**First dynamic behaviour tests at 300 km/h of the new multi-voltage ETR 500 high speed train on the 3 kV Italian high speed line**

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**Summary**

The multi-voltage ETR 500 will operate at 300 km/h the new 25 kV high-speed lines in Italy and the link between Italy and France. The paper presents the first dynamic behaviour tests to pass the 300 km/h threshold on the Italian 3 kV high speed lines.

**Abstract**

The new multi-voltage ETR 500, with 1.5 and 3 kV d.c. and 25 kV a.c. traction system and a top speed of 300 km/h, has been designed to achieve a double aim: to operate the high speed network and the 3kV traditional lines in Italy and to enable operations between Italy and France on the French high speed and traditional lines.

After the acceptance tests and the dynamic behaviour tests required by the UIC standards, the new ETR 500 was homologated at 250 km/h and the first trains of the fleet have started operations on Direttissima line on May 2000. As the new high speed lines are not yet available in Italy for the dynamic acceptance at 300 km/h, the complete acceptance tests have been planned on the French 25 kV high speed lines on 2002, while a reduced session at 300 km/h has been carried out on the Italian 3 kV Direttissima line on September 2000.

The purpose of these tests was to achieve a preliminary verification of the dynamic behaviour and of the performances of the ETR 500 when it runs at 300 km/h on the 1/20 track. The tests have been undertaken on a train consisting of 2 locomotives and 8 trailer cars, the normal configuration that will operate between Italy and France. The main dynamic parameters as well as the braking performances and the pantograph motion have been measured and monitored. The measurements required by the UIC standards to verify safety, track fatigue and ride quality, together with many other measurements, were undertaken on a locomotive and on a trailer car.

The test-runs were carried out on a line section of 53 km between Firenze and Arezzo, where speeds up to 300 km/h are allowed under test conditions. On several test-runs the speed was maintained over 300 km/h for a distance of about 12 km, while the maximum speed achieved in the tests was 320 km/h. It was the first time in Italy that the speed of 300 km/h was achieved and passed with a train normally used in operations. An overview on the tests and on the dynamic results about is presented in the paper.

**Keywords**

Dynamic behaviour, high speed trains, wheel rail forces, full-scale tests
1 Introduction

The Italian high-speed network will include a north-south line linking Milano to Firenze, Roma and Napoli and a west-east line linking Torino to Milano and Venezia. The Direttissima line is the section now in service linking Roma to Firenze. It has a 3 kV d.c. feeding system and it is operated at a speed of 250 km/h. The rest of the network, now under construction with a 25 kV a.c. feeding system, will be completed in the next years and it will be operated at 300 km/h. Operations on the new high-speed lines will be undertaken by a fleet of 30 new ETR 500 high speed trains.

The new multi-voltage ETR 500, with 1.5 and 3 kV ac and 25 kV ac traction system and a top speed of 300 km/h, has been designed to achieve a double aim: to operate the high speed network and the 3kV traditional lines in Italy and to enable operations between Italy and France on French high speed and traditional lines.

After the acceptance tests and the dynamic behaviour tests required by the UIC 518 code, the new ETR 500 was homologated at 250 km/h and the first trains of the fleet started operations on Direttissima line on May 2000. As the new high speed lines are not yet available in Italy for the dynamic acceptance at 300 km/h, the complete acceptance tests were planned on the French 25 kV high speed lines on 2002 and 2003, while two reduced sessions up to 300 km/h and 320 km/h were carried out on the Italian 3 kV Direttissima line on August - September 2000 and May - June 2001.

The purpose of these tests was to achieve a preliminary verification of the dynamic behaviour and of the performances of the ETR 500 when it runs at 300 km/h on 1/20 track. Such tests were undertaken on a train with 2 locomotives and 8 trailer cars, the normal configuration that will be used for operations between Italy and France. The main dynamic parameters as well as the braking performances and the pantograph motion were measured and monitored. On a locomotive and on a trailer car FS Trenitalia undertook all the measurements required by the UIC codes to verify safety, track fatigue and ride quality, together with many other measurements related to the bogie elements. To this sake, two wheel-sets on a locomotive and other two on a trailer car were instrumented with strain gages and telemetry systems to measure the wheel-rail contact forces. The running behaviour of the other cars was verified by accelerometers. An overview of the tests and the main results is presented in the paper.

2 The multi-voltage ETR 500 high speed train

The multi-voltage ETR 500 is the second generation of the ETR 500 high-speed train operating in Italy (the first series was a mono-voltage type). The train is manufactured by the TREVI consortium, that joins the main Italian manufacturers.

The main features of the multi-voltage ETR 500 are listed in Table 1. The figure 1 shows the graphs of the traction curves of the ETR 500 locomotive.

While no differences exist between the trailer cars of the mono and the multi-voltage series, the locomotive is completely new. As regard the electric equipments, the main difference with the first series is the possibility to feed energy at three different voltages: 3 kV dc (as the first series), 25 kV ac and 1.5 dc, that is all the voltages existing on the traditional and on the high speed lines in Italy and in France. As regard the bogies, the main difference is the central pivot applying traction and braking forces (instead of the traction rod). Finally, a more streamlined nose improves the aerodynamic features of the locomotive.

The figure 2 shows a side view of the nose of the locomotive.
Table 1   Main features of ETR 500 Politensione series

<table>
<thead>
<tr>
<th>ETR 500 Politensione features</th>
<th>Locomotive</th>
<th>Trailer car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration for Italian routes</td>
<td>2 locomotives and 11 trailer cars - Length 328.0 m</td>
<td>-</td>
</tr>
<tr>
<td>Configuration for Italy – France routes</td>
<td>2 locomotives and 8 trailer cars – Length 249.7 m</td>
<td>-</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>3 kV dc</td>
<td>25 kV ac</td>
</tr>
<tr>
<td>Working voltage:</td>
<td>2 x 4</td>
<td>19 = 27.5</td>
</tr>
<tr>
<td>Continuous power at rim [ kW ]</td>
<td>4400 x 2</td>
<td>3300 x 2</td>
</tr>
<tr>
<td>Traction force at leaving [ kN ]</td>
<td>170</td>
<td>170</td>
</tr>
<tr>
<td>Maximum speed [ km/h ]</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Lowest speed at constant power [ km/h ]</td>
<td>164</td>
<td>125</td>
</tr>
<tr>
<td>Recovery braking power [ kW ]</td>
<td>4400 x2 - V&gt;185</td>
<td>4400 x2 - V&gt;185</td>
</tr>
<tr>
<td>Maximum force with recovery braking [ kN ]</td>
<td>84 x2 - V&lt;185</td>
<td>84 x2 - V&lt;185</td>
</tr>
<tr>
<td>Braking power with rheostat [ kW ]</td>
<td>3750 x2 - V&gt;185</td>
<td>3750 x2 - V&gt;185</td>
</tr>
<tr>
<td>Maximum force with rheostat braking [ kN ]</td>
<td>84 x2 - V&lt;160</td>
<td>84 x2 - V&lt;160</td>
</tr>
<tr>
<td>Vehicle features</td>
<td>Locomotive</td>
<td>Trailer car</td>
</tr>
<tr>
<td>Motors</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Bogie type</td>
<td>2 motors</td>
<td>2 level vertical suspens.</td>
</tr>
<tr>
<td>Gear type</td>
<td>Omokykinetic with double quill fully suspended</td>
<td>-</td>
</tr>
<tr>
<td>Traction and braking force transmission type</td>
<td>Central pivot</td>
<td>-</td>
</tr>
<tr>
<td>Seats</td>
<td>-</td>
<td>first class cars: 52</td>
</tr>
<tr>
<td>-</td>
<td>second class cars: 68</td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>4000 x 3020 x 20460 mm</td>
<td>3800 x 2860 x 26100 mm</td>
</tr>
<tr>
<td>Distance between pivots</td>
<td>11450 mm</td>
<td>19000 mm</td>
</tr>
<tr>
<td>Wheel-base</td>
<td>3000 mm</td>
<td>3000 mm</td>
</tr>
<tr>
<td>Wheel diameter (new profiles)</td>
<td>1040 mm</td>
<td>890 mm</td>
</tr>
<tr>
<td>Mass</td>
<td>67200 kg</td>
<td>44500 kg</td>
</tr>
<tr>
<td>Bogie mass</td>
<td>8900 kg</td>
<td>6380 kg</td>
</tr>
</tbody>
</table>

Figure 1   Traction curves of the multi-voltage ETR 500 locomotive
On 1999 a four months campaign was undertaken in Italy for the acceptance tests of the multi-voltage ETR 500 from the point of view of the dynamic behaviour. The train was accepted for an operating speed of 250 km/h and a permissible cant deficiency of 150 mm.

The fleet of 30 trains started to operate on May 2000. The operations in Italy are carried out with a train-set consisting of 2 locomotives and 11 trailer cars. The test campaign at 300 km/h has been carried out on the configuration that will operate on the Italy – France routes, which consists of 2 locomotives and 8 trailer cars.

3 The test line

The actual Italian high speed line, the Direttissima line, links Firenze to Roma and allows operations at a maximum speed of 250 km/h. The line was built with rails laid at 1/20 and with a feeding system at 3 kV d.c. voltage.

The tests were undertaken in the section between Firenze and Arezzo that is long about 53 km. In this section a speed up to 320 km/h is allowed under test conditions within a segment of 17 km. As some curves have a radius of 3875 m and a cant of 135 mm, a cant deficiency of 175 mm can be achieved at the speed of 320 km/h. This cant deficiency is 15 % higher than the design and the acceptance value of the ETR 500. The figure 3 shows the maximum allowed speeds within the test section, the slope of the line and also the non-compensated acceleration achieved at the maximum speed.

FS RFI (the Italian infrastructure manager) allowed the tests with two main constraints. The first condition was that the operations had to stop within the test line, so that both tracks were free of trains within the whole section of 53 km. The safety about braking required not to have other trains on the current track of the test-runs; as several
double track tunnels with a cross section of 69 m$^2$ exist on the test line, the health requirements about pressure in tunnels required not to pass trains running on the other track of the line.

As second constraint, the Italian infrastructure manager required to check the state of the tracks and the catenary by means of its monitoring vehicles, before restarting the operations after the end of each test session.

4 The test runs

The test campaign was divided in two phases, the first one undertaken between August and September 2000 and the second one between May and June 2001. A total of 64 test-runs were carried out in the two phases. As the line is overcrowded by a mixed traffic of high speed, IC and IR trains during the daytime, all the test-runs were carried out by night.

The objective of the first phase was to achieve the evidence that the dynamic behaviour of the ETR 500 satisfies the safety requirements in the speed range from 250...
km/h to 300 km/h. A total of 32 test-runs were planned on 4 nights on both directions of the line. On each night 4 test-runs were repeated on the direction Arezzo – Firenze and 4 on the direction Arezzo – Firenze with the following sequence of speed: 250 km/h, 280 km/h and two times 300 km/h. In this phase the speed of 300 km/h was maintained for a whole distance of about 50 km. Moreover, on the 7th September 2000 the ETR 500 achieved the speed of 310 km/h on the direction Arezzo – Firenze, that is the highest speed reached in Italy with a train in operations.

The objective of the second phase was to verify and collect data about the dynamic behaviour of the ETR 500 at speeds higher than 300 km/h. Also in this phase 32 test-runs were planned on 4 nights on both directions of the line. On each night 4 test-runs were repeated on the direction Arezzo – Firenze and 4 on the direction Arezzo – Firenze with the following sequence of speed: 250 km/h, 280 km/h, 300 km/h and 320 km/h. In this phase the speed was maintained in the range between 300 and 320 km/h for a whole distance of about 80 km. On the 30th May 2001 on the direction Arezzo – Firenze the ETR 500 achieved the speed of 319 km/h, the top speed reached in Italy. This threshold was increased on the 9th June 2001, again on the direction Arezzo – Firenze, to the speed of 320 km/h, the actual top speed on the Italian network achieved within the line segment between km 229 and km 231 (see the figure 4).

![Figure 4 Speed achieved on the direction Arezzo - Firenze](image)

5 The measurements

Even if no acceptance tests at high speed were possible, as the test section was not enough extended, the dynamic behaviour in the high-speed range was verified measuring all the quantities requested by the UIC 518 code for the acceptance tests. Measurements were carried out on a locomotive and on a trailer car.

According to the UIC requirements the wheel to rail forces, the accelerations on the car body and the accelerations on the bogie have to be measured for the assessment of the safety, the track fatigue and the ride comfort. To this sake two wheel-sets of the first bogie of the locomotive and other two on the trailer car were instrumented with
strain gauges and telemetry systems to measure the wheel to rail forces. On the same locomotive and trailer car accelerometers were installed on the bogies and on the car body. In addition, the displacements of the primary suspensions as well as the displacements of the secondary suspensions and the relative displacements between the bogie and the car body were measured on the two vehicles. All the other vehicles were monitored by accelerometers located on each bogie.

The figure 5 shows the main measurements carried out on the locomotive and on the trailer car. The symbols are the same used in the UIC code:

\( Y_{ij} \) lateral force on the wheel \( ij \);
\( Y_j \) sum of the guiding forces on the wheel-set \( j \);
\( Q_{ij} \) vertical force on the wheel \( ij \);
\( Y/Q_{ij} \) derailment coefficient on the wheel \( ij \);
\( y_{++ij} \) lateral acceleration on the bogie frame over the wheel \( ij \);
\( y_{++j} \) lateral acceleration on the car frame over the bogie \( j \);
\( z_{++j} \) vertical acceleration on the car frame over the bogie \( j \);
\( x_{++j} \) longitudinal acceleration on the car frame over the bogie \( j \);
\( z_{ij} \) vertical displacement of the primary suspension of the wheel \( ij \).

**Figure 5** Main measurements on the high-speed tests of the ETR 500 Politensione

6 The statistical analysis of the dynamic data

The UIC standards codify the assessment of the vehicle dynamic behaviour. According to the UIC 518 code the safety and the vehicle dynamics is assessed on the basis of criteria relating to the directly measured parameters and to the quantities that are calculated from the measured parameters. The UIC code requires a statistical analysis of the following assessment quantities:

- the sum of the guiding forces (that is the track shifting force);
- the derailment coefficient;
– the lateral acceleration on the bogie;
– the vertical force of the outer wheels in curves;
– the lateral force of the leading wheel in curves;
– the vertical acceleration on the car body;
– the lateral acceleration on the car body.

The statistical evaluation of the first three quantities enables the assessment of the safety; the evaluation of the forces on the wheels the assessment of the track fatigue and the accelerations on the car body the assessment of the riding quality of the vehicle.

For this analysis the test line is divided into sections with homogeneous geometry (that is tangent track, full curve or curve transition). The length of the sections depends on the train speed. For the high-speed trains the section length is 500 m if they are located on the tangent track and on large radius curves.

Each section identifies a distribution of the values of the assessment quantities. The first step of the statistical analysis is the calculation at each section of the following parameters of the assessment quantities:

– peak values (distribution function values for 0.15% and 99.85%);
– mean values (distribution function values for 50%);
– root mean square values.

At this time, as many data as the line sections have been calculated for each assessment quantity. If the requirements of the UIC 518 code are fulfilled in the tests, the measurements and the analysis produce large databases for the tangent track sections and for the different categories of curve sections. Moreover each database collects data generated by homogeneous conditions of train speed and cant deficiency. According to the UIC code, a one-dimensional analysis is finally carried out to calculate an estimated maximum value that is then compared with the UIC limits.

In the tests of the ETR 500 on the Direttissima line, the speed restrictions and the short length of the test section have produced a limited amount of data not complying the UIC requirements and not allowing the UIC one-dimensional analysis requested for the acceptance tests. Anyway, the available data supply significant information about the running behaviour in the high-speed range and have been analysed with two different statistical methods, a processing per section and a two-dimensional analysis.

The processing per section that has been performed is the same analysis carried out at the first stage of the UIC one-dimensional method. In this analysis the statistical parameters of the measured quantities are calculated in all the sections of the test line. This analysis is used to produce histograms of the statistical parameters that allows a comparison with their limit values at the end of each test runs.

The figure 6 shows the histograms (that is the values at each line section) of the measured quantities related to safety along all the track sections of the test line. The data refer to a test at a maximum speed of 300 km/h on the direction Firenze – Arezzo. In the figure all the safety quantities are normalized with respect to the UIC limit values. From the top to the bottom the figure shows the following quantities of the locomotive:

– the train speed;
– the sum of the guiding forces for the two wheel sets of the rear bogie;
– the derailments coefficients of the leading wheel set of the rear bogie;
– the lateral accelerations on the two bogies over each wheel sets;
– the non compensated acceleration.
Figure 6  Safety parameters of the ETR 500 at 300 km/h on Firenze – Arezzo line
As can be seen in the figure, all the safety quantities stay noticeably below the limits. Similar histograms are produced for the parameters related to the track fatigue and the ride quality. This analysis is aimed to verify real time during the test-runs the safety and the dynamic behaviour of the train and allows an immediate comparison between the data recorded in the different tests.

The two-dimensional analysis is the second processing performed on the high-speed data. The analysis is based upon the data calculated by the processing per section. The data are divided into different populations on the tangent track and on the curves. The rules used to select the data for the statistical parameters are the ones described in the UIC 518 code for the processing per zone. The analysis has been used to determine the influence of the train speed on the populations selected on the tangent track and the influence of the cant deficiency on the populations in the curves.

The two-dimensional analysis has been undertaken for all the parameters required by the UIC 518 code to analyse safety, track fatigue and running behaviour. Both the measurements of the locomotive and the trailer car of the ETR 500 were analysed. The results for the safety and track fatigue of the ETR 500 locomotive are presented in the next sections.

7 The dynamic behaviour at high speed on tangent track

The main factor affecting the dynamic behaviour on tangent track is the geometry of the wheel-rail contact. The wheel profile of the locomotive and the trailer cars of the ETR 500 is the S 1002 type. The S 1002 profiles coupled with the rail profile of the Direttissima line laid at 1/20 produces very low values of equivalent conicity when the wheels are new (as they were on the test train at the time of the test campaign). The figure 7 shows the graphs of the equivalent conicity calculated according to the UIC 519 code for the S1002 profile coupled with the rail profiles laid at 1/20.

A consequence of the excellent dynamic qualities of the ETR 500 bogies and of the low conicity of the wheel-rail contact, is that no unstable behaviour of the train was found on the tangent track in the whole speed range up to 320 km/h. Thus, all the statistical parameters related to safety and track fatigue stay below the UIC limits.

Even if the populations are restricted, the two-dimensional analysis in the figures 8, 9 and 10 gives an overview of the dynamic behaviour on tangent track.

![Equivalent conicity - UIC 519 method](image)

**Figure 7** Conicity of ETR 500 new wheels and UIC 60 rails laid at 1/20
Figure 8  Tangent track - Sum of guiding forces on wheel-sets 1 and 2 – 99.85% values

Figure 9  Tangent track – Bogie lateral acceleration over wheels 11 and 21 – 99.85% values
The analysis has been undertaken to investigate the influence of the train speed. The data analysed on tangent track were measured on a group of tests-runs carried out on the Arezzo–Firenze direction. In this direction the measuring bogie was in front of the train. The values of statistical parameters were calculated on a group of track sections that is the same in the different test-runs. The length of all the sections is 500 m. The speeds of the ETR 500 on these sections in the different test-runs were about the following: 250 km/h, 280 km/h, 300 km/h and 320 km/h.

The figures 8, 9 and 10 show the results of the two-dimensional regression over the speed of the quantities related to safety and track fatigue of the ETR 500 locomotive. Each figure shows the population of data and its linear regression. The blue and green lines plotted in the figures are far from the linear regression 3 or 2.2 times the standard deviation of the data set measured at the speed of about 320 km.

The figures 8 and 9 present the results regarding the safety. The figure 8 shows the 0.15% and 99.85% values of the sum of the guiding forces for the two wheel-sets of the front bogie of the locomotive. The values of both wheel-sets stand below 40% of the Proud’homme limit. As can be seen, the values of the leading wheel-set of the measuring bogie are little affected by the speed, while in the case of the rear wheel-set the values of the regressions increase from 10% of the limit at 250 km/h to 20% at 320 km/h.

The figure 9 shows the 0.15% and 99.85% values of the lateral accelerations on the frame of the first bogie of the locomotive over each wheel-set. The values of both accelerations are below 50% of the limit and their regressions show a limited increase with the train speed.

The figure 10 presents the results regarding the track fatigue on tangent track. The figure shows the 99.85% values of the vertical forces on the wheels of the front bogie of the locomotive. No significant effect of the train speed can be found on this parameter.

8 The dynamic behaviour at high speed in the curves

A two-dimensional analysis on the large radius curves has been undertaken to investigate the influence of cant deficiency on the parameters of safety and track fatigue.
As in the case of the tangent track, the values of the statistical parameters were calculated on a set of track sections that is the same in the different test-runs.

Also in this case the number of track sections is restricted. The curve radius is included in the range between 3875 m and 5952 m and most of the sections have a radius of 4000 m and a cant of 135 mm. To enlarge the populations also sections shorter than 500 m have been analysed. The length of all sections is in the range between 225 m and 500 m.

The data of the large radius curves were measured on a group of tests-runs carried out on the Firenze – Arezzo direction. In this direction the measuring bogie was at the rear of the train. The speeds of the ETR 500 in the different test-runs were about the following: 250 km/h, 280 km/h and 300 km/h. The values of cant deficiency linked to these speeds are included in the range between 40 mm and 140 mm.

The figures in this section show the results of the two-dimensional regression over the cant deficiency of the quantities related to safety and track fatigue of the ETR 500 locomotive. Each figure shows the population of data and its linear regression. The blue and green lines plotted in the figures are far from the linear regression 3 or 2.2 times the standard deviation of the data set at the speed of about 300 km.

**Figure 11**  Large radius curves - Sum of guiding forces on wheel-sets 3 and 4 – 99.85% values

**Figure 12**  Large radius curves – Derailment coefficient of the outer wheels – 99.85% values
The figures 11, 12 and 13 present the results regarding the safety. The figure 11 shows the 0.15% and 99.85% values of the sum of the guiding forces for the two wheel-sets of the rear bogie of the locomotive. The populations of both wheel-sets stand below 75% of the Proud’homme limit. The values of the rear wheel-set are higher than the leading one. In the case of the rear wheel-set the values of the regressions increase from about 30% of the limit at a cant deficiency of 50 mm (achieved at a speed of 250 km/h on 4000 m curves) to about 60% at 130 mm (achieved at 300 km/h on 4000 m curves).

The figure 12 shows the 0.15% and 99.85% values of the derailment coefficients of the leading wheel-set of the locomotive rear bogie. The population of the two wheels stands below 50% of the limit. The regression increases from about 15% of the limit at a cant deficiency of 50 mm to about 30% at 130 mm.

The figure 13 shows the 0.15% and 99.85% values of the lateral accelerations measured on the frame of the rear bogies of the locomotive. The values of both accelerations are below the limit and their regressions show a significant increase with the cant deficiency. In the graphs some high values of accelerations can be noticed at a cant deficiency of about 130 mm. These high values are linked to a starting of unstable behaviour that appears only within the full curve and only on the left curves. This behaviour has been attributed a small radius difference between the left and the right wheels of the locomotive bogies. As example of phenomenon, the figure 14 shows the accelerations measured at about 300 km/h on the rear bogie of the locomotive within a line segment that includes a sequence of a left curve, a right curve and again a left curve. As can be seen, the higher accelerations appear only on the left curves.

The figures 15, 16 and 17 present the results regarding the track fatigue on the large radius curves.
Figure 14  Bogie lateral accelerations on large radius curve

Figure 15  Large radius curves – Vertical forces on the outer wheels of bogie 2 – 99.85% values
The figure 15 shows the 99.85% values of the vertical forces on each outer wheel of the rear bogie of the locomotive. The increase of the cant deficiency generates a reduced increase of the dynamic values of the vertical forces.

The figure 16 shows the 50% values of the lateral forces for the outer wheels of the rear bogie of the locomotive. As can be seen, on the large radius curves the quasi-static lateral force on the outer wheels of the rear wheel-set are higher than on the leading wheel-set. This difference is amplified by the increase of the cant deficiency.

Finally, the figure 17 shows the 50% values of the vertical forces on the outer wheels of the rear bogie of the locomotive. As expected, the quasi-static vertical forces increase with the cant deficiency.

9 Conclusions

The high-speed tests of the new multi-voltage ETR 500 high speed train have achieved the objective to produce a preliminary verification of the behaviour of the train at the speed of 300 km/h. The tests were carried out on the Italian high-speed line linking Firenze to Roma, with a feeding system of 3 kV d.c. On several test-runs the train speed was maintained over 300 km/h for a whole distance of about 80 km, while
the maximum speed reached in the tests was 320 km/h. It was the first time in Italy that the speed of 320 km/h was achieved and it was the first time that the 300 km/h threshold was passed with a train normally used in operations.

This test campaign made possible to generate a significant database about the dynamic behaviour and the performances of the ETR 500 in the high-speed range. The success of the tests was the first step for the future operations of the ETR 500 at 300 km/h on the Italian and the European routes.

BIBLIOGRAPHY


