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Analyses of the OBDII Data Collected From the Wisconsin I/M Lanes

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1.0 Summary and Conclusions

Since August 1998, Wisconsin's inspection and maintenance (I/M) program contractor, Envirotest Systems Corporation, has been sending EPA staff onboard diagnostic (OBD) scanning and IM240 test results data collected on model year (MY) 1996 and newer vehicles coming through the Wisconsin I/M test lanes. The data provided by Envirotest includes vehicle identification, and IM240, OBD-I/M, and gas cap test results (for a full list of the 40 data fields included in the Wisconsin data, see the Appendix A at the end of this report). In analyzing the Wisconsin data, EPA focused on: 1) the readiness status of the OBD monitors 2) the frequency of MIL illumination and 3) the relative failure rate of OBD-equipped vehicles based upon OBD-I/M, IM240, and gas cap evaporative system testing. The following observations were made:

Regarding readiness

- The majority of vehicles showing up at the I/M lane with monitors reading "not ready" were from MY 1996; the "not ready" rate for MY 1996 vehicles was 5.8%.
- Vehicle "not readiness" dropped off with each successive model year – to 2.2% for MY 1997 and 1.4% for MY1998.
- If an exemption were allowed for up to two monitors to read as "not ready" before a vehicle would be rejected from further testing, the rejection rate drops – to 2.2% for MY 1996 and to 0.2% for MY 1997 and MY 1998, for a three model year average of 0.9%.

Regarding MIL illumination

- After the first 40,000 miles, MIL illumination seems to increase with mileage and age.
- The greatest MIL illumination rate was seen among MY 1996 vehicles (2.5%) followed by MY 1997 (0.7%) and MY 1998 (0.5%).

Regarding the relative failure rate of OBD-I/M and other I/M tests

- The OBD-I/M and IM240 tests fail roughly the same overall number of MY 1996 and newer vehicles but very few vehicles fail both tests.
- The stand-alone gas cap evaporative system leak test fails several times more vehicles than does the OBD-based evaporative system monitor.

2.0 Background

The OBD system monitors the status of up to 11 emission control related subsystems by performing either continuous or periodic functional tests of specific components and vehicle conditions. The first three testing categories – misfire, fuel trim, and comprehensive components – are continuous, while the remaining eight only run after a certain set of conditions has been met. The algorithms for running these eight, periodic monitors are confidential to each manufacturer and involve such things as ambient temperature as well as driving times and conditions. Most vehicles will have at least five of the eight remaining monitors (catalyst, evaporative system, oxygen sensor, heated oxygen sensor, and exhaust gas recirculation or EGR system) while the remaining three (air conditioning, secondary air, and heated catalyst) are not necessarily applicable to all vehicles. When a vehicle is scanned at an OBD-I/M test site, these monitors can appear as either "ready" (meaning the test in question has been run), "not ready" (meaning the test has not yet been run), or "not applicable" (meaning the vehicle is not equipped with the components in question).

Current Federal regulations for OBD-I/M testing require that I/M programs reject from further testing any MY 1996 or newer OBD-equipped vehicle that is found to have one or more unset readiness flags. The reason vehicles with unset readiness flags are rejected but not failed is because an unset readiness flag is not necessarily an indication of an emission problem. Rather, it is an indication that certain monitor(s) that are intended to determine whether or not there may be an emission problem have not been run to evaluate the system. In the case of rejection, the issue of whether or not the vehicle requires repairs is deferred until the readiness flag(s) have been set and the monitor(s) run.

To determine the extent to which vehicles may be appearing for their OBD-I/M check with unset readiness flags in the real world, EPA looked at OBD readiness data from Wisconsin's I/M program for the last five months of 1998 and the last eight months of 1999. Wisconsin is currently conducting OBD-I/M checks in conjunction with a biennial, centralized, IM240-based enhanced I/M program which also includes a separate gas cap pressure test. The OBD-I/M check is only conducted on MY 1996 and newer light-duty vehicles and light-duty trucks, and the results of the test are purely advisory (i.e., vehicles are not being rejected or failed on the basis of the OBD-I/M check at this time).

The program data EPA analyzed included IM240, gas cap, and OBD MIL illumination and readiness data for over 116,000 MY 1996 and newer vehicles (see the Appendix A at the end of this report for a full list of the 40 data fields included in the Wisconsin raw data). The data was analyzed to determine the size of the readiness problem, the number of model years affected, and the approximate percentage of vehicles that would be rejected under a variety of possible readiness criteria. EPA also looked at the frequency of MIL illumination across model years and vehicle types, and compared the relative failure rates of OBD-I/M to that of lane-based IM240s and gas cap tests. Lastly, EPA compared mileage accumulation and vehicle age data to MIL and readiness rates to determine the impact of vehicle age and mileage.

3.0 Description of the Vehicle Sample

In performing the analyses discussed in this report, EPA used a sample of 116,669 MY

1996 and newer, OBD-equipped vehicles coming through the Wisconsin I/M program, submitted to EPA between August 1998 through December 1999. Although Wisconsin began OBD-I/M checks in 1998, odometer data on the vehicles tested was not submitted to EPA until May 1999. As a result, EPA does not have odometer data for MY 1997 vehicles (which received their first OBD-I/M checks when they turned one year old in calendar year 1998). For the sake of its analysis, EPA assumed that the mileage accumulation on MY 1997 vehicles after their first year of operation was comparable to that of MY 1998 vehicles after their first year. Unlike the MY 1997 vehicles, EPA does have odometer data for the MY 1998 vehicles, which was gathered when those vehicles received their first OBD-I/M check in 1999 (when they turned one year old).

Table 1 below presents the number of vehicles per model year included in the data set EPA analyzed, including the period during which this vehicle data was gathered, and whether or not odometer data was recorded. Omitting the first four months of 1999 because of the lack of odometer data simplified these analyses. EPA does not believe that including the January - April 1999 data would have changed the conclusions drawn from this already very large sample.

Table 1: Model Year Profile of the Wisconsin OBD-I/M Data Set

MYs	# of vehicles	Gathered during...	Odometer recorded?
1997	22,602	7/98 - 12/98	No
1996	50,297	5/99 - 12/99	Yes
1998	43,691	5/99 - 12/99	Yes

The odometer data for these analyses was separated into mileage "bins" broken into 5,000 mile increments. Odometer readings were recorded in 1,000-mile units, using only the digits before the comma with no attempt at rounding. Using this methodology, odometer readings of 9,000 and 9,999 miles would be considered equal, and both would be recorded as a 9. The process of "binning" tends to introduce a certain amount of scatter to the data because vehicles are not evenly distributed throughout the bin. Some bins will have a larger fraction of vehicles in the top half of the bin and some in the lower half. To smooth the curves and make them easier to read, EPA used a running average of three points as a filtering mechanism. Using this approach, the values for bins 4,9,14 were averaged together and plotted as bin 9.

For the charts presented in this report, each data point represents a minimum of 150 vehicles. Table 2 below presents the maximum and minimum mileage for each vehicle configuration, along with the actual number of vehicle records used for the limiting mileage. Mileages below the minimum or above the maximum mileages listed in Table 2 were recorded on fewer than 150 vehicles and were therefore excluded from the analysis performed to produce the mileage accumulation based charts in this report. Table 3 shows the average mileage accumulation in the sample, by model year.

Table 2: Minimum and Maximum Mileages

Vehicles	min. mileage	# vehicles	max. mileage	# vehicles
1996 LDV	9,000	342	99,000	197
1996 LDT	14,000	172	94,000	182
1996 Total	9,000	413	109,000	174
1998 LDV	4,000	1,076	59,000	207
1998 LDT	4,000	429	59,000	191
1998 Total	4,000	1,505	69,000	185

Table 3: Average Mileage Accumulation, by Model Year and Vehicle Type

Vehicle class	1996	1998
LDVs	45,385	20,745
LDTs	51,018	22,962

Chart 1 shows the number of vehicles in each mileage bin. Note that the 1998 vehicles have considerably less mileage than the 1996 vehicles, as would be expected. There is no odometer data for MY 1997 vehicles tested in calendar year 1998 but we expect that it will be similar to the plotted MY 1998 data since both models were one year old when tested (as previously discussed). Conversely, MY 1996 vehicles were three years old at the time of testing.

In a separate report[1] an argument was made that trucks (LDTs) and cars (LDVs) should be considered separately because they have different emission standards. In this report we also keep LDTs and LDVs separate, creating six categories: 1996, 1997 and 1998 LDTs and LDVs. The criteria used for separating cars from trucks were the IM240 cutpoints used in the I/M lane. As a result, all vehicles subject to a hydrocarbon (HC) cutpoint of 0.6 gram per mile (gpm) were considered LDVs. Using this approach leads to a slight distortion in the data because some small trucks (i.e., the smallest 4 cylinder trucks like the S10 and Ranger) were classified as LDVs as opposed to LDTs. EPA does not believe that this anomaly will have much impact on the general conclusions drawn in this report.

4.0 Results

The results of EPA's analysis of Wisconsin's OBD-I/M data are presented below, separated based upon the analysis focus areas discussed earlier: Readiness status, MIL frequency, and test type comparison.

4.1 Readiness Status

[1] "Evaluation of On Board Diagnostics For Use In Detecting High Emitting Vehicles" by Ed Gardetto and Ted Trimble.

4.1.1 Tabular Results

Table 4 below presents the "not ready" status for MY 1996-98 LDVs and LDTs in the Wisconsin data set while Table 5 shows "not ready" status for the same model years, by monitor. Note that the majority of the "not ready" vehicles are MY 1996 LDVs (6.9%) and that the majority (77%) of all "not ready" MY 1996 LDVs were not ready for the catalyst monitor, while MY 1998 LDVs were more frequently "not ready" for the evaporative system monitor. Note further that by MY 1998, the "not ready" rate for LDVs dropped over five-fold – from 6.9% to 1.3% – while the overall "not ready" rate for MY 1996 vehicles (5.8%) dropped more than four-fold by MY 1998 – to 1.4 %.

Table 4: "Not Ready" (NR) Status for MY 1996-98

	Total Tested	Not Ready (NR)	One NR	Two NR
96 LDV	27,313	1,873	1,155	884
%		6.9%	4.2%	3.2%
96 LDT	16,423	651	169	64
%		4.0%	1.0%	0.4%
96 Total	43,736	2,524	1,324	948
%		**5.8%**	3.0%	2.2%
97 LDV	14,946	360	58	30
%		2.4%	0.4%	0.2%
97 LDT	7,656	171	34	14
%		2.2%	0.4%	0.2%
97 Total	22,602	531	92	44
%		**2.3%**	0.4%	0.2%
98 LDV	27,615	361	101	61
%		1.3%	0.4%	0.2%
98 LDT	22,716	350	69	32
%		1.5%	0.3%	0.1%
98 Total	50,331	711	170	93
%		**1.4%**	0.3%	0.2%
TOTAL	116,669	3,766	1,586	1,085
%		**3.2%**	1.4%	0.9%

Table 5: "Not Ready" Status for MY 1996-98 (By Monitor)

	Total Tested	Catalyst	Evap	O2	Heated O2	EGR valve
96 LDV	27,313	1,435	475	826	880	1,041
%		5.3%	1.7%	3.0%	3.2%	3.8%

96 LDT	16,423	471	184	74	186	72
%		2.9%	1.1%	0.5%	1.1%	0.4%
96 Total	43,736	1,906	659	900	1,064	1,113
%		4.4%	1.5%	2.1%	2.4%	2.5%
97 LDV	14,946	87	209	38	102	33
%		0.6%	1.4%	0.3%	0.7%	0.2%
97 LDT	7,656	88	77	11	31	18
%		1.1%	1.0%	0.1%	0.4%	0.2%
97 Total	22,602	175	286	49	133	51
%		0.8%	1.3%	0.2%	0.6%	0.2%
98 LDV	27,615	105	287	59	61	55
%		0.4%	1.0%	0.2%	0.2%	0.2%
98 LDT	22,716	221	182	32	55	17
%		1.0%	0.8%	0.1%	0.2%	0.1%
98 Total	50,331	326	469	91	116	72
%		0.6%	0.9%	0.2%	0.2%	0.1%
TOTAL	116,669	2,407	1,414	1,040	1,313	1,236
%		2.1%	1.2%	0.9%	1.1%	1.1%

As discussed above, the Wisconsin data includes test results from MY 1997 and MY 1998 vehicles that were receiving their first tests on their one-year anniversary of purchase. Unfortunately, as we also discussed above, EPA does not have mileage accumulation data for MY 1997. Nevertheless, in the absence of any compelling reason to assume that MY 1997 vehicles were driven more or less than their MY 1998 counterparts in their first year of operation, we believe it is reasonable to assume that MY 1997 and MY 1998 vehicles exhibited comparable, accumulated mileage. The fact that the data in Table 4 still shows a significant decline in “not ready” rate from MY 1997 to MY 1998 – from an overall average of 2.3% to 1.4% – suggests that manufacturer learning curve is at least a likely explanation for the significant trend toward improvement in observed “not ready” rates. Chart 5 provides a graphic illustration of this trend in readiness by model year.

In performing its analysis of the Wisconsin data, EPA also looked at the impact of adjusting “not ready” rates based upon a variety of possible readiness waiver scenarios. In Table 4 above, the column headed “One NR” reflects the “not ready” rate by model year and vehicle type adjusted to reflect a waiver of the “not ready” rejection requirement if only one monitor is listed as “not ready.” The column headed “Two NR” reflects a similar adjustment of the “not ready” rate, but this time assuming a waiver of the rejection requirement if up to two monitors are listed as “not ready.” Table 4 shows that if any one monitor is allowed to be "not ready" the overall rejection rate among MY 1996-98 vehicles goes from 3.2% to 1.4%. If exemptions are allowed for vehicles with up to two unset readiness flags, the overall rejection rate goes down even further – to 0.9%. Table 4 also breaks out the readiness status of the vehicles in the Wisconsin data by monitor.

4.1.2 Graphic Results

Chart 6 shows the effect of each monitor on the total readiness of the MY 1996 vehicles, while Charts 7 and 8 show the same for MY 1997 and MY 1998 respectively. Note that the catalyst monitor was the most important factor in determining MY 1996 vehicle readiness but in MY 1997 and MY 1998, the evaporative system monitor also played a significant role.

Chart 9 shows the relative readiness of MY 1996 vehicles plotted against mileage accumulation. Note that the trendline is similar to the MIL illumination trendline for MY 1996 vehicles presented in Chart 3 (i.e., a third order polynomial). A break at about 40,000 miles is evident in both charts, although not as dramatic as seen in Chart 3. Also there does not seem to be the same break in the truck curve and trucks are relatively “more ready” than cars. Chart 12 shows the same information as Chart 9, but for MY 1998 LDVs and LDTs. Because fewer vehicles are “not ready” among the MY 1998 vehicles, there is more scatter in the data, but the break at 40,000 miles is still evident.

Chart 10 shows the readiness of all the individual monitors in the MY 1996 LDTs. The vehicle trendline plotted is a straight line (i.e., a first order polynomial). The first and second orders are almost indistinguishable. Also shown is the strong influence of the catalyst monitor on the readiness of these vehicles. Chart 11 presents the same information as Chart 10, but for MY 1996 LDVs instead of LDTs. Again the catalyst monitor has a strong influence and now the break at 40,000 is quite evident.

Chart 13 shows the readiness of all the individual monitors on MY 1998 LDTs. As can be seen, the readiness of MY 1998 trucks is basically a function of the readiness of the catalyst and evaporative system monitors. Chart 14 shows the same information as does Chart 13, but for MY 1998 LDVs. In the case of MY 1998 LDVs, vehicle readiness is almost exclusively a function of the readiness status of the evaporative system monitor

4.2 MIL Frequency

4.2.1 Tabular Results

Currently, EPA has very little data concerning how the average motorist reacts to the MIL (also known as a "Check Engine" light). For the sake of this analysis, however, EPA assumed that the people of Wisconsin knew that their vehicles would not be failed for having the MIL on and so had no problem going to the I/M lane with it illuminated.

Table 6 below shows the number of vehicles in the Wisconsin OBD data set that were tested by model year and vehicle type, as well as the number and percent of such vehicles with the MIL commanded on. As was the case with readiness status, the majority of MIL-on vehicles were from the 1996 model year.

Table 6: MIL-on Frequency in the Wisconsin Data Set

Vehicle	Number tested	Number w/ MIL on	Percent w/ MIL on
1996 LDV	27,310	645	2.4%
1996 LDT	16,420	436	2.7%
1996 Total	43,730	1,081	2.5%
1997 LDV	14,946	91	0.6%
1997 LDT	7,656	66	0.9%
1997 Total	22,602	157	0.7%
1998 LDV	27,630	118	0.4%
1998 LDT	22,720	123	0.5%
1998 Total	50,350	241	0.5%

4.2.2 Graphic Results

In Chart 2 we see that 2.5% of MY 1996 vehicles appeared in the I/M lanes with the MIL illuminated but only 0.7% of MY 1997 vehicles and 0.5% of MY 1998 vehicles were so afflicted. EPA assumes that mileage is not a factor in the difference between MY 1997 and MY 1998 but may be a factor in the difference between MY 1996 and either MY 1997 or MY 1998 vehicles. The reason for this assumption is the fact that MY 1996 vehicle test results represent three-years-worth of accumulated mileage, while MY 1997 and MY 1998 both represent only a single year of mileage accumulation each. EPA has no data concerning how many of these vehicles may have had a MIL illumination in the past which resulted in a repair, regardless of model year or warranty status.

Chart 3 shows the change in MIL illumination of MY 1996 vehicles with mileage. EPA notes a decline in MIL illuminations until about 40,000 miles, followed by a noticeable increase in MIL illuminations. Although a continuous trendline is best represented by a third order polynomial, two straight lines could just as easily represent the data; the break is so evident. It should be noted that the warranty period for comprehensive coverage on these vehicles expires at 36,000 miles. Chart 4 shows the same information as Chart 3, but for MY 1998 vehicles. There is more scatter to the data this time because the MIL illumination levels were about half what was observed for MY 1996. MY 1998 LDVs and LDTs are not very different with regard to MIL illumination rates up to 40,000 miles, but LDVs were found to have noticeably fewer MIL illuminations at mileages over 40,000 miles.

4.3 Test Type Comparison

4.3.1 MIL-on and IM240 Failure Rates

Table 7 below compares the relative failure rates for OBD-I/M versus IM240 observed in Wisconsin, and the degree to which the test results overlap. As can be seen from the data, OBD-I/M almost always fails slightly more vehicles than does the IM240 (MY 1998 LDVs are the only exception).

Table 7: OBD-I/M Fails vs. IM240 Fails

MY/Class	Total Tested	OBD Fail (number)	OBD Fail (percent)	IM240 Fail (number)	IM240 Fail (percent)	Failed Both (number)	Failed Both (percent)
1996 LDV	27,313	645	2.4%	569	2.1%	59	0.2%
1996 LDT	16,422	436	2.7%	383	2.3%	100	0.6%
1996 Total	43,735	1,081	2.5%	952	2.2%	159	0.4%
1997 LDV	14,944	91	0.6%	71	0.5%	7	0.2%
1997 LDT	7,656	66	0.9%	51	0.7%	0	0.0%
1997 Total	22,600	157	0.7%	122	0.5%	7	0.0%
1998 LDV	27,616	118	0.4%	223	0.8%	7	0.0%
1998 LDT	22,716	123	0.5%	47	0.2%	0	0.0%
1998 Total	50,332	241	0.5%	270	0.5%	7	0.0%

Table 7 also makes clear that the agreement between IM240 and the OBD-I/M check is exceedingly low for all model years and vehicle types, with the level of agreement dropping for the newer of the OBD-equipped model years. What is not clear from this data is which of the two tests is more beneficial to the environment. Determining which of the two tests -- OBD-I/M versus IM240 -- is more effective is outside the scope of this analysis, but was addressed as part of a separate pilot study performed by EPA between September 1997 and October 1999, involving 201 in-use MY 1996 and newer OBD-equipped vehicles which each received OBD-I/M, IM240, and federal certification tests[2].

[2] "Evaluation of On Board Diagnostics For Use In Detecting High Emitting Vehicles" by Ed Gardetto and Ted Trimble.

4.3.2 Gas Cap Testing vs. OBD-I/M

Unlike the OBD exhaust test versus the IM240, where the failure criteria for OBD are tighter than the failure criteria for the IM240, the OBD failure criteria for leak detection are known to be more lenient than the gas cap pressure test currently in use in several states. Although in theory this difference in test stringency should result in a greater number of failures for the gas cap test than for the OBD-based evaporative system test, it is not obvious that vehicles actually develop such "in between" leaks in the real world. To shed light on this issue, EPA looked at the Wisconsin data, focusing on the relative failure rates for the OBD-based evaporative system test versus the gas cap pressure test. The results of that comparison are presented in Table 8 below.

Table 8: Gas Cap vs. OBD Evaporative System Failure Rates

MY/Class	Total Tested	Gas Cap Fail (number)	Gas Cap Fail (percent)	OBD Evap Fail (number)	OBD Evap Fail (percent)
1996 LDV	27,313	291	1.1%	7	0.03%
1996 LDT	16,422	245	1.5%	3	0.02%
1996 Total	43,735	536	1.2%	10	0.02%
1997 LDV	14,944	83	0.6%	2	0.01%
1997 LDT	7,656	48	0.6%	1	0.01%
1997 Total	22,600	131	0.6%	3	0.01%
1998 LDV	27,616	170	0.6%	6	0.02%
1998 LDT	22,716	155	0.7%	1	0.004%
1998 Total	50,332	325	0.6%	7	0.01%

Note that the gas cap failure rate is several orders of magnitude higher than the OBD-I/M failure rate for the entire evaporative emission system. Clearly, some of this is due to the fact that enhanced OBD evaporative system monitoring was phased in over the model years being looked at in this sample[3]. Furthermore, as described in our earlier discussion on OBD readiness, the overall OBD readiness on MY 1998 LDVs was dominated by vehicles which showed up at the test lane without their evaporative system monitors having run.

5.0 Conclusions

[3] The phase-in requirements for MY 1996, 1997, 1998, and 1999+ are 20%, 40%, 90% and 100%, respectively.

Based upon its analysis of the Wisconsin OBD data set, EPA concluded the following:

- MIL illuminations increase with mileage and age, although MY 1996 vehicles show a definite decline until about 40,000 miles when a noticeable increase occurs.

- 5.8% of MY 1996 vehicles that showed up in the I/M lanes were not ready. Allowing the test to be performed with two monitors not ready cuts the rejection rate to 2.2% for MY 1996 vehicles. The number of not ready vehicles is much less among MY 1997 and MY 1998 vehicles, although that may be due to the fewer miles driven.

- Conclusions regarding vehicle trends based on an average mileage of 22,000 (MY 1997 and MY 1998) are not as strong as the conclusions based on MY 1996 data, with an average mileage accumulation of about 48,000 miles.

- OBD-I/M and IM240 fail about the same number of vehicles but very few vehicles fail both tests.

- The gas cap leak check fails significantly more vehicles than does the OBD-I/M evaporative system test.

6.0 Next Steps

EPA continues to receive data from the Wisconsin I/M program and intends to continue to monitor this data through calendar year (CY) 2000. Based upon past experience, EPA estimates that this will mean an additional 85,000 records for MY 1997 vehicles and an additional 85,000 records for MY 1999 vehicles will be available for analysis by the end of the calendar year. It will be interesting to see how this data compares with the current data set. For example, it is possible the differences that we see now among the MY 1996-98 vehicles may prove to be mileage and/or age related and not so much the result of vehicle improvements. In the current data set discussed in this report, the MY 1997 vehicles are similar to the MY 1998 vehicles in terms of age (i.e., both are one year old, as previously discussed) and, presumably, mileage accumulation, while the MY 1996 vehicles are unique in being three years old. By contrast, the MY 1997 vehicle data collected during CY 2000 will be for vehicles that are now three years old and these may show the same mileage patterns that were seen among MY 1996 vehicles in the data set discussed in this report. Similarly, the MY 1999 vehicle data gathered in CY 2000 should compare to the current MY 1998 vehicle data. Lastly, there may also be an opportunity to compare some individual MY 1997 vehicles to their results from the previous test cycle 2 years earlier.

Appendix A: Wisconsin I/M and OBD Data Fields

A	Date/time	Date and time the vehicle was tested
B	Mod yr.	Model year
C	Make	Make
D	Model	Model
E	Vin	Vin number
F	Test	Test number, 1 for the first time vehicle has been tested in this test cycle, 2 for the first retest. A very few vehicles have been retested up to four times.
G	HC Stan	Final cutpoints, 0.6 grams per mile for cars
H	Co Stan	Final cutpoints, 1.5 grams per mile for cars
I	NOx	Final cutpoints 0.7 grams per mile for cars, Wisconsin does not fail for NOx
J	HC	Actual emissions total grams divided by the total miles, at the time the test was terminated
K	Co	Actual emissions total grams divided by the total miles, at the time the test was terminated
L	NOx	Actual emissions total grams divided by the total miles, at the time the test was terminated
M	Em fsec	Number of seconds that the test ran. ("0" for the full 240 second test)
N	Em res	P or F, pass or fail the I/M240 tailpipe test
O	Pr cap Stan	Pressure cap standard, inches of water
P	Pr cap ini	Initial pressure, inches of water
Q	Pr cap	Final pressure, inches of water
R	Pr cap res	P or F, pass or fail pressure cap test
S	Onboard	Whether the technician could find the OBD connection. No cases where he could not after October 98
T	Obd res	Pass or fail
U	Tr no	Number of codes present (sum of V through AA) but is sometimes wrong
V	Code1	The next six columns list the OBD trouble codes, if any
W	Code2	

X	Code3	
Y	Code4	
Z	Code5	
AA	Code6	
AB	Ready misfire	The next 11 columns list the readiness flags. 0 means that the monitor is not fitted. 1 means that the monitor is fitted but not ready. 2 means that the monitor is ready
AC	Fuel	Fuel trim
AD	Comp	Various circuits necessary for the other monitors to work
AA	Cat	Catalyst
AF	Hcat	Heated catalyst
AG	Evap	Evaporative system
AH	Sair	Secondary air
AI	Acsys	Air conditioning
AJ	Oxy	Oxygen sensor
AK	Hoxy	Heated oxygen sensor
AL	Egr	Exhaust gas recirculation sensor
AM	Obd Mil	Mil light, 1 if lighted, 0 if not. Should be same as column T
AN	Odo	Odometer reading to nearest 1,000 miles (truncated)

Appendix B: Criteria of Failure

Wisconsin judges that a vehicle has failed OBDII if a DTC is revealed. Thus if a code number appears in column V there is an "F" recorded in Column T. For the purposes of this report a vehicle is considered to have failed the OBDII test if the number 1 appears in column AM, which signifies that the MIL is commanded on. All three of these columns are generated by the computer and no visual check of the light is made.

Wisconsin judges that a vehicle has failed a cutpoint if the recorded value is above the cutpoint by any amount. In other words no rounding to the correct number of significant figures occurs.

A number of vehicles that fail the cutpoints after a full 240 seconds are passed in the Wisconsin system. This apparently occurs because of the notion that a vehicle passes if it passes either of two tests, the fast pass or the full 240. A vehicle can fast pass for HC and CO but not NOx. It would then go the full 240 seconds but because Wisconsin does not fail for NOx, these vehicles would be considered to have passed the fast pass algorithms and would receive a passing grade even if they failed the full 240 second test. This brings into question the effectiveness of the algorithms for the tier 1 vehicles. For this report all vehicles that were above the cutpoints for any of the three pollutants after a 240 second test were considered failures of the 240 test.

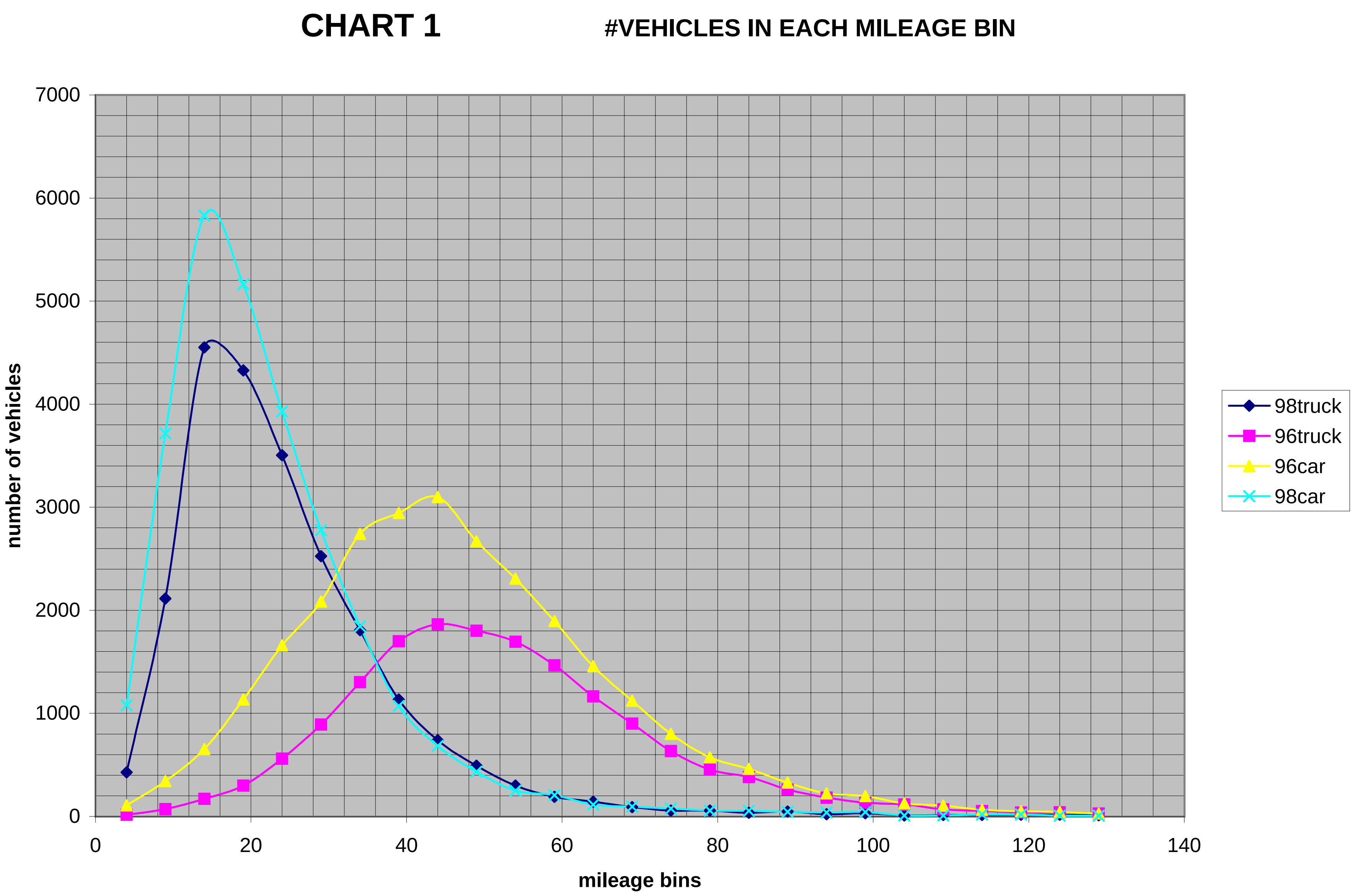


CHART 1
#VEHICLES IN EACH MILEAGE BIN
number of vehicles
7000
6000
5000
4000
3000
2000
1000
0
0
20
40
60
80
100
120
140
mileage bins
98truck
96truck
96car
98car

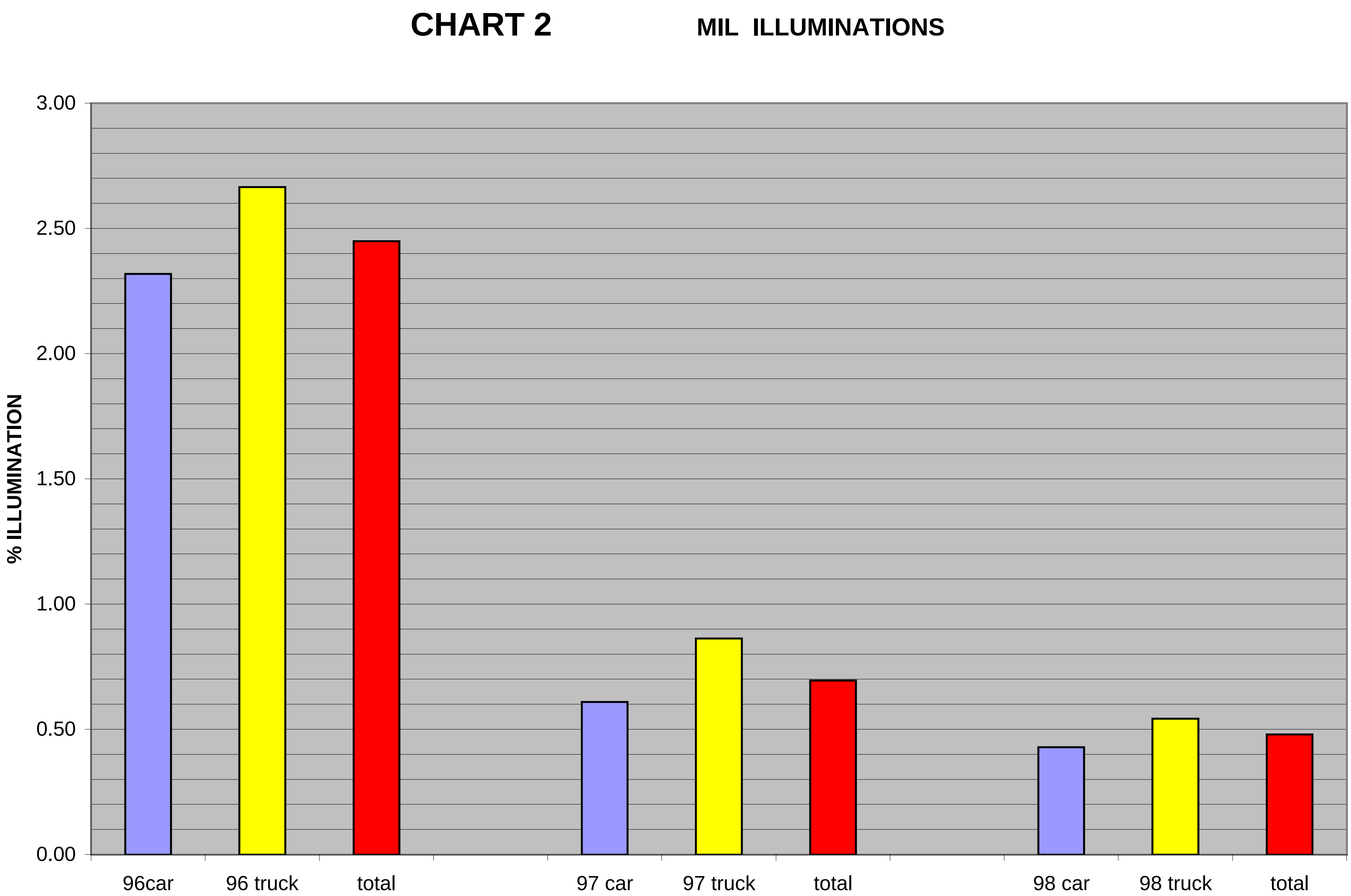


CHART 2
MIL ILLUMINATIONS
% ILLUMINATION
3.00
2.50
2.00
1.50
1.00
0.50
0.00
96car
96 truck
total
97 car
97 truck
total
98 car
98 truck
total

CHART 3 **1996 VEHICLES WITH MIL ON**

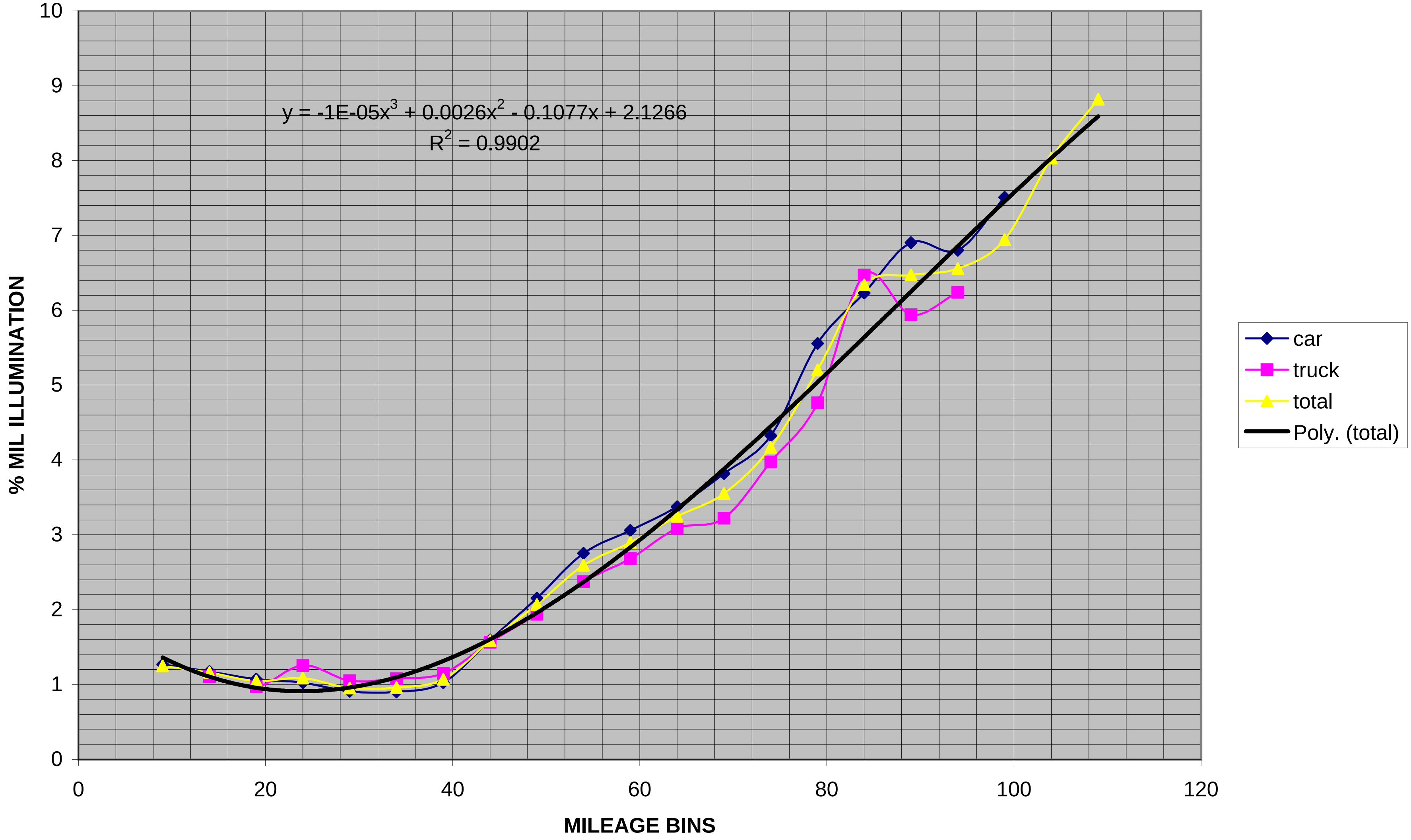


CHART 4 1998 VEHICLES WITH MIL

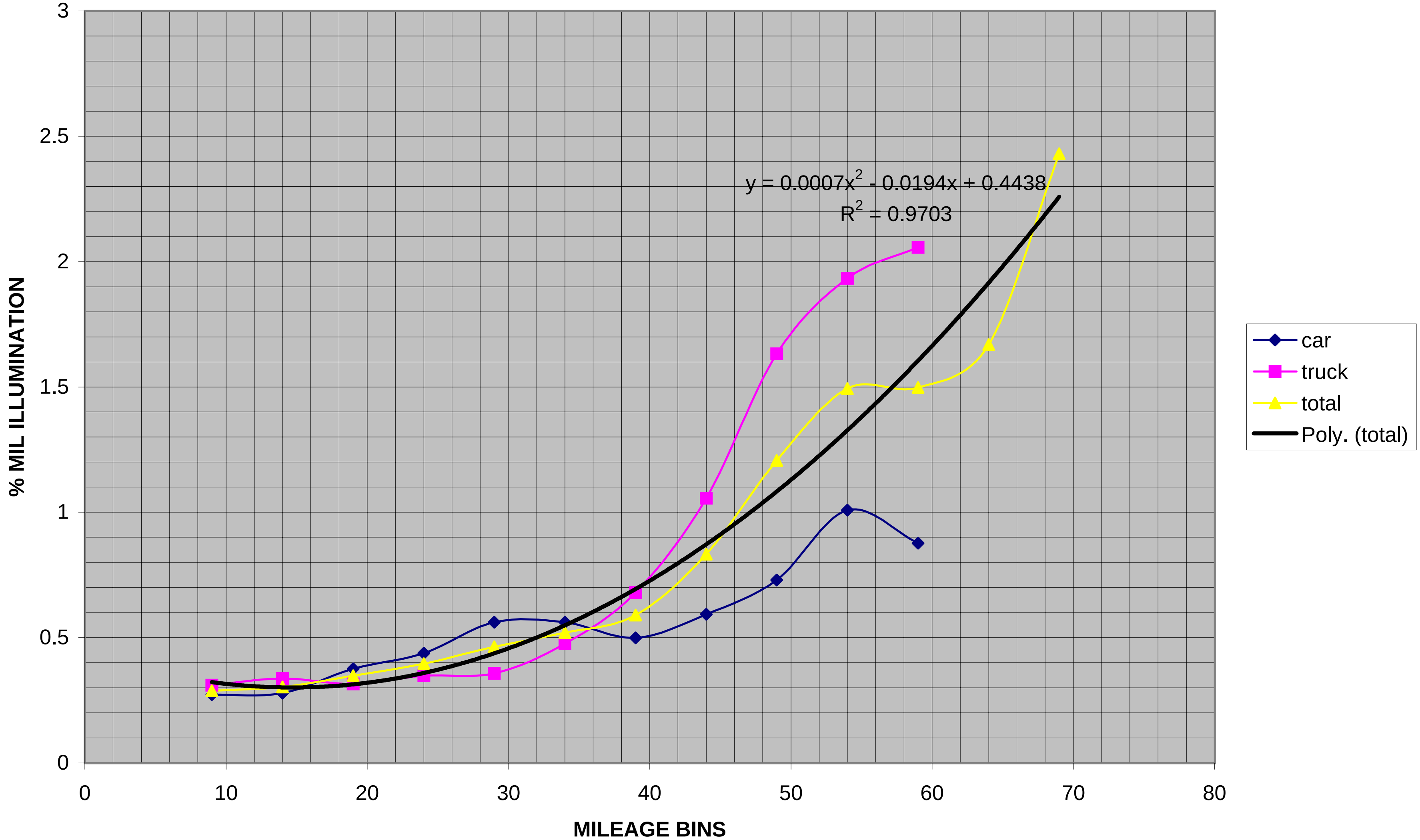
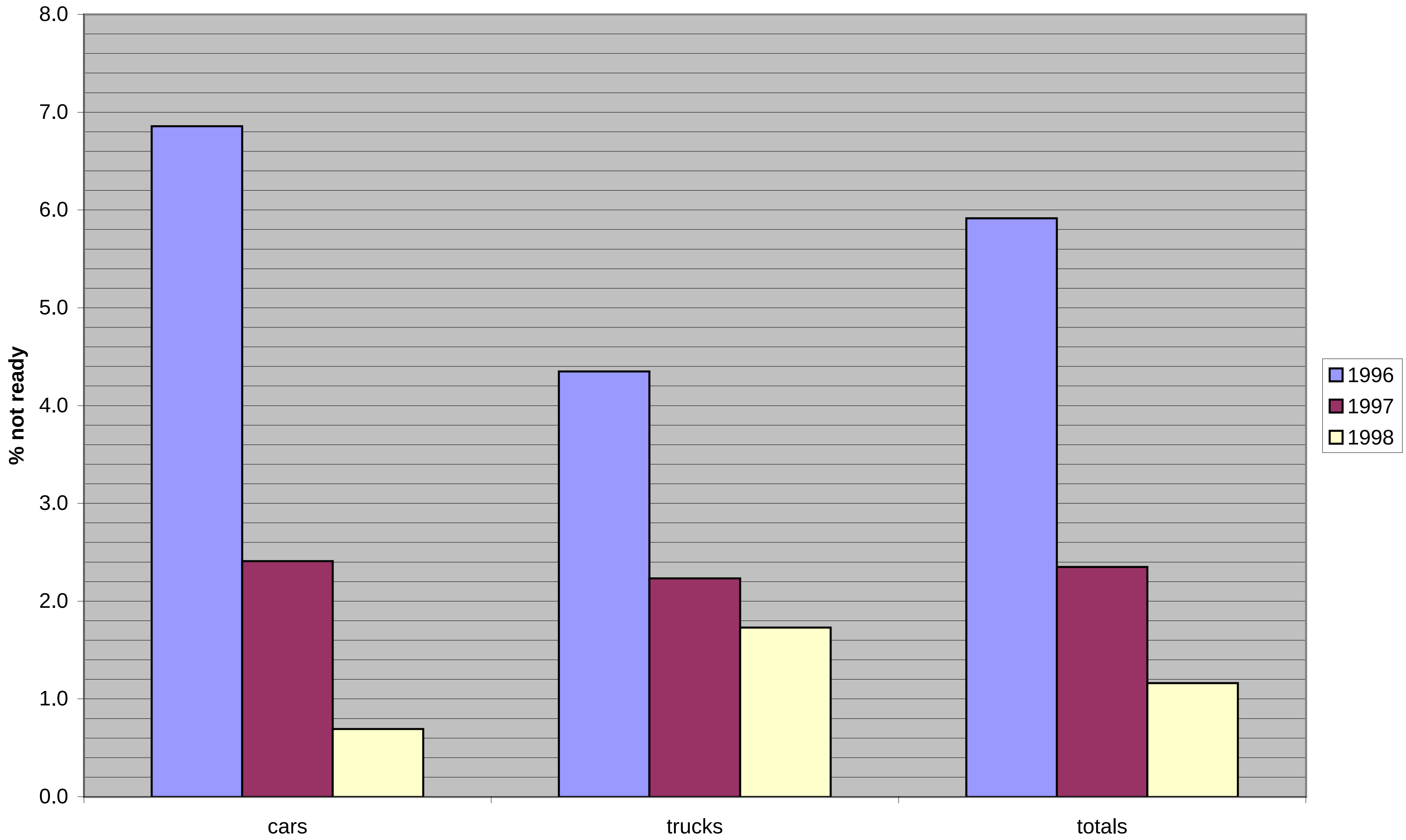


CHART 5 Readiness by model year



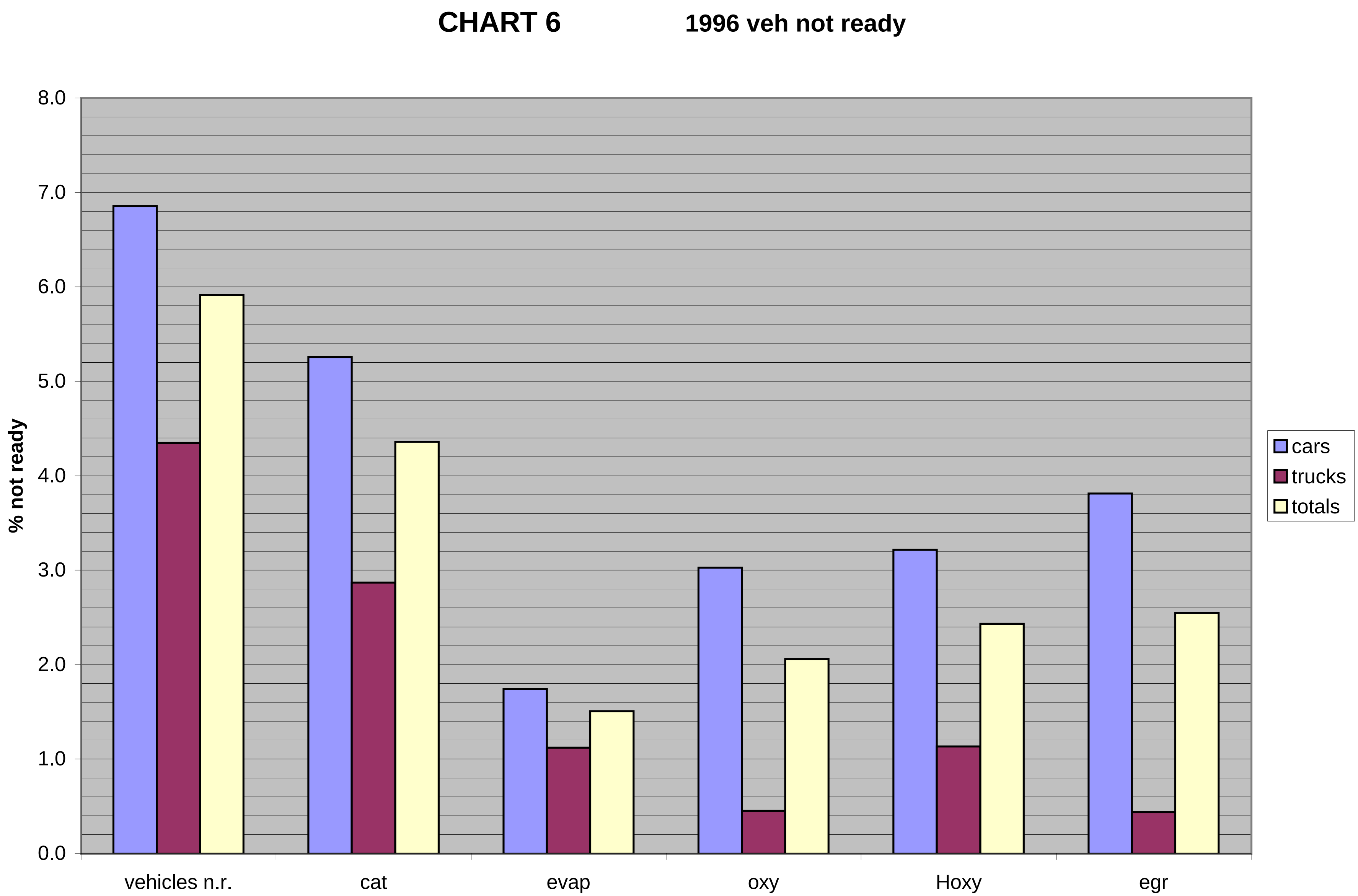


CHART 6
1996 veh not ready
% not ready
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
vehicles n.r.
cat
evap
oxy
Hoxy
egr
cars
trucks
totals

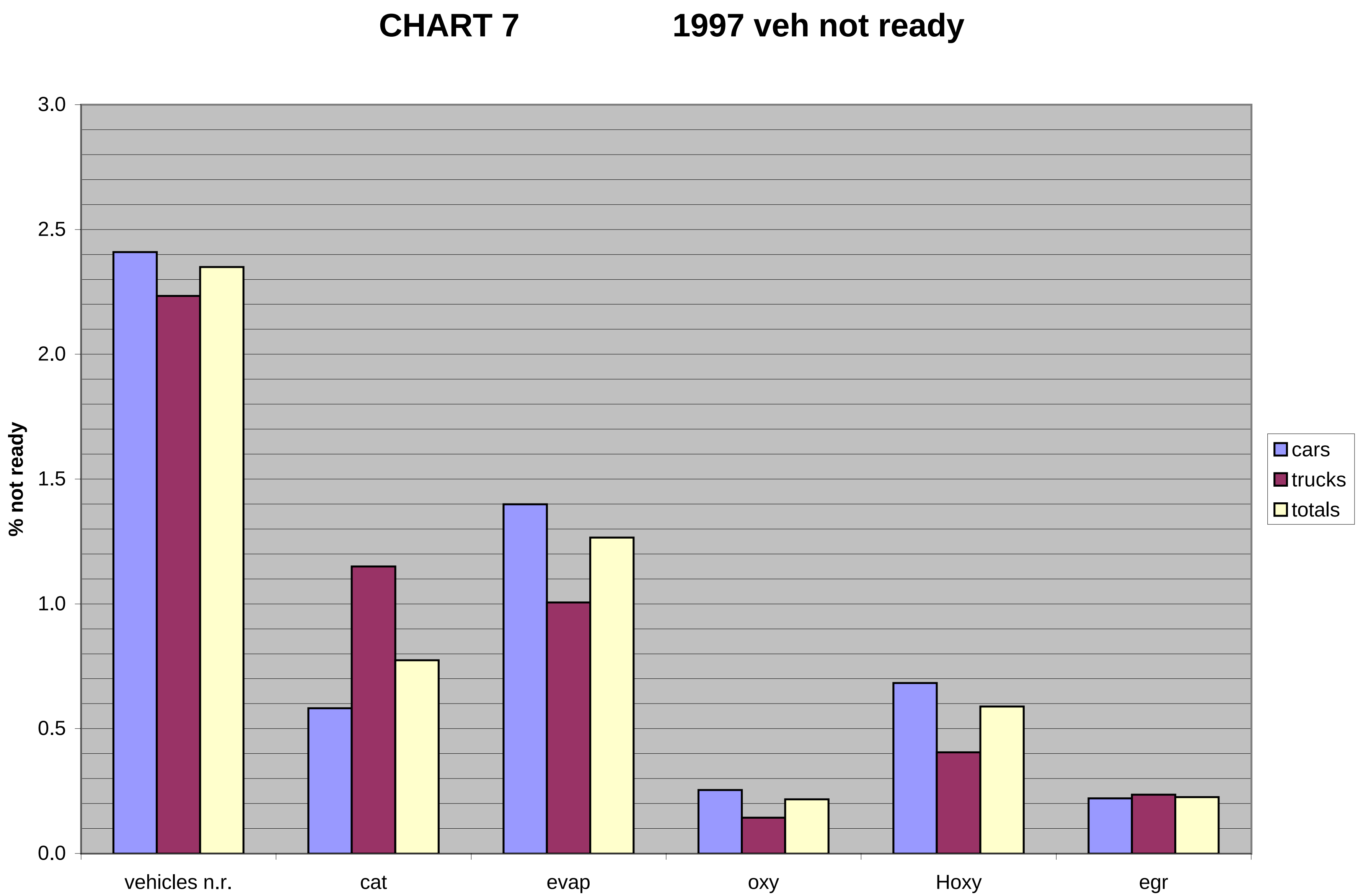


CHART 7
1997 veh not ready
% not ready
3.0
2.5
2.0
1.5
1.0
0.5
0.0
vehicles n.r.
cat
evap
oxy
Hoxy
egr
cars
trucks
totals

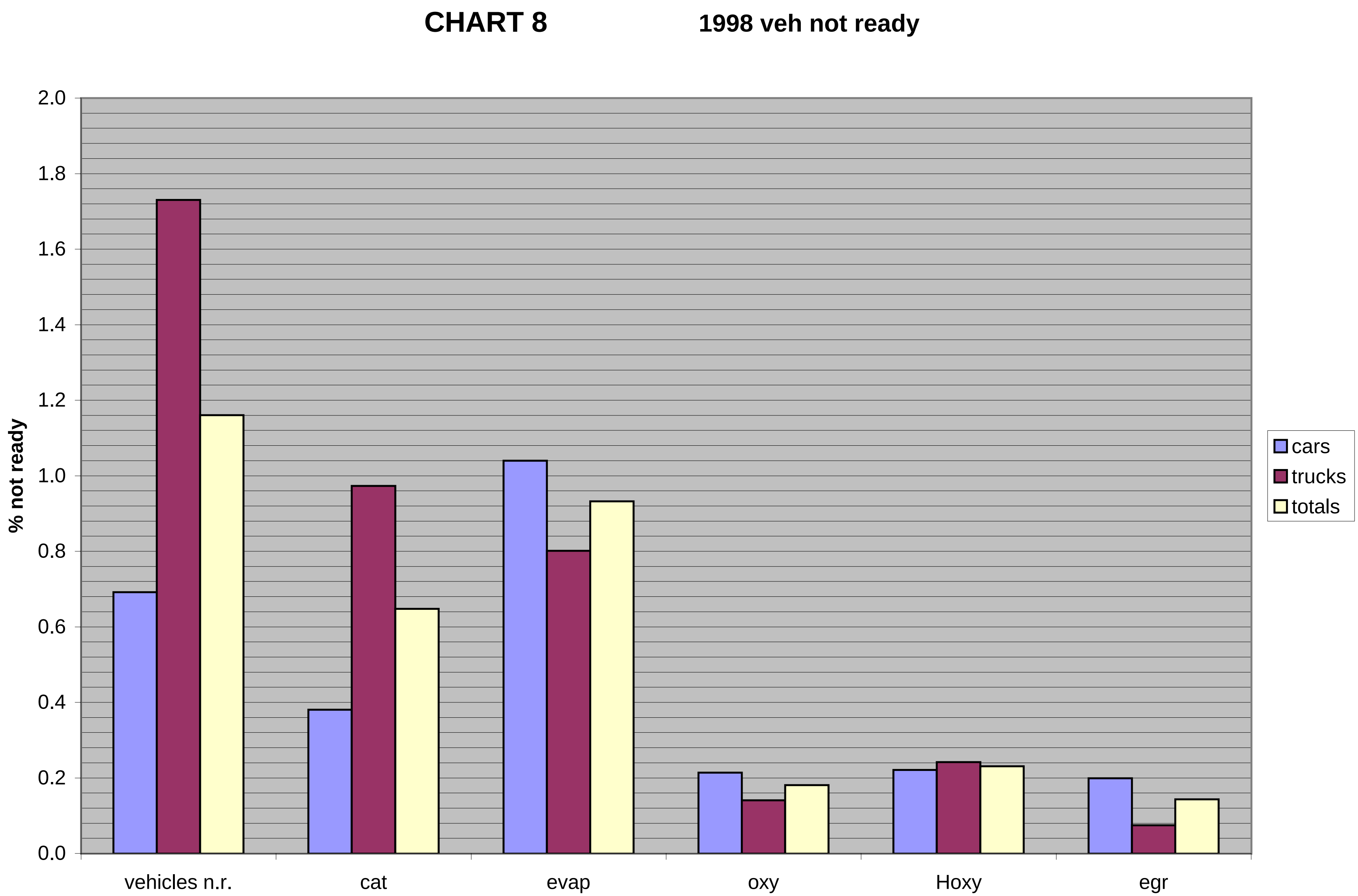


CHART 8
1998 veh not ready
% not ready
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
vehicles n.r.
cat
evap
oxy
Hoxy
egr
cars
trucks
totals

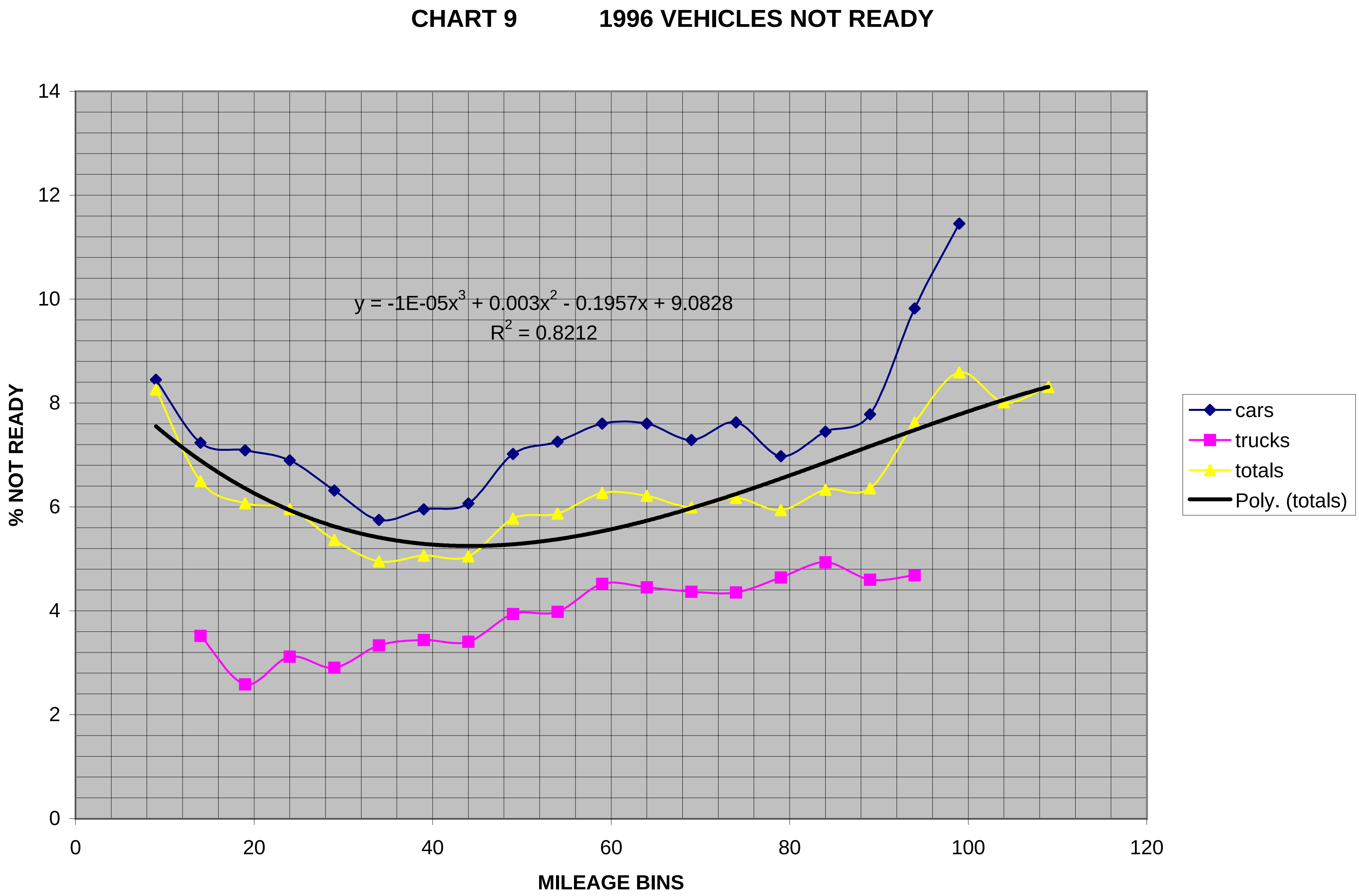
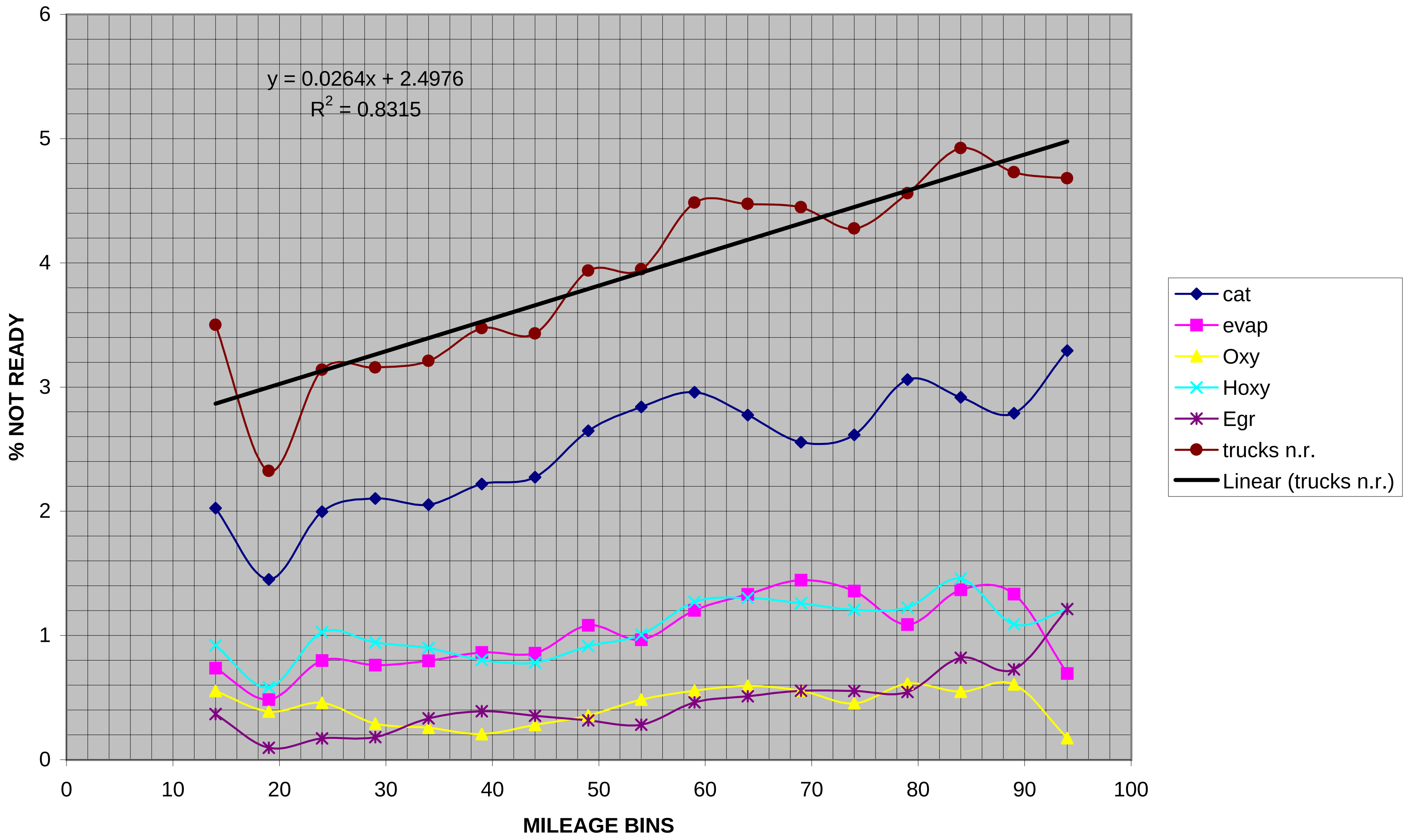


CHART 9 1996 VEHICLES NOT READY
% NOT READY
MILEAGE BINS
y = -1E-05x3 + 0.003x2 - 0.1957x + 9.0828
R2 = 0.8212
cars
trucks
totals
Poly. (totals)
0
2
4
6
8
10
12
14
0
20
40
60
80
100
120

CHART 10 1996 TRUCKS NOT READY



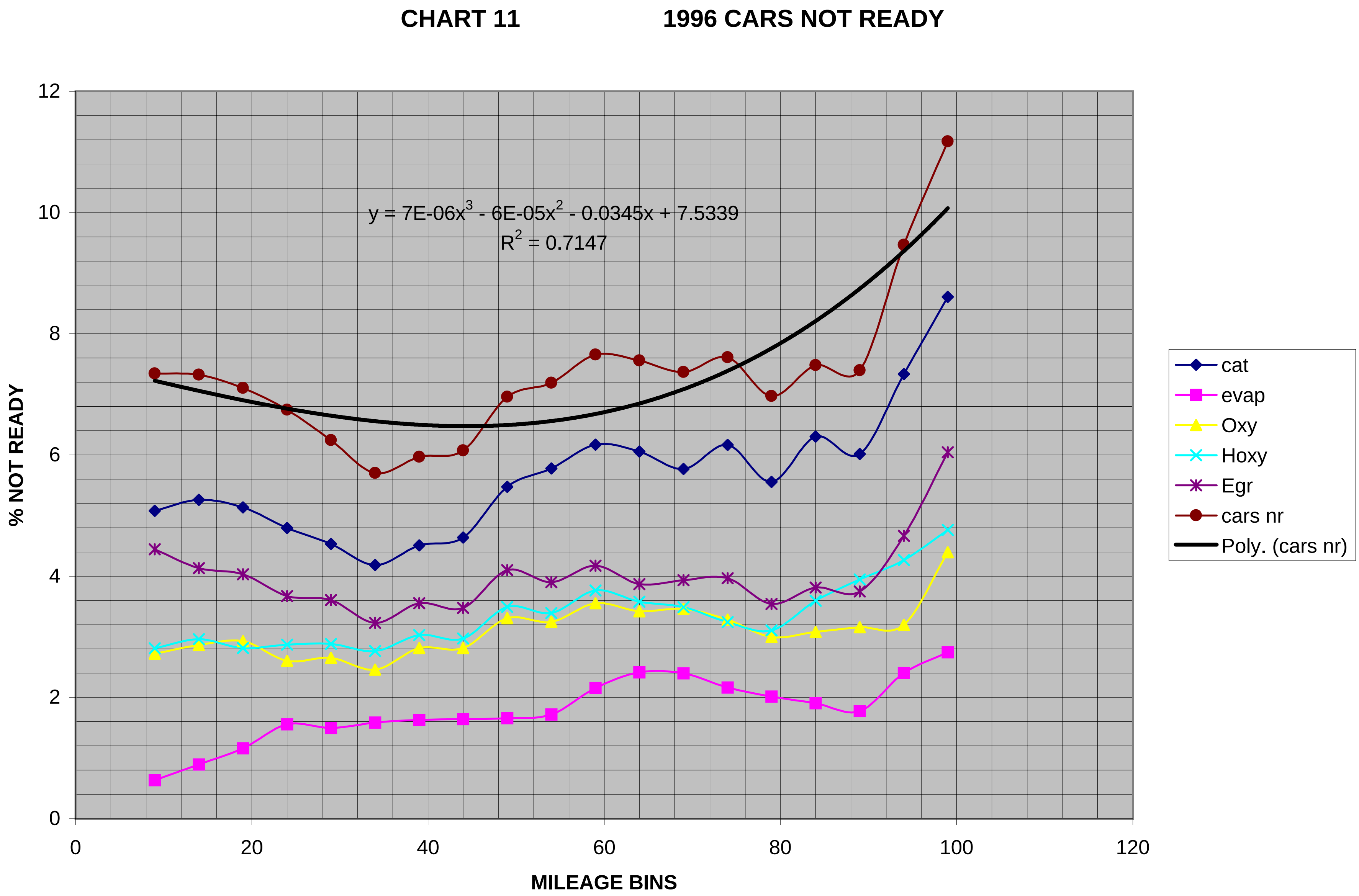


CHART 11
1996 CARS NOT READY
y = 7E-06x3 - 6E-05x2 - 0.0345x + 7.5339
R2 = 0.7147
% NOT READY
MILEAGE BINS
0
2
4
6
8
10
12
0
20
40
60
80
100
120
cat
evap
Oxy
Hoxy
Egr
cars nr
Poly. (cars nr)

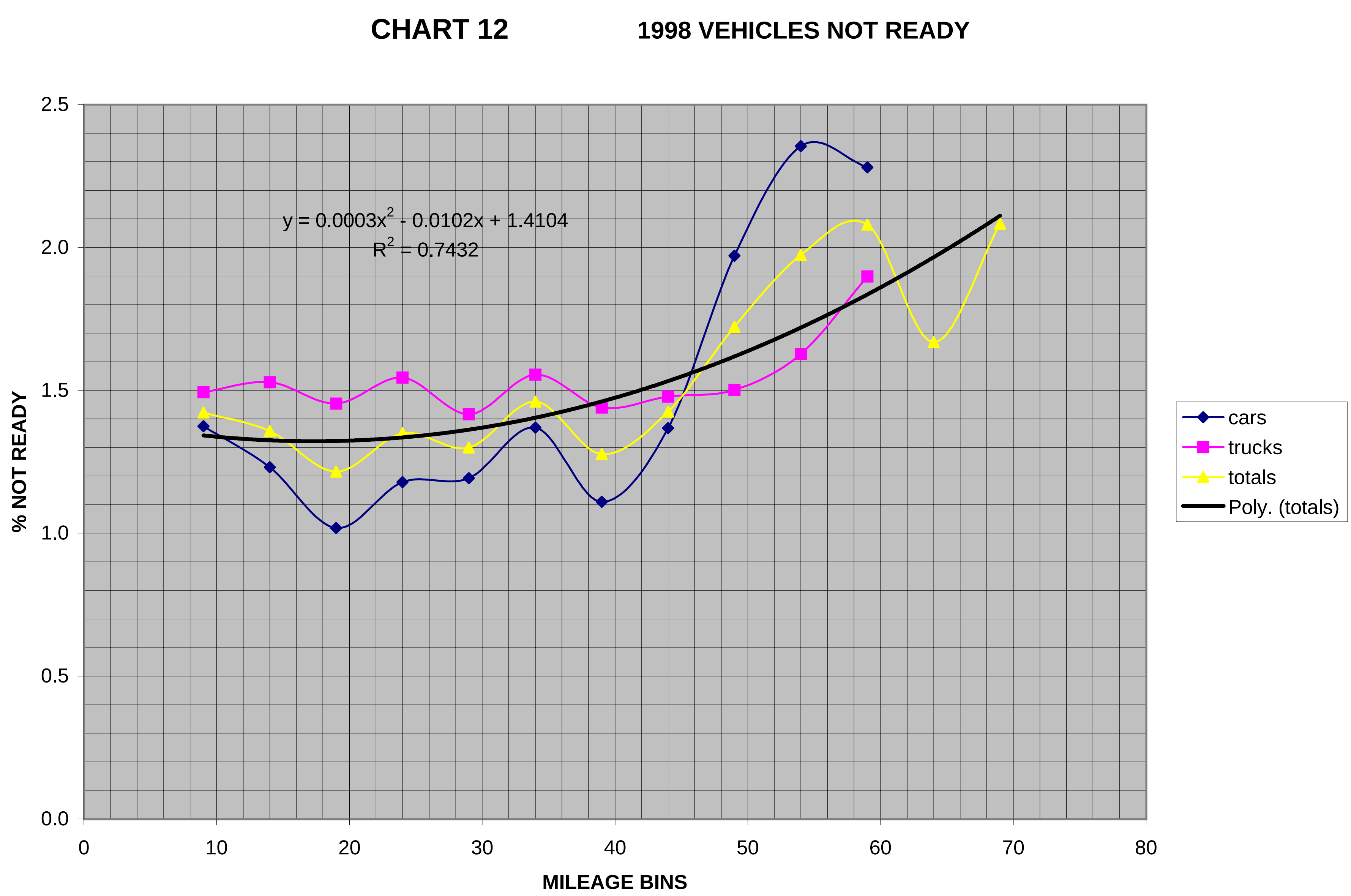


CHART 12
1998 VEHICLES NOT READY
y = 0.0003x2 - 0.0102x + 1.4104
R2 = 0.7432
% NOT READY
MILEAGE BINS
0.0
0.5
1.0
1.5
2.0
2.5
0
10
20
30
40
50
60
70
80
cars
trucks
totals
Poly. (totals)

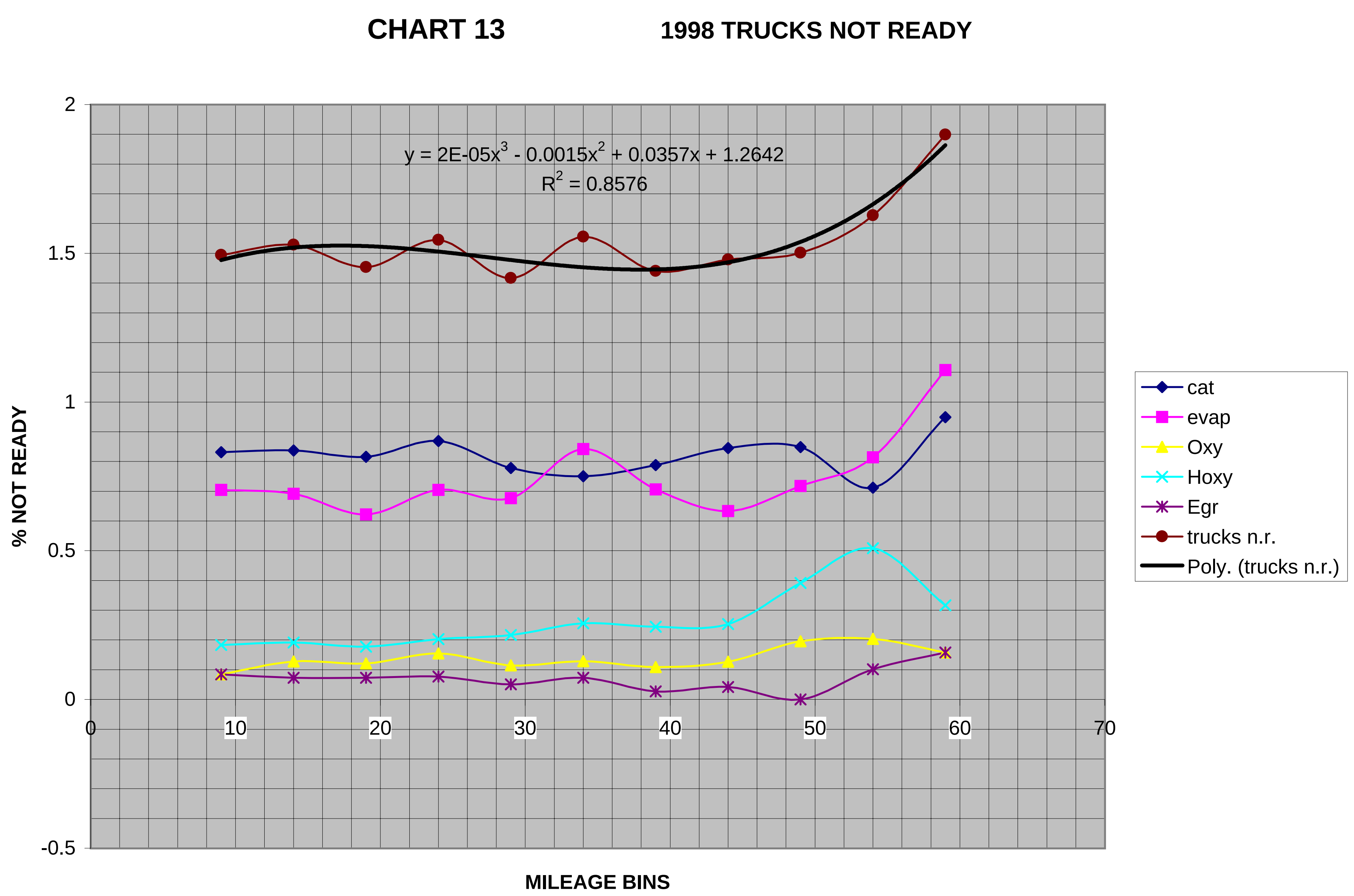


CHART 13
1998 TRUCKS NOT READY
y = 2E-05x3 - 0.0015x2 + 0.0357x + 1.2642
R2 = 0.8576
% NOT READY
MILEAGE BINS
2
1.5
1
0.5
0
-0.5
0
10
20
30
40
50
60
70
cat
evap
Oxy
Hoxy
Egr
trucks n.r.
Poly. (trucks n.r.)

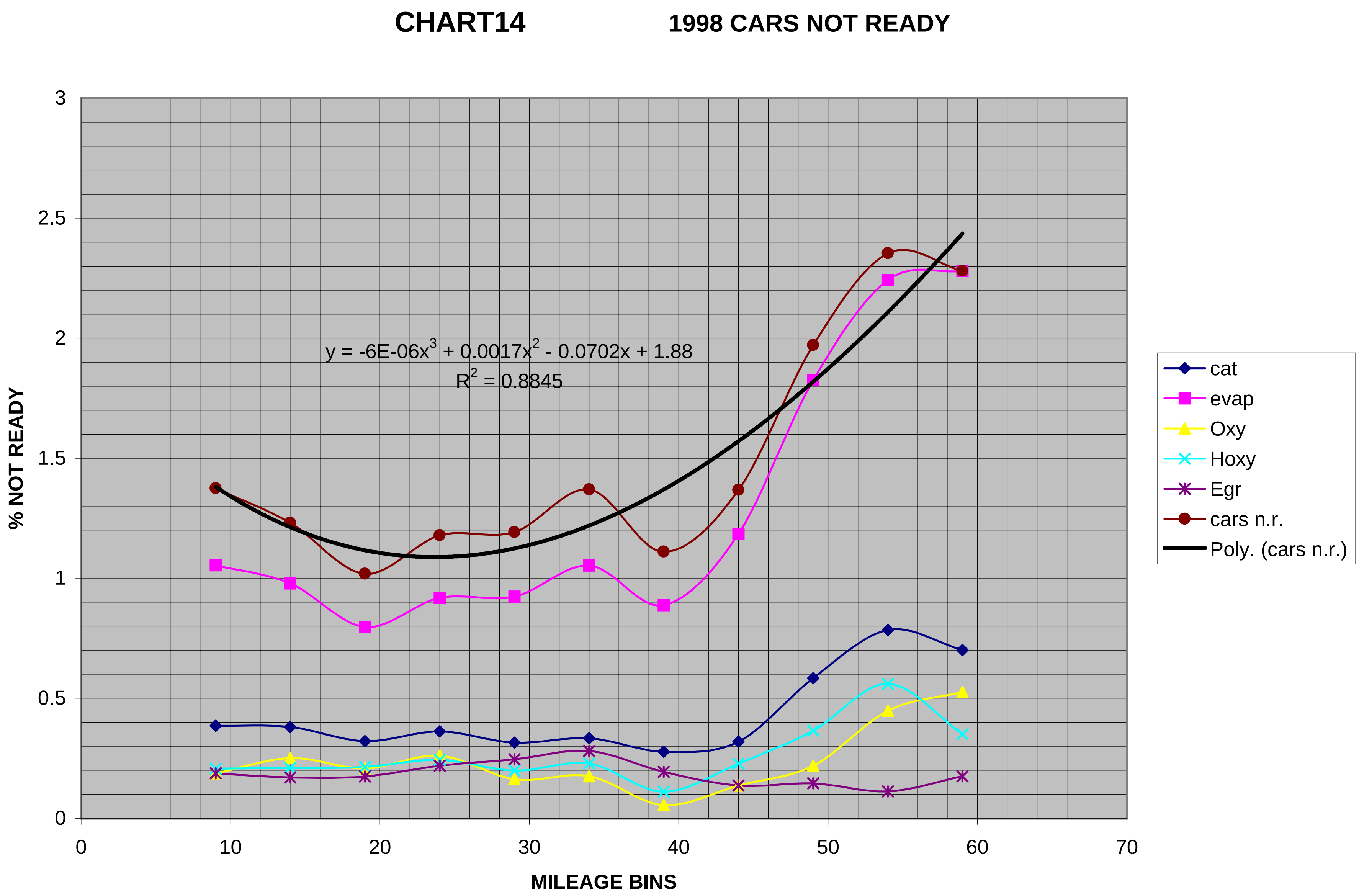


CHART14
1998 CARS NOT READY
% NOT READY
MILEAGE BINS
y = -6E-06x3 + 0.0017x2 - 0.0702x + 1.88
R2 = 0.8845
cat
evap
Oxy
Hoxy
Egr
cars n.r.
Poly. (cars n.r.)
0
0.5
1
1.5
2
2.5
3
0
10
20
30
40
50
60
70