Assessment of Electrical Safety Risks Associated with Electrolyte Leakage in VFBs

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Introduction

There is currently a lack of understanding of potential electrical safety risks associated with electrolyte leakage. This work presents a quantitative analysis of electric field distribution and body currents associated with electrolyte leaks from a 30 kW containerised VFB.

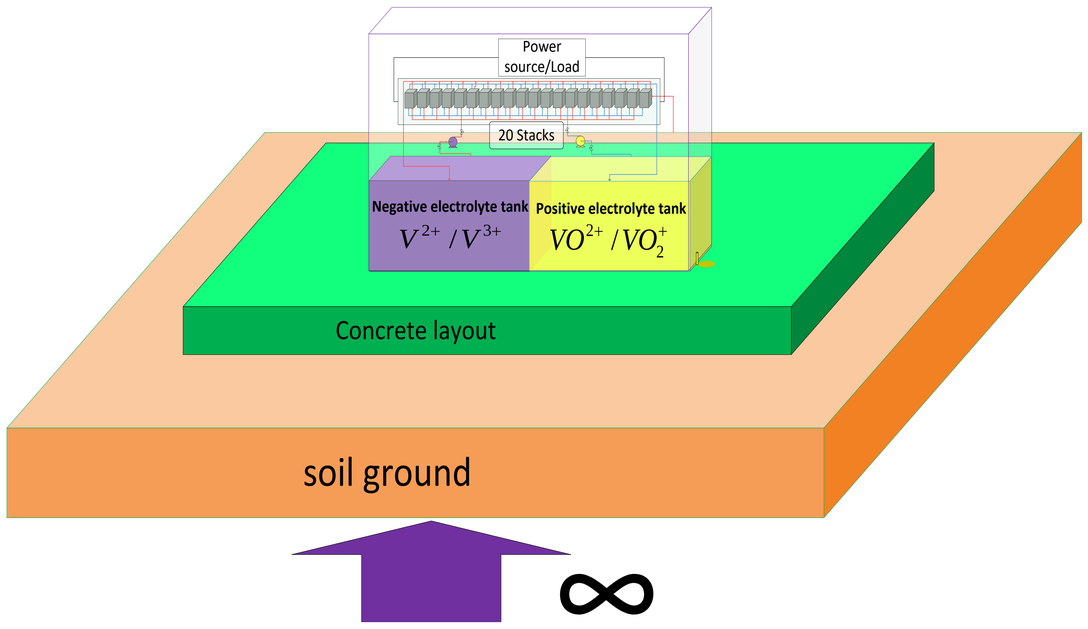


Figure 1: Overview of continuous electrolyte leakage situation

System configuration

Simulations are conducted based on a **30 kW-130 kWh** VFB system

- Configuration 1: 20 battery stacks are divided into 10 groups. In each group, two stacks are electrically connected in series, while the battery groups are electrically connected in parallel.
- Configuration 2: 20 stacks will be electrically connected in series, reaching the maximum terminal voltage.

Leaked Voltage analysis

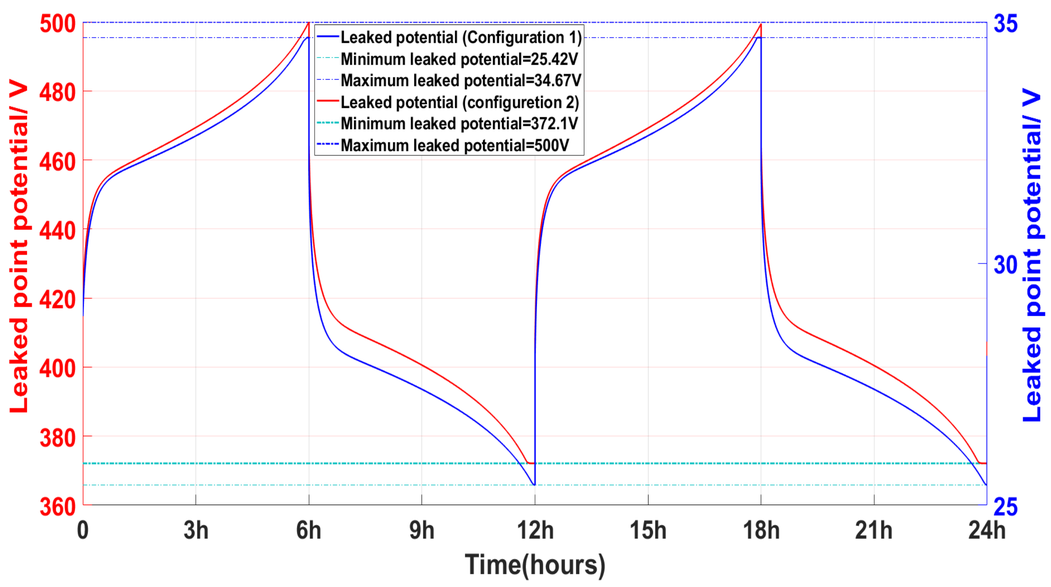
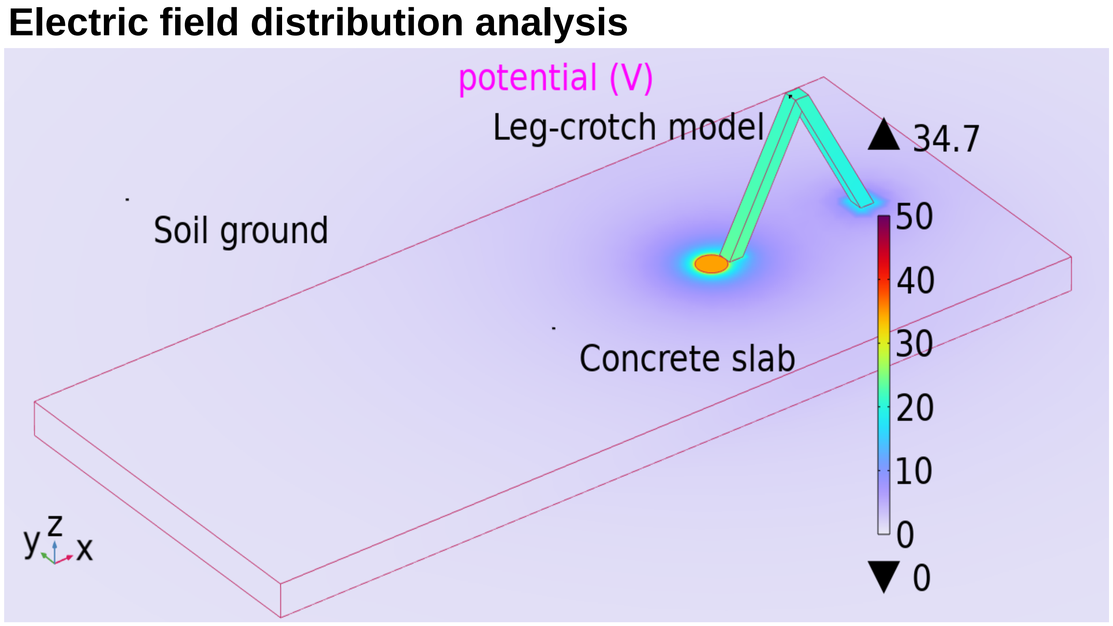
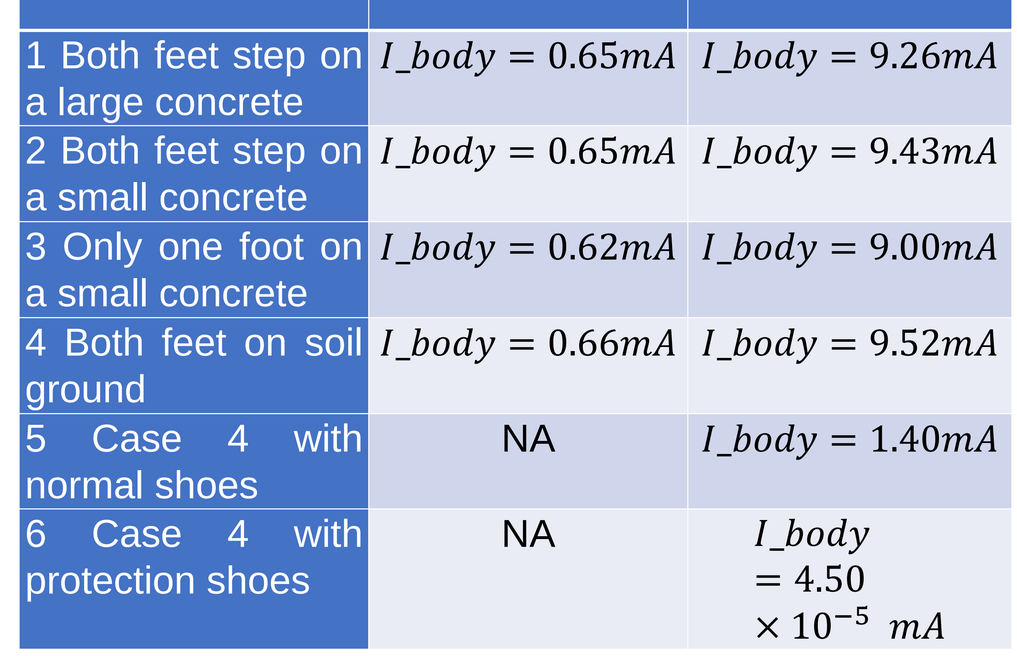


Figure 2: Leaked potential with continuous charging-discharging profile (blue) Configuration 1 (red) Configuration 2

Electric field distribution analysis



(a)



(b)

Figure 3: Electric field distribution and potential (a) Configuration 1 (b) configuration 2

Table 1 Body current in different scenarios

Scenarios	Configuration 1	Configuration 2
1 Both feet step on a large concrete	$I\_body = 0.65mA$	$I\_body = 9.26mA$
2 Both feet step on a small concrete	$I\_body = 0.65mA$	$I\_body = 9.43mA$
3 Only one foot on a small concrete	$I\_body = 0.62mA$	$I\_body = 9.00mA$
4 Both feet on soil ground	$I\_body = 0.66mA$	$I\_body = 9.52mA$
5 Case 4 with normal shoes	NA	$I\_body = 1.40mA$
6 Case 4 with protection shoes	NA	$I\_body = 4.50 \times 10^{-5}\ mA$

Conclusion

The body currents associated with leaks from the series connected 30 kW VFB system is about 10 mA when shoe protection is unavailable. This current level is in the DC-2 region and the current in this region can cause involutory muscular contraction, according to IEC TS 60479. Tolerance for a 10 mA current varies among individuals and may not prevent falls. Protection of normal shoes is limited, and protective shoes are needed under configuration 2. The body current under the existing parallel configuration 1 remains safe when continuous electrolyte leakage occurs. Further analysis would be needed for larger higher power flow battery systems.

Acknowledgement

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References

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