix 3) ..... kW
- 4) rated speed - gas generator ..... r.p.m  
- free turbine (output shaft) ..... r.p.m
- 5) type of heat exchanger, where provided
- 6) mass of the gas turbine as installed with and  
without oil ..... kg
- 7) usable fuels
- 8) specific fuel consumption
  - a) full load (rated output) ..... kg/kWh
  - b) 3/4 load (3/4 rated output) ..... kg/kWh
  - c) 1/2 load (1/2 rated output) ..... kg/kWh
  - d) idling ..... kg/h

9) Fuel pressure

- a) nominal ..... bar
- b) minimal ..... bar

with indication of the measuring point

10) Air flow under working conditions and at rated output ..... kg/s

11) Air filtering regulations

12) Recommended lubricating oil

13) Maximum permissible percentage of fuel in the oil (dilution) ..... %

14) Capacity of lubrication circuit ..... l

15) Heat power to be dissipated by the lubricating oil at rated output ..... kW

16) Oil temperature at rated output

- a) normal ..... °C
- b) permissible maximum for an ambient of 35 °C ..... °C

with indication of the measuring point.

17) Oil pressure

- a) normal ..... bar
- b) minimum when idling at an ambient of 35 °C ..... bar

with indication of the measuring point

18) Oil consumption at rated output (if measurable) ..... kg/h

19) Oil flow at rated output ..... l/min

- 20) Permissible maximum air inlet pressure loss ..... mbar  
 If the air is drawn into the gas turbine through separate ducts and there is no pressure equalization before entering the gas turbine, the permissible maximum pressure difference between the ducts must be shown.
- 21) Permissible maximum exhaust back pressure, with indication of the measuring point ..... mbar
- 22) Number and types of compressors (number of stages for each)
- 23) Total pressure ratio of the compressors at rated output
- 24) Type and number of combustion chambers
- 25) Types of injection and combustion
- 26) Types of igniters where these are separate from the injection system
- 27) Number and type of turbines (number of stages for each one)
- 28) Starting system (starter type, output and supply voltage)
- 29) Breakaway torque at 5 °C ..... N/m
- 30) Minimum firing speed at 5 °C ..... r.p.m
- 31) Maximum firing speed at 5 °C ..... s
- 32) Self-sustaining speed at 5 °C ..... r.p.m
- 33) Idling speed ..... r.p.m
- 34) Time to attain idling speed ..... s
- 35) Time to attain 97% of the rated speed ..... s

- 36) Minimum no-load speed (idling) of the gas generator ..... r.p.m
- 37) Permissible maximum speed  
 of the generator ..... r.p.m  
 of the free turbine (where applicable) ..... r.p.m
- 38) Speed ranges which must not be used continuously in service, if any ..... r.p.m
- 39) Permissible drop in speed of the gas generator at the end of the period between overhauls ..... r.p.m
- 40) Speed increases, temporary and permanent, at output shaft, when full load is tripped off (rated output) ..... r.p.m
- 41) Temporary speed variations of the gas generator above the rated output and below the idling speed, due to functioning in accordance with the prescribed load cycle ..... r.p.m
- 42) Thermal balance (mechanical equivalent) ..... kW
- 43) Anticipated time between overhauls (TBO) ..... h  
 Indicating those parts limiting the TBO.
- 44) Time between inspections ..... h
- 45) Anticipated service life of the major components ..... h
- 46) Necessary auxiliary equipment (compressed air supply, electrical energy etc.)
- 47) Manufacturer's scope of supply
- 48) Indication of the devices incorporated to prevent difficulties caused by irregular variations in pressure and temperature in the air intake.

49) Permissible maximum turbine inlet temperature on starting or under transitory conditions (to be specified on a temperature-time diagram).

°C

Under transitory conditions, the maximum temperature variation must not exceed the additional temperature permitted for the overload test (maximum 16 of Appendix 3).

50) Overall noise level (if possible)

- idling, under no-load
- at rated output

dB (A)  
dB (A)

under conditions of measurement as specified in Article 21 k).

10) Gas turbine characteristic curves

1°) The following are to be shown in the atmospheric conditions in Chapter 3-4a, in relation to the speed of the gas turbine output shaft from the nominal speed down to the minimum working speed :

- a) The specific fuel consumption expressed in g/kWh, either for the various output settings (single shaft turbine) or for various speeds of the gas generator (free turbine) between the power at idling speed and the maximum output (including the rated output).
- b) The output (or torque), either for the same settings (single shaft turbine) or for the same speeds of the gas generator (free turbine).
- c) The curve of the fuel consumption on no load in kg/h starting from the minimum idling speed.

d) The curve of the maximum permissible torque.

e) The pumping limit of the compressor and the maximum speed gradient (r/min/s) permissible on acceleration and deceleration.

2°) If the gas turbine has one or more air bleed pipes from the compressor(s), the above characteristics shall be established with and without the bleed cocks open, indicating the zones of functioning corresponding to both these cases.

3°) The following shall be indicated :

a) *in relation to the ambient temperature for a given barometric pressure (Appendix 4) :*

The ratio between the output under full load at this temperature and the rated output under the atmospheric conditions in Chapter 3-4a. The output setting is that for which the turbine develops its rated output.

b) *in relation to the atmospheric conditions and pressure losses at intake and exhaust of the machine (Article 4b).*

The correction formulae to be applied to the characteristics in paragraph 1, also the output characteristic in relation to t6.

c) *in relation to the output, in corrected co-ordinates :*

- the input temperature of the turbine (t6).

If this temperature t6 cannot be measured, the manufacturer must supply formulae (or diagrams) to calculate it.

- the hourly fuel consumption,

- the speed of the gas generator (for free turbine gas turbines).



## 11 - Protection systems

Protection devices are required for the following parameters :

- 1) Overspeed (upper limit).
- 2) Maximum temperature of the gases ( $t_6$ ) on input at the first stage of the turbine in continuous operation and on starting.

If the temperature  $t_6$  is not directly measurable, the manufacturer must define a representative measuring point for  $t_6$ .

- 3) Oil pressure (lower limit).
- 4) Oil temperature (upper limit) if the difference between the functioning temperatures and the limiting temperature is negligible.

## B - RULES FOR THE ACCEPTANCE OF GAS TURBINES

### 6 - GENERAL

#### 12 - Gas turbine nameplate

Each gas turbine must bear a metal plate showing the name of the manufacturer, the type of gas turbine, the serial number, the rated output, the rated speed and the year of manufacture.

#### 13 - Direction of rotation of the gas turbine

The direction of rotation of the gas turbine must be defined on a clockwise basis, from the free end of the output shaft.

### 7 - ACCEPTANCE

#### 14 - Condition of the gas turbines on submission

If a gas turbine requires running in or calibration (adjustment of the fuel setting), these must take place before submission for tests.

The gas turbine must be calibrated to ensure compliance with the tolerance  $\pm 1.5\%$  on the speed of the gas generator at rated output under the atmospheric conditions in Article 4a.

#### 15 - Acceptance

The acceptance of gas turbines comprises :

- a) inspection during manufacture if required,
- b) acceptance tests :
  - ba) type test,
  - bb) routine test,
- c) final acceptance.

### 8 - INSPECTION DURING MANUFACTURE

#### 16 - Inspection during manufacture

The construction of the gas turbines and their components may be supervised at the factory by the purchaser or his representative, in accordance with the conditions of the contract.

## 9 - TYPE TEST FOR GAS TURBINES

### 17 - Scope

In principle, the type test must be made on at least one gas turbine of the first batch of a new type.

If provided for in the contract, the type test shall also be made on gas turbines of a type already in use, when an important modification has been made.

The gas turbines to be subjected to the type test shall be selected from the total delivery by the purchaser or his representative.

In the event of submission of the only available example of a prototype gas turbine, the type test may be authorised as an exceptional case. This circumstance must be clearly mentioned at the beginning of the test report.

In general, acceptance shall take place on the test-bed of the manufacturer.

### 18 - Performance of type test

#### a) Fuel and oil

The type test shall be made :

- with a diesel fuel possessing the following characteristics :

- 1 - No foreign matter or determinable quantities of free mineral acids, transparent at normal temperature (no cloudiness).

- 2 - The sulphur content must be at least equal to 0.3% by mass,
- 3 - The Conradson test (on residuum of 10% and calculated as a mass of this residuum) must be at least equal to 0.03%.
- 4 - Maximum water content : 0.05%.
- 5 - Content by mass of contaminating substances : The content of contaminating substances (Va, Ca, K, Na, Pb) shall be checked in order to make sure that it remains within the averages of commercial diesel fuel,
  - with an oil selected from a list prepared by the manufacturer and possessing the standard qualities of commercial oil produced by at least two different suppliers.

#### b) Atmospheric conditions

Atmospheric pressure, ambient temperature and the relative humidity of the air are measured at a specific distance from the gas turbine inlet to ensure that it does not affect the readings. If the atmospheric temperature is lower than 15° , it is compulsory to raise the air supplied to this temperature.

The output of the gas turbine must be corrected for variations in the ambient conditions in relation to the conditions in Chapter 3-4a.

For this purpose, the correction formulae supplied by the manufacturer in accordance with Chapter 5-10, paragraph 3b, must be used.

All the official readings shall be taken in full, in all cases, so that they are available to assist with assessment of the test if required.

c) Recording of the characteristics and testing of the test-bed

The type tests consist, in the following order, of:

- 1 - A record of all the working characteristics shown in the table (Article 9) (1) and the curves (Article 10) of Chapter 5.
- 2 - The endurance test, consisting of continuous operation for 60 hours carried out as under and in the following order:
  - 20 hours at international rating,
  - 1 hour on overload,
  - 19 hours at partial load,
  - 20 hours at intermittent load.
- 3 - During the overload test, the gas turbine shall operate at the permissible maximum temperature  $t_6$  at input of the turbine (point B of Appendix 3). This maximum temperature shall be 40 °C above nominal working temperature  $t_{6n}$  at the same point (Point A of Appendix 3). The variation of  $t_6$  maximum in relation to the ambient temperature is given in Appendix 4. The overload test is carried out:
  - during the first 45 minutes at the maximum torque on the output shaft indicated in Article 10 - 1d.
  - during the last 15 minutes at the maximum permissible speed of the output shaft indicated in Article 9, point 37, unless, at this point of functioning, the maximum permissible speed of the gas generator, indicated in Article 9, point 37, is exceeded. In this case, the working point at  $t_6$  max corresponds to this maximum speed.

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(1) If the verification of the torque 29, and speed 30 - 32 and time 31, is not possible at  $\pm 5$  °C, it shall be replaced by the measuring of this torque, speed and time at the lowest possible temperature after prolonged stopping of the gas turbine. The temperature at which the verifications take place shall be noted in the test report.

Tests under partial load must be carried out in decreasing order. The test shall comprise at least four equivalent periods of operation at speeds ranging between the rated speed and the minimum working speed of the output shaft, and at the maximum torque indicated on the curve referred to in Article 10 (paragraph 1d).

The test under intermittent loads shall include, for the complete test period, without interruption, alternate running for three minutes at rated output and three minutes at idling speed on no-load. The re-acceleration to attain the rated output and the reduction in load must be effected by operation of the controls enabling the maximum permissible speed gradient indicated in Article 10 of Chapter 5 (paragraph 1e), to be obtained.

During the course of these performance tests, the gas turbine must function practically without smoke at all loads and on no-load.

19 - Accidental interruptions

During the 60-hour type test, a maximum of two interruptions necessitated by manufacturing defects will be permitted, but none of these shall exceed 20 minutes between the interruption of the test and the restarting of the gas turbine, it being understood that the test conditions shall be obtained within the minimum time allowed by the testing plant. The period of the type test will be prolonged by the extent of these interruptions.

If, however, it becomes necessary to interrupt a test due to a cause not dependent upon manufacture, the purchaser or his representative shall decide whether the test must be recommenced or merely prolonged for a period at least equal to that of these interruptions.

In all cases, and whatever the cause of the interruptions, the latter shall not exceed three during the course of the type test, it being understood that an interruption due to a cause not dependent upon manufacture, shall count as two if the manufacturer takes advantage of the interruption to rectify slight constructional defects and has not requested, in addition, a delay of more than 20 minutes.

**20 - Assessment of results of the type test**

After the 60-hour test, the gas turbine shall be stripped in the presence of the purchaser or his representative. All parts shall be checked. In order to determine the extent of wear, the exact dimensions of these parts must have been noted during assembly of the gas turbine.

If the results of the 60-hour acceptance test or the conditions of the gas turbine after the test are not satisfactory, the gas turbine shall not be accepted.

If the type test is to be re-run, the purchaser may request that it be done on a different gas turbine which he will select. If defects are found, these shall be put right by the manufacturer.

**21 - Recordings to be made during the tests**

*a) Intervals at which the recordings shall be made*

During the 60-hour endurance test, periodical readings shall be taken to permit the preparation of a complete test report.

These readings shall be made respectively at the following intervals:

- during the 20-hour test at the rated output each hour
- during the overload test every quarter of an hour
- during the 19-hour test under partial load each hour
- during the 20-hour test under intermittent loads :
  - at the rated output each hour
  - idling, under no-load every three hours

*b) Measurement of speed*

The turbine speeds (gas generator and free turbine, where applicable) shall be measured with a revolution counter in addition to a recording tachometer.

*c) Measurement of temperature t<sub>6</sub>*

The measurement of temperature t<sub>6</sub> shall be recorded. If it cannot be directly measured, the representative temperature defined in Article 11 shall be recorded.

*d) Fuel consumption*

Fuel consumption is expressed in g/kWh under load and in kg/h at no-load respectively.

The precision of the measuring instruments and the method used must enable this consumption to be measured within a limit of approximately  $\pm 2\%$ .

The latter must not exceed the consumptions stated in the curves of Chapter 5.

When the fuel used has a lower calorific value different from that of the basic fuel, the recorded consumption is to be converted by means of the following formula :

$$\frac{\text{measured fuel consumption} \times \text{actual lower calorific value}}{10\ 000}$$

The weight of any fuel from leaks is to be determined and recorded. It shall be included in the fuel consumption if it is not normally recoverable.

*e) Measurements relating to lubricating oil*

Oil must not be consumed to a measurable extent, and the oil level must not reach the lower limit at any stage in the tests.

During the 20-hour test at rated output and the 1 hour overload test, the oil pressure and temperature at the points indicated in the table of technical information in Chapter 5 - Article 9, shall be recorded.

During the acceptance test, the lubricating oil shall be used in closed circuit, as in normal service conditions. No additional pump shall be allowed.

During the acceptance test, the temperature of the lubricating oil shall be maintained at the normal value shown in the table of Article 9 of Chapter 5.

*f) Measurement relating to cooling air*

The gas turbine shall be provided with a graduated air inlet pipe for measuring the flow.

*g) Temperature of the exhaust gases*

The temperature and composition of the gases in the exhaust pipe(s) shall be measured in relation to the engine setting.

The speed of the exhaust gases can be measured or calculated.

*h) Speed governor and variations in the speed of the gas turbine relative to its operation.*

The following provisions concern single shaft gas turbines.

They also apply to free-turbine gas turbines if they incorporate a speed governor for the free turbine. These provisions relate to this governor.

A distinction must be made between :

- 1) The instantaneous speed variation: *drs*, i.e. the maximum instantaneous variation in speed, expressed as a percentage of the rated speed, after the rated load has been quickly reduced to zero, or vice versa :

$$drs = \frac{\text{Maximum speed} - \text{rated speed}}{\text{Rated speed}} \times 100$$

2) The permanent speed variation  $dr$ , or governor droop, i.e. the permanent speed variation expressed as a percentage of the rated speed, after a gradual variation of the load from the rated load to zero or visa versa, obtained without altering the position of the governor :

$$dr = \frac{\text{Maximum no-load speed} - \text{Rated speed}}{\text{Rated speed}} \times 100$$

In order to assess the instantaneous speed variation of the gas turbine under the control of its governor, the variation in speed noted after the sudden removal of all load (or equivalent operation) is measured, the gas turbine having previously attained a steady operating condition.

At the rated speed, and for sudden removal of the rated load, this instantaneous speed variation must not exceed 10% of the rated speed.

For the other speed ranges, the instantaneous speed variation shall be determined by the purchaser in each particular case, in relation to the purpose for which the gas turbine is intended.

In order to assess the governor droop at the rated output, the output is varied gradually between the rated value of the latter and zero, the speed being read during steady conditions of operation before and after the above mentioned gradual variation, without using the governor.

The purchaser shall decide whether it is necessary to lay down conditions concerning the permanent speed variation in relation to the purpose for which the gas turbine is intended.

*i) Heat balance*

The heat balance of the gas turbine for the rated output shall be determined under steady-state conditions. The heat diagram must show, for the balancing procedure, the following calorific values, expressed in kW :

- of the fuel consumed,
- at the output shaft,
- dissipated by the lubricating oil of the gas turbine,
- carried away in the exhaust gases,
- lost by radiation.

*j) Noise spectra at idling and at rated output recorded in the open :*

- at 1 m distance along the centre line of the air intake,
- at 1 m from the exhaust pipe end, laterally and vertically.

**22 - Type test report**

The type test shall be the subject of a comprehensive report containing all the readings.

## 10 - ROUTINE TEST FOR GAS TURBINES

### 23 - Scope

The routine test is to be carried out for all gas turbines, except those which have been submitted to the type test. Acceptance will take place on the test-bed of the manufacturer.

### 24 - Acceptance test

The routine test will include recording characteristics and an operational test at four different load levels each lasting 10 minutes under the general conditions specified for the type test. One of these levels shall correspond to the rated output, corrected in relation to the ambient conditions (1). Only one interruption, of a maximum of 20 minutes shall be permitted.

### 25 - Determination of characteristics on the test-bed

During the routine test, the following readings will be taken in corrected co-ordinates :

- a) the relationship between the output and temperature  $t_6$  at the input of the turbine,

(1) When stipulated in the contract, this level can correspond to the maximum service output, this output being corrected under the same conditions.

- b) the relationship between the output and fuel consumption.

The following will be recorded at each load level :

- a) the temperature of the lubricating oil,
- b) the pressure of the lubricating oil in accordance with the conditions of Chapter 9, Article 21e.

If the characteristic between the output and temperature  $t_6$  is not obtained, recalibration must be carried out, so that the rated output is obtained without exceeding by more than 15 ° the temperature level at the input of the turbine, as fixed by the characteristic curve (Article 10), while complying with the condition in Chapter 7 - Article 14 regarding the speed of the gas generator.

The oil consumption must be recorded at the end of the test. The reading of the oil level must not show any appreciable consumption.

### 26 - Final setting

After the routine test, the settings limiting the output (maximum flow of fuel, maximum setting of the gas generator or of the single shaft turbine) shall be fixed at the values corresponding to the maximum service output, in order to limit to the maximum the reduction of this output in relation to the ageing of the gas turbine.

### 27 - Check after routine test

After the routine test, the gas turbine must be inspected generally, without dismantling, using endoscopic systems, where applicable.

**28 - Acceptance certificate**

The acceptance test details shall be shown on an acceptance certificate (see Appendix 1).

**11 - FINAL ACCEPTANCE**

**29 - Final acceptance**

If the gas turbine is to be installed on a vehicle in course of construction, final acceptance of the gas turbine shall take place on termination of the running test of this vehicle.

In the case of spare gas turbines, final acceptance is made on termination of the type test or the routine test on the test-bed.

**12 - GUARANTEE**

**30 - Guarantee**

The conditions relative to gas turbine guarantees are specified by the purchasing Railway at the time of concluding the contract.

Appendix 2 defines the guarantee conditions recommended for inclusion in the contract.

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ACCEPTANCE CERTIFICATE FOR GAS TURBINES

Rated output kW  
 Rated speed of the gas generator rev/m.  
 Rated speed of the free turbine rev/m.  
 Maximum speed of the free turbine (setting of the overspeed protection device) rev/m.  
 No-load idling speed rev/m.  
 Pressure ratio of the compressors at rated output  
 Time needed to attain idling speed s  
 Time needed to attain rated speed s  
 Time to reach self-sustaining speed s

Type

Name of manufacturer  
 Type of turbine  
 No. of the turbine  
 Governor Type  
 Fuel  
 Specific mass of the fuel kg/m<sup>3</sup>  
 Minimum calorific value of the fuel kJ/kg  
 Turbine lubricating oil  
 Oil consumption kg/h

Serial No.	Date	Running time		Output				Fuel consumption			Turbine lubricating oil		Temperature of gases °C			Air		Remarks	
		from	to	Turbine speed in rev/m		Brake weight kg	Turbine torque mdaN	Output kW	Quantity kg	Duration of run min	specific fuel consumption kg/kWh	Pressure bar	Temperature °C	Input first stage turbine 16	Input free turbine 17	Exhaust pipe 19	Pressure ratio $\frac{p_5}{p_1}$		Air flow G Kg/s
				gas generator	free turbine														
	19																		

During the above test, the atmospheric conditions were :  
 Atmospheric pressure  $p_n =$  mbar.  
 Air temperature  $t_n =$  °C  
 Relative air humidity  $\phi =$  %  
 Height of test site above sea level m

Turbine tested with - without  
 generator (1)  
 fan (1)  
 oil pump (1)  
 (1) Delete those not required

Remarks and any further particulars  
 No failures were noted during the above ... hour test  
 The turbine is in running order and may be despatched  
 Name of purchaser ..... 19  
 (date)

(Inspector's signature)

LENGTH OF VALIDITY AND SCOPE OF  
THE GUARANTEE FOR GAS TURBINES  
FOR TRACTION

1 - Length of validity of the guarantee

The guarantee for the gas turbine commences with the day of final acceptance and continues through a total running length of 150 000 km, although the length of validity of the guarantee may not exceed one calendar year. The purchaser is responsible for keeping a record of the distance run.

The length of validity of the guarantee for gas turbines which have been newly designed and for which operating data are still lacking is to be specially agreed between the purchaser and the manufacturer of the gas turbine in question.

2 - Extension of the guarantee period

If, during the guarantee period, the gas turbine is withdrawn from service to undergo repairs covered by the guarantee, the period of one year is extended in this case by the duration of these stoppages. The contractual guarantee expires, however, when the total distance of 150 000 km has been reached.

If, during the period of validity of the guarantee, similar faults arise in several gas turbines of the same type, belonging to the same delivery order, and if these faults endanger the correct running of the gas turbines, the purchaser has the right to extend the guarantee period for the contested gas turbines or for all the gas turbines belonging to the same order, to the extent of a further running distance of 150 000 km or, alternatively, by a further calendar year.

The preceding regulations apply equally to spare gas turbines.

Where gas turbines are not fitted into their respective vehicles immediately following delivery, the length of validity of the guarantee is increased to a maximum of 18 months, calculated from the time at which the gas turbines are handed over to the purchaser. However, the guarantee will still terminate after 150,000 kms, if this occurs within 18 months. The validity of the guarantee expires after 18 months, even if the gas turbines have not been put into service in the meantime.

Where gas turbines are replaced by the manufacturer in accordance with the terms of the guarantee, the latter is liable for the replaced gas turbine only up to the completion of the running distance or, alternatively, until expiry of the period of validity of the guarantee.

3 - Scope of the guarantee

The supplier is liable for faults in design, materials and assembly of all the gas turbines and gas turbine parts supplied by him. In addition, he is also responsible for the repair of damage caused by faults in other parts of the gas turbine which are covered by the terms of the guarantee.

The supplier is further liable for all costs accruing to him as a result of the guarantee obligation, for repairs or the furnishing of new parts, including costs of conveyance. The costs of removing and installing the gas turbine are borne by the purchaser, whereas the costs of dismantling and remounting the gas turbine are borne by the supplier.

The cost for parts which need to be repaired or replaced as a result of natural wear must be borne by the purchaser.

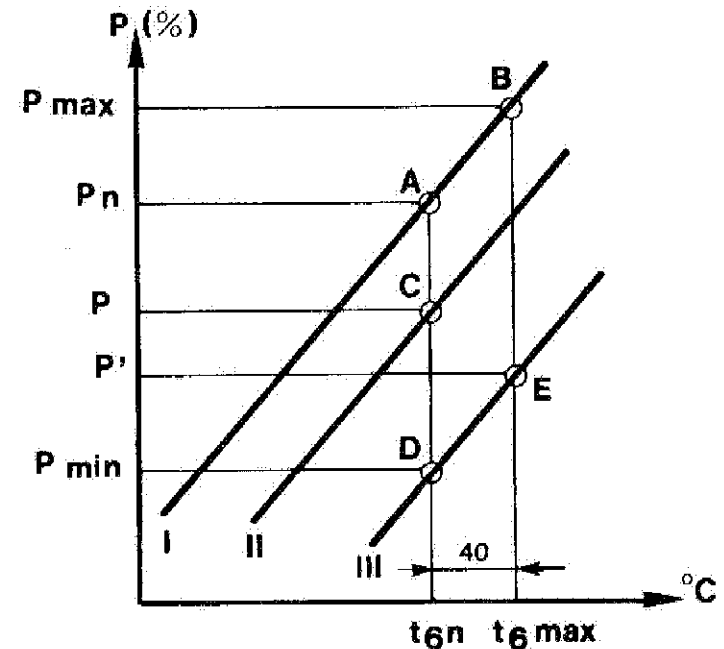
When, as a result of damage covered by the terms of the guarantee, further damage is caused to the gas turbine which could have been avoided by regular supervision and prompt withdrawal from service of the gas turbine in question, the purchaser must bear the costs of the additional repair work resulting therefrom.

Upon the appearance of a more serious fault, for the correction of which the terms of the guarantee are invoked, the manufacturer should be advised prior to the dismantling of the gas turbine in order that the cause of the fault which has occurred may be jointly determined and that the place where it will be repaired and the nature of the work to be done be simultaneously decided upon; the supplier is obliged to declare, within a period stipulated by the purchaser, whether this work is to be carried out in his own workshops, or if he is in agreement that the work be performed at his cost in the purchaser's workshops.

In urgent cases the purchaser has the right to correct minor faults without prior negotiation, provided repair costs, including overheads, do not exceed 5/100th of the purchase price of the gas turbine. The supplier must be advised of this immediately, however.

APPENDIX 3

OUTPUT CHARACTERISTICS



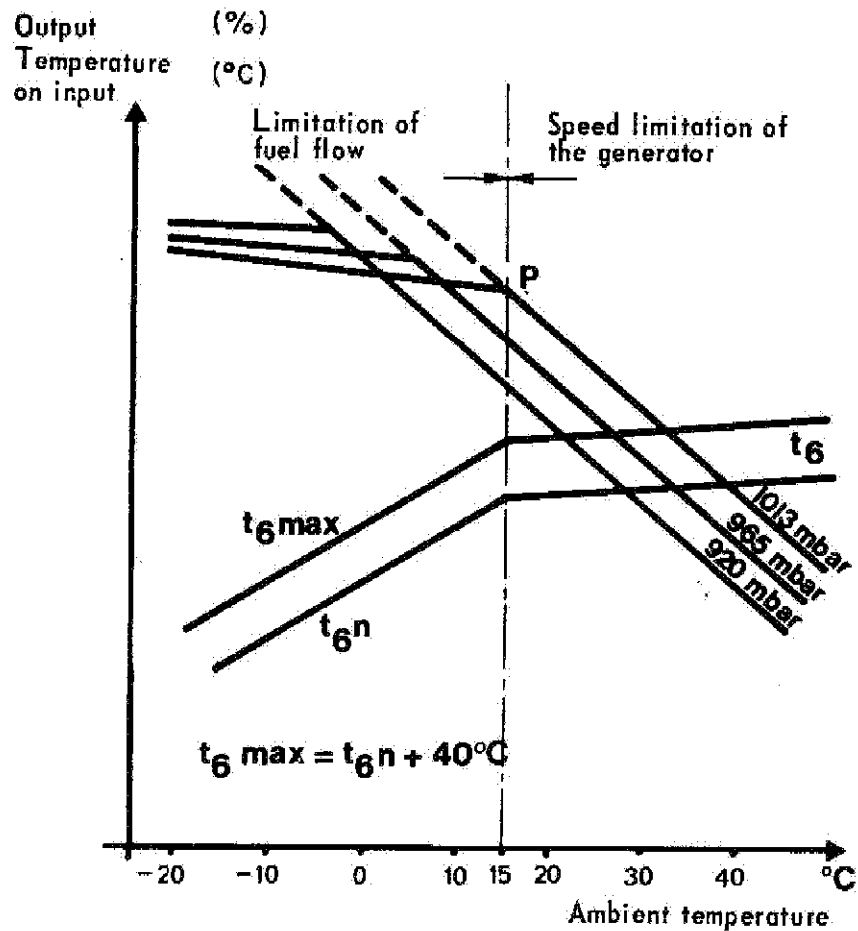
Temperature of the gases ( $t_6$ ) on input at the first stage of the turbine.

Key :

- I - New gas turbine on the test-bed without pressure losses
- II - New gas turbine on vehicle
- III - Gas turbine on vehicle at the end of an overhaul period

- $P_{max}$  (Point B) Maximum output which the gas turbine can develop for 1 hour without damage (Article 18 c)
- $P_n$  (Point A) International rating (Article 3)
- $P$  (Point C) Maximum service output (Article 7)
- $P'$  (Point E) Useful output at the end of an overhaul period
- $P_{min}$  (Point D) Minimum useful output guaranteed at the end of an overhaul period.

RATIO BETWEEN OUTPUT, TEMPERATURE  
ON INPUT AND AMBIENT TEMPERATURE



APPLICATION

With effect from 1 January 1976.

All Railways in the Union.

RECORD REFERENCES

Heading under which the question has been dealt with :

- Gas turbines for rail traction

( Traction and Rolling Stock Committee : Edinburgh, June, 1975).