

Field Test Results and Correlation with SAE J2727

Presentation from
Japan Automotive Manufacturers Association

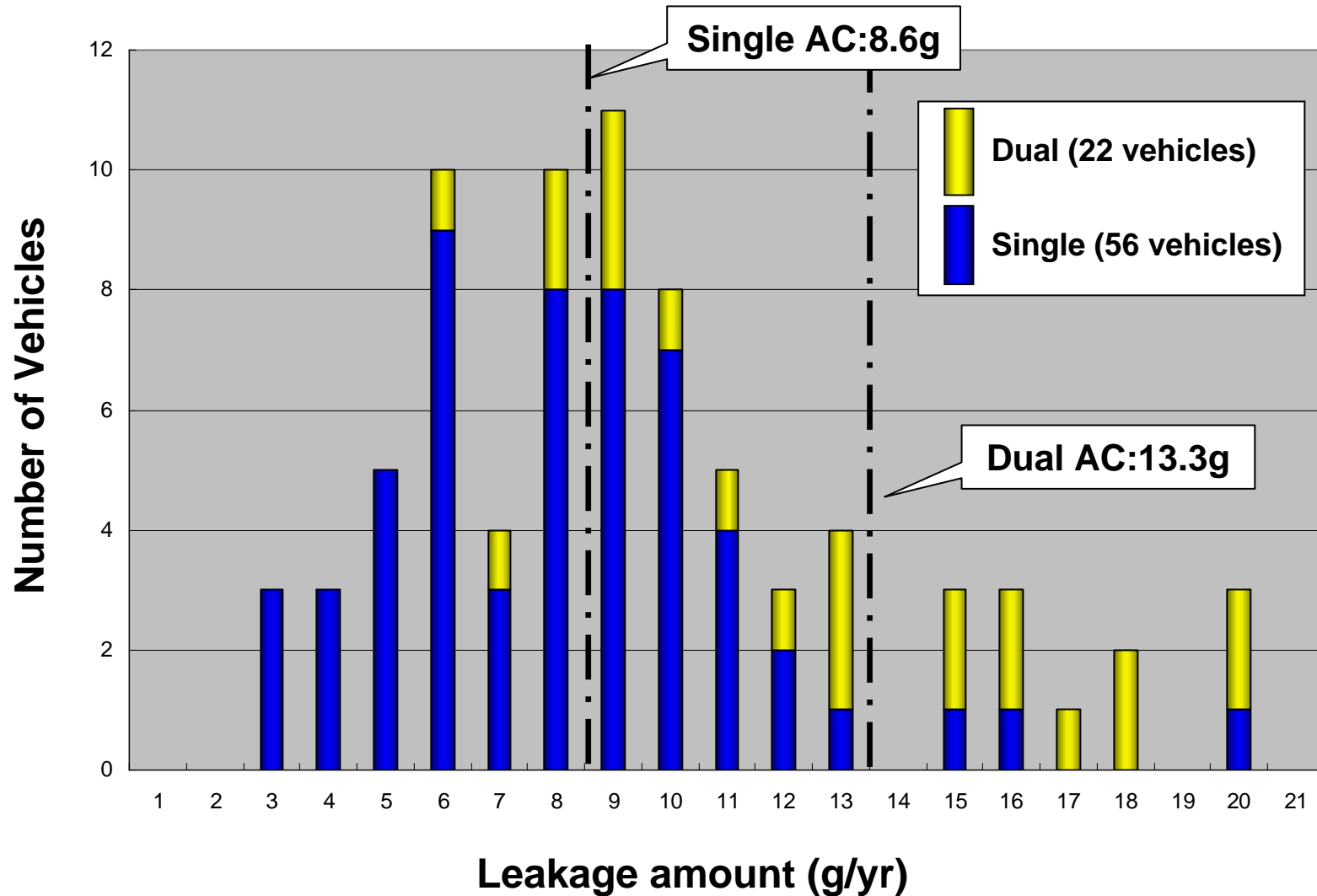
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Purpose

- **To understand the regular refrigerant leakage level, JAMA has conducted the fleet field test.**
- **To examine the possible usage of SAE J2727 for EU Refrigerant Regulation, based on the correlation between the test results and J2727**
 - 1. Field test result of JAMA**
 - 2. Correlation between JAMA's field test results and SAE J2727**
 - 3. Conclusion**

1. Field test result of JAMA

Region: Tokyo & Nagoya (Normal load), average temp.: 16C



Refrigerant Leakage Field Test

(From April, 2004 to December, 2005)

✓ Number of test vehicles

78 vehicles (seven auto makers)

✓ A/C system

Single AC (16 type vehicles)

Dual AC (6 type vehicles)

✓ Charge amount

Single:	Average: 516gram	Max: 760gram	Min:409gram
Dual:	Average: 804gram	Max: 1141gram	Min:663gram

✓ Location

Tokyo, Nagoya (average temperature 16C)

✓ Driving distance

Single:	Average: 17,402km	Max: 38,381km	Min:1,952km
Dual:	Average: 20,590km	Max: 40,983km	Min:4,803km

✓ Compressor running time

Single:	Average: 211.3hrs	Max: 938.0hrs	Min:24.4hrs
Dual:	Average: 248.9hrs	Max: 758.9hrs	Min:51.5hrs

✓ Compressor cycling number

Single	Average: 32,544	Max: 97,627	Min:253
Dual	Average: 36,302	Max: 98,777	Min:2178

Field Test Data - 1

Vehicle	# of vehicles	Single or dual	Test data (averaged)				
			Driving distance (km)	Comp. Running (hr.)	Clutch cycling (#)	Test period (yrs)	Averaged Leak (g/yr) (scattering)
Vehicle T-1 (Toyota Mark II)	3	S	17,323	138.9	50984	1.58	9.4 (Min.: 6.8, Max.: 13.0)
Vehicle T-2 (Toyota Corolla)	8	S	16,270	178.1	39645	1.58	9.1 (Min.: 6.4, Max.: 20.4)
Vehicle T-3 (Toyota Vista)	2	S	9,785	208.4	40423	1.59	7.3 (Min.: 5.5, Max.: 9.1)
Vehicle S-1 (Suzuki Lapin)	2	S	26,740	221.5	76,700	0.84	9.9 (Min.: 8.5, Max.: 11.3)
Vehicle N-1 (Nissan Cube)	3	S	21,473	187.3	8,619	1.42	8 (Min.: 4.2, Max.: 10.2)
Vehicle N-2 (Nissan Premera)	3	S	17,884	362.4	3,280	1.64	7.1 (Min.: 3.6, Max.: 12.0)
Vehicle N-3 (Nissan Cedric)	2	S	26,383	654.3	3,146	1.66	7.8 (Min.: 6.6, Max.: 9.0)
Vehicle N-4 (Nissan Tino)	2	S	24,031	297.4	41,024	1.66	8.1 (Min.: 7.8, Max.: 8.4)
Vehicle N-5 (Nissan Bluebird)	3	S	18,711	295.7	17,868	1.38	9.8 (Min.: 9.6, Max.: 10.2)
Vehicle N-6 (Nissan X-trail)	2	S	35,629	363.9	1,572	1.25	4.5 (Min.: 3.6, Max.: 5.4)

Field Test Data - 2

Vehicle	# of vehicles	Single or dual	Test data (averaged)				
			Driving distance (km)	Comp. Running (hr.)	Clutch cycling (#)	Test period (yrs)	Annual Leak (g/yr)
Vehicle F-1 (Subaru Forester)	2	S	19,089	269.5	75,344	1.53	13.7 (Min.: 11.0, Max.: 16.5)
Vehicle H-1 (Honda Fit)	10	S	9,720	108.6	26,080	1.60	9.2 (Min.: 4.9, Max.: 12.0)
Vehicle M-1 (Mazda Atenza)	4	S	21,987	209.3	58,220	1.67	8.7 (Min.: 7.9, Max.: 9.1)
Vehicle M-2 (Mazda Premacy)	4	S	24,120	199.9	40,285	1.67	7.7 (Min.: 6.2, Max.: 10.4)
Vehicle MI-1 (Mitsubishi EKwagon)	3	S	10,137	163.3	55,277	1.51	8.2 (Min.: 3.3, Max.: 15.2)
Vehicle MI-2 (Mitsubishi Lancer)	3	S	20,805	189.1	34,148	1.47	5.5 (Min.: 4.8, Max.: 6.1)

Field Test Data - 3

Vehicle	# of vehicles	Single or dual	Test data (averaged)				
			Driving distance (km)	Comp. Running (hr.)	Clutch cycling (#)	Test period (yrs)	Annual Leak (g/yr)
Vehicle N-7 (Nissan Serena)	8	D	23,728	228.8	56,544	1.63	12.3 (Min.: 6.1, Max.: 17.6)
Vehicle N-8 (Nissan Elgrand)	4	D	23,218	529.1	13,334	1.65	14.7 (Min.: 8.8, Max.: 18.0)
Vehicle H-2 (Honda Stepwgn)	3	D	18,770	180.7	24,919	1.41	10.2 (Min.: 8.4, Max.: 12.4)
Vehicle H-3 (Honda Odyssey)	2	D	23,937	181.2	35,335	1.30	15.6 (Min.: 11.0, Max.: 20.3)
Vehicle M-3 (Mazda MPV)	2	D	22,730	172.1	51,004	1.67	9.3 (Min.: 9.0, Max.: 9.6)
Vehicle MI-3 (Mitsubishi Grandis)	3	D	11,160	134.6	24,868	1.07	17.9 (Min.: 15.4, Max.: 20.1)

Various types of vehicles from compact sedan to compact mini-van of several Automotive companies were covered in JAMA's field test

2. Correlation between JAMA's field test and SAE J2727

SAE J2727 Leakage Calculation Method

Fittings →

Service ports →

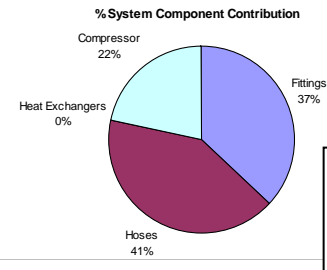
Flexible hoses →

Heat exchangers →

Compressor →

Total Rating →

TEMPLATE							
Leakage Chart							
System Component Connection							Calculated Value
Fittings							Do Not Enter Data
Rigid Pipe connections	Single O-ring	Single Captured O-ring	Multiple O-ring	Seal Washer	Seal Washer with O-ring	Metal Gasket	
Total Emissions	125	75	50	10	5	1	
Number of fittings:		13					0.975
High Side service port							
Total Emissions	60	60	40	10	5	1	
Number of fittings:	1						0.060
Low-Side service port							
Total Emissions	40	40	25	10	10	1	
Number of fittings:	1						0.040
PRV, Switches, Transducers							
Total Emissions	40	40	25	10	10	1	
Number of fittings:	3						0.120
							Fittings Total
							1.195
Flexible Hose							Calculated Value
Includes Hose and Hose Coupling Crimps [End Connections included in Component Connection]	Length [mm]	Diameter [mm]	Surface Area Do Not Enter Data	Type of Hose	All Rubber Hose	Standard Barrier or Veneer Hose	Ultra-low Perm Barrier or Veneer Hose
Heat Exchangers							
Assumpton = 0.001	[heat exchanger value pre-set value 1]					Heat Exchange Total	0.001
Compressor							
	Single Lip+ Body O-rings	Single Lip+Body Gaskets	Multiple Lip and Body O-rings	Multiple Lip + Gaskets	Type of seal		Do Not Enter Data
Total Emissions	2500	2000	1200	700			
Compressor				1			Compressor Total
							0.700
							[place a "1" in the appropriate cell]
Summary		% Contribution					
Fittings		37.0%					
Hoses		41.2%					
Heat Exchangers		0.0%					
Compressor		21.7%					
		100.0%					
Rating Value		Rating TOTAL					
		3.2					
> 1 - Leakage Enhancement Level IV							
2 - Leakage Enhancement Level III							
3 - Leakage Enhancement Level II							
4 - Leakage Enhancement Level I							
< 5 - Standard leakage							



% of components contribution

Present SAE J2727

- ✓ SAE J2727 was formulated based upon the past leakage data of components and experience with leakage characteristics.
- ✓ SAE J2727 shows the degree of improvements when changing AC system, but does not show the annual refrigerant leakage directly.

Correlation between SAE J2727's Score and Field test

Estimation of Leakage by Score -1

Vehicle	# of vehicles	Single or dual	Test data (averaged) Averaged Leak (g/yr) (scattering)	Evaluation by SAE J2727			Conversion constant (leakage/ score)	
				Score	% system component contribution			
					Comp.	Fittings		Hoses
Vehicle T-1 (Toyota Mark II)	3	S	9.4 (Min.: 6.8, Max.: 13.0)	3.1	23	41	36	3.03
Vehicle T-2 (Toyota Corolla)	8	S	9.1 (Min.: 6.4, Max.: 20.4)	3.2	22	37	41	2.84
Vehicle T-3 (Toyota Vista)	2	S	7.3 (Min.: 5.5, Max.: 9.1)	3.1	23	41	36	2.35
Vehicle S-1 (Suzuki Lapin)	2	S	9.9 (Min.:8.5,Max.:11.3)	3.1	40	29	31	3.19
Vehicle N-1 (Nissan Cube)	3	S	8 (Min.: 4.2, Max.: 10.2)	2.6	27	40	33	3.08
Vehicle N-2 (Nissan Premera)	3	S	7.1 (Min.: 3.6, Max.: 12.0)	2.8	25	38	37	2.54
Vehicle N-3 (Nissan Cedric)	2	S	7.8 (Min.: 6.6, Max.: 9.0)	2.7	26	39	35	2.89
Vehicle N-4 (Nissan Tino)	2	S	8.1 (Min.: 7.8, Max.: 8.4)	3.0	23	36	41	2.70
Vehicle N-5 (Nissan Bluebird)	3	S	9.8 (Min.: 9.6, Max.: 10.2)	2.8	25	39	36	3.50
Vehicle N-6 (Nissan X-trail)	2	S	4.5 (Min.: 3.6, Max.: 5.4)	2.8	25	37	38	1.61

Estimation of Leakage by Score -2

Climate condition
N:averaged temp.16dc

Vehicle	# of vehicles	Single or dual	Test data (averaged)		Evaluation by SAE J2727			Conversion constant (leakage/score)
			Averaged Leak (g/yr) (scattering)	Score	% system component contribution			
					Comp.	Fittings	Hoses	
Vehicle F-1 (Subaru Forester)	2	S	13.7 (Min: 11.0, Max.: 16.5)	3.4	28	23	49	4.02
Vehicle H-1 (Honda Fit)	10	S	9.2 (Min.: 4.9, Max.: 12.0)	3.3	37	30	33	2.79
Vehicle M-1 (Mazda Atenza)	4	S	8.7 (Min.: 7.9, Max.: 9.1)	4.0	30	39	31	2.87
Vehicle M-2 (Mazda Premacy)	4	S	7.7 (Min.: 6.2, Max.: 10.4)	3.3	36	53	11	2.33
Vehicle MI-1 (Mitsubishi EKwagon)	3	S	8.2 (Min.: 3.3, Max.: 15.2)	3.7	32	35	33	2.22
Vehicle MI-2 (Mitsubishi Lancer)	3	S	5.5 (Min.: 4.8, Max.: 6.1)	3.1	39	50	11	1.77

Average conversion constant for single A/C: 2.73

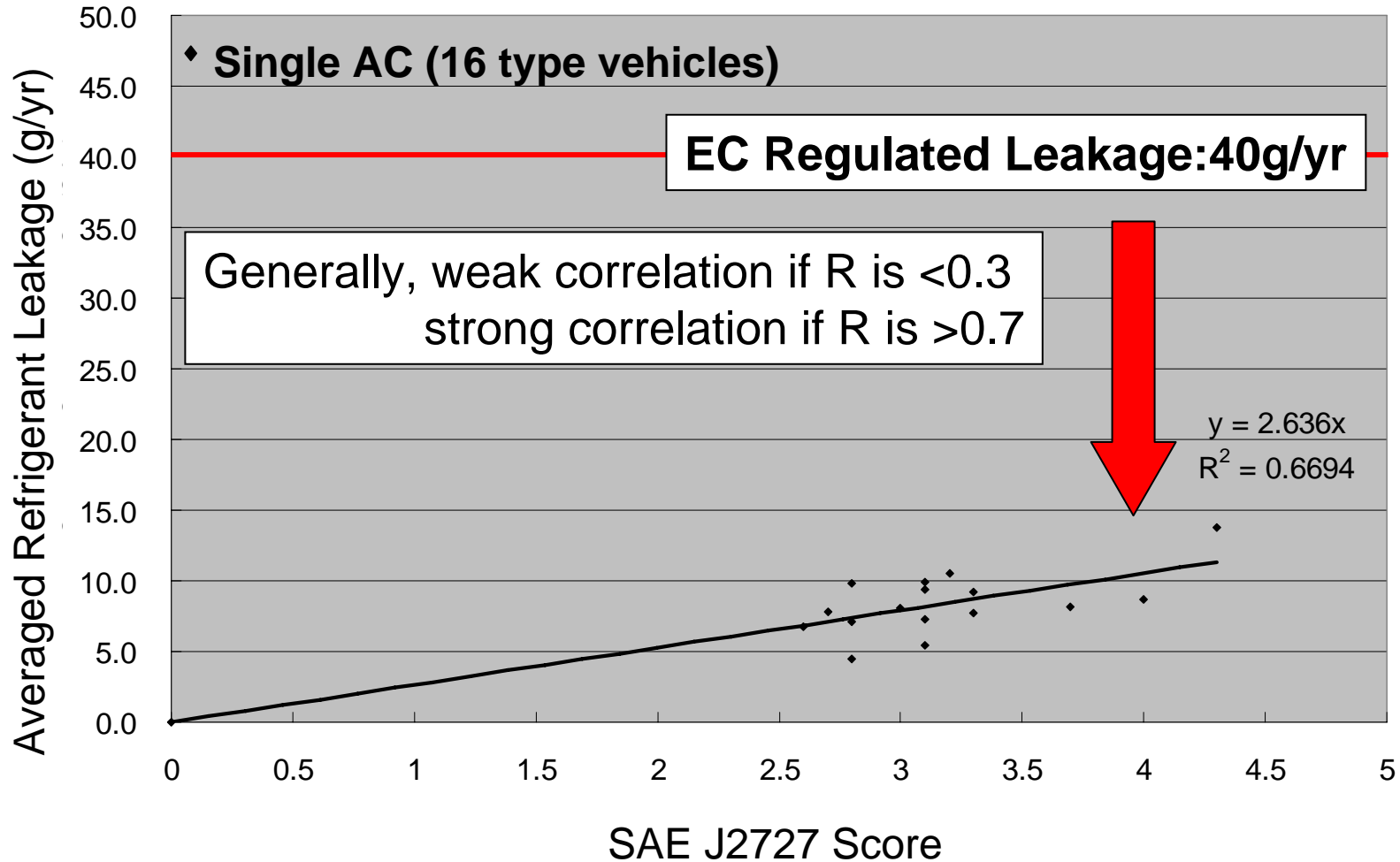
Estimation of Leakage by Score - 3

Climate condition
N:averaged temp.16dc

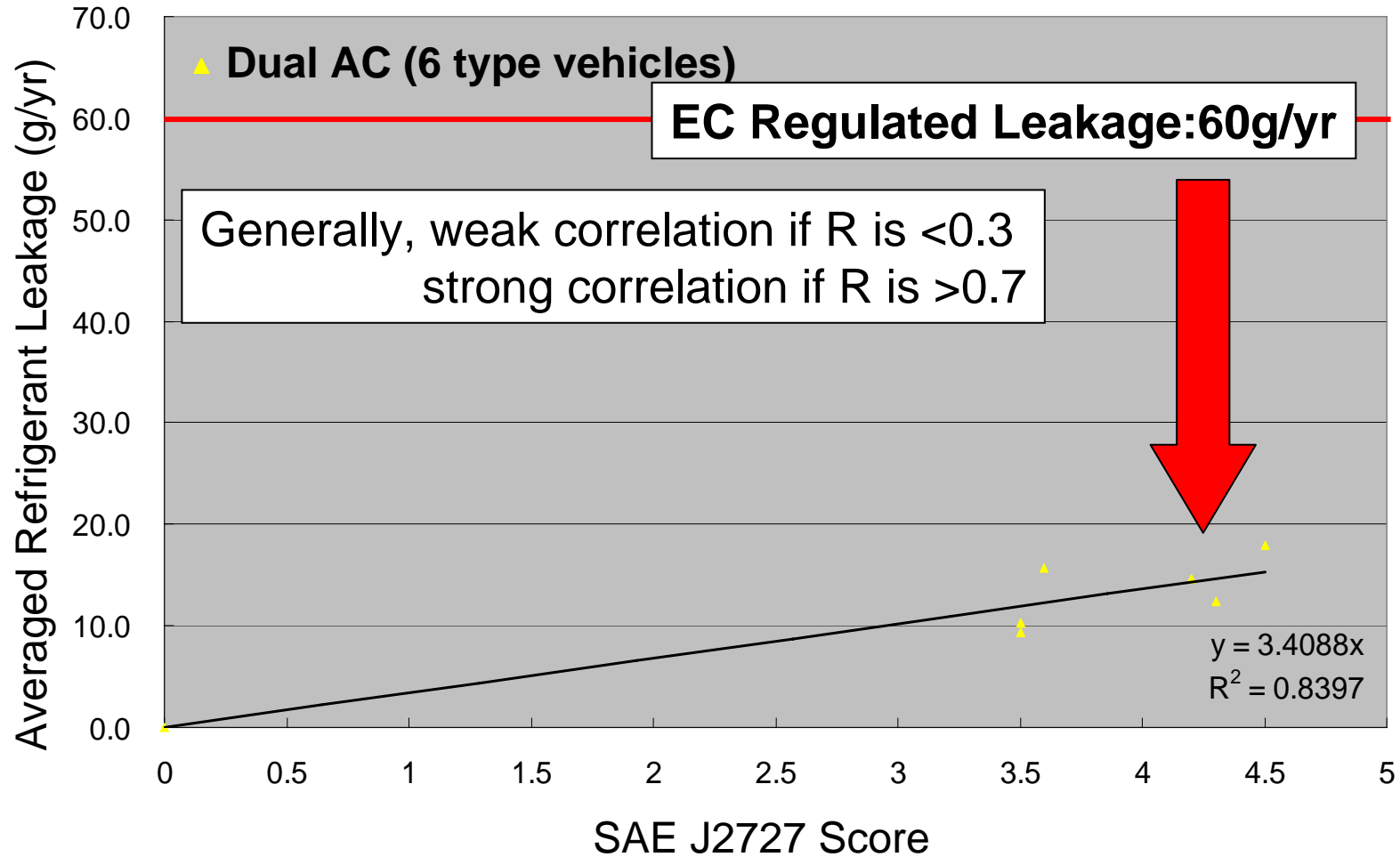
Vehicle	# of vehicles	Single or dual	Test data (averaged)	Evaluation by SAE J2727			Conversion constant (leakage/score)	
			Averaged Leak (g/yr) (scattering)	Score	% system component contribution			
					Comp.	Fittings		Hoses
Vehicle N-7 (Nissan Serena)	8	D	12.3 (Min.: 6.1, Max.: 17.6)	4.3	16	38	46	2.86
Vehicle N-8 (Nissan Elgrand)	4	D	14.7 (Min.: 8.8, Max.: 18.0)	4.2	17	50	33	3.50
Vehicle H-2 (Honda Stepwgn)	3	D	10.2 (Min.: 8.4, Max.: 12.4)	3.5	20	40	40	2.91
Vehicle H-3 (Honda Odyssey)	2	D	15.6 (Min.: 11.0, Max.: 20.3)	3.6	19	39	42	4.33
Vehicle M-3 (Mazda MPV)	2	D	9.3 (Min.: 9.0, Max.: 9.6)	3.5	20	52	28	2.66
Vehicle MI-3 (Mitsubishi Grandis)	3	D	17.9 (Min.:15.4, Max: 20.1)	4.5	27	44	29	3.98

Average conversion constant for dual A/C: 3.37

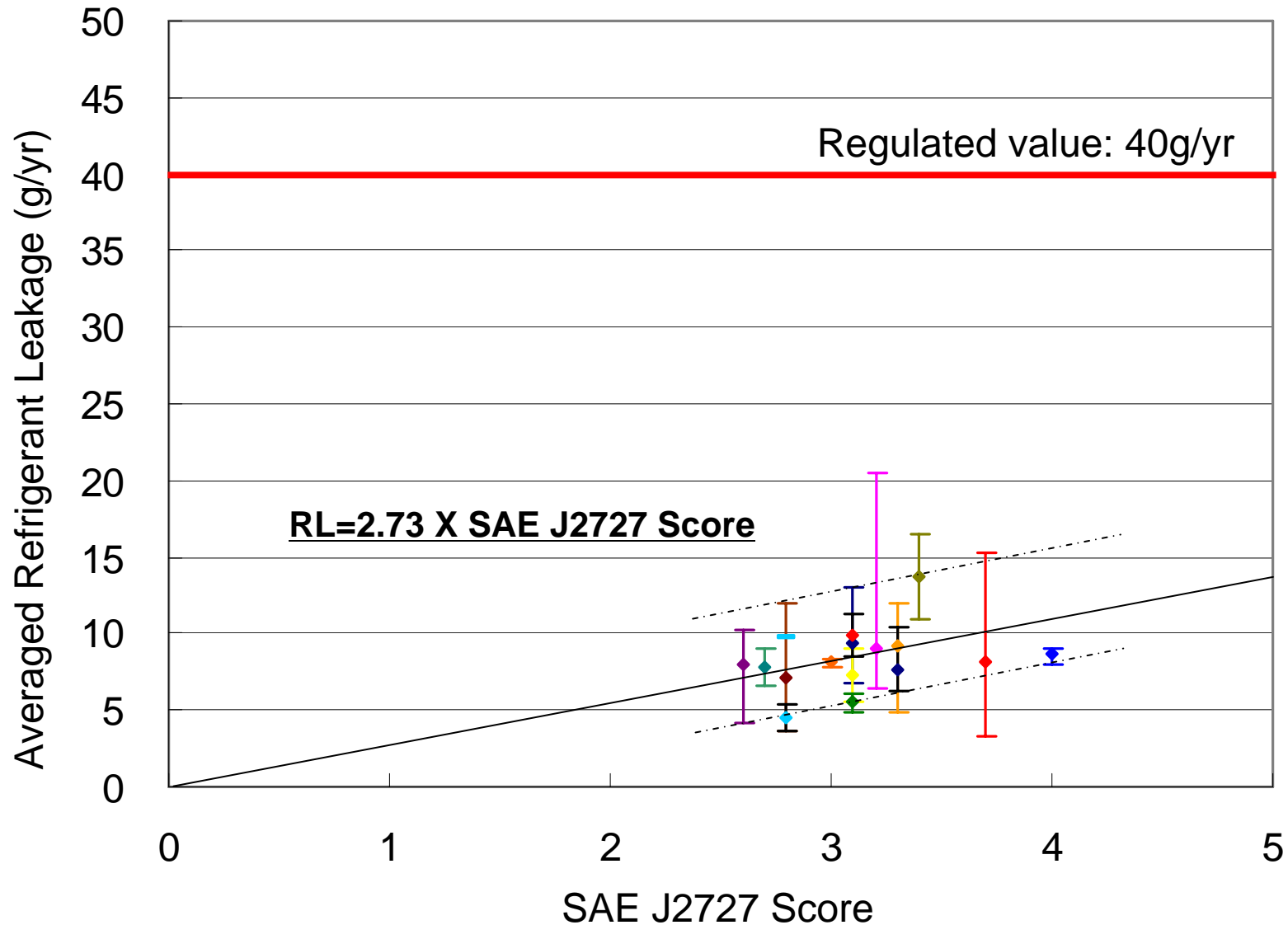
3. Correlation between SAE J2727's Score and Field test



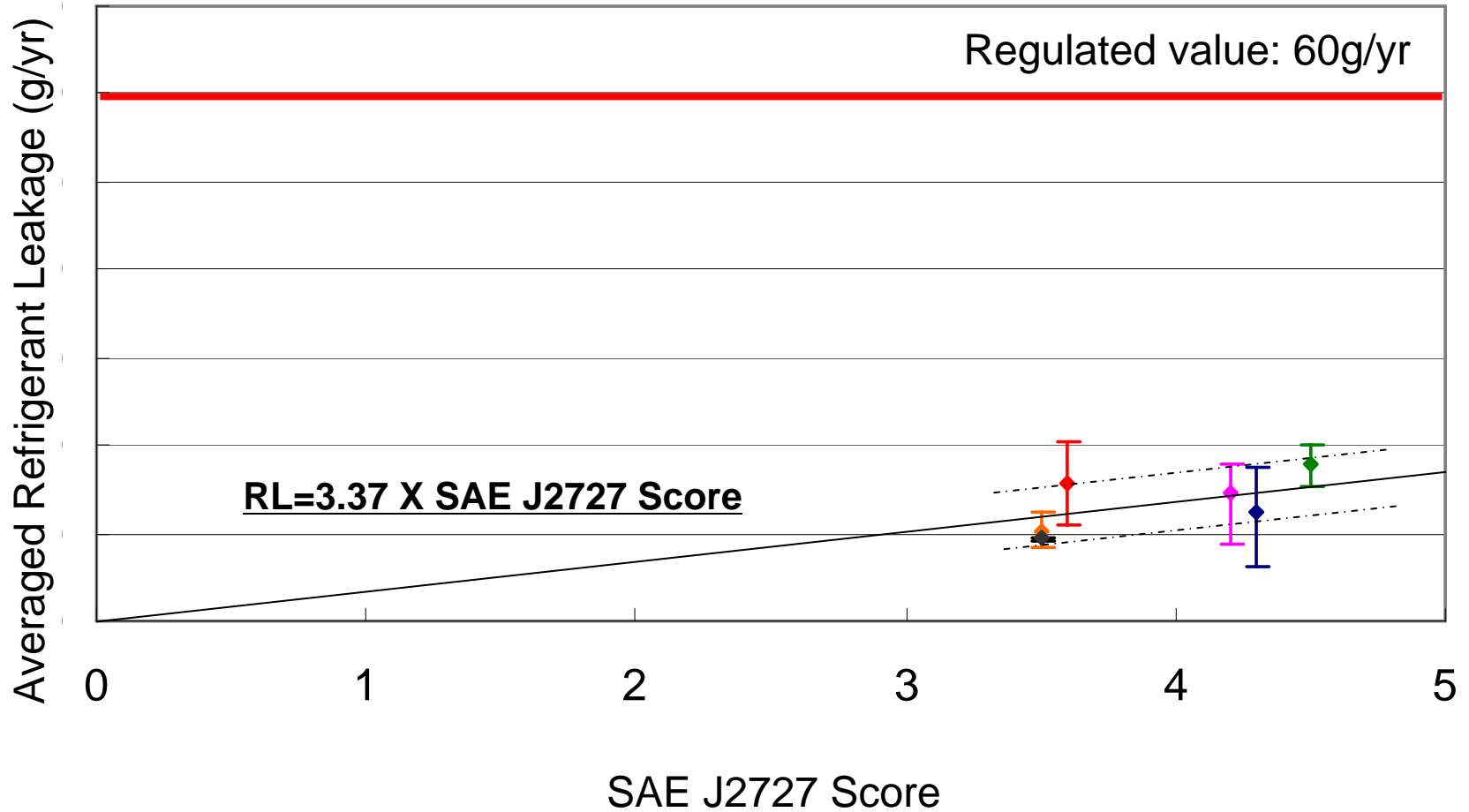
3. Correlation between SAE J2727's Score and Field test



Estimation of Leakage by Score : Single AC



Estimation of Leakage by Score : Dual AC

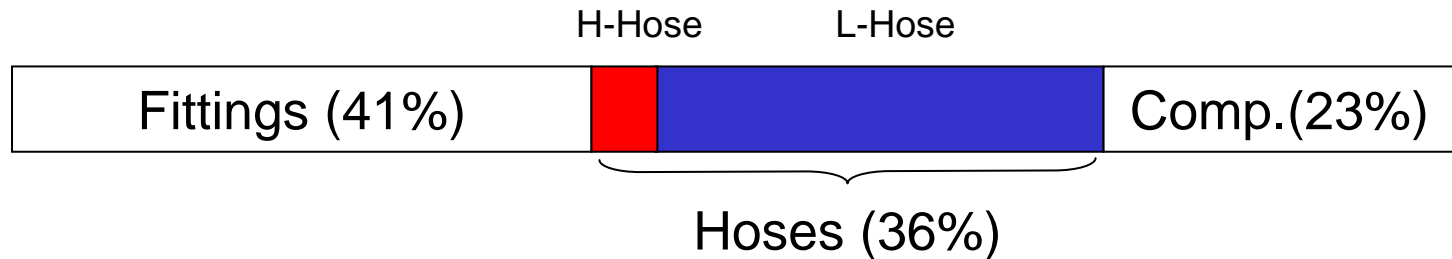


Example of Modification Points of SAE J2727

Rough correlation found, but component contribution might have a problem

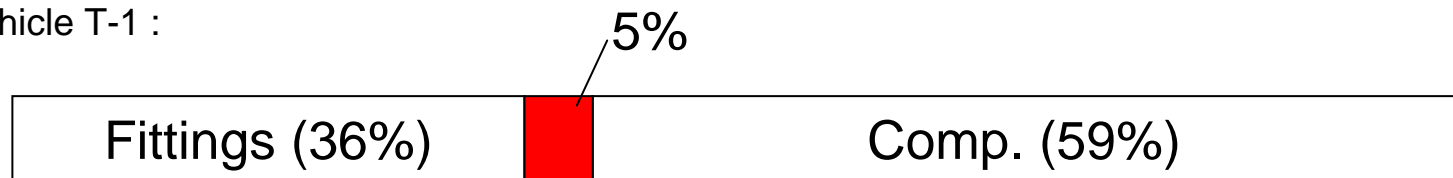
■ SAE J2727 rating system

Vehicle T-1 : SAE J2727 Score 3.1



■ Components leakage data

Vehicle T-1 :



- ✓ Contribution ratio of compressor and hose according to the current SAE J2727 rating system needs to be further reviewed.
- ✓ Especially large discrepancy for the hose.
 - ✓ SAE J2727 gives six times more leakage for the low side hose than the high side hose. In the real world, little refrigerant leak from the low side hose.

3. Conclusion

- ✓ Actual leakage is far below the European MAC directive's regulated leakage rate
- ✓ The current SAE J2727 stands well in correlation with actual leakage. But, component contribution by SAE J2727 is expected to be slightly different from actual contribution.
- ✓ The reliability is expected to be improved by modifying SAE J2727.
- ✓ Modified SAE J2727 could be a useful tool to estimate annual leakage.

Acknowledge

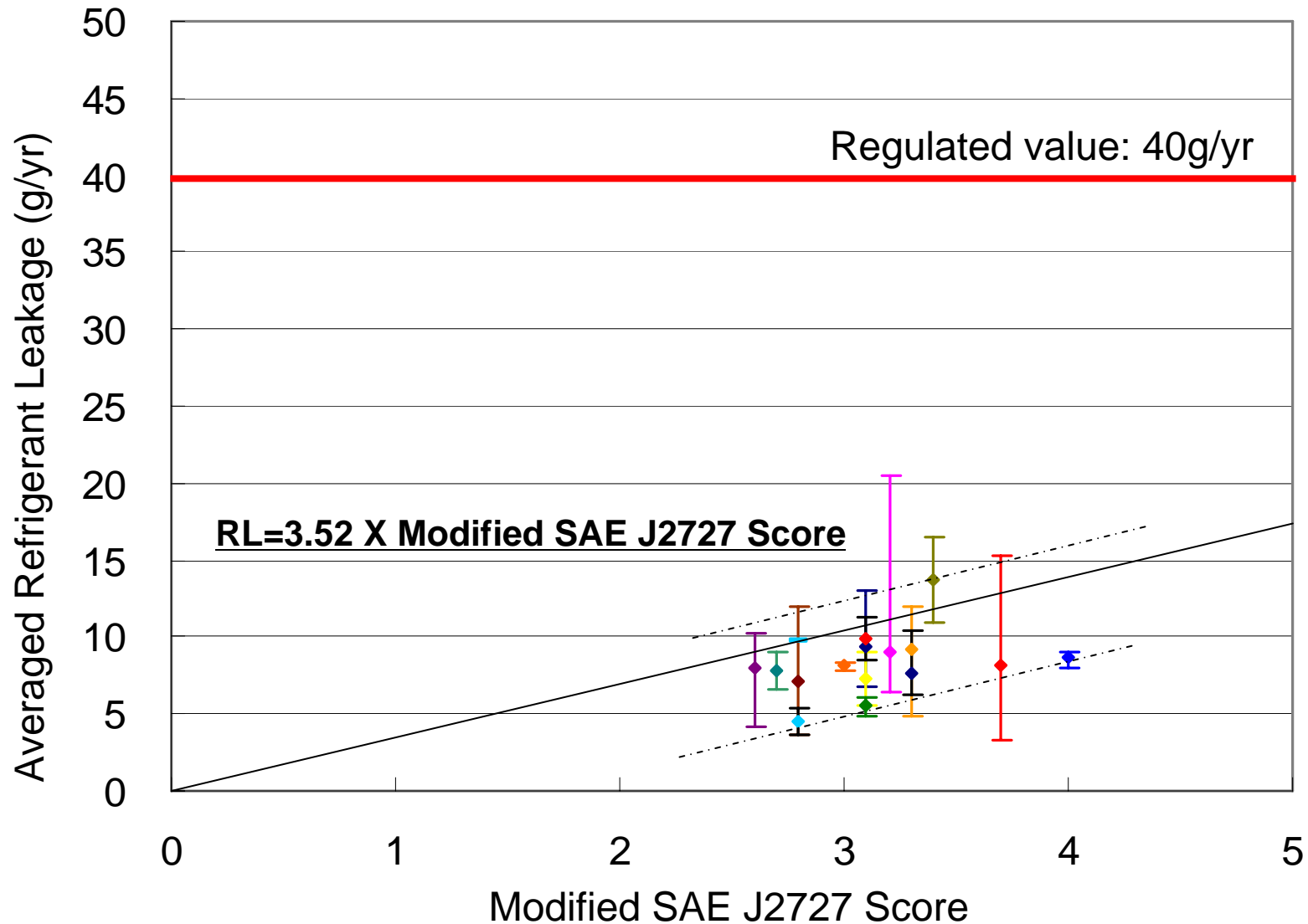
JAPIA: Japan Auto Parts Industries Association

JAMA

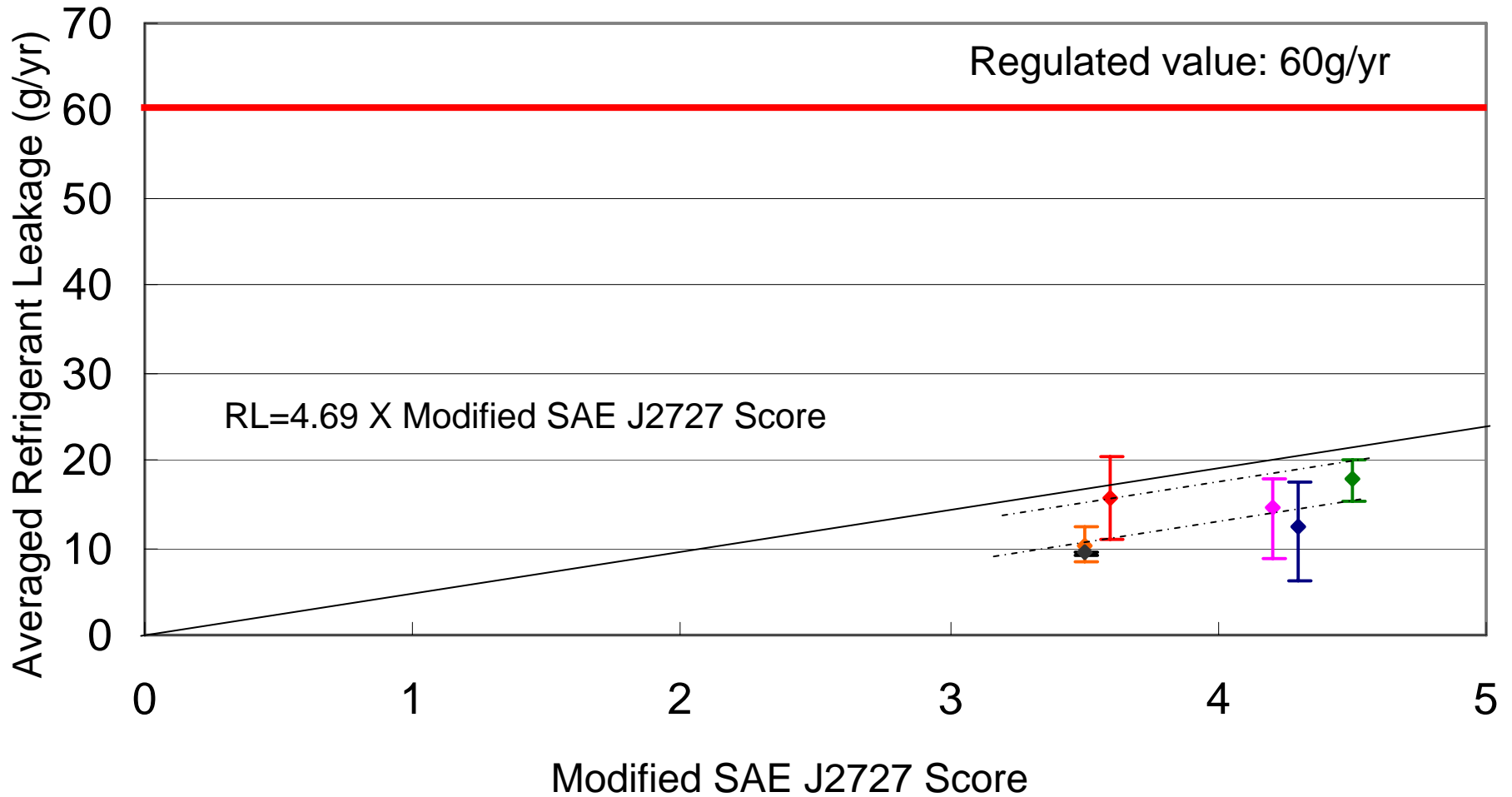


**Thank you for your
kind attention!**

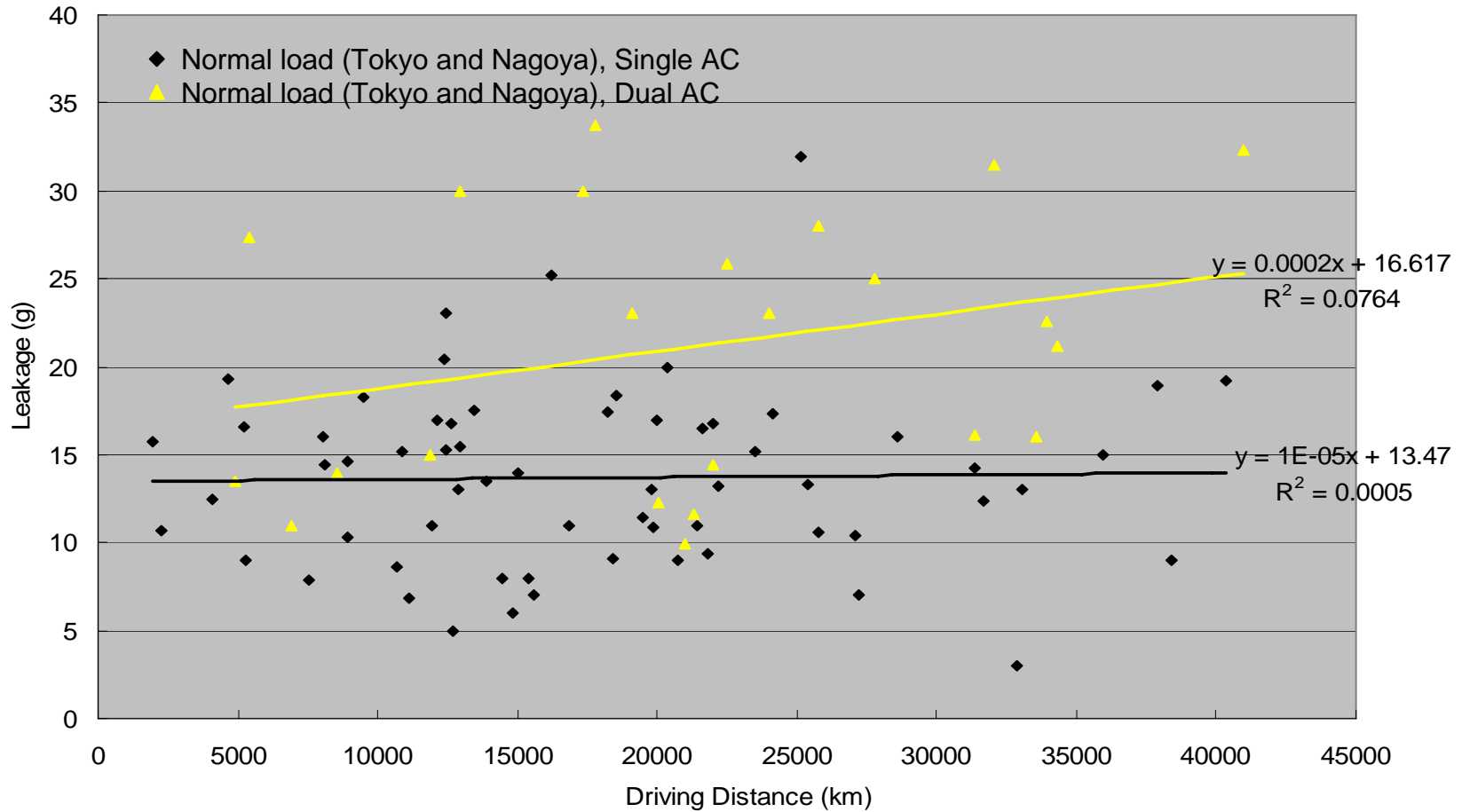
Estimation of Leakage by Score : Single AC



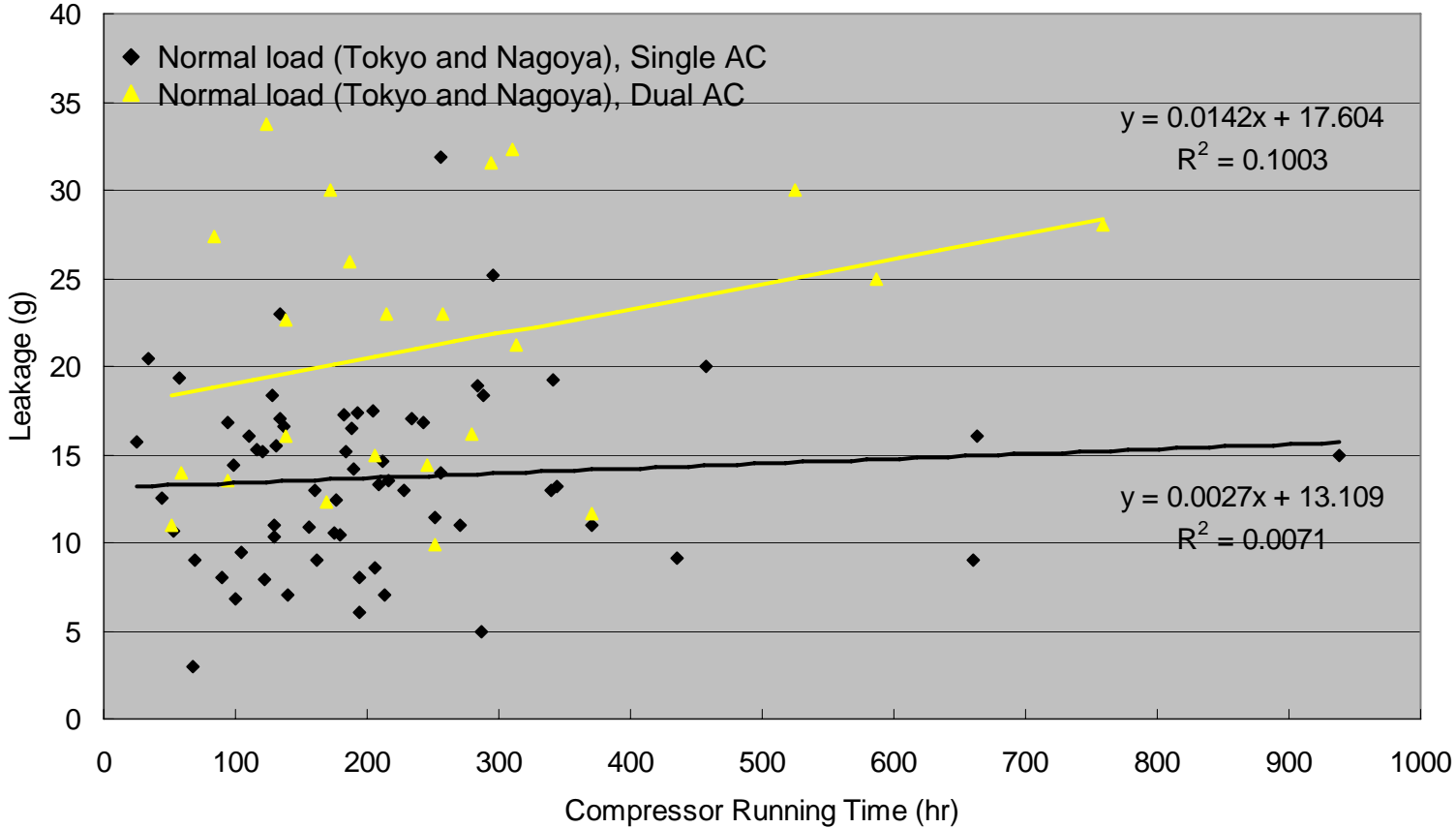
Estimation of Leakage by Score : Dual AC



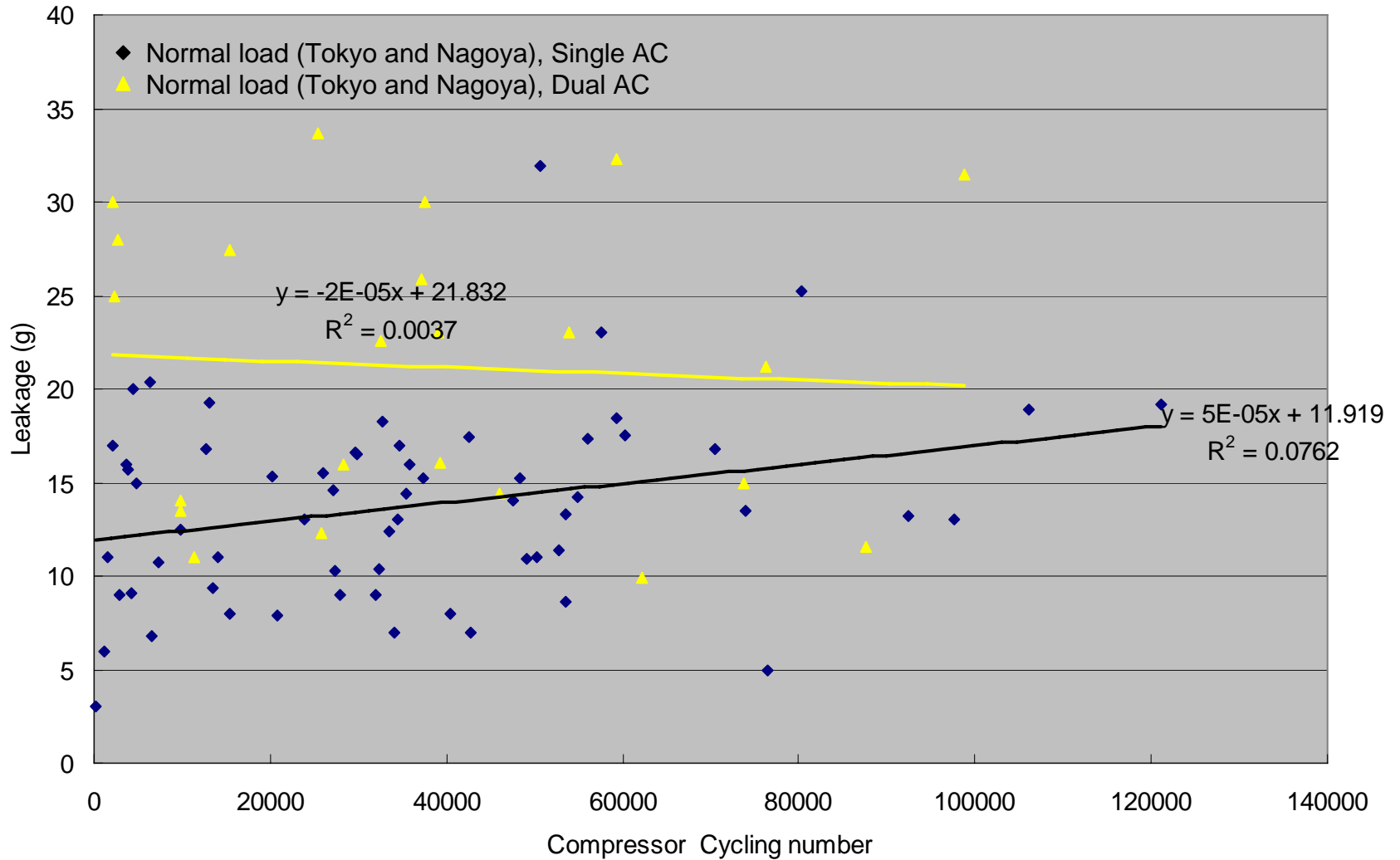
Influence of Driving Distance



Influence of Compressor Running time



Influence of Compressor Cycling



Refrigerant Leakage Field Test (From April, 2004 to December, 2005)

✓Location

Okinawa (average temperature 22C)

✓Number of test vehicles

26 vehicles (one auto maker)

✓A/C system

Single AC (2 type vehicles)

Dual AC (0 type vehicles)

✓Charge amount

Single:	Average: 513gram	Max: 578gram	Min:449gram
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✓Driving distance

Single:	Average: 31,502km	Max: 41,177km	Min:14,830km
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✓Compressor running time

Single:	Average: 476.9hrs	Max: 766.2hrs	Min:185.4hrs
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✓Compressor cycling number

Single	Average: 86,020	Max: 138,875	Min:44,531
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Annual Refrigerant Leakage

Region: Okinawa (High load), average temp.: 22C

