RCAR Design Evaluation Tool

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Content

1. INTRODUCTION

This document describes the RCAR evaluation procedure to assess a vehicle's damageability and repairability (D&R) without conducting a laboratory crash test, based on the evaluation of design parameters in the vehicle's front and rear end. The choice and weighting of these design parameters were evolved from a number of crash test results in several RCAR institutes.

RCAR is aware that effects like airbag deployments or failure of structural elements can only be seen in real life crashes and hence the non-destructive method needs to be regarded as a supplementary tool. This Design Evaluation Tool (DET) is therefore not intended to replace a crash test but aims to give the best possible approximation to a real crash test result where no destructive testing is possible, such as early prototypes or build levels.

2. SCOPE

Improving passenger vehicle damageability and reparability has been an important RCAR topic since the Council was established in 1972. Towards this end, RCAR implemented two 15 km/h, 40% overlap crash tests to encourage vehicle designers to limit unnecessary damage to the structure of passenger vehicles in low-speed front and rear crashes.

In addition to this test procedure, RCAR implemented a lower speed (10 & 5 km/h) bumper test in 2010 which encourages vehicle manufacturers to produce bumper systems that feature tall energy absorbing beams and crash boxes that are fitted at common height; both of which can effectively protect the vehicle in low-speed crashes.

The results of crash tests according to these standards have been implemented in insurance group rating procedures in several markets over the world. The precondition, however, is access to testing facilities and the availability of vehicles representing a certain number of models for destructive testing. This effort is not negligible and in defined cases it might be appropriate to limit these efforts by adjacent non-destructive and impartial methods, like the DET.

The following procedure applies to passenger vehicles with unitized body structure (i.e. unibody), with a mass of 3,500 kilograms or less (Euro M1 category). Other vehicles may be similarly treated if required by the manufacturer or the test facility. Criteria of DET items are a compilation of knowledge based on the bumper and structural test in the past, so the evaluation with DET may not be as accurate as the actual crash test result. DET would be updated according to new findings by RCAR institutes.

DET scores just show relative importance of items. Factors like parts price or labor cost which differ between markets need to be considered and handled separately.

3. DESCRIPTION OF DET

3.1. CONTENTS

The DET consists of the check sheet (Appendix) and supplemental documents.

3.1.1. CHECK SHEET

The DET check sheet is a collection of DET items that include criteria for enhancing the D&R performance of a vehicle. The criteria of the items are generally applicable and effective for various types of vehicles, covering the cosmetic, structural, and mechanical components in the front and rear sections.

Each item is assigned a score that indicates its significance or effectiveness in the D&R performance. It is possible to comparatively and quantitatively assess the D&R performance of vehicles by calculating the DET scores based on the evaluation results.

PART CODE AND NAME

The list includes the components that can enhance a vehicle's D&R performance.
F or R in the code indicates that the DET item is for the front or rear section of a vehicle respectively. B, S, or M denotes whether the item pertains to a bolted, structural, or mechanical part respectively (e.g. The DET item of part code FB1-1 indicates that the item is for the front section bolted part no. 1-1).

CRITERIA

The criteria refer to the commonly and broadly applicable structures or conditions that can enhance a vehicle's D&R performance on the RCAR Bumper and Structure Tests.

SCORE OF EACH ITEM

The score of each item reflects its significance in improving D&R performance, as determined by the results of laboratory crash tests (the RCAR Structure and Bumper Tests)[1)].

DET SCORE

The DET score represents a relative value that indicates overall D&R performance of a vehicle.
The score is derived from the evaluation result of each item. The calculation method is described in 3.3.2.

3.1.2. SUPPLEMENTAL DOCUMENT

The supplemental documents provide additional information on each DET item to assess a vehicle. The information includes the rationale behind the criteria, as well as specific examples. For some items that require further explanation, the documents provide procedures for determining the results of the items.
These documents are available on the official RCAR website (URL…).

3.2. MATERIAL AND CONDITION FOR EVALUATION

To conduct the evaluation, a subject vehicle, repair manual, and parts catalog are necessary.

VEHICLE

The vehicle used for the evaluation does not need to be new, but it must have the same parts as a new vehicle without any damage or previous repairs (pre-production vehicles are acceptable in some cases). Some disassembly of parts is required for the evaluation.

WORKSHOP MANUAL AND PARTS CATALOG

For evaluation, it is necessary to use information that is officially provided by manufacturers and widely available in the market.

REQUIRED KNOWLEDGE FOR EVALUATION

The evaluation requires basic knowledge of engineering, vehicle inspection and vehicle repair.

3.3. EVALUATION

Examine the structure and condition of the vehicle on the basis of the criteria of each DET item.
Some DET items may require dimensional measurement. The measurement points are explained in detail in the supplemental documents.

3.3.1. DETERMINING THE RESULT OF EACH ITEM

Each evaluation results in one of the following.

ACCEPT: The condition of the evaluated vehicle meets the criteria of item

REJECT: The condition of the evaluated vehicle does not meet the criteria of the item

NOT APPLICABLE: The evaluated vehicle does not have the condition or structure to be evaluated

3.3.2. CALCULATING THE DET SCORE

The DET score of the evaluated vehicle is calculated using the following expression.

$$\frac{Sum\ of\ the\ scores\ of\ \boldsymbol{ACCEPT}}{Sum\ of\ the\ scores\ of\ \boldsymbol{ACCEPT}\ and\ \boldsymbol{REJECT}}$$

The DET score is a relative value that signifies a D&R performance of a vehicle.

The score makes it possible to compare the performance between different vehicles. According to the research by the RCAR institute, the correlation between the DET scores and the normalized repair cost* (median) in the market indicates that the scores reflect the D&R performance of the vehicle in the real world[1)].

[1)] Yasushi Komatsu, Satoshi Mizukami and Shigeki Michihata. Development of DET (Design Evaluation Tool) to Evaluate the Performance of Damageability and Repairability by Investigating the Vehicle Structure (Japanese only). Proceedings No. 138-21, 2021 JSAE Annual Congress (autumn).
Summarized paper available in English https://www.jsae.or.jp/2021aki/english/ (262sp.pdf)

* The DET focuses purely on the structural damageability and repairability performance of a vehicle. Therefore, it is necessary to normalize the Impact of parts costs, which are typically correlated with vehicle prices, and labor costs when analyzing the correlation between DET scores and repair costs in the market.

Appendix

DET Check sheet

(Microsoft Excel version available on RCAR official website: http://www.rcar.org/)

No.	Code		Relevant Test		Viewpoint	Parts Name	Criteria	Score	ACCEPT / REJECT / NOT APPLICABLE	Note
			Bumper	Structure						
1	FB1	1	✓	✓	Damageability	Front Bumper Cover	The Front Bumper Cover (including Radiator Grill) mount should be easily detached in a collision to prevent damage from spreading to the Headlamp, fender, and other expensive peripheral parts.	1.40		
2	FB2	1	✓		Damageability	Front Bumper Reinforcement	The Front Bumper Reinforcement and the Bumper Barrier should have an engaging amount of 75 mm or more. If the engaging amount is less than that, a structure should be used that prevents underride.	6.63		
3		2	✓		Damageability		The Bumper Reinforcement should have a section modulus as following that provides sufficient strength suitable for the vehicle weight. ≧ the vehicle weight x 7.5 when the tensile strength of the reinforcement is <1500MPa or unknow, ≧ the vehicle weight x 5.0 when the tensile strength of the reinforcement is ≧1500MPa.	3.63		
4		3	✓	✓	Damageability		The clearance between the Front Bumper Reinforcement and the expensive parts behind it should be 100mm or more.	1.83		
5		4	✓		Damageability		The Front Bumper Reinforcement should be installed without weld studs.	1.00		
6		5	✓		Damageability		The center front end of the Bumper Reinforcement should be at the same position as the front-most tip of the Headlamp, or extending forward.	0.80		
7	FB3	1		✓	Damageability	Front Crush Box	The Front Crush Box should be fastened with bolts or nuts, and have the length longer than 160 mm.	1.00		
8	FB4	1	✓		Damageability	Radar Sensor	The Radar Sensor should be installed at a position except in front of and above the Front Bumper Reinforcement where it can be easily damaged on the Bumper Test.	2.33		
9		2	✓	✓	Damageability		The Radar Sensor should be protected to prevent it from contacting peripheral parts in a collision.	1.00		
10		3	✓	✓	Repairability		The bracket of the Radar Sensor should be supplied individually.	0.35		
11		4	✓	✓	Repairability		The inspection procedure for the Radar Sensor should be provided in the repair manual.	0.35		
12	FB5	1	✓	✓	Repairability	Radiator Grille	Ornament parts installed on the Radiator Grille as separate parts should be supplied individually.	0.70		
13	FB6	1	✓	✓	Damageability	Headlamp	The Headlamp and the Fender should be detached easily in a collision so that damage to the Fender does not occur.	1.00		
14		2	✓	✓	Repairability		Expensive Headlamps such as LEDs should be disassemblable and the lens, housing, controller unit, etc. should be supplied individually.	1.40		
15		3	✓	✓	Repairability		Brackets used for the Headlamp repairs should be supplied individually and covered to hide the marks from repairs.	1.40		
16	FB7	1		✓	Damageability	Hood	The center front edge of the Hood should be at the same position as or behind the front end of the Front Crush Box.	1.00		
17		2	✓		Damageability		The center front edge of the Hood should be higher than the height of the Backstop of the Bumper Barrier (755 mm), or the edge should be at the same position as or behind the front surface of the Front Bumper Reinforcement.	1.00		
18	FB8	1	✓	✓	Damageability	Front Fender	The Front Fender around the Opera Window Glass should be fixed to prevent the molding of the Opera Window Glass from being damaged by the Front Fender in a collision.	1.00		
19	FS1	1		✓	Damageability	Radiator Support	The Radiator Support should allow the Condenser and Radiator to slide rearward together when a force is applied.	1.50		
20		2	✓	✓	Repairability		The Radiator Support should be supplied as an assembly, sub-assembly, or individually to allow replacement depending on the extent of damage.	0.70		
21		3	✓	✓	Repairability		The upper and lower Radiator Supports should be fastened with bolts.	0.70		
22	FS2	1	✓	✓	Damageability	Hood Lock	The Hood Lock should be attached at the rear of the Radiator Support Upper to prevent damage from spreading through the Hood Lock to the Hood on the Bumper and Structure Test.	1.00		
23	FS3	1	✓	✓	Damageability	Hood Lock Support	A Hood Lock Support should not be used as it can damage peripheral parts in a collision.	0.42		
24	FS4	1		✓	Damageability	Front Fender Apron	The Front Fender Apron should be set back from the Side Member.	1.00		
25	FS5	1	✓	✓	Damageability	Front Side Member	Sectioning of the Front Side Member should be officially offered, and one of the following conditions should be also met to prevent damage to the rear of the semi-cut position. For the Side Member with the Crush Box attached with bolts or nuts : The length of the Crush Box should be 110 mm or longer. For the Side Member other than 1 : The length from the tip of the FSM to the sectioning position should be 200 mm or longer.	4.50		
26		2	✓	✓	Repairability		The part at the front end of the Front Side Member, where the Bumper Reinforcement or the Crush Box is installed, should be supplied individually so that the part can be replaced separately.	0.70		
27		3	✓	✓	Repairability		For the Front Side Member, the parts before the Dash Panel should be supplied individually or as a sub-assembly (front).	0.70		
28		4	✓	✓	Repairability		Partial replacement or sectioning of the front part of Front Side Member (both its inner and outer) should be possible without removing the Engine, at least by removing auxiliary parts.	0.35		
29	RB1	1	✓	✓	Damageability	Rear Bumper Cover	The Rear Bumper Cover should not directly fixed with the Quarter Panel with fasteners, like bolts, nuts, screws or clips.	2.00		
30	RB2	1	✓	✓	Damageability	Rear Bumper Reinforcement	The Bumper Reinforcement should have a section modulus as following that provides sufficient strength suitable for the vehicle weight. ≧ the vehicle weight x 7.5 when the tensile strength of the reinforcement is <1500MPa or unknow, ≧ the vehicle weight x 5.0 when the tensile strength of the reinforcement is ≧1500MPa.	7.00		
31		2	✓		Damageability		The Rear Bumper Reinforcement (RBR) should have a sufficient distance to the Back Panel according to its section modulus. - For the RBR whose section modulus at the center is at least 7.5 times the vehicle weight; L1 should be at least 60 mm, and L2 should be at least 50 mm - For the RBR whose section modulus at the center is less than 7.5 times the vehicle weight; L1 should be at least 80 mm, and L2 should be at least 70 mm	2.00		
32	RB3	1		✓	Damageability	Rear Crush Box	The Rear Crush Box should be fastened with bolts or nuts, and should be at least 90 mm long.	4.80		
33		2		✓	Damageability		The panel of the Rear Crush Box which is in contact with and fixed to the vehicle body, should be thicker than the main part of the Crush Box to prevent the Crush Box from collapsing in the event of a collision.	0.60		
34	RB4	1	✓	✓	Damageability	Tailgate / Trunk	The bottom end of the Tailgate (or Trunk) should be higher than the barrier (705 mm).	1.00		
35	RB5	1	✓	✓	Damageability	Tail Lamp	The bottom end of the Tail Lamp should be higher than the barrier (705 mm).	2.00		
36		2	✓	✓	Repairability		There should be a Tail Lamp Garnish between the Rear Door and the Tail Lamp and the Tail Lamp Garnish should be supplied individually.	1.40		
37	RB6	1	✓		Damageability	Quarter Trim	The Quarter Trim should be made of felt fabric so that white marks caused by damage do not stand out. When the Quarter Trim is made with a material other than felt fabric, the Quarter Trim should not extend to the Rear Door opening. If it extends to the Rear Door opening, that portion should be supplied separately.	1.00		
38	RB7	1	✓		Damageability	Floor Board Trim	The Floor Board Trim should have the structure which does not transmit crash forces to forward components when the Trim is pushed forward due to the Back Panel intrusion in a rear-end collision.	1.00		
39	RS1	1	✓	✓	Repairability	Back Panel	The Rear Panel should be installed at an outermost position more than the Rear Quarter Panel, Tail Lamp Housing, etc. to facilitate replacement or repair.	3.50		
40	RS2	1		✓	Repairability	Rear Quarter Panel	The Rear Quarter panel should be divided into upper and lower sections or the lower section can be cut off to be replaced (sectioning).	0.35		
41		2		✓	Repairability		The lower section of the Rear Quarter Panel should be supplied individually.	0.35		
42	RS3	1	✓	✓	Repairability	C/D-Pillar	The C/D Pillar should be supplied as a sub-assembly or individually so that it can be replaced according to the degree of damage.	0.70		
43	RS4	1	✓	✓	Repairability	Rear Inside Panel	The Rear Inside Panel should be supplied as a sub-assembly or individually so that it can be replaced according to the degree of damage.	0.70		
44	RS5	1	✓	✓	Repairability	Rear Floor	The parts for the Rear Floor should be supplied separated into the rear floor, rear floor center, and rear floor side.	0.70		
45		2	✓	✓	Repairability		Sectioning at a desired position on the Rear Floor should be possible.	0.70		
46	RS6	1	✓	✓	Damageability Repairability	Rear Side Member	Partial replacement or sectioning of the rear part of the Rear Side Member should be officially offered and the spare part should be supplied individually. The length from the rear end of the Rear Side Member to the Partial replacement or sectioning position should be 60 mm or longer.	4.00		
47		2	✓	✓	Damageability		The rear end of the Rear Side Member should be reinforced to prevent the Crush Box from falling over on the Bumper and Structure Test.	0.60		

48	M1	1	✓		Damageability	Air Conditioner Condenser	The Air Conditioner Condenser should not have parts on the front of the Condenser to avoid penetration.	0.42		
49	M2	1	✓	✓	Damageability Repairability	AC Pipe and other Pipes	Pipes including the Air Conditioner Condenser Pipe should be divided into front and rear sections and each section should be supplied individually.	1.00		
50		2	✓	✓	Damageability		Pipes including the Air Conditioner Condenser Pipe should be installed at a position where interference from peripheral parts can be avoided in a collision.	1.00		
51	M3	1	✓	✓	Damageability	Fan Shroud	The forward-backward clearances between the Fan Shroud and auxiliary parts behind it should be 80 mm or larger.	1.50		
52		2	✓	✓	Repairability		The parts for the Fan Shroud should be supplied as a sub-assembly or individually so that it can be replaced according to the degree of damage.	0.70		
53	M4	1		✓	Damageability	Compressor (Applicable only to the mini vehicles particular in Japan)	The Compressor should be installed behind and below the lower end of the Side Member.	1.00		
54	M5	1	✓	✓	Damageability	Auxiliary Battery	The Auxiliary Battery should be fixed directly and at least partly to the body to prevent moving during a collision.	1.00		
55	M6	1		✓	Damageability	Suspension Member & Suspension Member Brace	The front end of the Front Suspension Member should be in the same as or behind the front end of the Front Crash Box.	1.00		
56		2		✓			The front end of the Front Suspension Member Brace should be at least 140 mm behind the front end of the Front Crush Box.			
57	M7	1	✓	✓	Damageability	Exhausted manifold converter (Applicable only to the mini vehicles particular in Japan)	The Exhaust Manifold Converter should be protected with a protective cover to prevent damage from the front peripheral parts in a collision.	1.00		
58	M8	1	✓	✓	Repairability	Airbag	The Airbag Harness or repair connector should be supplied individually so that only the damaged section can be replaced.	1.40		
59		2		✓	Repairability		The Airbag-side Instrument Panel should be partially replaceable when the Passenger Seat Airbag has deployed.	0.70		
60	M9	1		✓	Damageability	Muffler (Silencer)	The rear end of the Muffler should be located at least 50 mm inside the rear end of the structural component on the same vertical plane as the Rear Side Member.	1.00		
61		2	✓	✓	Repairability		The Rear Muffler should be supplied individually. When the muffler finisher is used, it should be separable and supplied individually.	0.70		
62	M10	1		✓	Repairability	Fuel Filler Neck	The Fuel Filler Neck should be able to be moved or detachable individually instead of together with the Fuel Tank.	0.70		
63	M11	1	✓	✓	Repairability	Wire Harness	Connectors in the area where damage is likely to occur should be supplied individually and listed in the parts catalog.	0.70		
64		2	✓	✓	Repairability		Harness Clips, Harness Bands, and Connector Clips in the area where damage is likely to occur should be listed as an individual part in the parts catalog.	0.70		

sum of Accept	0
sum of Reject	0
sum of Not Applicable	0
DET score	**#DIV/0!**