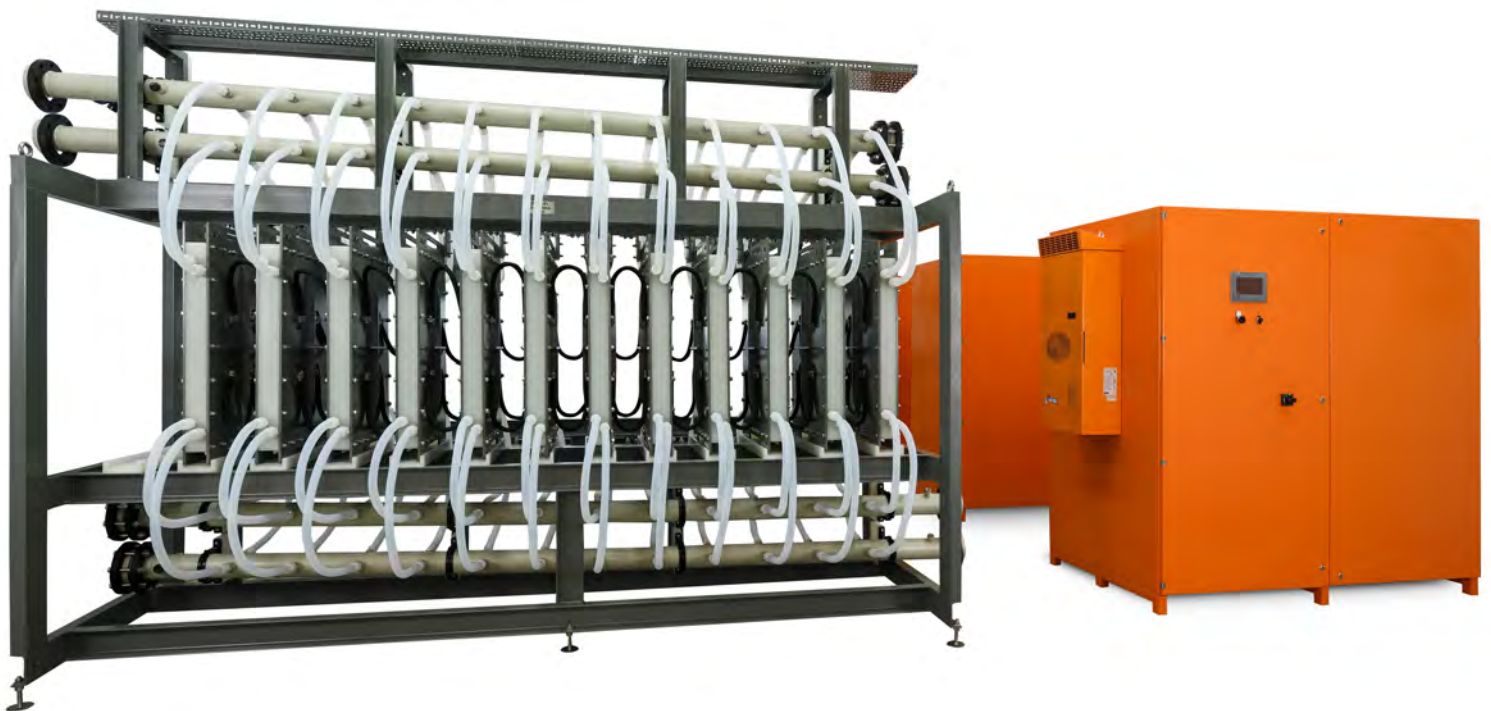




# C-Tech

INNOVATION

## Vanadium Electrolyte Production Equipment



C-Tech Innovation are the **World leader in the design, build and installation of electrochemical equipment for vanadium electrolyte manufacturing.**



**BUILDING FOR THE FUTURE BY  
INNOVATION**

# C-Tech Innovation Vanadium Electrolyte Production Technology

C-Tech Innovation are the world's leading supplier of vanadium electrolyser plant for VRFB electrolyte production. Our proprietary electrochemical process is proven at production scale with installed plants in the UK and USA and with ongoing projects in Australia and South Africa.

Our technology is a one-step electrochemical reduction that produces electrolyte of specified charge state directly from vanadium pentoxide and sulfuric acid. The reduction step is purely electrochemical and it avoids the need for the additional chemical reagents conventionally used to overcome the poor solubility of vanadium pentoxide in acid. The plant can be tailored for different starting materials and integrated into upstream and downstream processes.

The equipment is modular. A typical module has 12 C-Flow™ PRD cells and a capacity of 1 million litres of finished vanadium electrolyte per year. The modular design means that the plant is easily scalable by adding more modules. Our proprietary C-Flow™ PRD electrolyser cell design features unrestricted internal flow paths and is tolerant to particulate contamination. The plant is provided with power supply and a fully automated control system for the electrolyzers and balance of plant.



*Electrochemical modules and control system by C-Tech Innovation for the manufacture of sulfuric acid based vanadium electrolyte for redox flow batteries*

# Technology Features

## Highest Purity Vanadium Electrolyte

- No chemical reagents used means significantly higher purities of vanadium electrolyte.
- High purity electrolyte is critical to achieving optimum VRFB performance and electrolyte recyclability.

## Low Production Cost

- No chemical reagents are required for the reduction process, and there is no downstream processing required to remove unwanted by-products. The only reagent is electricity. The result is that the production costs are significantly lower than wet chemistry methods.

## Flexibility and Scalability

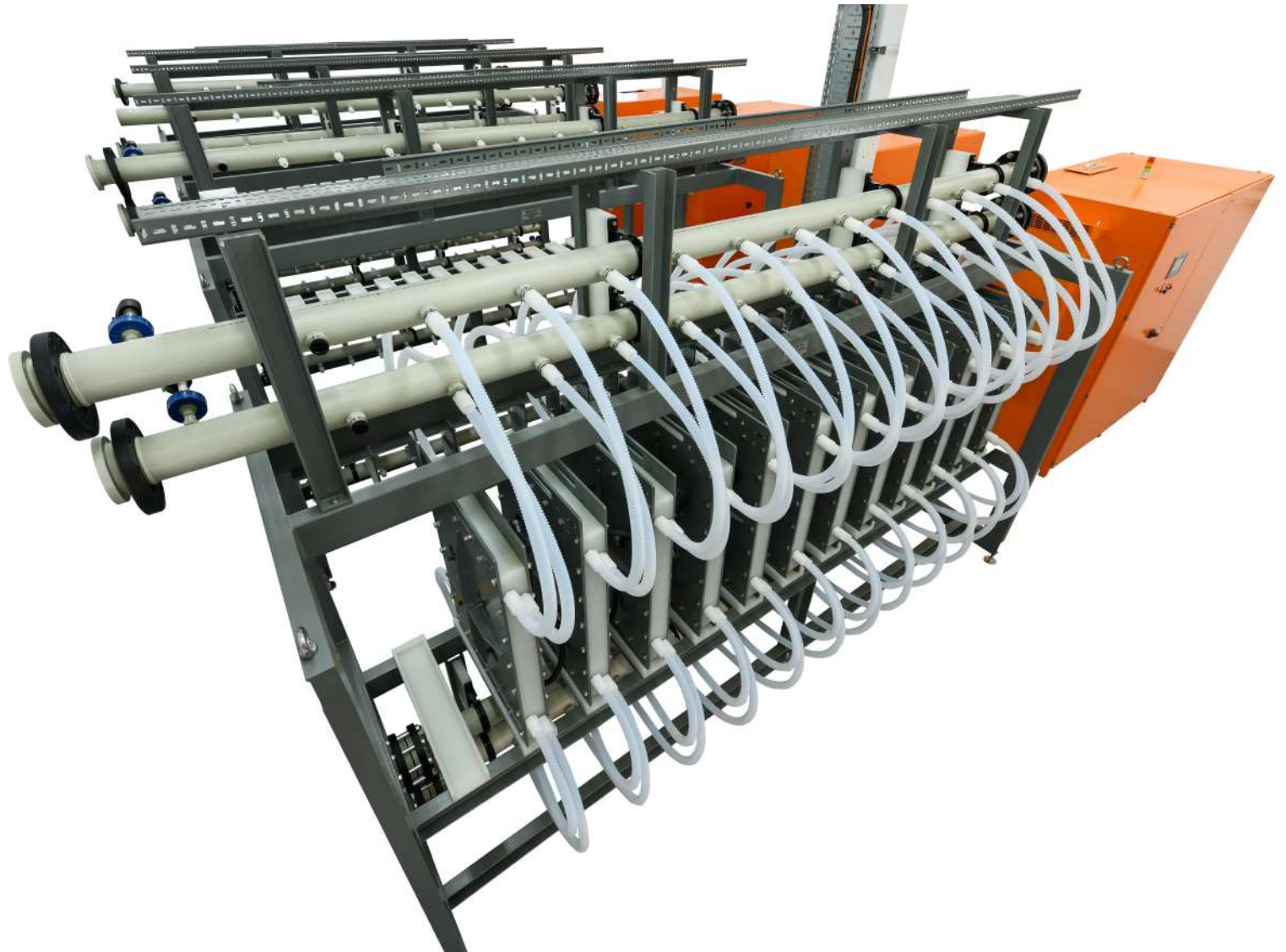
- Systems are designed to your requirements with easy expansion offered by the additional of extra modules.
- A wide operating range gives a significant turndown capability.

## Low Maintenance Requirement

- The system requires minimum maintenance, typically one service visit per year with a downtime of less than 3 days.

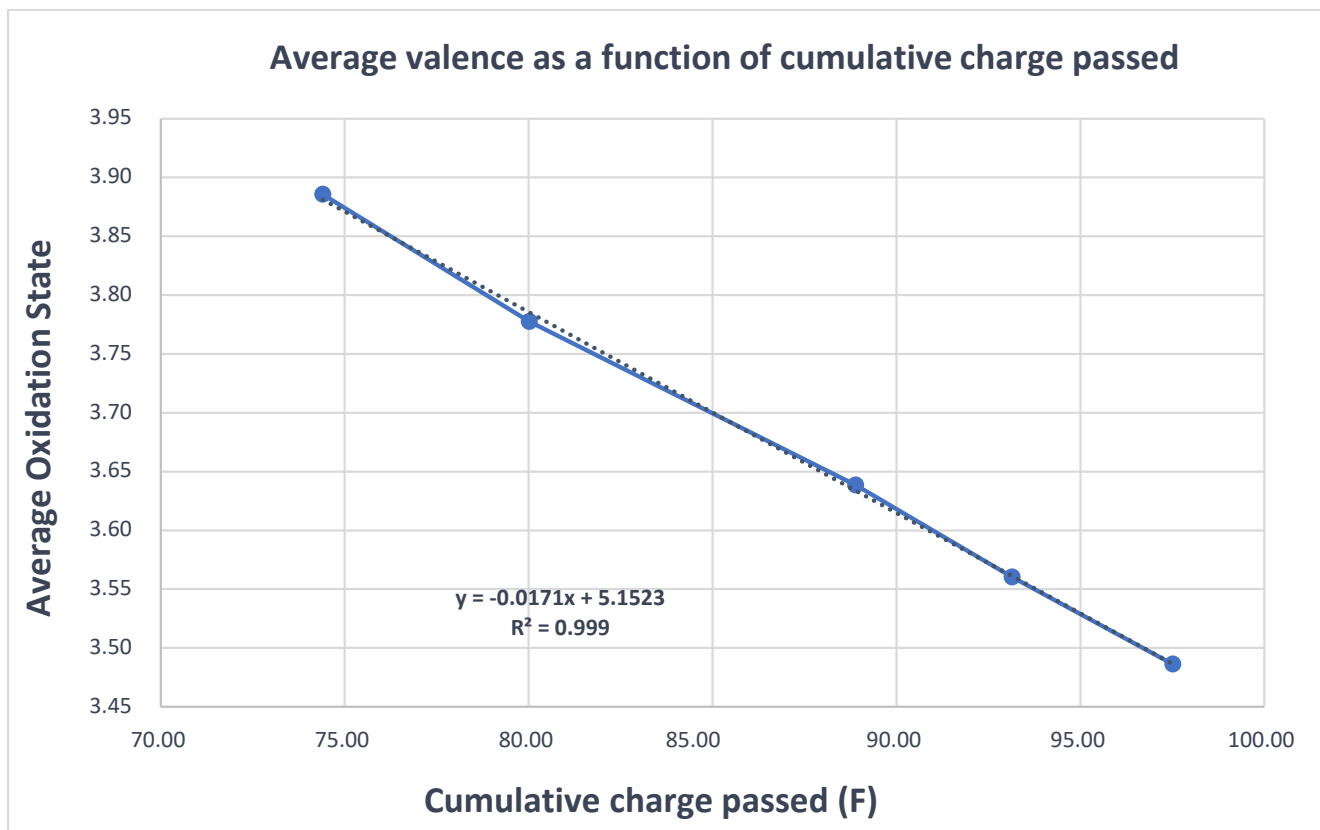


## OFFERS UNSURPASSED RECYLABILITY OF VANADIUM ELECTROLYTE



# Vanadium Reduction Efficiency

The C-Flow™ PRD cells are 94.2% efficient in their use of electrical current to reduce the oxidation state of vanadium. This is illustrated in the graph below which shows the reduction in average oxidation state of a vanadium solution in sulfuric acid, as a function of the cumulative charge passed expressed in Faradays.



The electrochemical efficiency is defined as the ratio of the quantity of oxidation number change in moles to the quantity of charge passed in Faradays (moles of charge). A perfect electrochemical efficiency will therefore have a value of 1.00 mol.F<sup>-1</sup>. The value is obtained by taking the slope of cumulative charge passed plotted against the average oxidation state of the vanadium, to give a measure of the change in oxidation state as a function of the charge passed, and multiplying this by the amount of vanadium present.

$$\text{current efficiency (mol.F}^{-1}\text{)} = \text{amount (mol)} * \frac{\text{change in oxidation state}}{\text{charge passed (F)}}$$

From the graph the gradient is 0.0171 mol.F<sup>-1</sup>, and the amount of vanadium present was 55.07 mol, so that the current efficiency was 0.942, +/- 0.003.

The data shown were obtained using a single C-Flow PRD TM cell. It was operated at 42 °C. The solution was 4.00 M in sulfuric acid and 1.80 M in vanadium.

# Typical Element Analysis of Electrolyte Produced

The analysis shown below is of a vanadium electrolyte solution prepared from vanadium pentoxide in sulfuric acid using a C-Flow™ PRD cell. It is a semi-quantitative analysis by ICP-MS.

| Metal | Vanadium Pentoxide Analysis               | Expected electrolyte result based on Analysis | Actual electrolyte result using C-Tech Electrolyser Plant |
|-------|-------------------------------------------|-----------------------------------------------|-----------------------------------------------------------|
|       | Typical Vanadium Pentoxide Analysis (ppm) | (ppm)                                         | (ppm)                                                     |
| Na    | 308.3                                     | 36.7                                          | 35.9                                                      |
| Al    | 124.0                                     | 14.8                                          | 18.4                                                      |
| Fe    | 91.2                                      | 10.9                                          | 10.8                                                      |
| Co    | 61.8                                      | 7.4                                           | 7.1                                                       |
| Mo    | 31.4                                      | 3.7                                           | 4.3                                                       |
| Ca    | 0.2                                       | <1                                            | <1                                                        |
| Ni    | 21.9                                      | 2.6                                           | 2.5                                                       |
| Rb    | 8.1                                       | 1.0                                           | 1                                                         |
| Mg    | 8.0                                       | 0.9                                           | 1                                                         |
| W     | 10.3                                      | 1.2                                           | 1                                                         |
| Zn    | 3.9                                       | 0.5                                           | <1                                                        |
| Mn    | 3.8                                       | 0.5                                           | <1                                                        |
| Ba    | 1.3                                       | 0.2                                           | <1                                                        |
| Cs    | 1.0                                       | 0.1                                           | <1                                                        |
| Cu    | 0.4                                       | <1                                            | <1                                                        |
| U     | 0.4                                       | <1                                            | <1                                                        |
| B     | 0.5                                       | <1                                            | 1                                                         |
| As    | 0.3                                       | <1                                            | <1                                                        |
| Ga    | 0.4                                       | <1                                            | <1                                                        |
| K     | 373.0                                     | 44.4                                          | 46.1                                                      |
| Sb    | 0.2                                       | <1                                            | <1                                                        |
| Sr    | 0.1                                       | <1                                            | <1                                                        |
| Cr    | 0.3                                       | <1                                            | <1                                                        |
| Th    | <1                                        | <1                                            | <1                                                        |
| Se    | 0.1                                       | <1                                            | <1                                                        |
| Ge    | <1                                        | <1                                            | <1                                                        |

# How We Work

## *Your One Source Solution*

C-Tech Innovation provides a comprehensive design and construction service with full support including installation, commissioning, training and maintenance. We have supplied vanadium electrolyte production systems from 500,000 litres (15MWh) to 8 million litres (250MWh) per annum. Our competitive advantage is the scientific and engineering expertise of our team and the wide experience the company has of implementing applications across a diverse range of sectors. Our in-house team includes highly qualified and industry experienced chemists, process engineers, mechanical, electrical and control system engineers.

- ✓ We offer a full service in-house, from initial concept through to delivery of a production unit for installation on your site.
- ✓ We can advise or instruct your EPC contractor, according to your requirements.
- ✓ We have fully equipped laboratories allowing us to carry out process trials as required.

### **1 REQUIREMENTS REVIEW**

We discuss your requirements with you. User Requirement Specification and Preliminary Schedule agreed.

### **2 PROPOSAL & AGREEMENT**

Project Proposal with Costings and Schedule is sent for your review. Project Manager and Design Team allocated.

### **3 PRELIMINARY DESIGN**

Including a Basis of Design, Process Flow Diagram, preliminary P&ID, plant sizing, general arrangement, process control, safety, certification and testing requirements.

### **4 DETAILED DESIGN PHASE**

Including Detailed P&ID, component specification, drawings, Bill of Materials, safety study, Inspection and Test Plan, preliminary Operating Manual.

### **5 BUILD**

Procurement, inspection of materials and components, manufacture and assembly at our site.

### **6 TESTING**

Factory Acceptance Testing according to the Inspection and Test Plan, with client witness as required.

### **7 INSTALLATION**

Installed on your site by our mechanical and electrical engineers and technicians.

### **8 COMMISSIONING & TRAINING**

On-site commissioning and client operator training as required.

## SCALABLE, MODULAR DESIGN TO SUIT YOUR REQUIREMENTS



*Designed and built by C-Tech Innovation, each of the electrochemical modules is able to manufacture 1,000,000 litres of finished vanadium electrolyte per annum. The units are scalable, to increase capacity simply add more modules.*

**See more at:**

[www.ctechinnovation.com](http://www.ctechinnovation.com)

**To discuss please call: +44 (0)151 347 2969  
or email us at [info@ctechinnovation.com](mailto:info@ctechinnovation.com)**

