

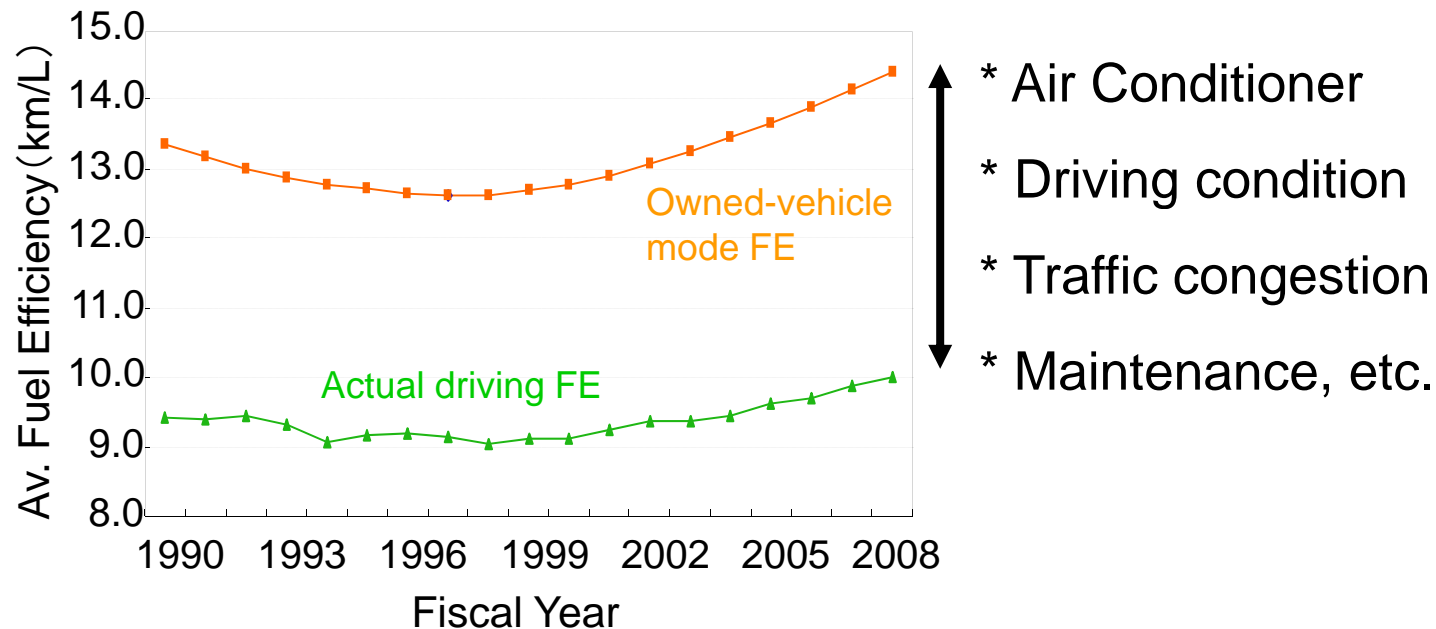
Fuel Efficiency Measurement Method considering the Effect of Air Conditioner

Prepared by Japan

4th MACTP Informal group Meeting
5 June 2012

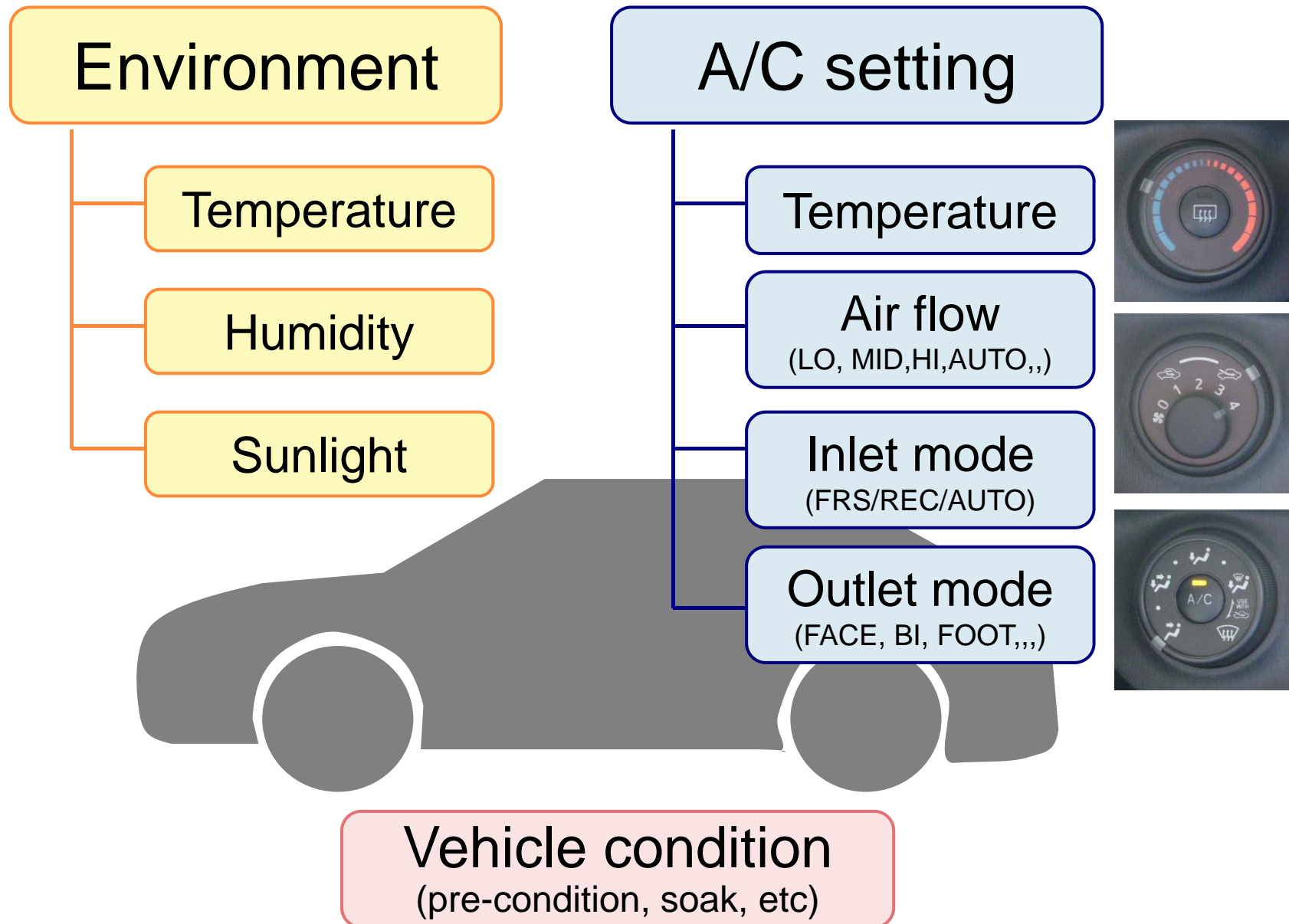
Divergence Between Mode FE and Actual FE

- Average fuel efficiency (FE) of new vehicles has been improving due to the regulations.
- Measurable divergence exists between mode FE and actual driving FE.
- Main factors are Air Conditioner, Driving condition, Traffic congestion, Maintenance, etc.
- Divergence should be reduced since consumers are more curious about fuel efficiency than before in the background of the global warming and high oil price.



- Development of the test procedures to measure the fuel efficiency including the influence of A/C, in order to
 1. provide better information to car users, and to
 2. promote the manufacturers to improve the energy efficiencies of A/C.
- The method for evaluating the A/C efficiency/effect on FE
 1. Should represent the effect on FE in the real world as much as possible.
 2. Should be able to evaluate different A/C systems fairly.
 3. Should be able to be incorporated into the vehicle FE test method.
 4. Should improve the A/C efficiency and the resultant FE through its incorporation into the FE test method.
 5. Should be cost-effective.

Main Parameters regarding A/C



Parameters

- Test cell condition
- Vehicle Hot/Cold condition
- A/C setting condition
(Blower level, Temp. Setting, intake air)
- Compressor type
(fixed/variable capacity)
- MAC system (dual/single)

Actual data in use

- Statistic review for Representative environmental condition in Japan
- Questionnaire for A/C in use



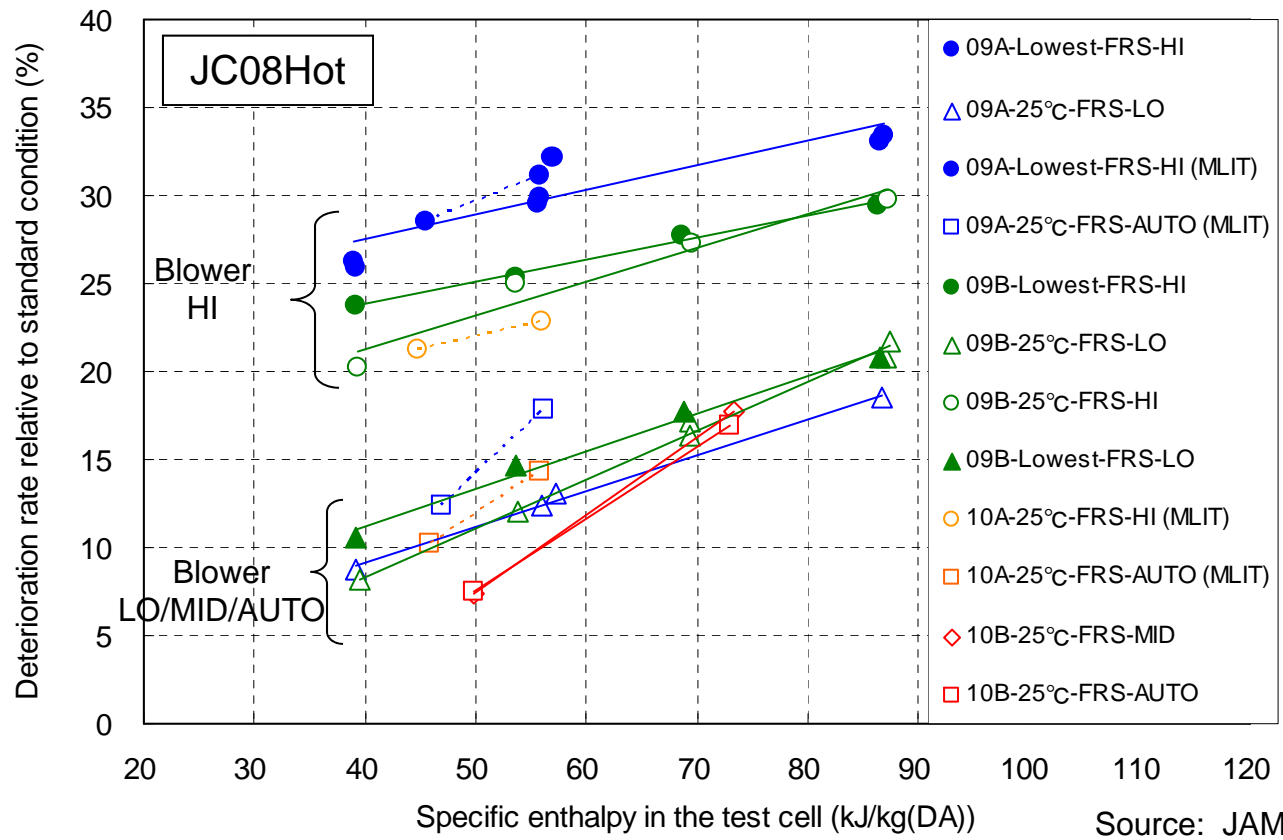
Develop the test procedures

Tested Vehicle

Vehicle No.	09A	09B	10A	10B	10C	11A	11B	11C	11D
Vehicle category	PC	PC	PC	PC	PC	PC	PC	PC	PC
Emission standard	JP05	JP05	JP05	JP05	JP05	JP05	JP05	JP05	JP05
Fuel type	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Engine displacement	1496	1498	3955	2339	658	1329	1997	2290	1986
Max. rated power	88/6600	80/6000	203/5600	125/6000	40/6500	70/6000	101/5200	180/5000	116/6200
Curb vehicle mass	1170	1150	2120	1650	940	1000	1410	1840	1600
Transmission	5AT	CVT	5AT	CVT	CVT	CVT	CVT	6AT	CVT
MAC system	Single	Single	Single	Single	Single	Single	Single	Dual	Dual
Control method	Automatic	Automatic	Automatic	Automatic	Automatic	Manual	Automatic	Automatic	Automatic
Refrigerant gas	HFC134a	HFC134a	HFC134a	HFC134a	HFC134a	HFC134a	HFC134a	HFC134a	HFC134a
Compressor type	Fixed volume	Fixed volume	Fixed volume	Fixed volume	Fixed volume	Variable volume	Variable volume	Fixed volume	Variable volume

Relation between Test Cell Specific Enthalpy and FE Deterioration Rate

- ◆ Test conditions: 20 – 30°C, 40 – 82% RH
- ◆ Insolation condition: N/A
- ◆ Test mode: JC08 mode (Hot)
- ◆ A/C Setting: Temperature: Lowest / 25°C, Blower level: LO / HI / AUTO, Air: FRS



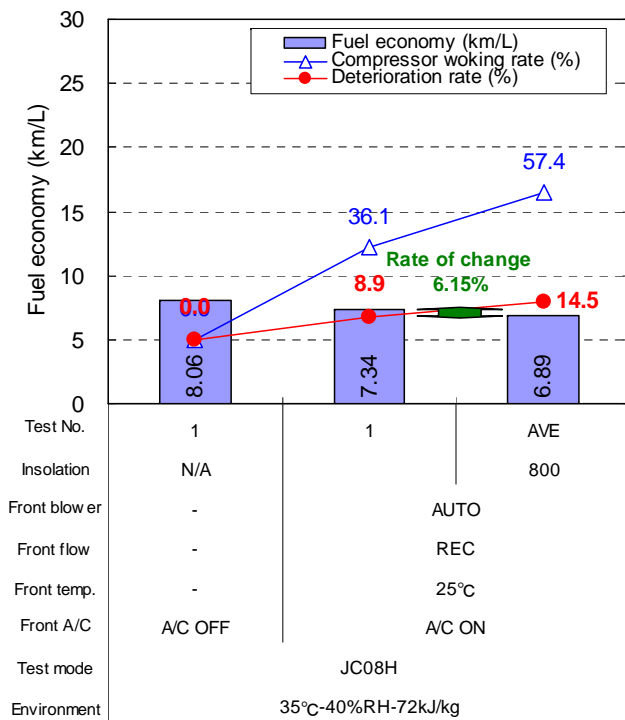
*) Standard condition: JC08H, A/C OFF, Test cell condition: 25°C-50%RH

Fuel efficiency tends to be deteriorated as specific enthalpy become larger.

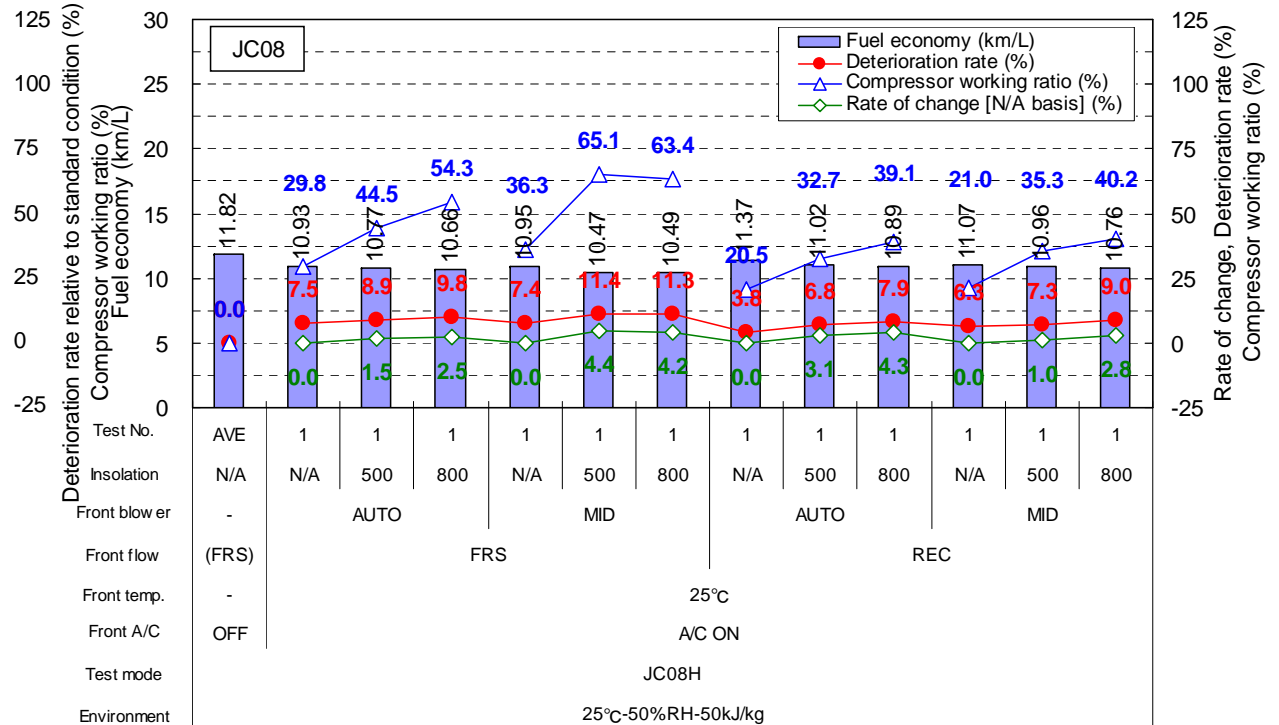
Relation between Insolation and Rate of change on FE

- ◆ Test conditions: 25°C - 50% RH, 35°C - 40%RH
- ◆ Insolation condition: N/A, 500 W/m², 800 W/m²
- ◆ Test mode: JC08 mode (Hot)
- ◆ A/C Setting: Temperature: 25°C, Blower level: MID / AUTO, Air: FRS / REC

10A (35°C)



10B (25°C)

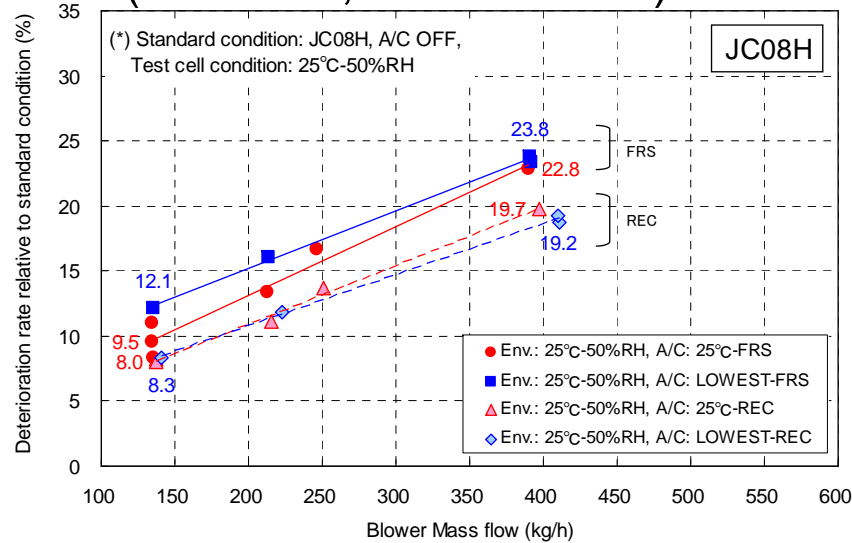


Source: JAMA&MLIT

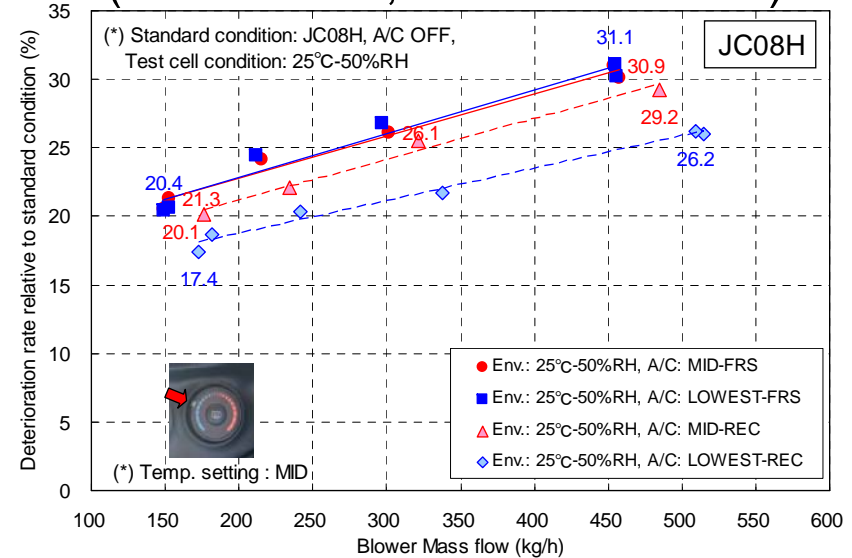
Insolation influences to fuel efficiency less than 6 % in our research.

Blower mass flow and FE (Fixed/Variable compressor)

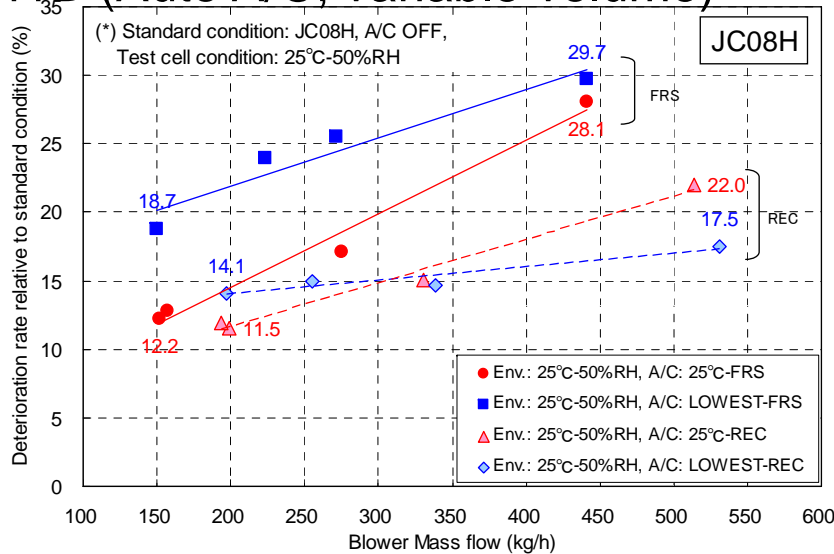
10C (Auto A/C, fixed volume)



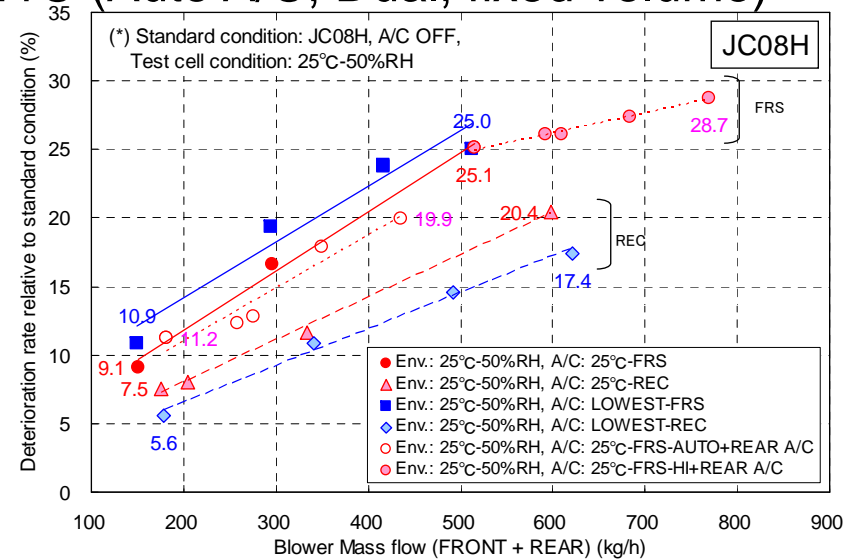
11A (Manual A/C, variable volume)



11B (Auto A/C, variable volume)



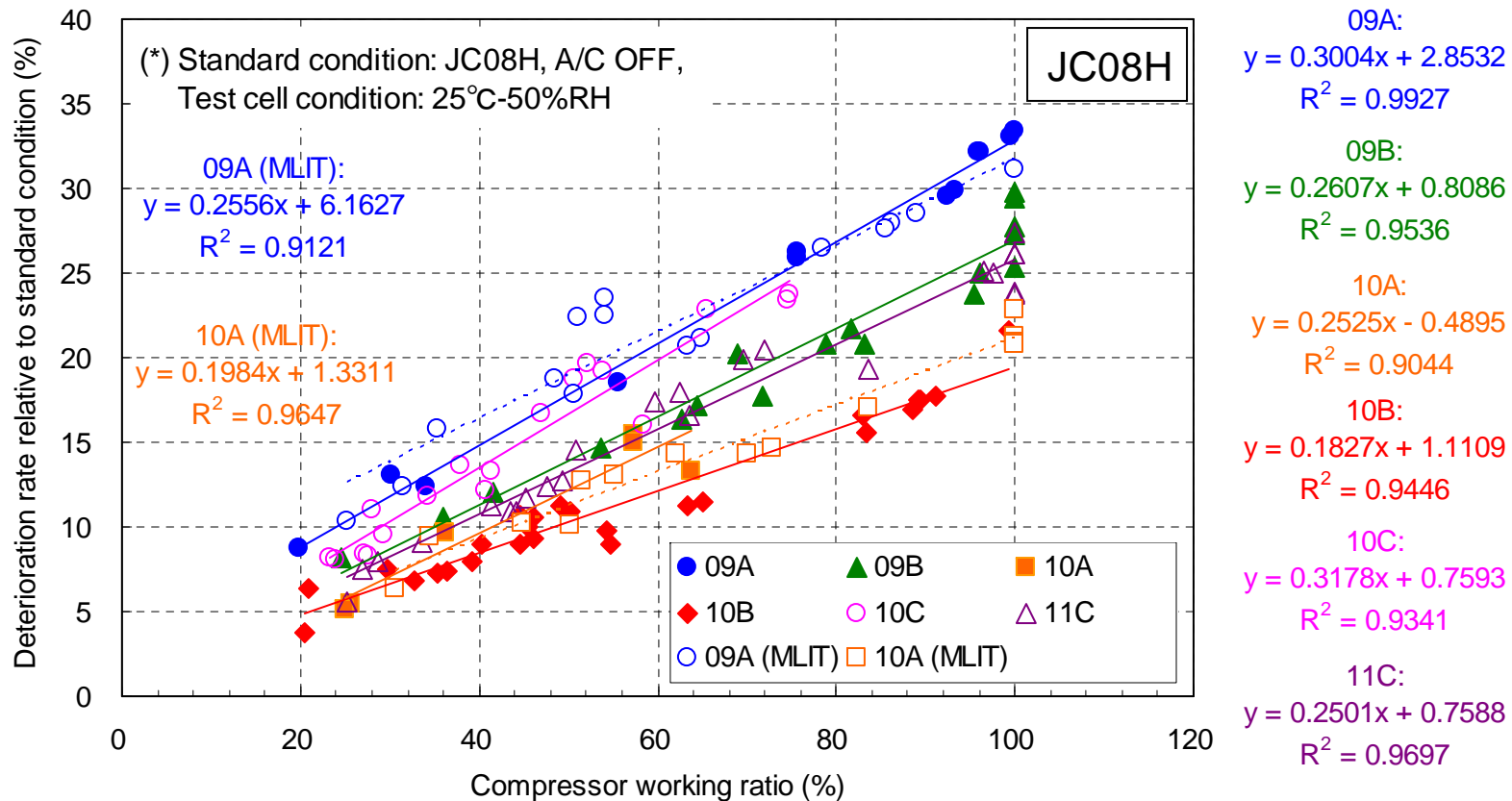
11C (Auto A/C, Dual, fixed volume)



Deterioration rate is about 10% as blower mass flow is changed.

Relation between Compressor Working Ratio and FE Deterioration Rate

- ◆ Test conditions: 15 – 35°C, 40 – 80% RH
- ◆ Insolation condition: 0 / 500 / 800 W/m²
- ◆ Test mode: JC08 mode (Hot)
- ◆ A/C Setting: Temperature: Lowest / 25°C, Blower level: LO / MID / HI / AUTO, Air: FRS / REC



- Results show good repeatability even in the dynamic driving mode (JC08).

Vehicle	Environment	A/C setting				Fuel economy (km/L)				Rate of change (%)
		A/C use	Temp.	Inlet	Blower	N1	N2	N3	Average	[(MAX-MIN)/AVE]
09A	25°C-50%RH	A/C OFF	-	-	-	15.10	15.02	-	15.06	0.6
	20°C-40%RH		-	-	-	15.08	15.15	-	15.11	0.5
	30°C-75%RH		-	-	-	15.07	15.24	-	15.15	1.1
	21°C-75%RH		-	-	-	15.06	15.10	-	15.08	0.3
09B	25°C-50%RH		-	-	-	16.38	16.61	-	16.50	1.3
10B			-	-	-	12.02	11.55	11.89	11.82	4.0
10C			-	-	-	20.72	20.93	-	20.82	1.0
11A			-	-	-	20.05	20.05	-	20.05	0.0
09A	25°C-50%RH	A/C ON	LOWEST	FRS	HI	10.22	10.21	-	10.22	0.1
	20°C-40%RH					11.11	11.15	-	11.13	0.4
	30°C-75%RH					10.09	10.04	-	10.06	0.5
	21°C-75%RH					10.61	10.57	-	10.59	0.4
	25°C-40%RH					11.64	11.49	-	11.56	1.3
09B	28°C-60%RH		25°C	FRS	LO	13.66	13.80	-	13.73	1.0
	30°C-75%RH		13.07	12.91	-	12.99	1.3			
10A	15°C-80%RH		25°C	FRS	AUTO	7.67	7.70	-	7.69	0.4
	35°C-40%RH		6.87	6.91		-	6.89	0.6		
10B	35°C-40%RH		25°C	REC	AUTO	10.76	10.64	-	10.70	1.1
10C	25°C-50%RH		25°C	FRS	AUTO	18.53	19.08	-	18.81	2.9
11A	25°C-50%RH		LOWEST	FRS	LO	15.78	15.94	-	15.86	1.0
					HI	13.84	14.01	-	13.92	1.2
				REC	LO	15.92	15.95	-	15.94	0.2
		HI			13.82	13.99	-	13.91	1.2	
				LO	16.30	16.56	-	16.43	1.6	
				HI	14.83	14.79	-	14.81	0.3	

Source: JAMA&MLIT

- As specific enthalpy becomes larger, compressor working ratio gets higher and fuel efficiency would be deteriorated.
- Insolation influences to fuel efficiency less than 6 % in our research.
- A compressor working ratio becomes high as blower level increases, and fuel efficiency gets worse (about 10%).
- Compressor working ratio is proportional to deterioration rate of fuel efficiency.
- Results show **good repeatability** even in the dynamic driving mode (JC08), when vehicle warming (30min, 60km/h constant speed) was done.

【Objective】

Questionnaire to investigate the actual data in use of A/C in order to decide test conditions

【Target】

Over 18-year old men/women with driving license who drive one more time per week, and whose driving car have mobile air conditioners.

【Questionnaire type】

Internet-based questionnaire

【Sample number】

6,000 sample (M/F: 3,000 in each)

【Questionnaire period】

January 13 ~ January 24, 2012

A/C setting in summer

A/C type		Item	Results
Manual A/C		Penetration	Manual A/C penetration: 41.3%
		A/C use rate	Almost always: 54%, Rather using: 30% (Total 85%)
		Temp.	Coolest: 47%, middle: 18%
		Blower level	Middle (3/5): 27%, Weak (2/5): 25%
		Intake air	Circulation: 46%, Fresh air: 18%
		Face/Foot	Face: 47%, Face & Foot: 34%
Auto A/C		Penetration	Auto A/C penetration: 45.2%
		A/C use rate	Almost always: 70%, Rather using: 23 % (Total 93%)
		Temp.	25°C: 21%, 20°C: 13%
		Blower level	Auto: 40%, Medium (3/5): 23%
		Intake air	Circulation: 43%, Fresh air: 16%
		Face/Foot	Auto: 31%, Face & Foot: 30%
Dual A/C	Total	Penetration	Dual A/C penetration: 13.5%
		A/C use rate	Almost always: 75%, Rather using 18% (Total 93%)
	Front	Temp.	25°C: 17%, 20°C: 14%
		Blower level	Auto: 38% Medium (3/5): 25%
		Intake air	Circulation: 48%, Fresh air: 14%
	Rear	Face/Foot	Face & Foot: 31%, Auto: 29%
		Temp.	Impossible: 32%, 25°C: 13%
		Blower level	Auto: 30%, Medium (3/5): 25%

- Our objective is to develop the test procedures to measure the fuel efficiency including the influence of mobile air conditioners, in order to **provide better information to car users**, and to promote the manufacturers to **improve the energy efficiencies of mobile air conditioners**.
- Fuel efficiency measurement tests in JC08 mode with A/C are conducted with various environment / A/C setting conditions.
- Our results show **good repeatability even in the dynamic driving mode (JC08)**.
- **Questionnaire are done in order to investigate the actual A/C use.**
- Discussion on test conditions and verification tests are required to be done.
- Further discussion should be done about how to provide the A/C energy efficiency information to car users in order to avoid misunderstanding and confusion.