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Crimping Standard DIN vs USCAR Gap Analysis

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Abstract. *In this paper the main objective is to present the current status of the automotive specifications related to the crimping process, an in particular how these specifications were adopted by the suppliers of the crimping components (e.g. Terminals and cables). For this reason, we took as reference two of the most worldwide used standards form the automotive manufacturing industry: DIN ("Deutsches Institut für Normung") with the corresponding Romanian standard SR EN 60352-2:2006 and SAE/USCAR-21 REVISION 3.*

Keywords: *crimping standard, gap analysis, crimping microsection, statistical analysis, crimping compression*

1. Introduction

In the current world of automotive wiring harness manufacturing industry one of the critical processes is the crimping assembly between the wiring cable and the terminals design by the OEM's. Due to this reason all Original Equipment Manufactures in automotive industry were adopting a common approach to issue a set of specifications that will enable a higher stability and subsequently a higher quality of the product throughout product lifetime [1], [2].

As the biggest markets from the world European Union and US manufacturers were adopting specific norms to define and control the crimping process like DIN (SR EN 60352-2:2006) and SAE/USCAR-21 Rev 3.

The purpose of this paper is to evaluate how the crimping process specifications in both these standards fit together and where there are gaps, how these gaps influence the current production process of the component suppliers and, finally, to have a better understanding of potential optimization of the crimped assembly from a productivity, quality, and financial indicators point of view.

To enable us to do the analysis, we focus our research on the critical parameter requirement of a crimped splice assembly between a copper plated terminal and a standard FLRY-A wire with a cross section of 0.50 [3], [4].

Our objective was to analyze the compression specifications in both European and US standards and to construct a gap analyze of the main specification, and in the second stage of the study to observe the influence of these specification and how these standards were introduced in a operational environment. The paper is a starting point in the quest to determine using statistical analysis tools the optimum compression requirement that will enable wiring systems manufacturers to have a clear standard specification when validating the crimp-joint.

This will enable a significant improvement of the overall manufacturing cost incurred by the wear and tear of the active parts on any applicator tool due to the tendency of the tools manufacturing suppliers to increase the percentage of the compression factor which will secure a better resistivity but by doing this negatively influencing significantly the life time of the crimp applicator tool.

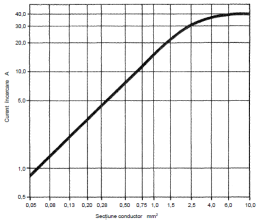
2. Methodology

The study was structured in two distinct steps that enable was to investigate the theoretical implication of the specification over the compression characteristics of a crimped assembly and how this specification was adopted in a real manufacturing environment.

In the first step we put together a Gap Analyze chart focused on the specification that control the behavior of the compression of a crimped assembly as specified in both standards (Table 1).

Table 1. Gap Analysis on compression specification

Specification details	SR EN 6032-2:2006	SAE/USCAR-21 Rev.3
Degree of compression	Not specified	From 15% to 20% upward as minimum requirement
Quality of the crimped microsection	Not specified	Quality of the crimped area influenced by the compression and controlled by the crimping tool and terminal design. It is recommended to document the cable cross section of the cable used in production to be in accordance with the one used for terminal validation
Compression specification limits	Not define LSL or USL	Not specified (LSL – just as indication start from 15%-20%) No Upper Limit

<table>
<tr><th>Specification details</th><th>SR EN 6032-2:2006</th><th>SAE/USCAR-21 Rev.3</th></tr>
<tr><td>Cycle Current Test</td><td>
</td><td><table>
<tr><th>ISO Wire Size (mm²)</th><th>Wire Gauge</th><th>Test Current (A)</th></tr>
<tr><td>0.13</td><td>26</td><td>4</td></tr>
<tr><td>0.35</td><td>22</td><td>10</td></tr>
<tr><td>0.50</td><td>20</td><td>14</td></tr>
<tr><td>0.75</td><td>18</td><td>18</td></tr>
<tr><td>1</td><td>16</td><td>22</td></tr>
<tr><td>1.5</td><td>-</td><td>26</td></tr>
<tr><td>2</td><td>14</td><td>30</td></tr>
<tr><td>2.5</td><td>-</td><td>35</td></tr>
<tr><td>3</td><td>12</td><td>40</td></tr>
<tr><td>4</td><td>-</td><td>52</td></tr>
<tr><td>5</td><td>10</td><td>65</td></tr>
<tr><td>6</td><td>-</td><td>80</td></tr>
<tr><td>≥ 8</td><td>≤ 8</td><td>Use step 8</td></tr>
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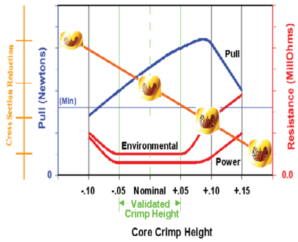
<tr><td>Correlation between Compression/Pull test/Resistance</td><td>Not specified</td><td>
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By analyzing the outcome of the gaps what we clearly observed is that the European Standard has a much general approach and is leaving a high degree of freedom to the components suppliers to define their own operational standards. By comparation the USCAR have a more specific requirements in relation to the compression and to the general aspect of the cross section but also the approach is very general and is allowing the suppliers to develop their own specifications.

As summary of the gap analysis, we observed that related to the compression and general requirements of a standard output in a crimped process we will need to achieve a minimum 15% to 20% compression rate without any specification on upper limit, the general aspect of the cross section needs to be defined and documented by the component manufacturer and that the test currents are significant different EN standard specifying half the values.

Having this as a base to further understand the impact inside a real production environment we selected as second step in our study a Schaefer eps 2000 (Fig. 1), and 75 crimping tools (Fig. 2). All the crimping tools were set to enable a crimped assembly between 75 terminals specific for 0.50 mm² cross section and a FLRY-A cable 0.50 mm² in cross section:

Figure 1. Schaefer eps 2000 crimping machine

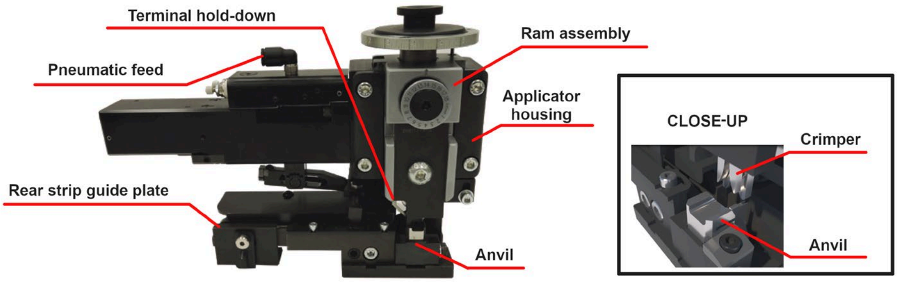

Figure 2. Crip tooling: applicator parts and close-up of inserts

For all the 75 combinations between terminal and cable we used a set of 125 samples for which we performed microsection analysis using a test equipment Komax Microlab35 (Fig. 3) and pull test capability study.

Figure 3. Komax MICROLAB 35

All the datasets were collected in a Data Collection Plan to enable our team to perform with the help of Minitab software a more comprehensive analysis [5], for a better understanding of the compression behavior in a real production environment and by performing statistical analysis to determine a statistical relevance of that behavior. In addition, for each terminal-cable assembly we performed a capability study on pull test to understand the behavior of the CmK (Capability Index) across the full sample range.

3. Data analysis and assumptions

The Data Collection Plan presented in Table 2 was focused in collecting the type of the terminal used, the wire cable the compression obtained after the crimping process and the Capability index on the pull test performed.

Table 2. Data Collection Plan (extract)

Nr. Crt.	Applicator	Terminal part number	Supplier	Cross section cable	Cable Type	Comp-ression	CmK pull test
1	CV-001-B	P00005123	TYCO	0.50	FLRY-A	76.20%	3.96
2	CV-001-B	P00039988	TYCO	0.50	FLRY-A	75.12%	4.09
3	CV-003-N	P00009924	TYCO	0.50	FLRY-A	75.00%	3.72
4	CV-003-M	P00009926	TYCO	0.50	FLRY-A	79.00%	3.22
5	CV-005-L	P00106149	TYCO	0.50	FLRY-A	76.60%	3.64
6	CV-005-L	P00106155	TYCO	0.50	FLRY-A	76.60%	3.82
7	CV-006-B	P00005035	TYCO	0.50	FLRY-A	74.20%	2.5
8	CV-009-A	P00009916	TYCO	0.50	FLRY-A	81.20%	2.51
9	CV-012-B	P00005162	TYCO	0.50	FLRY-A	72.00%	4.84
10	CV-015-E	P00001731	TYCO	0.50	FLRY-A	76.60%	2.8
11	CV-015-E	P00004238	TYCO	0.50	FLRY-A	71.40%	4.32
12	CV-021-A	413003926	LEAR	0.50	FLRY-A	75.00%	4.92
13	CV-025-B	P00002984	TYCO	0.50	FLRY-A	78.60%	5.41
14	CV-033-I	P00005553	TYCO	0.50	FLRY-A	83.00%	2.49
15	CV-035-B	P00009976	TYCO	0.50	FLRY-A	74.20%	4.54
16	CV-052-A	P00002178	TYCO	0.50	FLRY-A	74.25%	2.49

Looking over the data collected from the beginning it was clearly visible that the range of the compression values was quite high and to have a statistical overview of the data we performed an I-MR Chart on compression (Fig.4) and for better understanding of the process stability we completed the data analysis with a Boxplot chart (Fig.5).

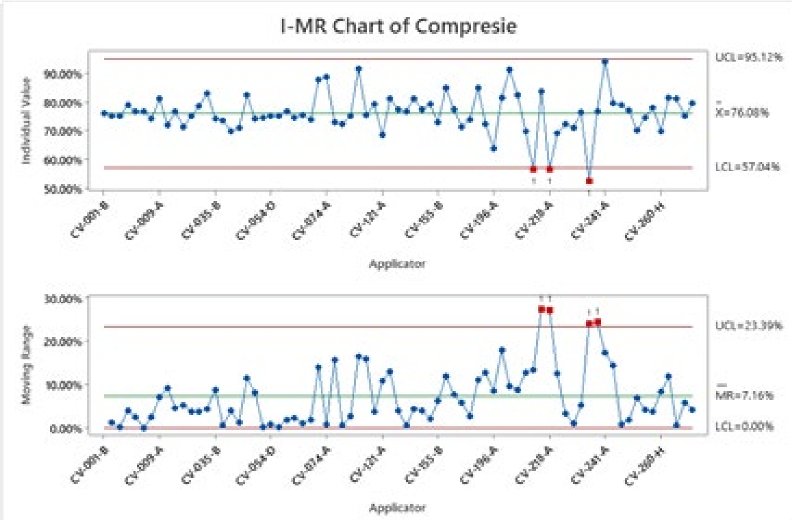

Figure 4. Control chart of Compression

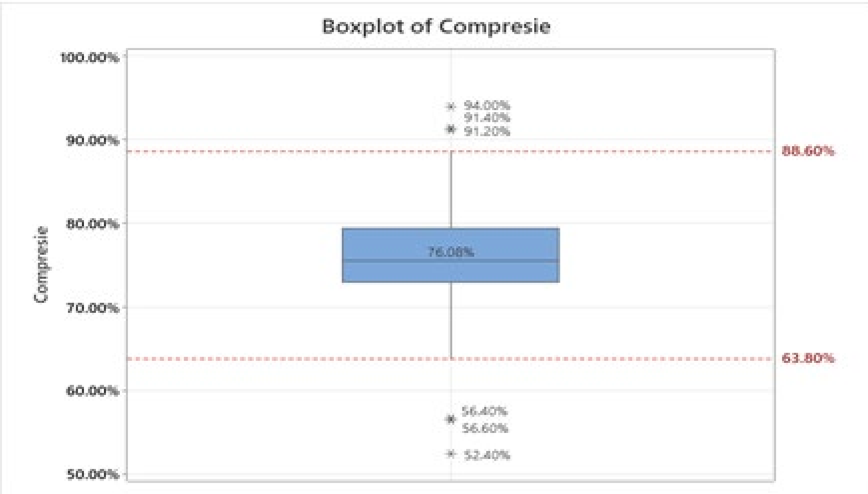

Figure 5. Boxplot analysis of Compression

In both charts the data analyzed shows that the process is a stable one with a average around the compression value of 76% and in the Box plot chart we see that the minimum compression registered is 52.4% and the maximum is 94%. Also analyzing the evolution of the CmK index at the pull test it is clear that the pull test process is also very stable with high capability index.

4. Conclusions

After observing the range of all the compression level values and the minimum and maximum related to the pull test Capability Index, as well as the investigation carried out to understand the requirements of European and US standards we can conclude that it is necessary to introduce a predictive model, [6], which allows wiring systems suppliers to better understand the limits of the compression and basically to enable them to obtain an optimum ratio between compression percentage of a crimped cross section and pull test and subsequently the resistance of the specified crimped joint.

As showed in the current study each supplier can develop his own standards that due to the too general specifications of the European Standards and US standards will fit in within the general requirements and be treated on a case-by-case basis, without a real potential of predicting an optimal cluster of specifications [7].

The current study shows that the control limits of the compression for an optimal crimping process is inside 63.8% to 88.6% interval. If we want to translate this into lifetime cycle of an active part for a crimping applicator tool, we will observe that operating on the upper specification limit the operational lifespan of the tool will decrease with more than 50% which will have as immediate effect a 50% increase in the spare part consumption. This shows the need for a clear more strict specification on compression to enable tool manufactures and wiring harness supplier to align and to follow that optimum specification when validating a new crimp joint assembly.

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