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PROTON SATRIA MAIN MUFFLER DEVELOPMENT FOR EUROPE HOMOLOGATION PASS BY NOISE TESTS

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ABSTRACT

A pass by test was carried out on Satria Gti to fulfill some regulation requirements before the car is sold to Europe. Three sources of noise were identified and noise ranking method was used to identify the highest contribution of noise level. The exhaust system was identified as the main source and a modified main muffler was developed and fabricated which successfully reduced noise level below 74 dB(A).

1.0 INTRODUCTION

In the year 2000, PROTON has launched Satria Gti 1.8L for domestic market in order to boost the Automotive Industry in the young and sporty segment. However, to export the car to Europe, there are some regulation requirements (Homologation requirement) that were needed before the car could be sold to Europe (especially the United kingdom) and one of them is pass by noise regulation.

The current Malaysia Noise Emission regulation level of 78 dB(A) fulfills the domestic requirement as stipulated in Table 1. However, with [1]European requirement pass by noise level of 74 dB(A) has made PROTON to re-engineer the car to meet the global market.

Table 1 Satria Gti Car Base Measurement

Car Variant	Engine	Tyre	Pass By Results	Remark
Satria Gti	1.8 L	205 45 R15	Only meet domestic requirement but not EU	Domestic regulation : 78 dB(A) EU regulation : 74 dB(A)

[1] For pass by noise PROTON followed regulation R51.02 and directive 1995/101

2.0 WHAT IS PASS BY NOISE

Pass by (or Exterior Noise or Drive By) noise test is a noise emission test which measures the noise level of a particular moving vehicle (with at least four wheels and having maximum speed exceeding 25 km/h).

2.1 The measurement method

a. The approaching steady speed of the vehicle at line AA' as shown in Figure 1 can be either 50 km/h or the speed of three quarters of a maximum power of the engine (having engine power no greater than 225 kW). However for this test, PROTON opted for 50 km/h of the approaching speed of the car. For manual transmission engine, two gear speeds were used namely the 2nd and 3rd gear while for automatic transmission engine, the driving speed was at 'D' range

b. The test must be done on ISO test track surface that conforms to the European Commission Directive 70/157/EEC. The surface must be a dense asphaltic concrete, having maximum chipping size of 8 mm and the binder shall be a straight penetration grade bitumen without modification. Thus, using such ISO surface, it is intended that the test track would give a repeatable and reproducible result for this pass by noise test. It is also intended to be reflective as noise emitted from the car would not be absorbed by the surface whilst making the road noise minimized.

c. The ambient noise must be at least a minimum of 10 dB(A) lower than the noise being measured.

2.2 Test equipment

a. Precision integrated sound level meter was used for the test. The equipment was calibrated and 'fast' response of the sound level meter with 'A' weighting curve was selected.

b. The calibrated non contact speedometer for measuring engine speed and vehicle speed was used.

c. Climomaster for weather measuring, for example ambient temperature, wind speed, humidity was chosen.

3.0 SOURCE RANKING AND DEVELOPMENT

A source ranking method was used to identify the highest noise emission. This method is a classic method used by all automotive manufacturers to identify noise source that contributes towards pass by noise measurements. When the noise source has been identified, for example intake system, the development of the intake system must be manufacturing viable and should involve efficient cost implementation in terms of design, manufacturing and installation.

During the Satria Gti development, 3 areas have been looked into as they have always been a contribution towards the pass by noise levels. These are:

a. Intake system
b. Tyre noise
c. Muffler and exhaust system

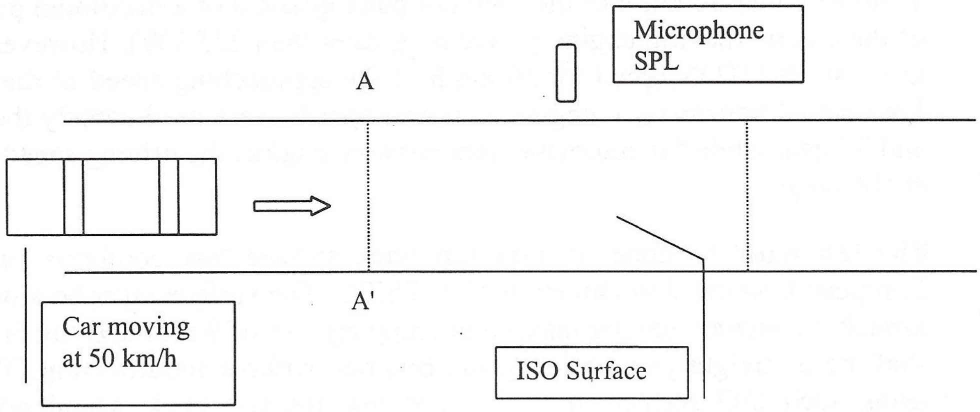

Figure 1 Pass By Layout

Noise emitted from engine was omitted during this activity. The engine is a standard reliable engine and has been homologated for export. The PROTON cars fitted with 1.8l DOHC engine have been sold throughout the world for the past 10 years. The engine has already been fine tuned to meet all requirements in Europe (in terms of noise, emission, reliability).

3.1 Intake System

An infinite intake condition for pass by noise was implemented. The infinite air intake system is defined as the intake system of the car coupled with a very long hose. Air intake noise can be eliminated as the noise dissipates along the hose while the car is moving. Thus by using this infinite air intake method, one can judge the amount of noise contributed by intake system towards the pass by noise emission levels. The test results are tabulated in Table 2.

Table 2 indicates that by using the infinite intake system, it can pass the noise emission limit which is just marginally below 74 dB(A). This result suggests that the air intake system needs a much more bigger air volume for the resonator to reduce the noise level of the air intake system. However due to space limitation inside the engine compartment, the only feasible air resonator that can be fitted in is only tuned to 180 Hz which is twice the size of the current production resonator. However the result was very discouraging as it only reduced by 1.4 dB(A) from the base measurement.

Table 2 Intake Noise data

Condition	Results	Remarks
Base measurement	Did not meet 74 dB(A) target	Standard condition is fitted with 270 Hz resonator
Infinite intake hose	Reduced 2.6 dB(A) from base. (met 74 dB level-marginal)	5 m long hose for giving infinite intake noise
Fitted with 180 Hz resonator	Reduced 1.4 dB(A) from base. (Did not meet 74 dB level)	

3.2 Tyre noise measurement

Several data acquisition methods have been used by the automotive manufacturer to obtain tyre noise level. However in this activity the pass by method was used but without the engine running. The engine was switched off as it passed the line A-A with the speed at 50 km/h.

Table 3 Tyre Noise Tests

Tire	Tyre size	Remarks	Moise Level
Tire A	205 45 R15	Local tyre A	67.5 db(A)
Tire B	205 45 R15	Imported tyre B	66.6 dB(A)
Tire C	205 50 R15	Imported tyre C	66.8 dB(A)

The results from Table 3 indicate that changing tyres from one manufacturer to another does not give any difference in noise level as the variance from one tyres to another is less than 1 dB(A). Hence it does not improve the noise level in pass by.

3.3 Exhaust system measurement

Noise emitted from the exhaust system also contributes towards the pass by noise emission level. Similar to the intake system, a study on the muffler noise emissions was carried out to obtain a clear overall picture of the noise emissions.

Table 4 Exhaust Noise Level

Condition	Results	Remarks
Base Measurement	Did not meet 74 dB(A) target	Main muffler with standard pre muffler (0.8 L)
Fitted with bigger pre muffler	Reduced 0.7 dB(A). (Did not meet 74 dB(A) level)	Using 1.9L pre-muffler with standard main muffler
Fitted with modified design of main muffler	Reduced 3.5 dB(A). Meet well below 74 dB(A) target level	Using 1.9L pre-muffler with standard main muffler

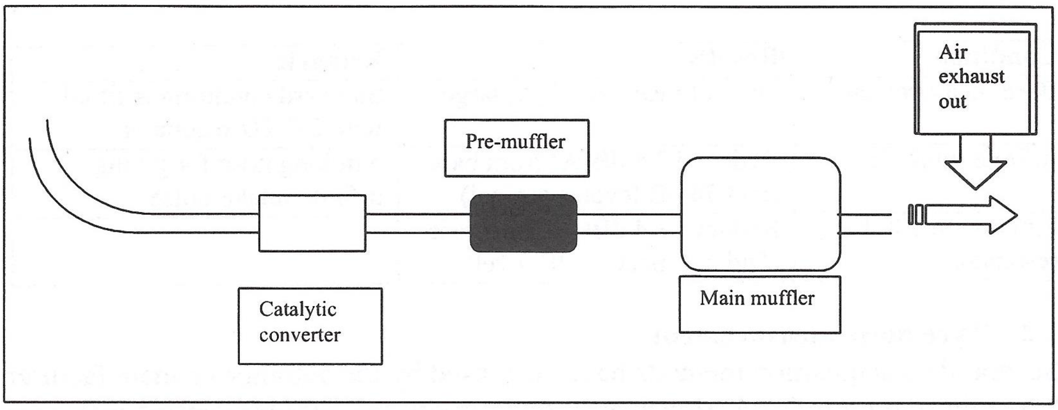

Figure 2 Sketch layout of exhaust system

Table 4 shows the test results of the exhaust noise level based on the sketch layout of the exhaust system shown in Figure 2. The results given in Table 4, show that a bigger pre-muffler reduced the pass by noise by 0.7 dB(A). Test using prototype design muffler (of having extra expansion chamber inside) with heavy layer of glasswool wrap around the main muffler body for reducing reverberations and muffler resonance gave very encouraging result (3.5 dB reduction).

From this source ranking activity it is concluded that the main contributors for this pass by Noise activity are as follows :

i) Exhaust system
ii) Air Intake system
iii) Tyre noise emission.

4.0 SELECTED MAIN SOURCE FOR DEVELOPMENT

The noise source ranking activity has indicated that the exhaust system is the main contributor towards emitting higher pass by noise level. A thorough investigation of redesigning the exhaust system was carried out by performing engine bench test for configuring the internal design of the main muffler. During this activity, several muffler designs were fabricated and tested and finally, an optimum muffler design was selected which met the expectation in lowering the noise emission level.

The current design illustrated in Figure 3 shows that the main muffler consists of baffler plates creating resonating chambers with each chamber having a different volume. Each chamber is connected with intermediate pipes with holes. The holes are meant for gas to flow freely into the intended chamber. For this current design only 4 chambers are used with 2 intermediate connecting pipes. At the most right side of the muffler, the fifth chamber acts as a dummy with no gas flow.

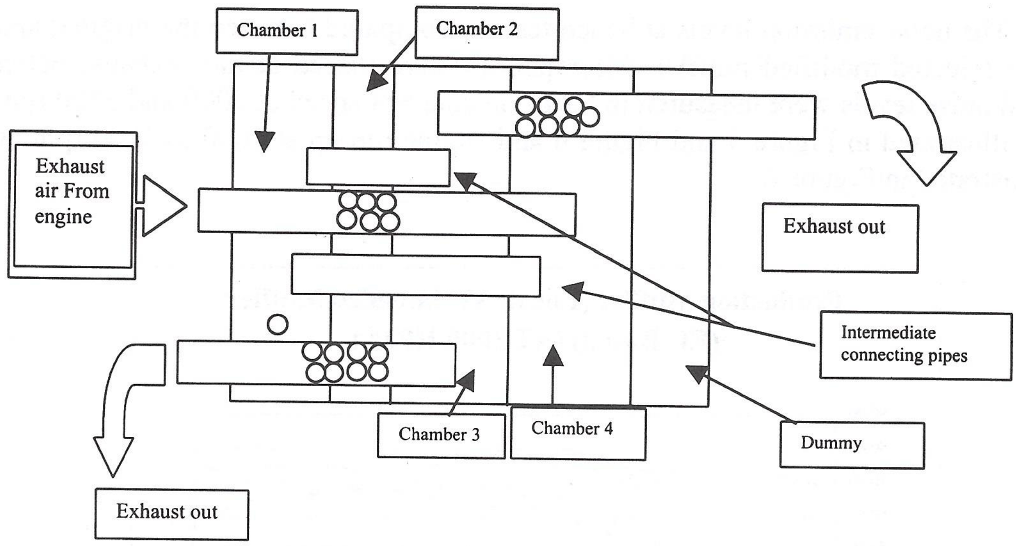

Figure 3 Original Muffler for Domestic

A modified main muffler as illustrated in Figure 4 was fabricated. It is different from the original one as an extra pipe and a chamber have been added. The results on this main muffler indicate that it has effectively attenuated some noise emission. However this main muffler gave a small increment of backpressure than the original which is acceptable as the increment is marginal.

4.1 Engine bench test results :

Engine bench tests were carried with the engine placed in the engine chamber and the muffler at the exhaust chamber. This is to separate these two noise sources as the main muffler was measured in the rear tail pipe.

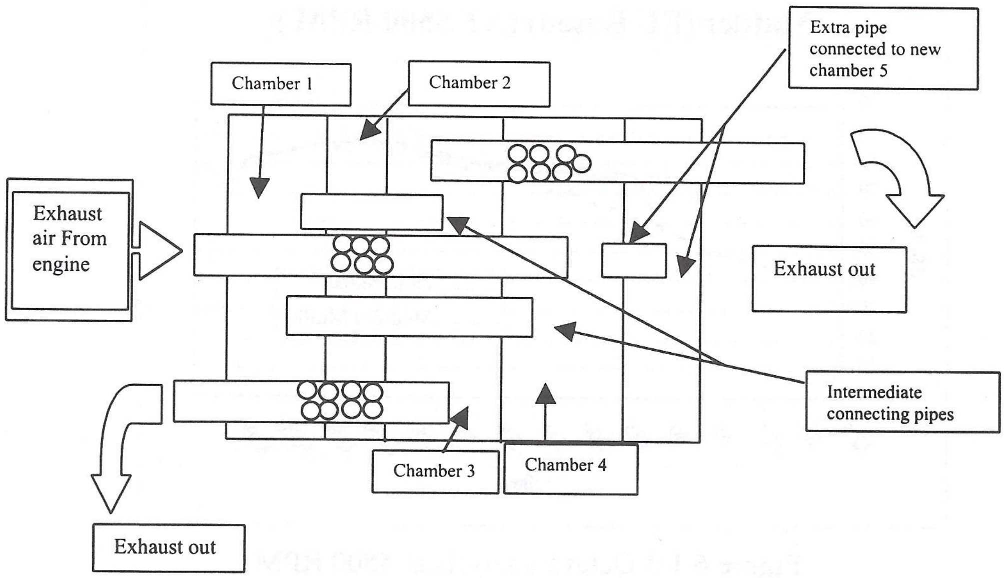

Figure 4 Selected Muffler for EU market

The noise emission levels at bench test are compared between the original and the selected modified muffler. Microphones were placed at the exhaust outlet and noise levels were measured in terms on constant speed at 3000 and 5500 rpm as illustrated in Figure 5 and Figure 6 and engine run up at 1000 to 6000 rpm as illustrated in Figure 7.

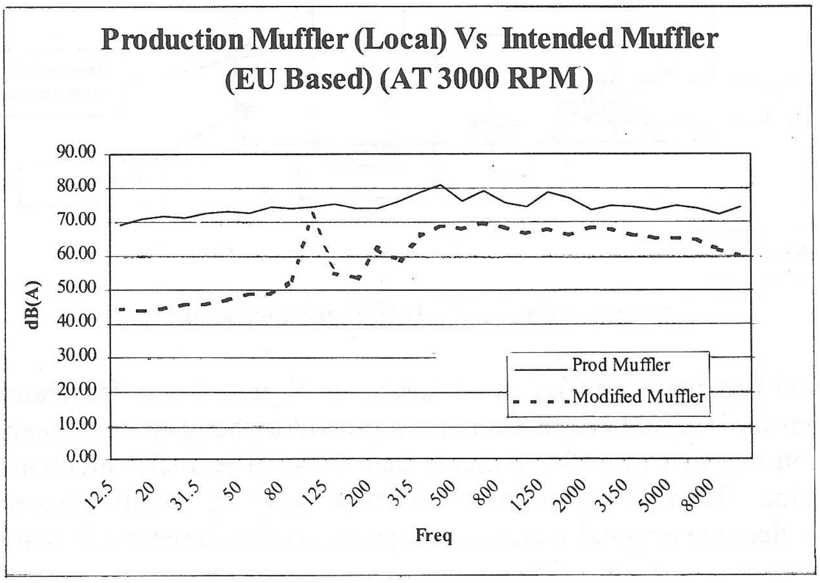

Figure 5 1/3 Octave Analysis at 3000 RPM

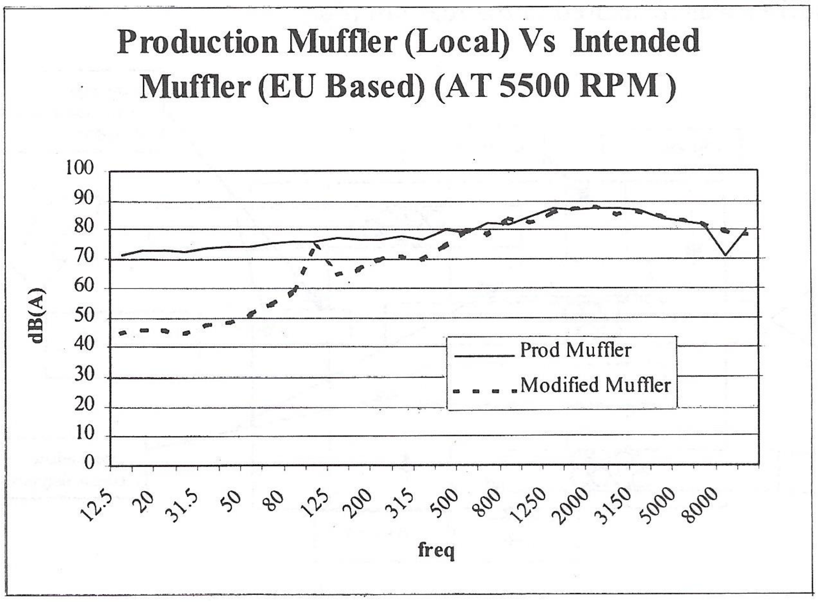

Figure 6 1/3 Octave analysis at 5500 RPM

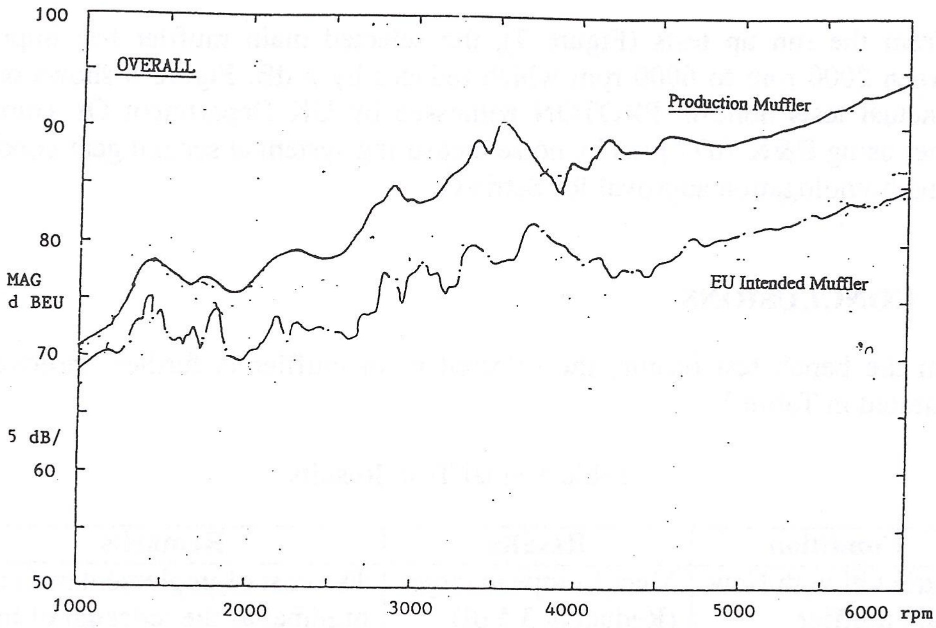

Figure 7 RPM Tracking Comparison Between Production Muffler Vs EU Intended Muffler

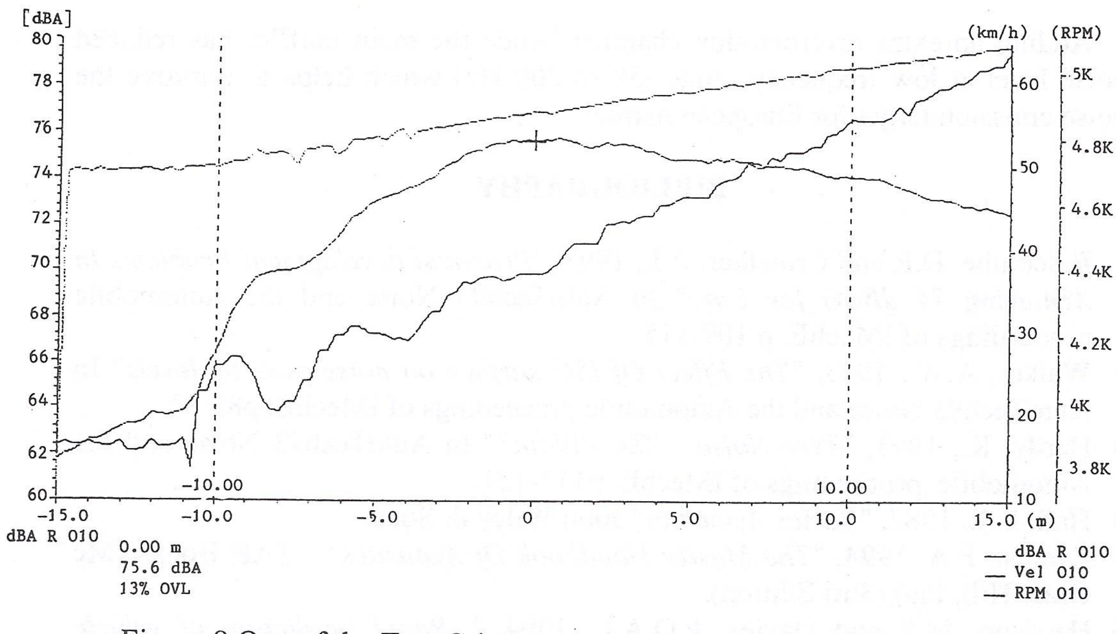

Figure 8 One of the Test Gti Data Graphs At Second Gear Using B&K 7677 Pass by Noise Measurement

It shows that at 3000 rpm constant speed, using 1/3 octave analysis the modified main muffler has improved at all frequency range and having significantly improved from 12.5 to 80 Hz. This trend is similar when tested at 5500 rpm constant speed where it improves significantly at 12.5 to 80 Hz.

From the run up tests (Figure 7), the selected main muffler has improved between 2000 rpm to 6000 rpm which reduces by 5 dB. Figure 8 shows one of the actual tests done in PROTON witnessed by UK Department Of Transport officer using B&K 7677 pass by noise measuring system at second gear condition during homologation approval for Satria Gti.

5.0 CONCLUSIONS

From the bench test results, the selected main muffler is further improved as illustrated in Table 5.

Table 5 Final Test Results

Condition	Results	Remarks
Satria Gti with New main muffler	Meet European target (Reducing 3.5 dB from base)	The cost of implementation is minimal as the redesign of the main muffler can be done very quickly and no new engineering parts are required.

Adding an extra reverberation chamber inside the main muffler has reduced noise level at low frequency range (50 to 200 Hz) which helps to improve the noise emission target for European market.

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