Short-Stack Test Fixture Kit Operation Manual

PARTS INCLUDED IN TEST KIT

Part Name	Description	Quantity
Ported NextCells	Cells included in the kit for testing.	15
Manifold	Test manifold.	1
Fuel Seal	Seals cell to the interconnect on fuel side.	30
Air Seal	Seals cell to the interconnect on air side.	30
Manifold Seal	Seals manifold to current plate.	5
LNCCu Cathode Ink	Contact paste for the cathode, 100 g pot	1
NiNiO Anode Ink	Contact paste for the anode, 100g pot.	1
Inconel Voltage Sense Wires	Sensing wire welded to interconnects and current plate	15
Expanded steel air current collector	Expanded steel meshes, pre-cut and shaped.	15
Nickel Foam fuel current collector	Nickel anode foam, pre-cut and shaped.	15
Cersleev Insulation	Insulation for voltage sense and current wires.	1
Backing Plate	Distributes load over the stack.	1
Silver Wire	Current wire.	2
Top Current Plate	Current collection plate.	3
Bottom Current Plate	Current collection plate with gas passthroughs.	3
¼”- 20 x ¼” Bolts / Washers	Used to secure current wires to current plates.	10

REQUIRED TOOLS AND EQUIPMENT

Equipment	Description	Quantity
Furnace	Appropriately sized furnace capable of 1000 °C max. temperature.	1
Compression System	Used to compress seals for good stack sealing	1
Anode humidifier (optional) and condensate collection.	Used to predict OCV, collection of condensate to prevent blockages of exhaust.	1
Electronic Load/ Power Supply	Used to collect performance data.	1
AC Impedance Spectroscopy	Used to study electrode characteristics and resistances.	1
Gas Controls	Used to control anode and cathode gas compositions.	1
Furnace Furniture and Insulation	Used to properly position cell and manifolds, insulate gas and current pass-throughs.	N/A

INTRODUCTION

This operating manual provides detailed instructions for preparing, assembling, and conditioning the Short-Stack kit. Some auxiliary equipment is required for successful testing but is not included with this kit. This manual assumes certain capabilities of that equipment and how it interfaces with the stack test kit. If you have unique setups or configurations, please contact us before purchasing to ensure compatibility.

Proper compression is essential for the functionality of this testing kit, as the included seals require adequate compression to form an effective seal. The recommended compressive force for the Short-Stack test kit is 45 lbf (200 N), applied evenly across the stack. Common methods for applying this force include:

- High-temperature steel blocks as weights
- Pneumatic or hydraulic cylinders
- Screw or lever clamping systems

A condensate collection system is recommended to prevent blockages in exhaust plumbing and to enable measurement of the water generation rate, which can assist in data analysis.

The manifold is supplied without fittings and comes with long, straight tubes attached. This allows users to select fittings compatible with their gas and exhaust infrastructure. The extended tubes provide flexibility to bend and fit test furnaces while ensuring proper integration with gas controls.

SAFETY PRECAUTIONS

There are no intrinsic hazards associated with the Short-stack test kit. However, safe operation of the kit requires the user to consider multiple sources of potential danger. There are three major sources of danger when operating the test kit.

- Explosive, flammable and toxic gases – Be sure to connect exhaust lines to appropriate ventilation. Use flammable gases only in concentrations above or below their explosion limits unless there are appropriate measures in place to protect against explosion. The manifold set is NOT shipped in an oxygen clean state, use in pure oxygen is not recommended.
- Electrical shock – The manifold itself is not energized while testing. However, the current wires and voltage sense wires are. Use appropriate insulation and connections outside the furnace to prevent shorting. Ensure that the test kit does not contact the heating elements of the test furnace. This can energize the manifold and present a shock hazard.
- Hot surfaces – The furnace and any tubing or wires within will become extremely hot during operation. Use insulation, PPE and guarding to prevent burns.

ASSEMBLY AND LOADING INSTRUCTIONS

Before Testing:

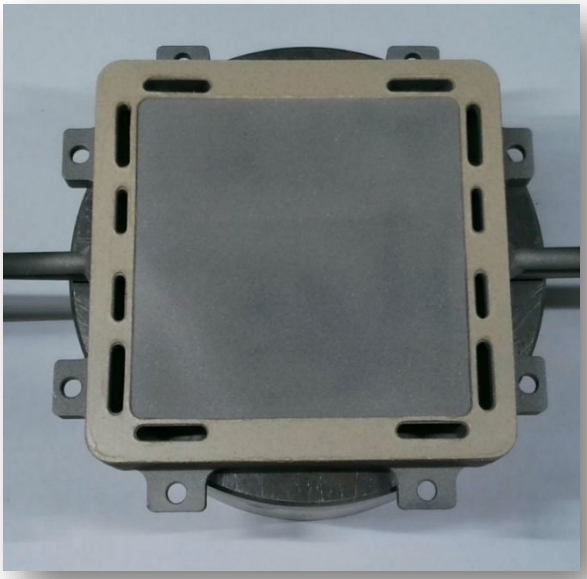
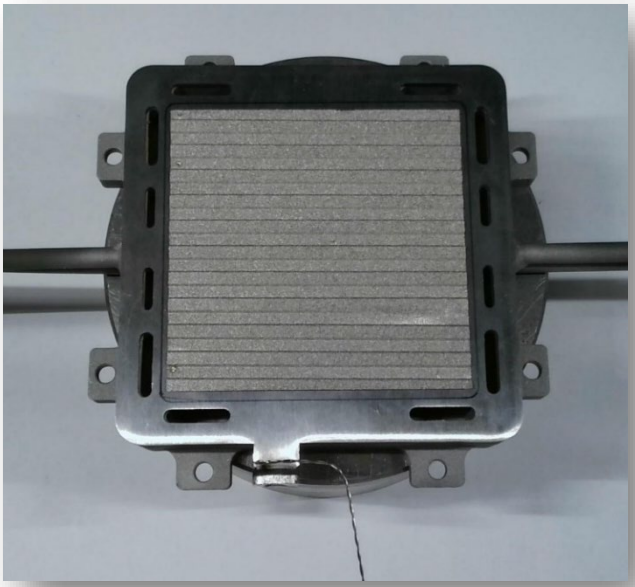
- **Before building a stack, test fit the manifold in your furnace to see what bends, if any are required for tubing, and where the voltage sense and current wires will exit. Choose what fittings and electrical connections you will use to control gas composition and collect data.**

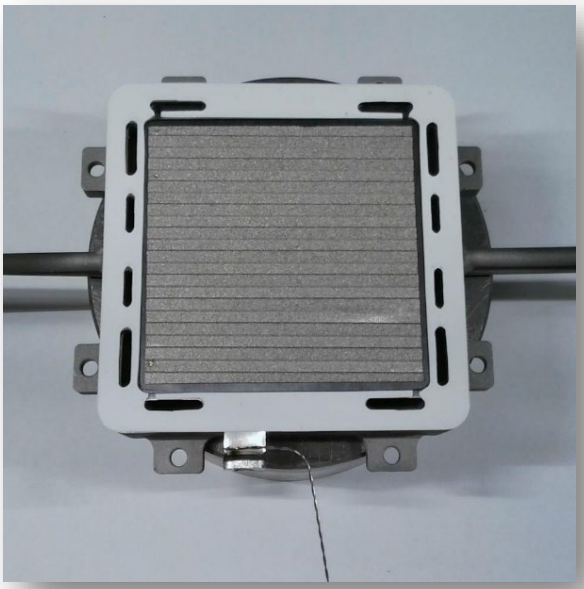
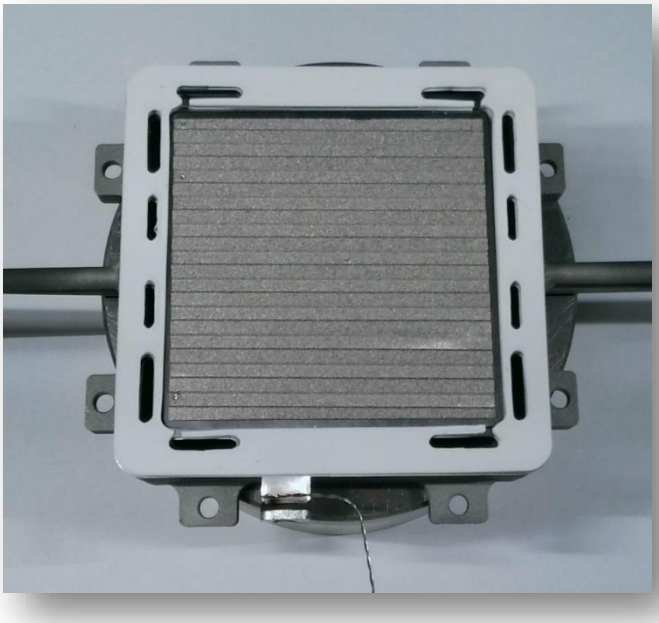
- **This test fixture performs best when configured for co-flow, where the fuel and air inlets are on the same side of the manifold. However, you can test counter-flow by changing the inlet and outlet locations.**

- **The manifold does not require any heat-treatment or conditioning prior to first use.**

Short-stack Assembly:

Step	Description
1. Set Anode Manifold on Flat Stable Surface.	

2. Place the Manifold Seal on the Manifold	 • Be sure not to obstruct any of the gas ports.
3. Place the Anode Current Plate onto the Manifold Seal	

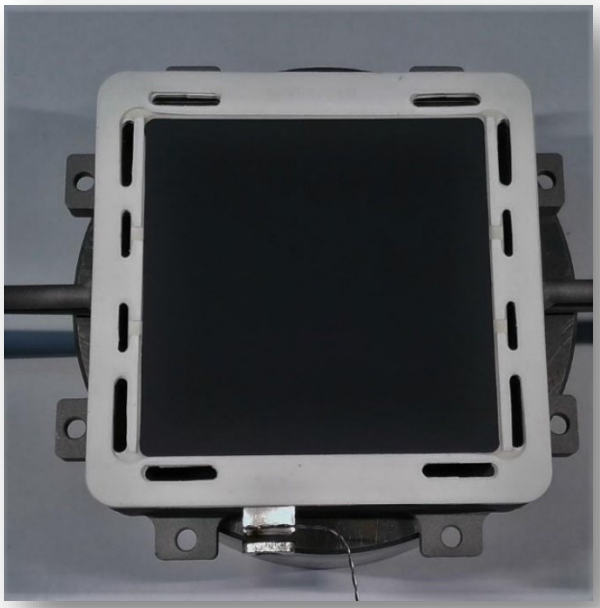
4. Place the first Anode Cell Seal.	
5. Place second anode cell seal on the gas spacer shim	

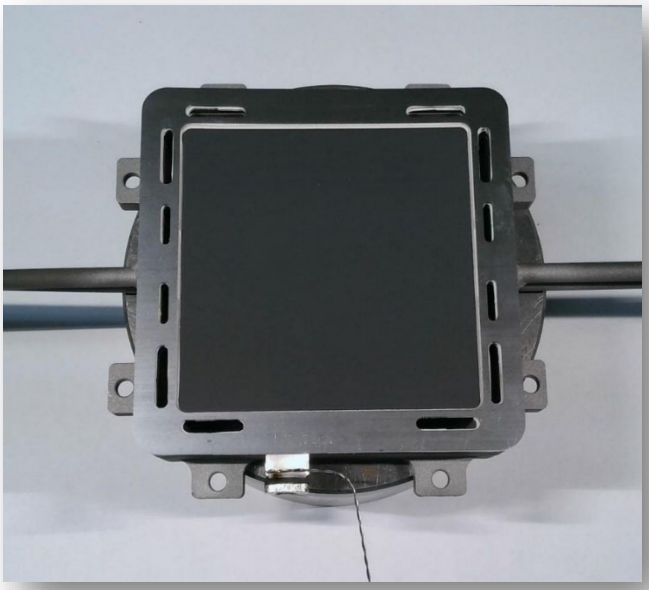
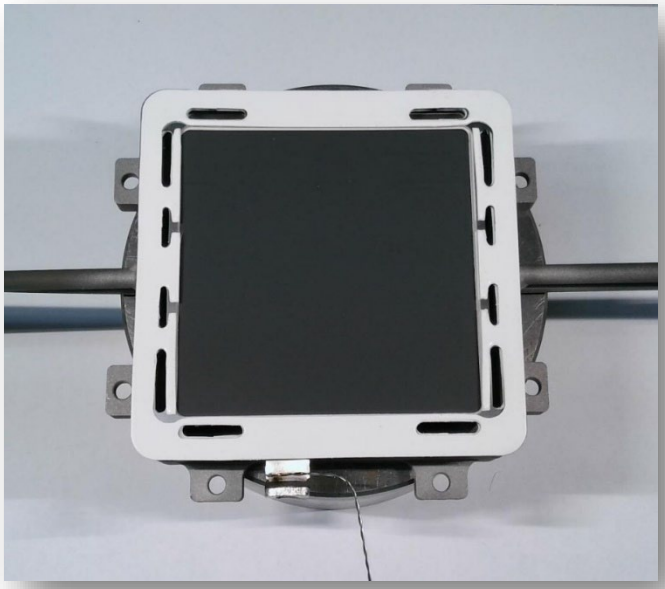
6. **Apply Contact Paste to the cell Anode.**

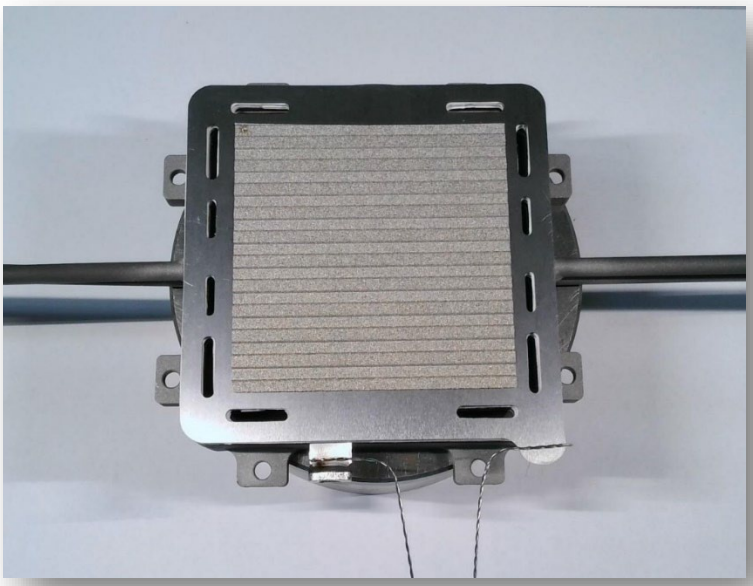
- Evenly apply approximately 3 grams of the nickel contact paste to the anode of the cell
- Verify the seal area of the cell does not have any contact pase applied.
- Allow the cell to dry at room temperature overnight, or at 90 °C until the paste has fully dried.
- It is reccomended to paint and dry all the cells you will need for your build at one time.

7. Apply contact paste to the cathode electrode of the cell	 • Evenly apply approximately 3 grams of the LNCCu paste to the anode of the cell • Verify the seal area of the cell does not have any contact pase applied. • Make sure to assemble the stack while the cathode contact paste is still wet.

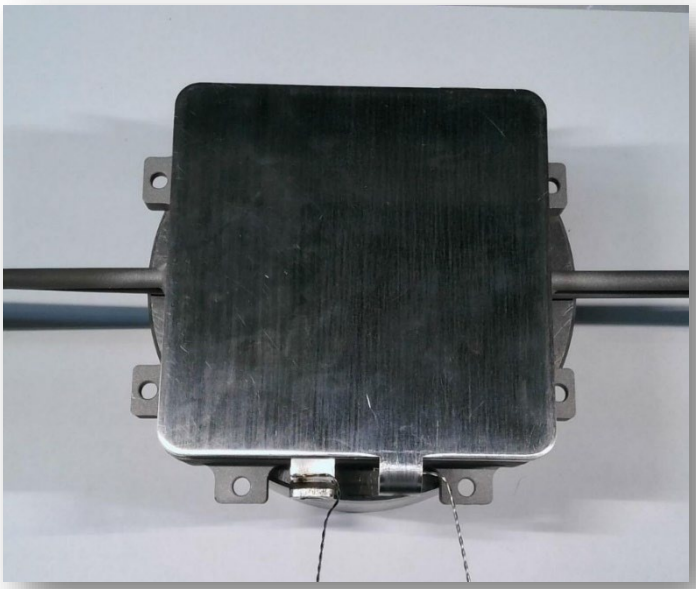
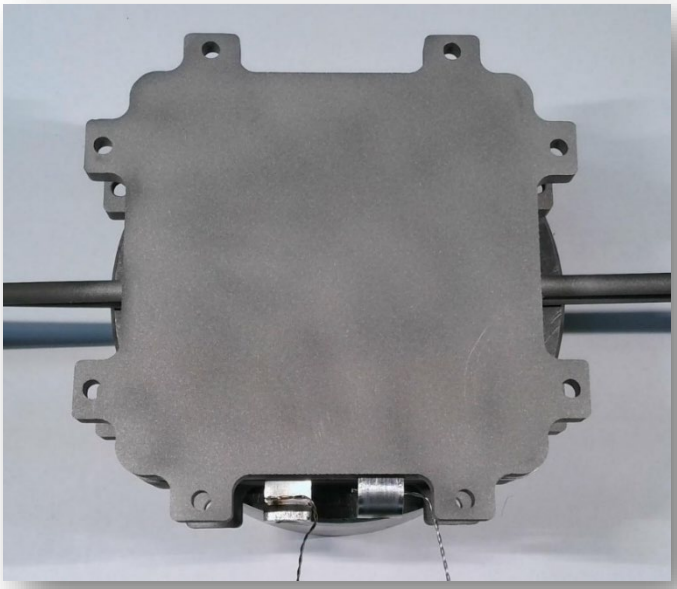
8. Place the cell fuel electrode side down onto the stack.	 • Verify the seal area of the cell does not have any contact paste applied.

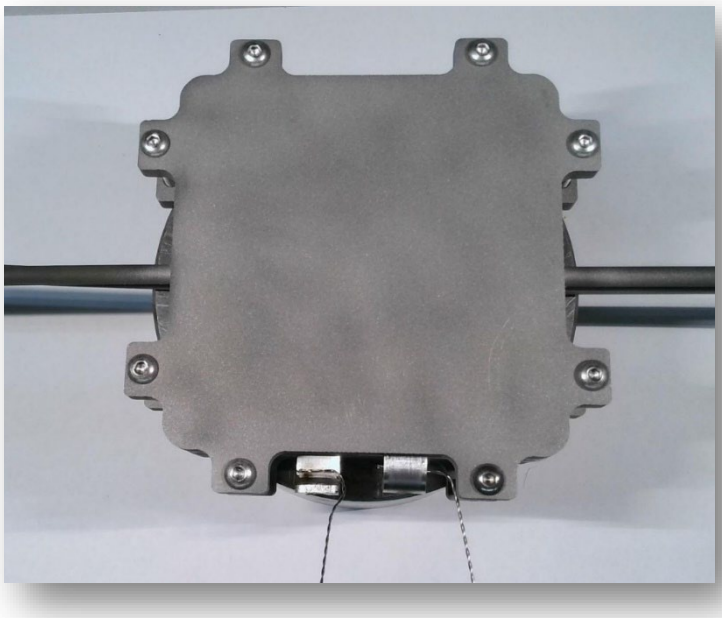
9. Place the Cathode Cell Seal onto the Cell.	 • Ensure the seal is aligned with the edges of the manifold, current plate and the Cell.

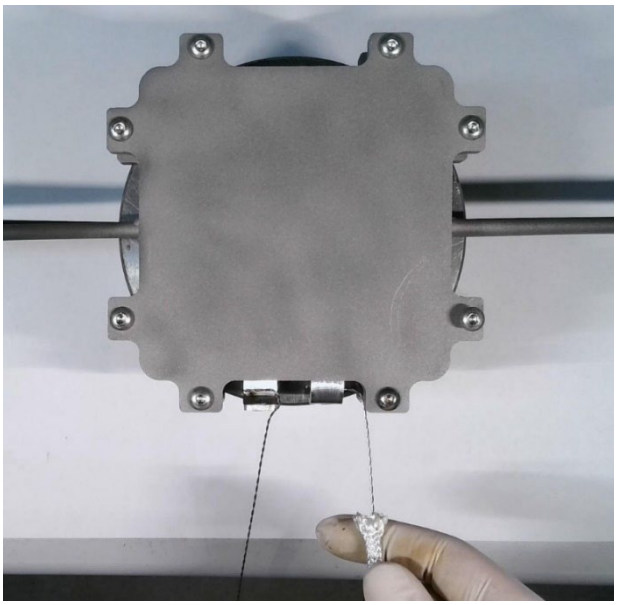
10. Place gas spacer shim onto cathode cell seal.	 • Ensure the shim is aligned with the edge of the cell and manifold.
11. Place the second cathode cell seal onto the spacer shim.	

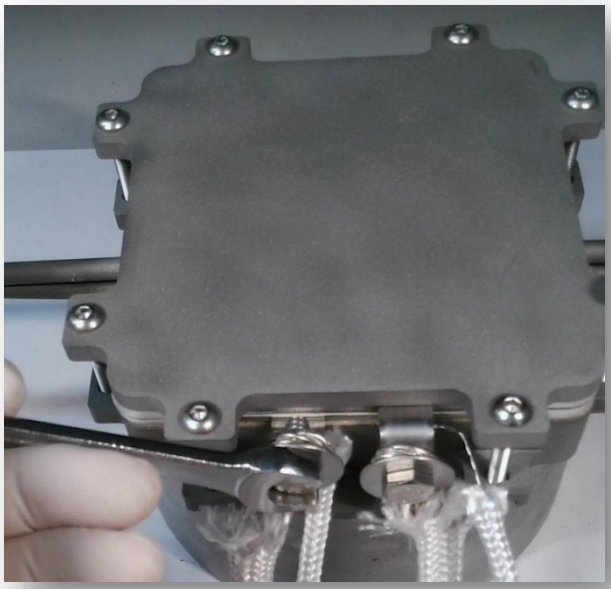
12. Place interconnect Ni side up onto the second cathode cell seal.	

13. Stack Repeat Units until stack is the desired number of cells.	• Repeat the process of stacking components:
	  ○ First fuel seal
	  ○ Spacer shim
	  ○ Second fuel seal
	  ○ Ported NextCell – Fuel side down.
	  ○ First Air seal
	  ○ Spacer shim
	  ○ Second air seal
	  ○ Welded interconnect – Ni side up.

14. Place the Cathode Current Plate onto the second Cathode Cell Seal on the final repeat unit.	
15. Place the backing plate onto the cathode current plate.	

16. Place appropriate length bolts, lightly tighten them by hand to locate the nut.	
17. Tighten each bolt to 3 in-lbs.	 • Tighten each bolt in a star pattern to 3 in-lbs of torque.

18. Use the insulation sleeving to isolate voltage sense wires.	 • Label the voltage wires. • Be careful not to pull the voltage wires off of the welded interconnects.

19. Attach Current Wires.	 • Using a 7/16” wrench, tighten the bolts to secure the current wires.
20. Transfer Assembly to Furnace	• Ensure all seals, plates and cells are aligned in the furnace before applying compression.
21. Apply Compression	• Apply 45lbf (200 N) to the assembly.
22. Connect Gas lines, Voltage Sense and Current wires.	• Attach the gas inlets to your gas control system. Connect exhausts. Connect the voltage sense and current wires to your electronic load. • Insulate all openings to furnace, taking care to prevent shorts between the sense wires or current wires. • **You can check for continuity between the voltage sense wires or current wires while the furnace is cool to check for shorts.** • The system is now ready for cell conditioning

STACK CONDITIONING

Before heating up the stack assembly, check that the cathode current wire is not connected to the electronic load. Follow the recipe below to heat-up, condition and reduce the cell. Conditioning is considered the heating of the cell with nitrogen on the anode, and air on the cathode respectively. Reduction begins once the furnace has reached 800 °C (step 4 below table), and the hydrogen concentration slowly begins to increase.

The table below shows an example curing and reduction profile for ONE cell, modification of the flow is needed based on the number of cells you are testing.

Cell Conditioning / Reduction – Flows Per Cell					
Furnace and Dwell Times			Oxygen Electrode	Fuel Electrode	
Step	Time [hh:mm:ss]	Temperature [°C]	Air Flow [SLPM]	Nitrogen Flow [SLPM]	Hydrogen Flow [SLPM]
1	14:00:00	0 → 850	0.757	0.757	0.000
2	10:00:00	850	0.757	0.757	0.000
3	1:00:00	850→800	0.757	0.757	0.000
4	0:00:00	800	1.27	0.506	0.253
5	0:30:00	800	2.53	0.253	0.370
6	0:30:00	800	2.53	0.000	0.663
7	0:30:00	800	2.57	0.000	0.886
8	0:30:00	800	2.57	0.000	1.140

The cell is considered fully reduced when the OCV has stabilized in the final gas flow condition. The stack is now ready for testing.