Engineering Report

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Subject: ***Laboratory Comparison of Generic Auto Parts with OEM Parts of Toyota Corolla 2001.***

Ordered by: Mr. Joseph Eden,
Operating & Service Manager
Union Motors Ltd.
Yavne
Israel

Meir Kendler

Matrix Engineering Ltd.
Subsidiary of *Institute of Failure Analysis®*

Scope

On 1.1.2003 a new legislation was validated in Israel. This legislation considered generic auto parts as completely compatible with OEM (Original Equipment Manufacturer) auto parts.
Union Motors Ltd. is the representative of Toyota Motors Ltd. in Israel. As being concerned of the safety implications it stated the following question, as a result:

Are the generic parts compatible with OEM parts concerning two issues: dimensions and material & process aspects?

Matrix Engineering obtained a mandate to determine where and how to conduct the dimensional measurements, and also what type of testing to perform in the laboratory. During the period November 2002-March 2003, 4 couples of items were obtained for inspection:

- Right front fender
- Front fender
- Hood
- Front bumper

The couples were a set of generic (**G**) and OEM (**O**) parts, and the testing procedure was on both components similarly. 3 couples were metal made components and one couple (bumper) was polymer-based component.

The work was performed by:
Mechanical Engineer, head of Matrix Engineering
Skilled Metallurgist, expert in thin sheets behavior.
Ms.C. Chemical Engineer, expert in polymer & rubber.

Article A- Right Fender

Technical Data

The Original fender obtained is designated by manufacturer as 53811-02070 .

Dimensional Measurements

The dimensions measured are marked on Fig. 1 in Appendix 1. The measurements were performed by Coordinate Measuring Machine (X-Y-Z system), Sip make.

Parameter	O [mm]	G [mm]
R_3	R20	R22
R_4	R9-9.5	R9-9.5
L_A	191.3	192.2
L_B	337	338
L_{G1}	780	780
L_{G2}	502.4	502.9
L_{G3}	45.2	No hole
V_I	46.8	46.3
V_w	27.5	29.7

Table 1: Geometry measurements

Material & Process testing

Metallurgical specimens were prepared perpendicular to both fender sheets in order to measure and examine the coating and the welding procedures.

Coating:

O-specimen - coating or primer of 11 microns and upper paint of 40 microns. The paint and coating layers are uniform in thickness.

G-specimen – only one paint layer of 33 microns. Thickness is varying between 8 to 45 microns.

P.O.B 3021 Even-Yehuda 40500 Israel Tel:972-9-8999862 Fax:972-9-8999821 E-mail: matrix@actcom.co.il

Joining:

The radius of fender lip that clamps together the fender with the vehicle fender eat was measured - ; O – 17mm radius and G- 25mm radius.

Conclusions

a. Deviations in length of arbitrary selected dimension L_A, L_B L_{G3} and the differences in edge radius indicates geometry differences between generic and OEM parts, exit.

b. A significant difference was measured at the assembly winker hole: G hole is significantly bigger than O. That result may affect post assembly sealing, G-hole will enable water penetration and initiation of corrosion process.

c. The O-part is protected by a double sided **uniform** coating that provides a better environmental protection than the G-part (on which only one **non-uniform** layer of paint).

P.O.B 3021 Even-Yehuda 40500 Israel Tel:972-9-8999862 Fax:972-9-8999821 E-mail: matrix@actcom.co.il

Article B- Front Fender

Technical Data

Part number of the OEM fender is 53903-12110.

Dimensional Measurements

The dimensions measured are marked on Fig. 2 in Appendix 2. The measurements were performed by Coordinate Measuring Machine (X-Y-Z system), Sip make.

Parameter	O [mm]	G [mm]
L_1	862	866.5
L_2	362	362
L_3	725	735
d_A	27.5	27.5
d_B	74.5	74.6
d_D	39	36
R_{dmax}	79	79;78
L_4	417	424
L_5	147.2	147.2
L_6	1059	1066

Table 2: Geometry measurements

Material & Process testing

Metallurgical specimens were prepared perpendicular to the fender sheet in order to measure and examine the coating and the join procedures.

Joining

The joining method used is Spot Welding. Differences in the applied spots are noticeable by visual examination: Size – mean diameter of spots within O-parts is 6.4 mm while at G-parts mean diameter is 5.1mm, i.e., a difference of 20% exist in the spot diameters between the parts. Similar observations were made on the metallurgical specimens.

P.O.B 3021 Even-Yehuda 40500 Israel Tel:972-9-8999862 Fax:972-9-8999821 E-mail: matrix@actcom.co.il

Material

Sheet thickness of the fender: **O** - 1 mm and **G** - 0.8 mm, a difference of 20%.

Conclusions

a. At least in three arbitrary selected dimensions (L_3, L_4 and L_6) an obvious deviation in geometry was verified. That fact will eventually cause assembling difficulties that will undertake component distortion by the mechanic

b. The significant changes between parts in both spot weld quality (lower size and roundness in the G-part) and sheet thickness (G is thinner) implies that the G-component is weaker in strength up to 30% relative to O-component.

P.O.B 3021 Even-Yehuda 40500 Israel Tel:972-9-8999862 Fax:972-9-8999821 E-mail: matrix@actcom.co.il

Article C- Hood

Technical Data

Part number of the couple of hoods is as follows: OEM - 53301-02070 and Generic - TY20097A.

Dimensional Measurements

The dimensions measured are marked on Fig. 3 in Appendix 3. The measurements were performed by Coordinate Measuring Machine (X-Y-Z system), Sip make.

Parameter	O [mm]	G [mm]
L_1	1179.8	1179.8
Right L_2	1000.0	1000.6
Left L_2	1000.03	998.3
L_3	1303.5	1302.5
L_4	60.0	60.5
L_5	740.0	740.7
L_6	1058.4±0.2	1058.2±0.2
R_1	14	15-16
ΔR_3	Δ1.5	
ΔH	Δ4	

Note: H is the height between imaginary line A-B and mid radius R_4.

Table 3: measurements of Hood

Material & Process testing

Preliminary examination of spot welding area was conducted, but since paint covered the O-part a paint remover was applied. O paint could not be chemically removed.

Metallurgical specimens were prepared from front hook peripherals, in order to evaluate the sheet structure interface, coating thickness and welding procedures.

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Joining

The area within the hood that was inspected is constructed of three sheets, all spot welded together.

O – The spots are positioned exactly within the weld seats and join all 3 metal sheets.

G – The position of all spots is shifted away from each and every weld seats. Lack of weld penetration and separation of one of the 3 sheets is observed. On the inner sheet surface burn marks are observed at the spot weld trace. These marks are a result of improper welding conditions during production.

Coating

O - both hood surfaces (inner and outer) are coated with 2 homogenous epoxy-based layers, of 7 and 12 microns thick, respectively. The sheet thickness at the joins is 0.6mm.

G – Only one layer of coating is evident on the outer surface of the outer sheet. A non-uniform double layer coating is observed; their thickness is 1 and 20 microns, respectively. Sheet thickness is 0.5 mm – a difference of 17% relative to OEM thickness, at the same location.

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Conclusions

a. Significant differences in dimensions {of L_2 and of height clearance of 4 mm (ΔH)} will create curvatures on the hood during assembling. Furthermore, a noticeable gap between the hood and its seat is expected to remain. Such a gap may be fixed only by excessive work of the technician in the car depot.

b. The spot welds on G- parts are of inferior quality compared to the O similar parts. The lack of weld penetration and the improper positioning of the spot weld means that undesirable stress distribution will be generated within the metal (of G item). Lower join strength is expected also within these parts. The partial spot weld eventually will lead, during regular operation, to crack initiation by Stress Corrosion Cracking mechanism. Such cracking may lead to disconnecting of the joins even to a sudden catastrophic disintegration.

c. The coating system of the O-part is far more efficient than the G-part. All sheet components that construct the hood of OEM are coated on both sides (external and inner), while the G-parts are coated on the outer external surface. The difference in the coating layout has a direct consequence on environmental protection – the G-part is susceptible to corrosion (rust)

P.O.B 3021 Even-Yehuda 40500 Israel Tel:972-9-8999862 Fax:972-9-8999821 E-mail: matrix@actcom.co.il

Article D- Front Bumper

Technical Data

Part number of the couple of bumpers is as follows: OEM - 52159-1A750 and Generic - TA644-74-A.

The test procedures used to examine these bumpers consist of:

- Chemical analysis by Fourier Transform Infra Red Spectroscopy (FTIR).
- Thermal analysis by Direct System Calorimetry (DSC).
- Soot residue analysis according to ASTM-D- 4218.
- Impact test according to DIN 53453 under two conditions: as received (a.r) and after exposure to 1000 hours of UV radiation – thus simulating 1 year of local condition sun-exposure.

Test results

Part	Base material	%Soot	%talc
O	Polypropylene and EPDM mixture	0.5	10.6
G	Polypropylene and Linear Polyethylene mixture	1.6	4.2

Part	Tm_1 [^{0}C]	Tm_2 [^{0}C]	TCR	ΔH_1 [J/g]	ΔH_2 [J/g]	ΔHcr [J/g]	Impact result [mJ/mm^2]	
							a.r	UV
O	165.4	165.2	128.2	53.9	63.2	61.3	21.44	22.14
G	*125.9+ 164.6	*125.7+ 163.3	122.9	78.5	90.4	89.2	9.3	14.7

* Two peaks characterizing two different materials in the mixture.

Table 4: Test results

Note: See DSC thermograms of both materials in appendix 4

Conclusions

a. Although the chemical analysis indicates that base material of both parts is apparently similar i.e., polypropylene, the main difference lays in the specific additive that exist in O bumper and is missing in G part. Bumper O is made of a mixture of Polypropylene and EPDM that enable better strength and flexibility properties, while in bumper G these properties are poor due the absence of EPDM.

b. The thermal analysis measured lower level of crystalinity of O than G. The consequence is that O is more flexible and better in impact energy absorbing. These results conform to the behavior of the specific materials under impact loading test: the G samples fractured during the test, while the O-samples bent without fracturing.

c. The Impact test indicated that the G-samples are inferior in energy absorbing (50%) than the O-samples.

d. The affect of UV radiation, which simulates exposure to sunlight, indicated that mechanical properties of the O-samples (impact strength) are stable also after 1000 hours of exposure. As for the G-samples, not only that at regular conditions it failed under lower load it sustained unstable behavior after UV exposure. In both cases (before and after UV exposure) the O-bumper failed in a bending mode with almost no fracture, while the G-bumper failed in full fracture mode.

P.O.B 3021 Even-Yehuda 40500 Israel Tel:972-9-8999862 Fax:972-9-8999821 E-mail: matrix@actcom.co.il

Summary

Due to the different nature of materials examined in this research the summery will consider each type separately, Metallic components and Polymer components.

Metal Component

- **Sheet thickness** – the Generic parts are 20% thinner then the OEM. It implies obviously on lower strength of the Generic components.
- **Geometry** – although apparently, generic and OEM components look the same visually, dimensional measurements indicated the existence of significant differences. The effect of this differences on the use of generic parts may be summarized as:
    1. Lack of fitting during assembly, generation of significant gaps between neighboring components in the vehicle. Extra mechanic work will be required at the garage to fix these mishaps.
    2. Wherever gaps or curvatures may be generated due to the "extra- mechanic-work" unaesthetic traces are to be expected.
    3. Sealing of various internal components will be under question. That may lead to water penetration and excessive corrosion.
- **Welding** – inferior quality of spot weld in generic parts is evident. That defect consist of improper positioning within weld seat, partial stamping and penetration of welds. These irregularities may effect directly two issues, first it may shorten life-span of component, and most important – there is a safety hazard of self disintegration of hood during low speed collision, or even during a regular cruise.

P.O.B 3021 Even-Yehuda 40500 Israel Tel:972-9-8999862 Fax:972-9-8999821 E-mail: matrix@actcom.co.il

Polymer Component

- **Chemical composition** – principal difference in chemical composition effect significantly material most important properties. OEM is a mixture of Polypropylene and EPDM, while the generic is mainly Polypropylene.
- **Brittleness -** Generic bumper is brittle in any overloaded condition tested. The OEM behavior was, on the other hand, most flexible within similar loading conditions.
- **Impact resistance** – Decrease of 40% was measured on the Generic bumper part relative to OEM. This means that the generic part can absorb less energy than the OEM part during impact. For illustration if the OEM bumper yield at 20 km/h impact-speed, the generic bumper will break at only 8 km/h impact-speed.
- **UV radiation resistance** – The mechanical properties of OEM material were stable during UV radiation exposure (relative to exposure of 1 year of operation in Israel), while under the same conditions the Generic material was unstable. This result may imply also of Generic material uniformity.

To conclude this article, it is clear that these results have significant safety implications: The Generic part is weaker then the OEM under shock load. At low velocity the generic part fail under brittle fracture mechanism, that may cut or injure any pedestrian. The OEM does not fracture but yield by bending mechanism.

P.O.B 3021 Even-Yehuda 40500 Israel Tel:972-9-8999862 Fax:972-9-8999821 E-mail: matrix@actcom.co.il

Appendix 1

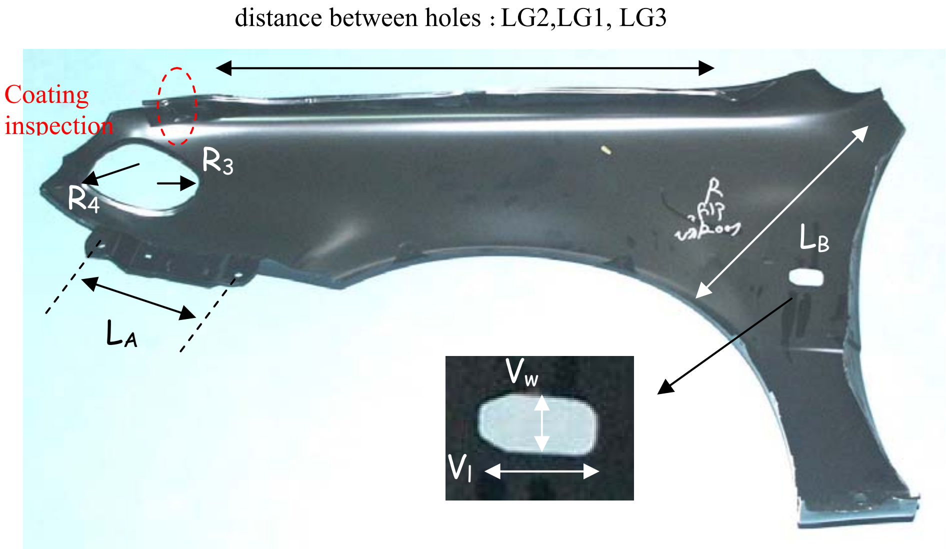

Fig. 1: parameters measured on the right front fender

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Appendix 2

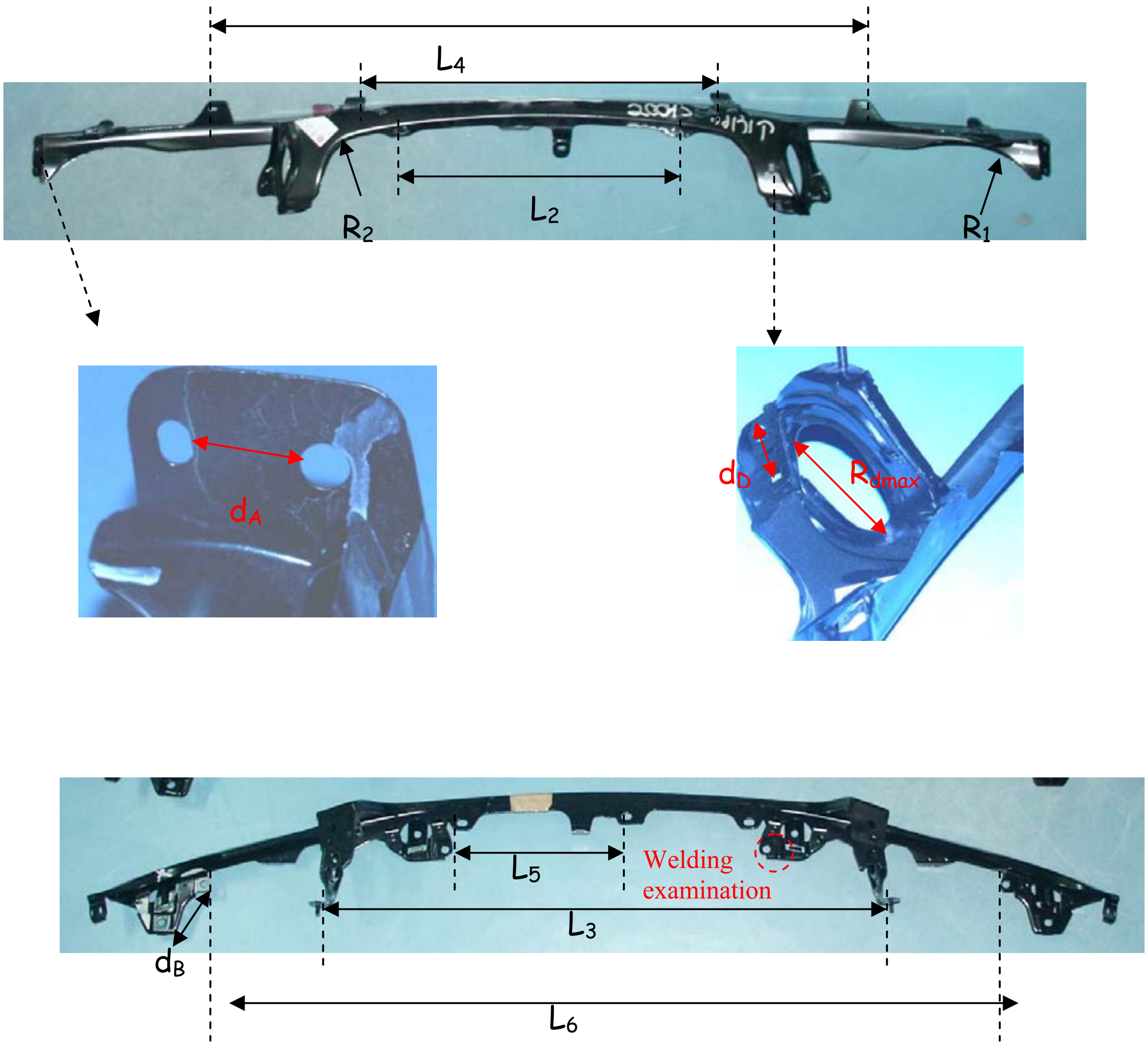


Fig. 2: parameters measured on the front fender

Appendix 3

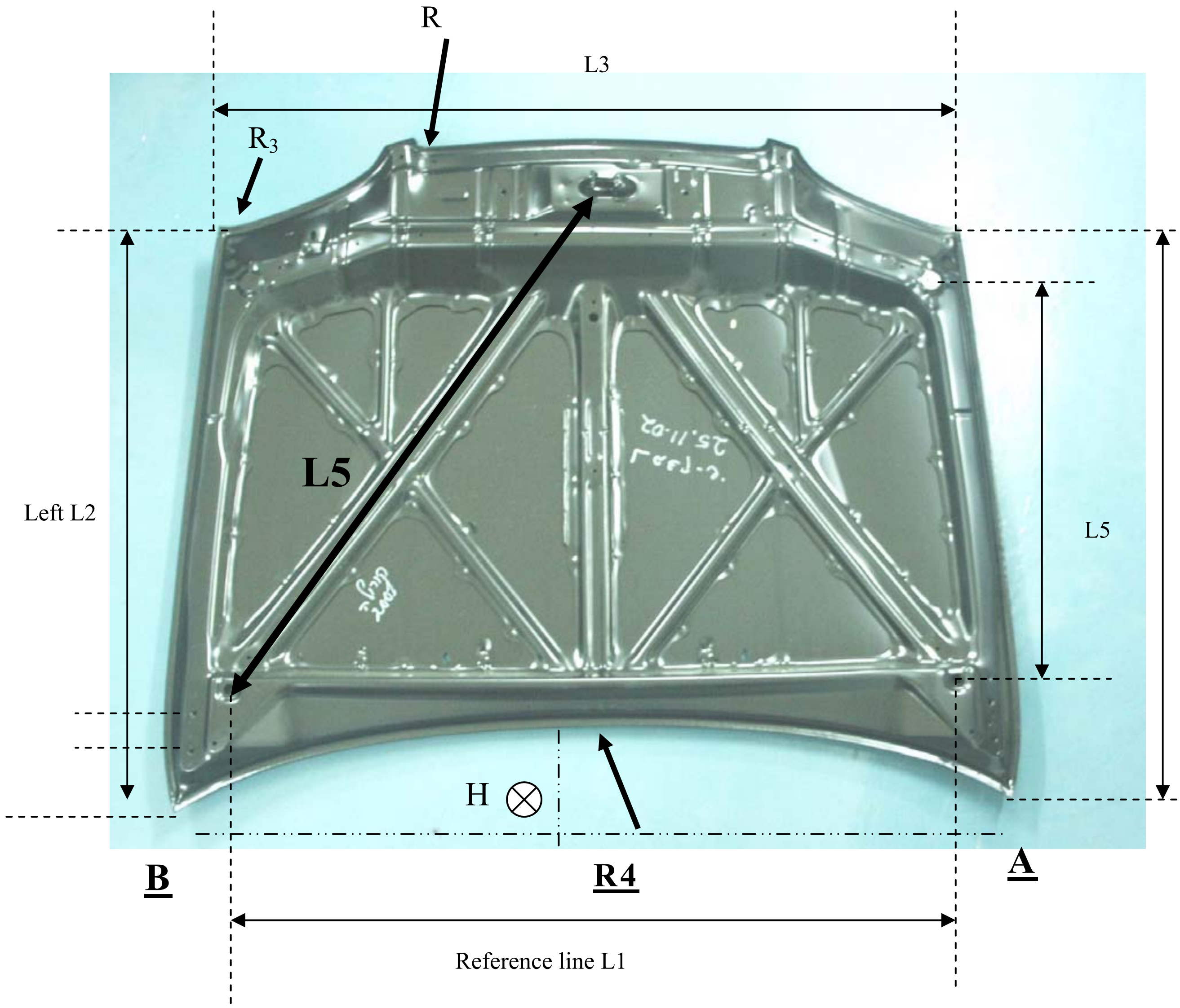
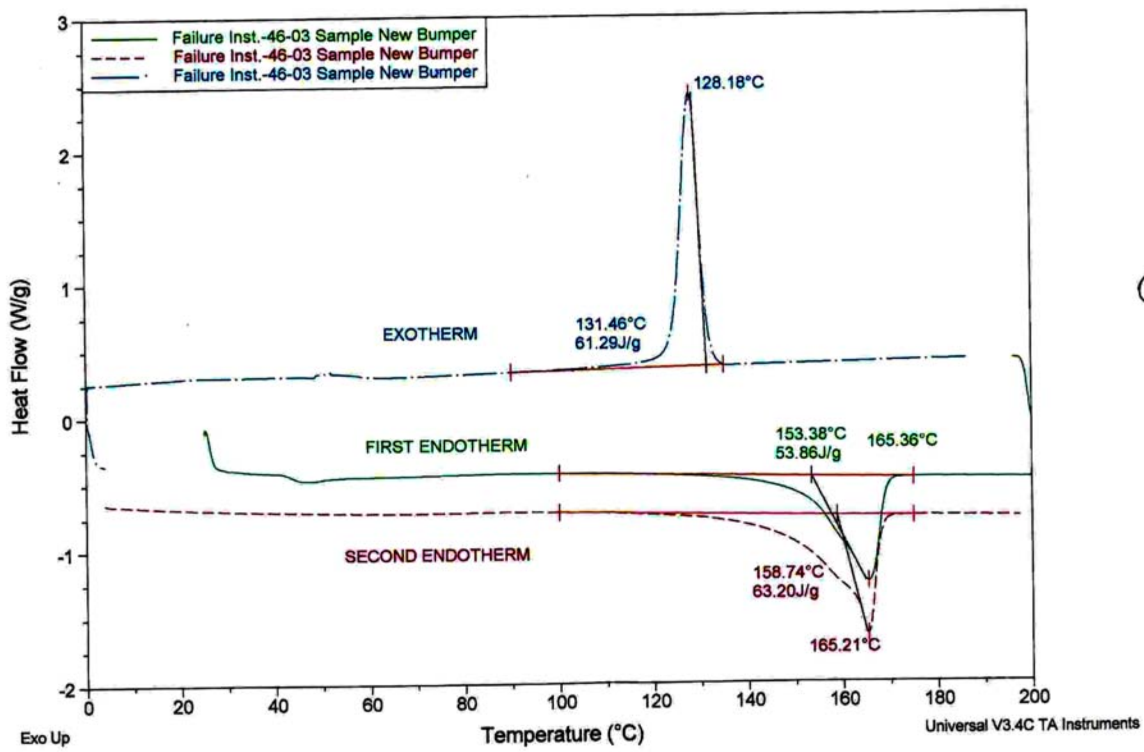
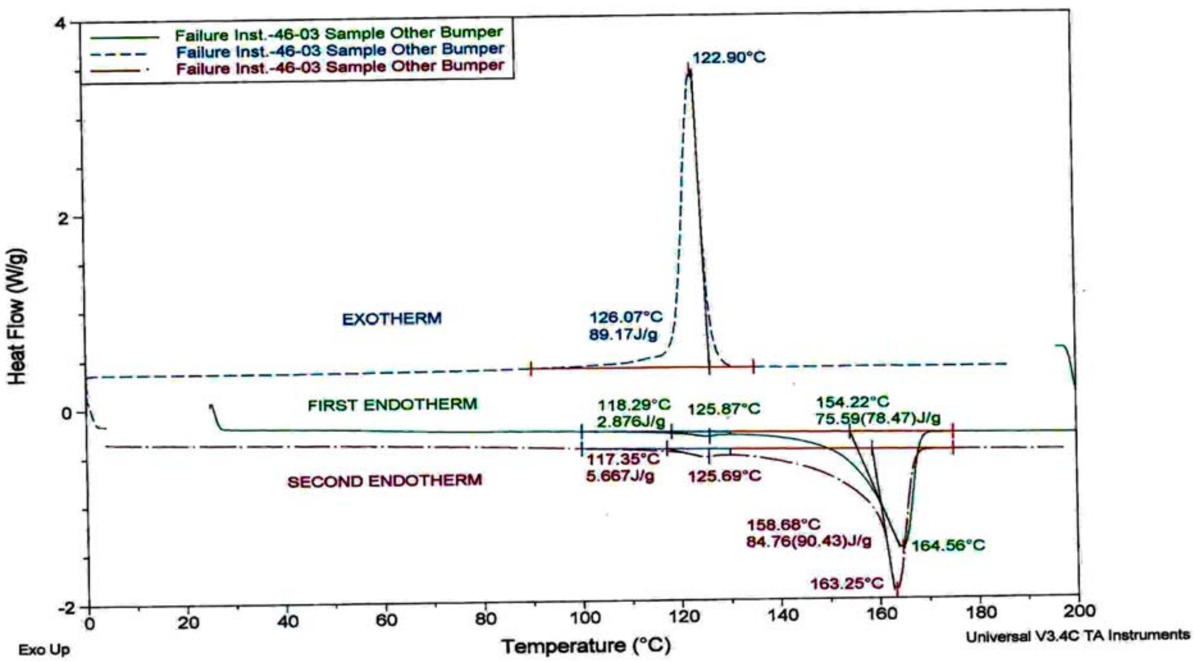


Fig. 3: parameters measured on hood.

Appendix 4



O – bumper with low crystallinity



G – bumper with high crystallinity

Fig. 4: DSC material thermograms of both bumpers

P.O.B 3021 Even-Yehuda 40500 Israel Tel:972-9-8999862 Fax:972-9-8999821 E-mail: matrix@actcom.co.il