



***Research Result for
Bio-RID II & Hybrid III Dummy
Repeatability and Reproducibility
on Head Restraints GTR***

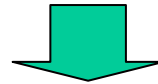
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Purpose

- **Dynamic testing methods to reduce damage to the neck of the occupants from a rear-end collision is being studied internationally for head restraints GTR and other regulations.**



Points of Examination

- **Variance between testing labs and testing procedures**
- **Dummy's fidelity to human body**
- **Dummy's reproducibility and repeatability**



Purpose

Examine the repeatability and reproducibility of dummy candidates (Bio-RID II and Hybrid III).

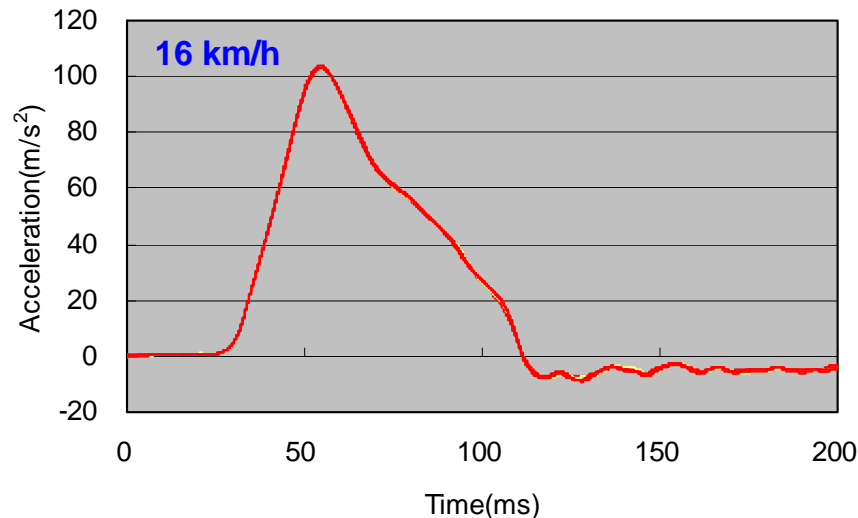


Method of Evaluation

- Examine the reproducibility and repeatability of the dummy candidate (Bio-RID II and Hybrid III) in an HYGE sled test simulating a rear-end collision
- A rigid seat is used to allow a study of dummies characteristics
- Test three Bio RID-II dummies (A, B, C) and three Hybrid-III dummies (A, B, C) five times in the same conditions



BioRID-II



Sled waveform



Hybrid-III



Specifications of the dummies evaluated

BioRID-II Level F

Dummy A: Owner A (With standard calibration)

Dummy B: Owner B (**Without calibration**)

Dummy C: Owner C (With standard calibration)

Hybrid-III

Dummy A: Owner A (With standard calibration)

Dummy B: Owner D (With standard calibration)

Dummy C: Owner E (With standard calibration)

Bio RID Standard calibration

· Hit the upper body on the sled with an impactor.

Backward tilting angle of the head, backward tilting angle of the neck, acceleration of the first thoracic vertebra (T1), impact load.

Hybrid III Standard calibration

· Head drop test Head acceleration

· Neck pendulum test (flexion and extension)

Head rotating angle, maximum moment

Chest pendulum test

Chest displacement, impact load

· Leg (knees) Impact load

· Thighs Torque



Evaluation Indicators

BioRID-II

- Acceleration of the first thoracic vertebra (T1) (T1_Acc)
- Shearing load to the neck (Fx)
- Axial load to the neck (Fz)

Referential evaluation

- Acceleration of the head (Head_Acc)
- Neck moment (My)
- Backward tilting angle of the head (HA-TA)

Hybrid-III

- Backward tilting angle of the head (HA-TA)

Referential evaluation

- Acceleration of the first thoracic vertebra (T1)(T1_Acc)
- Shearing load to the neck (Fx)
- Axial load to the neck (Fz)
- Acceleration of the head (Head_Acc)
- Neck moment (My)



Method and Criteria for Evaluation of Repeatability

■ Method of evaluation

Comparison of coefficient of variation (CV)

$$\text{Repeatability} \quad C.V = \frac{S_d}{\bar{X}} \quad 100 (\%)$$

\bar{X} = *Mean value of each dummy*

S_d = *Standard deviation of each dummy*

■ Criteria Admissible level: CV 10

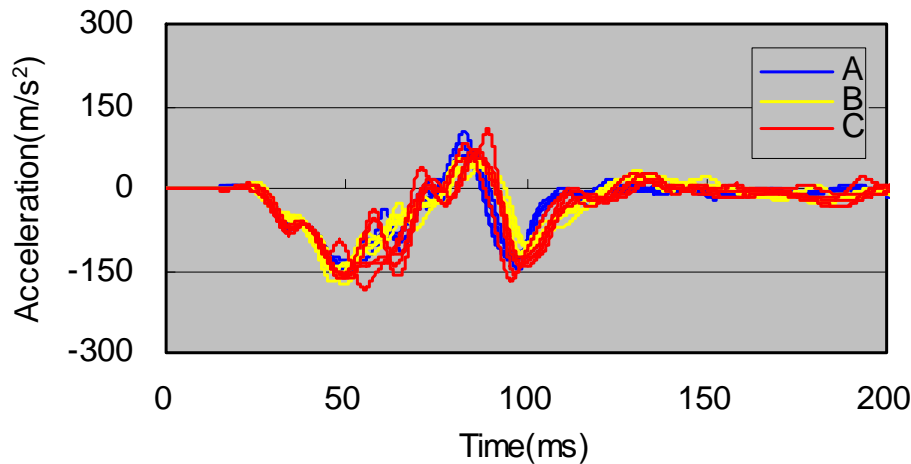


•Response to acceleration of the first thoracic vertebra (T1)

The repeatability of Bio RID II was within the limit of tolerance for all the three dummies.

BioRID-II

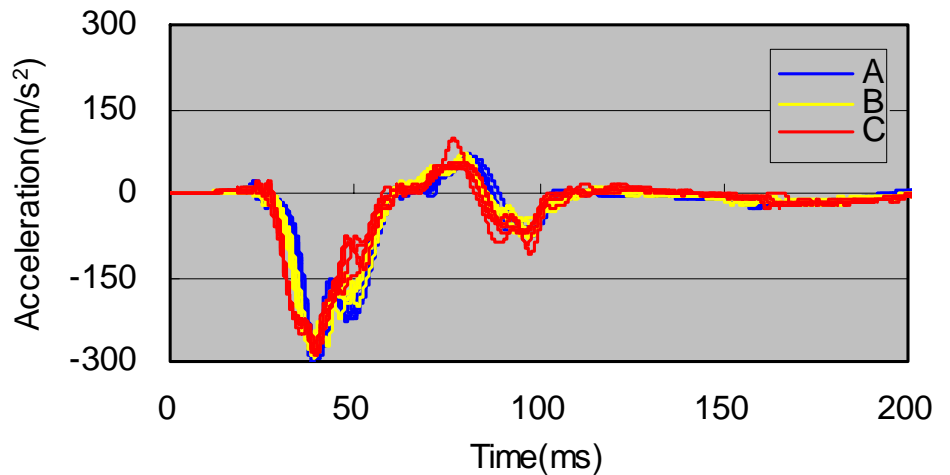
T1 x-axis Acc.



Hybrid-III

(Reference)

T1 x-axis Acc.



Part	BioRID-II	Mean Value	Standard Deviation	Repeatability C.V(%)
T1 Acc. (m/s ²)	A	-144.4	7.2	5.0
	B	-158.9	14.0	8.8
	C	-166.7	10.0	6.0

Part	Hibrid-III	Mean Value	Standard Deviation	Repeatability C.V(%)
T1 Acc. (m/s ²)	A	-288.8	9.7	3.3
	B	-276.9	12.8	4.6
	C	-283.2	7.2	2.6



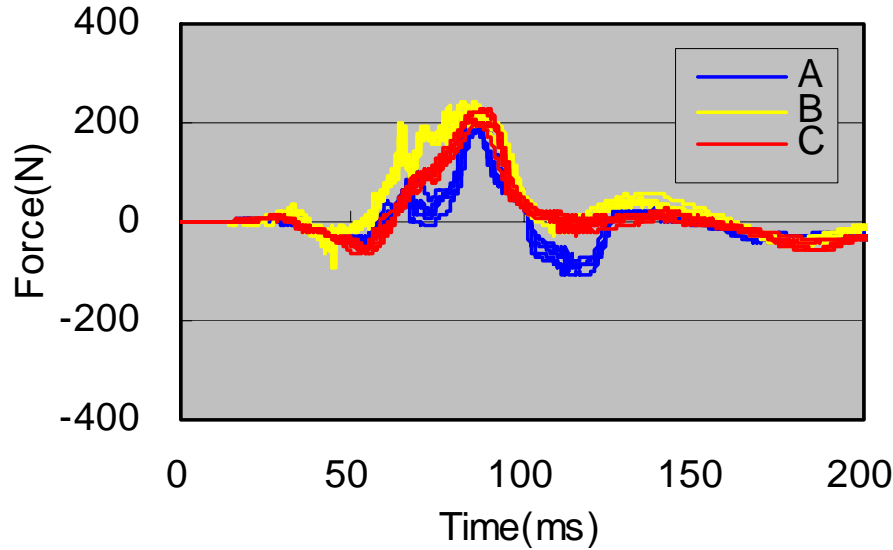
•Response to Shearing Load to the Neck

(Fx)

The repeatability of Bio RID II was within the limit of tolerance for all the three dummies.

BioRID-II

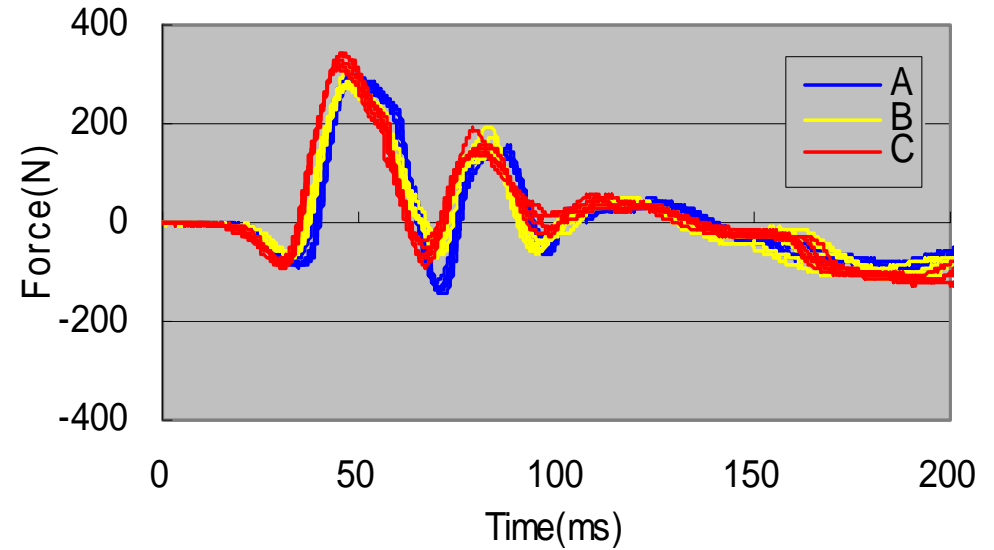
Upper Neck Fx



Hybrid-III

(Reference)

Neck Fx



Part	BioRID-II	Mean Value	Standard Deviation	Repeatability C.V.(%)
Fx (N)	A	206.2	15.1	7.3
	B	231.9	13.2	5.7
	C	215.7	13.9	6.4

Part	Hibrid-III	Mean Value	Standard Deviation	Repeatability C.V.(%)
Fx (N)	A	294.2	4.3	1.5
	B	285.5	16.3	5.7
	C	331.1	13.2	4.0

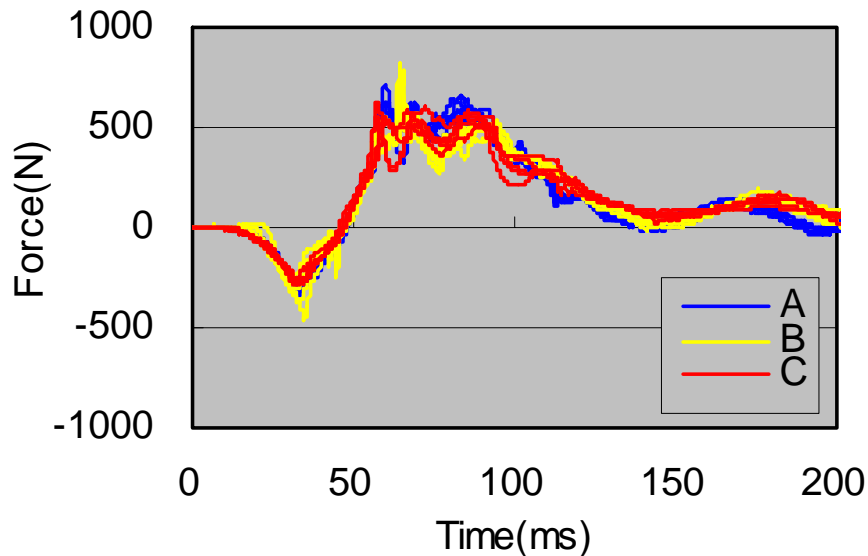


•Response to Axial load to the neck (Fz)

The repeatability of Bio RID II was within the limit of tolerance for all the three dummies.

BioRID-II

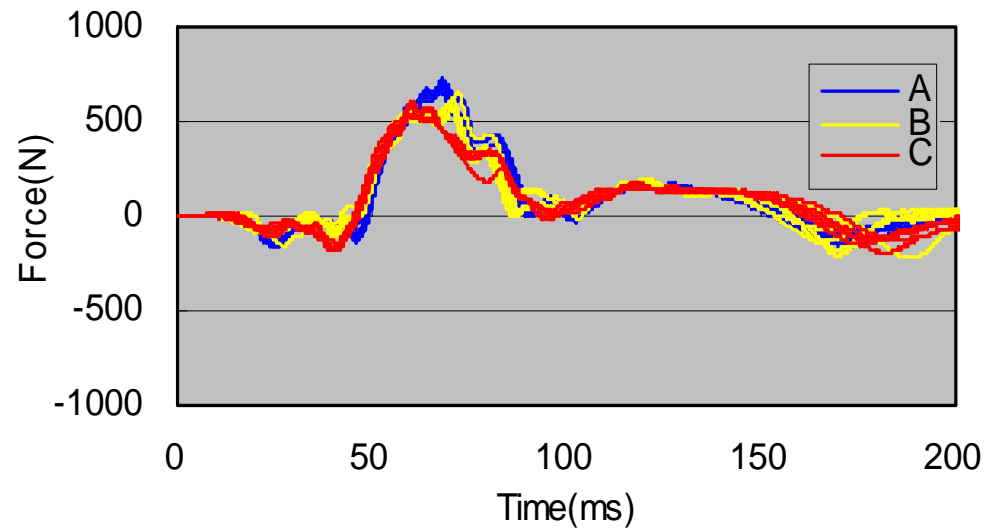
Upper Neck Fz



Hybrid-III

(Reference)

Neck Fz



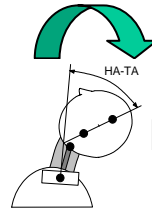
Part	BioRID-II	Mean Value	Standard Deviation	Repeatability C.V(%)
Fz (N)	A	648.9	39.0	6.0
	B	757.9	53.0	7.0
	C	572.4	39.9	7.0

Part	Hibrid-III	Mean Value	Standard Deviation	Repeatability C.V(%)
Fz (N)	A	698.4	15.7	2.2
	B	606.6	31.2	5.1
	C	571.4	29.0	5.1

•Response to Backward Tilting Angle of the Head (HA-TA)



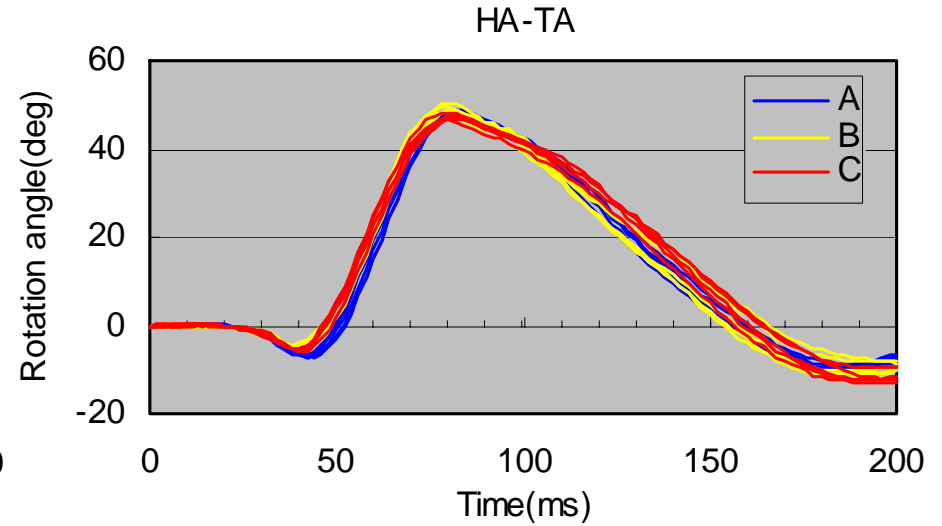
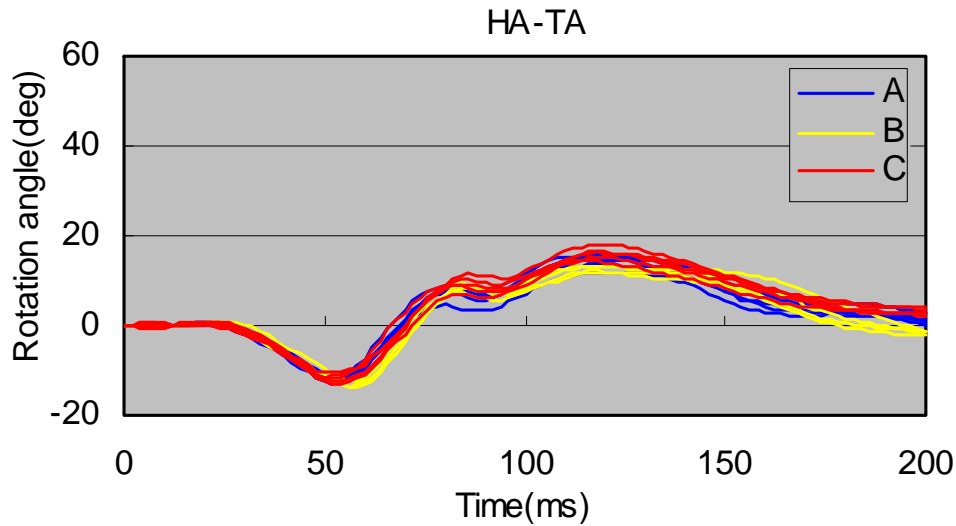
The repeatability of Bio RID II was within the limit of tolerance for all the three dummies.



+ Direction

BioRID-II (Reference)

Hybrid-III



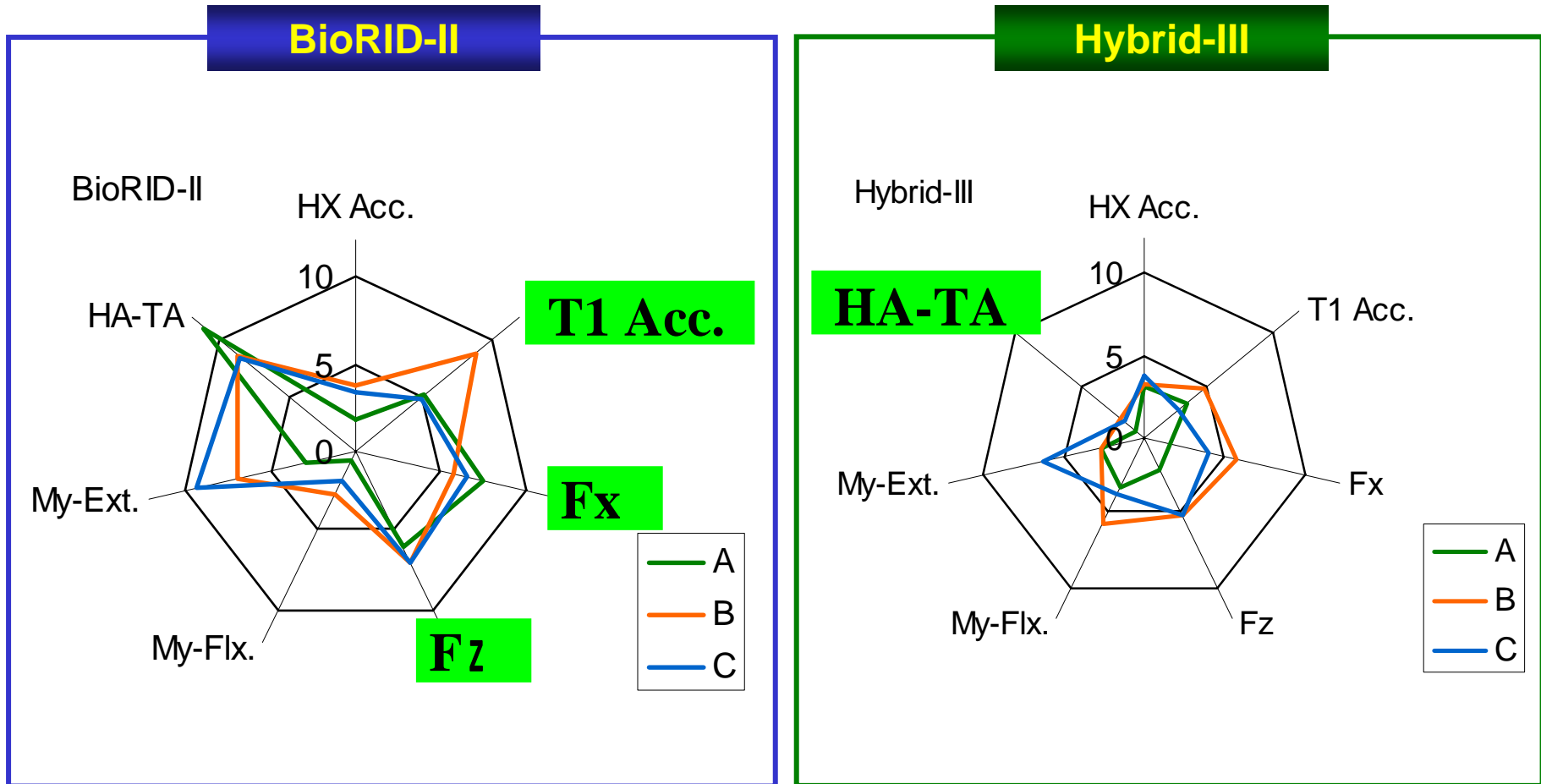
Part	BioRID-II	Mean Value	Standard Deviation	Repeatability C.V(%)
HA-TA (deg)	A	14.3	1.6	11.1
	B	12.6	0.7	5.5
	C	16.0	1.3	8.4

Part	Hibrid-III	Mean Value	Standard Deviation	Repeatability C.V(%)
HA-TA (deg)	A	48.5	0.3	0.7
	B	49.0	0.9	1.8
	C	47.2	0.7	1.5



Summary of Evaluation of Repeatability Based on CV

- For both of Bio RID-II and Hybrid-III, the repeatability of the evaluation indicators was within the limit of tolerance.





Method and Criteria for Evaluation of Reproducibility

■ Method of evaluation

Comparison of coefficient of variation (CV)

$$\text{Reproducibility } C.V = \frac{S_B}{\bar{X}_G} \quad 100 (\%)$$

$$S_B = \left[\frac{MSB-MSW}{n} \right]^{1/2}$$

\bar{X}_G = Mean value of 3 dummies

S_d

MSB : Mean square among groups (dummies)

MSW : Mean square in a group (each dummy)

n : Number of repetitions of test

■ Criteria

Admissible level: CV 10

Summary of Evaluation of Repeatability Based on CV



- For Hybrid-III, the reproducibility of the evaluation indicators was within the limit of tolerance.

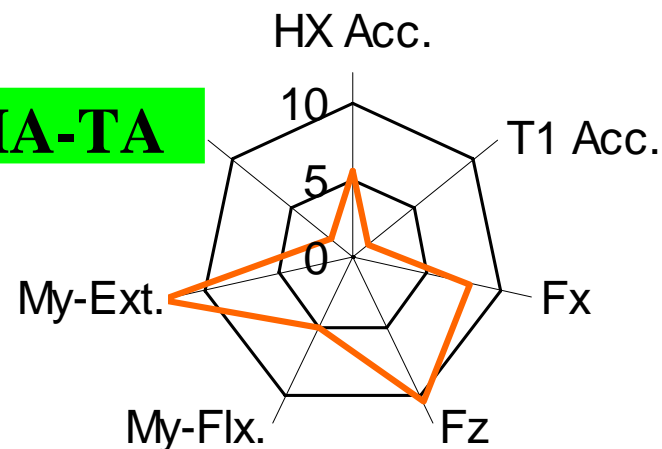
BioRID-II

Since calibration was different among the three dummies, evaluation was not possible.

Hybrid-III

Hybrid-III

HA-TA



Summary of Evaluation of Reproducibility and Repeatability



Summary

- **For repeatability, the evaluation indicators was within the limit of tolerance for both of Bio RID-II and Hybrid-III.**
- **For reproducibility, the evaluation indicators was within the limit of tolerance Hybrid-III, but evaluation was not possible for Bio RID-II because calibration method of dummies was different among the dummies.**
- **Since Bio RID-II ensured repeatability, however, it is estimated that reproducibility may be ensured by specifying the method of calibration more in detail.**