Report of the Product Development and Manufacturing Center

# STUDY OF THE IMPACT OF R4 ON ENGINES

**Version 1.0**

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## 1.0 OBJECTIVE

The objective of this test was to determine the affect the introduction of R4 to an engine. This "single-engine" study looked to see if any immediate and durability improvements were seen through the introduction of R4 to a 225 Slant-Six engine with almost 200,000 miles on it.

## 2.0 RESULTS AND CONCLUSION

From running road tests, acceleration tests, and parking-lot tests as described below the following results were attained from treating a 1968 Dart with a 225 Slant-Six engine with almost 200,000 miles on it.

| | Pre R4 Treatment | After R4 Treatment | Improvement |
|---|---|---|---|
| **Fuel Economy MPG** | **9.2 MPG** | **10.8 MPG** | **17%** |
| **0-50 Acceleration** | 11.3 Sec | 9.8 Sec | 15% |
| **Cylinder Compression** | 100-110 PSI | 100-100 PSI | -- |
| **Engine Temp** | 210-240 F | 190-220 F | 20 Degree Drop |
| **Vibration** | Noticeable | Reduced | Improved |

**Table 1.0 – Summary to Test Finding on 1968 Dodge Dart**

From the above data, one can conclude that the introduction of R4 had a significant impact on the performance of a vehicle, whose engine is in serious need of repair. The conclusion of the PDM Center from this test, is that it appears that R4 may be considered as a treatment for engines with performances below what they should be. Considering an engine rebuild, which would be necessary to bring the Dart engine back to its previous level of performance, would cost about $3000, R4 would be an inexpensive and quick alternative. If the engine didn't see an improvement from R4, then a rebuild may not be necessary, and other problems may be suspected such as a fuel or transmission problem.

## 3.0 PRODUCT BACKGROUND

R4 is a technology that encapsulates small particles of highly reactive bronze in and inert matrix so when it comes in contact with high heat, such as that seen in frictional surfaces, the bronze is liberated and allowed to bond to the metal surfaces. The purported benefits of this mechanism are many. First, it can help "rebuild" damages surfaces (such as those in an engine cylinder). This will provide a smoother surface that can improve seal, and return power to the engine. This will also reduce engine vibration and noise, helping the engine run smoother. The rebuilding of damages surfaces will also allow the engine to be more durable, allowing more miles between failures due to the improved clearances.

A second area of improvement is in the starting of an engine. If an engine is allowed to sit for some time, the oil will migrate to the bottom of the engine, and leave little protection when the engine is started. It takes time for the oil pump to return pressure through the system, and begin to effectively lubricate the engine. Because of the "bronze-coating" of the frictional surfaces, this retains oil better, so there is some lubricant available when the motor starts. Again, this will help development of a protective lubricating layer which will help engine life.

## 4.0 TEST DESCRIPTION

The basic idea of the test was to develop an systemic test, which put the product in a vehicle in need of some help, and determine the impact the product had. A test vehicle (1968 Dodge Dart) equipped with a 225 Slant-Six Engine was the test subject. The testing was done in three phases, the baselining phase, the treatment phase, and the durability phase.

### 4.1 PHASE I: TEST BASELINE DEVELOPMENT

In the first phase, the performance of the vehicle was measured along many axis. The Dart was brought into "reasonable" operating condition, including, the changing of oil, flush and change of radiator, cleaning of fuel system, and other minor maintenance to make sure that the vehicle was safe to operate. Once that was completed, the vehicle was operated for 20 hours with the following data being taken:

1) **Oil Analysis** – Checking the oil for wear metals and oil condition that could indicate a problem that could invalidate the test results.
2) **Fuel Economy** – Measuring fuel consumption around a fixed course. To do this a flow meter was added in the fuel line and the actual consumption of fuel was measured. The description of the road course is shown below.
3) **0-60 Acceleration** – The time it took for the vehicle to travel 0-60 MPH was done many times. This part of the test consisted of going from rest to full throttle and using accelerometers and data acquisition devices to record the times for each 10 MPH up to 60.
4) **Engine Temperature Tests** – Using a pyrometer accurate to 1.%, the temperature of certain points on the block was measured.
5) **Cylinder Compression Tests** – The maximum air pressure created by the cylinder when cranked was measured, which indicates any problems with seals, valves sticking open or other issues.
6) **Vibration Tests** – A subjective test performed by the driver, determining the vibration in the vehicle due to the engine in idle.

The road course performed was a highway test that was a little over 1.5 miles and included four stops. The driver was instructed to stop at all points, decelerate at fixed points, and accelerate to a constant speed. The drive was able to do this very repeatable. The track is shown in Figure 1.0 below.

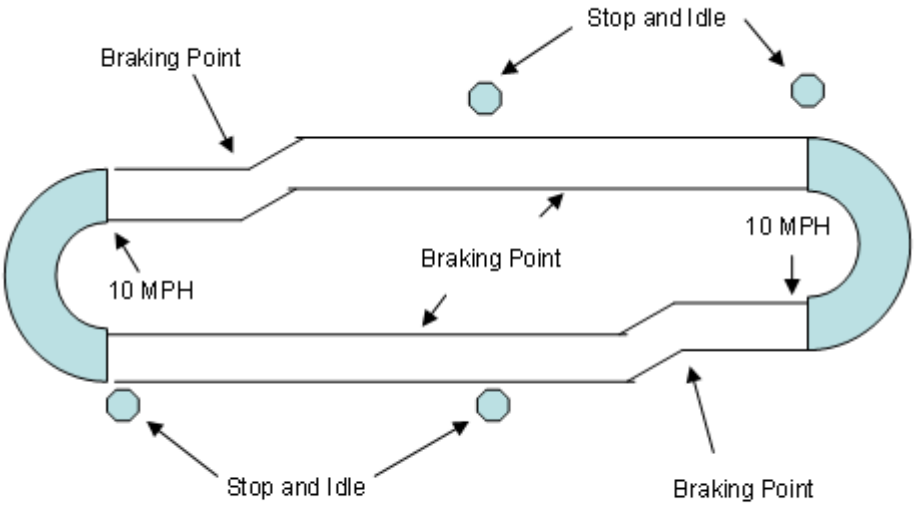


Figure 1.0 – Road Course Layout

To perform the tests, a trailing vehicle was used to record the times the vehicle stopped and the idle time before acceleration to the next stop. The driver was in communication of the trailing vehicle and would read back fuel consumption numbers off the flow meter at every stop. The trailing vehicle would record the times at every stop with a stop watch, and each idle time.

In baselining the Dart was run through this course for 4 hours with the last 10 trips being recorded in the above manner. At the end of 10 trips, ten 0-60 accelerations tests were run. When these tests were completed, the vehicle was taken into the PDM Center garage and allowed to idle. At that point, the oil sample was drawn for testing, after 30 minutes of idling, the engine temp was taken, and the vibration and sound of the vehicle were noted. These results are shown in Appendix A.

### 4.2 PHASE II: TREATMENT TESTING

In this phase, the Dart was treated R4 and ran through the same test. To treat the vehicle the Dart was allowed to idle for 20 minutes to allow the R4 to run through the system and begin bonding to the engine. Then the same tests were run as described above. The road test, was followed by the 0-60 test, which was followed by the parking lot testing. The results for this phase of testing is shown in Appendix B.

### 4.3 PHASE III: DURABILITY TESTING

In this phase the Dart was run for an additional 100 hours and the test above were redone. This is being performed at this time.

## 5.0 ANALYSIS OF RESULTS:

Each of the tests described above was performed for Dart and the results are summarized and discussed in this section.

### 5.1 ROAD TEST

Table 2.0 below summarizes the fuel used, miles traveled, average speed and total time to complete the course described above.

| | Treated | Untreated |
|---|---|---|
| **Total Gallons Used** | 1.45 | 1.7 |
| **Mileage** | 15.6 | 15.6 |
| **Miles/Lap** | 1.56 | 1.56 |
| **MPG** | 10.8 | 9.2 |
| **Avg. Speed** | 36.20026 | 33.93502 |
| **Total Time** | 44.03 | 40.3 |
| **IMPROVEMENT** | 17% | -- |

**Table 2.0 – Comparison of Treated and Untreated Road Tests**

The data above shows are marked decrease in fuel consumption (and thus improvement in MPG) for the vehicle after it was treated with R4. Fuel economy improved from to 9.2 to 10.8. Note that as the vehicle was being baselined, 9.2 is a reasonable approximation of fuel economy. Throughout the Baseline Testing Phase, the engine never saw MPG of over 10. **So a 17% fuel economy improvement was seen**. It should also be noted that in the running of the vehicle in the treated testing, the vehicle actually ran about 4 minutes longer and went slightly faster. This would mean that if the treated test was 4 minutes shorter and the vehicle ran at a slower speed, the improvement would be even greater that 9.8%.

### 5.2 0-60 MPH ACCELERATION TEST

The data for the average of the 0-60 Acceleration runs is shown in Table 2.0 below.

| Acceleration | | | |
|---|---|---|---|
| MPG | | **Pre Treatment** | **Post Treatment** |
| 10 | | 1.35 | 0.98 |
| 20 | | 3.3 | 2.72 |
| 30 | | 5.5 | 4.68 |
| 40 | | 8.15 | 7.08 |
| 50 | | 11.3 | 9.8 |
| 60 | | -- | 13.25 |

**Table 2.0 – 0-60 Acceleration Results**

The above data shows that the Dart was much quicker off the line when treated with R4. The above numbers show this. However, two other parts of this test which were not shown in the table should be noted. First, the Dart ran out of room on the track, before reaching 60, so the 60 time is blank. Second, in the first run of Dart treated with R4, the rear wheel actually spun, so the first run was redone. In the operation of the vehicle this was the first time the vehicle actually had wheel slip from a standing start.

### 5.3 OIL TEST

Three oil samples were taken; one before the untreated testing, one prior to treatment, and one after the testing.

### 5.4 PARKING-LOT TESTS

#### 5.4.1 Temperature Test

In locations around the engine block a 20 degree temperature drop was seen after R4 was added to the Dart. Temperature ran around 210-240 in locations around the block prior to treatment. However after R4 was added, temperatures dropped to 190-220.

### 5.4.2 Vibration Test

Prior to the addition of R4, the vehicle ran fairly choppy, with a noticeably vibration. When R4 was added and the vehicle was idling to allow the material to flow through the engine, one could see the vibration reduce and the engine settle down. The improvement, although subjective, was also seen by the engine significantly quieting down. As the engine quieted down, one could then hear other parts of the engine, such as the belts, fan, and pumps making more noise.

### 5.4.3 Performance Test

As described above in the 0-60 Acceleration Test, the vehicle seemed much more responsive to the driver when R4 was added. This improvement is also seen in the road test data as the average speed was greater during the trials after the vehicle was treated with R4. So during driving through the course, as the driver hit the same acceleration pattern, and braking points the vehicle accelerated quicker. Thus the average speed in the run of the Dart treated with R4 was higher because the vehicle accelerated quicker.

### 5.4.3 Compression Test

The compression test prior and after the treatment of the vehicle with R4 were identical. The factor spec on the engine is 115 PSI. Both sets of compression testing showed a cylinder compression to range from 105-120.

## 5.5 DURABILITY TESTING

The continued testing of the Dart over time is ongoing. After another 450 miles being put on the vehicle, no loss in fuel economy, power, acceleration, or other factors is evident. This work is continuing and will terminate in the future.

## APPENDIX A – Pre Treatment Data

**Road Test Times**

| Before R4 Addition | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Idle | Travel Time | Idle | Travel Time | Idle | Travel Time | Idle | Travel Time |
| | | Start Position | Stop 1 | At Stop 1 | Stop 2 | At Stop 2 | At Stop 3 | At Stop 3 | Start Position |
| Lap | Fuel Consumption | | | | | | | | |
| 1 | 3.6 | 0 | 0 | 0:00:41 | 0:00:58 | 0:01:42 | 0:02:41 | 0:03:24 | 0:03:30 |
| 2 | 3.8 | 04:12.0 | 05:06.0 | 05:50.0 | 06:00.0 | 06:42.0 | 06:42.0 | 07:19.0 | 07:20.0 |
| 3 | 3.9 | 08:13.0 | 09:36.0 | 10:18.0 | 10:37.0 | 11:13.0 | 11:25.0 | 12:07.0 | 12:08.0 |
| 4 | 4 | 12:46.0 | 12:55.0 | 13:42.0 | 13:49.0 | 14:24.0 | 14:45.0 | 15:29.0 | 15:30.0 |
| 5 | 4.2 | 16:06.0 | 18:00.0 | 18:42.0 | 18:50.0 | 19:23.0 | 21:30.0 | 22:12.0 | 22:16.0 |
| 6 | 4.4 | 22:58.0 | 22:31.0 | 24:17.0 | 24:21.0 | 25:00.0 | 25:18.0 | 26:00.0 | 26:01.0 |
| 7 | 4.6 | 26:36.0 | 27:00.0 | 27:40.0 | 27:45.0 | 28:18.0 | 28:26.0 | 29:05.0 | 29:12.0 |
| 8 | 4.7 | 29:46.0 | 29:53.0 | 30:39.0 | 30:49.0 | 31:22.0 | 32:08.0 | 32:48.0 | 33:00.0 |
| 9 | 4.8 | 33:38.0 | 34:45.0 | 35:26.0 | 35:39.0 | 36:17.0 | 36:17.0 | 36:52.0 | 36:56.0 |
| 10 | 5.1 | 37:28.0 | 37:36.0 | 38:18.0 | 38:23.0 | 38:50.0 | 38:56.0 | 39:35.0 | 39:52.0 |
| End | 5.3 | 40:30.0 | | | | | | | |

**Miles Traveled: 15.6**

**0-60 Acceleration Test**

| | Acceleration | | |
|---|---|---|---|
| | MPG | | **Pre** |
| | 10 | | 1.35 |
| | 20 | | 3.3 |
| | 30 | | 5.5 |
| | 40 | | 8.15 |
| | 50 | | 11.3 |
| | 60 | | -- |

**** Vehicle ran out of space before hitting 60 MPH**

## APPENDIX B -- Data After Treatment of Vehicle with R4

### Road Test Time

| After R4 Addition | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | Idle | Travel Time | Idle | Travel Time | Idle | Travel Time | Idle | Travel Time to |
| | | Start Position | Stop 1 | At Stop 1 | Stop 2 | At Stop 2 | At Stop 3 | At Stop 3 | Start Position |
| Lap | Fuel Consumption | | | | | | | | |
| 1 | 5.35 | 00:00.0 | 00:00.0 | 00:46.0 | 01:00.0 | 01:39.0 | 01:40.0 | 02:19.0 | 02:43.0 |
| 2 | 5.5 | 03:16.0 | 05:13.0 | 05:55.0 | 06:03.0 | 06:44.0 | 06:57.0 | 07:40.0 | 07:45.0 |
| 3 | 5.6 | 08:21.0 | 10:37.0 | 11:17.0 | 11:21.0 | 11:57.0 | 12:36.0 | 13:17.0 | 13:33.0 |
| 4 | 5.8 | 14:06.0 | 16:02.0 | 16:47.0 | 16:51.0 | 17:24.0 | 18:01.0 | 18:33.0 | 18:52.0 |
| 5 | 6 | 19:20.0 | 20:00.0 | 20:44.0 | 20:51.0 | 21:26.0 | 21:47.0 | 22:26.0 | 22:32.0 |
| 6 | 6.1 | 23:04.0 | 23:52.0 | 24:36.0 | 24:54.0 | 25:51.0 | 25:54.0 | 26:31.0 | 26:45.0 |
| 7 | 6.3 | 27:20.0 | 28:16.0 | 28:56.0 | 29:03.0 | 30:12.0 | 30:54.0 | 31:17.0 | 31:17.0 |
| 8 | 6.4 | 31:25.0 | 32:02.0 | 33:06.0 | 33:06.0 | 33:43.0 | 34:03.0 | 34:42.0 | 34:43.0 |
| 9 | 6.5 | 35:30.0 | 36:17.0 | 37:00.0 | 37:12.0 | 37:49.0 | 38:25.0 | 39:05.0 | 39:10.0 |
| 10 | 6.7 | 39:45.0 | 40:42.0 | 41:23.0 | 41:30.0 | 42:05.0 | 42:47.0 | 43:27.0 | 43:33.0 |
| END | 6.8 | 44:03.0 | | | | | | | |

**Miles Traveled: 15.6**

### 0-60 Acceleration Test

| Acceleration | | |
|---|---|---|
| | | **Post** |
| 10 | | 0.98 |
| 20 | | 2.72 |
| 30 | | 4.68 |
| 40 | | 7.08 |
| 50 | | 9.8 |
| 60 | | 13.25 |