July 30, 2025, Version 1.3

Hyper-Cold Fusion Experimental Apparatus: Design Specifications and Operating Procedures

Nano Fusion Design
Ryoji Furui
info@nanofusion.design

I presented a poster at the international conference ICCF26 held in Iwate, Japan, in May 2025, and subsequently authored a proceedings paper[1]. The following is a description of the experimental design of the hyper-cold fusion experiment.

1. Introduction

This document describes the experimental apparatus in detail, including explosion-proof safety equipment, and provides comprehensive operating procedures. This document will be revised and distributed as needed to serve as a foundational reference for those implementing this experiment and for third parties conducting follow-up tests and similar developments.

The contents of this document are primarily intended for readers who have extensive background in cold fusion research and experimental experience, as it focuses on the newly introduced concept of hyper-cold fusion. Future updates are expected to provide a comprehensive experimental guide for newcomers to the field. Input from various fields of expertise is welcomed.

One rapidly developed application of high-pressure hydrogen gas in recent years is fuel for hydrogen-powered vehicles. In fuel tanks, hydrogen gas is typically compressed to approximately 80 MPa at room temperature, which represents the current operational compression limit. In this experiment, hydrogen at a maximum working pressure of 100 MPa is contained and heated to several hundred degrees Celsius, creating handling challenges that exceed those of existing high-pressure hydrogen gas applications. It is anticipated that conventional materials for high-pressure hydrogen systems will be inadequate for these conditions. Considering the heat and pressure resistance requirements of components made from various materials, the equipment should be designed specifically for high-load and long-duration operation. Specifically, the fuel materials (including graphene) are heated in a primary container, with a secondary sealed container (referred to as a sealed core socket) completely enclosed within the primary container. Following the heating operation, the internal pressure and residue in the core socket are measured after the primary container has cooled and been opened. Measuring the core socket's internal pressure requires a remotely operated opening device.

[1] Ryoji Furui "Introducing Hyper-Cold Fusion (Draft version)"
https://github.com/nanofusion/hypercoldfusion/blob/main/iccf26proceeding.pdf

2. Equipment Specifications and Schematic Diagram

The experimental setup primarily consists of two chambers. Chamber 1 (C1) serves as the fusion reaction chamber, containing fuel and providing heating capability. As detailed in Table 1, it must withstand high-temperature, high-pressure hydrogen gas conditions. Chamber 2 (C2), specified in Table 2, contains inert gas to provide explosion-proof containment for C1. When high-temperature, high-pressure hydrogen gas leaks from C1, it mixes with the inert gas in C2 to create a non-flammable gas mixture. For 100 MPa operation in C1, C2 requires a 200 L volume to achieve a non-flammable state.

Table 1: C1 Specifications

Entry	Name	Specification		Remarks
1	Container	Material: Hastelloy X		
2	Capacity	Design volume: 100 mL	Working volume: 50 mL	
3	Pressure	Design pressure: 150 MPa	Operating pressure: 100 MPa	
4	Temperature	Design temp: 1000 °C	Operating temp: 600 ℃	
5	Contents	Graphene and borophane powder, hydrogen gas generation		*1

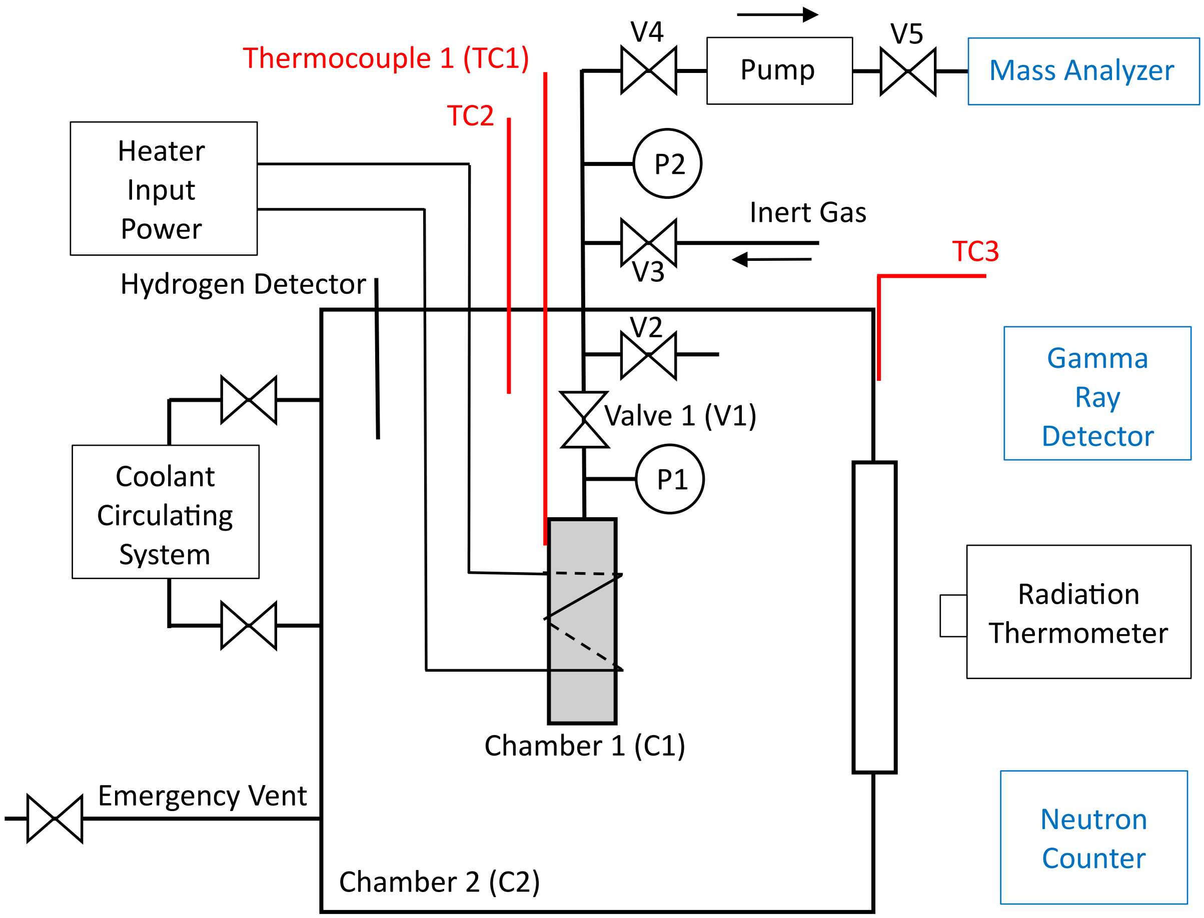
*1: Hydrogen gas is produced when borophane powder is heated above 200°C.

Table 2: C2 Specifications

Entry	Name	Specification		Remarks
1	Container	Material: SUS316		
2	Capacity	Design volume: 100 L	Working volume: 100 L	
3	Pressure	Design pressure: 5 MPa	Operating pressure: 2.5 MPa	
4	Temperature	Design temp: 1000 °C	Operating temp: 600 ℃	
5	Contents	Inert gases such as nitrogen, argon, etc.		

The experimental apparatus, including the internal explosion-proof structure, is described in Figure 1. The explosion-proof safety equipment details, including the inert gas system (Inert Gas), cooling system (Coolant Circulating System), and leak detection and monitoring (Hydrogen Detector), are described in conjunction with the C2 installation. The arrangement of the various nuclear detection sensors is shown in blue in the figure.

Figure 1: Schematic of experimental setup



For temperature sensing (thermocouples), TC1 measures the C1 outer wall temperature, TC2 measures the C2 internal gas temperature, and TC3 measures the C2 outer wall temperature. Pressure gauge P1 measures the gas pressure inside C1, and P2 measures the gas pressure inside C2. The operation of the valves is described in the following procedure. The cooling system and emergency vent are normally inactive with their valves closed, but can be operated as needed based on operational conditions.

The right wall of C2 features a sapphire window that allows interior viewing. An infrared thermometer (Radiation Thermometer) is used to measure the temperature of C1's outer wall. V1, P1 are directly connected to C1, which operates at 100 MPa pressure. These components represent the most heavily loaded parts of the entire system and are potential leak points for hydrogen gas from C1.

3. Operating Procedure

The following is an example of an operating procedure in which a sample (0.1 g of graphene and 0.02 g of borophane) is placed in C1 and 0.1 MPa of argon gas is loaded into C2. The gas pressure in C1 is assumed to be 5 MPa during heating. The end state of each component is described in a table for each process.

Regarding container construction, both C1 and C2 have flanges installed on their tops, which are opened and closed during operation. Although not shown in Figure 1, the upper flanges of both C1 and C2 are secured by a frame or similar mounting system. The piping to valve 1 (V1), heater wires, and TC1 connected to C1 are typically handled as a fixed assembly with the frame.

1) Initial condition: Initially, the heater is turned off (OFF), the top flange (F1) of C1 and the top flange (F2) of C2 are closed (C), and all valves are closed. Air is contained in C1 and C2.

Part	Heater	F1	F2	V1	V2	V3	V4	V5	C1	C2
State	OFF	C	C	C	C	C	C	C	Air	Air

2) Open F2 (O) and then open F1.

Part	Heater	F1	F2	V1	V2	V3	V4	V5	C1	C2
State	OFF	O	O	C	C	C	C	C	Air	Air

3) Place the sample inside F1, close F1 (C) and open V1 (O).

Part	Heater	F1	F2	V1	V2	V3	V4	V5	C1	C2
State	OFF	C	O	O	C	C	C	C	Air	Air

4) Open V4 and use a vacuum pump to create a vacuum of 1 Pa at C1.

Part	Heater	F1	F2	V1	V2	V3	V4	V5	C1	C2
State	OFF	C	O	O	C	C	O	C	1Pa	Air

5) Close V1, open V2, and close F2.

Part	Heater	F1	F2	V1	V2	V3	V4	V5	C1	C2
State	OFF	C	C	C	O	C	O	C	1Pa	Air

6) Vacuum C2 to 1 Pa with a vacuum pump (Pump).

Part	Heater	F1	F2	V1	V2	V3	V4	V5	C1	C2
State	OFF	C	C	C	O	C	O	C	1Pa	1Pa

7) Close V4 and open V3. Argon is supplied to C2 at 0.1 MPa.

Part	Heater	F1	F2	V1	V2	V3	V4	V5	C1	C2
State	OFF	C	C	C	O	O	C	C	1Pa	0.1MPa

8) Close V3, heat TC1 with a heater at 250°C for 3 hours, and take measurements from each instrument.

Part	Heater	F1	F2	V1	V2	V3	V4	V5	C1	C2
State	ON	C	C	C	O	C	C	C	5MPa	0.1MPa

9) After the heater is turned off and cooled sufficiently, open V4 and exhaust the gas.

Part	Heater	F1	F2	V1	V2	V3	V4	V5	C1	C2
State	OFF	C	C	C	O	C	O	C	5MPa	0.1MPa

10) Open F2 and close V2. Open V5.

Part	Heater	F1	F2	V1	V2	V3	V4	V5	C1	C2
State	OFF	C	O	C	C	C	O	O	5MPa	Air

11) Gradually open V1 to exhaust the high-pressure hydrogen from C1 and subject the gas to mass spectrometry.

Part	Heater	F1	F2	V1	V2	V3	V4	V5	C1	C2
State	OFF	C	O	O	C	C	O	O	1Pa	Air

12) Close V5, open V2; open F1, remove residue from C1 and other areas, and clean.

Part	Heater	F1	F2	V1	V2	V3	V4	V5	C1	C2
State	OFF	O	O	O	O	C	O	C	Air	Air

13) Close all the parts to return to the initial state.

Part	Heater	F1	F2	V1	V2	V3	V4	V5	C1	C2
State	OFF	C	C	C	C	C	C	C	Air	Air

4. Other Notes and Considerations

[1] Evacuate C1 and C2 or fill them with inert gas instead of air, depending on operating conditions, such as when the equipment will not be used for extended periods.

[2] The specifications for sealed and open core sockets will be finalized during the detailed design phase of each component.

[3] The cooling system is intended to operate in response to high-temperature anomalies in C2, but can also be used to stabilize temperatures during normal operation. A water-cooled circulation system could also be installed on C1's outer wall, potentially serving as an energy extraction method for commercial applications such as boilers.

[4] If the fusion reaction persists after heater input reduction, the coolant circulating system provides an alternative shutdown mechanism. This cooling-based shutdown procedure will be configured as a repeatable operation, enabling reliable device control through thermal management protocols as described in Note [3].

[5] It is conceivable that C1 could break or rupture during high-temperature operation, for example, due to deterioration from long-term use. In such a case, the shock wave may momentarily exceed the resistance of C2. In anticipation of such a situation, the system is operated remotely during operation and explosion-proof walls are installed. The C1 after cooling is still under high-pressure and has the same hazard. It is essential to establish a means to remotely operate the C1 under high-temperature or high-pressure conditions in order to conduct repeated experiments over a long period of time.

[6] If an emergency exhaust valve is installed, the exhaust port should be small in diameter and positioned to allow safe venting of high-temperature hydrogen gas during combustion. The valve should be operable both automatically and manually at any time.

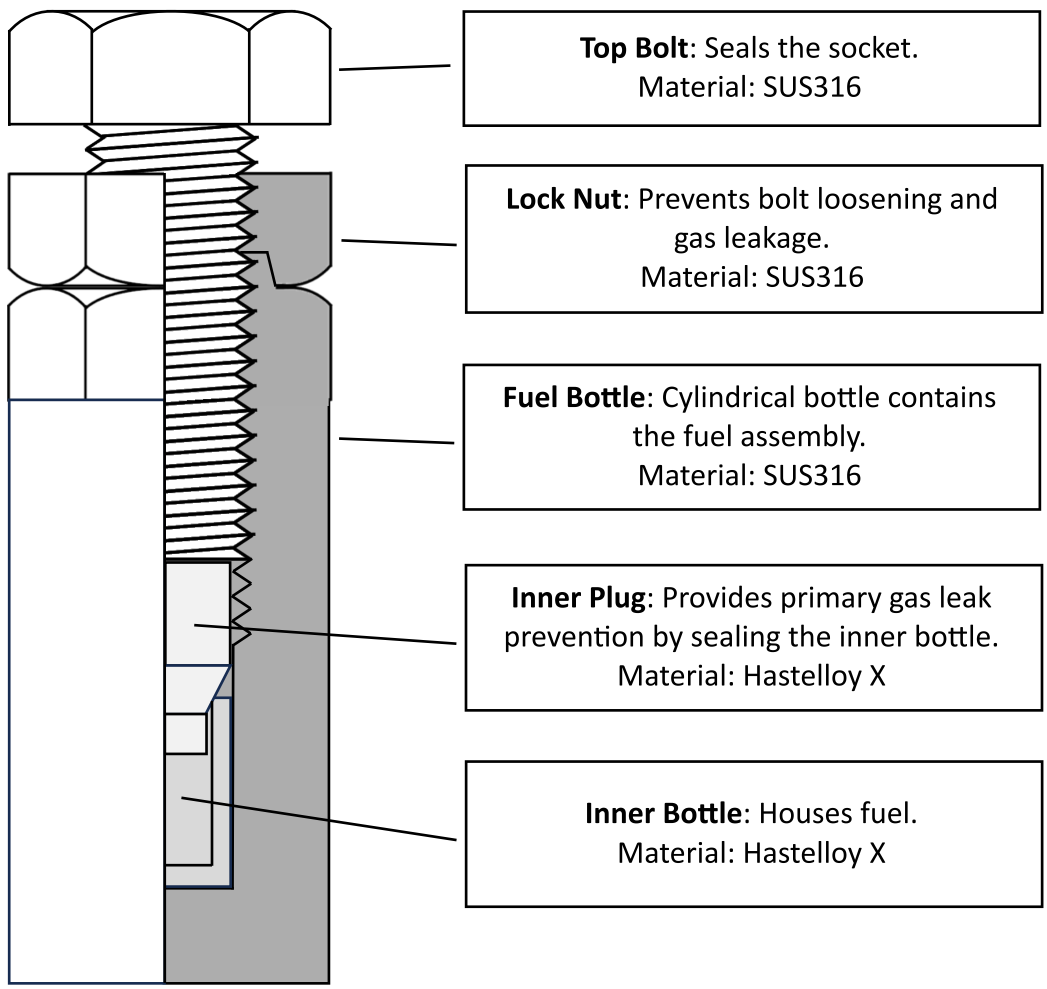
Appendix 1: Triplex Enclosure System for Intensive Operations

As discussed at the end of the Introduction and Section 2, we can introduce a secondary sealed container—the Sealed Core Socket (SCS)—for higher-temperature and higher-pressure operation. This system protects components V1 and P1 from overload conditions and enables them to monitor for gas leaks from the SCS into C1. Table 3 and Figure 2 detail the SCS design, which can be installed within the existing C1 enclosure. Additionally, the SCS can function as the primary fuel rod enclosure in commercial heat production.

Table 3: SCS Specifications

Entry	Name	Specification		Remarks
1	Container	Material: SUS316 and Hastelloy X		
2	Capacity	Design volume: 10 mL	Working volume: 10 mL	
3	Pressure	Design pressure: 150 MPa	Operating pressure: 120 MPa	
4	Temperature	Design temp: 1000 °C	Operating temp: 750 °C	
5	Contents	Graphene and borophane powder, hydrogen gas generation		

Figure 2. Schematic of SCS



Appendix 2: Hyper-Cold Fusion as a Battery (HB)

This appendix details modifications to the Sealed Core Socket (SCS) for battery implementation, building upon prior work in cold fusion battery design[2]. As shown in Figure 3, the design positions the cathode atop the SCS with the anode at its base. To prevent gas leakage, the HB specifications (Table 4) target reduced operating temperatures (<100 °C preferred) and pressures (<10 MPa preferred). The key design challenge involves channeling electron flow from anode to cathode through a power diode (Schottky or PN junction type). Finalizing the battery design requires additional experimental data on thermal output.

This approach enables direct electricity generation, bypassing traditional steam boilers and turbines for thermal-to-electric conversion. Despite reduced energy density, the system maintains efficiency advantages for electrical applications.

Figure 3: Diagram of HB component

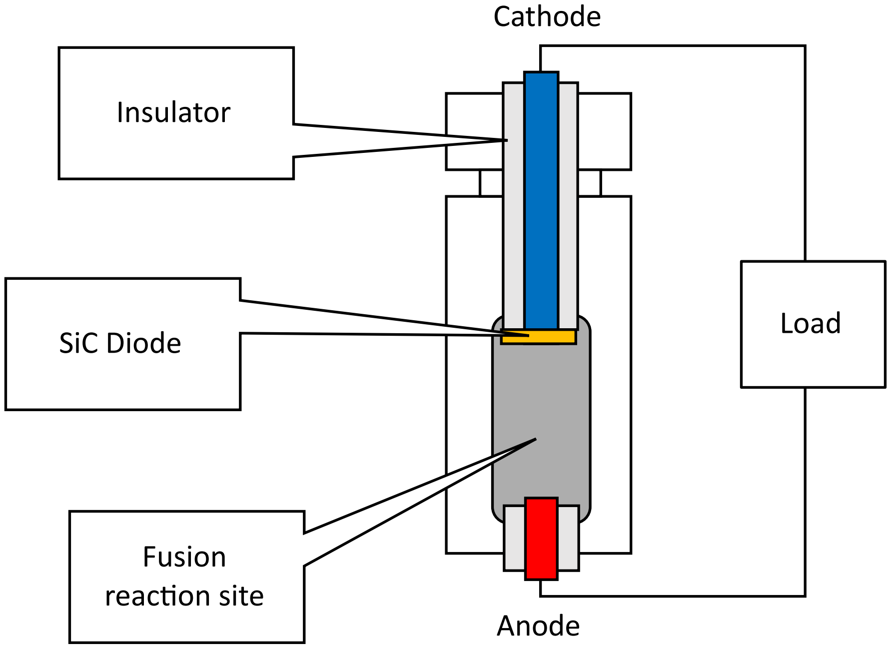


Table 4: HB Specifications

Entry	Name	Specification		Remarks
1	Container	Material: SUS316 and Hastelloy X		
2	Capacity	Design volume: 10 mL	Working volume: 10 mL	
3	Pressure	Design pressure: 50 MPa	Operating pressure: 25 MPa	
4	Temperature	Design temp: 300 °C	Operating temp: 200 ℃	
5	Contents	Graphene and borophane powder, hydrogen gas generation		

[2] Ryoji Furui "The Design of a Low-Nuclear Battery"
https://github.com/nanofusion/basic/blob/main/jcf24proceedings_RFurui2D.pdf

As shown in Figure 4, the battery components largely mirror the SCS design. However, electrodes sealed with ceramic insulators are installed at the reactor body's center alongside the diode. The diode must withstand extreme environmental conditions due to its placement within the nuclear reaction zone. Ideal semiconductor materials for this application include silicon carbide (SiC), gallium nitride (GaN), aluminum nitride (AlN), or synthetic diamond.

Figure 4. Schematic of HB