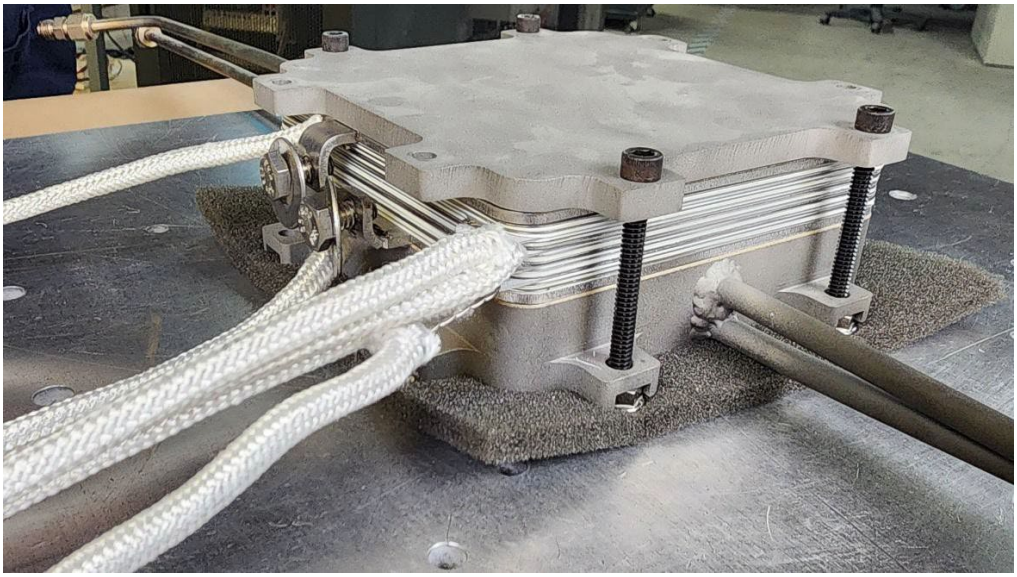
Short-Stack Test Fixture Kit Operations Manual



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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 as it is only rated to atmospheric levels of oxygen.
- 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 or accidental shocks. 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. The maximum allowable current is 60 A.
- Hot surfaces – The furnace and any tubing or wires within will become extremely hot during operation. Use insulation, PPE, and guarding to prevent burns.
- Maximum temperature - Ensure that the exhaust air temperature does not exceed 860 ºC. while operating in a fuel cell mode.

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.

An assembly video is available to accompany this document:

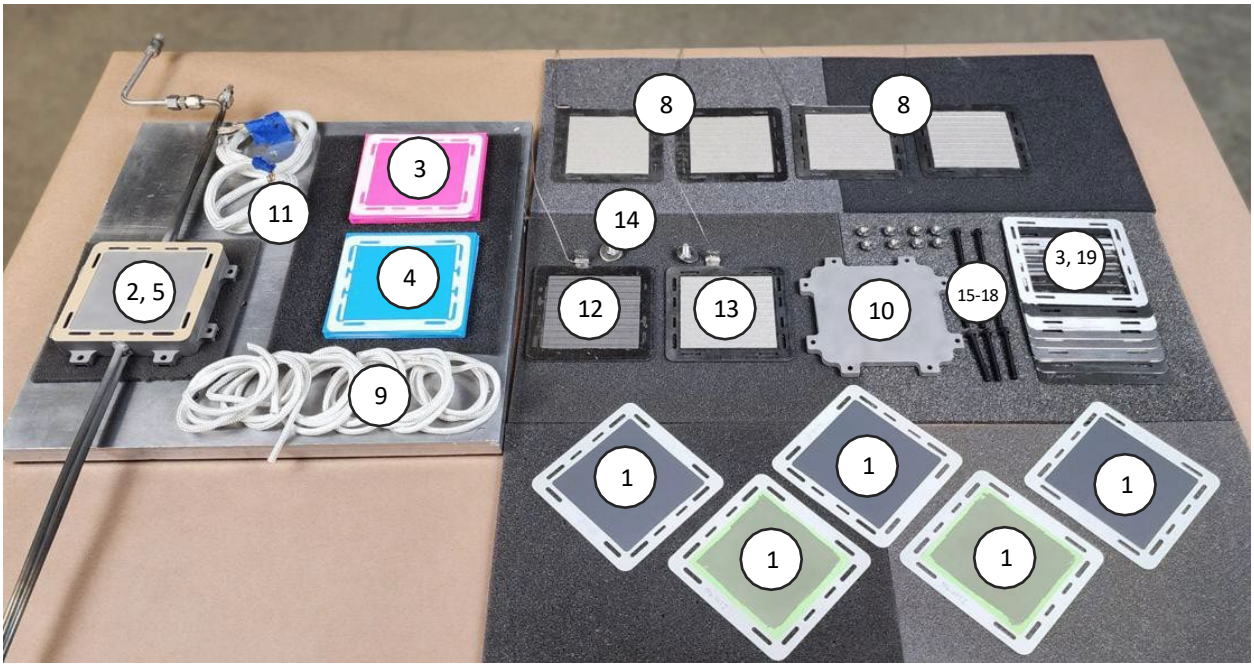
Short-Stack User Guide Video

Parts included in the Test Kit

Table 1. Parts Included in the Test Kit

#	Part Name	Description	Quantity
1	Ported NextCells	Cells included in the kit for testing	5
2	Manifold	Test manifold	1
3	Fuel Seal	Seals cell to the interconnect on fuel side	20
4	Air Seal	Seals cell to the interconnect on air side	20
5	Manifold Seal	Seals manifold to current plate	5
6	LNCCu Air Electrode Ink	Contact paste for the air electrode, 100 g pot	1
7	NiNiO Fuel Electrode Ink	Contact paste for the fuel electrode, 100g pot	1
8	Welded Interconnects	Interconnects with current collectors and voltage sense wires attached	10
9	Cersleev Insulation	Insulation for voltage sense and current wires	1
10	Backing Plate	Distributes load over the stack	1
11	Silver Wire	Current wire.	2
12	Top Current Plate	Current collection plate. Current Collectors and voltage sense wires attached	5
13	Bottom Current Plate	Current collection plate with gas pass-throughs. Current Collectors and voltage sense wires attached	5
14	¼"- 20 x ¼" Bolts / Washers	Used to secure current wires to current plates	10
15	1-3/8" 10-24 Screw	Used to attach the cell stack with height of 1	Varying
16	1-5/8" 10-24 Screw	Used to attach the cell stack with height of 3	Varying
17	1-7/8" 10-24 Screw	Used to attach the cell stack with height of 5	Varying
18	10-24 Thread Size Hex Nut	Used to secure the screws	Varying
19	Spacer Shim	Gas Cavity Spacer	20

Table 1. Parts Included in the Test Kit



Tools Not Included for Install

Table 2. Parts not Included for Install

Part Name	Description	Quantity
Scissors	Used to cut Cersleeve, voltage sense wires	1
Torque Wrench	Used to torque bolts, recommended 0-5 in-lb range	1
Brushes	Used to paint contact paste on electrodes	2
7/16" wrench	Used to secure silver current wires to stack	1
Square	Can assist in alignment of stack components	1
Cotton Applicators	Used to clean any contact paste in contact with seal area	As needed
Gloves	Used to load and deal with temperature of the furnace	1
Tape	Labeling the voltage and current wires	1

Equipment Necessary to Test

Table 3. Equipment Necessary to Test

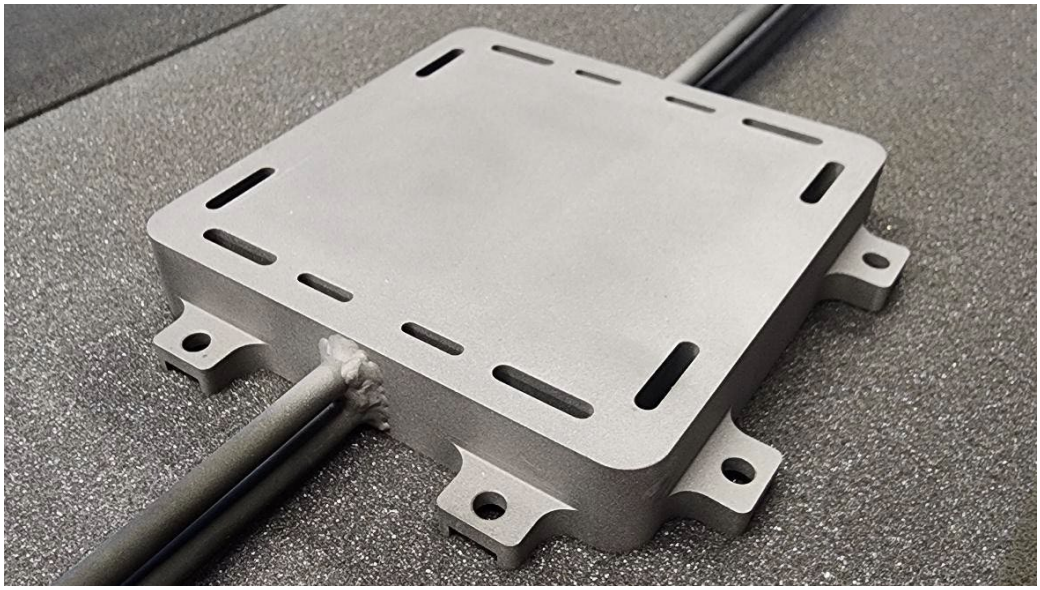
Part Name	Description	Quantity
Furnace	Appropriately sized furnace capable of 1000 °C maximum temperature	1
Compression System	Used to compress seals for good stack sealing	1
Fuel Electrode Humidifier (optional) and Condensate Collection.	Used to predict OCV, collection of condensate to prevent blockages of exhaust	1
Electronic Load/ Power Supply	Used to collect performance data	1
AC Impedance Spectroscopy	Used to study electrode characteristics and resistances (Optional)	1
Gas Controls	Used to control fuel electrode and air electrode gas compositions	1
Furnace Furniture and Insulation	Used to properly position stack assembly, insulate gas and current pass-throughs.	As Needed

- 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 counterflow by changing the inlet and outlet locations.

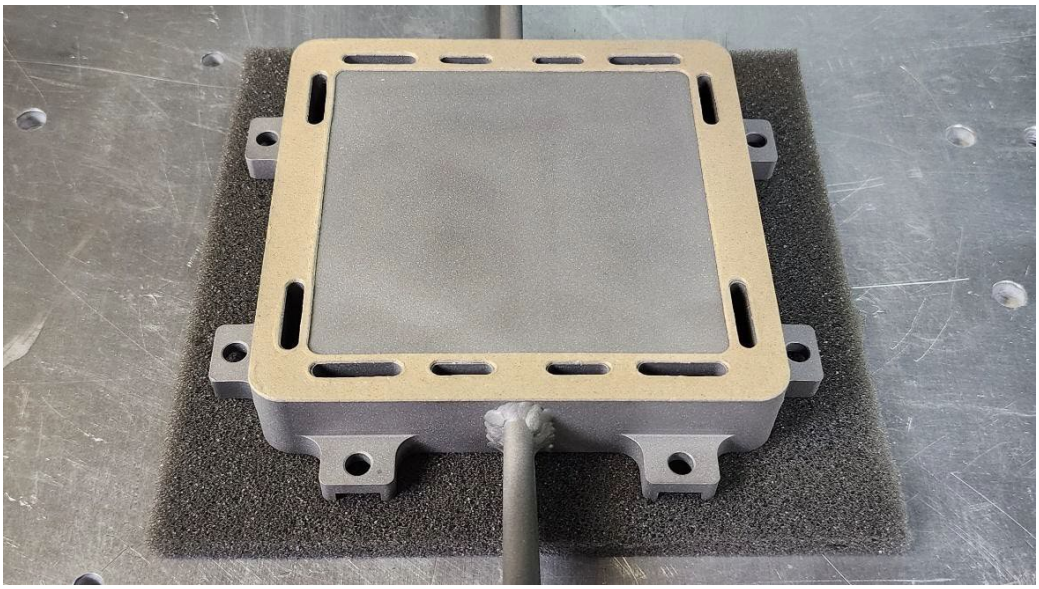
- The manifold does not require any heat treatment or conditioning prior to first use.

Step 1: Set manifold on flat, stable surface



A level surface is the foundation for a well-built stack. Ensure ports are clear of debris from previous tests. If there are debris or leftover seals stuck to the manifold, use 1200-grit sand paper and a flat sanding block to gently remove the residue.

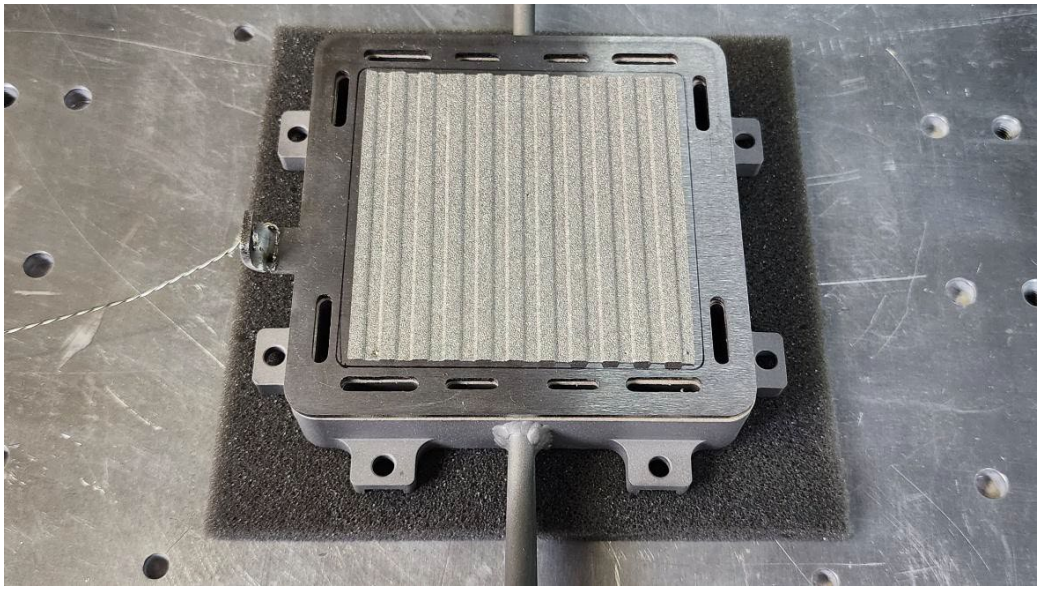
Step 2: Place the manifold seal on the manifold



Be sure not to obstruct any of the gas ports.

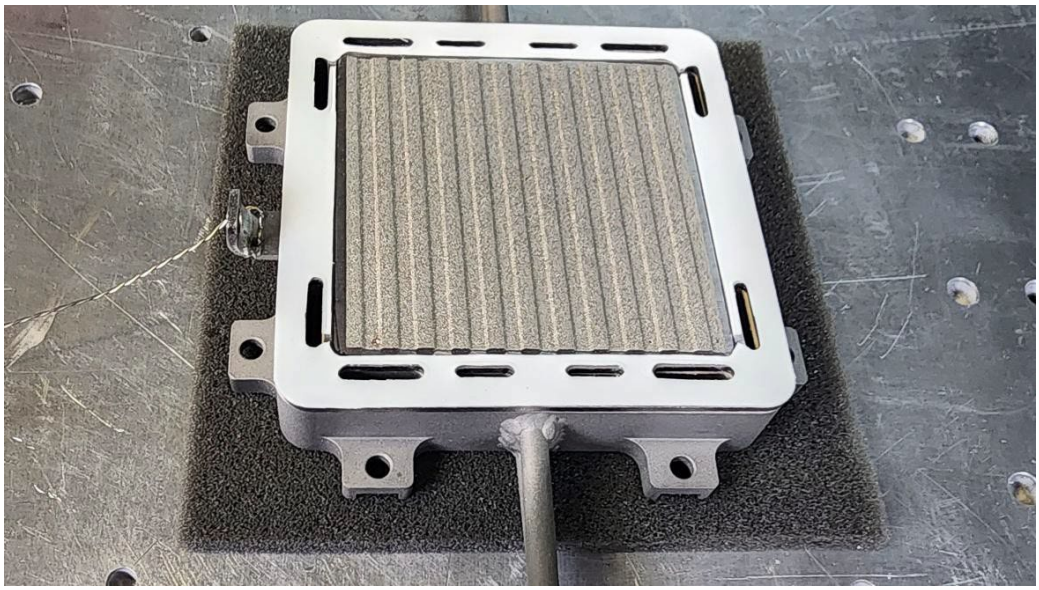
Helpful tips: You may use a small amount of cyanoacrylate between the components to keep them from shifting during the build.

Step 3: Place the fuel current plate onto the manifold seal



Consider the direction in which your current wires will exit the furnace when selecting an orientation.

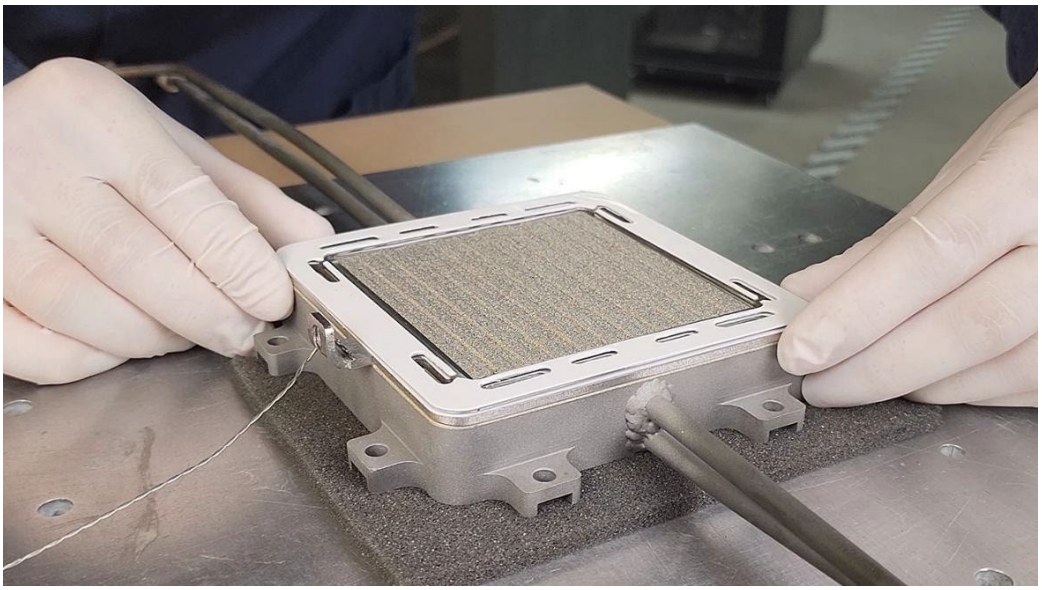
Step 4: Place the first fuel cell seal



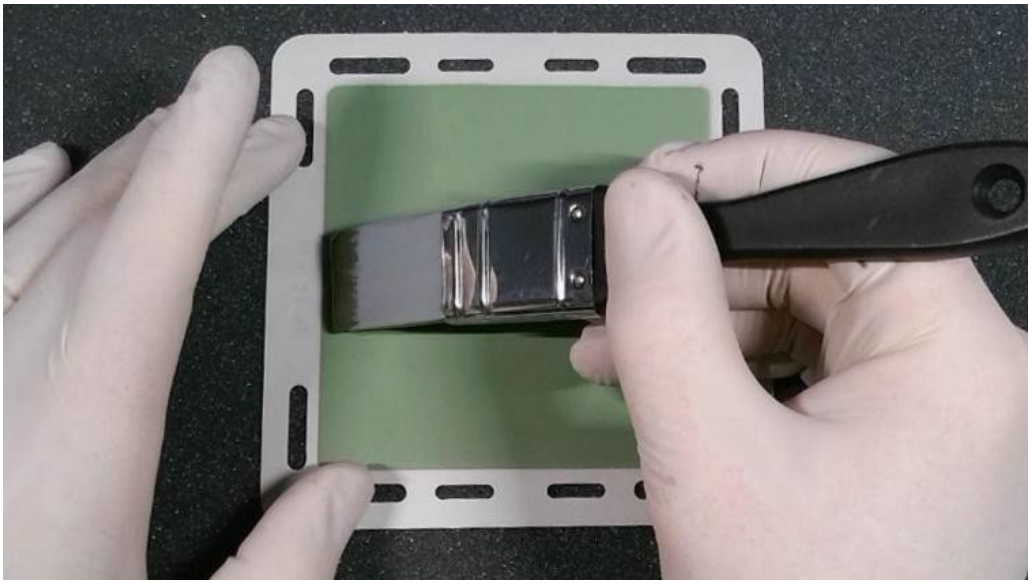
Step 5: Place the gas spacer shim on the first fuel cell seal

Use the corners of the manifold to help align the shim.

Step 6: Place second fuel cell seal on the gas spacer shim



Step 7: Apply contact paste to the cell fuel electrode



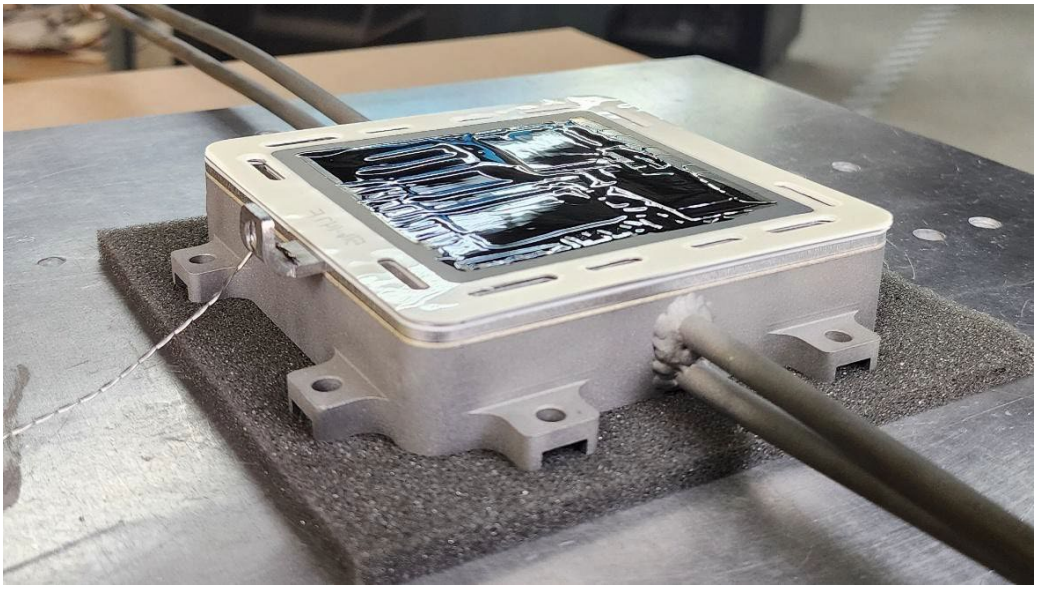
Evenly apply approximately 3 g of nickel contact paste to the fuel electrode of the cell and ensure that no paste is applied to the seal area. Allow the cell to dry either overnight at room temperature or at 90 °C for approximately one hour until the paste is fully dry. For efficiency, it is recommended to prepare and dry all required cells for the build in a single batch. During application and drying, take care not to obstruct any gas ports.

Helpful tips: This step can be done ahead of the short-stack build. A completely dry fuel electrode will make the build process easier to complete. You may leave 2-3mm of unpainted electrode on all edges to reduce the risk of seal contamination.

Step 8: Apply contact paste to the air electrode of the cell

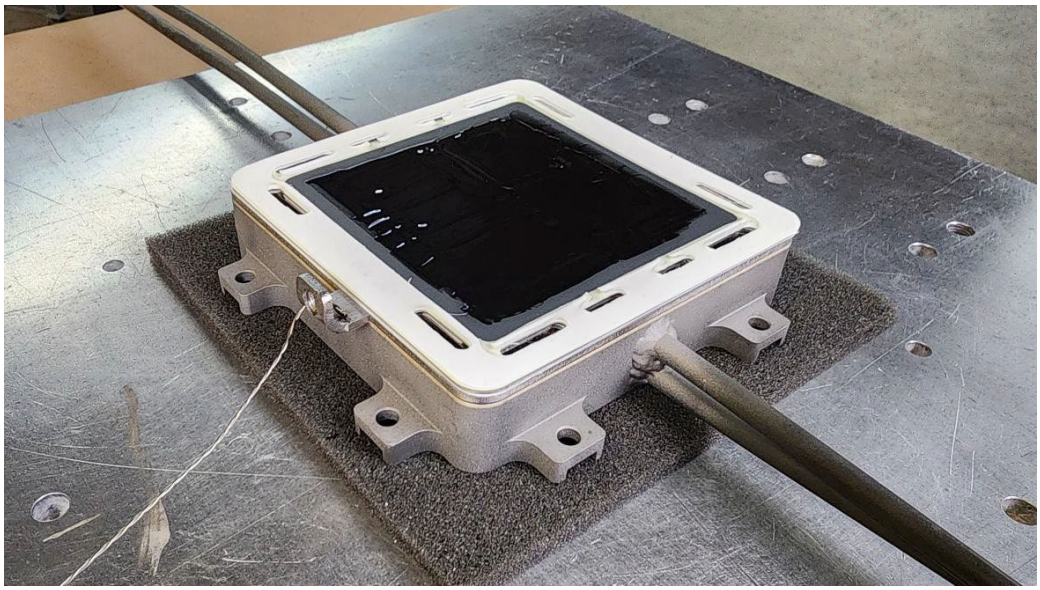
Evenly apply approximately 3 g of LNCCu paste to the air electrode of the cell and ensure that no paste is applied to the seal area. Assemble the stack while the air electrode contact paste is still wet to ensure the best possible connection. For additional protection against seal contamination, leave 2–3 mm of unpainted electrode along all edges.

Step 9: Place the cell fuel electrode side down onto the stack



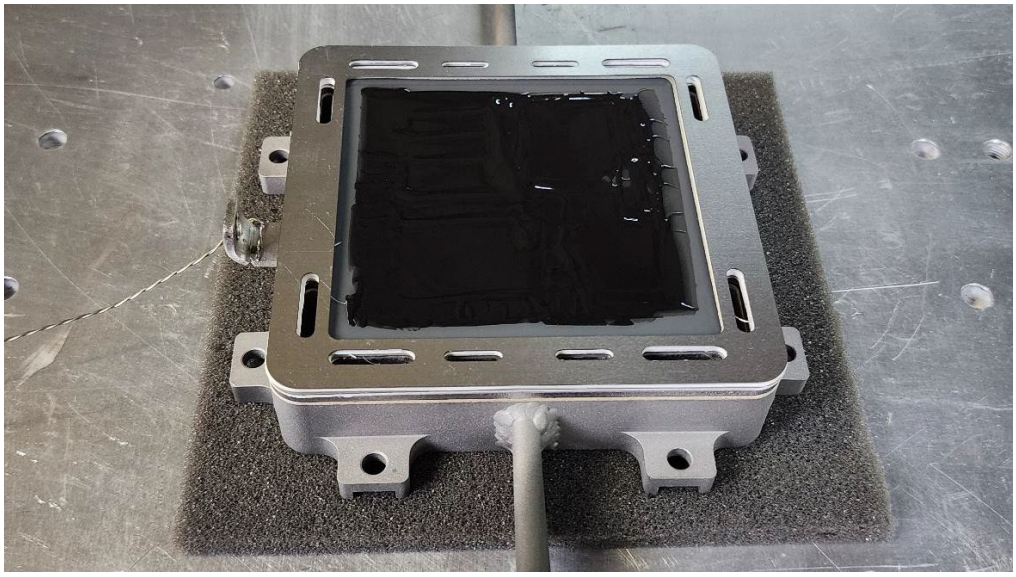
Verify the seal area of the cell does not have any contact paste applied.

Step 10: Place the air cell seal onto the cell

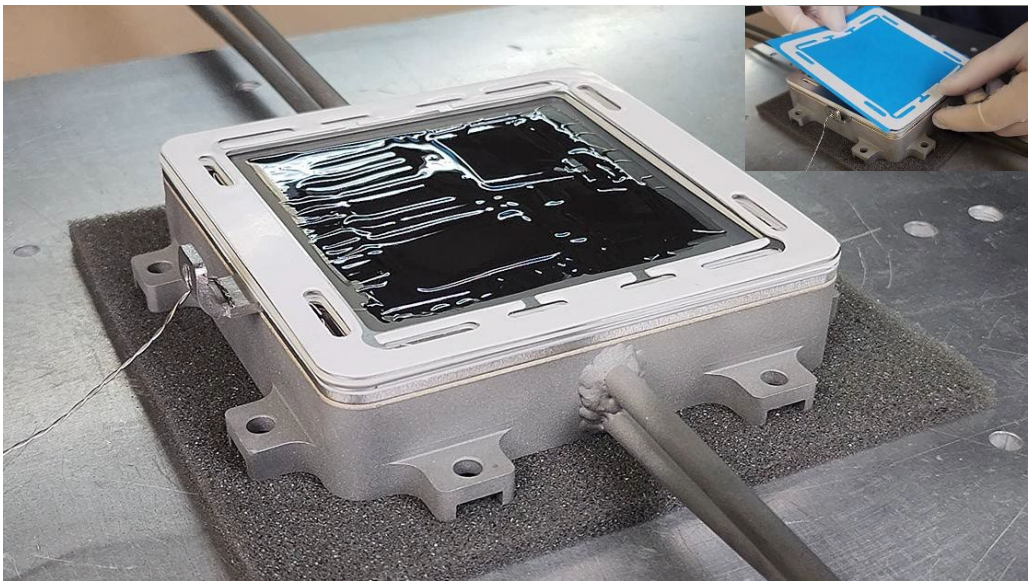


Ensure that the seal is properly aligned with the edges of the manifold, current plate, and cell. Because the seals are flexible, they can be adjusted if misalignment occurs during handling.

Step 11: Place gas spacer shim onto air cell seal



Step 12: Place the second air cell seal onto the spacer shim

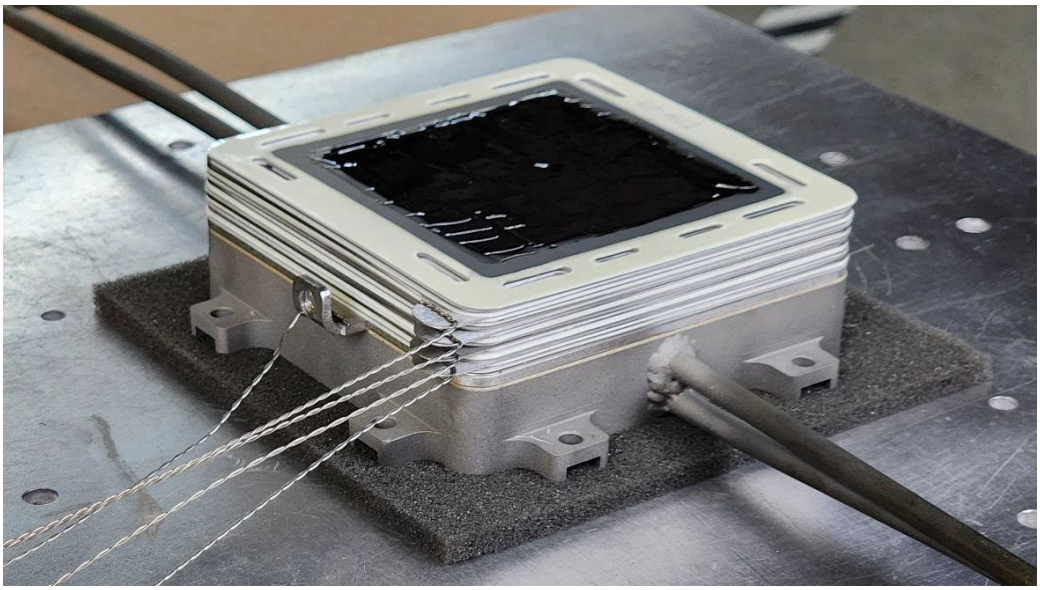


Lay the seal in place using the paper provided (shown in the top-right illustration) to minimize the risk of contamination. Refer to the build video for a demonstration of this procedure.

Step 13: Place interconnect Ni side up onto the second air cell seal

Consider the direction in which the voltage wires will exit the furnace when selecting orientation.

Step 14: Stack repeat units until stack is the desired number of cells



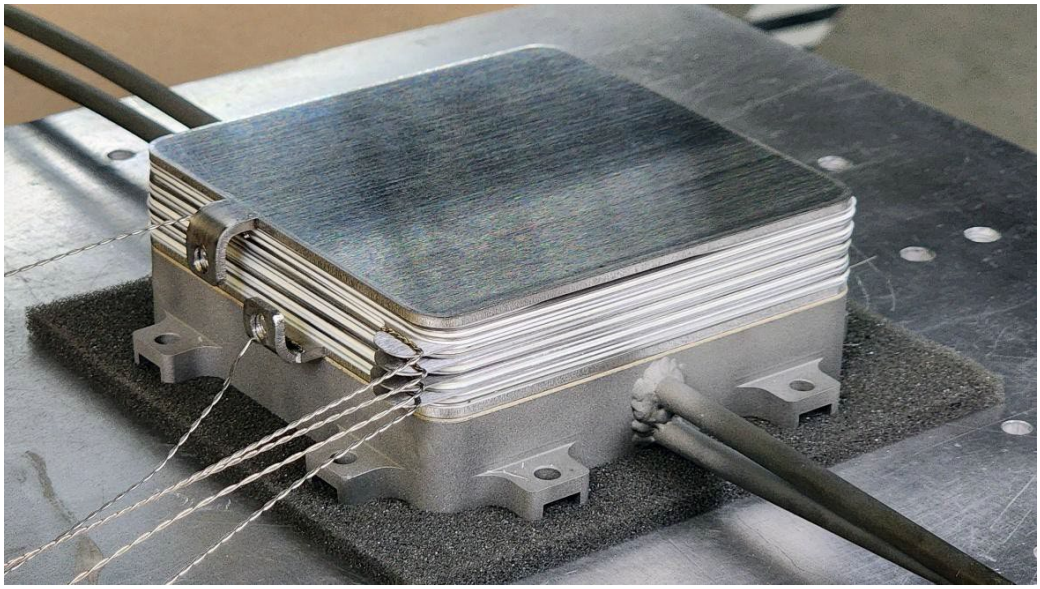
Repeat the component stacking process as needed. This short-stack kit is designed to accommodate between one and five cells. Use the checklist in Table 4 to confirm that each repeat unit contains all required components.

Table 4. Checklist of Materials for Each Unit

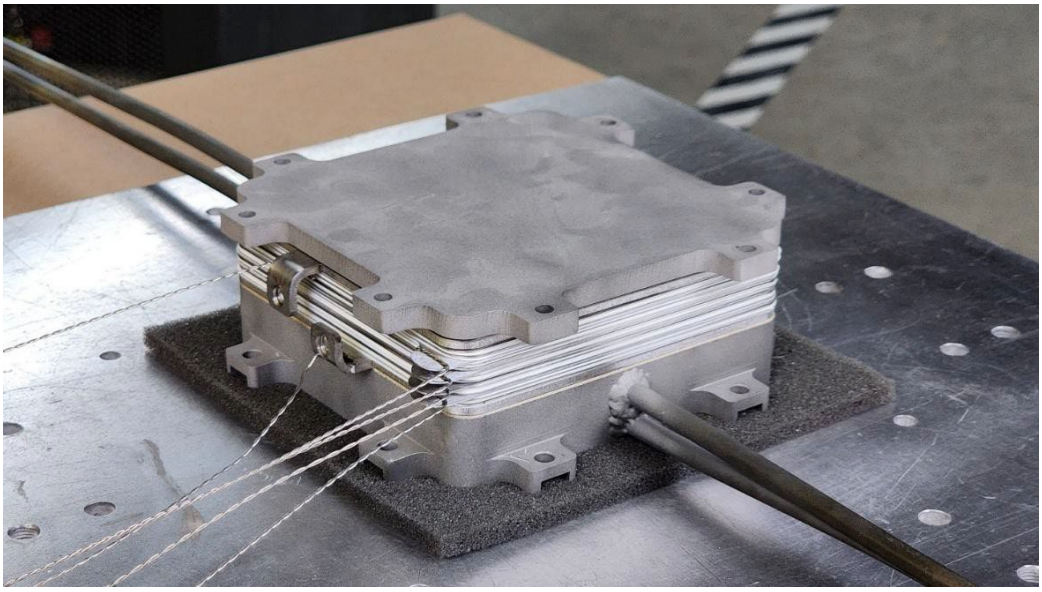
Part	Part Number*	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
First fuel seal	3					
Spacer shim	3					
Second fuel cell	3					
Ported NextCell-fuel side down	1					
First air seal	4					
Spacer shim	3					
Second air seal	4					
Welded interconnect-Ni side up	8					

** Part number used from Table 1*

Step 15: Place the air side current plate onto the second air side cell seal on the final repeat unit

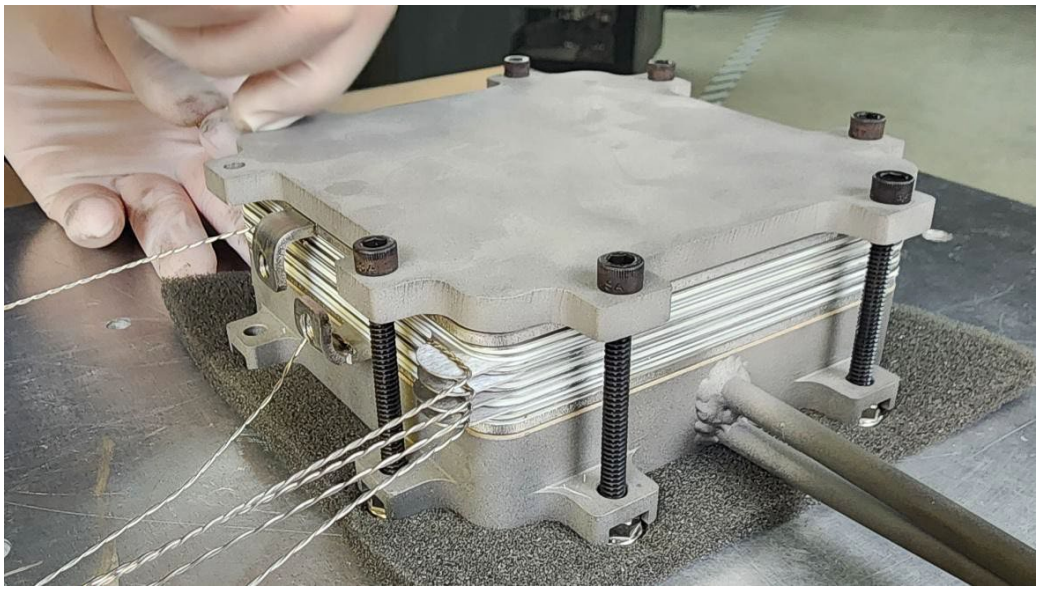


Step 16: Place the backing plate onto the air side current plate



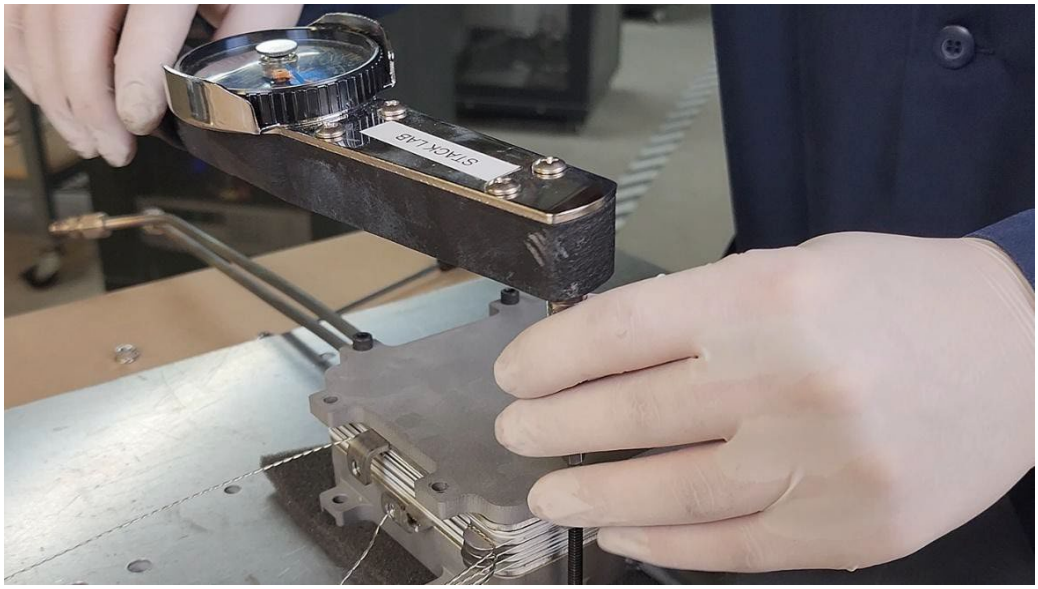
Align the edges of the backing plate to the edges of the air side current plate.

Step 17: Place nuts into the manifold, bolts into the backing plate, and hand-tighten



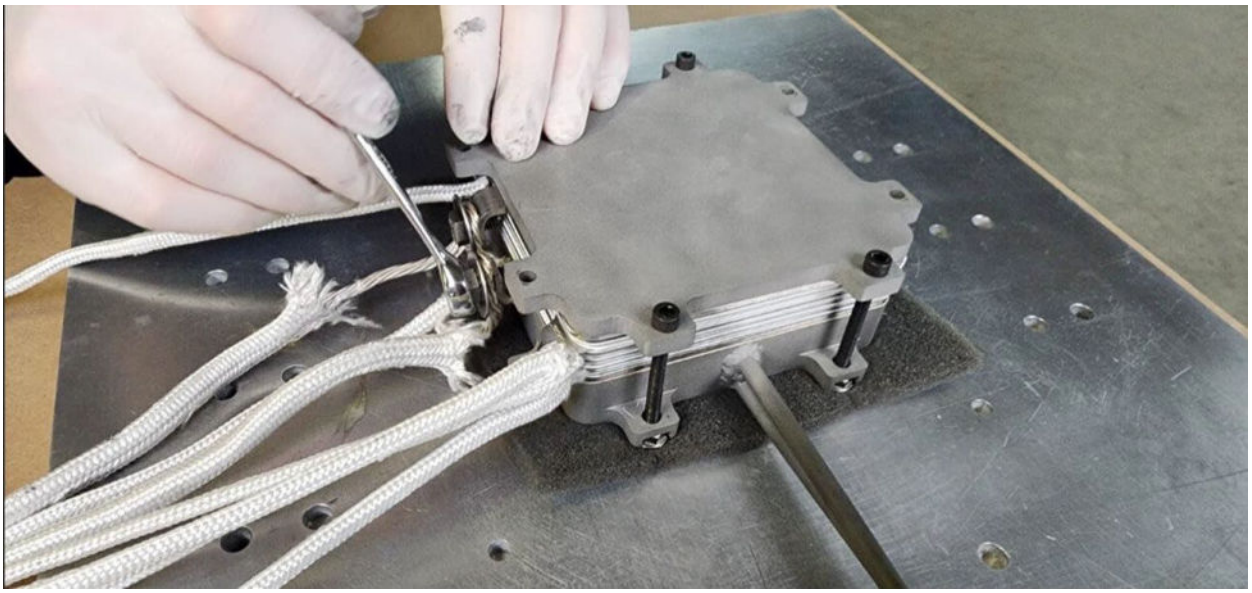
Hand tighten in a star-pattern. You may choose to use 4 bolts or 8.

Step 18: Tighten each bolt to 3 in-lbs



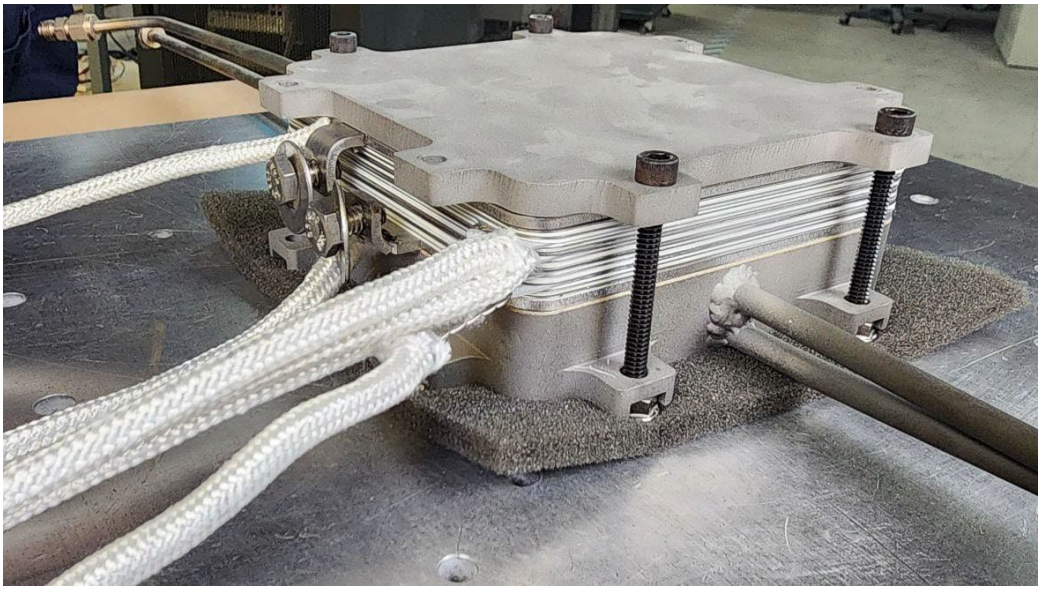
Tighten each bolt in a star pattern. As the manifold seal compresses, repeat the tightening sequence until all bolts reach an equal torque value.

Step 19: Attach current wires to the fuel and air side current plates



Using a **7/16 in.** wrench, tighten the bolts to secure the current wires. Apply anti-seize compound to the threads of the bolts only to facilitate removal of the current wires after testing.

Step 20: Install the insulation sleeves onto all wires



Helpful tips: Do not cut the looped end of the voltage wire before installing the insulation sleeves. Once the sleeves are in place, you may trim the voltage wire to the appropriate length.

Step 21: Transfer assembly to furnace

Ensure all seals, plates, and cells are aligned into the furnace before applying compression.

The bolts should be carefully removed before applying load. The nuts may be removed with a magnet or a pick.

Note: if the nuts and bolts are not removed at this point, they will become more difficult to remove.

Helpful tips: Route the voltage wires and current wires out of your furnace and fix with insulation before removing bolts to prevent misalignment.

Step 22: Apply compression

Gradually add weight or force to the assembly until it reaches the target of 45lbf (200N).

Step 23: Connect gas lines, voltage sense and current wires.

- Attach the gas inlets to your gas control system. Connect the exhausts. Connect the voltage sense and fuel current wire 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.

Helpful tips: Only manipulate tubing before bolts are removed or after compression is applied.

Completed Short Stack Configuration

The image depicts the exploded view of the completed short stack as assembled in the preceding steps with 5 cells.

Furnace Loading Instructions

Before heating up the stack assembly, check that the air side 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 fuel electrode, and air on the air side, 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 provides a sample curing and reduction profile for ONE cell. Adjust the flow parameters as needed based on the number of cells being tested, as the required flow rate scales proportionally with the number of cells.

Table 5. Curing and Reduction Profile of One Cell

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. You may reconnect the air side current wire.

Troubleshooting

If you ever run into challenges with either the stack build, your furnace setup, or conditioning the cell(s), Nexceris is standing by to support you. Please feel free to reach out to info@nexceris.com for support.