

Ageing tests in standards on Li-ion batteries

This table covers ageing tests for Li-ion batteries. It is made in the European projects eCaiman, Spicy and Naiades.



batterystandards.info



	IEC 62660-1:2010 (Cell Level)	ISO 12405-1:2011 (Module & System level)	ISO 12405-2:2012 (Module & System level)	CC/1 743:2006	DOE-INL/EXT-15-34184	SAE J2288																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
Charge retention	7.6.1 Storage tests - Charge retention test.	7.5 SOC loss at storage / 7.4 No-load SOC loss.	7.6 SOC loss at storage / 7.5 No load SOC loss.	6.2.9.x Charge holding and recovery characteristics at 6.2.9.1 normal temperature / 6.2.9.2 high temperature.	3.6 Self-Discharge Test																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	Cell level	Full system level with BMS activity / without BMS activity	Full system level with BMS activity / without BMS activity	Cell level	All levels																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	duration 28 days / checkup 28 days conditioned at 25°C ±2K	duration 30 days / checkup 1, 7 and 30 days conditioned at 25°C ±2K	duration 30 days / checkup 1, 7 and 30 days conditioned at 25°C ±2K	28 days / checkup 7 days conditioned at 20°C ±5K	duration 30 days / checkup 30 days conditioned at 30°C ±3K																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	tested at 45°C ±2K	tested at 45°C ±2K / 25°C and 40°C ±2K	tested at 45°C ±2K / 25°C and 40°C ±2K	tested at 20°C ±5K / tested at 55°C ±2K	tested at 30°C ±5K (proposed value)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	SOC 50%	SOC 50% / SOC 80%	SOC 50% / SOC 100%	SOC 100%	SOC 50% (State of Energy is used)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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Cycle life	7.7.x Cycle life tests - 7.7.1 BEV / 7.7.2 HEV.	7.9 Cycle life.	7.7 Cycle life.	6.2.11 Cycle life.	3.9 Cycle Life Dynamic Stress Tests	Full procedure dedicated to cycle life test																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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	convective cooling 45°C ±2K ambient	Active cooling 25-40°C ±2K	Active cooling 25-40°C ±2K	Convective cooling 20°C ±2K ambient	convective cooling at unspecified temperature																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	SOC window 100% - 20% / 80% - ~25% (defined by switching voltage)	SOC window 80% - 30%	SOC window 100% - 20%	SOC window 100% - 20%	Specified by manufacturer or application	SOC window 100% - 20%																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
	Different BEV profiles / Different HEV profiles	Different BEV and PHEV profiles	Different BEV profiles	Constant current CH and DCH with 0.33C	Dynamic Stress Tests Cycle Life Test Profile for the EV Battery	Dynamic capacity test profile from SAE J1798																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
Checkup every 28 days at 25°C ±2K	Checkup every 28 days at 25°C ±2K	Checkup every 28 days at 25°C ±2K	Checkup every 24h at test temperature	Checkup ~32 days or application specific	Checkup every 28 days																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
End of test if C(current)<0.8C(initial) or 6 months / P(current)<0.8P(initial) or 6 months	Limits during checkup to be defined before	Limits during checkup to be defined before	End of test if C(current)<0.8C(initial)	End of test is application specific. Recommendations e.g. insufficient energy or capacity to finish checkup or too few values achievable by HPPC test.	End of test if C(current)<0.8C(rated) or P(current)<0.8P(rated)@80%DOOD																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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Dynamic discharge profile B for BEV cycle test</b></p> <table border="1"> <thead> <tr> <th>Charge/discharge step</th> <th>Duration [s]</th> <th>Ratio to test power [%]</th> <th>Charge/discharge</th> </tr> </thead> <tbody> <tr><td>1</td><td>35</td><td>0.0</td><td>Discharge</td></tr> <tr><td>2</td><td>12</td><td>+25.0</td><td>Discharge</td></tr> <tr><td>3</td><td>12</td><td>+25.0</td><td>Discharge</td></tr> <tr><td>4</td><td>8</td><td>+12.5</td><td>Charge</td></tr> <tr><td>5</td><td>35</td><td>0.0</td><td>Discharge</td></tr> <tr><td>6</td><td>24</td><td>+12.5</td><td>Discharge</td></tr> <tr><td>7</td><td>12</td><td>+25.0</td><td>Discharge</td></tr> <tr><td>8</td><td>8</td><td>+12.5</td><td>Discharge</td></tr> <tr><td>9</td><td>16</td><td>0.0</td><td>Discharge</td></tr> <tr><td>10</td><td>35</td><td>+12.5</td><td>Discharge</td></tr> <tr><td>11</td><td>32</td><td>+25.0</td><td>Discharge</td></tr> <tr><td>12</td><td>8</td><td>+12.5</td><td>Charge</td></tr> <tr><td>13</td><td>35</td><td>0.0</td><td>Discharge</td></tr> <tr><td>14</td><td>35</td><td>+12.5</td><td>Discharge</td></tr> <tr><td>15</td><td>35</td><td>+25.0</td><td>Discharge</td></tr> <tr><td>16</td><td>24</td><td>+12.5</td><td>Discharge</td></tr> <tr><td>17</td><td>8</td><td>+25.0</td><td>Charge</td></tr> <tr><td>18</td><td>20</td><td>+25.0</td><td>Discharge</td></tr> <tr><td>19</td><td>8</td><td>+25.0</td><td>Charge</td></tr> <tr><td>20</td><td>44</td><td>0.0</td><td>-</td></tr> </tbody> </table>	Charge/discharge step	Duration [s]	Ratio to test power [%]	Charge/discharge	1	35	0.0	Discharge	2	35	+12.5	Discharge	3	12	+25.0	Discharge	4	8	+12.5	Charge	5	35	0.0	Discharge	6	24	+12.5	Discharge	7	12	+25.0	Discharge	8	8	+12.5	Discharge	9	16	0.0	Discharge	10	35	+12.5	Discharge	11	32	+25.0	Discharge	12	8	+12.5	Charge	13	35	0.0	Discharge	14	35	+12.5	Discharge	15	35	+25.0	Discharge	16	24	+12.5	Discharge	17	8	+25.0	Charge	18	20	+25.0	Discharge	19	8	+25.0	Charge	20	44	0.0	-	Charge/discharge step	Duration [s]	Ratio to test power [%]	Charge/discharge	1	35	0.0	Discharge	2	12	+25.0	Discharge	3	12	+25.0	Discharge	4	8	+12.5	Charge	5	35	0.0	Discharge	6	24	+12.5	Discharge	7	12	+25.0	Discharge	8	8	+12.5	Discharge	9	16	0.0	Discharge	10	35	+12.5	Discharge	11	32	+25.0	Discharge	12	8	+12.5	Charge	13	35	0.0	Discharge	14	35	+12.5	Discharge	15	35	+25.0	Discharge	16	24	+12.5	Discharge	17	8	+25.0	Charge	18	20	+25.0	Discharge	19	8	+25.0	Charge	20	44	0.0	-	<p><b>Figure 7 - Current profile for cycle life test - Discharge-rich profile</b></p> <p><b>Table 17 - Times and current profile - Discharge-rich profile</b></p> <table border="1"> <thead> <tr> <th>Time increment [s]</th> <th>Time cumulative [s]</th> <th>Current [A]</th> <th>Accumulated I²t [A²h]</th> </tr> </thead> <tbody> <tr><td>1</td><td>4</td><td>20</td><td>-2.776</td></tr> <tr><td>2</td><td>15</td><td>13</td><td>-5.564</td></tr> <tr><td>3</td><td>27</td><td>6</td><td>-10.000</td></tr> <tr><td>4</td><td>47</td><td>6</td><td>-10.000</td></tr> <tr><td>5</td><td>67</td><td>6</td><td>-10.000</td></tr> <tr><td>6</td><td>87</td><td>15</td><td>-7.317</td></tr> <tr><td>7</td><td>107</td><td>10</td><td>-5.339</td></tr> <tr><td>8</td><td>127</td><td>5</td><td>-0.600</td></tr> <tr><td>9</td><td>147</td><td>0</td><td>0.000</td></tr> <tr><td>10</td><td>167</td><td>15</td><td>-3.983</td></tr> <tr><td>11</td><td>187</td><td>10</td><td>-4.351</td></tr> <tr><td>12</td><td>197</td><td>5</td><td>-10.000</td></tr> <tr><td>13</td><td>217</td><td>6</td><td>-10.000</td></tr> <tr><td>14</td><td>237</td><td>12.5</td><td>-8.284</td></tr> <tr><td>15</td><td>257</td><td>17.5</td><td>-6.864</td></tr> <tr><td>16</td><td>277</td><td>15</td><td>-1.844</td></tr> <tr><td>17</td><td>300</td><td>0</td><td>-1.844</td></tr> </tbody> </table> <p><b>Table 18 - Times and current profile - Charge-rich profile</b></p> <table border="1"> <thead> <tr> <th>Time increment [s]</th> <th>Time cumulative [s]</th> <th>Current [A]</th> <th>Accumulated I²t [A²h]</th> </tr> </thead> <tbody> <tr><td>1</td><td>4</td><td>15</td><td>2.489</td></tr> <tr><td>2</td><td>15</td><td>18</td><td>4.451</td></tr> <tr><td>3</td><td>27</td><td>8</td><td>10.000</td></tr> <tr><td>4</td><td>47</td><td>8</td><td>10.000</td></tr> <tr><td>5</td><td>67</td><td>24</td><td>7.444</td></tr> <tr><td>6</td><td>87</td><td>15</td><td>4.444</td></tr> <tr><td>7</td><td>107</td><td>8</td><td>0.889</td></tr> <tr><td>8</td><td>127</td><td>15</td><td>0.889</td></tr> <tr><td>9</td><td>147</td><td>15</td><td>1.333</td></tr> <tr><td>10</td><td>167</td><td>15</td><td>1.333</td></tr> <tr><td>11</td><td>187</td><td>15</td><td>1.333</td></tr> <tr><td>12</td><td>207</td><td>15</td><td>1.333</td></tr> <tr><td>13</td><td>227</td><td>15</td><td>1.333</td></tr> <tr><td>14</td><td>247</td><td>15</td><td>1.333</td></tr> <tr><td>15</td><td>267</td><td>15</td><td>1.333</td></tr> <tr><td>16</td><td>287</td><td>15</td><td>1.333</td></tr> <tr><td>17</td><td>307</td><td>15</td><td>1.333</td></tr> <tr><td>18</td><td>327</td><td>15</td><td>1.333</td></tr> <tr><td>19</td><td>347</td><td>15</td><td>1.333</td></tr> <tr><td>20</td><td>367</td><td>15</td><td>1.333</td></tr> </tbody> </table>	Time increment [s]	Time cumulative [s]	Current [A]	Accumulated I²t [A²h]	1	4	20	-2.776	2	15	13	-5.564	3	27	6	-10.000	4	47	6	-10.000	5	67	6	-10.000	6	87	15	-7.317	7	107	10	-5.339	8	127	5	-0.600	9	147	0	0.000	10	167	15	-3.983	11	187	10	-4.351	12	197	5	-10.000	13	217	6	-10.000	14	237	12.5	-8.284	15	257	17.5	-6.864	16	277	15	-1.844	17	300	0	-1.844	Time increment [s]	Time cumulative [s]	Current [A]	Accumulated I²t [A²h]	1	4	15	2.489	2	15	18	4.451	3	27	8	10.000	4	47	8	10.000	5	67	24	7.444	6	87	15	4.444	7	107	8	0.889	8	127	15	0.889	9	147	15	1.333	10	167	15	1.333	11	187	15	1.333	12	207	15	1.333	13	227	15	1.333	14	247	15	1.333	15	267	15	1.333	16	287	15	1.333	17	307	15	1.333	18	327	15	1.333	19	347	15	1.333	20	367	15	1.333	<p><b>Table 12 - Time and power data - Dynamic discharge power profile A</b></p> <table border="1"> <thead> <tr> <th>Step</th> <th>Time increment [s]</th> <th>Time cumulative [s]</th> <th>Ratio to max. Power [%]</th> </tr> </thead> <tbody> <tr><td>1</td><td>16</td><td>16</td><td>0</td></tr> <tr><td>2</td><td>28</td><td>44</td><td>+12.5</td></tr> <tr><td>3</td><td>12</td><td>56</td><td>+25</td></tr> <tr><td>4</td><td>8</td><td>64</td><td>+12.5</td></tr> <tr><td>5</td><td>16</td><td>80</td><td>0</td></tr> <tr><td>6</td><td>24</td><td>104</td><td>+12.5</td></tr> <tr><td>7</td><td>12</td><td>116</td><td>+25</td></tr> <tr><td>8</td><td>8</td><td>124</td><td>+12.5</td></tr> <tr><td>9</td><td>16</td><td>140</td><td>0</td></tr> <tr><td>10</td><td>24</td><td>164</td><td>+12.5</td></tr> <tr><td>11</td><td>12</td><td>176</td><td>+25</td></tr> <tr><td>12</td><td>8</td><td>184</td><td>+12.5</td></tr> <tr><td>13</td><td>16</td><td>200</td><td>0</td></tr> <tr><td>14</td><td>24</td><td>224</td><td>+12.5</td></tr> <tr><td>15</td><td>8</td><td>232</td><td>+100</td></tr> <tr><td>16</td><td>24</td><td>256</td><td>+25</td></tr> <tr><td>17</td><td>8</td><td>264</td><td>+25</td></tr> <tr><td>18</td><td>32</td><td>296</td><td>+25</td></tr> <tr><td>19</td><td>8</td><td>304</td><td>80</td></tr> <tr><td>20</td><td>44</td><td>348</td><td>0</td></tr> </tbody> </table> <p><b>Table 13 - Time and power data - Dynamic discharge power profile B</b></p> <table border="1"> <thead> <tr> <th>Step</th> <th>Time increment [s]</th> <th>Time cumulative [s]</th> <th>Ratio to max. Power [%]</th> </tr> </thead> <tbody> <tr><td>1</td><td>16</td><td>16</td><td>0</td></tr> <tr><td>2</td><td>28</td><td>44</td><td>+12.5</td></tr> <tr><td>3</td><td>12</td><td>56</td><td>+25</td></tr> <tr><td>4</td><td>8</td><td>64</td><td>+12.5</td></tr> <tr><td>5</td><td>16</td><td>80</td><td>0</td></tr> <tr><td>6</td><td>24</td><td>104</td><td>+12.5</td></tr> <tr><td>7</td><td>12</td><td>116</td><td>+25</td></tr> <tr><td>8</td><td>8</td><td>124</td><td>+12.5</td></tr> <tr><td>9</td><td>16</td><td>140</td><td>0</td></tr> <tr><td>10</td><td>24</td><td>164</td><td>+12.5</td></tr> <tr><td>11</td><td>12</td><td>176</td><td>+25</td></tr> <tr><td>12</td><td>8</td><td>184</td><td>+12.5</td></tr> <tr><td>13</td><td>16</td><td>200</td><td>0</td></tr> <tr><td>14</td><td>24</td><td>224</td><td>+12.5</td></tr> <tr><td>15</td><td>8</td><td>232</td><td>+100</td></tr> <tr><td>16</td><td>24</td><td>256</td><td>+25</td></tr> <tr><td>17</td><td>8</td><td>264</td><td>+25</td></tr> <tr><td>18</td><td>32</td><td>296</td><td>+25</td></tr> <tr><td>19</td><td>8</td><td>304</td><td>80</td></tr> <tr><td>20</td><td>44</td><td>348</td><td>0</td></tr> </tbody> </table> <p><b>Table 3. DST Cycle Life Test Profile for the EV Battery</b></p> <table border="1"> <thead> <tr> <th>Step No</th> <th>Step Time (sec)</th> <th>Cum Time (sec)</th> <th>Power (%)</th> <th>Power (W/kg) System</th> <th>Power (W/kg) Cell</th> </tr> </thead> <tbody> <tr><td>1</td><td>16</td><td>16</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>2</td><td>28</td><td>44</td><td>12.5</td><td>58.75</td><td>87.50</td></tr> <tr><td>3</td><td>12</td><td>56</td><td>25</td><td>117.5</td><td>175.00</td></tr> <tr><td>4</td><td>8</td><td>64</td><td>-12.5</td><td>-58.75</td><td>-87.50</td></tr> <tr><td>5</td><td>16</td><td>80</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>6</td><td>24</td><td>104</td><td>12.5</td><td>58.75</td><td>87.50</td></tr> <tr><td>7</td><td>12</td><td>116</td><td>25</td><td>117.5</td><td>175.00</td></tr> <tr><td>8</td><td>8</td><td>124</td><td>-12.5</td><td>-58.75</td><td>-87.50</td></tr> <tr><td>9</td><td>16</td><td>140</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>10</td><td>24</td><td>164</td><td>12.5</td><td>58.75</td><td>87.50</td></tr> <tr><td>11</td><td>12</td><td>176</td><td>25</td><td>117.5</td><td>175.00</td></tr> <tr><td>12</td><td>8</td><td>184</td><td>-12.5</td><td>-58.75</td><td>-87.50</td></tr> <tr><td>13</td><td>16</td><td>200</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>14</td><td>24</td><td>224</td><td>12.5</td><td>58.75</td><td>87.50</td></tr> <tr><td>15</td><td>8</td><td>232</td><td>100</td><td>470</td><td>700.00</td></tr> <tr><td>16</td><td>24</td><td>256</td><td>62.5</td><td>293.75</td><td>437.50</td></tr> <tr><td>17</td><td>8</td><td>264</td><td>-25</td><td>-117.5</td><td>-175.00</td></tr> <tr><td>18</td><td>32</td><td>296</td><td>25</td><td>117.5</td><td>175.00</td></tr> <tr><td>19</td><td>8</td><td>304</td><td>-42.5</td><td>-200</td><td>-300.00</td></tr> <tr><td>20</td><td>44</td><td>348</td><td>0</td><td>0</td><td>0</td></tr> </tbody> </table> <p>Procedure:  a) Cycle life @ 20°C +/- SOC Charge C/3  b) Discharge 1.5C/3 to 80% SOC  c) Charge C/3  d) Repeat b), c) for 24h  e) Check capacity - Discharge C/3. If SOH &gt; 80% continue and repeat till target SOH &lt; 80%</p>	Step	Time increment [s]	Time cumulative [s]	Ratio to max. Power [%]	1	16	16	0	2	28	44	+12.5	3	12	56	+25	4	8	64	+12.5	5	16	80	0	6	24	104	+12.5	7	12	116	+25	8	8	124	+12.5	9	16	140	0	10	24	164	+12.5	11	12	176	+25	12	8	184	+12.5	13	16	200	0	14	24	224	+12.5	15	8	232	+100	16	24	256	+25	17	8	264	+25	18	32	296	+25	19	8	304	80	20	44	348	0	Step	Time increment [s]	Time cumulative [s]	Ratio to max. Power [%]	1	16	16	0	2	28	44	+12.5	3	12	56	+25	4	8	64	+12.5	5	16	80	0	6	24	104	+12.5	7	12	116	+25	8	8	124	+12.5	9	16	140	0	10	24	164	+12.5	11	12	176	+25	12	8	184	+12.5	13	16	200	0	14	24	224	+12.5	15	8	232	+100	16	24	256	+25	17	8	264	+25	18	32	296	+25	19	8	304	80	20	44	348	0	Step No	Step Time (sec)	Cum Time (sec)	Power (%)	Power (W/kg) System	Power (W/kg) Cell	1	16	16	0	0	0	2	28	44	12.5	58.75	87.50	3	12	56	25	117.5	175.00	4	8	64	-12.5	-58.75	-87.50	5	16	80	0	0	0	6	24	104	12.5	58.75	87.50	7	12	116	25	117.5	175.00	8	8	124	-12.5	-58.75	-87.50	9	16	140	0	0	0	10	24	164	12.5	58.75	87.50	11	12	176	25	117.5	175.00	12	8	184	-12.5	-58.75	-87.50	13	16	200	0	0	0	14	24	224	12.5	58.75	87.50	15	8	232	100	470	700.00	16	24	256	62.5	293.75	437.50	17	8	264	-25	-117.5	-175.00	18	32	296	25	117.5	175.00	19	8	304	-42.5	-200	-300.00	20	44	348	0	0	0	Dynamic capacity test profile from SAE J1798
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19	8	304	-42.5	-200	-300.00																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
20	44	348	0	0	0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
Storage life	7.6.2 Storage life test.			6.2.10 Storage.	3.10 Calendar Life Test																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	Cell level			Cell level	cell level and higher																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	checkup every 42 days at 25°C ±2K			checkup every 90 days at 20°C ±5K	checkup daily with 1 Pulse and detailed profile every ~32 days or application specific																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	tested at 20°C ±2K			tested at 20°C ±5K	minimum of 3 different test temperatures is recommended																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	SOC 100% for BEV / SOC 50 for HEV			SOC 25%	Specified by manufacturer or application																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	determination with 0.33C for BEV / 1C for HEV			determination with 0.33C	determination with 0.33C																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	End of test after 3 repetitions			End of test is application specific. Recommendations e.g. insufficient energy or capacity to finish checkup or too few values achievable by HPPC test.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									

Despite our care we do not claim to cover all standards and that all test topics have been given here. The organisations that categorised the available test standards cannot be kept responsible for your decisions.

The involved institutes of this survey are:



