DEVELOPTMENT PROTOTYPE OF THE L3 CATEGORY EMISSION TESTING TOOL (CASE STUDY: BALAI PENGUJIAN KENDARAAN BERMOTOR KOTA BANDUNG)

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ABSTRACT

More than 70% of air pollution is caused by vehicle exhaust emissions, there was hydrocarbons (HC), carbon monoxide (CO) and Nitrogen oxides (Nox) in particular on two-wheeled vehicles or L3 categories. Based on the regulation from Kementrian Lingkungan Hidup about Quality Management of Emissions for L3 Category, the value for <150 cm³ cylinder is CO 2.0, HC 0,8 and Nox 0,15 while > 150 cm³ cylinder is CO 2.0, HC 0.3 and Nox 0,15. Balai Pengujian Kendaraan has limited L3 *Category emission test equipment, so that become the decission for development the prototype of L3 Category emission test equipment. This prototype can detect, quantify and display the result of CO, HC and Nox from the emission test. Gas sensor CO (MQ-7), HC (MQ-2) and Nox (MQ-135) as emission gas detection components used in this prototype. Analog output data from the sensor is processed into digital data using Mini PC Raspberry Pi then subsequent measurement results are shown dilayar web-based monitor. Based on the test results, it can work properly, but the value of the measurement results is still getting the average delta of 0.49% for CO and HC ppm to 152.25, where the value of the measurements obtained by test prototype emissions higher than the emissions test tool tools are in the Balai Pengujian Kendaraan Kota Bandung. So come by the conclusion that the prototype test emissions can work well but the value of measurement results have not been as accurate as testing tool with emissions in Balai Pengujian Kendaraan Kota Bandung.*

Keywords: *Emission, Emission test, L3 Category,Raspberry Pi, Gas Sensor*.

1. INTRODUCTION

According to the Ministry of the environment, approximately 70% of the air pollution caused by motor vehicle exhaust emissions. Vehicle exhaust emissions that exceed the specified thresholds may harm health and damage the environment. Then the emissions tests performed to measure levels of exhaust gas emission conditions as well as a motor vehicle. One of the vehicles tested, namely motor vehicles a new type of category L3. Vehicle categories L3 is a two-wheeled motor vehicles with a cylinder capacity of more than 50 cm ³ or with a design maximum speed of over 50 km/h, regardless of their motive with the parameters of the chemical compound tested i.e. carbon monoxide (CO), hydrogen (HC), oxides of nitrogen (Nox). However, the availability of emissions test tool for category L3 is still limited.

Based on the exposure to that already described, then carried out research on the development of a prototype of the vehicle emissions testing tool category L3 was performed. By utilizing Raspberry Pi and CO, HC and Nox gas sensor module as input devices the threshold assessment of emissions in the emissions testing system, then when the system finds the smoke from a motor vehicle that is directed to the sensor, the system will work to measure the levels of emissions from motor vehicles, and Raspberry Pi will forward it to the server. On the server, the results have been tested last is saved and compared with the standard emission test, then from the server are forwarded to a desktop application so that the results can be seen by someone who tested the emissions.

Based on the working order of the prototype vehicle emissions testing tool category L3 above, researchers hope to help create a special tool for assay activity emissions kedaraan.

2. RESULT

2.1 Analisys Hardware

Needs analysis Hardware contains about hardware components used in the construction of a prototype to test emissions.

2.1.1 Prototype Component

In the plan the design of the prototype vehicle emissions testing tool category L3 required components – components as follows:

- 1 Raspberry Pi 3 mobel B
- 1 modul sensor gas MQ-2
- 1 modul sensor gas MQ-7
- 1 modul sensor gas MQ-135
- 1 ADC (*Analog to Digital Converter*) MCP3008
- 1 *breadboard*
- few *jumperwire*
- adaptor 9 volt 2 *Ampere*

Use Raspberry Pi 3 and other supporting components components – is a flexible arrangement, since in its application can be made as required in its application

2.2 The Design Of The System

Construction of the prototype vehicle emissions testing tool category L3 is the development tool used for emission tests to know the information content of the substances found on the vehicle's emission category L3 that can help the emission test activities. This system will use gas sensor module as input devices sampling, is associated with a mini PC Raspberry Pi are controlled through the application to process and output media serbagai information generated from an emissions test. Prototype test emissions category L3 this user can find out the information content of the substance a hydrocarbon (HC), carbon monoxide (CO) and Nitrogen oxide (Nox) on vehicles that will be compared to the raw quality of emissions, so that the obtained information regarding graduation or whether the vehicle emissions test. Users can control the emissions test using the test tool application web-based.

On the construction of the system, the design of the system architecture are as follows:

1. The screen Smartphone or screen monitor as User Interface (UI) for a control test tool prototype emissions on emission test applications using the wifi network. The captured emissions sample data will be shown in the application of emission test.
2. Wifi network is used as an intermediate data exchange between raspberry and Smartphones.
3. Raspberry Pi is used to control the device needed for emission sampling. Raspberry pi will undertake appropriate command instruction application test emissions. Raspberry pi will send information to the test results to the database server through the internet network.
4. MCP3008 is used to read an analog input function to convert analog data on gas sensors to digital data.
5. Gas sensors are used to take a sample for testing emissions. Gas sensors are used i.e. MQ-2 to detect Hydrocarbons (HC), MQ-7 to detect carbon monoxide (CO) and MQ-135 to detect Nitrogen oxide (Nox).
6. Samples taken comes from the exhaust motor which is the vehicle categories L3. The sensor is directed to the exhaust motor to take samples of emissions that would sent the sample data from the sensors to the raspberries for processing.

At the stage of development of the system, emissions testing workflow created as shown in Figure 1:

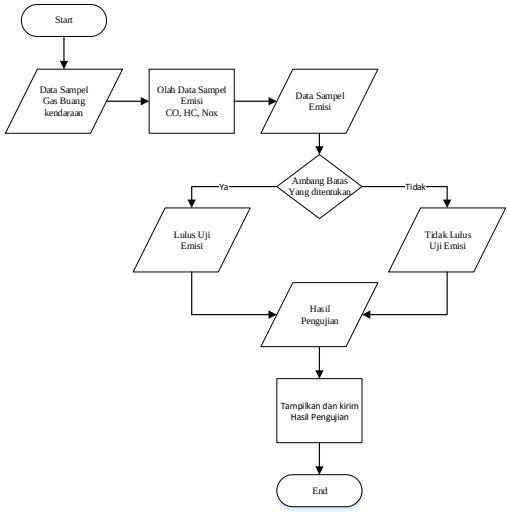


Figure 1. *Emissions Testing Flowchart*

2.3 Measurement Of Gas Content

Gas content measurements done by using data capture through the gas sensor. For the use of the gas sensor used programming languages to use the gas sensor. It takes three parameters that are required in the coding of the program i.e. x, y and slope or slope where y is the logarithm of 200, y is log10 (y1) and the value of the slope. So the calculation process is required.

2.3.1 Analysis Of Gas Detection

In this study, use 1 piece of the Pi 3 Raspberry device and gas sensor MQ-module 2, MQ-MQ-7 and 135 respectively 1 piece which is connected using a cable jumper through early breadboard mounted MCP3008. Gas sensor module will detect the content of gas in the vehicle emissions in accordance with the functions of each module of gas sensors.

Gas detection function to run on each gas sensor, use the file containing the code to run the functions of each module of gas sensors. the program in this experiment was built using the python programming language. Raspberry pi will run the function for detecting the content of gas at any gas sensor module is used. In doing detection Raspberry Pi will display the data content of the gases in units of PPM (Parts Per Million). Figure 3 shows the use of a scheme x sensor MQ-2, MQ and MQ-7-135 on Raspberry Pi.

2.3.2 Measurement Of Gas HC

For process gas HC (hydrocarbons), used a gas sensor MQ-module 2. MQ-2 can detect compounds that propane is a hydrocarbon gas. In measuring hydrocarbon gases in gas sensor MQ-2 compound values need to be measured, then propane should know how to measure propane compounds [3].

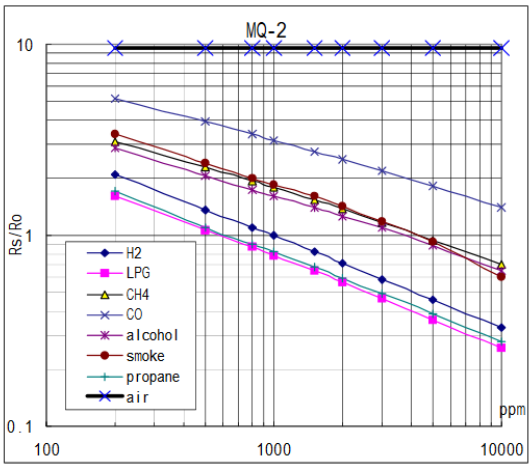


Figure 2. Graphs of characteristic gas sensor MQ-2

From Figure 2 then known for propane compounds (HC), based on the graph so obtained the point P1 (x = 200, y = ~ 1.70) and P2 (x = 10000, y = ~ 0.26). Then:

a) to calculate the value of x and y:

x = log200
x = 2.3
y = log10(1.70)
y = 0.23

b) to calculate the slope of the used formula:

$$slope = \frac{log10(y2) - log10(y1)}{log10(10000) - log10(200)}$$

Maka:

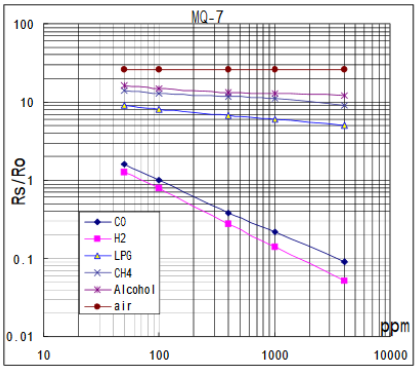
$$slope = \frac{log10(0.26) - log10(1.70)}{log10(10000) - log10(200)}$$

$$slope = \text{-}0.48$$

Then with the data format [x, y, slope] obtainable value [2.3, 0.23,-0.48] for propane gas Hydrocarbon compound curves.

2.2.3 Measurement Of Gas CO

For process gas CO (Karbonmonoksida), used a gas sensor MQ-module 7. MQ-7 can detect the content of gas karbonmonoksida [4]. In measuring gas karbonmonoksida in gas sensor MQ-7 value gas monoxide needs to be measured, then it should know how to measure the gas karbonmonoksida.



Gambar 3. Grafik karakteristik sensor gas MQ-7

Dari gambar 3 kemudian diketahui untuk senyawa CO, berdasarkan grafik maka didapatkan titik P1 (x = 50, y = ~ 1.40) dan P2 (x = 4000, y = ~ 0,09). Maka :

a) to calculate the value of x and y:

x = log50
x = 1.70
y = log10(1.40)
y = 0.15

b) to calculate the slope of the used formula:

$$slope = \frac{log10(y2) - log10(y1)}{log10(4000) - log10(50)}$$

Maka:

$$slope = \frac{log10(0.09) - log10(1.40)}{log10(4000) - log10(50)}$$

$$slope = \text{-}0.63$$

Then with the data format [x, y, slope] obtainable value [1.70, 0.15,-0.63] to curve the gas CO.

2.3.4 Measurement Of Gas Nox

For process gas Nox (Nitrogen oxides), used a gas sensor module MQ-135. MQ-135 can detect gas content of nitrogen oxides [5]. In measuring the gas nitrous oxide in the gas sensor MQ-135 gas nitrogen oxide values need to be measured, then it should know how to measure the gases nitrogen oxide.

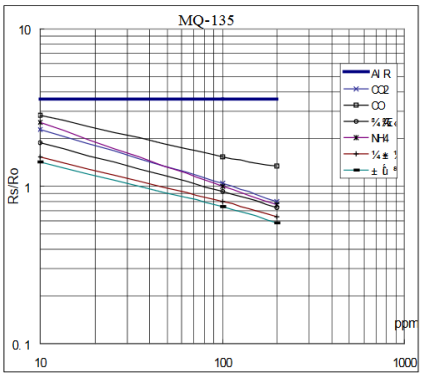


Figure 3. Graphs of characteristic Gas Sensor MQ-135

From Figure 2 then known u for nitrogen oxide gas, based on the graph so obtained the point P1 (x = 10, y = ~ 1.54) and P2 (x = 200, y = ~ 0.64). Then:

a) to calculate the value of x and y:

x = log10
x = 1
y = log10(1.54)
y = 0.19

b) to calculate the slope of the used formula:

$$slope = \frac{log10(y2) - log10(y1)}{log10(200) - log10(10)}$$

Maka:

$$slope = \frac{log10(0.64) - log10(1.54)}{log10(200) - log10(10)}$$

$$slope = -0.23$$

Then with the data format [x, y, slope] obtained values [1, 0.19,-0.23] for the curve of the gas nitrogen oxides.

2.3.5 Process Gas Measurement

In the process of taking the gas taken restrictions to do measurements. Limitations of measurements done for mambatasi measurement results.

Table 1. Sample Measurement Restrictions

Variabel	Nilai
Calibration sampe times	50
Calibration sample interval	500 ms
Read sample interval	50
Read sample times	5 ms
RL *Value*	5 ohms
RO *clean air factor*	9.83
Raw adc	-

Based on table 1 then step used in the measurement of gas are:

a) MQResistanceCalculation, which will calculate sesor resistace
b) With the formula: RL Value * (1023.0 – raw adc)/(raw adc)
c) MQCalibration, this function is used to assume that the State of the sensor located on the air cleaner. As well as to produce Ro from the sensor
d) With the formula: Calibration sample interval/1000
e) MQRead, this function is used to calculate the sensor resistance (Rs).
f) With the formula: MQResistanceCalculation/Read sample times
g) MQGasPercentage, this function uses the nialai on the MQGetPercentage function of the curve to mengkalkulasikan ppm of gas.
h) MQGetPercentage, this function uses the data curve taken with data format [x, y, slope]
i) With the formula: 10 ^ (log (the rs ro ratio) – y)/slope + x

The function of the steps are used, so that the results obtained will be gas value in units of ppm.

2.4 Testing

Methods used in this test is the Idle method where the vehicle in the condition is already lit up with normal engine rotation when the gas pedal is not pressed. In testing the tool performed 3 stages include the taking of samples from the test vehicle emissions in the test Hall, data retrieval tool prototype of samper emissions test and calculation of the difference between data drawn from tests using prototypes and test emissions.

Based on government regulations regarding the emission threshold values and procedures in the sampling of emissions, then sampling is limited for 30 minutes.

2.4.1 Testing Mechanism

Testing the detection of emission is the process by which a device prototype to detect the content of gas in the vehicle and display information about the contents of the vehicle emissions. These tests are done using idle method where the motor in case of normal.



Figure 4. Sampling Using Prototype

In Figure 4 the tool is mengabil samples for 30 seconds for the next emissions test measurements will be performed. During the process of sampling test tool using a funnel as a tool to take gas in the exhaust motor.

The use of the funnel meant so that during sampling no gas content only from the motor that can be measured, so that the accuracy could be better.

During testing in this study used 3 types of gas content container so that you can note the difference on each container, in order to deiketahui which are the most excellent.

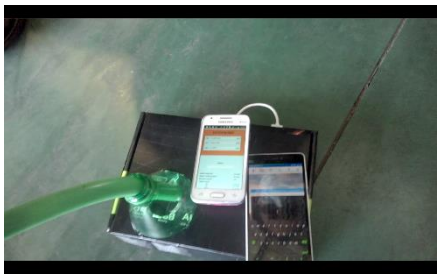


Table 5. Sample Calculation Process

In Figure 5 a sample calculation process will be displayed on the screen to simplify the use of smartphone prototypes test emissions. The screen will display the value for CO, HC and Nox. Over 30 programs to detect will run and after 30 seconds the program will automatically berheni to do the calculation, which in the end results will display the

results in the form of captions "pass the test" or "Not Tested".

On the test results will also display data in the form of average values for each gas deposits that have been measured. The test results are displayed as shown in Figure 5:

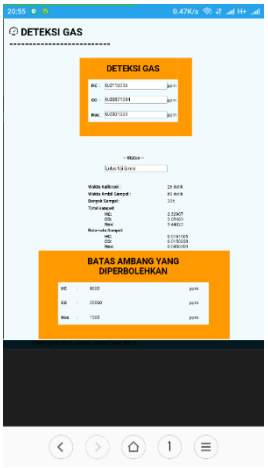


Figure 6. Gas measurement display

2.4.2 Prototype testing tool test the emission phase

Testing the detection of emission is the process by which the device microcontroller detects the content of gas in the vehicle and display information about the contents of the vehicle emissions. These tests are done using idle method where the motor in case of normal teeth.

Some limits used one is size dimensions measuring gas retrieval interval.

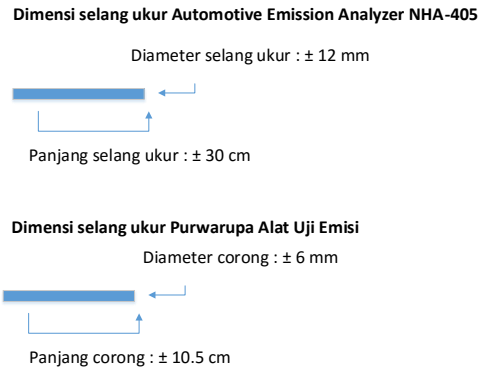


Figure 7. Comparison Of The Dimensions Of The Measuring Hose

In the first stage used a series of prototype test emissions by using gas reservoir with conditions such as in Figure 8:

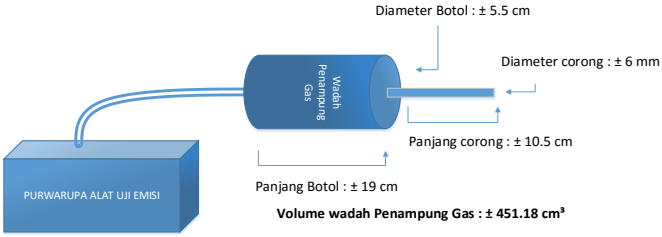


Figure 8. Dimensions of Container type 1

On the measurement of the first stage used a gas container with the provisions of the gas container volume is more or less 451.18 cm ³. the first stage of testing done on data retrieval sample as much as 5 times with estimated time of sampling every trial is for 30 seconds pengujiayang results obtained indicated on table 2:

Table 2. Testing phase 1

No. Polisi	No	Purwarupa Alat Uji Emisi			Keterangan
		CO (%)	HC (ppm)	Nox (ppm)	
D 4791 GJ	1	1.23	401.02	0.00	Tidak Lulus
	2	0.65	160.51	0.00	Lulus
	3	1.32	136.21	0.01	Lulus
	4	1.32	120.62	0.00	Lulus
	5	1.23	132.8	0.00	Lulus

Table 3. Emission Test Tools testing using phase 1

Alat Uji Emisi			Keterangan
CO (%)	HC (ppm)	Nox (ppm)	
0.63	38	-	Lulus
0.66	37	-	Lulus
0.67	38	-	Lulus
0.66	39	-	Lulus
0.68	38	-	Lulus

On the pegujian phase 1 testing, done in conjunction with the use of emission test tools in the test vehicle Hall of bandung city. For testing generated by emission test prototype was displayed on a table using the test tool test 1dan emissions are shown on table 2 of these tests yield a value that is smaller than the value produced by the emission test tool prototype.

2.4.3 Prototype testing Tool Test the emission phase 2

On the second stage used a series of prototype test emissions by using a gas container with conditions such as in Figure 9:

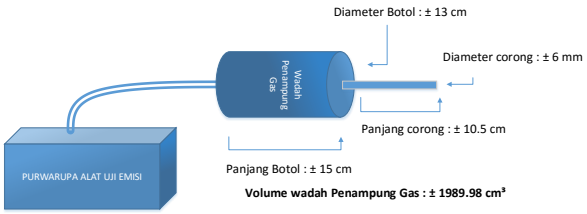


Figure 9. The dimensions of the size of the Gas Container type 2

On the measurement of the second stage of the gas container used by the terms of the volume of the gas container is approx 1989.98 cm ³. On the first test sample data retrieval done by estimation of sampling time for 30 seconds. The following

Table 4. Testing phase 2

No. Polisi	No.	Purwarupa Alat Uji Emisi			Keterangan
		CO (%)	HC (ppm)	Nox (ppm)	
D 4791 GJ	1	1.33	168.32	0.21	Lulus
	2	1.17	132.51	0.12	Lulus
	3	1.02	121.21	0.09	Lulus
	4	1.12	133.62	0.09	Lulus
	5	1.13	122.89	0.11	Lulus

On testing stage 2 obtained the test results obtained by the second stage results of the CO and HC that is smaller than the first stage of testing.

Table 4. Emission Test Tools testing using phase 2

Alat Uji Emisi			Keterangan
CO (%)	HC (ppm)	Nox (ppm)	
0.67	36	-	Lulus
0.62	37	-	Lulus
0.63	36	-	Lulus
0.65	37	-	Lulus
0.68	38	-	Lulus

On the pegujian phase 2 testing, done in conjunction with the use of emission test in the testing Hall of bandung city vehicles as in the first phase. For testing generated by emission test prototype was shown on table 3 and testing using the test tool of emissions shown on table 4 of the test produces a value that is smaller than the value produced by the emission test tool prototype. As well as testing phase 2 get a value that is smaller than the value that was generated in the first phase of testing.

2.4.4 Prototype testing Tool Test the emission phase 3

At the third stage used a series of prototype test emissions by using a gas container with conditions such as in Figure 10:

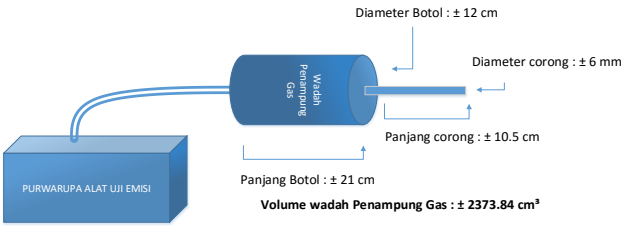


Figure 10. The dimensions of the size of the Gas Container type 3

On the measurement of the second stage of the gas container used by the terms of the volume of the gas container is approx 2373.84 cm ³. in the first phase of testing was done taking the sample data with estimated time of sampling for 30 seconds.

Table 5. Testing stage 3

No. Polisi	No.	Purwarupa Alat Uji Emisi			Keterangan
		CO (%)	HC (ppm)	Nox (ppm)	
D 4791 GJ	1	0.82	62.21	0.03	Lulus
	2	0.68	120.51	0.06	Lulus
	3	1.32	111.21	0.03	Lulus
	4	1.32	109.62	0.04	Lulus
	5	1.23	105.89	0.04	Lulus

Table 6. Emission Test Tools testing using phase 3

Alat Uji Emisi			Keterangan
CO (%)	HC (ppm)	Nox (ppm)	
0.65	37	-	Lulus
0.66	36	-	Lulus
0.67	38	-	Lulus
0.67	37	-	Lulus
0.66	37	-	Lulus

On the pegujian phase 2 testing, done in conjunction with the use of emission test in the testing Hall of bandung city vehicles as in the first phase. For testing generated by emission test prototype was shown on table 3 and testing using the test tool of emissions shown on table 4 of the test produces a value that is smaller than the value produced by the emission test tool prototype. As well as testing phase 2 get a value that is smaller than the value that was generated in the first phase of testing.

2.4.5 Testing Tools And Test Prototype Delta Emissions

Table 7. Delta is testing phase 1

No.	No. Polisi	No. Percobaan	Rata rata Delta		
			Delta CO (%)	Delta HC (ppm)	Delta Nox (ppm)
1	D 4791 GJ	1	0.66	132.32	-
		2	0.55	95.51	-
		3	0.39	85.21	-
		4	0.47	96.62	-
		5	0.45	84.89	-
Rata rata delta			**0.50**	**98.91**	**-**

In table 7 delta testing phase 1 obtained right difference difference between the value produced by prototype and test emissions.

The first stage of testing based on the obtained average delta of 0.50 ppm for CO and 98.91. for 5 times the sampling value for the HC did not experience a very high increase.

Table 8. Delta is testing phase 2

No.	No. Polisi	No. Percobaan	Rata rata Delta		
			Delta CO (%)	Delta HC (ppm)	Delta Nox (ppm)
1	D 4791 GJ	1	0.6	363.02	-
		2	0.01	123.51	-
		3	0.65	98.21	-
		4	0.66	81.62	-
		5	0.55	94.89	-
Rata rata delta			**0.49**	**152.25**	**-**

Table 9. Delta is testing phase 3

No.	No. Polisi	No. Percobaan	Rata rata Delta		
			Delta CO (%)	Delta HC (ppm)	Delta Nox (ppm)
1	D 4791 GJ	1	0.17	25.21	-
		2	0.02	84.51	-
		3	0.65	73.21	-
		4	0.65	72.62	-
		5	0.57	68.62	-
Rata rata delta			**0.41**	**64.89**	**-**

After the test is taken from the average gas content of each tested based on the difference between the data from emission testing of tools and prototypes from the porch of the test vehicle.

Because of the difference in the average delta or any of the contents of very large gas then it can be concluded that:

1. emissions test tool Prototype produces higher value from the test tool test Hall vehicle emissions in the city of bandung.
2. Testing using gas container type 3 get the average smallest kdelta i.e. 0.41% CO and HC ppm 64.89, so it can be inferred that a reservoir of gas type 3 better performance.
3. Testing using prototype less emissions test tool maximum for not sucking gas.
4. The size of a container of gas and gas sensor Position largely determine the sensitivity of sampling.
5. Pengujian Beta

The prototype was made already in accordance with the test vehicle emissions in the test Hall of bandung city, and can be used in performing the emissions content detection on vehicles of categories L3. But the level of precision that is processed by this tool still less so that less effective to use in the assay activity emissions.

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3. CONCLUSION

Based on research from the results of testing of prototype test emissions category L3 can be drawn some conclusions as beriikut:

1. emissions test tool Prototype can be used as a tool for measuring the gas content of the resulting vehicle emissions in particular L3 category vehicles that generate unhealthy vehicle fumes, so that air pollution can be minimized.
2. emissions test tool Prototypes can be used for non formal or may be used outside of the emissions test schedule, so that the public can use the tool to do a non formal emissions testing.
3. emission test tool Prototype can be used as a testing device that can add to the emissions test vehicle emissions in the test Hall, but due to the level of precision is still less then a future yet to be repaired.

Suggestions for the development of the prototype vehicle emissions testing tool category L3 this there are some suggestions that may be done include:

1. development of the interface more attractive.
2. The level of gas content calculation that is more accurate.
3. Generating Print Out test results.
4. Able to compute O2, Co2 and lamda.

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