# Ultima NiCd battery
# Technical Manual

SAFT
NIFE

# Contents

# 1. Introduction

The nickel cadmium battery is the most reliable battery system available in the market today. Its unique features enable it to be used in applications and environments untenable for other widely available battery systems. With the advent of the valve regulated lead acid battery a new concept was available to the customer, a battery that did not require water replenishment. However, this was obtained at the cost of reliability. To give the customer a highly reliable battery of zero or ultra low maintenance Saft have developed the Ultima recombination pocket plate battery.

This publication details the design and operating characteristics of the Saft Nife Ultima battery to enable a successful battery system to be achieved. A battery which in normal applications requires no topping up but has all the well proven advantages of the nickel cadmium pocket plate battery.

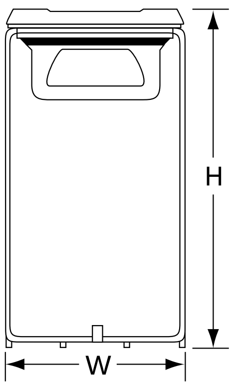
# 2. Battery applications

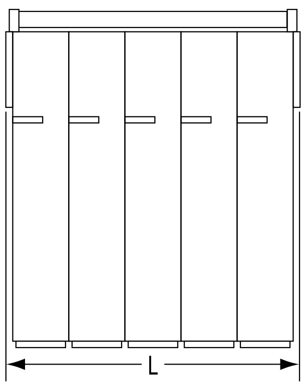
Ultima batteries are designed to meet the needs of applications requiring the traditional high reliability of nickel cadmium pocket plate cells without the need to top up with water. They are indeed the best solution for installations, whether they are UPS systems, emergency lighting systems, telecommunications, where the risk of failure of the system is unacceptable. Ultima batteries are also eminently suitable for “remote” applications such as photovoltaic systems, offshore applications and switching substations, where the system must have total reliability without the need for battery maintenance.

- Offshore oil and gas
- Fire and security systems
- Process control
- Telecommunications
- Mass transit
- Emergency lighting
- Railway signaling
- Switchgear
- Photovoltaics
- UPS

# 3. Ultima battery range and performances

| | Voltage (V) | Fully charged rated capacity $C_5$ Ah | Dimensions (mm) L | W | H | Weight (kg) | Cell connection bolt per pole | Electrolyte reserve cm³/cell |
|---|---|---|---|---|---|---|---|---|
| **SLM 8-5** | 6 | 8 | 162 | 123 | 270 | 6.8 | M5 | 48 |
| **SLM 8-10** | 12 | 8 | 308 | 123 | 270 | 13.3 | M5 | 48 |
| **SLM 16-5** | 6 | 16 | 162 | 123 | 270 | 7.6 | M5 | 95 |
| **SLM 16-10** | 12 | 16 | 308 | 123 | 270 | 14.8 | M5 | 95 |
| **SLM 24-5** | 6 | 24 | 187 | 123 | 270 | 9.0 | M5 | 145 |
| **SLM 24-10** | 12 | 24 | 358 | 123 | 270 | 17.8 | M5 | 145 |
| **SLM 32-4** | 4.8 | 32 | 201 | 123 | 270 | 10.0 | M5 | 190 |
| **SLM 32-5** | 6 | 32 | 247 | 123 | 270 | 12.4 | M5 | 190 |
| **SLM 32-6** | 7.2 | 32 | 293 | 123 | 270 | 14.8 | M5 | 190 |
| **SLM 40-4** | 4.8 | 40 | 249 | 123 | 270 | 12.3 | M5 | 240 |
| **SLM 40-5** | 6 | 40 | 307 | 123 | 270 | 15.3 | M5 | 240 |
| **SLM 40-6** | 7.2 | 40 | 365 | 123 | 270 | 18.3 | M5 | 240 |
| **SLM 48-4** | 4.8 | 48 | 249 | 123 | 270 | 13.7 | M5 | 290 |
| **SLM 48-5** | 6 | 48 | 307 | 123 | 270 | 17.0 | M5 | 290 |
| **SLM 48-6** | 7.2 | 48 | 365 | 123 | 270 | 20.3 | M5 | 290 |
| **SLM 71-2** | 2.4 | 71 | 97 | 195 | 406 | 10.2 | M8 | 425 |
| **SLM 71-3** | 3.6 | 71 | 133 | 195 | 406 | 14.6 | M8 | 425 |
| **SLM 95-2** | 2.4 | 95 | 112 | 195 | 406 | 13.3 | M8 | 570 |
| **SLM 95-3** | 3.6 | 95 | 155 | 195 | 406 | 19.4 | M8 | 570 |
| **SLM 119-2** | 2.4 | 119 | 133 | 195 | 406 | 15.8 | M10 | 715 |
| **SLM 119-3** | 3.6 | 119 | 187 | 195 | 406 | 23.2 | M10 | 715 |
| **SLM 142-2** | 2.4 | 142 | 145 | 195 | 406 | 18.5 | M10 | 850 |
| **SLM 142-3** | 3.6 | 142 | 205 | 195 | 406 | 27.0 | M10 | 850 |
| **SLM 166-2** | 2.4 | 166 | 184 | 195 | 406 | 22.8 | 2 x M8 | 995 |
| **SLM 166-3** | 3.6 | 166 | 263 | 195 | 406 | 33.6 | 2 x M8 | 995 |
| **SLM 190-2** | 2.4 | 190 | 198 | 195 | 406 | 25.5 | 2 x M8 | 1140 |
| **SLM 190-3** | 3.6 | 190 | 284 | 195 | 406 | 37.7 | 2 x M8 | 1140 |
| **SLM 238-2** | 2.4 | 238 | 241 | 195 | 406 | 30.5 | 2 x M10 | 1430 |
| **SLM 238-3** | 3.6 | 238 | 349 | 195 | 406 | 45.3 | 2 x M10 | 1430 |
| **SLM 285-2** | 2.4 | 285 | 265 | 195 | 406 | 33.6 | 2 x M10 | 1710 |
| **SLM 285-3** | 3.6 | 285 | 385 | 195 | 406 | 49.9 | 2 x M10 | 1710 |
| **SLM 357-1** | 1.2 | 357 | 187 | 195 | 406 | 23.2 | 3 x M10 | 2140 |
| **SLM 357-2** | 2.4 | 357 | 349 | 195 | 406 | 45.0 | 3 x M10 | 2140 |
| **SLM 426-1** | 1.2 | 426 | 205 | 195 | 406 | 27.0 | 3 x M10 | 2555 |
| **SLM 476-1** | 1.2 | 476 | 241 | 195 | 406 | 30.2 | 4 x M10 | 2855 |



## Tabular Discharge Data

Discharge data is for cells after floating at 1.42 Volts and allowing for voltage losses associated with connectors.

Available amperes at 20°C (68°F) fully charged — End voltage - **1.00 V/cell**

| Cell | $C_5$ | Hours | | | | | Minutes | | | | | | Seconds | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| type | Ah | 10 | 8 | 5 | 3 | 2 | 90 | 60 | 45 | 30 | 10 | 5 | 60 | 30 | 10 | 1 |
| **SLM 8** | 8 | 0.8 | 1.0 | 1.6 | 2.6 | 3.8 | 4.7 | 6.1 | 6.9 | 8.0 | 10.9 | 12.2 | 16.2 | 17.9 | 21.1 | 25.5 |
| **SLM 16** | 16 | 1.6 | 2.0 | 3.2 | 5.1 | 7.6 | 9.4 | 12.2 | 13.8 | 16.0 | 21.8 | 24.5 | 32.3 | 35.7 | 42.2 | 51.0 |
| **SLM 24** | 24 | 2.4 | 3.0 | 4.8 | 7.7 | 11.3 | 14.1 | 18.4 | 20.7 | 24.0 | 32.6 | 36.7 | 48.5 | 53.6 | 63.2 | 76.5 |
| **SLM 32** | 32 | 3.2 | 4.0 | 6.4 | 10.3 | 15.1 | 18.8 | 24.5 | 27.5 | 32.0 | 43.5 | 49.0 | 64.6 | 71.4 | 84.3 | 102 |
| **SLM 40** | 40 | 4.0 | 5.1 | 8.0 | 12.8 | 18.9 | 23.5 | 30.6 | 34.4 | 40.0 | 54.4 | 61.2 | 80.8 | 89.3 | 105 | 128 |
| **SLM 48** | 48 | 4.9 | 6.1 | 9.6 | 15.4 | 22.7 | 28.2 | 36.7 | 41.3 | 47.9 | 65.3 | 73.4 | 96.9 | 107 | 126 | 153 |
| **SLM 71** | 71 | 7.2 | 9.0 | 14.2 | 22.8 | 33.9 | 41.8 | 54.3 | 61.4 | 70.8 | 94.0 | 100.3 | 123 | 134 | 153 | 179 |
| **SLM 95** | 95 | 9.7 | 12.0 | 19.0 | 30.5 | 45.3 | 55.9 | 72.6 | 82.2 | 94.7 | 126 | 134 | 165 | 180 | 205 | 239 |
| **SLM 119** | 119 | 12.1 | 15.0 | 23.8 | 38.2 | 56.8 | 70.0 | 91.0 | 103 | 119 | 157 | 168 | 207 | 225 | 256 | 299 |
| **SLM 142** | 142 | 14.5 | 17.9 | 28.4 | 45.6 | 67.8 | 83.5 | 109 | 123 | 142 | 188 | 201 | 247 | 269 | 306 | 357 |
| **SLM 166** | 166 | 16.9 | 21.0 | 33.2 | 53.3 | 79.2 | 97.6 | 127 | 144 | 165 | 220 | 235 | 288 | 314 | 358 | 417 |
| **SLM 190** | 190 | 19.4 | 24.0 | 37.9 | 61.0 | 90.7 | 112 | 145 | 164 | 189 | 251 | 268 | 330 | 359 | 409 | 478 |
| **SLM 238** | 238 | 24.3 | 30.0 | 47.5 | 76.4 | 114 | 140 | 182 | 206 | 237 | 315 | 336 | 413 | 450 | 513 | 598 |
| **SLM 285** | 285 | 29.1 | 36.0 | 56.9 | 91.5 | 136 | 168 | 218 | 247 | 284 | 377 | 403 | 495 | 539 | 614 | 717 |
| **SLM 357** | 357 | 36.3 | 45.0 | 71.4 | 115 | 170 | 210 | 273 | 309 | 357 | 471 | 504 | 621 | 675 | 768 | 897 |
| **SLM 426** | 426 | 43.5 | 53.7 | 85.2 | 137 | 203 | 251 | 327 | 369 | 426 | 564 | 603 | 741 | 807 | 918 | 1071 |
| **SLM 476** | 476 | 48.6 | 60.0 | 95.0 | 153 | 228 | 280 | 364 | 412 | 474 | 630 | 672 | 826 | 900 | 1026 | 1196 |

Available amperes at 20°C (68°F) fully charged — End voltage - **1.05 V/cell**

| Cell | $C_5$ | Hours | | | | | Minutes | | | | | | Seconds | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| type | Ah | 10 | 8 | 5 | 3 | 2 | 90 | 60 | 45 | 30 | 10 | 5 | 60 | 30 | 10 | 1 |
| **SLM 8** | 8 | 0.8 | 1.0 | 1.6 | 2.5 | 3.5 | 4.3 | 5.4 | 5.9 | 6.5 | 8.5 | 9.9 | 13.3 | 15.0 | 17.5 | 22.1 |
| **SLM 16** | 16 | 1.6 | 2.0 | 3.2 | 5.1 | 7.1 | 8.7 | 10.9 | 11.8 | 12.9 | 17.0 | 19.7 | 26.5 | 29.9 | 35.0 | 44.2 |
| **SLM 24** | 24 | 2.4 | 3.0 | 4.7 | 7.6 | 10.6 | 13.0 | 16.3 | 17.7 | 19.4 | 25.5 | 29.6 | 39.8 | 44.9 | 52.5 | 66.3 |
| **SLM 32** | 32 | 3.2 | 4.0 | 6.3 | 10.1 | 14.2 | 17.3 | 21.8 | 23.7 | 25.8 | 34.0 | 39.4 | 53.0 | 59.8 | 70.0 | 88.4 |
| **SLM 40** | 40 | 4.1 | 5.0 | 7.9 | 12.7 | 17.7 | 21.7 | 27.2 | 29.6 | 32.3 | 42.5 | 49.3 | 66.3 | 74.8 | 87.6 | 111 |
| **SLM 48** | 48 | 4.9 | 6.0 | 9.5 | 15.2 | 21.2 | 26.0 | 32.6 | 35.5 | 38.8 | 51.0 | 59.2 | 79.6 | 89.8 | 105 | 133 |
| **SLM 71** | 71 | 7.2 | 8.9 | 14.1 | 22.8 | 32.6 | 38.3 | 46.3 | 51.6 | 59.6 | 74.8 | 83.3 | 106 | 114 | 128 | 149 |
| **SLM 95** | 95 | 9.6 | 11.9 | 18.9 | 30.5 | 43.6 | 51.2 | 61.9 | 69.1 | 79.8 | 100 | 111 | 142 | 152 | 171 | 199 |
| **SLM 119** | 119 | 12.0 | 14.9 | 23.6 | 38.2 | 54.6 | 64.2 | 77.6 | 86.5 | 100 | 125 | 140 | 178 | 191 | 214 | 249 |
| **SLM 142** | 142 | 14.3 | 17.7 | 28.2 | 45.6 | 65.1 | 76.6 | 92.6 | 103 | 119 | 150 | 167 | 213 | 228 | 255 | 298 |
| **SLM 166** | 166 | 16.7 | 20.7 | 33.0 | 53.3 | 76.1 | 89.5 | 108 | 121 | 139 | 175 | 195 | 248 | 266 | 298 | 348 |
| **SLM 190** | 190 | 19.2 | 23.7 | 37.7 | 61.0 | 87.1 | 102 | 124 | 138 | 160 | 200 | 223 | 284 | 305 | 341 | 398 |
| **SLM 238** | 238 | 24.0 | 29.7 | 47.2 | 76.4 | 109 | 128 | 155 | 173 | 200 | 251 | 279 | 356 | 382 | 427 | 499 |
| **SLM 285** | 285 | 28.7 | 35.6 | 56.6 | 91.5 | 131 | 154 | 186 | 207 | 239 | 300 | 334 | 426 | 457 | 512 | 597 |
| **SLM 357** | 357 | 36.0 | 44.7 | 70.8 | 115 | 164 | 193 | 233 | 260 | 300 | 375 | 420 | 534 | 573 | 642 | 747 |
| **SLM 426** | 426 | 42.9 | 53.1 | 84.6 | 137 | 195 | 230 | 278 | 309 | 357 | 450 | 501 | 639 | 684 | 765 | 894 |
| **SLM 476** | 476 | 48.0 | 59.4 | 94.4 | 153 | 218 | 256 | 310 | 346 | 400 | 502 | 558 | 712 | 764 | 854 | 998 |

Available amperes at 20°C (68°F) fully charged

End voltage - **1.10 V/cell**

| Cell type | $C_5$ Ah | Hours 10 | 8 | 5 | 3 | 2 | Minutes 90 | 60 | 45 | 30 | 10 | 5 | Seconds 60 | 30 | 10 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SLM 8** | 8 | 0.8 | 1.0 | 1.6 | 2.3 | 3.0 | 3.5 | 4.4 | 4.8 | 5.3 | 6.5 | 7.6 | 10.5 | 11.9 | 14.1 | 17.9 |
| **SLM 16** | 16 | 1.6 | 2.0 | 3.1 | 4.6 | 5.9 | 7.0 | 8.8 | 9.5 | 10.5 | 13.0 | 15.1 | 21.1 | 23.8 | 28.2 | 35.7 |
| **SLM 24** | 24 | 2.4 | 3.0 | 4.7 | 6.8 | 8.9 | 10.5 | 13.3 | 14.3 | 15.8 | 19.4 | 22.7 | 31.6 | 35.7 | 42.3 | 53.6 |
| **SLM 32** | 32 | 3.2 | 4.0 | 6.2 | 9.1 | 11.9 | 14.0 | 17.7 | 19.0 | 21.1 | 25.9 | 30.3 | 42.2 | 47.6 | 56.4 | 71.4 |
| **SLM 40** | 40 | 4.0 | 5.0 | 7.8 | 11.4 | 14.9 | 17.6 | 22.1 | 23.8 | 26.4 | 32.4 | 37.8 | 52.7 | 59.5 | 70.6 | 89.3 |
| **SLM 48** | 48 | 4.8 | 6.0 | 9.3 | 13.7 | 17.8 | 21.1 | 26.5 | 28.6 | 31.6 | 38.9 | 45.4 | 63.2 | 71.4 | 84.7 | 107 |
| **SLM 71** | 71 | 7.1 | 8.8 | 13.8 | 22.8 | 29.0 | 33.5 | 39.2 | 42.7 | 47.2 | 58.3 | 64.6 | 83.3 | 92.7 | 102 | 111 |
| **SLM 95** | 95 | 9.5 | 11.8 | 18.4 | 30.5 | 38.9 | 44.8 | 52.4 | 57.2 | 63.1 | 78.0 | 86.4 | 111 | 124 | 136 | 149 |
| **SLM 119** | 119 | 11.9 | 14.7 | 23.1 | 38.2 | 48.7 | 56.1 | 65.6 | 71.6 | 79.1 | 97.7 | 108 | 140 | 155 | 171 | 187 |
| **SLM 142** | 142 | 14.2 | 17.6 | 27.5 | 45.6 | 58.1 | 67.0 | 78.3 | 85.4 | 94.3 | 117 | 129 | 167 | 185 | 204 | 223 |
| **SLM 166** | 166 | 16.6 | 20.5 | 32.2 | 53.3 | 67.9 | 78.3 | 91.6 | 100 | 110 | 136 | 151 | 195 | 217 | 238 | 260 |
| **SLM 190** | 190 | 19.0 | 23.5 | 36.9 | 61.0 | 77.7 | 89.6 | 105 | 114 | 126 | 156 | 173 | 223 | 248 | 273 | 298 |
| **SLM 238** | 238 | 23.8 | 29.5 | 46.2 | 76.4 | 97.3 | 112 | 131 | 143 | 158 | 195 | 217 | 279 | 311 | 342 | 373 |
| **SLM 285** | 285 | 28.5 | 35.3 | 55.3 | 91.5 | 117 | 134 | 157 | 171 | 189 | 234 | 259 | 334 | 372 | 409 | 447 |
| **SLM 357** | 357 | 35.7 | 44.1 | 69.3 | 115 | 146 | 168 | 197 | 215 | 237 | 293 | 324 | 420 | 465 | 513 | 561 |
| **SLM 426** | 426 | 42.6 | 52.8 | 82.5 | 137 | 174 | 201 | 235 | 256 | 283 | 351 | 387 | 501 | 555 | 612 | 669 |
| **SLM 476** | 476 | 47.6 | 59.0 | 92.4 | 153 | 195 | 224 | 262 | 286 | 316 | 390 | 434 | 558 | 622 | 684 | 746 |

Available amperes at 20°C (68°F) fully charged

End voltage - **1.14 V/cell**

| Cell type | $C_5$ Ah | Hours 10 | 8 | 5 | 3 | 2 | Minutes 90 | 60 | 45 | 30 | 10 | 5 | Seconds 60 | 30 | 10 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SLM 8** | 8 | 0.8 | 1.0 | 1.5 | 2.0 | 2.4 | 2.7 | 3.4 | 3.7 | 4.1 | 5.3 | 6.2 | 8.3 | 9.7 | 11.6 | 15.1 |
| **SLM 16** | 16 | 1.6 | 1.9 | 3.0 | 3.9 | 4.8 | 5.5 | 6.7 | 7.3 | 8.2 | 10.5 | 12.3 | 16.7 | 19.4 | 23.1 | 30.3 |
| **SLM 24** | 24 | 2.3 | 2.9 | 4.6 | 5.9 | 7.2 | 8.2 | 10.1 | 11.0 | 12.2 | 15.8 | 18.5 | 25.0 | 29.1 | 34.7 | 45.4 |
| **SLM 32** | 32 | 3.1 | 3.8 | 6.1 | 7.9 | 9.6 | 11.0 | 13.5 | 14.6 | 16.3 | 21.1 | 24.6 | 33.3 | 38.8 | 46.2 | 60.5 |
| **SLM 40** | 40 | 3.9 | 4.8 | 7.6 | 9.9 | 12.0 | 13.7 | 16.8 | 18.3 | 20.4 | 26.4 | 30.8 | 41.7 | 48.5 | 57.8 | 75.7 |
| **SLM 48** | 48 | 4.7 | 5.7 | 9.1 | 11.8 | 14.4 | 16.5 | 20.2 | 21.9 | 24.5 | 31.6 | 36.9 | 50.0 | 58.1 | 69.4 | 90.8 |
| **SLM 71** | 71 | 6.9 | 8.5 | 13.5 | 18.5 | 22.0 | 23.7 | 27.1 | 28.5 | 32.9 | 41.8 | 48.5 | 62.9 | 68.0 | 76.5 | 86.7 |
| **SLM 95** | 95 | 9.2 | 11.4 | 18.0 | 24.7 | 29.4 | 31.7 | 36.3 | 38.1 | 44.1 | 55.9 | 64.8 | 84.2 | 91.0 | 102 | 116 |
| **SLM 119** | 119 | 11.6 | 14.3 | 22.6 | 31.0 | 36.9 | 39.7 | 45.5 | 47.7 | 55.2 | 70.0 | 81.2 | 105 | 114 | 128 | 145 |
| **SLM 142** | 142 | 13.8 | 17.1 | 27.0 | 37.0 | 44.0 | 47.3 | 54.3 | 57.0 | 65.9 | 83.5 | 96.9 | 126 | 136 | 153 | 173 |
| **SLM 166** | 166 | 16.1 | 19.9 | 31.5 | 43.2 | 51.4 | 55.3 | 63.5 | 66.6 | 77.0 | 97.6 | 113 | 147 | 159 | 179 | 203 |
| **SLM 190** | 190 | 18.5 | 22.8 | 36.1 | 49.5 | 58.9 | 63.3 | 72.6 | 76.2 | 88.1 | 112 | 130 | 168 | 182 | 205 | 232 |
| **SLM 238** | 238 | 23.1 | 28.6 | 45.2 | 62.0 | 73.7 | 79.3 | 91.0 | 95.5 | 110 | 140 | 162 | 211 | 228 | 256 | 291 |
| **SLM 285** | 285 | 27.7 | 34.2 | 54.1 | 74.2 | 88.3 | 95.0 | 109 | 114 | 132 | 168 | 194 | 252 | 273 | 307 | 348 |
| **SLM 357** | 357 | 34.8 | 42.9 | 67.8 | 93.0 | 111 | 119 | 137 | 143 | 166 | 210 | 244 | 315 | 342 | 384 | 435 |
| **SLM 426** | 426 | 41.4 | 51.3 | 81.0 | 111 | 132 | 142 | 163 | 171 | 198 | 251 | 291 | 378 | 408 | 459 | 519 |
| **SLM 476** | 476 | 46.2 | 57.2 | 90.4 | 124 | 147 | 159 | 182 | 191 | 220 | 280 | 324 | 422 | 456 | 512 | 582 |

# 4. Principles of the oxygen recombination cycle

In a conventional flooded electrolyte pocket plate nickel cadmium battery water is lost from the battery on overcharge due to the following reactions:

**At the positive plate**

$$4OH^- \longrightarrow 2H_2O + O_2 + 4e^-$$

(Oxygen evolution)

**At the negative plate**

$$4H_2O + 4e^- \longrightarrow 2H_2 + 4OH^-$$

(Hydrogen evolution)

This corresponds to a theoretical loss of 36 g of water for 107Ah of overcharge i.e. 0.335 cc per Ah. Hence a conventional cell requires periodic addition of water.
The frequency of this operation depends upon the cumulative amount of charge received and the operating temperature.

During the charging process evolution of oxygen begins to occur a little before the positive plate reaches its fully charged state and then becomes the main reaction when the fully charged condition is reached. However, the cadmium negative plate has a better charge acceptance than the positive plate and hydrogen is not evolved until this plate is virtually fully charged.

The Ultima battery has been designed with an excess of cadmium negative material to enhance this effect and ensure that oxygen evolution commences prior to hydrogen evolution.

The oxygen which is produced at the positive plate surface is collected by the special porous separator and thus not allowed to escape from the region between the plates. Some displacement of electrolyte within the separator occurs, thus generating extra unfilled pores for the diffusion of oxygen directly to the adjacent cadmium negative plate.

As soon as the oxygen reaches the negative plate it reacts either chemically:

$$2Cd + O_2 + 2H_2O \longrightarrow 2Cd(OH)_2 \quad (A)$$

or electrochemically:

$$O_2 + 2H_2O + 4e^- \longrightarrow 4OH^- \quad (B)$$

Reaction (A) has the effect of chemically discharging some of the cadmium to cadmium hydroxide. The current passing through the battery is used to recharge this material.

Reaction (B) consumes the current directly. Thus hydrogen evolution at the negative plate is suppressed because the preferred reaction is oxygen recombination. Hence the total process of oxygen generation and consumption is referred to as an oxygen recombination cycle.

The efficiency of this oxygen recombination process depends upon the relationship between the rate at which oxygen is produced and the rate at which it can be collected and transferred to the negative plate surface. The rate of collection and transfer of oxygen is controlled by the separator type and the cell design.

The rate at which oxygen is produced on overcharge is directly related to the charge current once the positive plate has reached a full state of charge. The charge current in turn is controlled by the charging voltage level set on the charging equipment and the ambient temperature. By controlling the charge voltage high efficiencies can be obtained and in this way the rate of water loss can be reduced to a fraction of that from conventional batteries.

Though the efficiency of this oxygen recombination is high it will never achieve 100% as small quantities of oxygen will escape from the separator before reaching and reacting at the negative plate. Thus a small quantity of hydrogen will ultimately be generated and hence a low rate of water loss will occur. The battery is designed to accommodate this by provision of a generous electrolyte reserve both above and around each cell pack within the battery. This ensures a long service life without the need to top up with water.

The Ultima battery is fitted with a low pressure vent on each cell. On overcharge the cells have an internal pressure above atmospheric pressure. The vent provides an outlet for the release of small quantities of hydrogen and non recombined oxygen and thus controls the internal pressure. When the pressure falls below the release pressure either on open circuit or on discharge the vent reseals to prevent ingress of air and minimize self discharge reactions.

# 5. Construction features of the Ultima battery

The construction of the Saft Nife Ultima cell is based upon the proven Saft Nife pocket plate technology but with special features to enhance the low water usage by means of the recombination cycle.

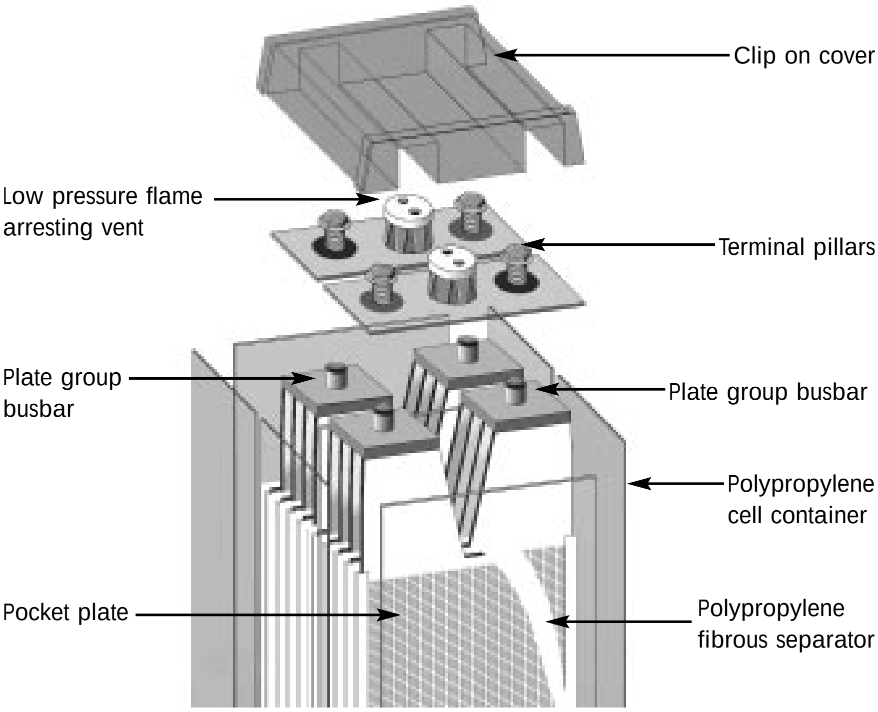
## 5.1 Plate Assembly

The nickel cadmium cell consists of two groups of plates, one containing nickel hydroxide (the positive plate) and the other containing cadmium hydroxide (the negative plate).

The active materials of the Saft Nife Ultima pocket plate are retained in pockets formed from nickel plated steel strips double perforated by a patented process. These pockets are mechanically linked together, cut to the size corresponding to the plate width and compressed to the final plate dimension. This process leads to a component which is not only mechanically robust but also retains its active material within a steel boundary which promotes conductivity and minimizes electrode swelling.

These plates are then welded to a current carrying busbar which further ensures the mechanical and electrical stability of the product.

The alkaline electrolyte does not react with steel, which means that the supporting structure of the Ultima battery stays intact and unchanged for the life of the battery. There is no corrosion and no risk of "sudden death".



## 5.2 Separation

As described in section 4, the separator is a key feature of the Saft Nife Ultima battery. It is polypropylene fibrous material which, after exhaustive analysis of available separator material, was specially developed for this product to give the features required.

Using this separator and plastic spacing ribs, the distance between the plates is carefully controlled to give the necessary gas retention to provide the level of recombination required.

By providing a large spacing between the positive and negative plates and a generous quantity of electrolyte between plates, the possibility of thermal runaway is eliminated.

## 5.3 Electrolyte

The electrolyte used in Ultima, which is a solution of potassium hydroxide and lithium hydroxide, is optimized to give the best combination of performance, life and energy efficiency over a wide temperature range.

The concentration is such as to allow the cell to be operated down to –20°C (for low temperature operation see section 6.4) and it is not necessary to change the electrolyte during the life of the cell.

It is an important consideration of Ultima, and indeed of all nickel cadmium batteries, that the electrolyte does not change during charge and discharge. It retains its ability to transfer ions between the cell plates irrespective of the charge level.

## 5.4 Terminal pillars

Short terminal pillars are welded to the plate busbars using a well proven battery construction method. These posts are manufactured from steel bar, internally threaded for bolting on connectors and are nickel plated.

The terminal pillar to lid seal is provided by a compressed visco-elastic sealing surface held in place by compression lock washers.
This assembly is designed to provide satisfactory sealing throughout the life of the product.

## 5.5 Venting system

Ultima is fitted with a low pressure flame arresting vent for each cell of the battery. This vent operates as a one way valve which will allow the release of small quantities of hydrogen and non recombined oxygen if the internal pressure exceeds a fixed safety value.
The nominal operating pressure of the vent is 0.2 bar.

When the pressure falls below the release pressure the vent reseals to prevent ingress of air.

The sealing vent has an integral flame-arresting porous disk to prevent any possibility of any external ignition from spreading into the Ultima cell.

## 5.6 Cell container

Ultima is built up using the well proven Saft Nife bloc battery construction. The tough polypropylene containers are welded together by heat sealing. Additional end walls are welded on to constrain the small internal pressure changes created by the recombination process and the low pressure vent.

The assembly of the blocs is completed by a clip on cover enclosing the top of the Ultima bloc, giving a non conducting, easy to clean, top surface.

# 6. Benefits of the Ultima battery

The benefits of the Saft Nife value regulated Ultima battery are:

**Complete reliability**
Does not suffer from the sudden death failure due to internal corrosion associated with other battery technologies.

**Exceptional long life**
Has all the design features associated with the conventional Saft Nife twenty plus years life battery products.

**Ultra low maintenance**
Ultima will give up to twenty years without topping up in normal applications but can be engineered for severe applications to give prolonged ultra low maintenance with the option of water replenishment as and when required.

**Office compatibility**
The Saft Nife Ultima battery is a valve regulated recombination product and it gives off imperceptible amounts of gas and no corrosive fumes.

**Wide operating temperature range**
The normal Ultima maximum operating temperature range is 0°C to +40°C. However, Ultima can survive extremes of temperature from as low as –40°C to up to +60°C.

**Resistance to mechanical abuse**
Ultima is designed to have the mechanical strength for use in both stationary and mobile applications.

**High resistance to electrical abuse**
Ultima will survive abuses which will destroy the valve regulated lead acid battery. In particular, it has a resistance to overcharging, deep discharging, short circuits, and a tolerance to up to 15% AC ripple.

**Low installation costs**
Ultima can be used with existing charging systems, has minimal gas evolution without any corrosive vapors, uses corrosion free polypropylene containers and has an easy bolted assembly system.

**Well proven pocket plate construction**
Saft Nife has over 80 years of manufacturing and application experience with the nickel cadmium pocket plate product and this expertise has been built into the twenty plus years design life of the Ultima product.

# 7. Operating features

## 7.1 Capacity

The Ultima battery capacity is rated in ampere hours (Ah) and is the quantity of electricity which it can supply for a 5 hour discharge to 1.0 V/cell after being fully charged. This figure is in agreement with the IEC623 standard.

In practice, Ultima is used in floating conditions and so the tabular data is based upon cell performance after several months of floating.
This eliminates certain correction factors which need to be used when sizing batteries with conventional fully charged open cell data (see section 10 – Battery sizing principles).

## 7.2 Cell voltage

The cell voltage of nickel cadmium cells results from the electrochemical potentials of the nickel and the cadmium active materials in the presence of the potassium hydroxide electrolyte. The nominal voltage is 1.2 V.

## 7.3 Internal resistance

The internal resistance of a cell varies with the type of service and the state of charge and is, therefore, difficult to define and measure accurately.

The most practical value for normal applications is the discharge voltage response to a change in discharge current.

The internal resistance per $^1/C_5$ of an Ultima cell at room temperature when measured after float charging at normal temperature is 80 milliohms for SLM 8 to SLM 48 cells and 100 milliohms for SLM 71 to SLM 476 cells; e.g. for an Ultima cell type SLM 8 (8 Ah) the internal resistance is $80 \times ^1/8$ = 10 milliohms.

The above figures are for fully charged cells. For lower states of charge the values increase.

For cells 50% discharged the internal resistance is about 20% higher and when 90% discharged it is about 80% higher. The internal resistance of a fully discharged cell has very little meaning.

Reducing the temperature also increases the internal resistance and, at 0°C, the internal resistance is about 40% higher than at room temperature.

## 7.4 Effect of temperature on performance

Variations in ambient temperature affect the performance of Ultima and this needs to be taken into account when sizing the battery.

Low temperature operation has the effect of reducing the performance but the higher temperature characteristics are similar to those at normal temperatures. The effect of temperature is more marked at higher rates of discharge.
The factors which are required in sizing a battery to compensate for temperature variations are given in a graphical form in Figure 1 for the normal recommended operating temperature range of 0°C to 40°C.

For use at temperatures outside this range please contact Saft for advice.

## 7.5 Short circuit values

The typical short circuit value in amperes for an Ultima cell is approximately 15 times the ampere-hour capacity.

The Ultima battery is designed to withstand a short circuit current of this magnitude for many minutes without damage.

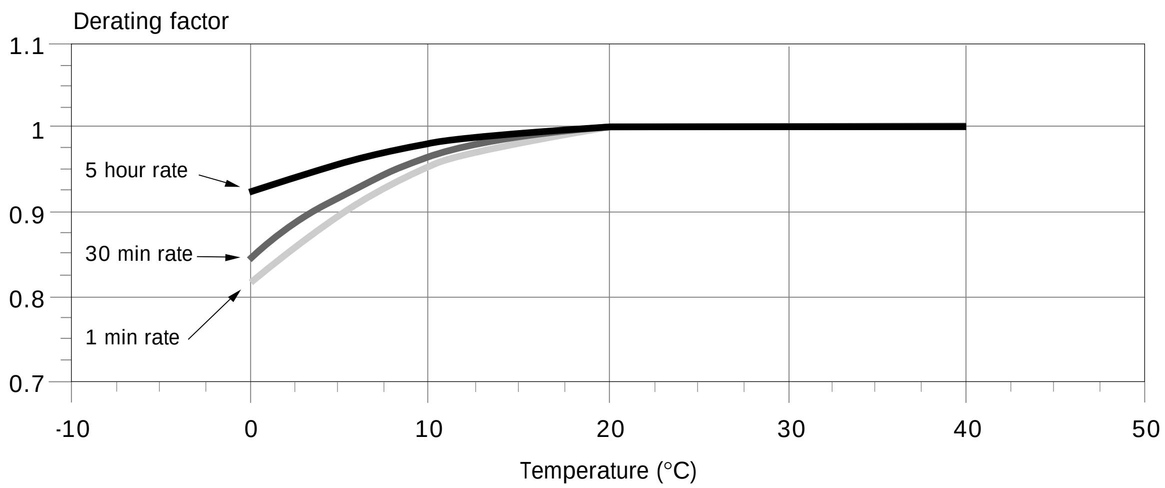



**Figure 1: Typical cell performance variation with temperature**

## 7.6 Open circuit loss

The state of charge of Ultima on open circuit slowly decreases with time due to self discharge.
In practice this decrease is relatively rapid during the first two weeks but then stabilizes to about 2% per month at 20°C.

The self discharge characteristics of a nickel cadmium cell are affected by the temperature. At low temperatures the charge retention is better than at normal temperature and so the open circuit loss is reduced. However, the self discharge is significantly increased at higher temperatures.

The open circuit loss for Ultima for the standard temperature and the extremes of the normal operating range is shown in Figure 2 for a one year period.

It is necessary to recharge Ultima each year for storage periods in excess of one year.

## 7.7 Cycling

Ultima is an ultra low maintenance product and therefore is used generally in standby and not continuous cycling applications. Nevertheless, it is designed using conventional pocket plate electrode technology and has therefore an equivalent cycling capability to the standard product.

If Ultima is used in a deep cycling application which requires a fast recharge, there will be significant gas evolved and the ultra low maintenance properties of the product will be severely reduced. However, there are cycling applications where Ultima can be beneficial. This will depend on the frequency and depth of discharge involved.

## 7.8 Water consumption

The Ultima battery works on the oxygen recombination principle and therefore has a much reduced water consumption. In practice, for the recommended charging voltages, Ultima has a level of recombination of 85% to 95%. This compares to the

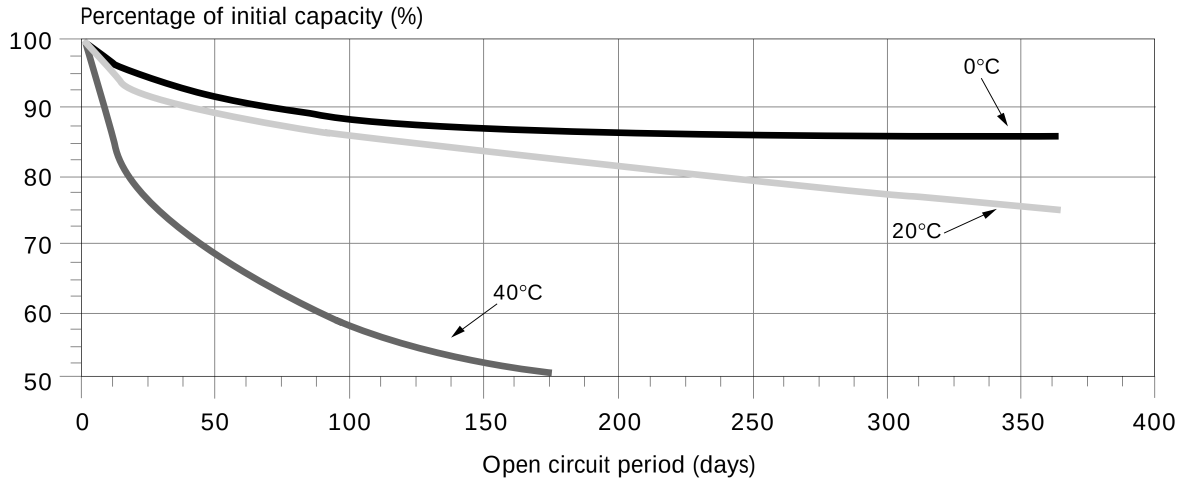



**Figure 2: Typical open circuit loss variation with time**

level of recombination found in equivalent vented pocket plate cells of 30% to 35%. Thus Ultima has a water usage reduced by a factor of up to 10 times of that of an open flooded cell. This means that at suitable charging voltages and temperatures, Ultima will not need water replenishment for more than 20 years.

However, not all needs are the same and Ultima is designed to allow water replenishment under different and more difficult charging conditions. Figure 3 gives a comparison of different water replenishment times under different float voltages at 20°C.

## 7.9 Gas evolution

The gas evolution is a function of the amount of water electrolyzed into hydrogen and oxygen which is not involved in the recombination cycle. The electrolysis of 1 cc of water produces about 2000 cc of gas mixture and this gas mixture is in the proportion of 2/3 hydrogen and 1/3 oxygen. Thus the electrolysis of 1 cc of water produces about 1300 cc of hydrogen.

As stated in the previous paragraph, under normal recommended float conditions Ultima has a recombination level of 85% to 95% and so the amount of water which is electrolyzed into gas is small.

Typically an Ultima cell will electrolyze about 0.002 cc of water per Ah of cell capacity per day. This value will be smaller or larger depending on the float voltage value. Thus a typical value of gas emission would be 3.5 cc per Ah of cell capacity per day, or 2.5 cc of hydrogen per Ah of cell capacity per day.

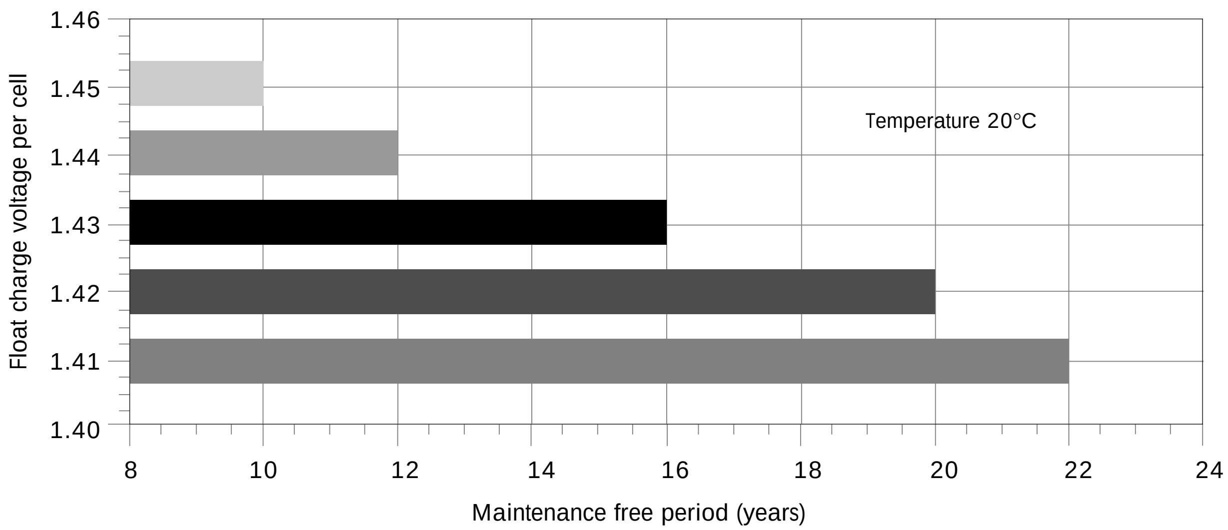



**Figure 3: Effect of charging voltage on maintenance free period**

# 8. Battery charging

In order to ensure that the ultra low maintenance properties of the Ultima battery are achieved, it is necessary to control the charge input to the battery to minimize the rate of water loss during the life of the product.

It is important therefore that the recommended charge conditions are complied with.

However, Ultima is unique in recombination valve regulated systems in allowing the possibility of replenishment of water in severe applications where excessive water loss is unavoidable.

## 8.1 Charging methods

Ultima batteries may be charged by the following methods:

**a) Two level constant potential charging:**

The initial stage of two rate constant potential charging consists of a first charging stage, with a current limit of 0.1 $C_5$ to an average maximum voltage of 1.45 V/cell.

Alternatively, if a faster rate of recharge is required, a voltage limit of 1.55 V/cell can be used. However, if frequent recharges are required this will increase the rate of water loss.

After this first stage the charger should be switched to a second maintenance stage at a float voltage in the range of 1.41 to 1.43 V/cell. After a prolonged mains failure the first stage should be reapplied manually or automatically.

**b) Single level float charging**

Ultima batteries may be float charged at 1.41 to 1.43 V/cell from a fully discharged condition to a high stage of charge. This is detailed in section 8.2 and about 80% of the capacity will be available after 16 hours of charge.

Alternatively, Ultima can be float charged at 1.45 V/cell if a faster recharge time is required. This will, however, increase the rate of water loss and reduce the maintenance interval by a factor of two.

Temperature compensation may be required as described in section 8.3.

## 8.2 Charge acceptance

The performance data sheets for Ultima are based upon several months' floating and so are for fully float charged cells.

A discharged cell will take a certain time to achieve this and Figure 4 gives the capacity available for the two principal charging voltages recommended for Ultima, 1.42 V/cell and 1.45 V/cell, during the first 30 hours of charge from a fully discharged state.

If the application has a particular recharge time requirement then this must be taken into account when calculating the battery (see section 10 – Battery sizing principles).

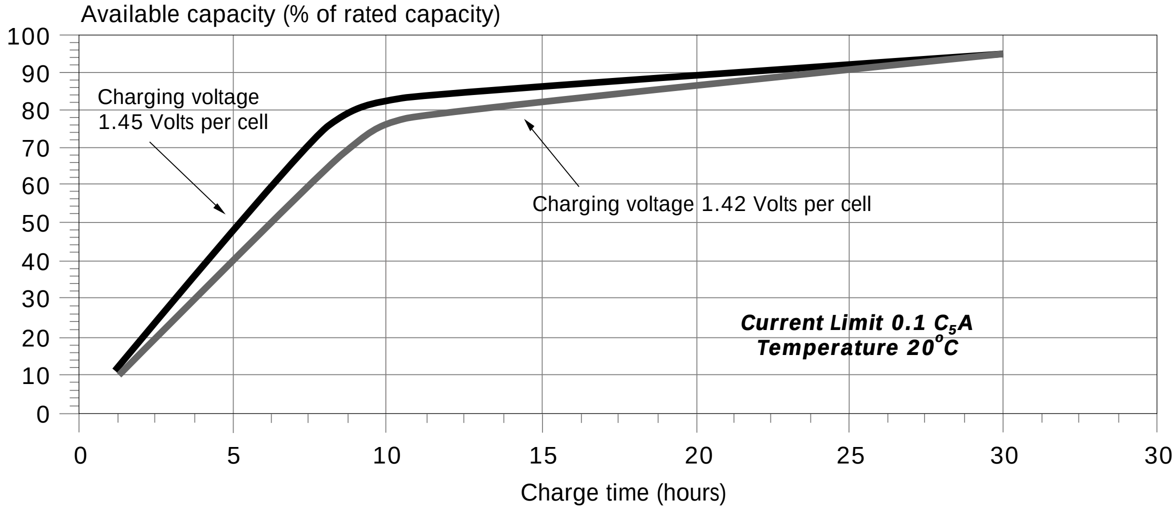



**Figure 4: Available capacity on float charge from a fully discharged cell**

## 8.3 Temperature effects

The recombination efficiency of the Ultima cell is dependent on the floating current and this, in itself, is a function of the floating voltage. Thus the floating voltages chosen for Ultima are carefully optimized at an ambient temperature of 20°C between the current required to charge the cell and the level of current required to give the ultra low maintenance features.

As the temperature increases then the electrochemical behavior becomes more active and so, for the same floating voltage, the current increases. As the temperature is reduced then the reverse occurs.

Increasing the current increases the water loss and reducing the current creates the risk that the cell will not be sufficiently charged. Thus as it is clearly important to maintain the same current through the cell, it is necessary to modify the floating voltage as the temperature changes. The change in voltage required, or “temperature compensation”, is given in Figure 5. If these values cannot be exactly met with a particular system then temperature compensation values of between –2.5 mV/°C and –3.5 mV/°C are acceptable.

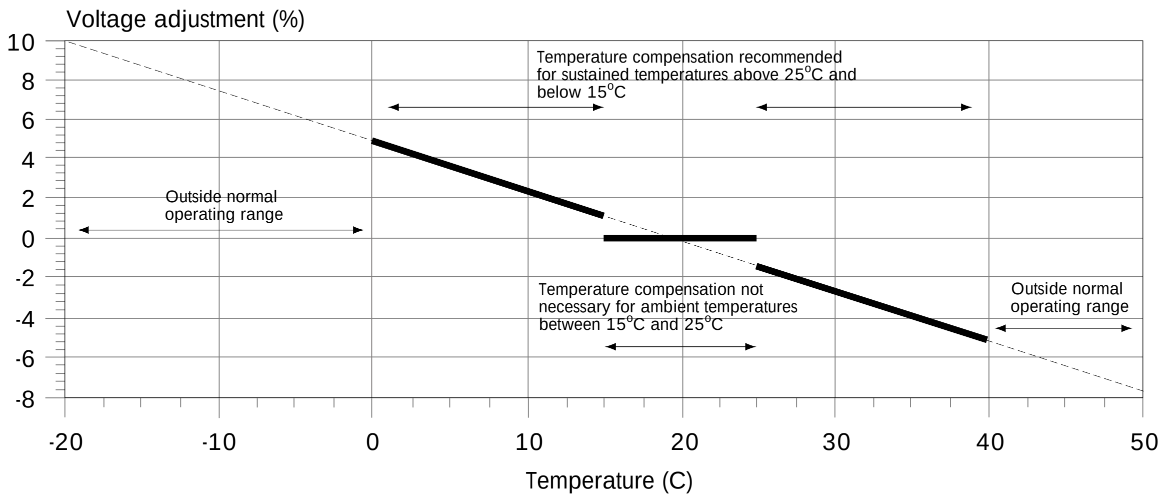



**Figure 5: Charging voltage adjustment for sustained temperatures**

The effect of increasing the continuous ambient temperatures is shown in Figure 6. For a continuous ambient temperature of 40°C the water consumption is doubled with respect to 20°C. If temperature compensation is used then this is largely eliminated, although not entirely as, at high temperatures, the gas occupies a larger volume and so it is less easily retained by the separator.

In practice, for a continuous ambient temperature of 20°C with fluctuations up to 30°C and down to 10°C, temperature compensation for the charger is not necessary as there is sufficient safety margin in the product design to allow for these fluctuations.

However, for ambient temperatures outside 15°C to 25°C or for temperature fluctuations beyond the 10°C to 30°C it is recommended that the temperature compensation should be used.

If the temperature range of the application is outside the operating range of 0°C to 40°C or the ambient temperature is outside 15°C to 25°C range and temperature compensation is not feasible, it is still possible that Ultima can be used but with some modification to voltages and maintenance interval. Under these circumstances please contact Saft for assistance.

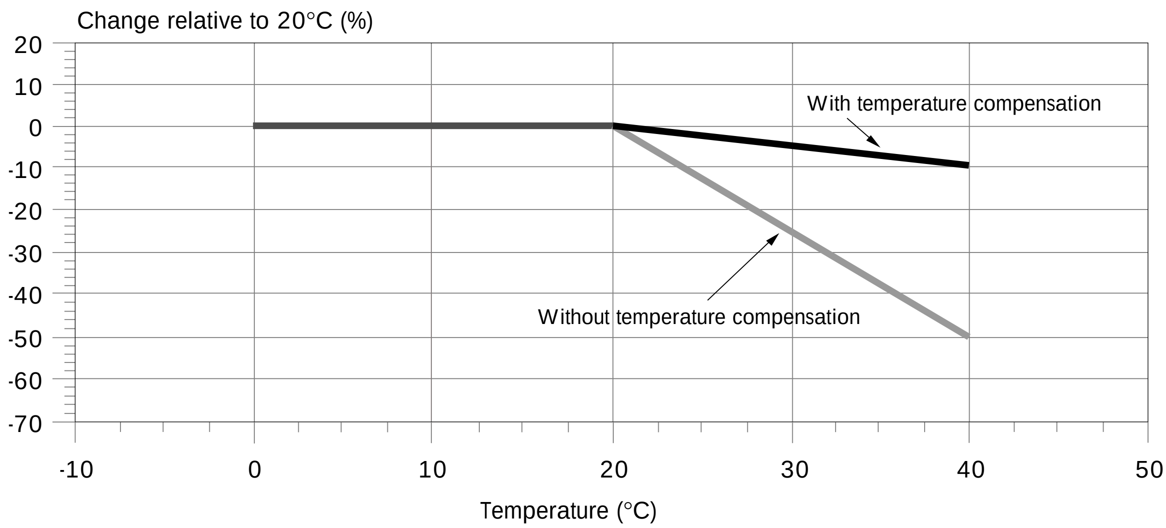



**Figure 6: Change in maintenance interval with continuous ambient temperature**

## 8.4 Commissioning requirements

### 8.4.1 Batteries filled and charged

Ultima batteries are normally supplied charged, ready for immediate use and, provided they have not been stored for more than six months, they may be put directly into service on float charge.
Under these circumstances they should not be given a commissioning charge before putting into service.

Batteries stored between six and twelve months should be treated as batteries filled and discharged - section 8.4.2

### 8.4.2 Batteries filled and discharged

Ultima batteries in a filled and discharged state require a commissioning charge prior to putting into service. This is a once only operation and is essential to prepare the battery for its long service life.

The commissioning charge requires an input of 160% of the rated ($C_5$) capacity before putting the battery into service.

Prolonged overcharging is not harmful to Ultima batteries but will reduce the initial electrolyte reserve and thus the service life without topping up. In the event of overcharge in excess of this recommendation, the level of electrolyte can be checked and restored to the maximum level.

The following methods of commissioning charge are recommended:

a) Charge 16 hours at 0.1 $C_5$ A maximum.

b) Charge at 1.65 V/cell for 16 hours maximum (0.1 $C_5$ A current limit).

If these recommended methods are not available in practice, then charging may be carried out at lower float voltages for extended periods.

# 9. Special operating factors

## 9.1 Electrical abuse

### 9.1.1 Ripple effects

The nickel cadmium battery is tolerant to high ripple from standard charging systems. Ultima has been tested with voltage ripple values of up to 15% without any effect on water loss.

### 9.1.2 Over-discharge

If more than the designed capacity is taken out of a battery then it becomes over-discharged. This is considered to be an abuse situation for a battery and should be avoided.

In the case of lead acid batteries this will lead to failure of the battery and is unacceptable.

The Ultima battery is designed to make recovery from this situation possible.

### 9.1.3 Overcharge

Overcharge of a recombination battery leads to an excessive use of water.

In a restricted electrolyte battery, such as valve regulated lead acid, this loss of electrolyte is irreversible and will lead to premature failure of the battery.

In the case of Ultima, with its generous electrolyte reserve, a small degree of overcharge will not significantly alter the maintenance period. In the case of excessive overcharge, a situation which will immediately destroy a valve regulated lead acid battery, Ultima can be refurbished as described in Section 13.

## 9.2 Mechanical abuse

### 9.2.1 Shock loads

The Ultima bloc battery concept has been tested to both IEC 68-2-29 (bump tests at 5 g, 10 g and 25 g) and IEC 77 (shock test 3 g).

### 9.2.2 Vibration resistance

The Ultima bloc battery concept has been tested to IEC 77 for 2 hours at 1 g.

### 9.2.3 External corrosion

Ultima nickel cadmium cells are manufactured in durable polypropylene, all external metal components are nickel plated and these components are protected by a neutral grease and a rigid plastic cover.

# 10. Battery sizing principles

Ultima is designed to be easy to use and specify and so the published data is based on cells which have been on float for several months, i.e. the data reflects the practical situation.

Thus in a situation at normal ambient temperature without any specific requirement with regard to recharge time the published data can be used directly to size the battery. However, if there are requirements with regard to recharge time or temperature then this will modify the result.

**Examples**

A standby system is to be sited in a building with an ambient temperature of 20°C and the temperature will always lie between 10°C and 30°C. It has a maximum voltage of 130 V and a minimum voltage of 95 V and requires a backup of 105 A for 2 hours.

In this case a simple 1.42 V/cell single level charger without temperature compensation can be used.

Number of cells = 130/1.42 = 91 and the final voltage will be 95/91 = 1.04 V/cell.

The Ultima data shows that the SLM 238 gives 109 A for 2 hours to 1.05 V/cell and so the battery would be 91 cells of SLM 238. At this single level voltage and at this temperature the battery would give 20 years without topping up.

However, if for this example there was a restriction that the battery must give 80% of its performance after 10 hours from a totally discharged state then certain modifications need to be made to the calculation.

If the single level 1.42 V/cell charger is retained, then from Figure 4 it can be seen that after 10 hours about 74% of the capacity is available and so the battery size will have to be increased by the factor 80/74 or, in other words, 8%. Thus for a current of 113 A (105 A + 8%) to 1.05 V/cell the battery required is 91 cells of SLM 285 as this gives 131 A to 1.05 V/cell. This battery will still give the 20 years without topping up.

From Figure 4, it can be seen that a voltage of 1.45 V/cell gives 80% of the capacity after 10 hours and so there is no need to increase the cell capacity to compensate for the charge. However, the battery has to be recalculated as, with the same voltage window, the higher charge voltage will modify the end of discharge voltage.

Thus, the number of cells = 130/1.45 = 89 and so the end of discharge voltage becomes 95/89 = 1.07 V. The Ultima performance table gives for 2 hours discharge at 117 A to 1.10 V/cell the SLM 285, and so in this case the battery is 89 cells of SLM 285.

The disadvantage of this solution is that a single level charger of 1.45 V/cell will only give 10 years without maintenance and so to achieve the 20 year maintenance level a two stage charger is required.

In principle it is always better to go to the lowest charge voltage as this gives the lowest end of discharge voltage, and generally a smaller cell capacity for the same duty, and gives the best maintenance interval.

Temperatures outside the standard range are treated in precisely the same way using Figure 1 for the derating factors.

When treating temperatures it is important to note that low temperatures reduce the performance (Figure 1) and so the battery size must be increased to accommodate this and at higher temperatures the ultra low maintenance is reduced (Figure 6) and so special consideration should be given to charging parameters.

This section is intended to give general guidelines in battery sizing. For advice on special battery applications contact Saft.

# 11. Installation and storage

## 11.1 Emplacement

The Saft Nife Ultima valve regulated recombination battery can be fitted onto stands, can be floor mounted or can be fitted into cabinets.

Local standards or codes normally define the mounting arrangements of the batteries, and these must be followed if applicable. However, if this is not the case the following comments can be used as a guide.

When the battery is housed in a cubicle or enclosed compartment it is necessary to provide adequate ventilation depending on utilization (see section 11.2 – Ventilation).

Allow sufficient space over the battery to ensure easy access during assembly.

Saft offers a wide selection of stands to suit most applications.

It is desirable to have easy access to all blocks on a stand mounted battery and they should be situated in a readily available position. Distances between stands, and between stands and walls, should be sufficient to give good access to the battery.

The overall weight of the battery must be considered and the load bearing on the flooring taken into account in the selection of the battery accommodation. In case of doubt, please contact Saft for advice.

When mounting the battery ensure that the cells are correctly interconnected with the appropriate polarity. The battery connection to load should be with nickel plated cable lugs. The connectors and terminal screws should be corrosion protected by coating with a thin layer of natural vaseline or anti-corrosion oil.

**Recommended terminal bolt tightening torques are:**

| Cell connection bolt per pole | Recommended torque Nm | Recommended torque lbf.in |
|---|---|---|
| M 5 | 7.5 | 70 |
| M 8 | 20 | 180 |
| M 10 | 30 | 270 |

To avoid accelerated ageing of the plastic due to UV light, batteries should not be exposed to direct sunlight, UV light sources or strong daylight for prolonged periods.

## 11.2 Ventilation

Under normal floating conditions the Saft Nife Ultima battery gives off up to 10 times less gas than a conventional open cell. Thus the need for ventilation is much reduced and in many cases no special ventilation requirements other than normal room ventilation are required. The quantity of hydrogen given off is given in section 7.9, Gas evolution. However, if the Ultima battery is commissioned in the final location or if the maximum recommended charge current of 0.1 $C_5$ is used then the quantity of gas given off will be increased.

A typical figure for room ventilation is about 2.5 air changes per hour and under such conditions it is satisfactory to install 700 watt hours of battery capacity per cubic meter if the final charge current is at 0.1 $C_5$ A.

Please refer to ventilation standards and requirements applicable in your country or area.

Care should also be taken with cubicle installations to ensure sufficient ventilation and battery spacing to prevent overloading and, hence, excess water usage.

## 11.3 Electrical

Ultima batteries are normally supplied filled with electrolyte and charged ready for immediate use. They may be stored in this condition for up to twelve months from the date of despatch from Saft.

If batteries are not put into service immediately, they should be stored in a clean, dry, cool and well ventilated store on open shelves. They should not be exposed to direct sunlight. Before storage ensure that the batteries are clean, with an adequate protective finish, such as an approved neutral grease, on the connectors, and that the flame arresting low pressure vents remain undisturbed.

Batteries filled and charged can be stored for up to one year without any conditioning charge requirement. If they are stored up to six months they should be put directly into service without any commissioning charge. If they have been stored for between six months and one year they should be given a commissioning charge as described in section 8.4.

Before putting into service ensure that the batteries are externally clean and with an adequate protective finish, such as an approved neutral grease, on the connectors.

If it is necessary to store the batteries for more than one year then they should be given the following conditioning discharge – charge cycle at the end of each year of storage.

- Discharge at 0.1 $C_5$ A to an end of discharge voltage of 1.1 V/cell, where $C_5$ is the rated capacity of the battery.
- Charge 160% battery's rated capacity at a maximum of 0.1 $C_5$ A for 16 hours.
- Return battery to store.
- Repeat every 12 months.

All batteries after storage must be prepared for service and fully commissioned as described for cells after one year's storage.

# 12. Maintenance of Ultima batteries in service

In a correctly designed standby application Ultima is a maintenance free product and requires the minimum of attention. However, it is good practice with any standby system to carry out a full discharge-charge cycle once per year to ensure that the charger, the battery and the ancillary electronics are all functioning correctly.

When this system service is carried out it is recommended that the Ultima cell levels should be checked visually to ensure that the level is above the minimum, the batteries should be checked for external cleanliness and if necessary cleaned with a damp cloth and that the cover should be removed to check that the protective grease on the terminals remains intact and that the vents are clean.

If there is evidence that electrolyte has been ejected from the vents or that there has been an excessive use of water, this could indicate a charger or system malfunction. Action should be taken to rectify this.

Please note that, when checking the levels, a fluctuation in level between adjacent cells is not abnormal and is due to the different levels of gas held in the separator of each cell.

# 13. Refurbishment of Ultima batteries

Refurbishment of the Ultima battery is recommended when the electrolyte level reaches the normal **minimum** mark on the cell but must be carried out before it reaches the **warning** level on the cell. Batteries operated at float charge rates above 1.42 V/cell will require refurbishment during their operating life (see section 8.8 – Water consumption).

Refurbishing of the Ultima battery is carried out as follows:

- Disconnect the battery from the load. Remove the orange terminal cover.
- With the terminal cover removed, the tops of the individual cells of the Ultima battery will be in view.
- Confirm that an adequate protective finish (recommended neutral grease) remains on glands, poles and connectors. Replenish if necessary.
- Carefully loosen the flame arresting low pressure vents to release any gas pressure and then remove each vent completely and retain for refitting.
- Top up each cell with approved water to the specified maximum level. Saft Nife can supply special topping up equipment on request.
- Wipe up any small spillage on cells using a clean cloth. Replace the vents taking care to tighten them correctly i.e. until resistance against a stop is experienced, and ensure that the seating rubber has not been disturbed out of position. If there is any doubt about the quality of the sealing ring replace with a new vent assembly.
- Replace the orange terminal cover.

The refurbished Ultima cell is now ready for recommissioning (see section 8.4.2 – Commissioning requirements: batteries filled and discharged).

Note: Before proceeding with any battery refurbishment please ensure that the Safety Precautions given in the Ultima Operating Instruction Sheet are complied with.

Saft, the battery sector of the Alcatel Alsthom group, supplies advanced off-line power solutions for its customers all over the world. Saft designs, manufactures, sells and services multi-technology cells and batteries as well as related power electronics systems. As one of Saft's three product groups, the Advanced and Industrial Battery Group spans an extremely broad range of industrial applications : aircraft, railways, electric vehicles, space, defense and other industries. Its plants, located in Bordeaux, Poitiers, France, Oskarshamn, Sweden and Valdosta, Georgia, U.S.A., are operated through a quality management system that extends to R&D and production automation.

All sites are ISO 9001 certified.

Nickel-cadmium batteries are 99.9% recyclable and Saft operates its own dedicated recycling center.

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