

Field Battery Investigation – Part I: Battery Characterization

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Introduction

For safe determination of state-of-function of lead batteries, precise knowledge about ageing in field is essential. Hence, more than 200 failed batteries from field were collected, electrically characterized and/or subjected to teardown.

Conclusion

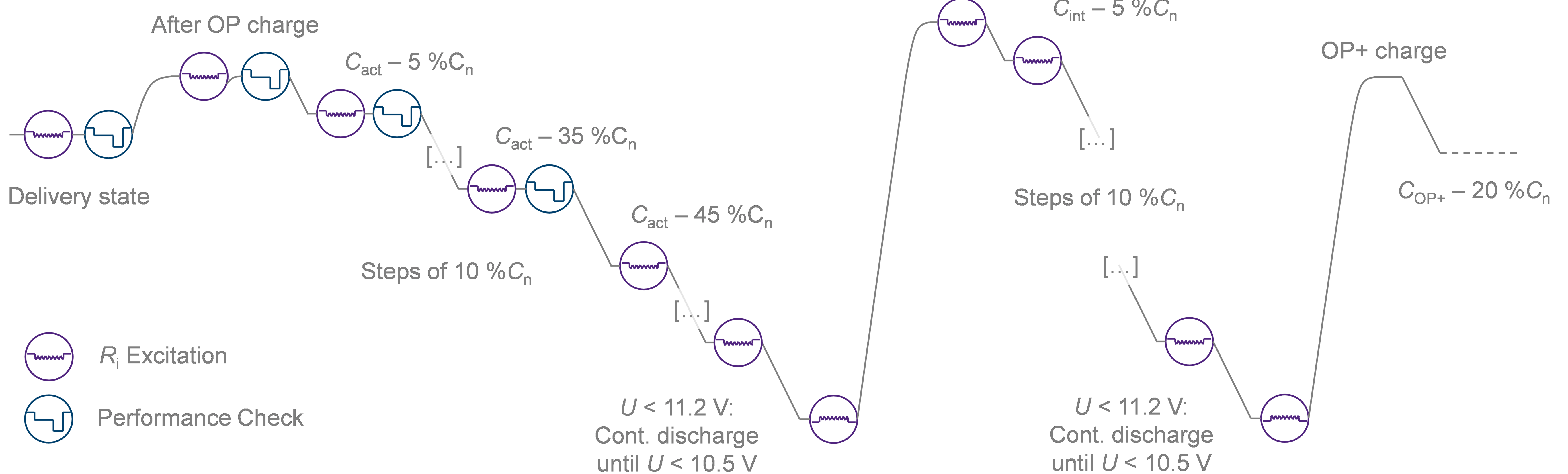
The electrical characterization offers a detailed insight into the ageing progress, complemented by teardown results. For further results, cf. poster “Field Battery Investigation – Part II”.

Inventory of collected samples

- Origin: workshop (~55 %) or roadside assistance (~45 %)
- Production date from pole stamp, nominal values (C_n , CCA)
- OCV (U_{inv}), 1 kHz AC resistance ($R_{i,1kHz}$)
 - > 50 mΩ: EN charge → SCI → check $R_{i,1kHz}$ again
 - ≤ 50 mΩ: Electrical characterization → SCI

Short circuit investigation (SCI)

- 2 weeks resting at 80 % (≤ 50 mΩ) or 100 % (> 50 mΩ)
- Weekly measurement of OCV and $R_{i,1kHz}$
 - Evaluation of dU/dt for short circuit determination



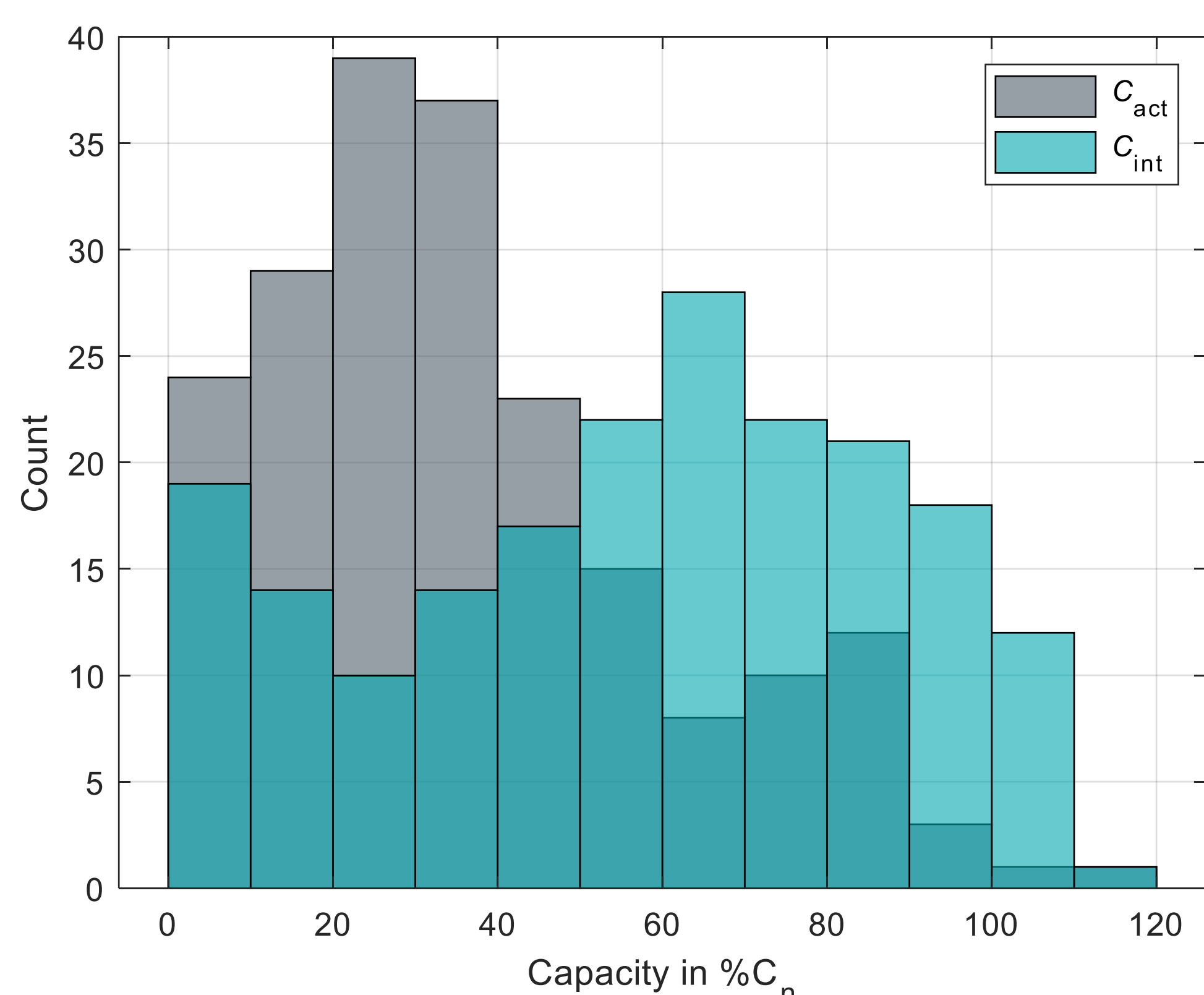
Electrical characterization sequence

- At delivery state: R_i excitation, performance check
- After operational (OP) charge:
 - R_i excitation, performance check and OCV over SoC
 - Actual capacity C_{act} available in field operation
- After intensive (EN + I_a) charge:
 - R_i excitation and OCV over SoC only
 - Capacity C_{int} after recovery of reversible sulfation C_{sul}

Profiles within electrical characterization

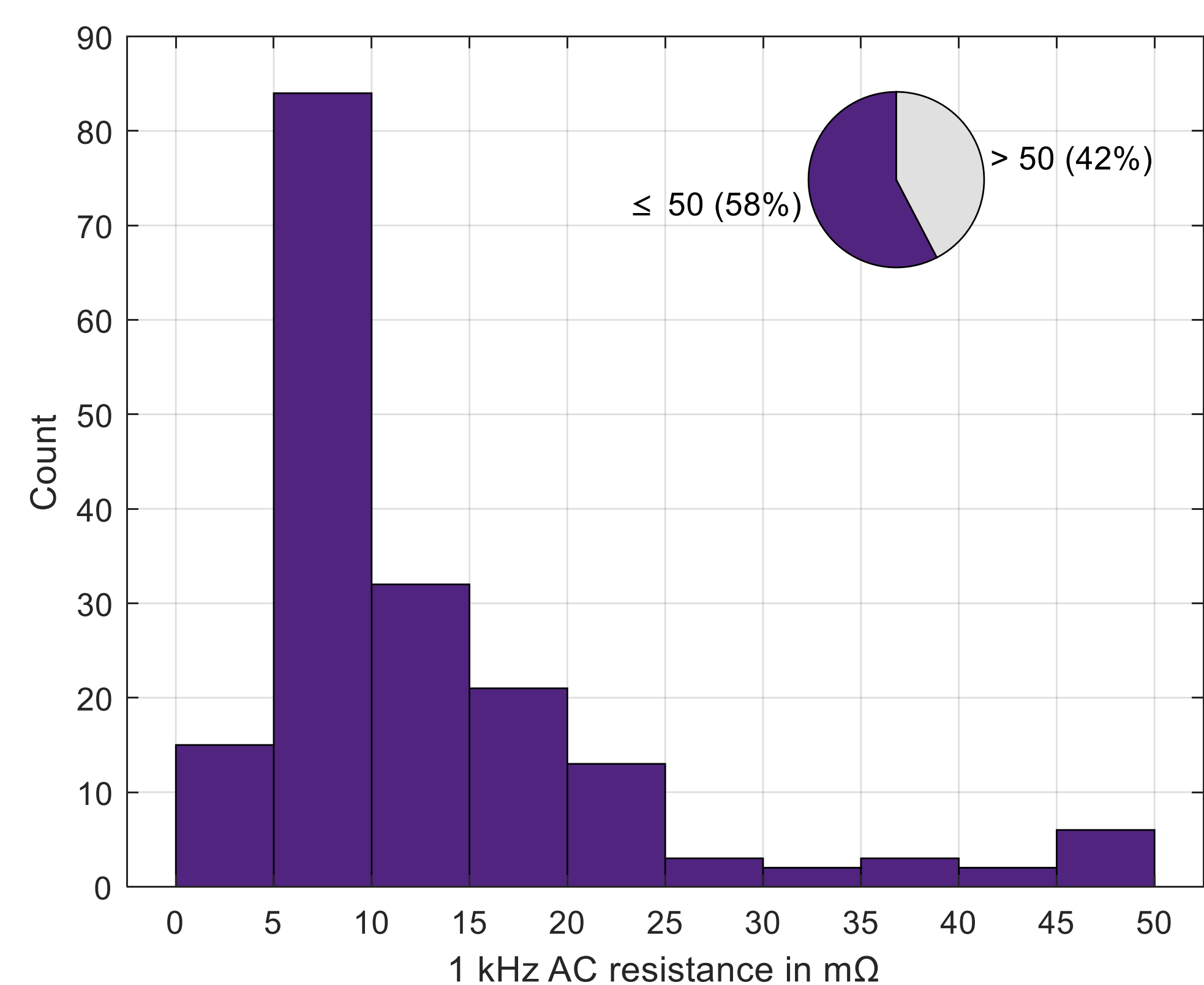
- R_i Excitation
 - Fast switching 3 A/30 A for R_i determination
 - Evaluation of lowest R_i as corrosion indicator
- Performance Check
 - Safe-stop maneuver with 2C for 30 s and 5C for 15 s
 - Evaluation of U_{end} as performance indicator

Teardown analysis • ≤ 50 mΩ: TDA light ($h_{el,cell}$, $\rho_{el,cell}$, $R_{i,1kHz,cell}$, U_{cell}) • > 50 mΩ: Full TDA to determine root cause of failure



Capacity after OP charge C_{act} vs. intensive charge C_{int}

- Peak moving from ~28 % C_n to ~65 % C_n , corresponding to 37 % reversible sulfation and 35 % irreversible capacity loss



Internal resistance $R_{i,1kHz}$ at inventory

- Peak of resistance at 5 to 10 mΩ, most batteries < 25 mΩ
- 42 % of batteries > 50 mΩ → subjected to EN charge first